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Network Optimization of Dynamically Complex Systems

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NETWORK OPTIMIZATION
OF
DYNAMICALLY COMPLEX SYSTEMS

by

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ABSTRACT

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The aim of this research is to optimize large scale network handling capabilities for large system inventories and to implement strategies for the purpose of reducing capital expenses. As computers become more and more networked, it is easier to share files among storage media. In addition, more bandwidth will be consumed by network flow because customers will be connected through networks which will transfer files and data, such as video files (MPEGn, AVI, WMV, etc.) to be watched at a customer's computer (host). Furthermore, these networks terminals will be used as mini warehouses to save files and data. Selective files will be transferred to the host computer depending on customers pre-requested profile and prioritization. The research will present techniques that optimize transfer storage media for the purpose of minimizing waiting time and hardware cost while maximizing efficiency and customer satisfaction.

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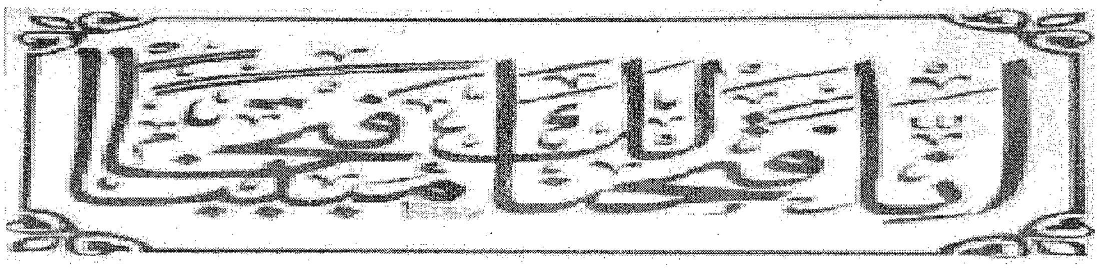

Translation: "Verily We have granted thee a manifest Victory" (AL QUR'AN 48:1)

During my research and study I have learned a lot from criticism, moved forward with enthusiasm, to develop a uniqueness in thinking and by developing different successful ideas and outcomes. In preparing my dissertation, ideas and thoughts were a great part of my work to get me from where I am to where I want to be. The efforts had been made in this dissertation to give a lot of thanks to the many people who have been very supportive and caring during the time it took to finish this dissertation.

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403. Total Download Bytes for H1 case scenario at hard drive size of 50GB and download bandwidth of 128kb/s 406

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405. Total Download Bytes for H1 case scenario at hard drive size of 150GB and download bandwidth of 128kb/s 407

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509. Total Download Bytes for H3 case scenario at hard drive size of 150GB and download bandwidth of 2000kb/s 459

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707. DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 25kb/s 558

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710. DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 50kb/s 560

711. DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 50kb/s 560

712. DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 100kb/s 561

713. DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 100kb/s 561

714. DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 100kb/s 562

715. DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 100kb/s 562

716. DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 128kb/s 563

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729. DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 1000kb/s 569

730. DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 1000kb/s 570

731. DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 1000kb/s 570

732. DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 2000kb/s 571

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746. DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 15000kb/s 578

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779. DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 2000kb/s 594

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795. DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 25kb/s 602

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941. DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 256kb/s 675

942. DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 256kb/s 676

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CHAPTER I

INTRODUCTION

During the Scientific Revolution of the 19th and 20th centuries there was a growing need to understand complex mechanisms that were central to human concerns. These complex mechanisms are known today as systems and complex systems. Systems are defined as a set of elements or entities that can be real or conceptual, encompassing a whole where each element interrelates or is correlated to at least one other element. A complex system is a system that has several degrees of freedom that often strongly interact with its components.

Sterman (1994) describes complexity by using Adams' "Law of Acceleration", which states how industrial growth of technology, population and production are formulated:

> Since 1800 scores of new forces had been discovered, old forces had been raised to higher powers. The complexity had extended itself on immense horizons, and arithmetical ratios were useless for any attempt at accuracy. If the science were to go on doubling or quadrupling its complexities every ten years, even mathematics should soon succumb. An average mind had succumbed already in 1850; it could no longer understand the problem in 1900. (Sterman, 1994)

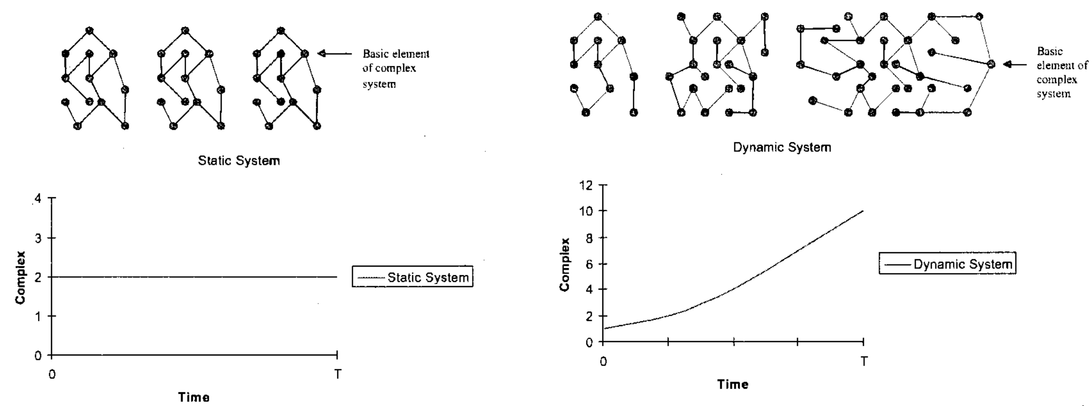
Today, new revolutions have been used as powerful tools to explain the complexity of a system, such as using mathematical analysis, experimental tools and software for computers (Fox, Funnanski, Ho, Koller, Simic, and Wong, 1989). Dynamic systems contain huge numbers of elements that vary simultaneously in space and time as well as surrounding environments which may also change with time.

Sterman (1994) shows that defenders of system thinking define the world around us as a complex system. Every thing in a system is interconnected, nothing can be accomplished singularly; therefore, system thinking is vital for survival of the system. Dynamic complexity stresses the system in any multi-process, such as multi-loop, multi- state or even nonlinear characteristics.

Increasingly, understanding dynamic change in a complex system demands mutually supportive research to analyze the allocation between all nodes that can interact within time but also within space. Fig 1 illustrates the differences between static systems and dynamic systems.

The style used to develop this dissertation was adapted from "Publication Manual of the American Psychological Association (5th edition) (ISBN: 1557987912)".

Figure 1: Static and Dynamic Complex Systems



(a) Static complex systems define in "Space" - "Time"

(b) Dynamic complex system define in "Space" - "Time"

Complex systems can be described by a general logistical and temporal analogy that indicates how both apply for the corresponding underlying data in "space" and how these data are performed on each element or node. Fox and Funnanski (1988a) suggest problems mapped with space and time were evolving optimization processes, that problems must be broken down into separate parst. Fox (1988) also stresses how important it is to take time to structure problems along with the importance of the data flow between nodes that exist on a time scale and the need to apply different strategies to express microscopic dynamic data flow (Fox and Funnanski, 1988b,9).

Furthermore, with regard to complex systems that contain different entities, Fox and Funnanski (1988a) state the different types of entities controlling the connection media between them, such as particles representing entities where the connection is compatible to a force if the entities are pixels, the connection between them will appear as the smallest link of convolution algorithms.

In a dynamically complex system, which includes several events that result from dynamic behavior for a variety of different classes - these classes can be different in time "including real time and discrete time" and in space "including discrete events" - was communally referred to as hybrid dynamical systems that "frequently exhibit simultaneously several kinds of dynamic behavior in different parts of the system" (Michel, 1999; Grossman and Larson, 1992). Dynamical systems, in general, can act on several types of behavior such as continuous-time dynamical systems, discontinuous-time dynamical systems and jump phenomena (Ye, Michel, and Antsaklis, 1995).

Dynamic system models using disorganized time series were highlighted by Haykin and Principe (1998) in a study of system nonlinearity but it was found to be difficult to describe the nonlinear algebra for the same system because of the unknown nonlinear-dynamics response of the system generation for the given disorganized time series. Therefore, the nonlinear theory of dynamic reconstruction was started to create a more physical interpretation for the time series.

The nature of digital networks, as described in Militzer, Suchomski, and Meyer-Wegener (2003), is comprised of non-variable bandwidth channels that transfer data. Furthermore, the growth of demand for transmitted visual data has been abruptly increased to satisfy customer needs, which resulted in the development of multi-video compression standards such as MPEG-2 (Boncelet, 2000), H.263 (Rijkse, 1996) and MPEG-4 (Militzer et al., 2003).

In today's world, there are two kinds of video transmissions that have been established, one of them consists of full transmission of stored packets of video from a server to the customer's premises before playback begins; the other is a concurrent transmission which is under a certain restriction of quality of service (QoS) and serves as a real-time application.

The nodes in Fig 1 represent a video between customers who requested the service to watch certain movies. The selected video file is downloaded to the customer's computer site according to the system requested. It is also added to an inventory which can be allocated to several other sites in the future. System redundancy has been taken into account with regard to system needs for any overly excessive demands.

Agent-based models (ABM) are used in simulating social life, not only to understand environmental change and human roles, but to be attractive to many practitioners from a variety of subject areas. Human changes can happen through space and on different time scales. Many vital opinions of ABM and simulations are that numerous phenomena, even though system is complexity, dynamically or both combined dynamically complexity, can be described as autonomous agents that are relatively simple and follow certain rules for interaction.

Computer models are used for interesting research practices and testing theories within certain discipline structures. The progression fundamentals of a real-world structure are difficult to be observe and collecting data as well as controlling it under certain conditions is impossible. Assumptions based on theories for these structures can be implemented in a computer model that can perform and compare to this practical data.

In this situation where real-world data exists, quality of performance is relatively easy to determine, but entities related to dynamically complexity are much harder to identify. Many approaches have been used to explain the exchange between goodness of fit and ABM. Both of them merge a maximum possibility term that determines fit and a consequence term to measure complexity. Conventionally, the majority of ordinary factors integrated in a complexity scenario are: number of free parameters, functionally forms, ranges of values for free parameters and number of self-governing data models (Forster, 2000; Myung and Pitt, 1997; Myung, 2000; Pitt, Myung, and Zhang, 2002).

Vicsek (2002) argues that modeling practice tends to follow scientific ideals, which increases common understanding and knowledge of a system by choosing models that are simplified, abstract and idealize the systems that these sciences are designed to mimic. On the other hand, several application domains of ABM are complex adaptive systems (CAS) (Bradbury, 2002) where large scale performance emerges from small scale performance and local exchanges.

System performance can not be understood if simply applied naturally and observed on an individual basis, so this kind of system obviously can not be analyzed as a simple system. Looking as this as a simple system and also modeling the behavior is in most cases impractical since no data would exist. Nor is analyzing complex systems into clear-cut probabilistic or statistical models. Complex system and CAS are often complexities by themselves (Bradbury, 2002).

The word "model" had been referred to as an entity by scientists, but with statisticians a model is used as a point of hypothesis for probability distributions (Myung, 2000), Rissanen (1978) describes a model where any hidden act was explained by model-ruled data for any theories. Definition of models differed until recently when (Rissanen, 1989) differentiated models into two categories: "models as a realization of theory" and "models as depiction of reality".

Further, Rissanen (1989) argued that model theory did not only explain model functionality but went beyond that by describing how the real world works and how models' data infer procedures and configurations primarily through experimental behavior. The models used in this dissertation can not predict the future because of unpredictable characters, such as initial conditions, path dependency and agent edition, as namely in CAS (Bradbury, 2002).

Generally, models used in this dissertation either use computational algorithms or procedure implementations developed by agent based models in any principal programming language or mathematical theory. In both cases, a model is defined as a compilation of a set of structures and processes assumed to underlie the behavior of a network system.

CHAPTER II

PROBLEM AREA

The dynamism of network applications is a complex conglomeration of rapidly growing fragmented data and files and depends on several factors. Network traffic has been exclusively modeled by functions and the number of times the file is executed (Gringeri, Shuaib, Egorov, Lewis, Khasnabish, and Basch, 1998). The amount of storage capacity needed for these functions and its variation gets increasingly large and constantly growing. Therefore, a dynamic adjustable storage size is a necessity, allowing for the freeing of space when it is no longer needed.

Moreover, a growing number of video on demand (VOD) services requires a large amount of bandwidth to transfer video file formats simultaneously to the end user. The centralization of VOD services requires huge amounts of storage media, in addition to large scale VOD server hardware, to adapt a smooth multicast in an inter-network as shown in Fig 2 (Sen, Towsley, Zhang, and Dey, 1999).

Figure 2: Multicast smoothing in an internetwork

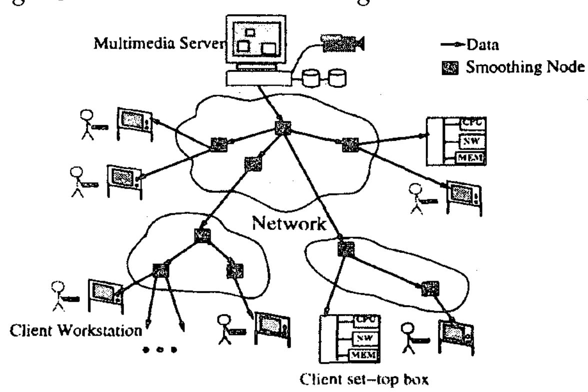


Fig 2 shows a video stream originating at a multimedia server then travelling through the inter-network, to multiple clients, including workstations and set-top boxes. A multicast smoothing service is performed at smoothing nodes within the network.

In order to satisfy the demands and needs of customers, more hardware must be deployed. In addition, it is becoming necessary to increase costs to adapt to the many and constant changes to networks. Issues such as these are becoming big problems for developers along with the fact that only a limited number of consumers can be served from specific networks - meaning that more networks are necessary to better serve the customers who are subscribed to the server. One solution is to have each individual computer connected to the network that can serve as a host for one or more other computer subscribers.

New subscribers can then connect to customers who have files they are requesting and find optimal download times to get files more rapidly. This research looks at computers serving as hosts to other users in addition to company servers that supply video files on demand.

Most video files, delivered in DVD or VOD formats have been deployed to the market and have not satisfied customer needs. Standard VOD services have limited choices to acquire and few choices to view contents in either a rental or ownership model. On the other hand, when customers are using DVD movies more than once, accidents can occur such as the surface being scratched which produces skipping when a DVD is playing. Additionally, shipping times can vary greatly and arrive after customer expectations.

A study of customers' profiles and priorities has additionally been taken in this research to provide a better focus on consumers' demands and to be able to use all sources of existing systems.

The primary scheme behind agent based modeling (ABM) is that independent elements are distributed by decision making, which either operate individually or may link together and collaborate. The main focus in this research is on macro-level prototypes in communal performance emerging from agents' individual uniqueness and micro-level occurrences, for example with local behavior and relations between agents.

ABM comes in numerous disguises but here the most interesting ones are the models in which agents can closely mimic real world phenomena and act as such in a simulated environment. Otherwise, assumptions will be made for the purpose of simulating a particular aspect or action to describe what the final approaches will be.

ABM also has access to the fields of multi-agent system (MAS), robotics and artificial intelligence, but at the same time modelers are not bothered with understanding artificial agents and how they are used inside an ABM. On other hand, ABM is mainly concerned with considering networks' nodes and links as well individual decision making. With these outcomes there is a need to represent agents' interactions, group behaviors, cooperation and materialization of high order network connectivity and network connection structures. This is why dedicated languages and toolkits are needed.

CHAPTER III

LITERATURE REVIEW

III.1 INVENTORY CONTROL MANAGEMENT

Inventory control management must span different criteria to insure proper delivery in order to achieve customer satisfaction. Decision makers have struggled to compete with customer demands including situations such as having too much or too little inventory on hand at a time of need (Cronin and Wyndrum, 1995):

- Too much inventory requires many financial resources that will drain from the company's financial assets.
- Too little inventory will result in the dissatisfaction of customers and a loss in sales.

With inventory management, several things need to be considered simultaneously; complications can include localization, invoicing, tracking, protocols and using many resources to keep the inventory up-to-date. Financial aspects also play a large role in controlling ordering and localizing inventory. In general, deliveries are made via transportation modes by using multi-echelon depot systems while individual depots hold inventory and order replenishments, as shown in Fig 3 (Shervais, Shannon, and Lendaris, 2003).

Figure 3: Physical distribution problem.

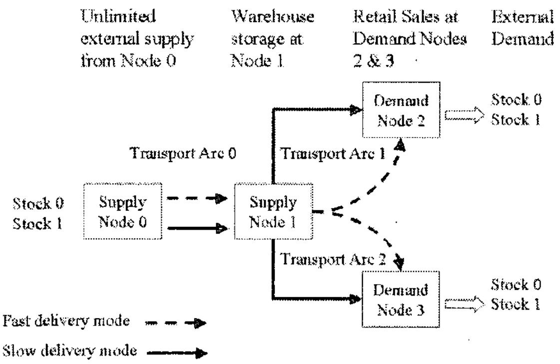


Fig 3 shows that inventory is generated at node 0 (a supply node), then moved to warehouse supply node 1 using a multi-node, but with limited transport capacity, then it is shipped as needed to meet stocking requirements and to fulfill external demand at retail demand nodes 2 and 3.

Transportation allocation resources fall under policy control with regard to the cost of physically distributed items. Multi-objective linear programming techniques are considered to minimize financial costs and the consumption of scarce resources, and in most cases the effort needed to create more efficiency within the system is considered impossible to obtain. As an example, physical distribution systems for any organization help to accomplish delivery of goods from suppliers to customers, but delivery sequences built under multi-level and highly multi-dimensional systems even within small firms, input values are discrete and end customers demands are described as random variables because inventories and deliveries are non-stationary problems (Aneja and Nair, 1979; Shervais et al., 2003).

As a result, inventory management must meet several criteria to keep up-to-date and accurate. It also needs to be recorded for the successful implementation of optimal networks (Mongeau, Barshefsky, Bass, Erman, Martin, Peterson, Rastogi, Narayan, Trickey, Xie, and Wu, 2004). Today's heterogeneous dynamic networks have been battling the current technologies of the telecommunications market for the past few years. The lack of network data-flow integrity would result in the collapsing of most of the entire network deliverability. Moreover, incompleteness and inaccurate inventory will prevent the maximization of revenue and minimization of expenses.

The main advantages of optimizing a network inventory are to save on the operating and capital expenses and to minimize the number of spares in the warehouse which may or may not add to better performance of the network reliability and its services (Chu and Chu, 2004). In the past, studies argued for optimizing the required demands and minimizing operating and capital expenses; therefore, centralized warehouses resulted in savings of resources and redundant equipment.

Shervais et al. (2003) argued that a non-stationary environment for physical distribution must be studied in the form of inventory control and the transportation problem of obtaining simultaneous network optimization.

Complex Adaptive Systems (CAS) (Pathak, Dilts, and Biswas, 2003) are used as a source to simulate dynamic supply chain networks in order to better understand the structure and behavior of a dynamic system. Supply chain networks are described as having parallel and lateral links, loops, bi-directional exchanges of information, materials, etc. Moreover, the structure of a dynamic system and its emergence was observed during time changes and discrete events.

Decision making has additionally been used in this analysis to satisfy environment demand. Simulation software has also been used to implement diversity of dynamic supply chains as agent-based models of exchange for media.

Network applications in the last decade have been growing rapidly to support different types of data that can be transferred across networks. In today's world, it was observed that network transfer is leaning toward networks and network applications that were implemented for the use of entrenched customer devices, such as memory, hard drives, DVDs, etc.

Network traffic is one of the factors that dynamic network applications depend on (Bartzas, Mamagkakis, Pouiklis, Atienza, Catthoor, Soudris, and Thanailakis, 2006). Static storage memory was found to be not enough so dynamic adjustments were required to free enough memory for new allocation files. Data management and data optimization (non-dynamic) were studied to view the outcome of any effect on the network. Transferring data through networks requires a complex data structure, and there is a need to map it with physical storage media results in order to build some distinctiveness within the designed network, such that required size, performance, power consumption, etc. were not highly recommended as a consequence for any system design.

On the other hand, dynamic memory allocation can not work without a storage management strategy because both factors guide the increase in the dependence of dynamic data types (DDT) towards the strategy of allocation data (Bartzas et al., 2006).

Different DDTs were implemented for different network applications because they were needed to be powered by complex dynamic behavior in order to obtain optimal results. Therefore, a mapping table was structured to direct the data transfer to implement dynamic data as many algorithms were developed to determine the different paths needed to be followed that related to customer behavior which leads to complex and dynamic data usage.

III.2 STORAGE

Storage systems occur in a variety of contexts, including manufacturing, warehousing, and the service sector. Most storage systems do not deal with dynamic complexity because they are static and are usually in the form of physical warehouses. Storage systems dealing with materials can be either continuous or discrete storage. There are three major factors affecting storage systems: depending on size of storage, storage methods and layout of the storage system.

Storage throughput has been used as a measurement to describe the number of storage that can be retrieved per time period storage/retrieval (S/R). From there the size of the storage system is powered by throughput and cost parameters of transferring materials. Storage system mission controls input/output (I/O) functionality that can be determined by storage requirements is distributed centrally over time.

The storage method contains specification of unit load, S/R and storage equipments; these methods can be handled by machine or by humans and can be automatically launched by automatic guided vehicles.

The storage system layout, by using three dimensions - height, length and width - can identify the location of storage items. In this chapter, the system layout control other storage parameters throughput and storage method will be discussed and five different storage system layouts will help to understand what the differences are between these physically traditional storage types and virtual layouts for our case scenario.

III.2.1 Dedicated Storage Location

Every SKU (Stock Keeping Unit) is related to items in a warehouse and has a unique storage dedicated to it is location. Dedicated storage is characterized by the assignment of fixed storage locations for the items stored in the warehouse (Malmborg and Krishnakumar, 1989). For items to be allocated as measured unites used in the warehouse, they are assigned the cube per order index (COI).

In such cases, the more popular items have to be near the I/O point in the warehouse for reduction in travel time and travel distance according to the S/R. As an example, active items have to be placed in the most convenient and accessible place; this minimizes cost effectiveness and gets item to I/O points.

Getting the items at I/O points depends on the warehouse's structure and the way in/out from the warehouse and whether or not it is at just one point or at multiple points. For the condition of optimality, there are three rules that determine the comprehensive management policy for warehouse operations. These rules are: assignment location for required items, order of the assignment to be picked and determination of the optimality for the order when it is picked.

The main disadvantages of using a dedicated storage location, if an out-of-stock condition exists for a given SKU, is that empty slots remain active as the inventory level decreases, the number of empty slots will increase.

III.2.2 Randomized Storage Location

The items in the storage warehouse are stored randomly in any available storage location. For an example, when the inbound load arrives for drop off, the item in the closest available slot is designated. This is known as first-in and first-out.

This is common in the case of randomized storage results when less storage space occurs. Having small sized parts stored in a space designed for large size parts wastes storage space, and for the same scenario, storing large parts to fit randomly can be impossible, so adjustable shelves may need to be used.

In randomized storage it is assumed each item of a certain product is equally likely to be recovered when multiple storage locations exist for the product, and the recovery operation is achieved. In the case where the warehouse is pretty full, the travel distances are significantly of the same "equal likelihood". (Francis, McGinnis, and White, 1992).

It has been recognized that dedicated storage is preferred in most cases over randomized storages even though randomized storage requires less space because with dedicated storage each item can be easily tracked as a fixed location or known address. At the same time with dedicated storage each product is assigned, according to its activity on a scale from highest to the least activity, to a specific slot on a scale of premium slots in a warehouse to the least desirable slots.

III.2.3 Class-Based Dedicated Storage

Class based storage is defined as a grouped of SKUs in one class. These classes are assigned to a dedicated storage spot, at the same time, these SKUs within an individual class are stored randomly and in a logical sequence.

The products are distributed according to their demand rates, among the number of classes and have a reserved a region within the storage area for each class. Accordingly, an incoming load is stored at an arbitrary available location for the same class.

We must look to the randomized storage location as a single class case of class-based storage policy where dedicated storage is counted as one class for each item.

In addition, the dedicated storage policy attempts to reduce travel times for S/V (storage/retrieval) by sorting the highest demand to the I/O point as well for class-based storage and calculate the product demand by COI (Hesket, 1963).

Van and J.P. (1996) presented a program using polynomial time algorithms to help distribute products for their locations among classes to minimize travel time. These algorithms allow variable inventory levels and calculate the storage space required for each class and calculates impossible risk levels on stock overflow.

III.2.4 Shared Storage

Shared storage is widely used within the computer networking industry and addresses the needs of corporate computing environments for storage systems that propose scalability, availability and flexibility.

Storage systems are known as storage computer systems (hosts) and are connected to multiple individual hosts while using the shared storage by these hosts and are managed independently and historically viewed (host-attached storage).

Shared storage systems enabled by networking technology can provide high bandwidth. In turn, it offers several benefits for today's businesses, for example by improving quality of service (QoS) and increasing operational efficiency.

Moreover, as growing needs for shares (files, data, etc.) become necessary, it is necessary to prevent buying mainframe computer complexes and computer clusters where a modest number of cooperating computer systems share a common set of storage devices.

As computing environments have grown in industry, computer storage systems have grown in storage size and in number as the cost of equipment becomes more reasonable in order to increase the computing environments.

The main disadvantage is that the known computer storage systems processors have failed and replacement parts can be required to get the system back for full operation which wastes time and is followed by a typically propagation delay of the restoration of the data.

III.2.5 Continuous Warehouse Storage

Increasing demand for continuous recording of hundreds of millions data daily, a necessary storage media should have the capability to handle data volumes and data flow rates.

These types of data could be called detailed records (CDRs) - which is commonly used by the telecommunication industry - at an individual basis for each customer. Software applications have been used to pose several challenges related to data volumes and data flow rates to data warehouses and to online analytical processing (OLAP).

These CDRs are built hundred of millions of time every day, and the necessary storage required to adapt to this increasing data has to be stored somewhere. Several solutions have been studied, such as increasing the storage capacity which is not cost effective as this data is recorded every day. A process search to look up for specific data is also time consuming. Other solutions include using application software to minimize the CDR data volumes and keep up with the data flow rate, which requires a longer process time.

III.2.6 Virtual Warehousing

As a physical location is not necessary to locate specific data content, data can be located within many virtual storage hosts. If a customer is looking for specific data to download, random locations can be used without specification and taking into account how many locations have been used.

The storage locations mentioned above, such as dedicated, randomized and class-based storage, can be used to benefit virtual storage warehouses with priority, size and rates of transferring data. On other hand, desired locations for data can be easily tracked and assigned to scale from the highest to the least high activities according to their demand.

At the same time, randomized storage results in a reduction in space and will be significant with regard to data travel time much less so than those traveling from a dedicated storage area.

Also, using other storage techniques, such as shared storage but on a large scale like the internet and without specifying certain hosts because data is already restored within different hosts. Finally continuous warehouse storage techniques use network capability and add more data to different new hosts entering to networks as well using existing hosts.

III.3 NETWORK CONNECTIVITY

Network connectivity is a complex conglomeration of systems resulting from the rapid growth of networks. Moreover, its complex structure, location, interconnectivity, capacity, etc. are driven by the environment's excessive demands. With regard to the growth of network topology, several studies have been undertaken in an effort to understand the complexities of network design, modeling and generation, and to achieve the highest performance of network connectivity.

Statistical properties explicitly studied replication fundamentals to address network growth. Node hierarchies were used to analyze and simulate the network and graphs that reflect real Inter-networks and their applications. The studies were then used to randomly generate networked topologies and provide precise analyses that show network modeling include (Zegura, Calvert, and Donahoo, 1997):

- Regular topology, such as liner, rings, trees, and stars;
- Well recognized topology, such as ARPANET or the NSFNET backbone;
- Arbitrarily generated topologies.

Observing each of these shows a clear conclusion. Regular and well recognized topologies reflect only past real networks, but arbitrary topologies reflect past and future networks as described by real network growth. Zegura et al. (1997) argue that the construction of detailed topological maps is one of the important aspects related to the decentralized administration and sheer scale.

The internet-wide system is viewed as a large scale structure with an underlying physical connectivity that deploys real experimental studies to evaluate system architectures, however this is not possible. Instead, a randomly generated network connectivity structure is used and has been accepted at the beginning as a node degree distribution technique. A generator - also known as a software based solution - is used to generate network nodes which represents network autonomous systems (AS), original power laws and connectivity to the Internet.

Medina, Matta, and Byers (2000) argued the network models that were developed are lacking in describing and representing the actual network topology for the systems. Most of the models lie under their description of network structure characteristics, and none of them challenge the network bandwidth and delays of the system. Later on, inter-operability was presented to merge multi-models into one single generation model, by using designed tools to understand the situation, such as BRITE, the Boston University Representative Internet Topology gEnerator.

The above works mainly focus on modeling the internet - a world wide network - and generate a topology to represent the network's connectivity. Additionally, this was built to help people understand possible consequences for web and network design. It was found the networks fall in four different classes: random generators, regular generators, hierarchical generators and degree power law generators.

Random generators use a fixed set of nodes and are uniformly and randomly distributed. According to Waxman (1991) when any two nodes have a relation, one link will be added with a probability depending on the distance between them given by:

$$p(u, v) = \beta \exp \frac{-d(u, v)}{L\alpha}$$

where $d(u, v)$ is a distance from u to v; L the maximum distance between two nods, $\alpha > 0$ and $\beta \leq 1$. However, this method does not obligate a large scale structure.

Regular generators generate a non-flexible structure only which can be used to perform algorithms through analytic studies. A hierarchical generator performs an effort to equalized between large scale random and regular classes.

Finally, the degree power law generator was found and verified by Medina et al. (2000) and is the best of all the classes. Several recent studies have developed ways to investigate the correctness of the power law exponent for network connectivity. Bu and Towsley (2002) implemented two metrics: the characteristic path length and the clustering coefficient. Therefore, to match the closest algorithm to the generated network connectivity, Barabási and Albert (1999) describe network complexity by developing an incremental algorithm. In addition, the incremental algorithm helps match the adopted metrics from real world ones.

However, these models can be ambiguous and future networks need to be judged and compared for any differences in network connectivity. Alderson, Doyle, Govindan, and Willinger (2002) recently presented an optimization framework as a way for networks to grow faster and address the strong demands required to optimize the network flow to better serve customer needs.

III.4 NETWORK COMPLEXITY

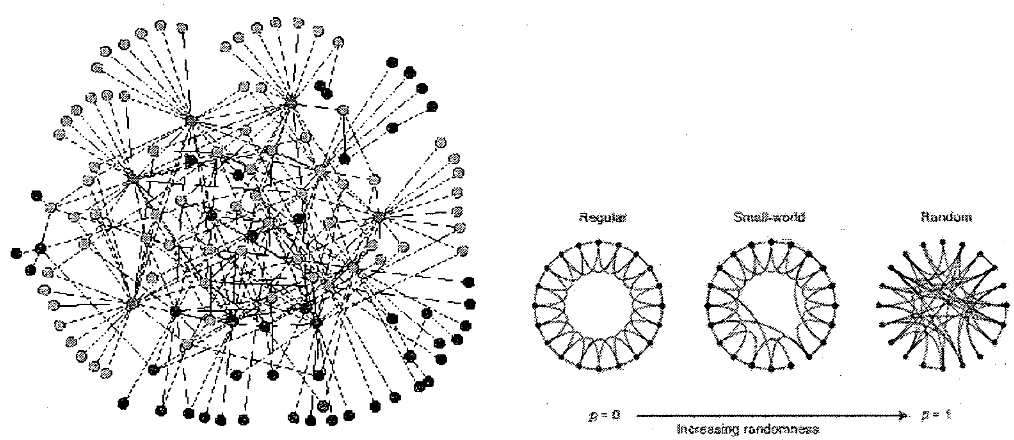
Albert, Jeong, and Barabási (2000) describe a systems' components for a network as a complex system because of its functionality and attribute it largely to redundancy node connections. A large scale network consists of a complex communication network (CCN) along with groups of telecommunication carriers and ISPs (Internet Service Providers). It is almost impossible to analyze the infrastructure but this can be done within the limited boundaries of individual networks (Claffy, Monk, and McROBB, 1999).

The redundancy of network connectivity, in other words scale-free network connections, represents an unpredicted degree of robustness for each kind of system, such as the internet, social networks or cellular (metabolic) networks. Network nodes break when faced with an extremely broken down communication rate. Under the network characteristic scale-free networks, the probability of the node having an extreme number of connectivities will be based on connectivity distribution $P(k)$, (Bollobás, 1985; Watts and Strogatz, 1998; Barabási and Albert, 1999) have a power-law tail in large k value as following:

$$P(k) \sim k^{-\beta}$$

$$where\ \beta = 2.3 \pm 0.1$$

Figure 4: Representation of selected networks. a: Representation of a large scale-free network. Each node has one or more links to guarantee the connectivity of a system, b: Representation of an interpolation between regular networks and random networks.



(a) Scale - Free

(b) Interpolation between Regular and Random Network

Fig 4 represents the redundancy of a system which is randomly connected between each node by one or more links, as realized by Albert et al. (2000). Few nodes need to be eliminated for a substantial increase of connectivity to the system.

The probability Pr_i of the system for each node needs to be connected as followed:

$$Pr_i = \frac{k_i}{\sum_j k_i}$$

where each node connected to node i depends on k_i. Longer periods of time lead to a stationary solution; as shown below:

$$P(k) = \frac{2m^2}{k^3}$$

where m is the new connection for every time step from the initial number started at m_0.

Albert, Jeong, and Barabási (1999) explained that a growth network, like the world wide web, can for example have a diameter of 800 million nodes. Lawrence and Giles (1999) showed that the diameter of the system is quite small, "19", and for the case of a social network having 6 billion entities, the diameter is around "6", which is a reverse-dependent formula (Albert et al., 2000).

III.5 PERSONALIZED SERVICE BASED ON CUSTOMER'S PREFERENCES

Personalization means providing selected and modified information to an individual in order to enable the selection of products in a much easier and quicker manner. During the past decade personalized services started to be an important issue when adapting to the fast growth in the number of broadcasting channels (Kang, Kim, Lee, Chang, Yang, Kim, Lee, and Kim, 2004). Personal devices were developed to help users to achieve their selected preferences by using servers such as personal computers, personal recorders, wrist watches and mobile phones (Nakajima, 2005).

Customer requirements have been placed in industries as the highest priority when obtaining appropriate products. Personalized product recommendation helps both sides, customers and industry, to accomplish customer requirements quickly and easily (Zhang, Edwards, and Harding, 2007).

Digital broadcasting services are being utilized in a majority of broadcasting channels in today's world. This has increased the broadcasting channel capability tremendously in a very short period of time. At the same time, personal product recommendations help users navigate through the content and chose preferred programs within a specific group of interest or within general content. In addition to helping customers customize their preferred list of broadcasting channels, Kang et al. (2004) recommend using a set-top box (STB), which has the capability to store the multimedia, also known as a personal digital recorder (PDR), which is similar to a digital video recorder (DVR) (Chorianopoulos and Spinellis, 2007).

In addition, it is necessary to develop a technique for customers that is capable of managing the stored media in a PDR and handling the changes of user preferences by filtering and navigating through the content using data to describe the multimedia content of audio and video - such as metadata (Kang et al., 2004). This metadata allows software applications to follow and understand user preferences (Kim, Lee, Choi, and Hong, 2006). These applications work side-by-side with metadata for personalized broadcasting program content, in general.

PDRs show improvement side-by-side by using software application metadata and filtering the specified channels to be recorded on a PDR for a customer who watches it later on during their spare time. When selections are spanned such as searching web pages and customers' preference with regard to interested movies, personalized recommender systems (PRS) were developed to support the users' profiles and our study with personalized movie recommender systems (PMRS) (Jung, Park, and Lee, 2004).

PRS, when first developed, used information filtering technology. This technique used two different classes: collaborative and content-based filtering (Jung, Choi, Rim, and Lee, 2003; Jung et al., 2004). Jung et al. (2004) argue that by using PMRS with a hybrid 2-way filter in addition to developing a web root agent showed significant performance increases rather than when applying two classes purely individually.

III.6 AGENT BASED MODELS (ABM)

Agent based model methodology has been applied to several studies, for example, social dynamics and communication and cooperation under ecological risk (Andras, Roberts, and Lazarus, 2003); complexity in artificial life applications (Menczer and Belew, 1996)' common dilemmas for ecological economics (Jager, Janssen, Vries, Greef, and Vlek, 2000); language evaluation (Bartlett and Kazakov, 2004); armed forces contradictions (Cioffi-Revilla and Gotts, 2003); and human social interaction interpolating with regeneration management (Deadman and Gimblett, 1994).

Huigen (2004) anticipates an ABM structure, called MameLuke, which will study human environment interaction. For like structures agents are categorized according to user definitions and determinations from the objective's study, meaning that individual agent sets can fit into multiple non-divergence categories. Potential option paths (POPs) are rule-based implementation through decision making, which depends on the agent's category.

ABM was significantly used in a spatial interest group within computational mathematical organization theory (CMOT). Today, on the other hand, simulations using ABM have expanded further than its boundaries of use and has to link up with groups of people and cover work in a variety of different disciplines such as economics, biology, sociology, artificial intelligence, physics, computer science, archaeology and anthropology.

In the last few years, growth of ABM has been significant realized especially after releasing more helpful software toolkits. This was enough to attract many practitioners from different fields to simulate numerous subject areas. Some of the more well known toolkits are Swarm, Repast, AnyLogic, MASON, Ascape and NetLogo.

Gilbert and Troitzsch (1999) express an example of using ABM in the artificial intelligent field for developing cellular automata. At the time, Swarm, introduced in 1996, was the only agent based modeling simulation tool available (Minar, Burkhart, Langton, and Askenazi, 1996).

The primary characteristic of an agent is the potential to make decisions on individual bases. On the other hand, agents, in a true case, are discrete events handled individually with a set of attributes and policies that influence its actions and decision making capability. In addition, an agent may have supplementary policies that modify its policies or attributes. An agent can be purposely independent in its atmosphere and in its interactions with other agents as well itself if not over an imperfect scope of posts. An agent has objectives to accomplish (not optimize) as goal bound within its actions. Furthermore, an agent is flexible and has the ability to learn and adapt its performance over time based on ongoing skills, in other word, some form of memory.

III.6.1 Complex Adaptive Systems (CAS)

Complex adaptive systems were at first triggered by studies into the adaptation and emergence of biological systems. CAS' are able to dynamically restructure their components as well self organize. Both of these phenomena of CAS have better ways to continue and excel in their atmosphere. Considering CAS properties and mechanisms can lead to understand behavior, as shown in Table 1 and 2 (Holland, 1995).

Using these properties and mechanisms provides a helpful structure for designing agent based models. Bonabeau, Dorigo, and Theraulaz (1999) argued that Swarm follows a procedure using basic mechanisms supported by genetic algorithms to adapt the nature of behavior of agent based models (Holland, 1992).

Table 1: CAS Properties

CAS properties	classifications
Aggregation	Formation of groups
Nonlinearity	Invalidates simple extrapolation
Flows	Allow transfer and transformation of resources and information
Diversity	Allows agents to behave differently from one another and often leads to system's property of robustness

Table 2: CAS Mechanisms

CAS mechanisms	classifications
Tagging	Allows agents to be named and recognized
Internal Models	Allows agents to reason about their worlds
Building Blocks	Allows components and whole systems' components to be composed of many levels

III.6.2 Swarm

Swarm is an origin and extensive software toolkit used for modeling complex adaptive systems. It was designed particularly for artificial life and developed by Chris Langton at the Santa Fe Institute (Minar et al., 1996). It is a method of using elaboration, refinement and generalization to study biological phenomena and to gather biologic mechanisms to categorize unifying dynamical properties of biological systems. The first layout edition of Swarm was used in 1996, and it continues to be applied to different fields by researchers. Swarm is a free open source software library maintained by the Swarm Corporation.

Furthermore, by having an ABM software toolkit available for different expandable environments, Swarm can maintain a wide range of different support features explicit to agent based modeling, for instance: flexible interaction teleology, large scale development support, time scheduling, range of architectural choices and facilities for storing and displaying agent states.

Swarm allows propagation of different fields along with the most contemporary principles of software design, which allows for emphasis, targeting the design and coming up with an end product through an object-oriented design model. Swarm is a straightforward simulation application dealing with objects, by defining classes as types of agents and objects as special agents. Each object has its own set variables and classes to provide a generic definition of its attribute.

III.6.3 Repast

Repast (Recursive Porous Agent Simulation Toolkit) is an open source software toolkit first developed at the University of Chicago by Collier, Howe, and North in 2000 (Collier, Howe, and North, 2003). It was used to support rapid social science discovery in the Argonne National Laboratory based on extensive computational simulation (Sallach and Macal, 2001). Because of high demand to use ABM on a large scale for agent based simulation, several releases of Repast have been issued to accommodate practitioners of different fields.

Repast can handle a variety of different fields such as academic, government and industrial organization with the support of the Argonne National Laboratory and the University of Chicago who formed the Repast Organization for Architecture and Design (ROAD).

The most used software programming language is Java language and Microsoft.NET. Repast was built in these languages. Java is used for straightforward programming to build library components for Repast while using high level visual script language for users who do not understand Java coding language in a WYSIWYG (what you see is what you get) format. This helps Repast to allow for more uniqueness and be more attractive to professional modelers. Repast has innovation capability to be a great simulation toolkit for allowing social interventions to stand on hypotheses and data (Tobias and Hofmann, 2004).

III.6.4 NetLogo

NetLogo was originally developed to provide and allow for importing image files (agent settings). NetLogo was essentially invented for deployment models through the world wide web and can provide a smooth progress of development with certain spatial models.

NetLogo was first certified by Uri Wilensky at Northwestern University. The main reason for inventing NetLogo was to develop a multi-agent modeling environment, with extensive build-up for the complex systems community to simulate various applications from biology and physics to the social sciences. It is well suited to work with large scale agent environments by modeling a set collection of independent agents expanded through time and space. This makes it a popular resolution to simulate and analyze distributed systems for instance modern wireless networks.

Modelers using NetLogo can give directions to numerous individual agents simultaneously, which makes NetLogo a toolkit fit to explore the connectivity between micro-level performance of entities and macro-level prototypes that come out from massive agent interfaces.

In addition, NetLogo is an open source toolkit with excellent documentation, including tutorials, available as a free download, that gives an explicitly advantage over other ABM simulation toolkits. It is easy to use on an individual basis; for instance, students and teachers can build their own simulation models and run them individually as well as part of a classroom environment by using separate simulation tools called HubNet linked to the NetLogo software toolkit.

As agent based modeling becomes more handy and merges allows for more complicated programming which wasn't possible in the past. With the help of innovation, new software toolkits are now available to numerous analysts and less programming experience is needed. As difficulties of conditioning become less attached to and limited by the tools' ability and user familiarity with available tools, the area of expertise retains great assurance of attracting new expansion and opportunities.

CHAPTER IV

METHODOLOGY

IV.1 OVERVIEW

Network optimization processes cover several degrees of interest and will continue to grow in the future expanding and developing into a top priority for any business in today's world, especially with regard to serving customers' needs. Moreover, gaining the trust required from the company increases the demands to reach the optimal solution of building more reliable, strong, fast networks that can handle the load required for the demand.

Today's networks are increasingly more powerful; network complexity is currently expanding around the globe faster than it did for the last decade, and is changing over time and over space which makes it hard to predict future results. Therefore, the aim of this research is to study and simulate network complexities over dynamic changes. I will divide the problems to subcategories according to their metrics and optimize each category along with a large scale network operation to solve final optimization problems.

The research method is a four-step process to develop a simulation solution from a problem statement. The first step gathers information about the system and identifies the system's metrics. In the second step, system attributes and construct logic simulation diagram are defined. In the third step, an analysis of the logical simulation diagram is performed to identify ways to optimize the system based on the system's metrics. The fourth, and final, step is to evaluate the heuristic results based on a simulated logic diagram. A more detailed discussion of the research method is described below.

IV.2 STEP 1: GATHERING INFORMATION ABOUT THE SYSTEM AND IDENTIFYING THE SYSTEM'S METRICS

The goal of setting several systems' metrics for a topology network is to design a virtual network that is similar to a real life network. Networks consist of several nodes which represent customers' computers connecting to servers as well with each other virtually. These customers' computers will further act laterally with the server as a host for other computer subscribers to over come any over load to the main server.

The data is saved and imaged in the servers. This allows subscribers in any network to download a requested file. In addition, the network studies customers' preferences to provide the best network flexibility to ensure that the facilities are in place to support customers' requests.

In this dissertation, I evaluate a generated topology and show how well this network matches the large scale properties of the internet as measured by system metrics.

First, I start by describing and defining networks including nodes, data, and system's assumptions; second, I explain the purpose of a system, and finally, I identify system metrics.

IV.2.1 Network Description and Functionality

The network that will be handled in this dissertation has a total of 250 nodes which represent the total number of customers carried by this network. These nodes are virtually connected by the internet and each address is recorded and knows the location of each customer. Each node in the network follows these assumptions:

- Each node is connected to the network and works online all year long with no bad connections.
- All nodes share the same bandwidth speed (uploading or downloading), and uploading bandwidth is half the speed of downloading bandwidth.
- The bandwidth speeds that will be used are limited to 128kb, 512kb, 1000kb, 2000kb and 5000kb per second.
- Uploading bandwidth and downloading bandwidth are two different streams and separated at each node.
- All nodes are spread all over the internet and connect to a separate network that can be located physically anywhere with no adverse affects on location or distance.
- All nodes can download simultaneously from the server with no affect on delay or connectivity.
- Each node can be used as virtual storage and upload any necessary file needed by another node upon request and can only to do this one node at a time.
- Each node can be downloaded from the server or from another node according to these guidelines:

  - Each node can download, at the maximum, from two locations and can be the server, the server and a single node or two nodes simultaneously.
  - Only one file can be downloaded at a time.
  - If the file exists in two virtual locations in network, the server will be exempt.

- All 250 nodes will be divided into five categories. Each category includes 50 nodes selected randomly. These categories are Actions, Crime, Comedy, Drama and Romance.

- Each node has an internal storage device and is selected randomly from a set of sizes: 50, 100, 150, 200, 250, 300, 350, 400, 450 or 500GB.

Each node will be studied throughout the year and is equivalent to 8760 hours download time and is evaluated for how many files has been selected and downloaded as these files are selected according to each node's preferences.

Selected files will be chosen randomly and according to each node's preferences. These files have the following characteristics and assumptions:

- The network will handle files of different sizes having different time durations, and is limited to 10,000 files and all files can be downloaded from the server.

- The 10,000 files will be divided to five categories. Each category includes 2,000 files ranked from the highest priority to the lowest according to the power law degree distribution $P(k) \sim k^y$ with an exponent y range between 2 and 3. These categories are Actions, Crime, Comedy, Drama and Romance.

- The files can be downloaded from server, two nodes or a node and server at the same time by splitting the file's size to two batches - each batch contains half of the file.

- The file's batches will be downloaded either simultaneously by dividing the downstream bandwidth in half or downloading individually as the second batch will not start till the first one is completely downloaded.

- These files do not have expiration time but rather are replaceable inside the network's virtual storage which is located at the nodes. If the node's storage device reaches 75%, the files will be deleted according to the file's priority from low to high with the exception of the server. In this case, it will be remain stored as a reference for future requests.

All nodes will be able to download any files from a server at any time with no delay. All files are ranked according to its priority and stored in the server in the five different categories. Any node can search for any file across the entire network and download it in another in order to overcome network load and reach an optimum for the network.

IV.2.2 Networks and Their Dynamic Complexity Purpose

Networks act as a huge virtual storage warehouse that are dynamically changed over a period of time. The address of the nodes will be constant, but a file's location will be changed from node to other node with time and determined priority.

The duration of this study is equivalent to 8760 hours over an entire year. This study will follow several procedures to highlight and identify the purposes of this research. In addition, it will also simulate the generated data not only to show the output results but to also understand how the network works with layers of dynamic changes as the files flow across the network.

A network's complexity is represented by nodes and a server that are interactively and laterally ordering files from the server, other neighbor nodes or both at the same time. Also, the simulation of each of these nodes requires further study. The criteria and procedure will follow:

- Gathering data of inter-arrival time which was observed for each node during the 8760 hours.
- Gathering information about what type of file category customers were interested in as well as how many files per node were accessed.
- Gathering information from where the files were downloaded by each node.
- Calculating the arrival time by each node.
- Calculating the inter-arrival download time for each file by each node.
- Calculating the arrival download time for each node.
- Setting up groups of files preferences for each customer at the time of ordering and calculating the watched time at an individual basis for each file with download time to calculate the penalty time that occurred, each group will include random numbers of files between one and six files sets at a time which represent a set ordering one time group.

A network is a set of nodes connected virtually by an intranet at all times. These nodes shares their contents at the same time and evaluate best practices to reach an optimal scenario as an ideal network which can change periodically over space and time.

Optimizing a network has a set of fundamentals that are required to help to simulate this kind of network and evaluate the results. In order to do that, the next section describes a set of identifying metrics that have to be fully gathered and understood in order to direct these types of networks to the second stage, which is ready to be integrated as an optimal large scale dynamic complexity network.

IV.2.3 Identifying Network's Parameters

Highlighting different parameters needs to be studied because it is a main reason of getting a network simulated and evaluated in order to find the weakest and strongest points affecting the network under study.

These parameters can be identified by using part of the data generated, which is as close to a realistic scenario as possible. Data have been randomly generated by using a log normal distribution curve for two independent and continuous parameters μ and $\sigma > 0$.

$$f(x) = \frac{1}{x\sigma\sqrt{2\pi}}e^{-\frac{z^2}{2}}$$

$$where\ z = \frac{ln(x) - \mu}{\sigma}$$

The log normal distribution's random values have to be close to realistic events. A customer can order and watch a movie in a reasonable time, and that also has to account for a new customer joining the service, and the time it takes to decide which movie will be watched, how long a movie can take to download, etc.

All this has been taken in consideration and is accounted for in a real-life situation. This is why the continuous parameters have to be chosen in a range suitable for generating data that can be used in a runtime simulation. In addition, these values had been chosen with as the maximum range possible to get more verifiable random generated data to meet this research study. μ is a range between 2.42 and 7 and σ is a range between 0.1 and 1.

$$p(x) = \frac{1}{b-a}\ for\ x\ value\ (a \le x \le b)$$

Where a and b are continuous boundary parameters and $b > a$.

The generated data is used to describe different parameters for system boundaries and express the simulation technique used to evaluate our network. These parameters will, next, be highlighted in detail using generated random output data.

Inter-Arrival Time

Inter-arrival time represents the time the movie starts being watched. This starts by setting the log normal distribution to generate no more than 800 output values per node These data sets have to meet the total required estimated hours to be watched by each node and can't exceed 8760 hours per equivalent year. The result will represent how many files are watched by each node for the entire year.

This process is repeated using the log normal distribution for 250 nodes which will bring a total number of 200,000 data outputs. For this study, by repeating all the above steps 100 times allows the simulation of multiple different scenarios. By cumulating the inter-arrival time for each event by a past ones will produce arrival time.

Inter-Arrival Download

Inter-arrival download time represents the length of time it takes for each file to download to a storage device within a single node. This is calculated from the data collected from the inter-arrival time (the number of files that have been downloaded to each storage device in the network), the size of each file and download bandwidth used.

Inter-arrival download time is used to calculate the penalty of each node resulting from a system functioning with either a high or low optimum value. Calculating inter-arrival download time for each event with data from former events, arrival download time can be computed

Downlink and Uplink Bandwidth

Bandwidth is a major factor in this simulation as each bandwidth characteristic will affect the network's simulation and different results can be obtained.

Downloading bandwidth is considered as a separate scenario than uploading bandwidth. This leads to running simulations with two independent factors.

Downloading bandwidth is twice the value of uploading bandwidth. These bandwidths used in this case are 128kb, 512kb, 1000kb, 2000kb and 5000kb.

File Prioritized Using Power Law Distribution

Power law distribution relates two or more variables and shows areas that are more dominant in a distribution. The more dominant area has excessive priority. In this study, this shows the most common movies recommended by customers and most requested.

The least requested movies will be ranked lower, according to customer preference, and will be removed from virtual storage in a network after a certain time period if not being used and will be replaced by the most requested ones.

IV.2.4 Identifying Network's Metrics

Networks need to be integrated to the second stage. This is essential to our goal which includes studying the different heuristics of the system and the different possibilities that will lead to the main goal of this research dissertation. The simulation part helps to demonstrate interactions between nodes as well as with the server with regard to transforming requirements and the needs of each user and purposes of the services offered.

Highlighting different metrics needs to be studied because it is a main reason of getting a network simulated and evaluated in order to find the weakest and strongest points affecting the network under study.

These metrics can be identified by using part of the data generated, which is as close to a realistic scenario as possible. The generated data is used to describe different metrics for system boundaries and expresses the simulation technique used to evaluate our network. These metrics will, next, be highlighted in detail to measure our network by using parameters output data.

Server Load

The server load will be determine by the amount of the excessive bandwidth used from the server to upload movie files to each node from the start of the first hour of the service till the last hour at the end of the entire year.

The server load measurements depend on several factors; these factors control the results and the way the network accelerates to reach the optimum values. These factors are described as follows:

- **Bandwidth**: the upload and download link between each node and the ability the server has to control getting the requested files on time and accelerating and de-accelerating the customer of ordering more movies to watch. The bandwidth as described before will help to download the same file from other exiting nodes than downloaded from the server including decrease the server load to be minimum as possible to serve any requested files not eventually uploaded to the network.

- **Physical hard drive sizes**: hard drive size installed in each node will be one of the key factors to determine the requested file from any other node in the network is existing in the current network or has to be downloaded from the server. Limited hard drive sizes will result in the limitation of number files that can be stored in the network, and from there will affect by increasing more loads on the server following effects on the network optimization.

Customer's Request Penalties

The customer's requests penalties will be determined by the desired time to watch the requested movie and the actually watched time; a larger time span between the desired viewing time and the actual verifying time will affect the entire future requests for more files to be downloaded and watched.

The customer's requests penalties depends on several factors; these factors control the results and the way the network acceleration reaches the optimum values. These factors are described as follows:

- **Files size** : the files size affect the time taken to download a selected file, each file size is ranged from 3.5GB to 9GB (Gigabytes) and that will lead to delay the actually watched time by a customer if the file takes longer than is expected to be downloaded.

- **Files duration** : the files duration affect the time it will take to watch a selected file, each file duration is ranged from 70 minutes to 200 minutes long and that will lead to delaying the followed file to be downloaded on the wish list and that will affect watching time and result of a propagated delay on a downloaded file after.

- **Bandwidth** : the upload and download link between each node and the server and between each node and other nodes in the network control the ability of getting the requested files on time by accelerating or de-accelerating the customer of ordering more movies to watch. The bandwidth as described before will help to download files from other nodes from the server and affect by increasing or decreasing the time span between desired watched time and actually watched time.

Total Download Amount

Total download amount will be determined from the total bytes downloaded to the nodes from either the server, nodes or server and nodes through the entire year; total download bytes will represent the efficiency of the system and how well network operation goes toward maximization. Also total bytes will be presented per time frame for easy evaluation during our analysis for all heuristics as it will be describe later in STEP 4.

IV.3 STEP 2: DEFINING SYSTEM ATTRIBUTES AND CONSTRUCTING LOGICAL SIMULATION DIAGRAMS

The fundamental requirement when constructing a logical simulation diagram is to first approach problem solving with modeling software and simulate a system to allow it to carry out experiments and test development processes in order to optimize the network.

This technique will shorten the system development process and reduce costs. Using Matlab [1] as a source to simulate the data required to produce and formulate metrics along with all available methods, techniques and tools have helped to support the logic simulation diagram.

To represent STEP 1 in this research, introducing a new technique will help to demonstrate how networks interact with their components and deliver the required services to the proper destination. Matlab has been chosen to analyze dynamic complexity networks and to show what the attributes are that play a major role in optimizing the network as a whole system, including elements and metrics.

IV.3.1 System Attributes

A system's attributes are classified into three categories: input attributes, control attributes and output attributes, by specifying the functionality of each category. An attribute y is an input attribute if the value y affects the value of the output attribute. An attribute y is a control attribute if y appears in a condition expression of an action cluster. An attribute y is an output attribute if the action of action cluster can change the value of the attribute y.

Input attributes consist of nodes, servers, movie files, generated data, customer personalization and customer preferences. Output attributes consist of file accessibility, file

[1] See http://www.mathworks.com/ for more information on Matlab.

availability, final target location of downloading and uploading requested files and network deliverability. Control attributes consist several of actions that help the network behave, such as bandwidth speed, files prioritized under condition expressions. These conditions follow power law distribution and customer behavioral patterns.

Building dynamic complexity systems requires finding an appropriate method in advance. For example, modeling technique has the capability, expandability, stability and reprocess-ability. In most cases, a few assumptions are required with regard to the functionality of the proposed system. This needs to be known before the structure is formulated. Requirements of systems have to sequentially identify a system's attributes and study its interactions. This allows for interpretation of these requirements into design.

Understanding the process and these requirements assists practitioners to formulate a layout of the system based on the Matlab simulation. Otherwise a misunderstanding of a system can occur. Simulation software is used to design and implement a specific and unique implementation for the selected proposed system. Matlab will run and provide output data. This data is used to describe system states and after that, a system's concept can be evaluated and studied.

The purpose of this design procedure is to transfer a system's requirements into an accepted entry that can be understood by the practitioner developing a model. The simulation software used in this research paper is Matlab. More explanation about this software toolkit will be presented in STEP 3.

Building a simulation program is an intermediate task required after defining system attributes. Optimizing the dynamic complexity of a proposed system often makes it hard to know where to start, and system developers frequently have to build new system simulations from scratch. System attributes and their characteristics help when it is identified in the first place, resolves difficulties that are facing system developers when building simulation software programming and employing their techniques.

Being able to understand a system's attributes and its interactions helps to provide a way to imitate the performance of the proposed system. Based on the system's attributes and its interactions, it would be possible to construct a logical simulation diagram which can be parsed to build a modeling simulation technique in a desired simulation environment.

IV.3.2 Logical Simulation Diagram

This logical simulation diagram highlights the flow of simulation techniques that will be used to study all network capability by using the given data to reach the final target of optimizing the current network.

Fig 5 shows the three different layers of the network that will be studied in our scenario. Starting with input attributes, our network has inputs for the simulation software to be used as parameters in order to understand the system's boundaries and interactions to produce some source of effective network operations, each attribute will be described as follow:

Server

Server will present the main storage device serving all nodes and the operation center of analyzing a network load and demand and fulfill the requirements needed to reach optimum results.

Nodes

Nodes will present the customers side of getting benefits of downloading movies from the server. Nodes have more demands from the network than just downloading files from the main server also can act as a virtual storage media, can host files, serve other nodes in the network, which helps decrease load on the server. In addition, each of these nodes has special requirements that depend on the customer's preferences and customer's personalization.

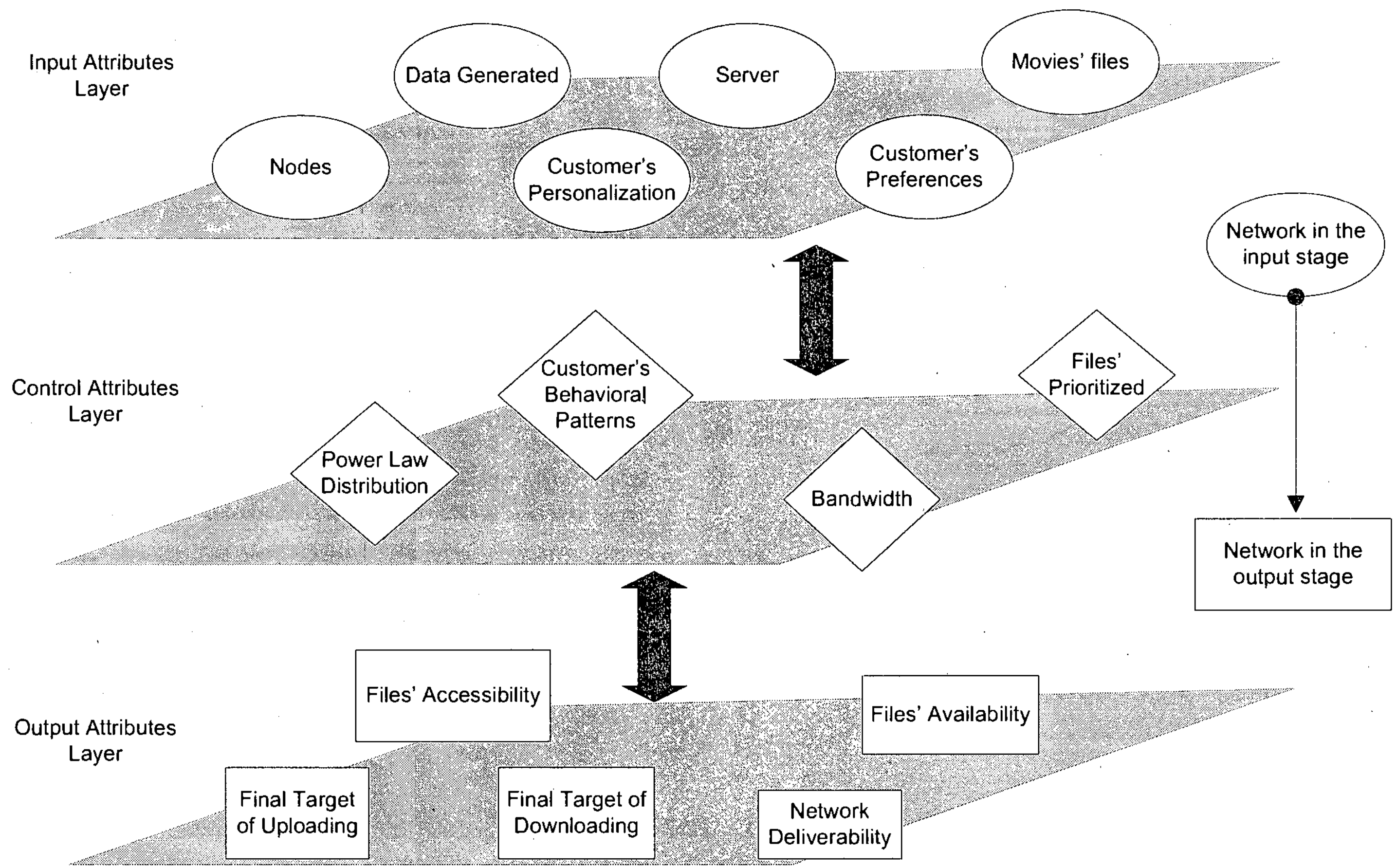
Movies' Files

The actual files hosted on the main server and downloaded by all network's nodes, are in different sizes and duration times. If the same file is downloaded from two different storage media, they can be split in half but can not be downloaded simultaneously at the same time; it has be each piece at a time.

Data Generated

Generated data is used to identify customers' behavior, these behaviors; represent a time of ordering files, watched time, types of files downloaded, file's index number, number of files downloaded and files' priorities.

Figure 5: Logical Simulation Diagram



Customer's Preferences

Customer's preference represents what customers are interested in looking at to be downloaded from files that have most priority to be watched by customer. Also these preferences can be translated to different of categories, in what priority is ranked within each category and how soon needed.

Customer's Personalizations

Each customer has its own behavior and personal information that helps to identify customer's preference for future reference by the system of making certain files available depending on customer's personalization. Customer's personalization has a set of parameters; these parameters represent the customer's most interested movies in his list upon signing on to the new services. These parameters are: customer ID, Customer most preferred category, customer second preferred category, actors preferred list, released date, most wanted, first to be watched list wish, last to be watched list wish, etc.

Second defining control attributes that control output attributes from input attributes. Control attributes play mainly in the heart of the system by developing techniques and strategies to reach the system goal of optimizing the network. These attributes will be describes as follows:

Customer's Behavioral Patterns

Customers interest to watch movies and how to order them in batches; each batch will be ordered at the time of the customer plans to watch them. While these batches follow a certain rule as follows:

- Customers allow ordering each batch at a time.
- Batches will not be ordered until the last file of the last batch had been watched.
- Batches will vary between one to six files, depending on customer's interested and experiences on what type of movie will be watched.

Power Law Distribution

Power law as explained in STEP 2 has a major impact of the customers' decisions of selected files to be watched. Power law distribution organizes the five categories files to be ranked from highest priority to the lowest one according to the total watched movies during one calendar year of 8760 hours by all nodes.

Files' Priorities

Files' priorities is one of controlled attributes for the selected files as having the highest preference for the customer, which controls the flow of selected files by customer to be eventually in a virtual storage located within the network for any interested customer to watch in advance.

Bandwidth

Bandwidth has the highest impact on the customers' decision on number of files to be ordered from the network and availability to be watched on their schedule. Bandwidth represents the speed of transferring a file from point A to point B; Point A can be server or node, and point B will be node. Also the bandwidth will allow the file to be downloaded or uploaded at a certain speed, these speeds have been defined in STEP 1.

Finally, the output attributes represents the output from input attributes and control attributes. The output attributes deals with the final stage of the network after it has gone through several steps to be finally balanced and optimized through the system's metrics. Output attributes will be decreased in more details as follows:

Files' Accessibility

As a results these files stored on the main server are transferred and stored on different hard drives located in nodes within the network; later on these files are allowed to be moved from any where in the network from node to other node upon the request of customer's preference.

Files' Availability

As a result from transferring, these files and easy the access that allowed them to be allocated from node to other node within the network upon corresponding of identifying and analyzing the customer's personalization. Customer's personalization has a set of parameters that identify the customer's needs

Network Deliverability

Network deliverability will present the final stage of reaching the optimum state of maximizing the efficiency of all nodes by reaching the final requirements from delivering the files to each requested nodes in the network and decreasing the server load over time.

Final Target of Downloading

After one calendar year of 8760 hours, all the nodes reach the final target of downloading all the requested files from an optimized network.

Final Target of Uploading

After one calendar year of 8760 hours, most of the nodes will be able to upload to others individually needed nodes upon request, and any files can be reached either from server or from node to satisfy the needs and before over loading the network with heavy traffic of data can be overcome.

The next step will handle in more detail how to analyze the logical simulation diagram by using Matlab and explain more in depth the factors used to optimize the network.

IV.4 STEP 3: ANALYZING LOGICAL SIMULATION DIAGRAM AND IDENTIFY WAYS TO OPTIMIZE THE SYSTEM BASED ON THE SYSTEM'S METRICS

Main aspect of the research is to study the system's boundaries and identify what the rules to be followed are and how from there we can define the system's metrics. System's metrics are the set of techniques used to measure the systems and find how the system functions and inter-correlates with it.

System's metrics have been defined in STEP 1 in this chapter. As one of the main techniques to measure the system, there are also simulations of the functionality of the system to help us study the system's behaviors.

In this step we will define different heuristics that will be simulated in our research study and develop techniques to measure the system's metrics which lead to a better way to analyze our network and get to the optimum values.

The heuristics describe here will work from the idle to optimum scenario; the idle scenario will be presented by Base Line study case and followed by four heuristics H1, H2, H3 and H4 where H4 is the optimum solution case study of knowing all the data and information ahead of time and running the simulation based on our knowledge. Idle and heuristics scenarios will be defined more in depth.

IV.4.1 Base Line Scenario

The Base Line represents an ideal scenario of running the network simulation; network will be unlimited accessing and downloading, the following assumption will be based on Base Line simulation:

- All nodes have limited bandwidth between themselves and the server in the same network.
- All nodes have internal infinite storage device for unlimited number saved movies' files can be downloaded.
- Nodes only can download files from server; there are no individual uploading to the network.
- Penalty will be count on, which is the difference between the desired time of watching the movie by individual customer and the actually watched time with no traffic jam.

IV.4.2 H1 Heuristic Scenario

The first heuristic represents the same scenario for Base Line with few limitations added on for more study of how the network can act and work toward optimization. The following assumption will be based on H1 heuristic simulation:

- All nodes have limited bandwidth between themselves and the server in the same network.
- All nodes have the same limitations bandwidth with themselves as they do with the server.
- All nodes have internal limited storage device with different sizes that limited number of saved movies' files can be downloaded either from the server or others nodes on the same network.

- Nodes are able to download files either from the server or from others nodes on the same network but following these guidelines:
  - If the file exists on the server only, all nodes are able to download with no exception or limitation but depends on the bandwidth speed, file size and ordered time.
  - If the file exists on the server and other node, any node can download the same file from the server and from the node hosting that file, but the node hosting the file will not upload it to more than one requested node at the same time.
  - If the file exists on two nodes, any node can download the same file from these two nodes hosting that file and ignoring the server, but the nodes hosting the file will not upload it to more than one requested node at the same time.
- Penalty will be count on, which is the difference between the desired time of watching the movie by the individual customer and the actually watched time with no traffic jam.

IV.4.3 H2 Heuristic Scenario

The second heuristic represents the same scenario for first heuristic with few exceptions added for more study of how the network can act and work toward optimization. The following assumptions will be based on H2 heuristic simulation:

- All nodes have limited bandwidth between themselves and the server in the same network.
- All nodes have the same limitations bandwidth with themselves as they do with the server.
- All nodes have internal limited storage device with different sizes that limited number of saved movies' files can be downloaded either from the server or others nodes on the same network.
- Few nodes will be forced to keep certain files on their internal storage media by preempting these files during their normal operations with the network.
- Nodes are able to download files either from the server or from others nodes on the same network but following these guidelines:

- If the file exists on the server only, all nodes are able to download with no exception or limitation but depends on the bandwidth speed, file size and ordered time.
- If the file exists on the server and other node, any node can download the same file from the server and from the node hosting that file, but the node hosting the file will not upload it to more than one requested node at the same time.
- If the file exists on two nodes, any node can download the same from file from these two nodes hosting that file, but the nodes hosting the file will not upload it to more than one requested node at the same time.

- Penalty will be count on, which is the difference between the desired time of watching the movie by the individual customer and the actually watched time with no traffic jam.

IV.4.4 H3 Heuristic Scenario

The third heuristic represents the same scenario for the first heuristic with few exceptions added of using customer's preferences for more study of how the network can act and work toward optimization. The following assumption will be based on H3 heuristics simulation:

- All nodes have limited bandwidth between themselves and the server in the same network.
- All nodes have the same limitations bandwidth with themselves as they do with the server.
- All nodes have internal limited storage device with different sizes that a limited number of saved movies' files can be downloaded either from the server or others nodes on the same network.
- Few nodes will be forced to upload certain files on their internal storage media and depends on their customer's preference and personalization in addition to the files' preferences during their normal operations with the network.
- Nodes are able to download files either from the server or from others nodes on the same network but following these guidelines:

  - If the file exists on the server only, all nodes are able to download with no exception or limitation but depends on the bandwidth speed, file size and ordered time.
  - If the file exists on the server and other node, any node can download the same file from the server and from the node hosting that file, but the node hosting the file will not upload it to more than one requested node at the same time.
  - If the file existing on two nodes, any node can download the same file from these two nodes hosting that file, but the nodes hosting the file will not upload it to more than one requested node at the same time.

- Penalty will be count on, which is the difference between the desired time of watching the movie by the individual customer and the actually watched time with no traffic jam.

IV.4.5 H4 Heuristic Scenario (Near Optimum Solution Scenario)

The forth heuristic represents a near optimum solution of the network by reaching the highest values of deliverables files and acting on lower than normal operations from any excessive load demand on any of the server as well other nodes.

By gaining experience from running past simulations of Base Line and different heuristics (H1, H2 and H3) and also collecting the data, we found it will help us to understand the network situations. Running a simulation with a knowledge about the system ahead of time that will given an advantage to drive our network operation that is also dynamically complex changes over time and space. The following will be an assumption and steps will be guided for H4 heuristic simulation:

- All nodes have limited bandwidth between themselves and the server in the same network.
- All nodes have the same limitations bandwidth with themselves as they do with the server.
- All nodes have internal limited storage device with different sizes that a limited number of saved movies' files can be downloaded either from the server or others nodes on the same network.

Table 3: Five Heuristics Scenarios

Base Line Scenario.	(Idle)
H1 Heuristic Scenario.	(Server and Nodes)
H2 Heuristic Scenario.	(Preemptive certain files)
H3 Heuristic Scenario.	(Customer's preferences and Files)
H4 Heuristic Scenario.	(Near optimum Solution)

- Few nodes will be forced to upload certain files on their internal storage media depending on their customer's preference and personalization in addition to the files' preferences during their normal operations with the network.
- Nodes are able to download files either from the server or from others nodes on the same network but following these guidelines:
  - If the file exists on the server only, certain nodes will be able to download with no exception or limitation but depends on the bandwidth speed, file size and ordered time.
  - If the file exists on the server and other node, certain nodes can download the same file from the server and from the node hosting that file, but the node hosting the file will not upload it to more than one requested node at the same time and will follow a strategic plan of uploading the files hosted on internal storage media.
  - If the file exists on two nodes, certain node can download the same file from these two nodes hosting that file, but the nodes hosting the file will not upload it to more than one requested node at the same time but will follow a strategic plan of uploading the files hosted on internal storage media.
- Penalty is described as the difference between the desired time of watching the movie by an individual customer compared to when the movie is actually available.

Table 3 summarizes each of the heuristics and gives a brief description as follows:

IV.5 STEP 4: HEURISTICS RESULTS EVALUATIONS BASED ON SIMULATED LOGIC DIAGRAM

In STEP 4, after going through different heuristics, a simulation technique will be placed to study these heuristics and evaluate the output results; the results will be collected after running 100 samples of data by each heuristic scenario; these scenarios are collected according to the simulation program as follows:

- Running each heuristic scenario per different bandwidth speeds with constant individual storage media size.
- Running each heuristic scenario per different individual storage media size with constant bandwidth speeds.

Evaluation of all the output data we collected will summarize how the network acted and balanced to reach near optimum values. The data will be evaluated using different analysis to highlight where the threshold points of the system act to move the system towards stability while maximizing efficiency of the system. These stages can be described accordingly to how the system reacts to change by either one node or all other nodes.

Eventually the data will present differences and similarities between all heuristic scenarios and changes that occur. There are many different analysis techniques that can be used to evaluate the heuristics results, but two major ones will be used mainly in our evaluations as follows:

IV.5.1 Analysis of Standard Deviation

Standard deviation will measure the dispersion and how far spread out the data is from the measured mean; in the case of normal distribution one standard deviation will describe the data spread by 68% away from the mean values in opposite directions. The formula used to calculate a standard deviation from a set of data is:

$$\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

Where σ is the Standard Deviation, n is the number of data points, x_i is the individual data points and $\bar{x}$ is the mean of data points.

The standard deviation will be used to calculate the confidence interval around the mean, the values will be around upper 95% and lower 95% around the mean values, these expressions will follow:

$$The\ upper\ 95\% = \bar{x} + (\sigma * 1.96)\ and\ the\ lower\ 95\% = \bar{x} - (\sigma * 1.96)$$

IV.5.2 Analysis of Time Series

Time series is a sequence of data points measured in an interval time periodically. Analyzing the time series is to attempt to understand the output data point sequence that measured in time passing through one year of 8760 hours “in our scenario the heuristic studies”.

In our heuristics scenarios, the time series studies will be used to describe server load and develop confidence bound based on the standard deviations of the distributions associated with the trends; the results will explain more in depth how the system stages through different time intervals.

The following chapters will explain more in depth the results from different heuristics scenarios as well find the solution to overcome system analysis and simulations.

Based on our analysis the time series will be focused on two major aspects, these aspects will be described as follows:

Time Series Analysis

Time series analysis is studying the Base Line and the four Heuristics scenarios in a time domain with upper and lower of 95% of standard deviation. These studies will show the similarities and differences between all heuristics scenario by studying 15 combination graphs; the graphs will represent the output results of using independent variables in 5 scenarios for the three system's metrics.

Differential Time Analysis

Differential time analysis is a four time series analysis and studies the results of a subtraction between two time series analysis heuristics. The four subtractions will be subtracted H1 from Base Line, H2 from H1, H3 from H2 and H4 from H3.

IV.5.3 Response Surface Analysis

Each heuristic scenario will be presented with three dimensional graphs to show where the optimum values are; the values resulted from heuristics simulation analysis by plotting each individual system's metric with other coordinates; coordinates are internal storage media and bandwidth of download speed.

The next chapter will be presenting 15 combinations responses surface analysis for five scenarios and three individual system's metrics. The other coordinates will be presented by changing the following intervals according to the given independents parameters:

Internal Storage Media

Each individual storage media installed in each node will act as storage for movie files downloaded from the network; these storage capacities start by 50GB (Gigabytes) with increment of 50GB up to 1TB (Terabytes) and plots the changes for each interval at constant values of bandwidth download speed.

Bandwidth Download Speed

Bandwidth will be used as an independent parameter of controlling all the connectivity speed through the network; bandwidth will have an initial start of 25Kb/s (Kilobits/second) with increment of 25Kb/s up to 5Mb/s (Megabits/second) of downloading speed and plotting the changes for each interval at constant values of internal storage media.

IV.5.4 Statistical Analysis

In analyzing the results, it needed to be in advance of highlighting all scenario cases studied and completing evaluating the data; the Analysis of Variance (ANOVA) has been selected to show the differences and the similarities between different heuristics results from the simulation program.

There will be 27 total ANOVA analyses and diagrams using common bandwidths and internal storage medias used by all nodes. In studying ANOVA analysis bandwidth values will be limited to 1Mb/s, 2Mb/s and 5Mb/s and internal storage media will be limited to 50GB, 100GB and 200GB.

The results from the simulation of 100 samples by each experiment will be evaluated as a comparison between five heuristics (Base Line and four following heuristics), these data will be mainly calculated and compared on the basis of two individual heuristics of ANOVA analysis by using one of the post-hoc tests.

Post-hoc test is used to determine which groups of each individual heuristics differ from other groups of heuristics. Tukey's honestly significant difference (HSD) post-hoc test will be used as test for ANOVA results. First at all, Tuhey's HSD post-hoc will calculate and compare pairs of means of all groups using these values as a comparison with the critical values to find the similarities and differences by using the formula:

$$Tukey's = \frac{M_A - M_B}{S_e}$$

$$Where\ S_e = \frac{Standard\ Deviasion}{\sqrt{n}}$$

M_A is the large of two means being compared, M_B is the small of two means being compared and n is the number samples (size) used to calculate S_e (Standard error).

CHAPTER V

HEURISTICS RESULTS

This chapter presents the results obtained of running Matlab simulation on different Heuristics Scenario described in details in the previous chapter. The data that has been collected is transformed to graphs for better explanation; the graphs are used in different plotting ways like bars, lines connected between points and 3-D dimensional graphs.

As noted before this data will be analyzed in different measures that are suitable for the type of experimental run and described in the last chapter. There is numerous data that will be impracticable to present in this chapter, but important ones will be presented as a key to show the differences and similarities and as the aim of this dissertation to show how networks can be dynamic and change complexity in time and space which then can be optimized based on specified performance measures.

The graphs will be presented in Appendix C and are summarized from the data generated that serve the purpose of the research.

V.1 TIME SERIES ANALYSIS

V.1.1 Server Load

Graphs represented here are the results from studying how server loads were effected by different Heuristics.

Base Line Case Scenario

Time Series was conducted on a Base Line for different bandwidth loaded on the server with no nodes sharing the load with the server: the hard drive was not a study factor in this experiment and each node using the same value of bandwidth download speed from the server at the same time of analyzes.

The analysis was done on different bandwidth values (128, 512, 1000, 2000, 5000 kb/s) as shown on Figs 88, 89, 90, 91 and 92. These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

Heuristic H1 Case Scenario

Time Series was conducted on a H1 for different hard drive sizes and different download bandwidth speed loaded on the server with other nodes sharing the load with the server; the hard drive had different effects on the study in this experiment and each node using the same value of bandwidth download speed from the server and same value of hard drive size at the same time of analysis.

The analysis was done on different hard drive values between 50GB and 1TB with 50GB interval - but it was noticed the data collected for hard drives 200GB and above are the same so the 200GB hard drive capacity will be used for any reference for higher capacities above 200GB value - and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) as shown between figures (93 and 136). These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

Heuristic H2 Case Scenario

Time Series was conducted on a H2 for different hard drive sizes and different download bandwidth speed loaded on the server with other nodes sharing the load with the server; the hard drive had different effects on the study in this experiment and each node using the same value of bandwidth download speed from the server and same value of hard drive size at the same time of analysis.

Preemptive technique was used in this Case Scenario for limited files to be uploading during network operations.

The analysis was done on different hard drive values between 50GB and 1TB with 50GB interval - but it was noticed the data collected for hard drives 200GB and above are the same so the 200GB hard drive capacity will be used for any reference for higher capacities above 200GB value - and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) as shown between figures (137 and 180). These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

Heuristic H3 Case Scenario

Time Series was conducted on a H3 for different hard drive sizes and different download bandwidth speed loaded on the server with other nodes sharing the load with the server;

the hard drive had different effects on the study in this experiment and each node using the same value of bandwidth download speed from the server and same value of hard drive size at the same time of analysis.

Customer's preferences technique was used in this Case Scenario by uploading files during network operations according to customer's preference lists for each customer.

The analysis was done on different hard drive values between 50GB and 1TB with 50GB interval - but it was noticed the data collected for hard drives 200GB and above are the same so the 200GB hard drive capacity will be used for any reference for higher capacities above 200GB value - and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) as shown between figures (181 and 224). These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

Heuristic H4 Case Scenario

Time Series was conducted on a H4 for different hard drive sizes and different download bandwidth speed loaded on the server with other nodes sharing the load with the server; the hard drive had different effects on the study in this experiment and each node using the same value of bandwidth download speed from the server and same value of hard drive size at the same time of analysis.

All previous Heuristics studies techniques were used in this Case Scenario by maximize the efficiency of network operations according to the results studies from (Base Line and Heuristics of H2, H2 and H3) per each customer on the network.

The analysis was done on different hard drive values between 50GB and 1TB with 50GB interval - but it was noticed the data collected for hard drives 200GB and above are the same so the 200GB hard drive capacity will be used for any reference for higher capacities above 200GB value - and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) as shown between figures (225 and 268). These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

V.1.2 Penalty

Graphs represented here are results from studying how penalty was effected by different Heuristics. As Base Line and H1 Scenarios were used to download files as an initial start by the customer without any file insertion techniques used; from there we expect both of these Scenarios will be the same even if files were downloaded either from server or nodes.

Moreover, Base Line and H1 Heuristic will give the same results, so I indicate here one result by using H1 Scenario which can be used as a reference for Base Line study for penalty.

Heuristic H1 Case Scenario

Time Series was conducted on a H1 for different hard drive sizes and different download bandwidth speed loaded on the server with other nodes sharing the load with the server; the hard drive had different effects on the study in this experiment and each node using the same value of bandwidth download speed from the server and same value of hard drive size at the same time of analysis.

The analysis was done on different hard drive values between 50GB and 1TB with 50GB interval - but it was noticed the data collected for hard drives 200GB and above are the same so the 200GB hard drive capacity will be used for any reference for higher capacities above 200GB value - and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) as shown between figures (269 and 312). These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

Heuristic H2 Case Scenario

Time Series was conducted on a H2 for different hard drive sizes and different download bandwidth speed loaded on the server with other nodes sharing the load with the server; the hard drive had different effects on the study in this experiment and each node using the same value of bandwidth download speed from the server and same value of hard drive size at the same time of analysis.

Preemptive technique was used in this Case Scenario for limited files to be uploaded during network operations.

The analysis was done on different hard drive values between 50GB and 1TB with 50GB interval - but it was noticed the data collected for hard drives 200GB and above are the same so the 200GB hard drive capacity will be used for any reference for higher capacities above 200GB value - and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) as shown between figures (313 and 356). These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

Heuristic H3 Case Scenario

Time Series was conducted on a H3 for different hard drive sizes and different download bandwidth speed loaded on the server with other nodes sharing the load with the server; the hard drive had different effects on the study in this experiment and each node using the same value of bandwidth download speed from the server and same value of hard drive size at the same time of analyzes.

Customer's preferences technique was used in this Case Scenario by uploading files during network operations according to customer's preference lists for each customer.

The analysis was done on different hard drive values between 50GB and 1TB with 50GB interval - but it was noticed the data collected for hard drives 200GB and above are the same so the 200GB hard drive capacity will be used for any reference for higher capacities above 200GB value - and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) as shown between figures (357 and 400). These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

Heuristic H4 Case Scenario

Time Series was conducted on a H4 for different hard drive sizes and different download bandwidth speed loaded on the server with other nodes sharing the load with the server; the hard drive had different effects on the study in this experiment and each node using the same value of bandwidth download speed from the server and same value of hard drive size at the same time of analyzes.

All previous Heuristics studies techniques were used in this Case Scenario to maximize the efficiency of network operations according to the results studies from (Base Line and Heuristics of H2, H2 and H3) per each customer on the network.

The analysis was done on different hard drives values between 50GB and 1TB with 50GB interval - but it was noticed the data collected for hard drives 200GB and above are the same so the 200GB hard drive capacity will be used for any reference for higher capacities above 200GB value - and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) as shown between figures (401 and 444). These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

V.1.3 Total Download Bytes (TDB)

Graphs represent the results from studying how TDB were effected by different Heuristics. Base Line and H1 Scenarios were used to download files as an initial start by customer without any files insertion techniques used, from there we expect both these Scenarios will be the same even if files were downloaded either from server or nodes.

Moreover, representing Base Line and H1 Heuristic will be the same results, so I indicate here one result by using H1 Scenario which can be used as a reference for Base Line study for penalty.

Heuristic H1 Case Scenario

Time Series was conducted on a H1 for different hard drive sizes and different download bandwidth speed loaded on the server with other nodes sharing the load with the server; the hard drive had different effects on the study in this experiment and each node using the same value of bandwidth download speed from the server and same value of hard drive size at the same time of analyzes.

The analysis was done on different hard drives values between 50GB and 1TB with 50GB interval - but it was noticed the data collected for hard drives 200GB and above are the same so the 200GB hard drive capacity will be used for any reference for higher capacities above 200GB value - and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) as shown between figures (445 and 488). These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

Heuristic H2 Case Scenario

Time Series was conducted on a H2 for different hard drive sizes and different download bandwidth speed loaded on the server with other nodes sharing the load with the server; the hard drive had different effects on the study in this experiment and each node using the same value of bandwidth download speed from the server and same value of hard drive size at the same time of analyzes.

Preemptive technique was used in this Case Scenario for limited files to be uploading during network operations.

The analysis was done on different hard drives values between 50GB and 1TB with 50GB interval - but it was noticed the data collected for hard drives 200GB and above are the same so the 200GB hard drive capacity will be used for any reference for higher capacities above 200GB value - and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) as shown between figures (489 and 532). These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

Heuristic H3 Case Scenario

Time Series was conducted on a H3 for different hard drive sizes and different download bandwidth speed loaded on the server with other nodes sharing the load with the server; the hard drive had different effects on the study in this experiment and each node using the same value of bandwidth download speed from the server and same value of hard drive size at the same time of analyzes.

Customer's preferences technique was used in this Case Scenario by uploading files during network operations according to customer's preference lists for each customer.

The analysis was done on different hard drives values between 50GB and 1TB with 50GB interval - but it was noticed the data collected for hard drives 200GB and above are the same so the 200GB hard drive capacity will be used for any reference for higher capacities above 200GB value - and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) as shown between figures (533 and 576). These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

Heuristic H4 Case Scenario

Time Series was conducted on a H4 for different hard drive sizes and different download bandwidth speed loaded on the server with other nodes sharing the load with the server; the hard drive had different effects on the study in this experiment and each node using the same value of bandwidth download speed from the server and same value of hard drive size at the same time of analyzes.

All previous Heuristics studies techniques were used in this Case Scenario by maximizing the efficiency of network operations according to the results studies from (Base

Line and Heuristics of H2, H2 and H3) per each customer on the network.

The analysis was done on different hard drives values between 50GB and 1TB with 50GB interval - but it was noticed the data collected for hard drives 200GB and above are the same, so the 200GB hard drive capacity will be used for any reference for higher capacities above 200GB value - and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) as shown between figures (577 and 620). These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

V.2 DIFFERENTIAL TIME ANALYSIS (DTA)

V.2.1 Server Load

DTA Between H1 and Base Line Case Scenario

Differential Time Series analysis was conducted to determine the difference between Heuristic H1 and Base Line for different bandwidth loaded on the server.

The analysis was done on different bandwidths values (128, 512, 1000, 2000, 5000 kb/s) as shown on Fig 621, Fig 622, Fig 623, Fig 624 and 625. These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

DTA Between H2 and H1 Case Scenario

Differential Time Series analysis was conducted to determine the difference between Heuristic H2 and Heuristic H1 for different hard drive sizes and different download bandwidth speed loaded on the server.

The analysis was done on different hard drives values between 50GB and 1TB with 50GB interval - but it was noticed the data collected for hard drives 200GB and above are the same so the 200GB hard drive capacity will be used for any reference for higher capacities above 200GB value - and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) as shown between figures (626 and 669). These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

DTA Between H3 and H2 Case Scenario

Differential Time Series analysis was conducted to determine the difference between Heuristic H3 and Heuristic H2 for different hard drive sizes and different download bandwidth speed loaded on the server.

The analysis was done on different hard drives values between 50GB and 1TB with 50GB interval - but it was noticed the data collected for hard drives 200GB and above are the same so the 200GB hard drive capacity will be used for any reference for higher capacities above 200GB value - and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) as shown between figures (670 and 713). These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

DTA Between H4 and H3 Case Scenario

Differential Time Series analysis was conducted to determine the difference between Heuristic H4 and Heuristic H3 for different hard drive sizes and different download bandwidth speed loaded on the server.

The analysis was done on different hard drives values between 50GB and 1TB with 50GB interval - but it was noticed the data collected for hard drives 200GB and above are the same so the 200GB hard drive capacity will be used for any reference for higher capacities above 200GB value - and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) as shown between figures (714 and 757). These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

V.2.2 Penalty

DTA Between H2 and H1 Case Scenario

Differential Time Series analysis was conducted to determine the difference between Heuristic H2 and Heuristic H1 for different hard drive sizes and different download bandwidth speed loaded on the server.

The analysis was done on different hard drives values between 50GB and 1TB with 50GB interval - but it was noticed the data collected for hard drives 200GB and above are the same so the 200GB hard drive capacity will be used for any reference for higher capacities above 200GB value - and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) as shown between figures (758 and 801). These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

DTA Between H3 and H2 Case Scenario

Differential Time Series analysis was conducted to determine the difference between Heuristic H3 and Heuristic H2 for different hard drive sizes and different download bandwidth speed loaded on the server.

The analysis was done on different hard drives values between 50GB and 1TB with 50GB interval - but it was noticed the data collected for hard drives 200GB and above are the same so the 200GB hard drive capacity will be used for any reference for higher capacities above 200GB value - and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) as shown between figures (802 and 845). These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

DTA Between H4 and H3 Case Scenario

Differential Time Series analysis was conducted to determine the difference between Heuristic H4 and Heuristic H3 for different hard drive sizes and different download bandwidth speed loaded on the server.

The analysis was done on different hard drives values between 50GB and 1TB with 50GB interval - but it was noticed the data collected for hard drives 200GB and above are the same so the 200GB hard drive capacity will be used for any reference for higher capacities above 200GB value - and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) as shown between figures (846 and 889). These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

V.2.3 Total Download Bytes (TDB)

DTA Between H2 and H1 Case Scenario

Differential Time Series analysis was conducted to determine the difference between Heuristic H2 and Heuristic H1 for different hard drive sizes and different download bandwidth speed loaded on the server.

The analysis was done on different hard drives values between 50GB and 1TB with 50GB interval - but it was noticed the data collected for hard drives 200GB and above are the same so the 200GB hard drive capacity will be used for any reference for higher capacities above 200GB value - and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) as shown between figures (890 and 933). These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

DTA Between H3 and H2 Case Scenario

Differential Time Series analysis was conducted to determine the difference between Heuristic H3 and Heuristic H2 for different hard drive sizes and different download bandwidth speed loaded on the server.

The analysis was done on different hard drives values between 50GB and 1TB with 50GB interval - but it was noticed the data collected for hard drives 200GB and above are the same so the 200GB hard drive capacity will be used for any reference for higher capacities above 200GB value - and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) as shown between figures (934 and 977). These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

DTA Between H4 and H3 Case Scenario

Differential Time Series analysis was conducted to determine the difference between Heuristic H4 and Heuristic H3 for different hard drive sizes and different download bandwidth speed loaded on the server.

The analysis was done on different hard drives values between 50GB and 1TB with 50GB interval - but it was noticed the data collected for hard drives 200GB and above are the same so the 200GB hard drive capacity will be used for any reference for higher capacities above 200GB value - and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) as shown between figures (978 and 1021). These figures are presented per hours with interval mean value per each 100 hours through the entire year on x-axis and the mean downloaded time from the server on y-axis.

V.3 RESPONSE SURFACE ANALYSIS (RSA)

V.3.1 Server Load

Server Load RSA was conducted on a 3-D scale for different hard drive sizes and different download bandwidth speed loaded on the server for Base Line and different Heuristics (H1, H2, H3 and H4).

Heuristic H1 Case Scenario

RSA was conducted on a H1 for different hard drives values between 50GB and 1TB with 50GB interval on x-axis and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) on y-axis as shown between figures (1022 and 1031). These figures are presented with the mean downloaded time from the server on z-axis.

The mean downloaded time from the server per each figure will present on interval value accumulated after each of (100,1000, 1900, 2800, 3700, 4600, 5500, 6400, 7300 and 8200 hours).

Heuristic H2 Case Scenario

RSA was conducted on a H2 for different hard drives values between 50GB and 1TB with 50GB interval on x-axis and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) on y-axis as shown between figures (1032 and 1041). These figures are presented with the mean downloaded time from the server on z-axis.

The mean downloaded time from the server per each figure will present on interval value accumulated after each of (100,1000, 1900, 2800, 3700, 4600, 5500, 6400, 7300 and 8200 hours).

Heuristic H3 Case Scenario

RSA was conducted on a H3 for different hard drives values between 50GB and 1TB with 50GB interval on x-axis and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) on y-axis as shown between figures (1042 and 1051). These figures are presented with the mean downloaded time from the server on z-axis.

The mean downloaded time from the server per each figure will present on interval value accumulated after each of (100,1000, 1900, 2800, 3700, 4600, 5500, 6400, 7300 and 8200 hours).

Heuristic H4 Case Scenario

RSA was conducted on a H4 for different hard drives values between 50GB and 1TB with 50GB interval on x-axis and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) on y-axis as shown between figures (1052 and 1061). These figures are presented with the mean downloaded time from the server on z-axis.

The mean downloaded time from the server per each figure will present on interval value accumulated after each of (100,1000, 1900, 2800, 3700, 4600, 5500, 6400, 7300 and 8200 hours).

V.3.2 Penalty

Penalty RSA for 250 nodes was conducted on a 3-D scale for different hard drive sizes and different download bandwidth speed loaded on the server for Base Line and different Heuristics (H1, H2, H3 and H4).

Heuristic H1 Case Scenario

RSA was conducted on a H1 for different hard drives values between 50GB and 1TB with 50GB interval on x-axis and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) on y-axis as shown between figures (1062 and 1071). These figures are presented with the mean downloaded time from the server on z-axis.

The mean downloaded time from the server per each figure will present on interval value accumulated after each of (100,1000, 1900, 2800, 3700, 4600, 5500, 6400, 7300 and 8200 hours).

Heuristic H2 Case Scenario

RSA was conducted on a H2 for different hard drives values between 50GB and 1TB with 50GB interval on x-axis and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) on y-axis as shown between figures (1072 and 1081). These figures are presented with the mean downloaded time from the server on z-axis.

The mean downloaded time from the server per each figure will present on interval value accumulated after each of (100,1000, 1900, 2800, 3700, 4600, 5500, 6400, 7300 and 8200 hours).

Heuristic H3 Case Scenario

RSA was conducted on a H3 for different hard drives values between 50GB and 1TB with 50GB interval on x-axis and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) on y-axis as shown between figures (1082 and 1091). These figures are presented with the mean downloaded time from the server on z-axis.

The mean downloaded time from the server per each figure will present on interval value accumulated after each of (100,1000, 1900, 2800, 3700, 4600, 5500, 6400, 7300 and 8200 hours).

Heuristic H4 Case Scenario

RSA was conducted on a H4 for different hard drives values between 50GB and 1TB with 50GB interval on x-axis and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) on y-axis as shown between figures (1092 and 1101). These figures are presented with the mean downloaded time from the server on z-axis.

The mean downloaded time from the server per each figure will present on interval value accumulated after each of (100,1000, 1900, 2800, 3700, 4600, 5500, 6400, 7300 and 8200 hours).

V.3.3 Total Download Bytes (TDB)

Total download bytes RSA for 250 nodes was conducted on a 3-D scale for different hard drive sizes and different download bandwidth speed loaded on the server for Base Line and different Heuristics (H2, H2, H3 and H4).

Heuristic H1 Case Scenario

RSA was conducted on a H1 for different hard drives values between 50GB and 1TB with 50GB interval on x-axis and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) on y-axis as shown between figures (1102 and 1111). These figures are presented with the mean downloaded time from the server on z-axis.

The mean downloaded time from the server per each figure will present on interval value accumulated after each of (100,1000, 1900, 2800, 3700, 4600, 5500, 6400, 7300 and 8200 hours).

Heuristic H2 Case Scenario

RSA was conducted on a H2 for different hard drives values between 50GB and 1TB with 50GB interval on x-axis and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) on y-axis as shown between figures (1112 and 1121). These figures are presented with the mean downloaded time from the server on z-axis.

The mean downloaded time from the server per each figure will present on interval value accumulated after each of (100,1000, 1900, 2800, 3700, 4600, 5500, 6400, 7300 and 8200 hours).

Heuristic H3 Case Scenario

RSA was conducted on a H3 for different hard drives values between 50GB and 1TB with 50GB interval on x-axis and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) on y-axis as shown between figures (1122 and 1131). These figures are presented with the mean downloaded time from the server on z-axis.

The mean downloaded time from the server per each figure will present on interval value accumulated after each of (100,1000, 1900, 2800, 3700, 4600, 5500, 6400, 7300 and 8200 hours).

Heuristic H4 Case Scenario

RSA was conducted on a H4 for different hard drives values between 50GB and 1TB with 50GB interval on x-axis and different bandwidth values (25, 50, 128, 512, 1000, 2000, 5000, 10000, 15000 kb/s) on y-axis as shown between figures (1132 and 1141). These figures are presented with the mean downloaded time from the server on z-axis.

The mean downloaded time from the server per each figure will present on interval value accumulated after each of (100,1000, 1900, 2800, 3700, 4600, 5500, 6400, 7300 and 8200 hours).

CHAPTER VI

DISCUSSION

The general objective of this research is to compare and determine the optimal solution of a network that is dynamic and whose complexity changes over 'time' and 'space'. In addition to the general objective, the research also tested the following specific hypotheses:

- By uploading more files to the host, do any differences exist in the heuristics analyses of Server Load, Penalty and total download bytes (TDB)?
- Do any differences exit in the ANOVA analyses of the heuristics results?
- Do the heuristics improve the performance of the network and maintain customers' satisfaction of reaching an optimum solution?

The following section discusses the results obtained in this study.

VI.1 HEURISTIC COMPARISIONS

In order to determine how the heuristics compare to one another, analyses were performed on various performance measures that include: Server Load, Penalty and total download bytes. These results gave insight as to what heuristic gave maximum benefit to the user in the context of the previous mentioned performance measures.

VI.1.1 Server Load

The analyses were done on five (5) heuristics, each one is described as follows.

Base Line Case Scenario

The first heuristic is the baseline scenario in which the hard drive is assumed to be an irrelevant factor because files will not be download between nodes. The analysis is done on five (5) different bandwidth values (128, 512, 1000, 2000, 5000 kb/s). The results indicate the mean download time from the server is inversely proportionate to the bandwidth.

Figures 88, 89, 90, 91 and 92 demonstrate the mean download time of the baseline scenario in the time series analysis is completely dependent on the server for all files downloaded to each node.

The other two analyses 'differential time analysis (DTA) and 'response surface analysis (RSA)' are highlighted later on with the H1 Heuristic Case Scenario. Previous analysis from the previous chapter showed the baseline and H1 scenarios to have identical results in terms of mean download time, total download bytes, and Penalty.

H1 Heuristic Case Scenario

The second heuristic H1 was simulated on different hard drive sizes (from 50GB to 1TB with increment of 50GB); each size was run separately with five (5) different bandwidth values (128, 512, 1000, 2000, 5000 kb/s). The results indicate the mean download time from server values were decreased through exponential decay through the entire year for each individual bandwidth value, also the total mean values were decreased with increasing bandwidth value per each hard drive size. Also it was observed for individual bandwidths that increasing the hard drive size value will have no impact on values higher than 200GB; all results remained the same as if the hard drive size installed was 200GB because the network assumes it is an infinite size.

Figures (93 and136) demonstrate H1 in the time series analysis is totally shared between the server and the nodes to download for all requested files. The graphs show an exponential decay for all 250 customers 'nodes' for the entire year because of using existing files that have already been to other nodes as a sharing point with the server. As the time progresses, the customers are more likely downloading the files from other nodes than from the server.

Second figures shown on 621, 622, 623, 624 and 625 demonstrate differential Time Series analysis between heuristic H1 and Base Line for different bandwidths loaded on the server. The graphs show exponential decay on the negative y scale for all 250 customers 'nodes' for the entire year. This is because the H1 heuristic more likely download files from the server along with nodes not just from the server along as in the baseline case.

Third, figures (1022 and 1031) demonstrate the H1 scenario in the response surface analysis on 3D dimensions that represent hard drive size on the x-axis and the bandwidth scale on the y-axis; The graphs show two exponentials decay on both axis with different parameters; each point represents a total mean for entire year for 250 customers 'nodes'.

H2 Heuristic Case Scenario

The third heuristic H2 runs on different hard drive sizes (from 50GB to 1TB with increments of 50GB); each size was run separately with five (5) different bandwidth values

(128, 512, 1000, 2000, 5000 kb/s). The results indicate that the mean download time from server values decreased exponentially through the entire year for each individual bandwidth value, also the total mean values decreased with increasing bandwidth value per each hard drive size. Also it was noticed for individual bandwidths that increasing the hard drive size above 200GB did not impact the performance. All results remain the same as if the hard drive size installed was 200GB because the network assumes it is an infinite size.

Figures (137 and 180) demonstrate the H2 time series analysis is totally shared between the server and the nodes to download all the requested files. The graphs show an exponential decay for all 250 customers 'nodes' for the entire year because of using existing files that have already been downloaded before on other nodes as a sharing point along with the server. As the time goes on the customers are more likely downloading the files from other nodes than from the server.

Second figures (626 and 669) demonstrate differential Time Series analysis between heuristic H2 and H1 for different bandwidths loaded on the server. the graphs are show exponential decay than .05 for all 250 customers 'nodes' for the entire year because H2 and H1 are more likely the same toward the second half of the year.

Third, figures (1032 and 1041) demonstrate the H2 in the response surface analysis on 3D dimensions that represent hard drive scale on the x-axis and the bandwidth scale on the y-axis; The graphs show two exponential decays on both axis with different parameters; each point represents a total mean for entire year for 250 customers 'nodes'.

H3 HEURISTICS CASE SCENARIO

The forth heuristic H3 and assumes to run on different hard drive sizes (from 50GB to 1TB with increment of 50GB). Each size was run separately with five (5) different bandwidth values (128, 512, 1000, 2000, 5000 kb/s).

The results indicate the mean download time from server values were decreased through exponential decay for the entire year for each individual bandwidth value. Also the total mean values are decreased with increasing bandwidth value per each hard drive size. Also it was noticed for individual bandwidths that increasing the hard drive size above 200GB did not impact the performance. All results remain the same as if the hard drive size installed was 200GB because the network assumes it is an infinite size.

Figures (181 and 224) demonstrate H3 in time series analysis is totally shared between the server and the nodes to download all the requested files. The graphs show an exponential decay for all 250 customers 'nodes' for the entire year because of using an existing files that has already been on other nodes as a sharing point along with the server; as time progresses, the customers are more likely downloading the files from other nodes than from the server.

Second figures (670 and 713) demonstrate differential Time Series analysis between heuristic H3 and H2 for different bandwidths loaded on the server. The graphs show an increase until the middle of the year and exponential decay for the rest of the year for all 250 customers 'nodes' for the entire year because of using an existing files that has already been on other nodes as a sharing point along with the server.

In addition, more downloads are needed from the server because of using the preemptive technique. In other words the network is forcing more files to the nodes than the H2 scenario and exponential decay than .05 for all 250 customers 'nodes' for the entire year because H3 and H1 are more likely the same toward the second half of the year.

Third, figures (1042 and 1051) demonstrate the H3 in the response surface analysis on 3D dimensions that represent hard drive scale on the x-axis and the bandwidth scale on the y-axis; The graphs show two exponential decays on both axes with different parameters; each point represents a total mean for entire year for 250 customers 'nodes'.

H4 Heuristic Case Scenario

The fifth heuristic H4 runs on different hard drive sizes (from 50GB to 1TB with increment of 50GB); each size was run separately with five (5) different bandwidth values (128, 512, 1000, 2000, 5000 kb/s). The results indicate the mean download time from server values are decreasing exponentially for the entire year for each individual bandwidth value, also the total mean values are decreasing with increasing bandwidth value per each hard drive size. Also it was noticed for individual bandwidths that increasing the hard drive size above 200GB did not impact the performance. All results remain the same as if the hard drive size installed was 200GB because the network assumes it is an infinite size.

Figures (225 and 268) demonstrate the H4 in time series analysis is totally shared between the server and the nodes to download all the requested files. The graphs show an exponential decay for all 250 customers 'nodes' for the entire year because of using an existing files that has already been on other nodes as a sharing point along with the server, as the time progresses, the customers are more likely downloading the files from other nodes than from the server.

Second figures (714 and 757) demonstrate differential Time Series analysis between heuristic H4 and H3 for different bandwidths loaded on the server. The graphs show an increase until the middle of the year and exponential decay the rest of the year for all 250 customers 'nodes' for the entire year because of using an existing files that already has been downloaded before on other nodes as a sharing point along with the server. In addition, more downloads are needed from the server because of using the preemptive technique, in other words the network is forcing more files to the nodes than the H3 scenario and exponential decay than .05 for all 250 customers 'nodes' for the entire year because H4 and H3 are more likely the same toward the second half of the year.

Third, figures between1052 and 1061) demonstrate the H4 in the response surface analysis on 3D dimensions that represent hard drive scale on the x-axis and the bandwidth scale on the y-axis; the graphs are showing two exponential decays on both axes with different parameters; each point represents a total mean for entire year for 250 customers 'nodes'.

VI.1.2 Penalty

During the simulation analysis it was found from the previous chapter that baseline and H1 have the same results. The analyses were done in four (4) heuristics, each one describes as follow.

H1 Heuristic Case Scenario

The first heuristic H1 runs on different hard drive sizes (from 50GB to 1TB with increment of 50GB); each size was run separately with five (5) different bandwidth values (128, 512, 1000, 2000, 5000 kb/s). The results show that the mean Penalty per hour were increased by exponentially growth through a logistic function through the entire year for lower bandwidth value and exponential decay for higher bandwidths, also the total mean values were decreased with increasing bandwidth value per each had drive size. Also it was noticed for individual bandwidths that increasing the hard drive size above 200GB did not impact the performance. All results remain the same as if the hard drive size installed was 200GB because the network assumes it is an infinite size.

Figures (269 and 312) demonstrate the H1 in time series analysis is totally shared between the server and the nodes to download all the requested files. The graphs show an exponential growth by a logistic function for all 250 customers 'nodes' through entire year for lower bandwidths because large file sizes requested to be downloaded in a short time, there was not enough bandwidth to satisfy customer's needs.

However for higher bandwidth the graphs are show an exponentially decay because there is enough bandwidth to accommodate the file size. In addition, the existing files that have already been downloaded before on other nodes are used as a sharing point along with the server; as the time goes on, the customer's are more likely downloading the files from other nodes than from the server.

Second, figures (1062 and 1071) demonstrate the H1 in the response surface analysis on 3D dimensions that represent hard drive scale on the x-axis and the bandwidth scale on the y-axis; the graphs are show two exponential decays on both axes with different parameters; each point represents a total mean for entire year for 250 customers 'nodes'.

H2 Heuristic Case Scenario

The second heuristic H2 runs on different hard drive sizes (from 50GB to 1TB with increment of 50GB); each size was run separately with five (5) different bandwidth values (128, 512, 1000, 2000, 5000 kb/s). The results indicate the mean Penalty per hour were increased by exponentially growth through a logistic function through the entire year for lower bandwidth value and exponentially decayed for higher bandwidths. Also the total mean values were decreased with increasing bandwidth values per each had drive size. Also it was noticed for individual bandwidths that increasing the hard drive size above 200GB did not impact the performance. All results remain the same as if the hard drive size installed was 200GB because the network assumes it is an infinite size.

Figures (313 and 356) demonstrate the H2 in time series analysis is totally shared between the server and the nodes to download all the requested files. the graphs are showing an exponentially growth by logistic function for all 250 customers 'nodes' for the entire year for lower bandwidths because of the large file sizes requested to be downloaded in a short time and the fact there was not enough bandwidth to satisfy customer's needs. However for higher bandwidths The graphs show an exponential decay because of enough bandwidth to accommodate the file sizes. In addition, the existing files that have already been downloaded on other nodes are used as a sharing point along with the server; as the time goes on, the customers are more likely downloading the files from other nodes than from the server.

Second figures (758 and 801) demonstrate differential Time Series analysis between heuristic H2 and H1 for different bandwidths loaded on the server. The graphs show an exponential decay to negative that then goes up slightly toward zero for all 250 customers 'nodes' for the entire year because H2 and H1 are more likely the same toward the second half of the year.

Third, figures (1072 and 1081) demonstrate the H2 in the response surface analysis on 3D dimensions that represent hard drive scale on the x-axis and the bandwidth scale on the y-axis; the graphs are showing two exponentials decay on both axes with different parameters; each point represents a total mean for entire year for 250 customers 'nodes'.

H3 HEURISTICS CASE SCENARIO

The third heuristic H3 runs on different hard drive sizes (from 50GB to 1TB with increment of 50GB); each size was run separately with five (5) different bandwidth values (128, 512, 1000, 2000, 5000 kb/s). The results indicate of the mean Penalty per hour were increased through exponentially growth by a logistic function through the entire year for lower bandwidth values and exponential decay for higher bandwidths, also the total mean values are decreased with increasing bandwidth value per each had drive size. Also it was noticed for individual bandwidths that increasing the hard drive size above 200GB did not impact the performance. All results remain the same as if the hard drive size installed was 200GB because the network assumes it is an infinite size.

Figures (357 and 400)) demonstrate the H3 in time series analysis is totally shared between the server and the nodes to download all the requested files. The graphs show an exponentially growth by a logistic function for all 250 customers 'nodes' for through entire year for lower bandwidth because of the large file size file requested to be downloaded in short time and there are not enough bandwidth to satisfy customer's needs. However for higher bandwidths, the graphs are show an exponential decay because of enough bandwidth to accommodate the file sizes. In addition, the existing files that have already been downloaded before on other nodes are used as a sharing point along with the server; as the time goes on, the customers are more likely downloading the files from other nodes than from the server.

Second figures (802 and 845) demonstrate differential Time Series analysis between heuristic H3 and H2 for different bandwidths loaded on the server. The graphs show an exponential decay to negative and goes up slightly toward zero for all 250 customers 'nodes' for the entire year because H3 and H2 are more likely the same toward the second half of the year.

Third, figures (1082 and 1091) demonstrate the H3 in the response surface analysis on 3D dimensions that represent hard drive scale on the x-axis and the bandwidth scale on the y-axis; the graphs are showing two exponential decays on both axes with different parameters; each point represents a total mean for entire year for 250 customers 'nodes'.

H4 Heuristic Case Scenario

The forth heuristic H4 runs on different hard drive sizes (from 50GB to 1TB with increment of 50GB); each size was run separately with five (5) different bandwidth values (128, 512, 1000, 2000, 5000 kb/s). The results indicate of the mean Penalty per hour are increased through exponential growth by logistic function through the entire year for lower bandwidth value and exponential decay for higher bandwidth, also the total mean values are decreased with increasing bandwidth value per each had drive size. Also it was noticed for individual bandwidths that increasing the hard drive size above 200GB did not impact the performance. All results remain the same as if the hard drive size installed was 200GB because the network assumes it is an infinite size.

Figures (401 and 444) demonstrate the H4 in time series analysis is totally shared between the server and the nodes to download all the requested files. the graphs are show an exponential growth through a logistic function for all 250 customers 'nodes' for through entire year for lower bandwidth because of a large file size file requested to be downloaded in short time and there is not enough bandwidth to satisfy customer's needs. However, for higher bandwidths the graphs shgraphs are shownential decay because of enough bandwidth to accommodate the file size. In addition, the existing files that have already been before on other nodes are used as a sharing point along with the server; as the time goes on, the customers are more likely downloading the files from other nodes than from the server.

Second figures (846 and 889) demonstrate differential Time Series analysis between heuristic H4 and H3 for different bandwidths loaded on the server. The graphs show an exponential decay to negative and goes up slightly toward zero for all 250 customers 'nodes' for the entire year because H4 and H3 are more likely the same toward the second half of the year.

Third, figures (1092 and 1101) demonstrate the H4 in the response surface analysis on 3D dimensions that represent hard drive scale on the x-axis and the bandwidth scale on the y-axis; The graphs show two exponential decays on both axes with different parameters; each point represents a total mean for entire year for 250 customers 'nodes'.

VI.1.3 Total Download Bytes (TDB)

During the simulation analysis it was found from the previous chapter that baseline and H1 have the same results. The analyses were done in four (4) heuristics, each one describes as follow.

H1 Heuristic Case Scenario

First heuristic H1 runs on different hard drive sizes (from 50GB to 1TB with increment of 50GB); each size was run separately with five (5) different bandwidth values (128, 512, 1000, 2000, 5000 kb/s). The results show that the total download time from server were increased by exponentially growth through the entire year for each individual bandwidth value, also the total mean values are decreased with increasing bandwidth value per each had drive size. Also it was noticed for individual bandwidths that increasing the hard drive size above 200GB did not impact the performance. All results remain the same as if the hard drive size installed was 200GB because the network assumes it is an infinite size.

Figures (445 and 488) demonstrate the H1 in time series analysis is totally shared between the server and the nodes to download all the requested files. The graphs show an exponential growth for all 250 customers 'nodes' through entire year because of the need to download more files to network. However, the existing files that have already been before on other nodes are used as a sharing point along with the server which increase total download bytes for the entire network, as the time goes on the customers are more likely downloading the files from other nodes than from the server.

Second, figures (1102 and 1111) demonstrate the H1 in the response surface analysis on 3D dimensions that represent hard drive scale on the x-axis and the bandwidth scale on the y-axis; The graphs show exponential decay on x-axis, each point represents a total mean for entire year for 250 customers 'nodes'.

H2 Heuristic Case Scenario

Second heuristic H2 runs on different hard drive sizes (from 50GB to 1TB with increment of 50GB); each size was run separately with five (5) different bandwidth values (128, 512, 1000, 2000, 5000 kb/s). The results show that total download time from server are increased by exponentially growth through the entire year for each individual bandwidth value, also the total mean values are decreased with increasing bandwidth value per each had drive size. Also it was noticed for individual bandwidths that increasing the hard drive size above 200GB did not impact the performance. All results remain the same as if the hard drive size installed was 200GB because the network assumes it is an infinite size.

Figures (489 and 532) demonstrate the H2 in time series analysis is totally shared between the server and the nodes to download all the requested files. The graphs show an exponential growth for all 250 customers 'nodes' through entire year because of the need to download more files to network. In addition, the existing files that have already been downloaded before on other nodes are used as a sharing point along with the server which increase total download bytes for the entire network, as the time goes on the customers are more likely downloading the files from other nodes than from the server.

Second figures (890 and 933) demonstrate differential Time Series analysis between heuristic H2 and H1 for different bandwidths loaded on the server. The graphs show an exponential growth and steady after that for all 250 customers 'nodes' for the entire year because H2 and H1 are more likely to be close toward the second half of the year.

Third, figures (1112 and 1121) demonstrate the H2 in the response surface analysis on 3D dimensions that represent hard drive scale on the x-axis and the bandwidth scale on the y-axis; The graphs show exponential decay on x-axis, each point represents a total mean for entire year for 250 customers 'nodes'.

H3 HEURISTICS CASE SCENARIO

Third heuristic H3 runs on different hard drive sizes (from 50GB to 1TB with increment of 50GB); each size was run separately with five (5) different bandwidth values (128, 512, 1000, 2000, 5000 kb/s). The results indicate that the total download time from server are increased or exponentially growth through the entire year for each individual bandwidth value, also the total mean values are decreased with increasing bandwidth value per each had drive size. Also it was noticed for individual bandwidths that increasing the hard drive size above 200GB did not impact the performance. All results remain the same as if the hard drive size installed was 200GB because the network assumes it is an infinite size.

Figures (533 and 576) demonstrate the H3 in time series analysis is totally shared between the server and the nodes to download all the requested files. The graphs show an exponential growth for all 250 customers 'nodes' through entire year because of the need to download more files to network. In addition, the existing files that have already been downloaded before on other nodes are used as a sharing point along with the server which increase total download bytes for the entire network, as the time goes on the customers are more likely downloading the files from other nodes than from the server.

Second figures (934 and 977) demonstrate differential Time Series analysis between heuristic H3 and H2 for different bandwidths loaded on the server. The graphs show an graphs are shown growth and steady after that for all 250 customers 'nodes' for the entire year because H3 and H2 are more likely to be close toward the second half of the year.

Third, figures between1122 and 1131) demonstrate the H3 in the response surface analysis on 3D dimensions that represent hard drive scale on the x-axis and the bandwidth scale on the y-axis; the graphs are showing exponentials decay on x-axis, each point represents a total mean for entire year for 250 customers 'nodes'.

H4 Heuristic Case Scenario

Forth heuristic H4 runs on different hard drive sizes (from 50GB to 1TB with increment of 50GB); each size was run separately with five (5) different bandwidth values (128, 512, 1000, 2000, 5000 kb/s). The results indicate of the total download time from server are increased or exponentially growth through the entire year for each individual bandwidth value, also the total mean values are decreased with increasing bandwidth value per each had drive size. In addition, it has been realized that for an individual bandwidth that runs the analysis and changing the hard drive size value will have no more effects on values higher than 200GB, all results will remain the same as if the hard drive size installed was 200GB because the network assumes it is an infinity size.

Figures between (577 and 620) demonstrate the H4 in time series analysis is totally shared between the server and the nodes to download all the requested files. the graphs are showing an exponentially growth for all 250 customers 'nodes' through entire year because of the need to download more files to network. In addition, the existing files that have already been on other nodes are used as a sharing point along with the server which increase total download bytes for the entire network, as the time goes on the customers are more likely downloading the files from other nodes than from the server.

Second figures (978 and 1021) demonstrate differential Time Series analysis between heuristic H4 and H3 for different bandwidths loaded on the server. The graphs show an graphs are shown growth and steady after that for all 250 customers 'nodes' for the entire year because H4 and H3 are more likely to be close toward the second half of the year.

Third, figures (1132 1141) demonstrate the H4 in the response surface analysis on 3D dimensions that represent hard drive scale on the x-axis and the bandwidth scale on the y-axis; The graphs show exponentials decay on x-axis, each point represents a total mean for entire year for 250 customers 'nodes'.

VI.2 ANALYSIS OF VARIANCE (ANOVA)

In this chapter, ANOVA will be used to demonstrate the comparisons between the different heuristics that were performed in the last chapter and presented in Appendix C.

ANOVA was used to compare each of the five (5) heuristics pertaining to Server Load, Penalty and total downloaded bytes. A post-hoc analysis using Turkey's test was performed and the p-values for each comparison was reported. Reported p-values less than .05 indicate significant differences between the heuristics whereas value greater than .05 indicate no difference.

The standard ANOVA table also divides the variability of the data into two parts [1]:

- Variability due to the differences among the column means (variability between groups).
- Variability due to the differences between the data in each column and the column mean (variability within groups).

The standard ANOVA table has six columns [2]:

- The source of the variability.
- The sum of squares (SS) due to each source.
- The degrees of freedom (df) associated with each source.
- The mean squares (MS) for each source, which is the ratio SS/df.
- The F-statistic, which is the ratio of the mean squares.
- The p-value, which is derived from the Cumulative distribution function (cdf) of F.

In the following sections ANOVA will be used as a comparison between all the heuristic results followed by using Tukey's Post-hoc tests.

[1] See http://www.mathworks.com/ for more information on ANOVA.

[2] See http://web.mst.edu/~psyworld/virtualstat/anova/index.html for more information on how to calculate ANOVA.

VI.2.1 Server Load HEURISTICS ANALYSIS

ANOVA was used to analyze the five (5) heuristics on the server load output scenario from the previous chapter. ANOVA analysis was performed to a download bandwidth values of 1Mb/s, 2Mb/s, 5Mb/s and internal storage media will be limited to 50GB, 100GB and 200GB.

The result shown in Fig 6 for bandwidth 1Mb/s and hard drive size 50GB, describes the case study of Base Line scenario was mostly dependent on the server for downloading all the required files requested by nodes; these nodes are not using any other possibility of sharing other than nodes in a same network although they may have an existing file that can be shared in a network like H1 heuristic scenario. H1 has the lowest value because no preemptive storage is being done and files are being shared between nodes, thereby reducing the amount that needs to be downloaded from the server.

The other scenarios case studies like H2, H3 and H4 are more likely dependent on the server than H1 but still lesser than Base Line because of using different techniques of file insertion and preempting the highest recommended files to a network.

As the results from ANOVA analysis in Table 7 describes that *p*-value greater than .05 for the comparison, but in Table 8, for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

The result shown in Fig 9 ,for bandwidth 1Mb/s and hard drive size 100GB, describes the case study of Base Line scenario was mostly dependent on the server for downloading all the required files requested by nodes; these nodes are not using any other possibility of sharing other than nodes in a same network although they may have an existing file that can be shared in a network like H1 heuristic scenario. H1 has the lowest value because no preemptive storage is being done and files are being shared between nodes, thereby reducing the amount that needs to be downloaded from the server.

The other scenarios case studies like H2, H3 and H4 are more likely dependent on the server than H1 but still lesser than Base Line because of using different techniques of file insertion and preempting the highest recommended files to a network. In addition, increasing hard drive size that will bring all the comparison heuristics to be lower in values than previous result.

As the results from ANOVA analysis in Table 10 describes that *p*-value equal greater than .05 for the comparison, but in Table 11 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 6: ANOVA Analysis for Server Load at hard drive size of 50GB and download bandwidth of 1000kb/s

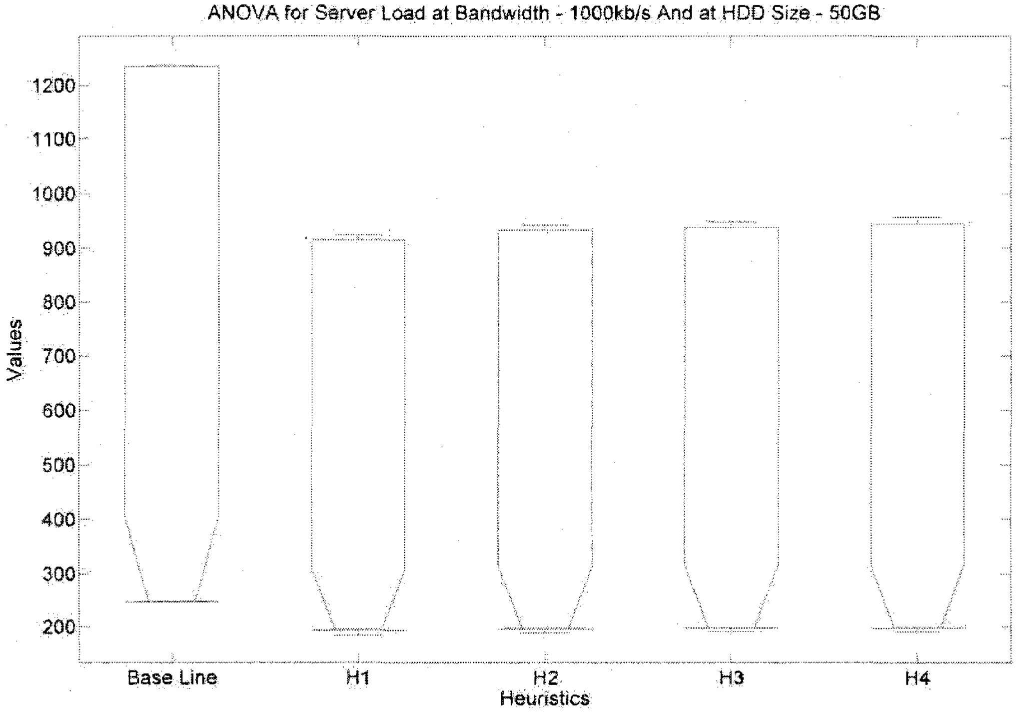


Figure 7: ANOVA Table for Server Load at hard drive size of 50GB and download bandwidth of 1000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1172667.5	4	293166.871	2.208	.067
Within Groups	65604480	494	132802.591		
Total	66777147	498			

Figure 8: Tukey's HSD table for Server Load at hard drive size of 50GB and download bandwidth of 1000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	126.1426	51.667	.104	-14.7932	267.0784
	3.00	126.2094	51.667	.104	-14.7263	267.1452
	4.00	116.8149	51.667	.158	-24.1209	257.7507
	5.00	114.7947	51.667	.172	-26.1411	255.7305
2.00	1.00	-126.1426	51.667	.104	-267.0784	14.7932
	3.00	6.682E-02	51.537	1.000	-140.5144	140.6481
	4.00	-9.3277	51.537	1.000	-149.9090	131.2535
	5.00	-11.3480	51.537	.999	-151.9292	129.2333
3.00	1.00	-126.2094	51.667	.104	-267.1452	14.7263
	2.00	-6.682E-02	51.537	1.000	-140.6481	140.5144
	4.00	-9.3945	51.537	1.000	-149.9758	131.1867
	5.00	-11.4148	51.537	.999	-151.9960	129.1665
4.00	1.00	-116.8149	51.667	.158	-257.7507	24.1209
	2.00	9.3277	51.537	1.000	-131.2535	149.9090
	3.00	9.3945	51.537	1.000	-131.1867	149.9758
	5.00	-2.0202	51.537	1.000	-142.6015	138.5610
5.00	1.00	-114.7947	51.667	.172	-255.7305	26.1411
	2.00	11.3480	51.537	.999	-129.2333	151.9292
	3.00	11.4148	51.537	.999	-129.1665	151.9960
	4.00	2.0202	51.537	1.000	-138.5610	142.6015

Figure 9: ANOVA Analysis for Server Load at hard drive size of 100GB and download bandwidth of 1000kb/s

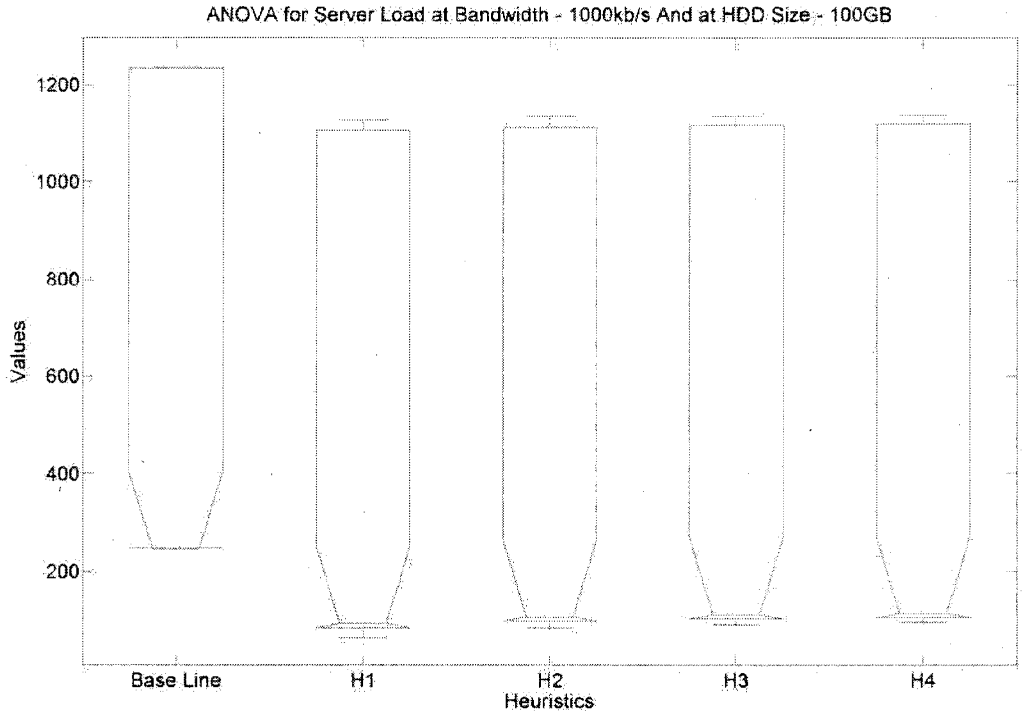


Figure 10: ANOVA Table for Server Load at hard drive size of 100GB and download bandwidth of 1000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1446829.9	4	361707.477	1.660	.158
Within Groups	1.08E+08	494	217888.022		
Total	1.09E+08	498			

Figure 11: Tukey's HSD table for Server Load at hard drive size of 100GB and download bandwidth of 1000kb/s

Tukey HSD

					95% Confidence Interval	
(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1.00	2.00	143.1921	66.180	.194	-37.3318	323.7160
	3.00	140.6617	66.180	.209	-39.8622	321.1856
	4.00	126.8418	66.180	.308	-53.6821	307.3657
	5.00	124.2429	66.180	.330	-56.2810	304.7668
2.00	1.00	-143.1921	66.180	.194	-323.7160	37.3318
	3.00	-2.5304	66.013	1.000	-182.6002	177.5393
	4.00	-16.3503	66.013	.999	-196.4201	163.7194
	5.00	-18.9492	66.013	.999	-199.0190	161.1205
3.00	1.00	-140.6617	66.180	.209	-321.1856	39.8622
	2.00	2.5304	66.013	1.000	-177.5393	182.6002
	4.00	-13.8199	66.013	1.000	-193.8897	166.2498
	5.00	-16.4188	66.013	.999	-196.4886	163.6509
4.00	1.00	-126.8418	66.180	.308	-307.3657	53.6821
	2.00	16.3503	66.013	.999	-163.7194	196.4201
	3.00	13.8199	66.013	1.000	-166.2498	193.8897
	5.00	-2.5989	66.013	1.000	-182.6686	177.4709
5.00	1.00	-124.2429	66.180	.330	-304.7668	56.2810
	2.00	18.9492	66.013	.999	-161.1205	199.0190
	3.00	16.4188	66.013	.999	-163.6509	196.4886
	4.00	2.5989	66.013	1.000	-177.4709	182.6686

The result shown in Fig 12 ,for bandwidth 1Mb/s and hard drive size 200GB, describes the case study of Base Line scenario was mostly dependent on the server for downloading all the required files requested by nodes; these nodes are not using any other possibility of sharing other than nodes in a same network although they may have an existing file that can be shared in a network like H1 heuristic scenario. H1 has the lowest value because no preemptive storage is being done and files are being shared between nodes, thereby reducing the amount that needs to be downloaded from the server.

The other scenarios case studies like H2, H3 and H4 are more likely dependent on the server than H1 but still lesser than Base Line because of using different techniques of file insertion and preempting the highest recommended files to a network. In addition, increasing hard drive size that will bring all the comparison heuristics to be lower in values than previous results.

As the results from ANOVA analysis in Table 13 describes that *p*-value equal less than .05 for the comparison, but in Table 14 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 12: ANOVA Analysis for Server Load at hard drive size of 200GB and download bandwidth of 1000kb/s

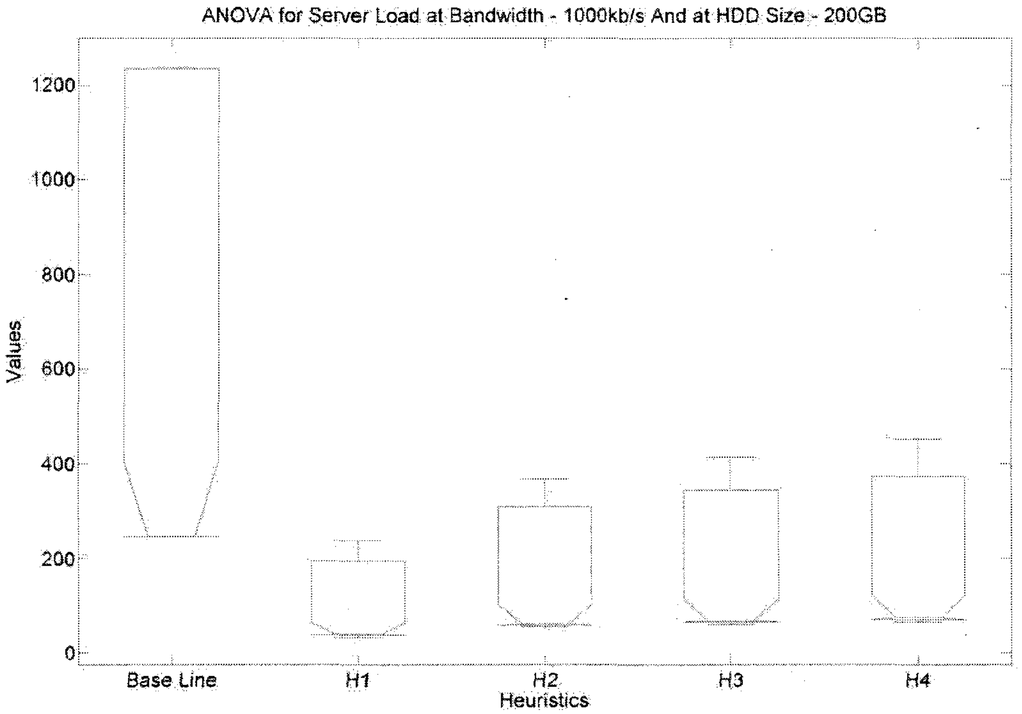


Figure 13: ANOVA Table for Server Load at hard drive size of 200GB and download bandwidth of 1000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	13042934	4	3260733.4	61.673	.000
Within Groups	26118511	494	52871.481		
Total	39161445	498			

Figure 14: Tukey's HSD table for Server Load at hard drive size of 200GB and download bandwidth of 1000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	448.5195*	32.600	.000	359.5935	537.4455
	3.00	400.5516*	32.600	.000	311.6255	489.4776
	4.00	381.1256*	32.600	.000	292.1996	470.0516
	5.00	368.0795*	32.600	.000	279.1535	457.0055
2.00	1.00	-448.5195*	32.600	.000	-537.4455	-359.5935
	3.00	-47.9679	32.518	.579	-136.6702	40.7344
	4.00	-67.3939	32.518	.232	-156.0962	21.3084
	5.00	-80.4400	32.518	.097	-169.1423	8.2623
3.00	1.00	-400.5516*	32.600	.000	-489.4776	-311.6255
	2.00	47.9679	32.518	.579	-40.7344	136.6702
	4.00	-19.4260	32.518	.976	-108.1283	69.2763
	5.00	-32.4721	32.518	.856	-121.1744	56.2302
4.00	1.00	-381.1256*	32.600	.000	-470.0516	-292.1996
	2.00	67.3939	32.518	.232	-21.3084	156.0962
	3.00	19.4260	32.518	.976	-69.2763	108.1283
	5.00	-13.0461	32.518	.995	-101.7484	75.6562
5.00	1.00	-368.0795*	32.600	.000	-457.0055	-279.1535
	2.00	80.4400	32.518	.097	-8.2623	169.1423
	3.00	32.4721	32.518	.856	-56.2302	121.1744
	4.00	13.0461	32.518	.995	-75.6562	101.7484

*. The mean difference is significant at the .05 level.

The result shown in Fig 15 ,for bandwidth 2Mb/s and hard drive size 50GB, describes the case study of Base Line scenario was mostly dependable on the server for downloading all the required files requested by nodes; these nodes are not using any other possibility of sharing other than nodes in a same network although they may have an existing file that can be shared in a network like H1 heuristic scenario. H1 has the lowest value because no preemptive storage is being done and files are being shared between nodes, thereby reducing the amount that needs to be downloaded from the server.

The other scenarios case studies like H2, H3 and H4 are more likely dependable on the server than H1 but still lesser than Base Line because of using different techniques of file insertion and preempting the highest recommended files to a network. In addition, increasing bandwidth that will bring all the comparison heuristics to be lower in values than previous results.

As the results from ANOVA analysis in Table 16 describes that p-value equal greater than .05 for the comparison, but in Table 17 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 15: ANOVA Analysis for Server Load at hard drive size of 50GB and download bandwidth of 2000kb/s

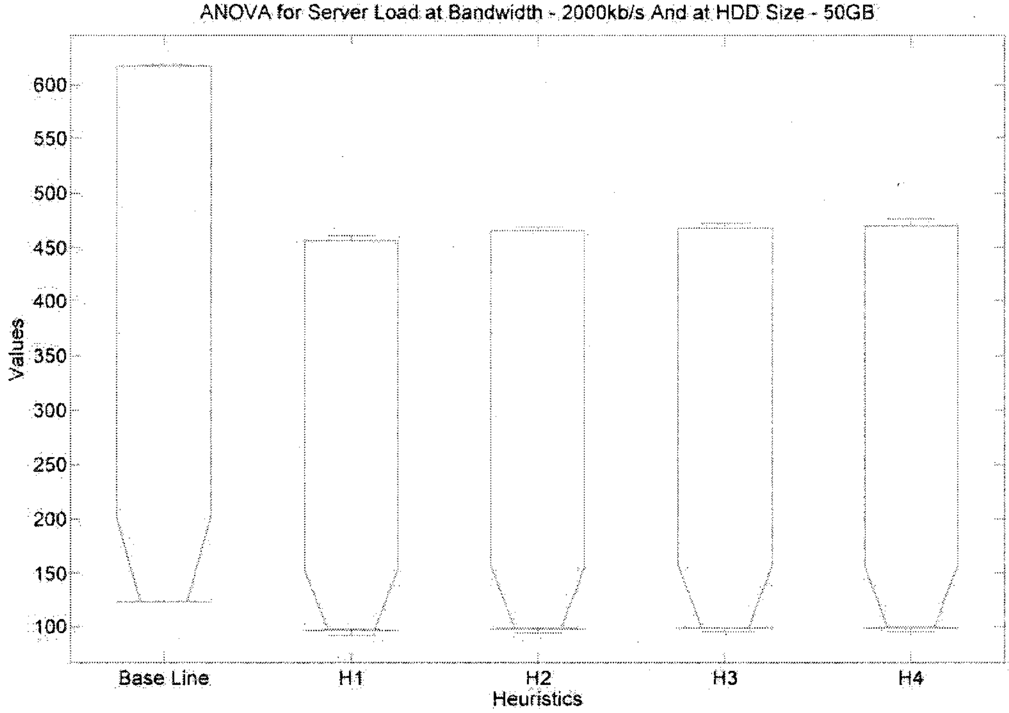


Figure 16: ANOVA Table for Server Load at hard drive size of 50GB and download bandwidth of 2000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	298999.053	4	74749.763	2.262	.062
Within Groups	16326215	494	33049.018		
Total	16625214	498			

Figure 17: Tukey's HSD table for Server Load at hard drive size of 50GB and download bandwidth of 2000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	63.5905	25.774	.098	-6.7163	133.8973
	3.00	63.5912	25.774	.098	-6.7156	133.8980
	4.00	59.0751	25.774	.147	-11.2317	129.3819
	5.00	58.2579	25.774	.158	-12.0489	128.5647
2.00	1.00	-63.5905	25.774	.098	-133.8973	6.7163
	3.00	7.298E-04	25.710	1.000	-70.1292	70.1307
	4.00	-4.5154	25.710	1.000	-74.6453	65.6145
	5.00	-5.3325	25.710	1.000	-75.4625	64.7974
3.00	1.00	-63.5912	25.774	.098	-133.8980	6.7156
	2.00	-7.298E-04	25.710	1.000	-70.1307	70.1292
	4.00	-4.5161	25.710	1.000	-74.6460	65.6138
	5.00	-5.3333	25.710	1.000	-75.4632	64.7967
4.00	1.00	-59.0751	25.774	.147	-129.3819	11.2317
	2.00	4.5154	25.710	1.000	-65.6145	74.6453
	3.00	4.5161	25.710	1.000	-65.6138	74.6460
	5.00	-.8172	25.710	1.000	-70.9471	69.3128
5.00	1.00	-58.2579	25.774	.158	-128.5647	12.0489
	2.00	5.3325	25.710	1.000	-64.7974	75.4625
	3.00	5.3333	25.710	1.000	-64.7967	75.4632
	4.00	.8172	25.710	1.000	-69.3128	70.9471

The result shown in Fig 18 ,for bandwidth 2Mb/s and hard drive size 100GB, describes the case study of Base Line scenario was mostly dependable on the server for downloading all the required files requested by nodes; these nodes are not using any other possibility of sharing other than nodes in a same network although they may have an existing file that can be shared in a network like H1 heuristic scenario. H1 has the lowest value because no preemptive storage is being done and files are being shared between nodes, thereby reducing the amount that needs to be downloaded from the server.

The other scenarios case studies like H2, H3 and H4 are more likely dependable on the server than H1 but still lesser than Base Line because of using different techniques of file insertion and preempting the highest recommended files to a network. In addition, increasing bandwidth and hard drive size that will bring all the comparison heuristics to be lower in values than previous results.

As the results from ANOVA analysis in Table 19 describes that p-value equal greater than .05 for the comparison, but in Table 20 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 18: ANOVA Analysis for Server Load at hard drive size of 100GB and download bandwidth of 2000kb/s

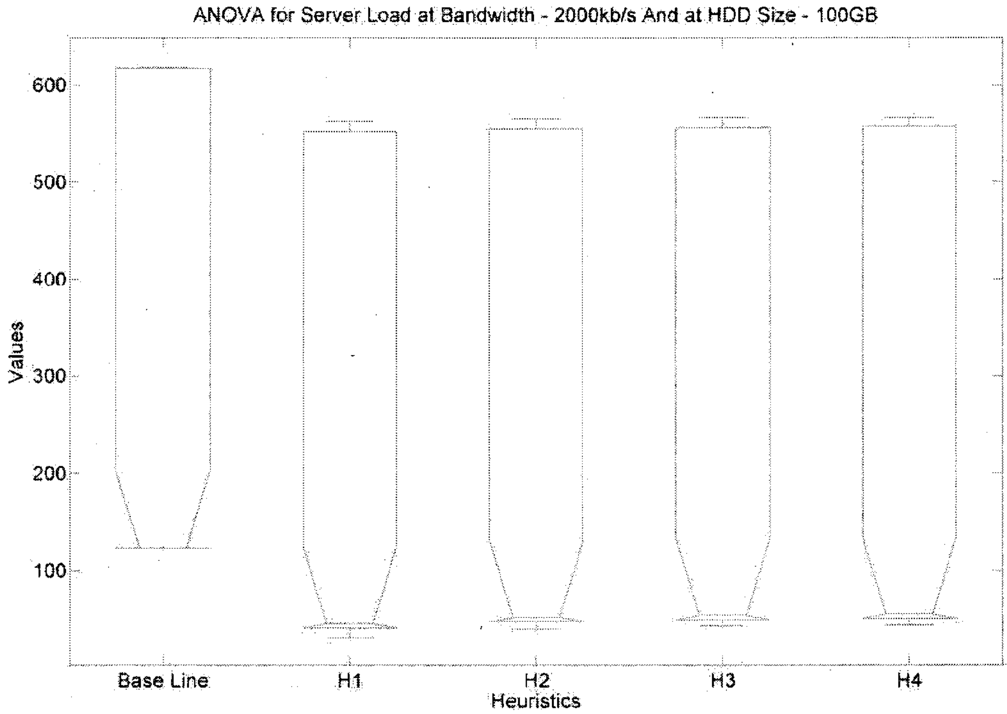


Figure 19: ANOVA Table for Server Load at hard drive size of 100GB and download bandwidth of 2000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	379925.960	4	94981.490	1.746	.139
Within Groups	26876565	494	54406.001		
Total	27256491	498			

Figure 20: Tukey's HSD table for Server Load at hard drive size of 100GB and download bandwidth of 2000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	72.8309	33.070	.179	-17.3763	163.0382
	3.00	72.1267	33.070	.187	-18.0806	162.3339
	4.00	65.3576	33.070	.278	-24.8496	155.5649
	5.00	64.2718	33.070	.294	-25.9354	154.4791
2.00	1.00	-72.8309	33.070	.179	-163.0382	17.3763
	3.00	-.7043	32.987	1.000	-90.6846	89.2761
	4.00	-7.4733	32.987	.999	-97.4536	82.5070
	5.00	-8.5591	32.987	.999	-98.5394	81.4212
3.00	1.00	-72.1267	33.070	.187	-162.3339	18.0806
	2.00	.7043	32.987	1.000	-89.2761	90.6846
	4.00	-6.7691	32.987	1.000	-96.7494	83.2113
	5.00	-7.8549	32.987	.999	-97.8352	82.1255
4.00	1.00	-65.3576	33.070	.278	-155.5649	24.8496
	2.00	7.4733	32.987	.999	-82.5070	97.4536
	3.00	6.7691	32.987	1.000	-83.2113	96.7494
	5.00	-1.0858	32.987	1.000	-91.0661	88.8945
5.00	1.00	-64.2718	33.070	.294	-154.4791	25.9354
	2.00	8.5591	32.987	.999	-81.4212	98.5394
	3.00	7.8549	32.987	.999	-82.1255	97.8352
	4.00	1.0858	32.987	1.000	-88.8945	91.0661

The result shown in Fig 21 ,for bandwidth 2Mb/s and hard drive size 200GB, describes the case study of Base Line scenario was mostly dependable on the server for downloading all the required files requested by nodes; these nodes are not using any other possibility of sharing other than nodes in a same network although they may have an existing file that can be shared in a network like H1 heuristic scenario. H1 has the lowest value because no preemptive storage is being done and files are being shared between nodes, thereby reducing the amount that needs to be downloaded from the server.

The other scenarios case studies like H2, H3 and H4 are more likely dependable on the server than H1 but still lesser than Base Line because of using different techniques of file insertion and preempting the highest recommended files to a network. In addition, increasing bandwidth hard drive size that will bring all the comparison heuristics to be lower in values than previous results.

As the results from ANOVA analysis in Table 22 describes that p-value equal less than .05 for the comparison, but in Table 23 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 21: ANOVA Analysis for Server Load at hard drive size of 200GB and download bandwidth of 2000kb/s

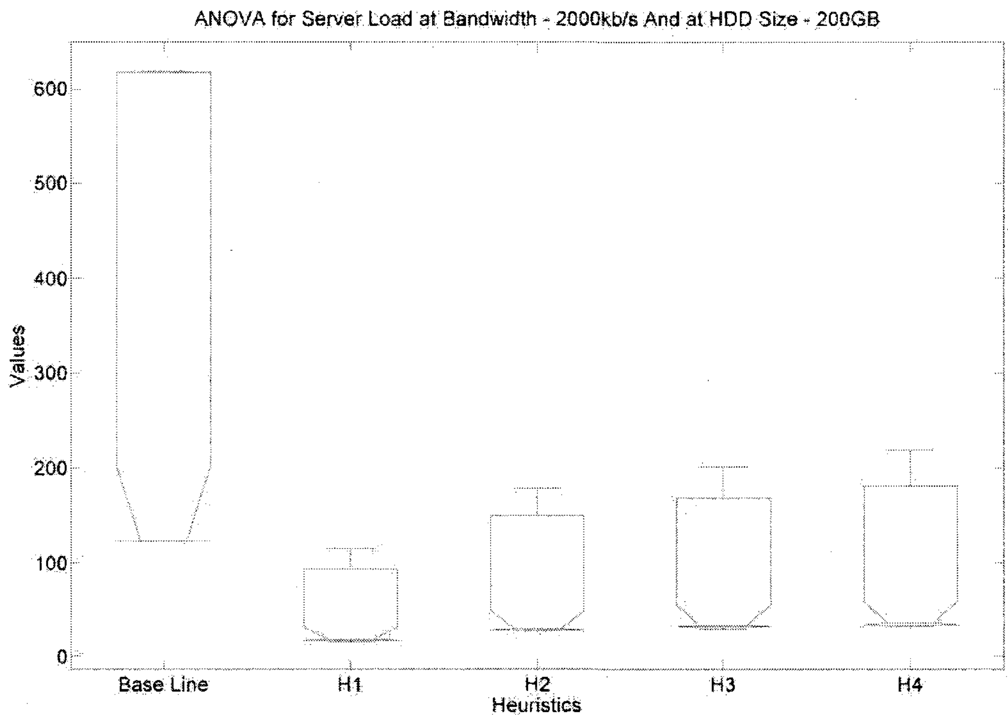


Figure 22: ANOVA Table for Server Load at hard drive size of 200GB and download bandwidth of 2000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3327109.4	4	831777.342	63.855	.000
Within Groups	6434885.3	494	13026.084		
Total	9761994.7	498			

Figure 23: Tukey's HSD table for Server Load at hard drive size of 200GB and download bandwidth of 2000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	225.8143*	16.181	.000	181.6750	269.9535
	3.00	202.4808*	16.181	.000	158.3415	246.6200
	4.00	192.9893*	16.181	.000	148.8501	237.1286
	5.00	186.8647*	16.181	.000	142.7255	231.0040
2.00	1.00	-225.8143*	16.181	.000	-269.9535	-181.6750
	3.00	-23.3335	16.141	.598	-67.3617	20.6947
	4.00	-32.8249	16.141	.250	-76.8532	11.2033
	5.00	-38.9495	16.141	.112	-82.9777	5.0787
3.00	1.00	-202.4808*	16.181	.000	-246.6200	-158.3415
	2.00	23.3335	16.141	.598	-20.6947	67.3617
	4.00	-9.4915	16.141	.977	-53.5197	34.5368
	5.00	-15.6160	16.141	.870	-59.6442	28.4122
4.00	1.00	-192.9893*	16.181	.000	-237.1286	-148.8501
	2.00	32.8249	16.141	.250	-11.2033	76.8532
	3.00	9.4915	16.141	.977	-34.5368	53.5197
	5.00	-6.1246	16.141	.996	-50.1528	37.9036
5.00	1.00	-186.8647*	16.181	.000	-231.0040	-142.7255
	2.00	38.9495	16.141	.112	-5.0787	82.9777
	3.00	15.6160	16.141	.870	-28.4122	59.6442
	4.00	6.1246	16.141	.996	-37.9036	50.1528

*. The mean difference is significant at the .05 level.

The result shown in Fig 24 ,for bandwidth 5Mb/s and hard drive size 50GB, describes the case study of Base Line scenario was mostly dependable on the server for downloading all the required files requested by nodes; these nodes are not using any other possibility of sharing other than nodes in a same network although they may have an existing file that can be shared in a network like H1 heuristic scenario. H1 has the lowest value because no preemptive storage is being done and files are being shared between nodes, thereby reducing the amount that needs to be downloaded from the server.

The other scenarios case studies like H2, H3 and H4 are more likely dependable on the server than H1 but still lesser than Base Line because of using different techniques of file insertion and preempting the highest recommended files to a network. In addition, increasing bandwidth and hard drive size that will bring all the comparison heuristics to be lower in values than previous result.

As the results from ANOVA analysis in Table 25 describes that *p*-value equal greater than .05 for the comparison, but in Table 26 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 24: ANOVA Analysis for Server Load at hard drive size of 50GB and download bandwidth of 5000kb/s

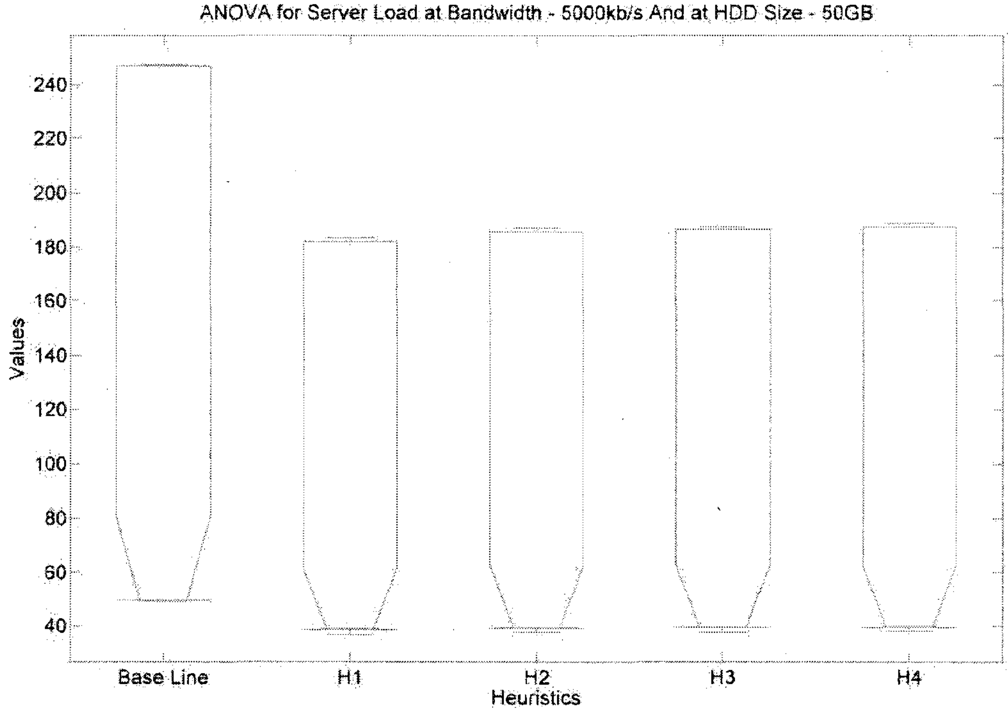


Figure 25: ANOVA Table for Server Load at hard drive size of 50GB and download bandwidth of 5000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	50307.210	4	12576.802	2.393	.050
Within Groups	2596294.4	494	5255.657		
Total	2646601.6	498			

Figure 26: Tukey's HSD table for Server Load at hard drive size of 50GB and download bandwidth of 5000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	25.5767	10.278	.093	-2.4603	53.6137
	3.00	27.0092	10.278	.065	-1.0278	55.0462
	4.00	23.7862	10.278	.140	-4.2508	51.8232
	5.00	23.5370	10.278	.148	-4.5000	51.5740
2.00	1.00	-25.5767	10.278	.093	-53.6137	2.4603
	3.00	1.4325	10.252	1.000	-26.5340	29.3989
	4.00	-1.7905	10.252	1.000	-29.7570	26.1760
	5.00	-2.0398	10.252	1.000	-30.0062	25.9267
3.00	1.00	-27.0092	10.278	.065	-55.0462	1.0278
	2.00	-1.4325	10.252	1.000	-29.3989	26.5340
	4.00	-3.2230	10.252	.998	-31.1894	24.7435
	5.00	-3.4722	10.252	.997	-31.4387	24.4942
4.00	1.00	-23.7862	10.278	.140	-51.8232	4.2508
	2.00	1.7905	10.252	1.000	-26.1760	29.7570
	3.00	3.2230	10.252	.998	-24.7435	31.1894
	5.00	-.2493	10.252	1.000	-28.2157	27.7172
5.00	1.00	-23.5370	10.278	.148	-51.5740	4.5000
	2.00	2.0398	10.252	1.000	-25.9267	30.0062
	3.00	3.4722	10.252	.997	-24.4942	31.4387
	4.00	.2493	10.252	1.000	-27.7172	28.2157

The result shown in Fig 27 ,for bandwidth 5Mb/s and hard drive size 100GB, describes the case study of Base Line scenario was mostly dependable on the server for downloading all the required files requested by nodes; these nodes are not using any other possibility of sharing other than nodes in a same network although they may have an existing file that can be shared in a network like H1 heuristic scenario. H1 has the lowest value because no preemptive storage is being done and files are being shared between nodes, thereby reducing the amount that needs to be downloaded from the server.

The other scenarios case studies like H2, H3 and H4 are more likely dependable on the server than H1 but still lesser than Base Line because of using different techniques of file insertion and preempting the highest recommended files to a network. In addition, increasing bandwidth and hard drive size that will bring all the comparison heuristics to be lower in values than previous result.

As the results from ANOVA analysis in Table 28 describes that p-value equal greater than .05 for the comparison, but in Table 29 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 27: ANOVA Analysis for Server Load at hard drive size of 100GB and download bandwidth of 5000kb/s

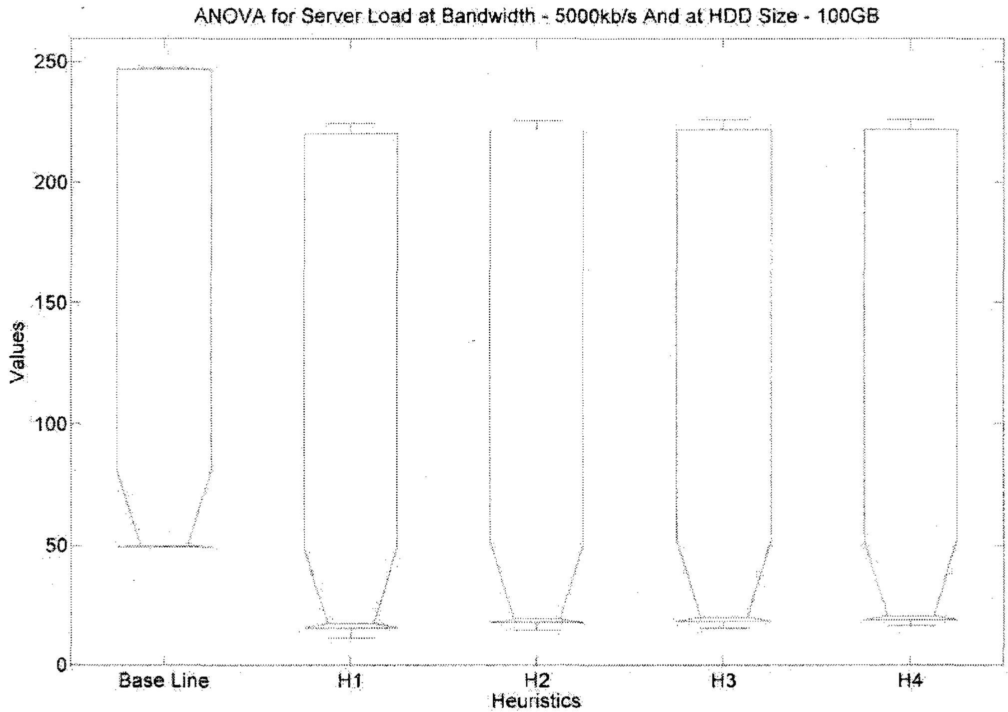


Figure 28: ANOVA Table for Server Load at hard drive size of 100GB and download bandwidth of 5000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	67553.630	4	16888.408	1.944	.102
Within Groups	4292393.0	494	8689.055		
Total	4359946.7	498			

Figure 29: Tukey's HSD table for Server Load at hard drive size of 100GB and download bandwidth of 5000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	29.6654	13.216	.163	-6.3845	65.7153
	3.00	31.7607	13.216	.114	-4.2892	67.8106
	4.00	27.1172	13.216	.241	-8.9327	63.1671
	5.00	26.7073	13.216	.256	-9.3426	62.7572
2.00	1.00	-29.6654	13.216	.163	-65.7153	6.3845
	3.00	2.0953	13.183	1.000	-33.8640	38.0545
	4.00	-2.5482	13.183	1.000	-38.5074	33.4110
	5.00	-2.9581	13.183	.999	-38.9174	33.0011
3.00	1.00	-31.7607	13.216	.114	-67.8106	4.2892
	2.00	-2.0953	13.183	1.000	-38.0545	33.8640
	4.00	-4.6435	13.183	.997	-40.6027	31.3158
	5.00	-5.0534	13.183	.995	-41.0126	30.9058
4.00	1.00	-27.1172	13.216	.241	-63.1671	8.9327
	2.00	2.5482	13.183	1.000	-33.4110	38.5074
	3.00	4.6435	13.183	.997	-31.3158	40.6027
	5.00	-.4099	13.183	1.000	-36.3692	35.5493
5.00	1.00	-26.7073	13.216	.256	-62.7572	9.3426
	2.00	2.9581	13.183	.999	-33.0011	38.9174
	3.00	5.0534	13.183	.995	-30.9058	41.0126
	4.00	.4099	13.183	1.000	-35.5493	36.3692

The result shown in Fig 30 ,for bandwidth 5Mb/s and hard drive size 200GB, describes the case study of Base Line scenario was mostly dependable on the server for downloading all the required files requested by nodes; these nodes are not using any other possibility of sharing other than nodes in a same network although they may have an existing file that can be shared in a network like H1 heuristic scenario. H1 has the lowest value because no preemptive storage is being done and files are being shared between nodes, thereby reducing the amount that needs to be downloaded from the server.

The other scenarios case studies like H2, H3 and H4 are more likely dependable on the server than H1 but still lesser than Base Line because of using different techniques of file insertion and preempting the highest recommended files to a network. In addition, increasing bandwidth and hard drive size that will bring all the comparison heuristics to be lower in values than previous result.

As the results from ANOVA analysis in Table 31 describes that p-value equal less than .05 for the comparison, but in Table 32 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 30: ANOVA Analysis for Server Load at hard drive size of 200GB and download bandwidth of 5000kb/s

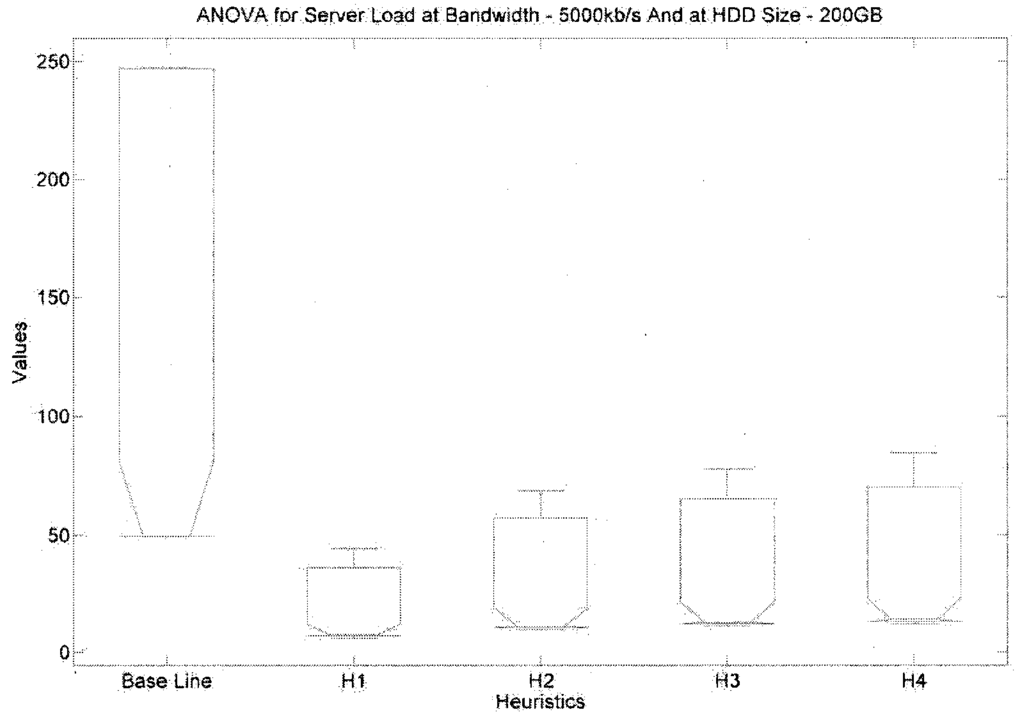


Figure 31: ANOVA Table for Server Load at hard drive size of 200GB and download bandwidth of 5000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	547844.862	4	136961.216	66.870	.000
Within Groups	1011791.3	494	2048.160		
Total	1559636.1	498			

Figure 32: Tukey's HSD table for Server Load at hard drive size of 200GB and download bandwidth of 5000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	91.0603*	6.416	.000	73.5578	108.5628
	3.00	82.7570*	6.416	.000	65.2546	100.2595
	4.00	78.4652*	6.416	.000	60.9627	95.9677
	5.00	76.0992*	6.416	.000	58.5967	93.6017
2.00	1.00	-91.0603*	6.416	.000	-108.5628	-73.5578
	3.00	-8.3033	6.400	.693	-25.7617	9.1552
	4.00	-12.5952	6.400	.282	-30.0536	4.8633
	5.00	-14.9612	6.400	.133	-32.4196	2.4973
3.00	1.00	-82.7570*	6.416	.000	-100.2595	-65.2546
	2.00	8.3033	6.400	.693	-9.1552	25.7617
	4.00	-4.2919	6.400	.963	-21.7503	13.1666
	5.00	-6.6579	6.400	.837	-24.1163	10.8006
4.00	1.00	-78.4652*	6.416	.000	-95.9677	-60.9627
	2.00	12.5952	6.400	.282	-4.8633	30.0536
	3.00	4.2919	6.400	.963	-13.1666	21.7503
	5.00	-2.3660	6.400	.996	-19.8245	15.0925
5.00	1.00	-76.0992*	6.416	.000	-93.6017	-58.5967
	2.00	14.9612	6.400	.133	-2.4973	32.4196
	3.00	6.6579	6.400	.837	-10.8006	24.1163
	4.00	2.3660	6.400	.996	-15.0925	19.8245

*. The mean difference is significant at the .05 level.

VI.2.2 Penalty Heuristic Analysis

ANOVA was used to analyze the five (5) heuristics on Penalty output scenario from the previous chapter. ANOVA analysis was performed to a download bandwidth values of 1Mb/s, 2Mb/s, 5Mb/s and internal storage media will be limited to 50GB, 100GB and 200GB.

The result shown in Fig 33 ,for bandwidth 1Mb/s and hard drive size 50GB, describes the case study of Base Line scenarios was high on Penalty for downloading all the required files requested by nodes; these nodes are not using any other possibility of sharing other than nodes in a same network although they may have an existing file that can be shared in a network like H1 heuristic scenario. The results for H1 are shown to be identical to the baseline due to the fact that the Penalty depends on the time delay from when the movie is requested to when it can be viewed.

The other scenarios case studies like H2, H3 and H4 are probability less likely to have a customer waiting too long to get their requested files on time because of using different techniques of file insertion and preempting the highest recommended files to a network.

As the results from ANOVA analysis in Table 34 describes that p-value equal greater than .05 for the comparison, but in Table 35 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 33: ANOVA analysis for Penalty at hard drive size of 50GB and download bandwidth of 1000kb/s

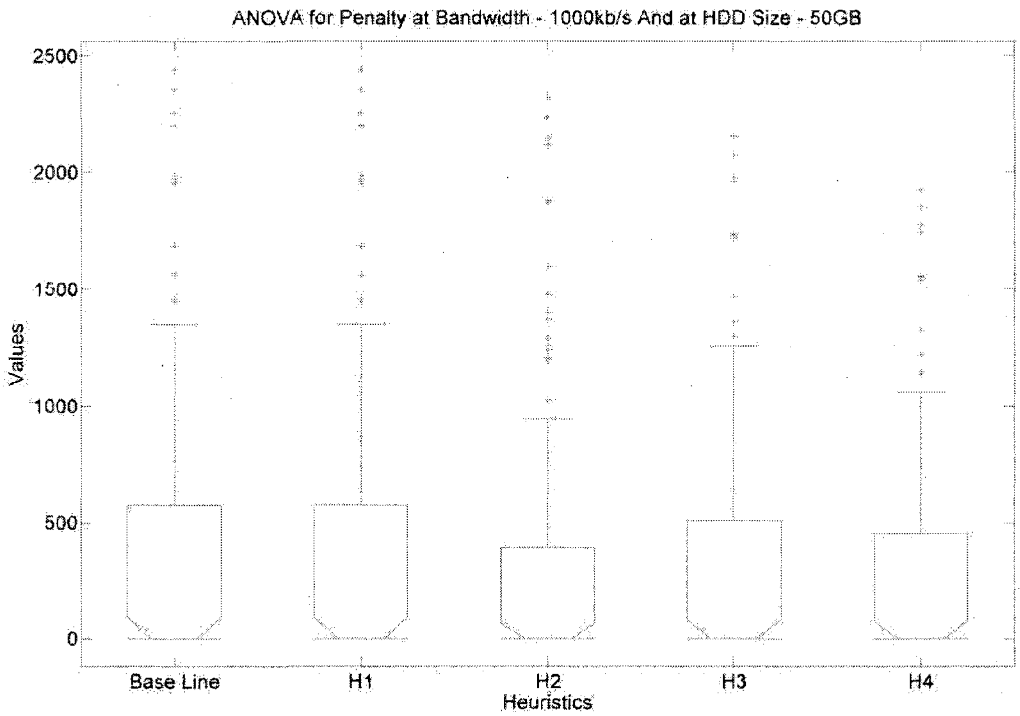


Figure 34: ANOVA table for Penalty at hard drive size of 50GB and download bandwidth of 1000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	452699.858	4	113174.965	.273	.895
Within Groups	2.05E+08	494	414342.138		
Total	2.05E+08	498			

Figure 35: Tukey's HSD table for Penalty at hard drive size of 50GB and download bandwidth of 1000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	-5.1112	91.262	1.000	-254.0528	243.8305
	3.00	21.0453	91.262	.999	-227.8963	269.9870
	4.00	41.6595	91.262	.991	-207.2821	290.6012
	5.00	77.2375	91.262	.916	-171.7042	326.1791
2.00	1.00	5.1112	91.262	1.000	-243.8305	254.0528
	3.00	26.1565	91.032	.999	-222.1589	274.4718
	4.00	46.7707	91.032	.986	-201.5447	295.0860
	5.00	82.3486	91.032	.895	-165.9667	330.6640
3.00	1.00	-21.0453	91.262	.999	-269.9870	227.8963
	2.00	-26.1565	91.032	.999	-274.4718	222.1589
	4.00	20.6142	91.032	.999	-227.7012	268.9296
	5.00	56.1922	91.032	.972	-192.1232	304.5076
4.00	1.00	-41.6595	91.262	.991	-290.6012	207.2821
	2.00	-46.7707	91.032	.986	-295.0860	201.5447
	3.00	-20.6142	91.032	.999	-268.9296	227.7012
	5.00	35.5780	91.032	.995	-212.7374	283.8934
5.00	1.00	-77.2375	91.262	.916	-326.1791	171.7042
	2.00	-82.3486	91.032	.895	-330.6640	165.9667
	3.00	-56.1922	91.032	.972	-304.5076	192.1232
	4.00	-35.5780	91.032	.995	-283.8934	212.7374

The result shown in Fig 36 ,for bandwidth 1Mb/s and hard drive size 100GB, describes the case study of Base Line scenarios was high on Penalty for downloading all the required files requested by nodes; these nodes are not using any other possibility of sharing other than nodes in a same network although they may have an existing file that can be shared in a network like H1 heuristic scenario. The results for H1 are shown to be identical to the baseline due to the fact that the Penalty depends on the time delay from when the movie is requested to when it can be viewed.

The other scenarios case studies like H2, H3 and H4 are probability less likely to have a customer waiting too long to get their requested files on time because of using different techniques of file insertion and preempting the highest recommended files to a network. In addition, increasing hard drive size that will bring all the comparison heuristics to be lower in values than previous result.

As the results from ANOVA analysis in Table 37 describes that p-value equal greater than .05 for the comparison, but in Table 38 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 36: ANOVA analysis for Penalty at hard drive size of 100GB and download bandwidth of 1000kb/s

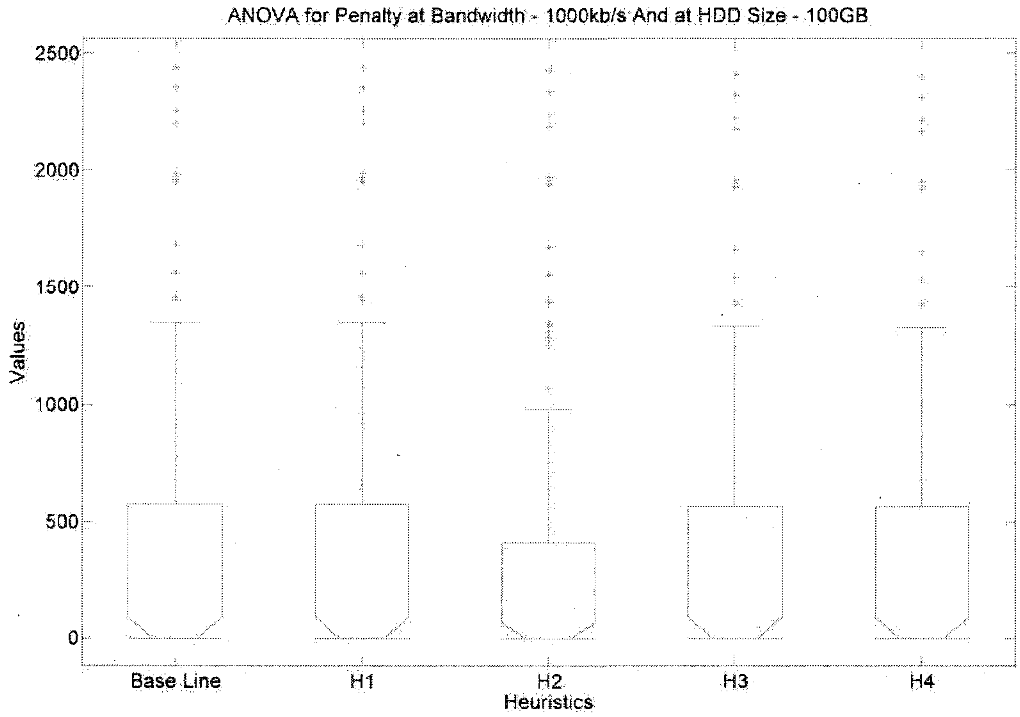


Figure 37: ANOVA table for Penalty at hard drive size of 100GB and download bandwidth of 1000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5531.123	4	1382.781	.003	1.000
Within Groups	2.34E+08	494	474647.052		
Total	2.34E+08	498			

Figure 38: Tukey's HSD table for Penalty at hard drive size of 100GB and download bandwidth of 1000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	-5.1112	97.677	1.000	-271.5536	261.3313
	3.00	5.1159	97.677	1.000	-261.3265	271.5584
	4.00	1.406E-02	97.677	1.000	-266.4284	266.4565
	5.00	1.9465	97.677	1.000	-264.4960	268.3889
2.00	1.00	5.1112	97.677	1.000	-261.3313	271.5536
	3.00	10.2271	97.432	1.000	-255.5451	275.9992
	4.00	5.1252	97.432	1.000	-260.6469	270.8974
	5.00	7.0576	97.432	1.000	-258.7145	272.8298
3.00	1.00	-5.1159	97.677	1.000	-271.5584	261.3265
	2.00	-10.2271	97.432	1.000	-275.9992	255.5451
	4.00	-5.1018	97.432	1.000	-270.8740	260.6703
	5.00	-3.1695	97.432	1.000	-268.9416	262.6027
4.00	1.00	-1.406E-02	97.677	1.000	-266.4565	266.4284
	2.00	-5.1252	97.432	1.000	-270.8974	260.6469
	3.00	5.1018	97.432	1.000	-260.6703	270.8740
	5.00	1.9324	97.432	1.000	-263.8398	267.7045
5.00	1.00	-1.9465	97.677	1.000	-268.3889	264.4960
	2.00	-7.0576	97.432	1.000	-272.8298	258.7145
	3.00	3.1695	97.432	1.000	-262.6027	268.9416
	4.00	-1.9324	97.432	1.000	-267.7045	263.8398

The result shown in Fig 39 ,for bandwidth 1Mb/s and hard drive size 200GB, describes the case study of Base Line scenarios was high on Penalty for downloading all the required files requested by nodes; these nodes are not using any other possibility of sharing other than nodes in a same network although they may have an existing file that can be shared in a network like H1 heuristic scenario. The results for H1 are shown to be identical to the baseline due to the fact that the Penalty depends on the time delay from when the movie is requested to when it can be viewed.

The other scenarios case studies like H2, H3 and H4 are probability less likely to have a customer waiting too long to get their requested files on time because of using different techniques of file insertion and preempting the highest recommended files to a network. In addition, increasing hard drive size that will bring all the comparison heuristics to be lower in values than previous result.

As the results from ANOVA analysis in Table 40 describes that p-value equal less than .05 for the comparison, but in Table 38 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 39: ANOVA analysis for Penalty at hard drive size of 200GB and download bandwidth of 1000kb/s

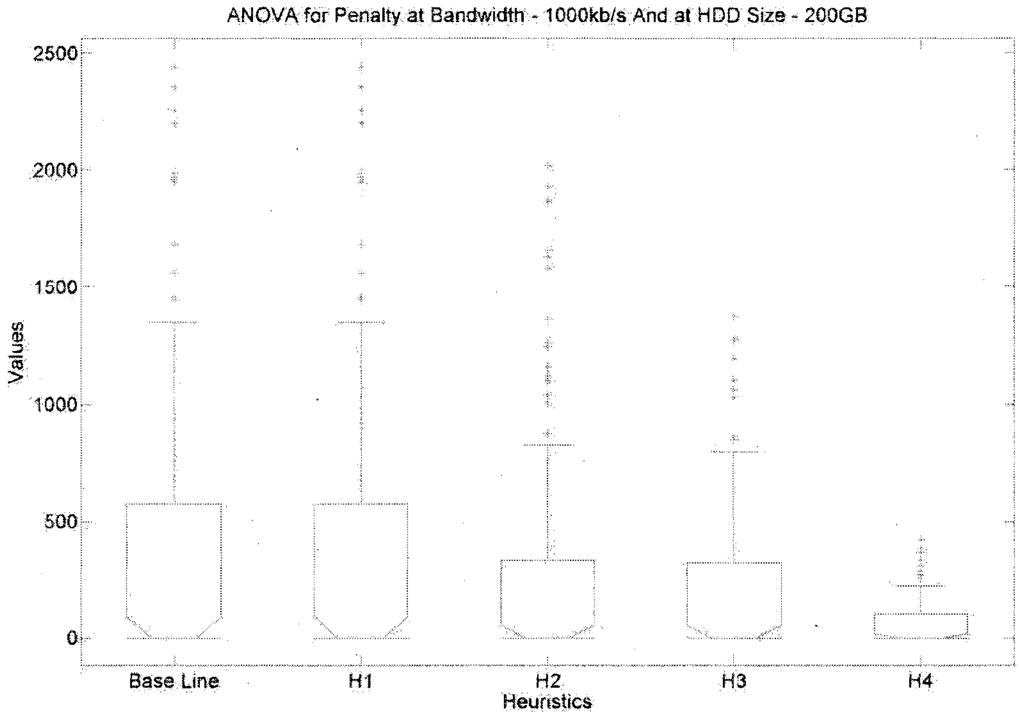


Figure 40: ANOVA table for Penalty at hard drive size of 200GB and download bandwidth of 1000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7539561.0	4	1884890.3	6.522	.000
Within Groups	1.43E+08	494	289022.286		
Total	1.50E+08	498			

Figure 41: Tukey's HSD table for Penalty at hard drive size of 200GB and download bandwidth of 1000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	-5.1112	76.221	1.000	-213.0251	202.8028
	3.00	70.0976	76.221	.889	-137.8164	278.0116
	4.00	173.4125	76.221	.153	-34.5015	381.3265
	5.00	321.1287*	76.221	.000	113.2147	529.0427
2.00	1.00	5.1112	76.221	1.000	-202.8028	213.0251
	3.00	75.2088	76.029	.860	-132.1822	282.5997
	4.00	178.5237	76.029	.130	-28.8673	385.9146
	5.00	326.2398*	76.029	.000	118.8489	533.6308
3.00	1.00	-70.0976	76.221	.889	-278.0116	137.8164
	2.00	-75.2088	76.029	.860	-282.5997	132.1822
	4.00	103.3149	76.029	.654	-104.0760	310.7058
	5.00	251.0311*	76.029	.009	43.6401	458.4220
4.00	1.00	-173.4125	76.221	.153	-381.3265	34.5015
	2.00	-178.5237	76.029	.130	-385.9146	28.8673
	3.00	-103.3149	76.029	.654	-310.7058	104.0760
	5.00	147.7162	76.029	.295	-59.6748	355.1071
5.00	1.00	-321.1287*	76.221	.000	-529.0427	-113.2147
	2.00	-326.2398*	76.029	.000	-533.6308	-118.8489
	3.00	-251.0311*	76.029	.009	-458.4220	-43.6401
	4.00	-147.7162	76.029	.295	-355.1071	59.6748

*. The mean difference is significant at the .05 level.

The result shown in Fig 42 ,for bandwidth 2Mb/s and hard drive size 50GB, describes the case study of Base Line scenarios was high on Penalty for downloading all the required files requested by nodes; these nodes are not using any other possibility of sharing other than nodes in a same network although they may have an existing file that can be shared in a network like H1 heuristic scenario. The results for H1 are shown to be identical to the baseline due to the fact that the Penalty depends on the time delay from when the movie is requested to when it can be viewed.

The other scenarios case studies like H2, H3 and H4 are probability less likely to have a customer waiting too long to get their requested files on time because of using different techniques of file insertion and preempting the highest recommended files to a network. In addition, increasing bandwidth that will bring all the comparison heuristics to be lower in values than previous result.

As the results from ANOVA analysis in Table 43 describes that *p*-value close greater than .05 for the comparison, but in Table 44 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 42: ANOVA analysis for Penalty at hard drive size of 50GB and download bandwidth of 2000kb/s

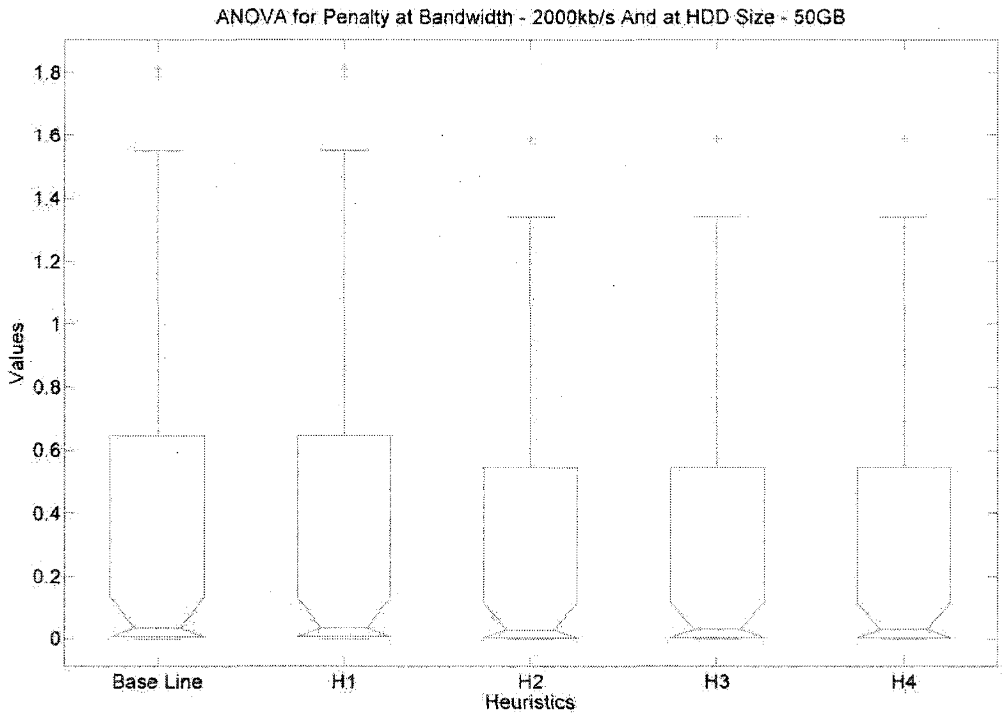


Figure 43: ANOVA table for Penalty at hard drive size of 50GB and download bandwidth of 2000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.427	4	.107	.589	.671
Within Groups	89.616	494	.181		
Total	90.043	498			

Figure 44: Tukey's HSD table for Penalty at hard drive size of 50GB and download bandwidth of 2000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	-2.163E-03	.060	1.000	-.1669	.1626
	3.00	6.083E-02	.060	.852	-.1039	.2256
	4.00	5.749E-02	.060	.876	-.1072	.2222
	5.00	5.749E-02	.060	.876	-.1072	.2222
2.00	1.00	2.163E-03	.060	1.000	-.1626	.1669
	3.00	6.300E-02	.060	.834	-.1013	.2273
	4.00	5.965E-02	.060	.860	-.1047	.2240
	5.00	5.965E-02	.060	.860	-.1047	.2240
3.00	1.00	-6.083E-02	.060	.852	-.2256	.1039
	2.00	-6.300E-02	.060	.834	-.2273	.1013
	4.00	-3.349E-03	.060	1.000	-.1677	.1610
	5.00	-3.349E-03	.060	1.000	-.1677	.1610
4.00	1.00	-5.749E-02	.060	.876	-.2222	.1072
	2.00	-5.965E-02	.060	.860	-.2240	.1047
	3.00	3.349E-03	.060	1.000	-.1610	.1677
	5.00	.0000	.060	1.000	-.1643	.1643
5.00	1.00	-5.749E-02	.060	.876	-.2222	.1072
	2.00	-5.965E-02	.060	.860	-.2240	.1047
	3.00	3.349E-03	.060	1.000	-.1610	.1677
	4.00	.0000	.060	1.000	-.1643	.1643

The result shown in Fig 45 ,for bandwidth 2Mb/s and hard drive size 100GB, describes the case study of Base Line scenarios was high on Penalty for downloading all the required files requested by nodes; these nodes are not using any other possibility of sharing other than nodes in a same network although they may have an existing file that can be shared in a network like H1 heuristic scenario. The results for H1 are shown to be identical to the baseline due to the fact that the Penalty depends on the time delay from when the movie is requested to when it can be viewed.

The other scenarios case studies like H2, H3 and H4 are probability less likely to have a customer waiting too long to get their requested files on time because of using different techniques of file insertion and preempting the highest recommended files to a network. In addition, increasing bandwidth and hard drive size that will bring all the comparison heuristics to be lower in values than previous result.

As the results from ANOVA analysis in Table 46 describes that *p*-value close greater than .05 for the comparison, but in Table 47 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 45: ANOVA analysis for Penalty at hard drive size of 100GB and download bandwidth of 2000kb/s

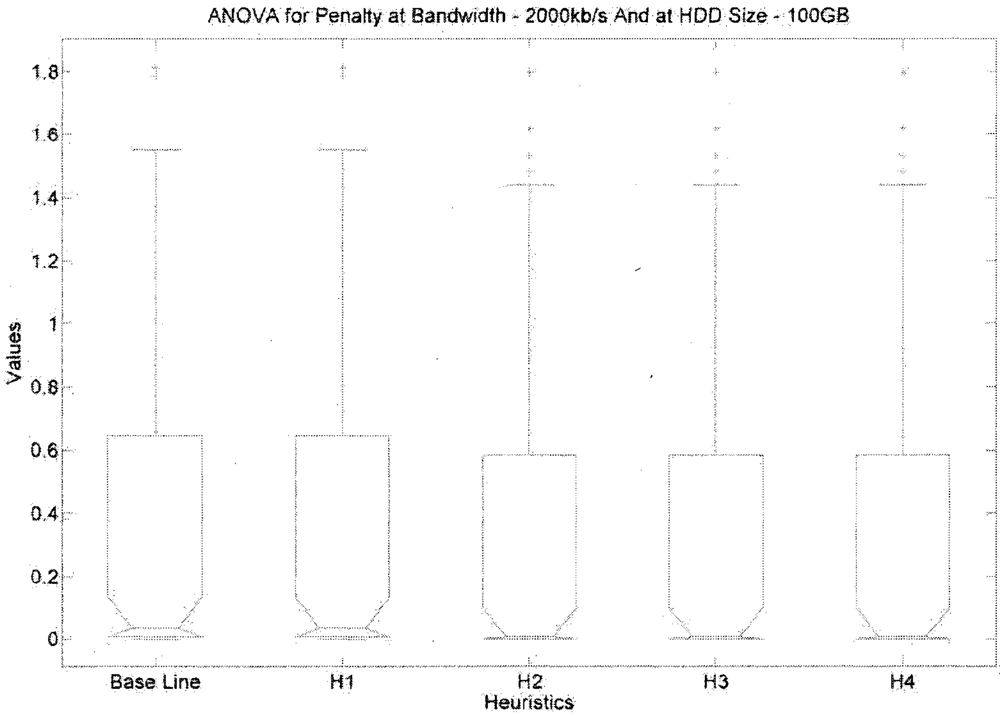


Figure 46: ANOVA table for Penalty at hard drive size of 100GB and download bandwidth of 2000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.802E-02	4	9.504E-03	.041	.997
Within Groups	113.549	494	.230		
Total	113.587	498			

Figure 47: Tukey's HSD table for Penalty at hard drive size of 100GB and download bandwidth of 2000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	-2.163E-03	.068	1.000	-.1876	.1833
	3.00	1.906E-02	.068	.999	-.1664	.2045
	4.00	1.513E-02	.068	.999	-.1703	.2005
	5.00	1.513E-02	.068	.999	-.1703	.2005
2.00	1.00	2.163E-03	.068	1.000	-.1833	.1876
	3.00	2.123E-02	.068	.998	-.1637	.2062
	4.00	1.729E-02	.068	.999	-.1677	.2022
	5.00	1.729E-02	.068	.999	-.1677	.2022
3.00	1.00	-1.906E-02	.068	.999	-.2045	.1664
	2.00	-2.123E-02	.068	.998	-.2062	.1637
	4.00	-3.935E-03	.068	1.000	-.1889	.1810
	5.00	-3.935E-03	.068	1.000	-.1889	.1810
4.00	1.00	-1.513E-02	.068	.999	-.2005	.1703
	2.00	-1.729E-02	.068	.999	-.2022	.1677
	3.00	3.935E-03	.068	1.000	-.1810	.1889
	5.00	.0000	.068	1.000	-.1849	.1849
5.00	1.00	-1.513E-02	.068	.999	-.2005	.1703
	2.00	-1.729E-02	.068	.999	-.2022	.1677
	3.00	3.935E-03	.068	1.000	-.1810	.1889
	4.00	.0000	.068	1.000	-.1849	.1849

The result shown in Fig 48 ,for bandwidth 2Mb/s and hard drive size 200GB, describes the case study of Base Line scenarios was high on Penalty for downloading all the required files requested by nodes; these nodes are not using any other possibility of sharing other than nodes in a same network although they may have an existing file that can be shared in a network like H1 heuristic scenario. The results for H1 are shown to be identical to the baseline due to the fact that the Penalty depends on the time delay from when the movie is requested to when it can be viewed.

The other scenarios case studies like H2, H3 and H4 are probability less likely to have a customer waiting too long to get their requested files on time because of using different techniques of file insertion and preempting the highest recommended files to a network. In addition, increasing bandwidth and hard drive size that will bring all the comparison heuristics to be lower in values than previous result.

As the results from ANOVA analysis in Table 49 describes that *p*-value close less than .05 for the comparison, but in Table 50 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 48: ANOVA analysis for Penalty at hard drive size of 200GB and download bandwidth of 2000kb/s

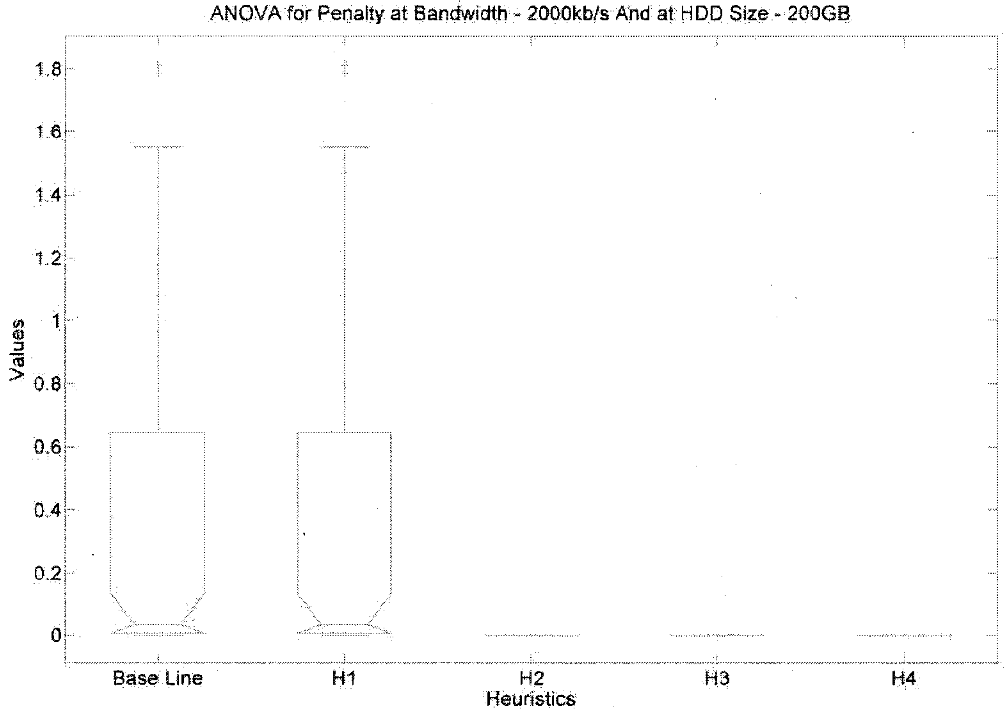


Figure 49: ANOVA table for Penalty at hard drive size of 200GB and download bandwidth of 2000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10.880	4	2.720	29.210	.000
Within Groups	46.000	494	9.312E-02		
Total	56.880	498			

Figure 50: Tukey's HSD table for Penalty at hard drive size of 200GB and download bandwidth of 2000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	-2.163E-03	.043	1.000	-.1202	.1159
	3.00	.3005*	.043	.000	.1825	.4185
	4.00	.3005*	.043	.000	.1825	.4185
	5.00	.3005*	.043	.000	.1825	.4185
2.00	1.00	2.163E-03	.043	1.000	-.1159	.1202
	3.00	.3026*	.043	.000	.1849	.4204
	4.00	.3026*	.043	.000	.1849	.4204
	5.00	.3026*	.043	.000	.1849	.4204
3.00	1.00	-.3005*	.043	.000	-.4185	-.1825
	2.00	-.3026*	.043	.000	-.4204	-.1849
	4.00	.0000	.043	1.000	-.1177	.1177
	5.00	.0000	.043	1.000	-.1177	.1177
4.00	1.00	-.3005*	.043	.000	-.4185	-.1825
	2.00	-.3026*	.043	.000	-.4204	-.1849
	3.00	.0000	.043	1.000	-.1177	.1177
	5.00	.0000	.043	1.000	-.1177	.1177
5.00	1.00	-.3005*	.043	.000	-.4185	-.1825
	2.00	-.3026*	.043	.000	-.4204	-.1849
	3.00	.0000	.043	1.000	-.1177	.1177
	4.00	.0000	.043	1.000	-.1177	.1177

*. The mean difference is significant at the .05 level.

The result shown in Fig 51 ,for bandwidth 5Mb/s and hard drive size 50GB, describes the case study of Base Line scenarios was high on Penalty for downloading all the required files requested by nodes; these nodes are not using any other possibility of sharing other than nodes in a same network although they may have an existing file that can be shared in a network like H1 heuristic scenario. The results for H1 are shown to be identical to the baseline due to the fact that the Penalty depends on the time delay from when the movie is requested to when it can be viewed.

The other scenarios case studies like H2, H3 and H4 are probability less likely to have a customer waiting too long to get their requested files on time because of using different techniques of file insertion and preempting the highest recommended files to a network. In addition, increasing bandwidth that will bring all the comparison heuristics to be lower in values than previous result.

As the results from ANOVA analysis in Table 52 describes that p-value close greater than .05 for the comparison, but in Table 53 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 51: ANOVA analysis for Penalty at hard drive size of 50GB and download bandwidth of 5000kb/s

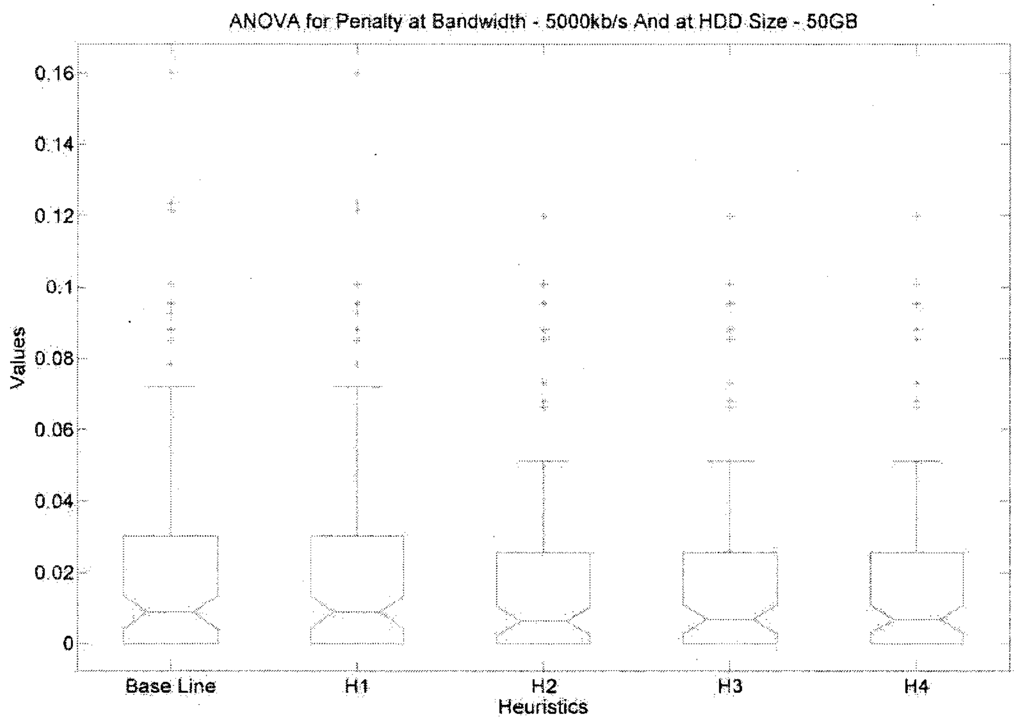


Figure 52: ANOVA table for Penalty at hard drive size of 50GB and download bandwidth of 5000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.102E-03	4	5.254E-04	.609	.657
Within Groups	.426	494	8.633E-04		
Total	.429	498			

Figure 53: Tukey's HSD table for Penalty at hard drive size of 50GB and download band-width of 5000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	2.277E-04	.004	1.000	-1.114E-02	1.159E-02
	3.00	4.533E-03	.004	.813	-6.830E-03	1.590E-02
	4.00	4.175E-03	.004	.854	-7.188E-03	1.554E-02
	5.00	4.175E-03	.004	.854	-7.188E-03	1.554E-02
2.00	1.00	-2.277E-04	.004	1.000	-1.159E-02	1.114E-02
	3.00	4.306E-03	.004	.839	-7.029E-03	1.564E-02
	4.00	3.948E-03	.004	.877	-7.387E-03	1.528E-02
	5.00	3.948E-03	.004	.877	-7.387E-03	1.528E-02
3.00	1.00	-4.533E-03	.004	.813	-1.590E-02	6.830E-03
	2.00	-4.306E-03	.004	.839	-1.564E-02	7.029E-03
	4.00	-3.582E-04	.004	1.000	-1.169E-02	1.098E-02
	5.00	-3.582E-04	.004	1.000	-1.169E-02	1.098E-02
4.00	1.00	-4.175E-03	.004	.854	-1.554E-02	7.188E-03
	2.00	-3.948E-03	.004	.877	-1.528E-02	7.387E-03
	3.00	3.582E-04	.004	1.000	-1.098E-02	1.169E-02
	5.00	.0000	.004	1.000	-1.133E-02	1.133E-02
5.00	1.00	-4.175E-03	.004	.854	-1.554E-02	7.188E-03
	2.00	-3.948E-03	.004	.877	-1.528E-02	7.387E-03
	3.00	3.582E-04	.004	1.000	-1.098E-02	1.169E-02
	4.00	.0000	.004	1.000	-1.133E-02	1.133E-02

The result shown in Fig 54 ,for bandwidth 5Mb/s and hard drive size 100GB, describes the case study of Base Line scenarios was high on Penalty for downloading all the required files requested by nodes; these nodes are not using any other possibility of sharing other than nodes in a same network although they may have an existing file that can be shared in a network like H1 heuristic scenario. The results for H1 are shown to be identical to the baseline due to the fact that the Penalty depends on the time delay from when the movie is requested to when it can be viewed.

The other scenarios case studies like H2, H3 and H4 are probability less likely to have a customer waiting too long to get their requested files on time because of using different techniques of file insertion and preempting the highest recommended files to a network. In addition, increasing bandwidth and hard drive size that will bring all the comparison heuristics to be lower in values than previous results.

As the results from ANOVA analysis in Table 55 describes that p-value close greater than .05 for the comparison, but in Table 56 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 54: ANOVA analysis for Penalty at hard drive size of 100GB and download bandwidth of 5000kb/s

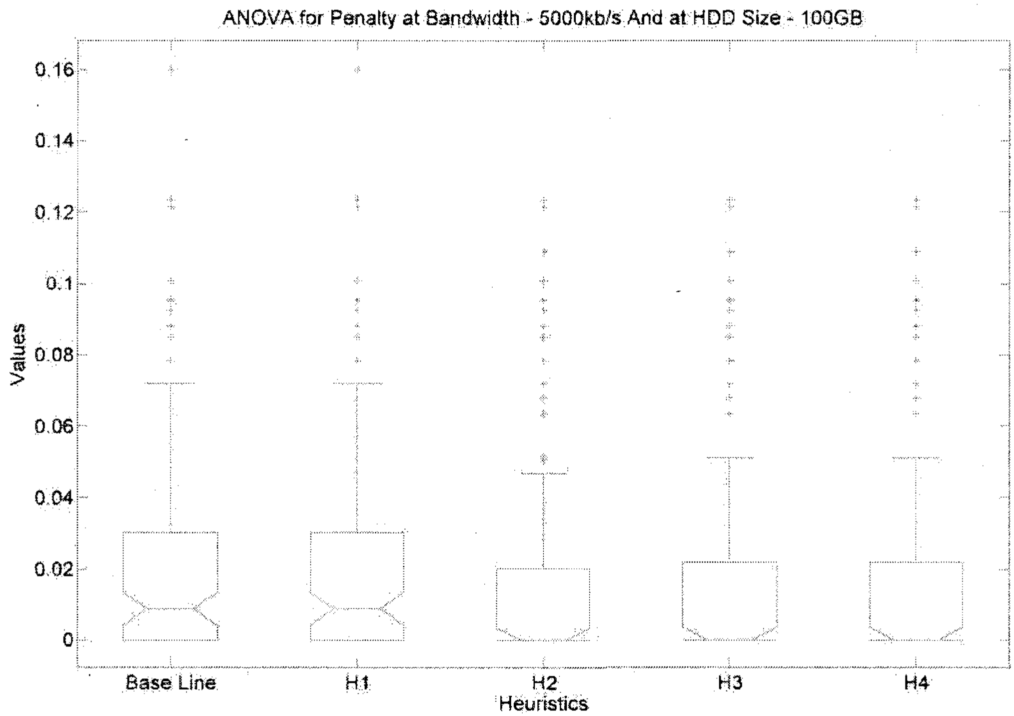


Figure 55: ANOVA table for Penalty at hard drive size of 100GB and download bandwidth of 5000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.296E-03	4	8.241E-04	.791	.532
Within Groups	.515	494	1.042E-03		
Total	.518	498			

Figure 56: Tukey's HSD table for Penalty at hard drive size of 100GB and download bandwidth of 5000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	2.277E-04	.005	1.000	-1.226E-02	1.271E-02
	3.00	5.593E-03	.005	.739	-6.893E-03	1.808E-02
	4.00	5.235E-03	.005	.783	-7.251E-03	1.772E-02
	5.00	5.235E-03	.005	.783	-7.251E-03	1.772E-02
2.00	1.00	-2.277E-04	.005	1.000	-1.271E-02	1.226E-02
	3.00	5.366E-03	.005	.766	-7.089E-03	1.782E-02
	4.00	5.008E-03	.005	.808	-7.447E-03	1.746E-02
	5.00	5.008E-03	.005	.808	-7.447E-03	1.746E-02
3.00	1.00	-5.593E-03	.005	.739	-1.808E-02	6.893E-03
	2.00	-5.366E-03	.005	.766	-1.782E-02	7.089E-03
	4.00	-3.582E-04	.005	1.000	-1.281E-02	1.210E-02
	5.00	-3.582E-04	.005	1.000	-1.281E-02	1.210E-02
4.00	1.00	-5.235E-03	.005	.783	-1.772E-02	7.251E-03
	2.00	-5.008E-03	.005	.808	-1.746E-02	7.447E-03
	3.00	3.582E-04	.005	1.000	-1.210E-02	1.281E-02
	5.00	.0000	.005	1.000	-1.245E-02	1.245E-02
5.00	1.00	-5.235E-03	.005	.783	-1.772E-02	7.251E-03
	2.00	-5.008E-03	.005	.808	-1.746E-02	7.447E-03
	3.00	3.582E-04	.005	1.000	-1.210E-02	1.281E-02
	4.00	.0000	.005	1.000	-1.245E-02	1.245E-02

The result shown in Fig 57 ,for bandwidth 5Mb/s and hard drive size 200GB, describes the case study of Base Line scenarios was high on Penalty for downloading all the required files requested by nodes; these nodes are not using any other possibility of sharing other than nodes in a same network although they may have an existing file that can be shared in a network like H1 heuristic scenario. The results for H1 are shown to be identical to the baseline due to the fact that the Penalty depends on the time delay from when the movie is requested to when it can be viewed.

The other scenarios case studies like H2, H3 and H4 are probability less likely to have a customer waiting too long to get their requested files on time because of using different techniques of file insertion and preempting the highest recommended files to a network. In addition, increasing bandwidth and hard drive size that will bring all the comparison heuristics to be lower in values than previous results.

As the results from ANOVA analysis in Table 58 describes that p-value close less than .05 for the comparison, but in Table 59 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 57: ANOVA analysis for Penalty at hard drive size of 200GB and download bandwidth of 5000kb/s

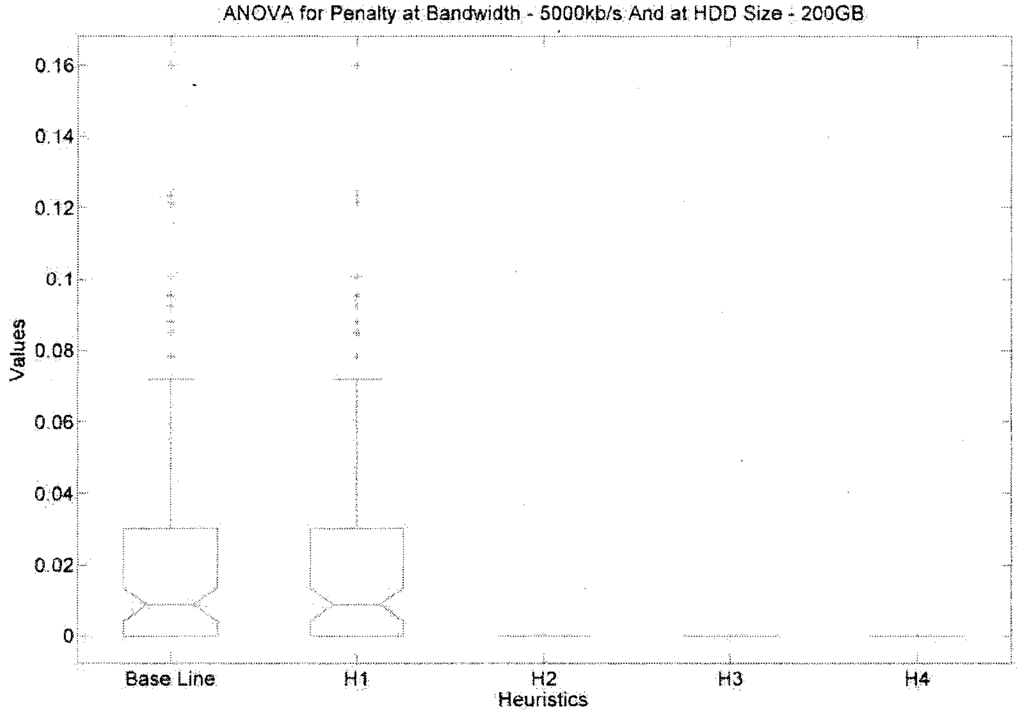


Figure 58: ANOVA table for Penalty at hard drive size of 200GB and download bandwidth of 5000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.297E-02	4	1.574E-02	36.390	.000
Within Groups	.214	494	4.326E-04		
Total	.277	498			

Figure 59: Tukey's HSD table for Penalty at hard drive size of 200GB and download bandwidth of 5000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	2.277E-04	.003	1.000	-7.816E-03	8.271E-03
	3.00	2.306E-02*	.003	.000	1.501E-02	3.110E-02
	4.00	2.306E-02*	.003	.000	1.501E-02	3.110E-02
	5.00	2.306E-02*	.003	.000	1.501E-02	3.110E-02
2.00	1.00	-2.277E-04	.003	1.000	-8.271E-03	7.816E-03
	3.00	2.283E-02*	.003	.000	1.480E-02	3.085E-02
	4.00	2.283E-02*	.003	.000	1.480E-02	3.085E-02
	5.00	2.283E-02*	.003	.000	1.480E-02	3.085E-02
3.00	1.00	-2.306E-02*	.003	.000	-3.110E-02	-1.501E-02
	2.00	-2.283E-02*	.003	.000	-3.085E-02	-1.480E-02
	4.00	.0000	.003	1.000	-8.023E-03	8.023E-03
	5.00	.0000	.003	1.000	-8.023E-03	8.023E-03
4.00	1.00	-2.306E-02*	.003	.000	-3.110E-02	-1.501E-02
	2.00	-2.283E-02*	.003	.000	-3.085E-02	-1.480E-02
	3.00	.0000	.003	1.000	-8.023E-03	8.023E-03
	5.00	.0000	.003	1.000	-8.023E-03	8.023E-03
5.00	1.00	-2.306E-02*	.003	.000	-3.110E-02	-1.501E-02
	2.00	-2.283E-02*	.003	.000	-3.085E-02	-1.480E-02
	3.00	.0000	.003	1.000	-8.023E-03	8.023E-03
	4.00	.0000	.003	1.000	-8.023E-03	8.023E-03

*. The mean difference is significant at the .05 level.

VI.2.3 Total Doenload Bytes (TDB) Heuristic Analysis

ANOVA was used to analyze the five (5) heuristics on total download bytes (TDB) output scenario from the previous chapter. ANOVA analysis was performed to a download bandwidth values of 1Mb/s, 2Mb/s, 5Mb/s and internal storage media will be limited to 50GB, 100GB and 200GB.

The result shown in Fig 60 ,for bandwidth 1Mb/s and hard drive size 50GB, describes the case study of Base Line scenario was the lowest on total download bytes (TDB) for downloading all the required files requested by nodes without using any other techniques like file insertion and preemptive from the server, the same scenario is happening with H1 heuristic because the requested files by customers will the only be downloaded to the nodes either from the server, node or both server and node. In the other hand, H1 is the same as it would be Base Line case study.

The other scenarios case studies like H2, H3 and H4 have higher values than Base Line and H1. Furthermore, H3 is higher than H2 and H4 is higher than H3 because of using different techniques of file insertion and preempting the highest recommended files to a network. H2 is just mainly files insertion for limited file that can be in advance requested by customers using existing service in future run. But at the case of H3 and H4 are using additional technique of forcing more files to be downloaded to the internal storage media for a future use and serve other nodes for easy access.

These two techniques, either files insertion or preemptive, need to download more files to the internal storage media. it has found that H3 is highly demand of more files to be exit in internal storage media than H2 and the same scenario between H3 and H4.

As the results from ANOVA analysis in Table 61 describes that p-value close greater than .05 for the comparison, but in Table 62 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 60: ANOVA analysis for TDB at hard drive size of 50GB and download bandwidth of 1000kb/s

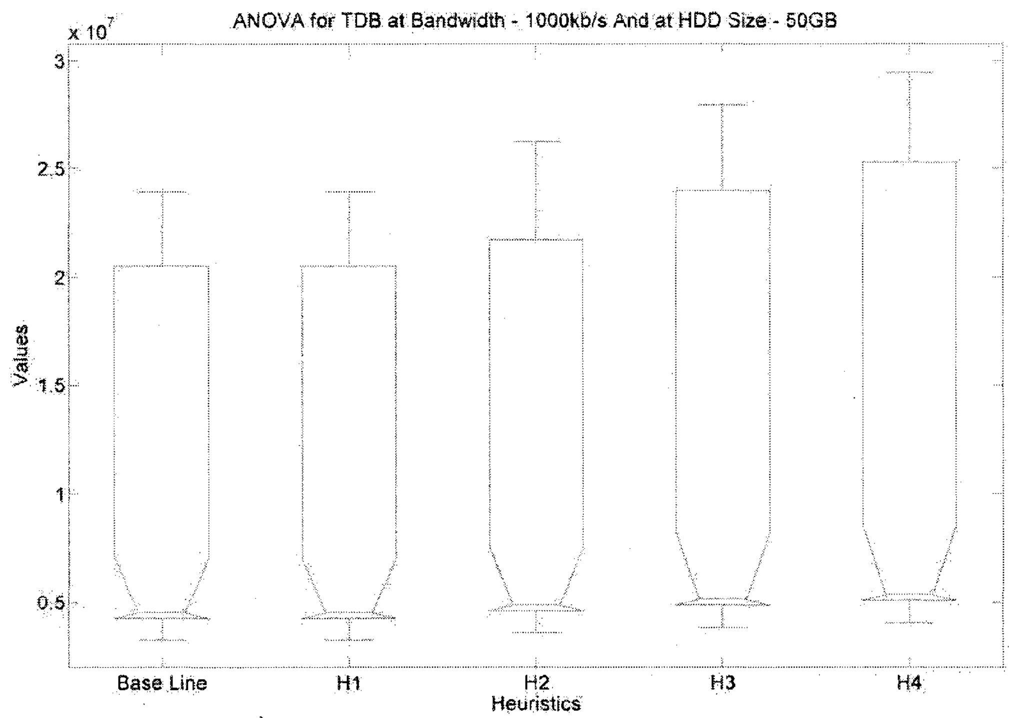


Figure 61: ANOVA table for TDB at hard drive size of 50GB and download bandwidth of 1000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.68E+14	4	9.20E+13	1.193	.313
Within Groups	3.81E+16	494	7.71E+13		
Total	3.84E+16	498			

Figure 62: Tukey's HSD table for TDB at hard drive size of 50GB and download bandwidth of 1000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	-125368.5	1244748	1.000	-3520764	3270027.2
	3.00	-816187.7	1244748	.966	-4211583	2579208.0
	4.00	-1644916	1244748	.678	-5040311	1750480.0
	5.00	-2217051	1244748	.385	-5612447	1178344.5
2.00	1.00	125368.50	1244748	1.000	-3270027	3520764.2
	3.00	-690819.3	1241616	.981	-4077673	2696034.6
	4.00	-1519547	1241616	.737	-4906401	1867306.6
	5.00	-2091683	1241616	.443	-5478537	1295171.1
3.00	1.00	816187.75	1244748	.966	-2579208	4211583.5
	2.00	690819.25	1241616	.981	-2696035	4077673.1
	4.00	-828727.9	1241616	.963	-4215582	2558125.9
	5.00	-1400863	1241616	.792	-4787717	1985990.3
4.00	1.00	1644915.7	1244748	.678	-1750480	5040311.4
	2.00	1519547.2	1241616	.737	-1867307	4906401.0
	3.00	828727.92	1241616	.963	-2558126	4215581.7
	5.00	-572135.6	1241616	.991	-3958989	2814718.3
5.00	1.00	2217051.2	1244748	.385	-1178344	5612446.9
	2.00	2091682.7	1241616	.443	-1295171	5478536.5
	3.00	1400863.5	1241616	.792	-1985990	4787717.3
	4.00	572135.56	1241616	.991	-2814718	3958989.4

The result shown in Fig 63 ,for bandwidth 1Mb/s and hard drive size 100GB, describes the case study of Base Line scenario was the lowest on total download bytes (TDB) for downloading all the required files requested by nodes without using any other techniques like file insertion and preemptive from the server, the same scenario is happening with H1 heuristic because the requested files by customers will the only be downloaded to the nodes either from the server, node or both server and node. In the other hand, H1 is the same as it would be Base Line case study.

The other scenarios case studies like H2, H3 and H4 have higher values than Base Line and H1. Furthermore, H3 is higher than H2 and H4 is higher than H3 because of using different techniques of file insertion and preempting the highest recommended files to a network. H2 is just mainly files insertion for limited file that can be in advance requested by customers using existing service in future run. But at the case of H3 and H4 are using additional technique of forcing more files to be downloaded to the internal storage media for a future use and serve other nodes for easy access.

These two techniques, either files insertion or preemptive, need to download more files to the internal storage media. it has found that H3 is highly demand of more files to be exit in internal storage media than H2 and the same scenario between H3 and H4. in addition, increasing hard drive size that will bring all the comparison heuristics to be higher in values than previous result.

As the results from ANOVA analysis in Table 64 describes that p-value close greater than .05 for the comparison, but in Table 65 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 63: ANOVA analysis for TDB at hard drive size of 100GB and download bandwidth of 1000kb/s

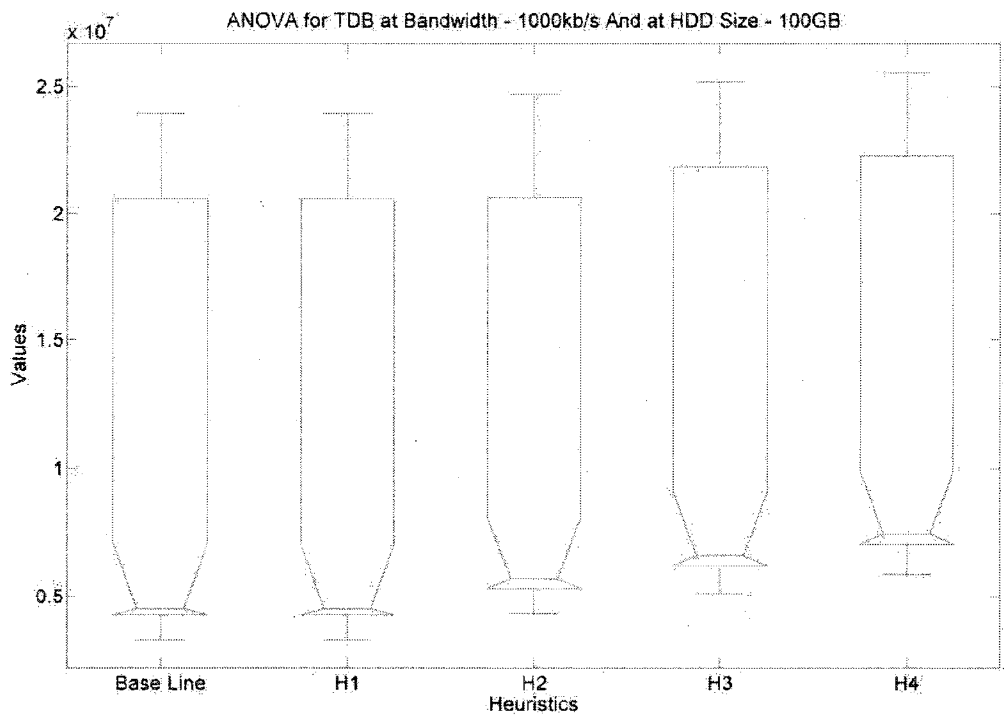


Figure 64: ANOVA table for TDB at hard drive size of 100GB and download bandwidth of 1000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.19E+14	4	1.30E+14	2.176	.071
Within Groups	2.95E+16	494	5.97E+13		
Total	3.00E+16	498			

Figure 65: Tukey's HSD table for TDB at hard drive size of 100GB and download bandwidth of 1000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	-125368.5	1095065	1.000	-3112463	2861725.6
	3.00	-992677.7	1095065	.895	-3979772	1994416.3
	4.00	-1924364	1095065	.399	-4911458	1062730.3
	5.00	-2636356	1095065	.113	-5623450	350737.79
2.00	1.00	125368.50	1095065	1.000	-2861726	3112462.6
	3.00	-867309.2	1092310	.932	-3846889	2112270.1
	4.00	-1798995	1092310	.467	-4778575	1180584.0
	5.00	-2510988	1092310	.145	-5490567	468591.57
3.00	1.00	992677.74	1095065	.895	-1994416	3979771.8
	2.00	867309.25	1092310	.932	-2112270	3846888.6
	4.00	-931686.1	1092310	.914	-3911265	2047893.3
	5.00	-1643679	1092310	.559	-4623258	1335900.8
4.00	1.00	1924363.8	1095065	.399	-1062730	4911457.9
	2.00	1798995.3	1092310	.467	-1180584	4778574.7
	3.00	931686.07	1092310	.914	-2047893	3911265.4
	5.00	-711992.5	1092310	.966	-3691572	2267586.9
5.00	1.00	2636356.3	1095065	.113	-350737.8	5623450.3
	2.00	2510987.8	1092310	.145	-468591.6	5490567.1
	3.00	1643678.5	1092310	.559	-1335901	4623257.9
	4.00	711992.46	1092310	.966	-2267587	3691571.8

The result shown in Fig 66 ,for bandwidth 1Mb/s and hard drive size 200GB, describes the case study of Base Line scenario was the lowest on total download bytes (TDB) for downloading all the required files requested by nodes without using any other techniques like file insertion and preemptive from the server, the same scenario is happening with H1 heuristic because the requested files by customers will the only be downloaded to the nodes either from the server, node or both server and node. In the other hand, H1 is the same as it would be Base Line case study.

The other scenarios case studies like H2, H3 and H4 have higher values than Base Line and H1. Furthermore, H3 is higher than H2 and H4 is higher than H3 because of using different techniques of file insertion and preempting the highest recommended files to a network. H2 is just mainly files insertion for limited file that can be in advance requested by customers using existing service in future run. But at the case of H3 and H4 are using additional technique of forcing more files to be downloaded to the internal storage media for a future use and serve other nodes for easy access.

These two techniques, either files insertion or preemptive, need to download more files to the internal storage media. it has found that H3 is highly demand of more files to be exit in internal storage media than H2 and the same scenario between H3 and H4. in addition, increasing hard drive size that will bring all the comparison heuristics to be higher in values than previous results.

As the results from ANOVA analysis in Table 67 describes that *p*-value close less than .05 for the comparison, but in Table 68 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 66: ANOVA analysis for TDB at hard drive size of 200GB and download bandwidth of 1000kb/s

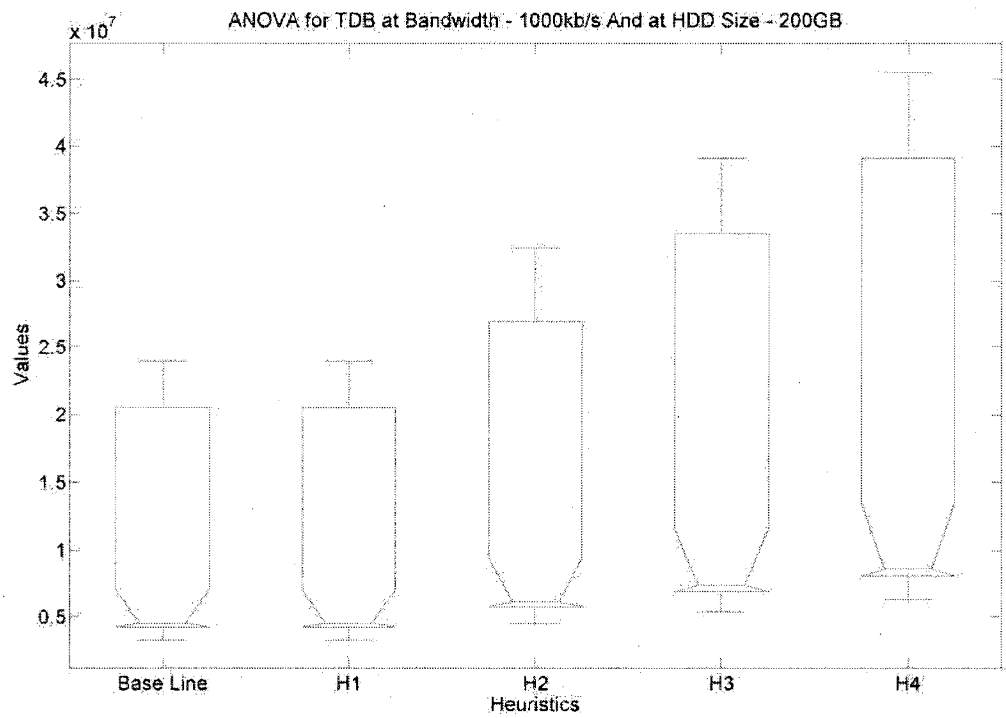


Figure 67: ANOVA table for TDB at hard drive size of 200GB and download bandwidth of 1000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.76E+15	4	1.44E+15	11.287	.000
Within Groups	6.30E+16	494	1.28E+14		
Total	6.88E+16	498			

Figure 68: Tukey's HSD table for TDB at hard drive size of 200GB and download bandwidth of 1000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	-125368.5	1601366	1.000	-4493539	4242802.1
	3.00	-3283672	1601366	.242	-7651843	1084498.4
	4.00	-6144037*	1601366	.001	-10512208	-1775867
	5.00	-8712739*	1601366	.000	-13080909	-4344568
2.00	1.00	125368.50	1601366	1.000	-4242802	4493539.1
	3.00	-3158304	1597337	.277	-7515485	1198877.8
	4.00	-6018669*	1597337	.002	-10375850	-1661487
	5.00	-8587370*	1597337	.000	-12944552	-4230189
3.00	1.00	3283672.2	1601366	.242	-1084498	7651842.8
	2.00	3158303.7	1597337	.277	-1198878	7515485.2
	4.00	-2860365	1597337	.379	-7217547	1496816.4
	5.00	-5429067*	1597337	.006	-9786248	-1071885
4.00	1.00	6144037.3*	1601366	.001	1775866.7	10512208
	2.00	6018668.8*	1597337	.002	1661487.3	10375850
	3.00	2860365.1	1597337	.379	-1496816	7217546.6
	5.00	-2568702	1597337	.492	-6925883	1788479.9
5.00	1.00	8712738.8*	1601366	.000	4344568.2	13080909
	2.00	8587370.3*	1597337	.000	4230188.9	12944552
	3.00	5429066.6*	1597337	.006	1071885.1	9786248.1
	4.00	2568701.5	1597337	.492	-1788480	6925883.0

*. The mean difference is significant at the .05 level.

The result shown in Fig 69 ,for bandwidth 2Mb/s and hard drive size 50GB, describes the case study of Base Line scenario was the lowest on total download bytes (TDB) for downloading all the required files requested by nodes without using any other techniques like file insertion and preemptive from the server, the same scenario is happening with H1 heuristic because the requested files by customers will the only be downloaded to the nodes either from the server, node or both server and node. In the other hand, H1 is the same as it would be Base Line case study.

The other scenarios case studies like H2, H3 and H4 have higher values than Base Line and H1. Furthermore, H3 is higher than H2 and H4 is higher than H3 because of using different techniques of file insertion and preempting the highest recommended files to a network. H2 is just mainly files insertion for limited file that can be in advance requested by customers using existing service in future run. But at the case of H3 and H4 are using additional technique of forcing more files to be downloaded to the internal storage media for a future use and serve other nodes for easy access.

These two techniques, either files insertion or preemptive, need to download more files to the internal storage media. it has found that H3 is highly demand of more files to be exit in internal storage media than H2 and the same scenario between H3 and H4. in addition, increasing bandwidth that will bring all the comparison heuristics to be higher in values than previous results.

As the results from ANOVA analysis in Table 70 describes that p-value close greater than .05 for the comparison, but in Table 71 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 69: ANOVA analysis for TDB at hard drive size of 50GB and download bandwidth of 2000kb/s

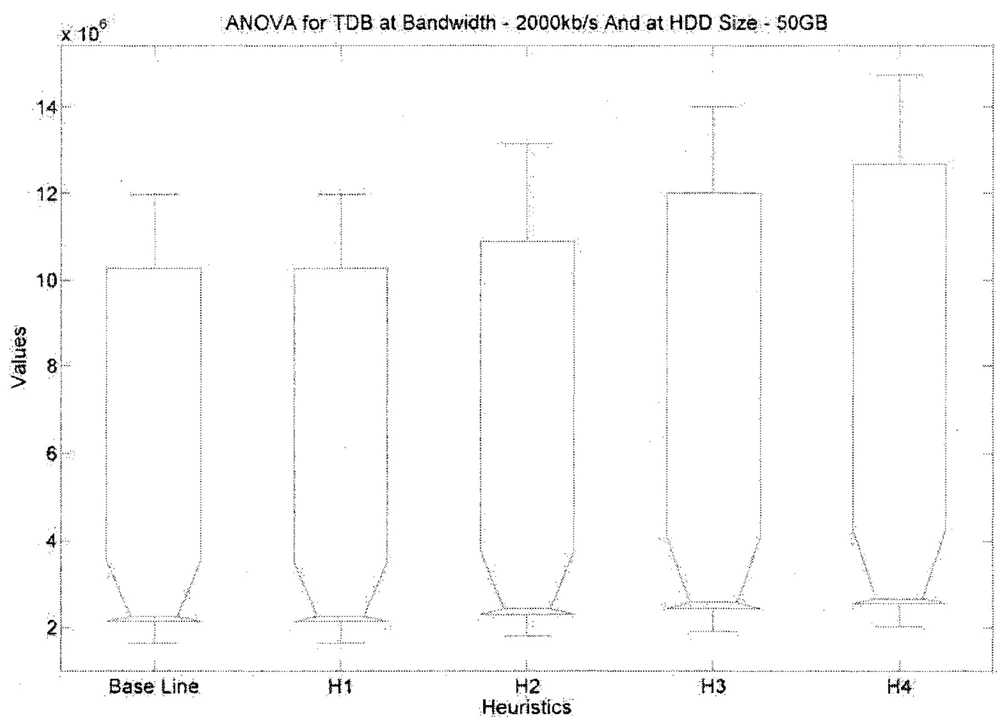


Figure 70: ANOVA table for TDB at hard drive size of 50GB and download bandwidth of 2000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.21E+13	4	2.30E+13	1.192	.314
Within Groups	9.54E+15	494	1.93E+13		
Total	9.63E+15	498			

Figure 71: Tukey's HSD table for TDB at hard drive size of 50GB and download bandwidth of 2000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	-62705.14	623138.0	1.000	-1762487	1637077.1
	3.00	-408194.2	623138.0	.966	-2107976	1291588.1
	4.00	-822810.0	623138.0	.678	-2522592	876972.23
	5.00	-1109123	623138.0	.385	-2808906	590658.91
2.00	1.00	62705.1424	623138.0	1.000	-1637077	1762487.4
	3.00	-345489.0	621570.3	.981	-2040995	1350017.0
	4.00	-760104.9	621570.3	.738	-2455611	935401.19
	5.00	-1046418	621570.3	.444	-2741924	649087.86
3.00	1.00	408194.16	623138.0	.966	-1291588	2107976.4
	2.00	345489.02	621570.3	.981	-1350017	2040995.1
	4.00	-414615.9	621570.3	.963	-2110122	1280890.2
	5.00	-700929.2	621570.3	.792	-2396435	994576.88
4.00	1.00	822810.01	623138.0	.678	-876972.2	2522592.3
	2.00	760104.87	621570.3	.738	-935401.2	2455610.9
	3.00	414615.85	621570.3	.963	-1280890	2110121.9
	5.00	-286313.3	621570.3	.991	-1981819	1409192.7
5.00	1.00	1109123.3	623138.0	.385	-590658.9	2808905.6
	2.00	1046418.2	621570.3	.444	-649087.9	2741924.3
	3.00	700929.18	621570.3	.792	-994576.9	2396435.2
	4.00	286313.33	621570.3	.991	-1409193	1981819.4

The result shown in Fig 72 ,for bandwidth 2Mb/s and hard drive size 100GB, describes the case study of Base Line scenario was the lowest on total download bytes (TDB) for downloading all the required files requested by nodes without using any other techniques like file insertion and preemptive from the server, the same scenario is happening with H1 heuristic because the requested files by customers will the only be downloaded to the nodes either from the server, node or both server and node. In the other hand, H1 is the same as it would be Base Line case study.

The other scenarios case studies like H2, H3 and H4 have higher values than Base Line and H1. Furthermore, H3 is higher than H2 and H4 is higher than H3 because of using different techniques of file insertion and preempting the highest recommended files to a network. H2 is just mainly files insertion for limited file that can be in advance requested by customers using existing service in future run. But at the case of H3 and H4 are using additional technique of forcing more files to be downloaded to the internal storage media for a future use and serve other nodes for easy access.

These two techniques, either files insertion or preemptive, need to download more files to the internal storage media. it has found that H3 is highly demand of more files to be exit in internal storage media than H2 and the same scenario between H3 and H4. in addition, increasing bandwidth and hard drive size that will bring all the comparison heuristics to be higher in values than previous results.

As the results from ANOVA analysis in Table 73 describes that *p*-value close greater than .05 for the comparison, but in Table 74 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 72: ANOVA analysis for TDB at hard drive size of 100GB and download bandwidth of 2000kb/s

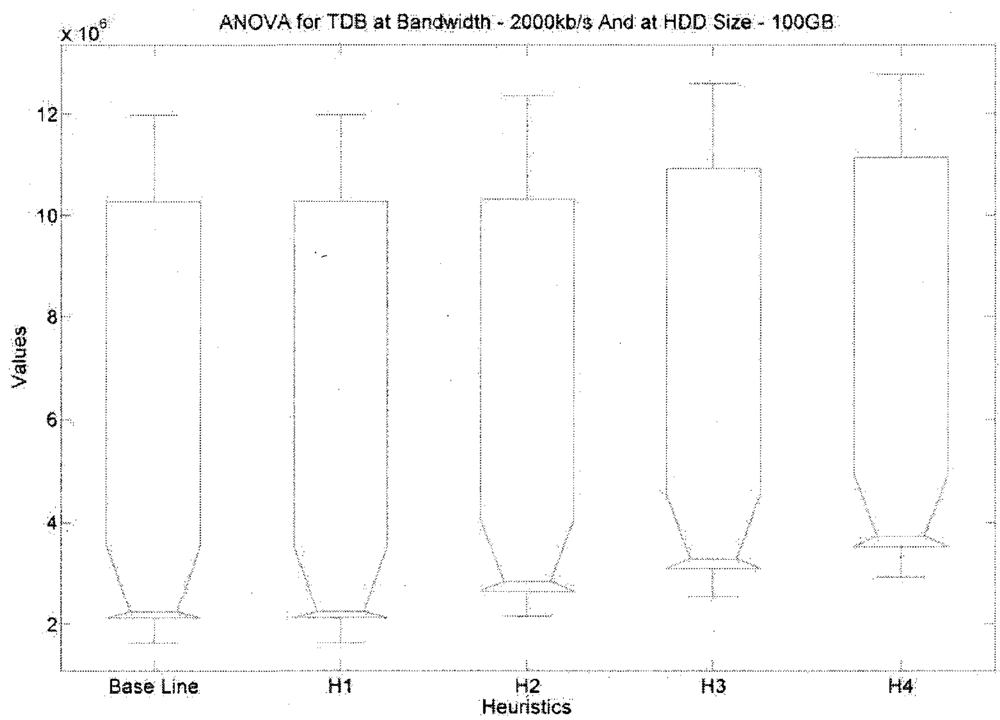


Figure 73: ANOVA table for TDB at hard drive size of 100GB and download bandwidth of 2000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.30E+14	4	3.25E+13	2.170	.071
Within Groups	7.39E+15	494	1.50E+13		
Total	7.52E+15	498			

Figure 74: Tukey's HSD table for TDB at hard drive size of 100GB and download bandwidth of 2000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	-62705.14	548254.2	1.000	-1558221	1432810.8
	3.00	-496301.4	548254.2	.895	-1991817	999214.61
	4.00	-962250.7	548254.2	.400	-2457767	533265.34
	5.00	-1318278	548254.2	.114	-2813794	177237.94
2.00	1.00	62705.1424	548254.2	1.000	-1432811	1558221.1
	3.00	-433596.2	546875.0	.933	-1925350	1058157.4
	4.00	-899545.5	546875.0	.469	-2391299	592208.17
	5.00	-1255573	546875.0	.146	-2747327	236180.77
3.00	1.00	496301.38	548254.2	.895	-999214.6	1991817.4
	2.00	433596.23	546875.0	.933	-1058157	1925349.9
	4.00	-465949.3	546875.0	.914	-1957703	1025804.4
	5.00	-821976.7	546875.0	.560	-2313730	669777.00
4.00	1.00	962250.65	548254.2	.400	-533265.3	2457766.6
	2.00	899545.51	546875.0	.469	-592208.2	2391299.2
	3.00	465949.27	546875.0	.914	-1025804	1957703.0
	5.00	-356027.4	546875.0	.967	-1847781	1135726.3
5.00	1.00	1318278.1	548254.2	.114	-177237.9	2813794.0
	2.00	1255572.9	546875.0	.146	-236180.8	2747326.6
	3.00	821976.68	546875.0	.560	-669777.0	2313730.4
	4.00	356027.40	546875.0	.967	-1135726	1847781.1

The result shown in Fig 75 ,for bandwidth 2Mb/s and hard drive size 200GB, describes the case study of Base Line scenario was the lowest on total download bytes (TDB) for downloading all the required files requested by nodes without using any other techniques like file insertion and preemptive from the server, the same scenario is happening with H1 heuristic because the requested files by customers will the only be downloaded to the nodes either from the server, node or both server and node. In the other hand, H1 is the same as it would be Base Line case study.

The other scenarios case studies like H2, H3 and H4 have higher values than Base Line and H1. Furthermore, H3 is higher than H2 and H4 is higher than H3 because of using different techniques of file insertion and preempting the highest recommended files to a network. H2 is just mainly files insertion for limited file that can be in advance requested by customers using existing service in future run. But at the case of H3 and H4 are using additional technique of forcing more files to be downloaded to the internal storage media for a future use and serve other nodes for easy access.

These two techniques, either files insertion or preemptive, need to download more files to the internal storage media. it has found that H3 is highly demand of more files to be exit in internal storage media than H2 and the same scenario between H3 and H4. in addition, increasing bandwidth and hard drive size that will bring all the comparison heuristics to be higher in values than previous results.

As the results from ANOVA analysis in Table 76 describes that *p*-value close less than .05 for the comparison, but in Table 77 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 75: ANOVA analysis for TDB at hard drive size of 200GB and download bandwidth of 2000kb/s

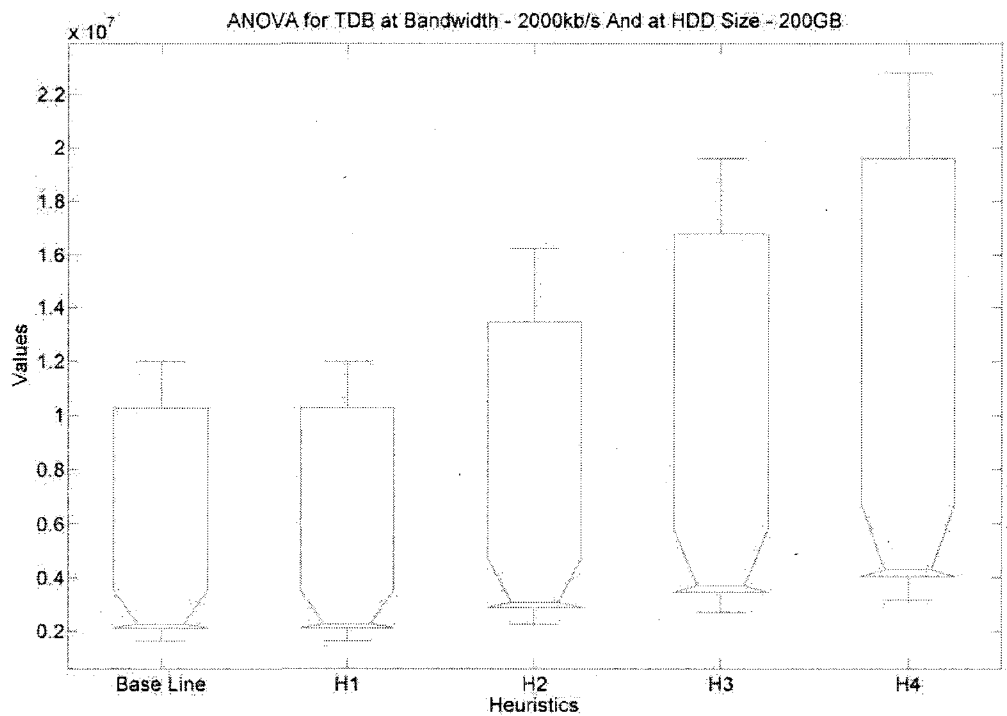


Figure 76: ANOVA table for TDB at hard drive size of 200GB and download bandwidth of 2000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.44E+15	4	3.60E+14	11.272	.000
Within Groups	1.58E+16	494	3.20E+13		
Total	1.72E+16	498			

Figure 77: Tukey's HSD table for TDB at hard drive size of 200GB and download bandwidth of 2000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1.00	2.00	-62705.14	801599.5	1.000	-2249291	2123880.6
	3.00	-1642376	801599.5	.243	-3828961	544209.98
	4.00	-3073304*	801599.5	.001	-5259890	-886718.2
	5.00	-4358639*	801599.5	.000	-6545224	-2172053
2.00	1.00	62705.1424	801599.5	1.000	-2123881	2249290.9
	3.00	-1579671	799582.9	.278	-3760755	601414.27
	4.00	-3010599*	799582.9	.002	-5191684	-829513.9
	5.00	-4295933*	799582.9	.000	-6477018	-2114849
3.00	1.00	1642375.7	801599.5	.243	-544210.0	3828961.5
	2.00	1579670.6	799582.9	.278	-601414.3	3760755.5
	4.00	-1430928	799582.9	.380	-3612013	750156.72
	5.00	-2716263*	799582.9	.006	-4897348	-535177.9
4.00	1.00	3073303.9*	801599.5	.001	886718.18	5259889.6
	2.00	3010598.8*	799582.9	.002	829513.89	5191683.6
	3.00	1430928.2	799582.9	.380	-750156.7	3612013.0
	5.00	-1285335	799582.9	.492	-3466419	895750.26
5.00	1.00	4358638.5*	801599.5	.000	2172052.8	6545224.2
	2.00	4295933.4*	799582.9	.000	2114848.5	6477018.3
	3.00	2716262.8*	799582.9	.006	535177.90	4897347.6
	4.00	1285334.6	799582.9	.492	-895750.3	3466419.5

*. The mean difference is significant at the .05 level.

The result shown in Fig 78 ,for bandwidth 5Mb/s and hard drive size 50GB, describes the case study of Base Line scenario was the lowest on total download bytes (TDB) for downloading all the required files requested by nodes without using any other techniques like file insertion and preemptive from the server, the same scenario is happening with H1 heuristic because the requested files by customers will the only be downloaded to the nodes either from the server, node or both server and node. In the other hand, H1 is the same as it would be Base Line case study.

The other scenarios case studies like H2, H3 and H4 have higher values than Base Line and H1. Furthermore, H3 is higher than H2 and H4 is higher than H3 because of using different techniques of file insertion and preempting the highest recommended files to a network. H2 is just mainly files insertion for limited file that can be in advance requested by customers using existing service in future run. But at the case of H3 and H4 are using additional technique of forcing more files to be downloaded to the internal storage media for a future use and serve other nodes for easy access.

These two techniques, either files insertion or preemptive, need to download more files to the internal storage media. it has found that H3 is highly demand of more files to be exit in internal storage media than H2 and the same scenario between H3 and H4. in addition, increasing bandwidth that will bring all the comparison heuristics to be higher in values than previous results.

As the results from ANOVA analysis in Table 79 describes that *p*-value close greater than .05 for the comparison, but in Table 80 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 78: ANOVA analysis for TDB at hard drive size of 50GB and download bandwidth of 5000kb/s

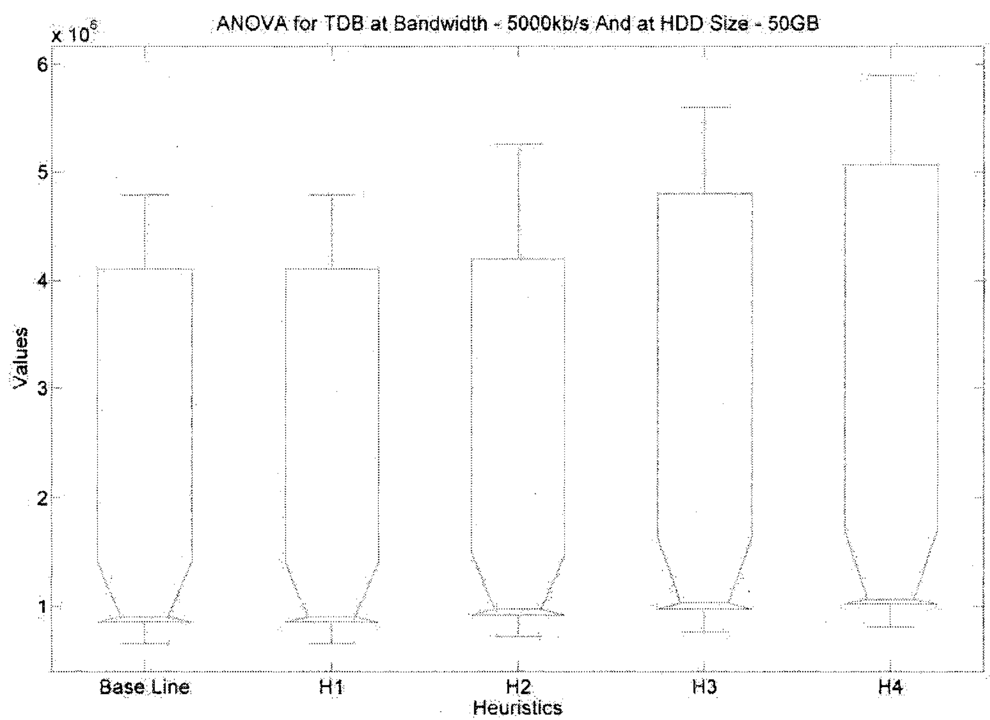


Figure 79: ANOVA table for TDB at hard drive size of 50GB and download bandwidth of 5000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.51E+13	4	3.77E+12	1.227	.298
Within Groups	1.52E+15	494	3.08E+12		
Total	1.53E+15	498			

Figure 80: Tukey's HSD table for TDB at hard drive size of 50GB and download bandwidth of 5000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	-25081.91	248632.8	1.000	-703297.0	653133.15
	3.00	-123216.9	248632.8	.988	-801431.9	554998.19
	4.00	-329129.1	248632.8	.676	-1007344	349085.94
	5.00	-443657.5	248632.8	.383	-1121873	234557.59
2.00	1.00	25081.9051	248632.8	1.000	-653133.2	703296.96
	3.00	-98134.96	248007.3	.995	-774643.8	578373.89
	4.00	-304047.2	248007.3	.736	-980556.1	372461.64
	5.00	-418575.6	248007.3	.442	-1095084	257933.30
3.00	1.00	123216.86	248632.8	.988	-554998.2	801431.92
	2.00	98134.9584	248007.3	.995	-578373.9	774643.81
	4.00	-205912.3	248007.3	.921	-882421.1	470596.60
	5.00	-320440.6	248007.3	.696	-996949.5	356068.25
4.00	1.00	329129.12	248632.8	.676	-349085.9	1007344.2
	2.00	304047.22	248007.3	.736	-372461.6	980556.07
	3.00	205912.26	248007.3	.921	-470596.6	882421.11
	5.00	-114528.3	248007.3	.991	-791037.2	561980.51
5.00	1.00	443657.46	248632.8	.383	-234557.6	1121872.5
	2.00	418575.56	248007.3	.442	-257933.3	1095084.4
	3.00	320440.60	248007.3	.696	-356068.3	996949.45
	4.00	114528.34	248007.3	.991	-561980.5	791037.20

The result shown in Fig 81 ,for bandwidth 5Mb/s and hard drive size 100GB, describes the case study of Base Line scenario was the lowest on total download bytes (TDB) for downloading all the required files requested by nodes without using any other techniques like file insertion and preemptive from the server, the same scenario is happening with H1 heuristic because the requested files by customers will the only be downloaded to the nodes either from the server, node or both server and node. In the other hand, H1 is the same as it would be Base Line case study.

The other scenarios case studies like H2, H3 and H4 have higher values than Base Line and H1. Furthermore, H3 is higher than H2 and H4 is higher than H3 because of using different techniques of file insertion and preempting the highest recommended files to a network. H2 is just mainly files insertion for limited file that can be in advance requested by customers using existing service in future run. But at the case of H3 and H4 are using additional technique of forcing more files to be downloaded to the internal storage media for a future use and serve other nodes for easy access.

These two techniques, either files insertion or preemptive, need to download more files to the internal storage media. it has found that H3 is highly demand of more files to be exit in internal storage media than H2 and the same scenario between H3 and H4. in addition, increasing bandwidth and hard drive size that will bring all the comparison heuristics to be higher in values than previous results.

As the results from ANOVA analysis in Table 82 describes that *p*-value close greater than .05 for the comparison, but in Table 83 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 81: ANOVA analysis for TDB at hard drive size of 100GB and download bandwidth of 5000kb/s

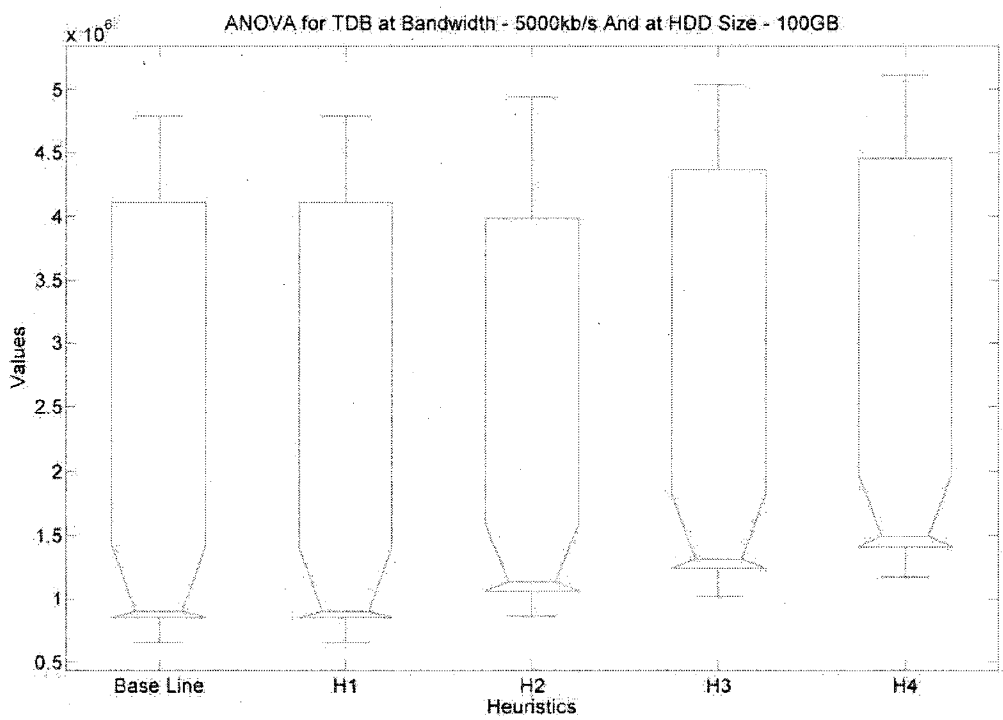


Figure 82: ANOVA table for TDB at hard drive size of 100GB and download bandwidth of 5000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.11E+13	4	5.27E+12	2.214	.066
Within Groups	1.18E+15	494	2.38E+12		
Total	1.20E+15	498			

Figure 83: Tukey's HSD table for TDB at hard drive size of 100GB and download bandwidth of 5000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	-25081.91	218737.4	1.000	-621749.2	571585.38
	3.00	-162736.4	218737.4	.946	-759403.6	433930.93
	4.00	-384899.9	218737.4	.397	-981567.2	211767.40
	5.00	-527312.3	218737.4	.112	-1123980	69354.9367
2.00	1.00	25081.9051	218737.4	1.000	-571585.4	621749.19
	3.00	-137654.5	218187.2	.970	-732820.7	457511.78
	4.00	-359818.0	218187.2	.466	-954984.2	235348.26
	5.00	-502230.4	218187.2	.144	-1097397	92935.7897
3.00	1.00	162736.36	218737.4	.946	-433930.9	759403.64
	2.00	137654.45	218187.2	.970	-457511.8	732820.69
	4.00	-222163.5	218187.2	.847	-817329.8	373002.71
	5.00	-364576.0	218187.2	.452	-959742.2	230590.24
4.00	1.00	384899.88	218737.4	.397	-211767.4	981567.17
	2.00	359817.98	218187.2	.466	-235348.3	954984.21
	3.00	222163.52	218187.2	.847	-373002.7	817329.76
	5.00	-142412.5	218187.2	.966	-737578.7	452753.77
5.00	1.00	527312.35	218737.4	.112	-69354.94	1123979.6
	2.00	502230.44	218187.2	.144	-92935.79	1097396.7
	3.00	364575.99	218187.2	.452	-230590.2	959742.22
	4.00	142412.47	218187.2	.966	-452753.8	737578.70

The result shown in Fig 84 ,for bandwidth 5Mb/s and hard drive size 200GB, describes the case study of Base Line scenario was the lowest on total download bytes (TDB) for downloading all the required files requested by nodes without using any other techniques like file insertion and preemptive from the server, the same scenario is happening with H1 heuristic because the requested files by customers will the only be downloaded to the nodes either from the server, node or both server and node. In the other hand, H1 is the same as it would be Base Line case study.

The other scenarios case studies like H2, H3 and H4 have higher values than Base Line and H1. Furthermore, H3 is higher than H2 and H4 is higher than H3 because of using different techniques of file insertion and preempting the highest recommended files to a network. H2 is just mainly files insertion for limited file that can be in advance requested by customers using existing service in future run. But at the case of H3 and H4 are using additional technique of forcing more files to be downloaded to the internal storage media for a future use and serve other nodes for easy access.

These two techniques, either files insertion or preemptive, need to download more files to the internal storage media. it has found that H3 is highly demand of more files to be exit in internal storage media than H2 and the same scenario between H3 and H4. in addition, increasing bandwidth and hard drive size that will bring all the comparison heuristics to be higher in values than previous results.

As the results from ANOVA analysis in Table 85 describes that *p*-value close less than .05 for the comparison, but in Table 86 ,for Tukey's test, highlights more in depth the significant differences between all five (5) heuristics.

Figure 84: ANOVA analysis for TDB at hard drive size of 200GB and download bandwidth of 5000kb/s

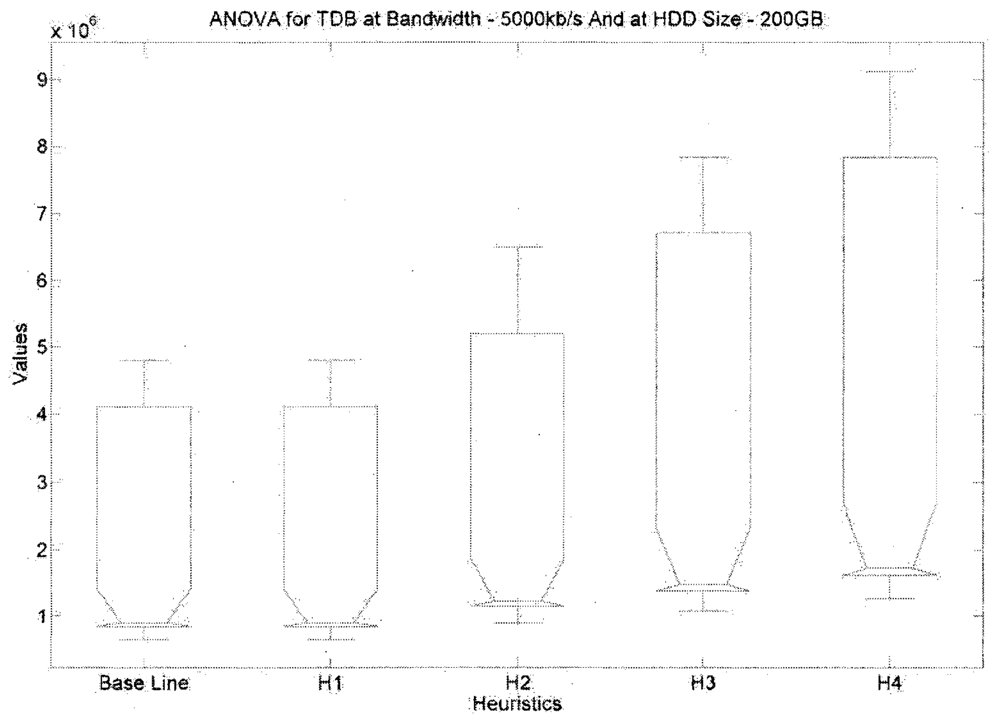


Figure 85: ANOVA table for TDB at hard drive size of 200GB and download bandwidth of 5000kb/s

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.32E+14	4	5.79E+13	11.371	.000
Within Groups	2.52E+15	494	5.09E+12		
Total	2.75E+15	498			

Figure 86: Tukey's HSD table for TDB at hard drive size of 200GB and download bandwidth of 5000kb/s

Tukey HSD

(I) F1	(J) F1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	-25081.91	319901.7	1.000	-897702.9	847539.07
	3.00	-607574.6	319901.7	.318	-1480196	265046.38
	4.00	-1229340*	319901.7	.001	-2101961	-356719.5
	5.00	-1743488*	319901.7	.000	-2616109	-870867.4
2.00	1.00	25081.9051	319901.7	1.000	-847539.1	897702.88
	3.00	-582492.7	319096.9	.359	-1452918	287933.01
	4.00	-1204259*	319096.9	.002	-2074684	-333832.8
	5.00	-1718406*	319096.9	.000	-2588832	-847980.7
3.00	1.00	607574.60	319901.7	.318	-265046.4	1480195.6
	2.00	582492.69	319096.9	.359	-287933.0	1452918.4
	4.00	-621765.9	319096.9	.292	-1492192	248659.85
	5.00	-1135914*	319096.9	.003	-2006339	-265488.0
4.00	1.00	1229340.5*	319901.7	.001	356719.48	2101961.4
	2.00	1204258.5*	319096.9	.002	333832.85	2074684.2
	3.00	621765.85	319096.9	.292	-248659.8	1492191.6
	5.00	-514147.9	319096.9	.490	-1384574	356277.82
5.00	1.00	1743488.3*	319901.7	.000	870867.36	2616109.3
	2.00	1718406.4*	319096.9	.000	847980.73	2588832.1
	3.00	1135913.7*	319096.9	.003	265488.04	2006339.4
	4.00	514147.88	319096.9	.490	-356277.8	1384573.6

*. The mean difference is significant at the .05 level.

CHAPTER VII

CONCLUSIONS AND EXTENSIONS

The goal of this research was twofold; the first goal was to develop a non-homogeneous network and develop an understanding of how the constructed network interacts with its internal elements.

The second goal was to evaluate and analyze the network that was optimized in two dimensions by changing 'space' and 'time'. As part of the research, a Matlab simulation of a network was developed to evaluate and analyze the network's elements interaction with each other and with the server. The server load, penalty and total download bytes along with different bandwidth and different hard drive sizes were also evaluated for their usability and effectiveness as measuring tools. In addition, performance measures of data output in a form of output graphs such as analysis of variance was used to compare the different outputs from the five (5) heuristics studies. The important conclusions are summarized below.

- The five (5) heuristics studies have an effect on understanding the network behavior. In general, the network behavior was dependent on the customers' preferences and file prioritizing. Customers' behavior was studied in this research to evaluate how the customers' behavior affected the network's connectivity. File prioritizing was also evaluated and its impact on how files are spread across the network as ascertained.

- Each heuristic study was evaluated and analyzed by generating 100 data sets; these data sets were used to emulate a real life scenario. Each of 100 data sets were collected by using their mean and standard deviation values to examine the range of data between minimum and maximum reachable points. These points alone with mean values were used later on by analysis of variance to describe and compare the five (5) heuristics studies.

- The time series analysis was used to evaluate network interactions along with file transfer and customers' demand through the entire year. In general, using the metrics has a great potential of highlighting network functionality and measuring the output data. These outputs have mainly resulted as a function of the studied metrics (Server Load, Penalty and Total Download Bytes 'TDB').

- The differential time analysis (DTA) was used to evaluate network differentiation in its functionality and performance along with file transfer and customers' demand through the entire year for the five (5) heuristics. In general, using the output data from the time series analysis to develop a comparison between the five (5) heuristics and evaluate how network operations can be optimized.

- The response surface analysis was used to evaluate network operation in three dimensions (3D). Each of metrics was evaluated along with bandwidths axis and hard drive sizes axis. The outputs mainly illustrate the best result scenario that can be used to optimize the network solution. In addition, the results were used as comparisons between different heuristics studies.

- As expected in, running the simulation software the results were performed more efficiently in H3 and H4 heuristics alone with reducing the excessive demand on network. The selected choice of using virtual storages in a network was recommended according to customers' demand and the highest priorities.

Based on the results of this study, it is evident the addition of real simulation of a network has the potential of improving the performance measured and thereby improving network operations and network optimization in 'space' and 'time'. The delivery method of real simulation needs to be determined. As a result, the author envisions the following extensions.

- A study that examines the transfer effects of media files to a real network should be investigated. This study should focus on determining if the results from simulating in fact transfer into nodes (customers) by conducting studies in the real network environment.

- The current study examined a constructed network with assumptions which are different than the real world network. A study needs to be conducted in order to see what is the optimal way of presenting a real world situation. In the real world, network connectivity may vary depending on the type of technology being used. A study might be conducted on a real network using real data to determine if the proposed metrics are adequate.

- The use of Matlab as simulation tools should be investigated further when a real world network is being used. With Matlab, the potential of a simulation exists and should be further explored. Expert analysts in a Matlab environment could expand the simulation tools and recommend tools to help achieve network performance. Also analysts could collect more information about the network in a real time environment. This could be beneficial on using the correct simulation tools. Analysis also allows for an infinite combination of possible heuristic scenarios unlike those found in the real world.

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APPENDIX A

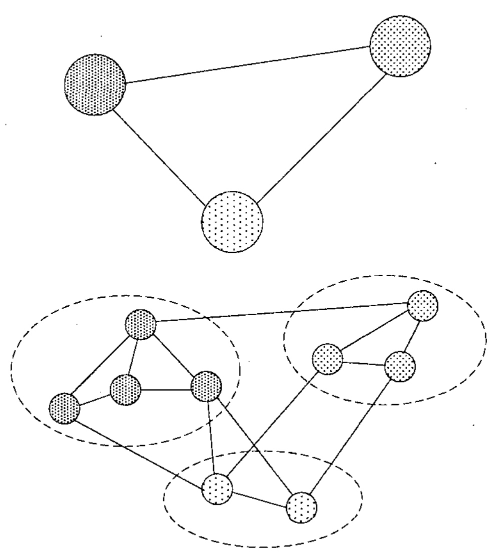
GENERATE NETWORK TOPOLOGIES

Researchers have defined several techniques to generate random graphs as a way to represent a real network topologies (Tangmunarunkit, Govindan, Jamin, Shenker, and Willinger, 2002; Lin and Tjoa, 2006). These techniques characterize ways to build models that need to measure network properties by using graph theories.

First of all, when we analyze network topology, including nodes and links, we have to define what level of network to where we point to. For instance, with autonomous systems (AS), each node represents a compilation of routers that emphasize the administration of AS and becomes visible to other AS as a single coherent and reachable routing plan.

On the other hand, router level (RL) corresponds to single terminal at IP stage. RL, in general, has approximately seventeen times more nodes and links than the corresponding AS.

Figure 87: Demonstrate difference between RL and AS for a network topology



The research had been done by Tangmunarunkit et al. (2002) and examines three major kinds of networks: measured networks, generated networks and canonical networks. Measured network can be simplified in two major categories of real network autonomous system (AS) and router levels (RL). Generated networks consist of random networks (Waxman, 1988), structural networks represented by a Transit Stub (Calvert, Doar, and Zegura,

Table 4: Network Topology

Type	Topology	Number of nodes	Average degree
Measured	RL	170589	2.53
	AS	10941	4.13
Generated	PLRG	9230	4.46
	Transit Stub (TS)	1008	2.78
	Waxman	5000	7.22
Canonical	Mesh	900	3.87
	Random	5018	4.18
	Tree	1093	2.00

Topology	Growth (Expansion)	Elasticity
AS	H	H
RL	H	H
PLRG	H	H
Tiers	L	H
TS	H	L
Waxman	H	H
Mesh	L	H
Random	H	H
Tree	H	L

Table 5: Networks' Classifications

1997) and Tiers (Doar, 1996), and degree-based networks represented by power law random graphs (PLRG) (Aiello, Chung, and Lu, 2000). Finally, canonical networks consist of binary trees, rectangular grids (mesh) and Erdos-Renyi random graphs (ER).

These models represent a large scale structure of real networks. Tangmunarunkit et al. (2002) argued the necessity of describing differences of these networks and providing fundamental references by using a developed three metrics including expansion, resilience and distortion. In this case, the study is based on growth related to expansion and elasticity and related to resilience, as distortion metrics are measuring how much a network will require for reassembly after being disassembled, which was not a part of this study.

Table 4 represents the types of networks that have been used. These networks were analyzed and compared by the metrics to describe each of the network properties of different network sizes.

As a result, these models were analyzed and classified according to Tangmunarunkit et al. (2002) to a high and low mark as shown in Table 5

APPENDIX B

MATLAB CODE

B.1 BASE LINE (M-FILE)

B.1.1 Initial Settings

```
clear;

FileSize=xlsread('F-S.xls');
 % [10,000 by 3] first colomn for file index second colomn for file size per GB.

for o=1:10;

    Ac=[]; Cr=[]; Co=[]; Dr=[]; Ro=[];
    i=0; j=0; l=0; N=0; n=0; m=0; x=0; y=0; k=0; errorr=0; g=0; BandWidth=0;
    abc=[]; cdc=[]; X=[]; Y=[]; C=[]; L=[];

    InterArrivalTime=[]; Node=[]; FileIndex=[]; BatchSize=[];
    FilePreference=[]; FilePreference1=[]; FilePreference2=[];
    FilePreference3=[]; FilePreference4=[]; FilePreference5=[];

    InterArrivalTime=csvread(['Data-Set-1',num2str(o),'.csv']);
              % [802 by 250] first two row is not belong to Interarrival time.

    Node=csvread(['Data-Set-b',num2str(o),'.csv']);
       % [3 by 250] last row for how many files watched by each node per year.

    % Initial Section:
    % ---------------

    % Produce random node number of count 50 for each of Action, Crime, Comedy,
    % Drama and Romance.

    N=randperm(250);

    N=N';

    Ac=N(1:50);
    Cr=N(51:100);
```

```
Co=N(101:150);
Dr=N(151:200);
Ro=N(201:250);

% First Section:
% --------------
% Divide 10,000 files to 5 category to Action, Crime, Comedy, Drama and
% Romance. as each category ranked from High to Low priority and get toatl
% of watches per node from Data-Set-b?.xls.

if  sum(Node(3,:))<40000;
   k=fix(sum(Node(3,:))/5);
    errorr=((k-6990)*130)/500*.00004/5;
    g=(k*.050911002/sum(Node(3,:)))+.0061+errorr;
elseif (sum(Node(3,:))>=40000) \& (sum(Node(3,:))<50000);
    k=fix(sum(Node(3,:))/5);
    errorr=((k-7000)*130)/500*.00004/5;
    g=(k*.050911002/sum(Node(3,:)))+.0061+errorr;
elseif (sum(Node(3,:))>=50000);
    k=fix(sum(Node(3,:))/5);
    errorr=((k-7035)*130)/500*.00004/5;
    g=(k*.050911002/sum(Node(3,:)))+.0061+errorr;
end;

i=1:2000;
FilePreference1(i)=fix(g*500000*((1/500)*exp(-((i)-1)/500)));

i=2001:4000;
FilePreference2(1:2000)=fix(g*500000*((1/500)*exp(-((i)-2001)/500)));

i=4001:6000;
FilePreference3(1:2000)=fix(g*500000*((1/500)*exp(-((i)-4001)/500)));

i=6001:8000;
FilePreference4(1:2000)=fix(g*500000*((1/500)*exp(-((i)-6001)/500)));

i=8001:10000;
FilePreference5(1:2000)=fix(g*500000*((1/500)*exp(-((i)-8001)/500)));

FilePreference=[FilePreference1' ; FilePreference2' ; FilePreference3' ;
                FilePreference4' ; FilePreference5'];
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Second Section:
% ---------------

% initial output by using input from a and b array in additional, input
% from two dimensional array of (10,000 by 250)
% each array has binomial data set for abc array of dimensions (10,000 by
% 250) and arrange it after that the output file Data-Set-New-ab-1.xls
% Data-Set-New-ab-100.xls
% will be used later here for more arranged.

abc=zeros(10000,250);


% Using the below loops for more arrange to adjust the final output file
% to be fully satisfy according to the two condition of summation equals a
% and b arrays.

%%%%%%% Actions

i=1;
j=1;

while (i<=2000);
  while (j<=50);
   if(sum(abc(i,:))<=FilePreference(i))\&(sum(abc(:,Ac(j)))<Node(3,Ac(j)));
            abc(i,Ac(j))=1;
elseif(sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Ac(j)))<Node(3,Ac(j)));
                abc(i,Ac(j))=1;
        else;
            abc(i,Ac(j))=0;
        end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

%%%%%%% Crime
```

```
i=2001;
j=1;

while (i<=4000);
  while (j<=50);
   if(sum(abc(i,:))<=FilePreference(i))\&(sum(abc(:,Cr(j)))<Node(3,Cr(j)));
            abc(i,Cr(j))=1;
elseif(sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Cr(j)))<Node(3,Cr(j)));
                abc(i,Cr(j))=1;
        else;
            abc(i,Cr(j))=0;
        end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

%%%%%%% Comedy

i=4001;
j=1;

while (i<=6000);
  while (j<=50);
   if(sum(abc(i,:))<=FilePreference(i))\&(sum(abc(:,Co(j)))<Node(3,Co(j)));
            abc(i,Co(j))=1;
elseif(sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Co(j)))<Node(3,Co(j)));
                abc(i,Co(j))=1;
        else;
            abc(i,Co(j))=0;
        end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

%%%%%%% Drama

i=6001;
```

```
j=1;

while (i<=8000);
    while (j<=50);
     ifsum(abc(i,:))<=FilePreference(i)\&(sum(abc(:,Dr(j)))<Node(3,Dr(j)));
            abc(i,Dr(j))=1;
elseif(sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Dr(j)))<Node(3,Dr(j)));
            abc(i,Dr(j))=1;
        else;
            abc(i,Dr(j))=0;
        end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

%%%%%%% Romance

i=8001;
j=1;

while (i<=10000);
  while (j<=50);
   if (sum(abc(i,:))<=FilePreference(i))\&(sum(abc(:,Ro(j)))<Node(3,Ro(j)));
            abc(i,Ro(j))=1;
elseif (sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Ro(j)))<Node(3,Ro(j)));
                abc(i,Ro(j))=1;
         else;
             abc(i,Ro(j))=0;
         end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

csvwrite(['Data-Set-abc',num2str(o),'.csv'],abc);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Third Section:
```

```
% --------------

% Identify each node on one set for assign Data File number (by other words
% which one from 10,000 file) and repeat it for 100 sets from output file
% Data-Set-New-ab-1.xls to Data-Set-New-ab-100.xls as output that
% will be used later for
% randomized build new 100 fresh sets.


cdc=zeros(800,250);

i=1;
j=1;
l=1;

while (j<=250);
    while (i<=10000);
        if abc(i,j)==1;
            cdc(l,j)=i;
            l=l+1;
        end;
        i=i+1;
    end;
    j=j+1;
    i=1;
    l=1;
end;

csvwrite(['Data-Set-cdc',num2str(o),'.csv'],cdc);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Forth Section:
% --------------


[Y,X]=max(cdc);

FileIndex=zeros(800,250);
    % [800 by 250] randomized file index per node and ranked for preference
    % watched according to the node index.
```

```
i=1;
j=1;

while (j<=250);

    Brandom=[];

    Brandom=randperm(X(j));

    while (i<=Node(3,j));
        if Node(3,j)\sim =0;
            FileIndex(i,j)=cdc(Brandom(i),j);
            i=i+1;
        else;
            break;
        end;
    end;
    j=j+1;
    i=1;
end;

csvwrite(['Data-Set-FileIndex',num2str(o),'.csv'],FileIndex);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Using the output from previous section or (cdc)
% to build batch size randomized but non-repeatable
% from 1 to 6, but the output file has first column 0's
% output to Data-Set-BatchSize-1.xls to Data-Set-BatchSize-100.xls

[C,L]=max(cdc);

%vdc=[];

i=1;
j=1;

while (j<=250);

    eval(['Node' num2str(j) ' =[];']);

    eval(['Node' num2str(j) ' =zeros(1,230);']);
```

```
        x=fix(L(j)/21);
        y=L(j)-x*21;

        m=0;
        n=0;

        while (i<=x);
            m=6*(i-1)+1;
            n=6*i;
            eval(['Node' num2str(j) ' (m:n)=randperm(6);']);
            i=i+1;
        end;

        if (y<=6);
            eval(['Node' num2str(j) ' (n+1)=y;']);
        elseif (y<=9);
            if (y>=7);
                eval(['Node' num2str(j) ' (n+1:n+3)=randperm(3);']);
                eval(['Node' num2str(j) ' (n+4)=y-6;']);
            end;
        elseif y==10;
            eval(['Node' num2str(j) ' (n+1:n+4)=randperm(4);']);
        elseif (y<=14);
            if (y>=11);
                eval(['Node' num2str(j) ' (n+1:n+4)=randperm(4);']);
                eval(['Node' num2str(j) ' (n+5)=y-10;']);
            end;
        elseif y==15;
            eval(['Node' num2str(j) ' (n+1:n+5)=randperm(5);']);
        else (y<=20);
            if (y>=16);
                eval(['Node' num2str(j) ' (n+1:n+5)=randperm(5);']);
                eval(['Node' num2str(j) ' (n+6)=y-15;']);
            end;
        end;

        BatchSize=[BatchSize ; eval(['Node' num2str(j)])];
        j=j+1;
        i=1;

    end;
```

```
BatchSize=BatchSize';

csvwrite(['Data-Set-BatchSize',num2str(o),'.csv'],BatchSize);
                                        % Batch Size for random(1-6).

end;
```

B.1.2 Main Body Code

```
% Calculate the Penality of the difference between download time and watched
% time For Base Line.

Ordered=2.8;
          % Used as initial order after first time subscribe to the service.

for BandWidth=[25,50,100,128,512,1000,2000,5000];

for o=1:50;

    ArrivalTime=[]; InterDownloadTime=[]; AccumulationDownloadTime=[];

    ArrivalTime=zeros(800,250); % To calculate Arrival Time (Watched Time).

    InterDownloadTime=zeros(800,250);
              % To calculate individual time has been taken for each file
              % index to be download per node.

    AccumulationDownloadTime=zeros(800,250);
              % To calculate Accumulation time per node has been take as a
              % total time per year according to Watched time (Arrival
              % Time).

    ArrivalTimeL=[];
              % Collect Arrival Time for all node under one line of matrix
              % [n by 1].

    AccumulationDownloadTimeL=[];
              % Collect Accumulation Download Time for all node under one
              % line of matrix [n by 1].
```

```
InterDownloadTimeL=[];
          % Collect Inter Download Time [n by 1].

NodeL=[];
          % Collect the node relatively to on the same row for Arrival
          %Time on one line of matrix [n by 1].

FileIndexandSizeL=[];
          % Collect File Index and File's Size on the same row for all
          % node on matrix [n by 3].

Available=[];
          % used to get availability of the file to be watched by the
          % node.

AvailableL=[];
          % Collect all the availabilty on one line matrix [n by 1];

Penalty=[];
          % Get to calculate each Penalty for each node for each file.

InterArrivalTimeL=[];
          % Collect Inter Arrival Time on one line matrix [n by 1].

Total=[];
         % Put all in one Matrix [File index, File Size, Arrival Time
         % Sorted, Accumulation Time, Node Number] all according to
         % Arrival Time (Batched Time).

m=1;
n=0;
i=1;
j=2;
k=0;

while (i<=250);

    if (Node(3,i) \sim =0);

        ArrivalTime(1,i)=InterArrivalTime(3,i);
```

```
 InterDownloadTime(1,i)=[FileSize(FileIndex(1,i),2)*8000000]/
[BandWidth*3600];

                InterDownloadTimeL=[InterDownloadTimeL;InterDownloadTime(1,i)];

                InterArrivalTimeL=[InterArrivalTimeL ; InterArrivalTime(3,i)];

                AccumulationDownloadTime(1,i)=InterDownloadTime(1,i);

                FileIndexandSizeL=[FileIndexandSizeL ;
                        FileSize(FileIndex(1,i),1)  FileSize(FileIndex(1,i),2)
                        FileSize(FileIndex(1,i),3)/60];

                Available(1,i)=Ordered+InterDownloadTime(1,i);

                if Available(1,i)>ArrivalTime(1,i);
                    Penalty=[Penalty ; Available(1,i)-ArrivalTime(1,i)];
                else;
                    Penalty=[Penalty ; 0];
                end;

                while (j<=Node(3,i));
                    InterDownloadTime(j,i)=[FileSize(FileIndex(j,i),2)*8000000]/
                                           [BandWidth*3600];

                    InterDownloadTimeL=[InterDownloadTimeL ;
                                        InterDownloadTime(j,i)];

                    InterArrivalTimeL=[InterArrivalTimeL ;
                                       InterArrivalTime(j+2,i)];

                    AccumulationDownloadTime(j,i)=InterDownloadTime(j,i)+
                                           AccumulationDownloadTime(j-1,i);

                    FileIndexandSizeL=[FileIndexandSizeL ;
                          FileSize(FileIndex(j,i),1)  FileSize(FileIndex(j,i),2)
                          FileSize(FileIndex(j,i),3)/60];

                   if j-1==(n+BatchSize(m,i));
```

```
            Available(j,i)=max(Available(j-1,i),ArrivalTime(j-1,i))+
                             (FileSize(FileIndex(j-1,i),3)/60)+
                              InterDownloadTime(j,i);

            ArrivalTime(j,i)=max(Available(j-1,i),
                                ArrivalTime(j-1,i))+
                               (FileSize(FileIndex(j-1,i),3)/60)+
                                InterArrivalTime(j+2,i);

            n=BatchSize(m,i);
            m=m+1;

            else
                Available(j,i)=Available(j-1,i)+InterDownloadTime(j,i);
                ArrivalTime(j,i)=ArrivalTime(j-1,i)+
                                InterArrivalTime(j+2,i);

            end;

            if Available(j,i)>ArrivalTime(j,i);
                Penalty=[Penalty ; Available(j,i)-ArrivalTime(j,i)];
            else;
                Penalty=[Penalty ; 0];
            end;

            j=j+1;

        end;

        ArrivalTimeL=[ArrivalTimeL ; ArrivalTime(1:Node(3,i),i)];
        AccumulationDownloadTimeL=[AccumulationDownloadTimeL ;
                              AccumulationDownloadTime(1:Node(3,i),i)];
        AvailableL=[AvailableL ; Available(1:Node(3,i),i)];

    end;

    if i==1;
        k=0;
    else
        k=k+Node(3,i-1);
    end;
```

```
            NodeL(k+1:k+Node(3,i),1)=i;

            i=i+1;
           j=2;
           m=1;
            n=0;

        end;

        Total=[FileIndexandSizeL  Penalty  InterArrivalTimeL  ArrivalTimeL
              InterDownloadTimeL  AccumulationDownloadTimeL  AvailableL  NodeL];

        csvwrite(['Data-Set-New-Total-BaseLine',num2str(BandWidth),'-',
                   num2str(o),'.csv'],Total);

    end;

end;
```

B.2 HEURISTIC H1 (M-FILE)

B.2.1 Initial Settings

```
clear;

FileSize=xlsread('F-S.xls');
 % [10,000 by 3] first colomn for file index second colomn for file size per GB.

for o=1:10;

    Ac=[]; Cr=[]; Co=[]; Dr=[]; Ro=[];
    i=0; j=0; l=0; N=0; n=0; m=0; x=0; y=0; k=0; errorr=0; g=0; BandWidth=0;
    abc=[]; cdc=[]; X=[]; Y=[]; C=[]; L=[];

    InterArrivalTime=[]; Node=[]; FileIndex=[]; BatchSize=[];
    FilePreference=[]; FilePreference1=[]; FilePreference2=[];
    FilePreference3=[]; FilePreference4=[]; FilePreference5=[];

    InterArrivalTime=csvread(['Data-Set-1',num2str(o),'.csv']);
```

```
        % [802 by 250] first two row is not belong to Interarrival time.

Node=csvread(['Data-Set-b',num2str(o),'.csv']);
   % [3 by 250] last row for how many files watched by each node per year.

% Initial Section:
% ---------------

% Produce random node number of count 50 for each of Action, Crime, Comedy,
% Drama and Romance.

N=randperm(250);

N=N';

Ac=N(1:50);
Cr=N(51:100);
Co=N(101:150);
Dr=N(151:200);
Ro=N(201:250);

% First Section:
% --------------
% Divide 10,000 files to 5 category to Action, Crime, Comedy, Drama and
% Romance. as each category ranked from High to Low priority and get toatl
% of watches per node from Data-Set-b?.xls.

if  sum(Node(3,:))<40000;
   k=fix(sum(Node(3,:))/5);
    errorr=((k-6990)*130)/500*.00004/5;
    g=(k*.050911002/sum(Node(3,:)))+.0061+errorr;
elseif (sum(Node(3,:))>=40000) \& (sum(Node(3,:))<50000);
    k=fix(sum(Node(3,:))/5);
    errorr=((k-7000)*130)/500*.00004/5;
    g=(k*.050911002/sum(Node(3,:)))+.0061+errorr;
elseif (sum(Node(3,:))>=50000);
    k=fix(sum(Node(3,:))/5);
    errorr=((k-7035)*130)/500*.00004/5;
    g=(k*.050911002/sum(Node(3,:)))+.0061+errorr;
end;
```

```
i=1:2000;
FilePreference1(i)=fix(g*500000*((1/500)*exp(-((i)-1)/500)));

i=2001:4000;
FilePreference2(1:2000)=fix(g*500000*((1/500)*exp(-((i)-2001)/500)));

i=4001:6000;
FilePreference3(1:2000)=fix(g*500000*((1/500)*exp(-((i)-4001)/500)));

i=6001:8000;
FilePreference4(1:2000)=fix(g*500000*((1/500)*exp(-((i)-6001)/500)));

i=8001:10000;
FilePreference5(1:2000)=fix(g*500000*((1/500)*exp(-((i)-8001)/500)));

FilePreference=[FilePreference1' ; FilePreference2' ; FilePreference3' ;
                FilePreference4' ; FilePreference5'];
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Second Section:
% ---------------

% initial output by using input from a and b array in additional, input
% from two dimensional array of (10,000 by 250)
% each array has binomial data set for abc array of dimensions (10,000 by
% 250) and arrange it after that the output file Data-Set-New-ab-1.xls
% Data-Set-New-ab-100.xls
% will be used later here for more arranged.

abc=zeros(10000,250);


% Using the below loops for more arrange to adjust the final output file
% to be fully satisfy according to the two condition of summation equals a
% and b arrays.

%%%%%%% Actions

i=1;
j=1;
```

```
while (i<=2000);
  while (j<=50);
   if(sum(abc(i,:))<=FilePreference(i))\&(sum(abc(:,Ac(j)))<Node(3,Ac(j)));
            abc(i,Ac(j))=1;
elseif(sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Ac(j)))<Node(3,Ac(j)));
                abc(i,Ac(j))=1;
        else;
            abc(i,Ac(j))=0;
        end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

%%%%%%% Crime

i=2001;
j=1;

while (i<=4000);
  while (j<=50);
   if(sum(abc(i,:))<=FilePreference(i))\&(sum(abc(:,Cr(j)))<Node(3,Cr(j)));
            abc(i,Cr(j))=1;
elseif(sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Cr(j)))<Node(3,Cr(j)));
                abc(i,Cr(j))=1;
        else;
            abc(i,Cr(j))=0;
        end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

%%%%%%% Comedy

i=4001;
j=1;

while (i<=6000);
```

```
  while (j<=50);
   if(sum(abc(i,:))<=FilePreference(i))\&(sum(abc(:,Co(j)))<Node(3,Co(j)));
            abc(i,Co(j))=1;
elseif(sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Co(j)))<Node(3,Co(j)));
                abc(i,Co(j))=1;
        else;
            abc(i,Co(j))=0;
        end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

%%%%%%% Drama

i=6001;
j=1;

while (i<=8000);
    while (j<=50);
     ifsum(abc(i,:))<=FilePreference(i)\&(sum(abc(:,Dr(j)))<Node(3,Dr(j)));
            abc(i,Dr(j))=1;
elseif(sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Dr(j)))<Node(3,Dr(j)));
            abc(i,Dr(j))=1;
        else;
            abc(i,Dr(j))=0;
        end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

%%%%%%% Romance

i=8001;
j=1;

while (i<=10000);
  while (j<=50);
```

```
   if (sum(abc(i,:))<=FilePreference(i))\&(sum(abc(:,Ro(j)))<Node(3,Ro(j)));
            abc(i,Ro(j))=1;
elseif (sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Ro(j)))<Node(3,Ro(j)));
                abc(i,Ro(j))=1;
         else;
             abc(i,Ro(j))=0;
         end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

csvwrite(['Data-Set-abc',num2str(o),'.csv'],abc);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Third Section:
% --------------

% Identify each node on one set for assign Data File number (by other words
% which one from 10,000 file) and repeat it for 100 sets from output file
% Data-Set-New-ab-1.xls to Data-Set-New-ab-100.xls as output that
% will be used later for
% randomized build new 100 fresh sets.


cdc=zeros(800,250);

i=1;
j=1;
l=1;

while (j<=250);
    while (i<=10000);
        if abc(i,j)==1;
            cdc(l,j)=i;
            l=l+1;
        end;
        i=i+1;
    end;
    j=j+1;
```

```
    i=1;
    l=1;
end;

csvwrite(['Data-Set-cdc',num2str(o),'.csv'],cdc);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Forth Section:
% --------------


[Y,X]=max(cdc);

FileIndex=zeros(800,250);
    % [800 by 250] randomized file index per node and ranked for preference
    % watched according to the node index.

i=1;
j=1;

while (j<=250);

    Brandom=[];

    Brandom=randperm(X(j));

    while (i<=Node(3,j));
        if Node(3,j)\sim =0;
            FileIndex(i,j)=cdc(Brandom(i),j);
            i=i+1;
        else;
            break;
        end;
    end;
    j=j+1;
    i=1;
end;

csvwrite(['Data-Set-FileIndex',num2str(o),'.csv'],FileIndex);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
% Using the output from previous section or (cdc)
% to build batch size randomized but non-repeatable
% from 1 to 6, but the output file has first column 0's
% output to Data-Set-BatchSize-1.xls to Data-Set-BatchSize-100.xls

[C,L]=max(cdc);

%vdc=[];

i=1;
j=1;

while (j<=250);

    eval(['Node' num2str(j) ' =[];']);

    eval(['Node' num2str(j) ' =zeros(1,230);']);
    x=fix(L(j)/21);
    y=L(j)-x*21;

    m=0;
    n=0;

    while (i<=x);
        m=6*(i-1)+1;
        n=6*i;
        eval(['Node' num2str(j) ' (m:n)=randperm(6);']);
        i=i+1;
    end;

    if (y<=6);
        eval(['Node' num2str(j) ' (n+1)=y;']);
    elseif (y<=9);
        if (y>=7);
            eval(['Node' num2str(j) ' (n+1:n+3)=randperm(3);']);
            eval(['Node' num2str(j) ' (n+4)=y-6;']);
        end;
    elseif y==10;
        eval(['Node' num2str(j) ' (n+1:n+4)=randperm(4);']);
    elseif (y<=14);
        if (y>=11);
```

```
            eval(['Node' num2str(j) ' (n+1:n+4)=randperm(4);']);
            eval(['Node' num2str(j) ' (n+5)=y-10;']);
        end;
    elseif y==15;
        eval(['Node' num2str(j) ' (n+1:n+5)=randperm(5);']);
    else (y<=20);
        if (y>=16);
            eval(['Node' num2str(j) ' (n+1:n+5)=randperm(5);']);
            eval(['Node' num2str(j) ' (n+6)=y-15;']);
        end;
    end;

    BatchSize=[BatchSize ; eval(['Node' num2str(j)])];
    j=j+1;
    i=1;

end;

BatchSize=BatchSize';

csvwrite(['Data-Set-BatchSize',num2str(o),'.csv'],BatchSize);
                                        % Batch Size for random(1-6).

end;
```

B.2.2 Main Body Code

```
% Calculate the Penality of the difference between download time and watched
% time For Base Line.

Ordered=2.8;
          % Used as initial order after first time subscribe to the service.

for BandWidth=[25,50,100,128,512,1000,2000,5000];

for o=1:50;

    ArrivalTime=[]; InterDownloadTime=[]; AccumulationDownloadTime=[];

    ArrivalTime=zeros(800,250); % To calculate Arrival Time (Watched Time).
```

```
InterDownloadTime=zeros(800,250);
          % To calculate individual time has been taken for each file
          % index to be download per node.

AccumulationDownloadTime=zeros(800,250);
          % To calculate Accumulation time per node has been take as a
          % total time per year according to Watched time (Arrival
          % Time).

ArrivalTimeL=[];
          % Collect Arrival Time for all node under one line of matrix
          % [n by 1].

AccumulationDownloadTimeL=[];
          % Collect Accumulation Download Time for all node under one
          % line of matrix [n by 1].

InterDownloadTimeL=[];
          % Collect Inter Download Time [n by 1].

NodeL=[];
          % Collect the node relatively to on the same row for Arrival
          %Time on one line of matrix [n by 1].

FileIndexandSizeL=[];
          % Collect File Index and File's Size on the same row for all
          % node on matrix [n by 3].

Available=[];
          % used to get availability of the file to be watched by the
          % node.

AvailableL=[];
          % Collect all the availabilty on one line matrix [n by 1];

Penalty=[];
          % Get to calculate each Penalty for each node for each file.

InterArrivalTimeL=[];
          % Collect Inter Arrival Time on one line matrix [n by 1].
```

```
Total=[];
         % Put all in one Matrix [File index, File Size, Arrival Time
         % Sorted, Accumulation Time, Node Number] all according to
         % Arrival Time (Batched Time).


m=1;
n=0;
i=1;
j=2;
k=0;

while (i<=250);

    if (Node(3,i) \sim =0);

        ArrivalTime(1,i)=InterArrivalTime(3,i);

        InterDownloadTime(1,i)=[FileSize(FileIndex(1,i),2)*8000000]/
                                       [BandWidth*3600];

        InterDownloadTimeL=[InterDownloadTimeL;InterDownloadTime(1,i)];

        InterArrivalTimeL=[InterArrivalTimeL ; InterArrivalTime(3,i)];

        AccumulationDownloadTime(1,i)=InterDownloadTime(1,i);

        FileIndexandSizeL=[FileIndexandSizeL ;
                FileSize(FileIndex(1,i),1)  FileSize(FileIndex(1,i),2)
                FileSize(FileIndex(1,i),3)/60];

        Available(1,i)=Ordered+InterDownloadTime(1,i);

        if Available(1,i)>ArrivalTime(1,i);
            Penalty=[Penalty ; Available(1,i)-ArrivalTime(1,i)];
        else;
            Penalty=[Penalty ; 0];
        end;

        while (j<=Node(3,i));
            InterDownloadTime(j,i)=[FileSize(FileIndex(j,i),2)*8000000]/
```

```
                        [BandWidth*3600];

 InterDownloadTimeL=[InterDownloadTimeL ;
                    InterDownloadTime(j,i)];

 InterArrivalTimeL=[InterArrivalTimeL ;
                   InterArrivalTime(j+2,i)];

 AccumulationDownloadTime(j,i)=InterDownloadTime(j,i)+
                           AccumulationDownloadTime(j-1,i);

 FileIndexandSizeL=[FileIndexandSizeL ;
       FileSize(FileIndex(j,i),1)  FileSize(FileIndex(j,i),2)
       FileSize(FileIndex(j,i),3)/60];

if j-1==(n+BatchSize(m,i));

 Available(j,i)=max(Available(j-1,i),ArrivalTime(j-1,i))+
                  (FileSize(FileIndex(j-1,i),3)/60)+
                   InterDownloadTime(j,i);

 ArrivalTime(j,i)=max(Available(j-1,i),
                     ArrivalTime(j-1,i))+
                    (FileSize(FileIndex(j-1,i),3)/60)+
                     InterArrivalTime(j+2,i);

 n=BatchSize(m,i);
 m=m+1;

 else
     Available(j,i)=Available(j-1,i)+InterDownloadTime(j,i);
     ArrivalTime(j,i)=ArrivalTime(j-1,i)+
                     InterArrivalTime(j+2,i);

 end;

 if Available(j,i)>ArrivalTime(j,i);
     Penalty=[Penalty ; Available(j,i)-ArrivalTime(j,i)];
 else;
     Penalty=[Penalty ; 0];
 end;
```

```
                j=j+1;

            end;

            ArrivalTimeL=[ArrivalTimeL ; ArrivalTime(1:Node(3,i),i)];
            AccumulationDownloadTimeL=[AccumulationDownloadTimeL ;
                                 AccumulationDownloadTime(1:Node(3,i),i)];
            AvailableL=[AvailableL ; Available(1:Node(3,i),i)];

        end;

        if i==1;
            k=0;
        else
            k=k+Node(3,i-1);
        end;

        NodeL(k+1:k+Node(3,i),1)=i;

        i=i+1;
       j=2;
       m=1;
        n=0;

    end;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

  % Calculate the amount can be saved in hard drive and what are the
  % priorities of files to keep in hard drives after emptying.

    for SizeHDD=50:50:1000;
        % Size of the hard disc drive is start from 50GB to 1000GB by 50GB
        % increment.

        Total=[];
            % Repeatable Rest. And Put all in one Matrix [File index, File
            % Size, Arrival Time Sorted, Accumulation Time, Node Number]
            % all according to Arrival Time (Eatched Time).
```

```
Total=[FileIndexandSizeL  Penalty  InterArrivalTimeL  ArrivalTimeL
       InterDownloadTimeL  AccumulationDownloadTimeL  AvailableL
       NodeL];

RemovedL=zeros(size(Total(:,1)));
ServerL=ones(size(Total(:,1)));

j=1;

while (j<=250);

    ContentSize=0; % Count the Totla files' size of exsiting HDD
    row=[]; % Used to get the row number for the file requested.
    row=find(Total(:,10)==j);

    if isempty(row)==0;

        if size(row)>=2;
            ContentSize=FileIndexandSizeL(row(1),2)+
                        FileIndexandSizeL(row(2),2);
        else;
            ContentSize=FileIndexandSizeL(row(1),2);
        end;

        for i=3:size(row);
            if ContentSize<(.75*SizeHDD);
                ContentSize=ContentSize+
                            FileIndexandSizeL(row(i),2);
            else;
                [s1,s2]=sort(Total(row(1):row(i-2),1));
                for k=size(s2):-1:1;
                    if ContentSize>(.5*SizeHDD);
                        ContentSize=ContentSize-
                                    FileIndexandSizeL
                                    (row(s2(k)),2);
                        RemovedL(row(s2(k)))=1;
                        FileIndexandSizeL(row(s2(k)),2)=0;
                    else;
                        break;
                    end;
                end;
```

```
            end;
        end;
    end;
    j=j+1;
end;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

j=1;

while (j<=10000);

    row=[]; % Used to get the row number for the file requested.
    Server=[];
       %Used to highlight where the file has been download from.
    InterDownloadFile=[]; %Find the exact file download time.

    row=find(Total(:,1)==j);

    if isempty(row)==0;

        [s1,s2]=sort(Total(row,9));

        InterDownloadFile=Total(row(1),7);

        Server(s2(1),1)=1;

        for i=2:max(s2);

            if (s1(1)>=InterDownloadFile &&
                        RemovedL(row(s2(1)))==0);
                Server(s2(2),1)=.5;
            else;
                Server(s2(2),1)=1;
            end;

            if i>=3;
                f=1;
                m=0;
                for k=i:-1:2;
                    if (s1(i)-s1(k-1)>=f*InterDownloadFile &&
```

```
                                        RemovedL(row(s2(i)))==0);
                                if f==1;
                                    Server(s2(i),1)=0;
                                    break;
                                else;
                                    Server(s2(i),1)=.5-m;
                                end;
                            elseif i-1==2
                                Server(s2(i))=1;
                                break;
                            else;
                                f=f+1;
                                if k==3;
                                    m=.5;
                                    Server(s2(i))=1;
                                end;
                            end;
                        end;
                    end;
                end;
            end;

            Server=Server(:).*Total(row,7);

            ServerL(row,1)=Server(:);

            j=j+1;

        end;

        Total=[Total  ServerL  RemovedL];

        csvwrite(['Data_Set_New_Total_H1_',num2str(BandWidth),'_',
                   num2str(SizeHDD),'_',num2str(o),'.csv'],Total);

    end;

end;

end;
```

B.3 HEURISTIC H2 (M-FILE)

B.3.1 Initial Settings

```
clear;

FileSize=xlsread('F-S.xls');
 % [10,000 by 3] first colomn for file index second colomn for file size per GB.

for o=1:10;

    Ac=[]; Cr=[]; Co=[]; Dr=[]; Ro=[];
    i=0; j=0; l=0; N=0; n=0; m=0; x=0; y=0; k=0; errorr=0; g=0; BandWidth=0;
    abc=[]; cdc=[]; X=[]; Y=[]; C=[]; L=[];

    InterArrivalTime=[]; Node=[]; FileIndex=[]; BatchSize=[];
    FilePreference=[]; FilePreference1=[]; FilePreference2=[];
    FilePreference3=[]; FilePreference4=[]; FilePreference5=[];

    InterArrivalTime=csvread(['Data-Set-1',num2str(o),'.csv']);
              % [802 by 250] first two row is not belong to Interarrival time.

    Node=csvread(['Data-Set-b',num2str(o),'.csv']);
       % [3 by 250] last row for how many files watched by each node per year.

    % Initial Section:
    % ---------------

    % Produce random node number of count 50 for each of Action, Crime, Comedy,
    % Drama and Romance.

    N=randperm(250);

    N=N';

    Ac=N(1:50);
    Cr=N(51:100);
    Co=N(101:150);
    Dr=N(151:200);
    Ro=N(201:250);
```

```
% First Section:
% --------------
% Divide 10,000 files to 5 category to Action, Crime, Comedy, Drama and
% Romance. as each category ranked from High to Low priority and get toatl
% of watches per node from Data-Set-b?.xls.

if  sum(Node(3,:))<40000;
   k=fix(sum(Node(3,:))/5);
    errorr=((k-6990)*130)/500*.00004/5;
    g=(k*.050911002/sum(Node(3,:)))+.0061+errorr;
elseif (sum(Node(3,:))>=40000) \& (sum(Node(3,:))<50000);
    k=fix(sum(Node(3,:))/5);
    errorr=((k-7000)*130)/500*.00004/5;
    g=(k*.050911002/sum(Node(3,:)))+.0061+errorr;
elseif (sum(Node(3,:))>=50000);
    k=fix(sum(Node(3,:))/5);
    errorr=((k-7035)*130)/500*.00004/5;
    g=(k*.050911002/sum(Node(3,:)))+.0061+errorr;
end;

i=1:2000;
FilePreference1(i)=fix(g*500000*((1/500)*exp(-((i)-1)/500)));

i=2001:4000;
FilePreference2(1:2000)=fix(g*500000*((1/500)*exp(-((i)-2001)/500)));

i=4001:6000;
FilePreference3(1:2000)=fix(g*500000*((1/500)*exp(-((i)-4001)/500)));

i=6001:8000;
FilePreference4(1:2000)=fix(g*500000*((1/500)*exp(-((i)-6001)/500)));

i=8001:10000;
FilePreference5(1:2000)=fix(g*500000*((1/500)*exp(-((i)-8001)/500)));

FilePreference=[FilePreference1' ; FilePreference2' ; FilePreference3' ;
                FilePreference4' ; FilePreference5'];
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Second Section:
% ---------------
```

```
% initial output by using input from a and b array in additional, input
% from two dimensional array of (10,000 by 250)
% each array has binomial data set for abc array of dimensions (10,000 by
% 250) and arrange it after that the output file Data-Set-New-ab-1.xls
% Data-Set-New-ab-100.xls
% will be used later here for more arranged.

abc=zeros(10000,250);


% Using the below loops for more arrange to adjust the final output file
% to be fully satisfy according to the two condition of summation equals a
% and b arrays.

%%%%%%% Actions

i=1;
j=1;

while (i<=2000);
  while (j<=50);
   if(sum(abc(i,:))<=FilePreference(i))\&(sum(abc(:,Ac(j)))<Node(3,Ac(j)));
            abc(i,Ac(j))=1;
elseif(sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Ac(j)))<Node(3,Ac(j)));
                abc(i,Ac(j))=1;
        else;
            abc(i,Ac(j))=0;
        end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

%%%%%%% Crime

i=2001;
j=1;

while (i<=4000);
```

```
  while (j<=50);
   if(sum(abc(i,:))<=FilePreference(i))\&(sum(abc(:,Cr(j)))<Node(3,Cr(j)));
            abc(i,Cr(j))=1;
elseif(sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Cr(j)))<Node(3,Cr(j)));
                abc(i,Cr(j))=1;
        else;
            abc(i,Cr(j))=0;
        end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

%%%%%%% Comedy

i=4001;
j=1;

while (i<=6000);
  while (j<=50);
   if(sum(abc(i,:))<=FilePreference(i))\&(sum(abc(:,Co(j)))<Node(3,Co(j)));
            abc(i,Co(j))=1;
elseif(sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Co(j)))<Node(3,Co(j)));
                abc(i,Co(j))=1;
        else;
            abc(i,Co(j))=0;
        end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

%%%%%%% Drama

i=6001;
j=1;

while (i<=8000);
    while (j<=50);
```

```
     ifsum(abc(i,:))<=FilePreference(i)\&(sum(abc(:,Dr(j)))<Node(3,Dr(j)));
            abc(i,Dr(j))=1;
elseif(sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Dr(j)))<Node(3,Dr(j)));
            abc(i,Dr(j))=1;
        else;
            abc(i,Dr(j))=0;
        end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

%%%%%%% Romance

i=8001;
j=1;

while (i<=10000);
  while (j<=50);
   if (sum(abc(i,:))<=FilePreference(i))\&(sum(abc(:,Ro(j)))<Node(3,Ro(j)));
            abc(i,Ro(j))=1;
elseif (sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Ro(j)))<Node(3,Ro(j)));
                abc(i,Ro(j))=1;
         else;
             abc(i,Ro(j))=0;
         end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

csvwrite(['Data-Set-abc',num2str(o),'.csv'],abc);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Third Section:
% --------------

% Identify each node on one set for assign Data File number (by other words
% which one from 10,000 file) and repeat it for 100 sets from output file
```

```
% Data-Set-New-ab-1.xls to Data-Set-New-ab-100.xls as output that
% will be used later for
% randomized build new 100 fresh sets.


cdc=zeros(800,250);

i=1;
j=1;
l=1;

while (j<=250);
    while (i<=10000);
        if abc(i,j)==1;
            cdc(l,j)=i;
            l=l+1;
        end;
        i=i+1;
    end;
    j=j+1;
    i=1;
    l=1;
end;

csvwrite(['Data-Set-cdc',num2str(o),'.csv'],cdc);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Forth Section:
% --------------


[Y,X]=max(cdc);

FileIndex=zeros(800,250);
    % [800 by 250] randomized file index per node and ranked for preference
    % watched according to the node index.

i=1;
j=1;

while (j<=250);
```

```
    Brandom=[];

    Brandom=randperm(X(j));

    while (i<=Node(3,j));
        if Node(3,j)\sim =0;
            FileIndex(i,j)=cdc(Brandom(i),j);
            i=i+1;
        else;
            break;
        end;
    end;
    j=j+1;
    i=1;
end;

csvwrite(['Data-Set-FileIndex',num2str(o),'.csv'],FileIndex);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Using the output from previous section or (cdc)
% to build batch size randomized but non-repeatable
% from 1 to 6, but the output file has first column 0's
% output to Data-Set-BatchSize-1.xls to Data-Set-BatchSize-100.xls

[C,L]=max(cdc);

%vdc=[];

i=1;
j=1;

while (j<=250);

    eval(['Node' num2str(j) ' =[];']);

    eval(['Node' num2str(j) ' =zeros(1,230);']);
    x=fix(L(j)/21);
    y=L(j)-x*21;

    m=0;
```

```
    n=0;

    while (i<=x);
        m=6*(i-1)+1;
        n=6*i;
        eval(['Node' num2str(j) ' (m:n)=randperm(6);']);
        i=i+1;
    end;

    if (y<=6);
        eval(['Node' num2str(j) ' (n+1)=y;']);
    elseif (y<=9);
        if (y>=7);
            eval(['Node' num2str(j) ' (n+1:n+3)=randperm(3);']);
            eval(['Node' num2str(j) ' (n+4)=y-6;']);
        end;
    elseif y==10;
        eval(['Node' num2str(j) ' (n+1:n+4)=randperm(4);']);
    elseif (y<=14);
        if (y>=11);
            eval(['Node' num2str(j) ' (n+1:n+4)=randperm(4);']);
            eval(['Node' num2str(j) ' (n+5)=y-10;']);
        end;
    elseif y==15;
        eval(['Node' num2str(j) ' (n+1:n+5)=randperm(5);']);
    else (y<=20);
        if (y>=16);
            eval(['Node' num2str(j) ' (n+1:n+5)=randperm(5);']);
            eval(['Node' num2str(j) ' (n+6)=y-15;']);
        end;
    end;

    BatchSize=[BatchSize ; eval(['Node' num2str(j)])];
    j=j+1;
    i=1;

end;

BatchSize=BatchSize';

csvwrite(['Data-Set-BatchSize',num2str(o),'.csv'],BatchSize);
```

```
                                        % Batch Size for random(1-6).

end;
```

B.3.2 Main Body Code

```
% Calculate the Penality of the difference between download time and watched
% time For Base Line.

Ordered=2.8;
          % Used as initial order after first time subscribe to the service.

for BandWidth=[25,50,100,128,512,1000,2000,5000];

for o=1:50;

    ArrivalTime=[]; InterDownloadTime=[]; AccumulationDownloadTime=[];

    ArrivalTime=zeros(800,250); % To calculate Arrival Time (Watched Time).

    InterDownloadTime=zeros(800,250);
              % To calculate individual time has been taken for each file
              % index to be download per node.

    AccumulationDownloadTime=zeros(800,250);
              % To calculate Accumulation time per node has been take as a
              % total time per year according to Watched time (Arrival
              % Time).

    ArrivalTimeL=[];
              % Collect Arrival Time for all node under one line of matrix
              % [n by 1].

    AccumulationDownloadTimeL=[];
              % Collect Accumulation Download Time for all node under one
              % line of matrix [n by 1].

    InterDownloadTimeL=[];
              % Collect Inter Download Time [n by 1].
```

```
NodeL=[];
          % Collect the node relatively to on the same row for Arrival
          %Time on one line of matrix [n by 1].

FileIndexandSizeL=[];
          % Collect File Index and File's Size on the same row for all
          % node on matrix [n by 3].

Available=[];
          % used to get availability of the file to be watched by the
          % node.

AvailableL=[];
          % Collect all the availabilty on one line matrix [n by 1];

Penalty=[];
          % Get to calculate each Penalty for each node for each file.

InterArrivalTimeL=[];
          % Collect Inter Arrival Time on one line matrix [n by 1].

Total=[];
         % Put all in one Matrix [File index, File Size, Arrival Time
         % Sorted, Accumulation Time, Node Number] all according to
         % Arrival Time (Batched Time).


m=1;
n=0;
i=1;
j=2;
k=0;

while (i<=250);

    if (Node(3,i) \sim =0);

        ArrivalTime(1,i)=InterArrivalTime(3,i);

        InterDownloadTime(1,i)=[FileSize(FileIndex(1,i),2)*8000000]/
                               [BandWidth*3600];
```

```
InterDownloadTimeL=[InterDownloadTimeL;InterDownloadTime(1,i)];

InterArrivalTimeL=[InterArrivalTimeL ; InterArrivalTime(3,i)];

AccumulationDownloadTime(1,i)=InterDownloadTime(1,i);

FileIndexandSizeL=[FileIndexandSizeL ;
        FileSize(FileIndex(1,i),1)  FileSize(FileIndex(1,i),2)
        FileSize(FileIndex(1,i),3)/60];

Available(1,i)=Ordered+InterDownloadTime(1,i);

if Available(1,i)>ArrivalTime(1,i);
    Penalty=[Penalty ; Available(1,i)-ArrivalTime(1,i)];
else;
    Penalty=[Penalty ; 0];
end;

while (j<=Node(3,i));
    InterDownloadTime(j,i)=[FileSize(FileIndex(j,i),2)*8000000]/
                           [BandWidth*3600];

    InterDownloadTimeL=[InterDownloadTimeL ;
                        InterDownloadTime(j,i)];

    InterArrivalTimeL=[InterArrivalTimeL ;
                       InterArrivalTime(j+2,i)];

    AccumulationDownloadTime(j,i)=InterDownloadTime(j,i)+
                                  AccumulationDownloadTime(j-1,i);

    FileIndexandSizeL=[FileIndexandSizeL ;
         FileSize(FileIndex(j,i),1)  FileSize(FileIndex(j,i),2)
         FileSize(FileIndex(j,i),3)/60];

   if j-1==(n+BatchSize(m,i));

    Available(j,i)=max(Available(j-1,i),ArrivalTime(j-1,i))+
                  (FileSize(FileIndex(j-1,i),3)/60)+
                   InterDownloadTime(j,i);
```

```
        ArrivalTime(j,i)=max(Available(j-1,i),
                             ArrivalTime(j-1,i))+
                             (FileSize(FileIndex(j-1,i),3)/60)+
                             InterArrivalTime(j+2,i);

        n=BatchSize(m,i);
        m=m+1;

        else
            Available(j,i)=Available(j-1,i)+InterDownloadTime(j,i);
            ArrivalTime(j,i)=ArrivalTime(j-1,i)+
                             InterArrivalTime(j+2,i);

        end;

        if Available(j,i)>ArrivalTime(j,i);
            Penalty=[Penalty ; Available(j,i)-ArrivalTime(j,i)];
        else;
            Penalty=[Penalty ; 0];
        end;

        j=j+1;

    end;

    ArrivalTimeL=[ArrivalTimeL ; ArrivalTime(1:Node(3,i),i)];
    AccumulationDownloadTimeL=[AccumulationDownloadTimeL ;
                           AccumulationDownloadTime(1:Node(3,i),i)];
    AvailableL=[AvailableL ; Available(1:Node(3,i),i)];

end;

if i==1;
    k=0;
else
    k=k+Node(3,i-1);
end;

NodeL(k+1:k+Node(3,i),1)=i;

i=i+1;
```

```
        j=2;
        m=1;
         n=0;

    end;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Calculate the amount can be saved in hard drive and what are the
% priorities of files to keep in hard drives after emptying.

    for SizeHDD=50:50:1000;
        % Size of the hard disc drive is start from 50GB to 1000GB by 50GB
        % increment.

        Total=[];
            % Repeatable Rest. And Put all in one Matrix [File index, File
            % Size, Arrival Time Sorted, Accumulation Time, Node Number]
            % all according to Arrival Time (Eatched Time).

        Total=[FileIndexandSizeL  Penalty  InterArrivalTimeL  ArrivalTimeL
               InterDownloadTimeL  AccumulationDownloadTimeL  AvailableL
               NodeL];

        RemovedL=zeros(size(Total(:,1)));
        ServerL=ones(size(Total(:,1)));

        j=1;

        while (j<=250);

            ContentSize=0; % Count the Totla files' size of exsiting HDD
            row=[]; % Used to get the row number for the file requested.
            row=find(Total(:,10)==j);

            if isempty(row)==0;

                if size(row)>=2;
                    ContentSize=FileIndexandSizeL(row(1),2)+
                                FileIndexandSizeL(row(2),2);
                else;
```

```
                ContentSize=FileIndexandSizeL(row(1),2);
            end;

            for i=3:size(row);
                if ContentSize<(.75*SizeHDD);
                    ContentSize=ContentSize+
                                FileIndexandSizeL(row(i),2);
                else;
                    [s1,s2]=sort(Total(row(1):row(i-2),1));
                    for k=size(s2):-1:1;
                        if ContentSize>(.5*SizeHDD);
                            ContentSize=ContentSize-
                                        FileIndexandSizeL
                                        (row(s2(k)),2);
                            RemovedL(row(s2(k)))=1;
                            FileIndexandSizeL(row(s2(k)),2)=0;
                        else;
                            break;
                        end;
                    end;
                end;
            end;
        end;
        j=j+1;
    end;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

    j=1;

    while (j<=10000);

        row=[]; % Used to get the row number for the file requested.
        Server=[];
           %Used to highlight where the file has been download from.
        InterDownloadFile=[]; %Find the exact file download time.

        row=find(Total(:,1)==j);

        if isempty(row)==0;
```

```
    [s1,s2]=sort(Total(row,9));

    InterDownloadFile=Total(row(1),7);

    Server(s2(1),1)=1;

    for i=2:max(s2);

        if (s1(1)>=InterDownloadFile &&
                    RemovedL(row(s2(1)))==0);
            Server(s2(2),1)=.5;
        else;
            Server(s2(2),1)=1;
        end;

        if i>=3;
            f=1;
            m=0;
            for k=i:-1:2;
                if (s1(i)-s1(k-1)>=f*InterDownloadFile &&
                                        RemovedL(row(s2(i)))==0);
                    if f==1;
                        Server(s2(i),1)=0;
                        break;
                    else;
                        Server(s2(i),1)=.5-m;
                    end;
                elseif i-1==2
                    Server(s2(i))=1;
                    break;
                else;
                    f=f+1;
                    if k==3;
                        m=.5;
                        Server(s2(i))=1;
                    end;
                end;
            end;
        end;
    end;
end;
```

```
        Server=Server(:).*Total(row,7);

        ServerL(row,1)=Server(:);

        j=j+1;

    end;

    Total=[Total  ServerL  RemovedL];

    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Calculate H2 (Preemptive 20%) by using Data Set Results from H1 for all
% different Hard Drive sizes and differnt BandWidth sizes.
% Get to Calculate H2 for Plotting a server download time versus actual download
% it from server.
% By using HDD size from 50GB to 1TB, and Band width from 50Kb/s to 15Mb/s

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

  %Calculate the Penality of the difference between download time and watched
  %time For base on preemtive case senario.


    PreemptiveL=[];

    j=1;

    while (j<=250);

        Preemptive=[]; % Incert Certain file during H2 Heuristc Senario.
        CountTwintyPersent=0;
                 % Use a counter to upload certain files to the Network.

        row=find(Total(:,10)==j);

        Preemptive=zeros(size(row));
                 %Rest The matrix for File Incertions.

        ExisttingFiles=Total(row,12);
```

```
                % Upload all possibilities of an existing file in Hard
                % Drives which is came from RemovedL matrix.

        ZeroMatrix=find(ExisttingFiles(:)==0);
                % Find Exact Files still on the Hard Drives.

        TwintyPersent=round(size(ZeroMatrix)*.2);
                % Calcuate an amount of files need to be distribute to
                % the Network which is 20%.

        if isempty(TwintyPersent(1))==0;

            CountTwintyPersent=1;

            for i=1:size(ExisttingFiles);
                if ExisttingFiles(i)==0;
                    if CountTwintyPersent<=TwintyPersent(1);
                        Preemptive(i)=1; % Incert file to the Network.
                        CountTwintyPersent=CountTwintyPersent+1;
                    end;
                end;
            end;
        end;

        PreemptiveL=[PreemptiveL ; Preemptive];

        j=j+1;


    end;

    Total=[Total  PreemptiveL];

    csvwrite(['Data_Set_New_Total_H2_',num2str(BandWidth),'_',
             num2str(SizeHDD),'_',num2str(o),'.csv'],Total);

end;

end;

end;
```

B.4 HEURISTIC H3 (M-FILE)

B.4.1 Initial Settings

```
clear;

FileSize=xlsread('F-S.xls');
 % [10,000 by 3] first colomn for file index second colomn for file size per GB.

for o=1:10;

    Ac=[]; Cr=[]; Co=[]; Dr=[]; Ro=[];
    i=0; j=0; l=0; N=0; n=0; m=0; x=0; y=0; k=0; errorr=0; g=0; BandWidth=0;
    abc=[]; cdc=[]; X=[]; Y=[]; C=[]; L=[];

    InterArrivalTime=[]; Node=[]; FileIndex=[]; BatchSize=[];
    FilePreference=[]; FilePreference1=[]; FilePreference2=[];
    FilePreference3=[]; FilePreference4=[]; FilePreference5=[];

    InterArrivalTime=csvread(['Data-Set-1',num2str(o),'.csv']);
              % [802 by 250] first two row is not belong to Interarrival time.

    Node=csvread(['Data-Set-b',num2str(o),'.csv']);
       % [3 by 250] last row for how many files watched by each node per year.

    % Initial Section:
    % ---------------

    % Produce random node number of count 50 for each of Action, Crime, Comedy,
    % Drama and Romance.

    N=randperm(250);

    N=N';

    Ac=N(1:50);
    Cr=N(51:100);
    Co=N(101:150);
    Dr=N(151:200);
```

```
Ro=N(201:250);

% First Section:
% --------------
% Divide 10,000 files to 5 category to Action, Crime, Comedy, Drama and
% Romance. as each category ranked from High to Low priority and get toatl
% of watches per node from Data-Set-b?.xls.

if  sum(Node(3,:))<40000;
   k=fix(sum(Node(3,:))/5);
    errorr=((k-6990)*130)/500*.00004/5;
    g=(k*.050911002/sum(Node(3,:)))+.0061+errorr;
elseif (sum(Node(3,:))>=40000) \& (sum(Node(3,:))<50000);
    k=fix(sum(Node(3,:))/5);
    errorr=((k-7000)*130)/500*.00004/5;
    g=(k*.050911002/sum(Node(3,:)))+.0061+errorr;
elseif (sum(Node(3,:))>=50000);
    k=fix(sum(Node(3,:))/5);
    errorr=((k-7035)*130)/500*.00004/5;
    g=(k*.050911002/sum(Node(3,:)))+.0061+errorr;
end;

i=1:2000;
FilePreference1(i)=fix(g*500000*((1/500)*exp(-((i)-1)/500)));

i=2001:4000;
FilePreference2(1:2000)=fix(g*500000*((1/500)*exp(-((i)-2001)/500)));

i=4001:6000;
FilePreference3(1:2000)=fix(g*500000*((1/500)*exp(-((i)-4001)/500)));

i=6001:8000;
FilePreference4(1:2000)=fix(g*500000*((1/500)*exp(-((i)-6001)/500)));

i=8001:10000;
FilePreference5(1:2000)=fix(g*500000*((1/500)*exp(-((i)-8001)/500)));

FilePreference=[FilePreference1' ; FilePreference2' ; FilePreference3' ;
                FilePreference4' ; FilePreference5'];
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
% Second Section:
% ---------------

% initial output by using input from a and b array in additional, input
% from two dimensional array of (10,000 by 250)
% each array has binomial data set for abc array of dimensions (10,000 by
% 250) and arrange it after that the output file Data-Set-New-ab-1.xls
% Data-Set-New-ab-100.xls
% will be used later here for more arranged.

abc=zeros(10000,250);


% Using the below loops for more arrange to adjust the final output file
% to be fully satisfy according to the two condition of summation equals a
% and b arrays.

%%%%%%% Actions

i=1;
j=1;

while (i<=2000);
  while (j<=50);
   if(sum(abc(i,:))<=FilePreference(i))\&(sum(abc(:,Ac(j)))<Node(3,Ac(j)));
            abc(i,Ac(j))=1;
elseif(sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Ac(j)))<Node(3,Ac(j)));
                abc(i,Ac(j))=1;
        else;
            abc(i,Ac(j))=0;
        end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

%%%%%%% Crime

i=2001;
j=1;
```

```
while (i<=4000);
  while (j<=50);
   if(sum(abc(i,:))<=FilePreference(i))\&(sum(abc(:,Cr(j)))<Node(3,Cr(j)));
            abc(i,Cr(j))=1;
elseif(sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Cr(j)))<Node(3,Cr(j)));
                abc(i,Cr(j))=1;
        else;
            abc(i,Cr(j))=0;
        end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

%%%%%%% Comedy

i=4001;
j=1;

while (i<=6000);
  while (j<=50);
   if(sum(abc(i,:))<=FilePreference(i))\&(sum(abc(:,Co(j)))<Node(3,Co(j)));
            abc(i,Co(j))=1;
elseif(sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Co(j)))<Node(3,Co(j)));
                abc(i,Co(j))=1;
        else;
            abc(i,Co(j))=0;
        end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

%%%%%%% Drama

i=6001;
j=1;
```

```
while (i<=8000);
    while (j<=50);
     ifsum(abc(i,:))<=FilePreference(i)\&(sum(abc(:,Dr(j)))<Node(3,Dr(j)));
            abc(i,Dr(j))=1;
elseif(sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Dr(j)))<Node(3,Dr(j)));
            abc(i,Dr(j))=1;
        else;
            abc(i,Dr(j))=0;
        end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

%%%%%%% Romance

i=8001;
j=1;

while (i<=10000);
  while (j<=50);
   if (sum(abc(i,:))<=FilePreference(i))\&(sum(abc(:,Ro(j)))<Node(3,Ro(j)));
            abc(i,Ro(j))=1;
elseif (sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Ro(j)))<Node(3,Ro(j)));
                abc(i,Ro(j))=1;
         else;
             abc(i,Ro(j))=0;
         end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

csvwrite(['Data-Set-abc',num2str(o),'.csv'],abc);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Third Section:
% --------------
```

```
% Identify each node on one set for assign Data File number (by other words
% which one from 10,000 file) and repeat it for 100 sets from output file
% Data-Set-New-ab-1.xls to Data-Set-New-ab-100.xls as output that
% will be used later for
% randomized build new 100 fresh sets.


cdc=zeros(800,250);

i=1;
j=1;
l=1;

while (j<=250);
    while (i<=10000);
        if abc(i,j)==1;
            cdc(l,j)=i;
            l=l+1;
        end;
        i=i+1;
    end;
    j=j+1;
    i=1;
    l=1;
end;

csvwrite(['Data-Set-cdc',num2str(o),'.csv'],cdc);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Forth Section:
% --------------


[Y,X]=max(cdc);

FileIndex=zeros(800,250);
    % [800 by 250] randomized file index per node and ranked for preference
    % watched according to the node index.

i=1;
j=1;
```

```
while (j<=250);

    Brandom=[];

    Brandom=randperm(X(j));

    while (i<=Node(3,j));
        if Node(3,j)\sim =0;
            FileIndex(i,j)=cdc(Brandom(i),j);
            i=i+1;
        else;
            break;
        end;
    end;
    j=j+1;
    i=1;
end;

csvwrite(['Data-Set-FileIndex',num2str(o),'.csv'],FileIndex);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Using the output from previous section or (cdc)
% to build batch size randomized but non-repeatable
% from 1 to 6, but the output file has first column 0's
% output to Data-Set-BatchSize-1.xls to Data-Set-BatchSize-100.xls

[C,L]=max(cdc);

%vdc=[];

i=1;
j=1;

while (j<=250);

    eval(['Node' num2str(j) ' =[];']);

    eval(['Node' num2str(j) ' =zeros(1,230);']);
    x=fix(L(j)/21);
    y=L(j)-x*21;
```

```
    m=0;
    n=0;

    while (i<=x);
        m=6*(i-1)+1;
        n=6*i;
        eval(['Node' num2str(j) ' (m:n)=randperm(6);']);
        i=i+1;
    end;

    if (y<=6);
        eval(['Node' num2str(j) ' (n+1)=y;']);
    elseif (y<=9);
        if (y>=7);
            eval(['Node' num2str(j) ' (n+1:n+3)=randperm(3);']);
            eval(['Node' num2str(j) ' (n+4)=y-6;']);
        end;
    elseif y==10;
        eval(['Node' num2str(j) ' (n+1:n+4)=randperm(4);']);
    elseif (y<=14);
        if (y>=11);
            eval(['Node' num2str(j) ' (n+1:n+4)=randperm(4);']);
            eval(['Node' num2str(j) ' (n+5)=y-10;']);
        end;
    elseif y==15;
        eval(['Node' num2str(j) ' (n+1:n+5)=randperm(5);']);
    else (y<=20);
        if (y>=16);
            eval(['Node' num2str(j) ' (n+1:n+5)=randperm(5);']);
            eval(['Node' num2str(j) ' (n+6)=y-15;']);
        end;
    end;

    BatchSize=[BatchSize ; eval(['Node' num2str(j)])];
    j=j+1;
    i=1;

end;

BatchSize=BatchSize';
```

```
    csvwrite(['Data-Set-BatchSize',num2str(o),'.csv'],BatchSize);
                                             % Batch Size for random(1-6).

end;
```

B.4.2 Main Body Code

```
    % Calculate the Penality of the difference between download time and watched
    % time For Base Line.

    Ordered=2.8;
              % Used as initial order after first time subscribe to the service.

    for BandWidth=[25,50,100,128,512,1000,2000,5000];

    for o=1:50;

        ArrivalTime=[]; InterDownloadTime=[]; AccumulationDownloadTime=[];

        ArrivalTime=zeros(800,250); % To calculate Arrival Time (Watched Time).

        InterDownloadTime=zeros(800,250);
                  % To calculate individual time has been taken for each file
                  % index to be download per node.

        AccumulationDownloadTime=zeros(800,250);
                  % To calculate Accumulation time per node has been take as a
                  % total time per year according to Watched time (Arrival
                  % Time).

        ArrivalTimeL=[];
                  % Collect Arrival Time for all node under one line of matrix
                  % [n by 1].

        AccumulationDownloadTimeL=[];
                  % Collect Accumulation Download Time for all node under one
                  % line of matrix [n by 1].

        InterDownloadTimeL=[];
```

```
          % Collect Inter Download Time [n by 1].

NodeL=[];
          % Collect the node relatively to on the same row for Arrival
          %Time on one line of matrix [n by 1].

FileIndexandSizeL=[];
          % Collect File Index and File's Size on the same row for all
          % node on matrix [n by 3].

Available=[];
          % used to get availability of the file to be watched by the
          % node.

AvailableL=[];
          % Collect all the availabilty on one line matrix [n by 1];

Penalty=[];
          % Get to calculate each Penalty for each node for each file.

InterArrivalTimeL=[];
          % Collect Inter Arrival Time on one line matrix [n by 1].

Total=[];
         % Put all in one Matrix [File index, File Size, Arrival Time
         % Sorted, Accumulation Time, Node Number] all according to
         % Arrival Time (Batched Time).

m=1;
n=0;
i=1;
j=2;
k=0;

while (i<=250);

    if (Node(3,i) \sim =0);

        ArrivalTime(1,i)=InterArrivalTime(3,i);

        InterDownloadTime(1,i)=[FileSize(FileIndex(1,i),2)*8000000]/
```

```
                    [BandWidth*3600];

InterDownloadTimeL=[InterDownloadTimeL;InterDownloadTime(1,i)];

InterArrivalTimeL=[InterArrivalTimeL ; InterArrivalTime(3,i)];

AccumulationDownloadTime(1,i)=InterDownloadTime(1,i);

FileIndexandSizeL=[FileIndexandSizeL ;
        FileSize(FileIndex(1,i),1)  FileSize(FileIndex(1,i),2)
        FileSize(FileIndex(1,i),3)/60];

Available(1,i)=Ordered+InterDownloadTime(1,i);

if Available(1,i)>ArrivalTime(1,i);
    Penalty=[Penalty ; Available(1,i)-ArrivalTime(1,i)];
else;
    Penalty=[Penalty ; 0];
end;

while (j<=Node(3,i));
    InterDownloadTime(j,i)=[FileSize(FileIndex(j,i),2)*8000000]/
                        [BandWidth*3600];

    InterDownloadTimeL=[InterDownloadTimeL ;
                    InterDownloadTime(j,i)];

    InterArrivalTimeL=[InterArrivalTimeL ;
                    InterArrivalTime(j+2,i)];

    AccumulationDownloadTime(j,i)=InterDownloadTime(j,i)+
                            AccumulationDownloadTime(j-1,i);

    FileIndexandSizeL=[FileIndexandSizeL ;
        FileSize(FileIndex(j,i),1)  FileSize(FileIndex(j,i),2)
        FileSize(FileIndex(j,i),3)/60];

   if j-1==(n+BatchSize(m,i));

    Available(j,i)=max(Available(j-1,i),ArrivalTime(j-1,i))+
                    (FileSize(FileIndex(j-1,i),3)/60)+
```

```
                                 InterDownloadTime(j,i);

            ArrivalTime(j,i)=max(Available(j-1,i),
                                   ArrivalTime(j-1,i))+
                                  (FileSize(FileIndex(j-1,i),3)/60)+
                                   InterArrivalTime(j+2,i);

            n=BatchSize(m,i);
            m=m+1;

            else
                Available(j,i)=Available(j-1,i)+InterDownloadTime(j,i);
                ArrivalTime(j,i)=ArrivalTime(j-1,i)+
                                   InterArrivalTime(j+2,i);

            end;

            if Available(j,i)>ArrivalTime(j,i);
                Penalty=[Penalty ; Available(j,i)-ArrivalTime(j,i)];
            else;
                Penalty=[Penalty ; 0];
            end;

            j=j+1;

        end;

        ArrivalTimeL=[ArrivalTimeL ; ArrivalTime(1:Node(3,i),i)];
        AccumulationDownloadTimeL=[AccumulationDownloadTimeL ;
                                 AccumulationDownloadTime(1:Node(3,i),i)];
        AvailableL=[AvailableL ; Available(1:Node(3,i),i)];

    end;

    if i==1;
        k=0;
    else
        k=k+Node(3,i-1);
    end;

    NodeL(k+1:k+Node(3,i),1)=i;
```

```
        i=i+1;
       j=2;
       m=1;
        n=0;

    end;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

  % Calculate the amount can be saved in hard drive and what are the
  % priorities of files to keep in hard drives after emptying.

      for SizeHDD=50:50:1000;
          % Size of the hard disc drive is start from 50GB to 1000GB by 50GB
          % increment.

          Total=[];
              % Repeatable Rest. And Put all in one Matrix [File index, File
              % Size, Arrival Time Sorted, Accumulation Time, Node Number]
              % all according to Arrival Time (Eatched Time).

          Total=[FileIndexandSizeL  Penalty  InterArrivalTimeL  ArrivalTimeL
                 InterDownloadTimeL  AccumulationDownloadTimeL  AvailableL
                 NodeL];

          RemovedL=zeros(size(Total(:,1)));
          ServerL=ones(size(Total(:,1)));

          j=1;

          while (j<=250);

              ContentSize=0; % Count the Totla files' size of exsiting HDD
              row=[]; % Used to get the row number for the file requested.
              row=find(Total(:,10)==j);

              if isempty(row)==0;

                  if size(row)>=2;
                      ContentSize=FileIndexandSizeL(row(1),2)+
```

```
                        FileIndexandSizeL(row(2),2);
            else;
                ContentSize=FileIndexandSizeL(row(1),2);
            end;

            for i=3:size(row);
                if ContentSize<(.75*SizeHDD);
                    ContentSize=ContentSize+
                                FileIndexandSizeL(row(i),2);
                else;
                    [s1,s2]=sort(Total(row(1):row(i-2),1));
                    for k=size(s2):-1:1;
                        if ContentSize>(.5*SizeHDD);
                            ContentSize=ContentSize-
                                        FileIndexandSizeL
                                        (row(s2(k)),2);
                            RemovedL(row(s2(k)))=1;
                            FileIndexandSizeL(row(s2(k)),2)=0;
                        else;
                            break;
                        end;
                    end;
                end;
            end;
        end;
        j=j+1;
    end;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

    j=1;

    while (j<=10000);

        row=[]; % Used to get the row number for the file requested.
        Server=[];
           %Used to highlight where the file has been download from.
        InterDownloadFile=[]; %Find the exact file download time.

        row=find(Total(:,1)==j);
```

```
if isempty(row)==0;

    [s1,s2]=sort(Total(row,9));

    InterDownloadFile=Total(row(1),7);

    Server(s2(1),1)=1;

    for i=2:max(s2);

        if (s1(1)>=InterDownloadFile &&
                    RemovedL(row(s2(1)))==0);
            Server(s2(2),1)=.5;
        else;
            Server(s2(2),1)=1;
        end;

        if i>=3;
            f=1;
            m=0;
            for k=i:-1:2;
                if (s1(i)-s1(k-1)>=f*InterDownloadFile &&
                                    RemovedL(row(s2(i)))==0);
                    if f==1;
                        Server(s2(i),1)=0;
                        break;
                    else;
                        Server(s2(i),1)=.5-m;
                    end;
                elseif i-1==2
                    Server(s2(i))=1;
                    break;
                else;
                    f=f+1;
                    if k==3;
                        m=.5;
                        Server(s2(i))=1;
                    end;
                end;
            end;
        end;
```

```
            end;
        end;

        Server=Server(:).*Total(row,7);

        ServerL(row,1)=Server(:);

        j=j+1;

    end;

    Total=[Total  ServerL  RemovedL];

    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Calculate H3 (Customer Preference 40%) by using Data Set Results from H1 and
% H2 for all different Hard Drive sizes and differnt BandWidth sizes.
% Get to Calculate H3 for Plotting a server download time versus actual download
% it from server.
% By using HDD size from 50GB to 1TB, and Band width from 50Kb/s to 15Mb/s

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

    %Calculate the Penality of the difference between download time and watched
    %time For base on Customer Preference case senario.


        CustomerPreferenceL=[];

        j=1;

        while (j<=250);

            CustomerPreference=[];
                            % Incert Certain file during H2 Heuristc Senario.
            CountFortyPersent=0;
                        % Use a counter to upload certain files to the Network.

            row=find(Total(:,10)==j);

            CustomerPreference=zeros(size(row));
```

```
                %Rest The matrix for File Incertions.

    ExisttingFiles=Total(row,12);
                % Upload all possibilities of an existing file
                % in Hard Drives which is came from RemovedL
                % matrix.

    ZeroMatrix=find(ExisttingFiles(:)==0);
                % Find Exact Files still on the Hard Drives.

    FortyPersent=round(size(ZeroMatrix)*.4);
                % Calcuate an amount of files need to be
                % distribute to the Network which is 40%.

    if isempty(FortyPersent(1))==0;

        CountFortyPersent=1;

        for i=1:size(ExisttingFiles);
            if ExisttingFiles(i)==0;
                if CountFortyPersent<=FortyPersent(1);
                    CustomerPreference(i)=1;
                                   % Incert file to the Network.
                    CountFortyPersent=CountFortyPersent+1;
                end;
            end;
        end;
    end;

    CustomerPreferenceL=[CustomerPreferenceL ; CustomerPreference];

    j=j+1;


end;

Total=[Total  CustomerPreferenceL];

csvwrite(['Data_Set_New_Total_H3_',num2str(BandWidth),'_',
           num2str(SizeHDD),'_',num2str(o),'.csv'],Total);
```

```
        end;

    end;

end;
```

B.5 HEURISTIC H4 (M-FILE)

B.5.1 Initial Settings

```
clear;

FileSize=xlsread('F-S.xls');
 % [10,000 by 3] first colomn for file index second colomn for file size per GB.

for o=1:10;

    Ac=[]; Cr=[]; Co=[]; Dr=[]; Ro=[];
    i=0; j=0; l=0; N=0; n=0; m=0; x=0; y=0; k=0; errorr=0; g=0; BandWidth=0;
    abc=[]; cdc=[]; X=[]; Y=[]; C=[]; L=[];

    InterArrivalTime=[]; Node=[]; FileIndex=[]; BatchSize=[];
    FilePreference=[]; FilePreference1=[]; FilePreference2=[];
    FilePreference3=[]; FilePreference4=[]; FilePreference5=[];

    InterArrivalTime=csvread(['Data-Set-1',num2str(o),'.csv']);
              % [802 by 250] first two row is not belong to Interarrival time.

    Node=csvread(['Data-Set-b',num2str(o),'.csv']);
       % [3 by 250] last row for how many files watched by each node per year.

    % Initial Section:
    % ---------------

    % Produce random node number of count 50 for each of Action, Crime, Comedy,
    % Drama and Romance.

    N=randperm(250);

    N=N';
```

```
Ac=N(1:50);
Cr=N(51:100);
Co=N(101:150);
Dr=N(151:200);
Ro=N(201:250);

% First Section:
% --------------
% Divide 10,000 files to 5 category to Action, Crime, Comedy, Drama and
% Romance. as each category ranked from High to Low priority and get toatl
% of watches per node from Data-Set-b?.xls.

if  sum(Node(3,:))<40000;
   k=fix(sum(Node(3,:))/5);
    errorr=((k-6990)*130)/500*.00004/5;
    g=(k*.050911002/sum(Node(3,:)))+.0061+errorr;
elseif (sum(Node(3,:))>=40000) \& (sum(Node(3,:))<50000);
    k=fix(sum(Node(3,:))/5);
    errorr=((k-7000)*130)/500*.00004/5;
    g=(k*.050911002/sum(Node(3,:)))+.0061+errorr;
elseif (sum(Node(3,:))>=50000);
    k=fix(sum(Node(3,:))/5);
    errorr=((k-7035)*130)/500*.00004/5;
    g=(k*.050911002/sum(Node(3,:)))+.0061+errorr;
end;

i=1:2000;
FilePreference1(i)=fix(g*500000*((1/500)*exp(-((i)-1)/500)));

i=2001:4000;
FilePreference2(1:2000)=fix(g*500000*((1/500)*exp(-((i)-2001)/500)));

i=4001:6000;
FilePreference3(1:2000)=fix(g*500000*((1/500)*exp(-((i)-4001)/500)));

i=6001:8000;
FilePreference4(1:2000)=fix(g*500000*((1/500)*exp(-((i)-6001)/500)));

i=8001:10000;
FilePreference5(1:2000)=fix(g*500000*((1/500)*exp(-((i)-8001)/500)));
```

```
FilePreference=[FilePreference1' ; FilePreference2' ; FilePreference3' ;
                FilePreference4' ; FilePreference5'];
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Second Section:
% ---------------

% initial output by using input from a and b array in additional, input
% from two dimensional array of (10,000 by 250)
% each array has binomial data set for abc array of dimensions (10,000 by
% 250) and arrange it after that the output file Data-Set-New-ab-1.xls
% Data-Set-New-ab-100.xls
% will be used later here for more arranged.

abc=zeros(10000,250);


% Using the below loops for more arrange to adjust the final output file
% to be fully satisfy according to the two condition of summation equals a
% and b arrays.

%%%%%%% Actions

i=1;
j=1;

while (i<=2000);
  while (j<=50);
   if(sum(abc(i,:))<=FilePreference(i))\&(sum(abc(:,Ac(j)))<Node(3,Ac(j)));
            abc(i,Ac(j))=1;
elseif(sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Ac(j)))<Node(3,Ac(j)));
                abc(i,Ac(j))=1;
        else;
            abc(i,Ac(j))=0;
        end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;
```

```
%%%%%%% Crime

i=2001;
j=1;

while (i<=4000);
  while (j<=50);
   if(sum(abc(i,:))<=FilePreference(i))\&(sum(abc(:,Cr(j)))<Node(3,Cr(j)));
            abc(i,Cr(j))=1;
elseif(sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Cr(j)))<Node(3,Cr(j)));
                abc(i,Cr(j))=1;
        else;
            abc(i,Cr(j))=0;
        end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

%%%%%%% Comedy

i=4001;
j=1;

while (i<=6000);
  while (j<=50);
   if(sum(abc(i,:))<=FilePreference(i))\&(sum(abc(:,Co(j)))<Node(3,Co(j)));
            abc(i,Co(j))=1;
elseif(sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Co(j)))<Node(3,Co(j)));
                abc(i,Co(j))=1;
        else;
            abc(i,Co(j))=0;
        end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;
```

```
%%%%%%% Drama

i=6001;
j=1;

while (i<=8000);
    while (j<=50);
     ifsum(abc(i,:))<=FilePreference(i)\&(sum(abc(:,Dr(j)))<Node(3,Dr(j)));
            abc(i,Dr(j))=1;
elseif(sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Dr(j)))<Node(3,Dr(j)));
            abc(i,Dr(j))=1;
        else;
            abc(i,Dr(j))=0;
        end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

%%%%%%% Romance

i=8001;
j=1;

while (i<=10000);
  while (j<=50);
   if (sum(abc(i,:))<=FilePreference(i))\&(sum(abc(:,Ro(j)))<Node(3,Ro(j)));
            abc(i,Ro(j))=1;
elseif (sum(abc(i,:))>FilePreference(i))\&(sum(abc(:,Ro(j)))<Node(3,Ro(j)));
                abc(i,Ro(j))=1;
         else;
             abc(i,Ro(j))=0;
         end;
        j=j+1;
    end;
    i=i+1;
    j=1;
end;

csvwrite(['Data-Set-abc',num2str(o),'.csv'],abc);
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Third Section:
% --------------

% Identify each node on one set for assign Data File number (by other words
% which one from 10,000 file) and repeat it for 100 sets from output file
% Data-Set-New-ab-1.xls to Data-Set-New-ab-100.xls as output that
% will be used later for
% randomized build new 100 fresh sets.


cdc=zeros(800,250);

i=1;
j=1;
l=1;

while (j<=250);
    while (i<=10000);
        if abc(i,j)==1;
            cdc(l,j)=i;
            l=l+1;
        end;
        i=i+1;
    end;
    j=j+1;
    i=1;
    l=1;
end;

csvwrite(['Data-Set-cdc',num2str(o),'.csv'],cdc);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Forth Section:
% --------------


[Y,X]=max(cdc);

FileIndex=zeros(800,250);
```

```
    % [800 by 250] randomized file index per node and ranked for preference
    % watched according to the node index.

i=1;
j=1;

while (j<=250);

    Brandom=[];

    Brandom=randperm(X(j));

    while (i<=Node(3,j));
        if Node(3,j)\sim =0;
            FileIndex(i,j)=cdc(Brandom(i),j);
            i=i+1;
        else;
            break;
        end;
    end;
    j=j+1;
    i=1;
end;

csvwrite(['Data-Set-FileIndex',num2str(o),'.csv'],FileIndex);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Using the output from previous section or (cdc)
% to build batch size randomized but non-repeatable
% from 1 to 6, but the output file has first column 0's
% output to Data-Set-BatchSize-1.xls to Data-Set-BatchSize-100.xls

[C,L]=max(cdc);

%vdc=[];

i=1;
j=1;

while (j<=250);
```

```
eval(['Node' num2str(j) ' =[];']);

eval(['Node' num2str(j) ' =zeros(1,230);']);
x=fix(L(j)/21);
y=L(j)-x*21;

m=0;
n=0;

while (i<=x);
    m=6*(i-1)+1;
    n=6*i;
    eval(['Node' num2str(j) ' (m:n)=randperm(6);']);
    i=i+1;
end;

if (y<=6);
    eval(['Node' num2str(j) ' (n+1)=y;']);
elseif (y<=9);
    if (y>=7);
        eval(['Node' num2str(j) ' (n+1:n+3)=randperm(3);']);
        eval(['Node' num2str(j) ' (n+4)=y-6;']);
    end;
elseif y==10;
    eval(['Node' num2str(j) ' (n+1:n+4)=randperm(4);']);
elseif (y<=14);
    if (y>=11);
        eval(['Node' num2str(j) ' (n+1:n+4)=randperm(4);']);
        eval(['Node' num2str(j) ' (n+5)=y-10;']);
    end;
elseif y==15;
    eval(['Node' num2str(j) ' (n+1:n+5)=randperm(5);']);
else (y<=20);
    if (y>=16);
        eval(['Node' num2str(j) ' (n+1:n+5)=randperm(5);']);
        eval(['Node' num2str(j) ' (n+6)=y-15;']);
    end;
end;

BatchSize=[BatchSize ; eval(['Node' num2str(j)])];
j=j+1;
```

```
        i=1;

    end;

    BatchSize=BatchSize';

    csvwrite(['Data-Set-BatchSize',num2str(o),'.csv'],BatchSize);
                                        % Batch Size for random(1-6).

end;
```

B.5.2 Main Body Code

```
% Calculate the Penality of the difference between download time and watched
% time For Base Line.

Ordered=2.8;
          % Used as initial order after first time subscribe to the service.

for BandWidth=[25,50,100,128,512,1000,2000,5000];

for o=1:50;

    ArrivalTime=[]; InterDownloadTime=[]; AccumulationDownloadTime=[];

    ArrivalTime=zeros(800,250); % To calculate Arrival Time (Watched Time).

    InterDownloadTime=zeros(800,250);
              % To calculate individual time has been taken for each file
              % index to be download per node.

    AccumulationDownloadTime=zeros(800,250);
              % To calculate Accumulation time per node has been take as a
              % total time per year according to Watched time (Arrival
              % Time).

    ArrivalTimeL=[];
              % Collect Arrival Time for all node under one line of matrix
              % [n by 1].
```

```
AccumulationDownloadTimeL=[];
          % Collect Accumulation Download Time for all node under one
          % line of matrix [n by 1].

InterDownloadTimeL=[];
          % Collect Inter Download Time [n by 1].

NodeL=[];
          % Collect the node relatively to on the same row for Arrival
          %Time on one line of matrix [n by 1].

FileIndexandSizeL=[];
          % Collect File Index and File's Size on the same row for all
          % node on matrix [n by 3].

Available=[];
          % used to get availability of the file to be watched by the
          % node.

AvailableL=[];
          % Collect all the availabilty on one line matrix [n by 1];

Penalty=[];
          % Get to calculate each Penalty for each node for each file.

InterArrivalTimeL=[];
          % Collect Inter Arrival Time on one line matrix [n by 1].

Total=[];
         % Put all in one Matrix [File index, File Size, Arrival Time
         % Sorted, Accumulation Time, Node Number] all according to
         % Arrival Time (Batched Time).

m=1;
n=0;
i=1;
j=2;
k=0;

while (i<=250);
```

```
if (Node(3,i) \sim =0);

    ArrivalTime(1,i)=InterArrivalTime(3,i);

    InterDownloadTime(1,i)=[FileSize(FileIndex(1,i),2)*8000000]/
                               [BandWidth*3600];

    InterDownloadTimeL=[InterDownloadTimeL;InterDownloadTime(1,i)];

    InterArrivalTimeL=[InterArrivalTimeL ; InterArrivalTime(3,i)];

    AccumulationDownloadTime(1,i)=InterDownloadTime(1,i);

    FileIndexandSizeL=[FileIndexandSizeL ;
            FileSize(FileIndex(1,i),1)  FileSize(FileIndex(1,i),2)
            FileSize(FileIndex(1,i),3)/60];

    Available(1,i)=Ordered+InterDownloadTime(1,i);

    if Available(1,i)>ArrivalTime(1,i);
        Penalty=[Penalty ; Available(1,i)-ArrivalTime(1,i)];
    else;
        Penalty=[Penalty ; 0];
    end;

    while (j<=Node(3,i));
        InterDownloadTime(j,i)=[FileSize(FileIndex(j,i),2)*8000000]/
                                   [BandWidth*3600];

        InterDownloadTimeL=[InterDownloadTimeL ;
                             InterDownloadTime(j,i)];

        InterArrivalTimeL=[InterArrivalTimeL ;
                            InterArrivalTime(j+2,i)];

        AccumulationDownloadTime(j,i)=InterDownloadTime(j,i)+
                                       AccumulationDownloadTime(j-1,i);

        FileIndexandSizeL=[FileIndexandSizeL ;
              FileSize(FileIndex(j,i),1)  FileSize(FileIndex(j,i),2)
              FileSize(FileIndex(j,i),3)/60];
```

```
        if j-1==(n+BatchSize(m,i));

         Available(j,i)=max(Available(j-1,i),ArrivalTime(j-1,i))+
                          (FileSize(FileIndex(j-1,i),3)/60)+
                           InterDownloadTime(j,i);

         ArrivalTime(j,i)=max(Available(j-1,i),
                              ArrivalTime(j-1,i))+
                             (FileSize(FileIndex(j-1,i),3)/60)+
                              InterArrivalTime(j+2,i);

         n=BatchSize(m,i);
         m=m+1;

         else
             Available(j,i)=Available(j-1,i)+InterDownloadTime(j,i);
             ArrivalTime(j,i)=ArrivalTime(j-1,i)+
                              InterArrivalTime(j+2,i);

         end;

         if Available(j,i)>ArrivalTime(j,i);
             Penalty=[Penalty ; Available(j,i)-ArrivalTime(j,i)];
         else;
             Penalty=[Penalty ; 0];
         end;

         j=j+1;

     end;

     ArrivalTimeL=[ArrivalTimeL ; ArrivalTime(1:Node(3,i),i)];
     AccumulationDownloadTimeL=[AccumulationDownloadTimeL ;
                           AccumulationDownloadTime(1:Node(3,i),i)];
     AvailableL=[AvailableL ; Available(1:Node(3,i),i)];

end;

if i==1;
    k=0;
```

```
            else
                k=k+Node(3,i-1);
            end;

            NodeL(k+1:k+Node(3,i),1)=i;

            i=i+1;
           j=2;
           m=1;
            n=0;

        end;
```

%%

```
    % Calculate the amount can be saved in hard drive and what are the
    % priorities of files to keep in hard drives after emptying.

        for SizeHDD=50:50:1000;
            % Size of the hard disc drive is start from 50GB to 1000GB by 50GB
            % increment.

            Total=[];
                % Repeatable Rest. And Put all in one Matrix [File index, File
                % Size, Arrival Time Sorted, Accumulation Time, Node Number]
                % all according to Arrival Time (Eatched Time).

            Total=[FileIndexandSizeL  Penalty  InterArrivalTimeL  ArrivalTimeL
                   InterDownloadTimeL  AccumulationDownloadTimeL  AvailableL
                   NodeL];

            RemovedL=zeros(size(Total(:,1)));
            ServerL=ones(size(Total(:,1)));

            j=1;

            while (j<=250);

                ContentSize=0; % Count the Totla files' size of exsiting HDD
                row=[]; % Used to get the row number for the file requested.
                row=find(Total(:,10)==j);
```

```
        if isempty(row)==0;

            if size(row)>=2;
                ContentSize=FileIndexandSizeL(row(1),2)+
                            FileIndexandSizeL(row(2),2);
            else;
                ContentSize=FileIndexandSizeL(row(1),2);
            end;

            for i=3:size(row);
                if ContentSize<(.75*SizeHDD);
                    ContentSize=ContentSize+
                                FileIndexandSizeL(row(i),2);
                else;
                    [s1,s2]=sort(Total(row(1):row(i-2),1));
                    for k=size(s2):-1:1;
                        if ContentSize>(.5*SizeHDD);
                            ContentSize=ContentSize-
                                        FileIndexandSizeL
                                        (row(s2(k)),2);
                            RemovedL(row(s2(k)))=1;
                            FileIndexandSizeL(row(s2(k)),2)=0;
                        else;
                            break;
                        end;
                    end;
                end;
            end;
        end;
        j=j+1;
    end;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

    j=1;

    while (j<=10000);

        row=[]; % Used to get the row number for the file requested.
        Server=[];
```

```
   %Used to highlight where the file has been download from.
InterDownloadFile=[]; %Find the exact file download time.

row=find(Total(:,1)==j);

if isempty(row)==0;

    [s1,s2]=sort(Total(row,9));

    InterDownloadFile=Total(row(1),7);

    Server(s2(1),1)=1;

    for i=2:max(s2);

        if (s1(1)>=InterDownloadFile &&
                   RemovedL(row(s2(1)))==0);
            Server(s2(2),1)=.5;
        else;
            Server(s2(2),1)=1;
        end;

        if i>=3;
            f=1;
            m=0;
            for k=i:-1:2;
                if (s1(i)-s1(k-1)>=f*InterDownloadFile &&
                                    RemovedL(row(s2(i)))==0);
                    if f==1;
                        Server(s2(i),1)=0;
                        break;
                    else;
                        Server(s2(i),1)=.5-m;
                    end;
                elseif i-1==2
                    Server(s2(i))=1;
                    break;
                else;
                    f=f+1;
                    if k==3;
                        m=.5;
```

```
                                    Server(s2(i))=1;
                                end;
                            end;
                        end;
                    end;
                end;
            end;

            Server=Server(:).*Total(row,7);

            ServerL(row,1)=Server(:);

            j=j+1;

        end;

        Total=[Total  ServerL  RemovedL];

        %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Calculate H4 (Customer Preference 70%) by using Data Set Results from H1, H2
% and H3 for all different Hard Drive sizes and differnt BandWidth sizes.
% Get to Calculate H3 for Plotting a server download time versus actual download
% it from server.
% By using HDD size from 50GB to 1TB, and Band width from 50Kb/s to 15Mb/s

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

    %Calculate the Penality of the difference between download time and watched
    %time For base on Customer Preference case senario.


        CustomerPreferenceL=[];

        j=1;

        while (j<=250);

            CustomerPreference=[];
                            % Incert Certain file during H2 Heuristc Senario.
            CountFortyPersent=0;
```

```
            % Use a counter to upload certain files to the Network.

    row=find(Total(:,10)==j);

    CustomerPreference=zeros(size(row));
                    %Rest The matrix for File Incertions.

    ExisttingFiles=Total(row,12);
                    % Upload all possibilities of an existing file
                    % in Hard Drives which is came from RemovedL
                    % matrix.

    ZeroMatrix=find(ExisttingFiles(:)==0);
                    % Find Exact Files still on the Hard Drives.

    FortyPersent=round(size(ZeroMatrix)*.7);
                    % Calcuate an amount of files need to be
                    % distribute to the Network which is 70%.

    if isempty(FortyPersent(1))==0;

        CountFortyPersent=1;

        for i=1:size(ExisttingFiles);
            if ExisttingFiles(i)==0;
                if CountFortyPersent<=FortyPersent(1);
                    CustomerPreference(i)=1;
                                       % Incert file to the Network.
                    CountFortyPersent=CountFortyPersent+1;
                end;
            end;
        end;
    end;

    CustomerPreferenceL=[CustomerPreferenceL ; CustomerPreference];

    j=j+1;


end;
```

```
            Total=[Total  CustomerPreferenceL];

            csvwrite(['Data_Set_New_Total_H4_',num2str(BandWidth),'_',
                      num2str(SizeHDD),'_',num2str(o),'.csv'],Total);

        end;

  end;

end;
```

APPENDIX C

HEURISTICS RESULTS GRAPH

Figure 88: Server load for Base Line case scenario at download bandwidth of 128kb/s

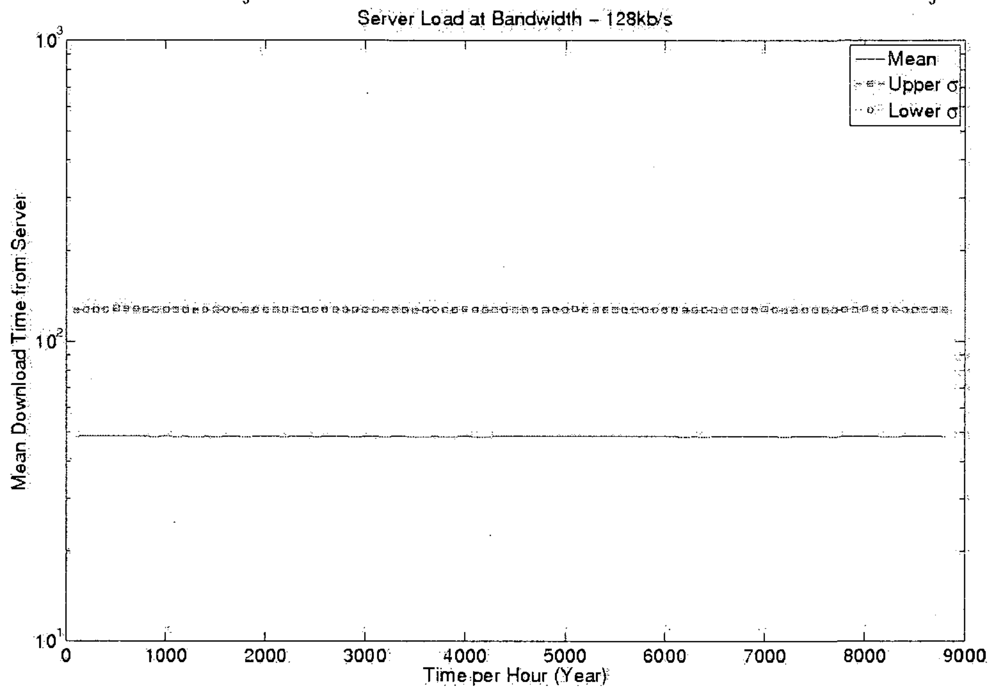


Figure 89: Server load for Base Line case scenario at download bandwidth of 512kb/s

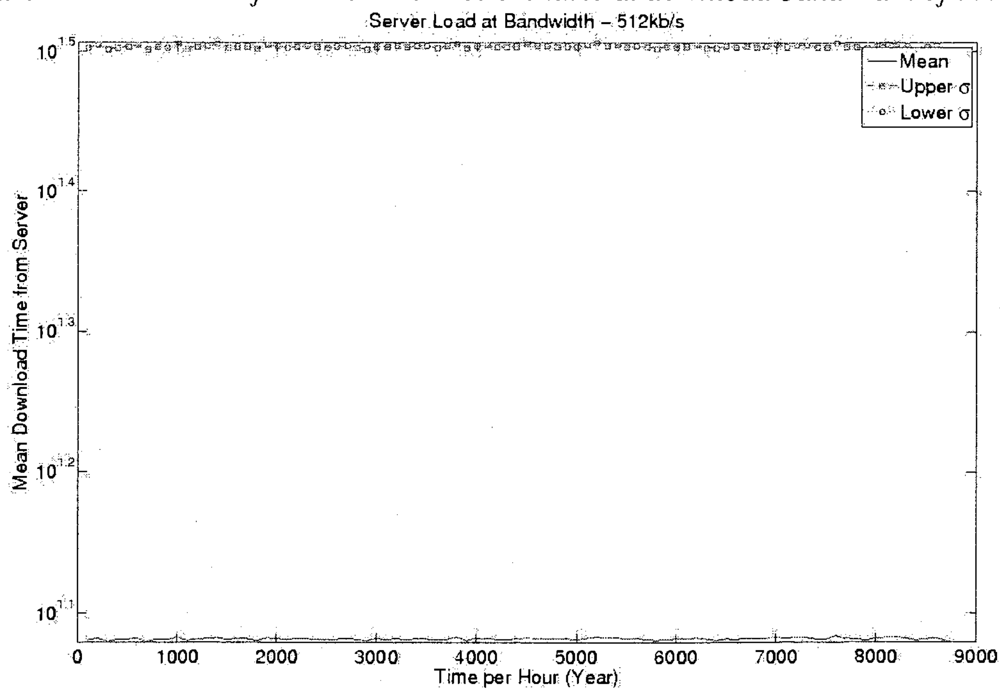


Figure 90: Server load for Base Line case scenario at download bandwidth of 1000kb/s

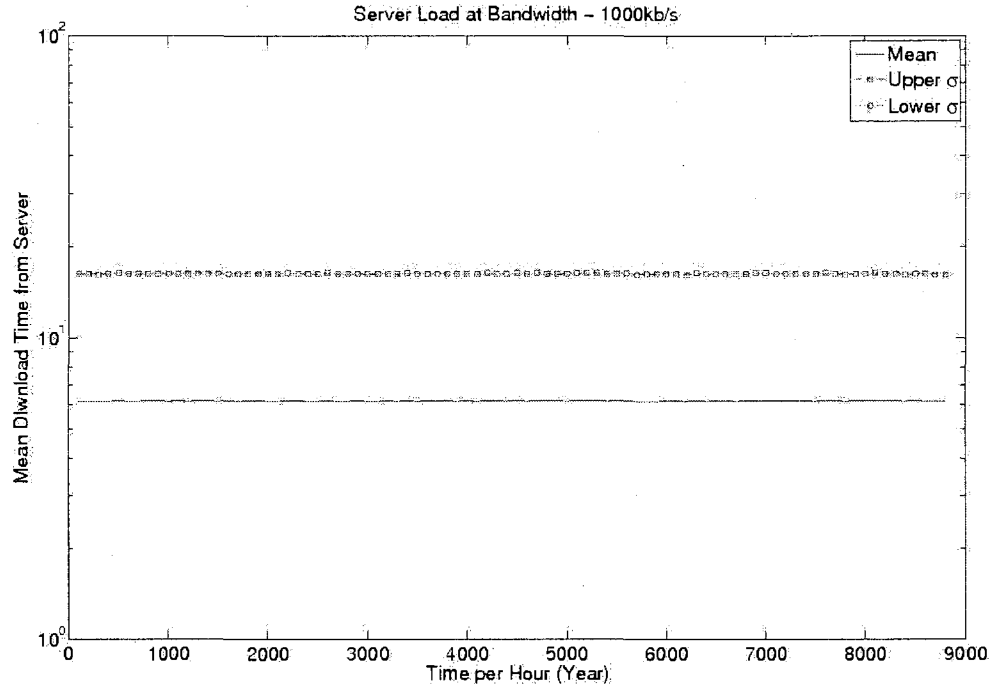


Figure 91: Server load for Base Line case scenario at download bandwidth of 2000kb/s

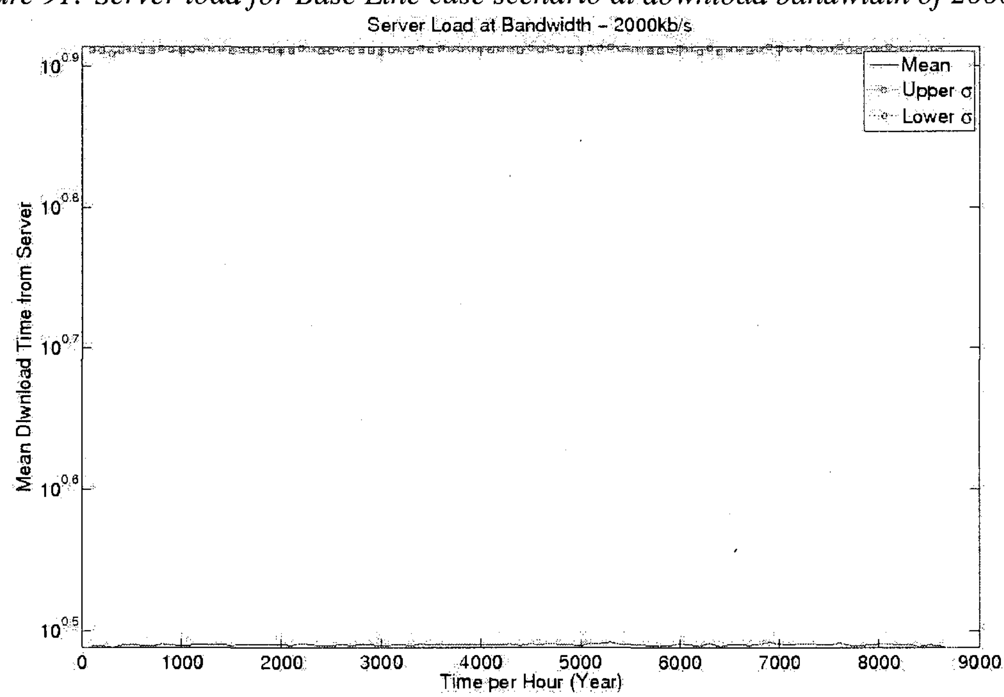


Figure 92: Server load for Base Line case scenario at download bandwidth of 5000kb/s

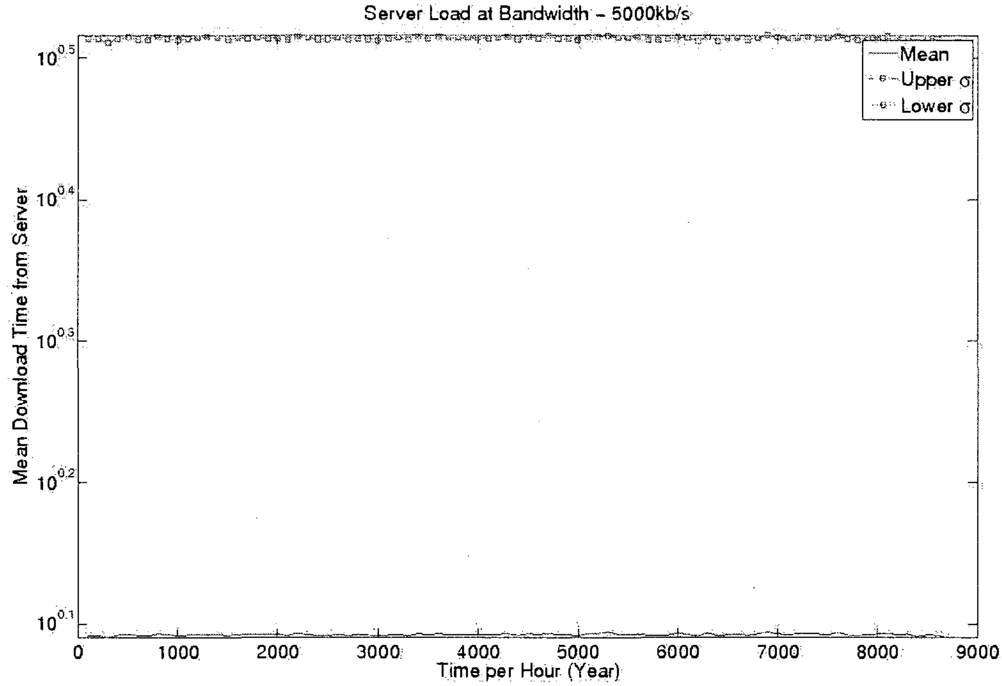


Figure 93: Server Load for H1 case scenario at hard drive size of 50GB and download bandwidth of 25kb/s

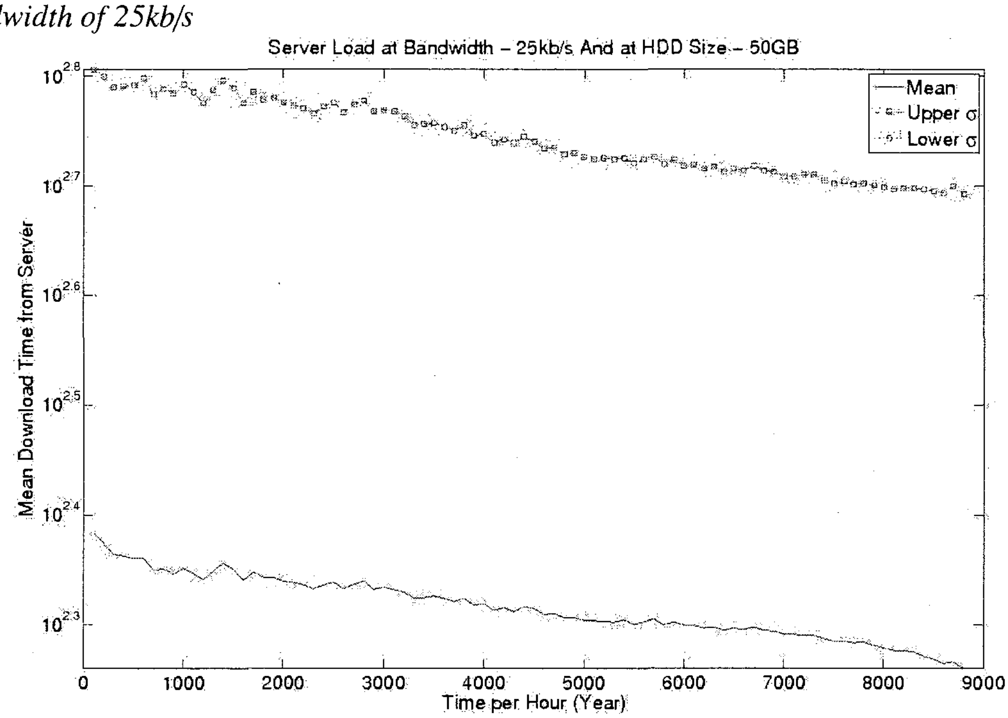


Figure 94: Server Load for H1 case scenario at hard drive size of 100GB and download bandwidth of 25kb/s

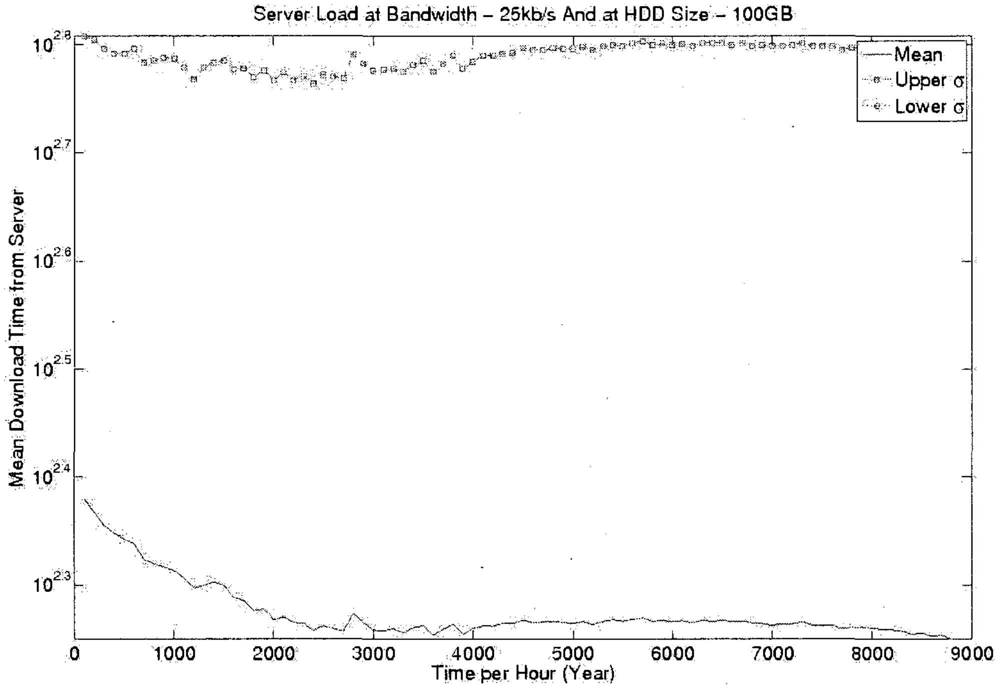


Figure 95: Server Load for H1 case scenario at hard drive size of 150GB and download bandwidth of 25kb/s

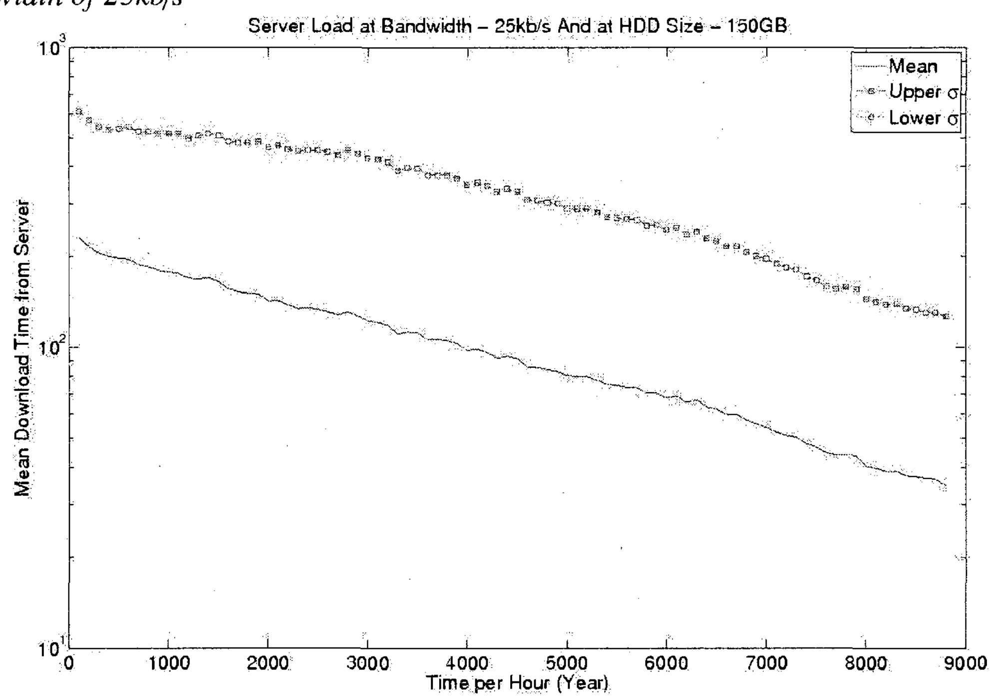


Figure 96: Server Load for H1 case scenario at hard drive size of 200GB and download bandwidth of 25kb/s

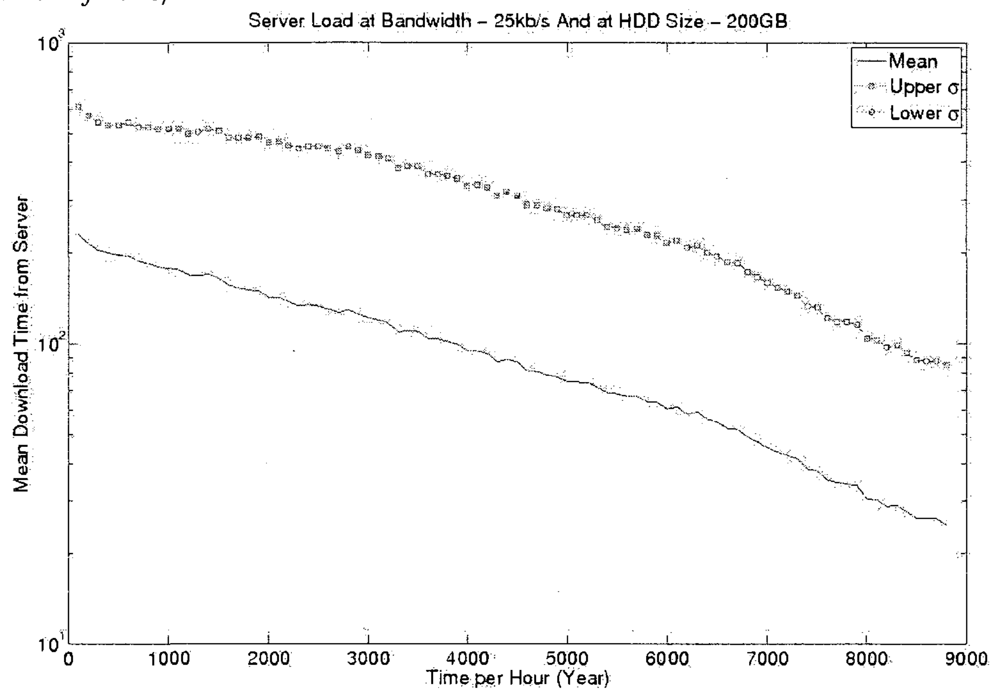


Figure 97: Server Load for H1 case scenario at hard drive size of 50GB and download bandwidth of 50kb/s

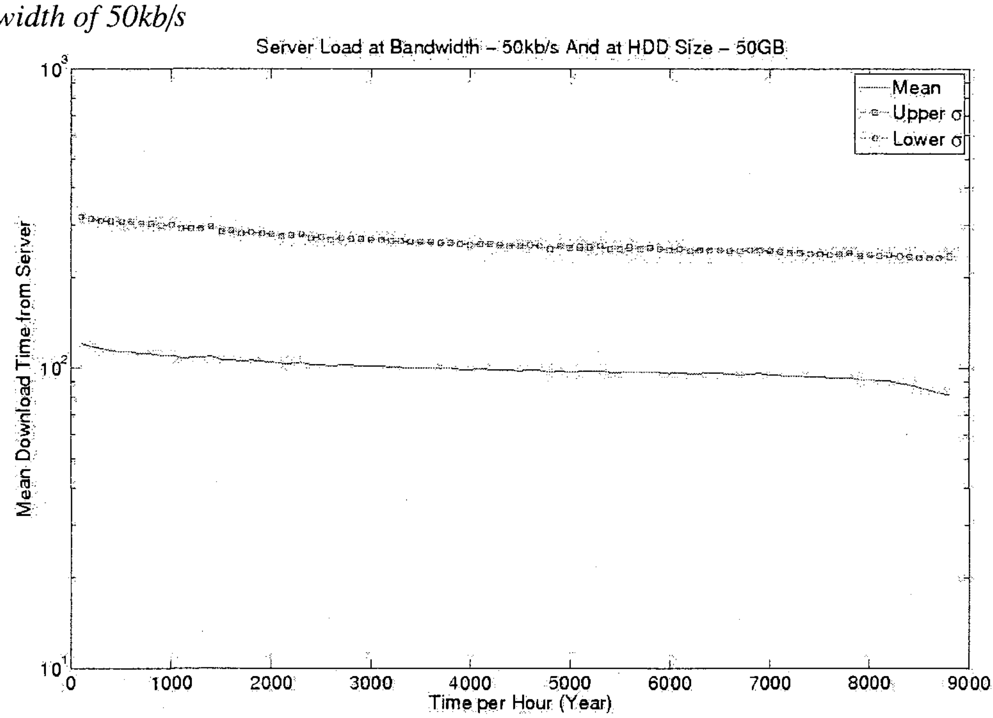


Figure 98: Server Load for H1 case scenario at hard drive size of 100GB and download bandwidth of 50kb/s

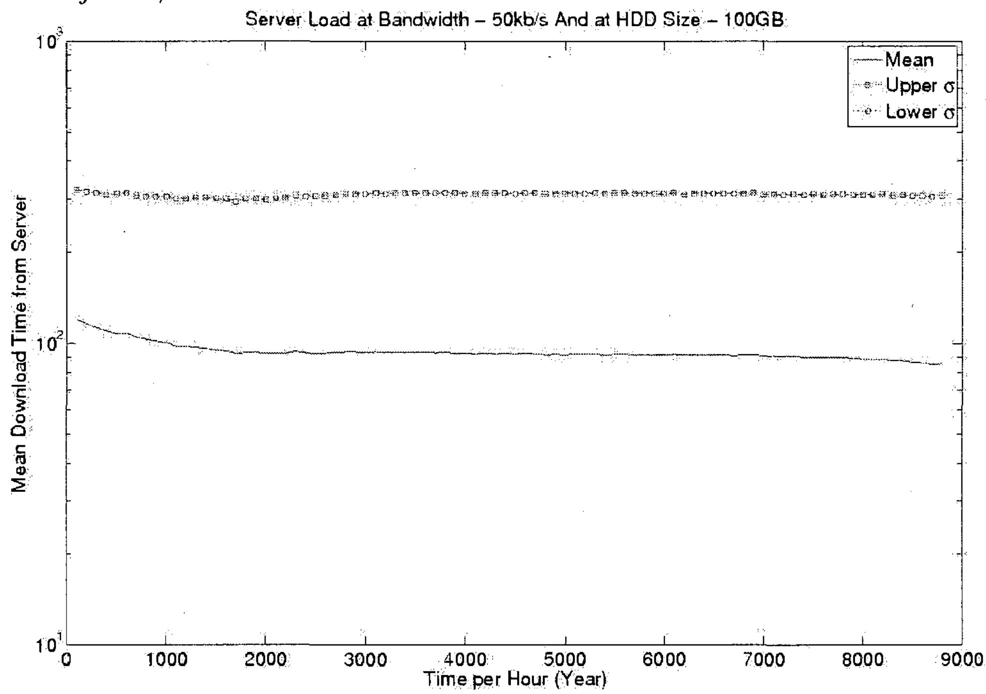


Figure 99: Server Load for H1 case scenario at hard drive size of 150GB and download bandwidth of 50kb/s

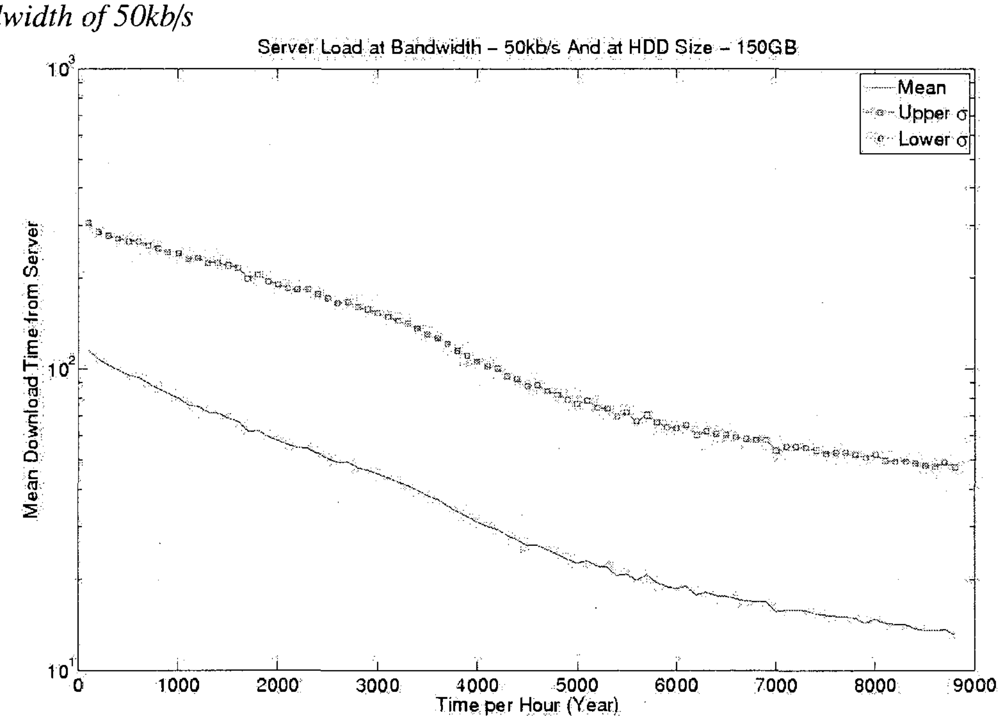


Figure 100: Server Load for H1 case scenario at hard drive size of 200GB and download bandwidth of 50kb/s

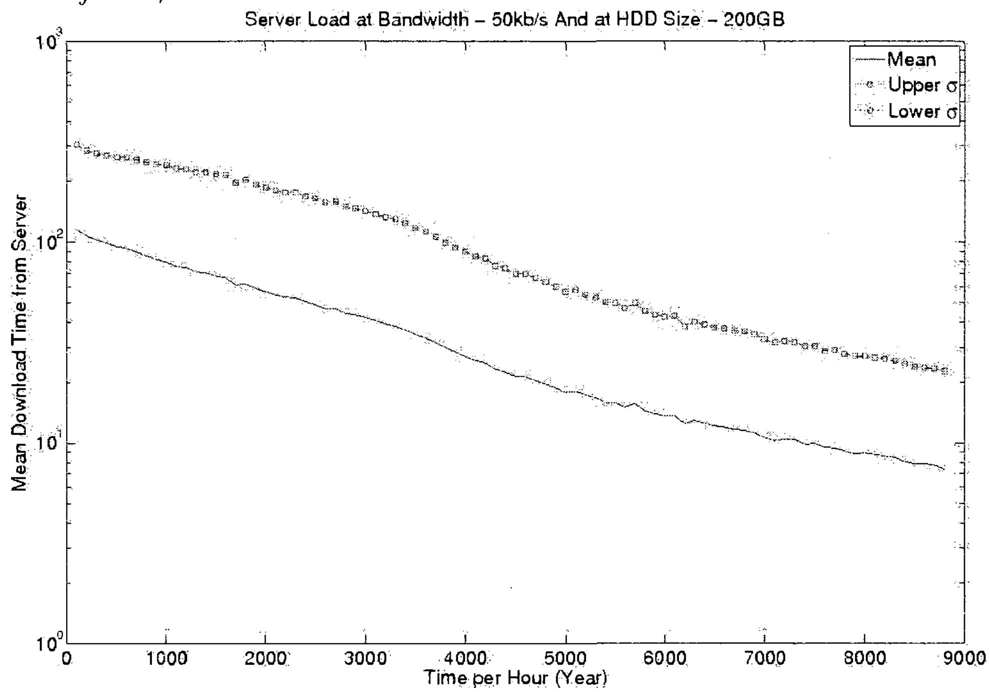


Figure 101: Server Load for H1 case scenario at hard drive size of 50GB and download bandwidth of 100kb/s

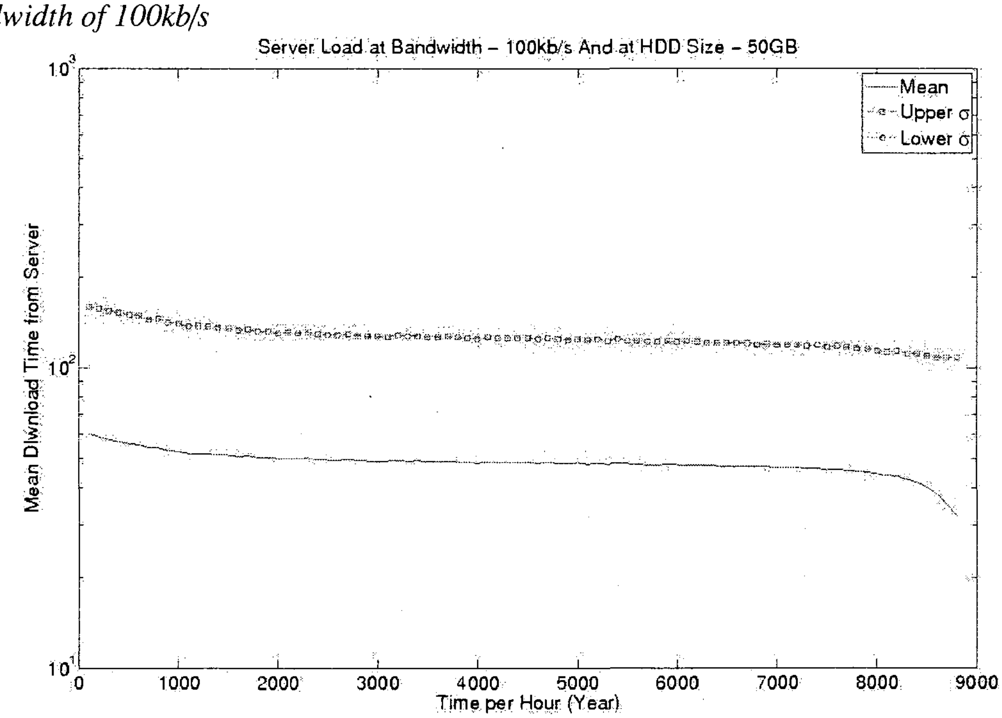


Figure 102: Server Load for H1 case scenario at hard drive size of 100GB and download bandwidth of 100kb/s

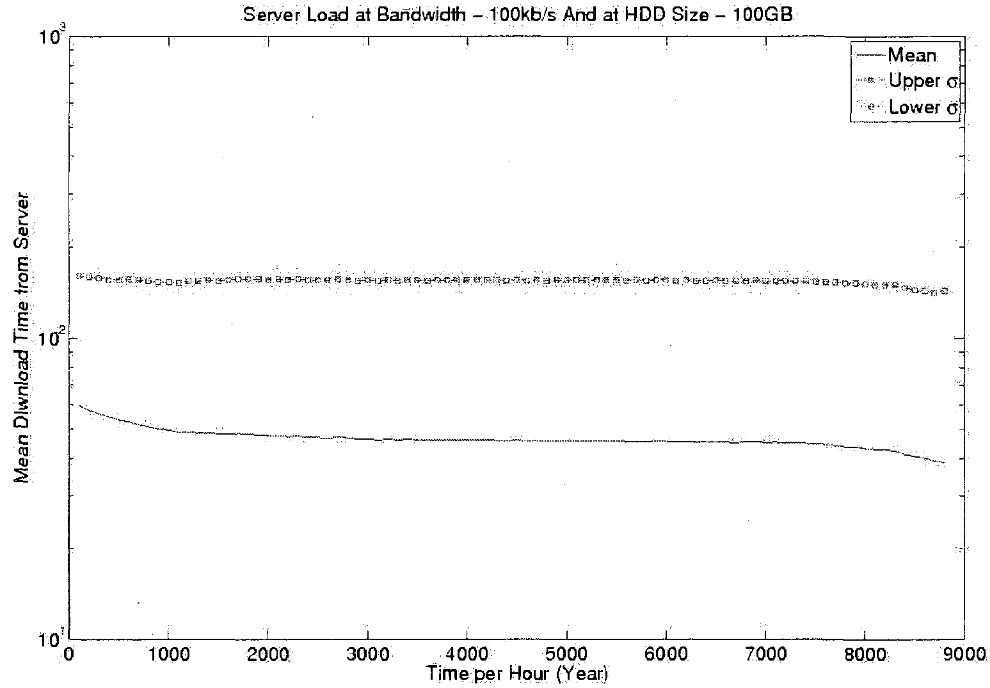


Figure 103: Server Load for H1 case scenario at hard drive size of 150GB and download bandwidth of 100kb/s

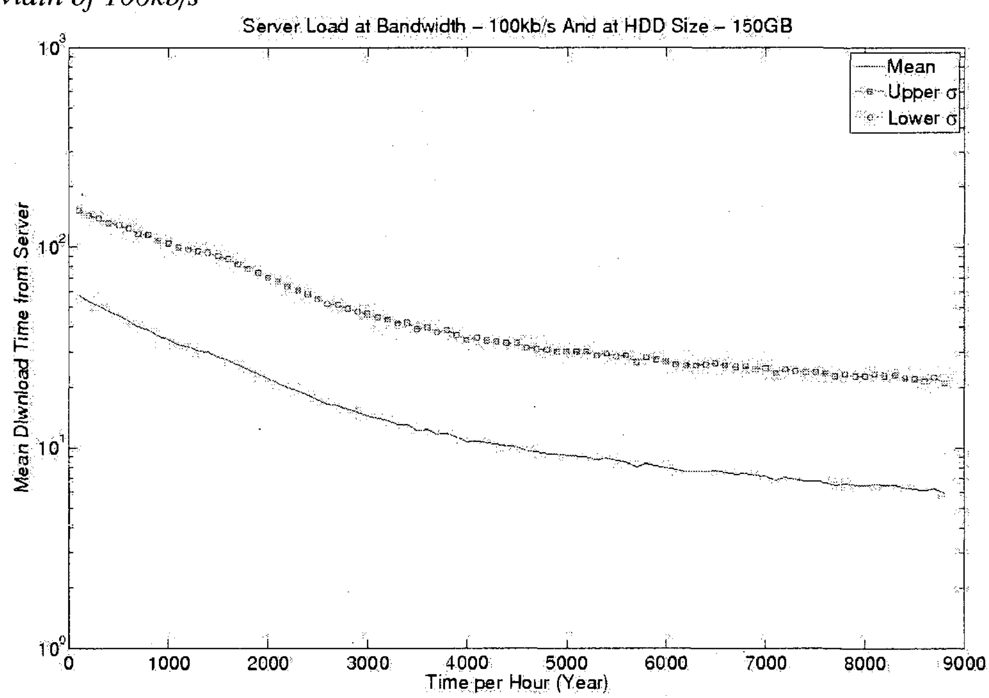


Figure 104: Server Load for H1 case scenario at hard drive size of 200GB and download bandwidth of 100kb/s

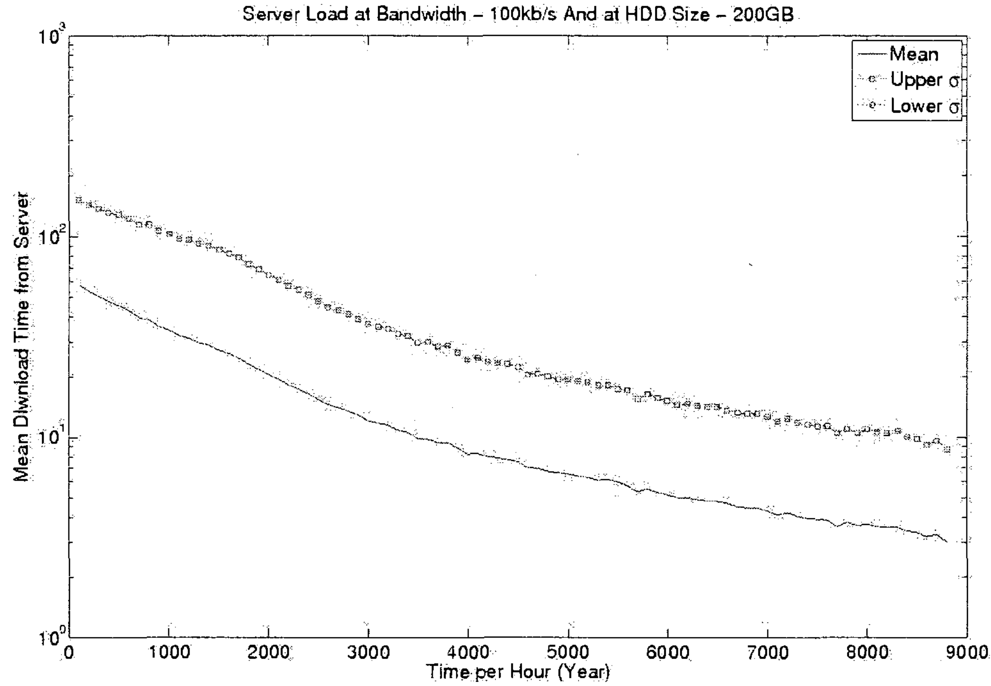


Figure 105: Server Load for H1 case scenario at hard drive size of 50GB and download bandwidth of 128kb/s

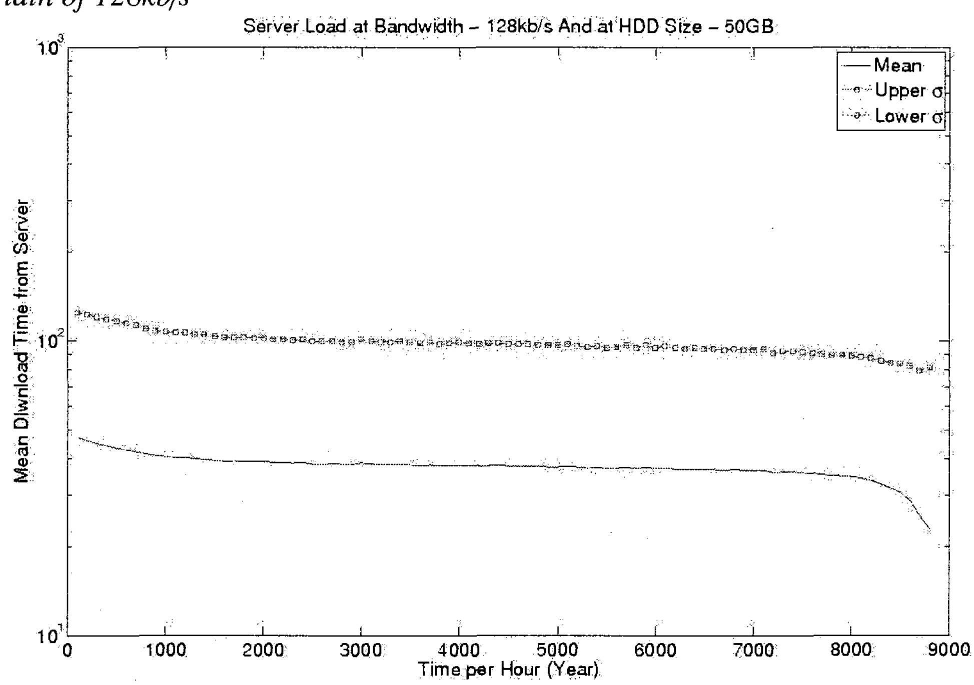


Figure 106: Server Load for H1 case scenario at hard drive size of 100GB and download bandwidth of 128kb/s

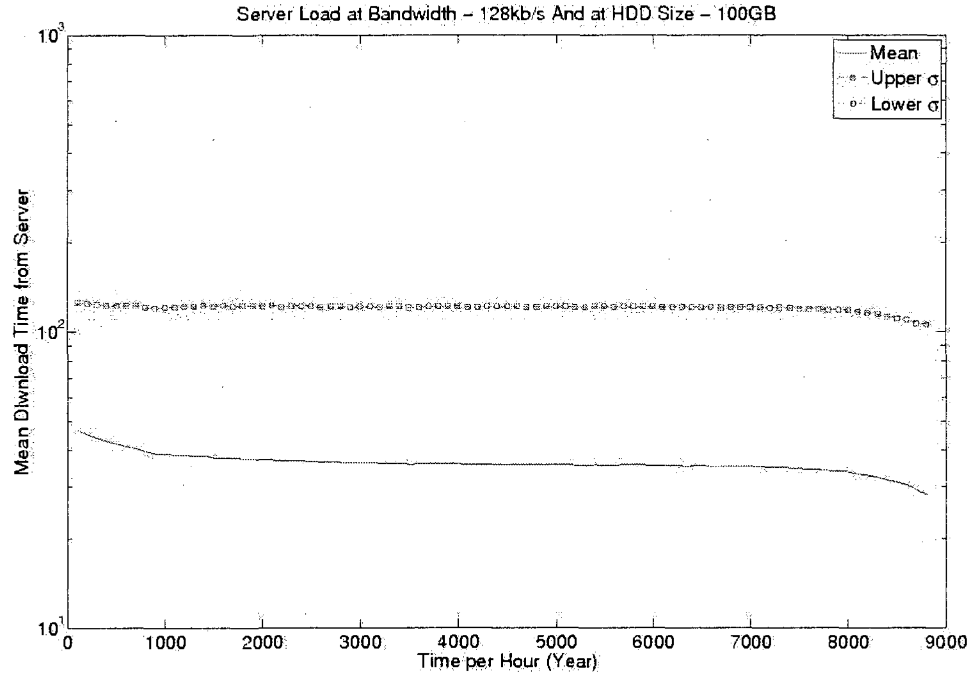


Figure 107: Server Load for H1 case scenario at hard drive size of 150GB and download bandwidth of 128kb/s

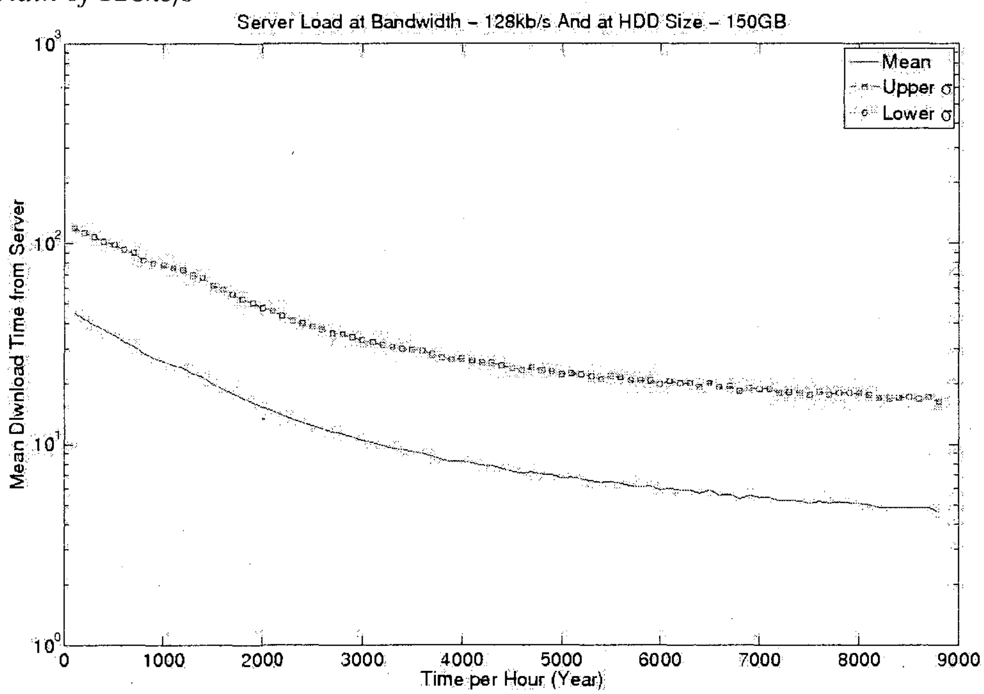


Figure 108: Server Load for H1 case scenario at hard drive size of 200GB and download bandwidth of 128kb/s

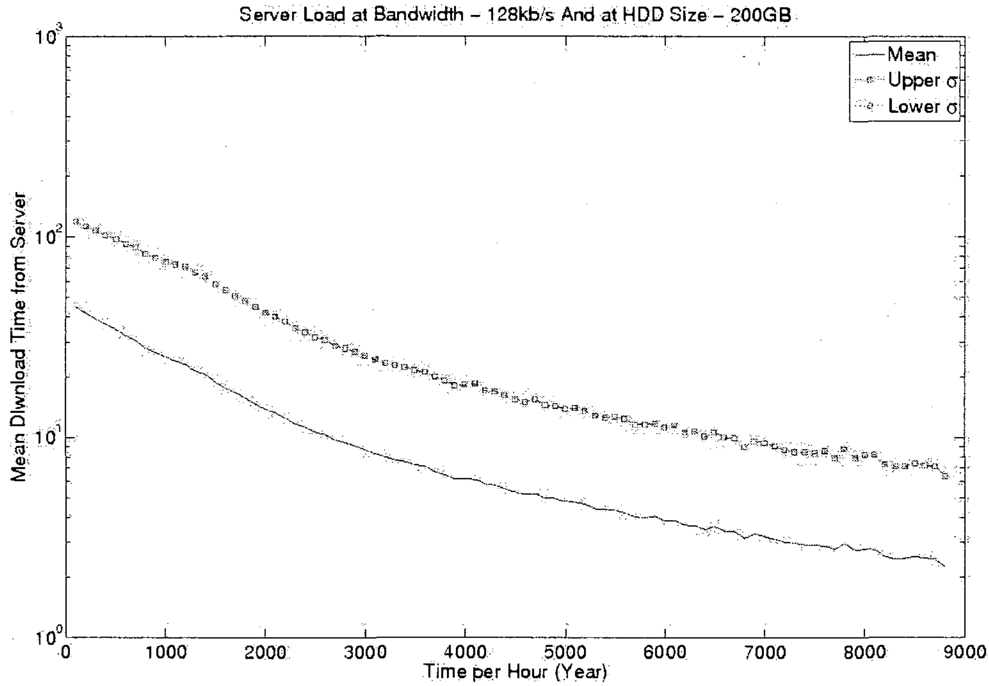


Figure 109: Server Load for H1 case scenario at hard drive size of 50GB and download bandwidth of 256kb/s

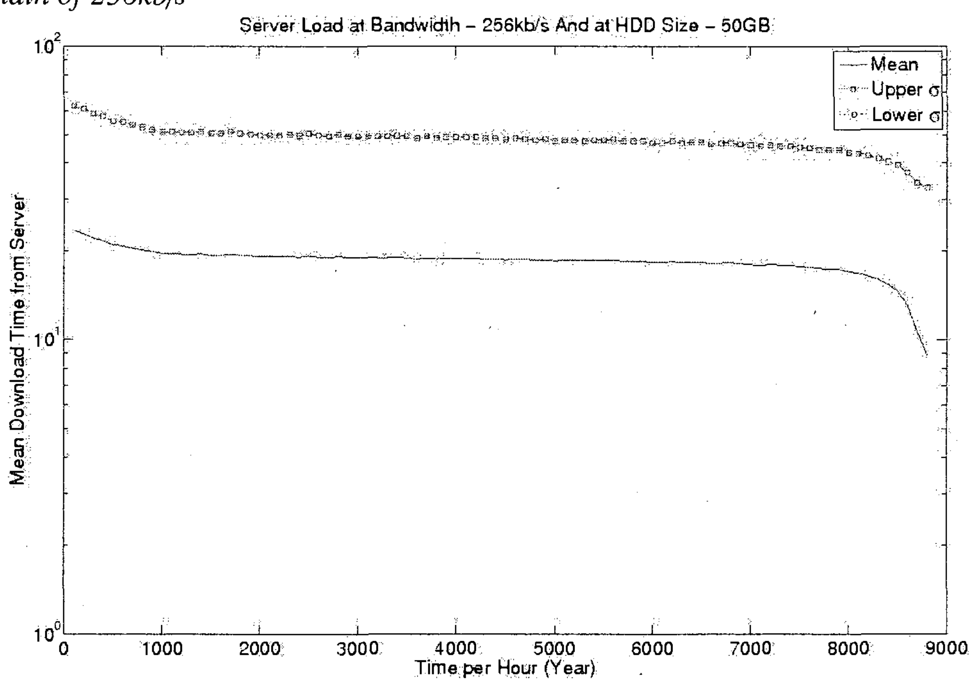


Figure 110: Server Load for H1 case scenario at hard drive size of 100GB and download bandwidth of 256kb/s

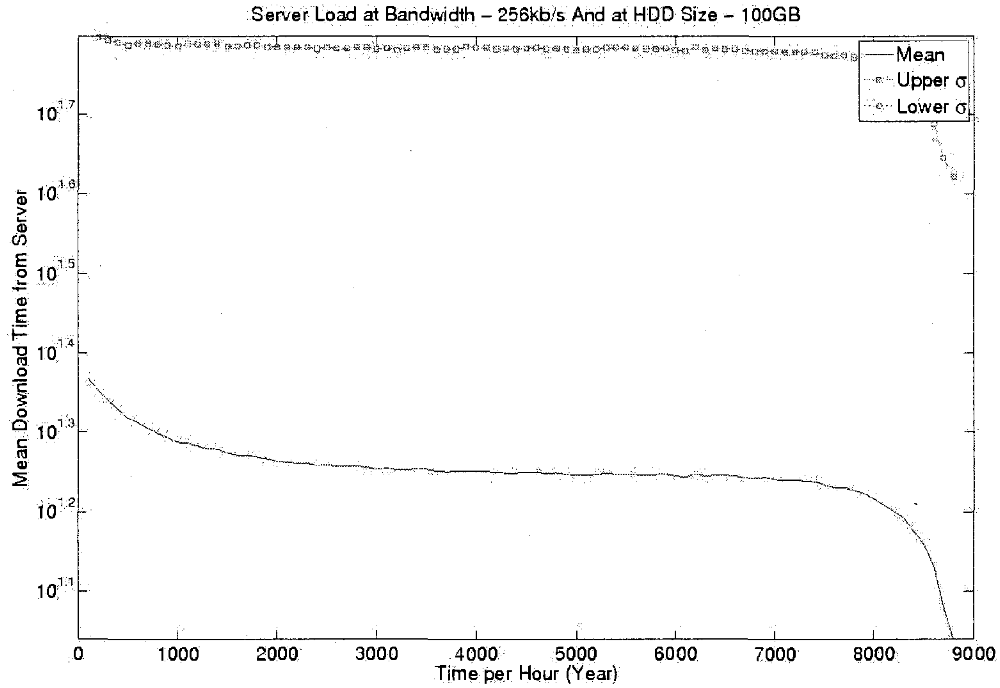


Figure 111: Server Load for H1 case scenario at hard drive size of 150GB and download bandwidth of 256kb/s

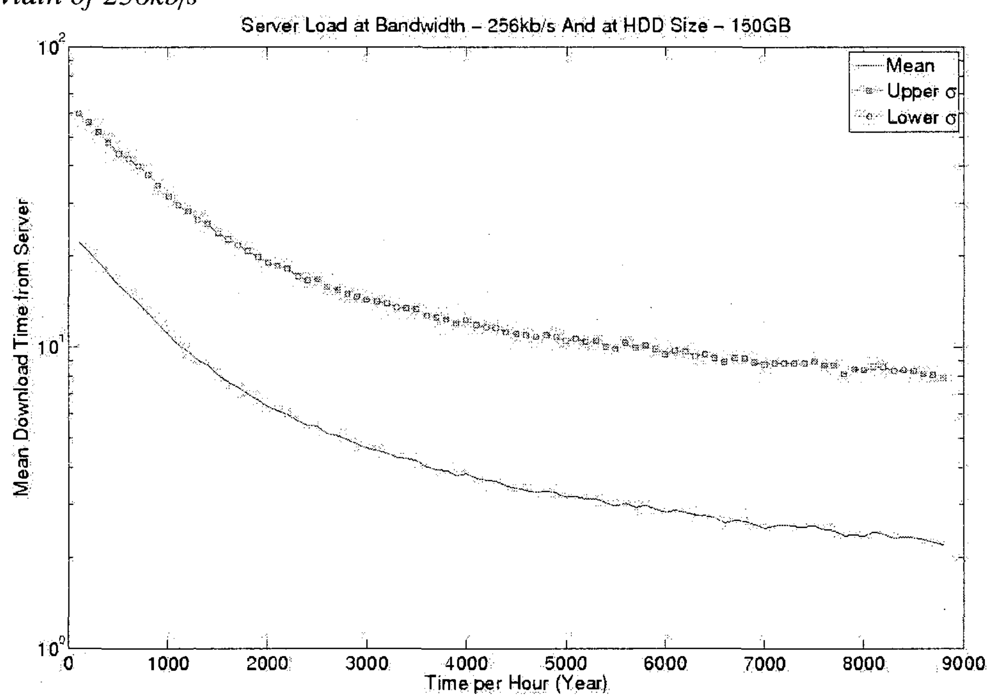


Figure 112: Server Load for H1 case scenario at hard drive size of 200GB and download bandwidth of 256kb/s

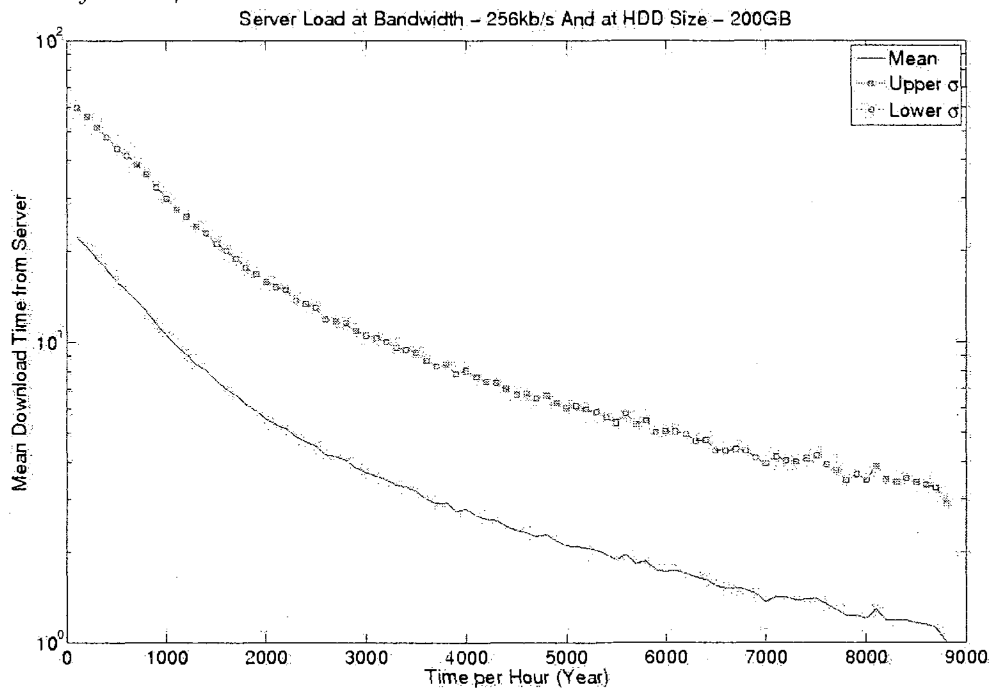


Figure 113: Server Load for H1 case scenario at hard drive size of 50GB and download bandwidth of 512kb/s

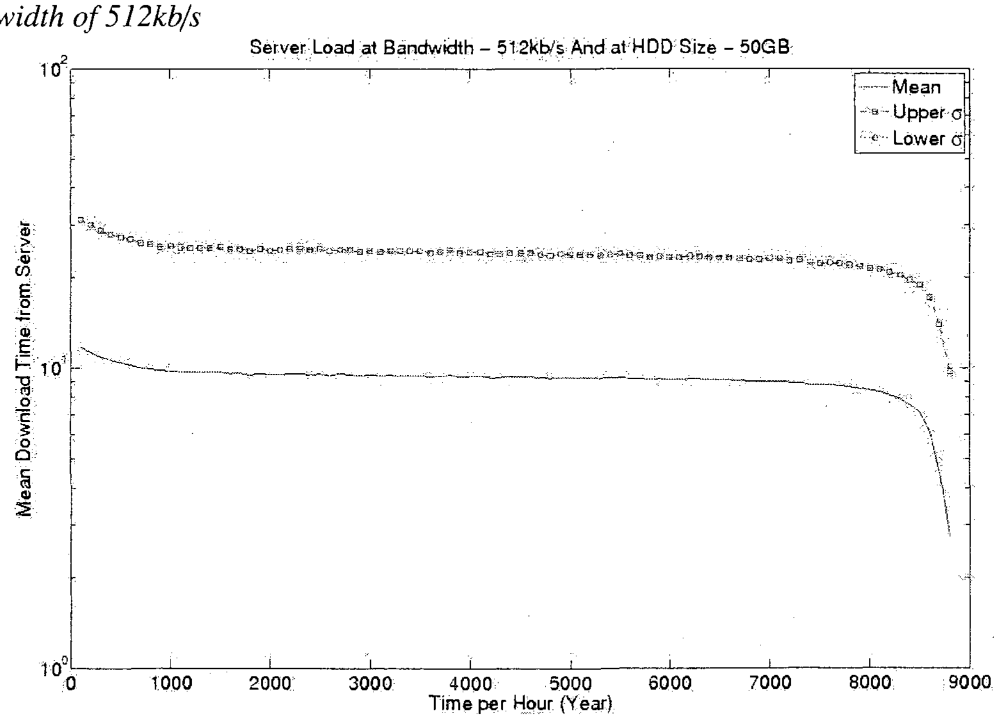


Figure 114: Server Load for H1 case scenario at hard drive size of 100GB and download bandwidth of 512kb/s

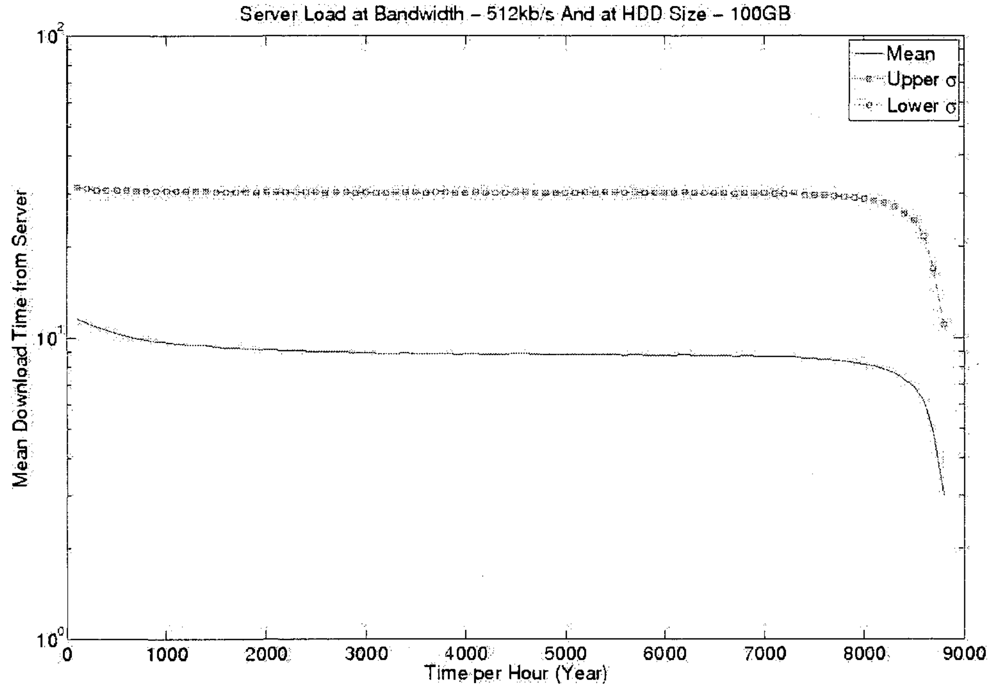


Figure 115: Server Load for H1 case scenario at hard drive size of 150GB and download bandwidth of 512kb/s

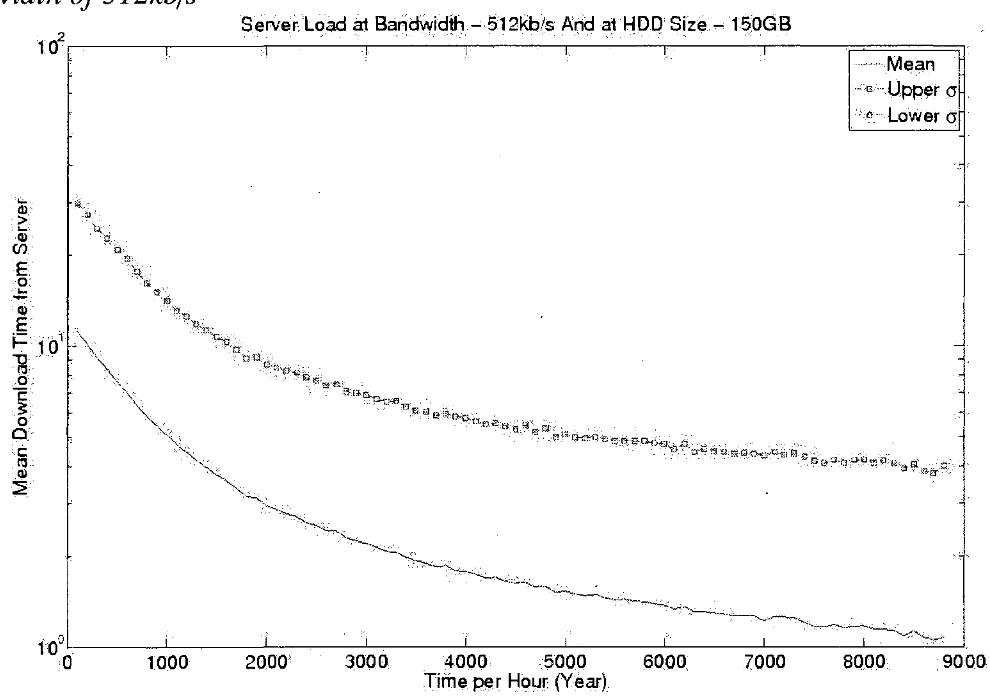


Figure 116: Server Load for H1 case scenario at hard drive size of 200GB and download bandwidth of 512kb/s

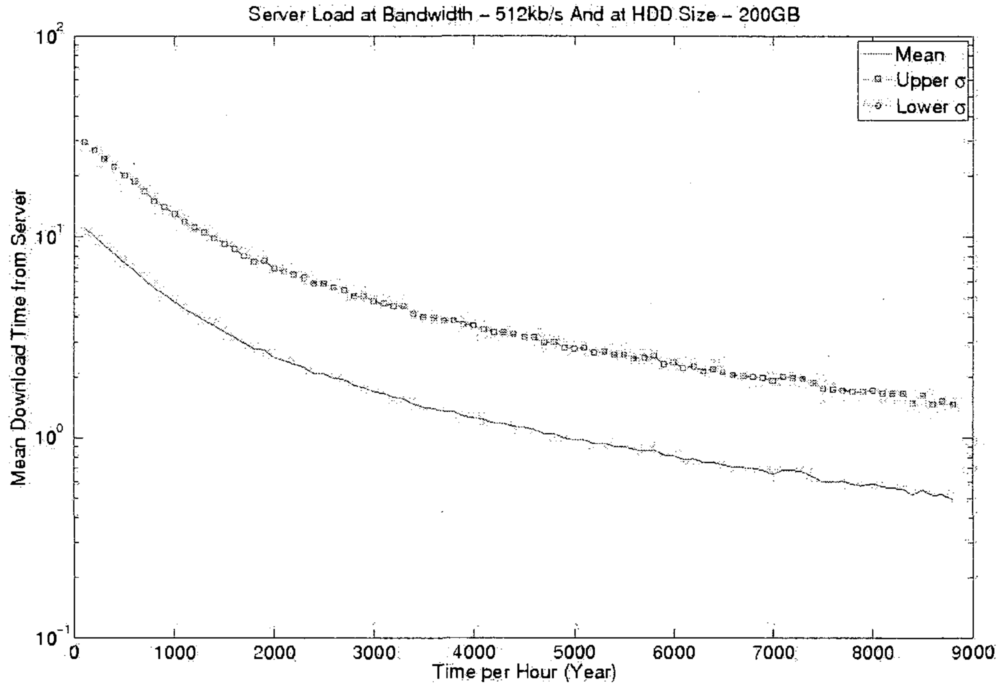


Figure 117: Server Load for H1 case scenario at hard drive size of 50GB and download bandwidth of 1000kb/s

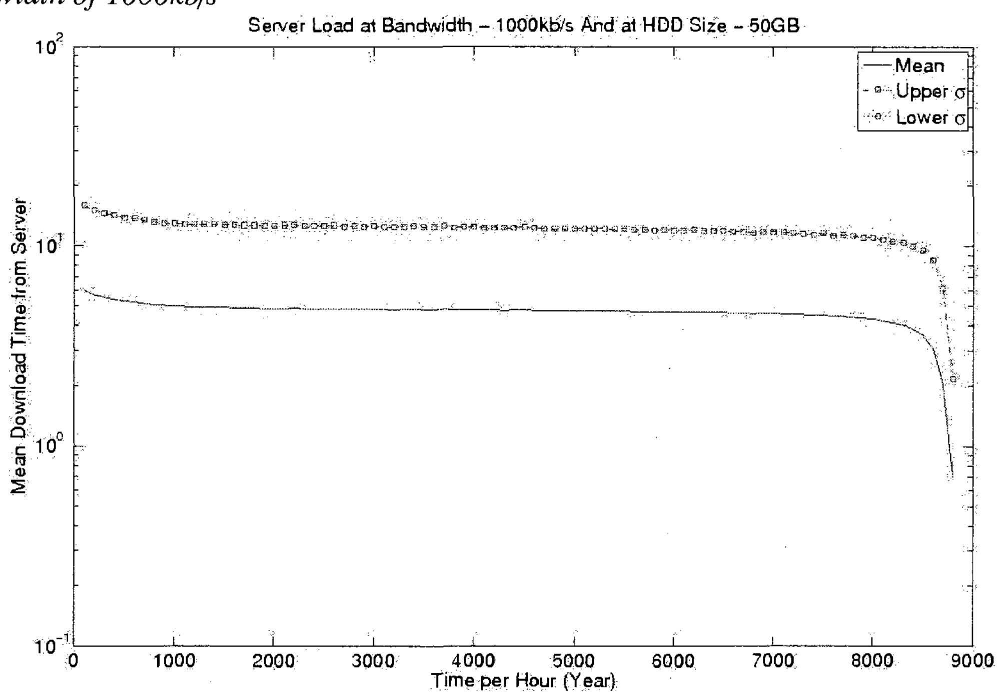


Figure 118: Server Load for H1 case scenario at hard drive size of 100GB and download bandwidth of 1000kb/s

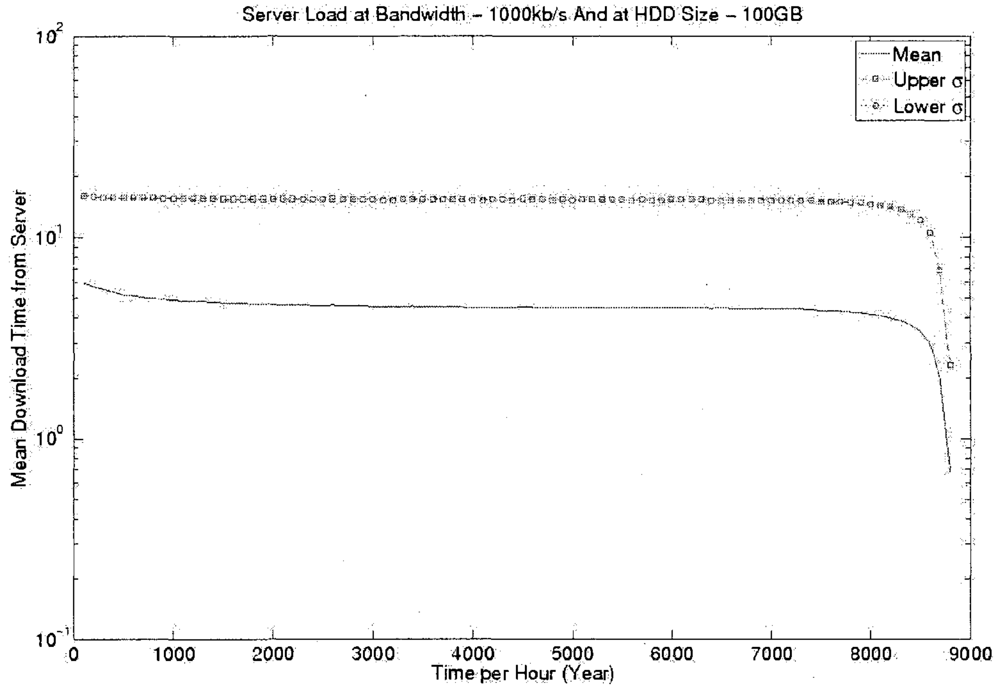


Figure 119: Server Load for H1 case scenario at hard drive size of 150GB and download bandwidth of 1000kb/s

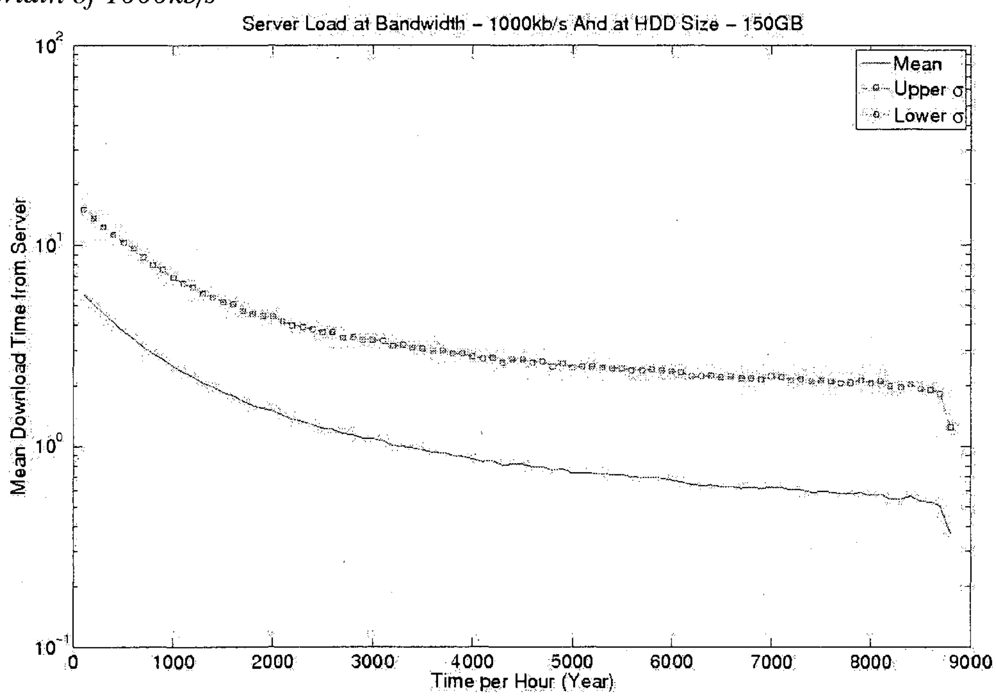


Figure 120: Server Load for H1 case scenario at hard drive size of 200GB and download bandwidth of 1000kb/s

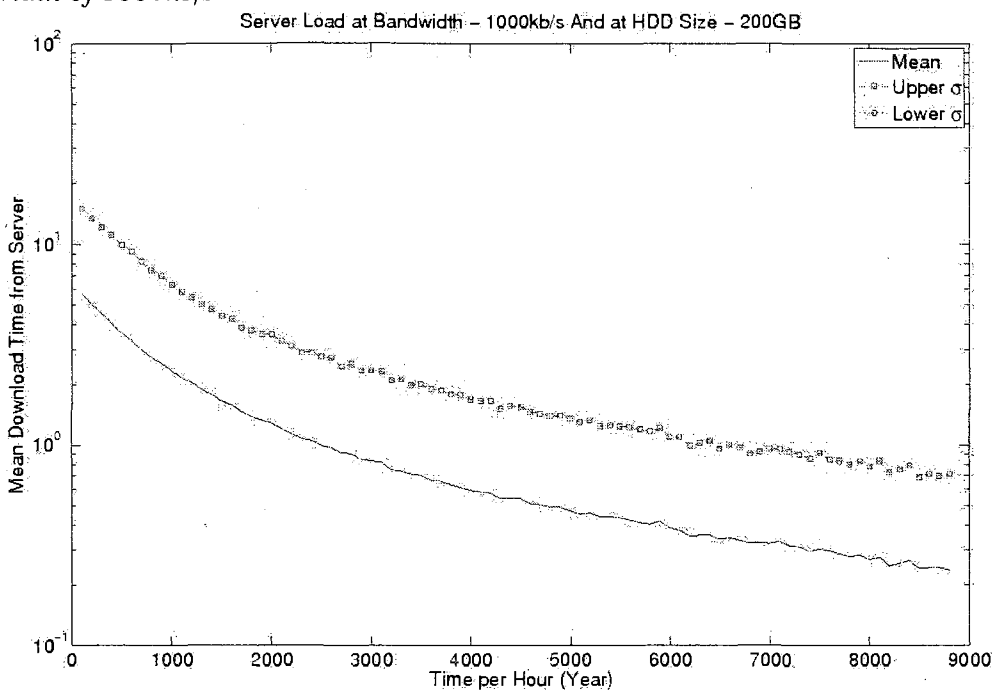


Figure 121: Server Load for H1 case scenario at hard drive size of 50GB and download bandwidth of 2000kb/s

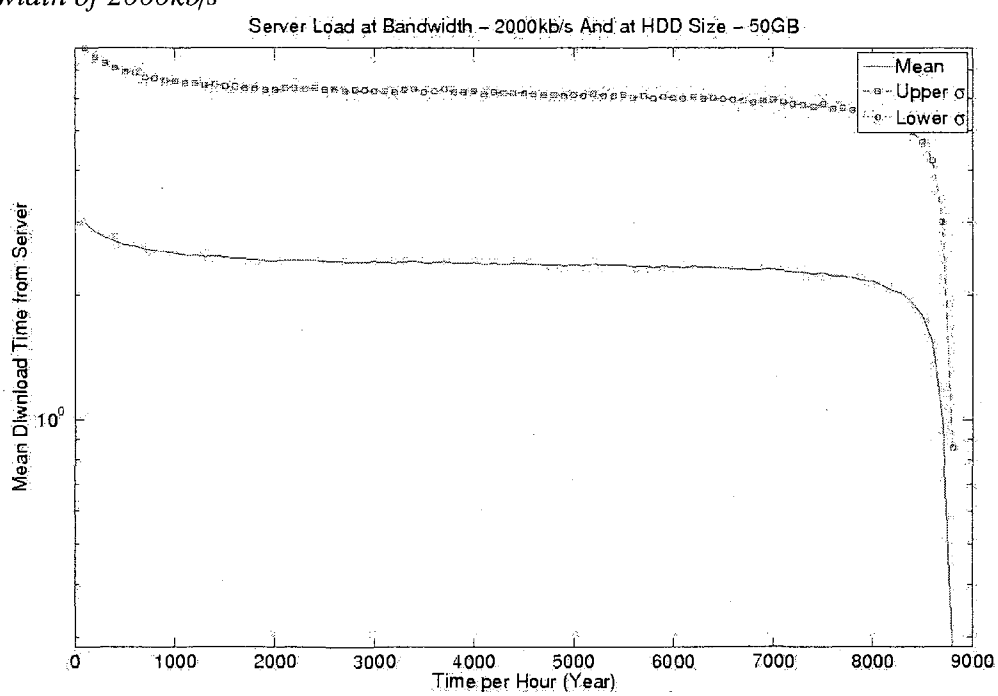


Figure 122: Server Load for H1 case scenario at hard drive size of 100GB and download bandwidth of 2000kb/s

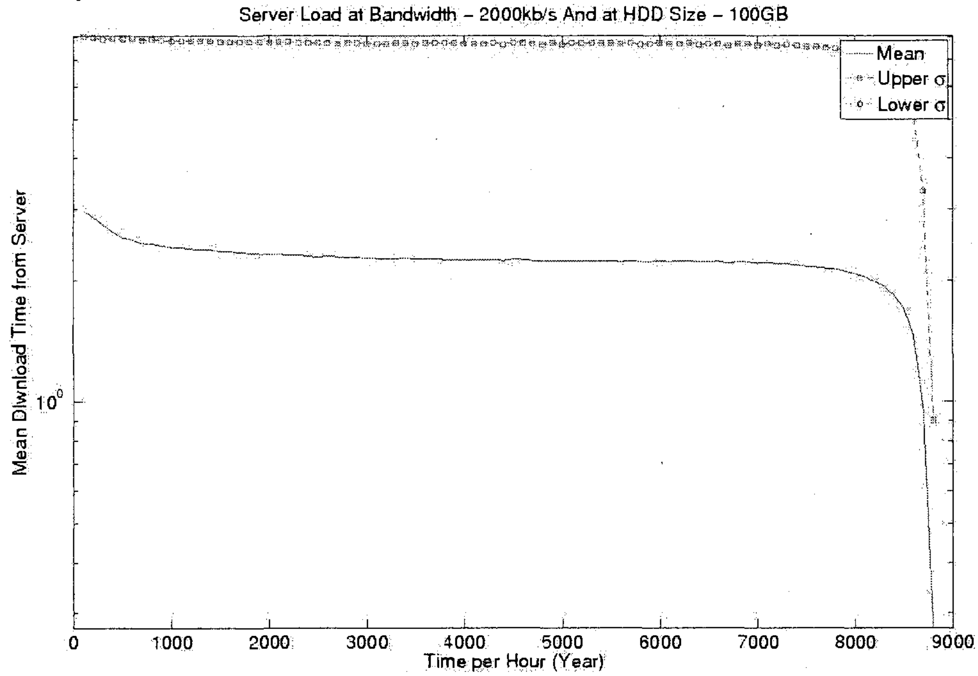


Figure 123: Server Load for H1 case scenario at hard drive size of 150GB and download bandwidth of 2000kb/s

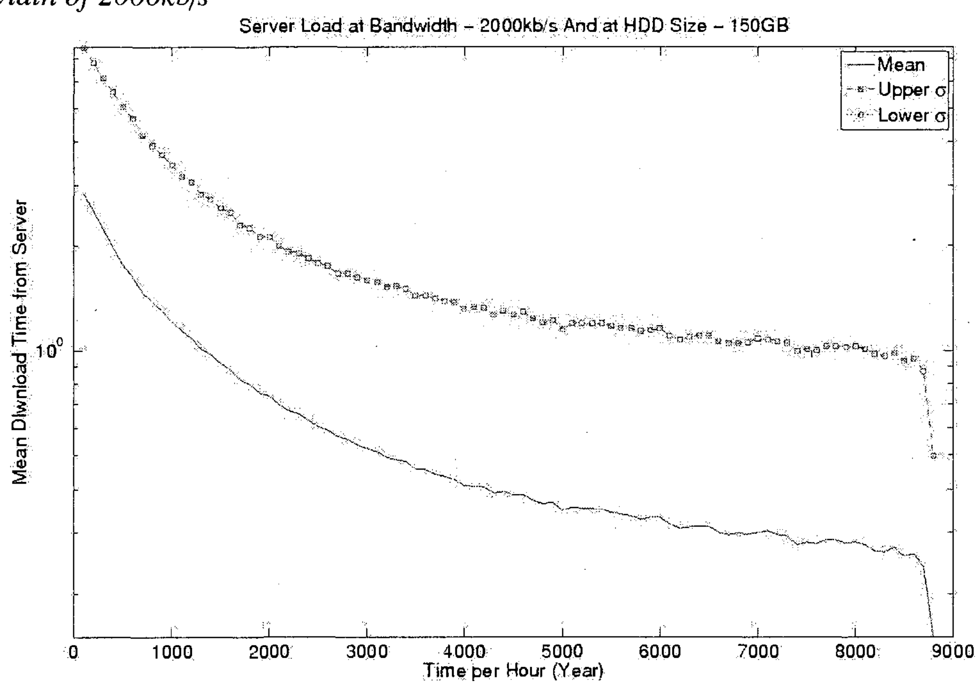


Figure 124: Server Load for H1 case scenario at hard drive size of 200GB and download bandwidth of 2000kb/s

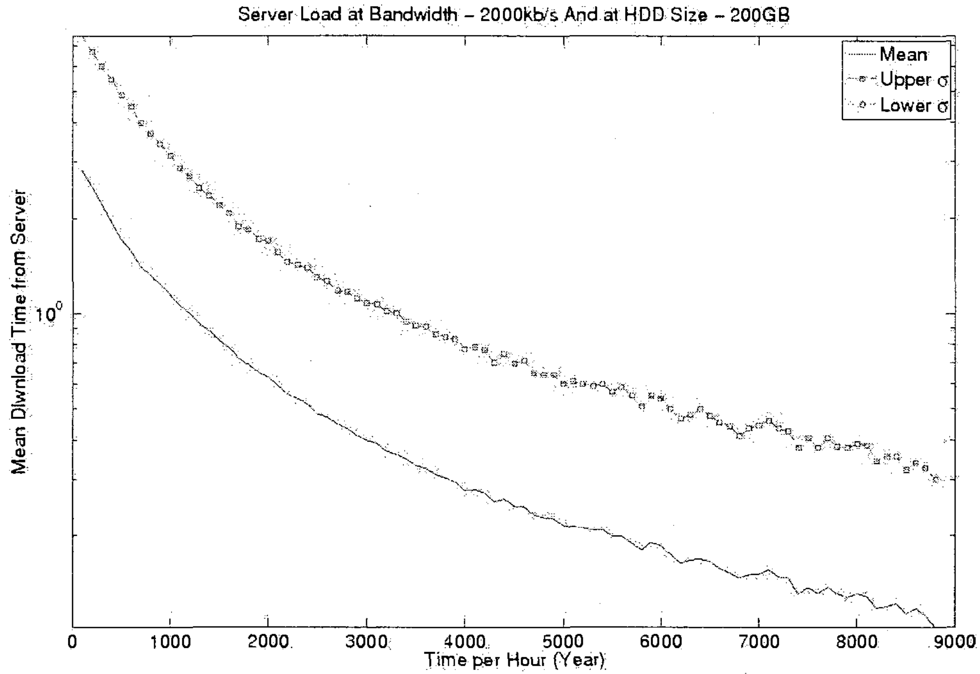


Figure 125: Server Load for H1 case scenario at hard drive size of 50GB and download bandwidth of 5000kb/s

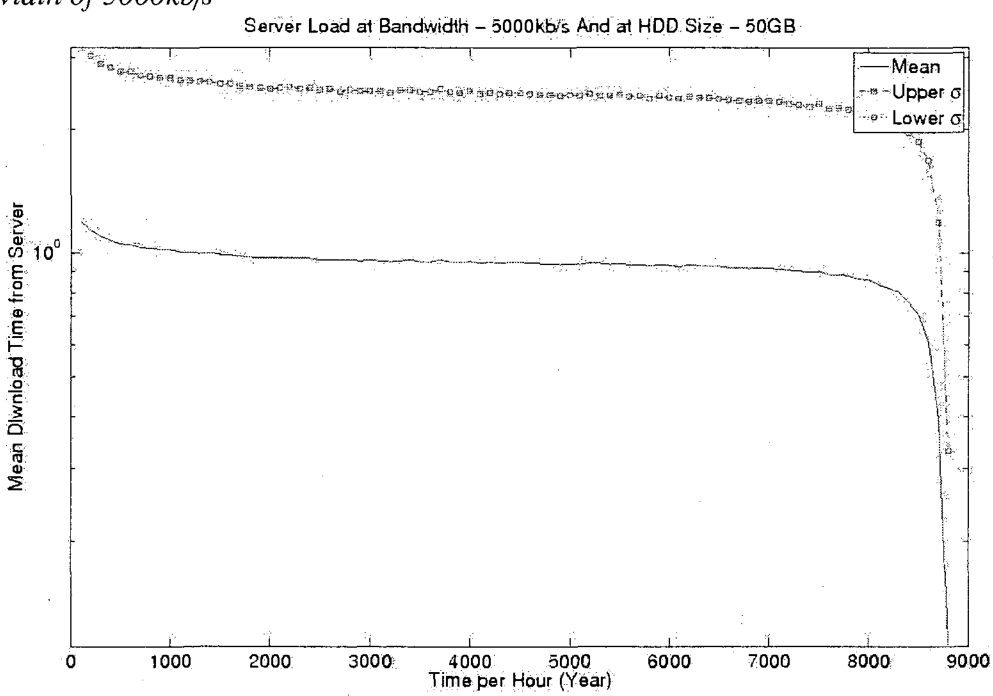


Figure 126: Server Load for H1 case scenario at hard drive size of 100GB and download bandwidth of 5000kb/s

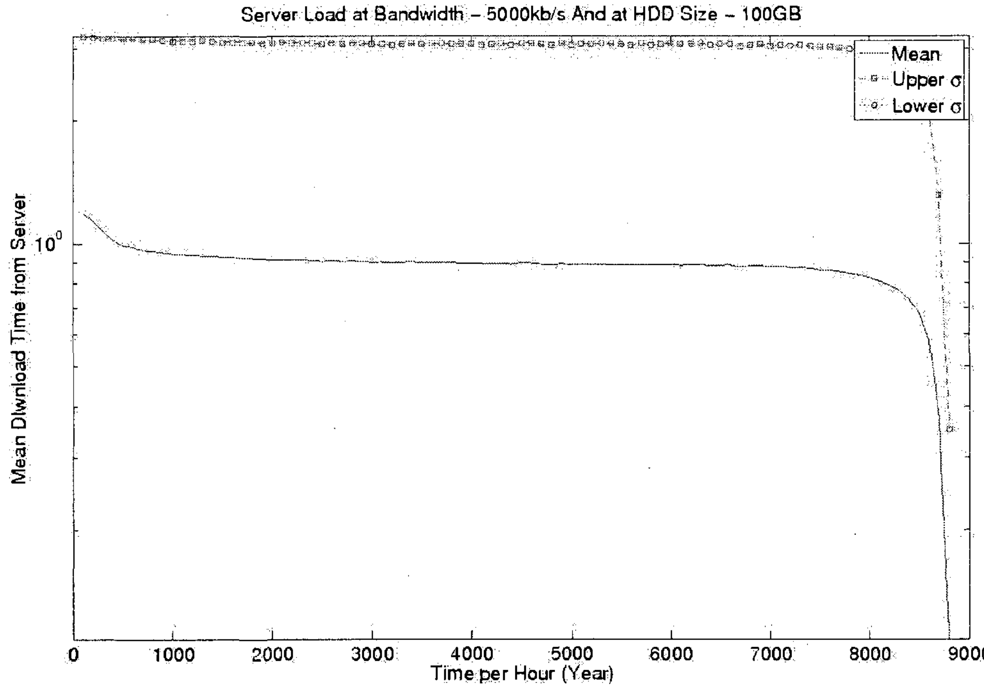


Figure 127: Server Load for H1 case scenario at hard drive size of 150GB and download bandwidth of 5000kb/s

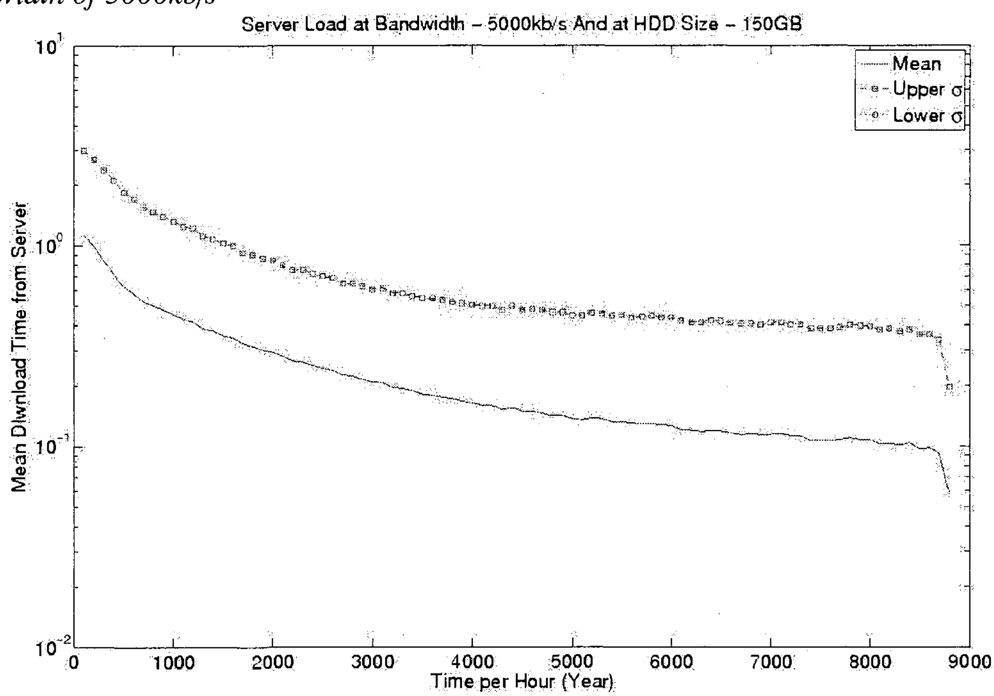


Figure 128: Server Load for H1 case scenario at hard drive size of 200GB and download bandwidth of 5000kb/s

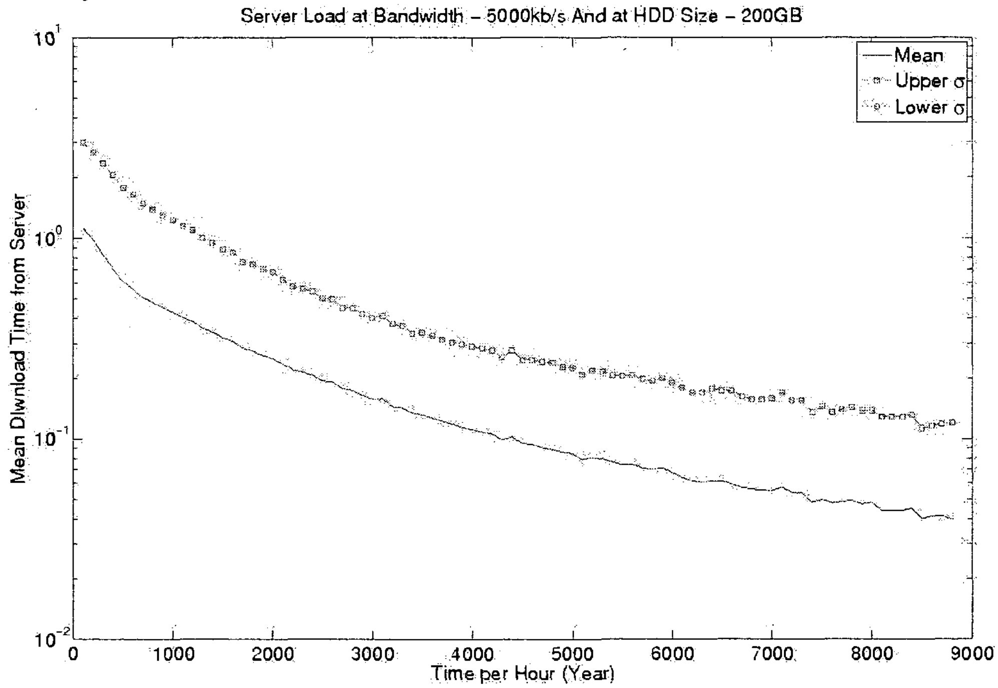


Figure 129: Server Load for H1 case scenario at hard drive size of 50GB and download bandwidth of 10000kb/s

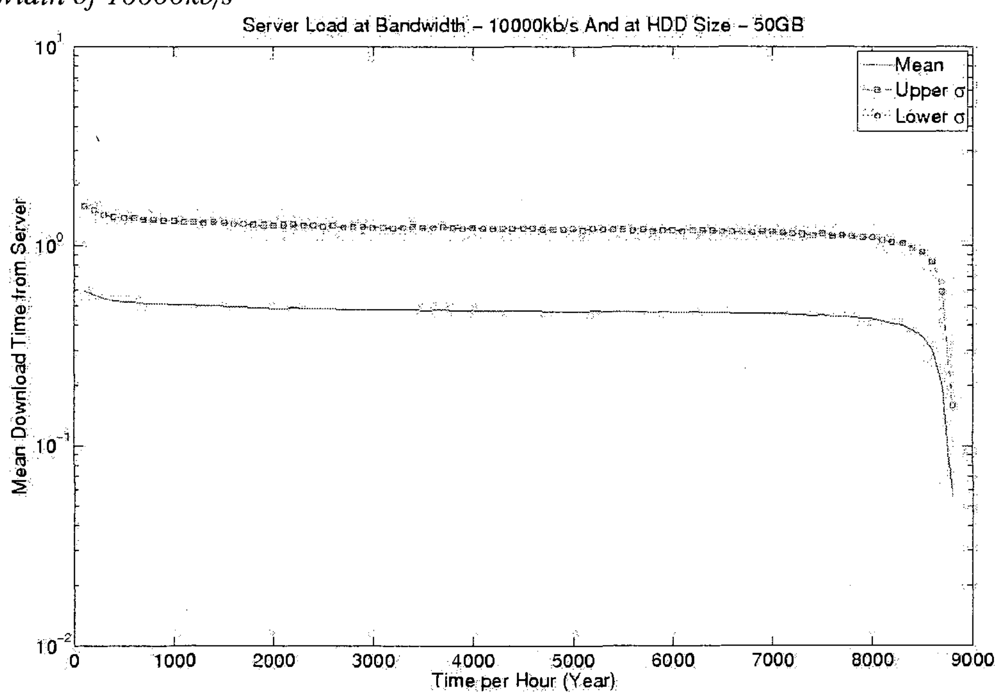


Figure 130: Server Load for H1 case scenario at hard drive size of 100GB and download bandwidth of 10000kb/s

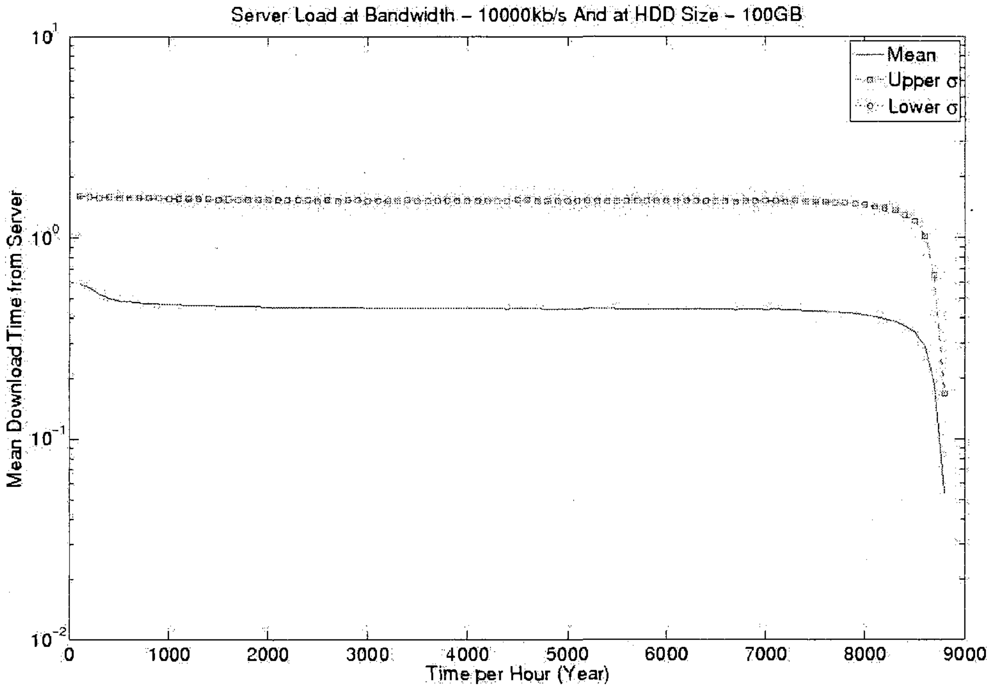


Figure 131: Server Load for H1 case scenario at hard drive size of 150GB and download bandwidth of 10000kb/s

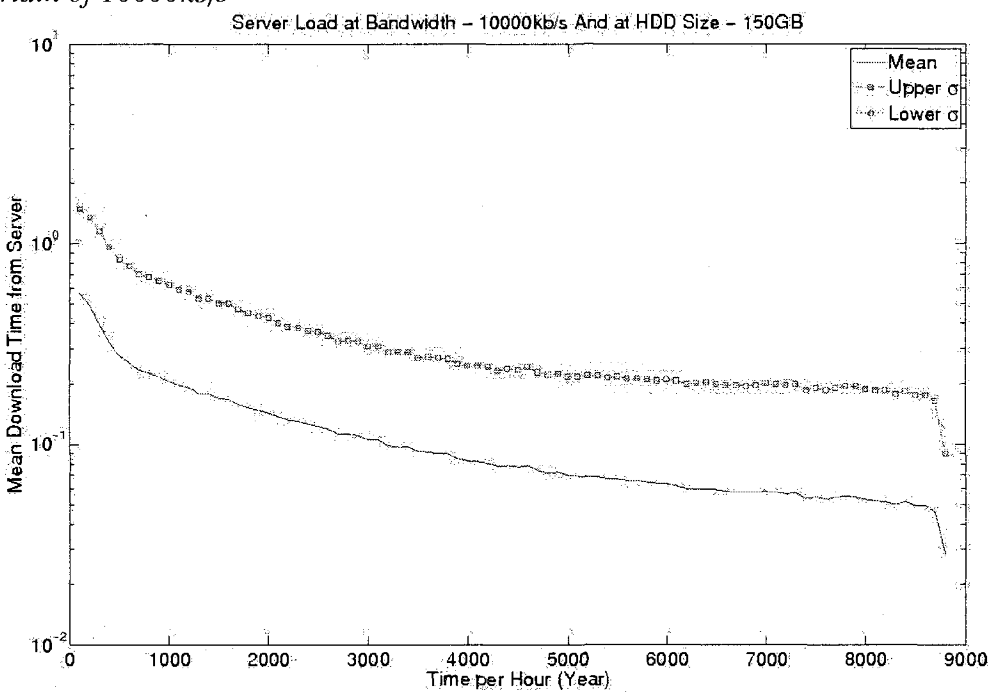


Figure 132: Server Load for H1 case scenario at hard drive size of 200GB and download bandwidth of 10000kb/s

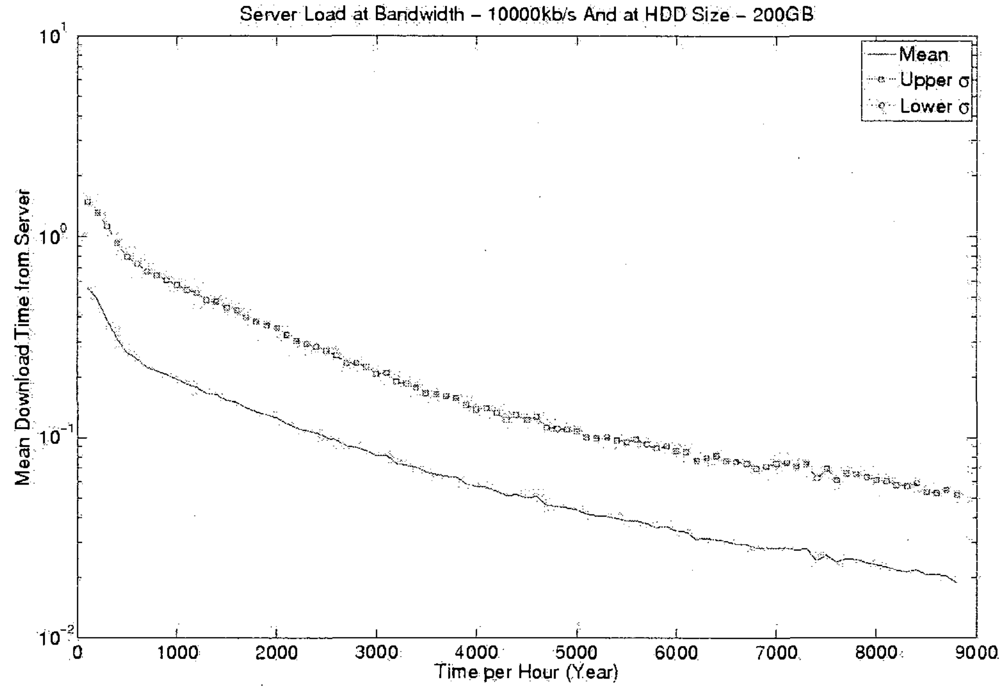


Figure 133: Server Load for H1 case scenario at hard drive size of 50GB and download bandwidth of 15000kb/s

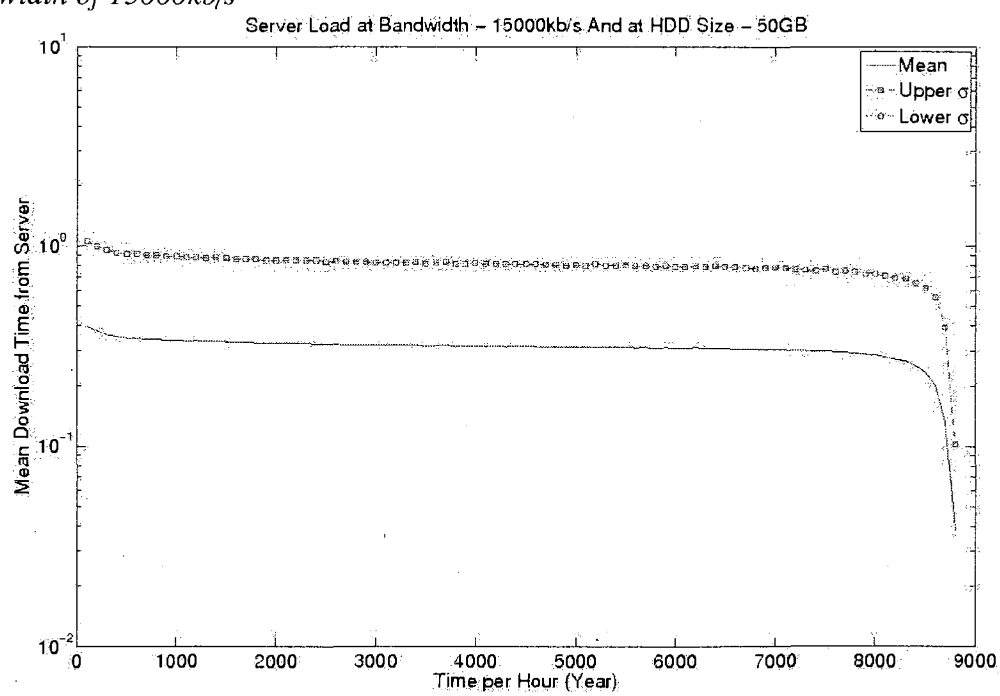


Figure 134: Server Load for H1 case scenario at hard drive size of 100GB and download bandwidth of 15000kb/s

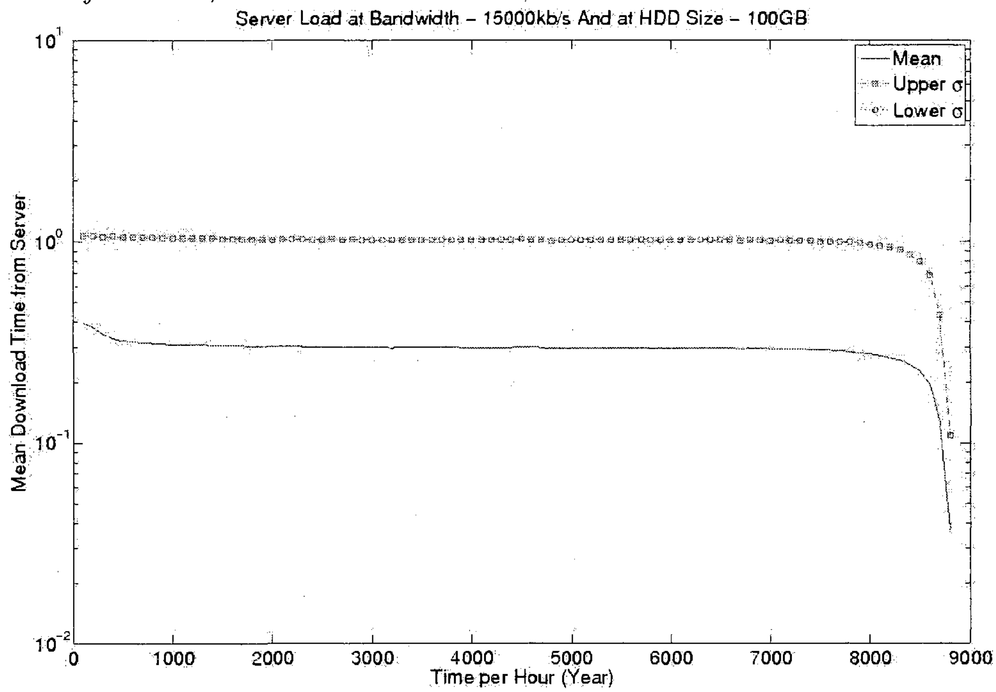


Figure 135: Server Load for H1 case scenario at hard drive size of 150GB and download bandwidth of 15000kb/s

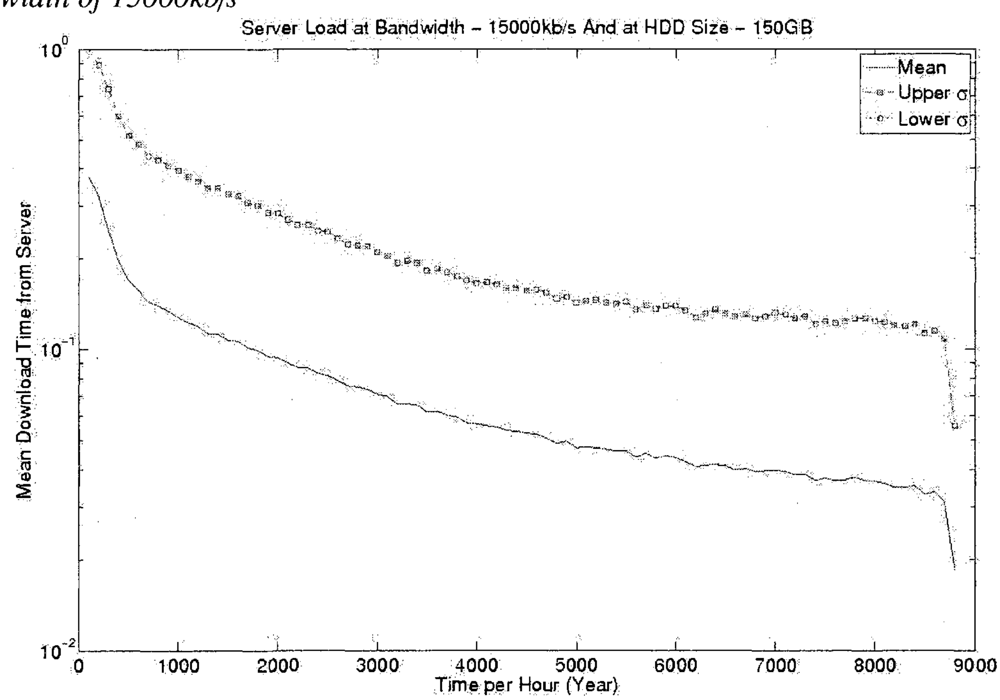


Figure 136: Server Load for H1 case scenario at hard drive size of 200GB and download bandwidth of 15000kb/s

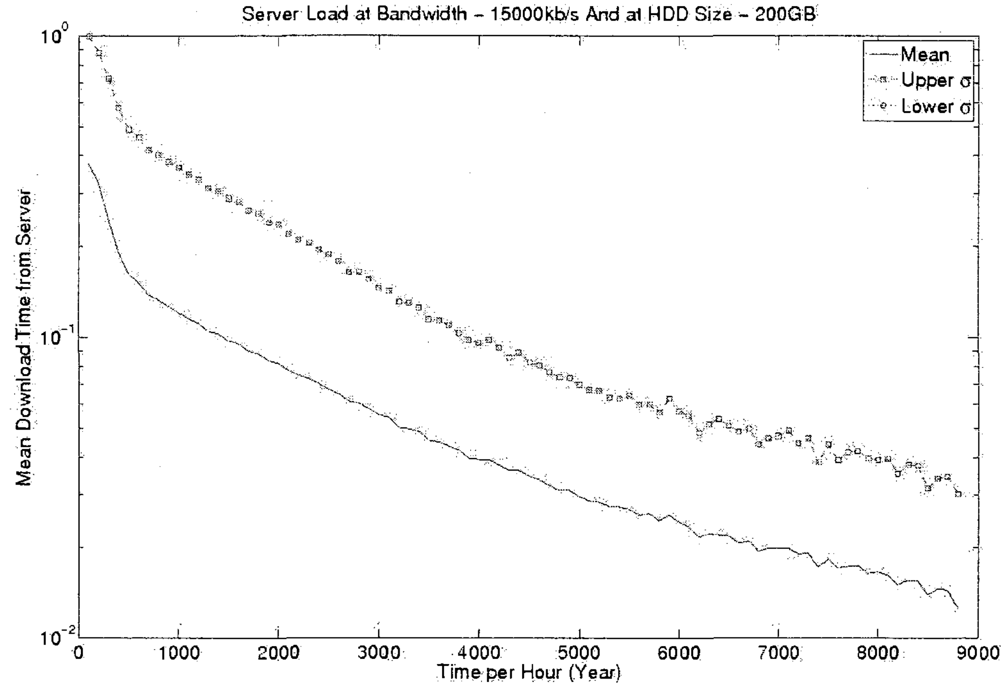


Figure 137: Server Load for H2 case scenario at hard drive size of 50GB and download bandwidth of 25kb/s

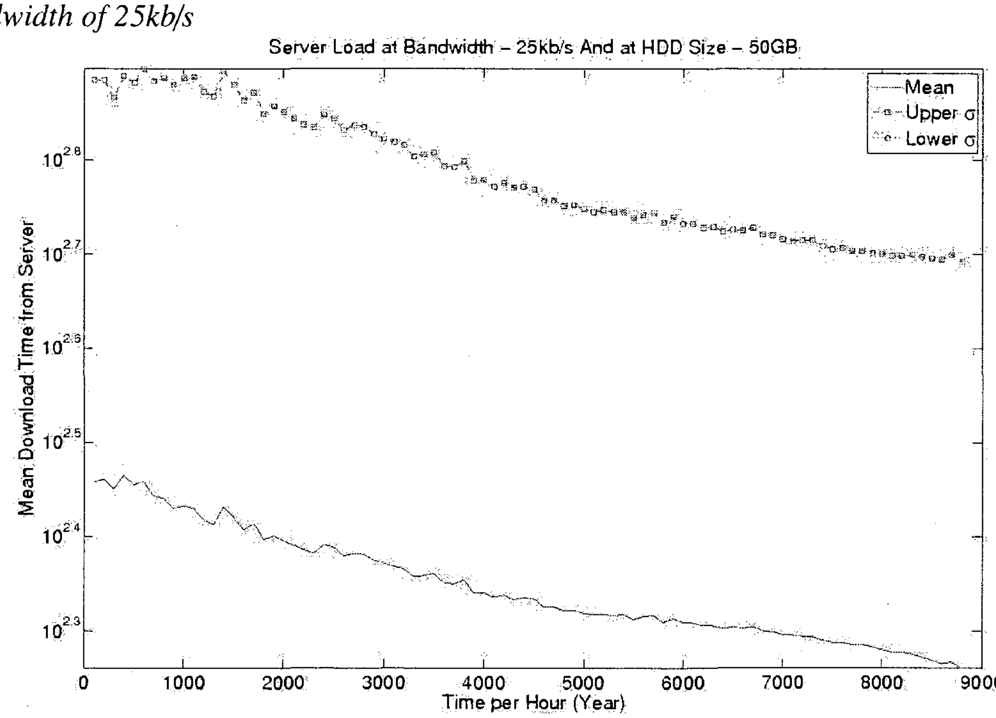


Figure 138: Server Load for H2 case scenario at hard drive size of 100GB and download bandwidth of 25kb/s

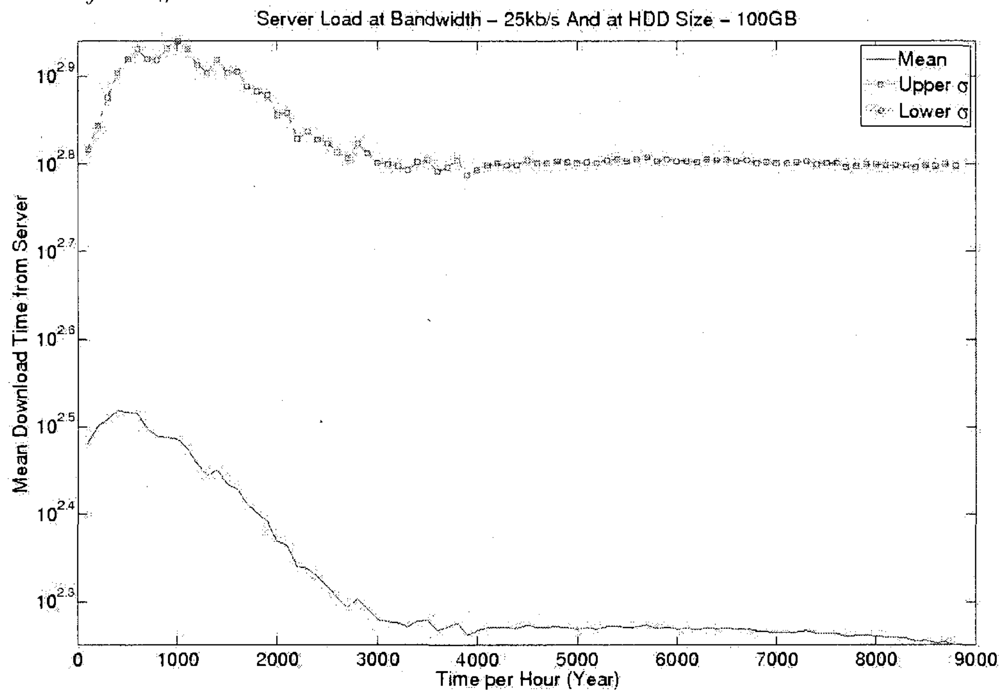


Figure 139: Server Load for H2 case scenario at hard drive size of 150GB and download bandwidth of 25kb/s

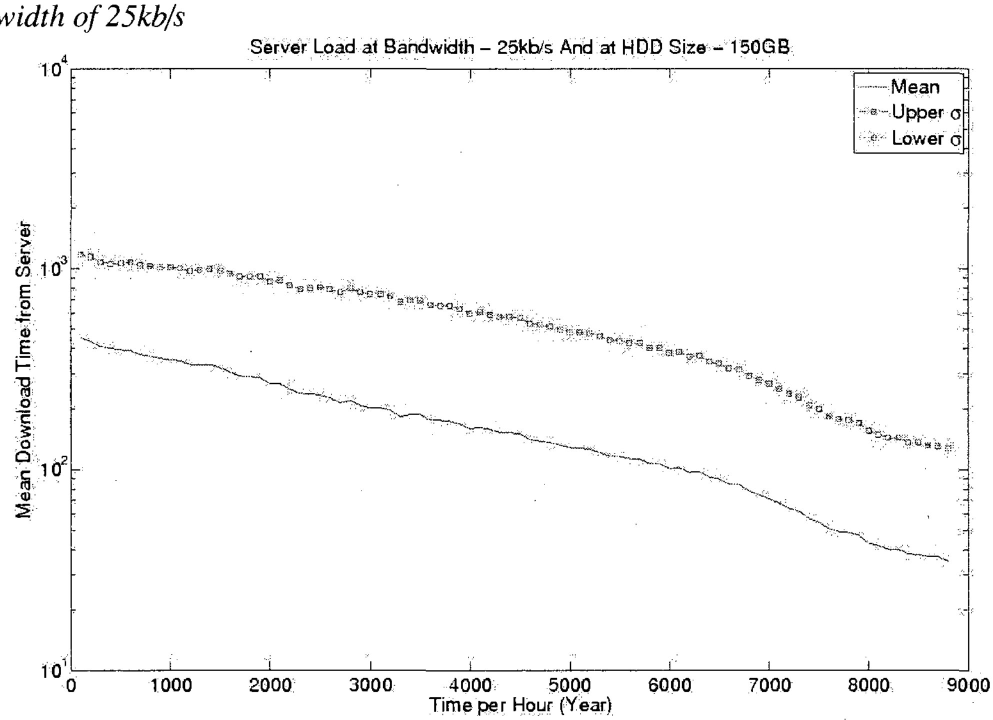


Figure 140: Server Load for H2 case scenario at hard drive size of 200GB and download bandwidth of 25kb/s

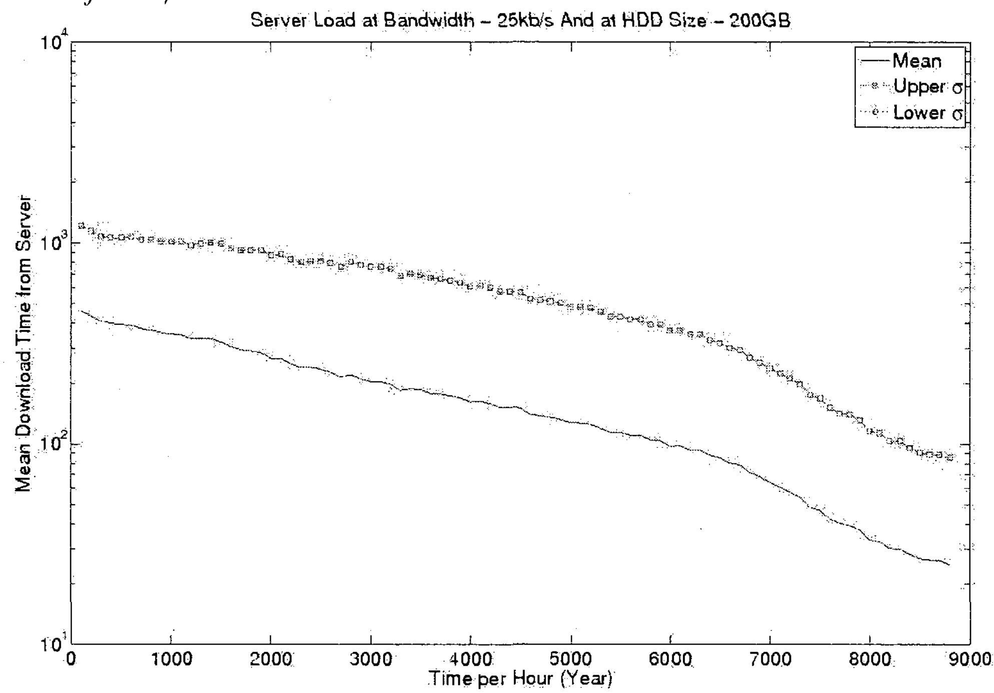


Figure 141: Server Load for H2 case scenario at hard drive size of 50GB and download bandwidth of 50kb/s

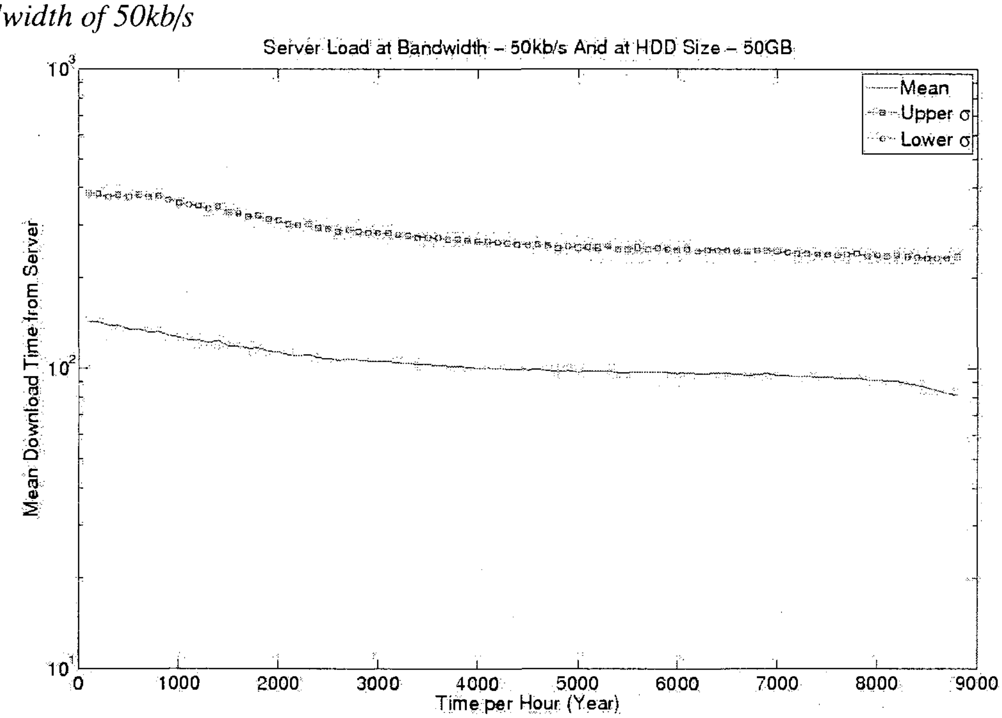


Figure 142: Server Load for H2 case scenario at hard drive size of 100GB and download bandwidth of 50kb/s

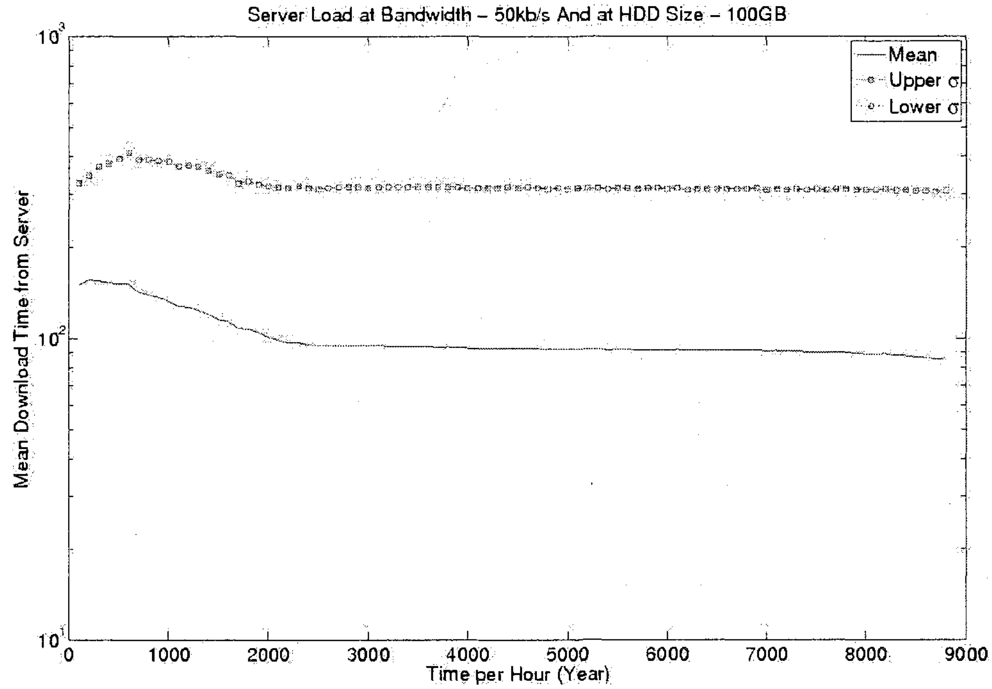


Figure 143: Server Load for H2 case scenario at hard drive size of 150GB and download bandwidth of 50kb/s

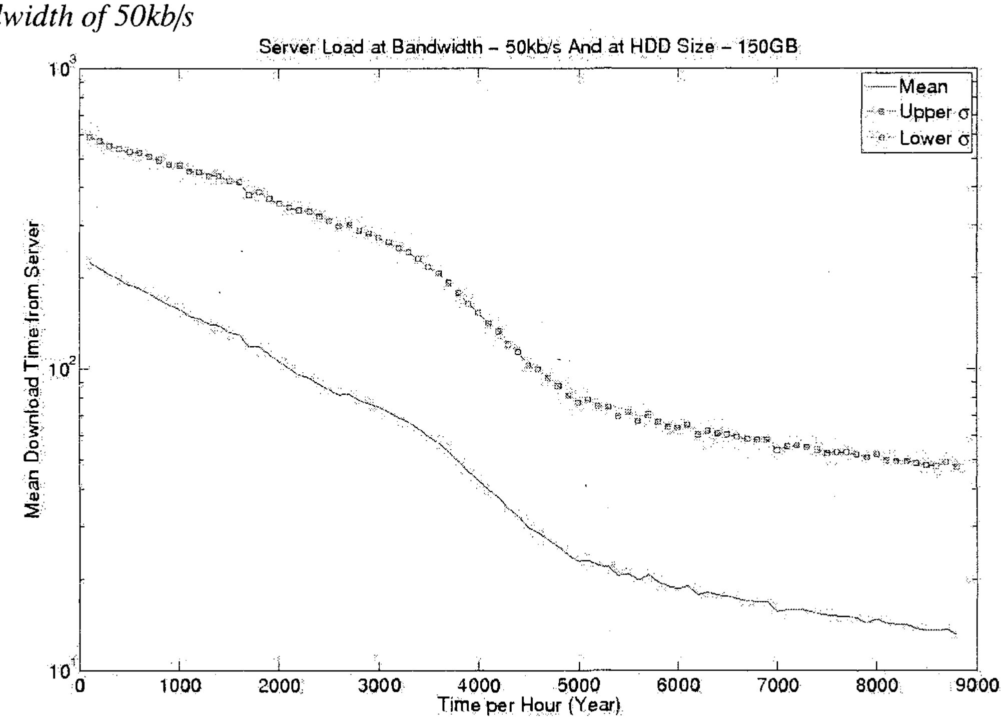


Figure 144: Server Load for H2 case scenario at hard drive size of 200GB and download bandwidth of 50kb/s

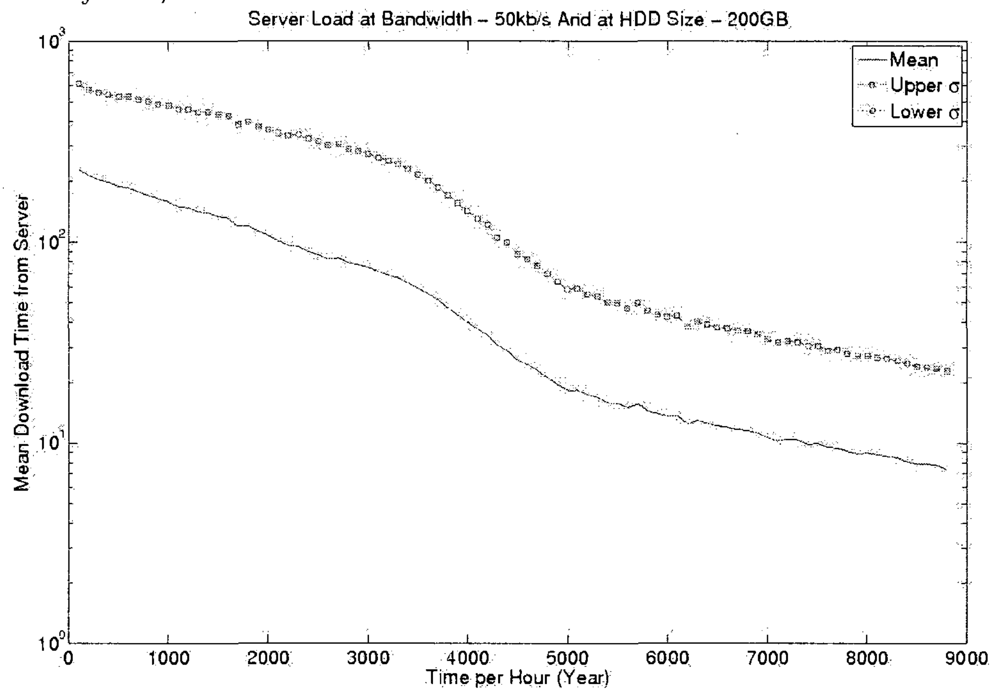


Figure 145: Server Load for H2 case scenario at hard drive size of 50GB and download bandwidth of 100kb/s

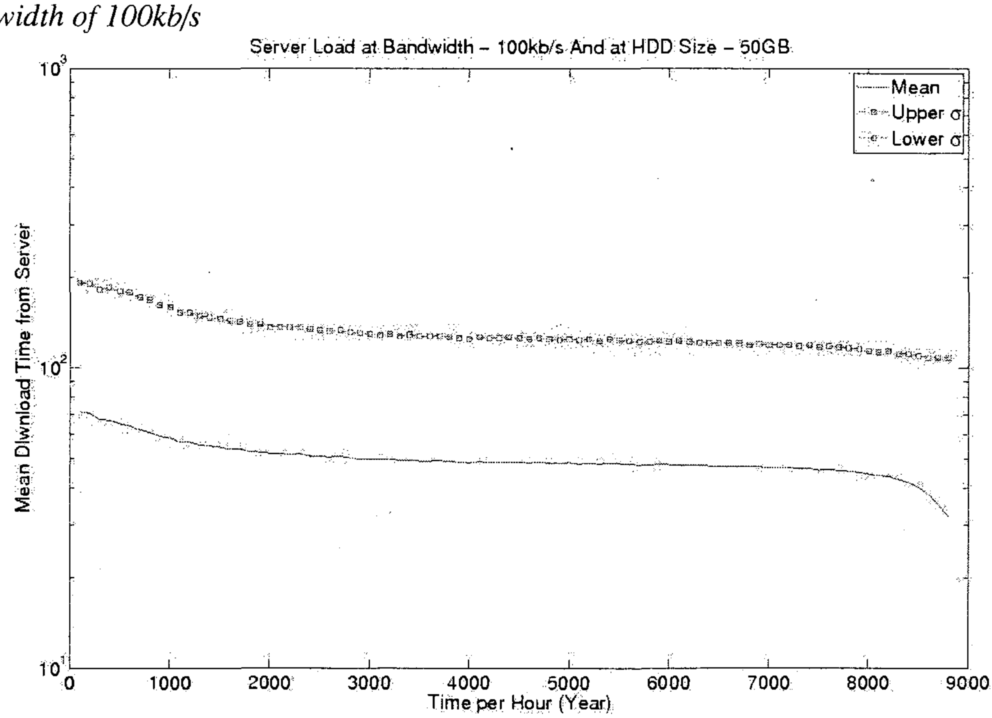


Figure 146: Server Load for H2 case scenario at hard drive size of 100GB and download bandwidth of 100kb/s

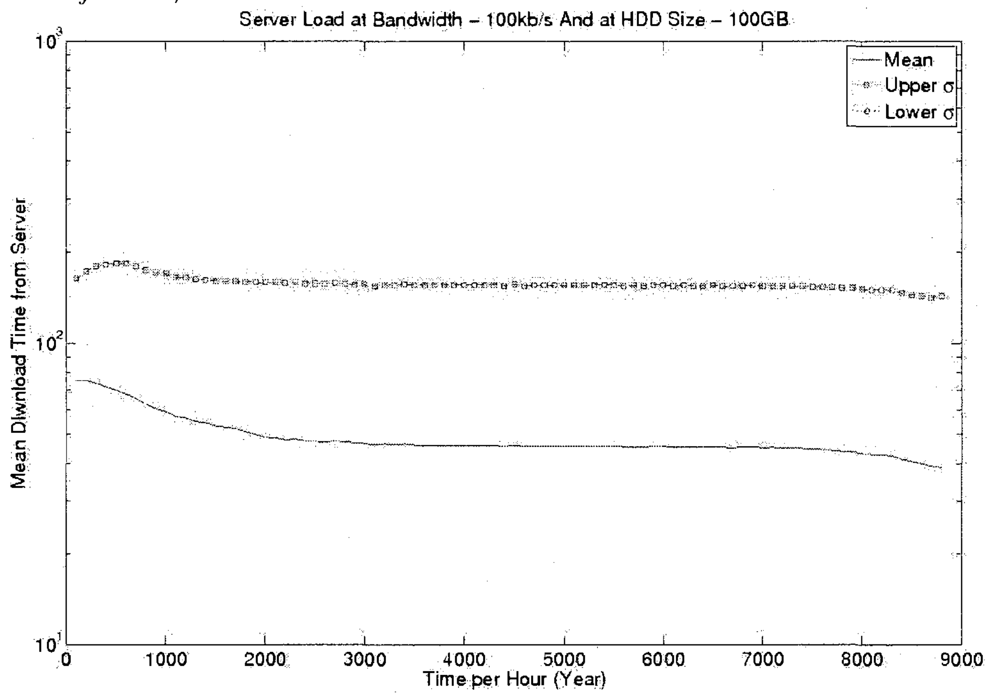


Figure 147: Server Load for H2 case scenario at hard drive size of 150GB and download bandwidth of 100kb/s

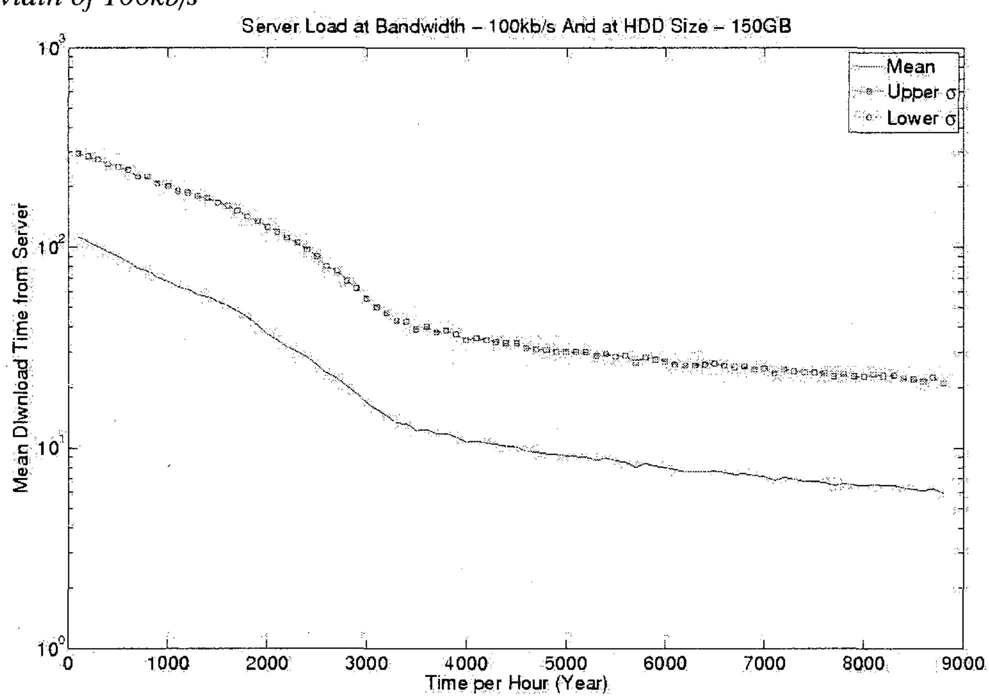


Figure 148: Server Load for H2 case scenario at hard drive size of 200GB and download bandwidth of 100kb/s

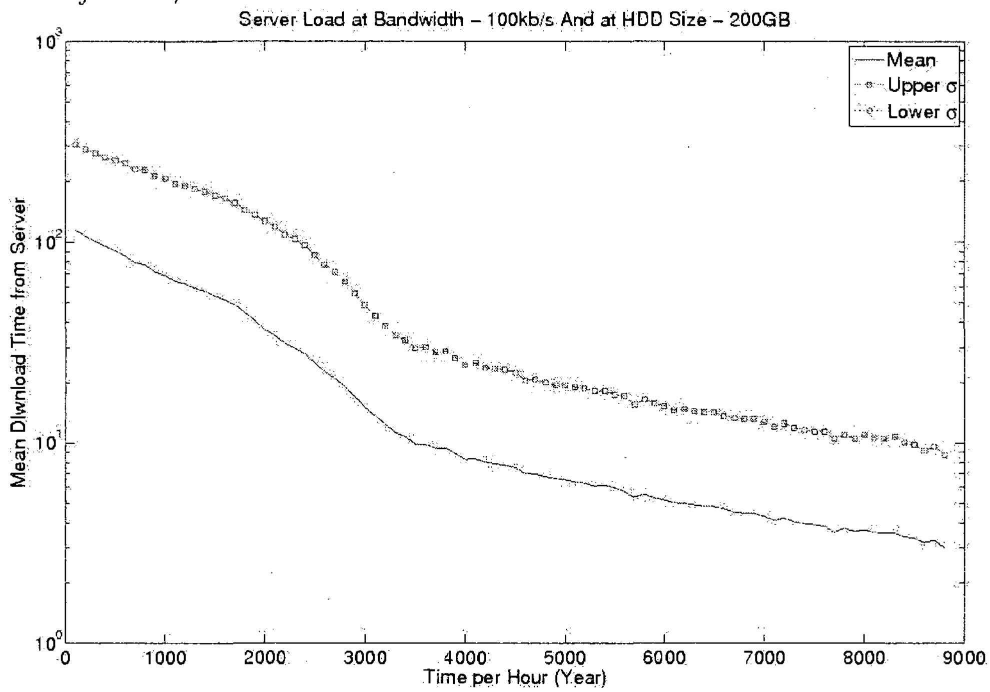


Figure 149: Server Load for H2 case scenario at hard drive size of 50GB and download bandwidth of 128kb/s

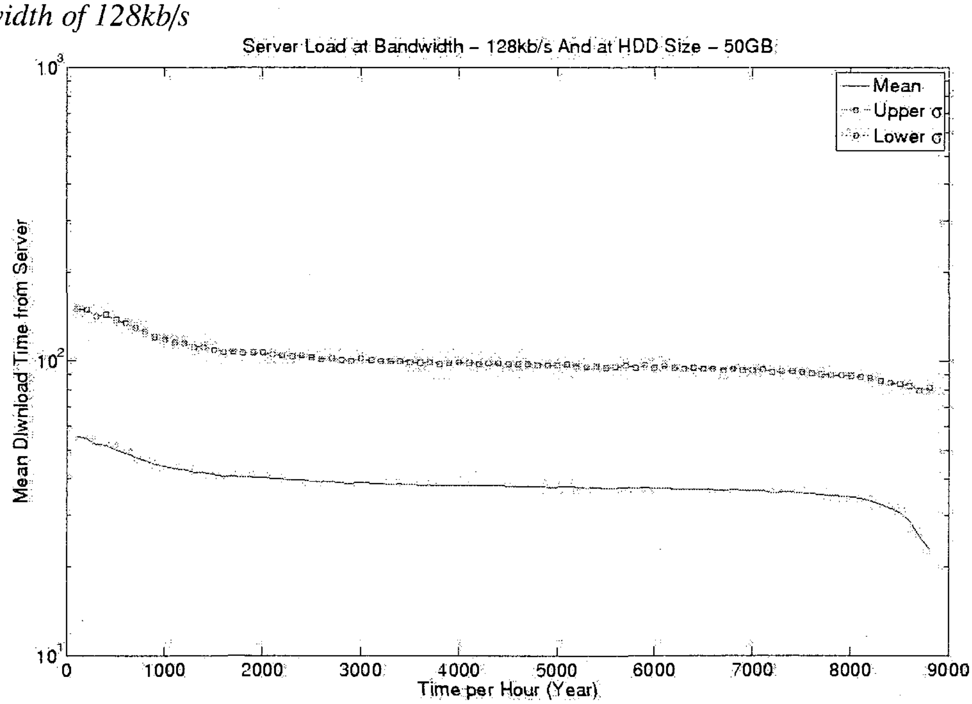


Figure 150: Server Load for H2 case scenario at hard drive size of 100GB and download bandwidth of 128kb/s

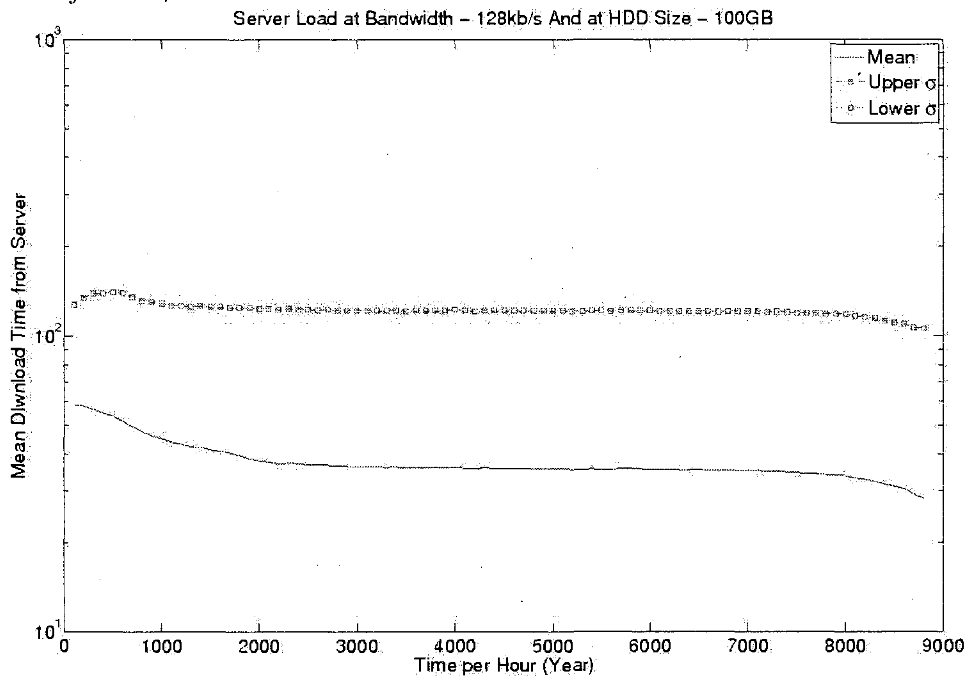


Figure 151: Server Load for H2 case scenario at hard drive size of 150GB and download bandwidth of 128kb/s

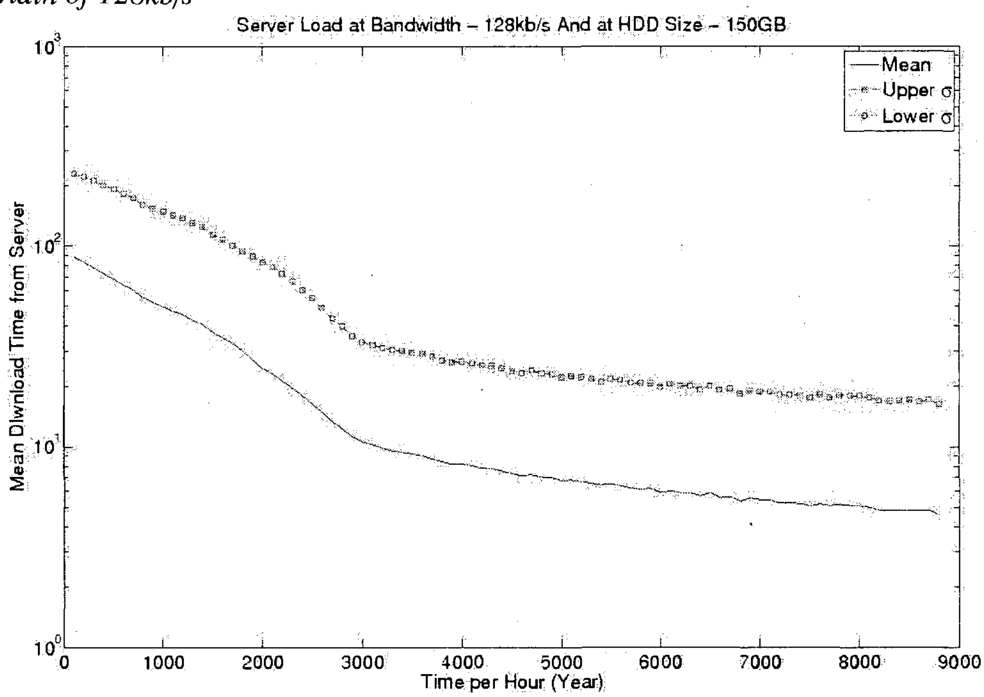


Figure 152: Server Load for H2 case scenario at hard drive size of 200GB and download bandwidth of 128kb/s

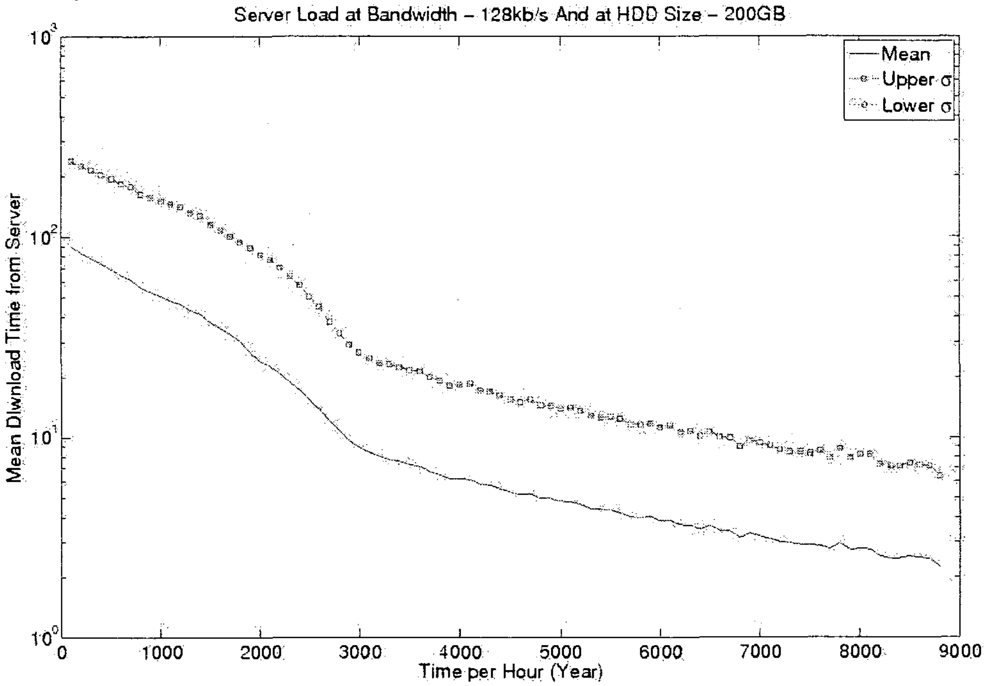


Figure 153: Server Load for H2 case scenario at hard drive size of 50GB and download bandwidth of 256kb/s

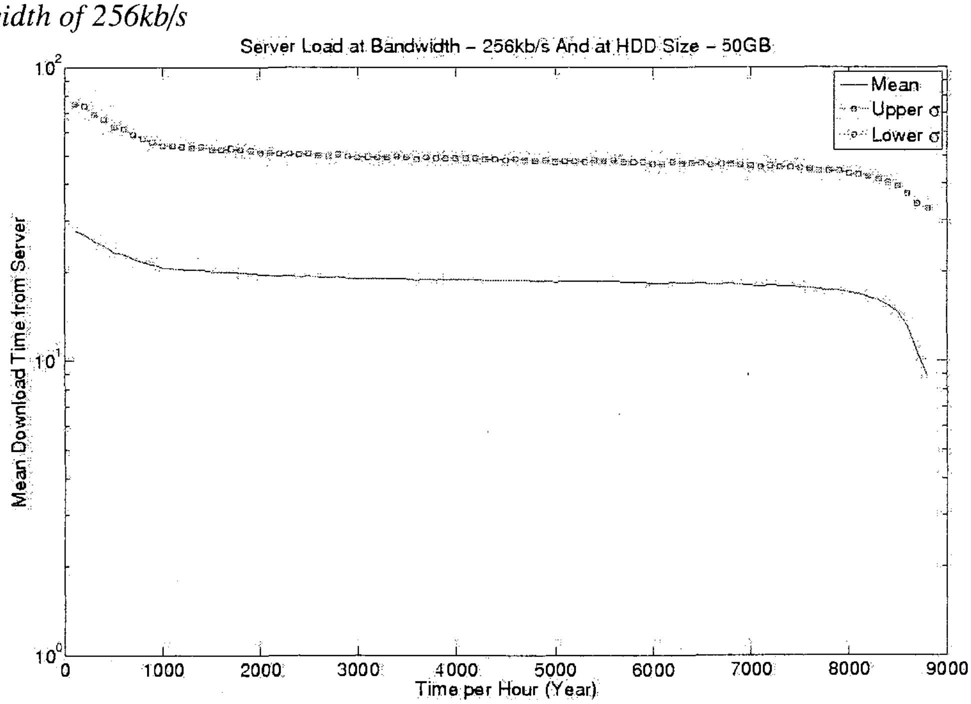


Figure 154: Server Load for H2 case scenario at hard drive size of 100GB and download bandwidth of 256kb/s

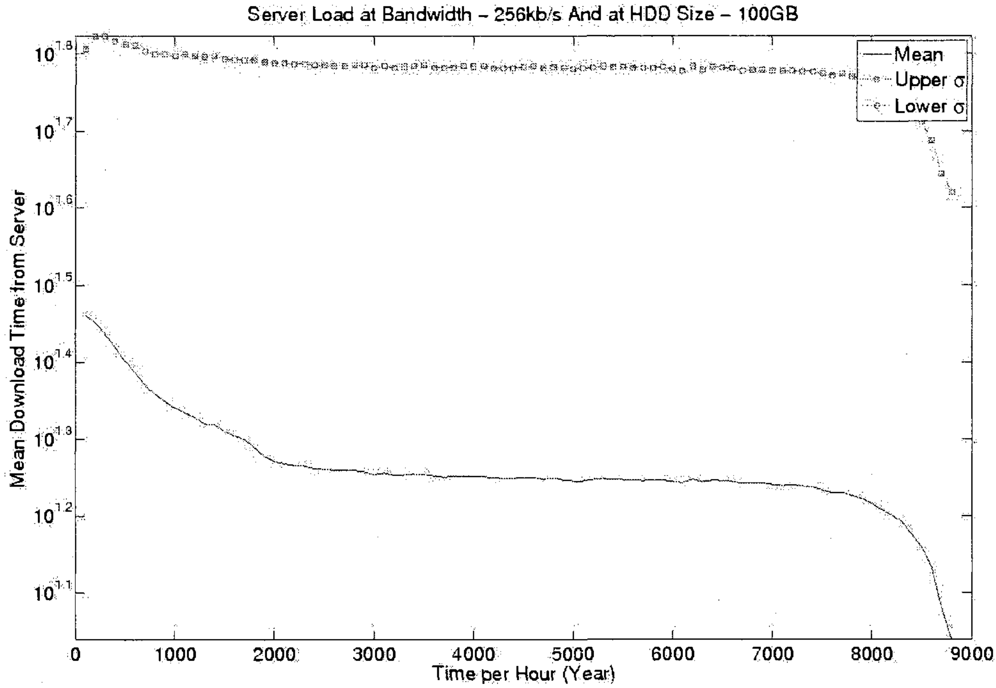


Figure 155: Server Load for H2 case scenario at hard drive size of 150GB and download bandwidth of 256kb/s

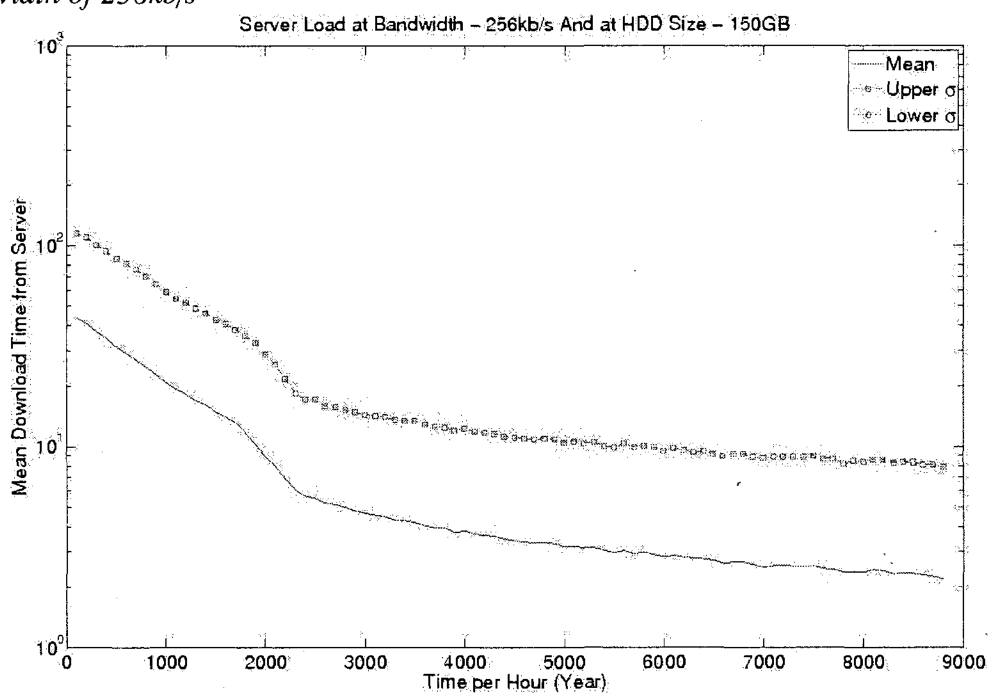


Figure 156: Server Load for H2 case scenario at hard drive size of 200GB and download bandwidth of 256kb/s

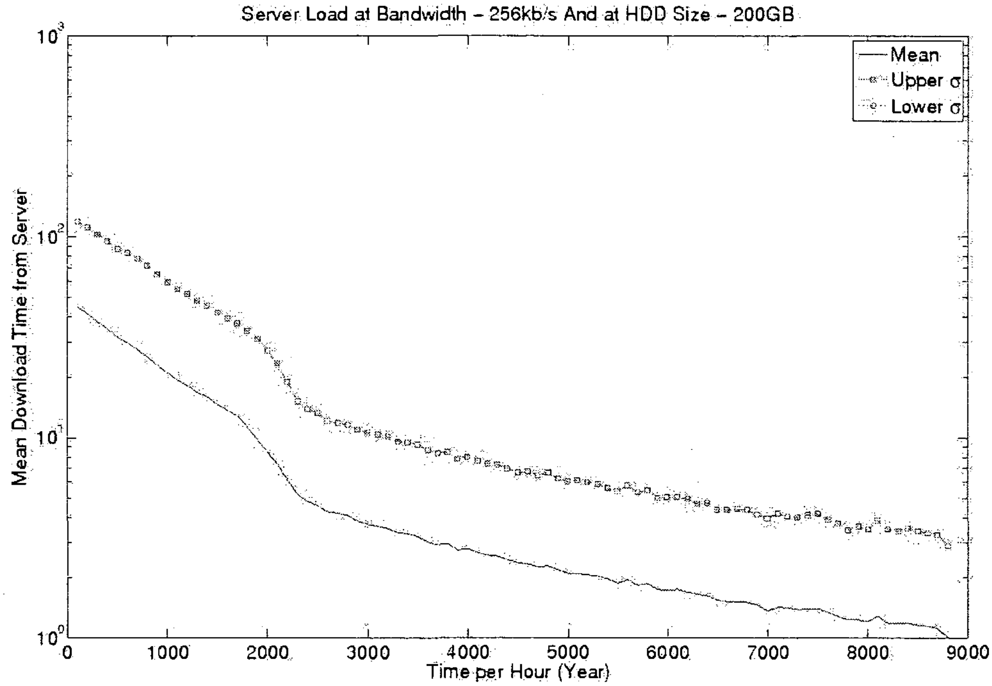


Figure 157: Server Load for H2 case scenario at hard drive size of 50GB and download bandwidth of 512kb/s

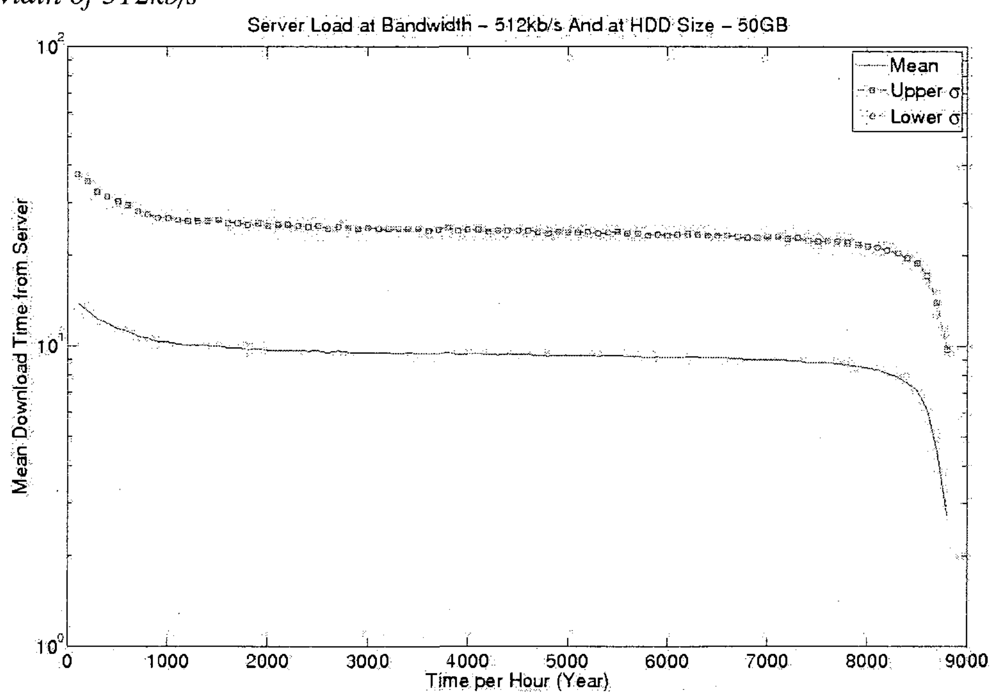


Figure 158: Server Load for H2 case scenario at hard drive size of 100GB and download bandwidth of 512kb/s

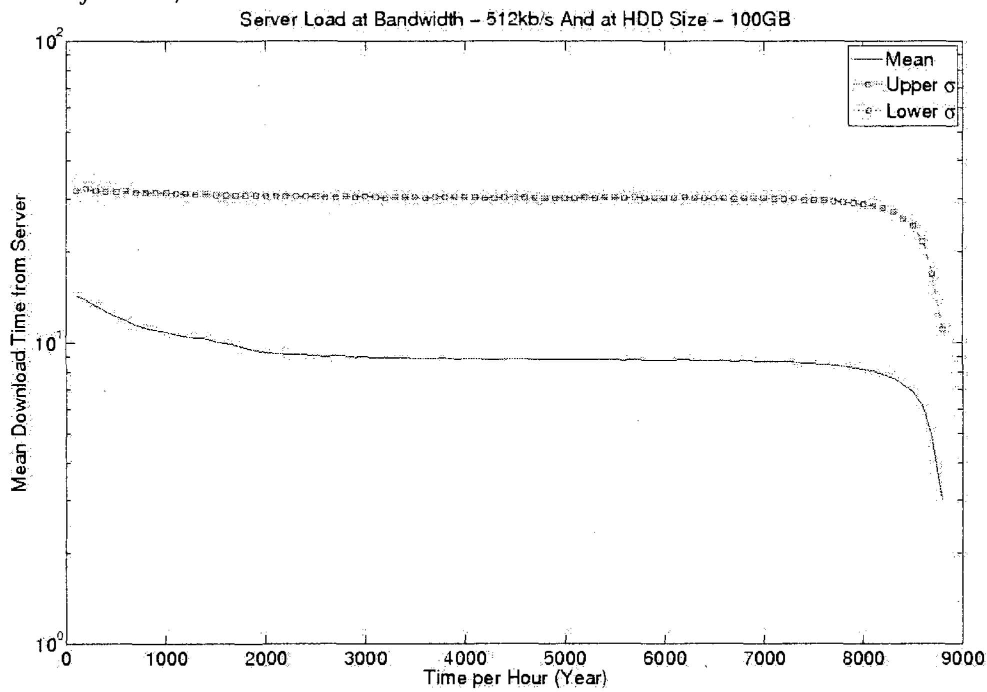


Figure 159: Server Load for H2 case scenario at hard drive size of 150GB and download bandwidth of 512kb/s

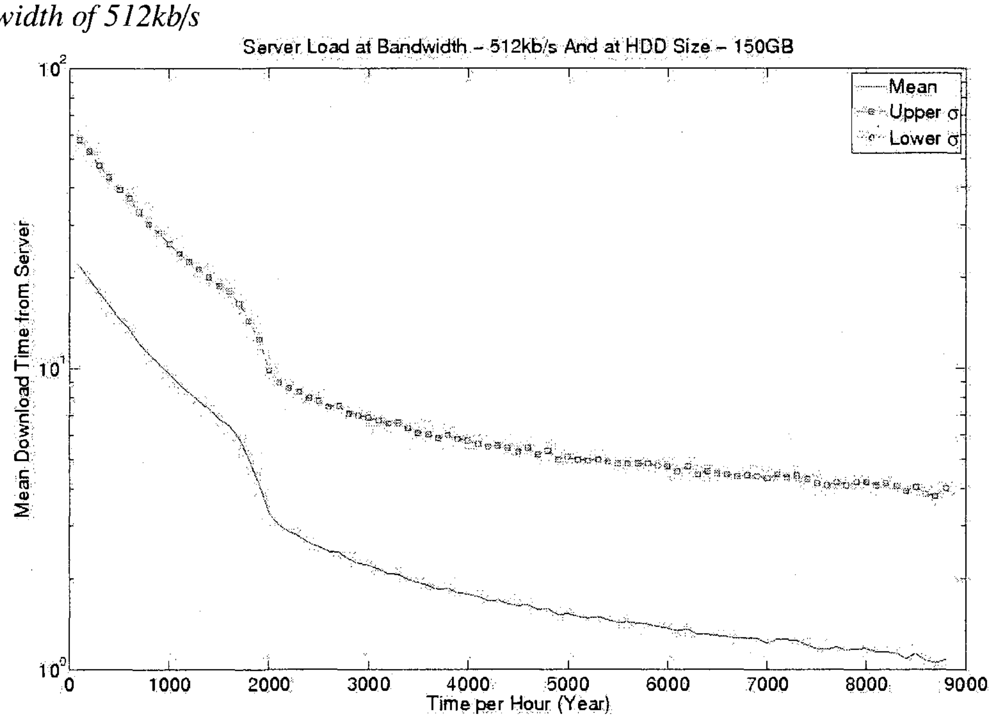


Figure 160: Server Load for H2 case scenario at hard drive size of 200GB and download bandwidth of 512kb/s

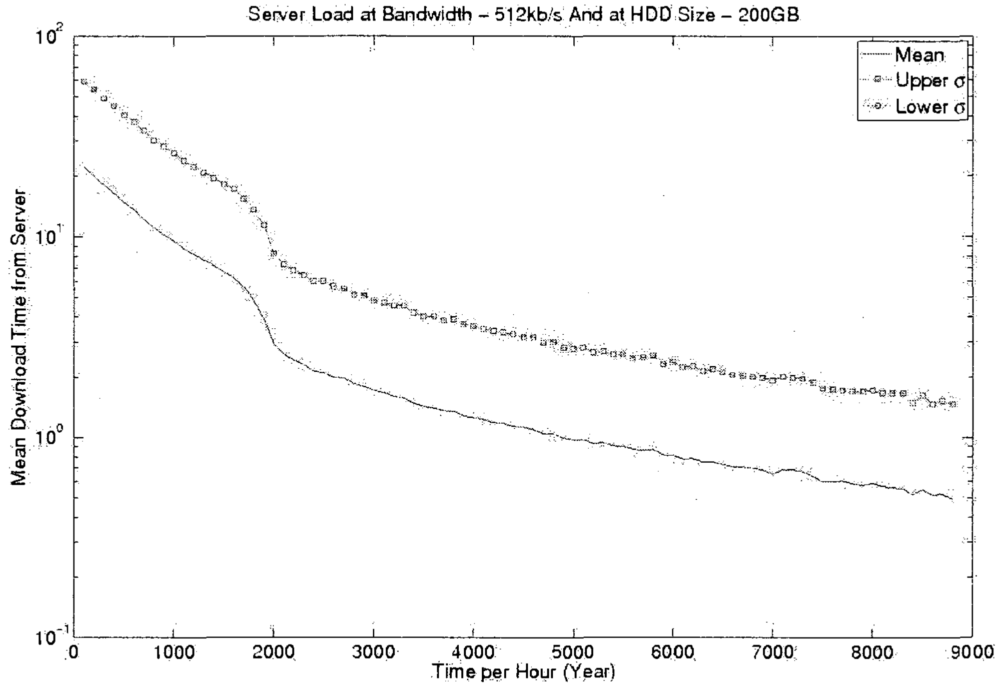


Figure 161: Server Load for H2 case scenario at hard drive size of 50GB and download bandwidth of 1000kb/s

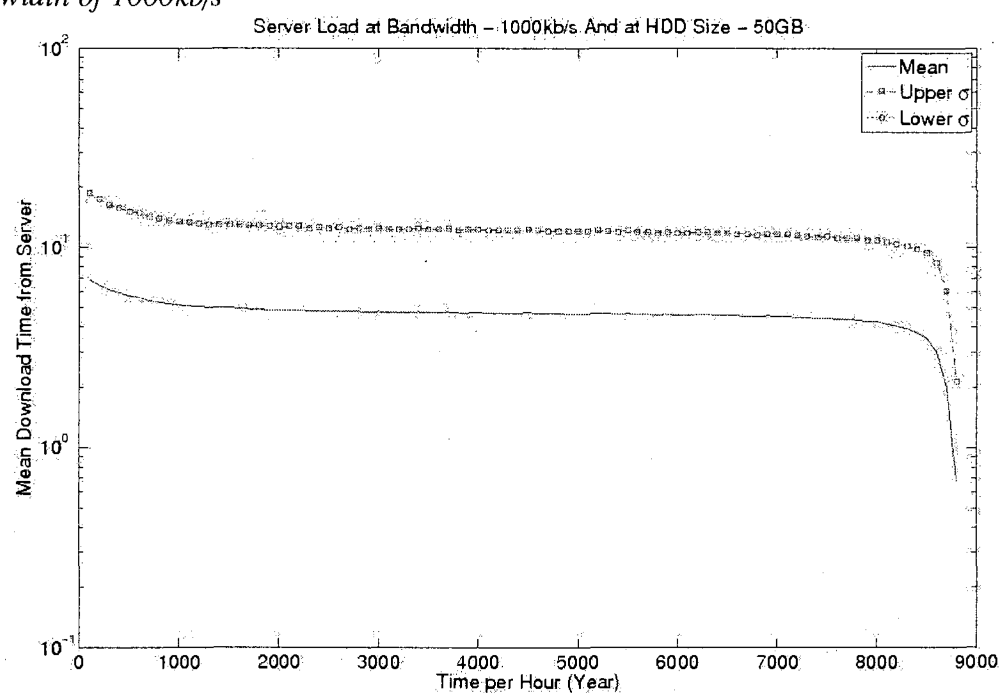


Figure 162: Server Load for H2 case scenario at hard drive size of 100GB and download bandwidth of 1000kb/s

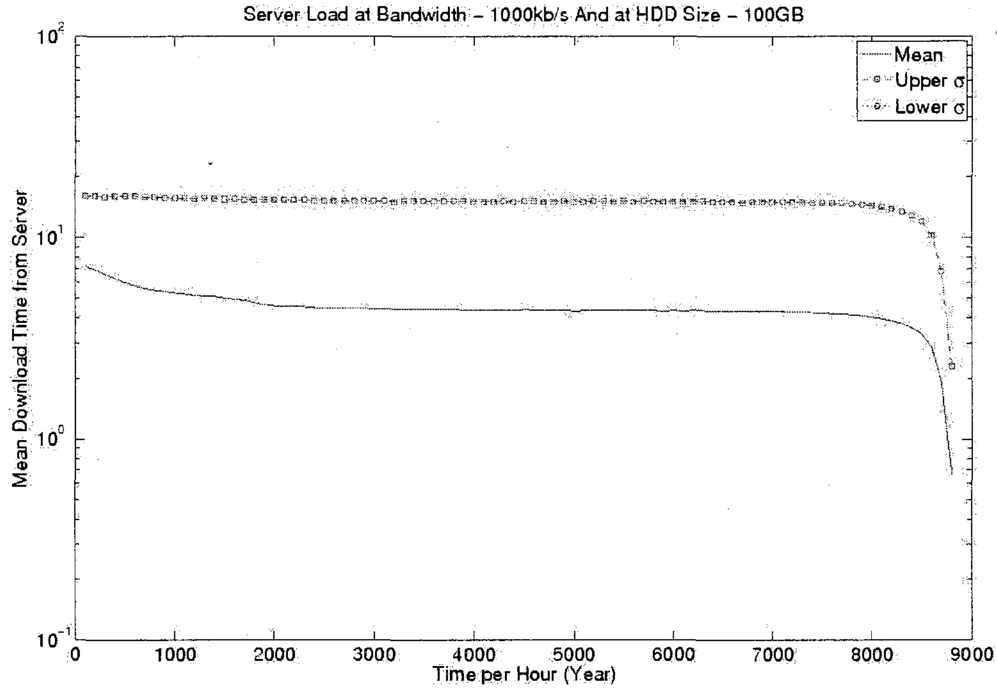


Figure 163: Server Load for H2 case scenario at hard drive size of 150GB and download bandwidth of 1000kb/s

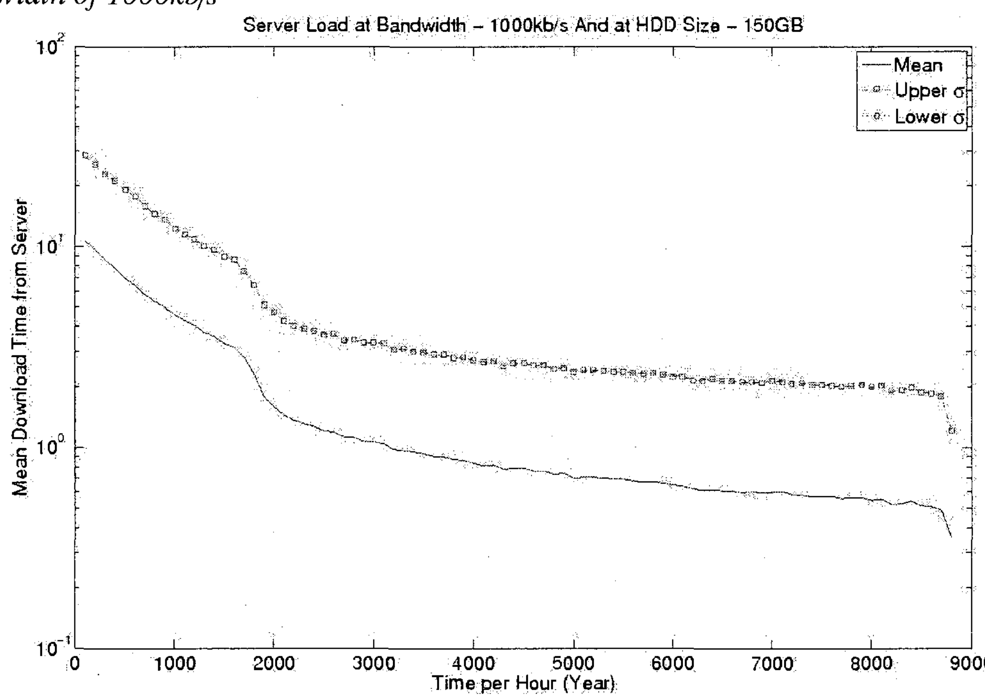


Figure 164: Server Load for H2 case scenario at hard drive size of 200GB and download bandwidth of 1000kb/s

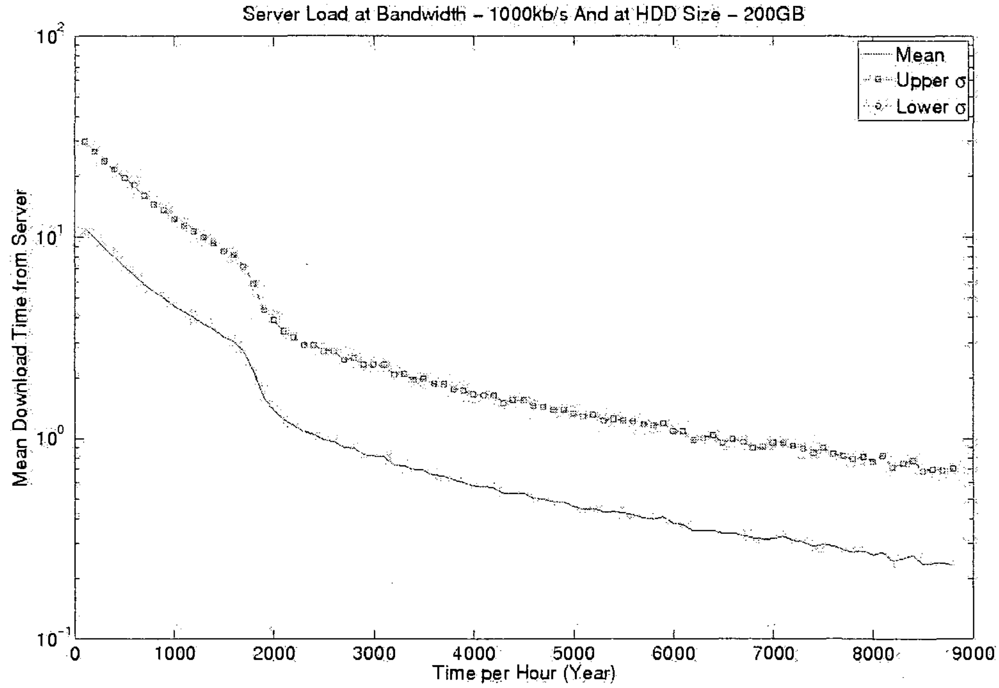


Figure 165: Server Load for H2 case scenario at hard drive size of 50GB and download bandwidth of 2000kb/s

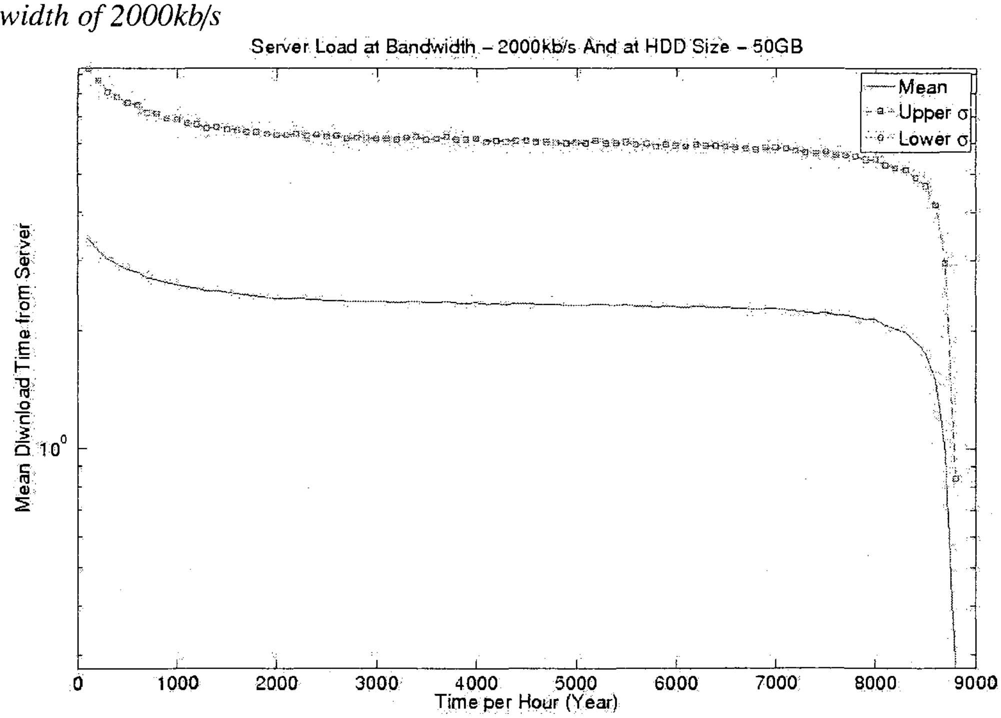


Figure 166: Server Load for H2 case scenario at hard drive size of 100GB and download bandwidth of 2000kb/s

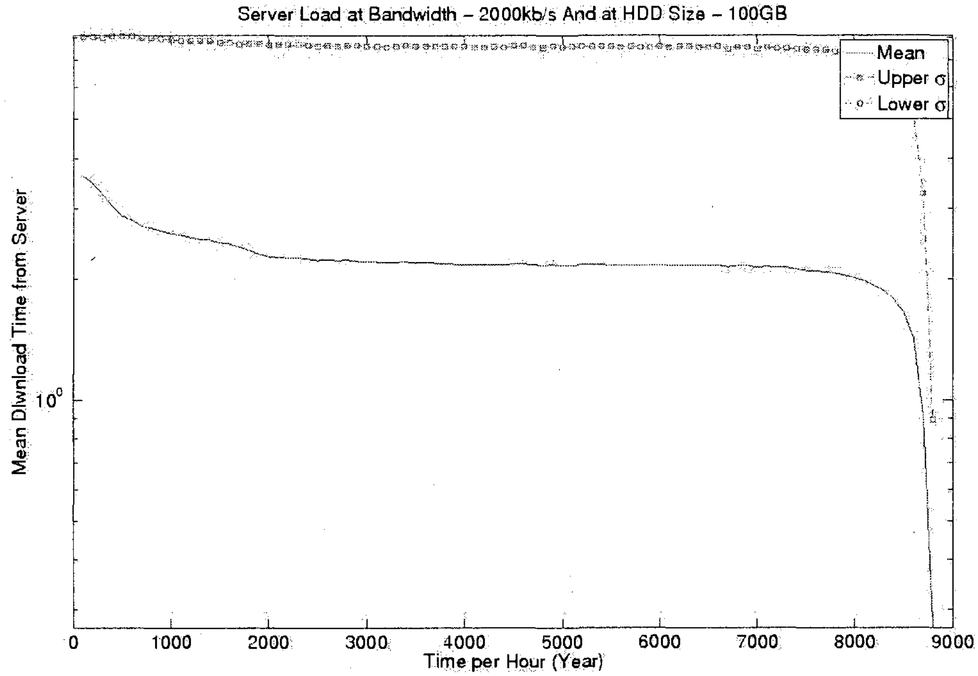


Figure 167: Server Load for H2 case scenario at hard drive size of 150GB and download bandwidth of 2000kb/s

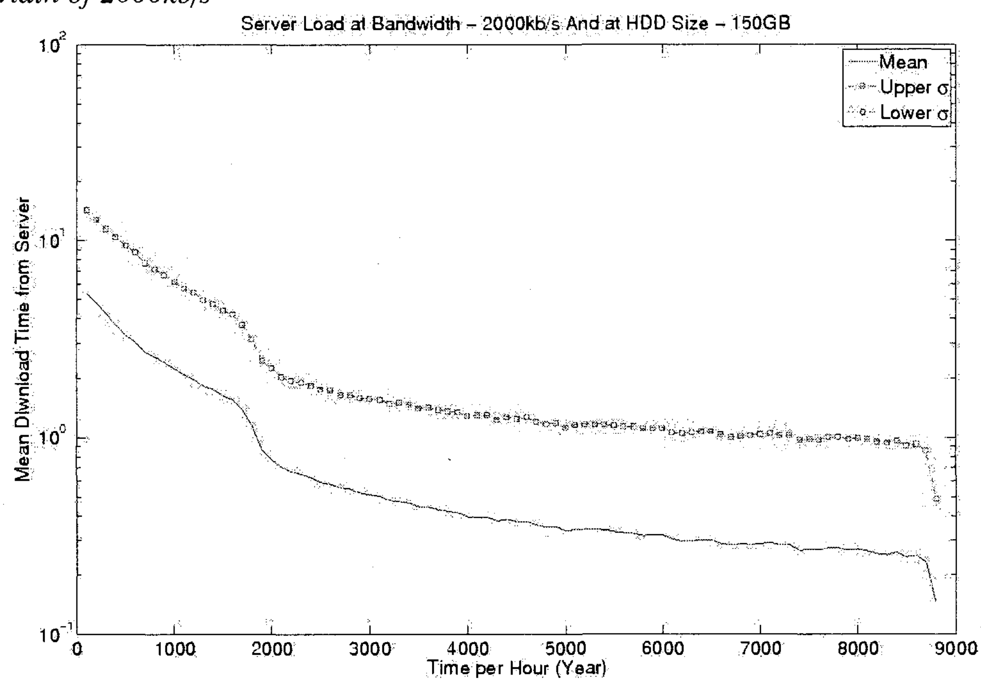


Figure 168: Server Load for H2 case scenario at hard drive size of 200GB and download bandwidth of 2000kb/s

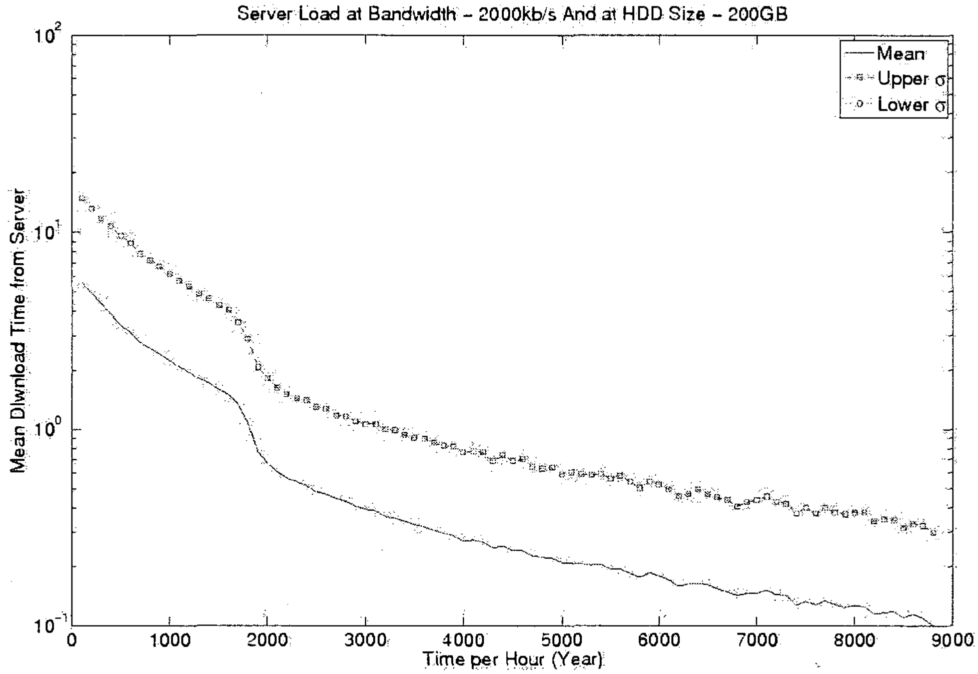


Figure 169: Server Load for H2 case scenario at hard drive size of 50GB and download bandwidth of 5000kb/s

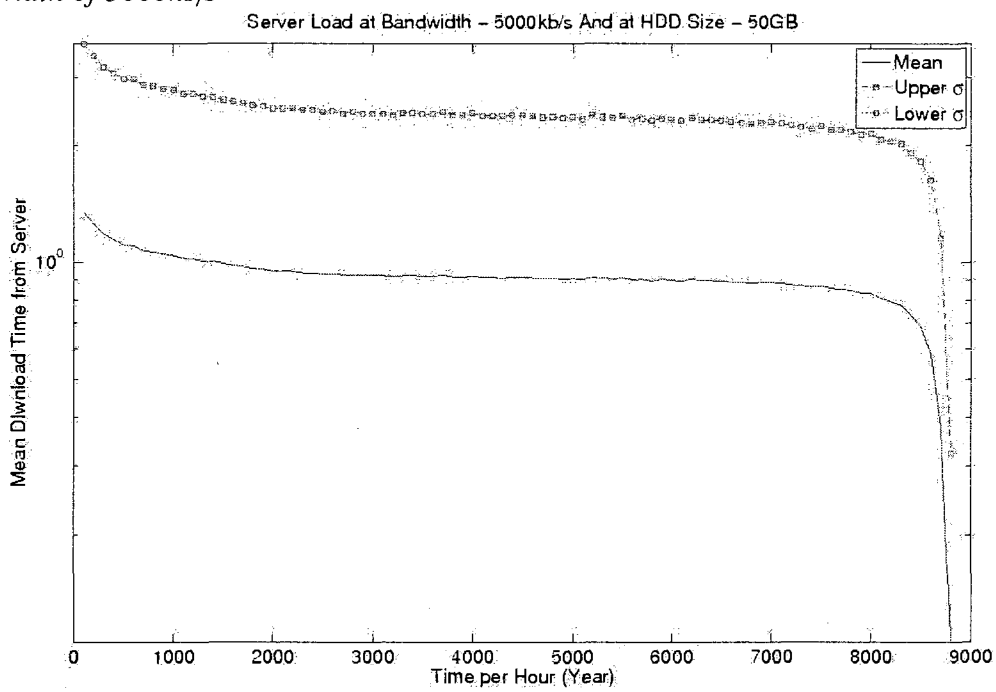


Figure 170: Server Load for H2 case scenario at hard drive size of 100GB and download bandwidth of 5000kb/s

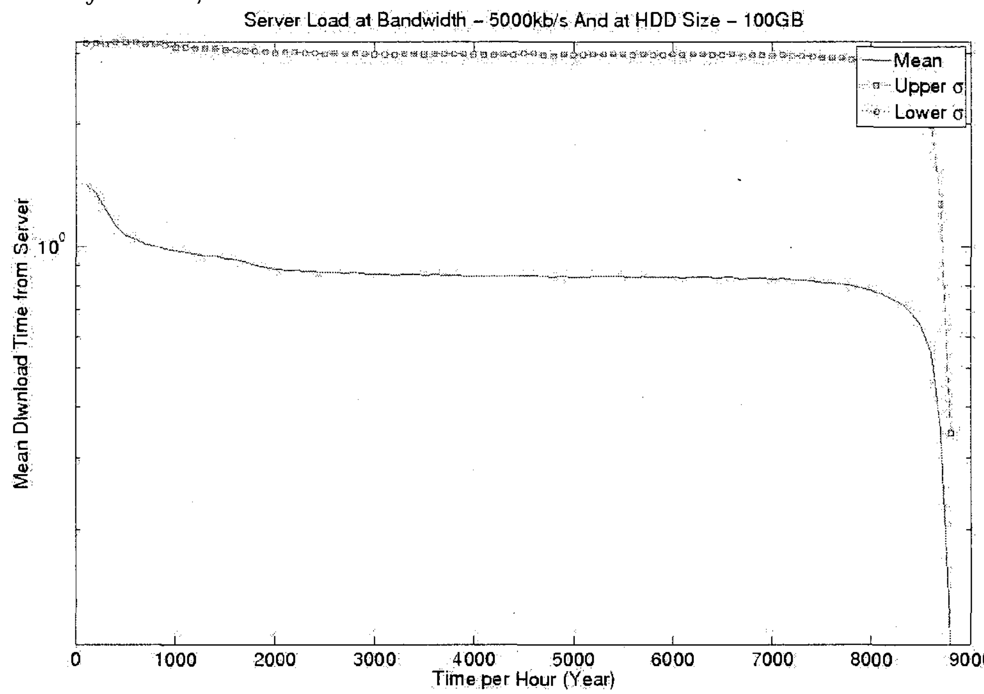


Figure 171: Server Load for H2 case scenario at hard drive size of 150GB and download bandwidth of 5000kb/s

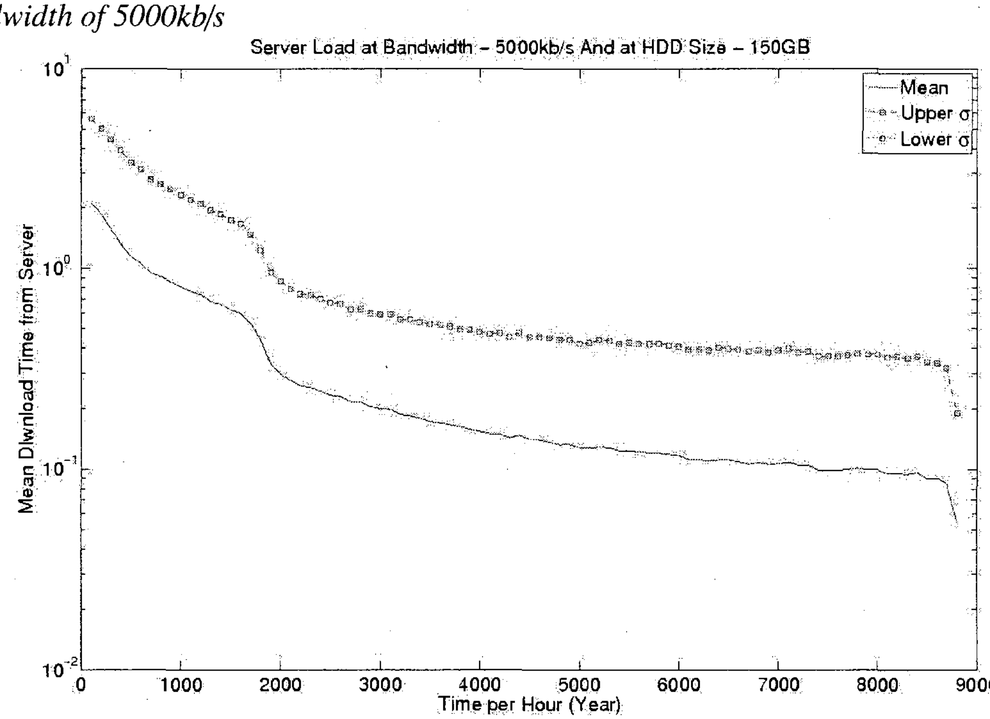


Figure 172: Server Load for H2 case scenario at hard drive size of 200GB and download bandwidth of 5000kb/s

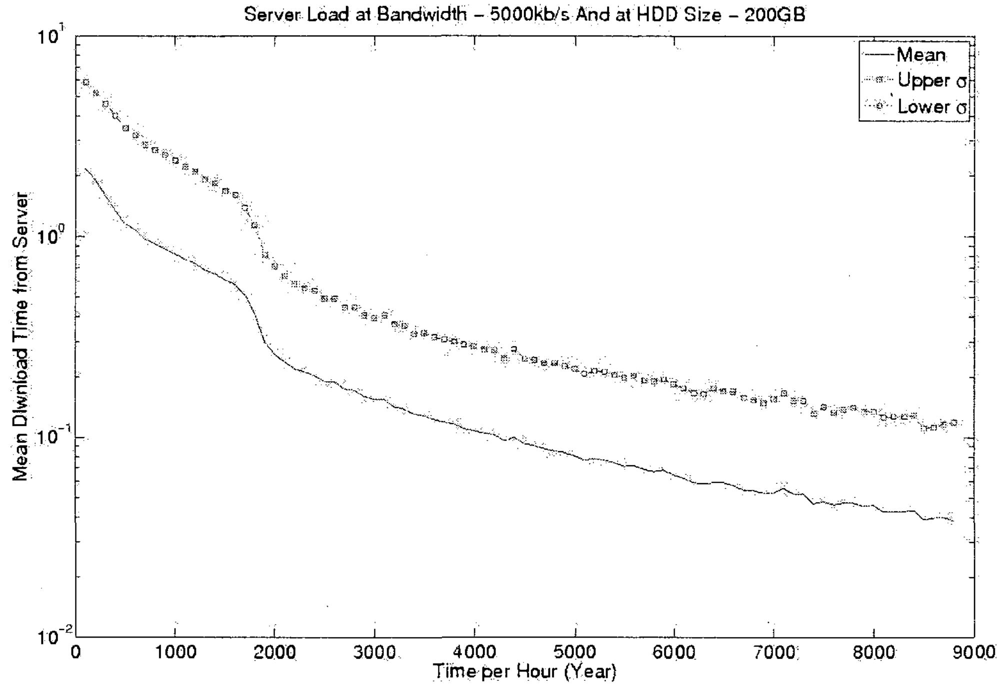


Figure 173: Server Load for H2 case scenario at hard drive size of 50GB and download bandwidth of 10000kb/s

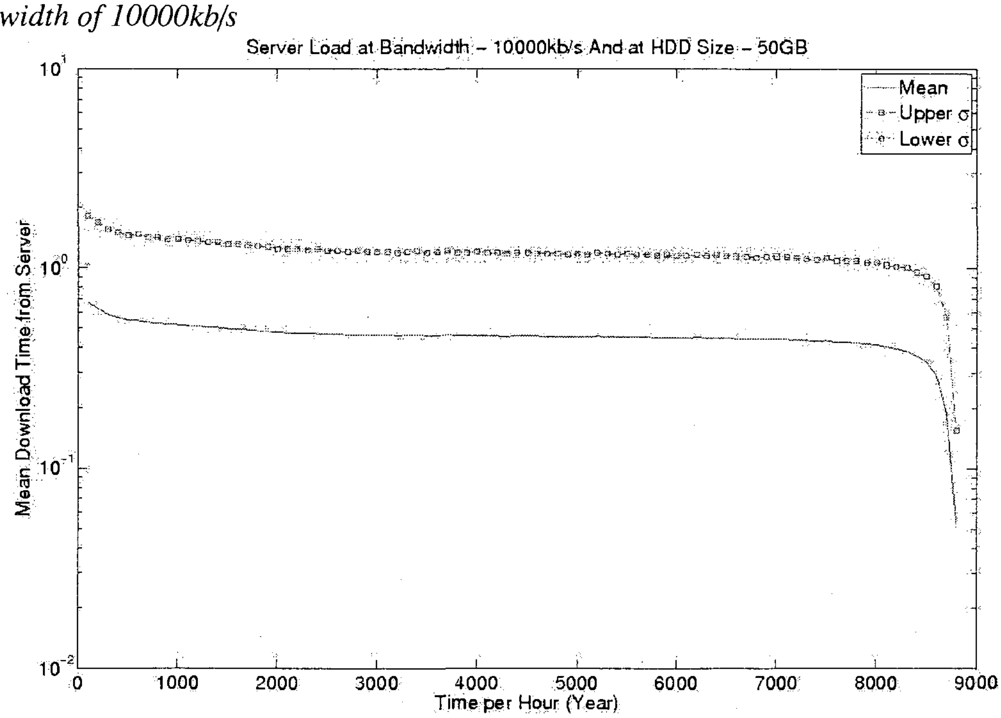


Figure 174: Server Load for H2 case scenario at hard drive size of 100GB and download bandwidth of 10000kb/s

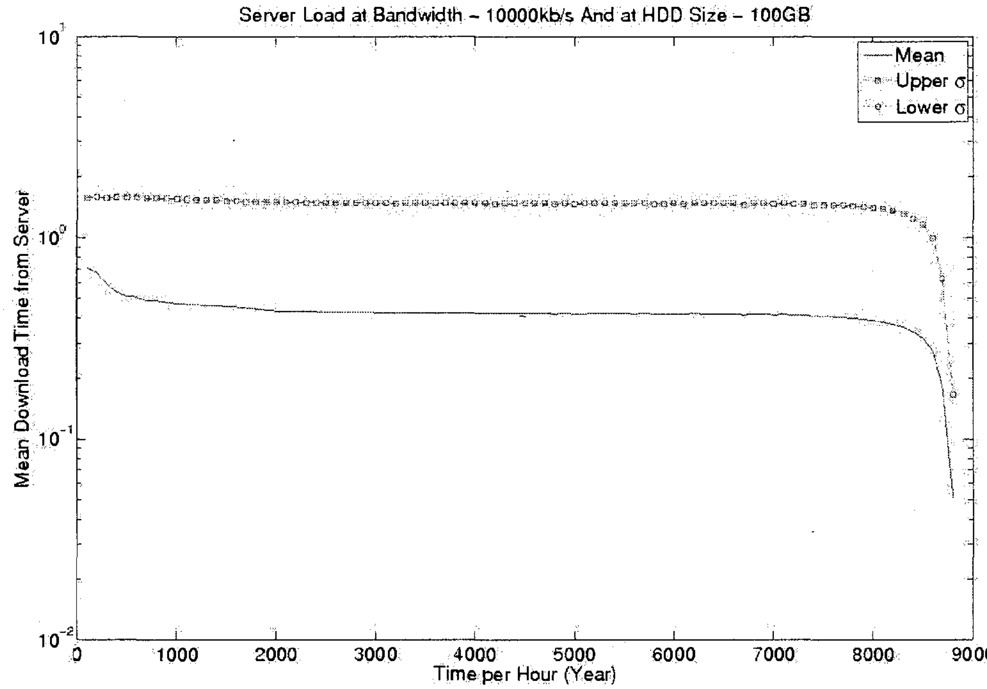


Figure 175: Server Load for H2 case scenario at hard drive size of 150GB and download bandwidth of 10000kb/s

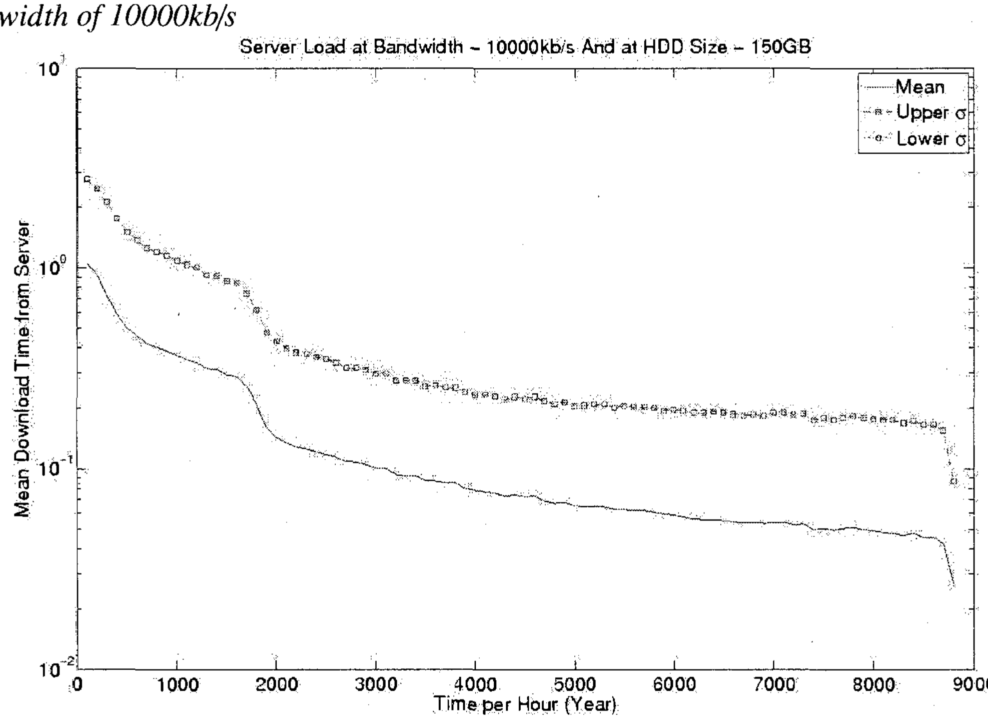


Figure 176: Server Load for H2 case scenario at hard drive size of 200GB and download bandwidth of 10000kb/s

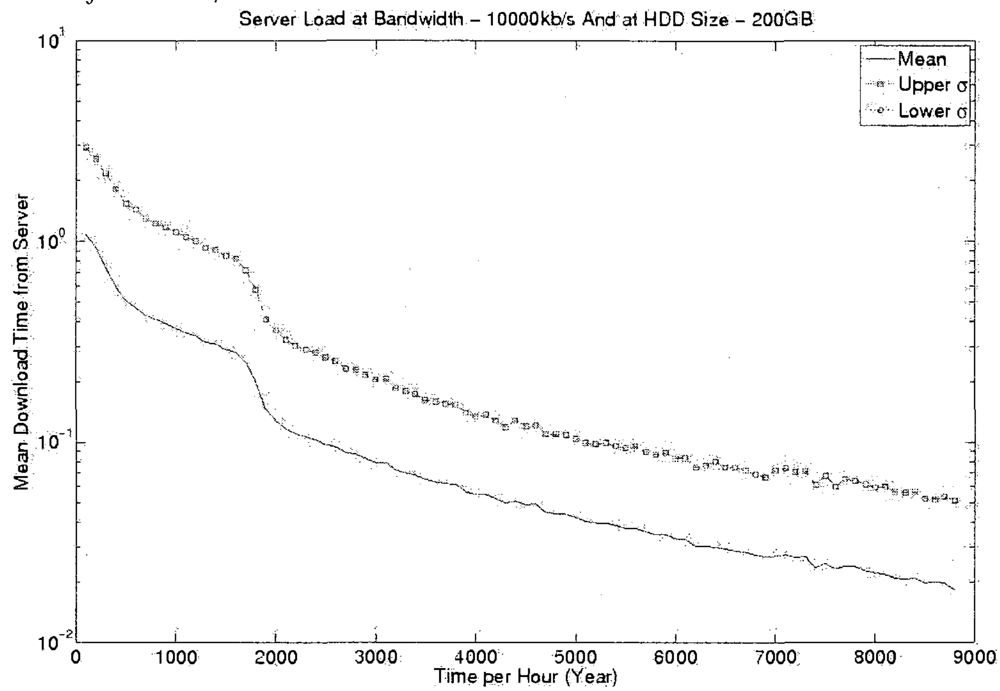


Figure 177: Server Load for H2 case scenario at hard drive size of 50GB and download bandwidth of 15000kb/s

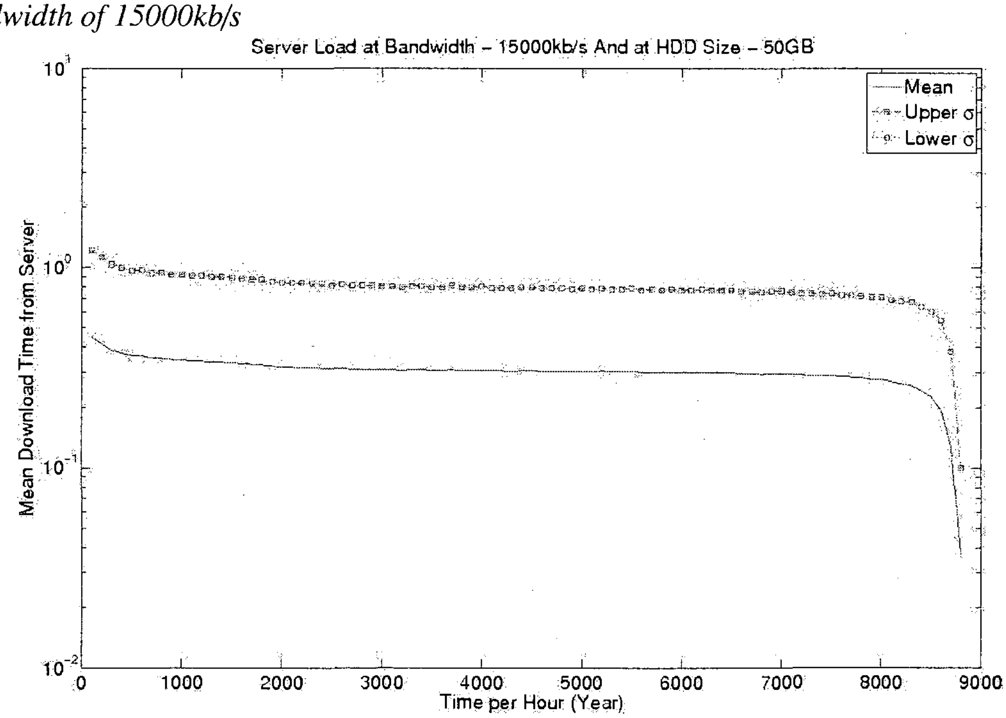


Figure 178: Server Load for H2 case scenario at hard drive size of 100GB and download bandwidth of 15000kb/s

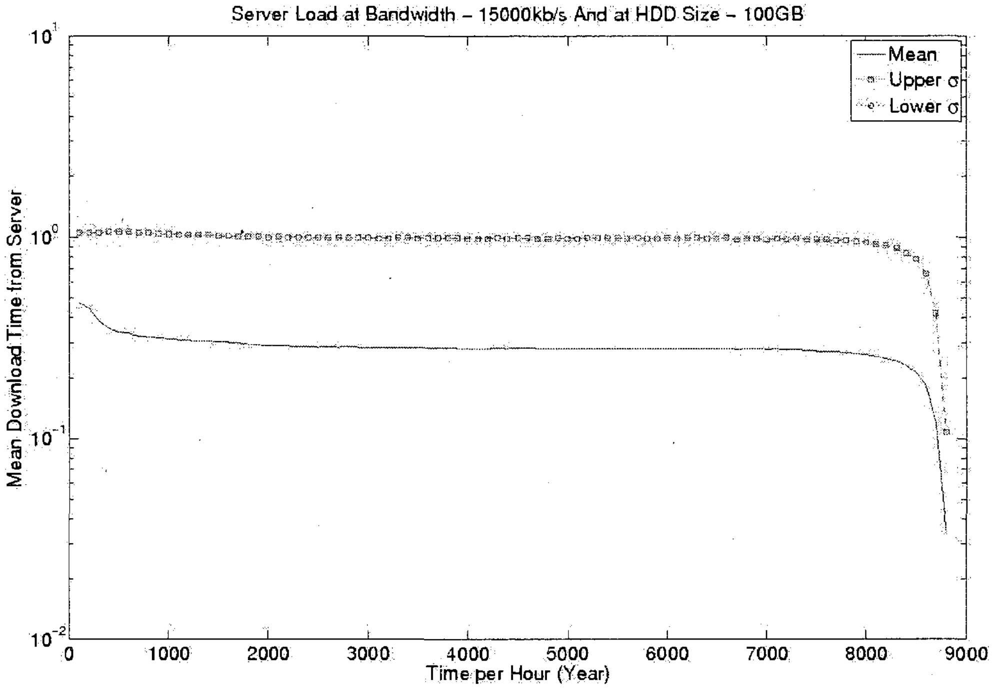


Figure 179: Server Load for H2 case scenario at hard drive size of 150GB and download bandwidth of 15000kb/s

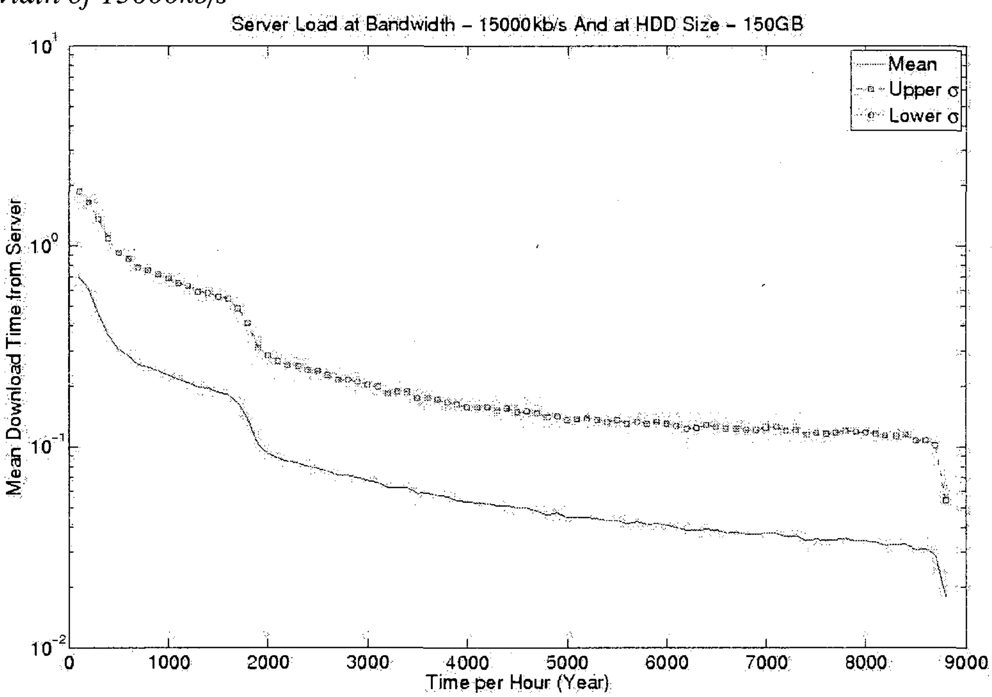


Figure 180: Server Load for H2 case scenario at hard drive size of 200GB and download bandwidth of 15000kb/s

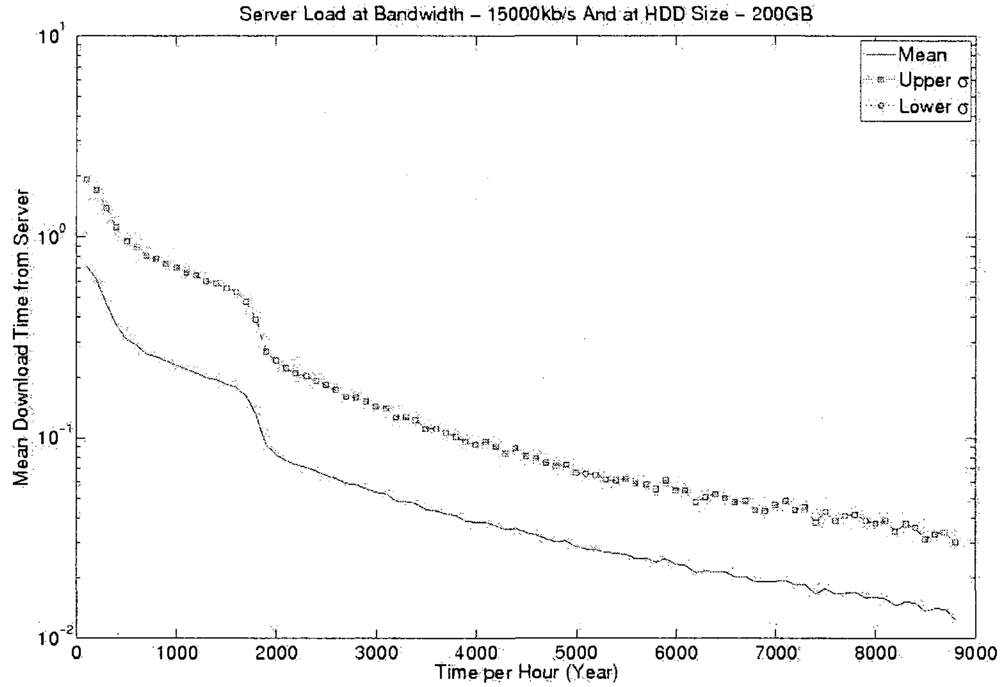


Figure 181: Server Load for H3 case scenario at hard drive size of 50GB and download bandwidth of 25kb/s

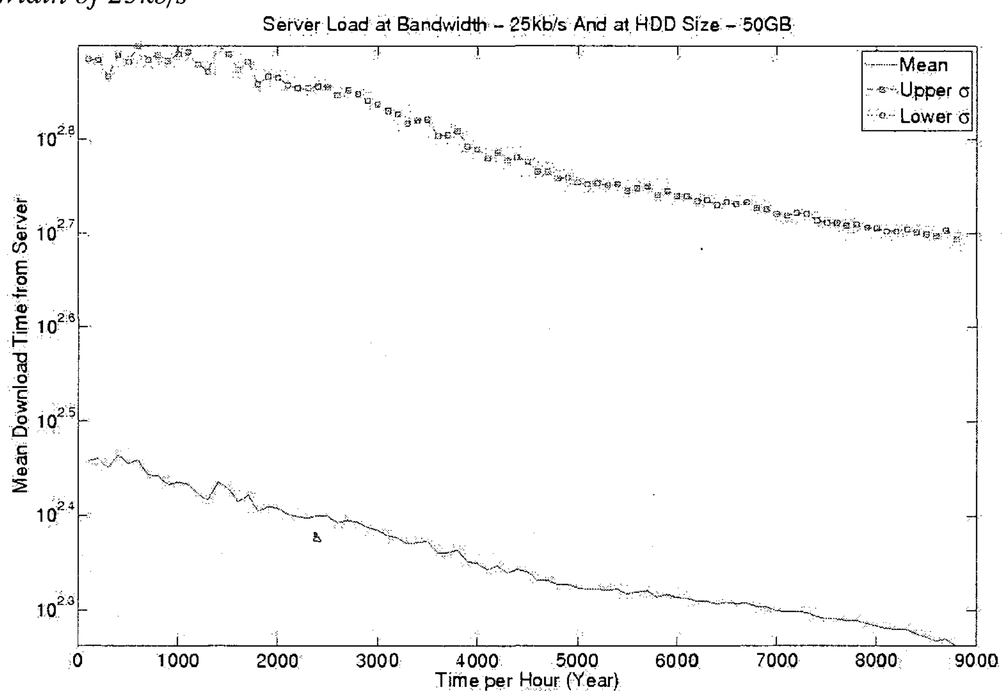


Figure 182: Server Load for H3 case scenario at hard drive size of 100GB and download bandwidth of 25kb/s

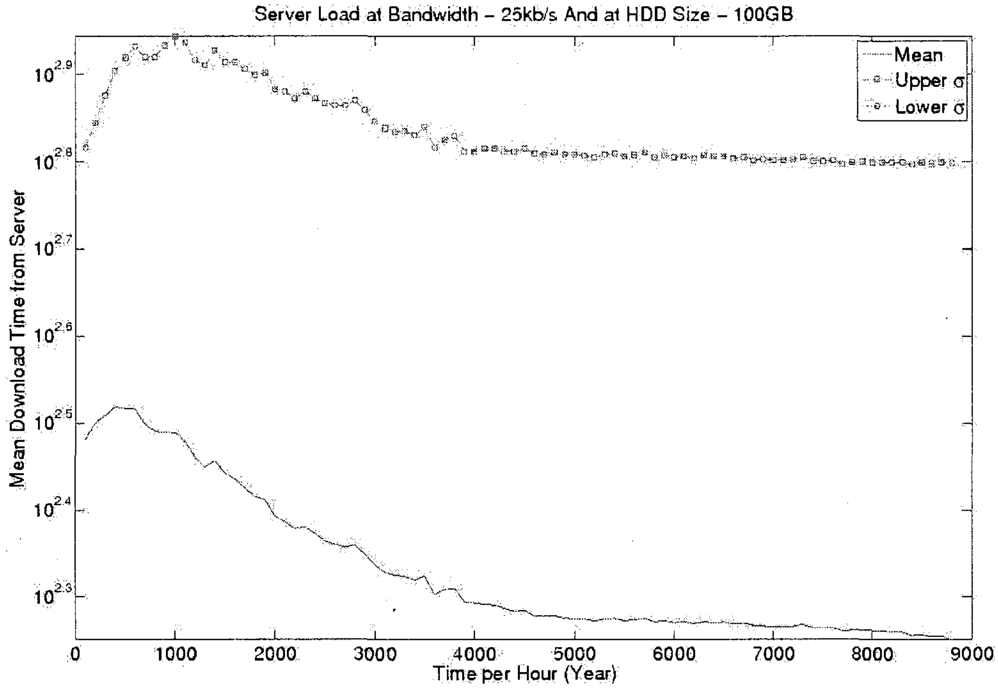


Figure 183: Server Load for H3 case scenario at hard drive size of 150GB and download bandwidth of 25kb/s

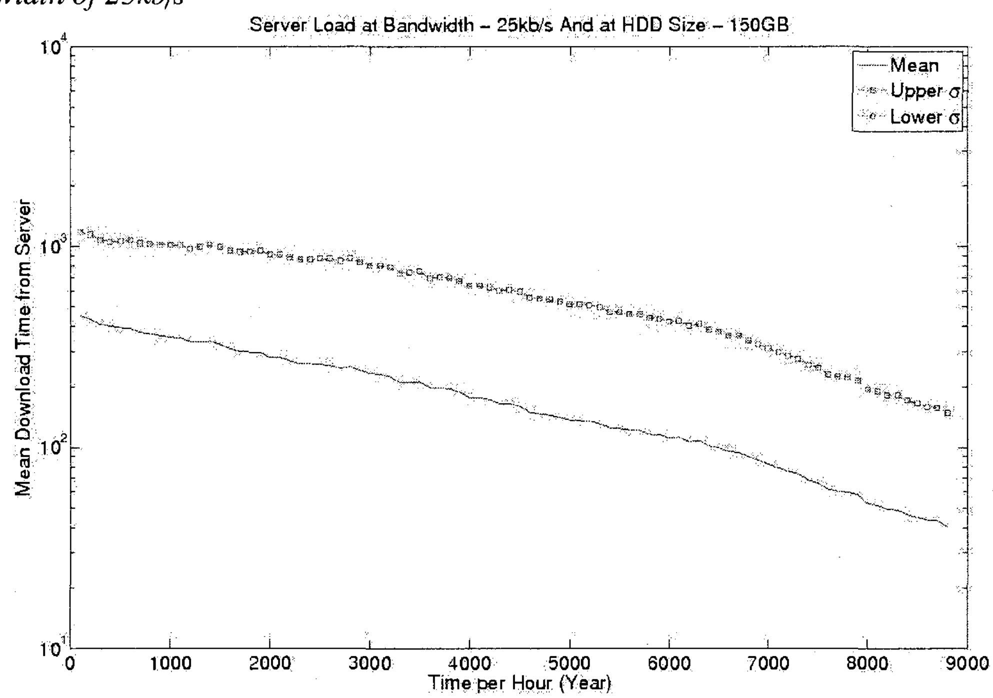


Figure 184: Server Load for H3 case scenario at hard drive size of 200GB and download bandwidth of 25kb/s

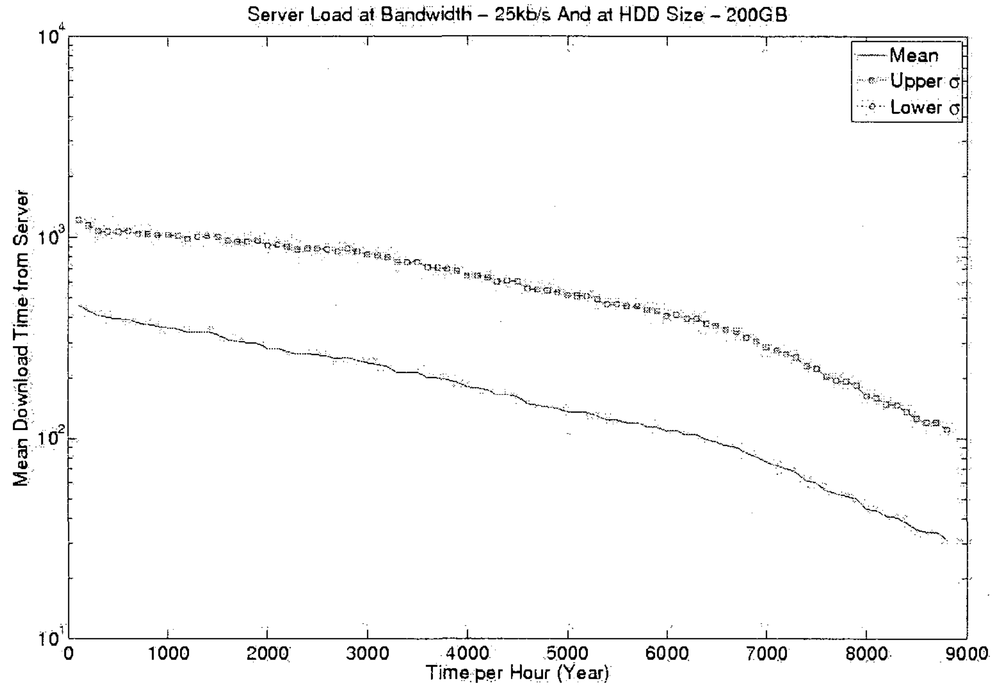


Figure 185: Server Load for H3 case scenario at hard drive size of 50GB and download bandwidth of 50kb/s

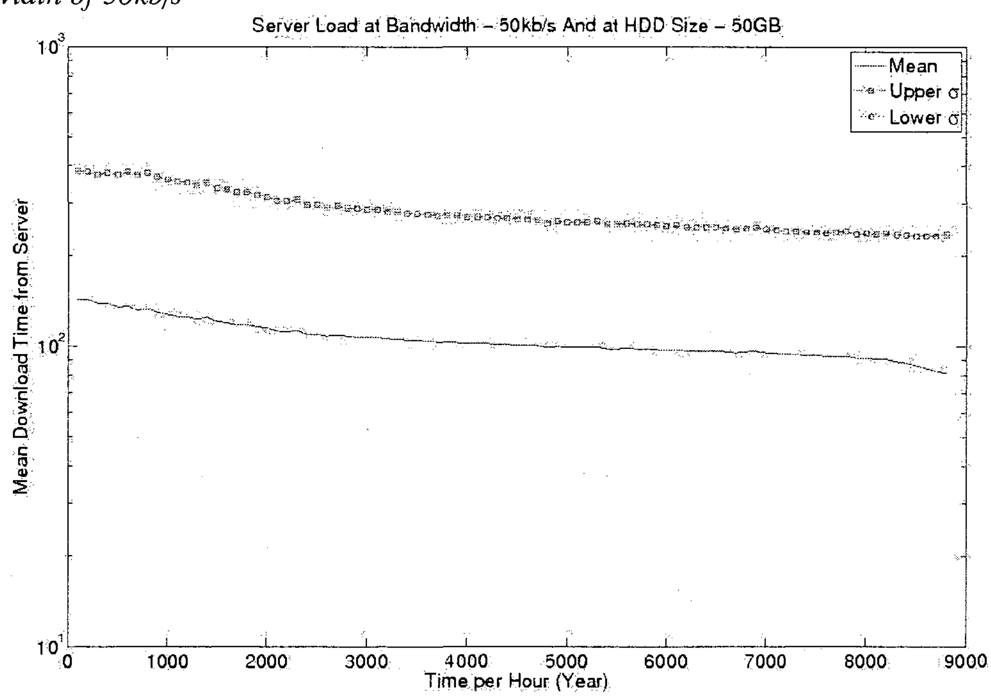


Figure 186: Server Load for H3 case scenario at hard drive size of 100GB and download bandwidth of 50kb/s

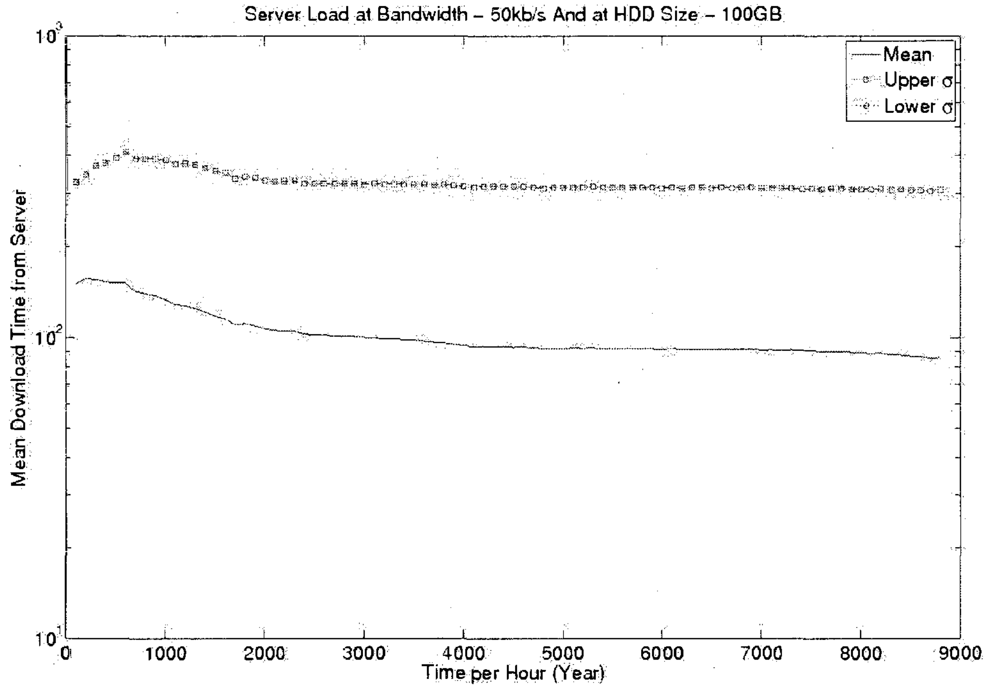


Figure 187: Server Load for H3 case scenario at hard drive size of 150GB and download bandwidth of 50kb/s

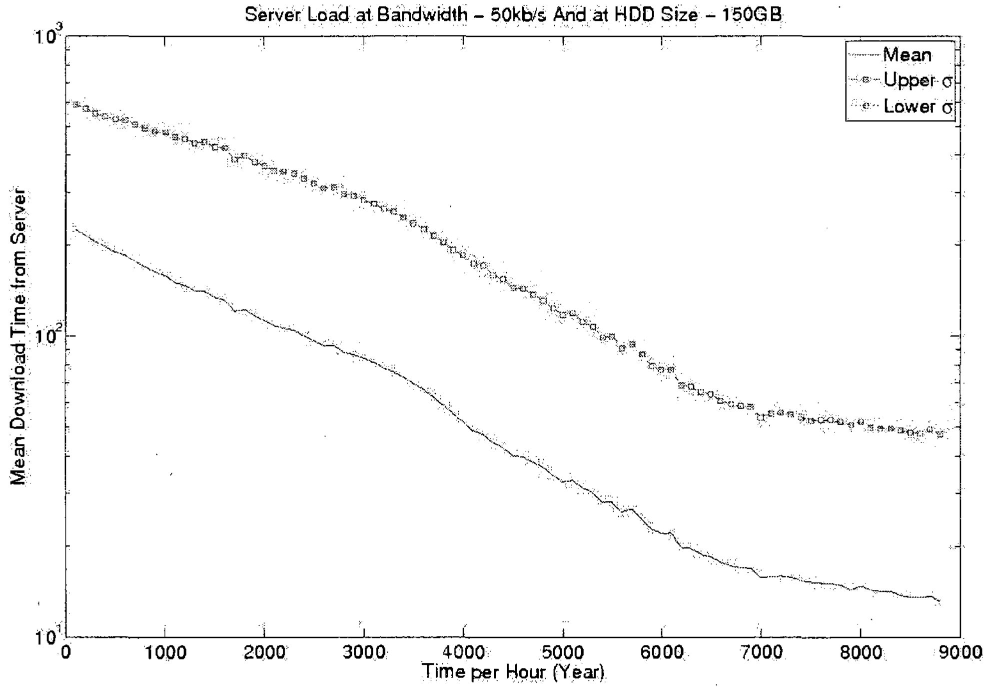


Figure 188: Server Load for H3 case scenario at hard drive size of 200GB and download bandwidth of 50kb/s

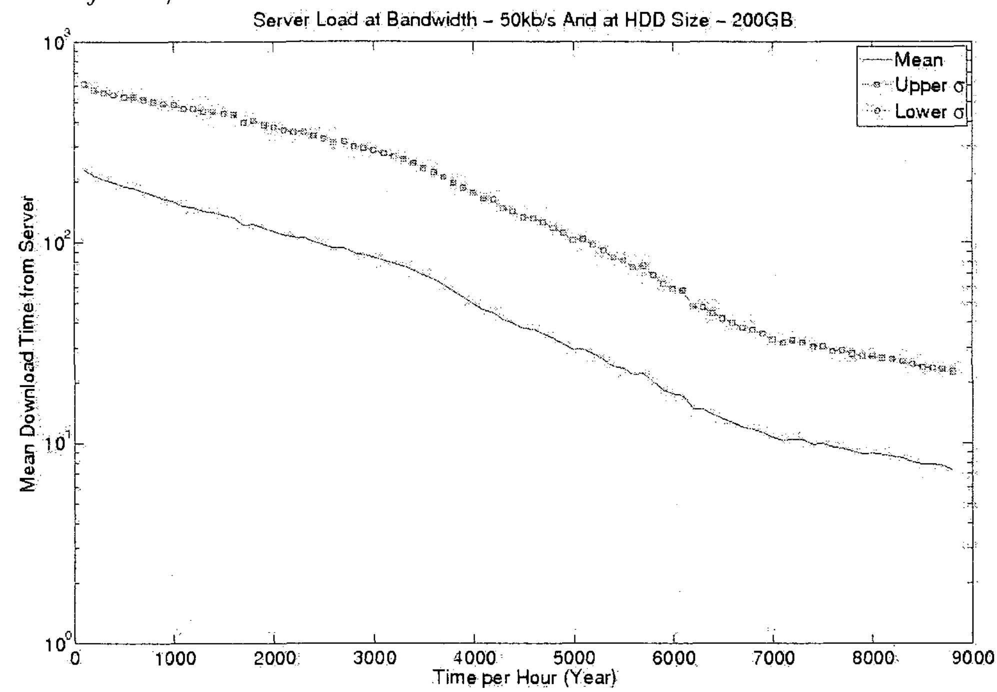


Figure 189: Server Load for H3 case scenario at hard drive size of 50GB and download bandwidth of 100kb/s

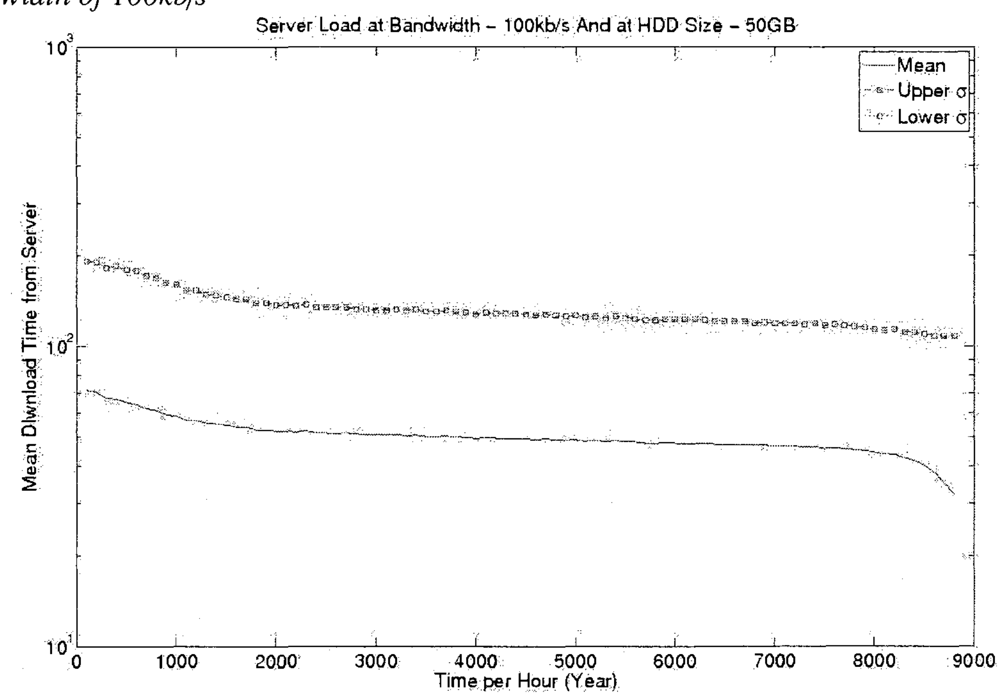


Figure 190: Server Load for H3 case scenario at hard drive size of 100GB and download bandwidth of 100kb/s

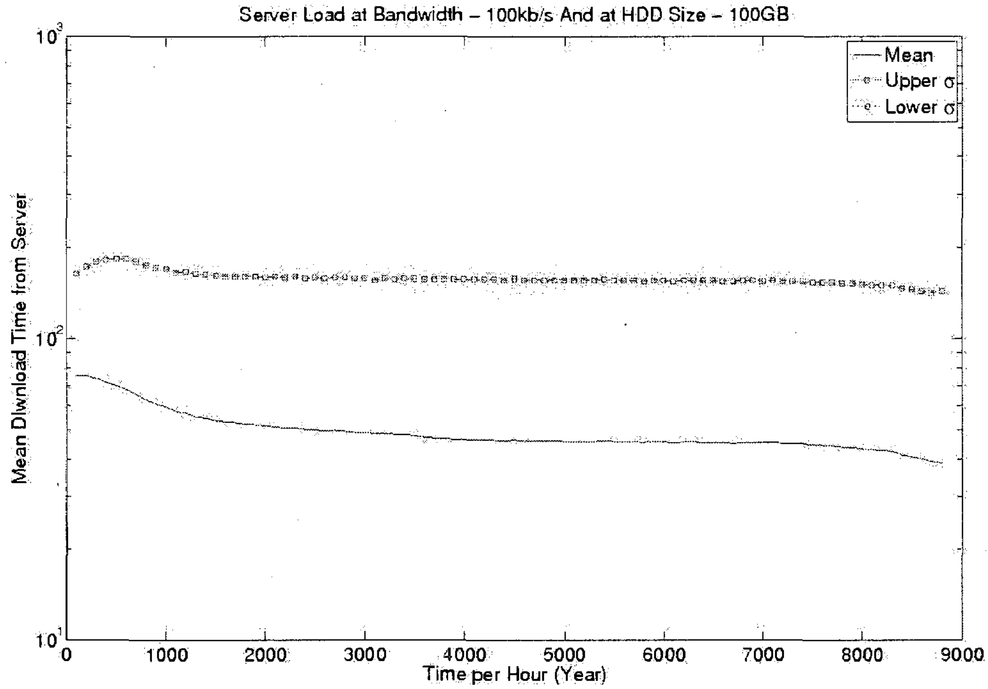


Figure 191: Server Load for H3 case scenario at hard drive size of 150GB and download bandwidth of 100kb/s

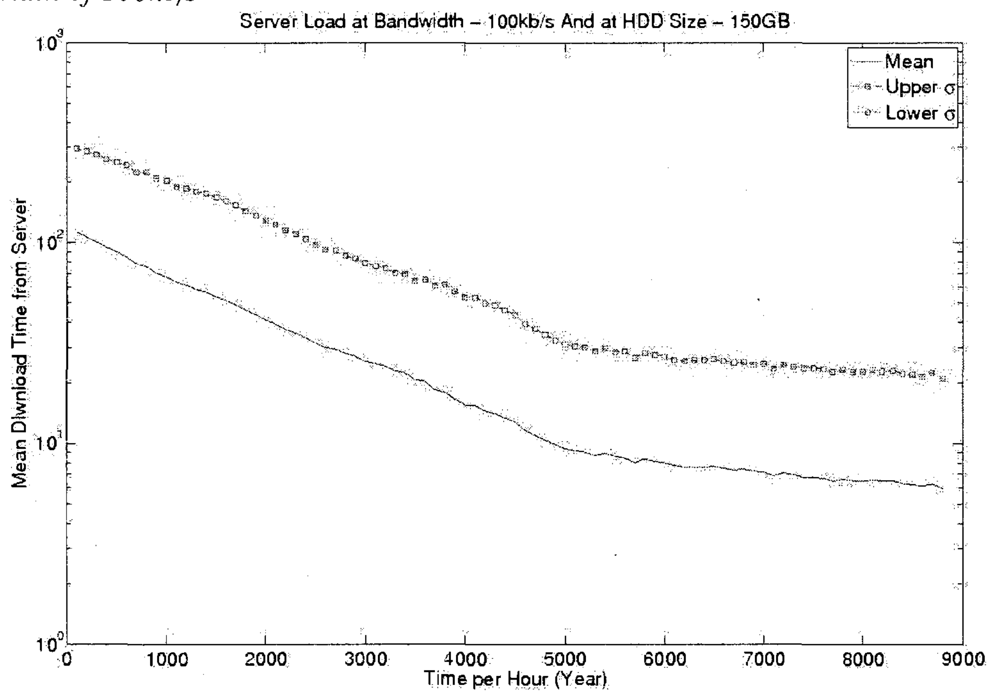


Figure 192: Server Load for H3 case scenario at hard drive size of 200GB and download bandwidth of 100kb/s

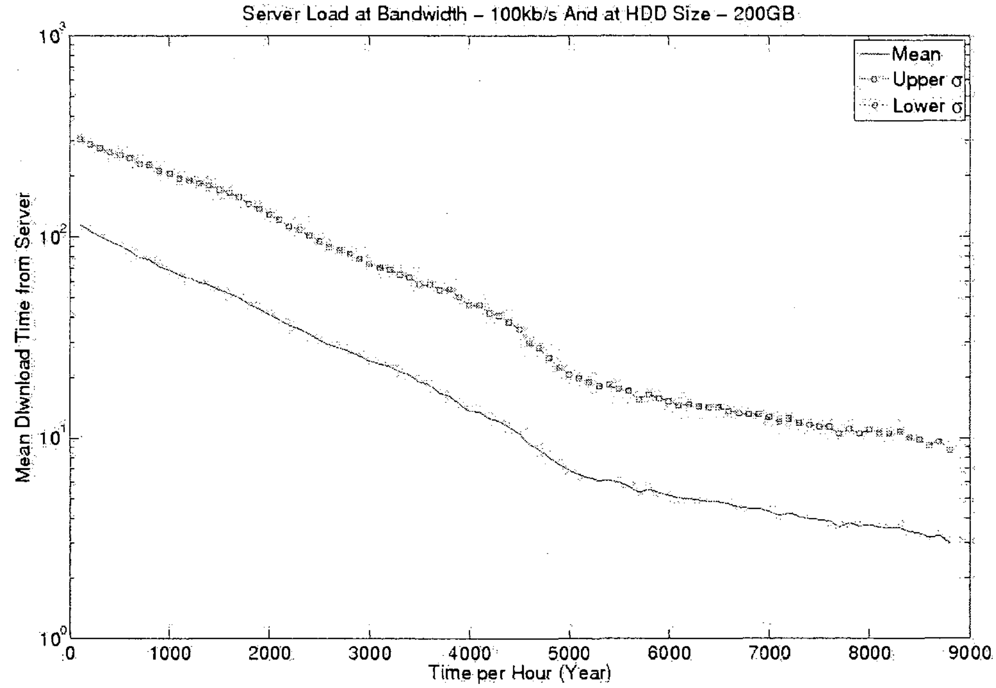


Figure 193: Server Load for H3 case scenario at hard drive size of 50GB and download bandwidth of 128kb/s

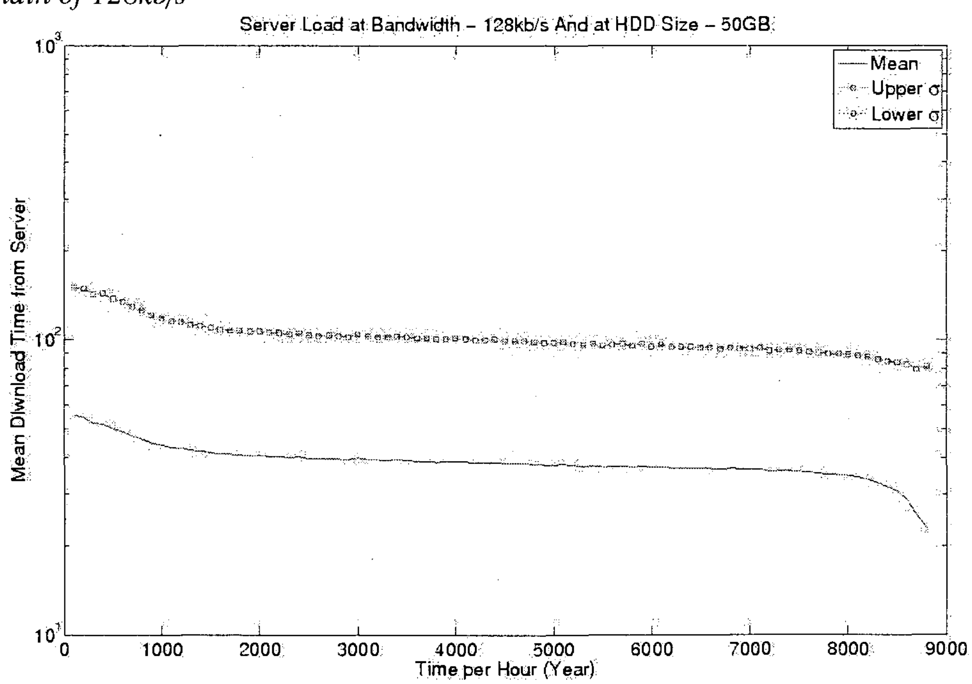


Figure 194: Server Load for H3 case scenario at hard drive size of 100GB and download bandwidth of 128kb/s

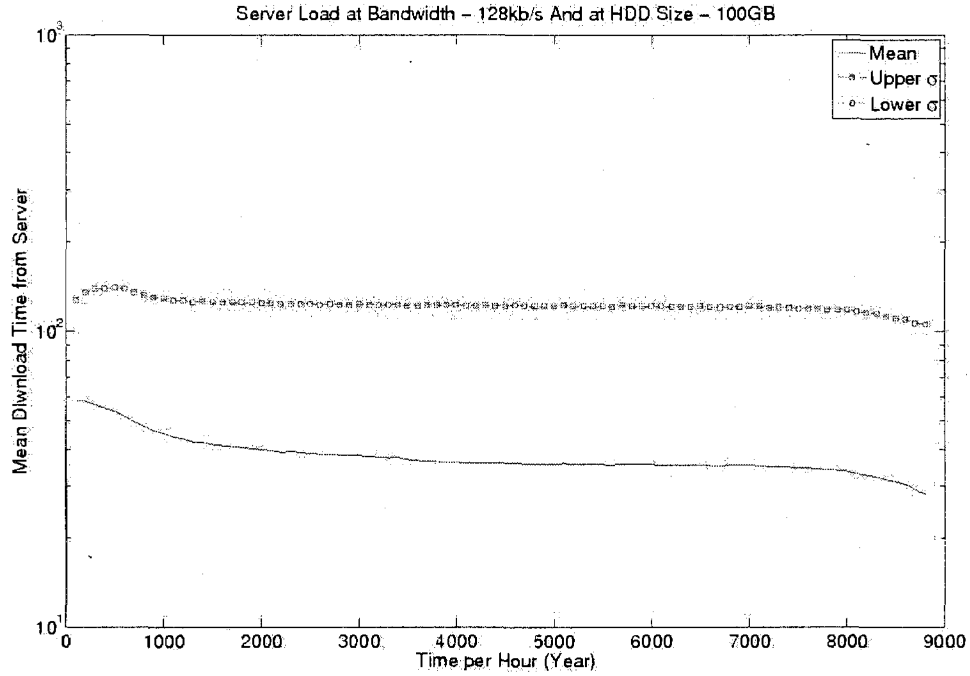


Figure 195: Server Load for H3 case scenario at hard drive size of 150GB and download bandwidth of 128kb/s

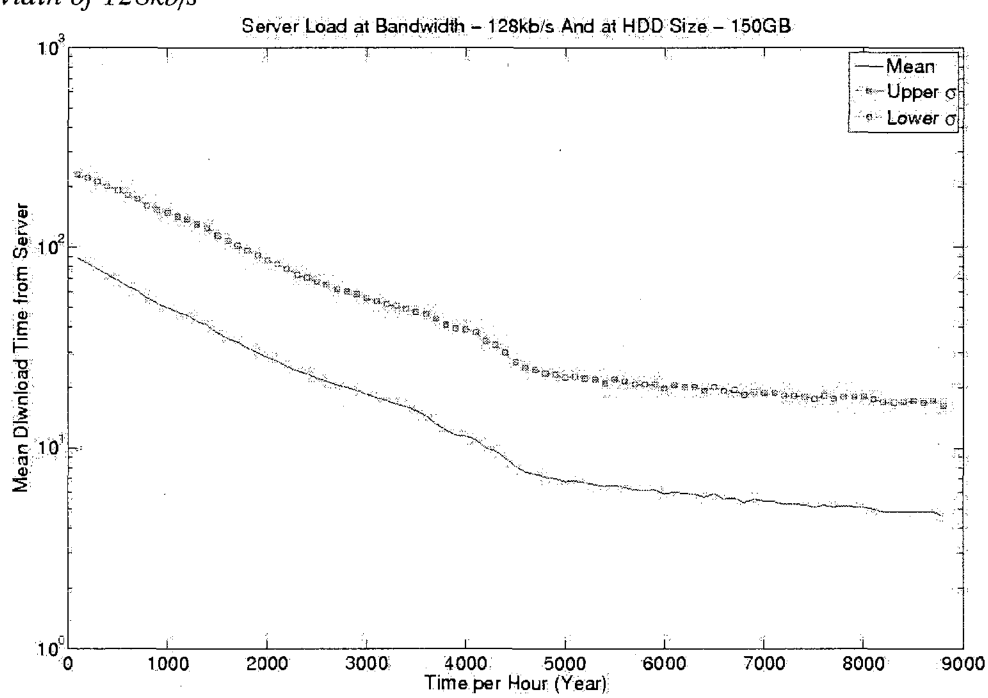


Figure 196: Server Load for H3 case scenario at hard drive size of 200GB and download bandwidth of 128kb/s

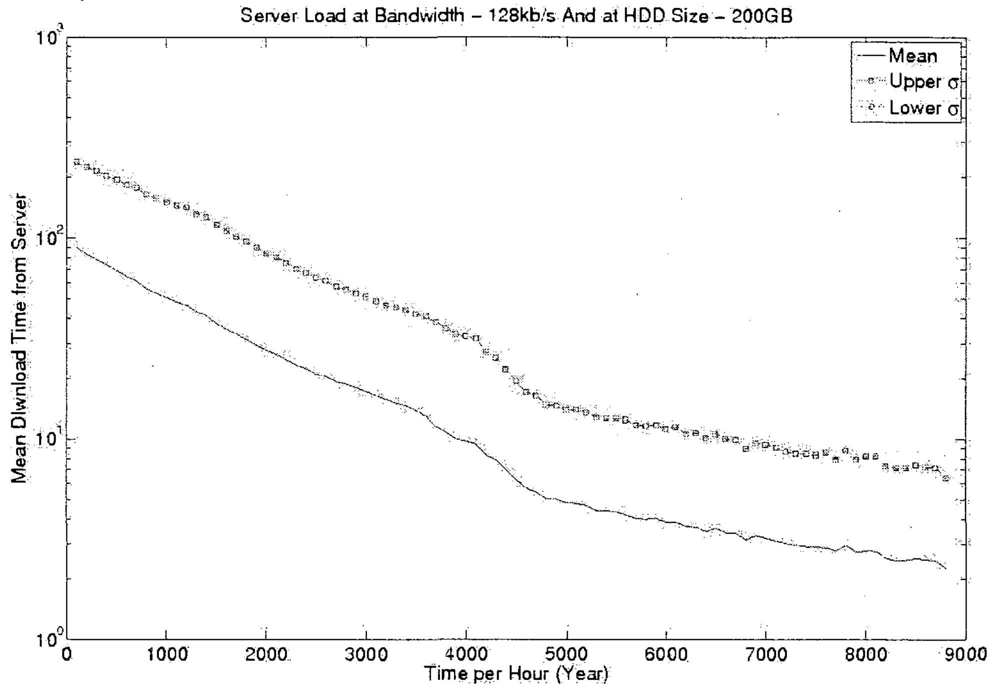


Figure 197: Server Load for H3 case scenario at hard drive size of 50GB and download bandwidth of 256kb/s

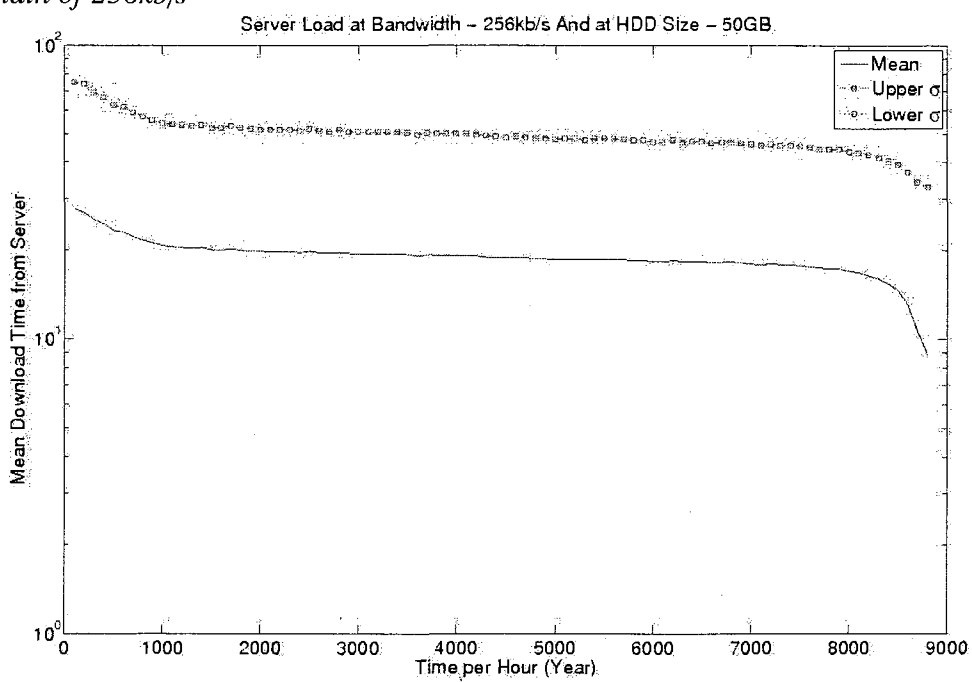


Figure 198: Server Load for H3 case scenario at hard drive size of 100GB and download bandwidth of 256kb/s

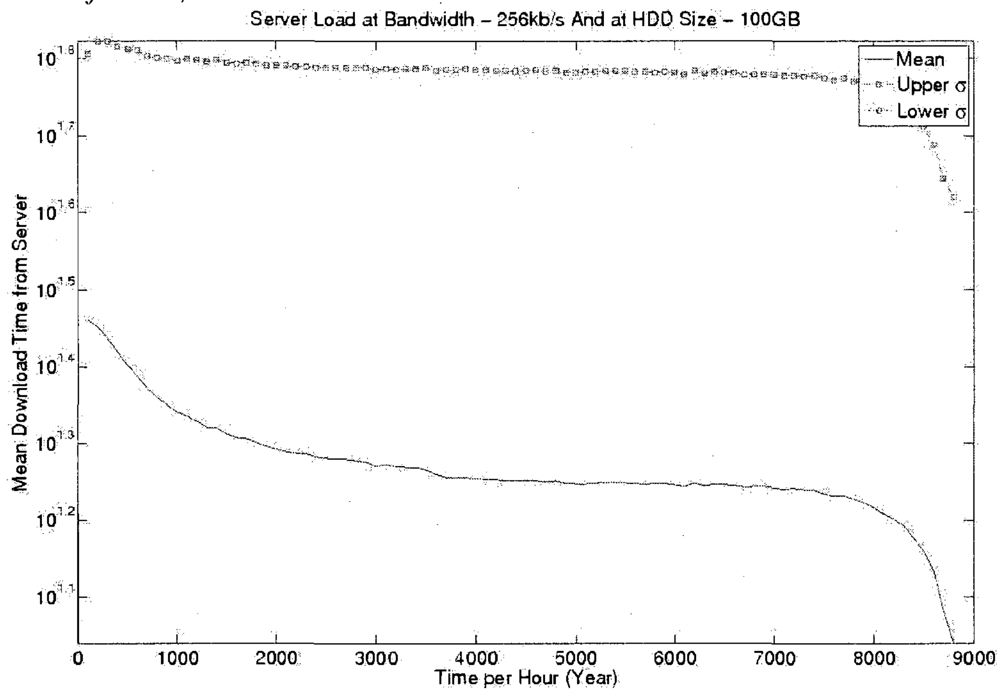


Figure 199: Server Load for H3 case scenario at hard drive size of 150GB and download bandwidth of 256kb/s

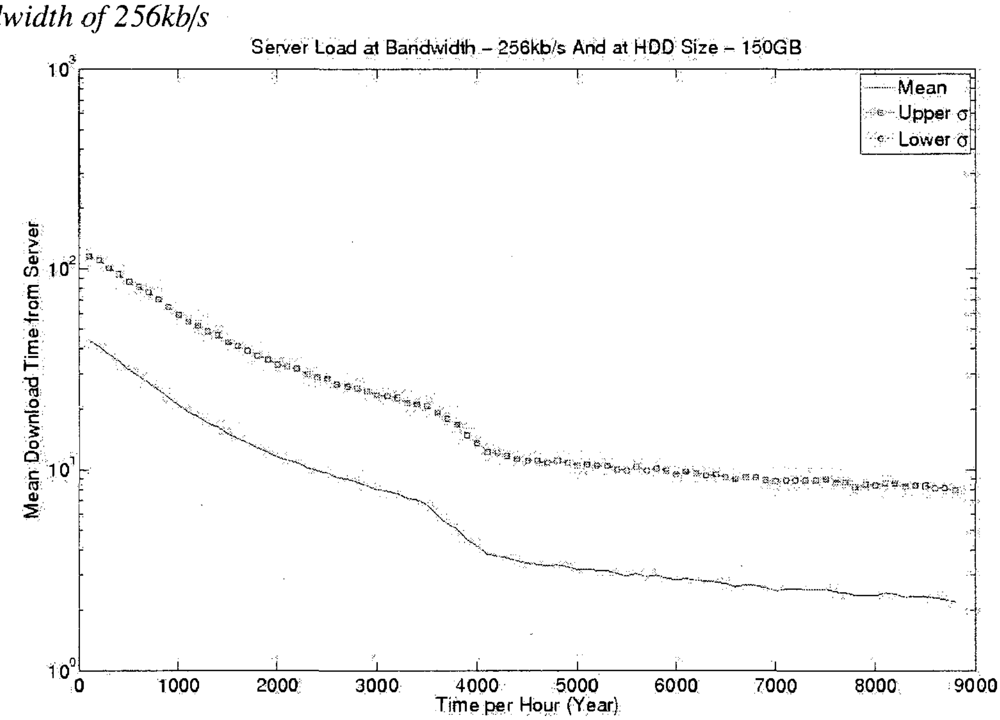


Figure 200: Server Load for H3 case scenario at hard drive size of 200GB and download bandwidth of 256kb/s

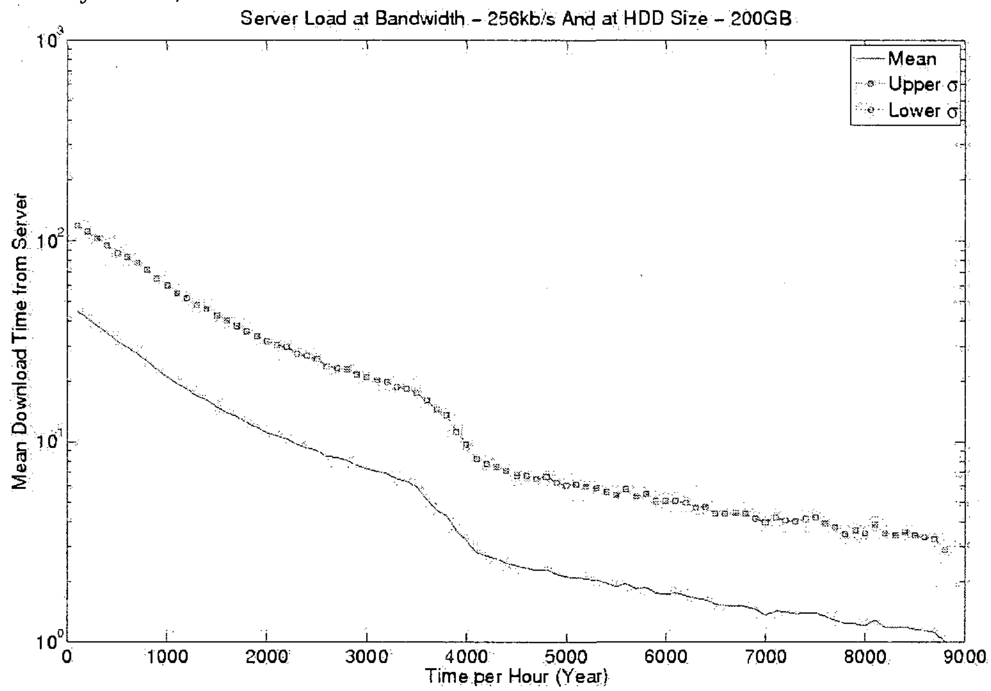


Figure 201: Server Load for H3 case scenario at hard drive size of 50GB and download bandwidth of 512kb/s

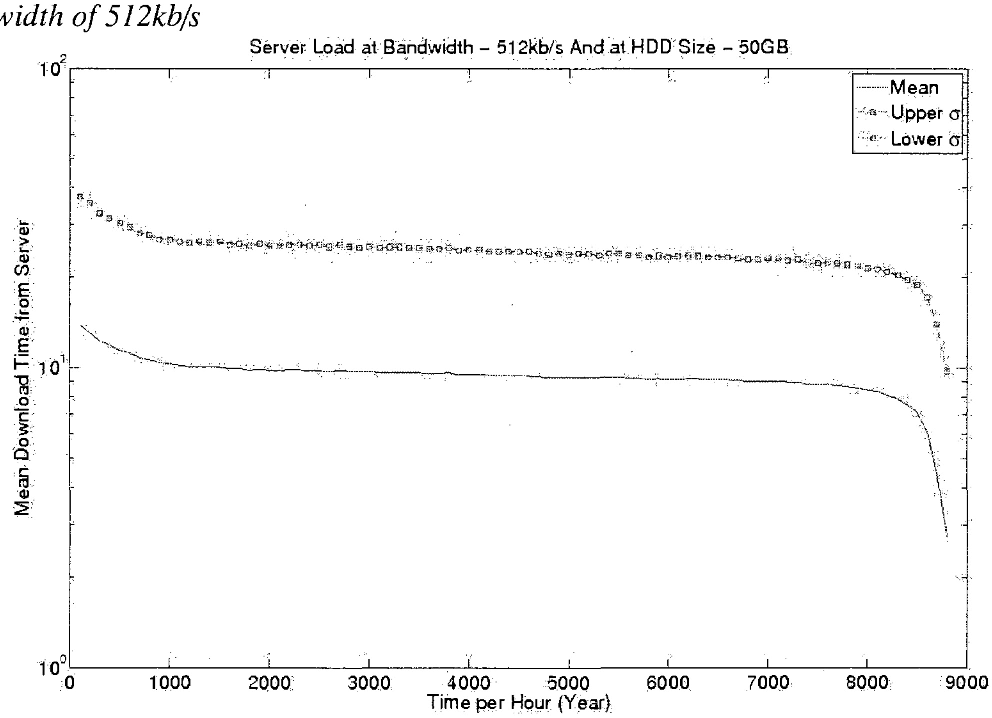


Figure 202: Server Load for H3 case scenario at hard drive size of 100GB and download bandwidth of 512kb/s

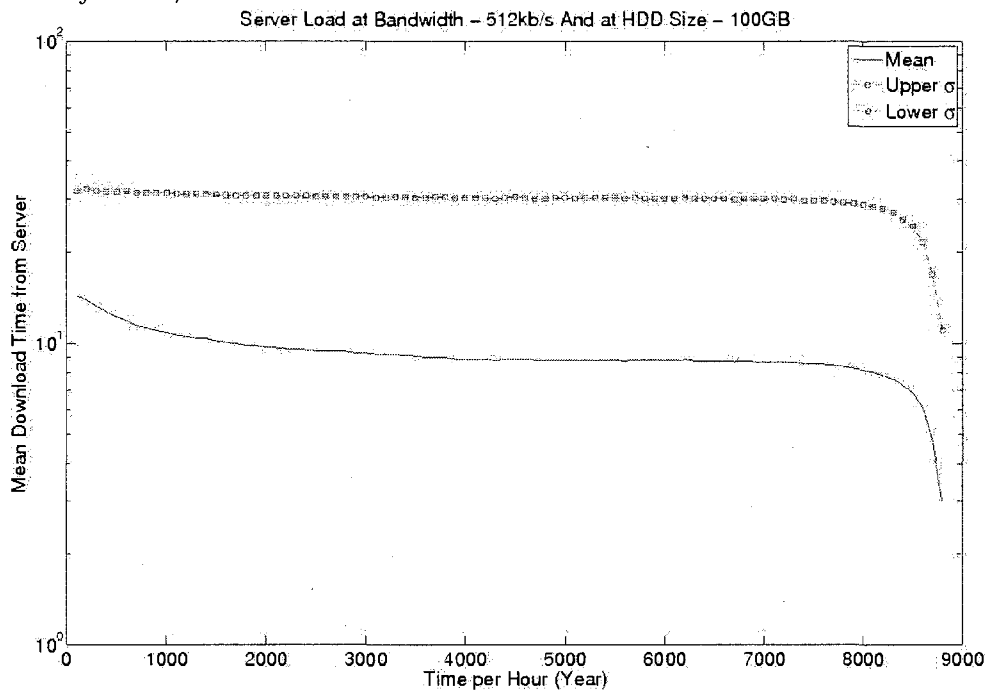


Figure 203: Server Load for H3 case scenario at hard drive size of 150GB and download bandwidth of 512kb/s

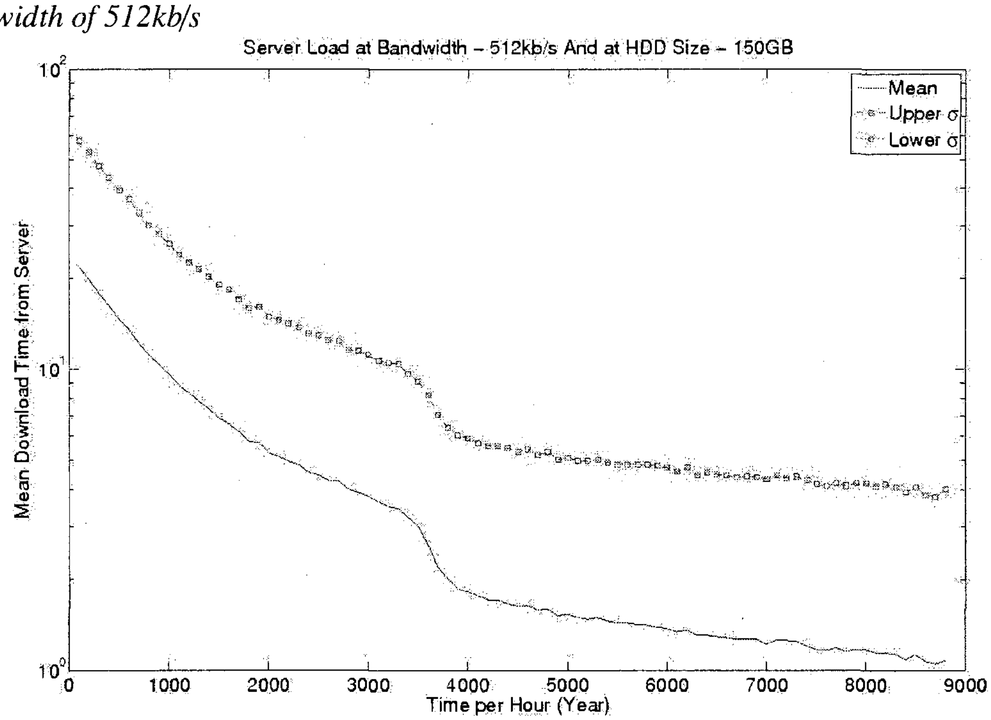


Figure 204: Server Load for H3 case scenario at hard drive size of 200GB and download bandwidth of 512kb/s

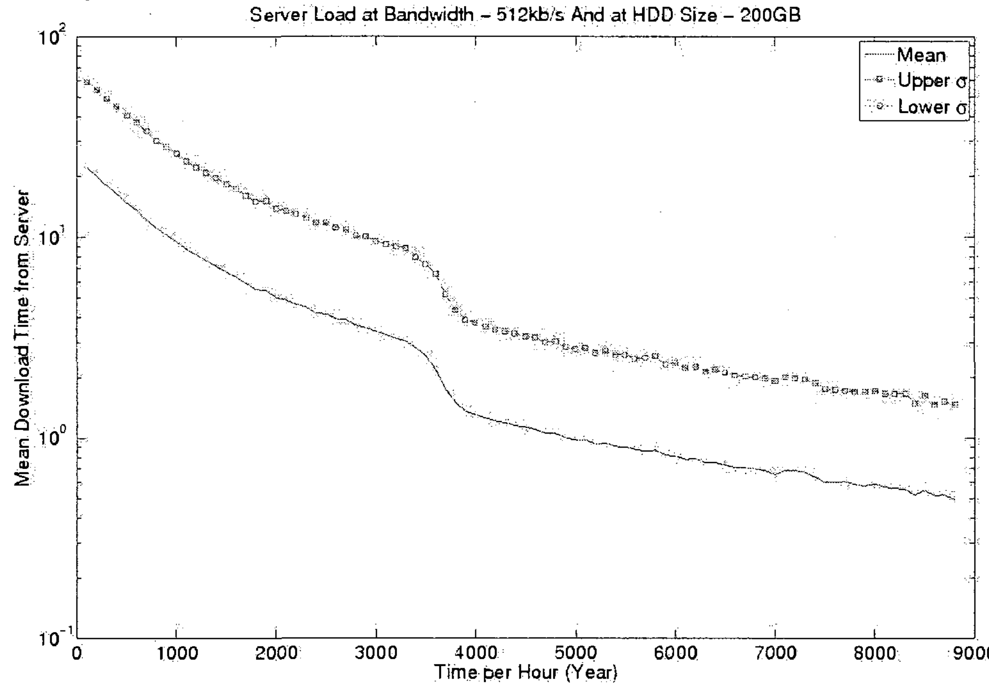


Figure 205: Server Load for H3 case scenario at hard drive size of 50GB and download bandwidth of 1000kb/s

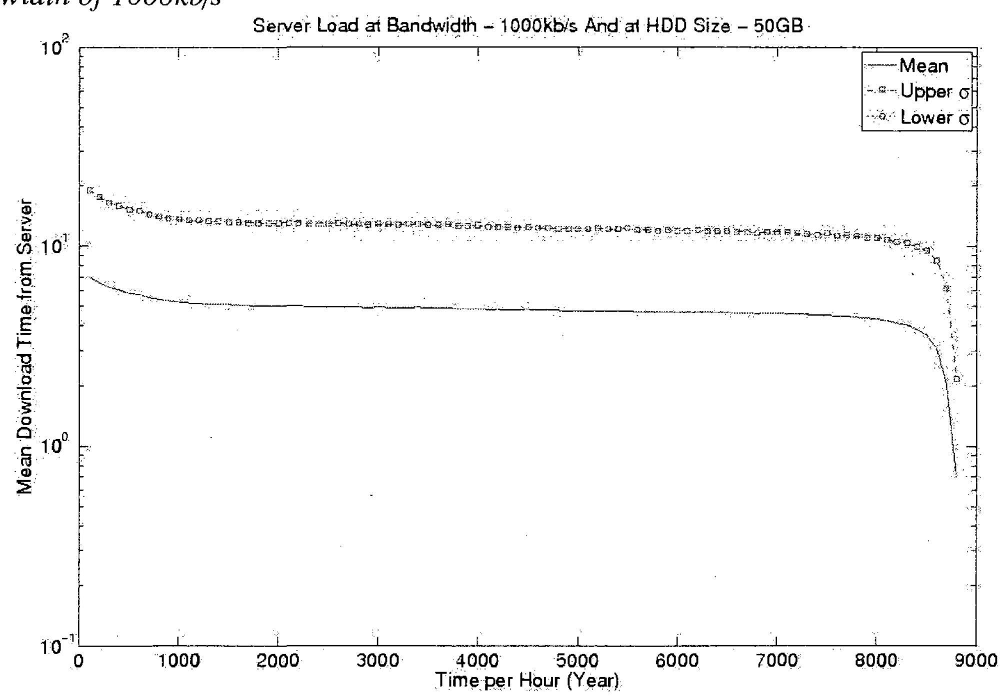


Figure 206: Server Load for H3 case scenario at hard drive size of 100GB and download bandwidth of 1000kb/s

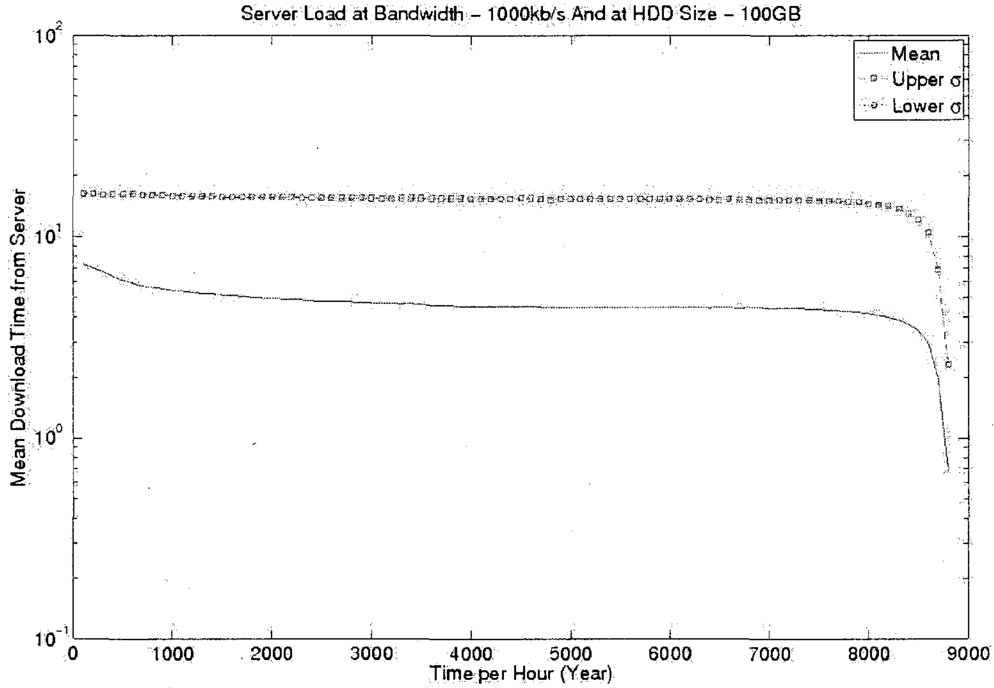


Figure 207: Server Load for H3 case scenario at hard drive size of 150GB and download bandwidth of 1000kb/s

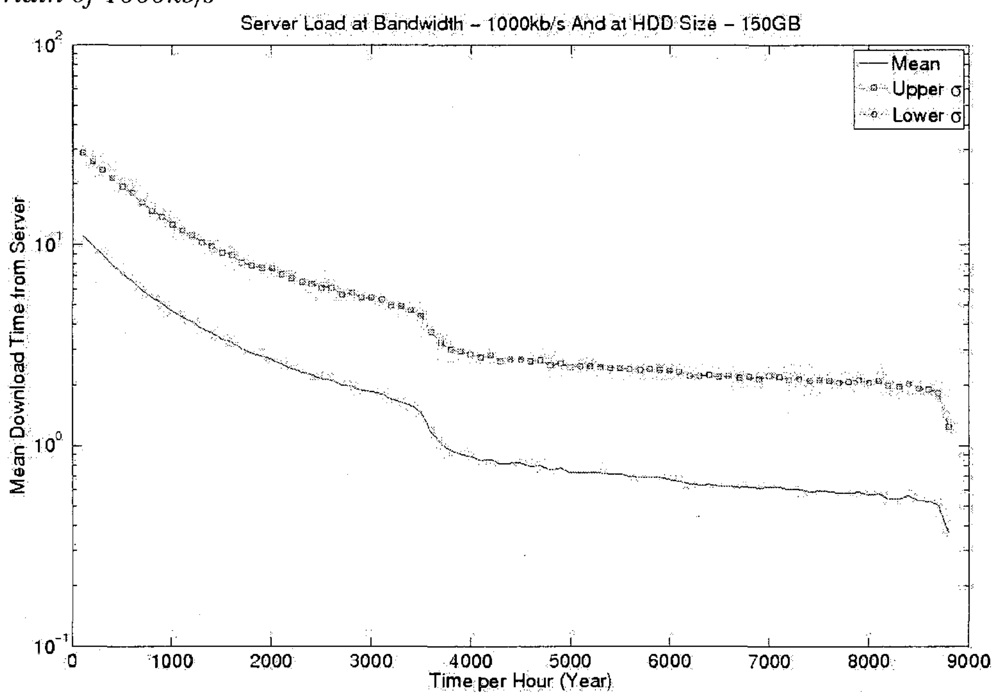


Figure 208: Server Load for H3 case scenario at hard drive size of 200GB and download bandwidth of 1000kb/s

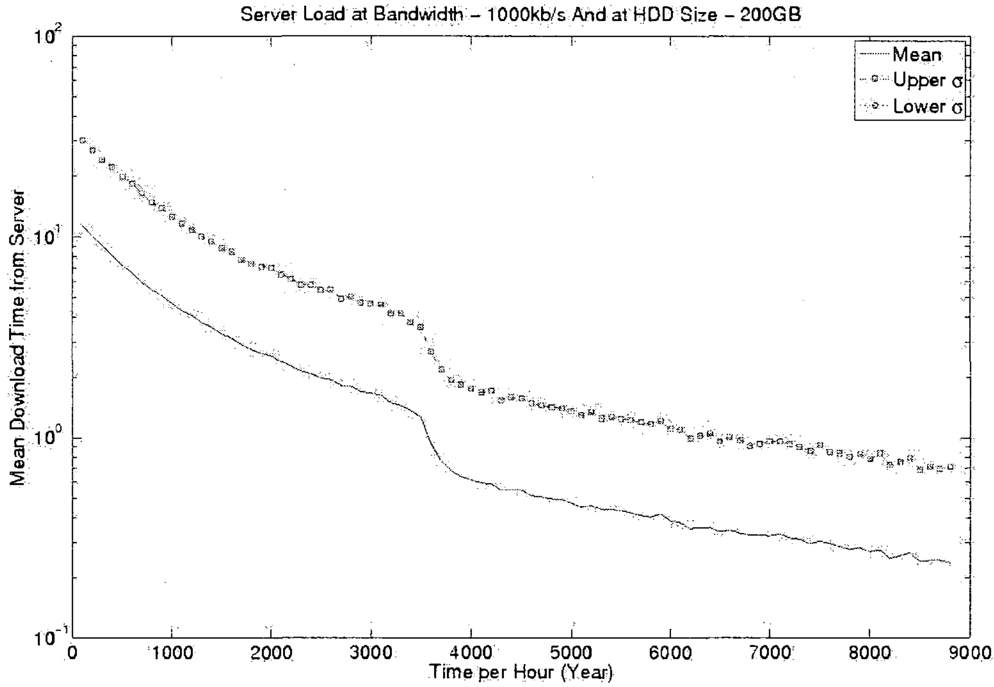


Figure 209: Server Load for H3 case scenario at hard drive size of 50GB and download bandwidth of 2000kb/s

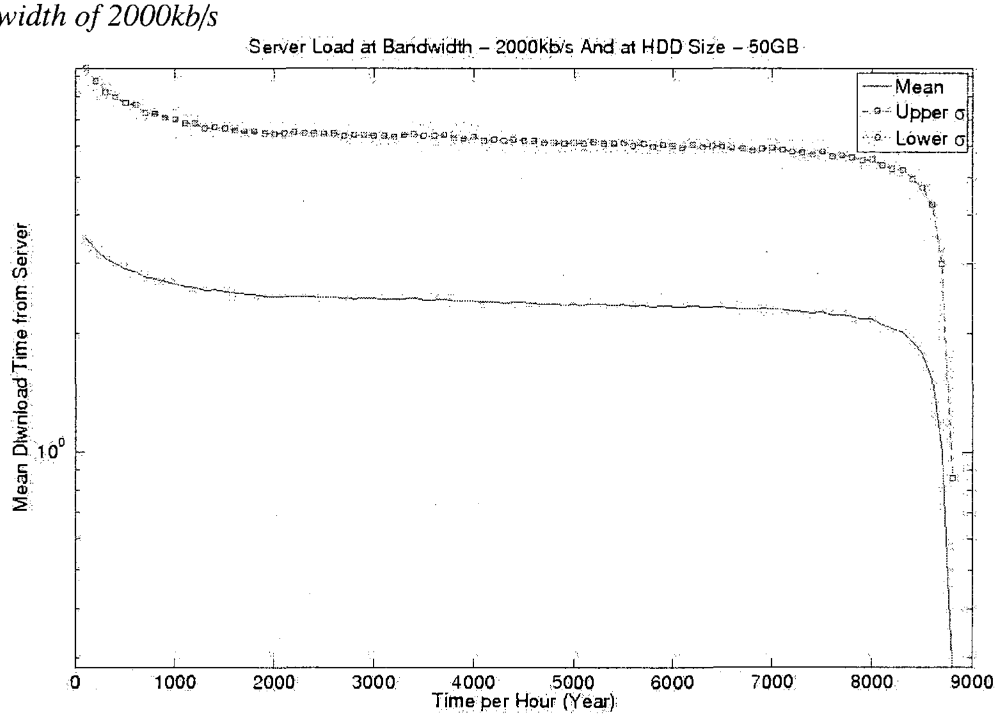


Figure 210: Server Load for H3 case scenario at hard drive size of 100GB and download bandwidth of 2000kb/s

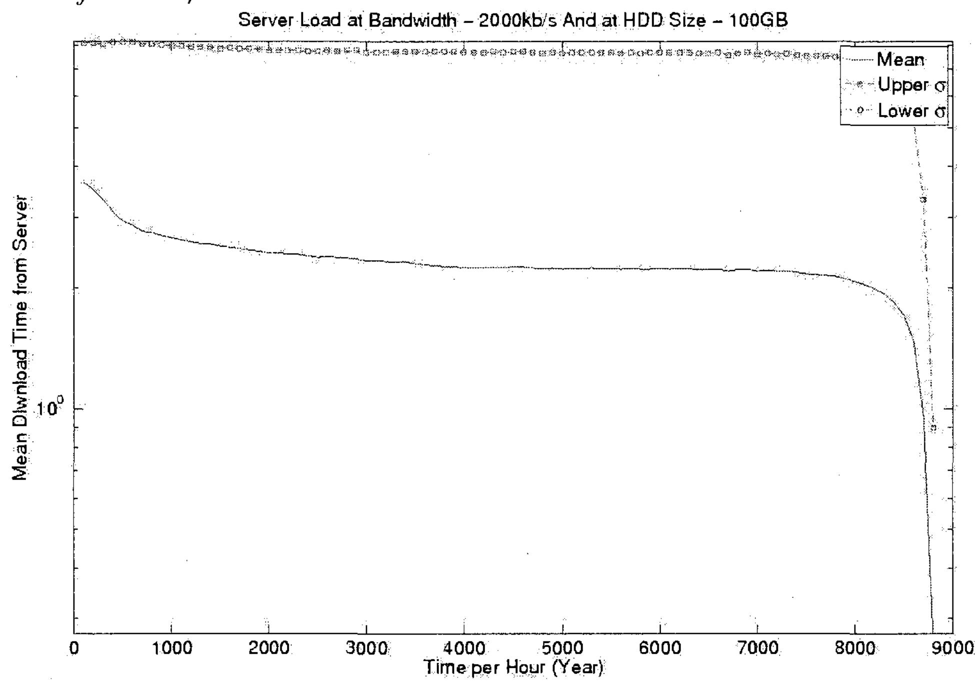


Figure 211: Server Load for H3 case scenario at hard drive size of 150GB and download bandwidth of 2000kb/s

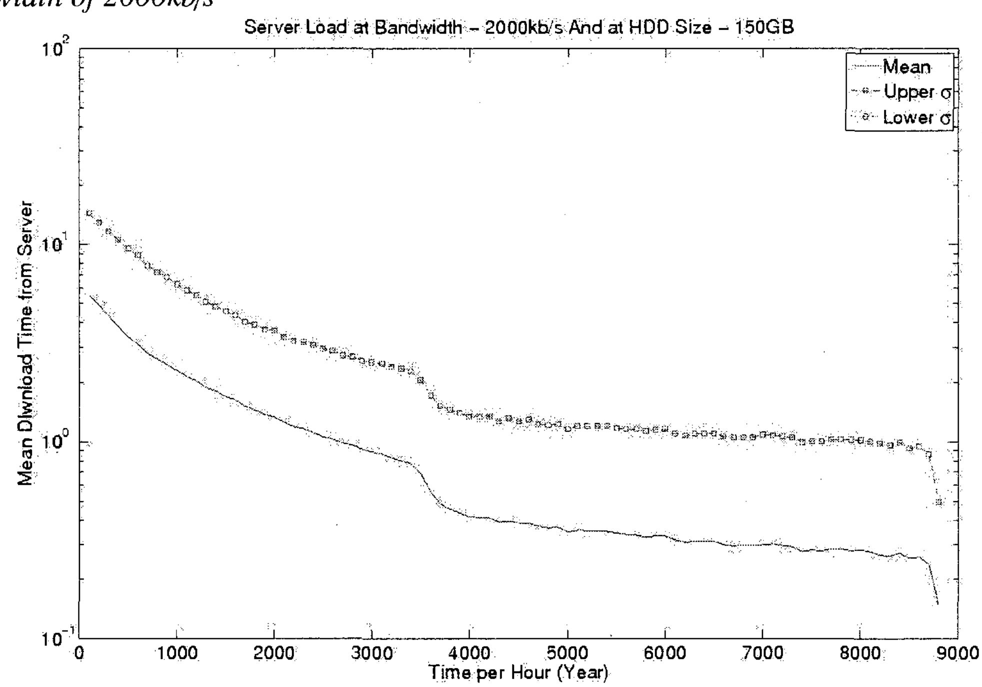


Figure 212: Server Load for H3 case scenario at hard drive size of 200GB and download bandwidth of 2000kb/s

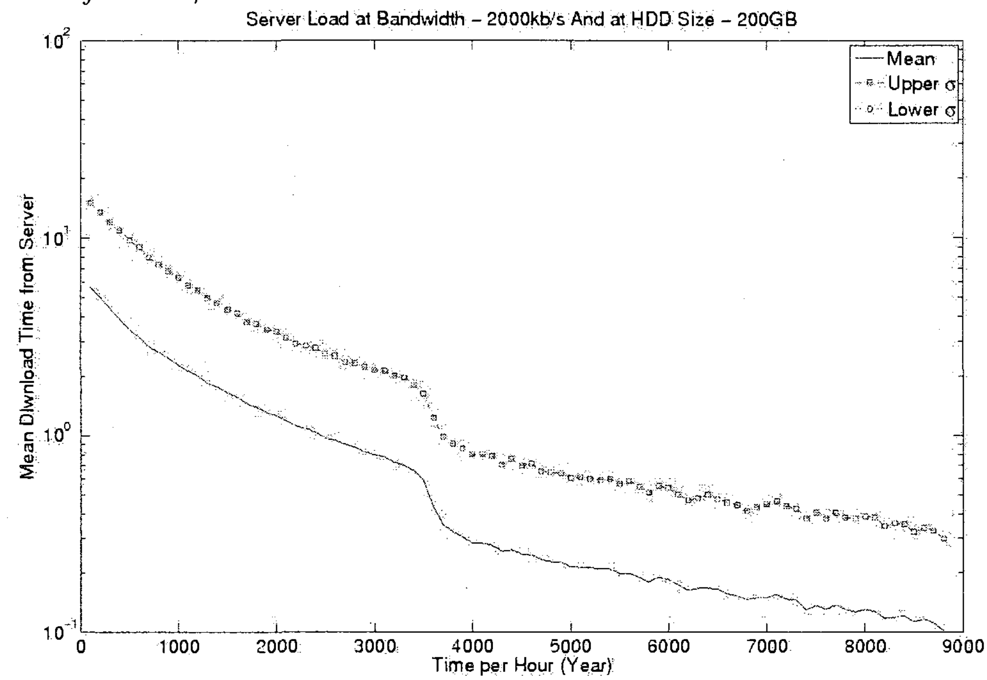


Figure 213: Server Load for H3 case scenario at hard drive size of 50GB and download bandwidth of 5000kb/s

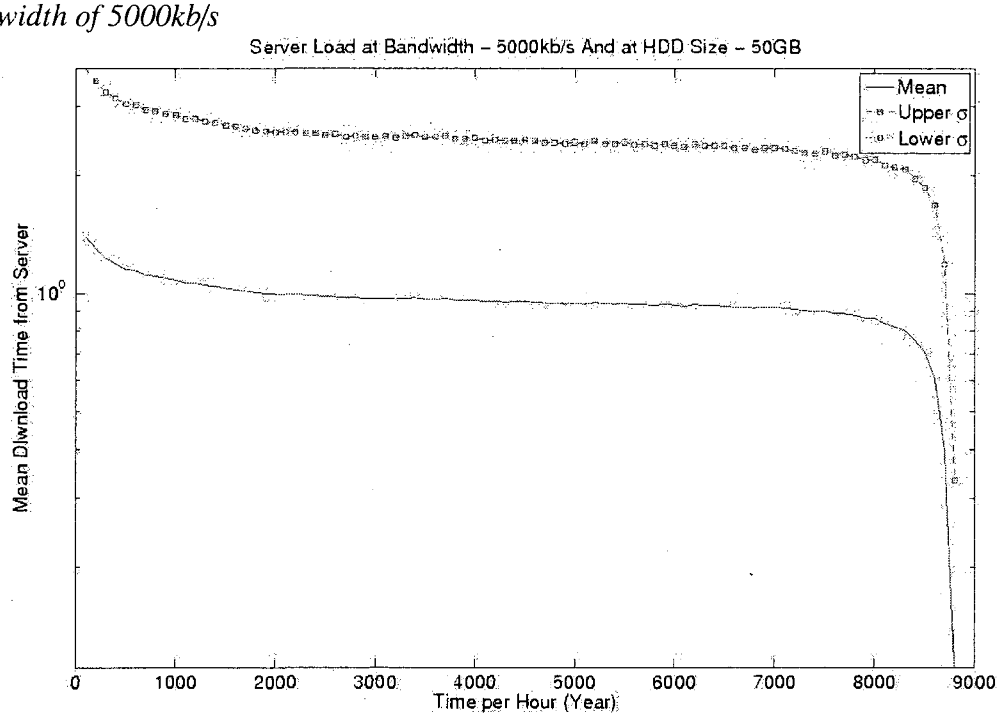


Figure 214: Server Load for H3 case scenario at hard drive size of 100GB and download bandwidth of 5000kb/s

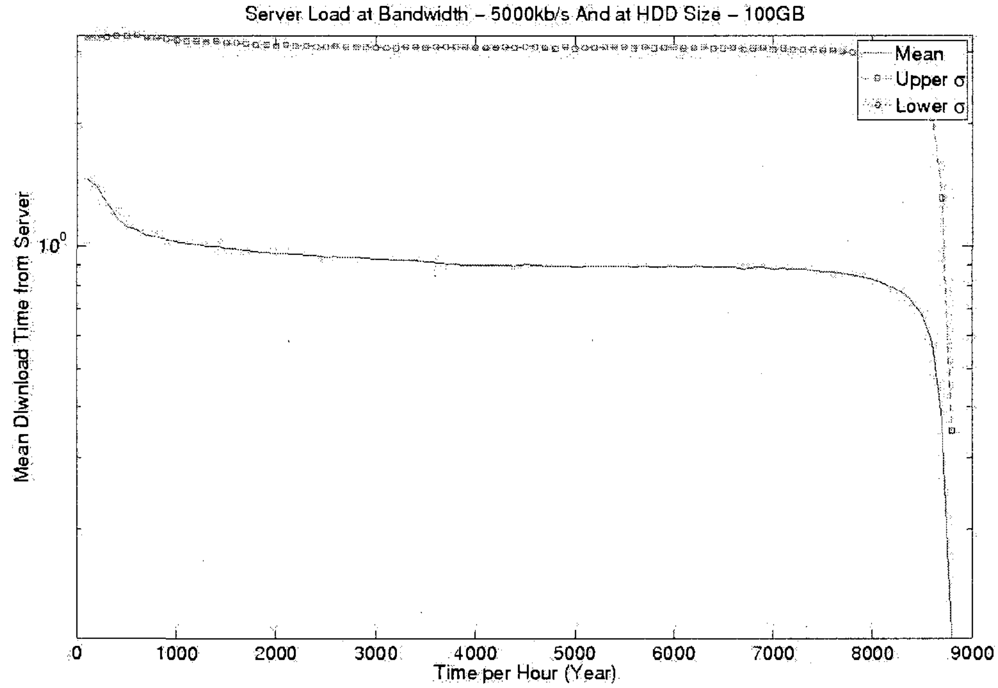


Figure 215: Server Load for H3 case scenario at hard drive size of 150GB and download bandwidth of 5000kb/s

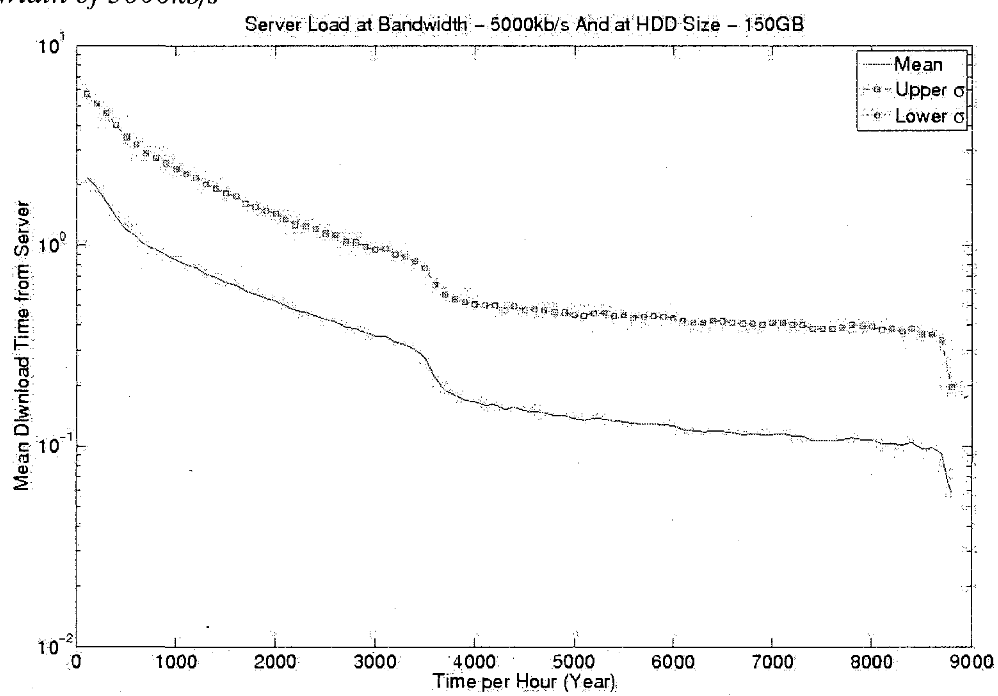


Figure 216: Server Load for H3 case scenario at hard drive size of 200GB and download bandwidth of 5000kb/s

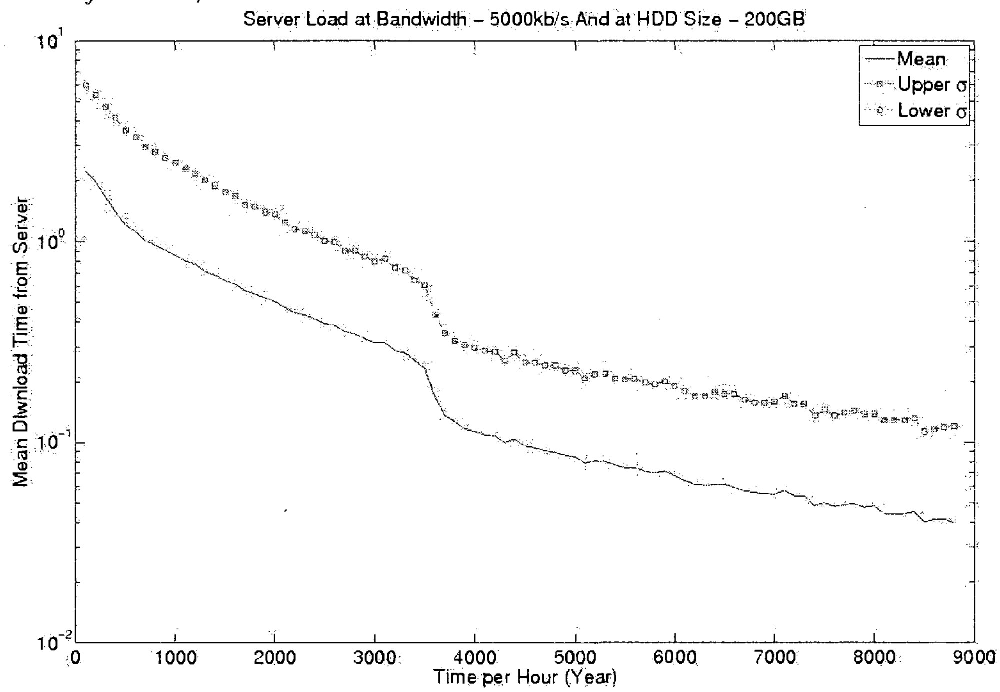


Figure 217: Server Load for H3 case scenario at hard drive size of 50GB and download bandwidth of 10000kb/s

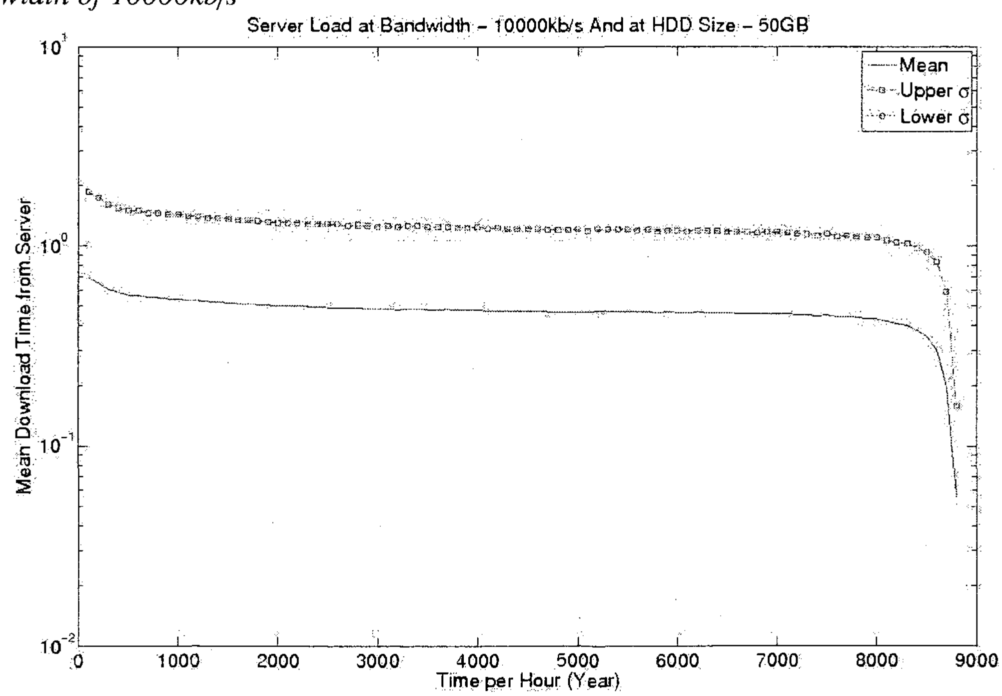


Figure 218: Server Load for H3 case scenario at hard drive size of 100GB and download bandwidth of 10000kb/s

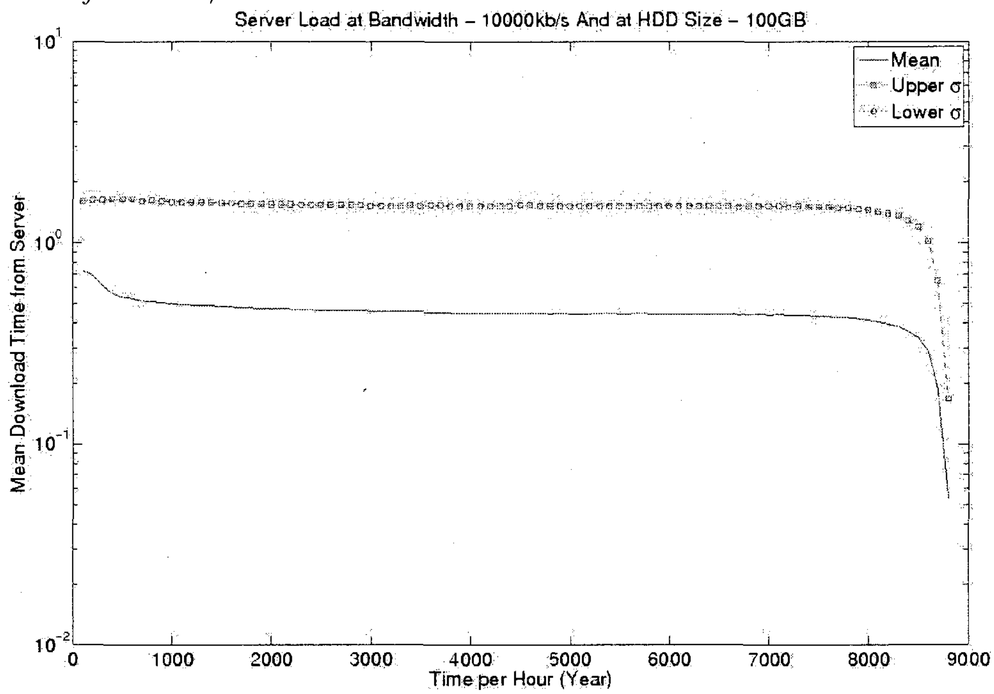


Figure 219: Server Load for H3 case scenario at hard drive size of 150GB and download bandwidth of 10000kb/s

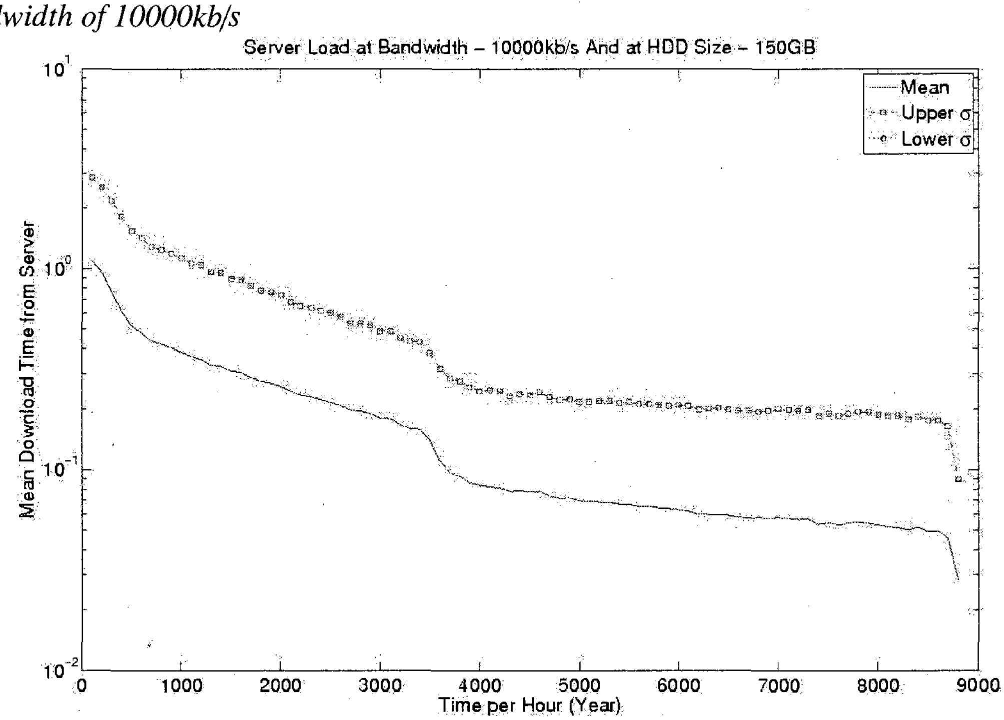


Figure 220: Server Load for H3 case scenario at hard drive size of 200GB and download bandwidth of 10000kb/s

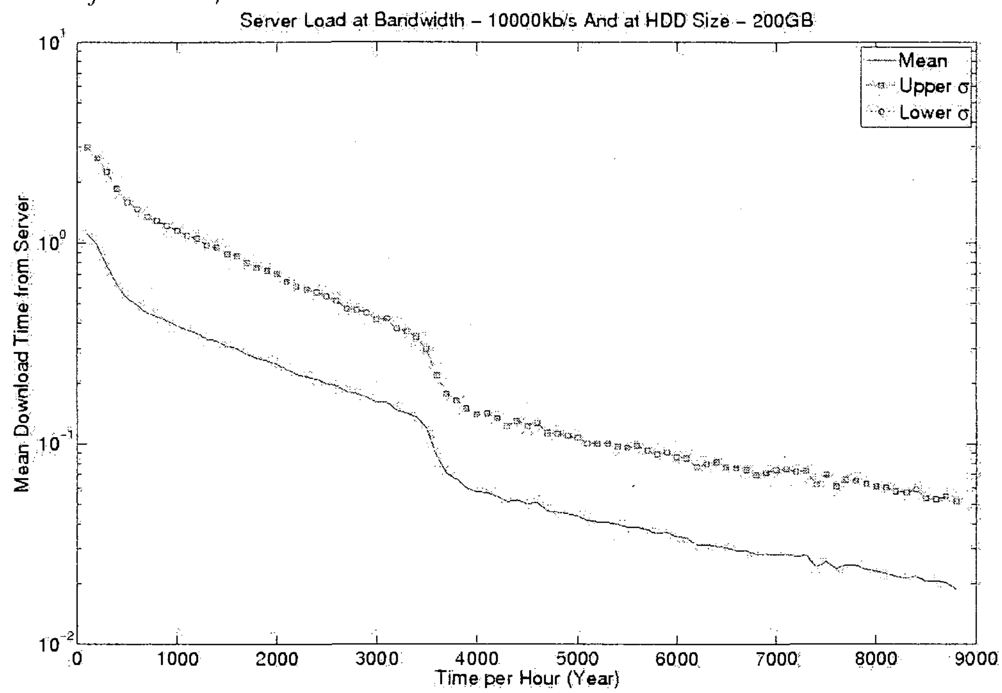


Figure 221: Server Load for H3 case scenario at hard drive size of 50GB and download bandwidth of 15000kb/s

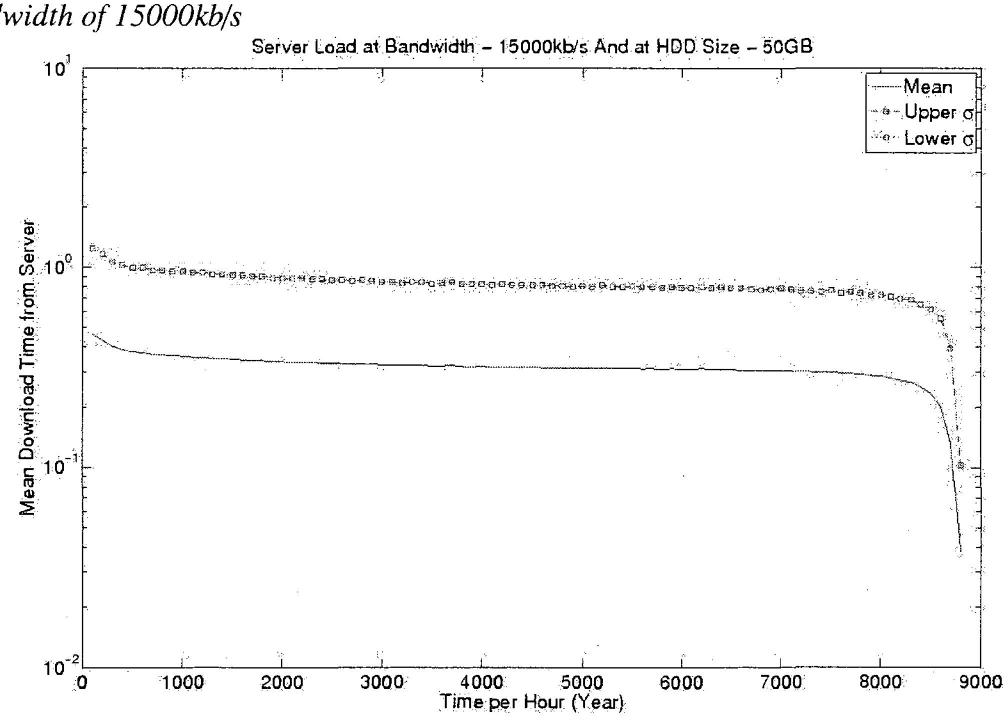


Figure 222: Server Load for H3 case scenario at hard drive size of 100GB and download bandwidth of 15000kb/s

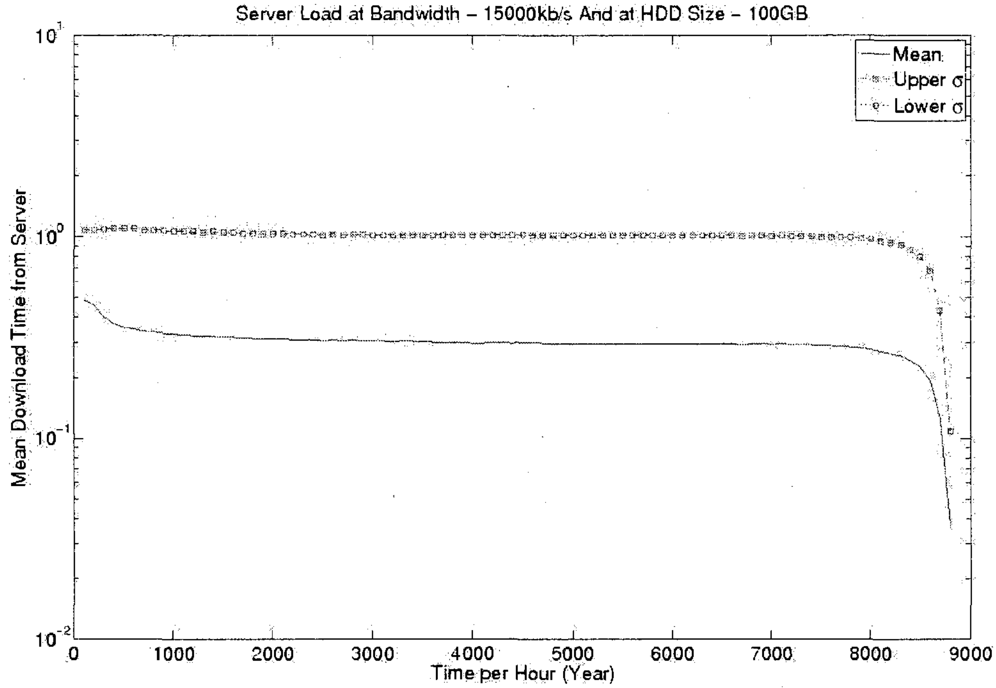


Figure 223: Server Load for H3 case scenario at hard drive size of 150GB and download bandwidth of 15000kb/s

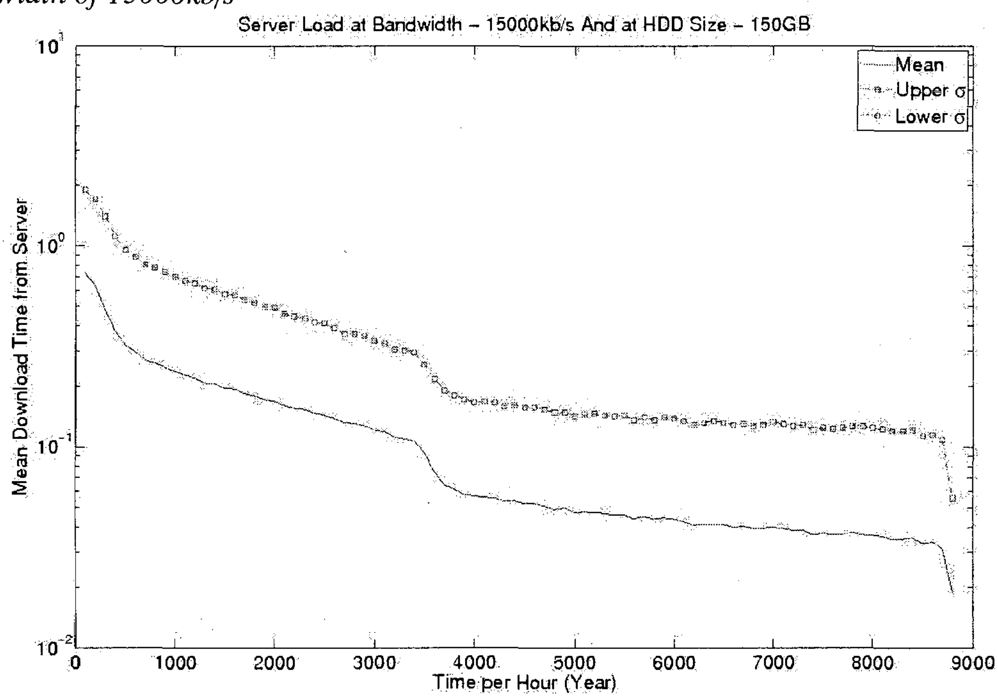


Figure 224: Server Load for H3 case scenario at hard drive size of 200GB and download bandwidth of 15000kb/s

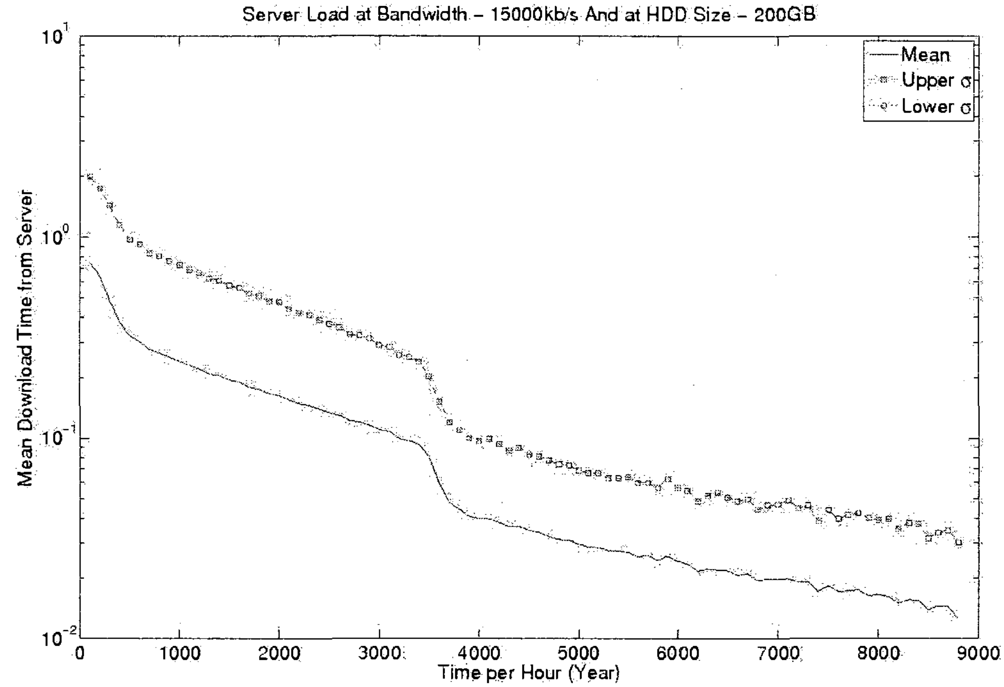


Figure 225: Server Load for H4 case scenario at hard drive size of 50GB and download bandwidth of 25kb/s

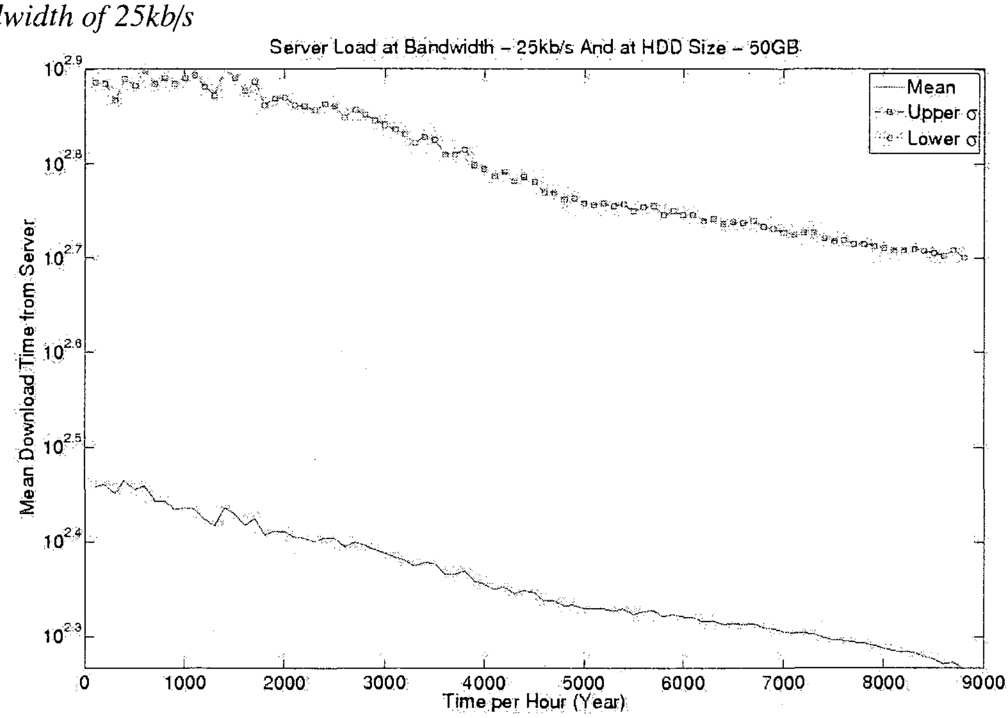


Figure 226: Server Load for H4 case scenario at hard drive size of 100GB and download bandwidth of 25kb/s

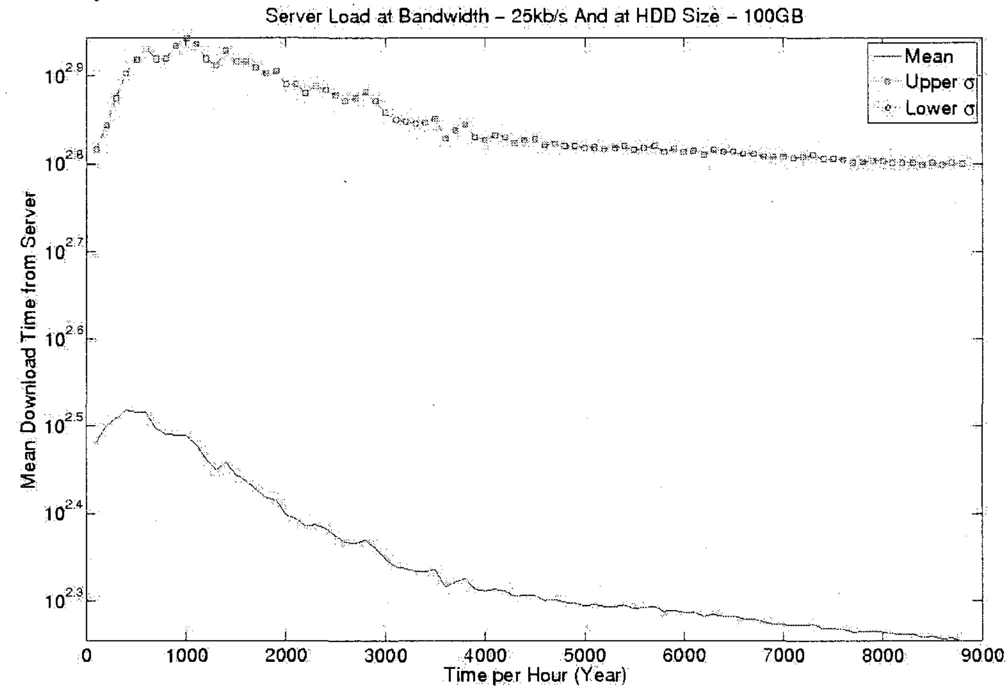


Figure 227: Server Load for H4 case scenario at hard drive size of 150GB and download bandwidth of 25kb/s

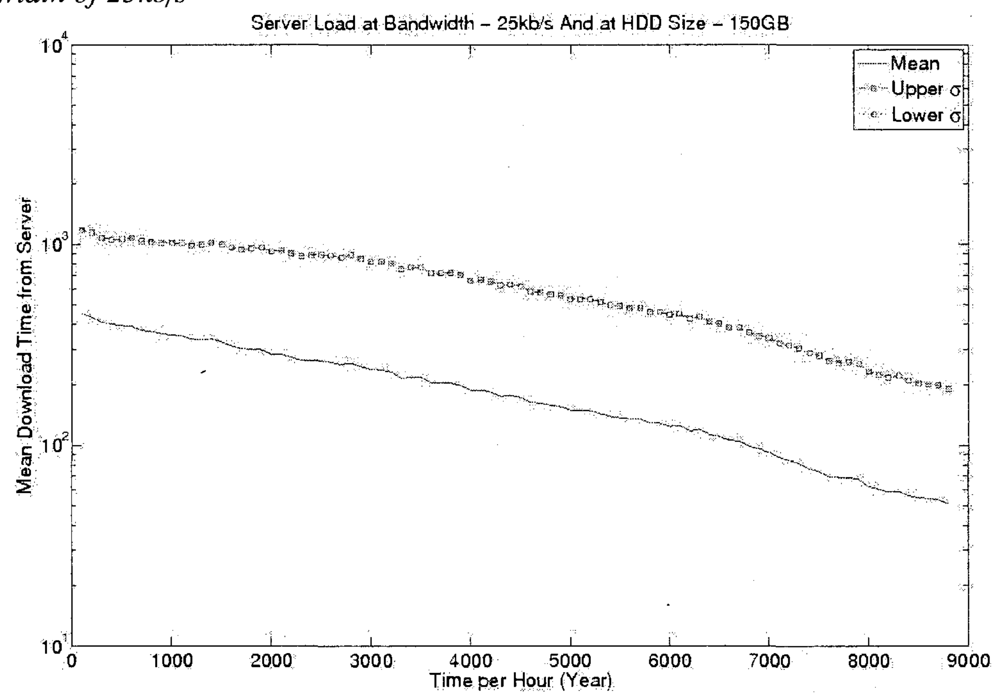


Figure 228: Server Load for H4 case scenario at hard drive size of 200GB and download bandwidth of 25kb/s

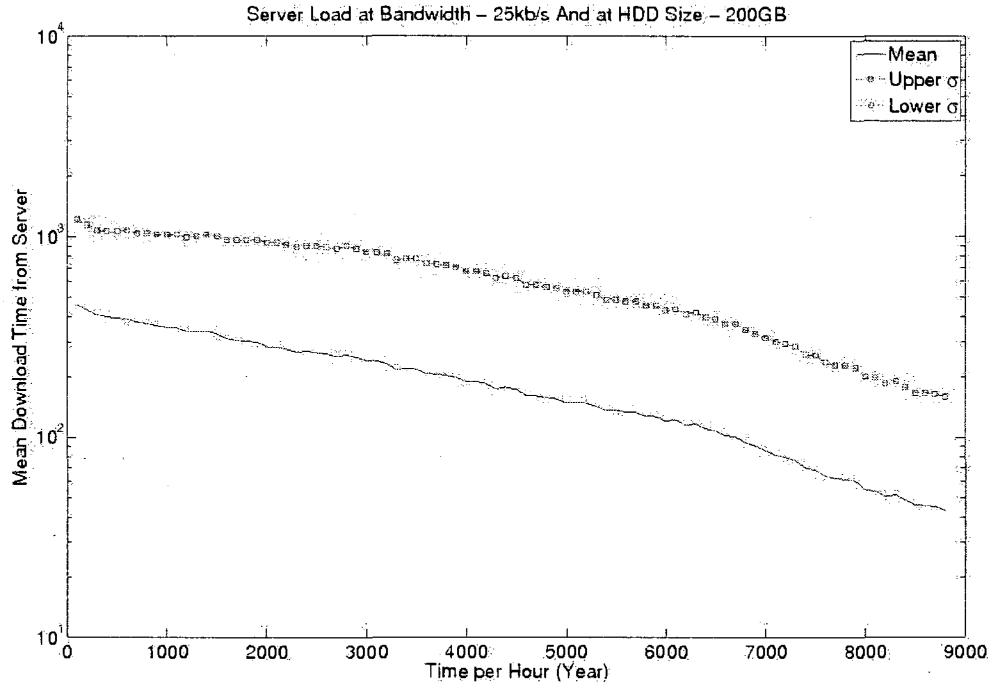


Figure 229: Server Load for H4 case scenario at hard drive size of 50GB and download bandwidth of 50kb/s

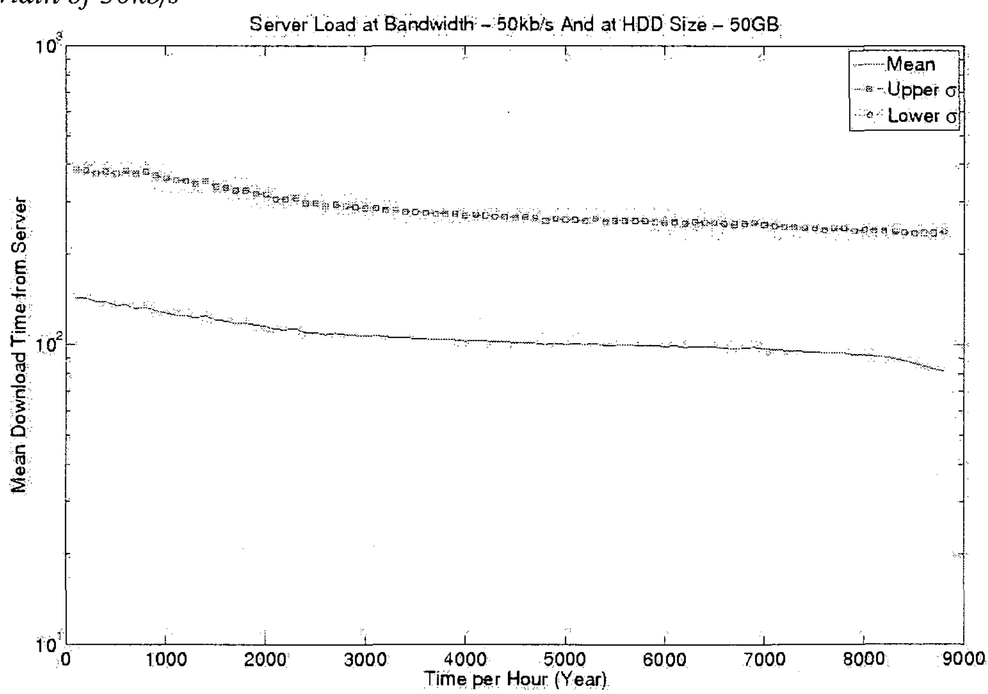


Figure 230: Server Load for H4 case scenario at hard drive size of 100GB and download bandwidth of 50kb/s

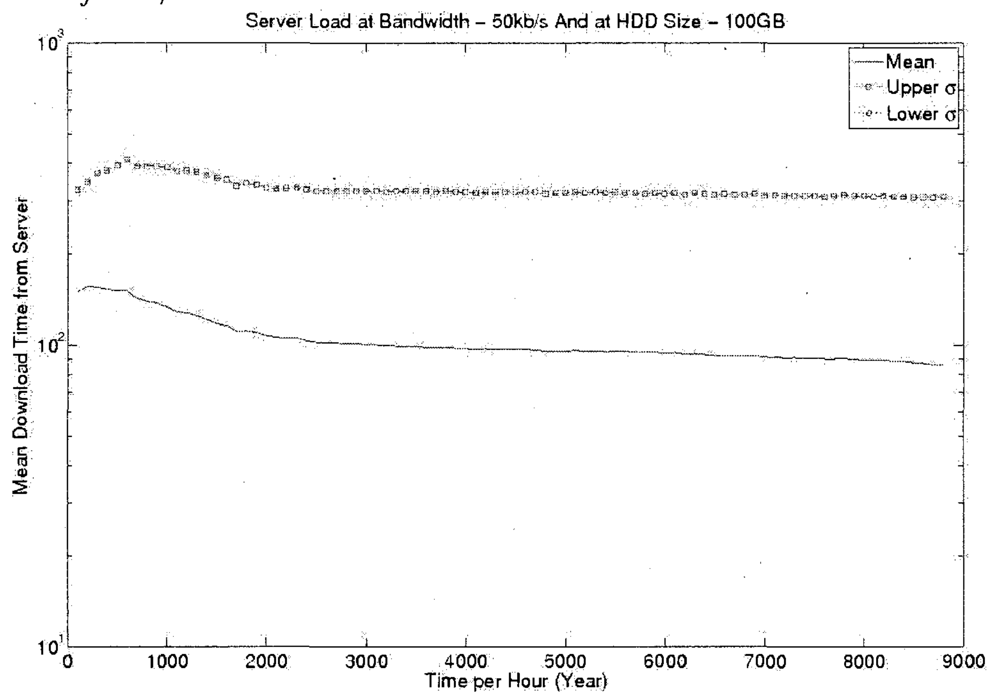


Figure 231: Server Load for H4 case scenario at hard drive size of 150GB and download bandwidth of 50kb/s

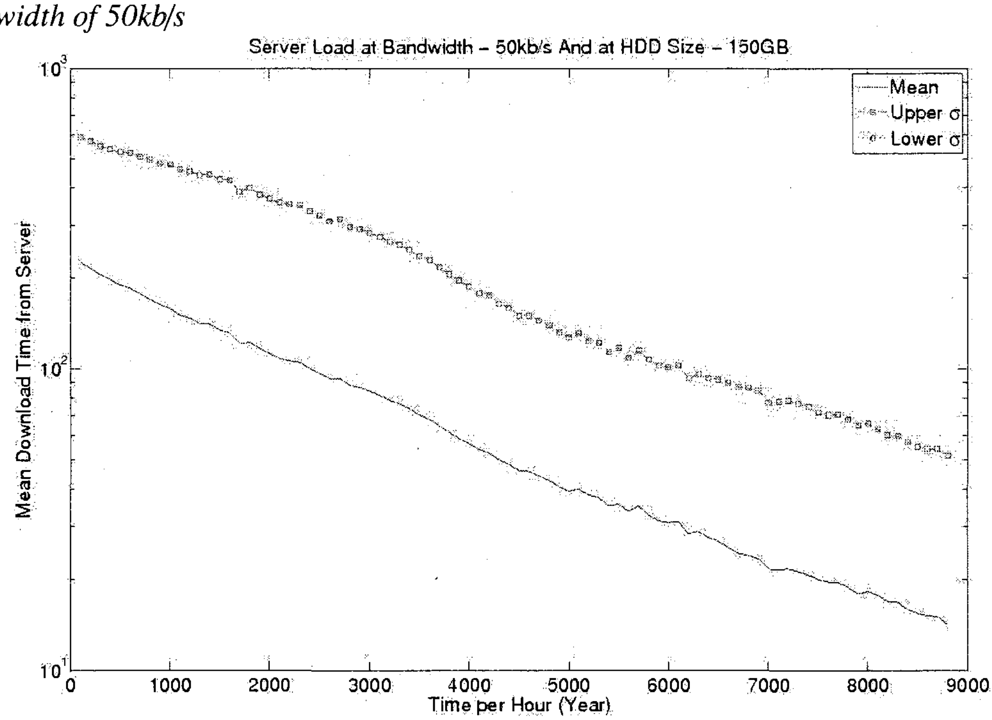


Figure 232: Server Load for H4 case scenario at hard drive size of 200GB and download bandwidth of 50kb/s

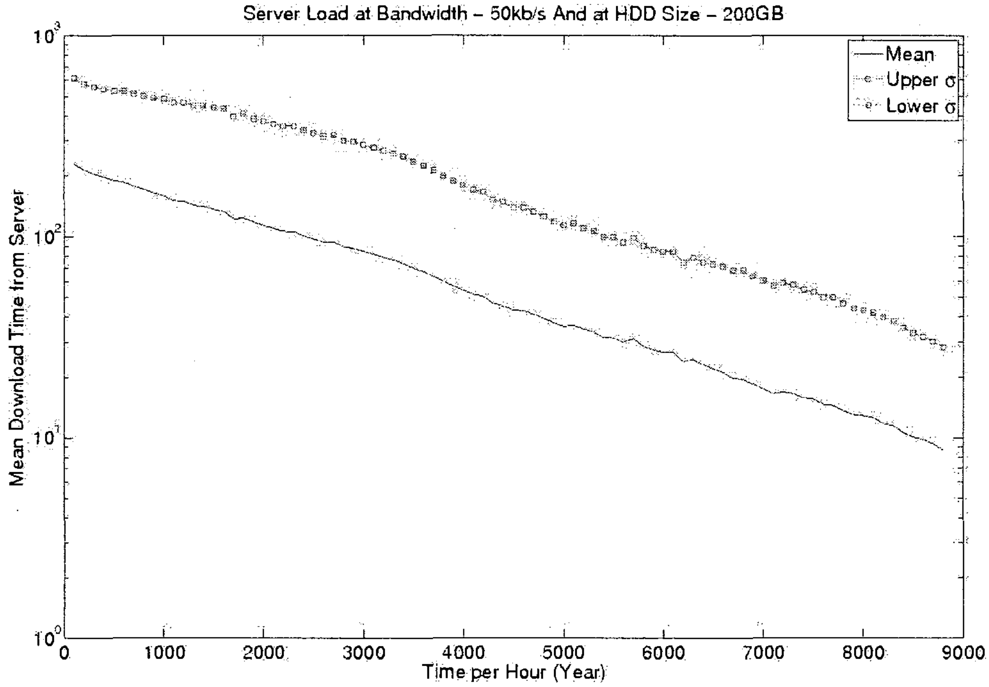


Figure 233: Server Load for H4 case scenario at hard drive size of 50GB and download bandwidth of 100kb/s

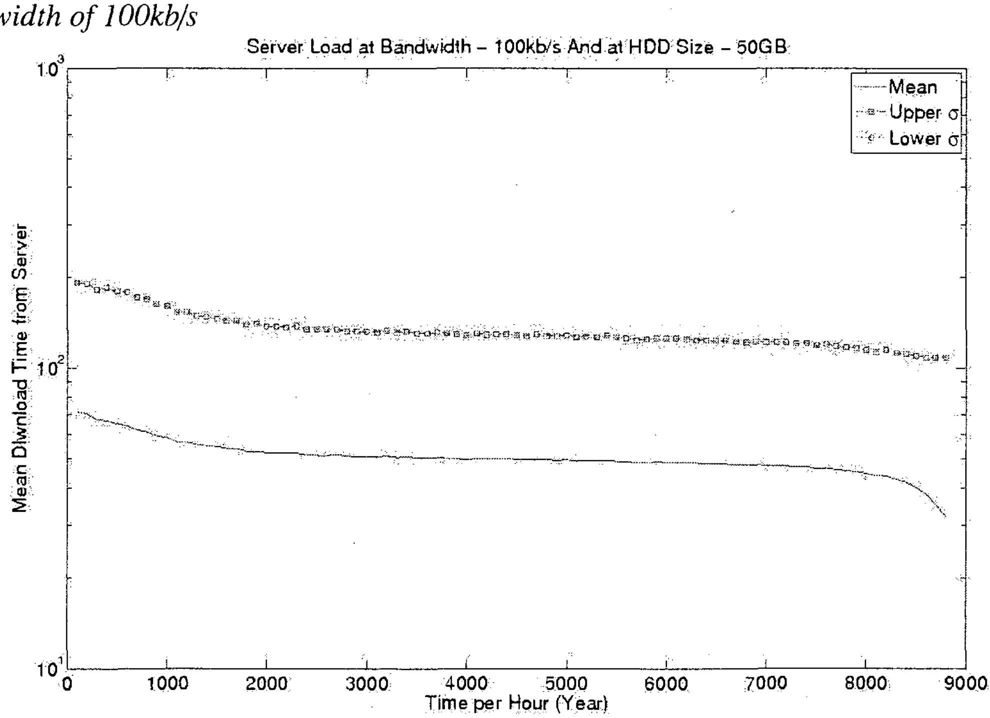


Figure 234: Server Load for H4 case scenario at hard drive size of 100GB and download bandwidth of 100kb/s

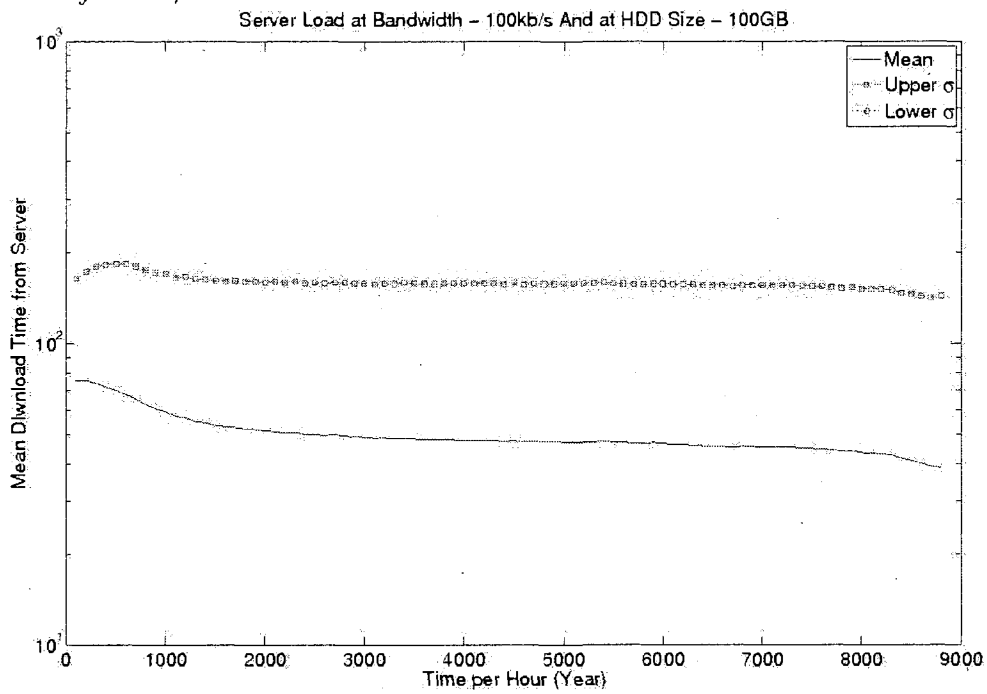


Figure 235: Server Load for H4 case scenario at hard drive size of 150GB and download bandwidth of 100kb/s

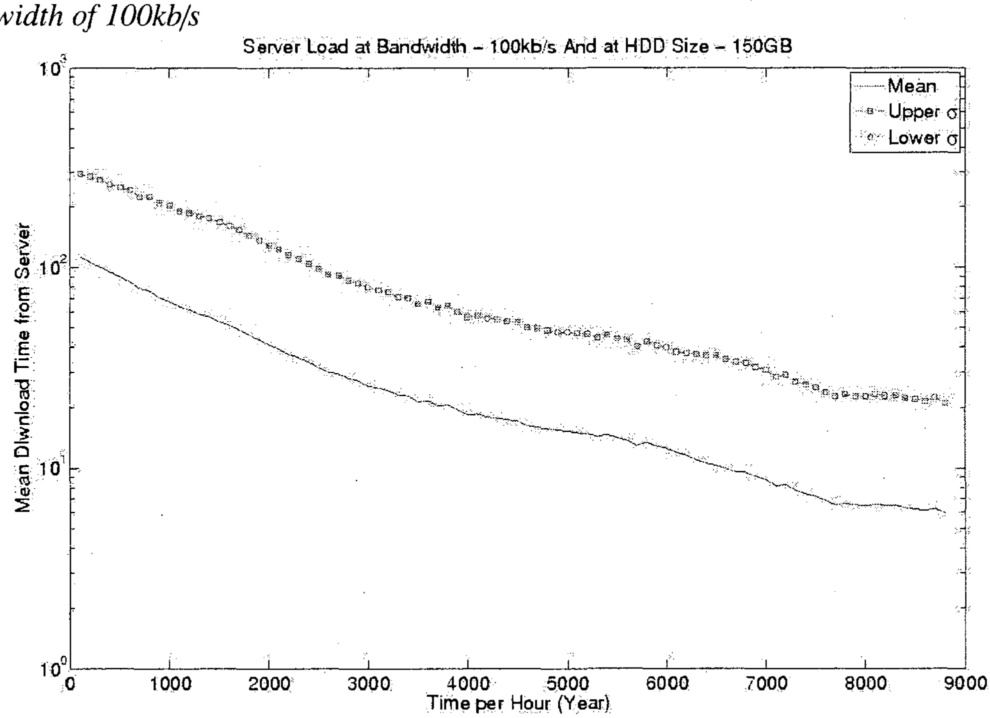


Figure 236: Server Load for H4 case scenario at hard drive size of 200GB and download bandwidth of 100kb/s

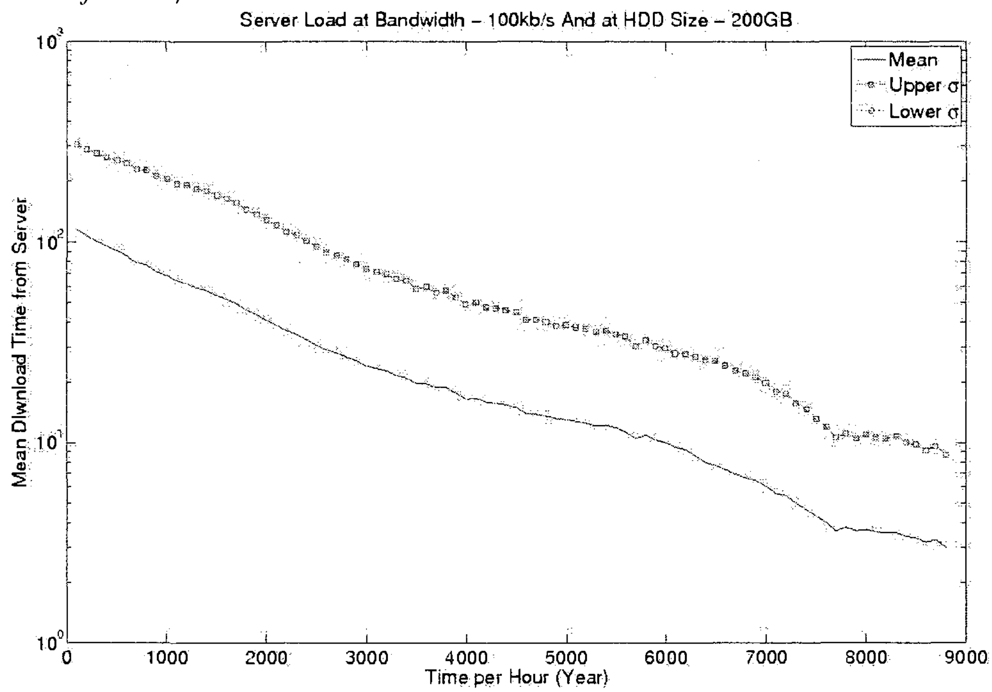


Figure 237: Server Load for H4 case scenario at hard drive size of 50GB and download bandwidth of 128kb/s

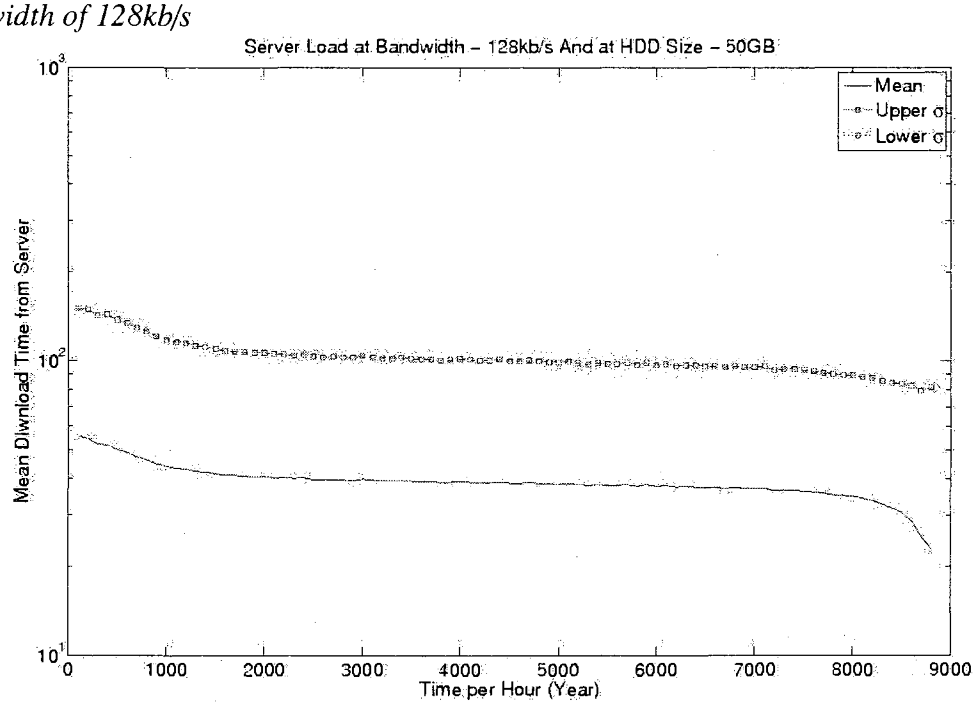


Figure 238: Server Load for H4 case scenario at hard drive size of 100GB and download bandwidth of 128kb/s

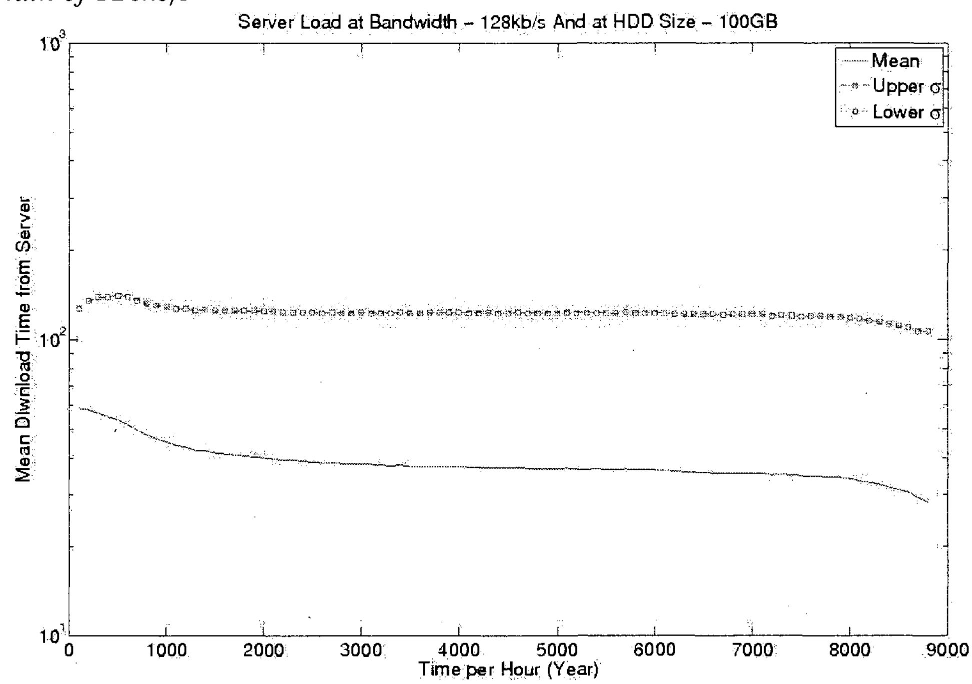


Figure 239: Server Load for H4 case scenario at hard drive size of 150GB and download bandwidth of 128kb/s

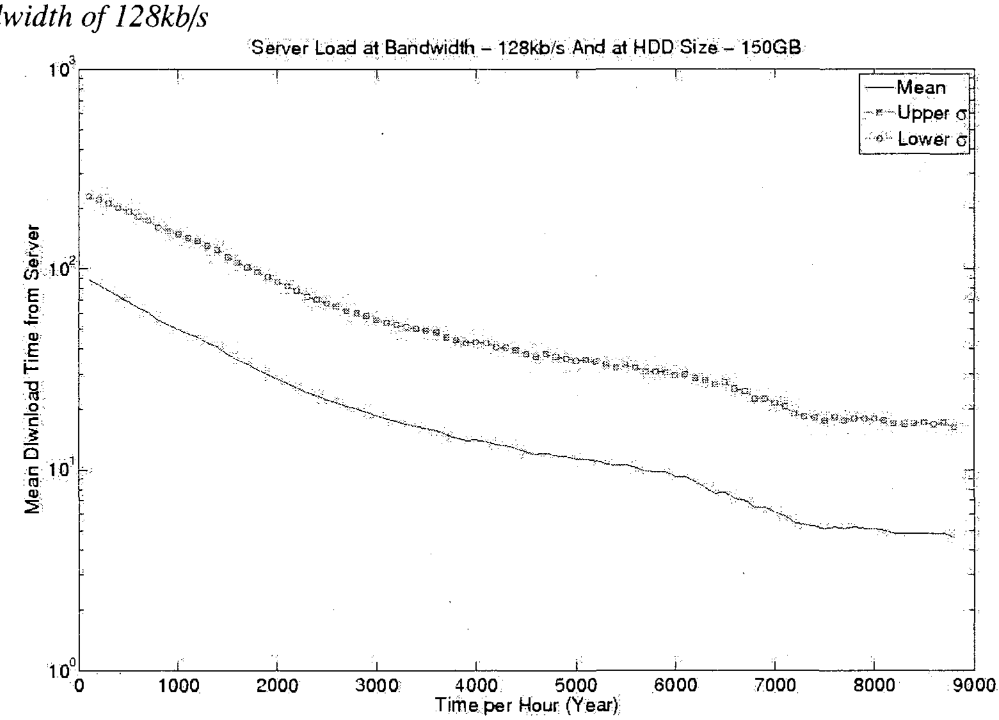


Figure 240: Server Load for H4 case scenario at hard drive size of 200GB and download bandwidth of 128kb/s

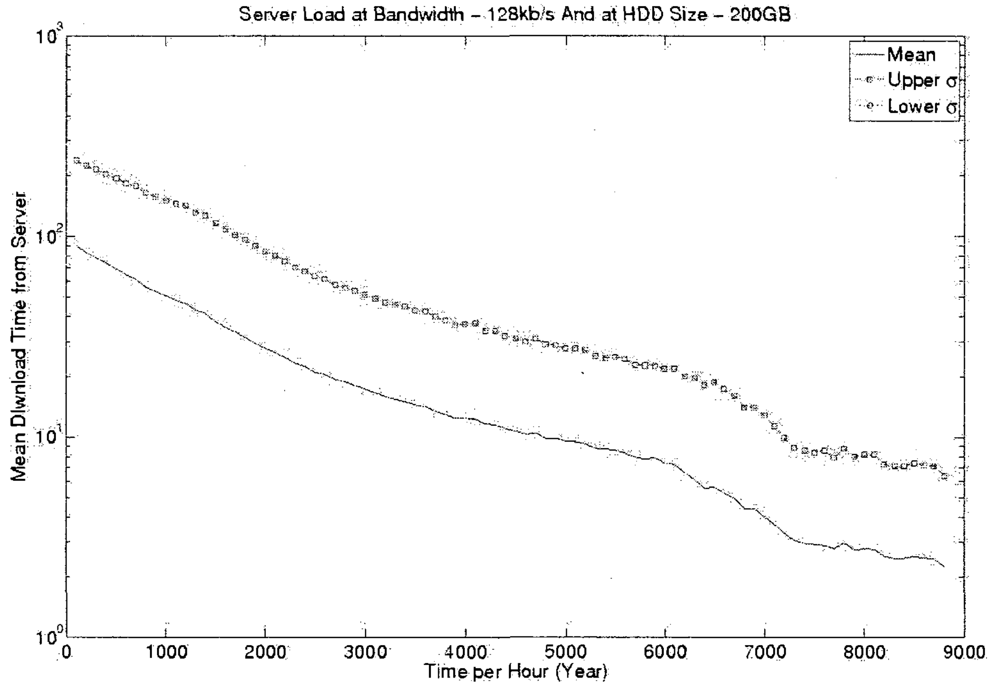


Figure 241: Server Load for H4 case scenario at hard drive size of 50GB and download bandwidth of 256kb/s

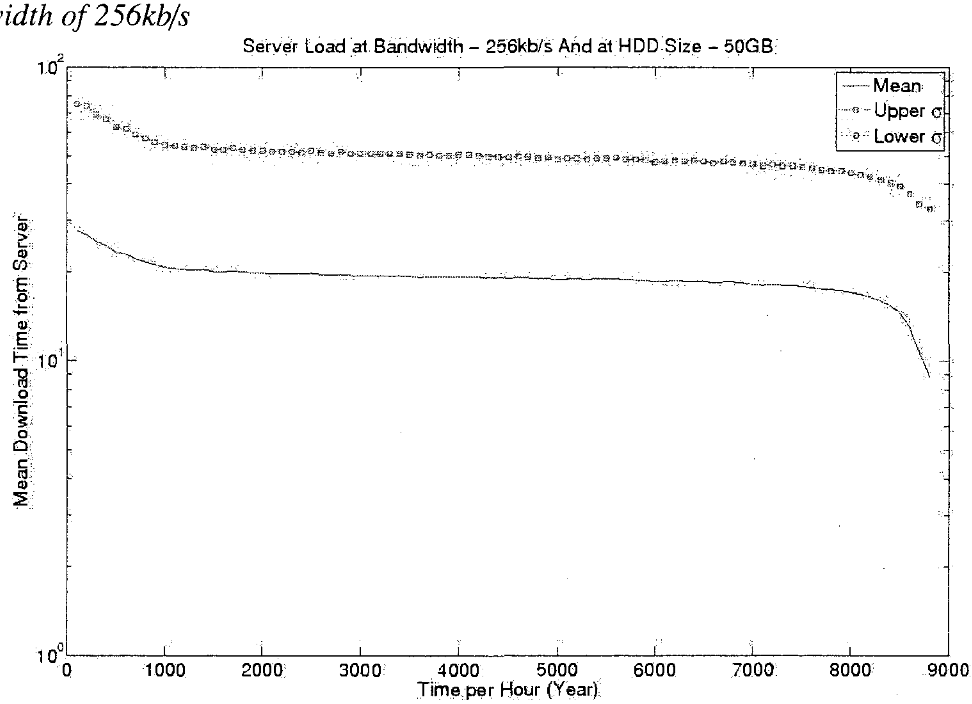


Figure 242: Server Load for H4 case scenario at hard drive size of 100GB and download bandwidth of 256kb/s

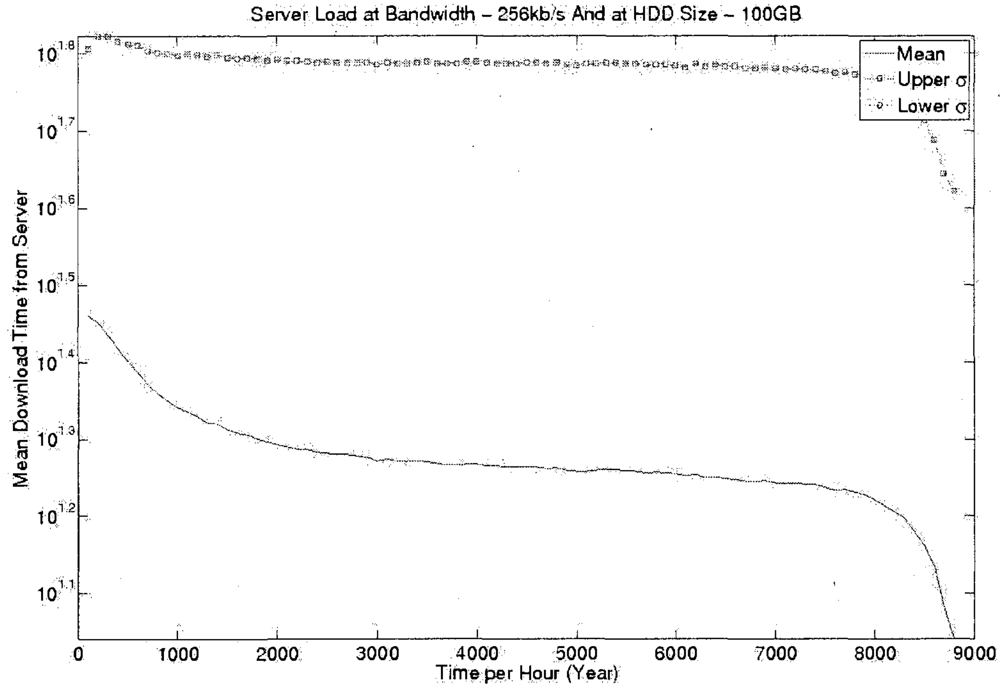


Figure 243: Server Load for H4 case scenario at hard drive size of 150GB and download bandwidth of 256kb/s

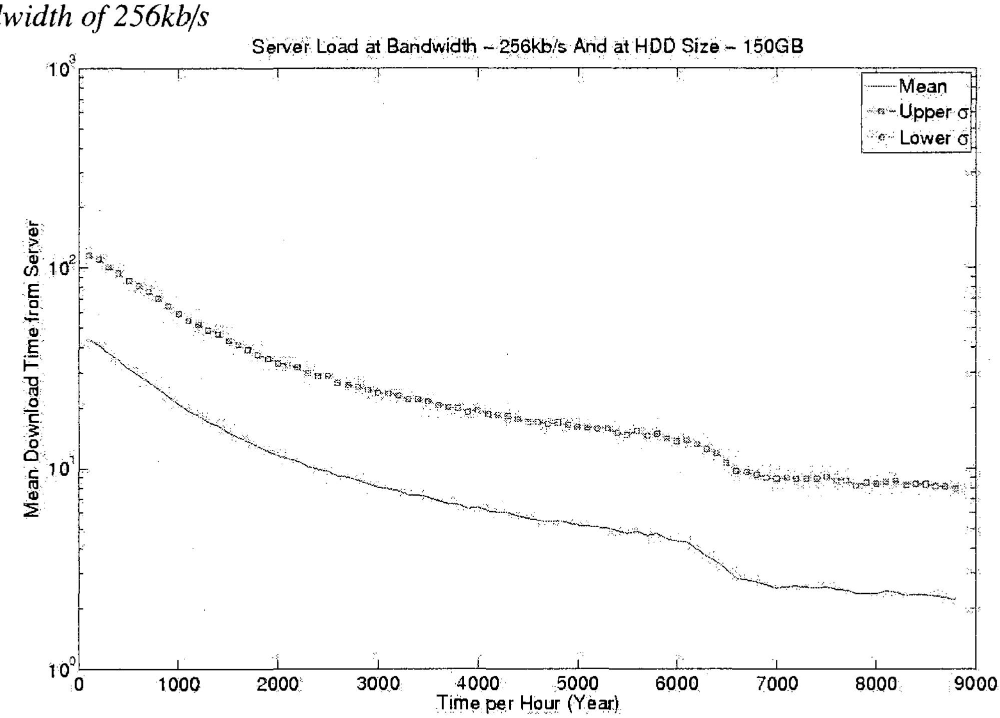


Figure 244: Server Load for H4 case scenario at hard drive size of 200GB and download bandwidth of 256kb/s

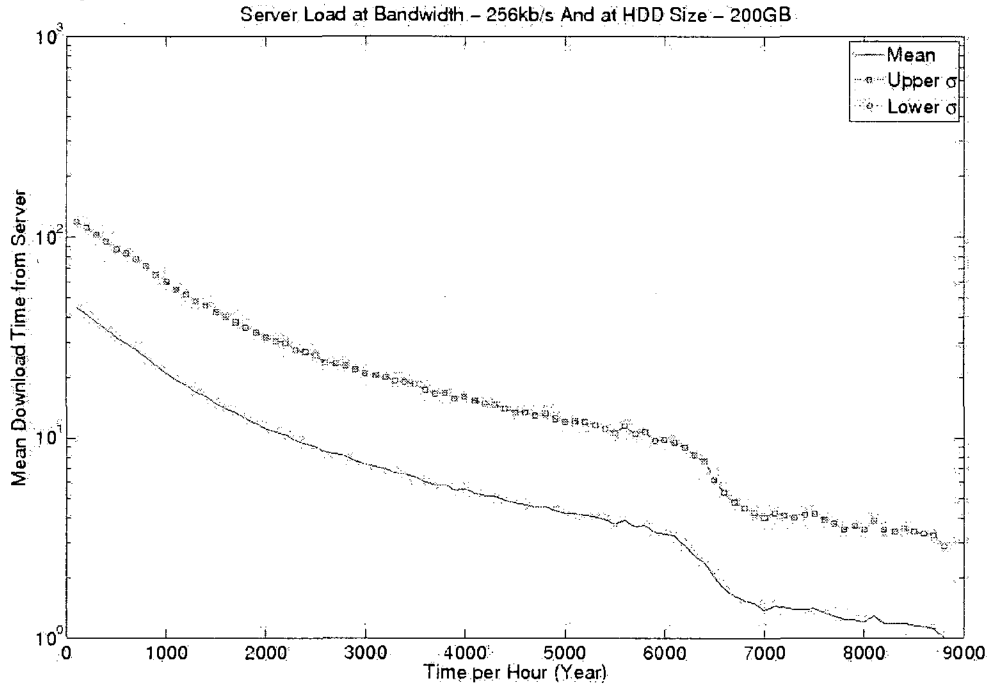


Figure 245: Server Load for H4 case scenario at hard drive size of 50GB and download bandwidth of 512kb/s

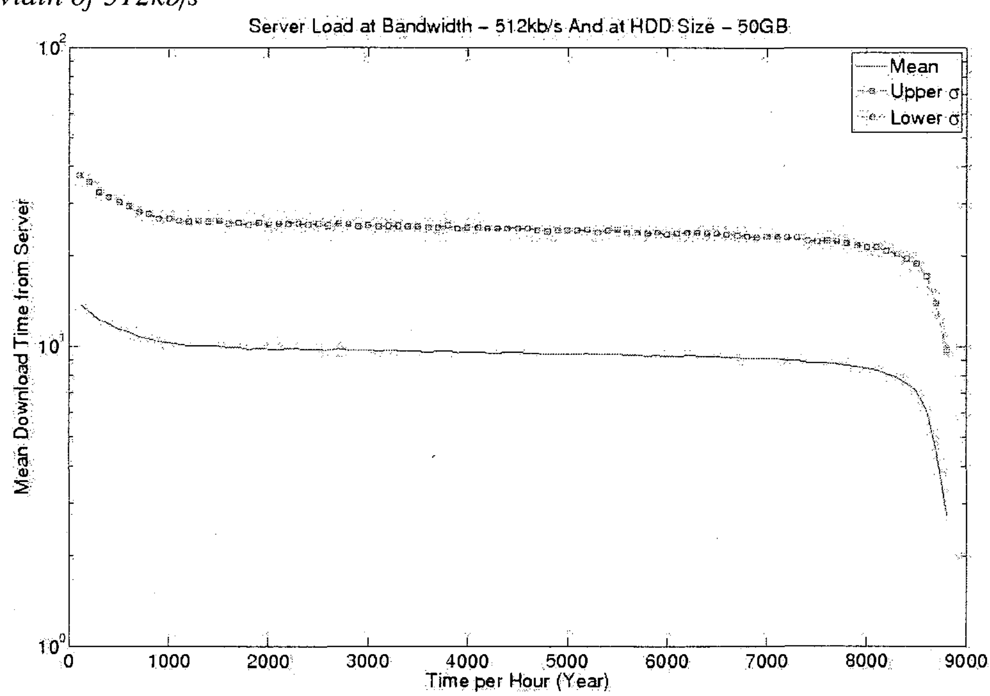


Figure 246: Server Load for H4 case scenario at hard drive size of 100GB and download bandwidth of 512kb/s

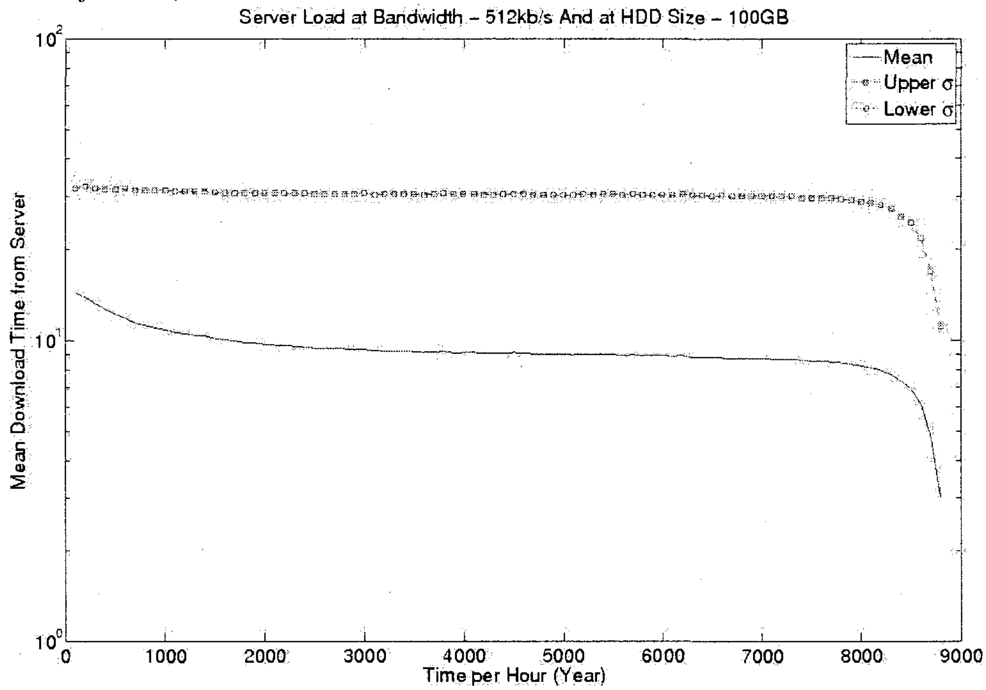


Figure 247: Server Load for H4 case scenario at hard drive size of 150GB and download bandwidth of 512kb/s

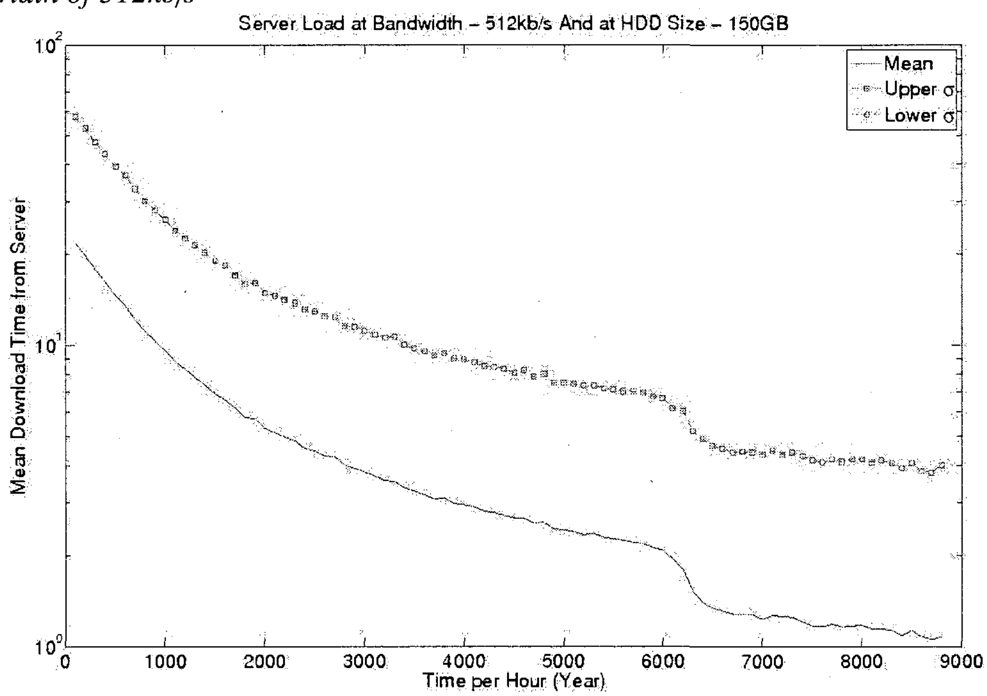


Figure 248: Server Load for H4 case scenario at hard drive size of 200GB and download bandwidth of 512kb/s

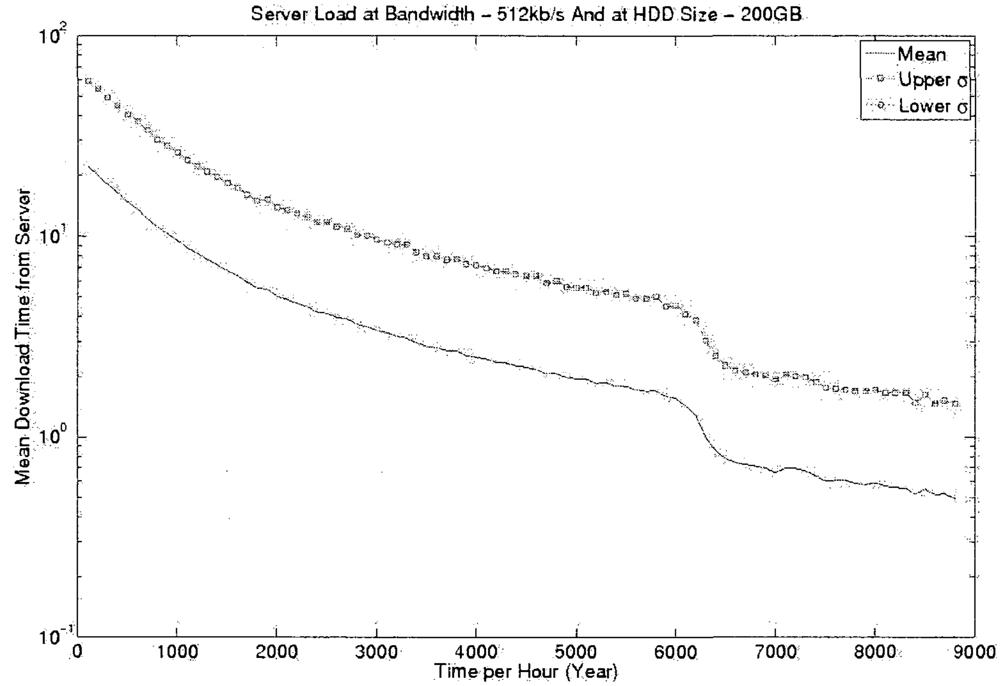


Figure 249: Server Load for H4 case scenario at hard drive size of 50GB and download bandwidth of 1000kb/s

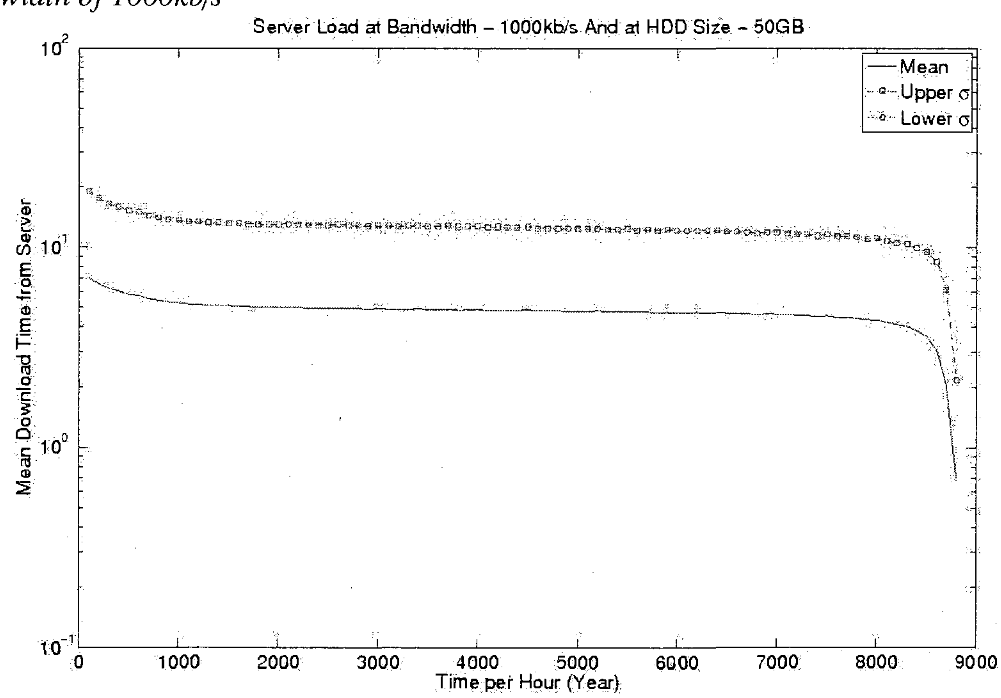


Figure 250: Server Load for H4 case scenario at hard drive size of 100GB and download bandwidth of 1000kb/s

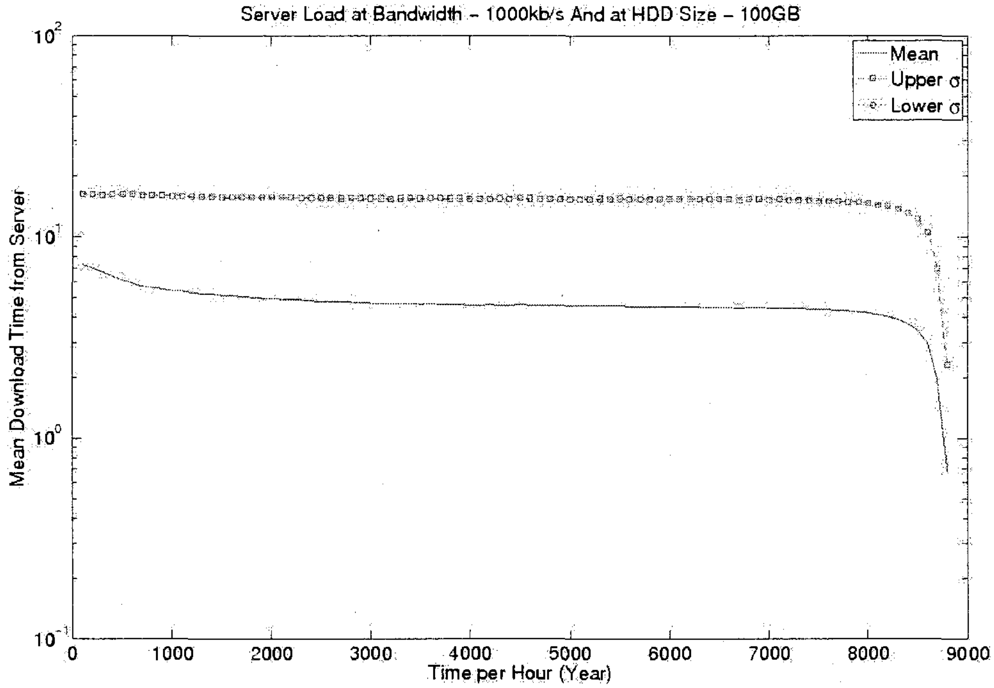


Figure 251: Server Load for H4 case scenario at hard drive size of 150GB and download bandwidth of 1000kb/s

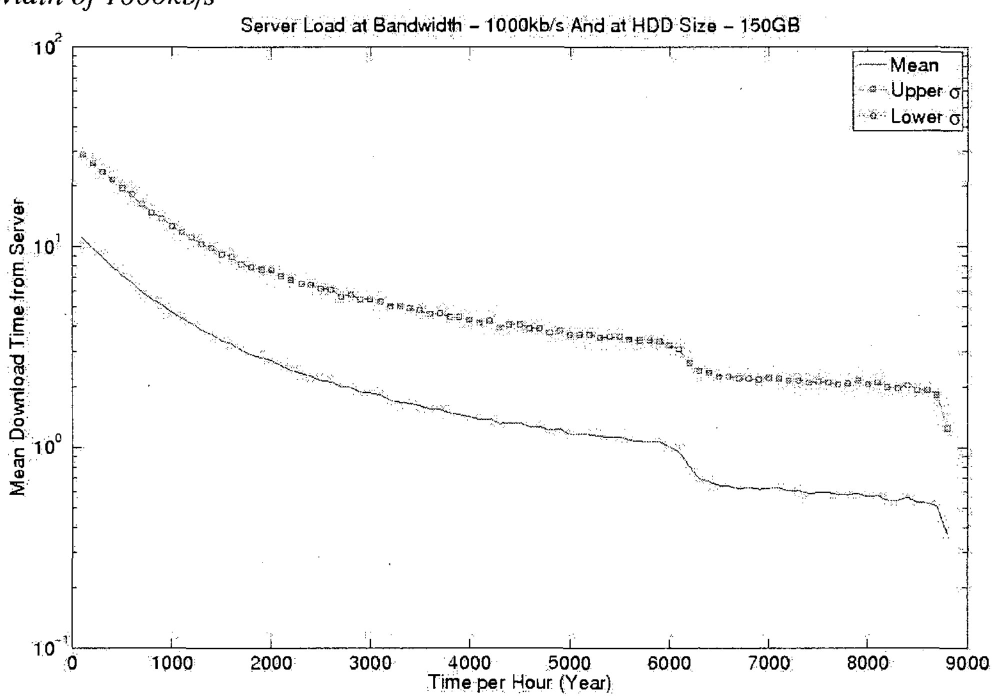


Figure 252: Server Load for H4 case scenario at hard drive size of 200GB and download bandwidth of 1000kb/s

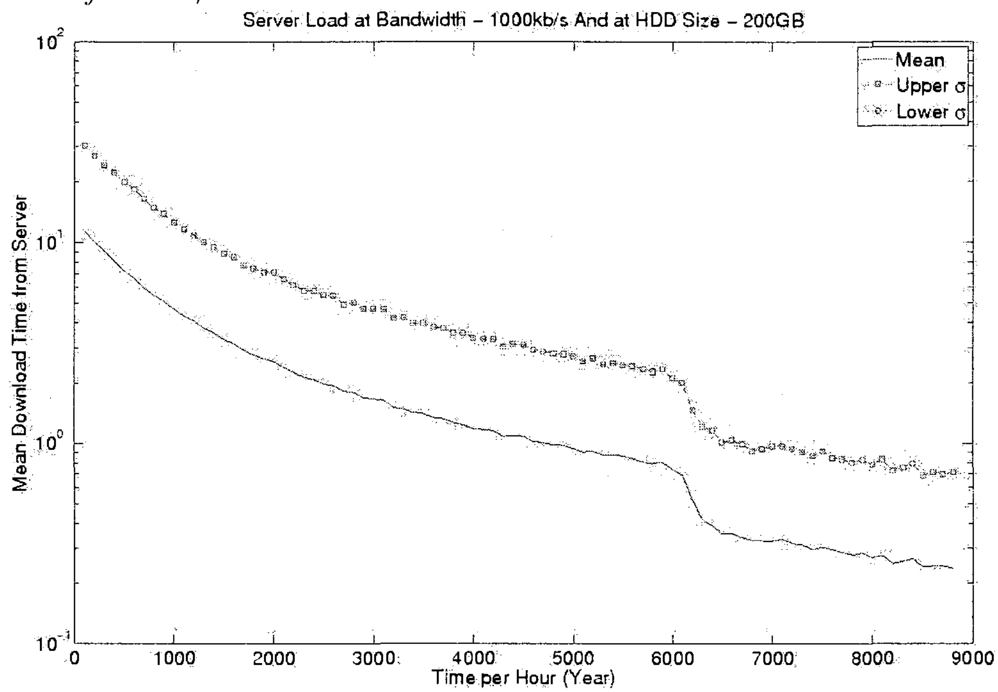


Figure 253: Server Load for H4 case scenario at hard drive size of 50GB and download bandwidth of 2000kb/s

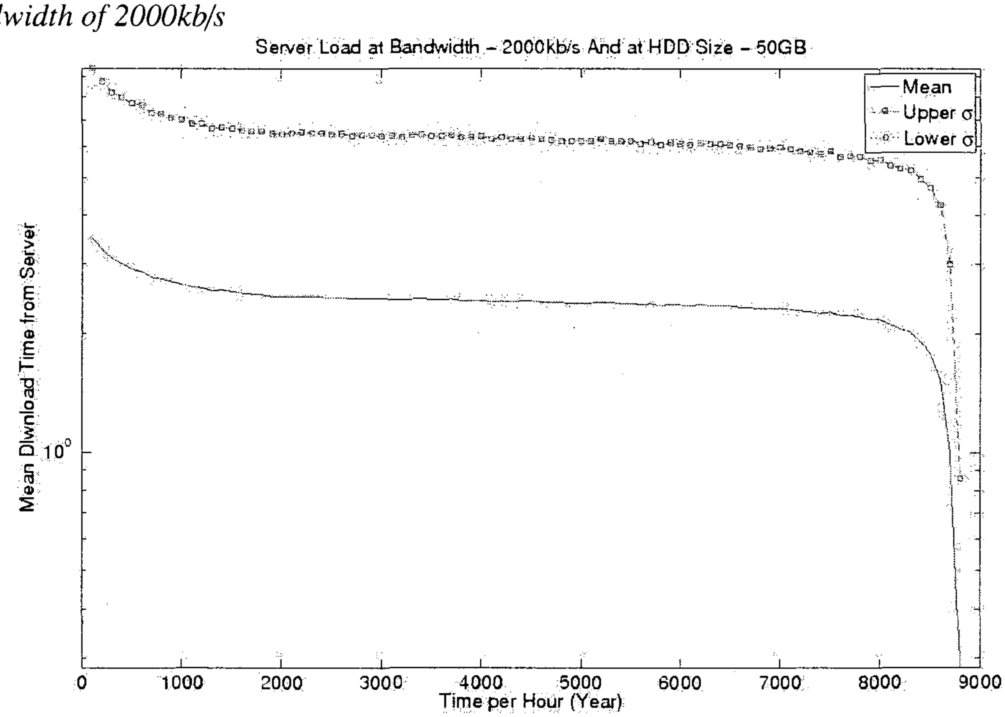


Figure 254: Server Load for H4 case scenario at hard drive size of 100GB and download bandwidth of 2000kb/s

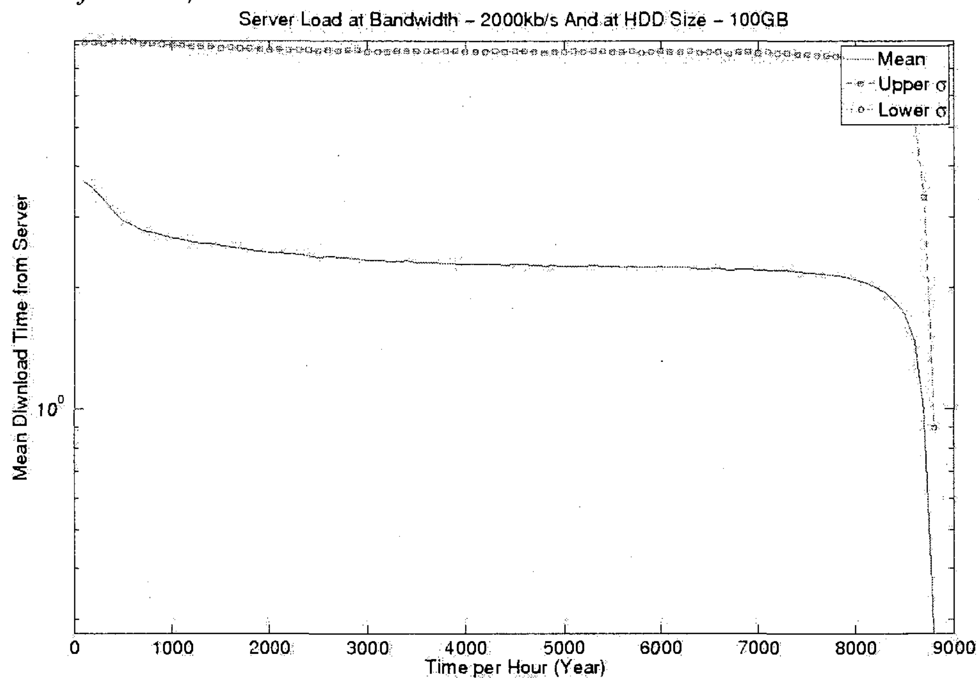


Figure 255: Server Load for H4 case scenario at hard drive size of 150GB and download bandwidth of 2000kb/s

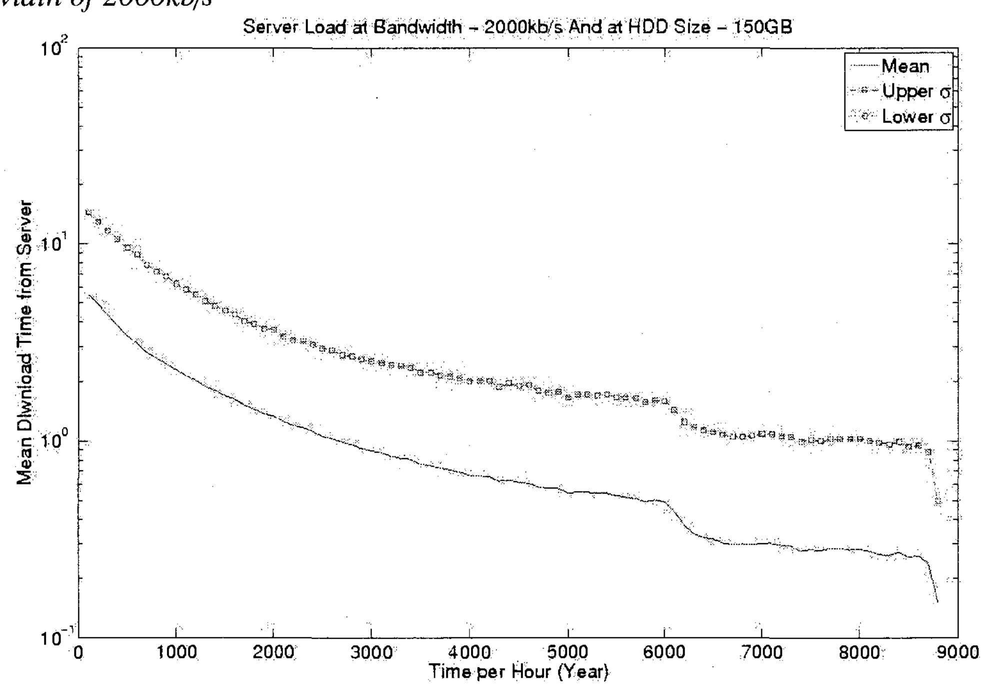


Figure 256: Server Load for H4 case scenario at hard drive size of 200GB and download bandwidth of 2000kb/s

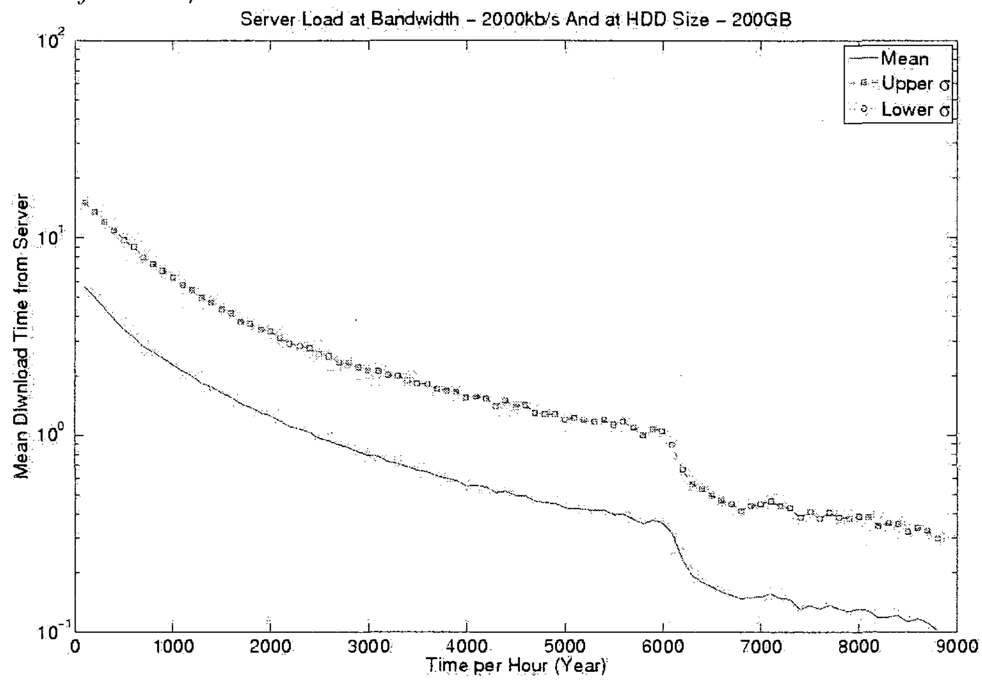


Figure 257: Server Load for H4 case scenario at hard drive size of 50GB and download bandwidth of 5000kb/s

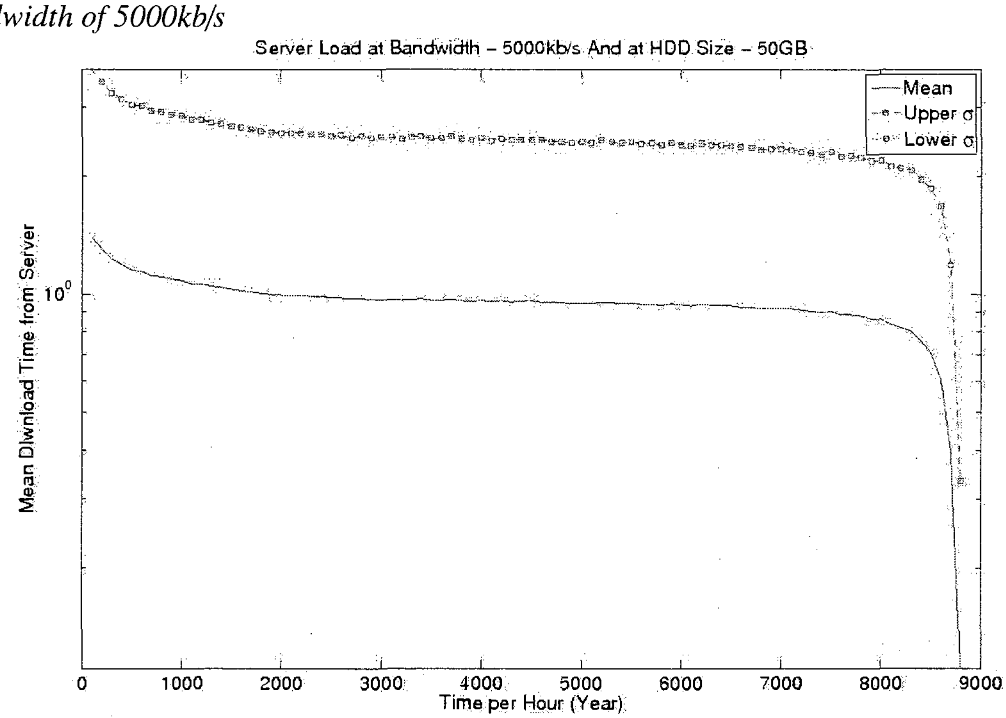


Figure 258: Server Load for H4 case scenario at hard drive size of 100GB and download bandwidth of 5000kb/s

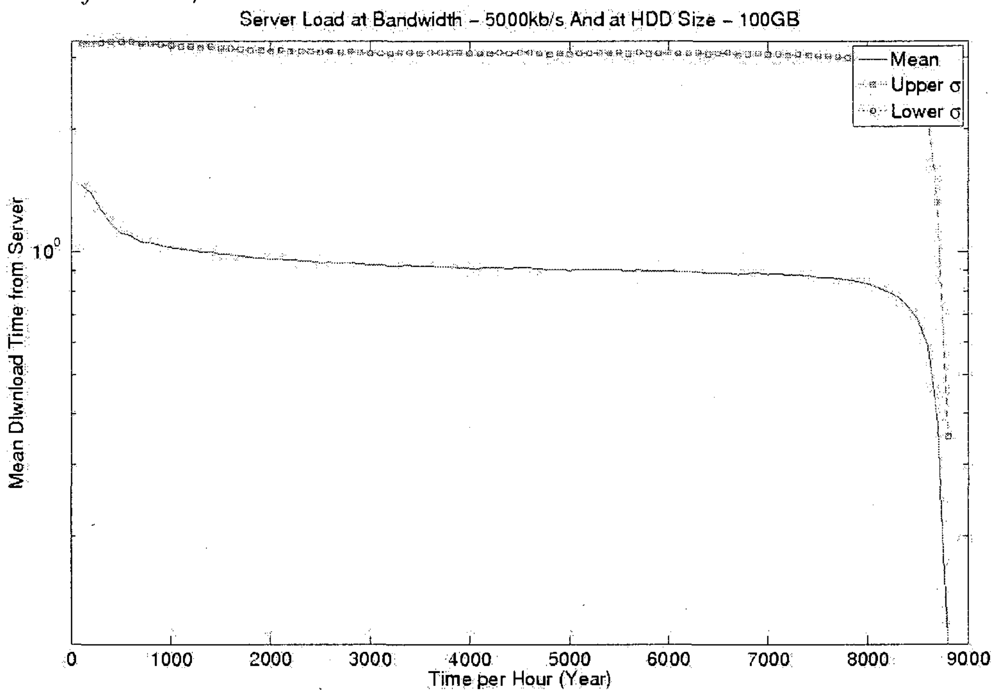


Figure 259: Server Load for H4 case scenario at hard drive size of 150GB and download bandwidth of 5000kb/s

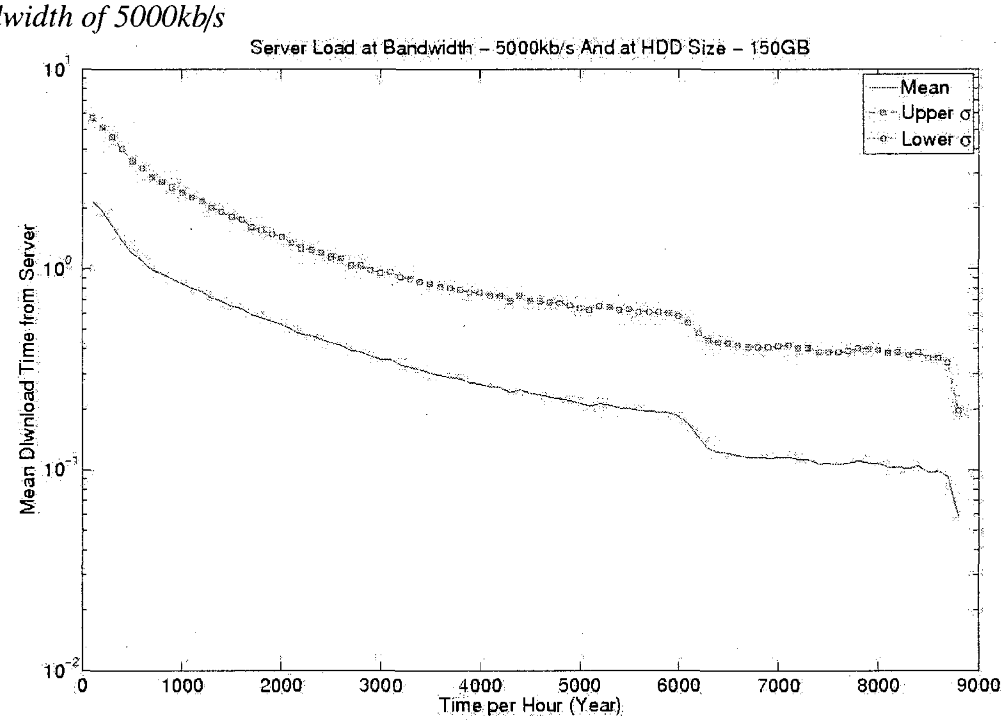


Figure 260: Server Load for H4 case scenario at hard drive size of 200GB and download bandwidth of 5000kb/s

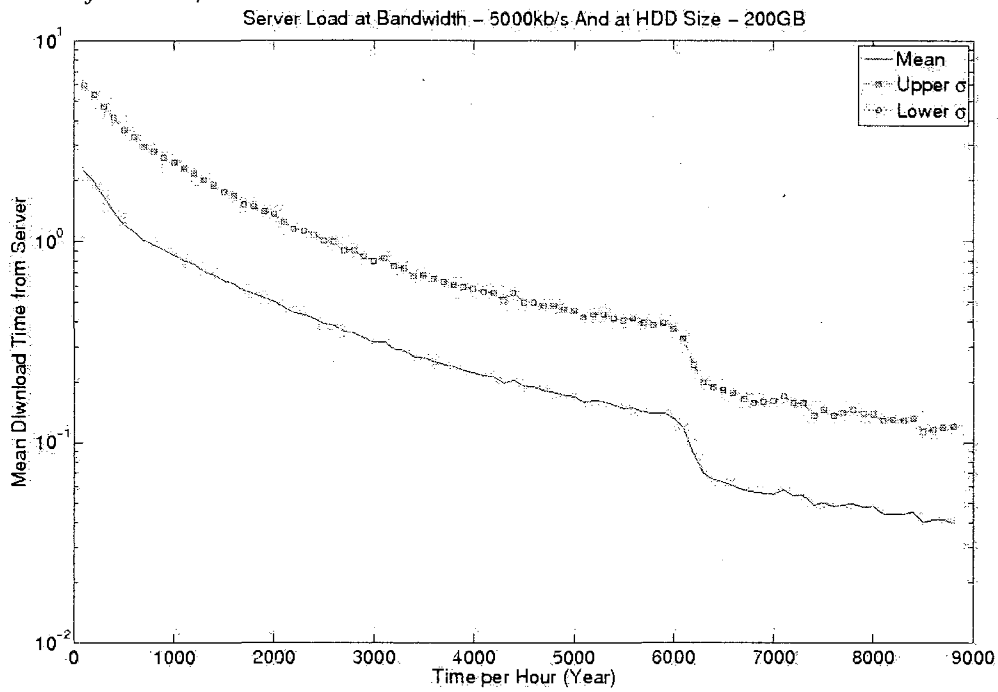


Figure 261: Server Load for H4 case scenario at hard drive size of 50GB and download bandwidth of 10000kb/s

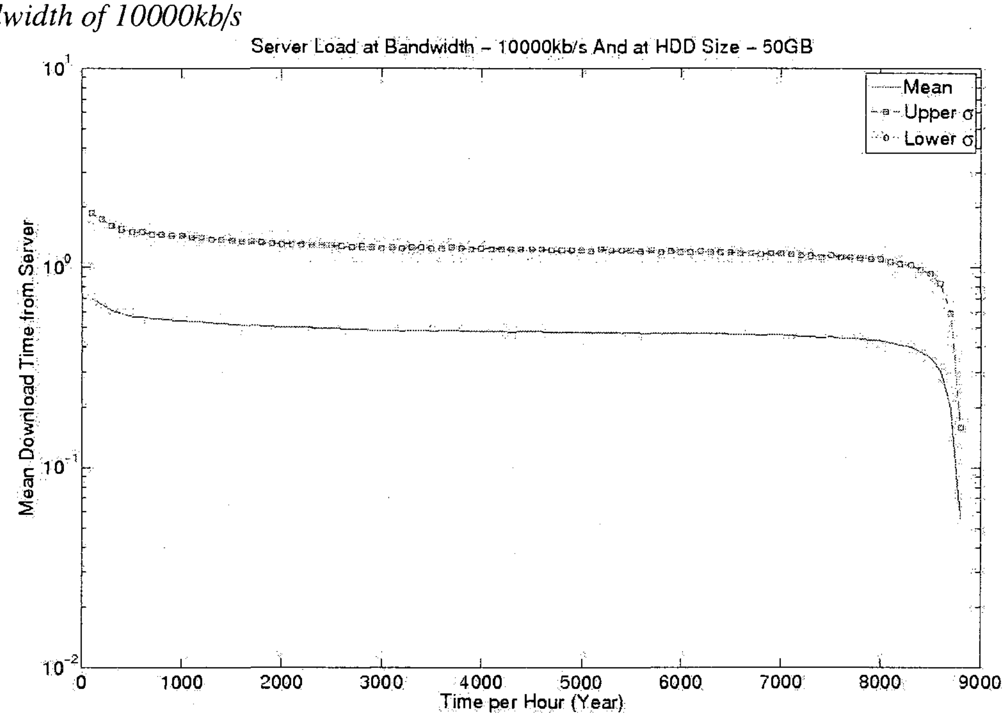


Figure 262: Server Load for H4 case scenario at hard drive size of 100GB and download bandwidth of 10000kb/s

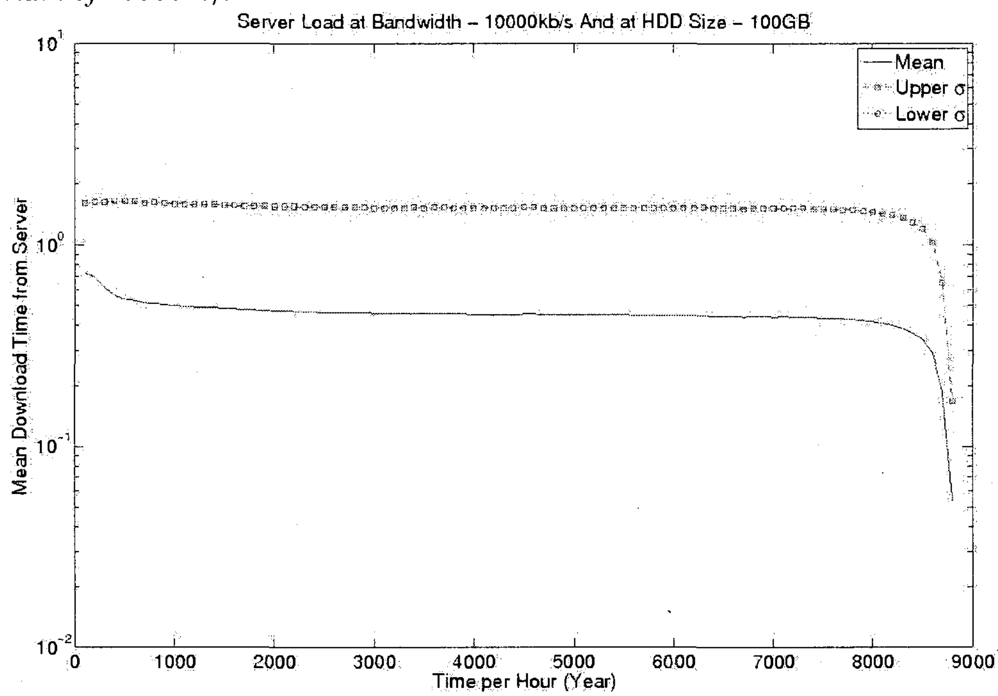


Figure 263: Server Load for H4 case scenario at hard drive size of 150GB and download bandwidth of 10000kb/s

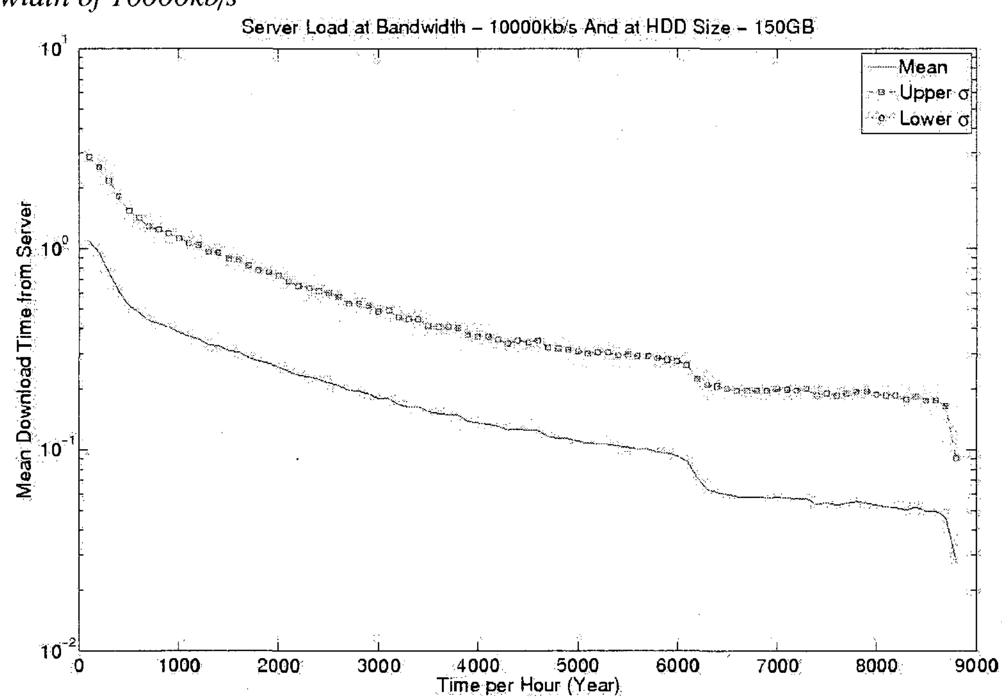


Figure 264: Server Load for H4 case scenario at hard drive size of 200GB and download bandwidth of 10000kb/s

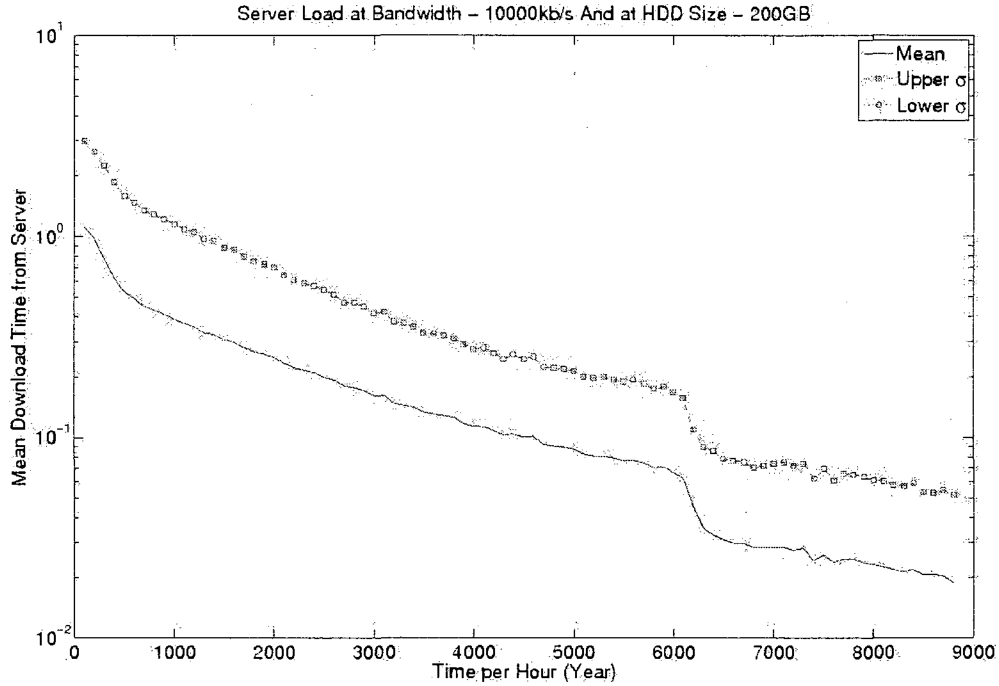


Figure 265: Server Load for H4 case scenario at hard drive size of 50GB and download bandwidth of 15000kb/s

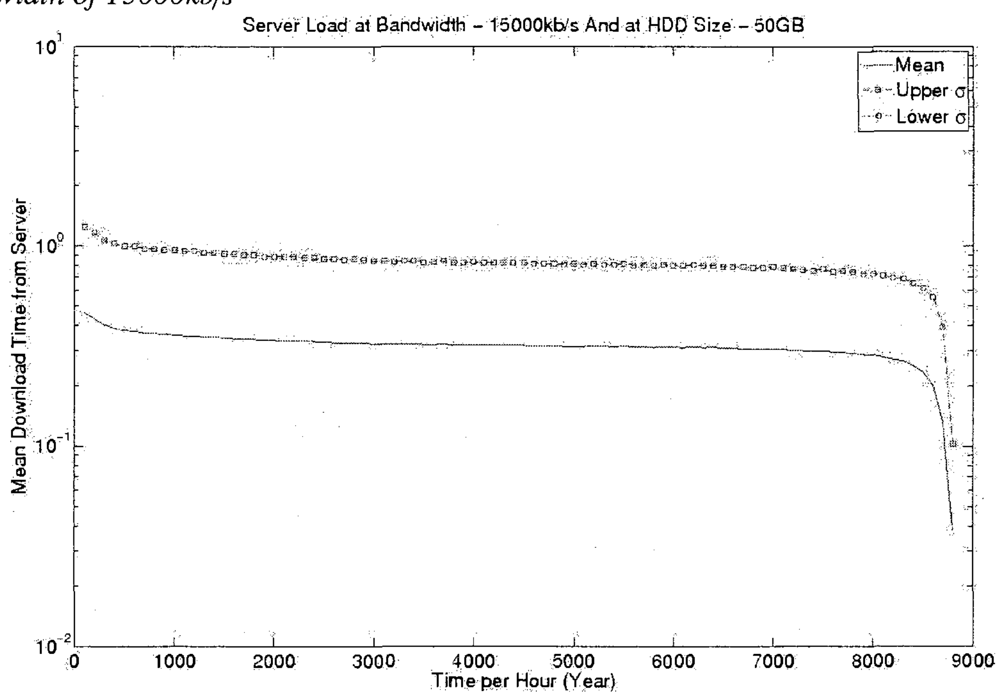


Figure 266: Server Load for H4 case scenario at hard drive size of 100GB and download bandwidth of 15000kb/s

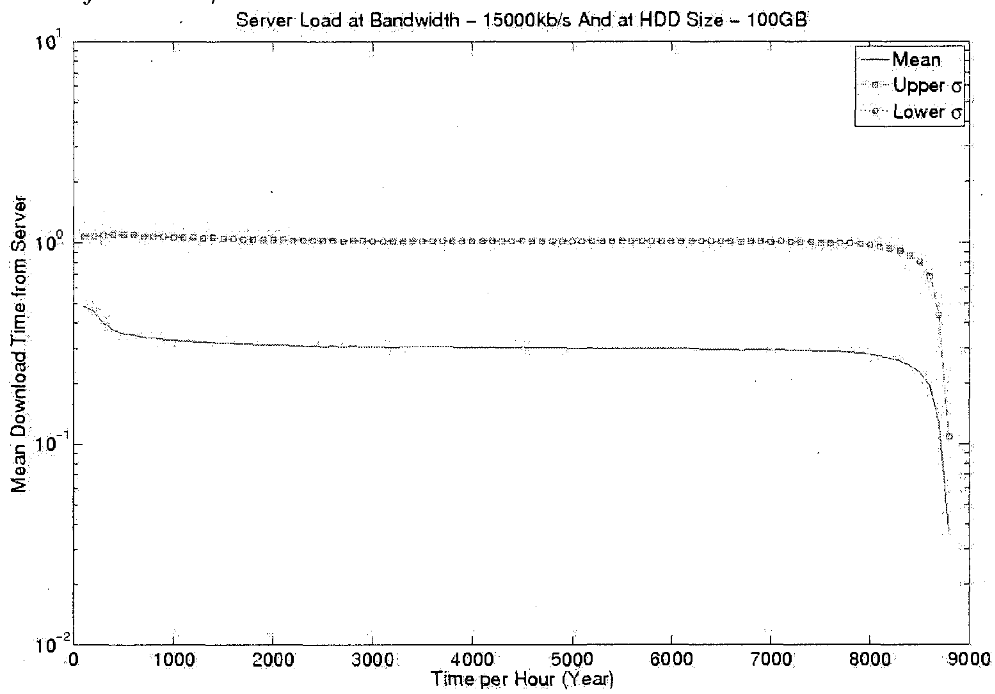


Figure 267: Server Load for H4 case scenario at hard drive size of 150GB and download bandwidth of 15000kb/s

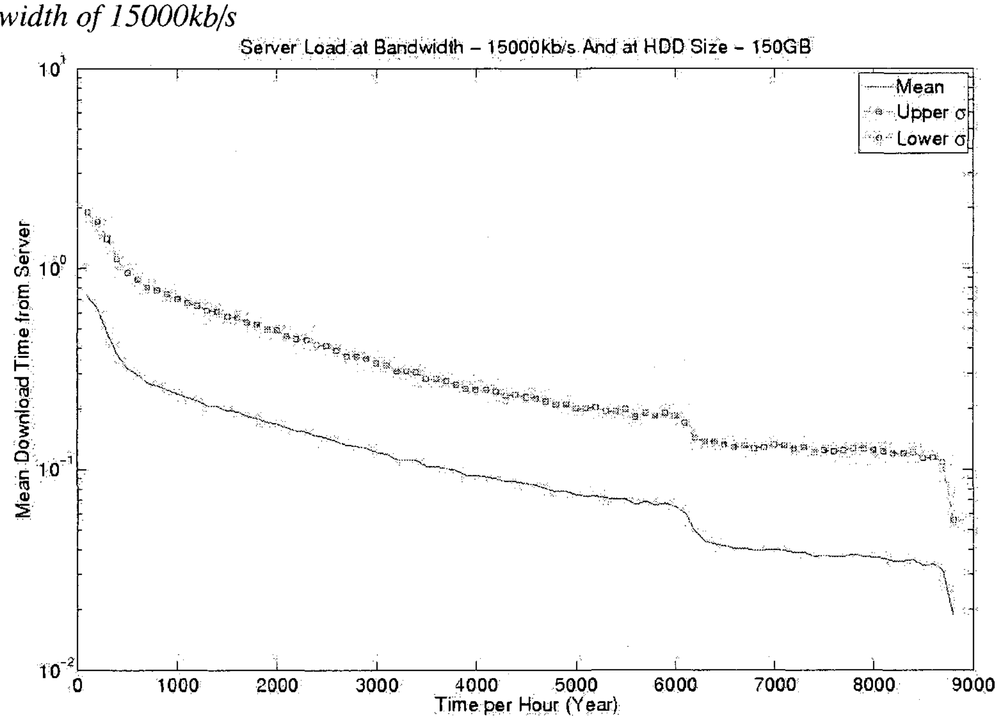


Figure 268: Server Load for H4 case scenario at hard drive size of 200GB and download bandwidth of 15000kb/s

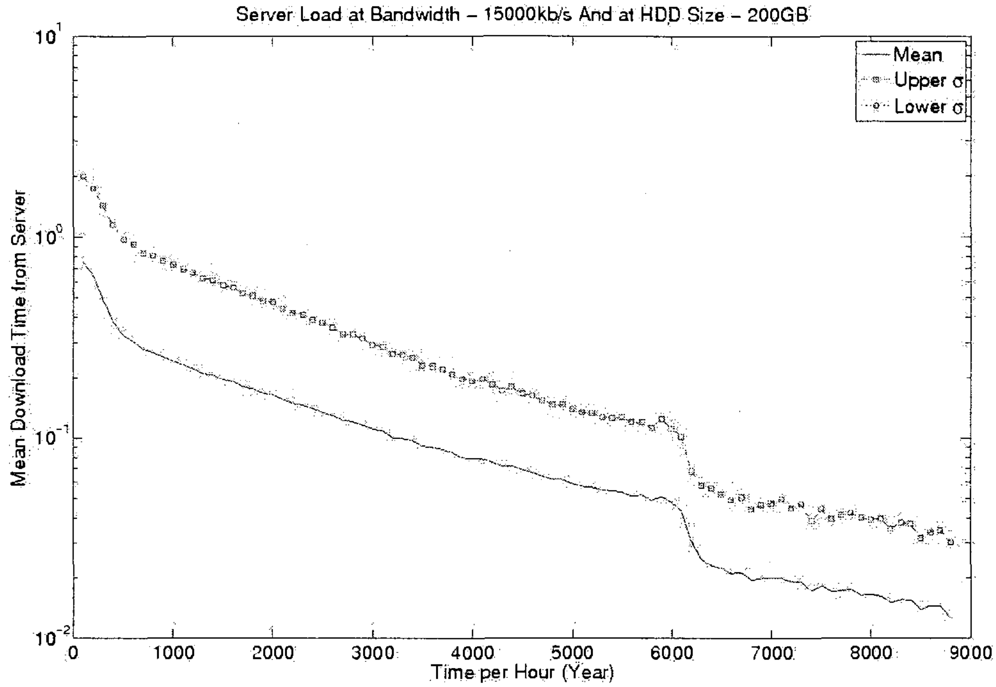


Figure 269: Penalty for H1 case scenario at hard drive size of 50GB and download bandwidth of 25kb/s

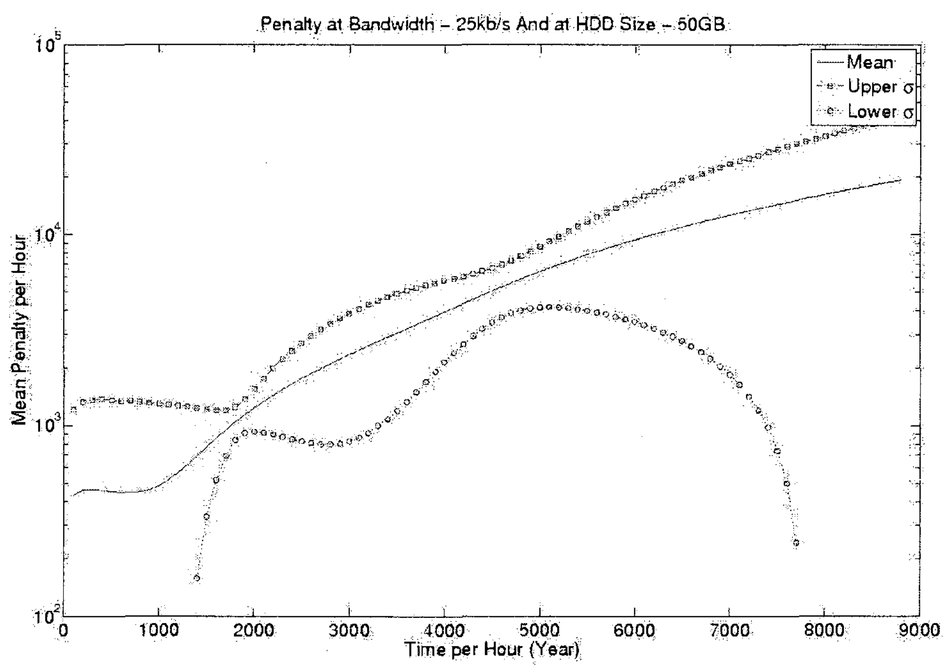


Figure 270: Penalty for H1 case scenario at hard drive size of 100GB and download bandwidth of 25kb/s

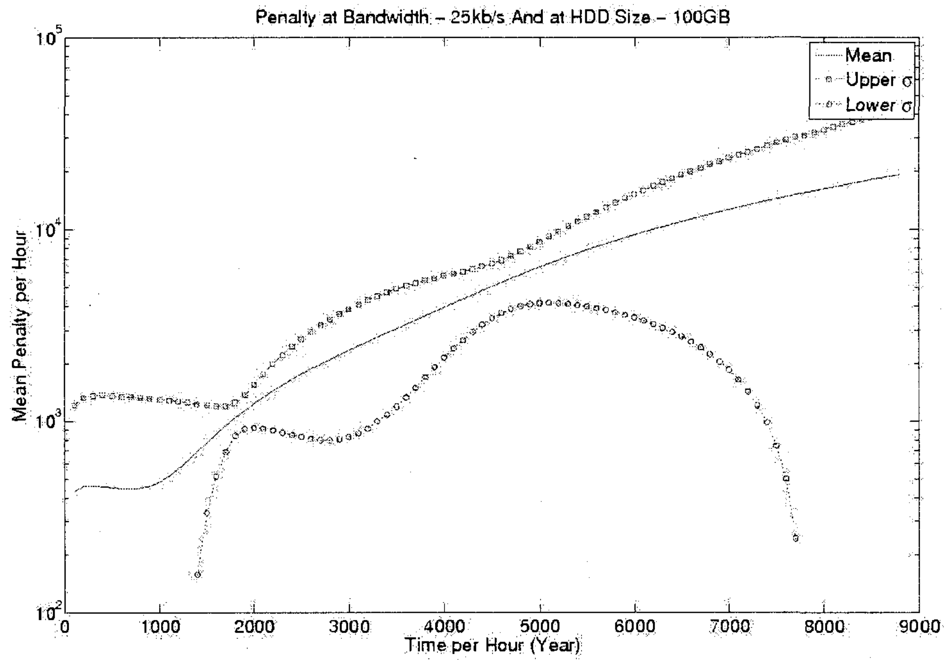


Figure 271: Penalty for H1 case scenario at hard drive size of 150GB and download bandwidth of 25kb/s

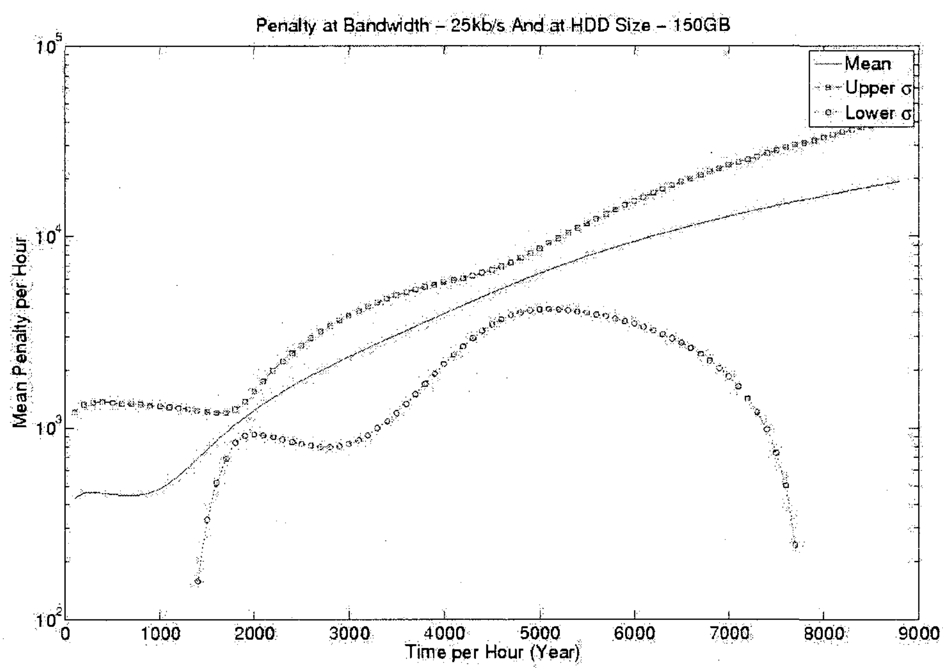


Figure 272: Penalty for H1 case scenario at hard drive size of 200GB and download bandwidth of 25kb/s

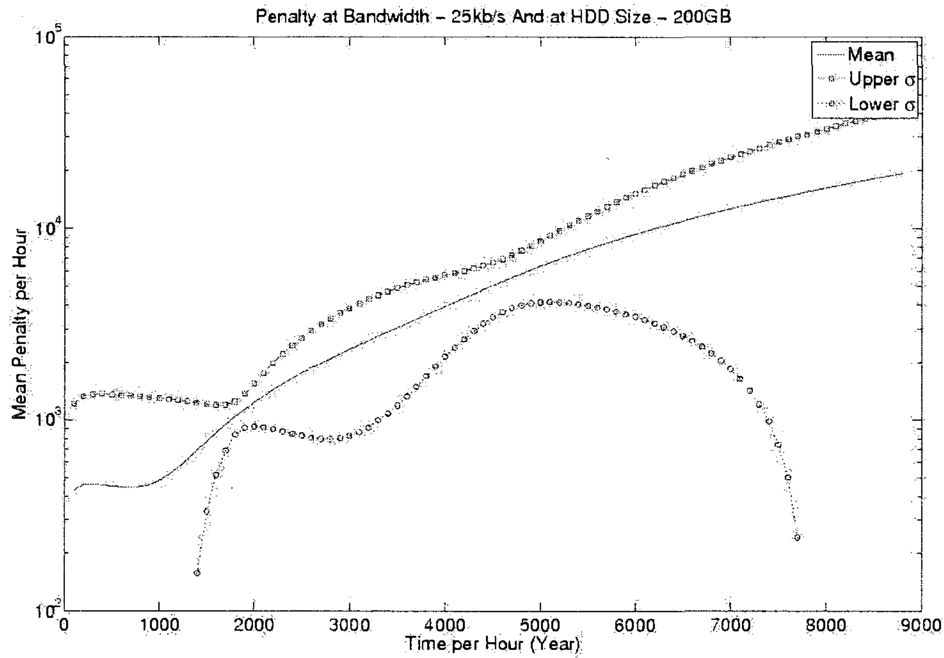


Figure 273: Penalty for H1 case scenario at hard drive size of 50GB and download bandwidth of 50kb/s

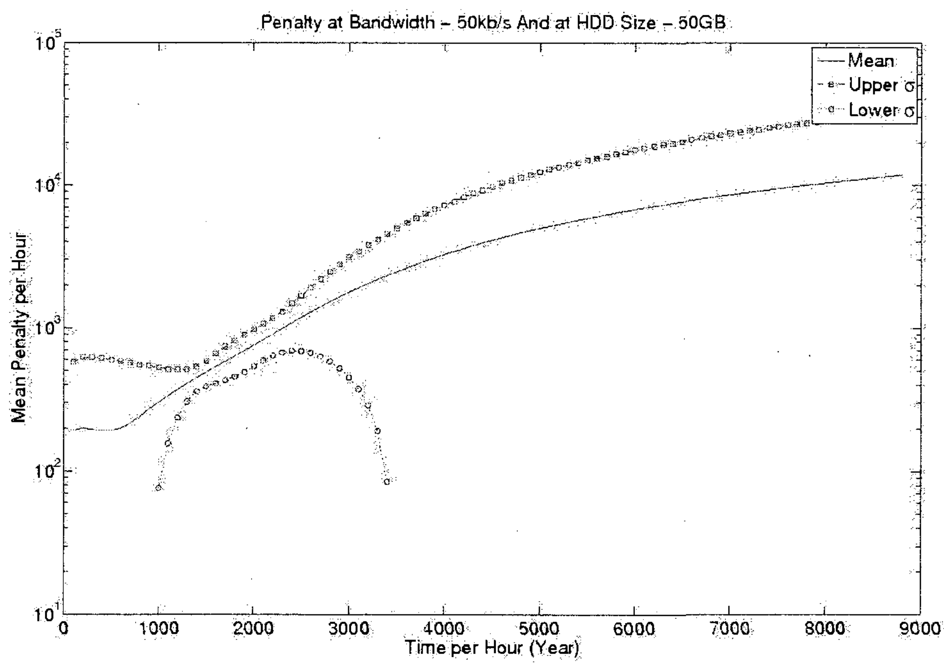


Figure 274: Penalty for H1 case scenario at hard drive size of 100GB and download bandwidth of 50kb/s

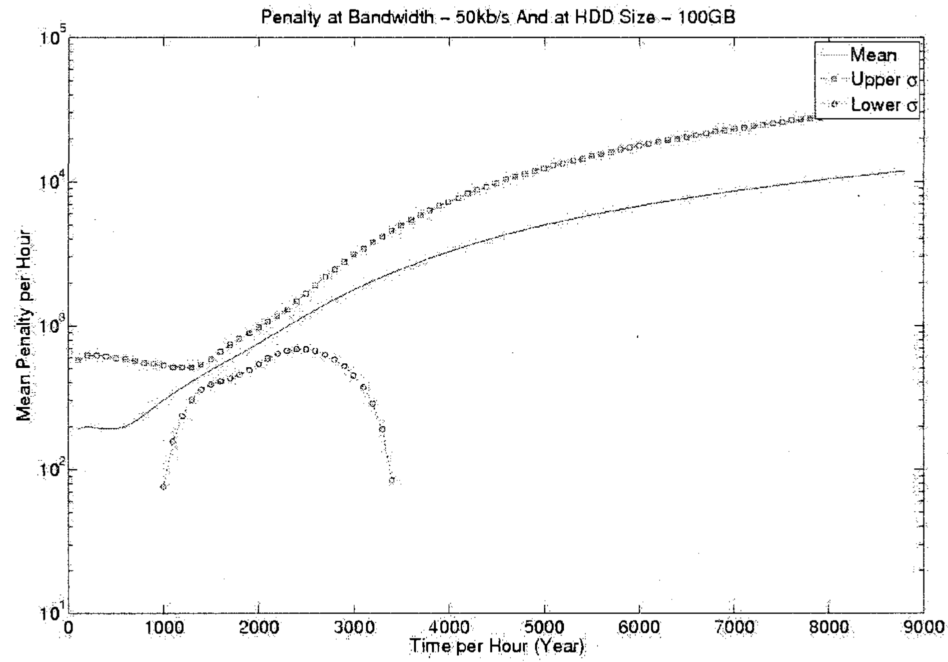


Figure 275: Penalty for H1 case scenario at hard drive size of 150GB and download bandwidth of 50kb/s

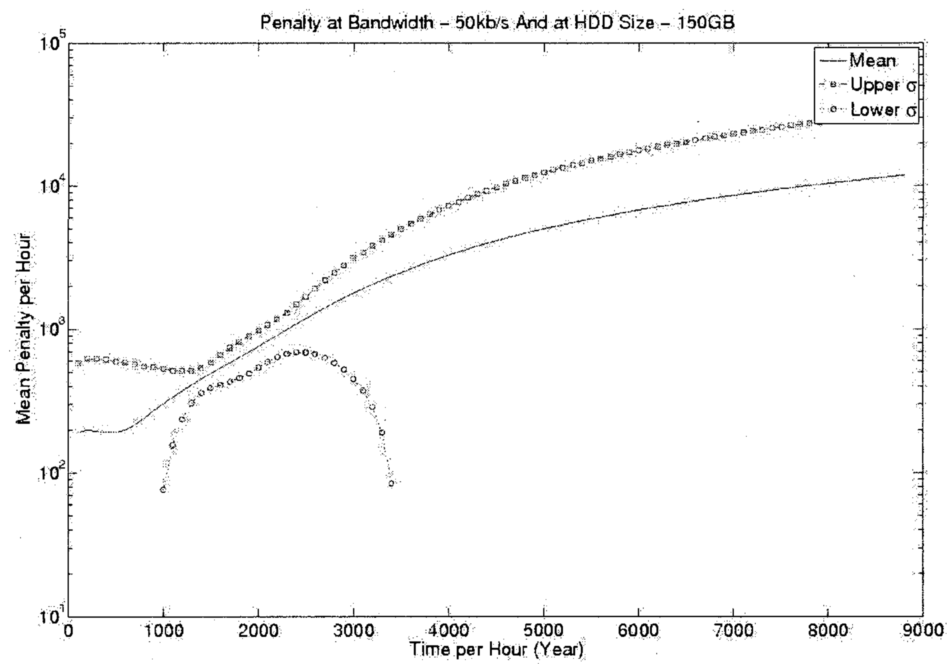


Figure 276: Penalty for H1 case scenario at hard drive size of 200GB and download bandwidth of 50kb/s

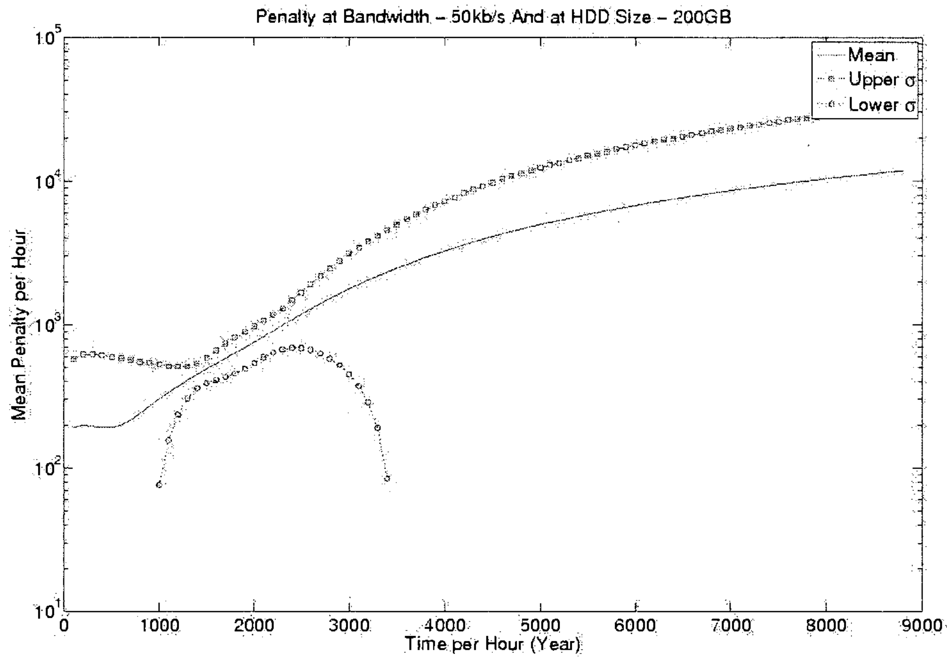


Figure 277: Penalty for H1 case scenario at hard drive size of 50GB and download bandwidth of 100kb/s

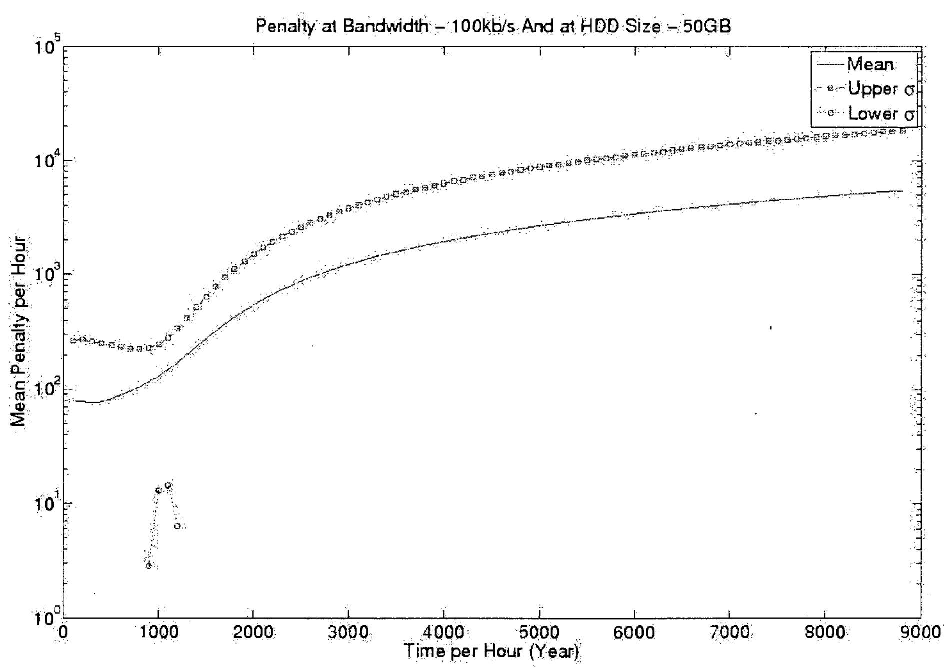


Figure 278: Penalty for H1 case scenario at hard drive size of 100GB and download bandwidth of 100kb/s

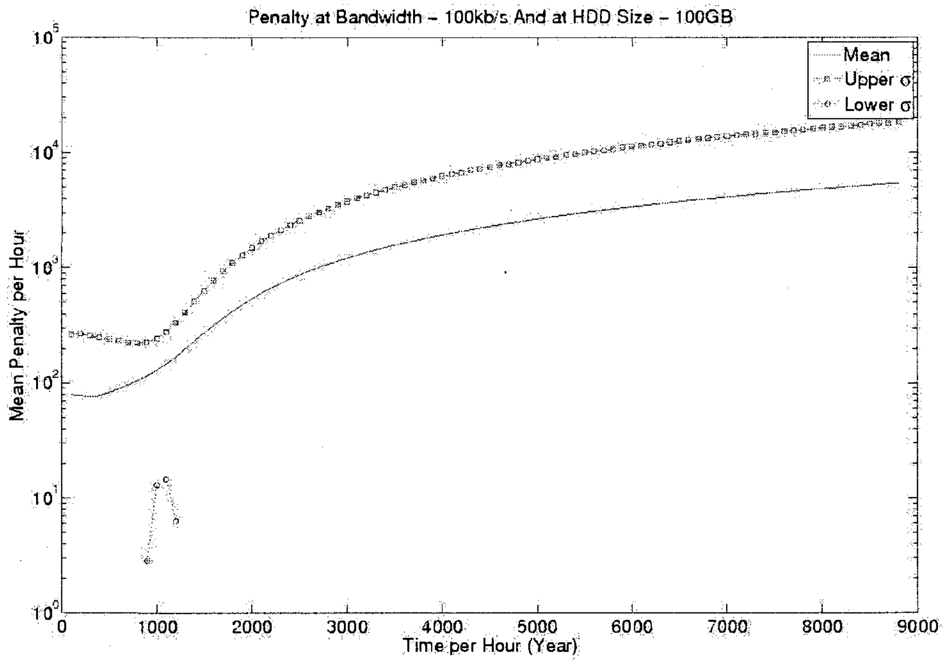


Figure 279: Penalty for H1 case scenario at hard drive size of 150GB and download bandwidth of 100kb/s

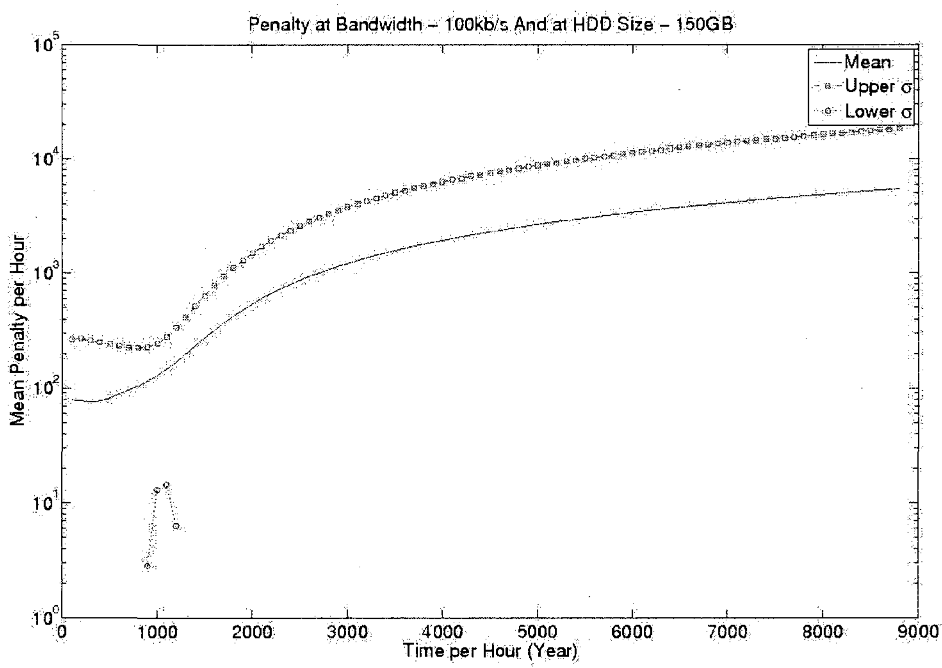


Figure 280: Penalty for H1 case scenario at hard drive size of 200GB and download bandwidth of 100kb/s

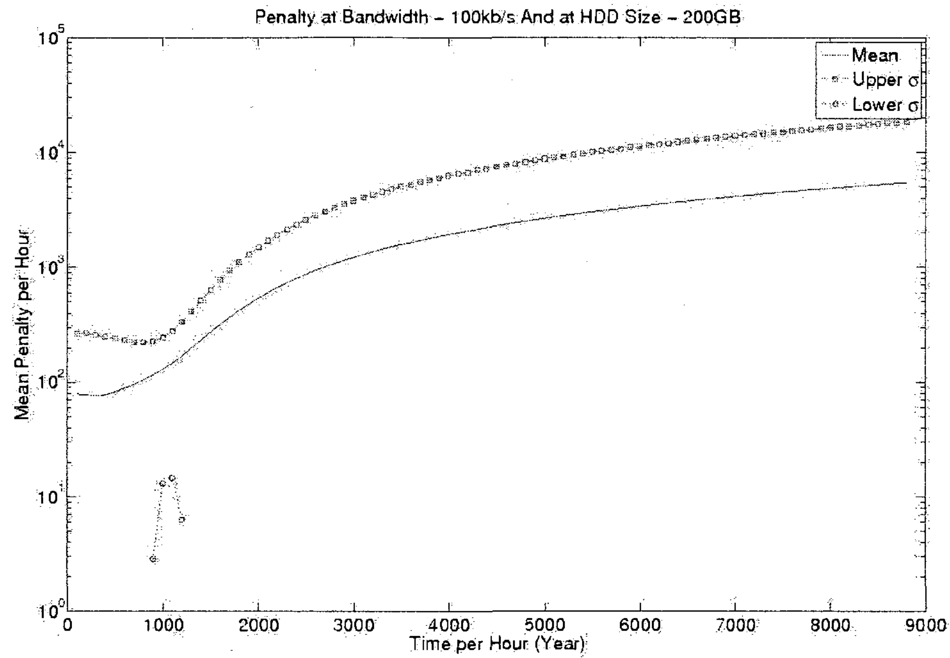


Figure 281: Penalty for H1 case scenario at hard drive size of 50GB and download bandwidth of 128kb/s

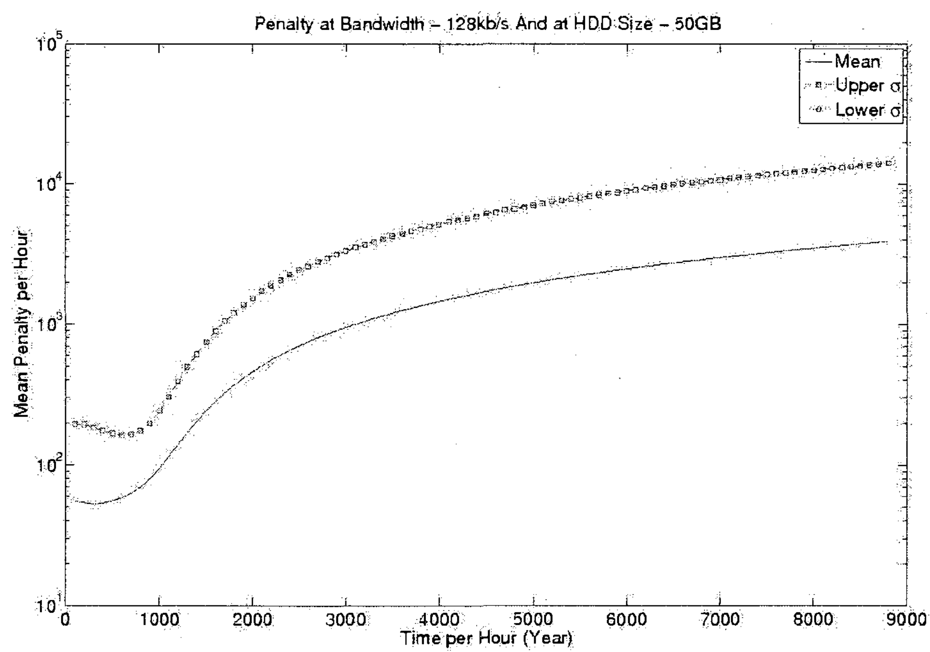


Figure 282: Penalty for H1 case scenario at hard drive size of 100GB and download bandwidth of 128kb/s

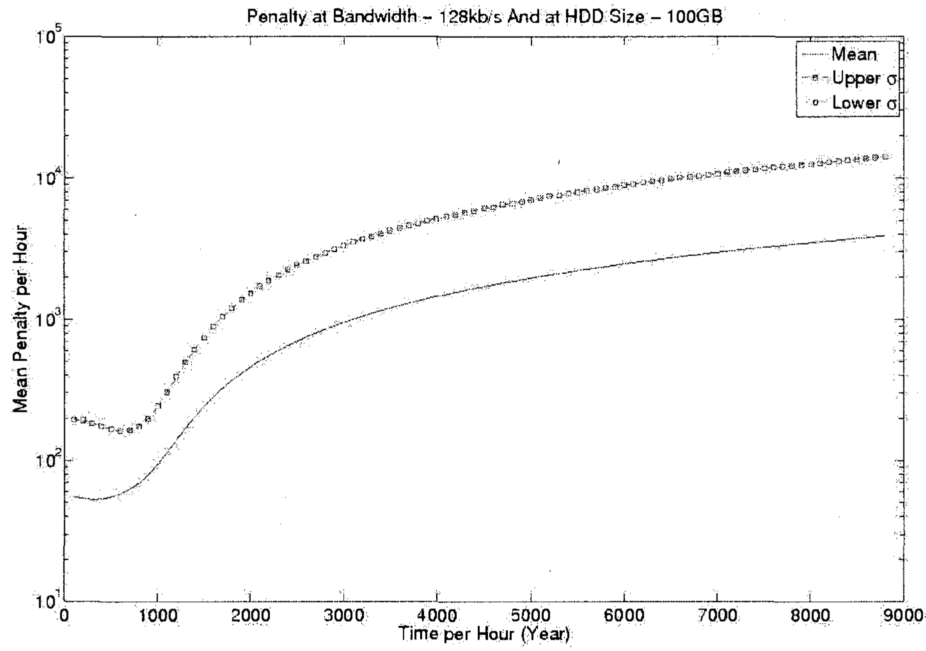


Figure 283: Penalty for H1 case scenario at hard drive size of 150GB and download bandwidth of 128kb/s

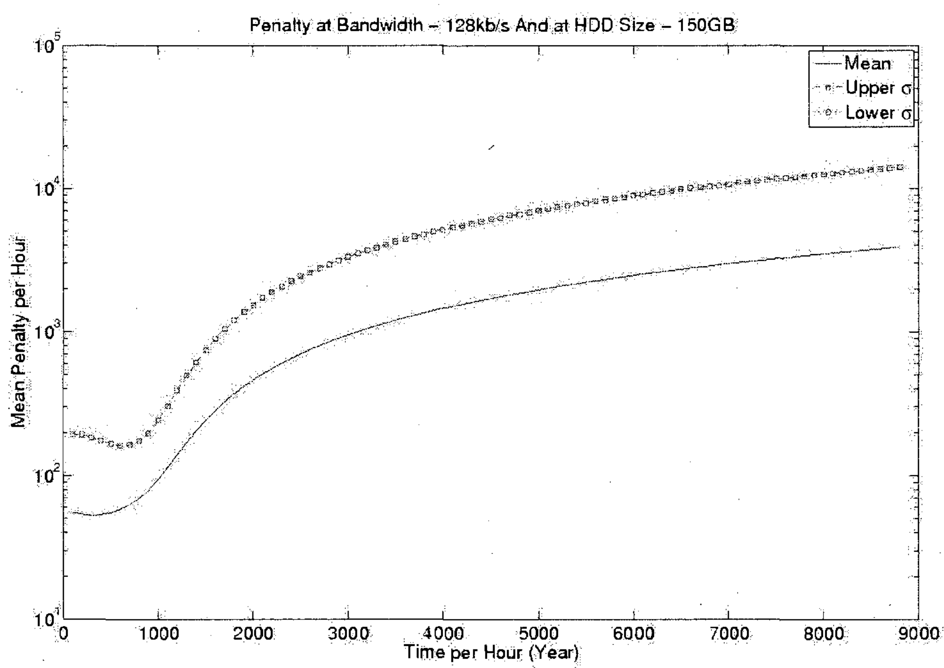


Figure 284: Penalty for H1 case scenario at hard drive size of 200GB and download bandwidth of 128kb/s

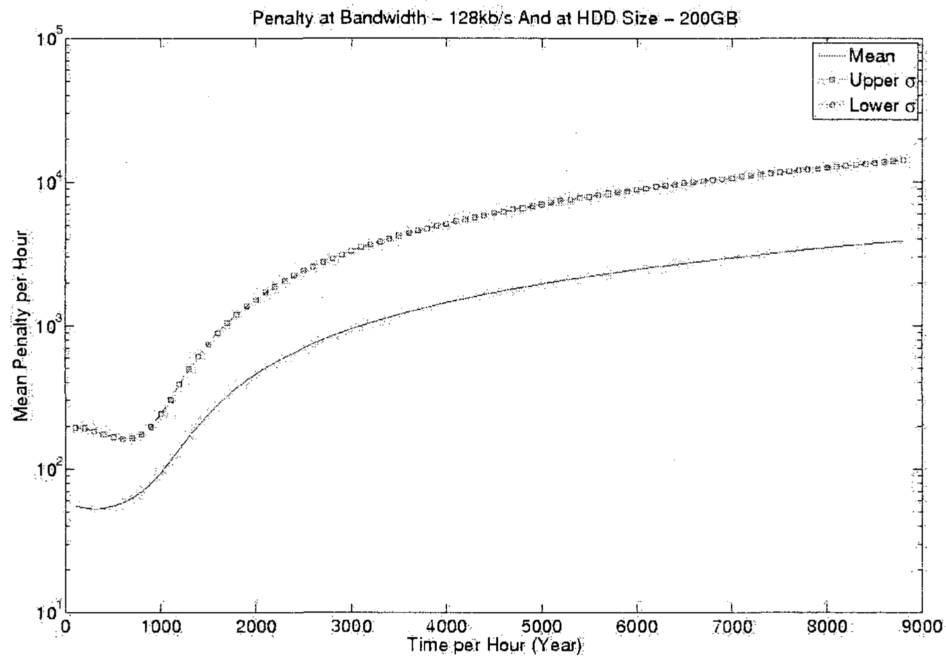


Figure 285: Penalty for H1 case scenario at hard drive size of 50GB and download bandwidth of 256kb/s

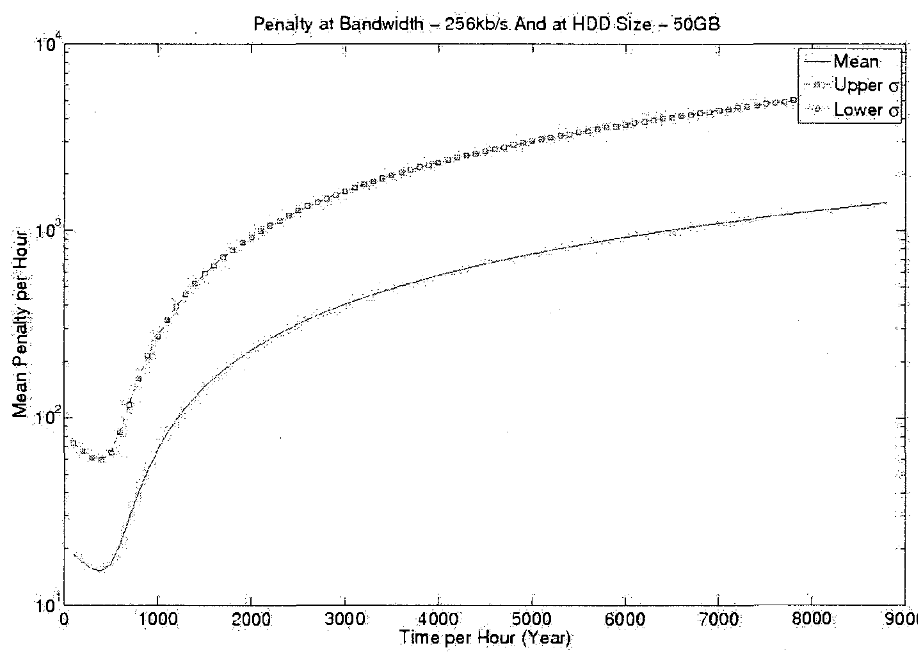


Figure 286: Penalty for H1 case scenario at hard drive size of 100GB and download bandwidth of 256kb/s

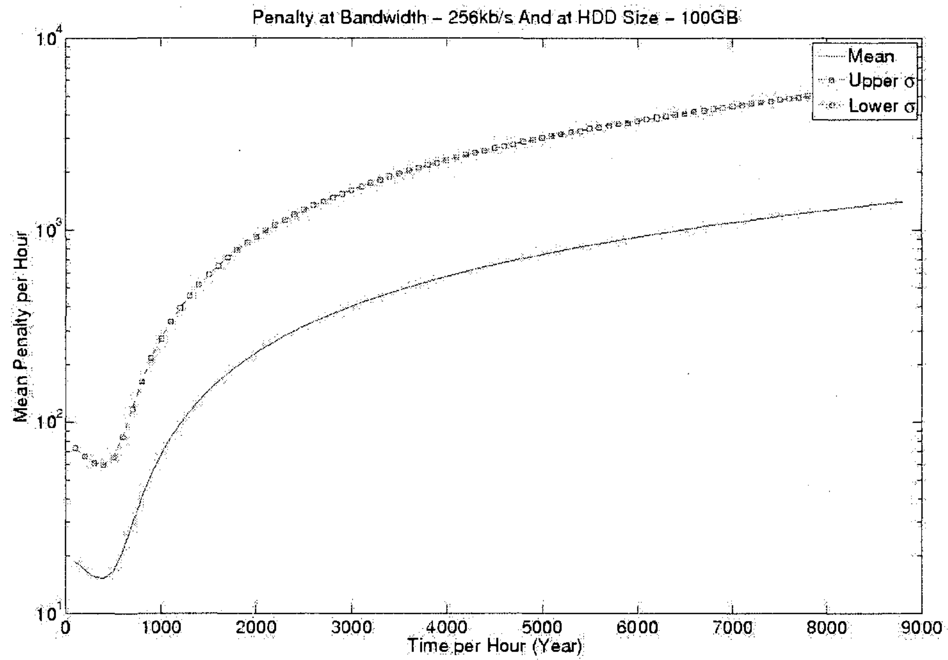


Figure 287: Penalty for H1 case scenario at hard drive size of 150GB and download bandwidth of 256kb/s

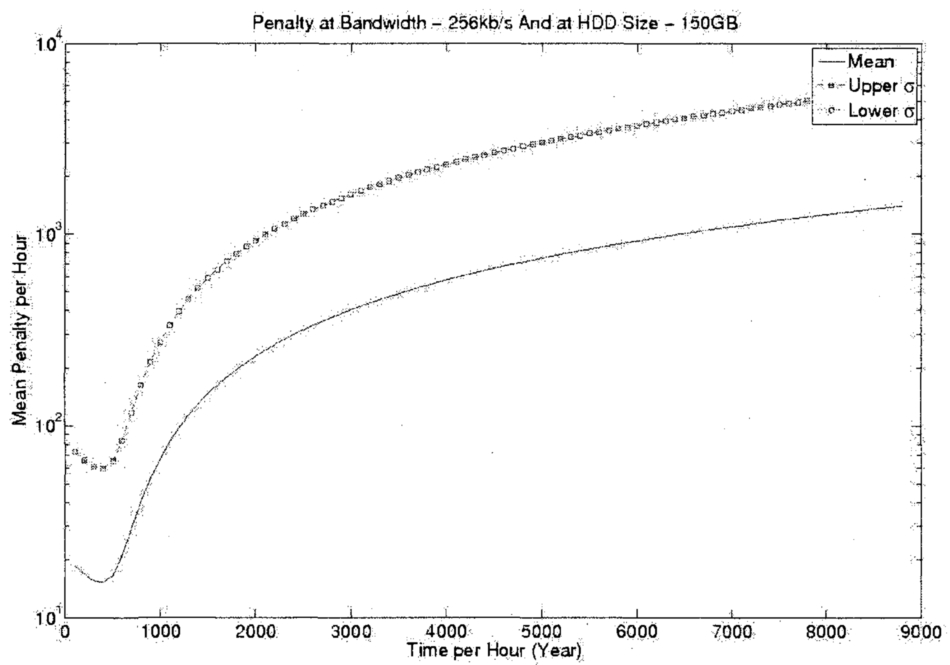


Figure 288: Penalty for H1 case scenario at hard drive size of 200GB and download bandwidth of 256kb/s

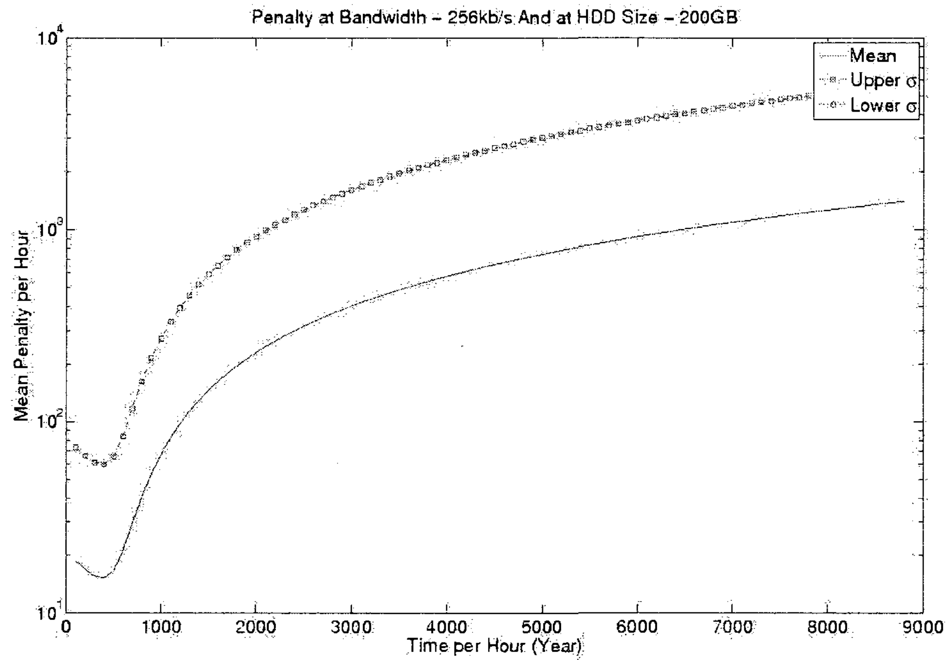


Figure 289: Penalty for H1 case scenario at hard drive size of 50GB and download bandwidth of 512kb/s

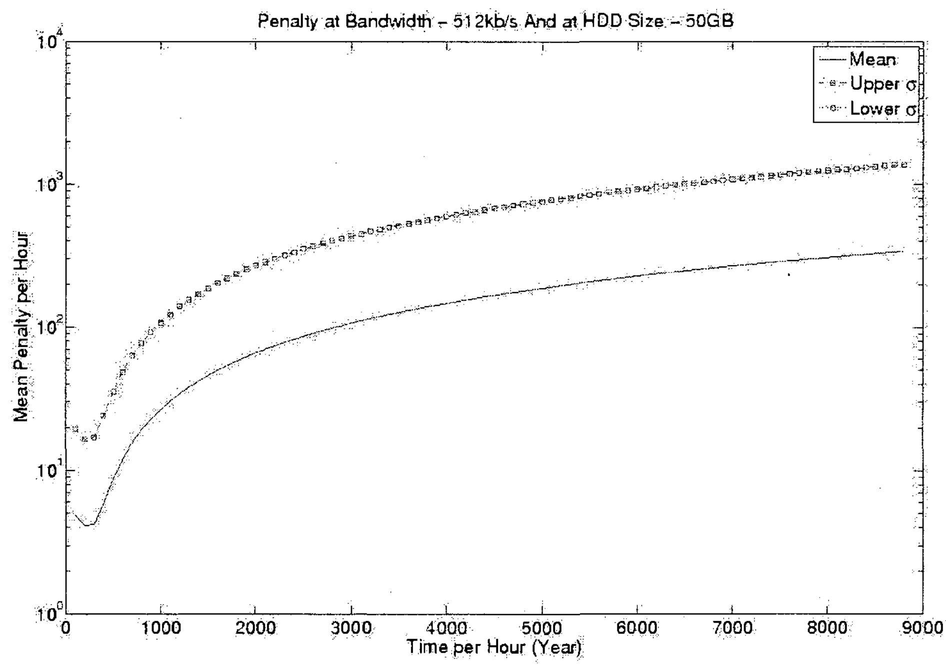


Figure 290: Penalty for H1 case scenario at hard drive size of 100GB and download bandwidth of 512kb/s

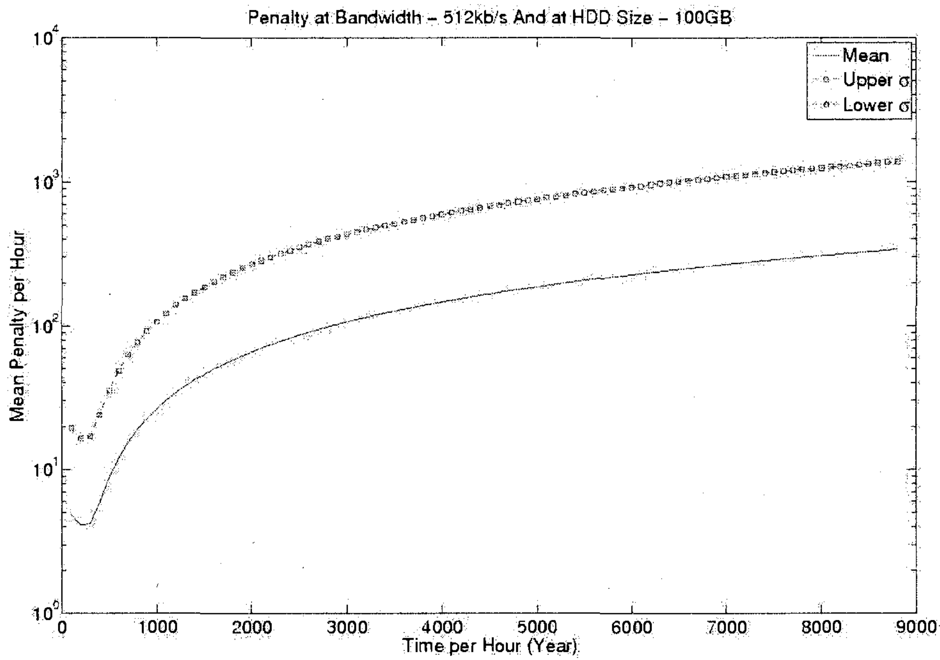


Figure 291: Penalty for H1 case scenario at hard drive size of 150GB and download bandwidth of 512kb/s

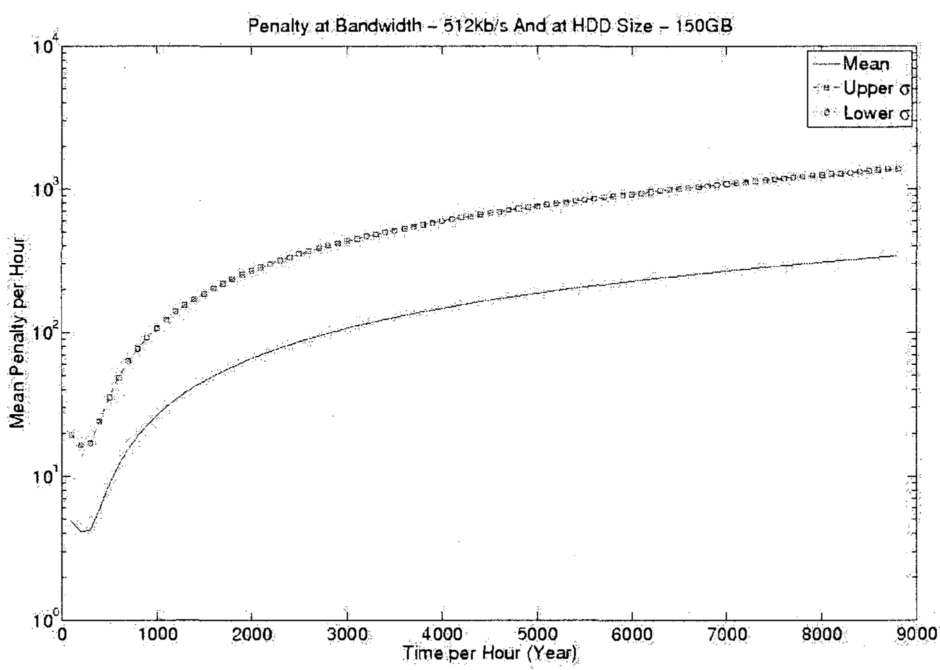


Figure 292: Penalty for H1 case scenario at hard drive size of 200GB and download bandwidth of 512kb/s

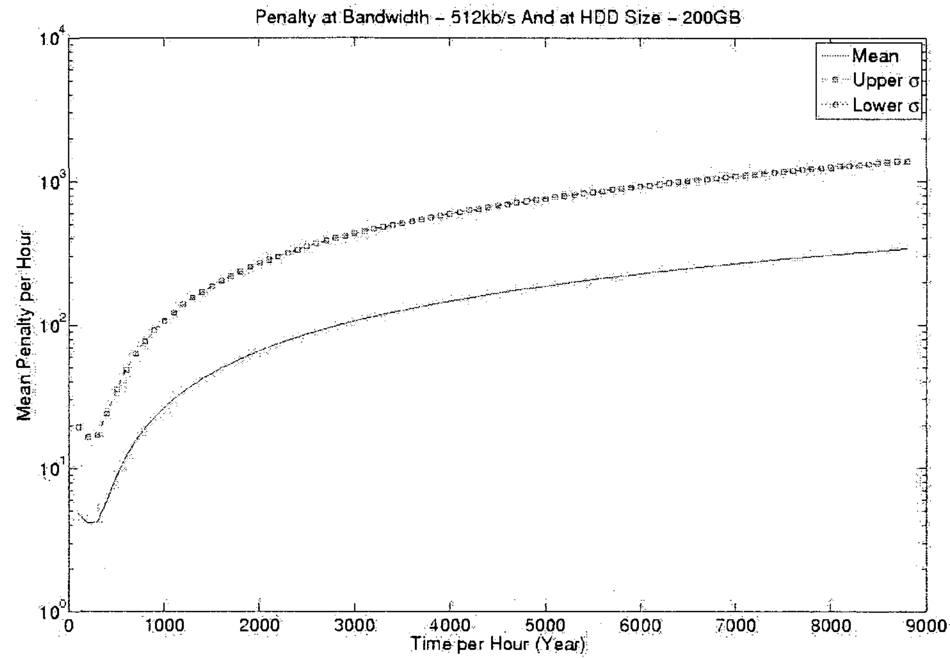


Figure 293: Penalty for H1 case scenario at hard drive size of 50GB and download bandwidth of 1000kb/s

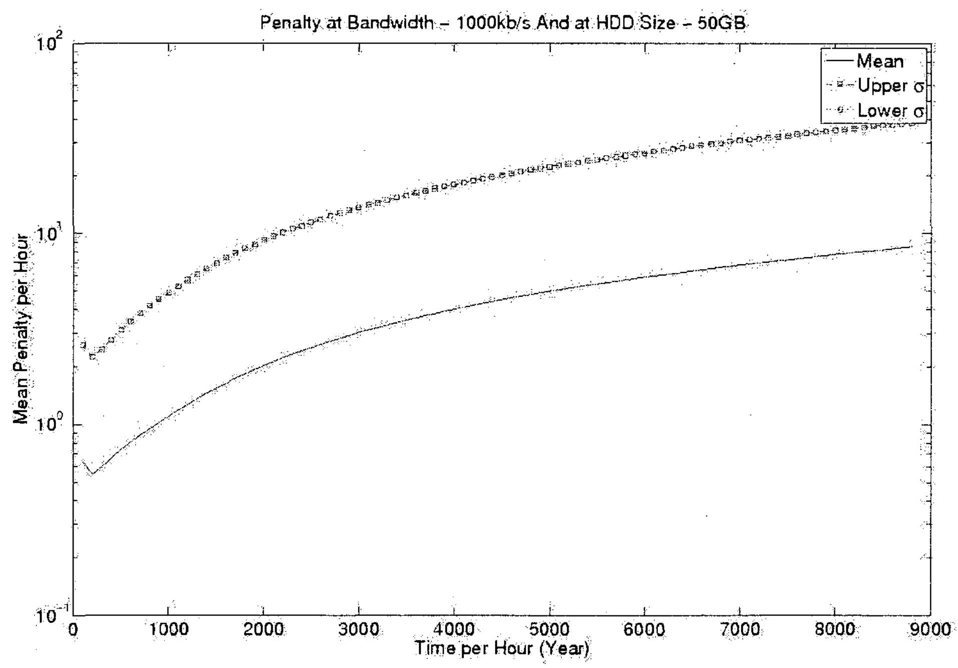


Figure 294: Penalty for H1 case scenario at hard drive size of 100GB and download bandwidth of 1000kb/s

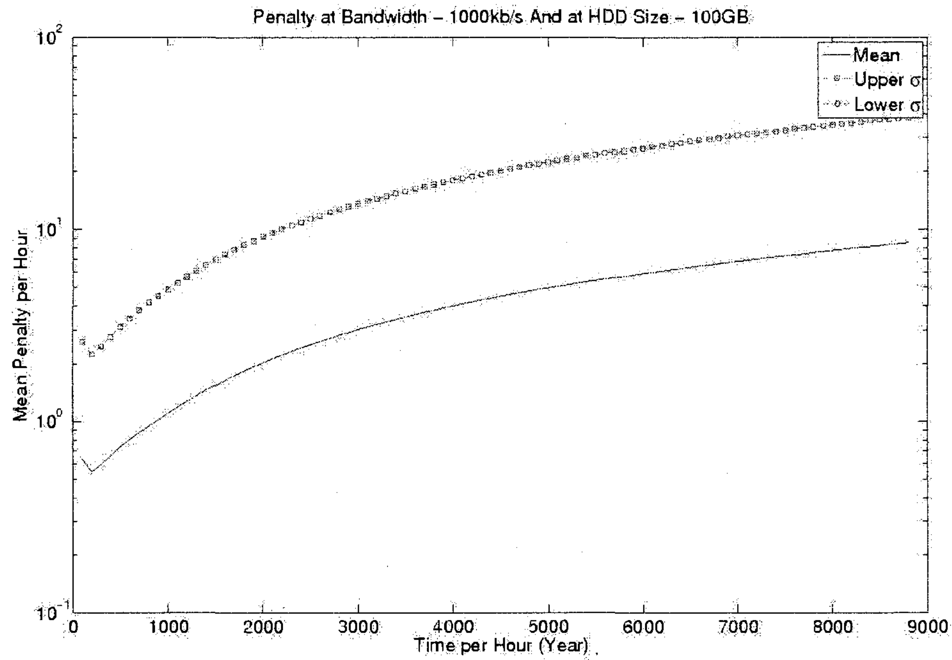


Figure 295: Penalty for H1 case scenario at hard drive size of 150GB and download bandwidth of 1000kb/s

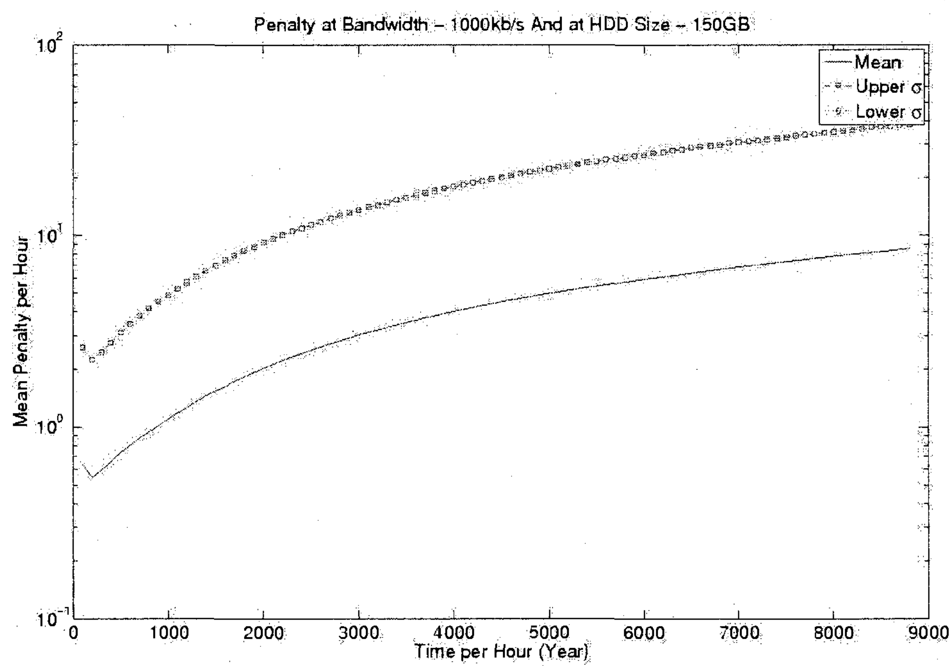


Figure 296: Penalty for H1 case scenario at hard drive size of 200GB and download bandwidth of 1000kb/s

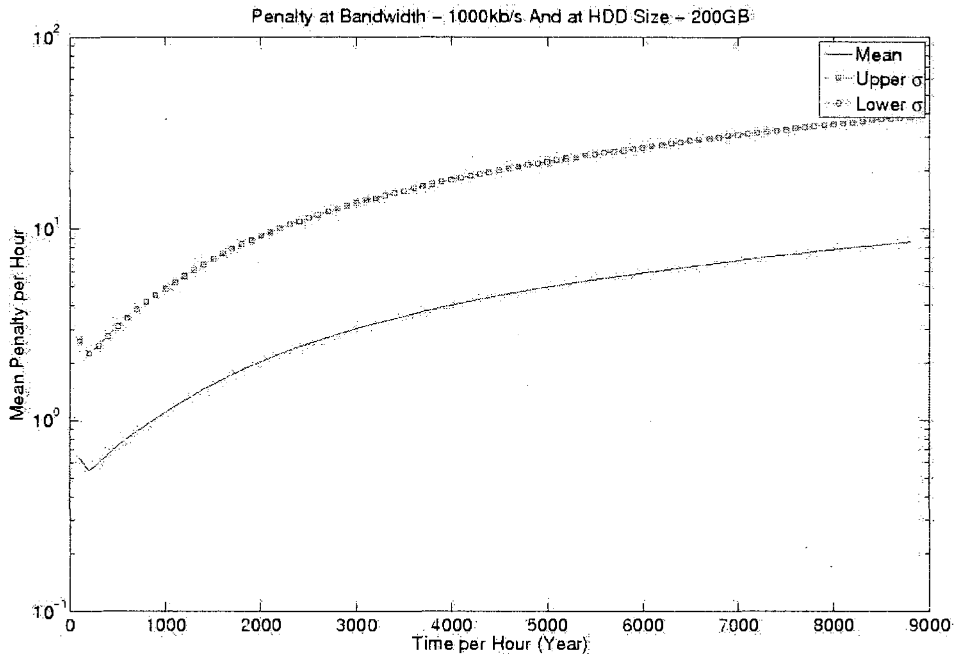


Figure 297: Penalty for H1 case scenario at hard drive size of 50GB and download bandwidth of 2000kb/s

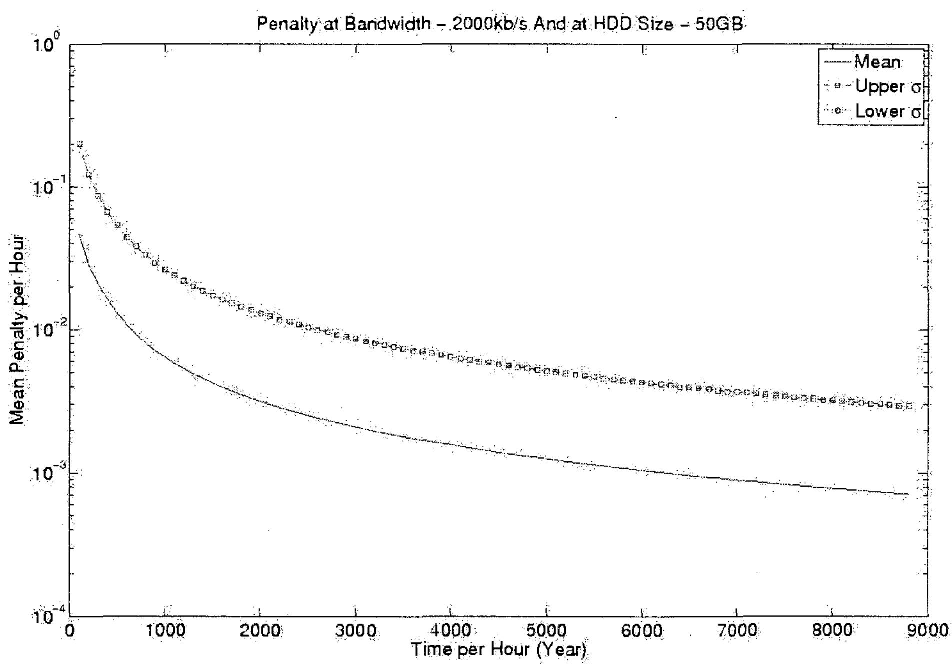


Figure 298: Penalty for H1 case scenario at hard drive size of 100GB and download bandwidth of 2000kb/s

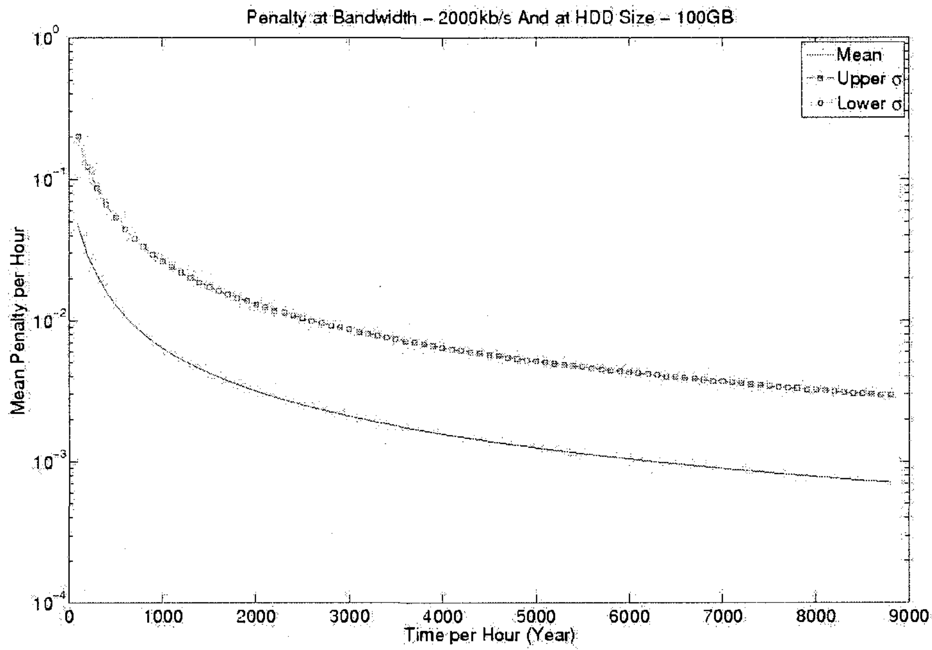


Figure 299: Penalty for H1 case scenario at hard drive size of 150GB and download bandwidth of 2000kb/s

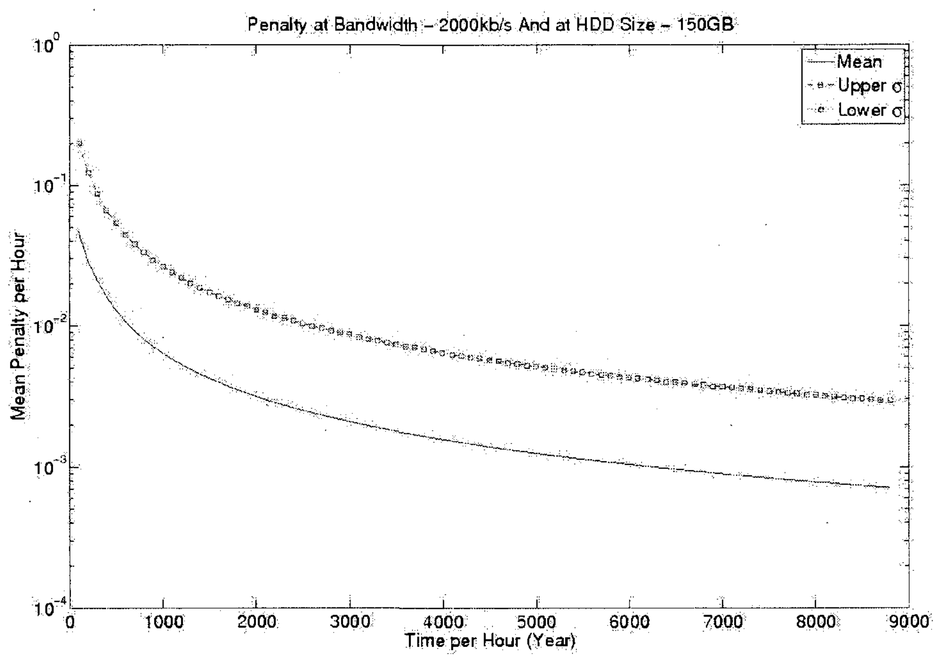


Figure 300: Penalty for H1 case scenario at hard drive size of 200GB and download bandwidth of 2000kb/s

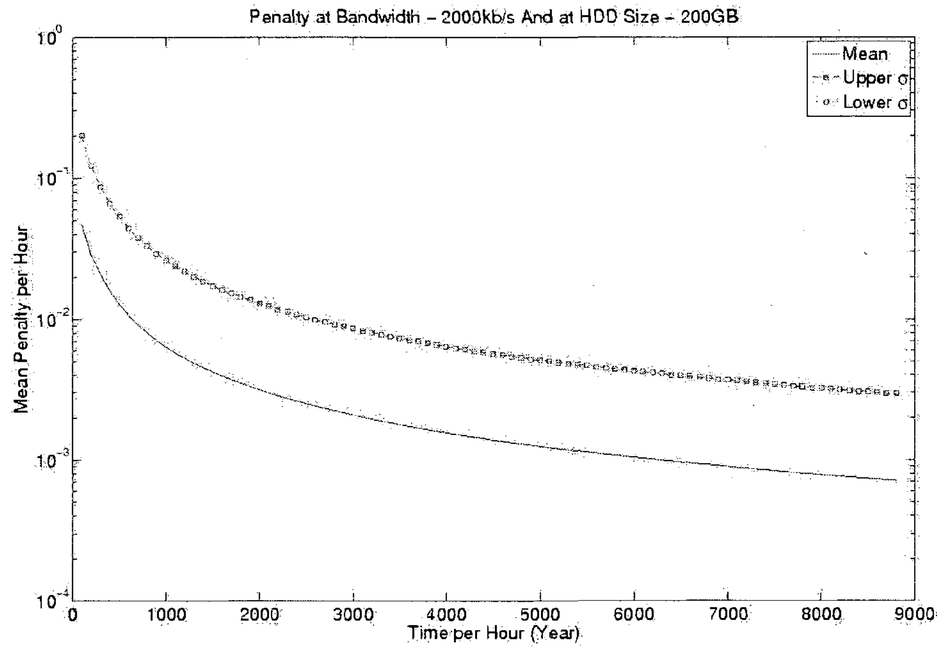


Figure 301: Penalty for H1 case scenario at hard drive size of 50GB and download bandwidth of 5000kb/s

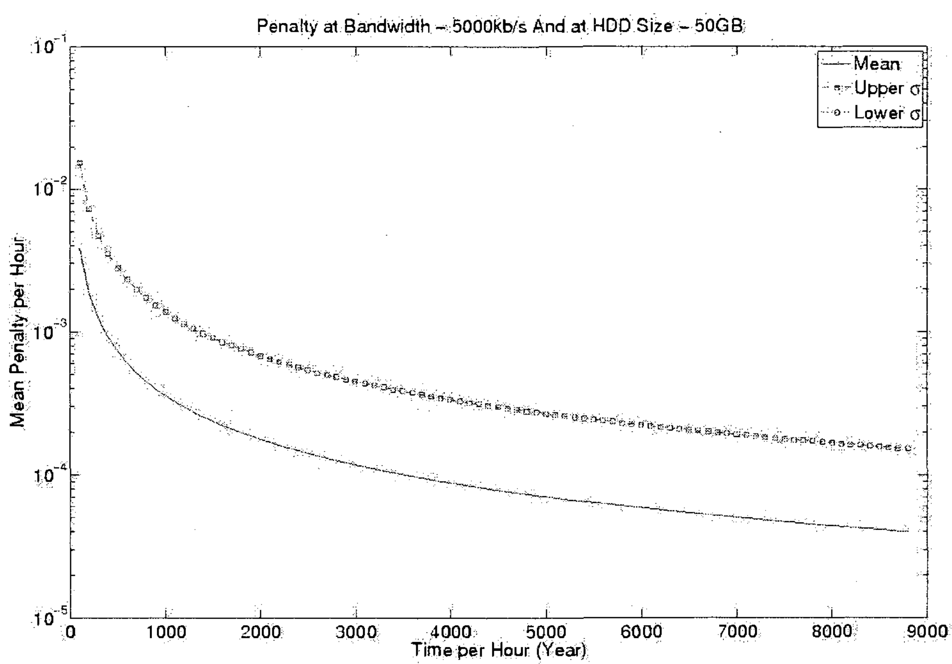


Figure 302: Penalty for H1 case scenario at hard drive size of 100GB and download bandwidth of 5000kb/s

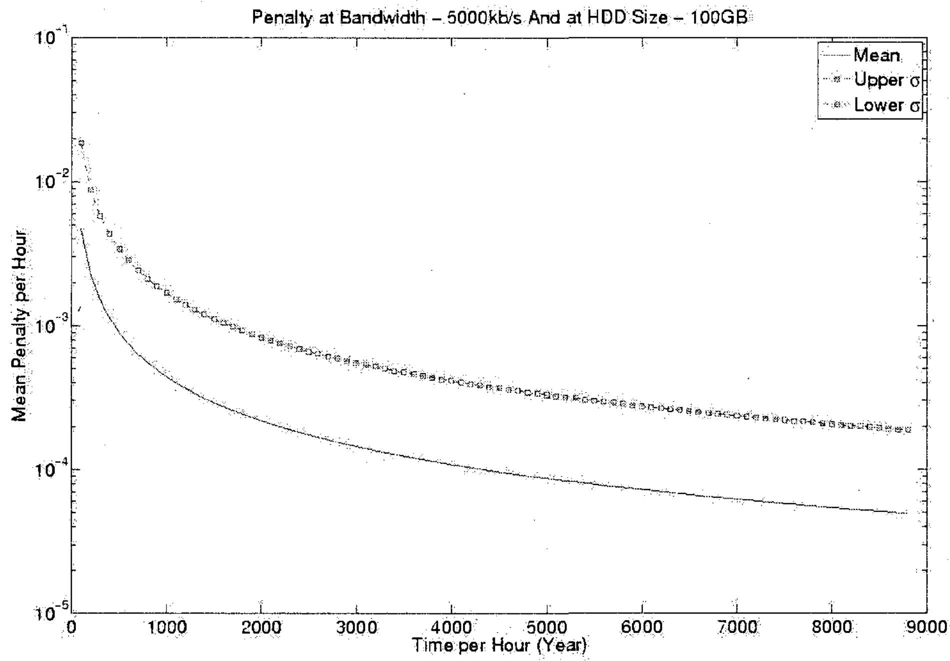


Figure 303: Penalty for H1 case scenario at hard drive size of 150GB and download bandwidth of 5000kb/s

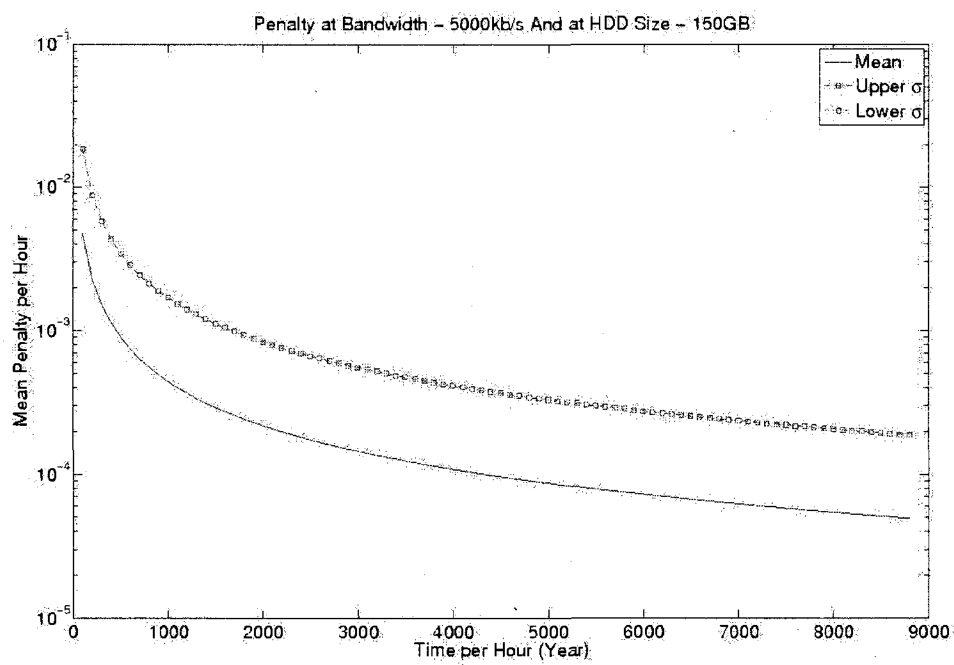


Figure 304: Penalty for H1 case scenario at hard drive size of 200GB and download bandwidth of 5000kb/s

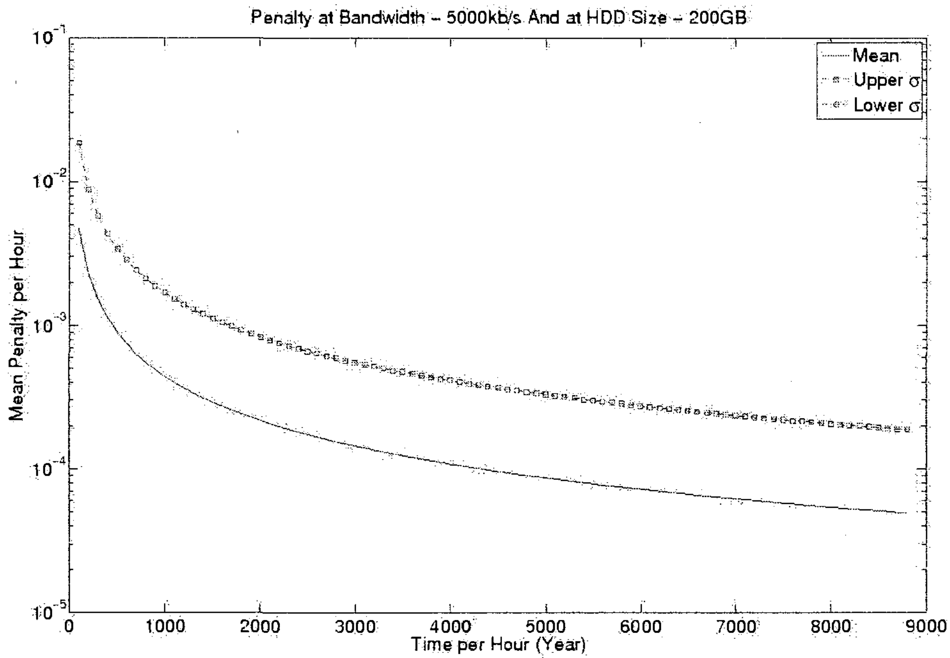


Figure 305: Penalty for H1 case scenario at hard drive size of 50GB and download bandwidth of 10000kb/s

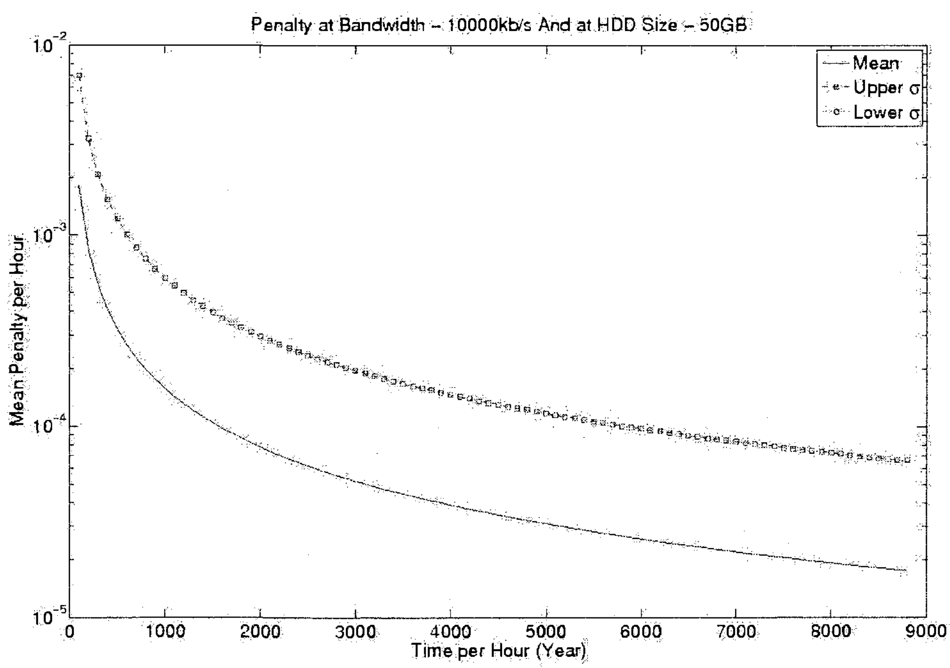


Figure 306: Penalty for H1 case scenario at hard drive size of 100GB and download bandwidth of 10000kb/s

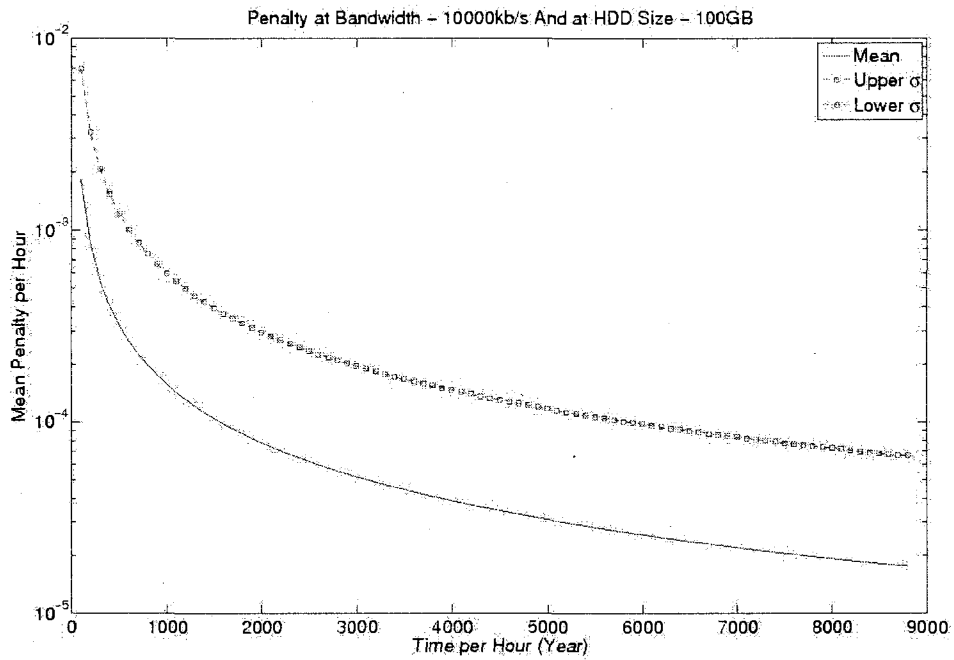


Figure 307: Penalty for H1 case scenario at hard drive size of 150GB and download bandwidth of 10000kb/s

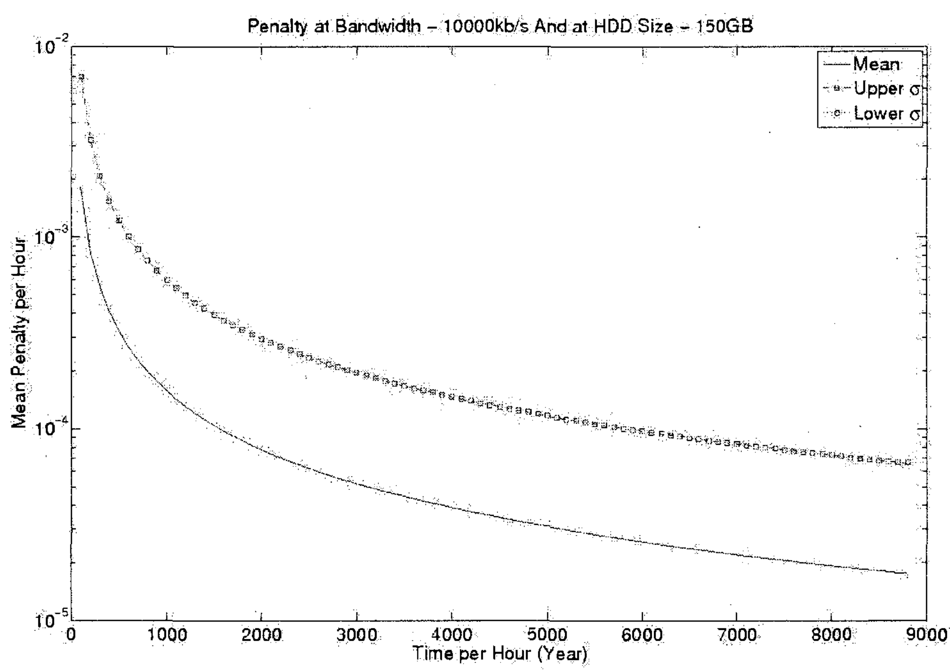


Figure 308: Penalty for H1 case scenario at hard drive size of 200GB and download bandwidth of 10000kb/s

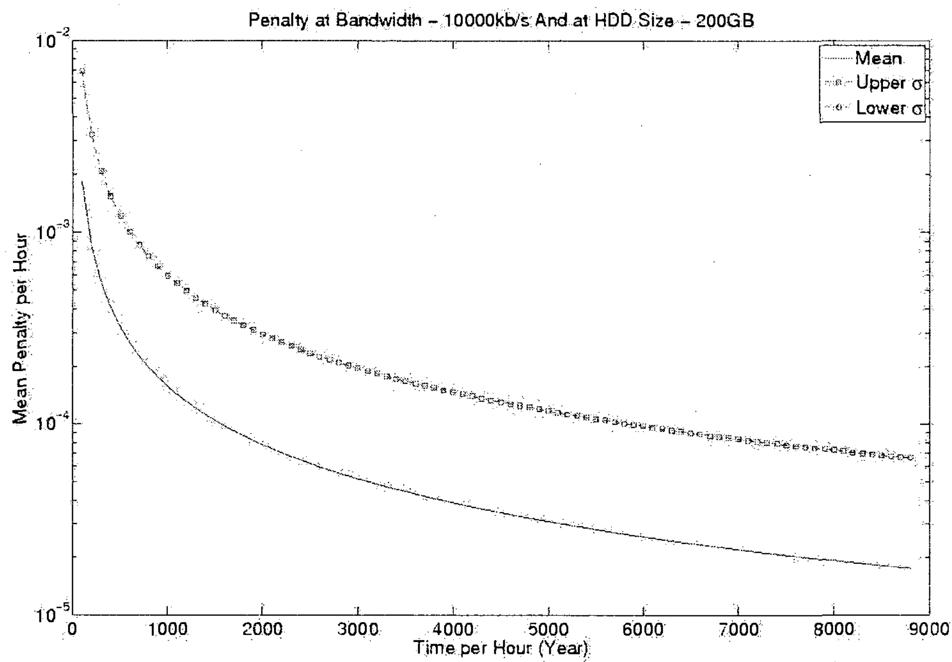


Figure 309: Penalty for H1 case scenario at hard drive size of 50GB and download bandwidth of 15000kb/s

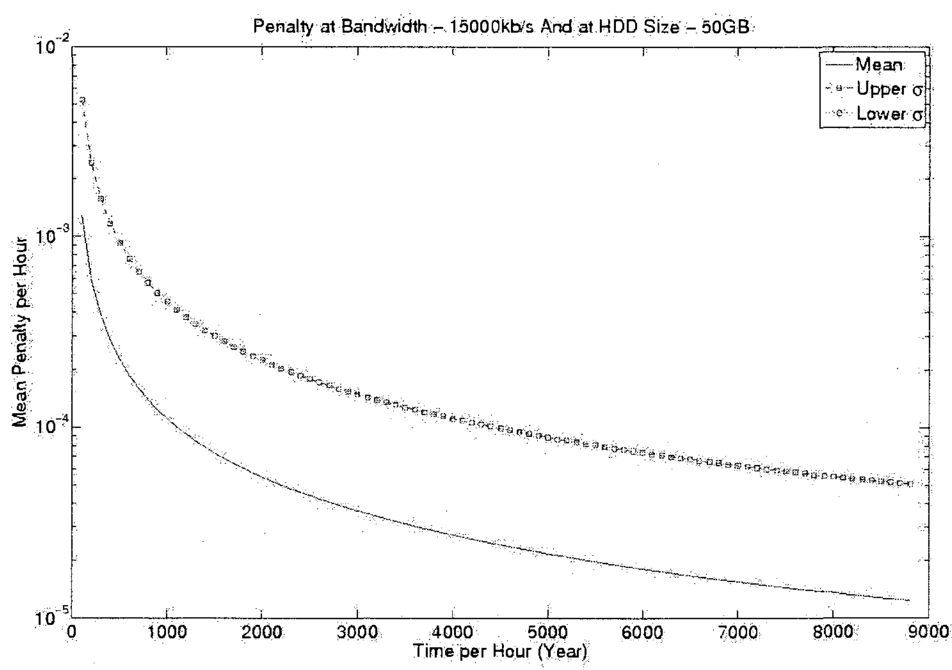


Figure 310: Penalty for H1 case scenario at hard drive size of 100GB and download bandwidth of 15000kb/s

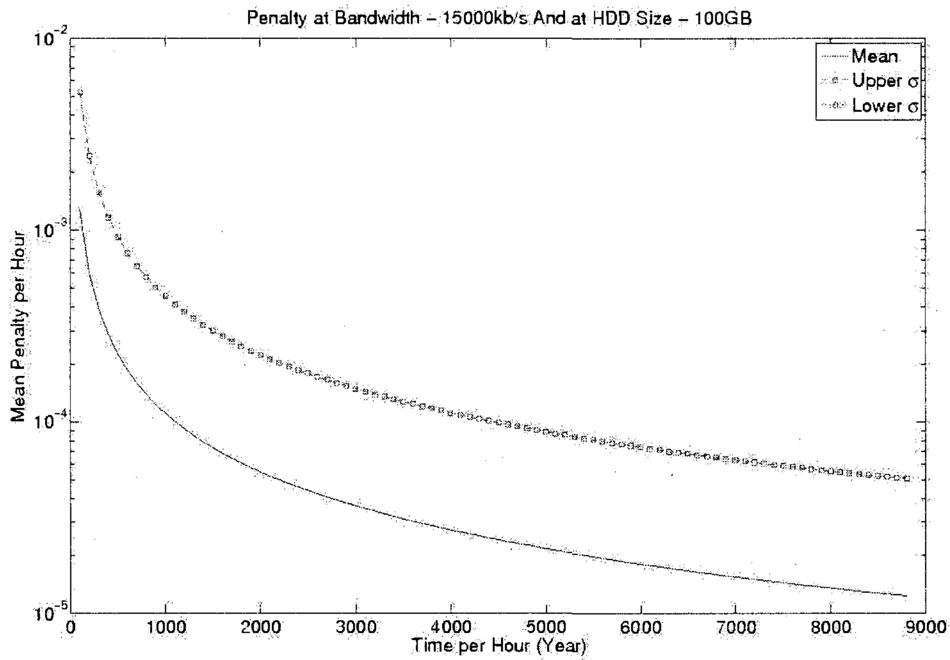


Figure 311: Penalty for H1 case scenario at hard drive size of 150GB and download bandwidth of 15000kb/s

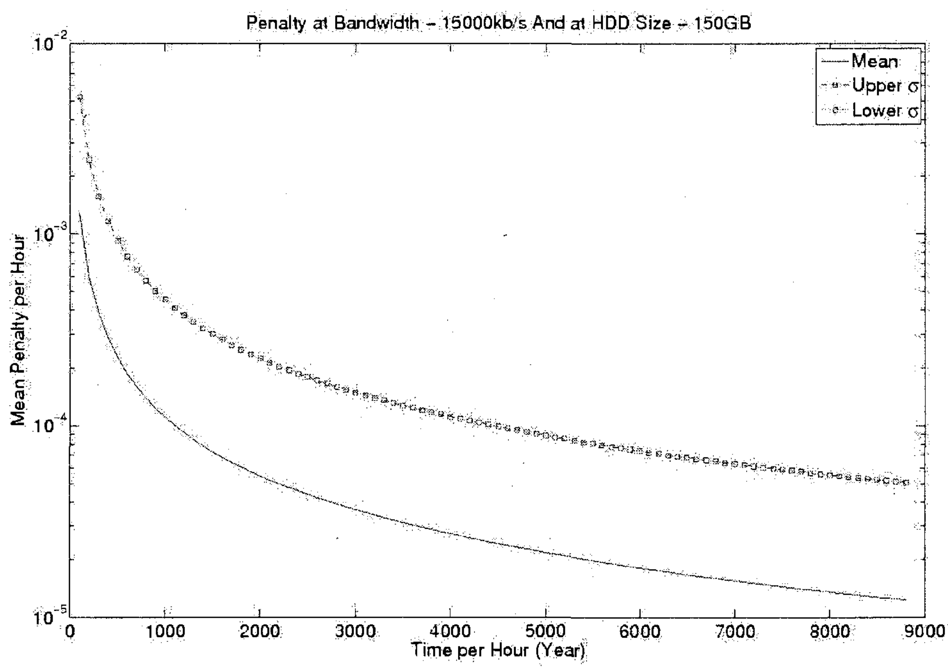


Figure 312: Penalty for H1 case scenario at hard drive size of 200GB and download bandwidth of 15000kb/s

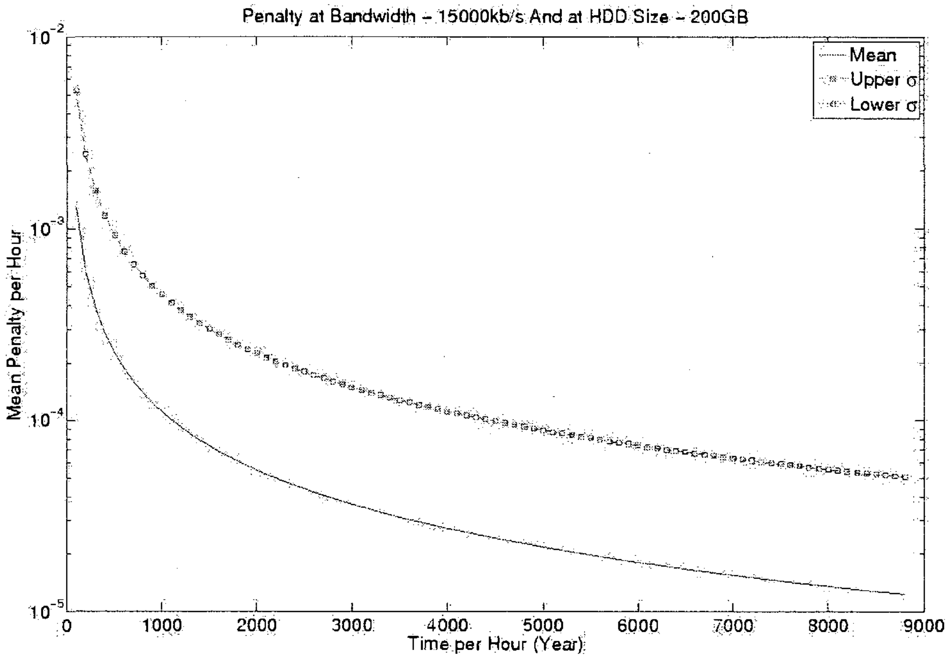


Figure 313: Penalty for H2 case scenario at hard drive size of 50GB and download bandwidth of 25kb/s

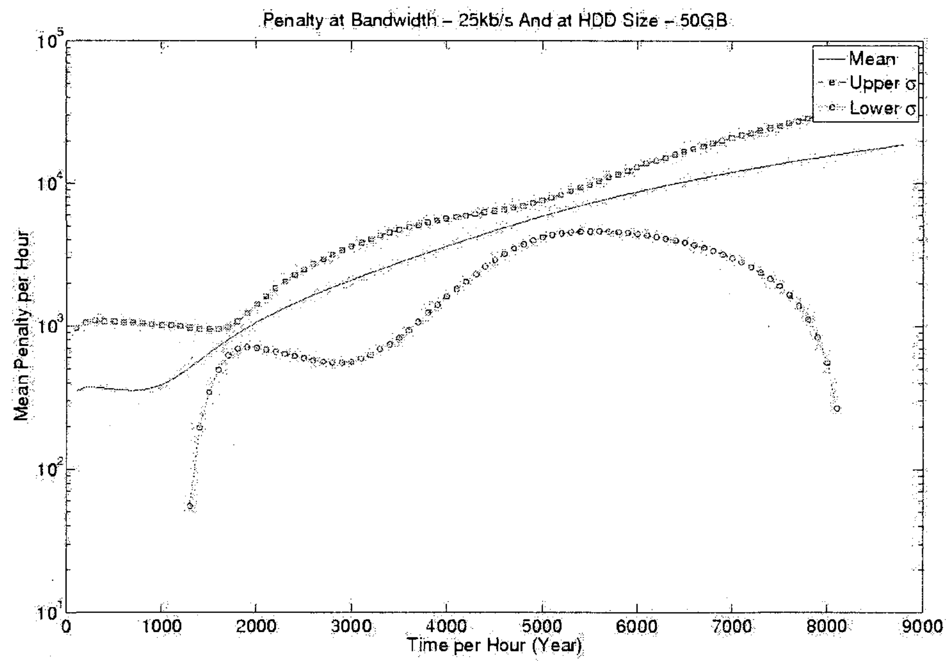


Figure 314: Penalty for H2 case scenario at hard drive size of 100GB and download bandwidth of 25kb/s

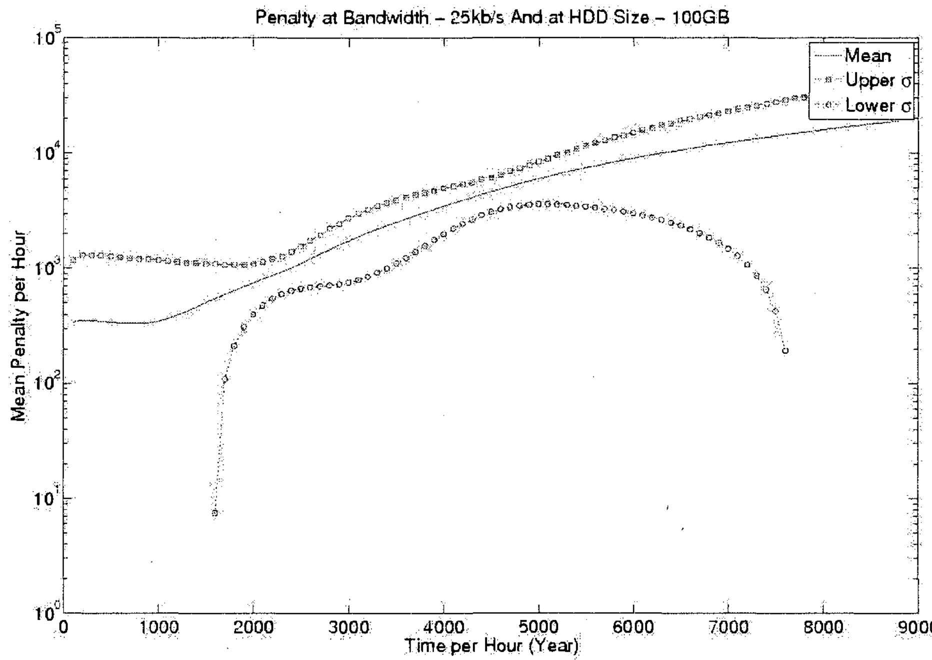


Figure 315: Penalty for H2 case scenario at hard drive size of 150GB and download bandwidth of 25kb/s

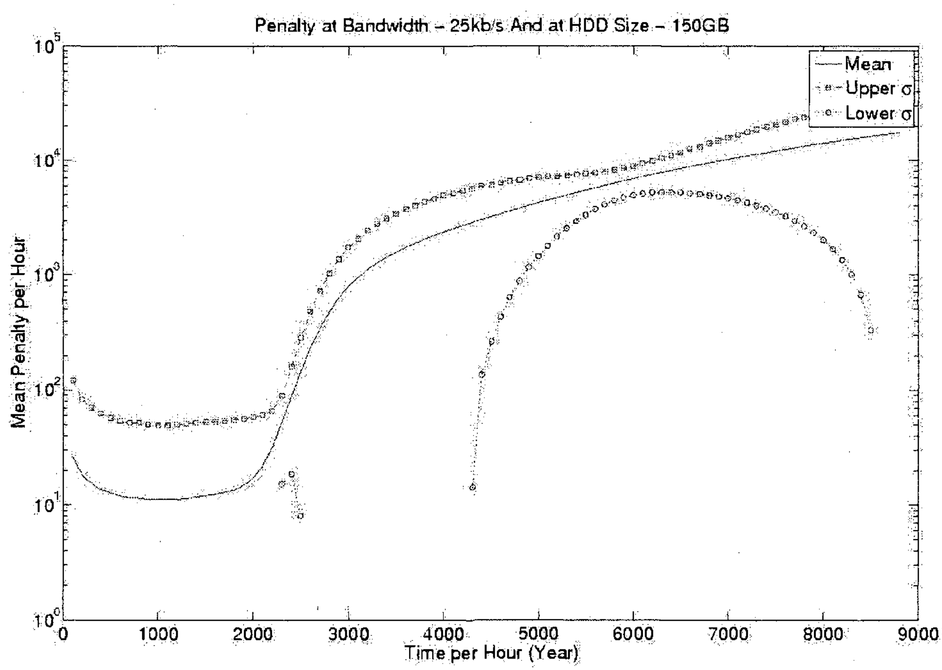


Figure 316: Penalty for H2 case scenario at hard drive size of 200GB and download bandwidth of 25kb/s

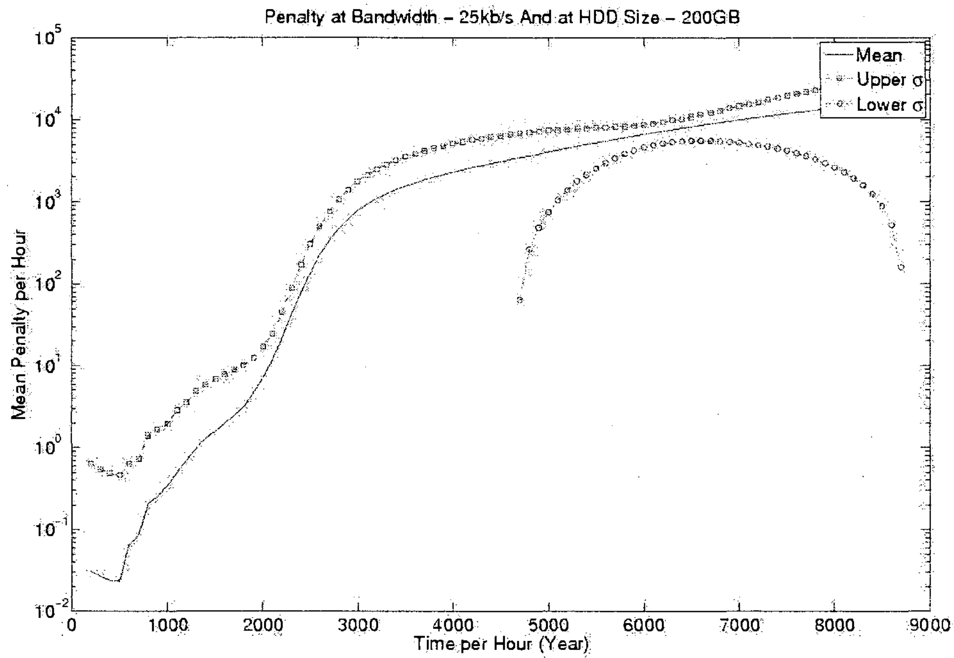


Figure 317: Penalty for H2 case scenario at hard drive size of 50GB and download bandwidth of 50kb/s

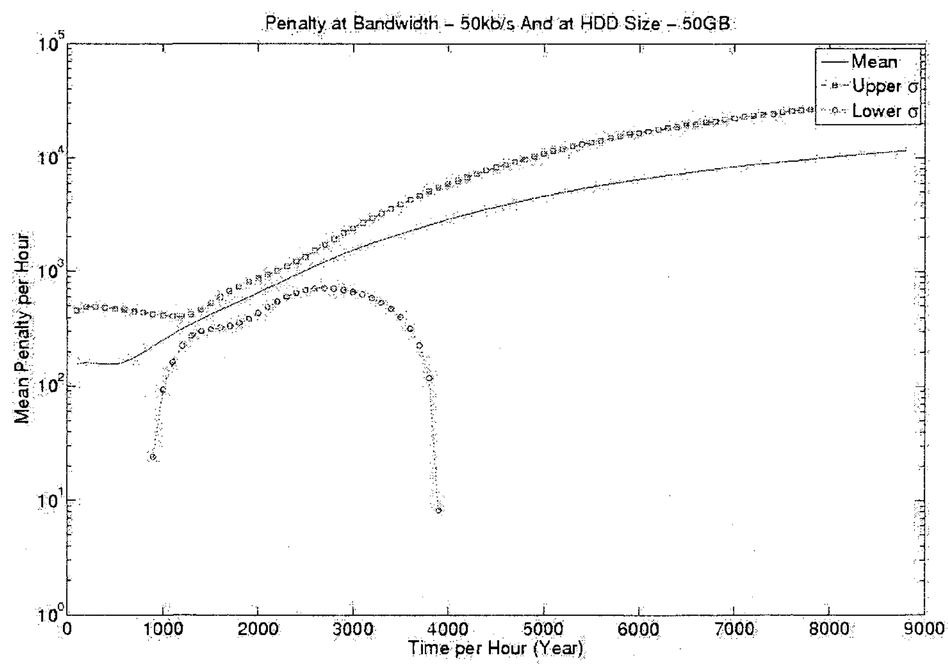


Figure 318: Penalty for H2 case scenario at hard drive size of 100GB and download bandwidth of 50kb/s

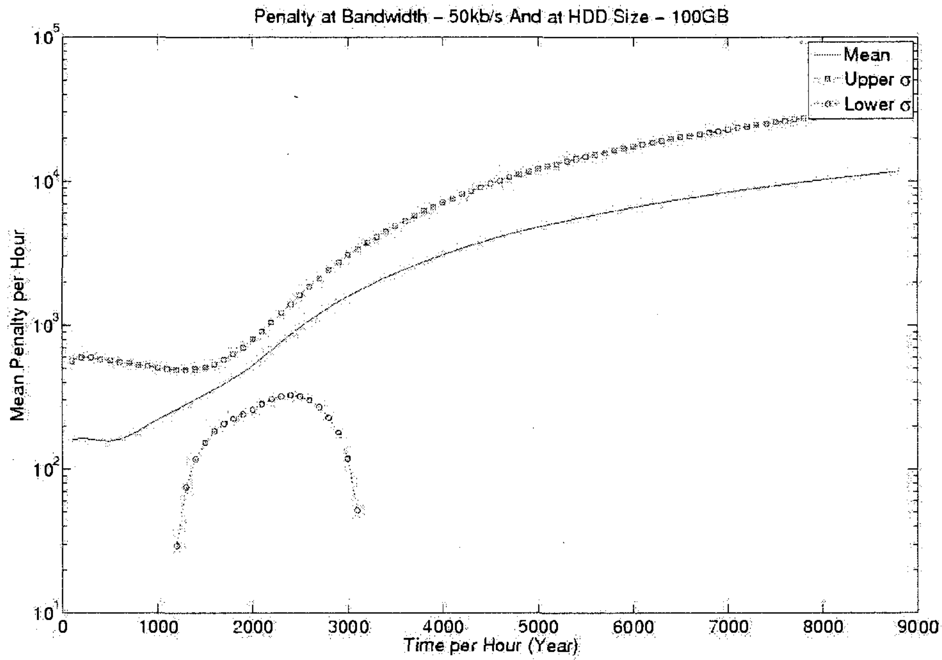


Figure 319: Penalty for H2 case scenario at hard drive size of 150GB and download bandwidth of 50kb/s

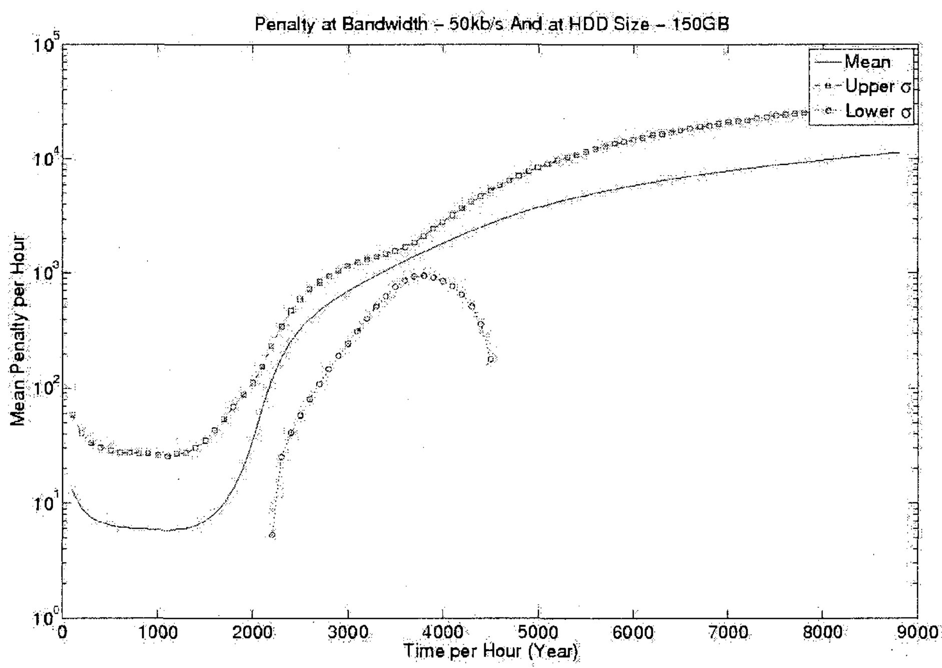


Figure 320: Penalty for H2 case scenario at hard drive size of 200GB and download bandwidth of 50kb/s

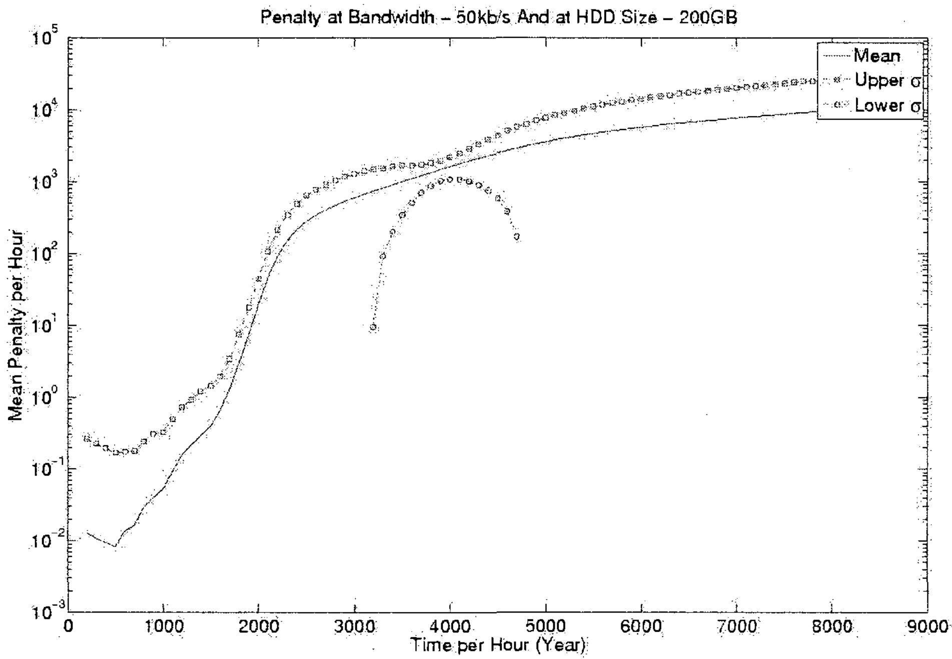


Figure 321: Penalty for H2 case scenario at hard drive size of 50GB and download bandwidth of 100kb/s

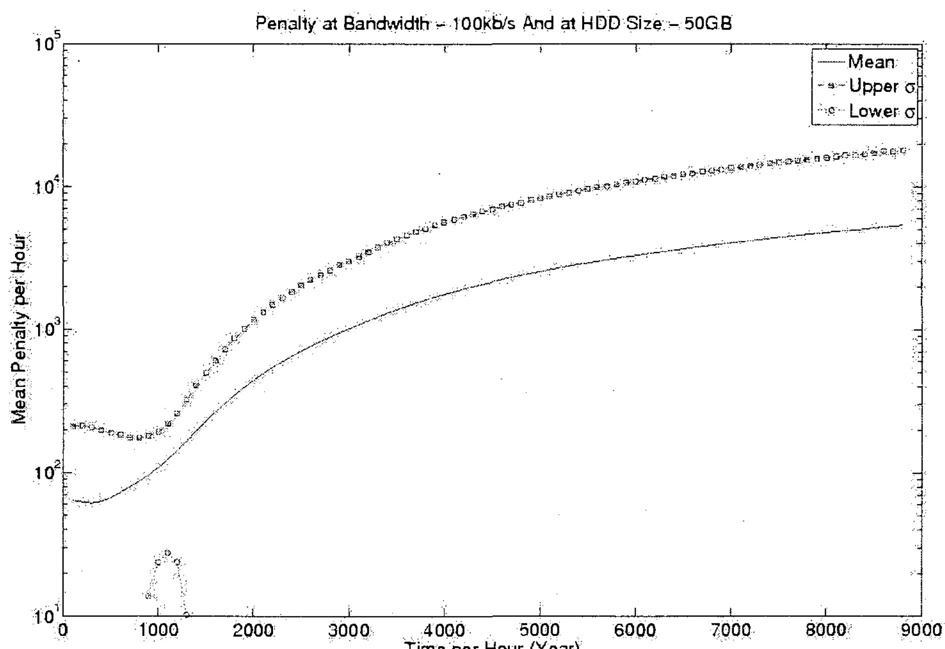


Figure 322: Penalty for H2 case scenario at hard drive size of 100GB and download bandwidth of 100kb/s

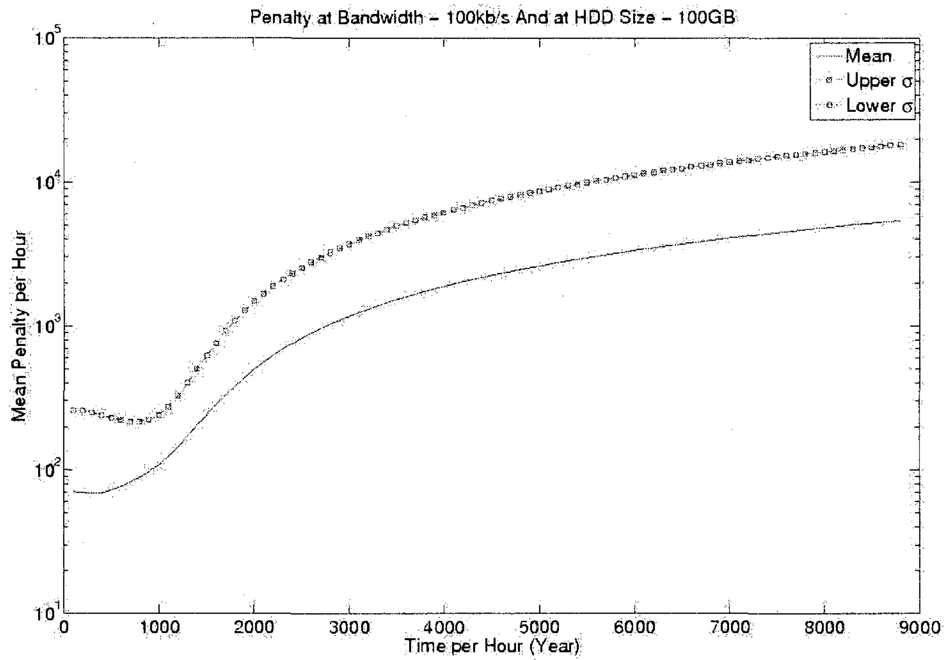


Figure 323: Penalty for H2 case scenario at hard drive size of 150GB and download bandwidth of 100kb/s

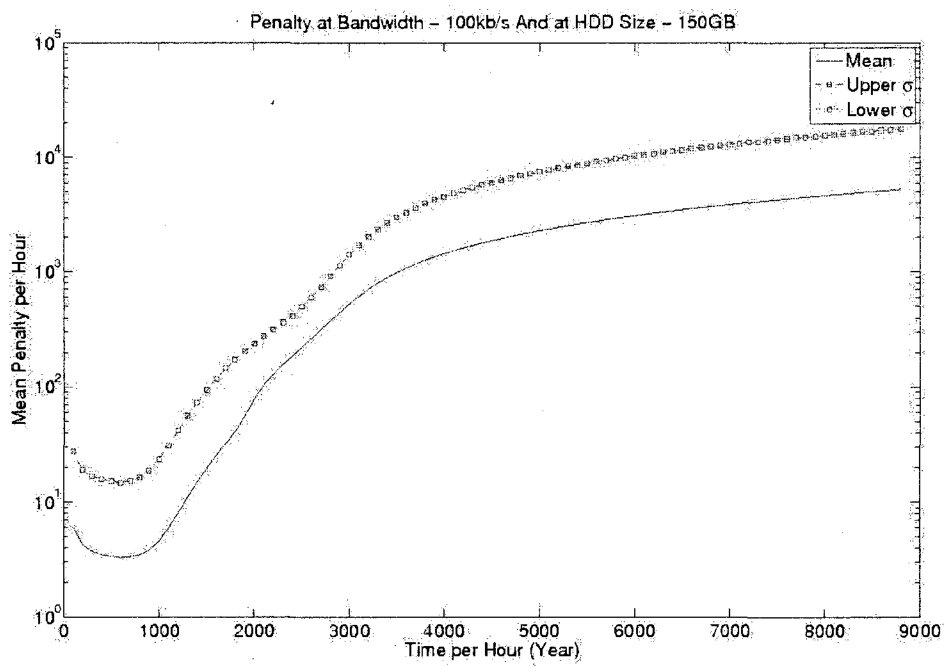


Figure 324: Penalty for H2 case scenario at hard drive size of 200GB and download bandwidth of 100kb/s

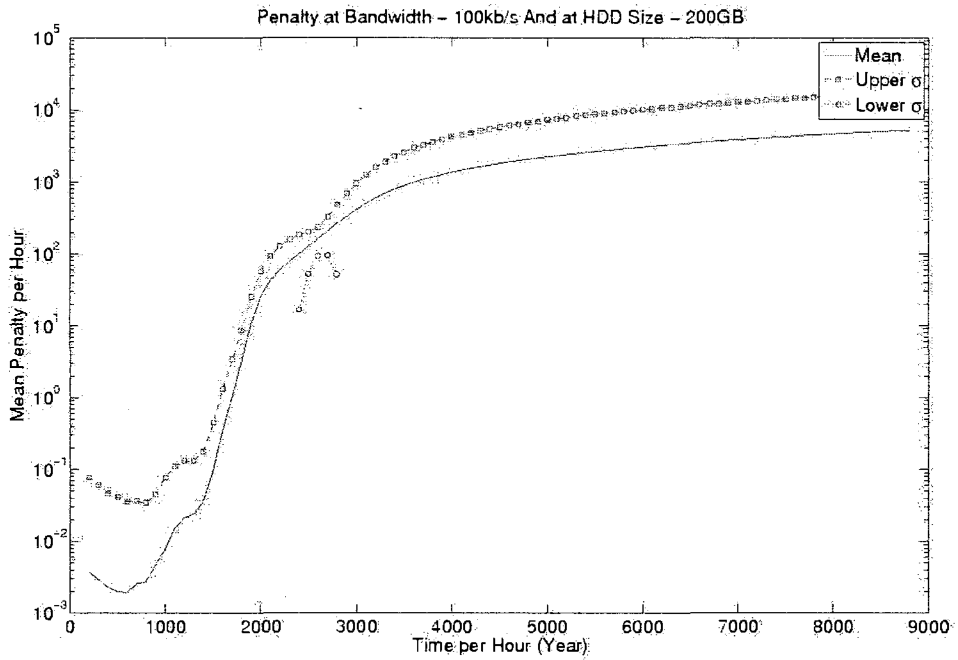


Figure 325: Penalty for H2 case scenario at hard drive size of 50GB and download bandwidth of 128kb/s

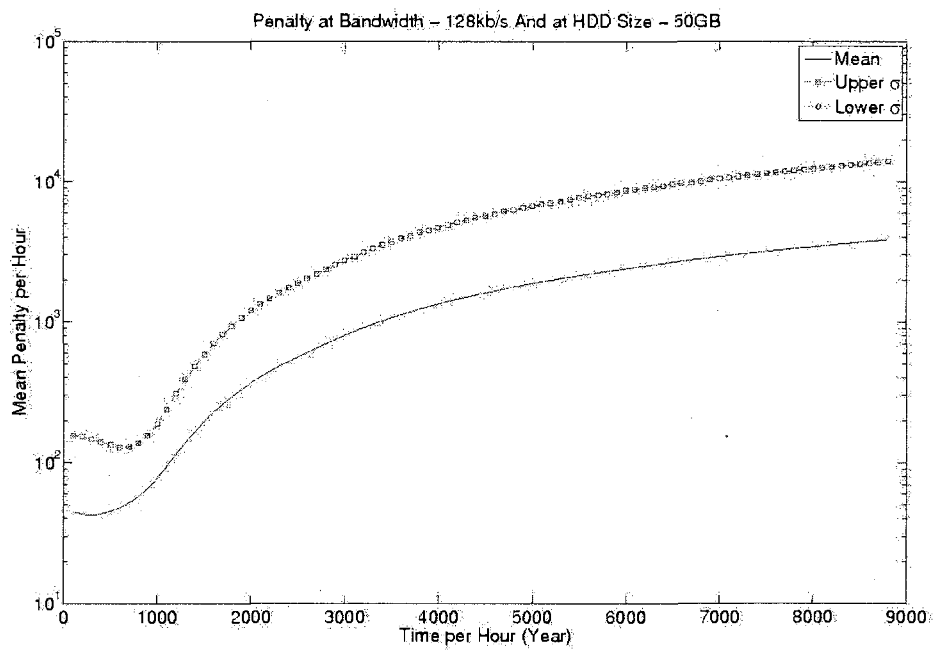


Figure 326: Penalty for H2 case scenario at hard drive size of 100GB and download bandwidth of 128kb/s

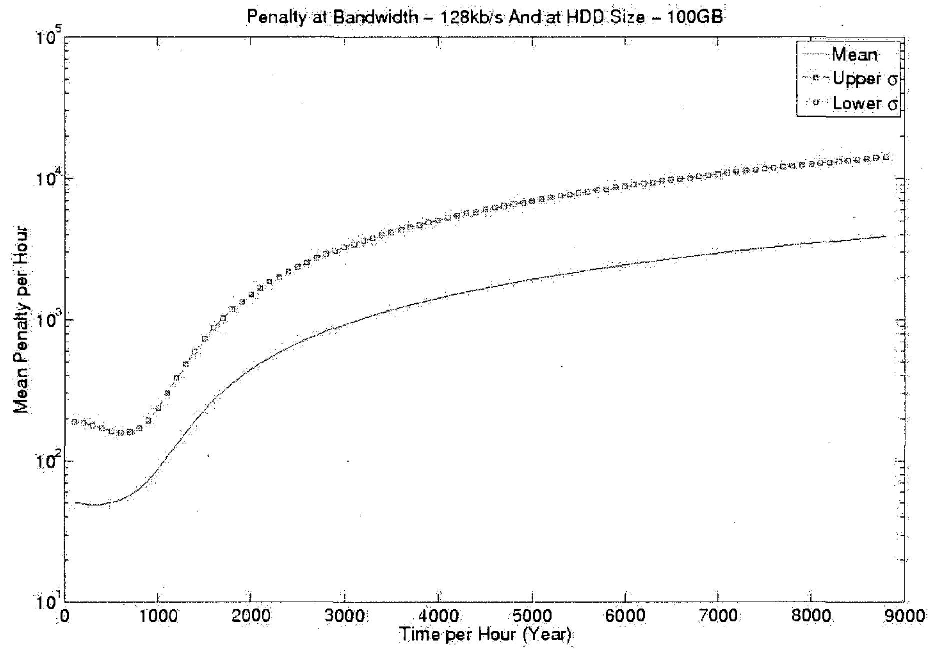


Figure 327: Penalty for H2 case scenario at hard drive size of 150GB and download bandwidth of 128kb/s

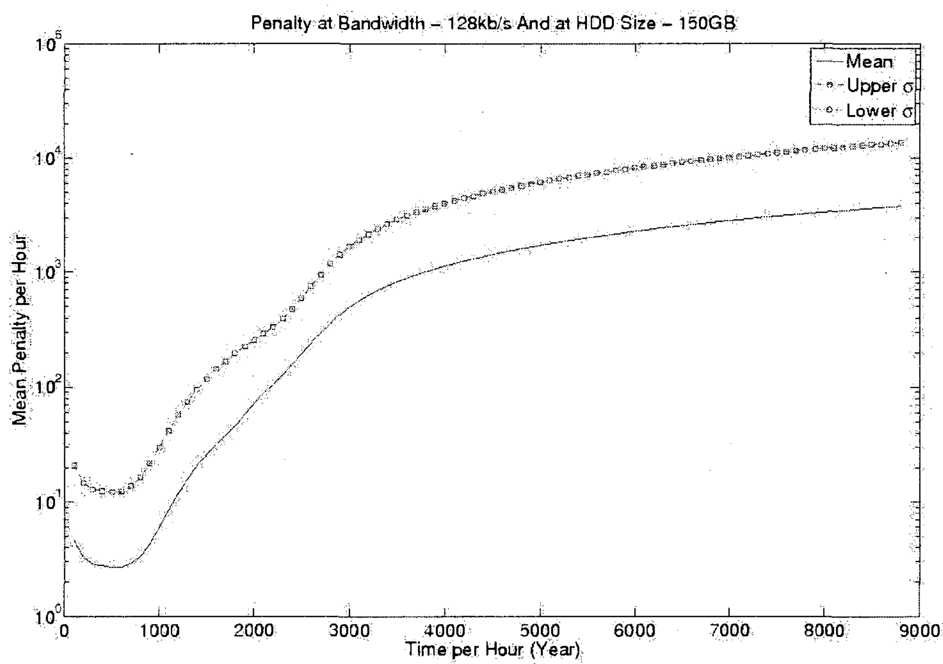


Figure 328: Penalty for H2 case scenario at hard drive size of 200GB and download bandwidth of 128kb/s

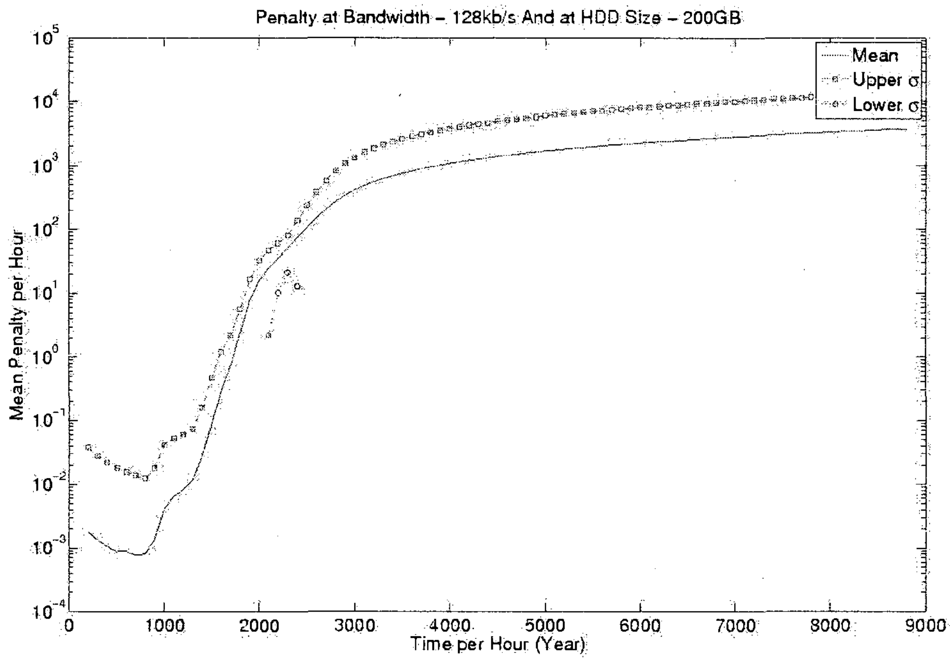


Figure 329: Penalty for H2 case scenario at hard drive size of 50GB and download bandwidth of 256kb/s

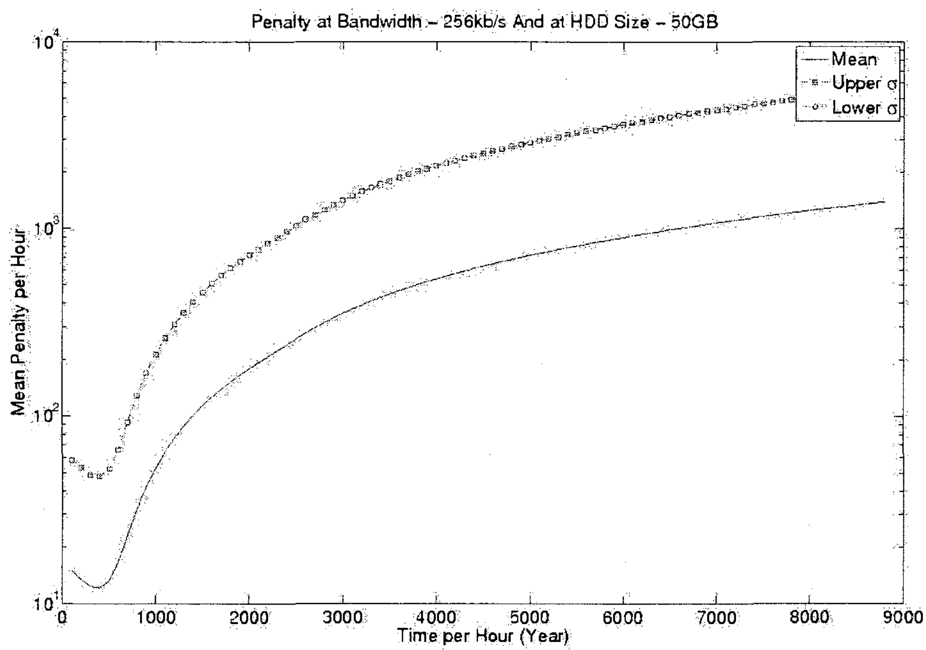


Figure 330: Penalty for H2 case scenario at hard drive size of 100GB and download bandwidth of 256kb/s

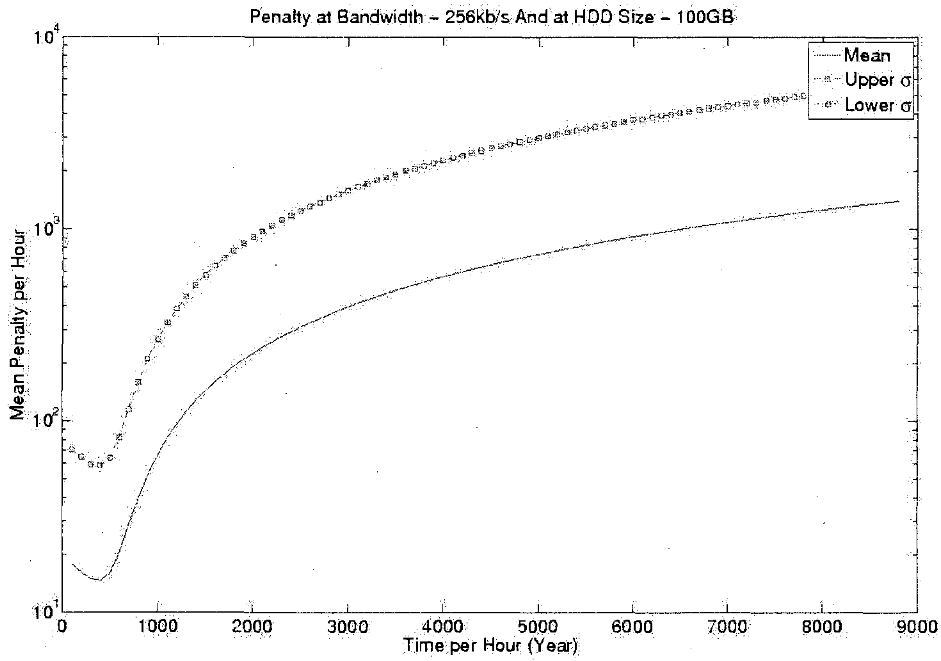


Figure 331: Penalty for H2 case scenario at hard drive size of 150GB and download bandwidth of 256kb/s

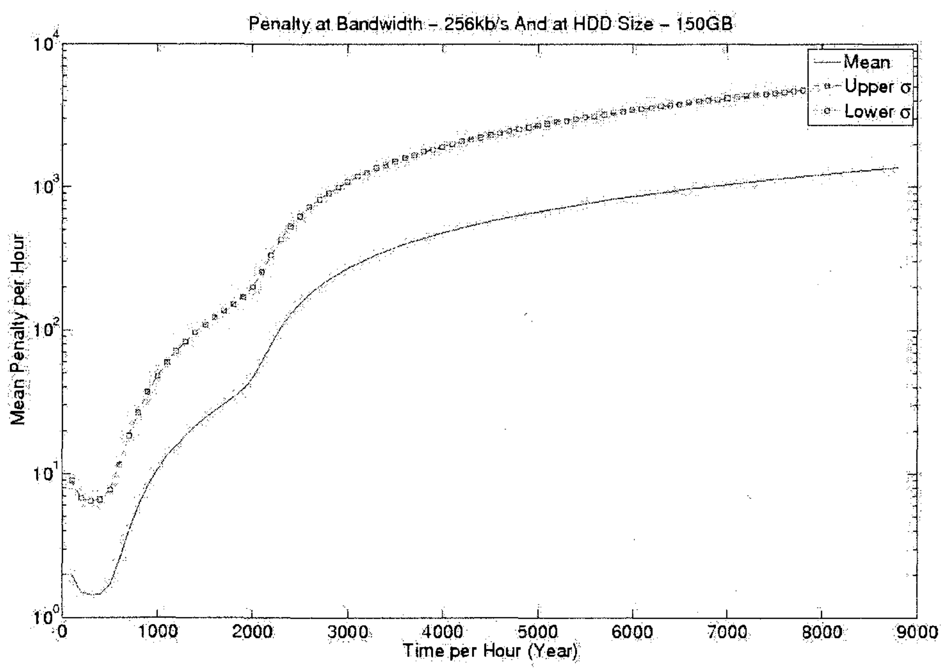


Figure 332: Penalty for H2 case scenario at hard drive size of 200GB and download bandwidth of 256kb/s

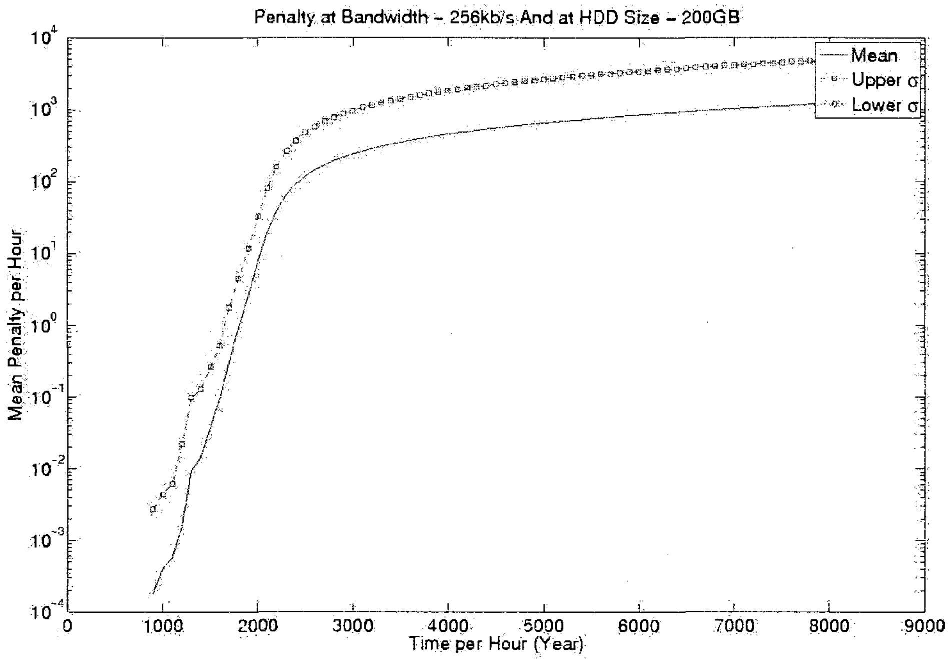


Figure 333: Penalty for H2 case scenario at hard drive size of 50GB and download bandwidth of 512kb/s

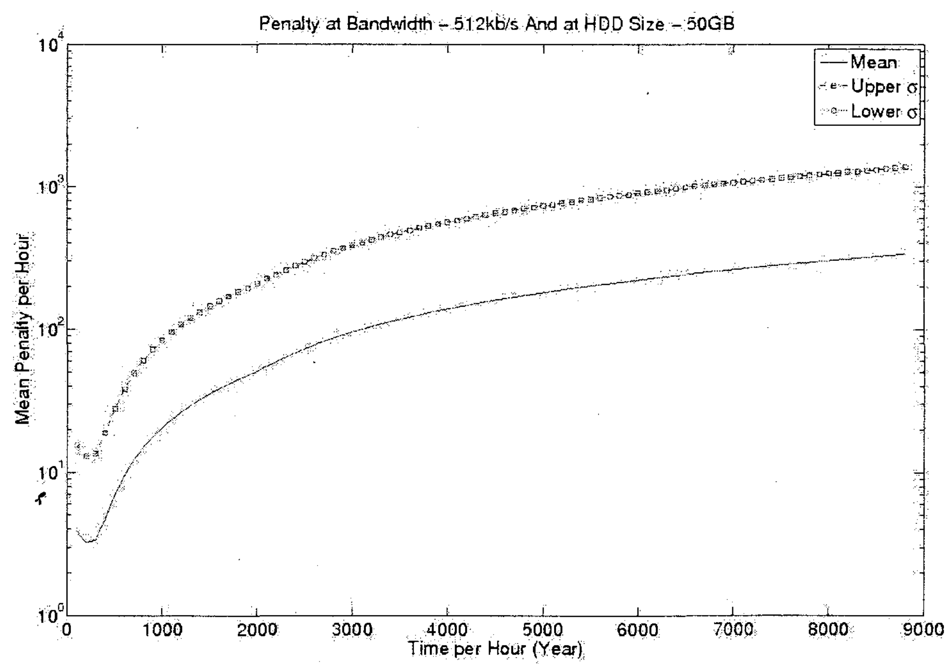


Figure 334: Penalty for H2 case scenario at hard drive size of 100GB and download bandwidth of 512kb/s

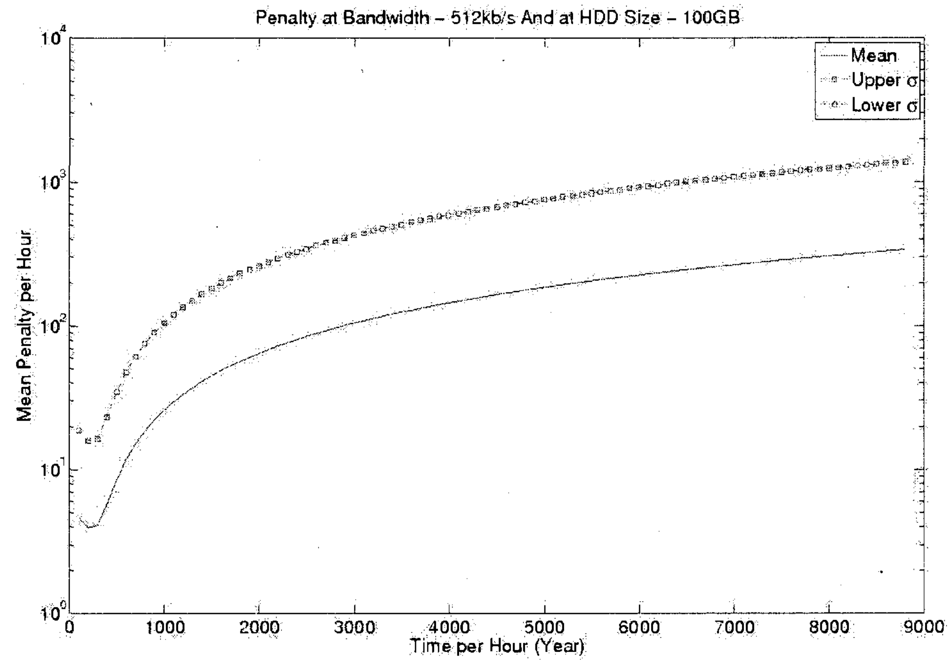


Figure 335: Penalty for H2 case scenario at hard drive size of 150GB and download bandwidth of 512kb/s

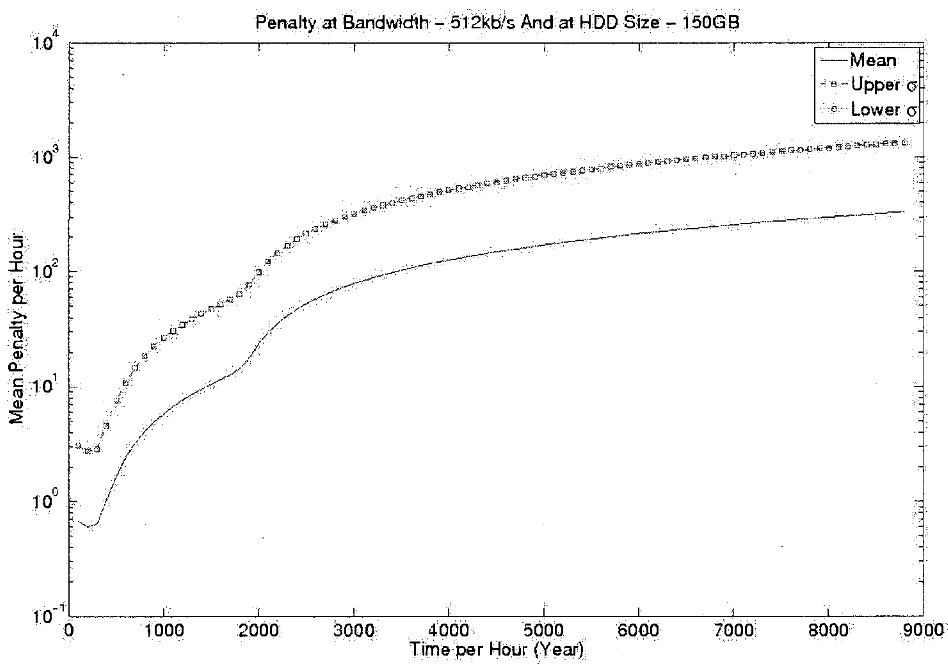


Figure 336: Penalty for H2 case scenario at hard drive size of 200GB and download bandwidth of 512kb/s

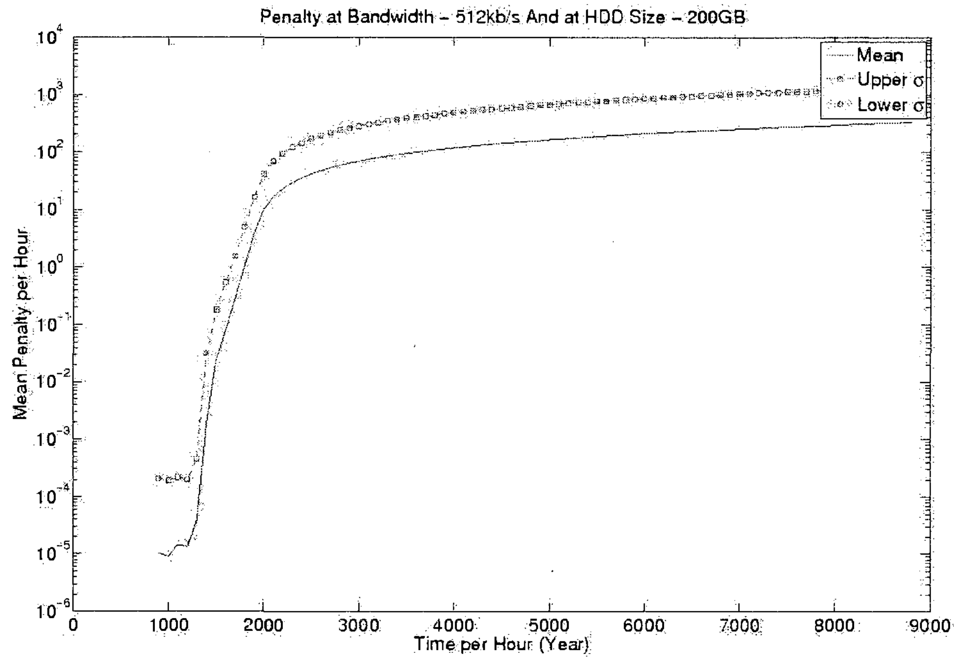


Figure 337: Penalty for H2 case scenario at hard drive size of 50GB and download bandwidth of 1000kb/s

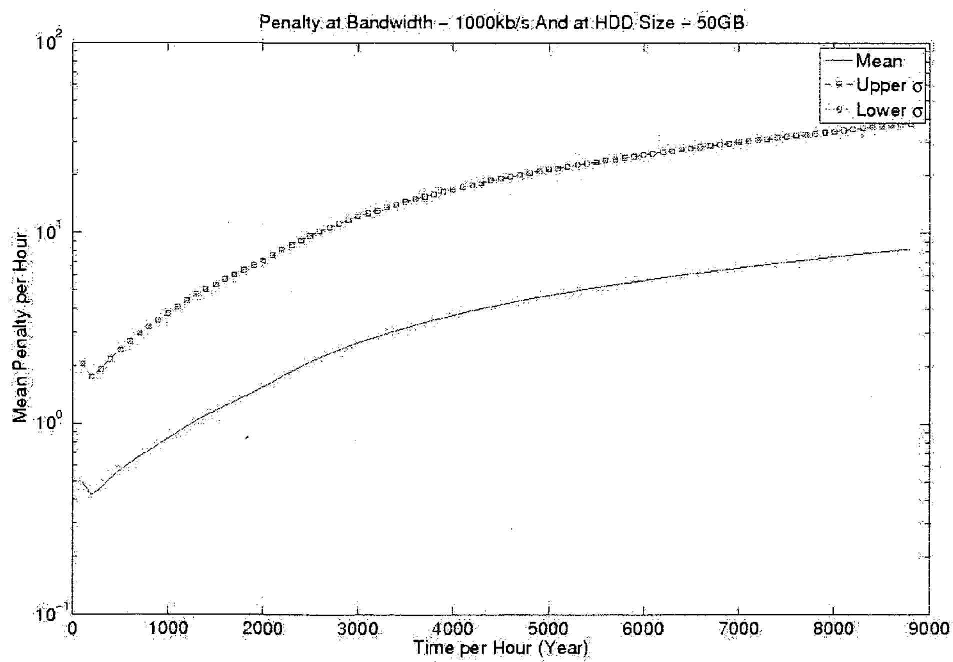


Figure 338: Penalty for H2 case scenario at hard drive size of 100GB and download bandwidth of 1000kb/s

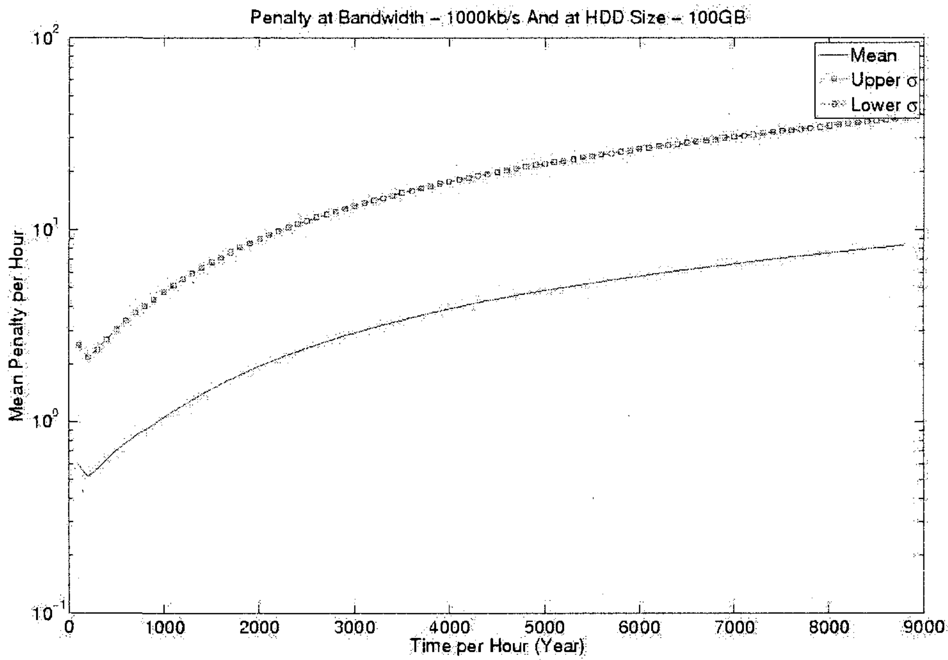


Figure 339: Penalty for H2 case scenario at hard drive size of 150GB and download bandwidth of 1000kb/s

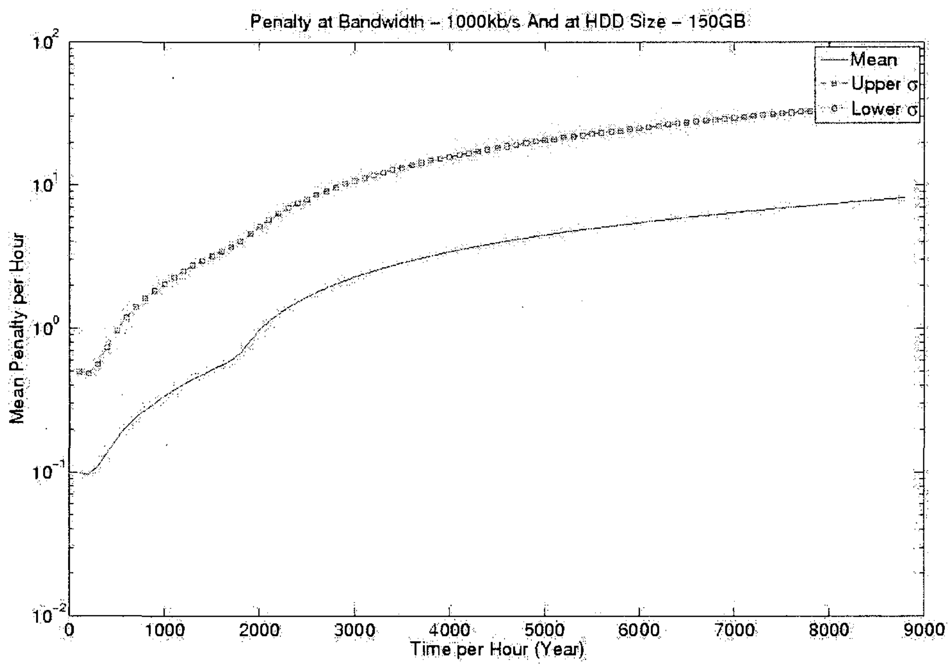


Figure 340: Penalty for H2 case scenario at hard drive size of 200GB and download bandwidth of 1000kb/s

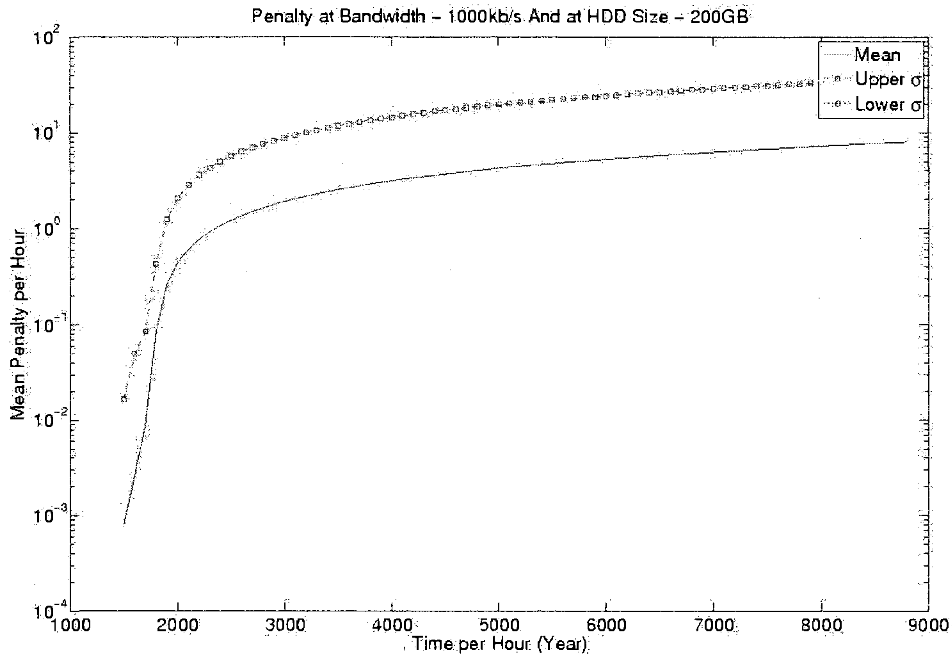


Figure 341: Penalty for H2 case scenario at hard drive size of 50GB and download bandwidth of 2000kb/s

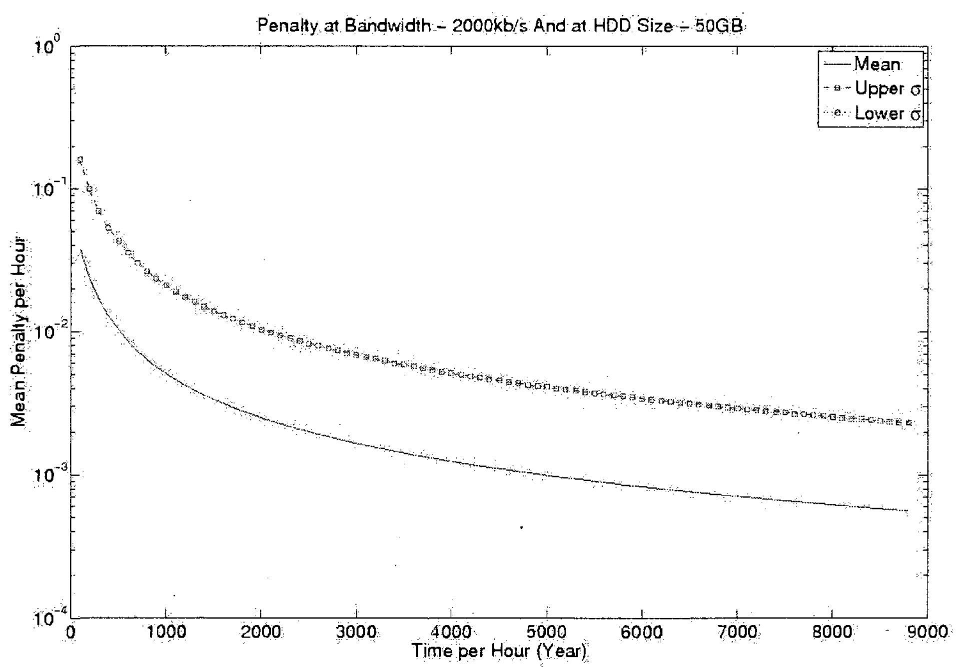


Figure 342: Penalty for H2 case scenario at hard drive size of 100GB and download bandwidth of 2000kb/s

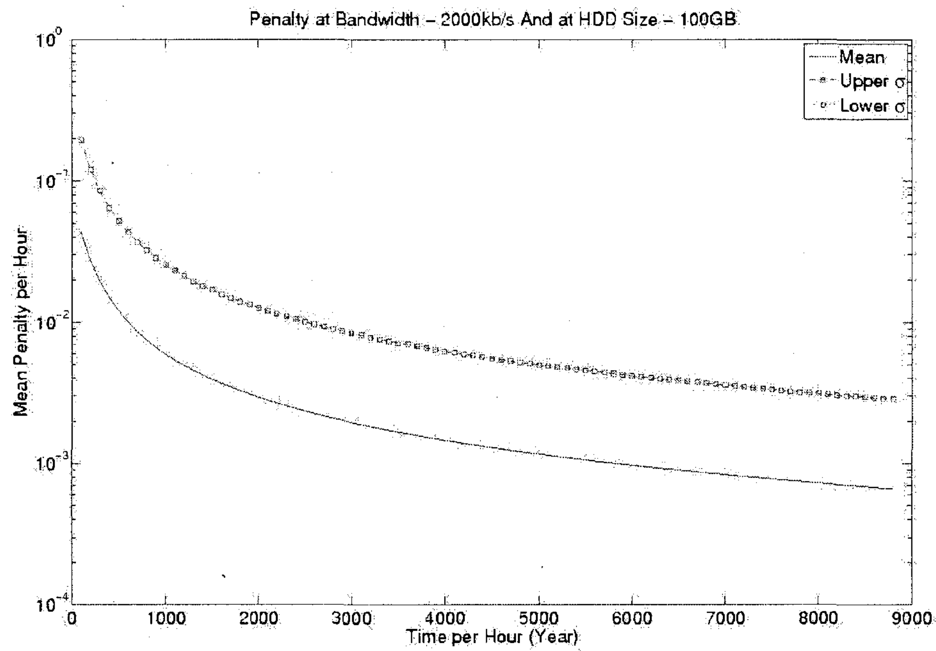


Figure 343: Penalty for H2 case scenario at hard drive size of 150GB and download bandwidth of 2000kb/s

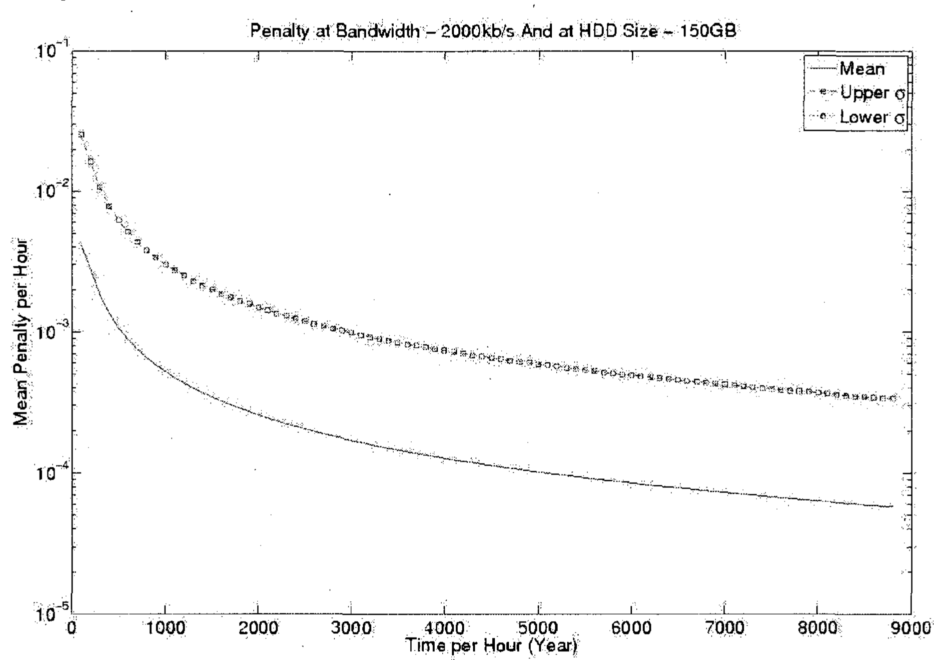


Figure 344: Penalty for H2 case scenario at hard drive size of 200GB and download bandwidth of 2000kb/s

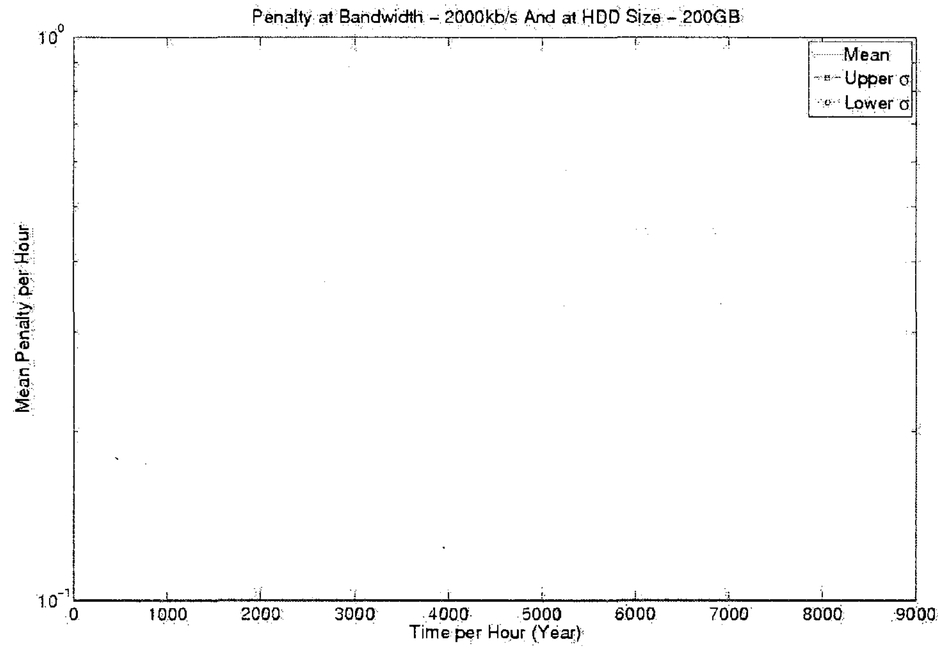


Figure 345: Penalty for H2 case scenario at hard drive size of 50GB and download bandwidth of 5000kb/s

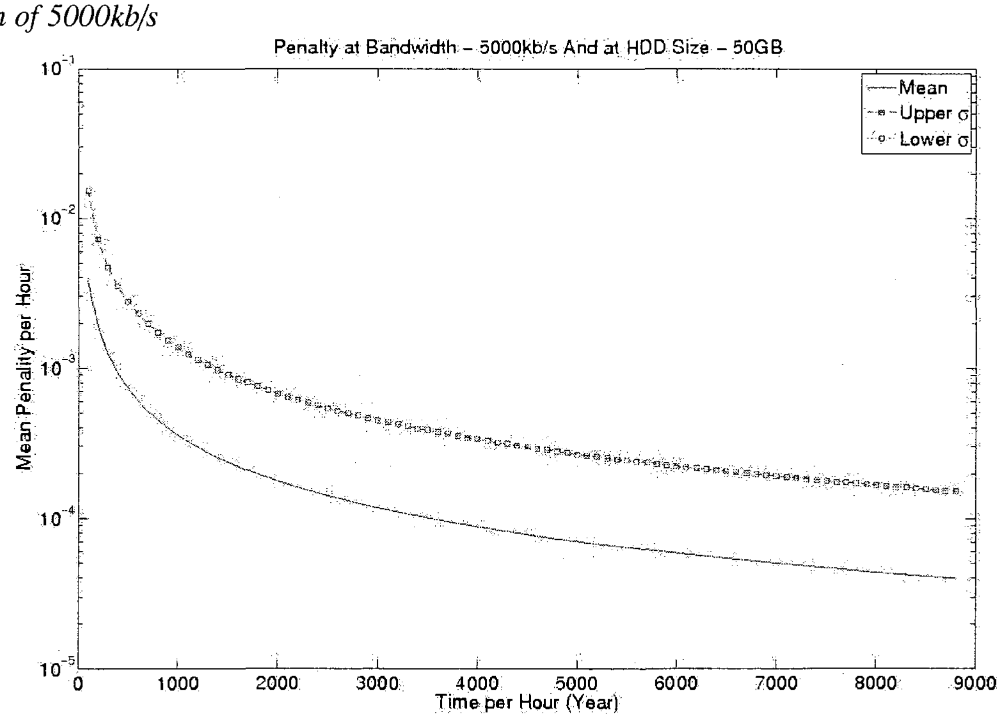


Figure 346: Penalty for H2 case scenario at hard drive size of 100GB and download bandwidth of 5000kb/s

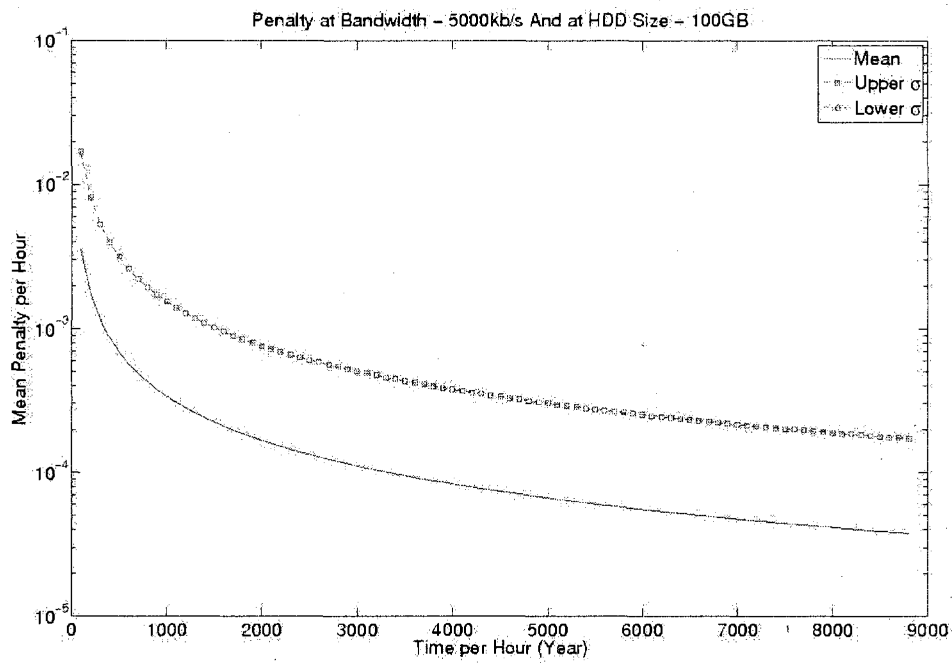


Figure 347: Penalty for H2 case scenario at hard drive size of 150GB and download bandwidth of 5000kb/s

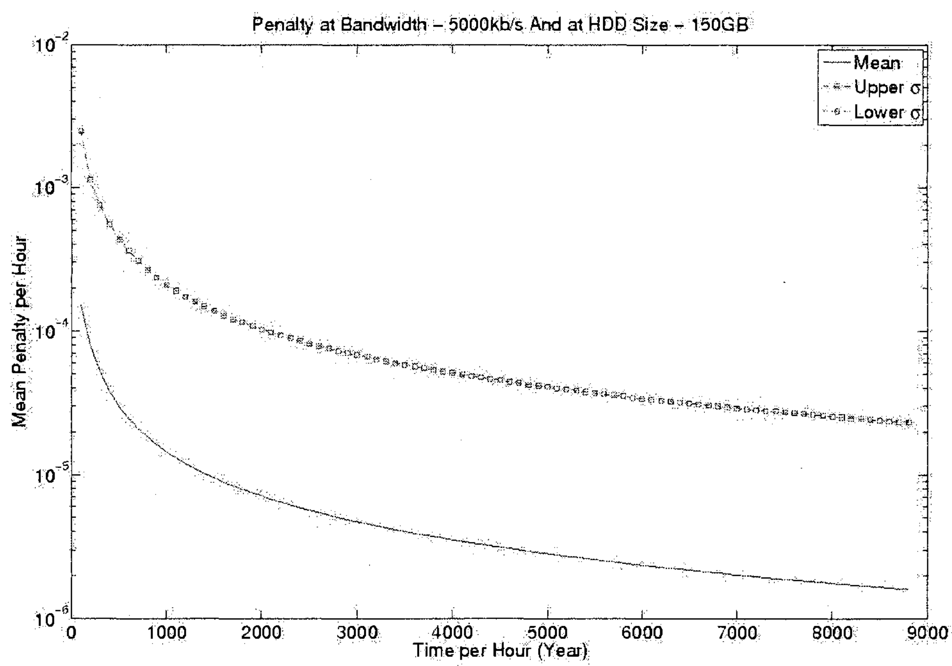


Figure 348: Penalty for H2 case scenario at hard drive size of 200GB and download bandwidth of 5000kb/s

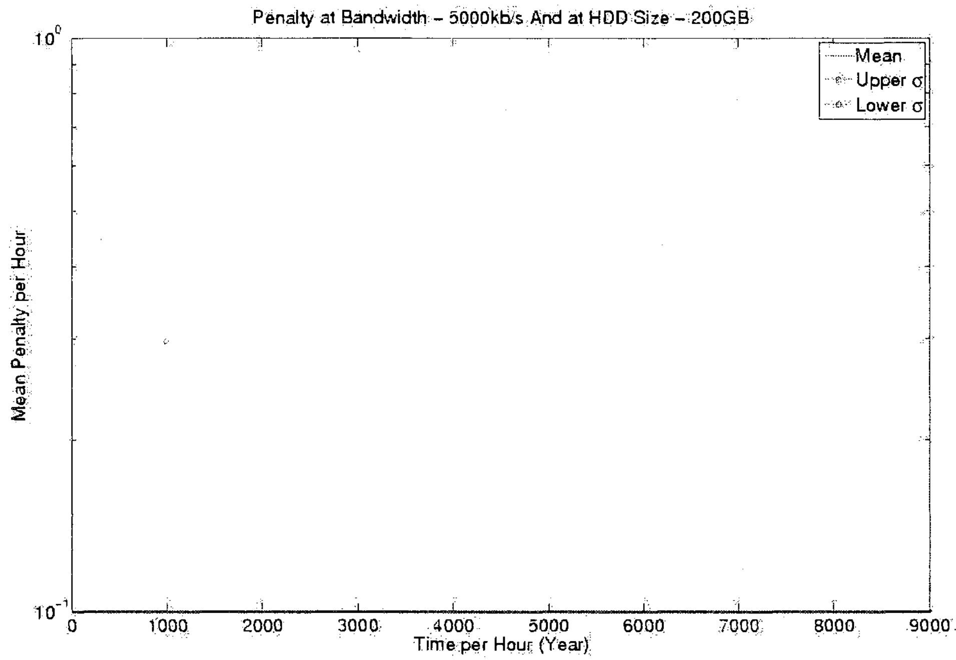


Figure 349: Penalty for H2 case scenario at hard drive size of 50GB and download bandwidth of 10000kb/s

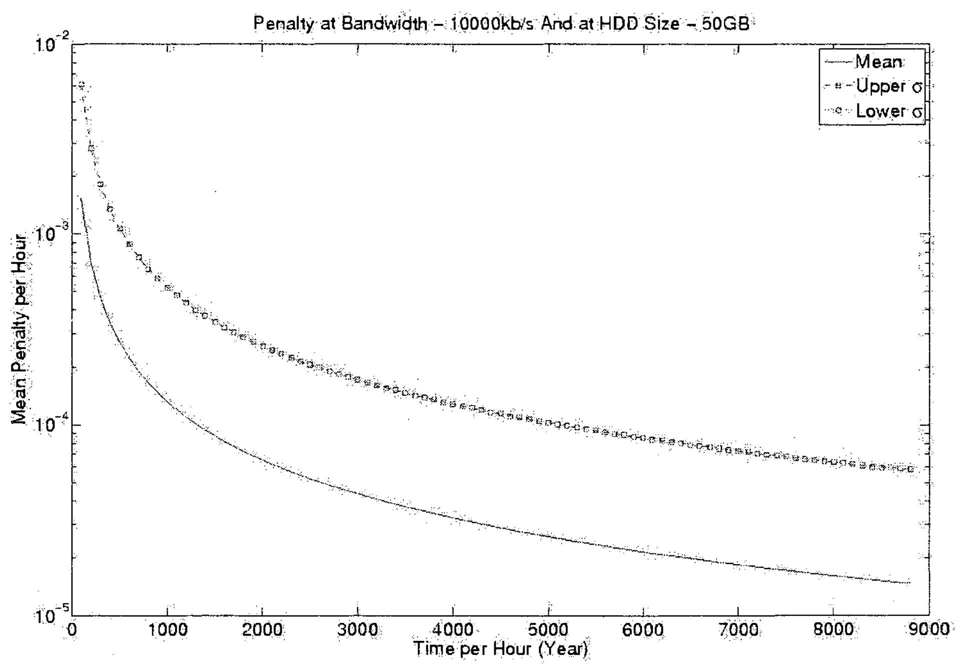


Figure 350: Penalty for H2 case scenario at hard drive size of 100GB and download bandwidth of 10000kb/s

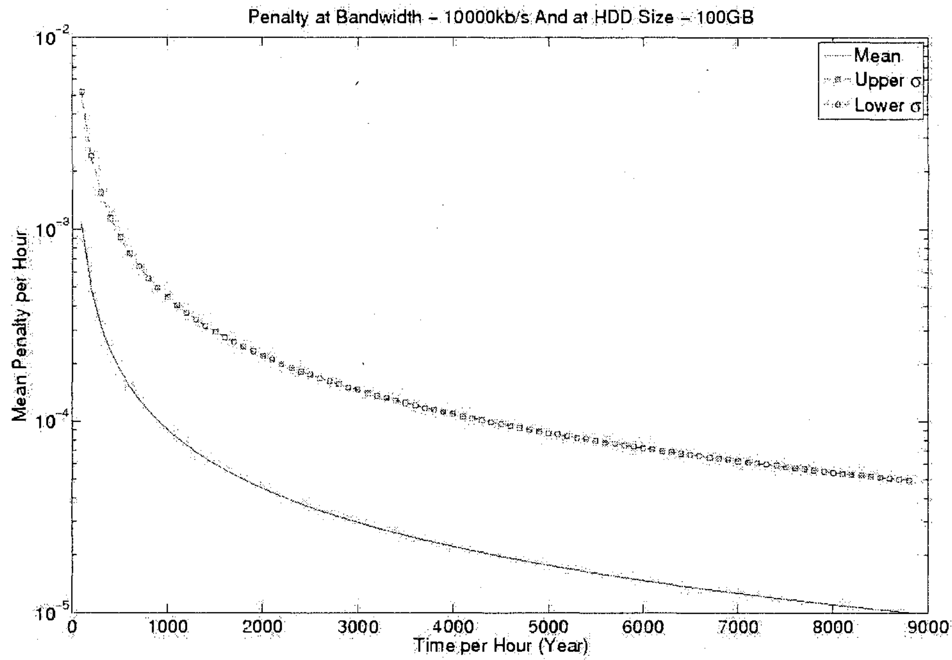


Figure 351: Penalty for H2 case scenario at hard drive size of 150GB and download bandwidth of 10000kb/s

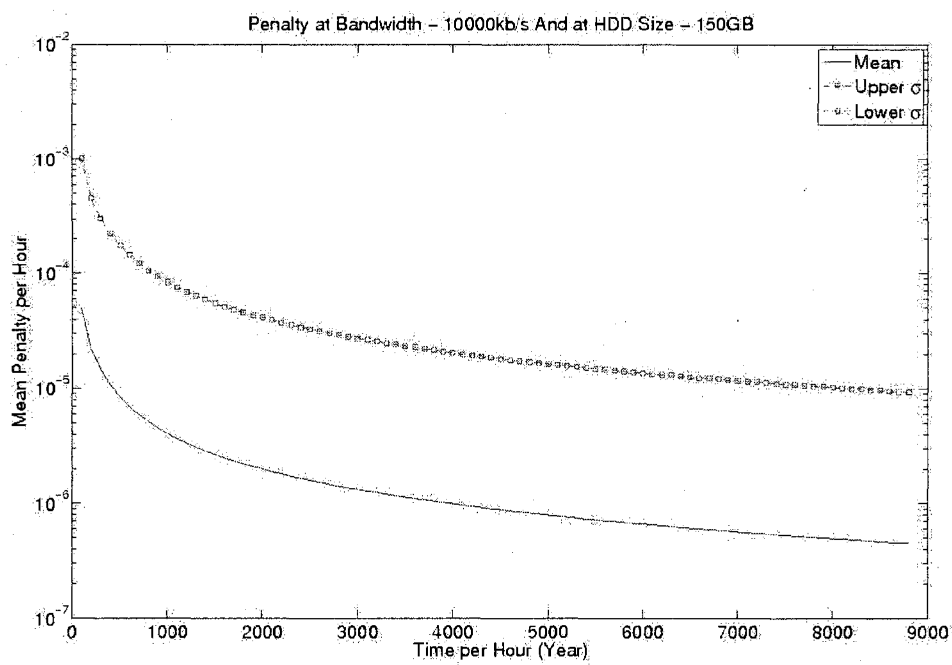


Figure 352: Penalty for H2 case scenario at hard drive size of 200GB and download bandwidth of 10000kb/s

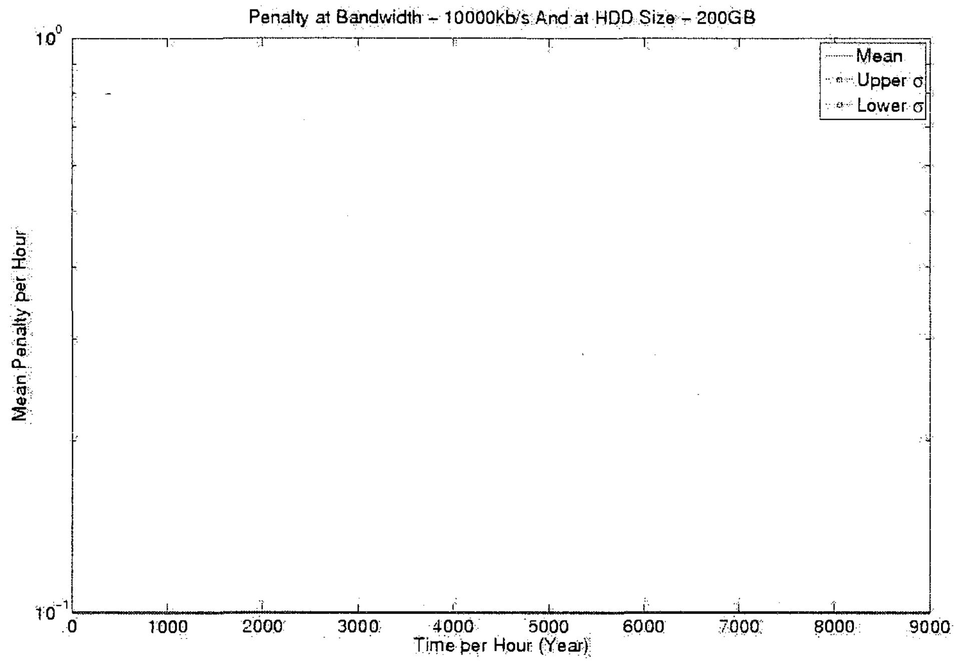


Figure 353: Penalty for H2 case scenario at hard drive size of 50GB and download bandwidth of 15000kb/s

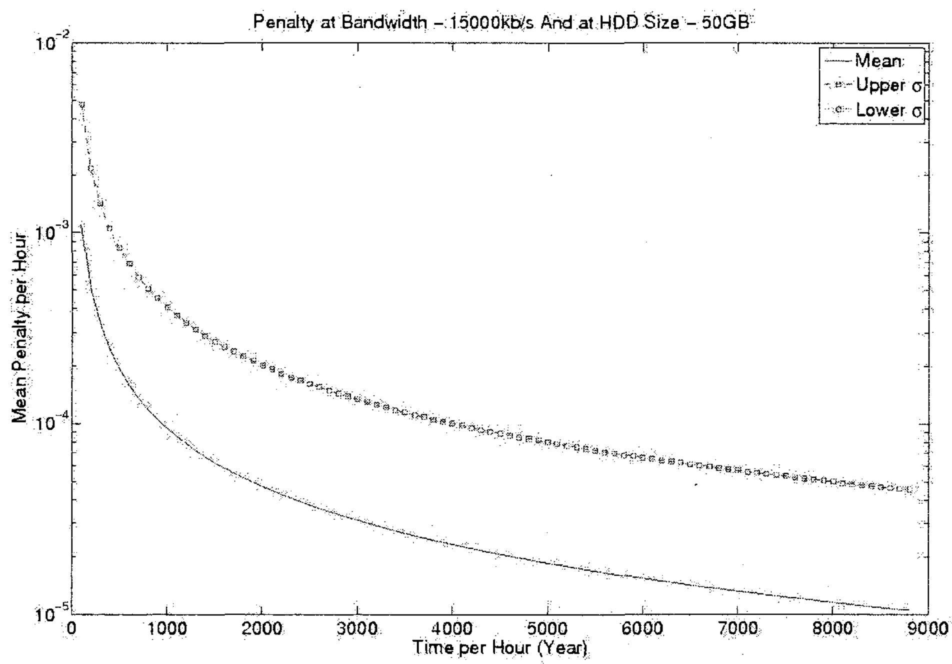


Figure 354: Penalty for H2 case scenario at hard drive size of 100GB and download bandwidth of 15000kb/s

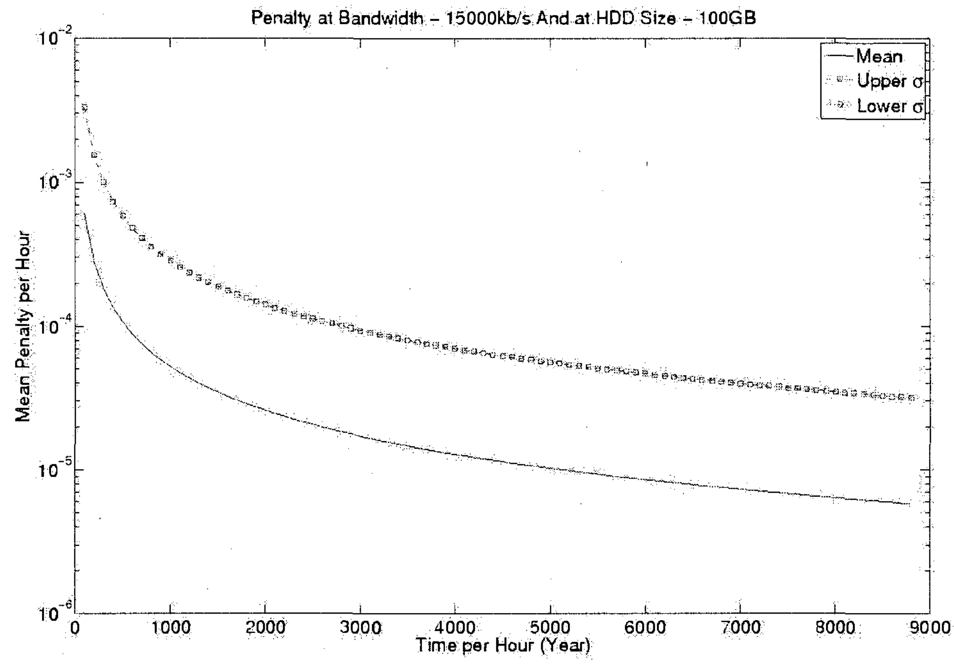


Figure 355: Penalty for H2 case scenario at hard drive size of 150GB and download bandwidth of 15000kb/s

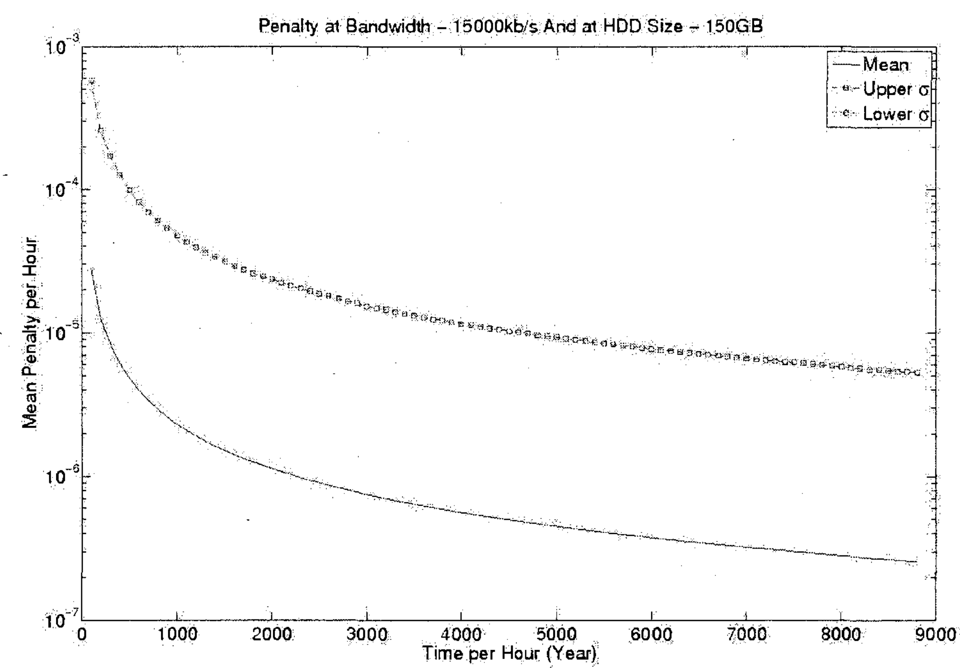


Figure 356: Penalty for H2 case scenario at hard drive size of 200GB and download bandwidth of 15000kb/s

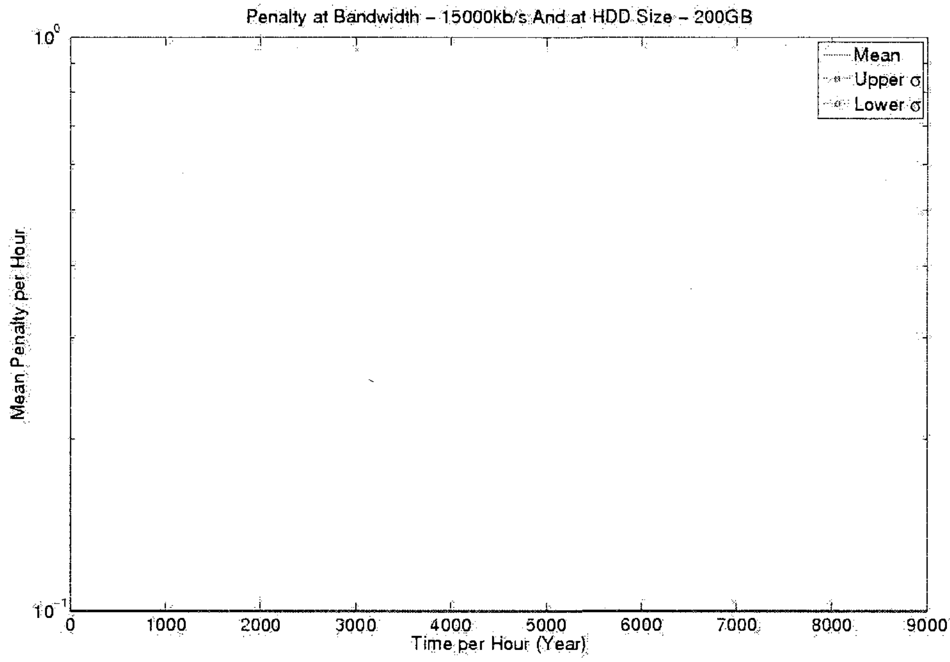


Figure 357: Penalty for H3 case scenario at hard drive size of 50GB and download bandwidth of 25kb/s

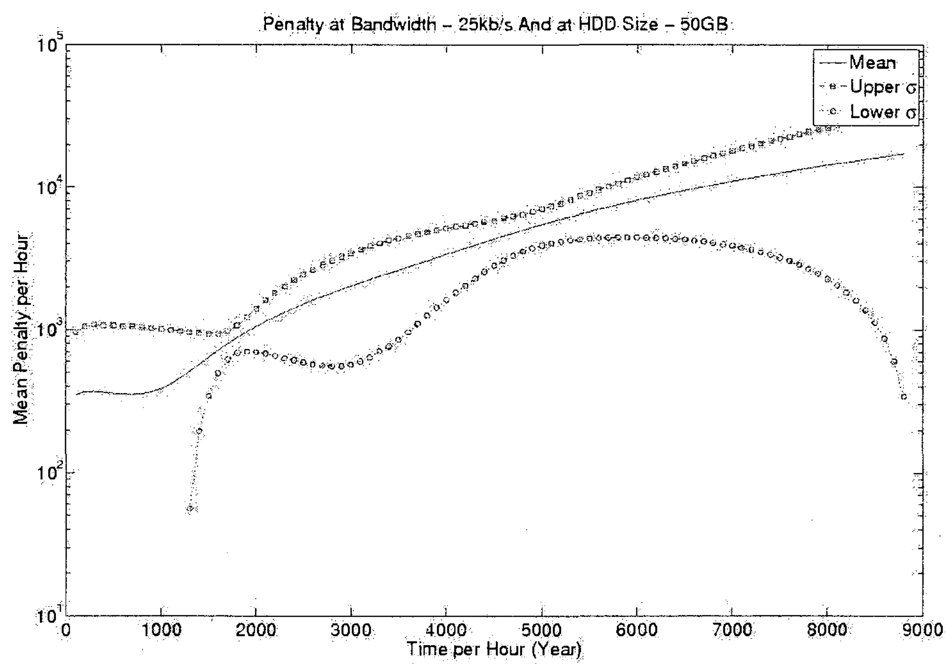


Figure 358: Penalty for H3 case scenario at hard drive size of 100GB and download bandwidth of 25kb/s

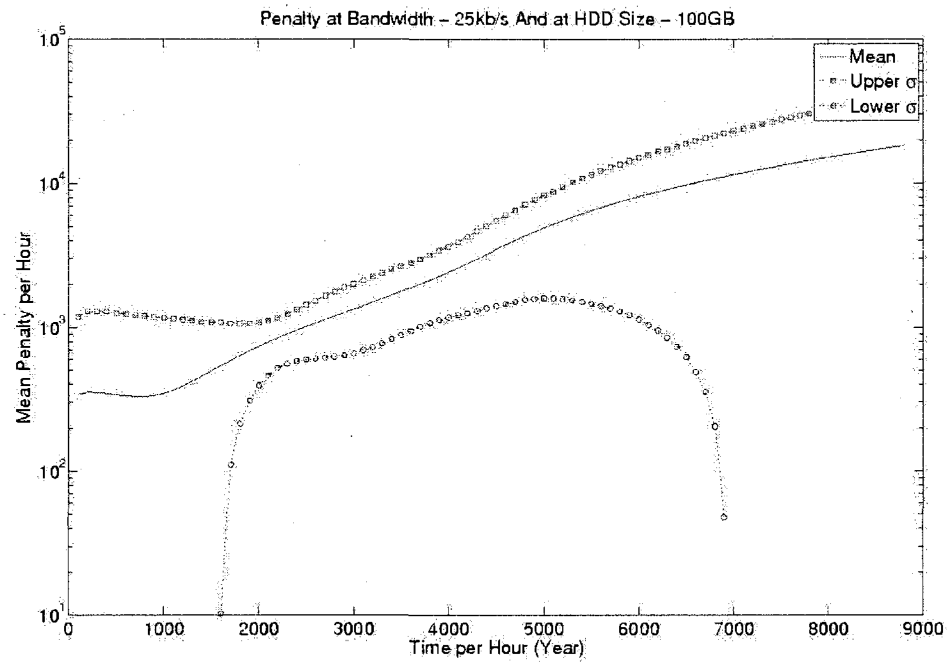


Figure 359: Penalty for H3 case scenario at hard drive size of 150GB and download bandwidth of 25kb/s

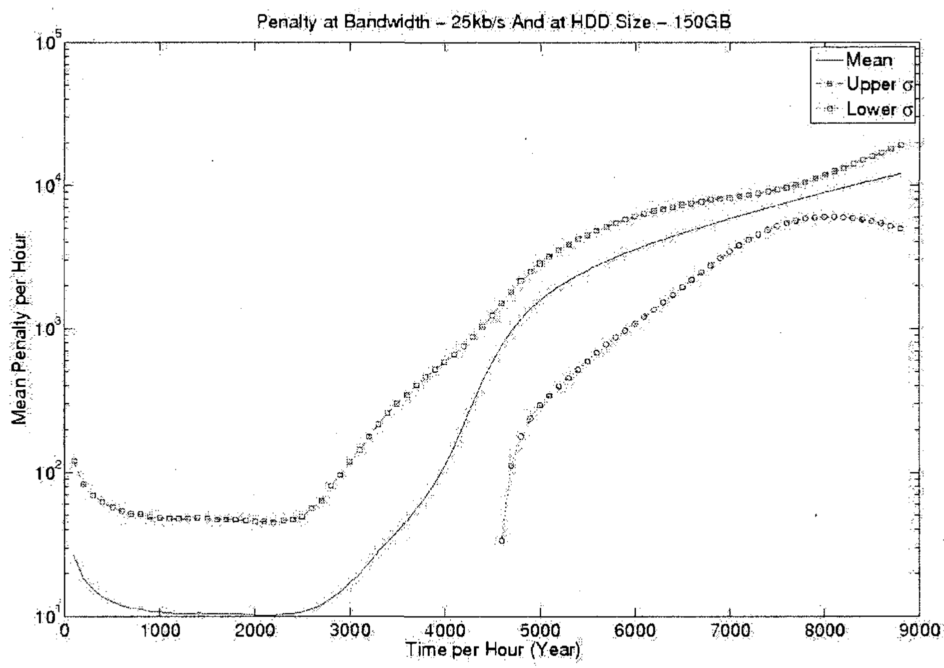


Figure 360: Penalty for H3 case scenario at hard drive size of 200GB and download bandwidth of 25kb/s

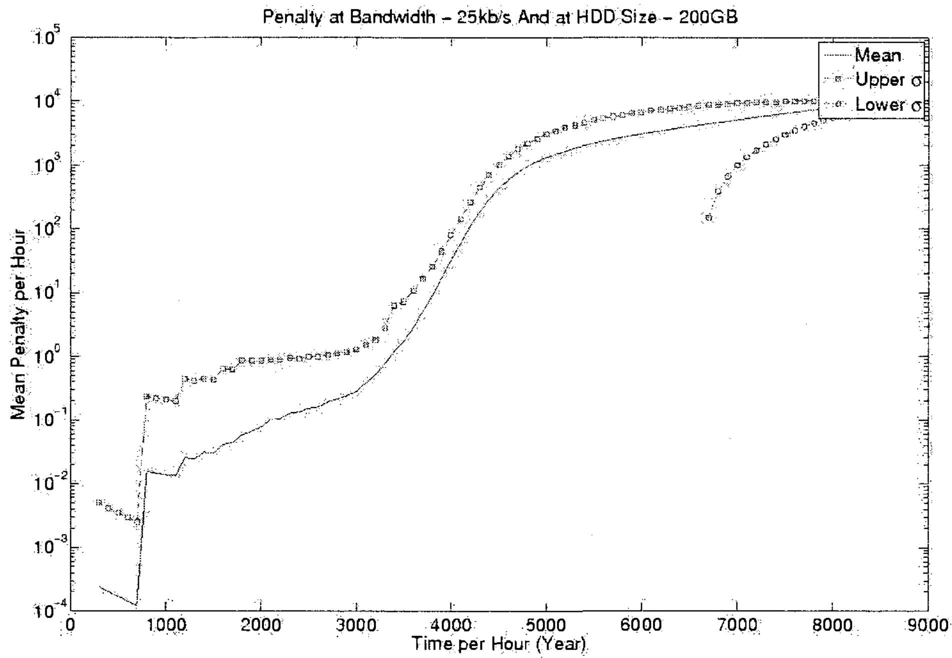


Figure 361: Penalty for H3 case scenario at hard drive size of 50GB and download bandwidth of 50kb/s

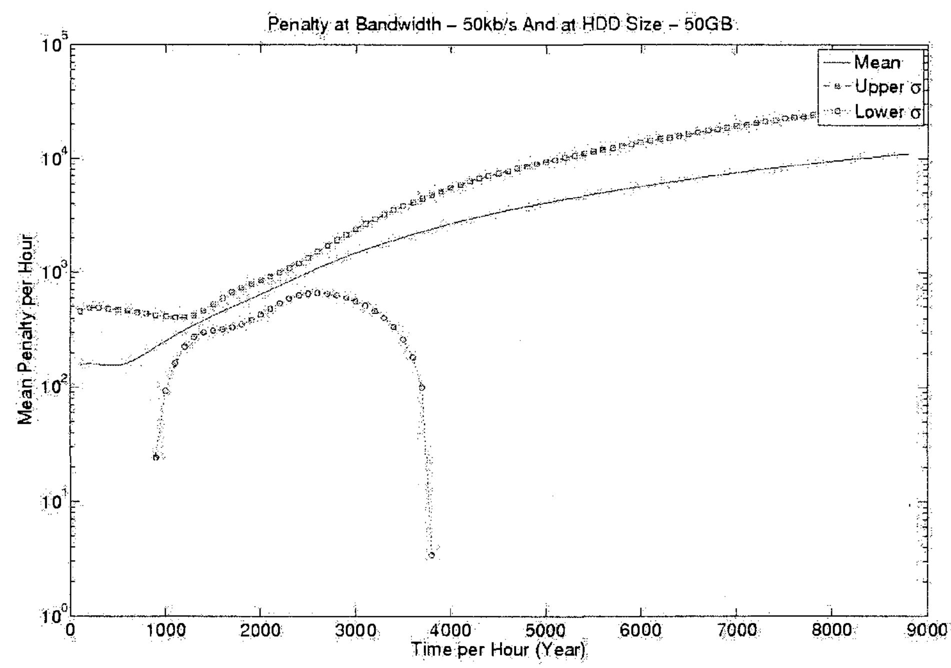


Figure 362: Penalty for H3 case scenario at hard drive size of 100GB and download bandwidth of 50kb/s

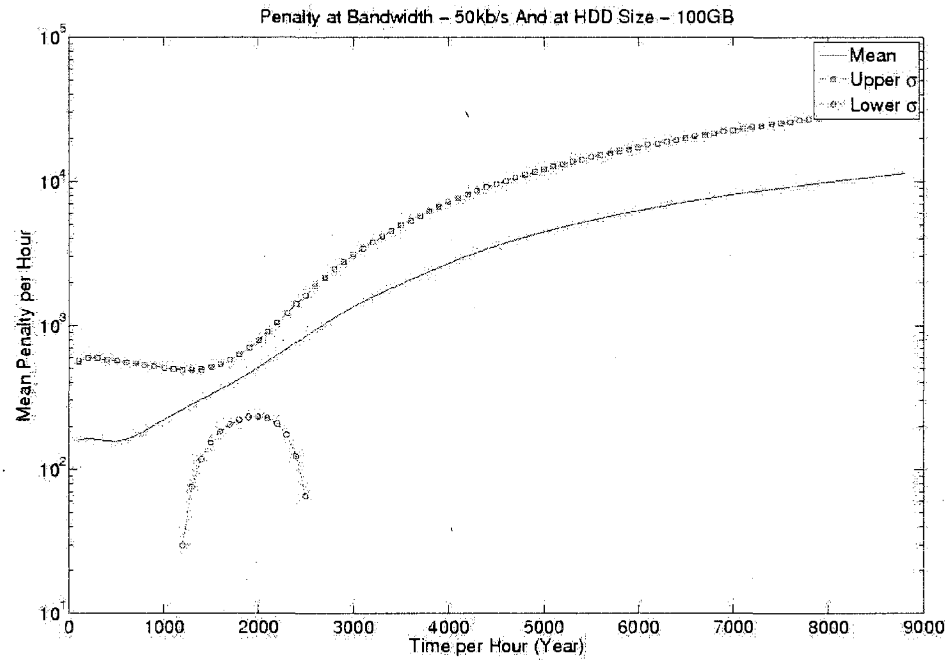


Figure 363: Penalty for H3 case scenario at hard drive size of 150GB and download bandwidth of 50kb/s

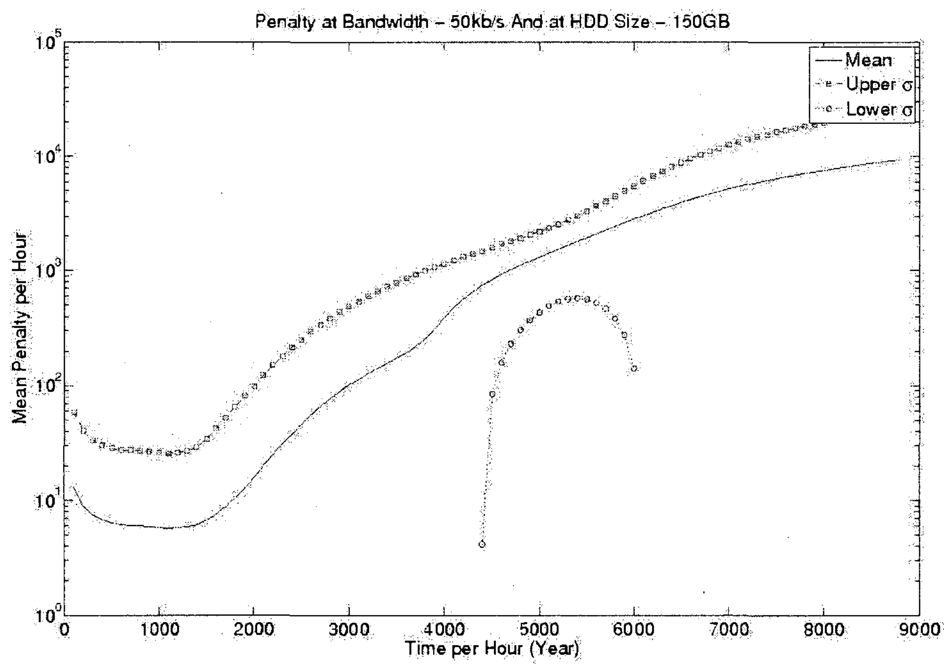


Figure 364: Penalty for H3 case scenario at hard drive size of 200GB and download bandwidth of 50kb/s

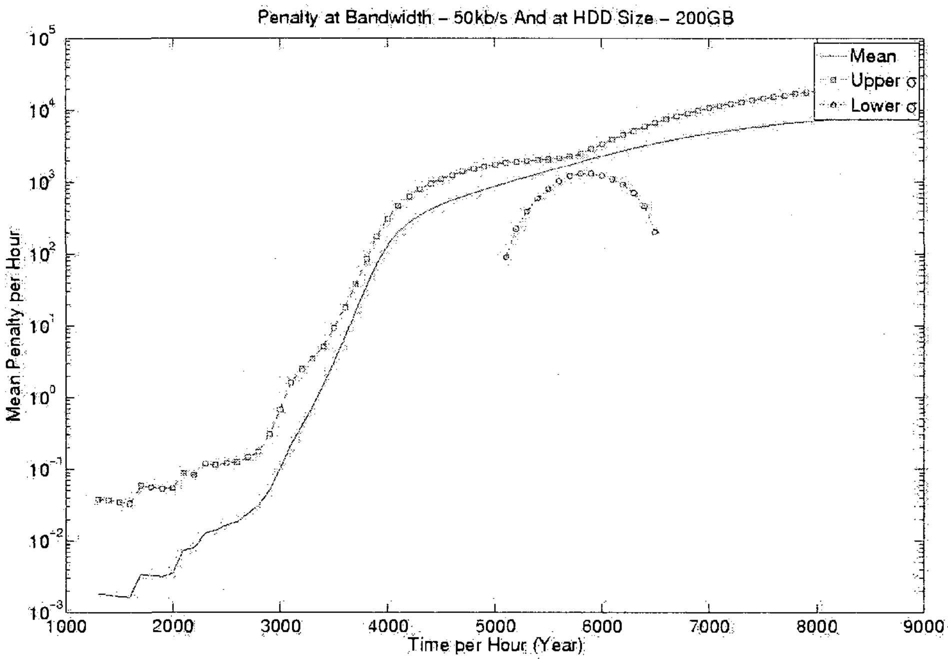


Figure 365: Penalty for H3 case scenario at hard drive size of 50GB and download bandwidth of 100kb/s

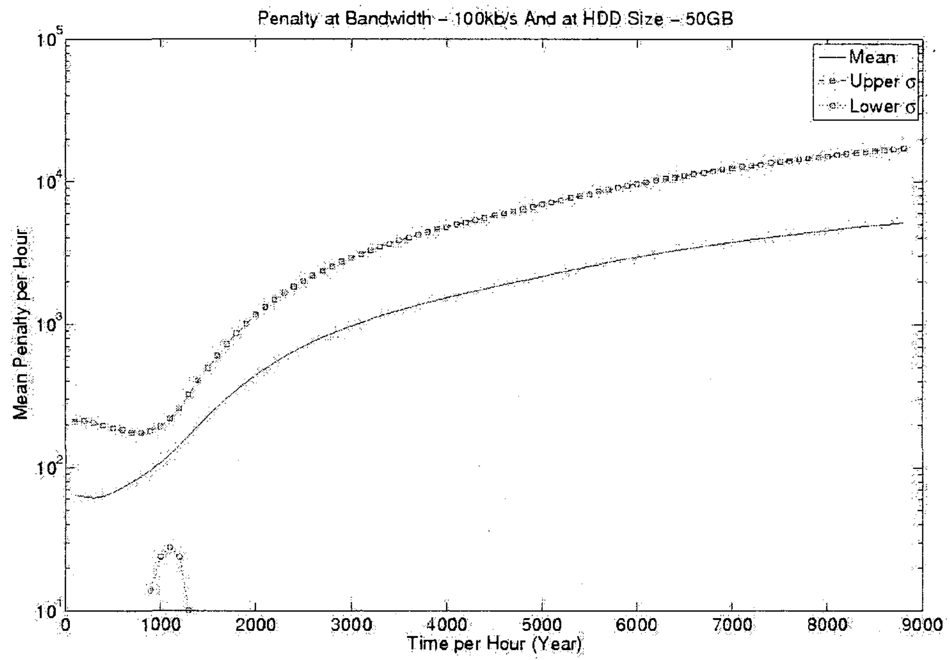


Figure 366: Penalty for H3 case scenario at hard drive size of 100GB and download bandwidth of 100kb/s

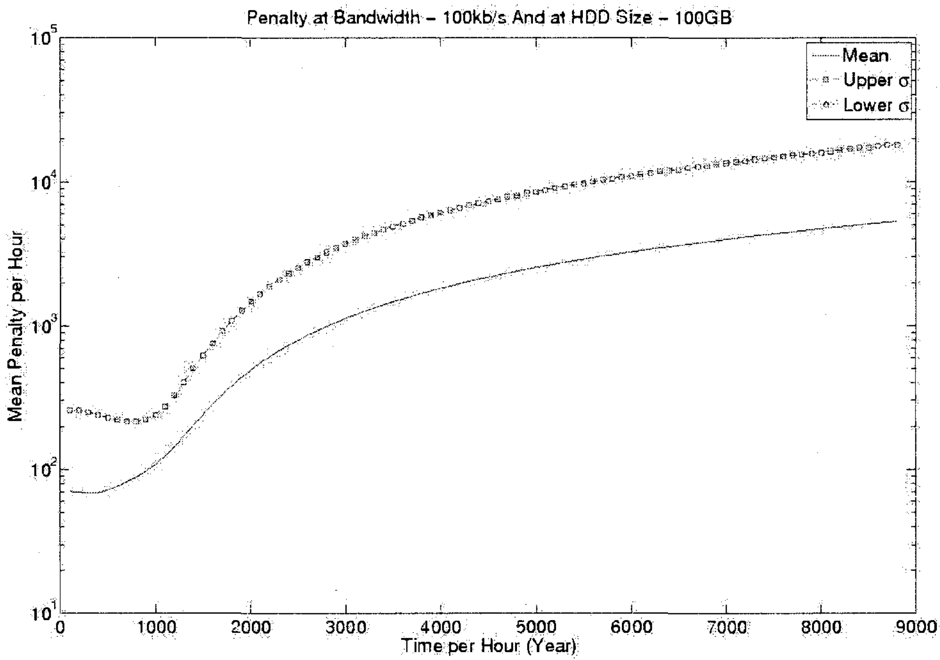


Figure 367: Penalty for H3 case scenario at hard drive size of 150GB and download bandwidth of 100kb/s

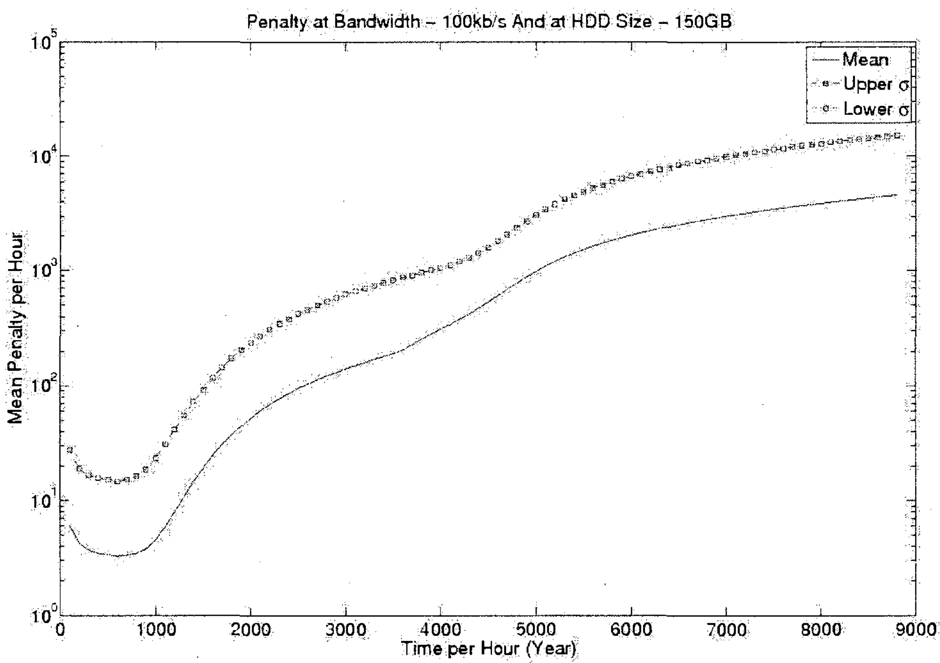


Figure 368: Penalty for H3 case scenario at hard drive size of 200GB and download bandwidth of 100kb/s

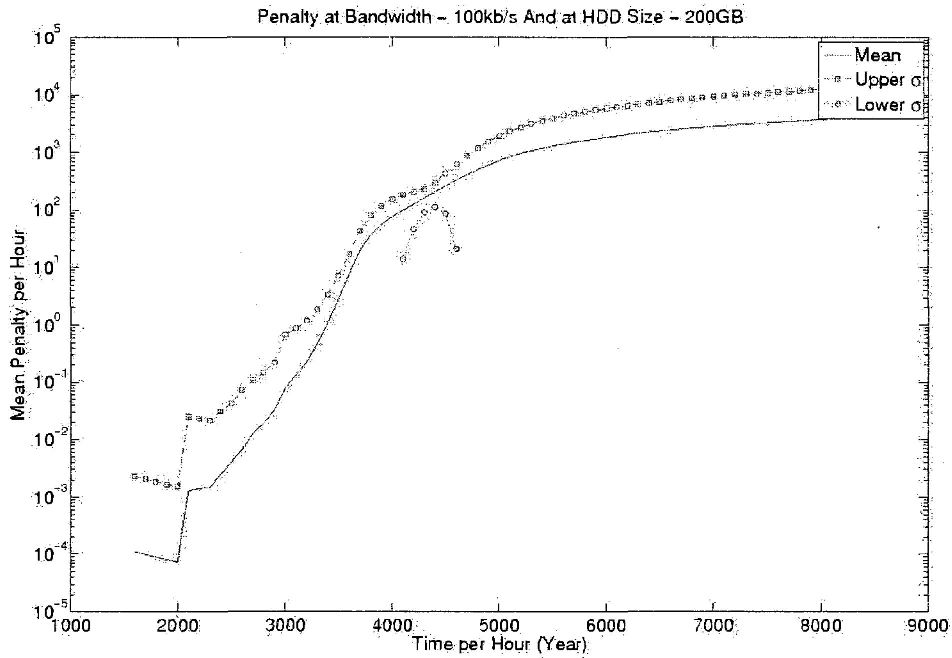


Figure 369: Penalty for H3 case scenario at hard drive size of 50GB and download bandwidth of 128kb/s

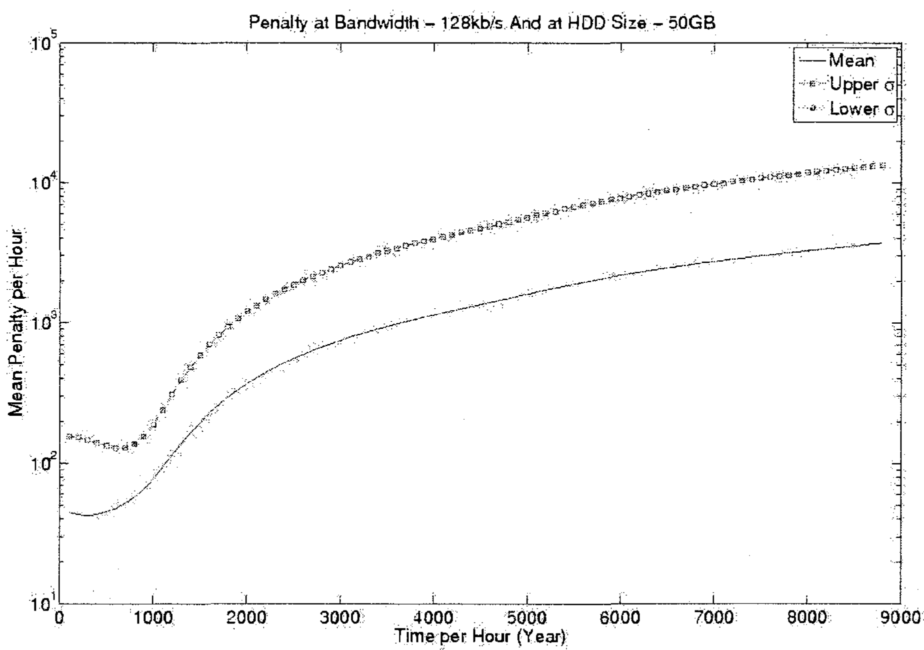


Figure 370: Penalty for H3 case scenario at hard drive size of 100GB and download bandwidth of 128kb/s

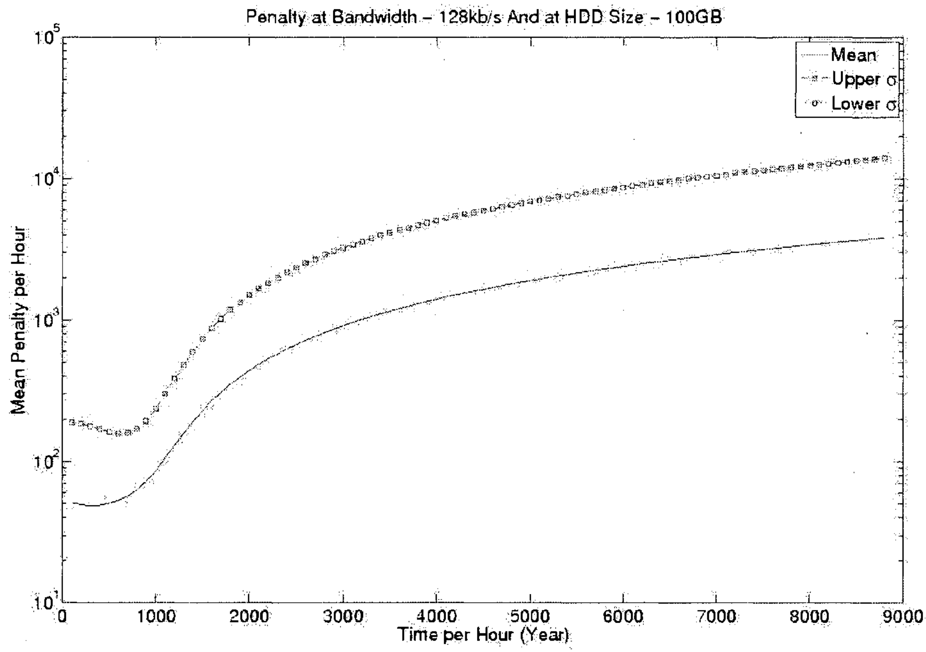


Figure 371: Penalty for H3 case scenario at hard drive size of 150GB and download bandwidth of 128kb/s

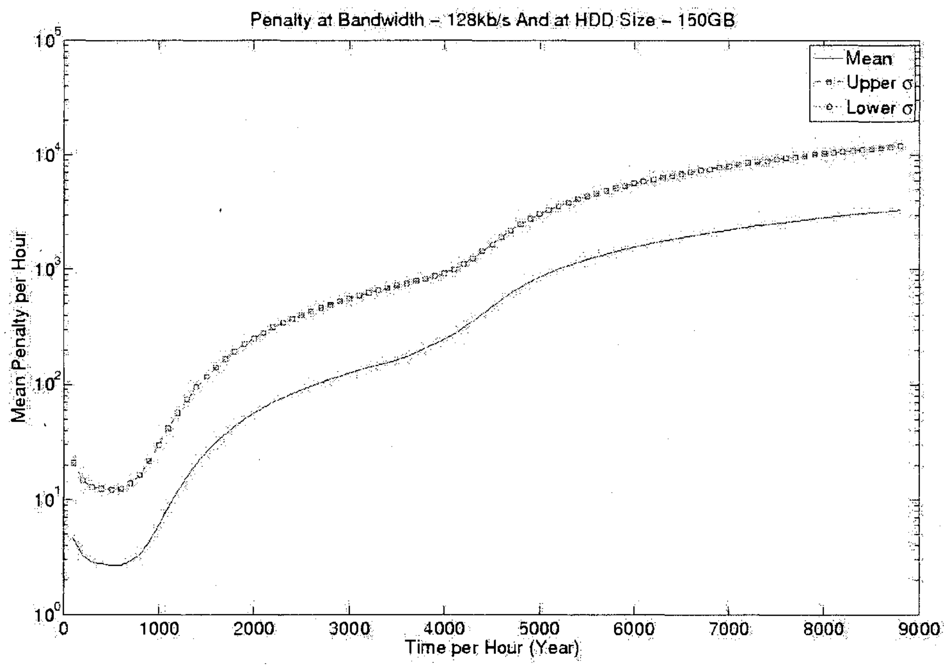


Figure 372: Penalty for H3 case scenario at hard drive size of 200GB and download bandwidth of 128kb/s

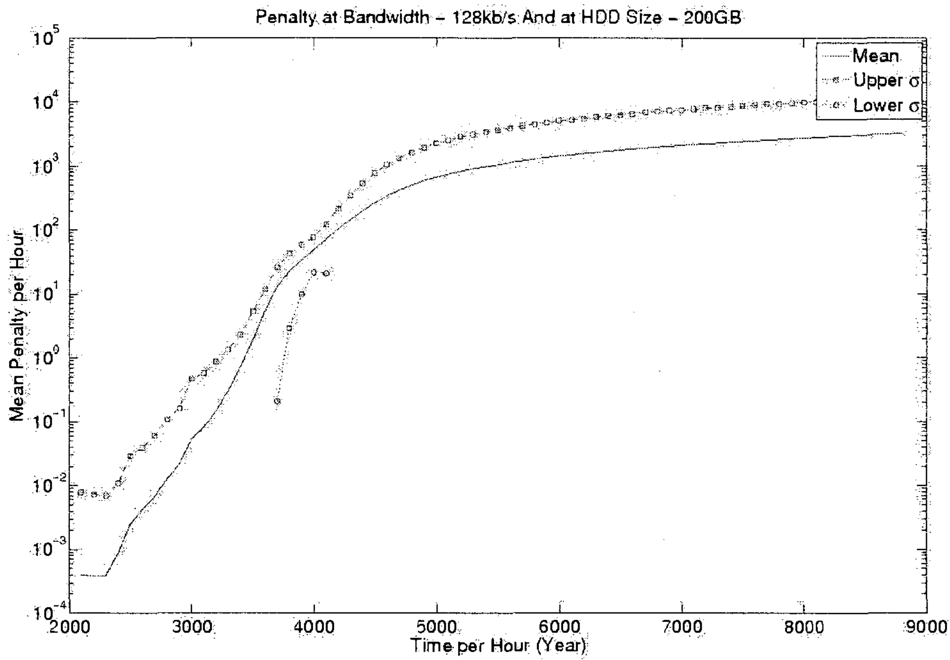


Figure 373: Penalty for H3 case scenario at hard drive size of 50GB and download bandwidth of 256kb/s

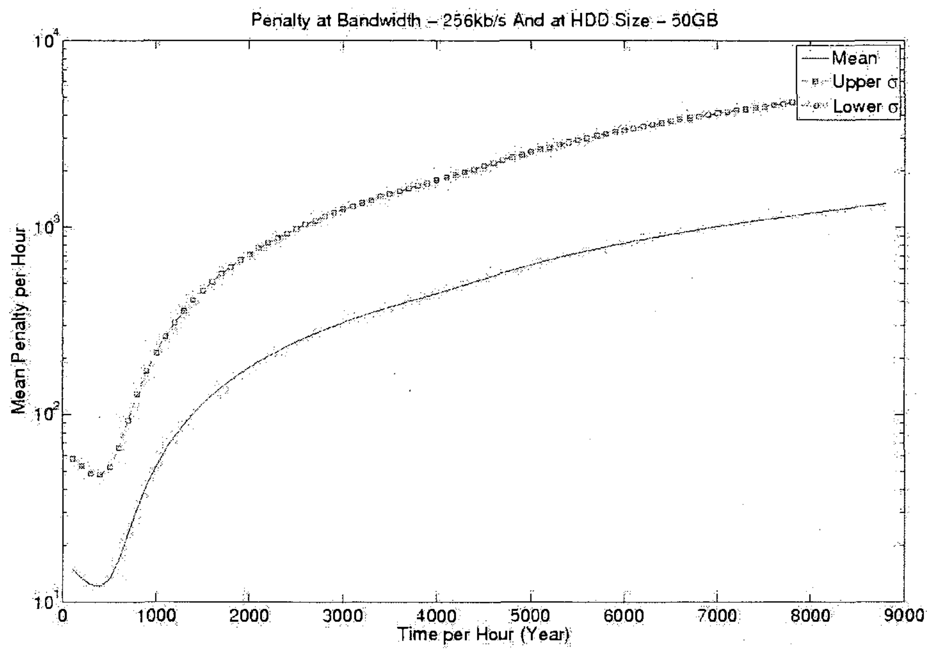


Figure 374: Penalty for H3 case scenario at hard drive size of 100GB and download bandwidth of 256kb/s

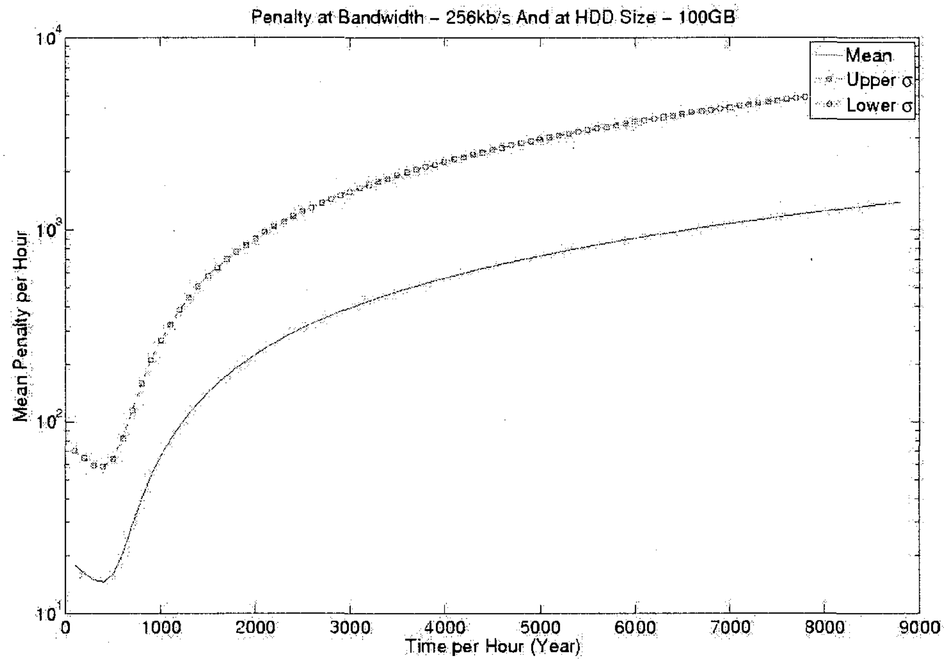


Figure 375: Penalty for H3 case scenario at hard drive size of 150GB and download bandwidth of 256kb/s

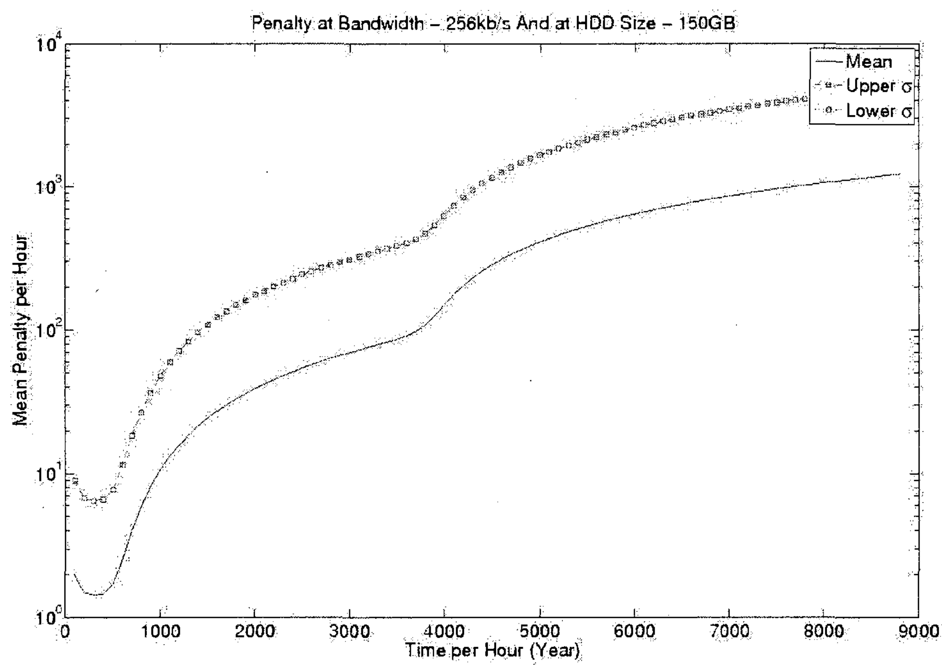


Figure 376: Penalty for H3 case scenario at hard drive size of 200GB and download bandwidth of 256kb/s

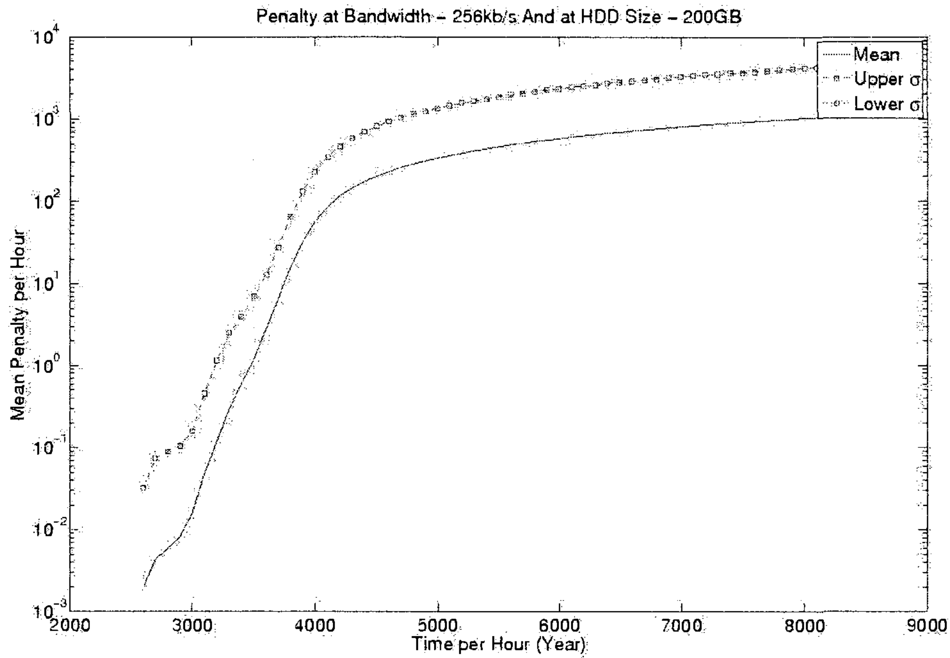


Figure 377: Penalty for H3 case scenario at hard drive size of 50GB and download bandwidth of 512kb/s

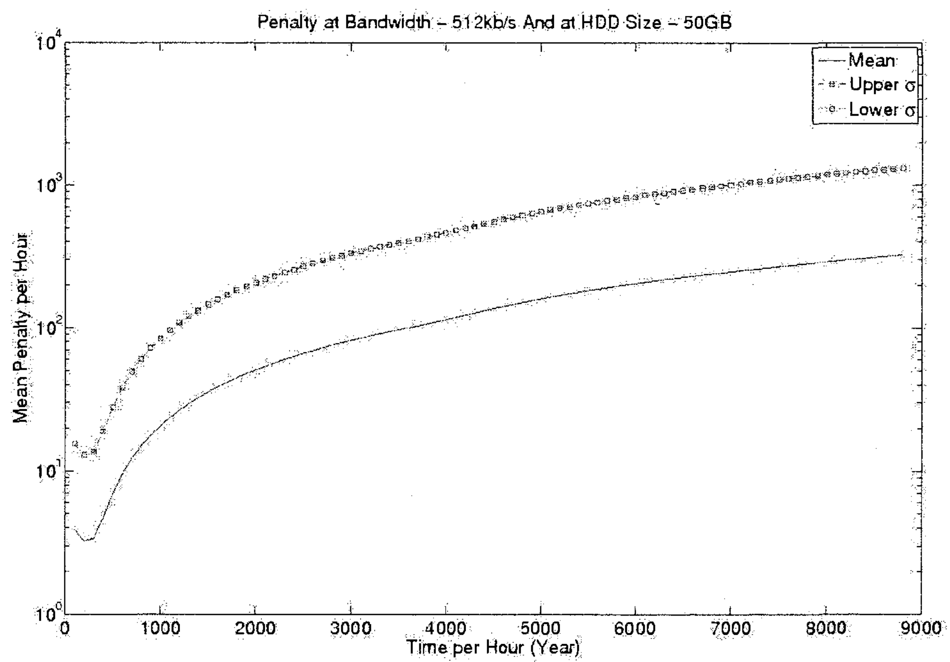


Figure 378: Penalty for H3 case scenario at hard drive size of 100GB and download bandwidth of 512kb/s

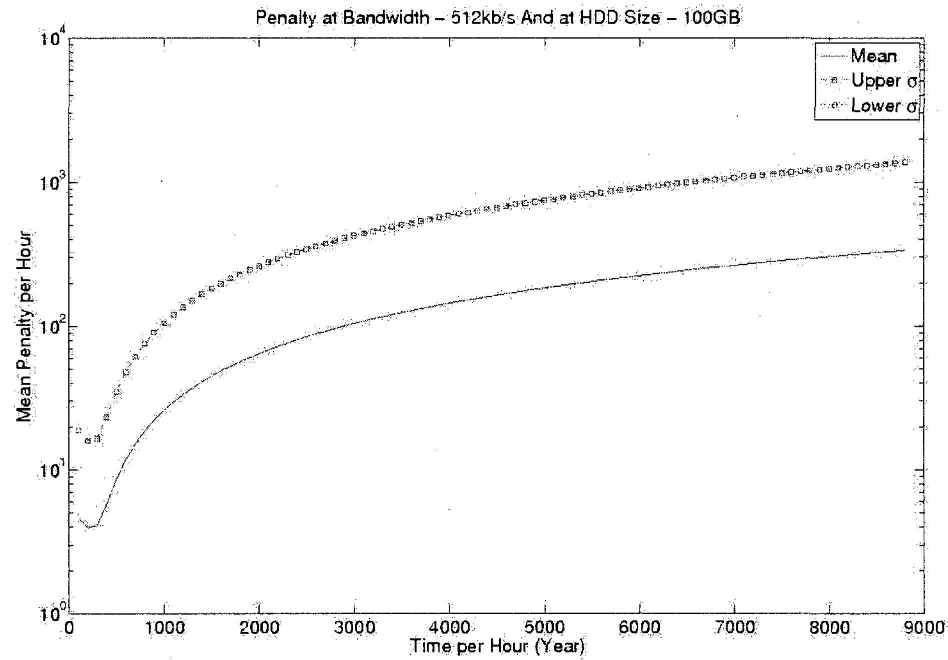


Figure 379: Penalty for H3 case scenario at hard drive size of 150GB and download bandwidth of 512kb/s

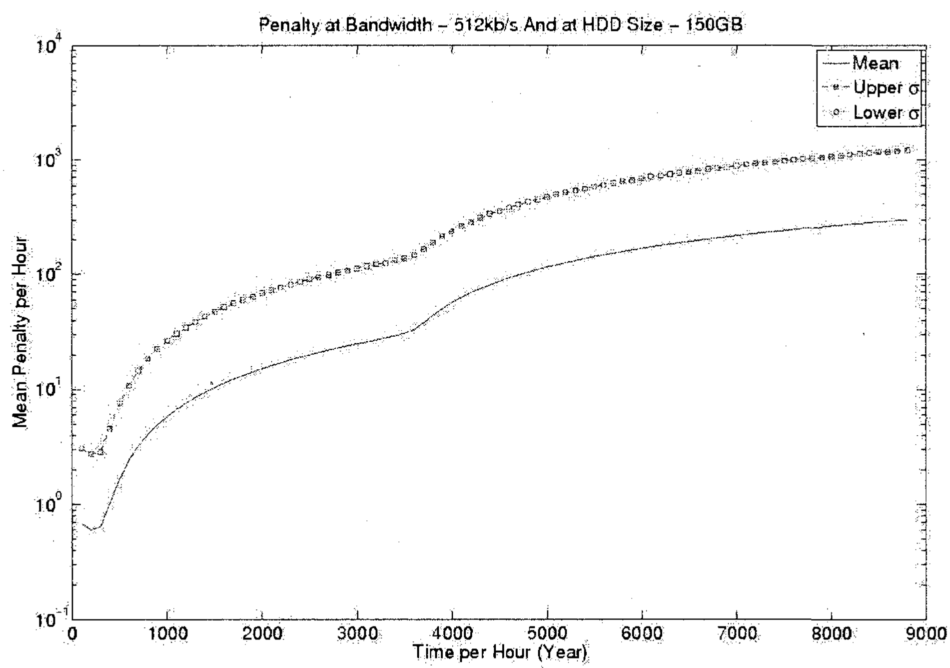


Figure 380: Penalty for H3 case scenario at hard drive size of 200GB and download bandwidth of 512kb/s

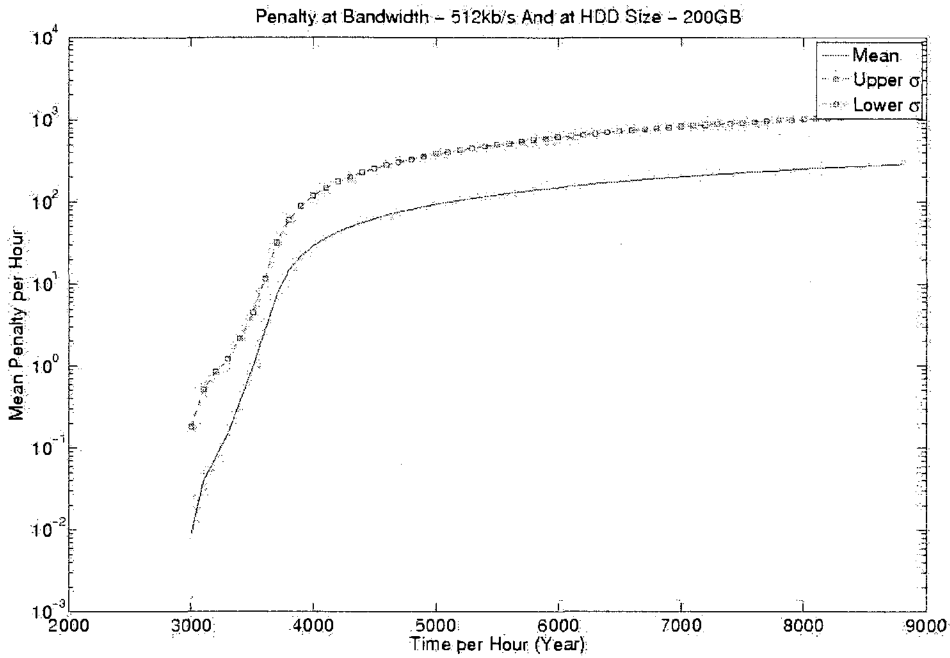


Figure 381: Penalty for H3 case scenario at hard drive size of 50GB and download bandwidth of 1000kb/s

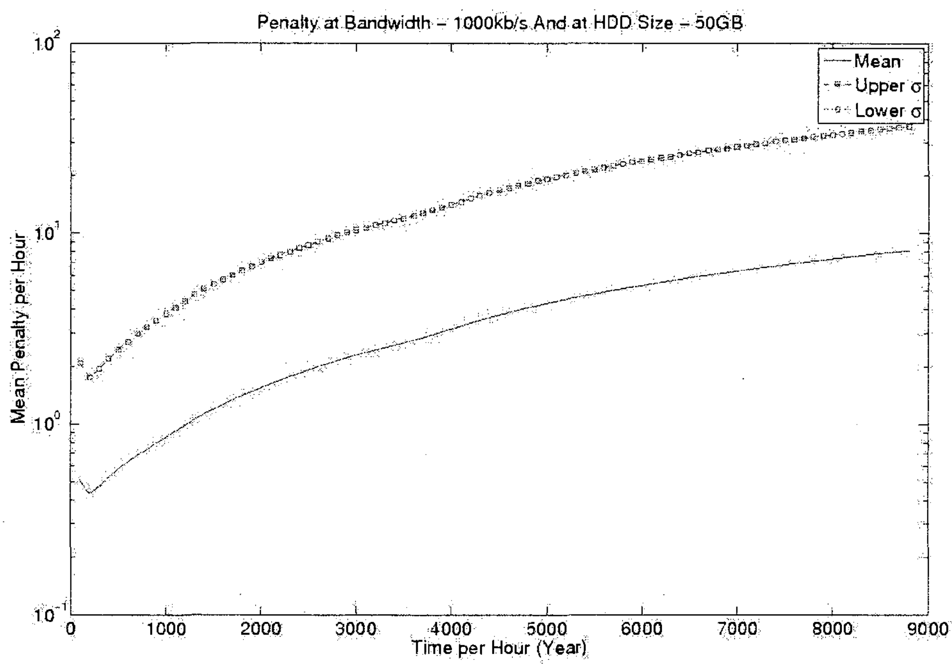


Figure 382: Penalty for H3 case scenario at hard drive size of 100GB and download bandwidth of 1000kb/s

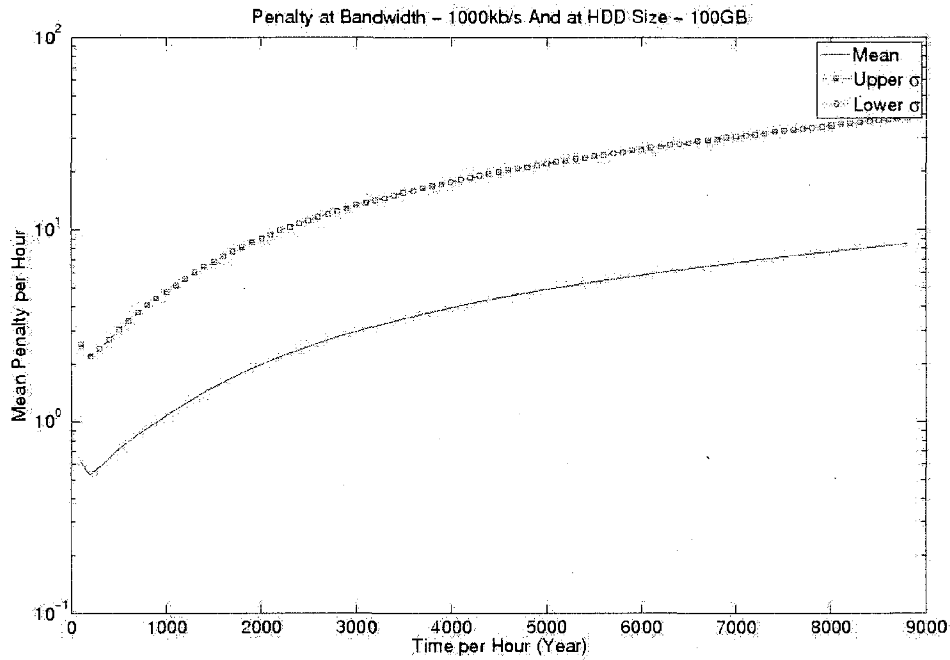


Figure 383: Penalty for H3 case scenario at hard drive size of 150GB and download bandwidth of 1000kb/s

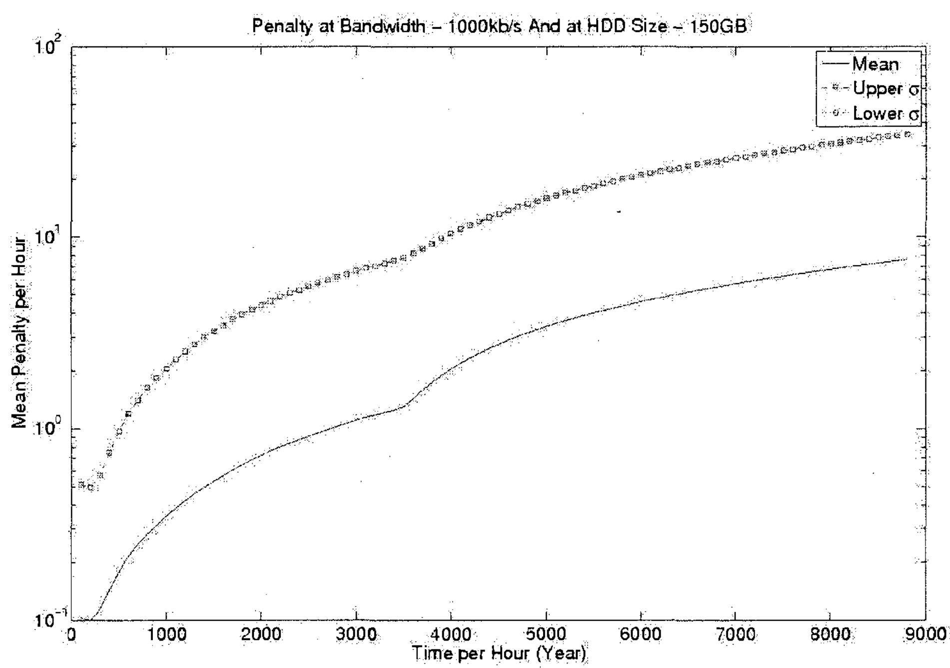


Figure 384: Penalty for H3 case scenario at hard drive size of 200GB and download bandwidth of 1000kb/s

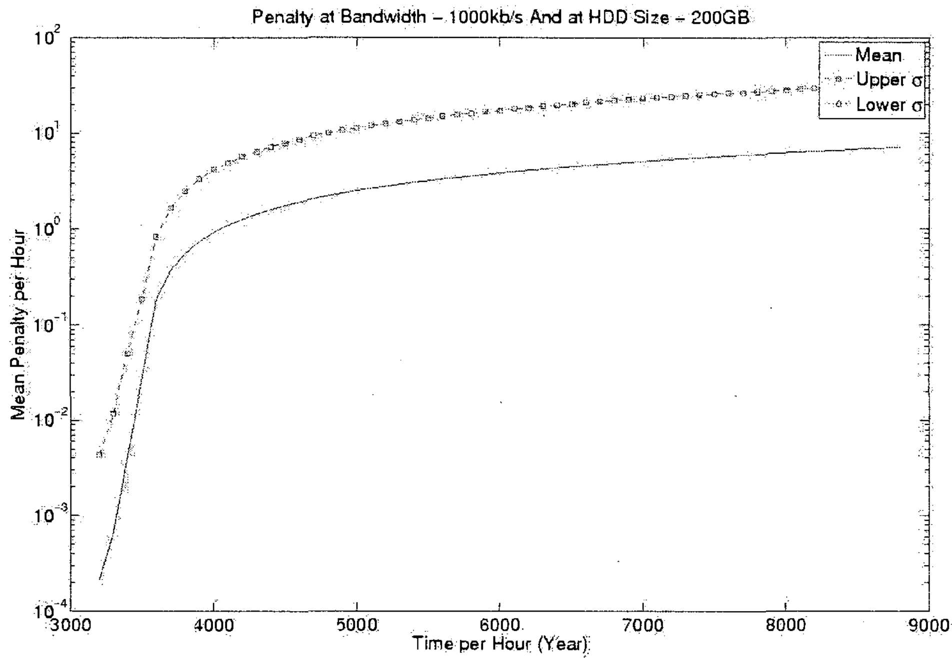


Figure 385: Penalty for H3 case scenario at hard drive size of 50GB and download bandwidth of 2000kb/s

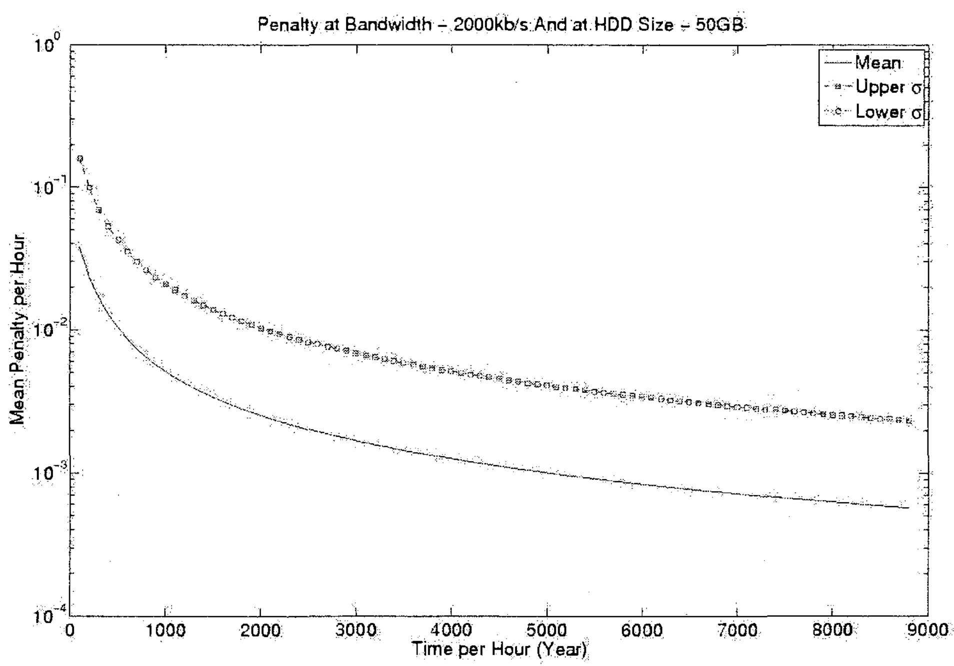


Figure 386: Penalty for H3 case scenario at hard drive size of 100GB and download bandwidth of 2000kb/s

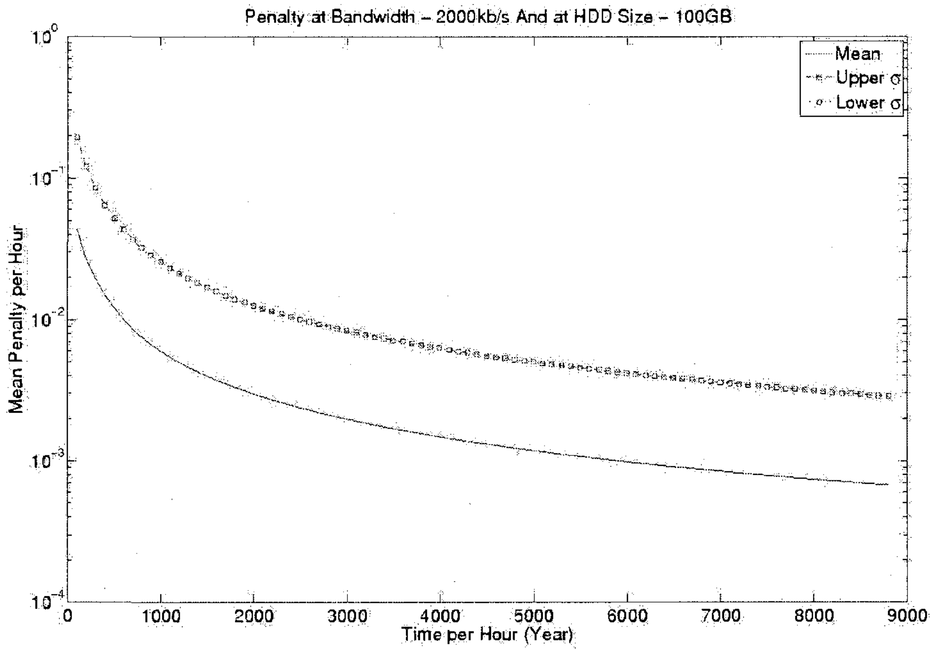


Figure 387: Penalty for H3 case scenario at hard drive size of 150GB and download bandwidth of 2000kb/s

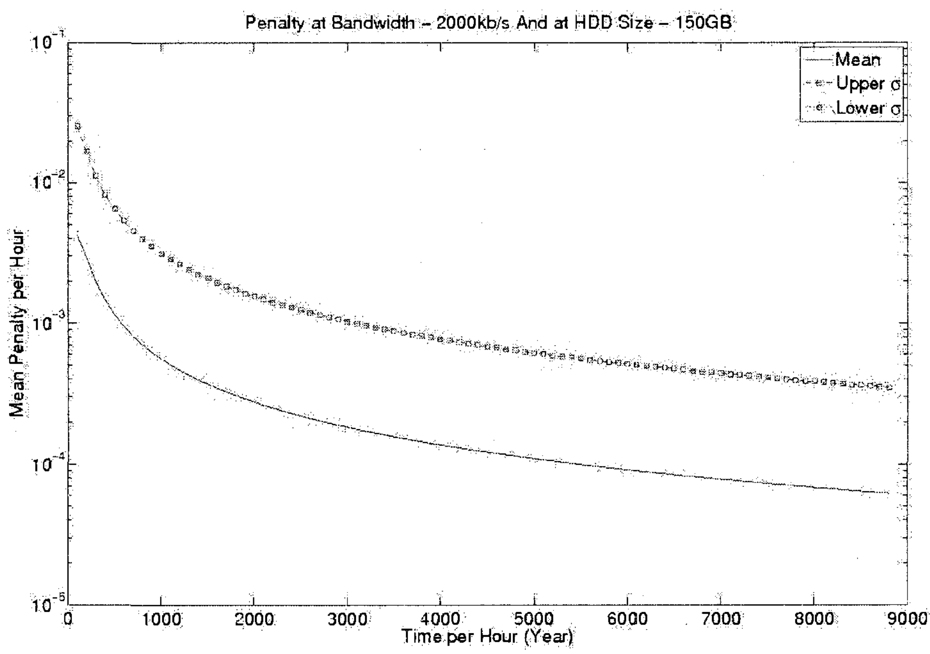


Figure 388: Penalty for H3 case scenario at hard drive size of 200GB and download bandwidth of 2000kb/s

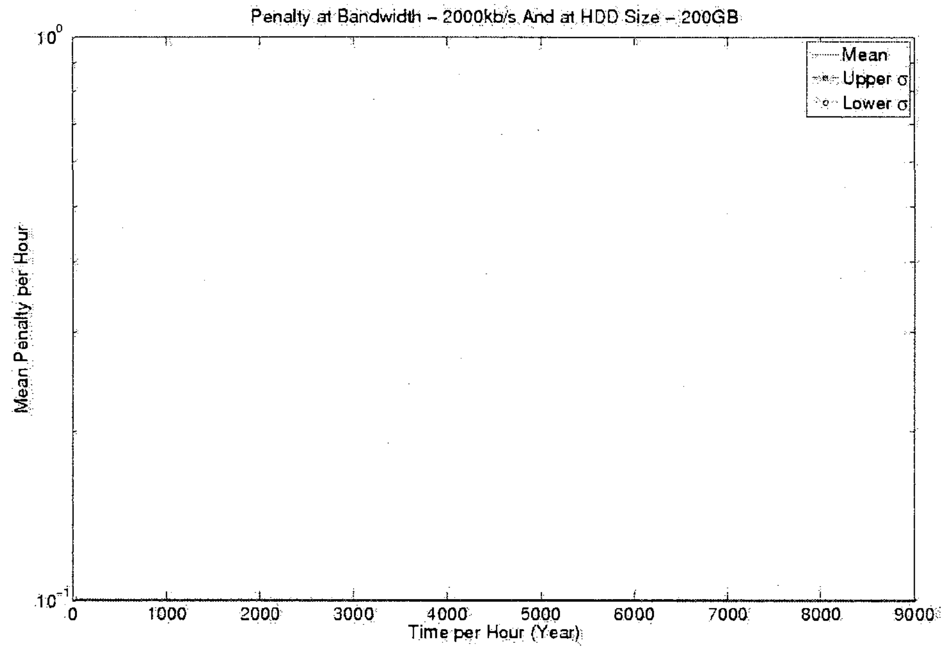


Figure 389: Penalty for H3 case scenario at hard drive size of 50GB and download bandwidth of 5000kb/s

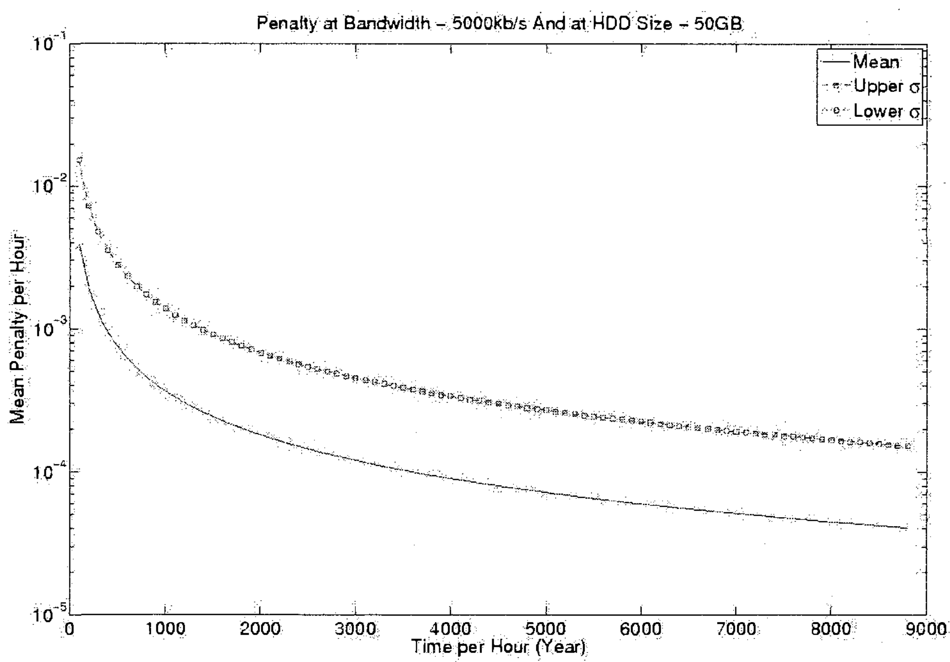


Figure 390: Penalty for H3 case scenario at hard drive size of 100GB and download bandwidth of 5000kb/s

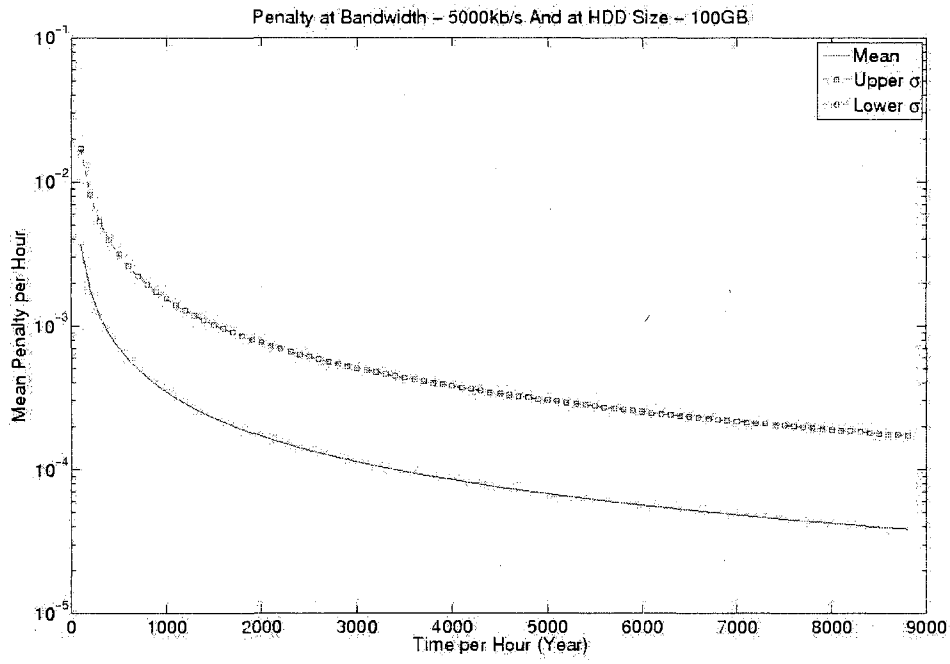


Figure 391: Penalty for H3 case scenario at hard drive size of 150GB and download bandwidth of 5000kb/s

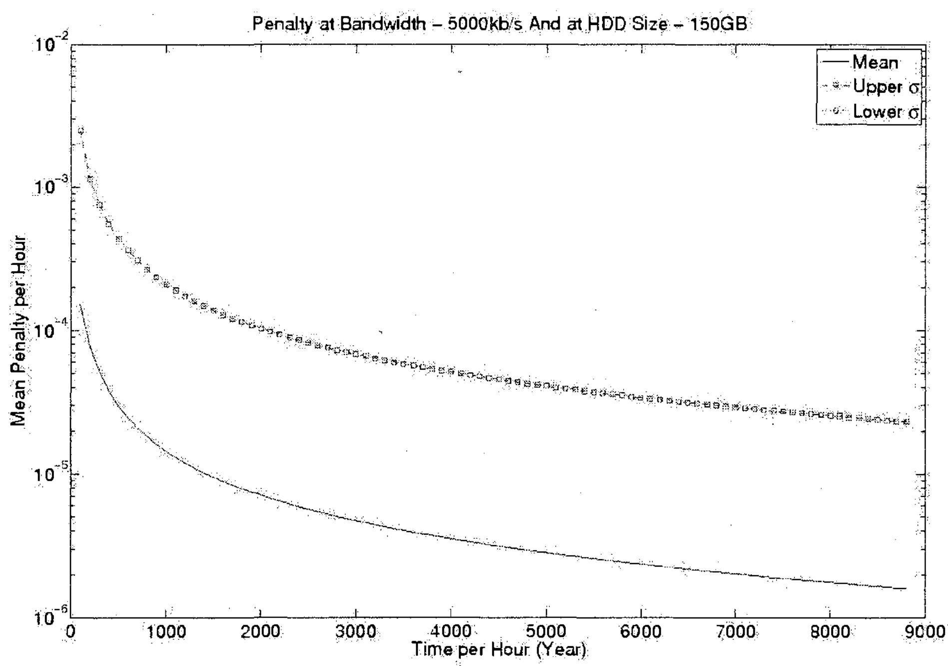


Figure 392: Penalty for H3 case scenario at hard drive size of 200GB and download bandwidth of 5000kb/s

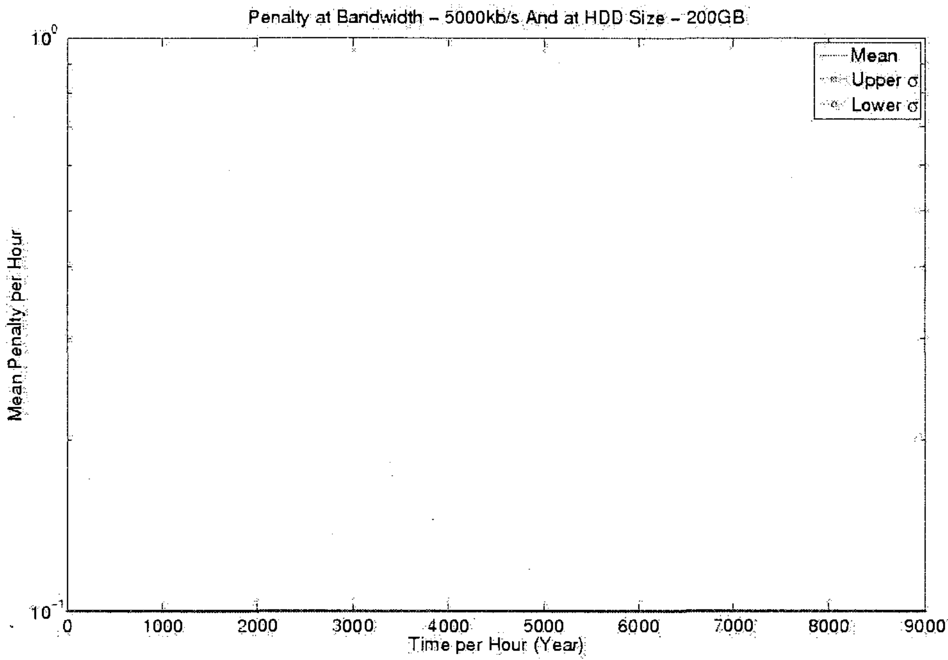


Figure 393: Penalty for H3 case scenario at hard drive size of 50GB and download bandwidth of 10000kb/s

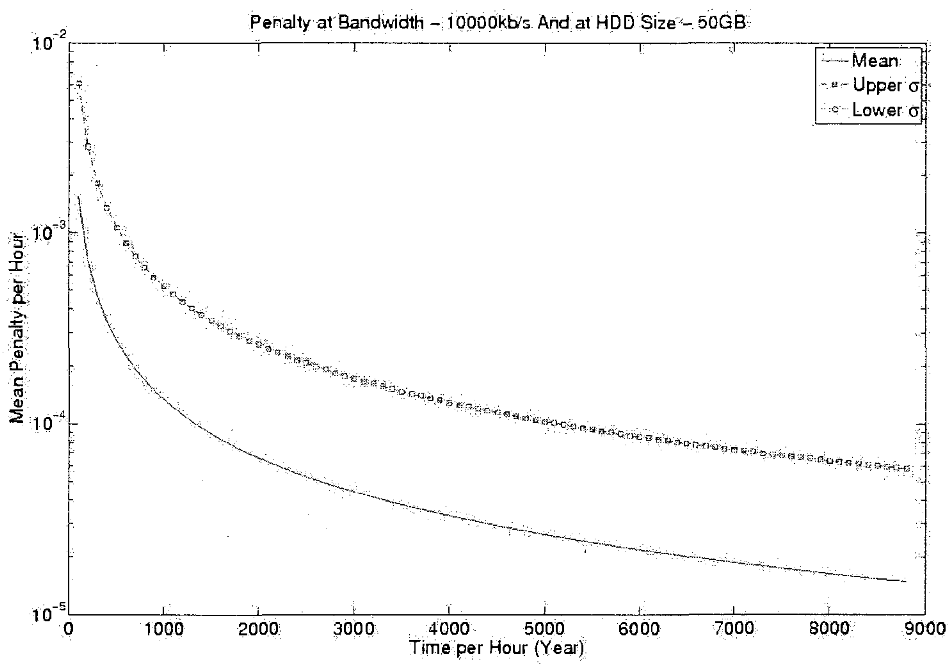


Figure 394: Penalty for H3 case scenario at hard drive size of 100GB and download bandwidth of 10000kb/s

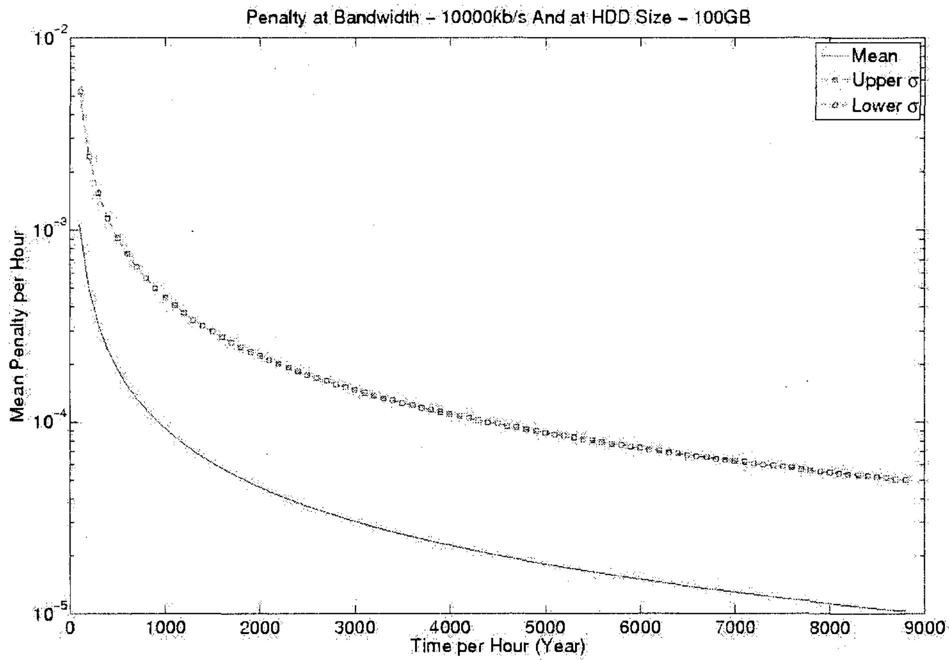


Figure 395: Penalty for H3 case scenario at hard drive size of 150GB and download bandwidth of 10000kb/s

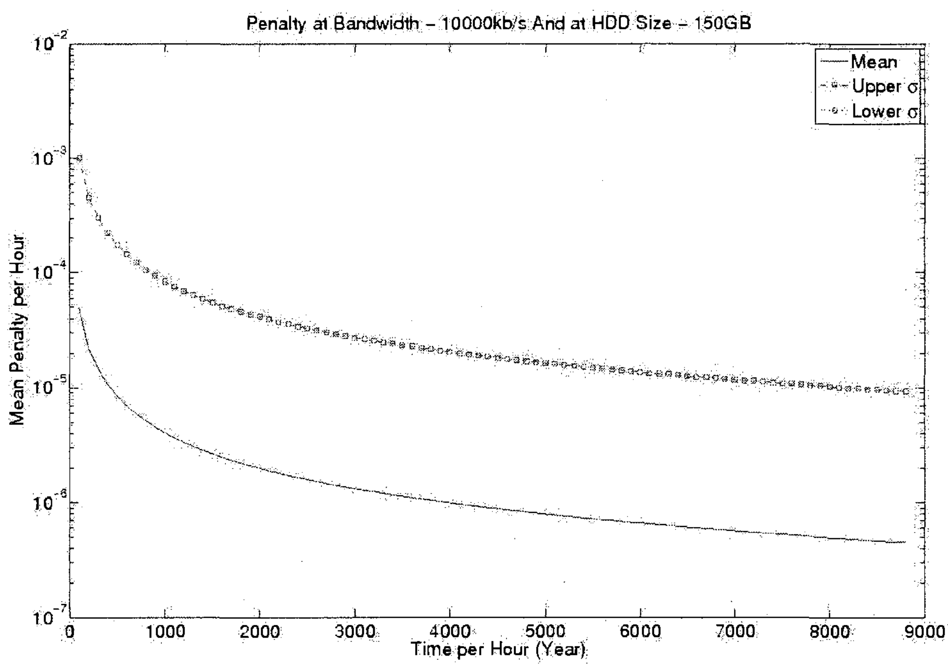


Figure 396: Penalty for H3 case scenario at hard drive size of 200GB and download bandwidth of 10000kb/s

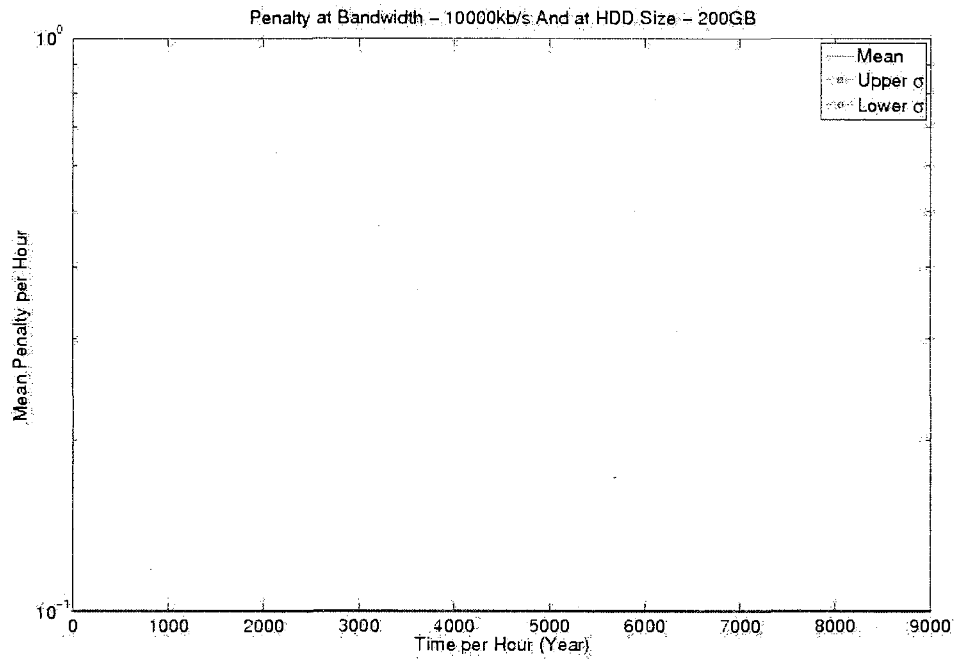


Figure 397: Penalty for H3 case scenario at hard drive size of 50GB and download bandwidth of 15000kb/s

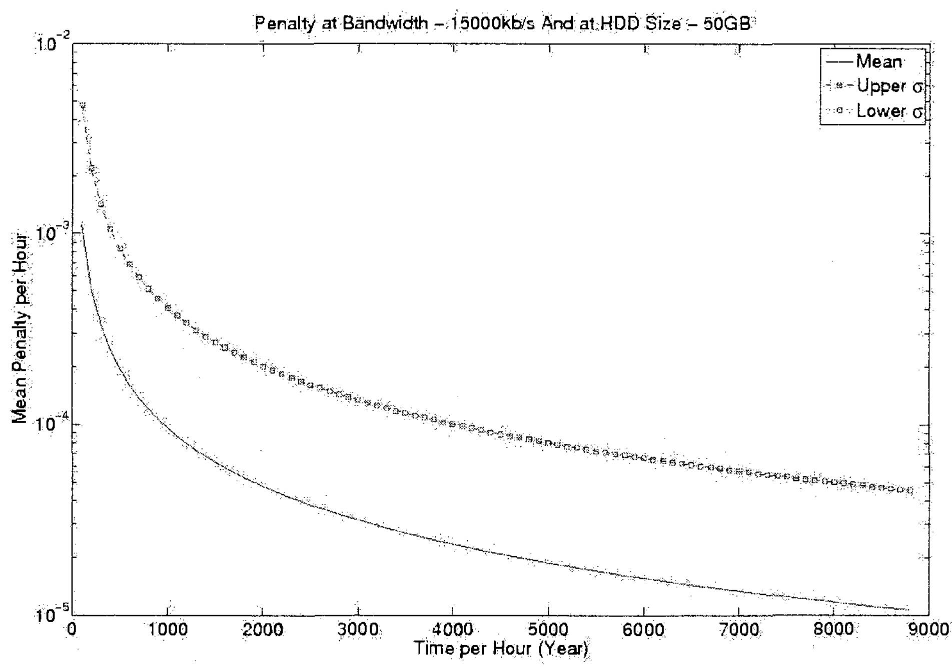


Figure 398: Penalty for H3 case scenario at hard drive size of 100GB and download bandwidth of 15000kb/s

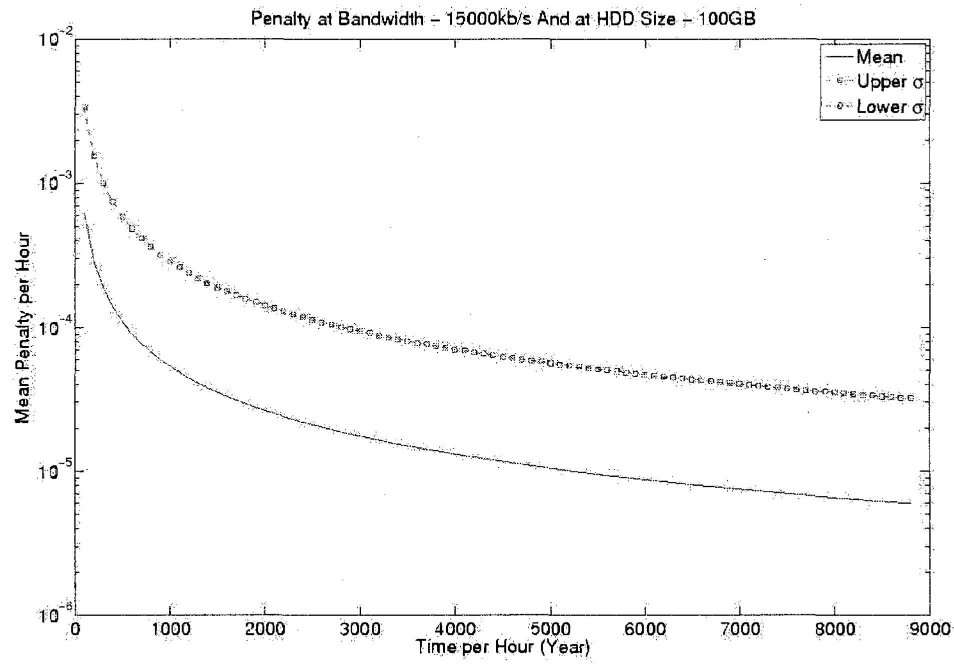


Figure 399: Penalty for H3 case scenario at hard drive size of 150GB and download bandwidth of 15000kb/s

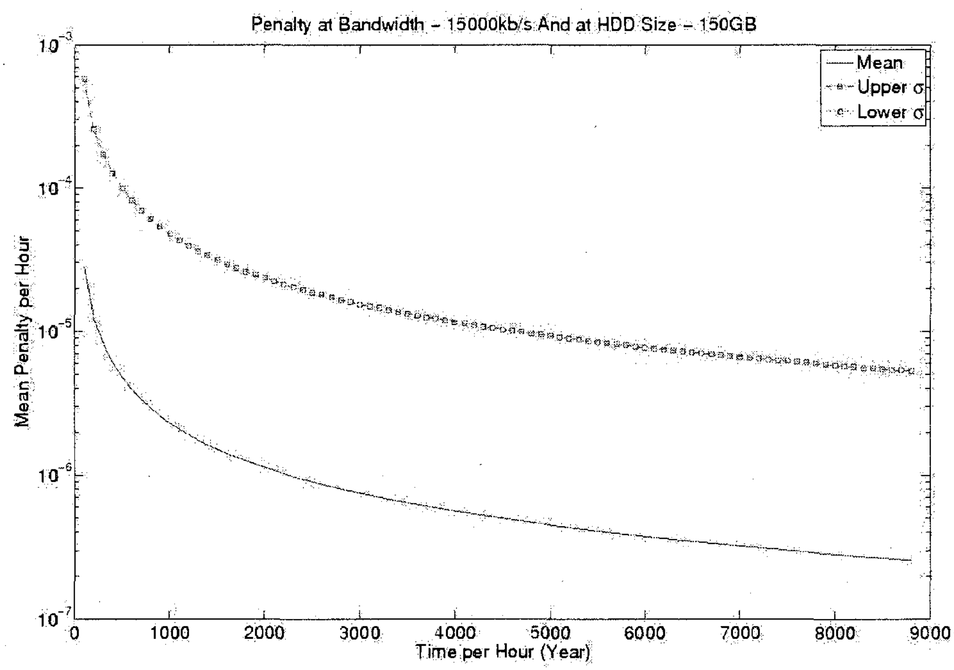


Figure 400: Penalty for H3 case scenario at hard drive size of 200GB and download bandwidth of 15000kb/s

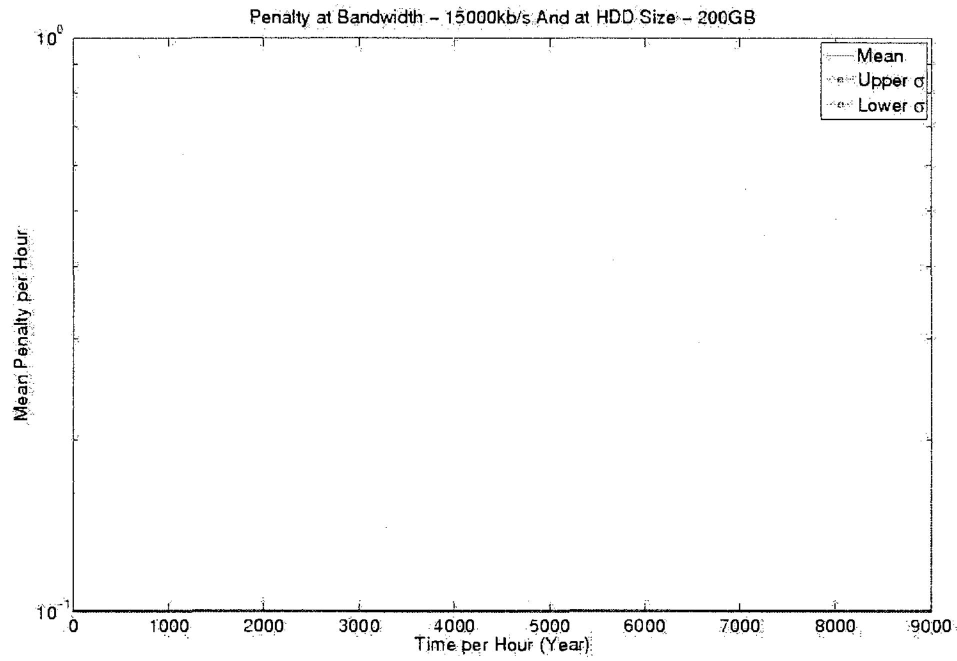


Figure 401: Penalty for H4 case scenario at hard drive size of 50GB and download bandwidth of 25kb/s

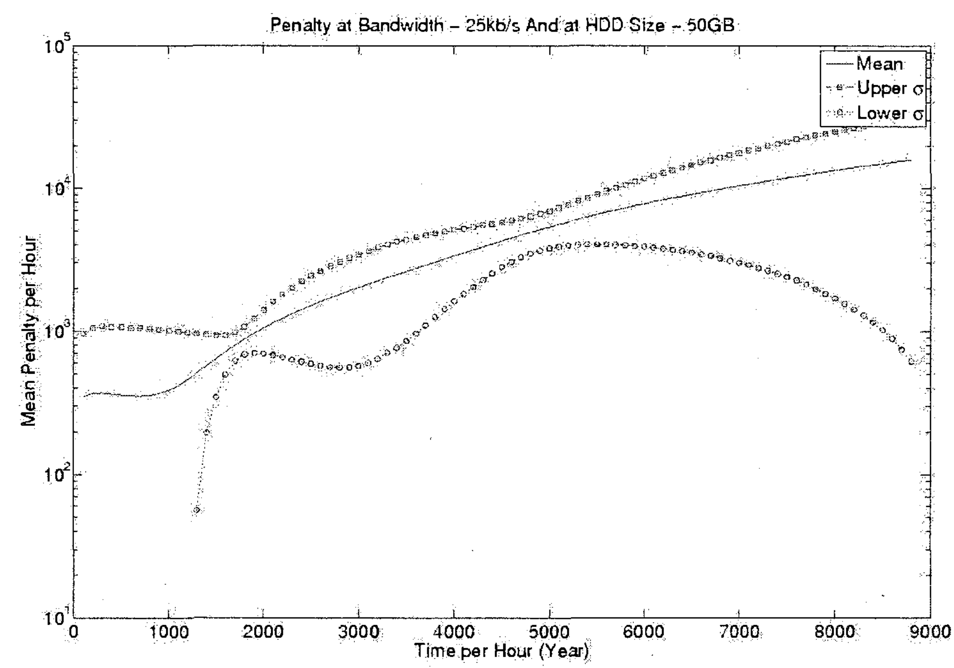


Figure 402: Penalty for H4 case scenario at hard drive size of 100GB and download bandwidth of 25kb/s

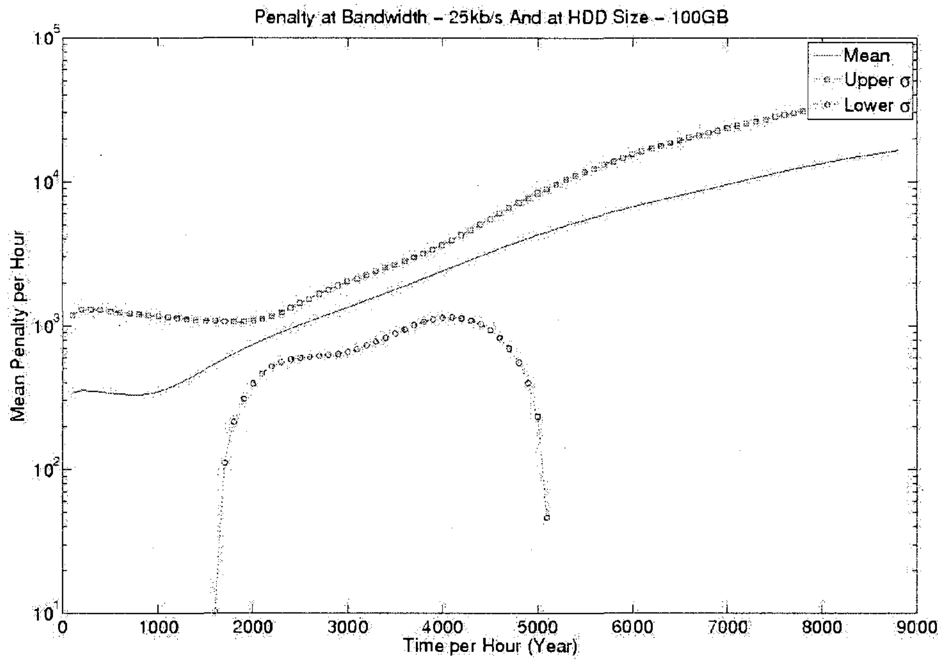


Figure 403: Penalty for H4 case scenario at hard drive size of 150GB and download bandwidth of 25kb/s

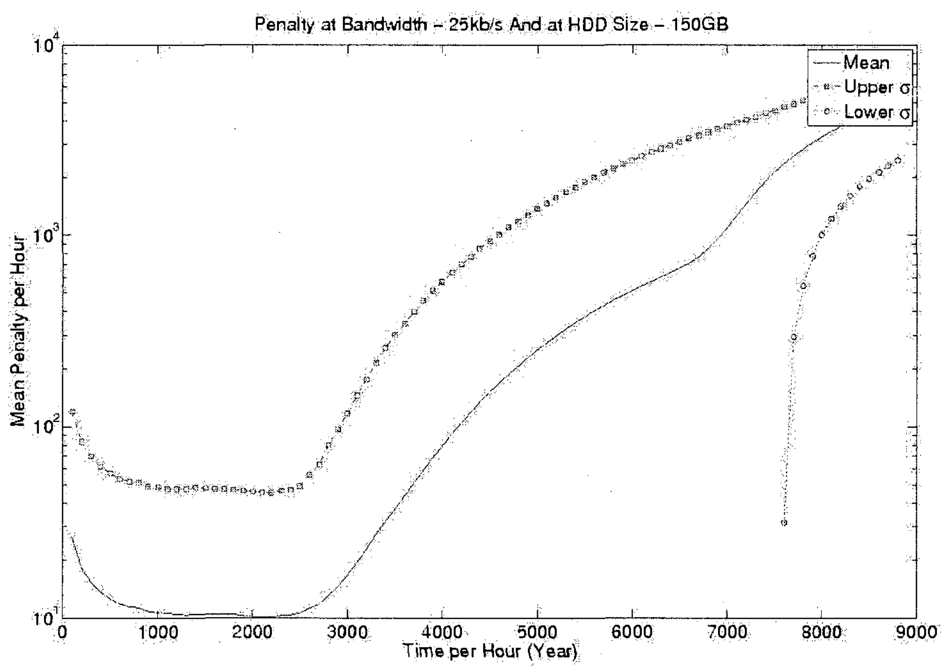


Figure 404: Penalty for H4 case scenario at hard drive size of 200GB and download bandwidth of 25kb/s

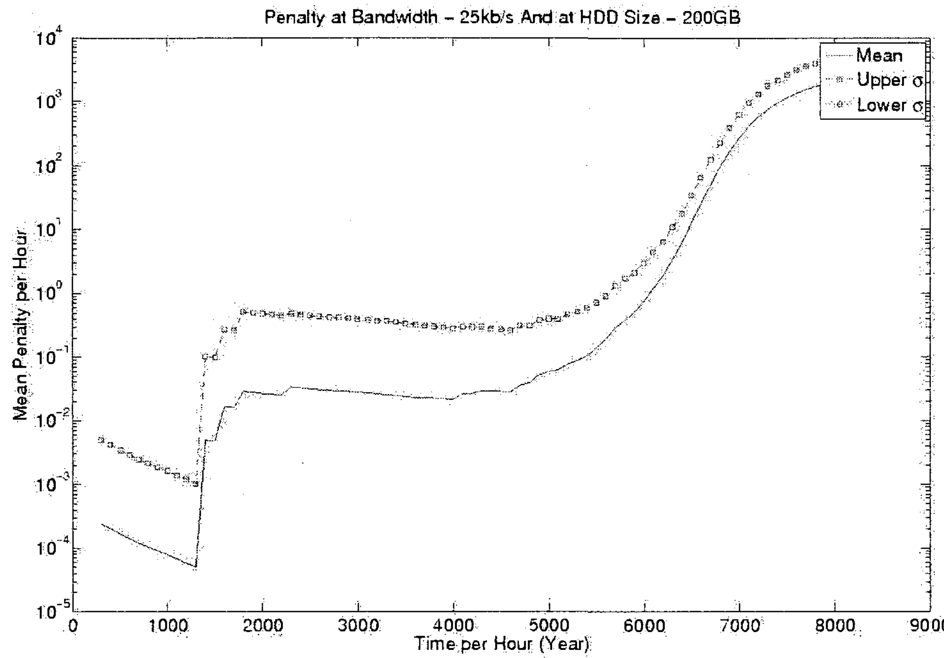


Figure 405: Penalty for H4 case scenario at hard drive size of 50GB and download bandwidth of 50kb/s

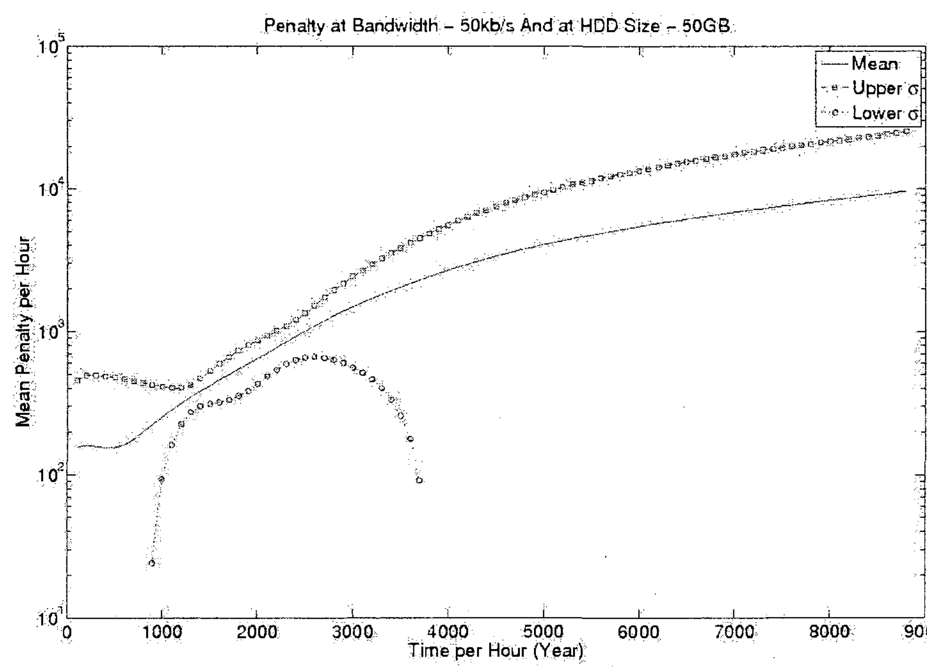


Figure 406: Penalty for H4 case scenario at hard drive size of 100GB and download bandwidth of 50kb/s

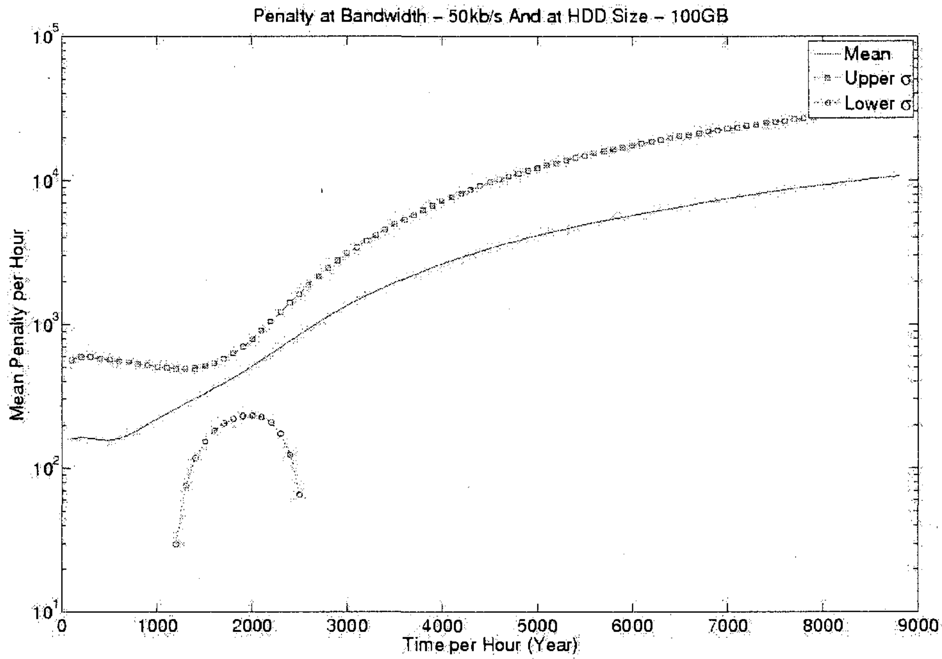


Figure 407: Penalty for H4 case scenario at hard drive size of 150GB and download bandwidth of 50kb/s

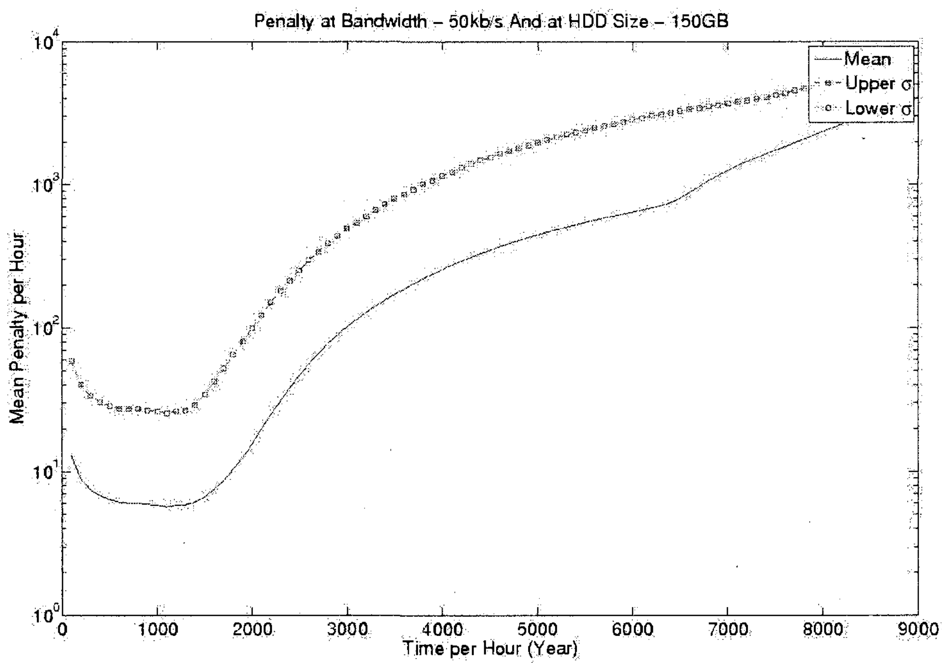


Figure 408: Penalty for H4 case scenario at hard drive size of 200GB and download bandwidth of 50kb/s

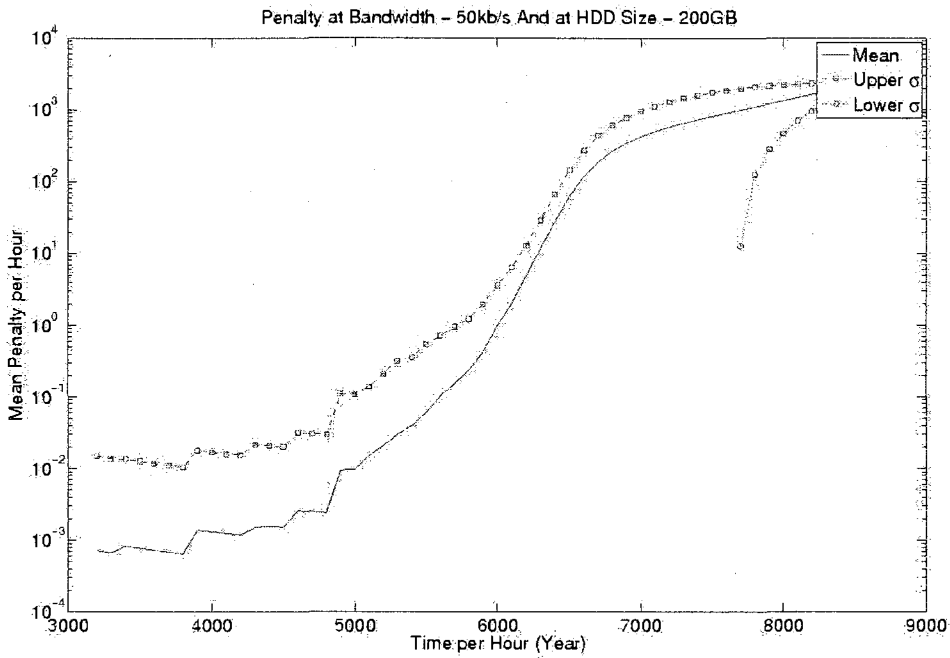


Figure 409: Penalty for H4 case scenario at hard drive size of 50GB and download bandwidth of 100kb/s

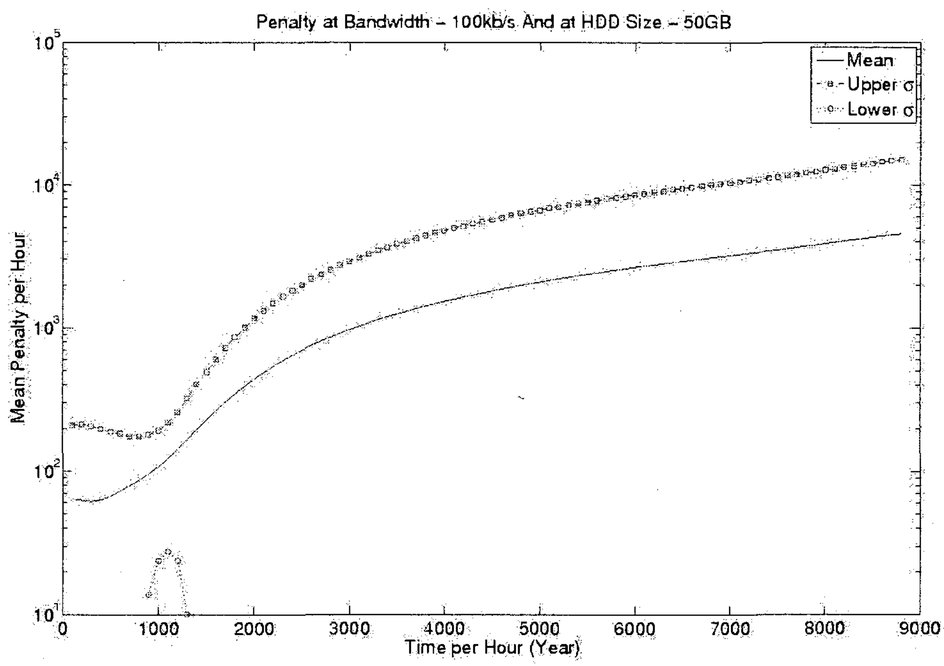


Figure 410: Penalty for H4 case scenario at hard drive size of 100GB and download bandwidth of 100kb/s

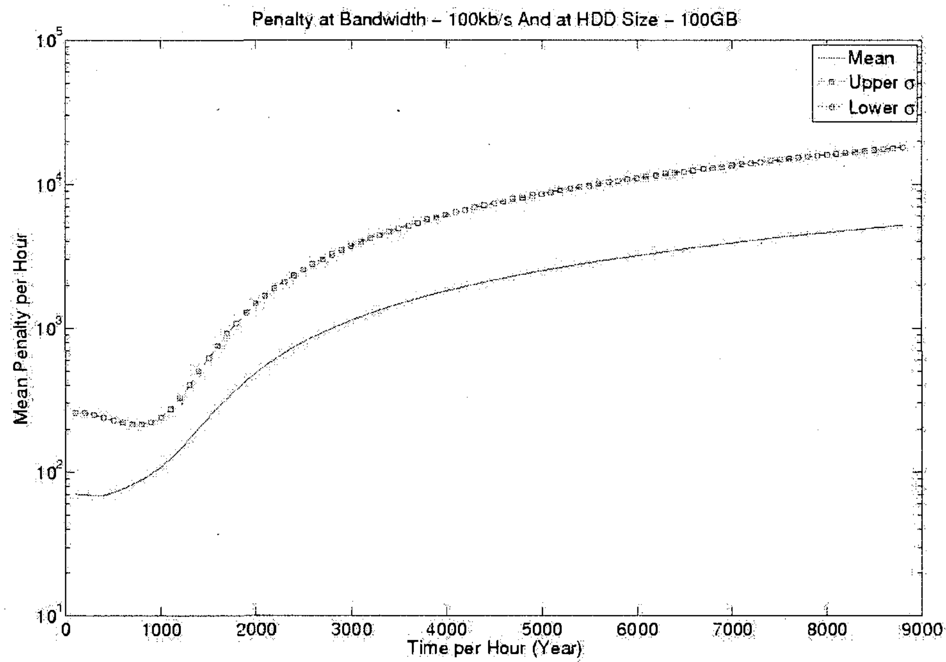


Figure 411: Penalty for H4 case scenario at hard drive size of 150GB and download bandwidth of 100kb/s

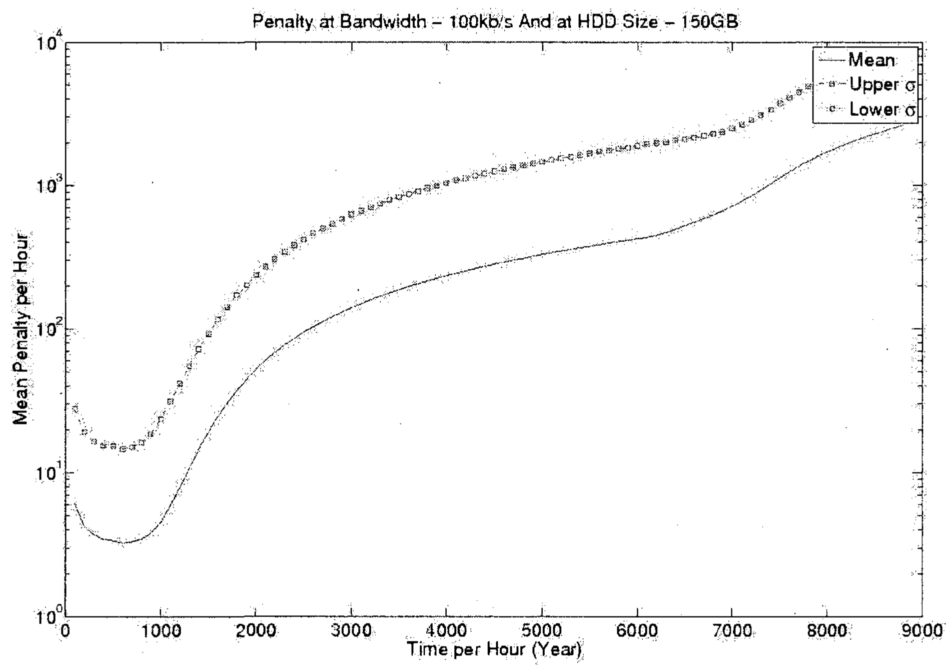


Figure 412: Penalty for H4 case scenario at hard drive size of 200GB and download bandwidth of 100kb/s

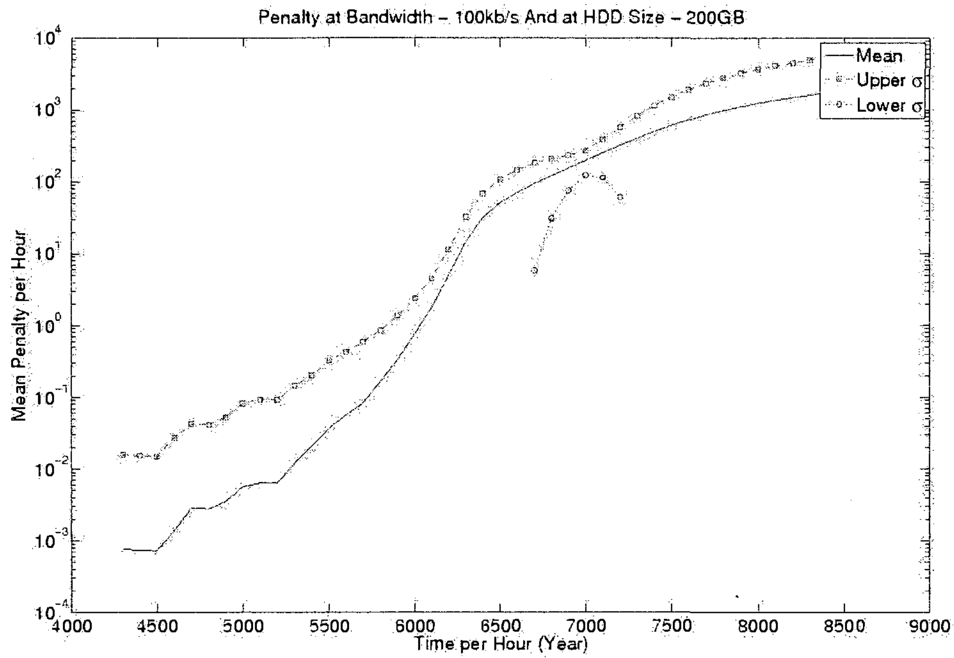


Figure 413: Penalty for H4 case scenario at hard drive size of 50GB and download bandwidth of 128kb/s

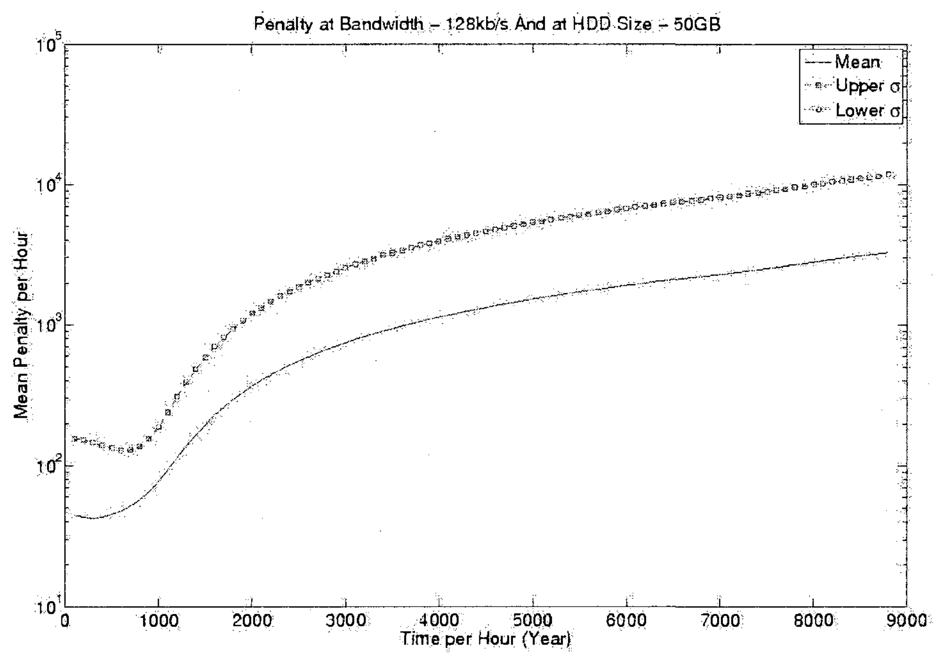


Figure 414: Penalty for H4 case scenario at hard drive size of 100GB and download bandwidth of 128kb/s

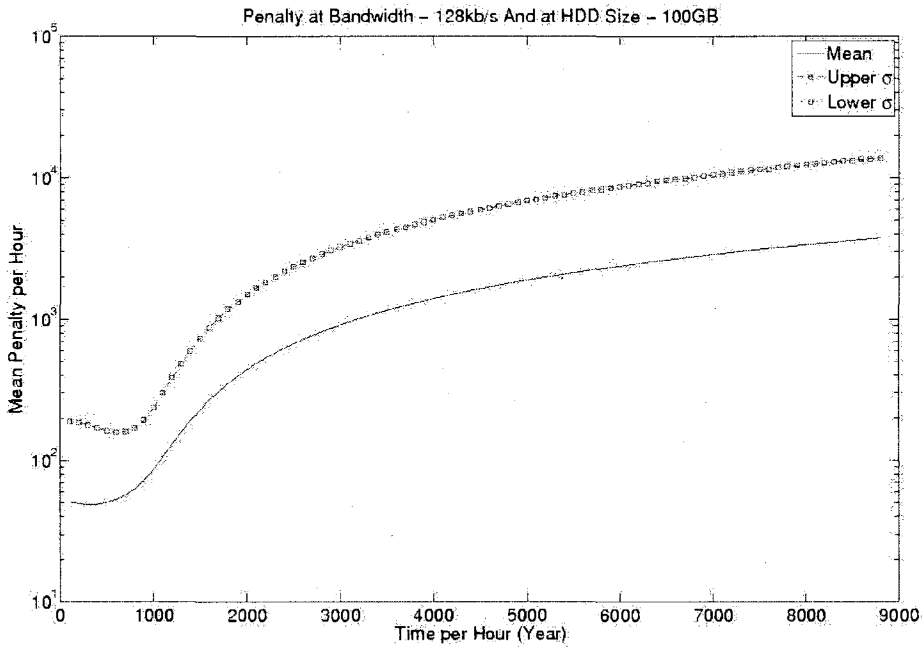


Figure 415: Penalty for H4 case scenario at hard drive size of 150GB and download bandwidth of 128kb/s

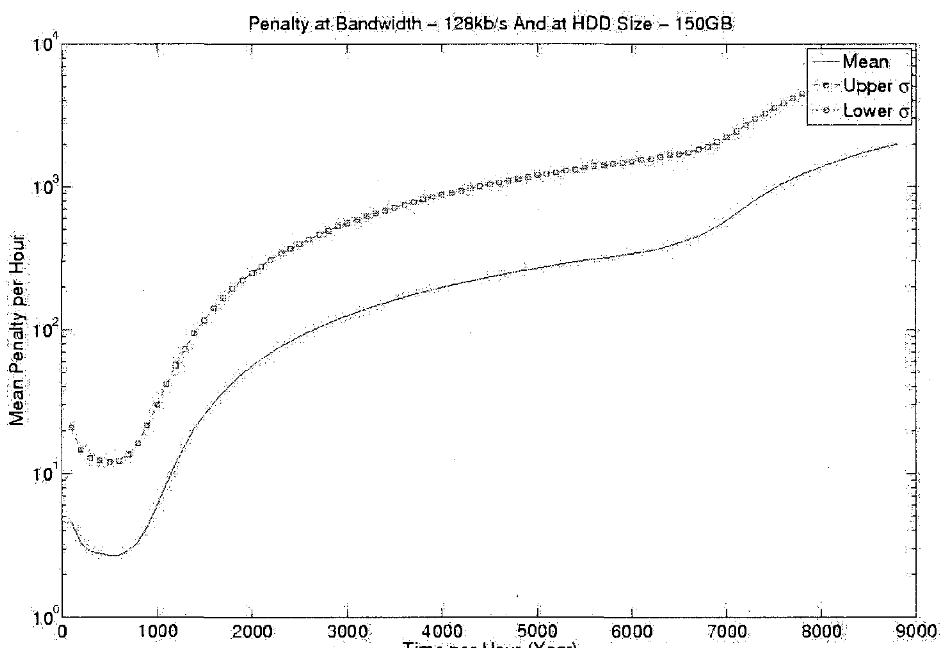


Figure 416: Penalty for H4 case scenario at hard drive size of 200GB and download bandwidth of 128kb/s

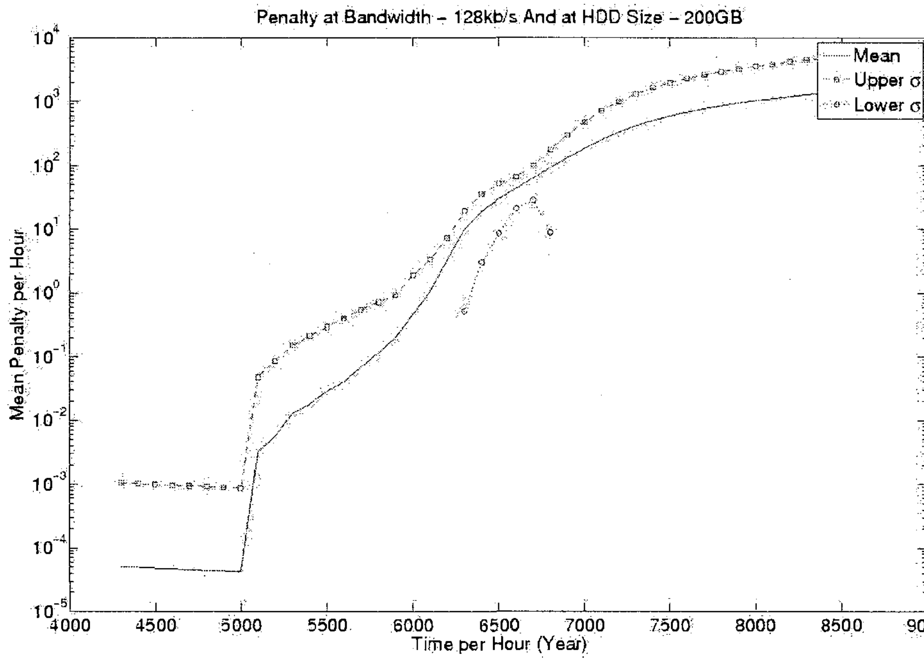


Figure 417: Penalty for H4 case scenario at hard drive size of 50GB and download bandwidth of 256kb/s

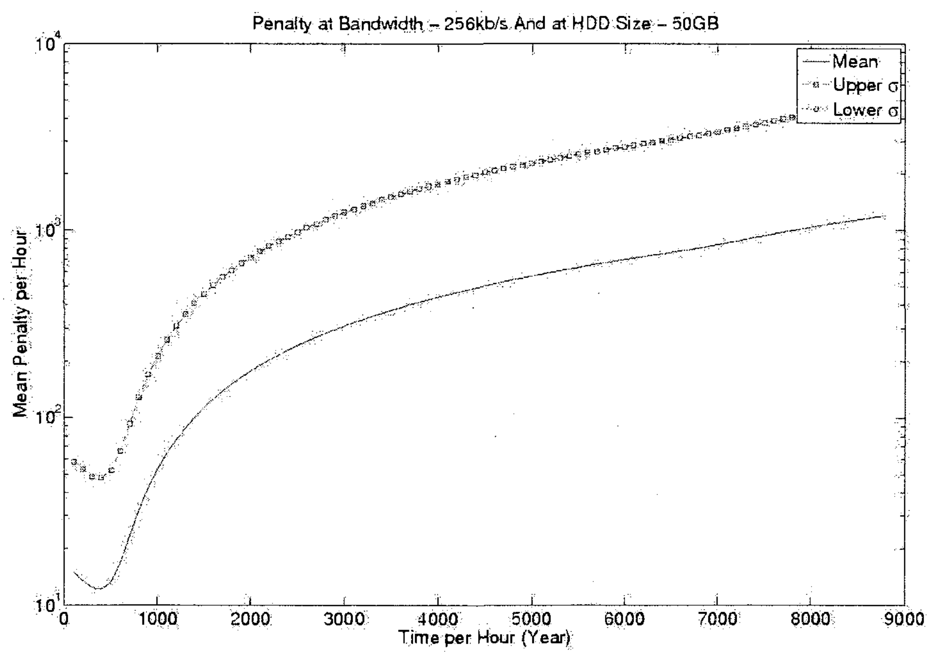


Figure 418: Penalty for H4 case scenario at hard drive size of 100GB and download bandwidth of 256kb/s

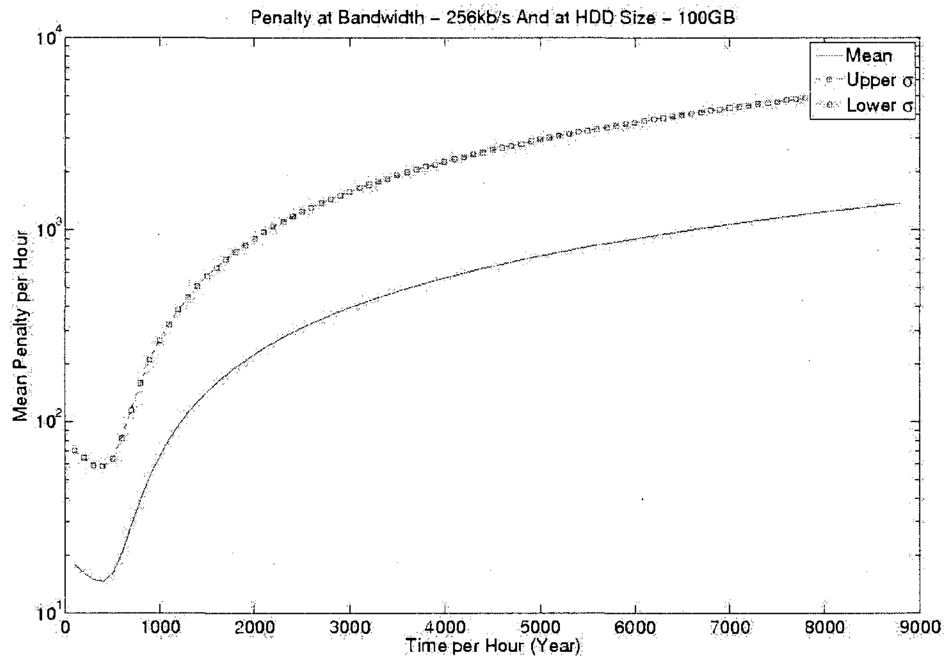


Figure 419: Penalty for H4 case scenario at hard drive size of 150GB and download bandwidth of 256kb/s

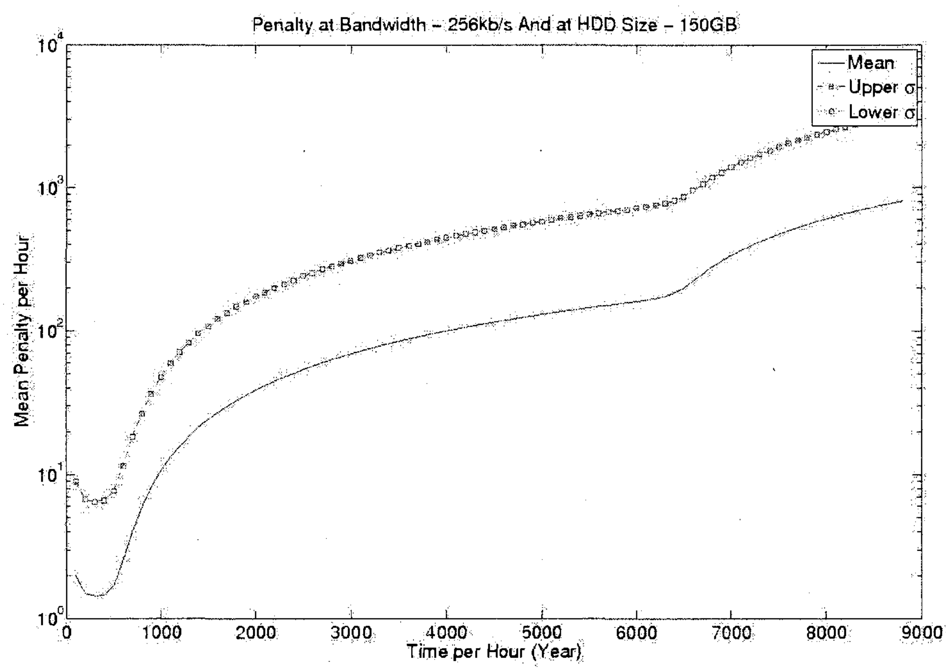


Figure 420: Penalty for H4 case scenario at hard drive size of 200GB and download bandwidth of 256kb/s

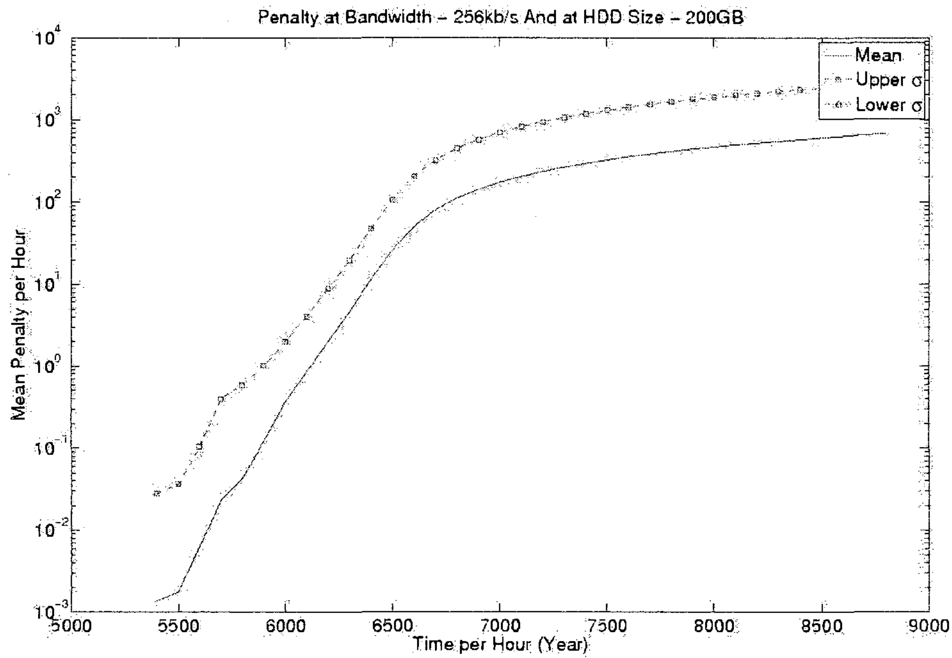


Figure 421: Penalty for H4 case scenario at hard drive size of 50GB and download bandwidth of 512kb/s

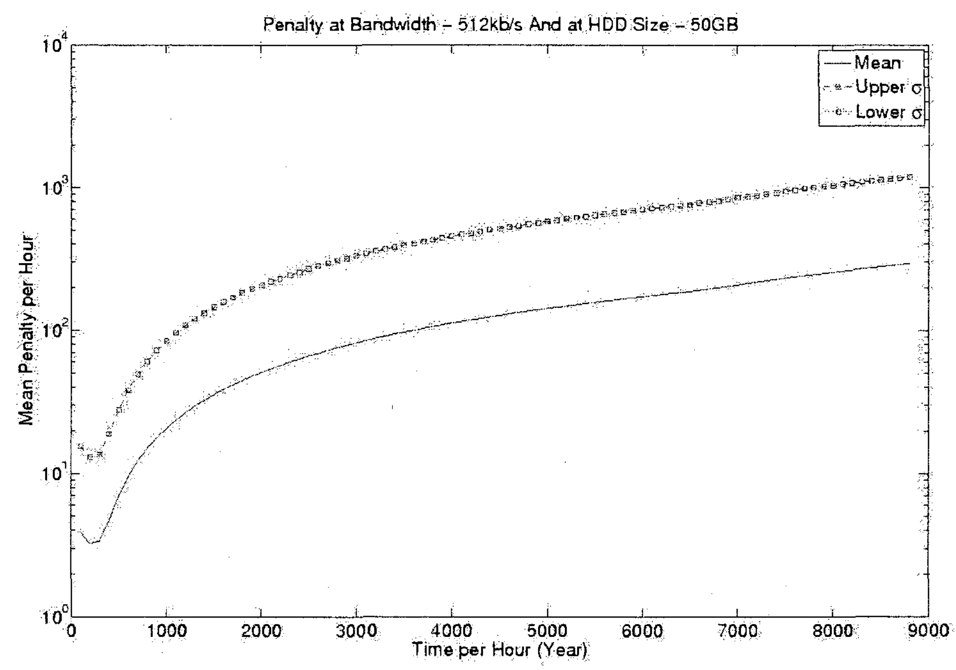


Figure 422: Penalty for H4 case scenario at hard drive size of 100GB and download bandwidth of 512kb/s

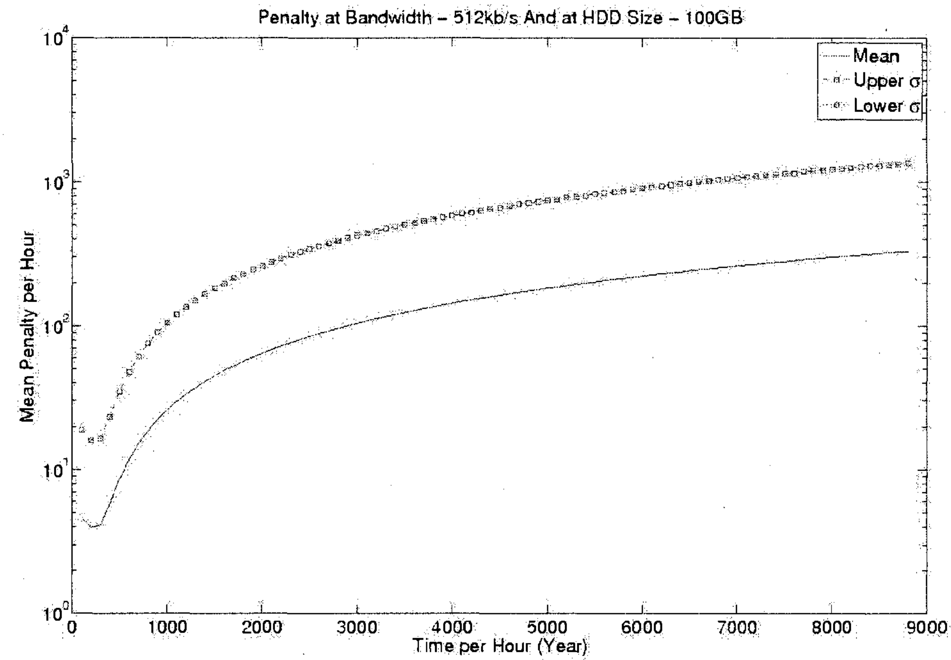


Figure 423: Penalty for H4 case scenario at hard drive size of 150GB and download bandwidth of 512kb/s

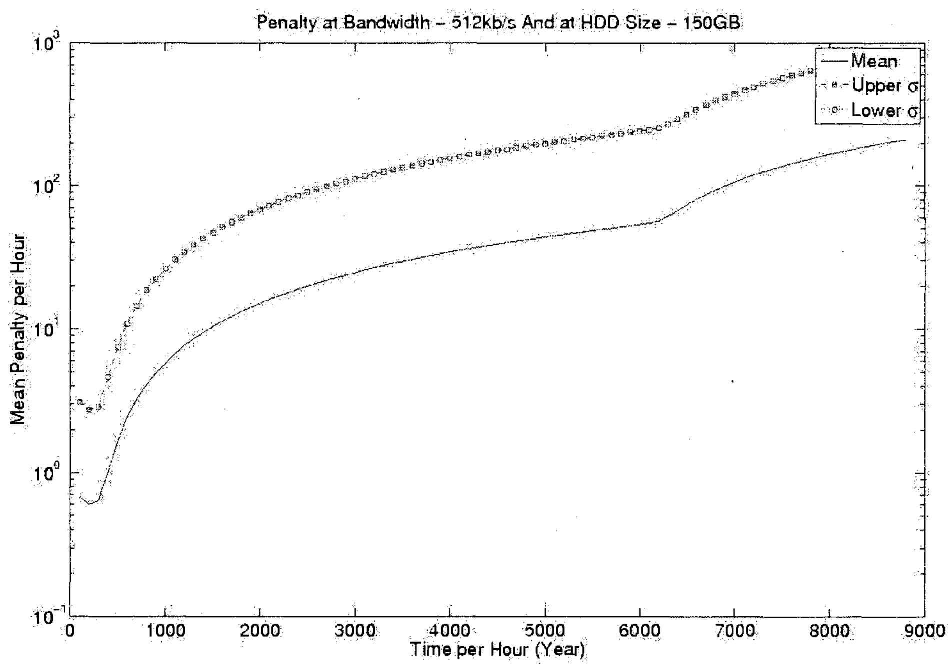


Figure 424: Penalty for H4 case scenario at hard drive size of 200GB and download bandwidth of 512kb/s

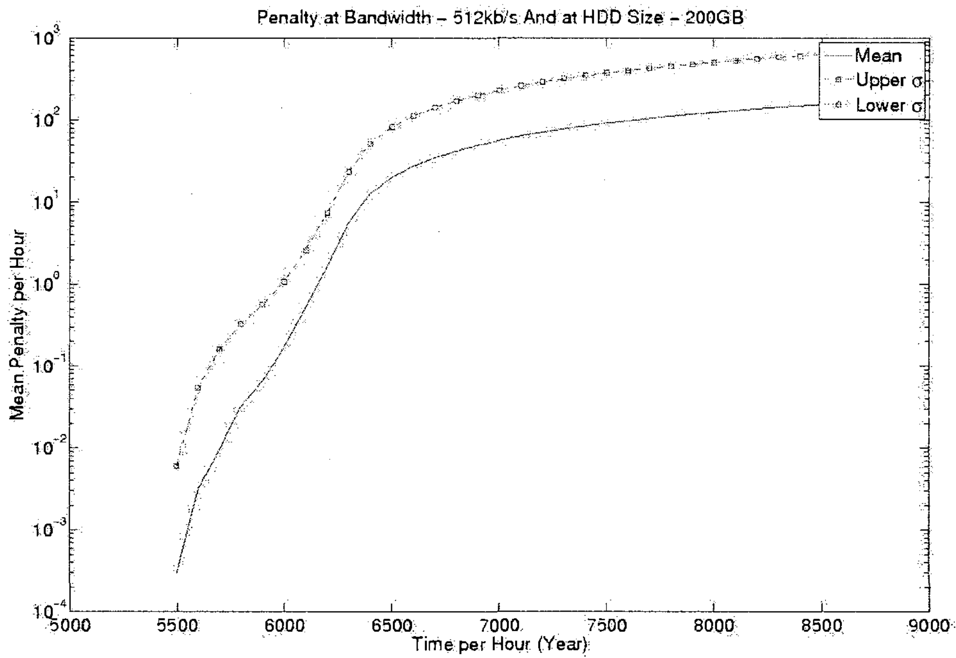


Figure 425: Penalty for H4 case scenario at hard drive size of 50GB and download bandwidth of 1000kb/s

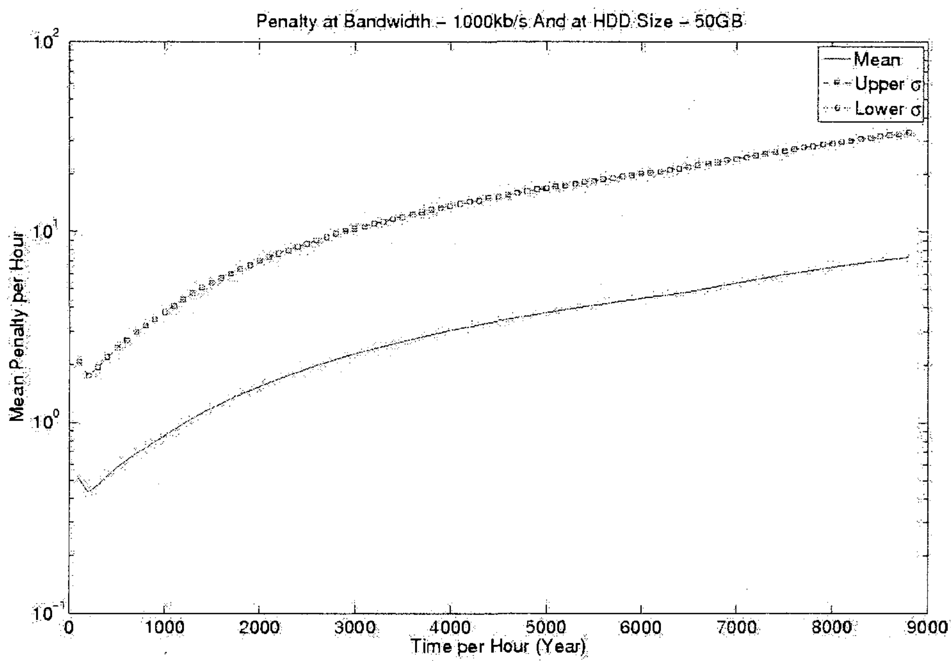


Figure 426: Penalty for H4 case scenario at hard drive size of 100GB and download bandwidth of 1000kb/s

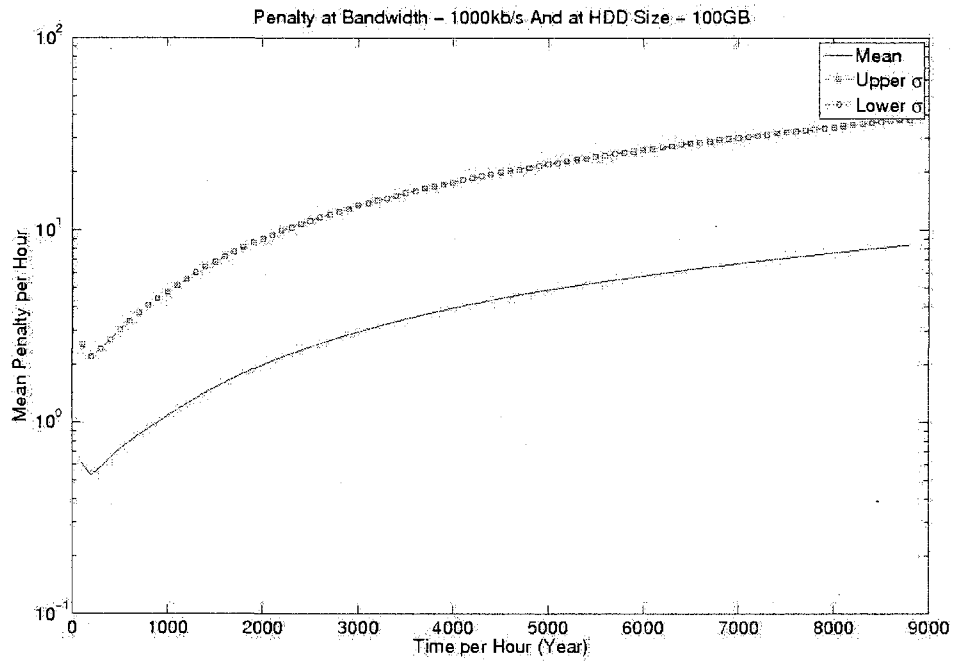


Figure 427: Penalty for H4 case scenario at hard drive size of 150GB and download bandwidth of 1000kb/s

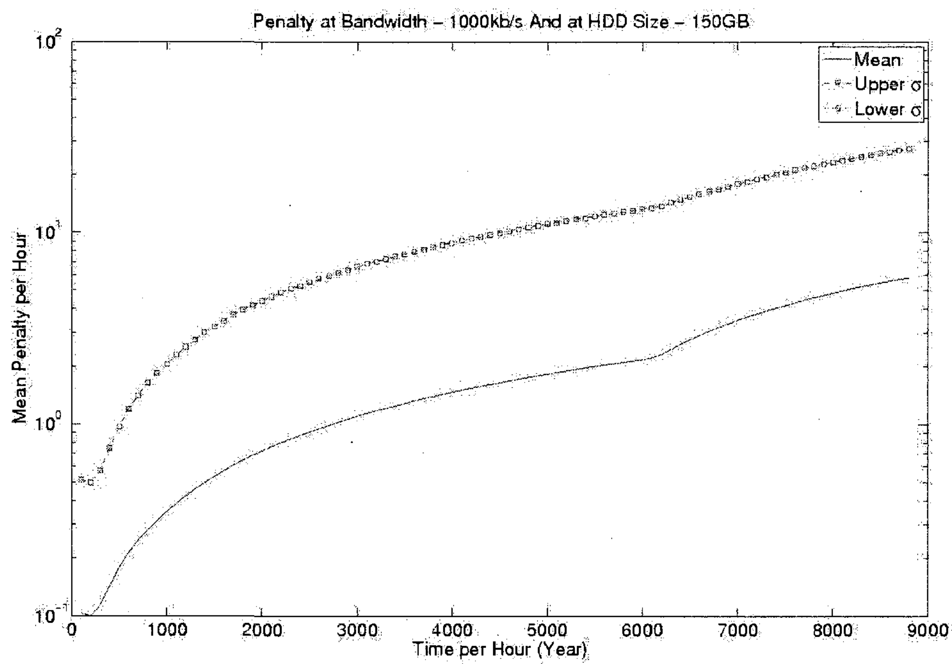


Figure 428: Penalty for H4 case scenario at hard drive size of 200GB and download bandwidth of 1000kb/s

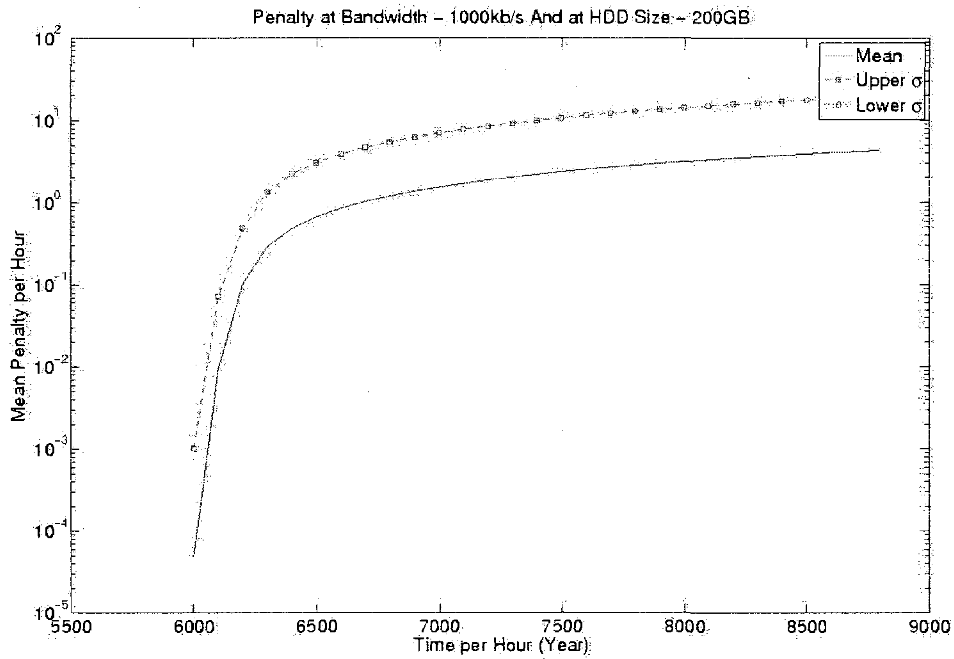


Figure 429: Penalty for H4 case scenario at hard drive size of 50GB and download bandwidth of 2000kb/s

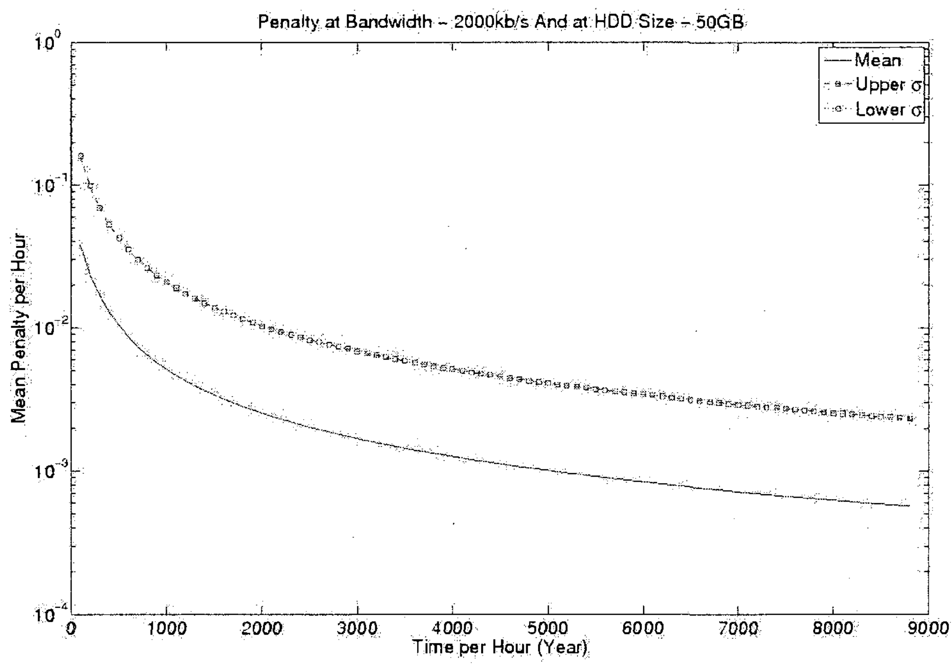


Figure 430: Penalty for H4 case scenario at hard drive size of 100GB and download bandwidth of 2000kb/s

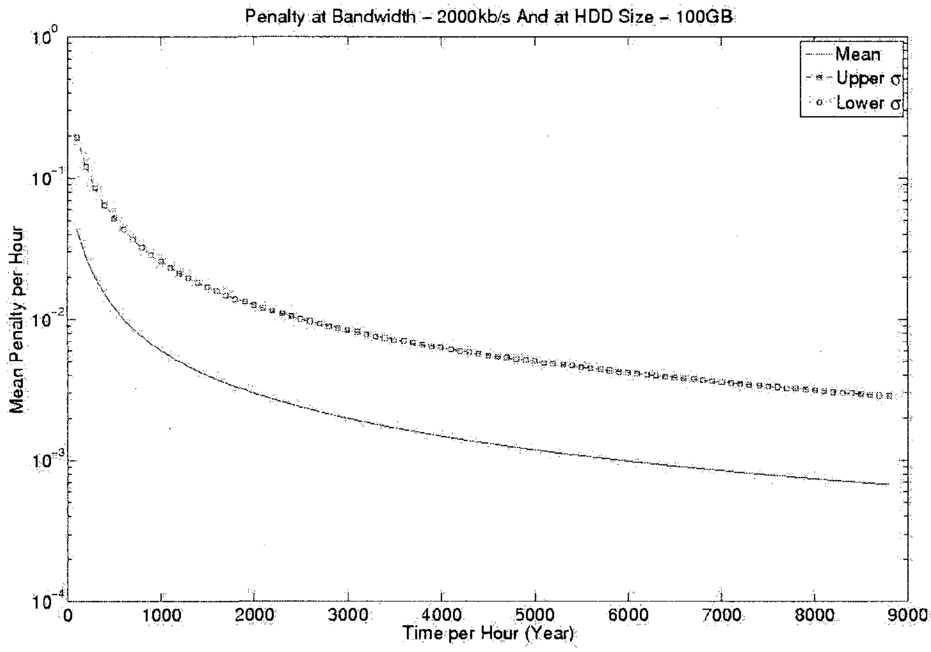


Figure 431: Penalty for H4 case scenario at hard drive size of 150GB and download bandwidth of 2000kb/s

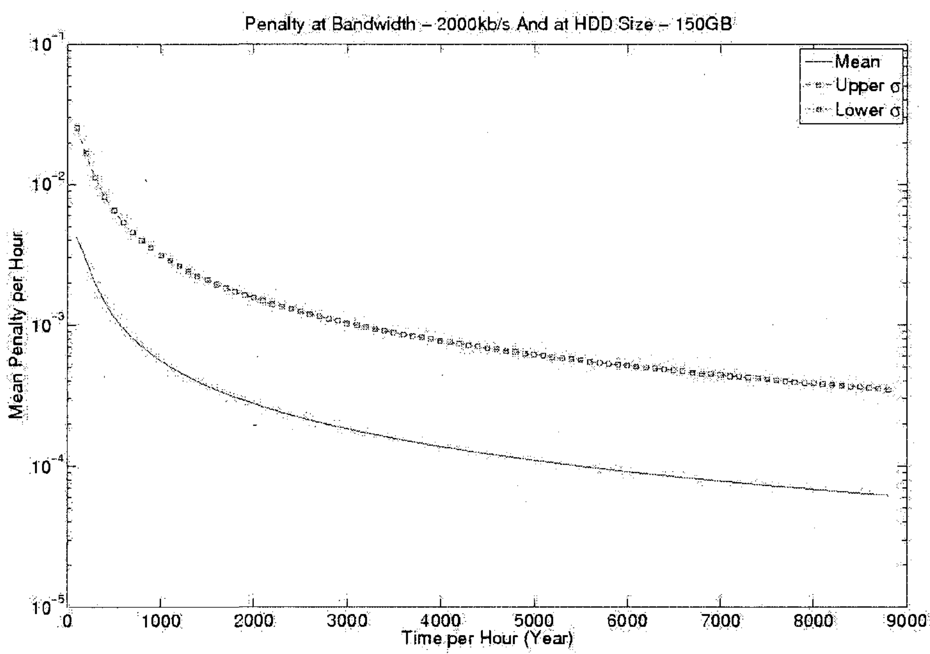


Figure 432: Penalty for H4 case scenario at hard drive size of 200GB and download bandwidth of 2000kb/s

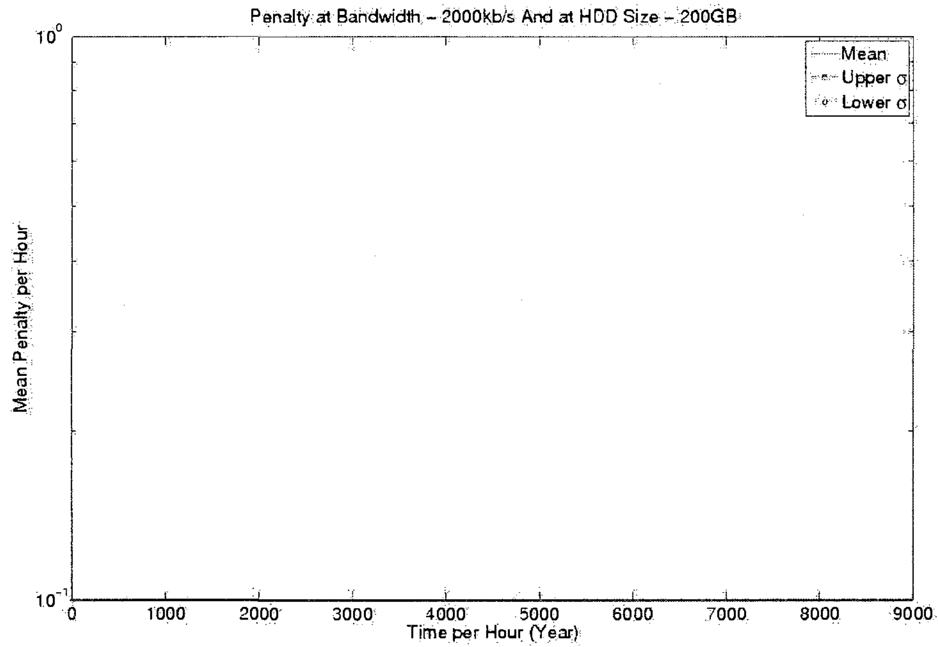


Figure 433: Penalty for H4 case scenario at hard drive size of 50GB and download bandwidth of 5000kb/s

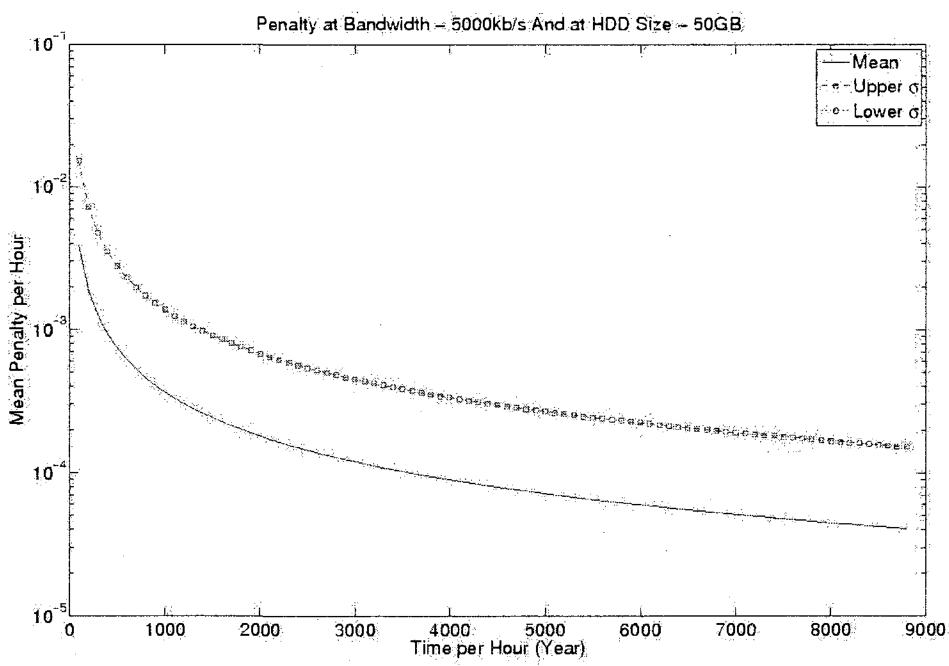


Figure 434: Penalty for H4 case scenario at hard drive size of 100GB and download bandwidth of 5000kb/s

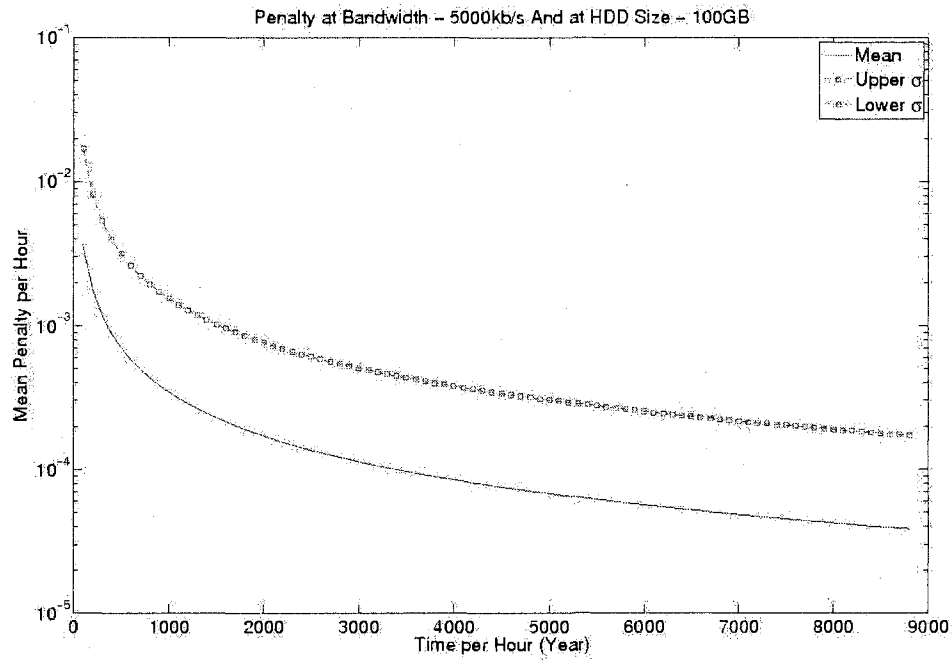


Figure 435: Penalty for H4 case scenario at hard drive size of 150GB and download bandwidth of 5000kb/s

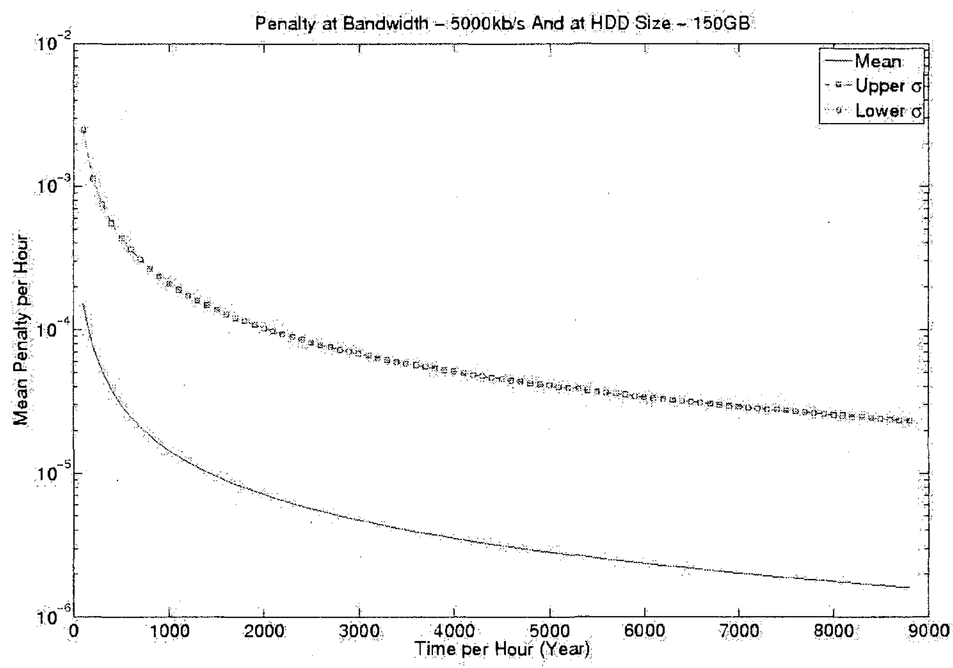


Figure 436: Penalty for H4 case scenario at hard drive size of 200GB and download bandwidth of 5000kb/s

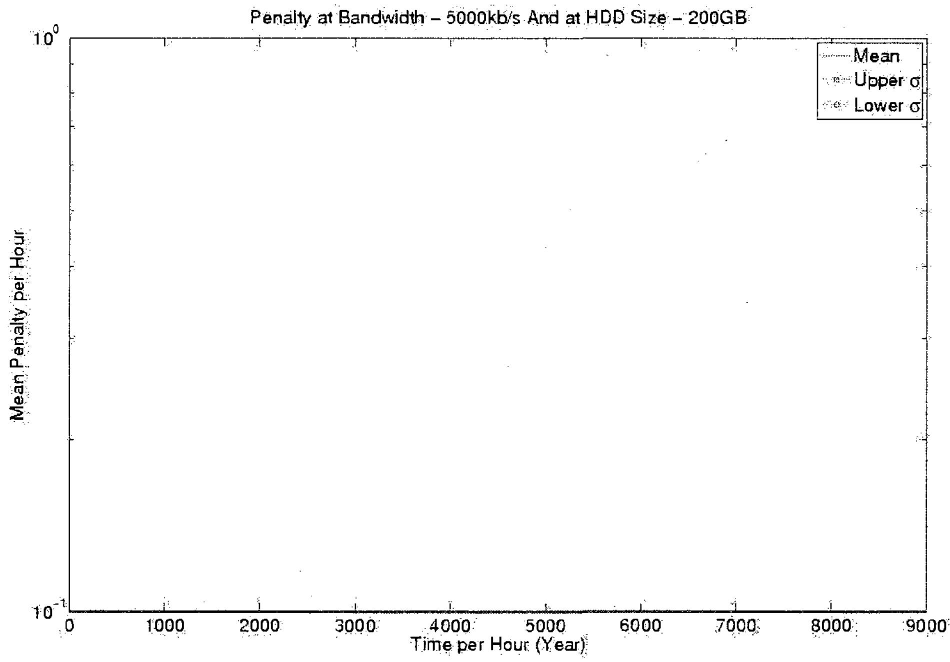


Figure 437: Penalty for H4 case scenario at hard drive size of 50GB and download bandwidth of 10000kb/s

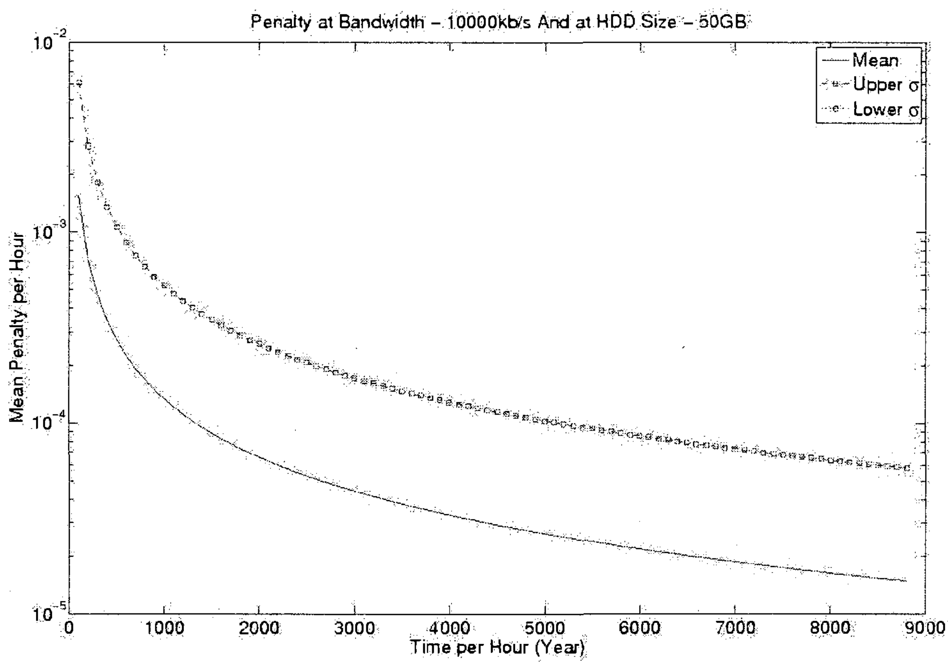


Figure 438: Penalty for H4 case scenario at hard drive size of 100GB and download bandwidth of 10000kb/s

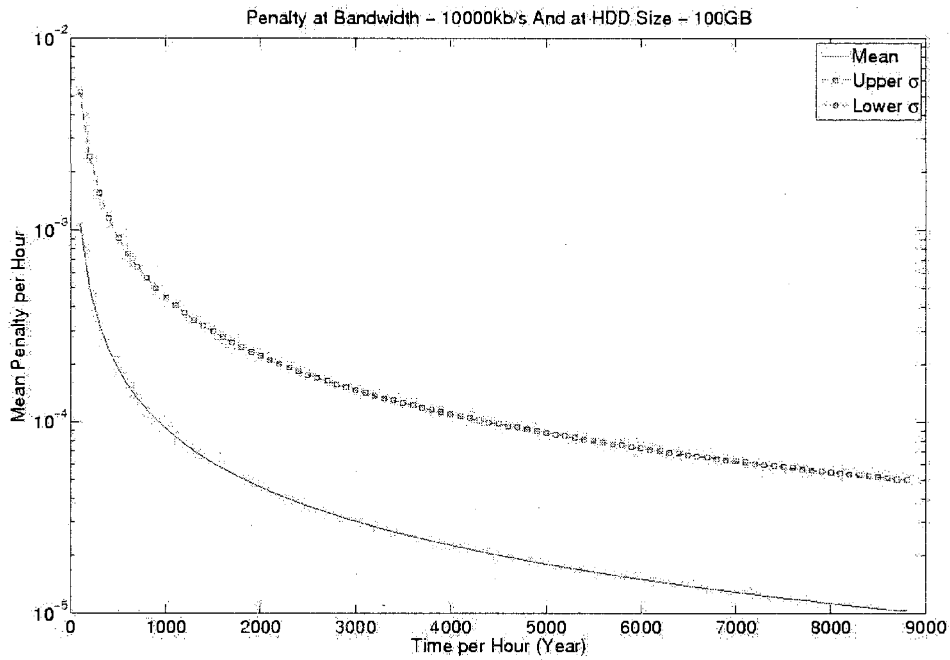


Figure 439: Penalty for H4 case scenario at hard drive size of 150GB and download bandwidth of 10000kb/s

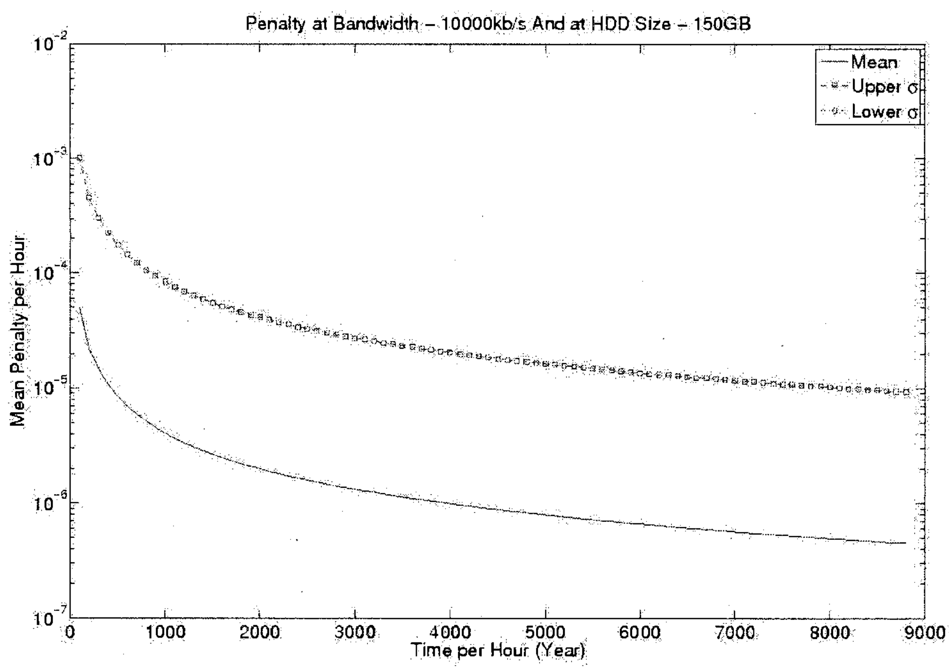


Figure 440: Penalty for H4 case scenario at hard drive size of 200GB and download bandwidth of 10000kb/s

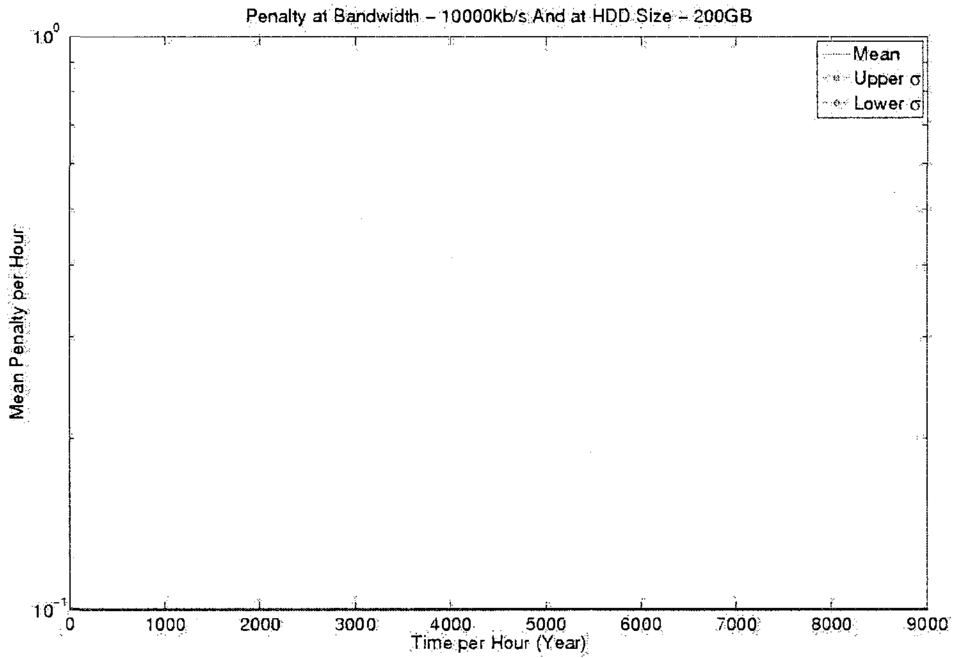


Figure 441: Penalty for H4 case scenario at hard drive size of 50GB and download bandwidth of 15000kb/s

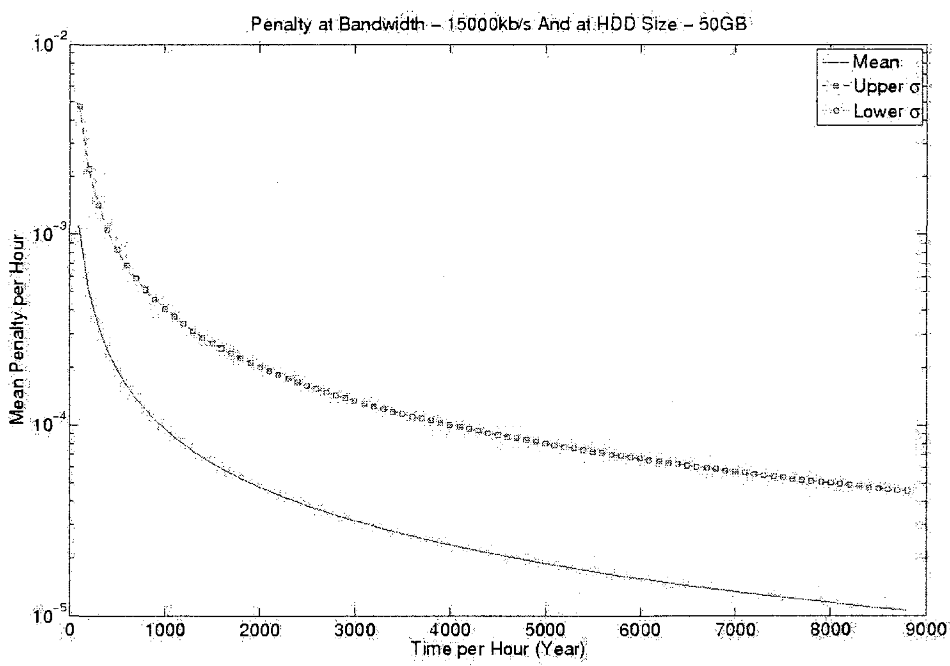


Figure 442: Penalty for H4 case scenario at hard drive size of 100GB and download bandwidth of 15000kb/s

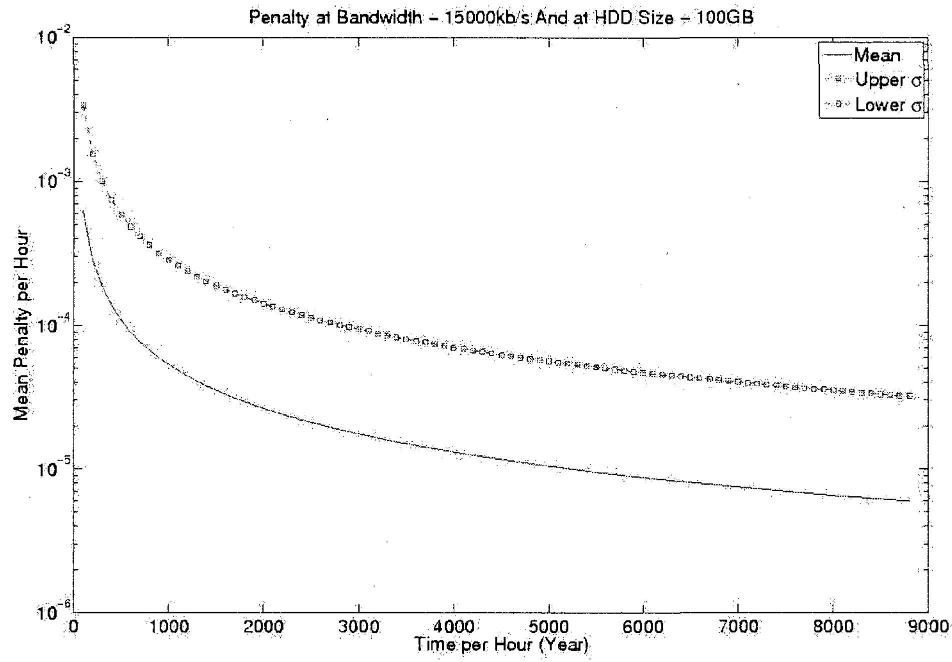


Figure 443: Penalty for H4 case scenario at hard drive size of 150GB and download bandwidth of 15000kb/s

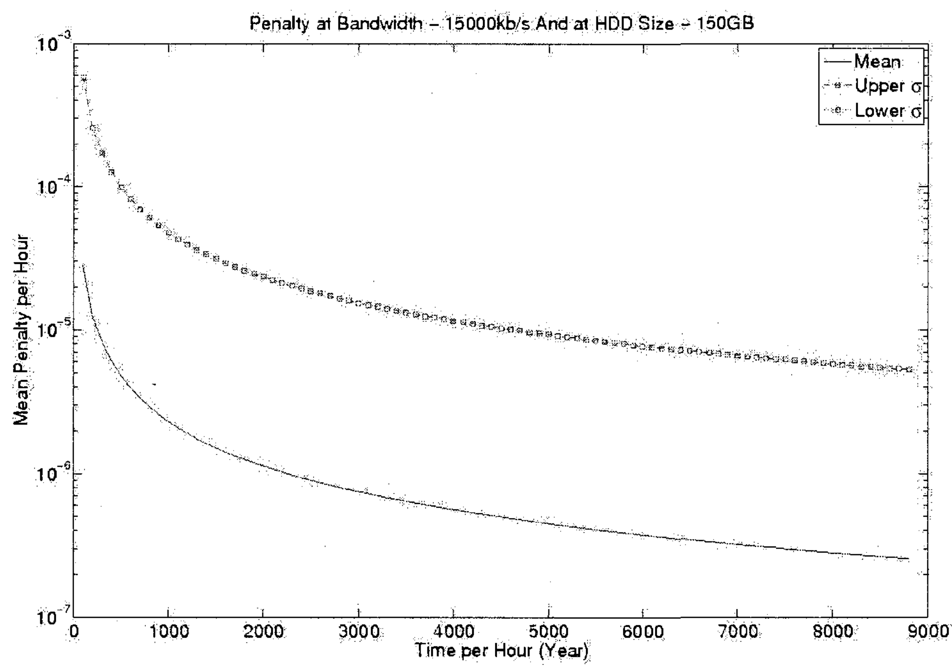


Figure 444: Penalty for H4 case scenario at hard drive size of 200GB and download bandwidth of 15000kb/s

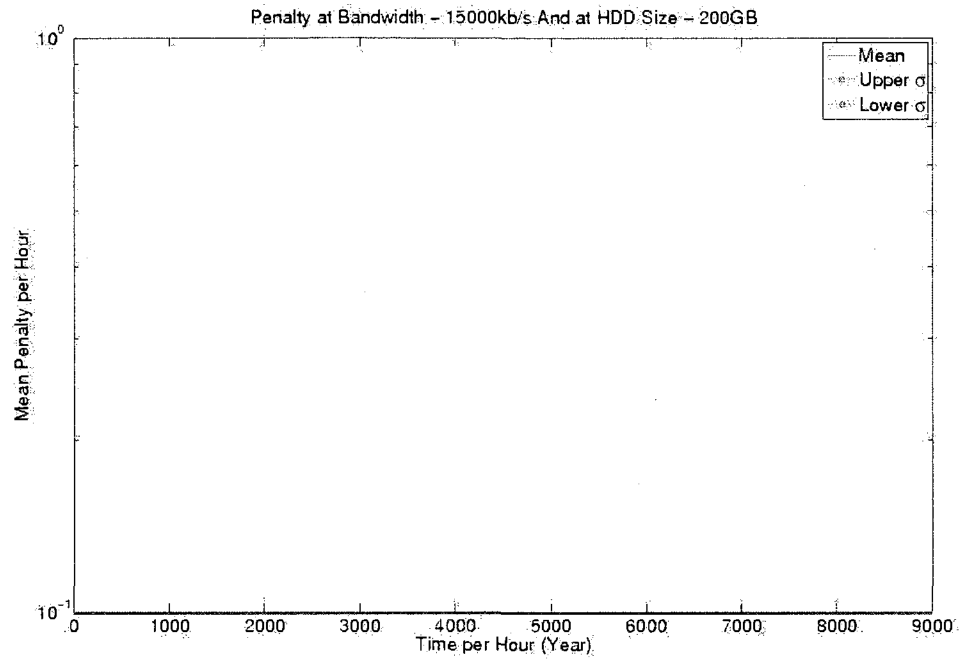


Figure 445: Total Download Bytes for H1 case scenario at hard drive size of 50GB and download bandwidth of 25kb/s

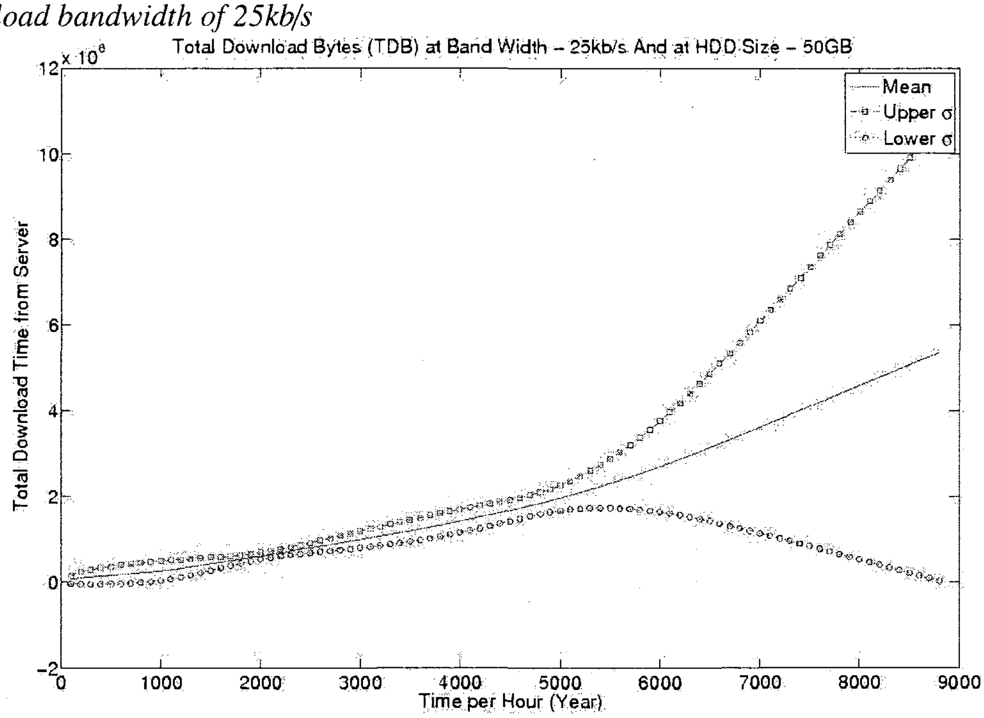


Figure 446: Total Download Bytes for H1 case scenario at hard drive size of 100GB and download bandwidth of 25kb/s

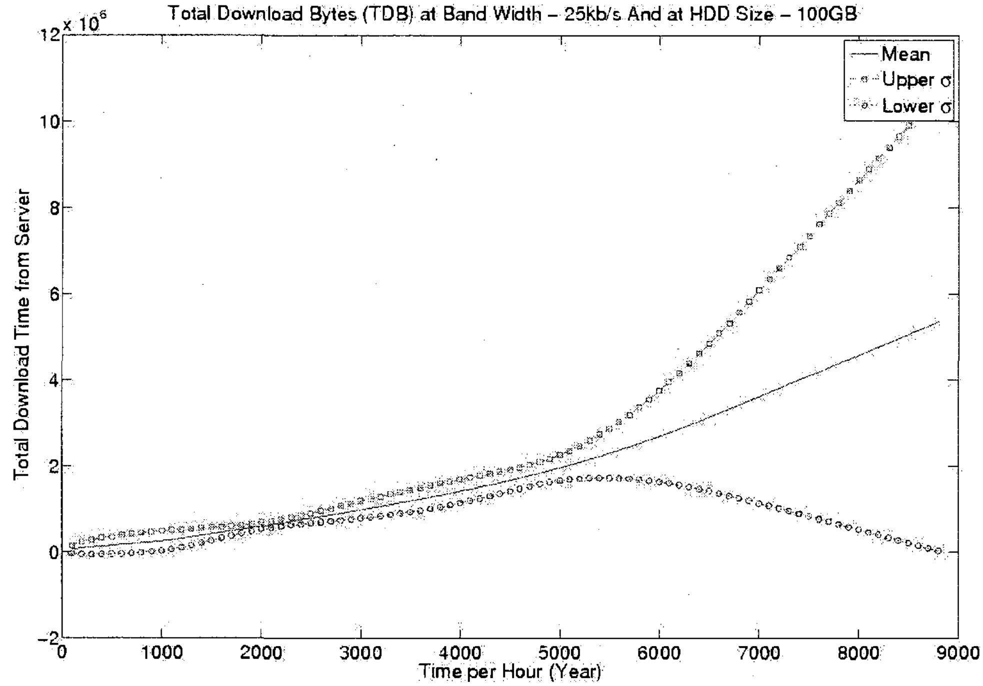


Figure 447: Total Download Bytes for H1 case scenario at hard drive size of 150GB and download bandwidth of 25kb/s

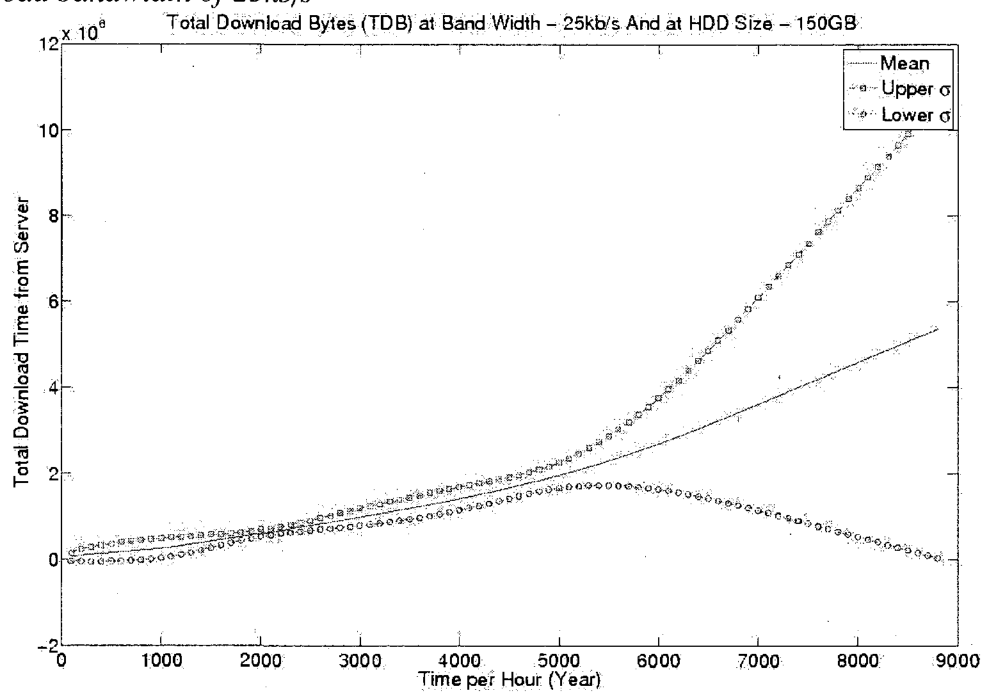


Figure 448: Total Download Bytes for H1 case scenario at hard drive size of 200GB and download bandwidth of 25kb/s

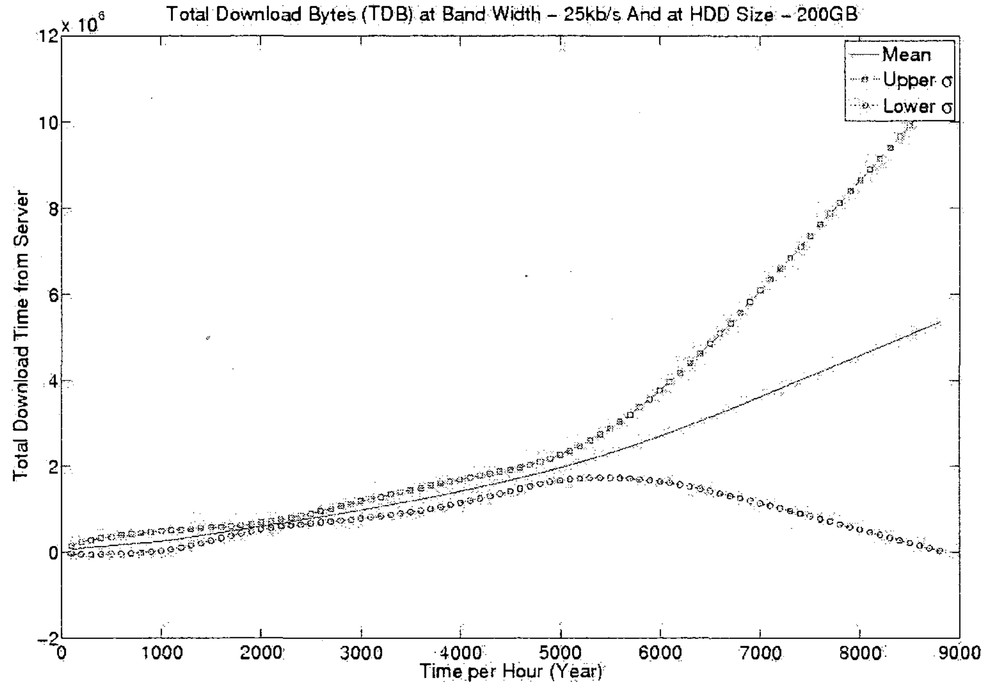


Figure 449: Total Download Bytes for H1 case scenario at hard drive size of 50GB and download bandwidth of 50kb/s

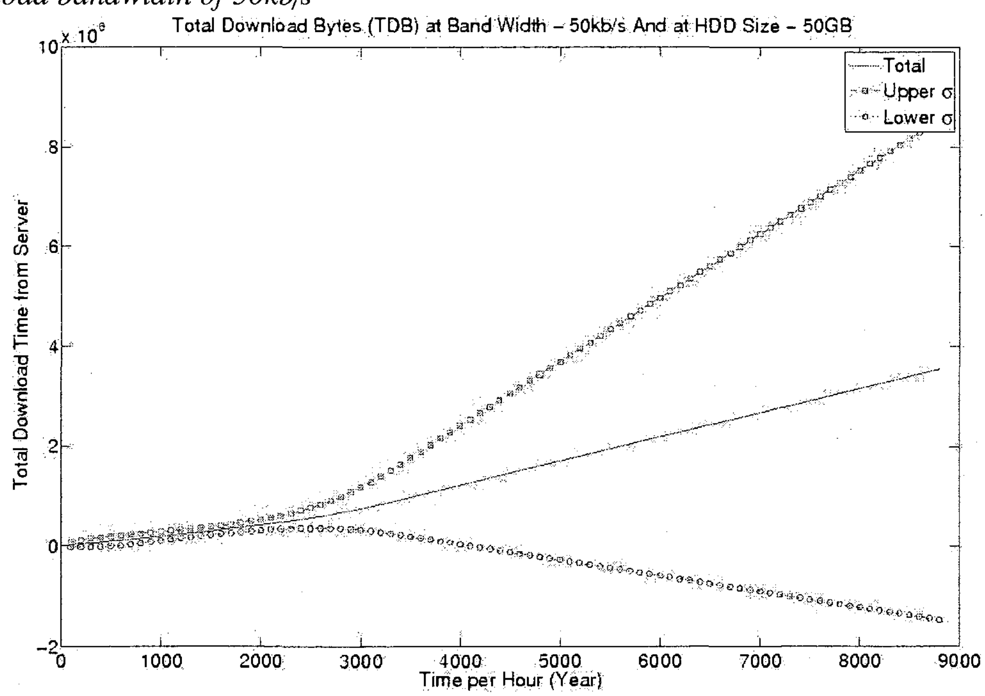


Figure 450: Total Download Bytes for H1 case scenario at hard drive size of 100GB and download bandwidth of 50kb/s

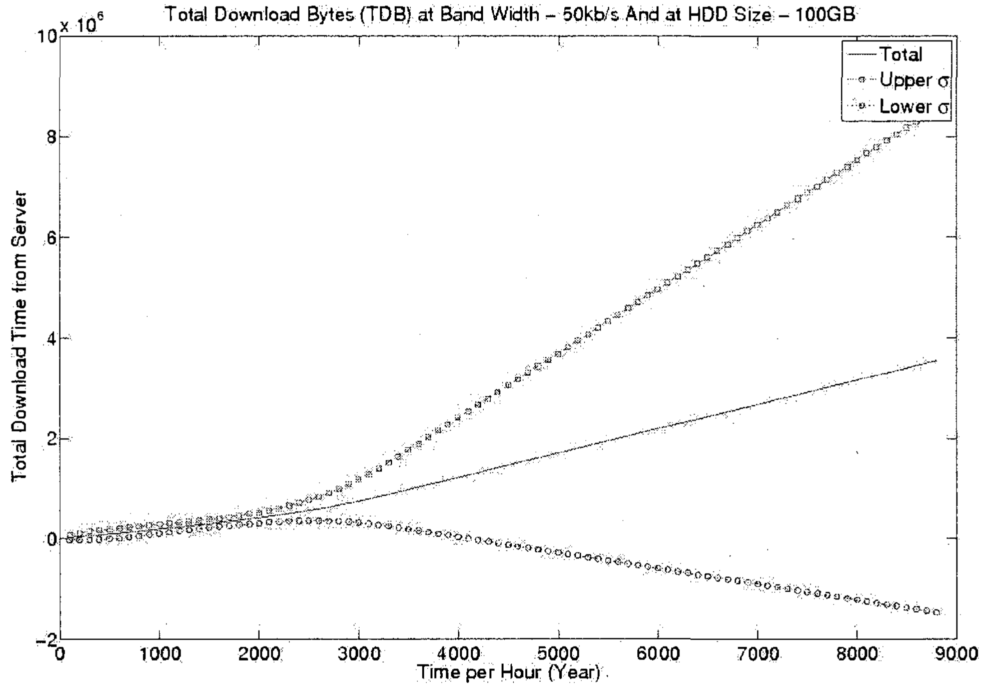


Figure 451: Total Download Bytes for H1 case scenario at hard drive size of 150GB and download bandwidth of 50kb/s

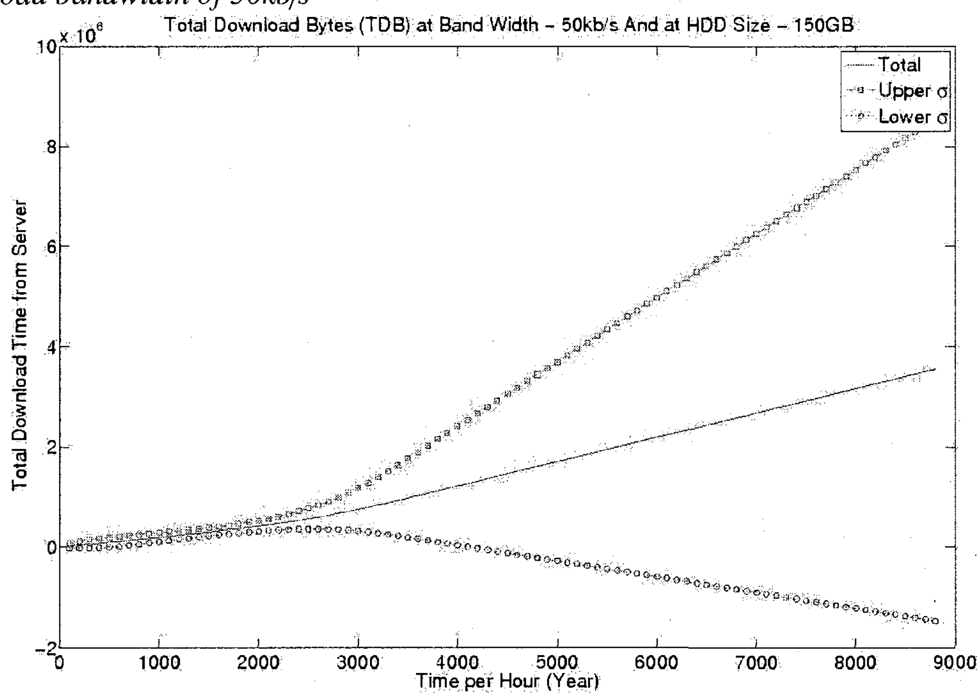


Figure 452: Total Download Bytes for H1 case scenario at hard drive size of 200GB and download bandwidth of 50kb/s

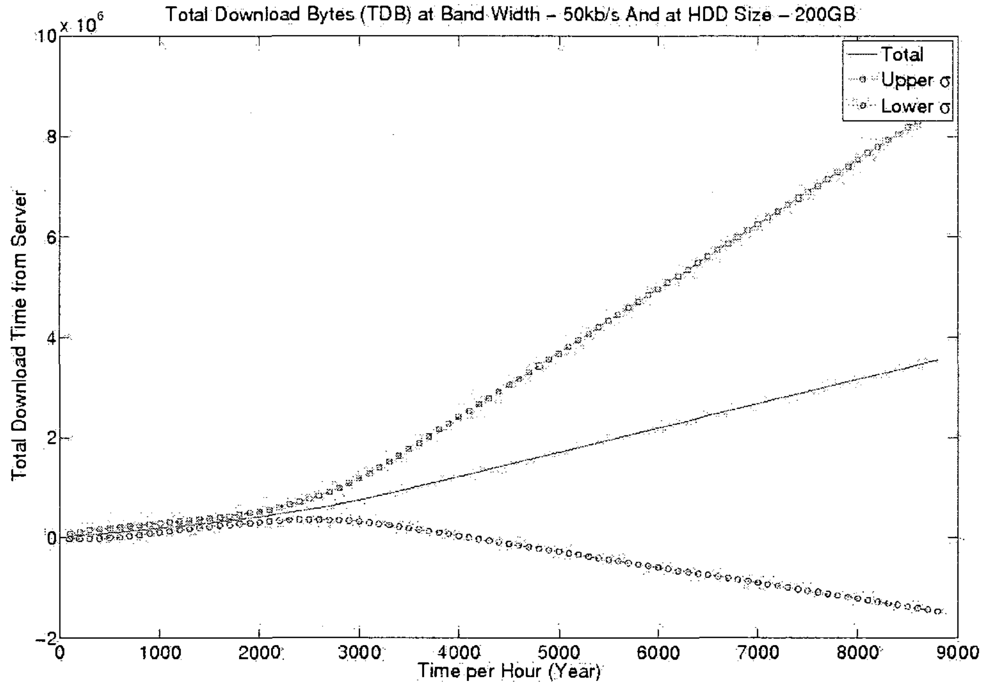


Figure 453: Total Download Bytes for H1 case scenario at hard drive size of 50GB and download bandwidth of 100kb/s

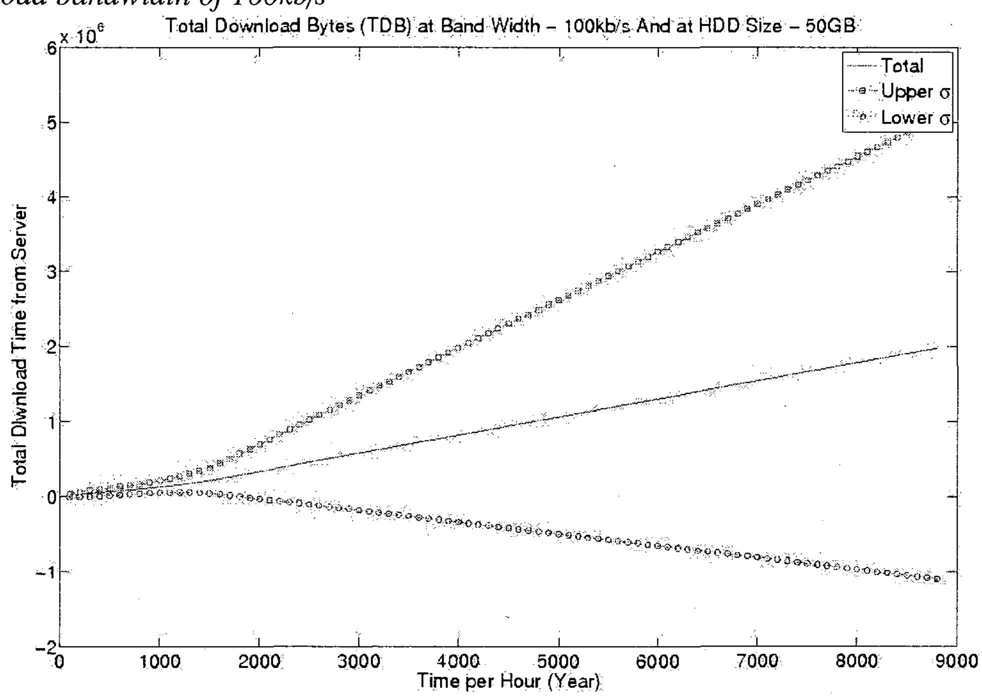


Figure 454: Total Download Bytes for H1 case scenario at hard drive size of 100GB and download bandwidth of 100kb/s

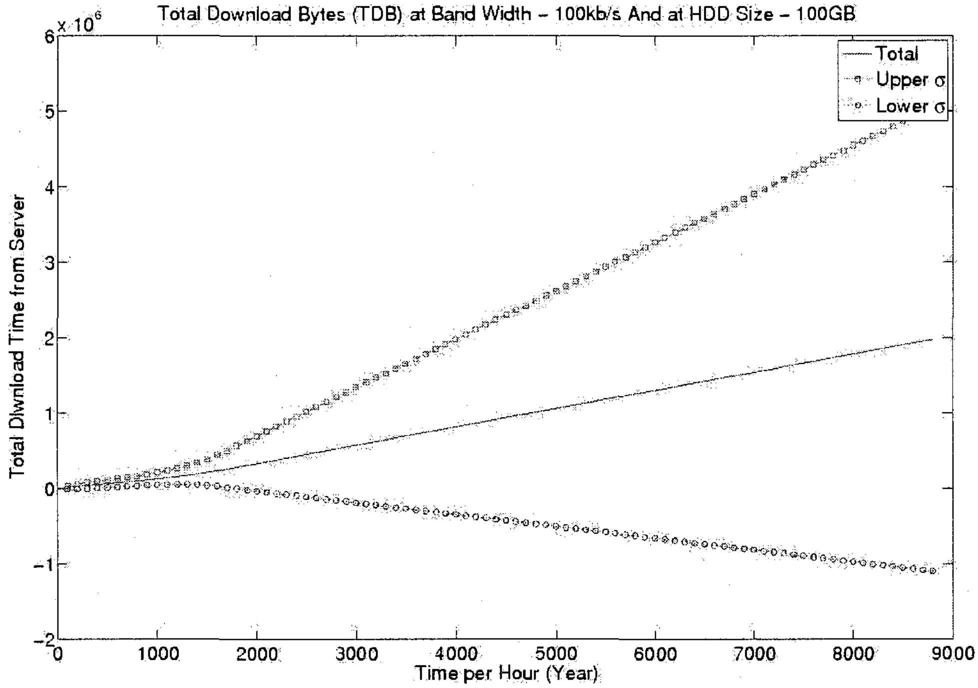


Figure 455: Total Download Bytes for H1 case scenario at hard drive size of 150GB and download bandwidth of 100kb/s

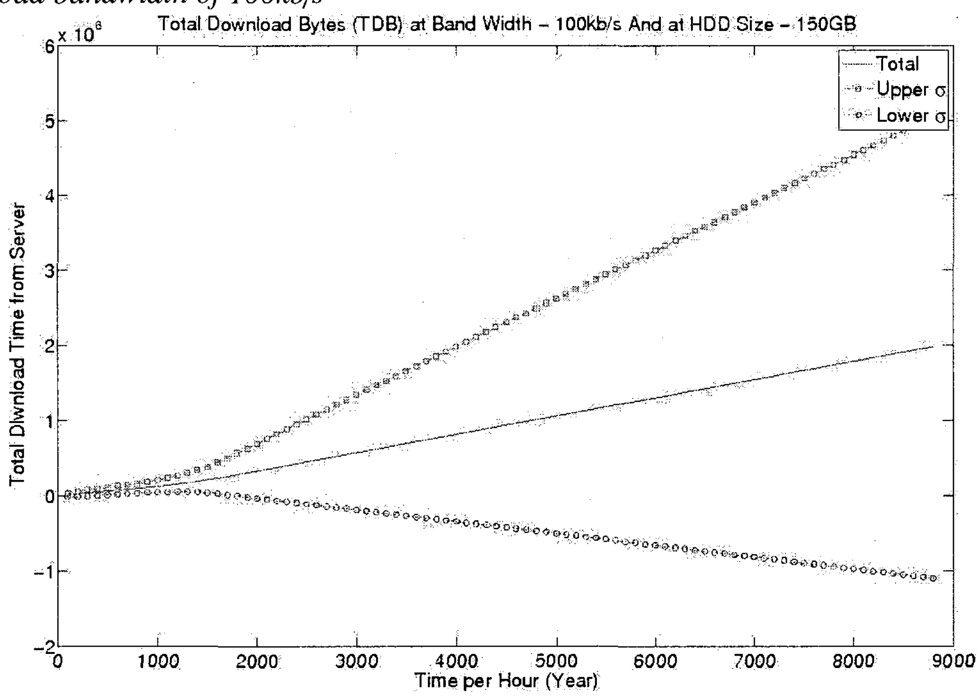


Figure 456: Total Download Bytes for H1 case scenario at hard drive size of 200GB and download bandwidth of 100kb/s

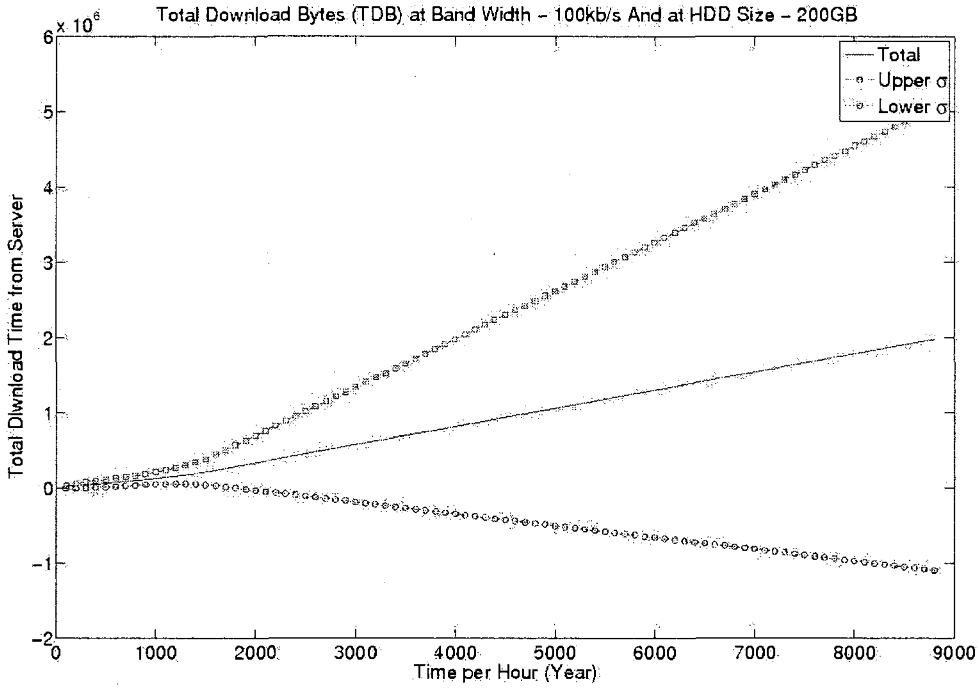


Figure 457: Total Download Bytes for H1 case scenario at hard drive size of 50GB and download bandwidth of 128kb/s

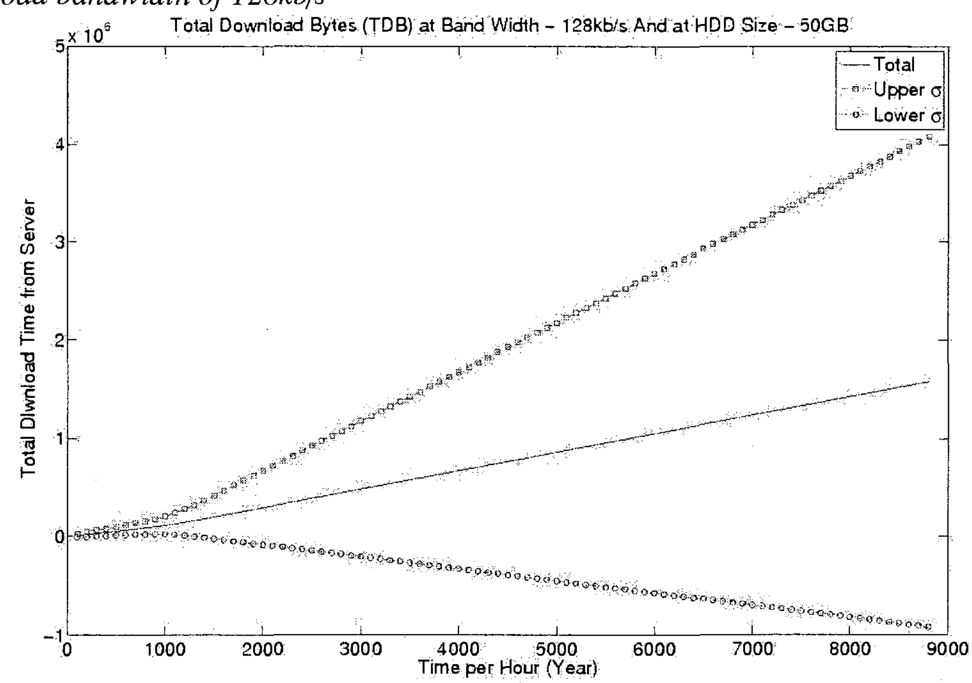


Figure 458: Total Download Bytes for H1 case scenario at hard drive size of 100GB and download bandwidth of 128kb/s

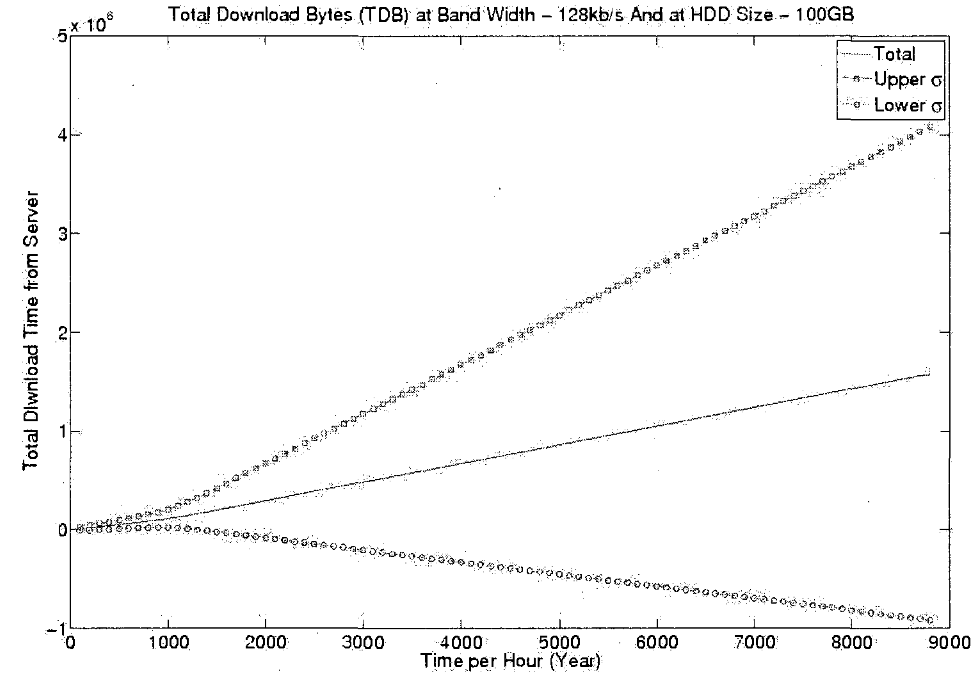


Figure 459: Total Download Bytes for H1 case scenario at hard drive size of 150GB and download bandwidth of 128kb/s

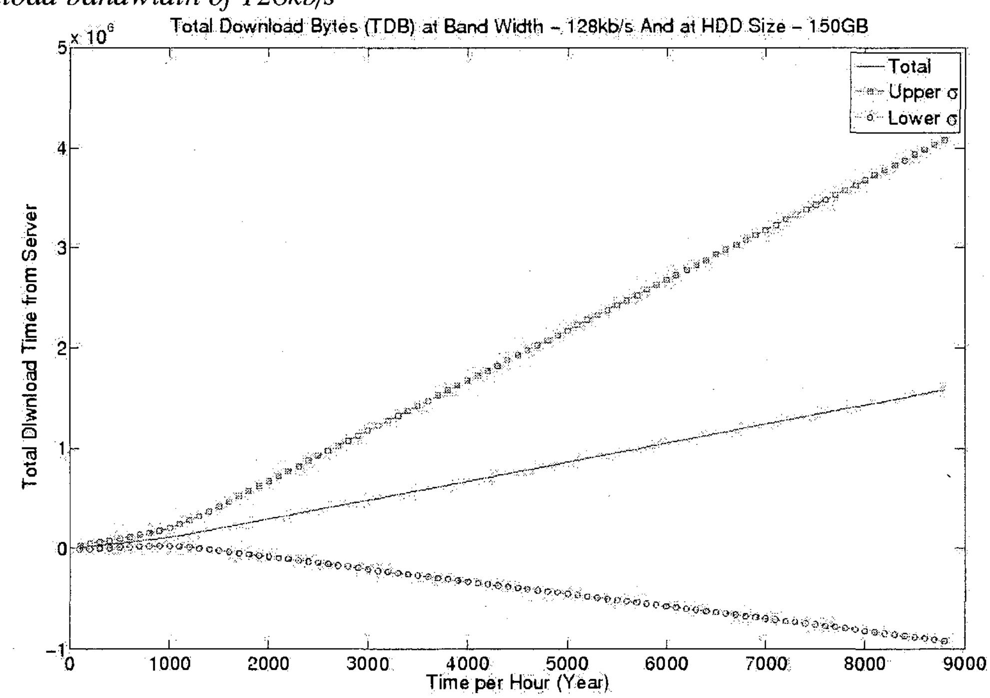


Figure 460: Total Download Bytes for H1 case scenario at hard drive size of 200GB and download bandwidth of 128kb/s

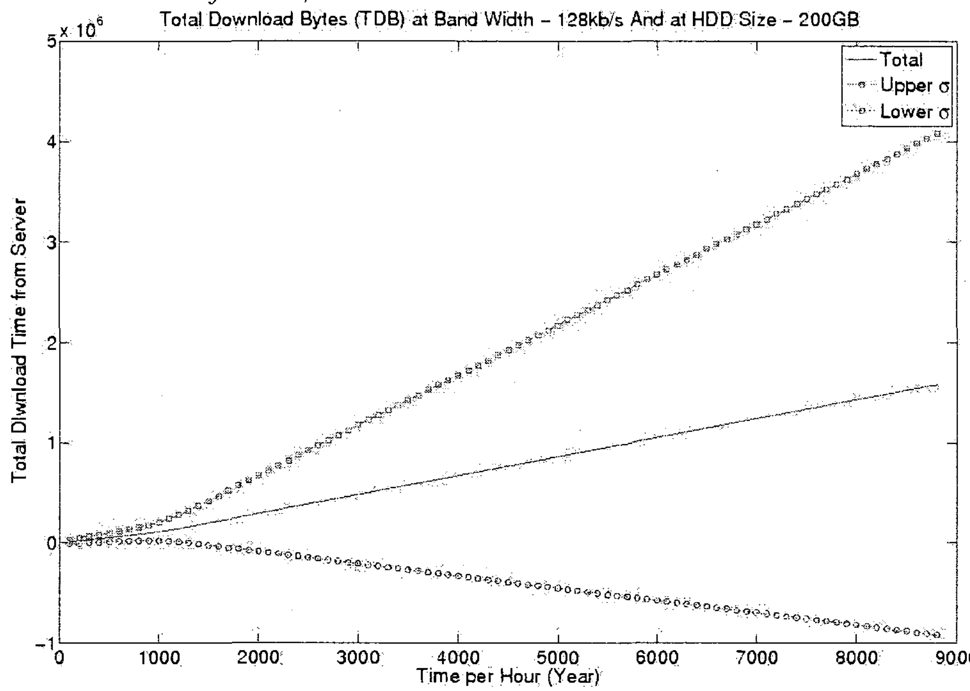


Figure 461: Total Download Bytes for H1 case scenario at hard drive size of 50GB and download bandwidth of 256kb/s

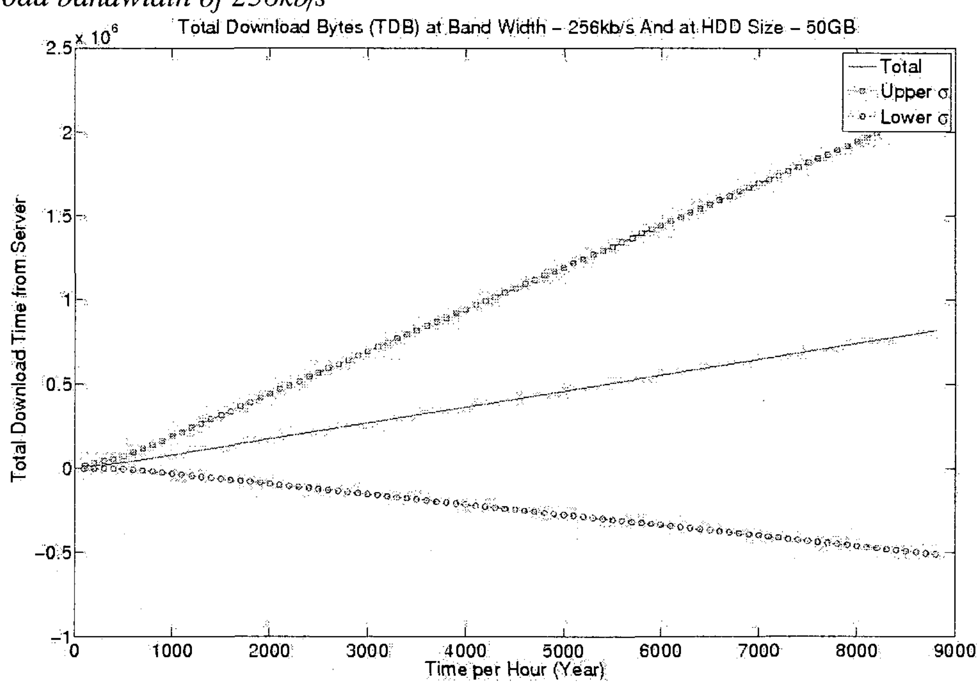


Figure 462: Total Download Bytes for H1 case scenario at hard drive size of 100GB and download bandwidth of 256kb/s

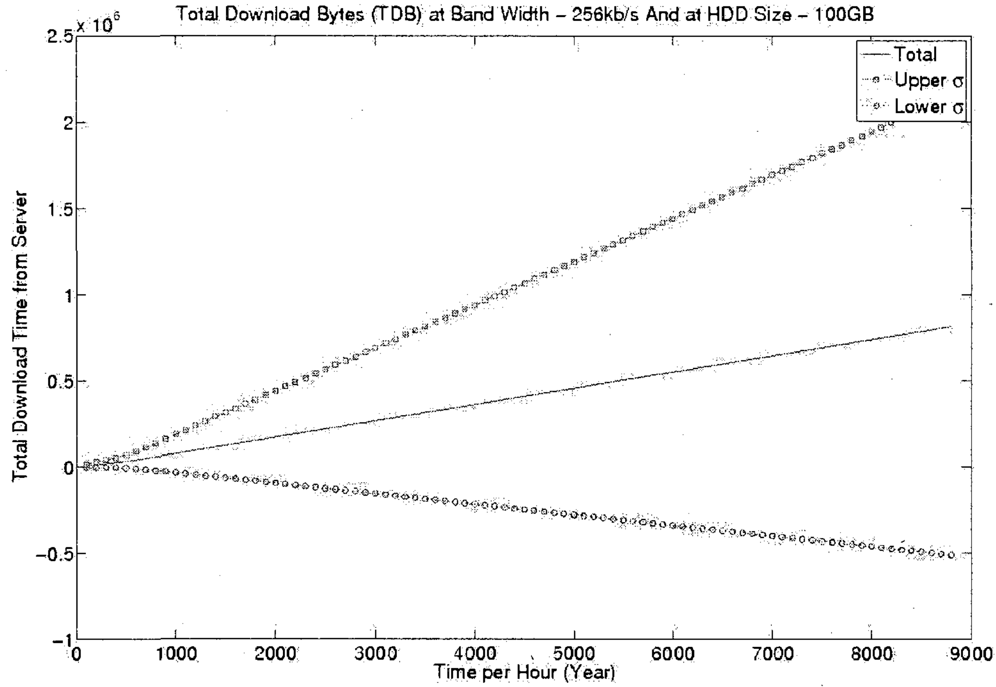


Figure 463: Total Download Bytes for H1 case scenario at hard drive size of 150GB and download bandwidth of 256kb/s

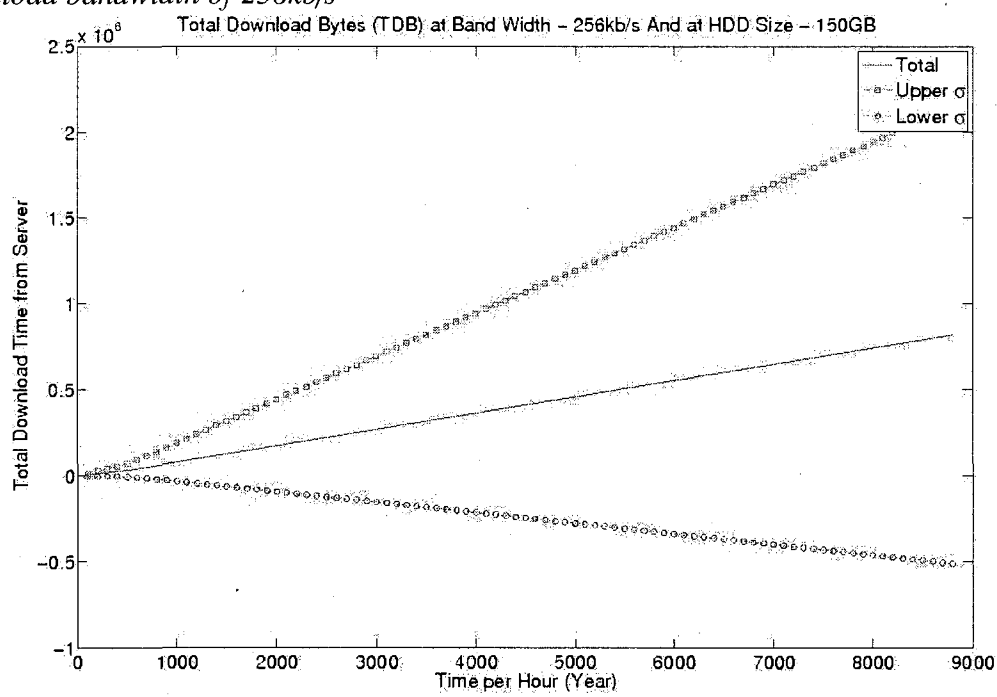


Figure 464: Total Download Bytes for H1 case scenario at hard drive size of 200GB and download bandwidth of 256kb/s

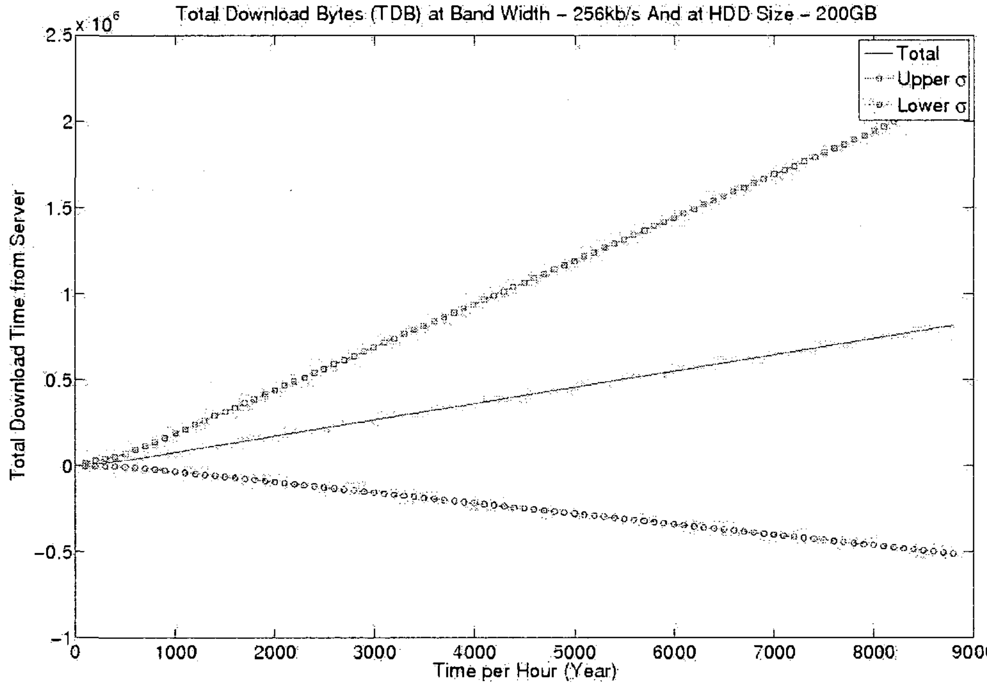


Figure 465: Total Download Bytes for H1 case scenario at hard drive size of 50GB and download bandwidth of 512kb/s

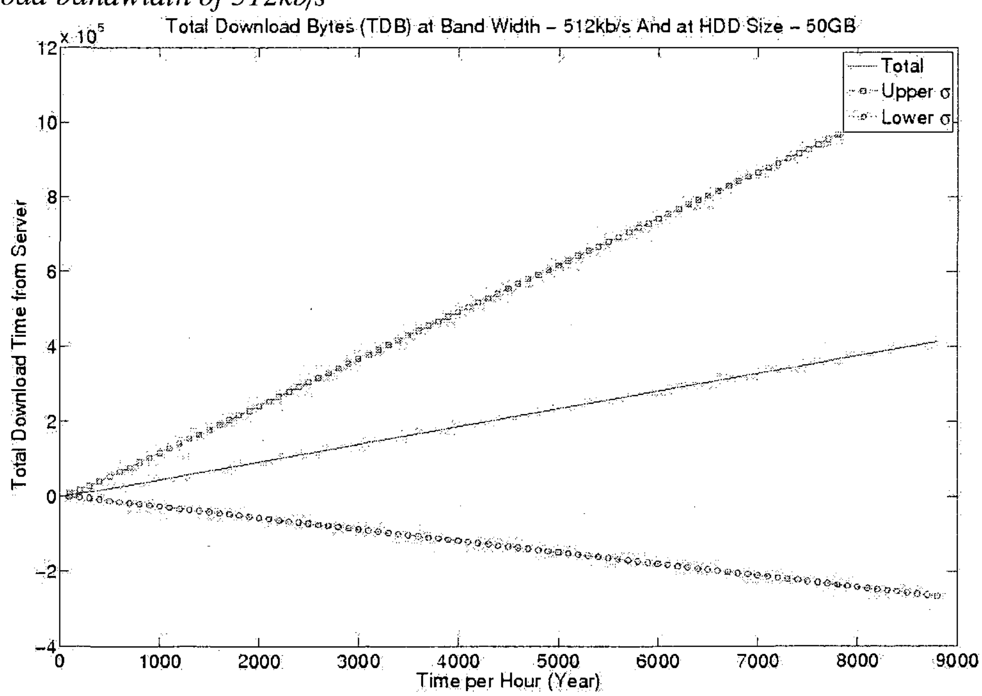


Figure 466: Total Download Bytes for H1 case scenario at hard drive size of 100GB and download bandwidth of 512kb/s

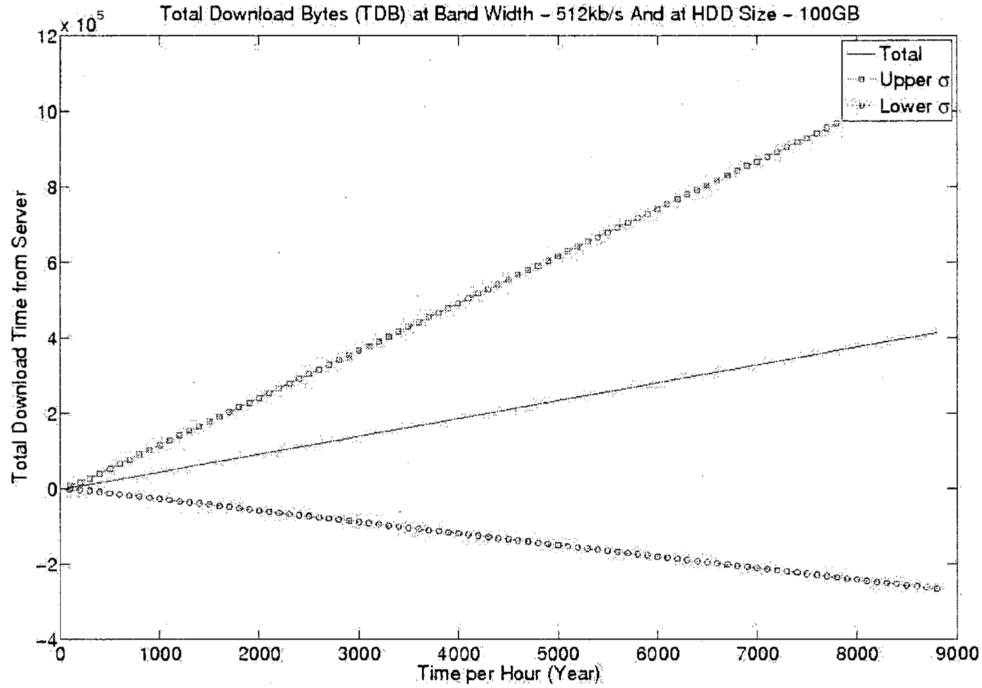


Figure 467: Total Download Bytes for H1 case scenario at hard drive size of 150GB and download bandwidth of 512kb/s

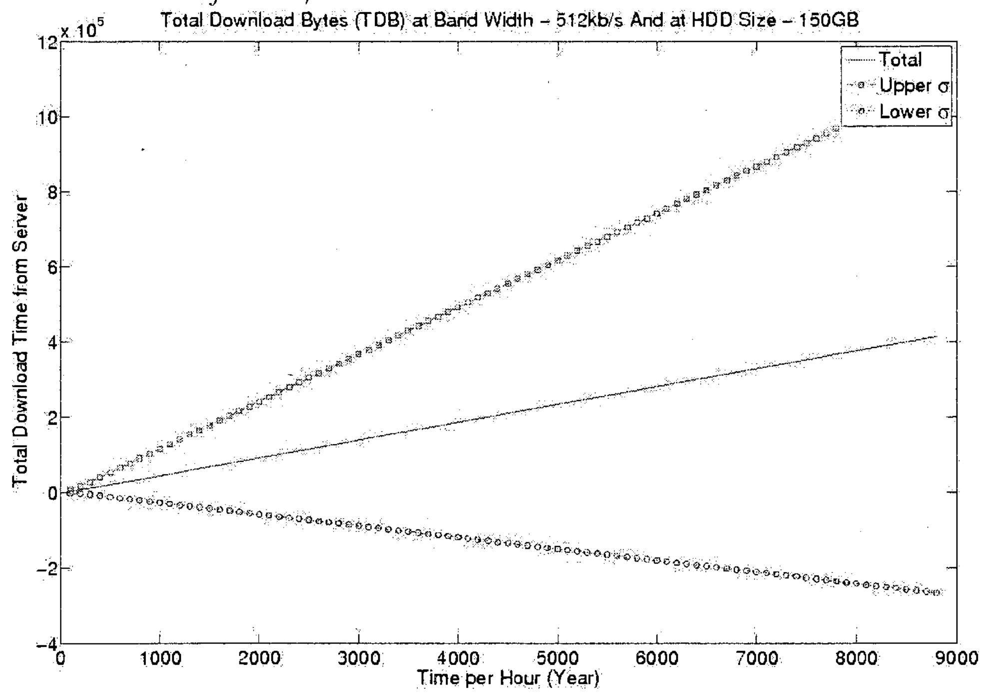


Figure 468: Total Download Bytes for H1 case scenario at hard drive size of 200GB and download bandwidth of 512kb/s

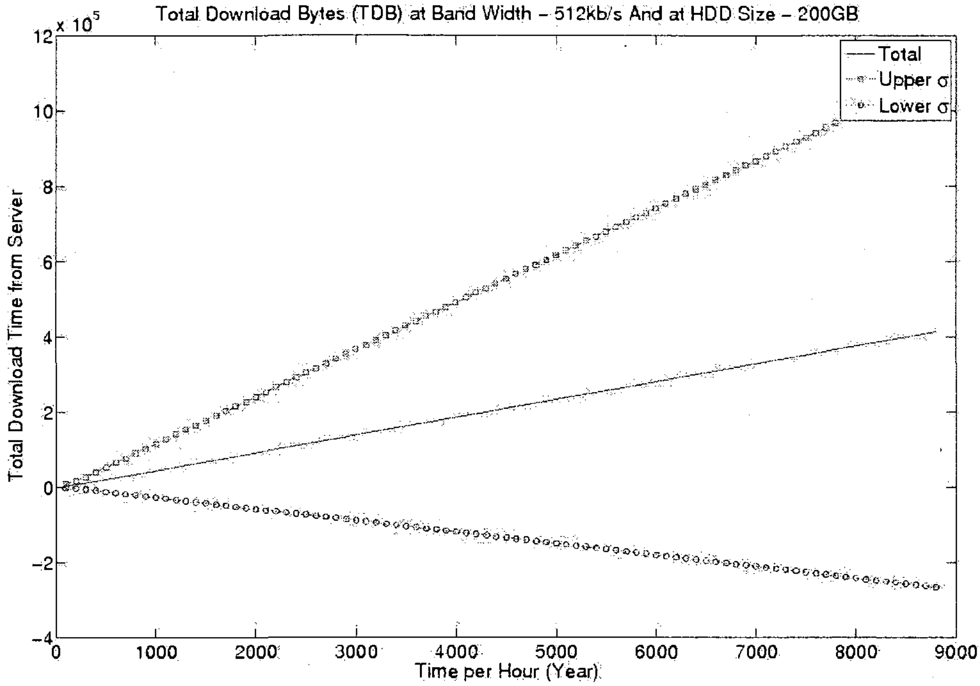


Figure 469: Total Download Bytes for H1 case scenario at hard drive size of 50GB and download bandwidth of 1000kb/s

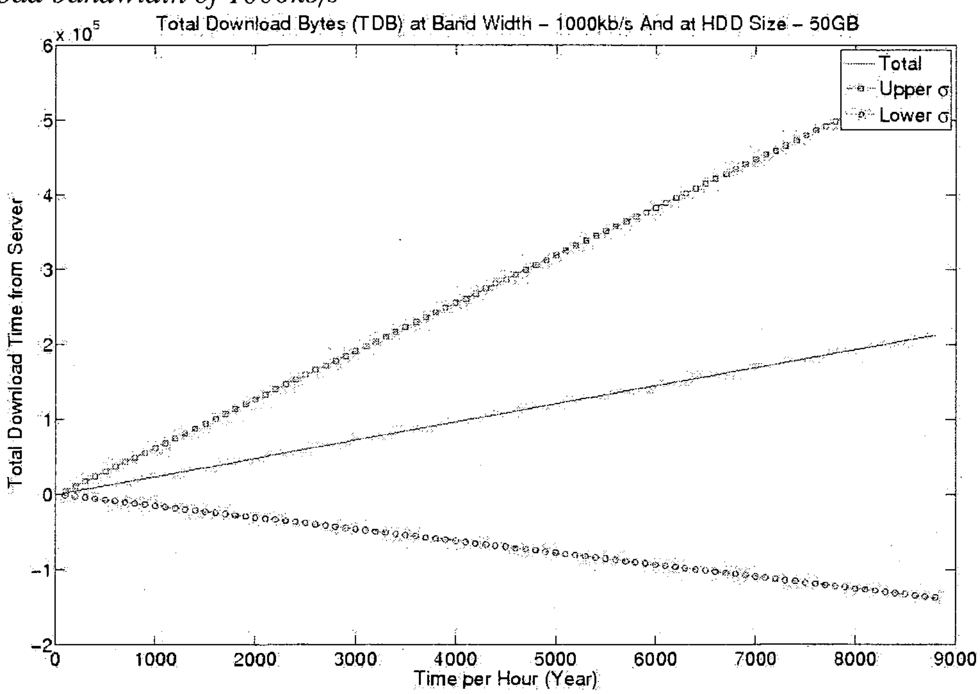


Figure 470: Total Download Bytes for H1 case scenario at hard drive size of 100GB and download bandwidth of 1000kb/s

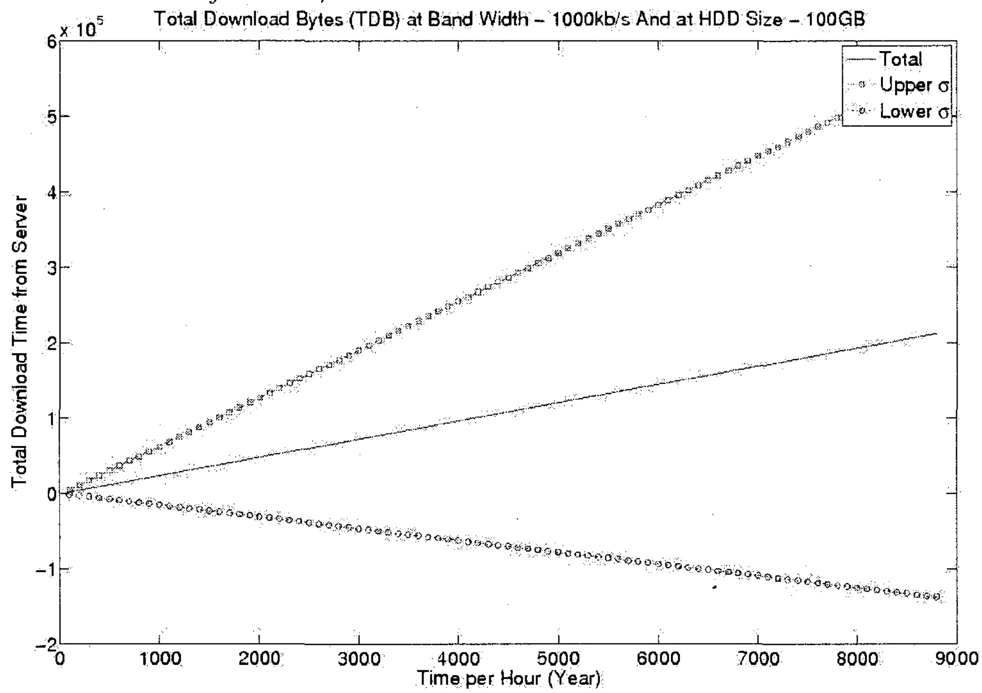


Figure 471: Total Download Bytes for H1 case scenario at hard drive size of 150GB and download bandwidth of 1000kb/s

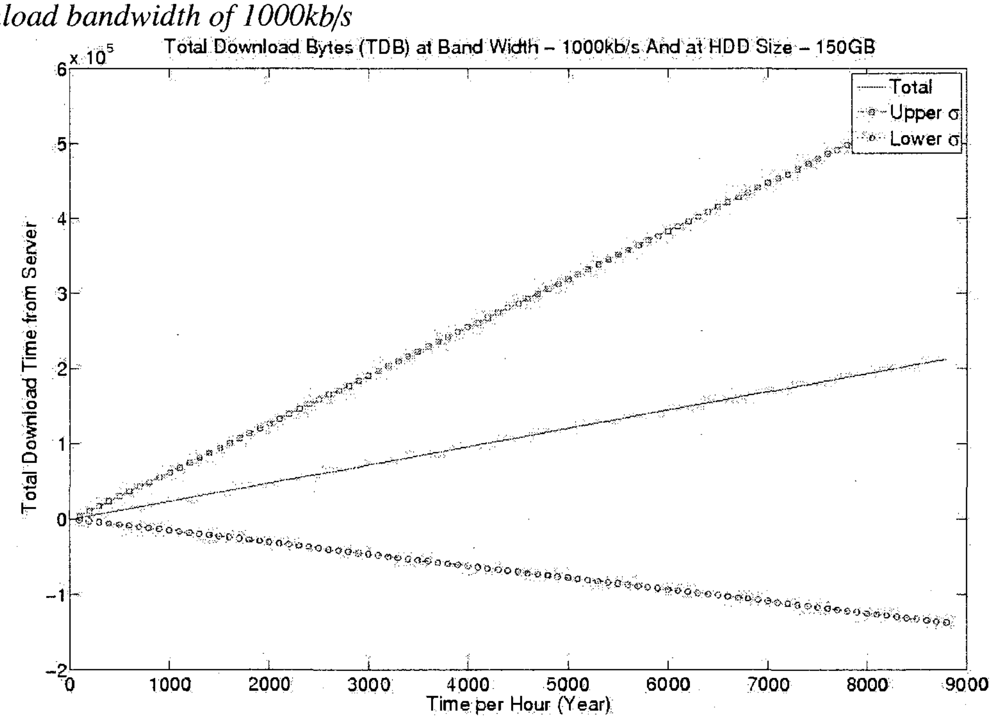


Figure 472: Total Download Bytes for H1 case scenario at hard drive size of 200GB and download bandwidth of 1000kb/s

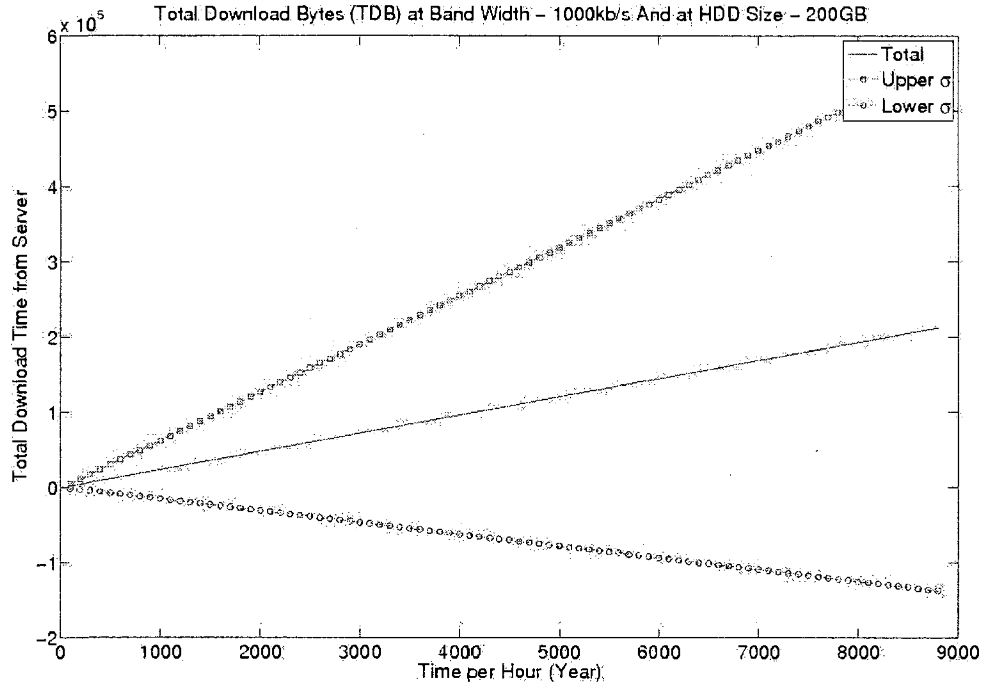


Figure 473: Total Download Bytes for H1 case scenario at hard drive size of 50GB and download bandwidth of 2000kb/s

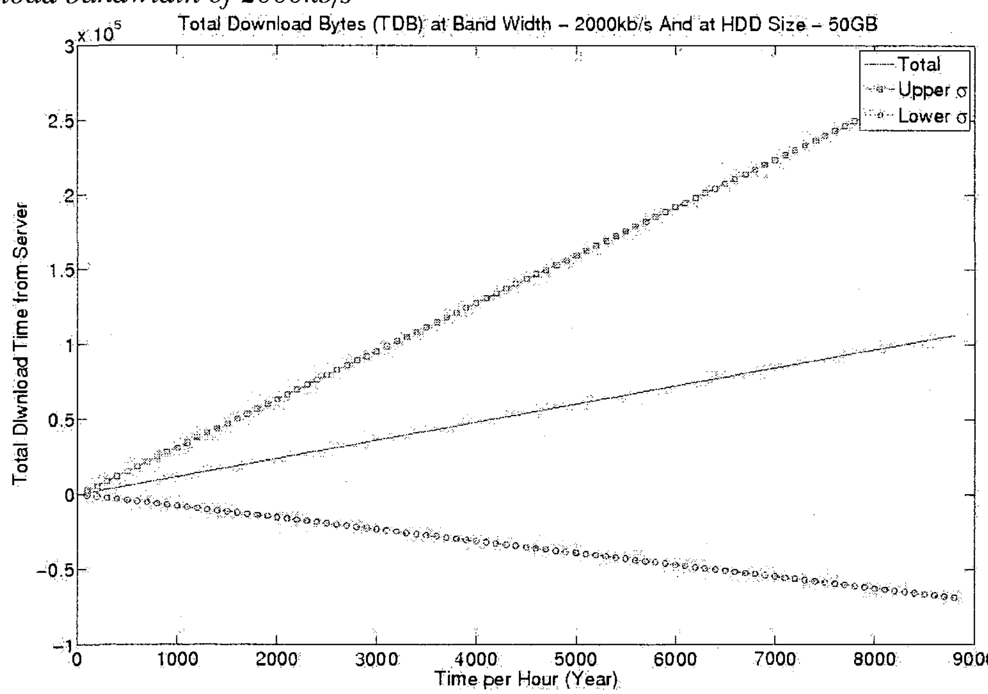


Figure 474: Total Download Bytes for H1 case scenario at hard drive size of 100GB and download bandwidth of 2000kb/s

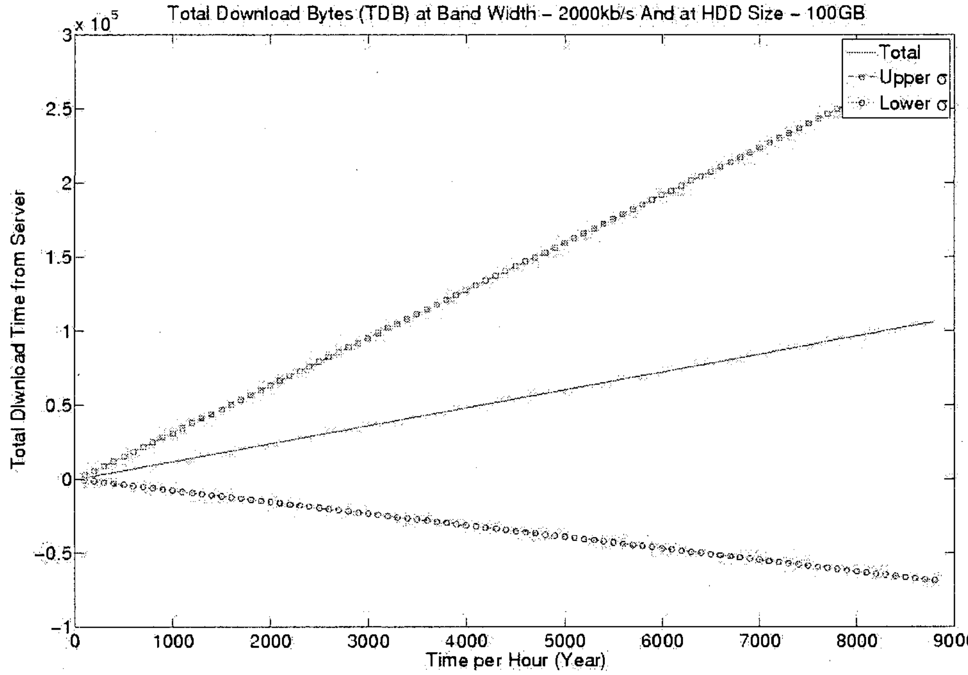


Figure 475: Total Download Bytes for H1 case scenario at hard drive size of 150GB and download bandwidth of 2000kb/s

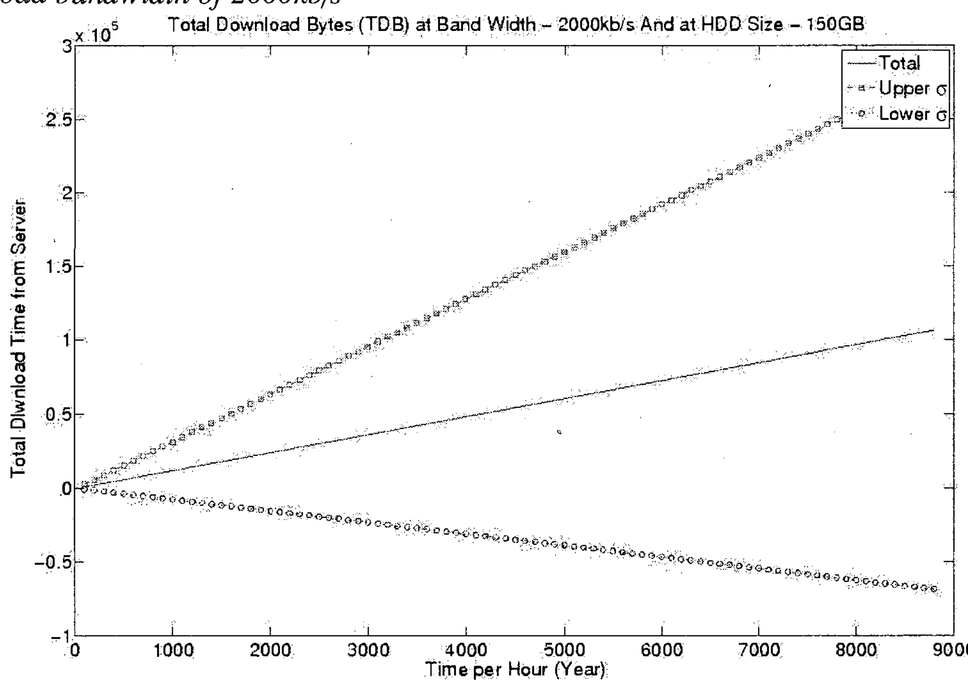


Figure 476: Total Download Bytes for H1 case scenario at hard drive size of 200GB and download bandwidth of 2000kb/s

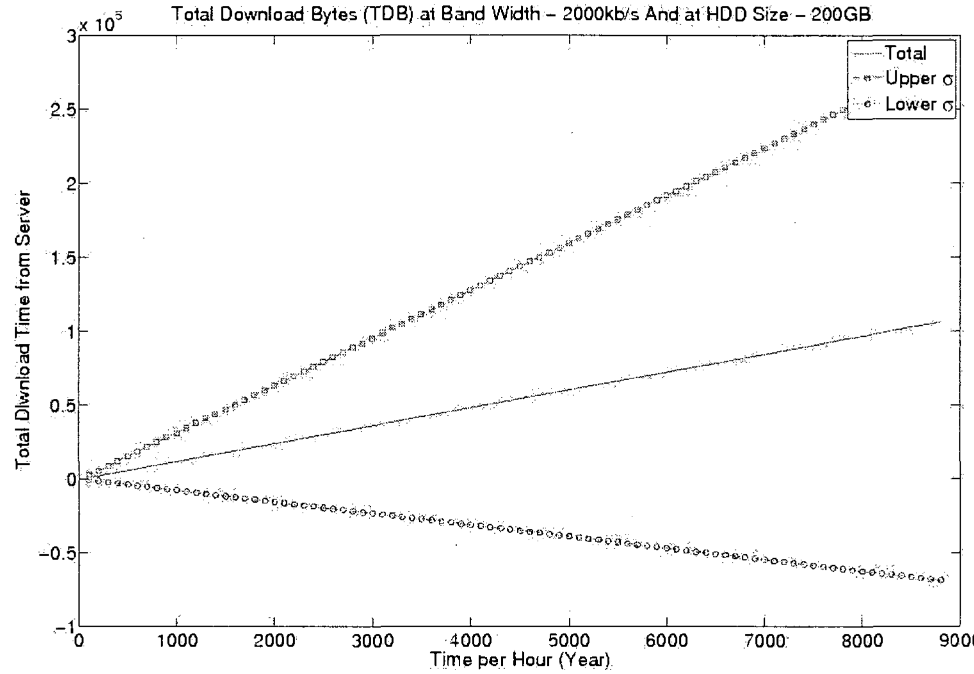


Figure 477: Total Download Bytes for H1 case scenario at hard drive size of 50GB and download bandwidth of 5000kb/s

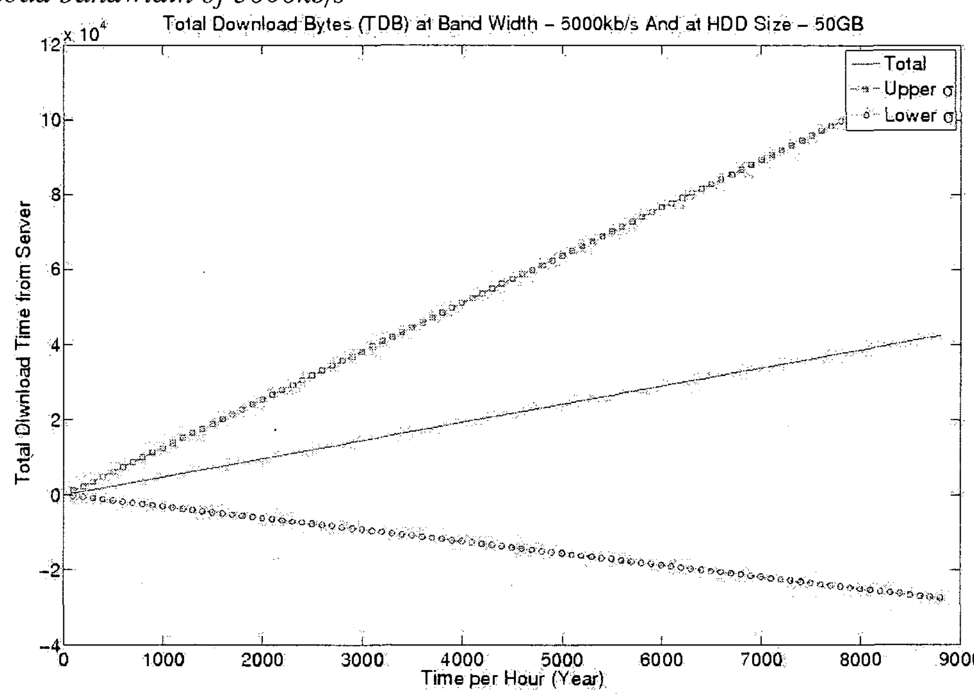


Figure 478: Total Download Bytes for H1 case scenario at hard drive size of 100GB and download bandwidth of 5000kb/s

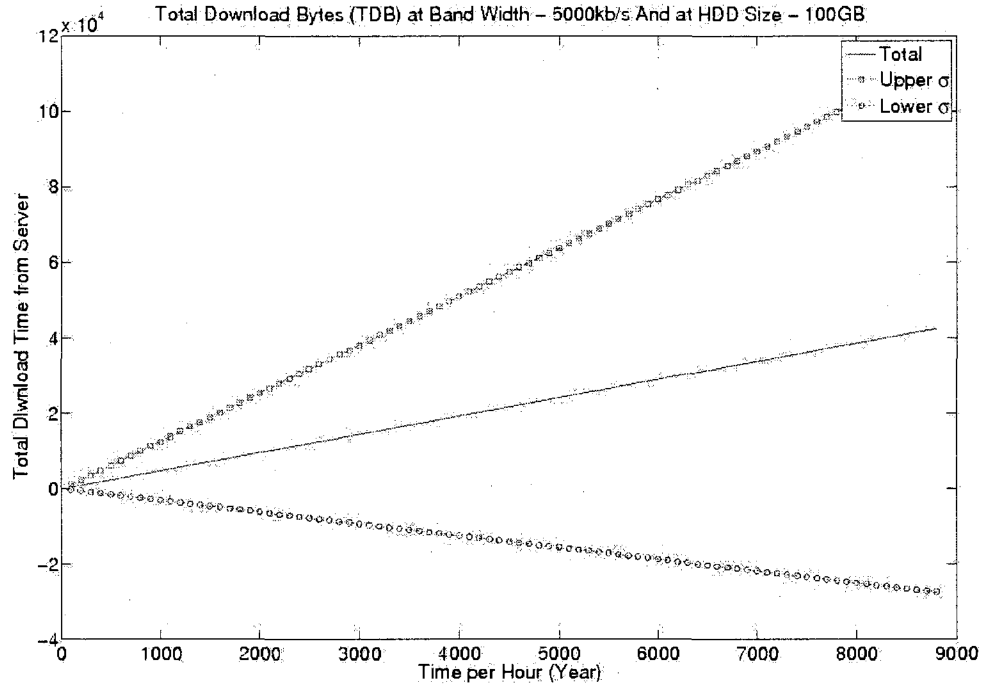


Figure 479: Total Download Bytes for H1 case scenario at hard drive size of 150GB and download bandwidth of 5000kb/s

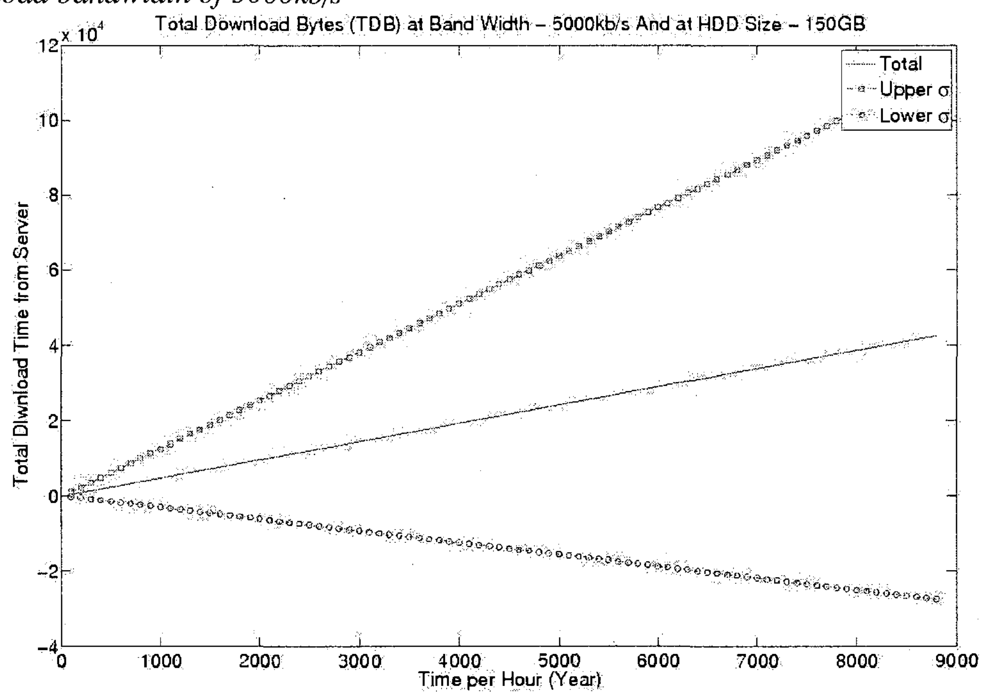


Figure 480: Total Download Bytes for H1 case scenario at hard drive size of 200GB and download bandwidth of 5000kb/s

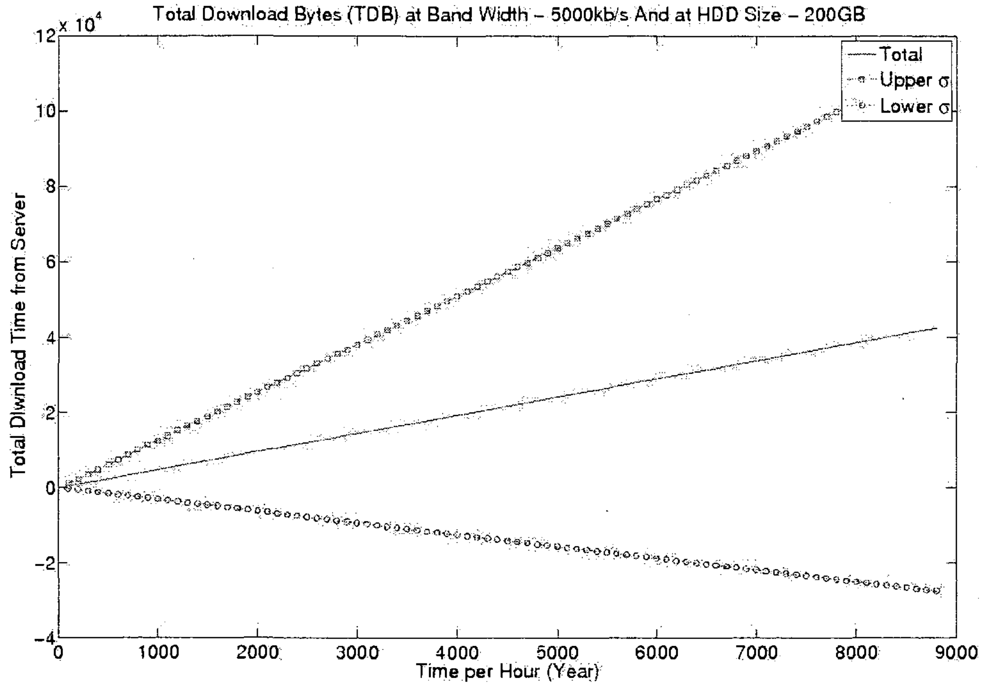


Figure 481: Total Download Bytes for H1 case scenario at hard drive size of 50GB and download bandwidth of 10000kb/s

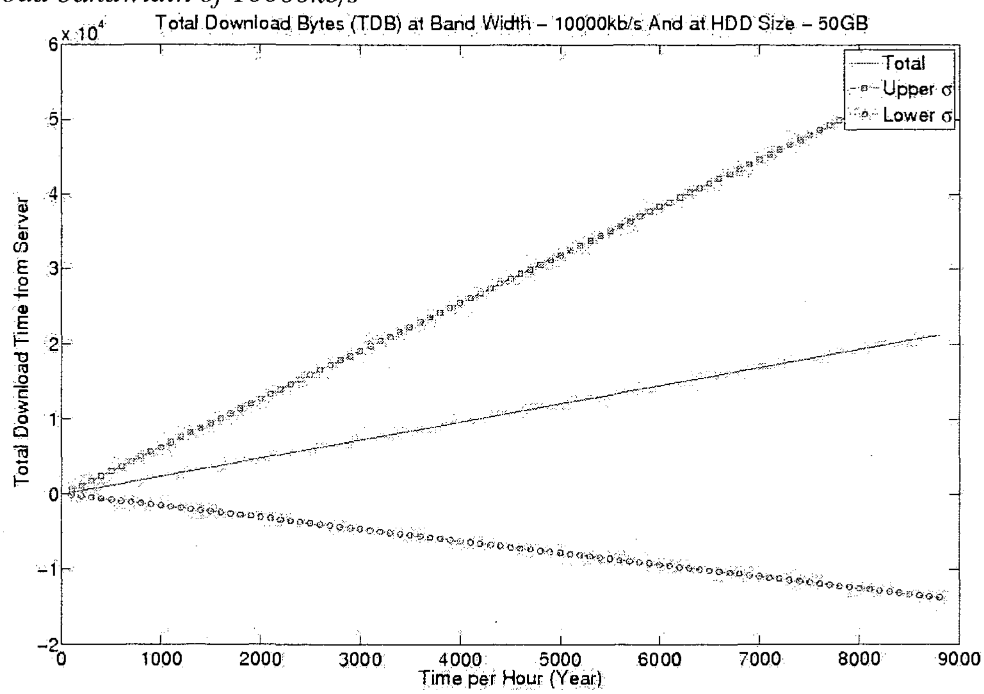


Figure 482: Total Download Bytes for H1 case scenario at hard drive size of 100GB and download bandwidth of 10000kb/s

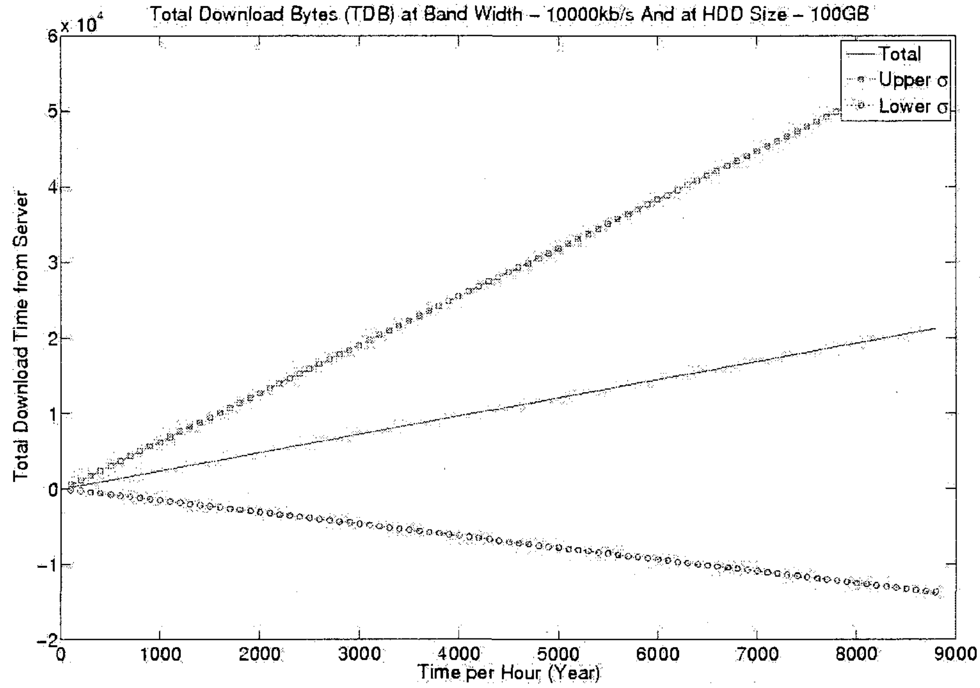


Figure 483: Total Download Bytes for H1 case scenario at hard drive size of 150GB and download bandwidth of 10000kb/s

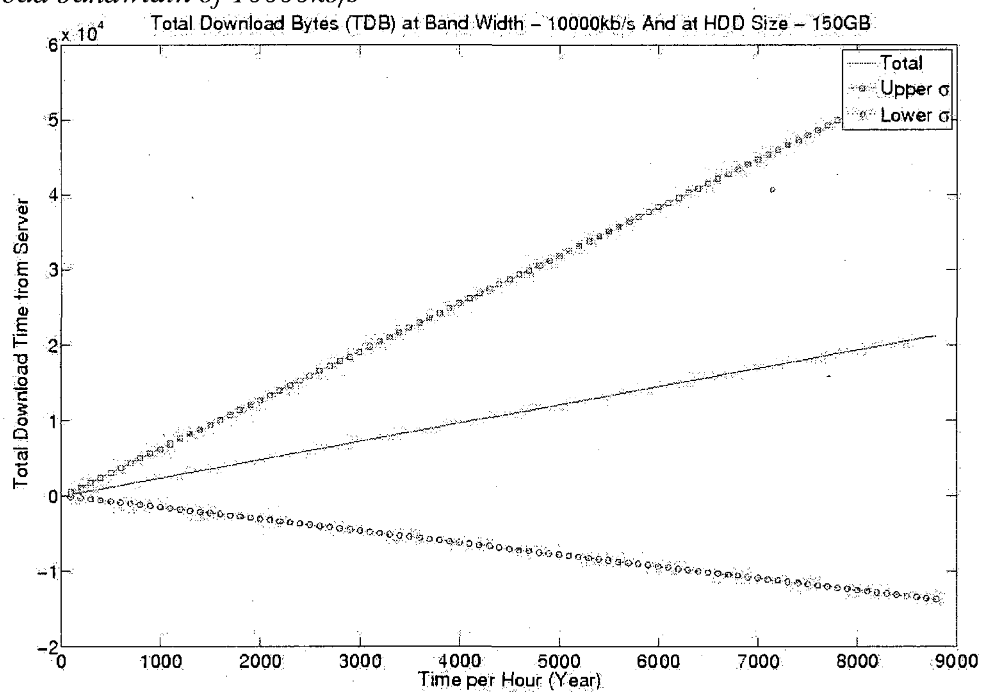


Figure 484: Total Download Bytes for H1 case scenario at hard drive size of 200GB and download bandwidth of 10000kb/s

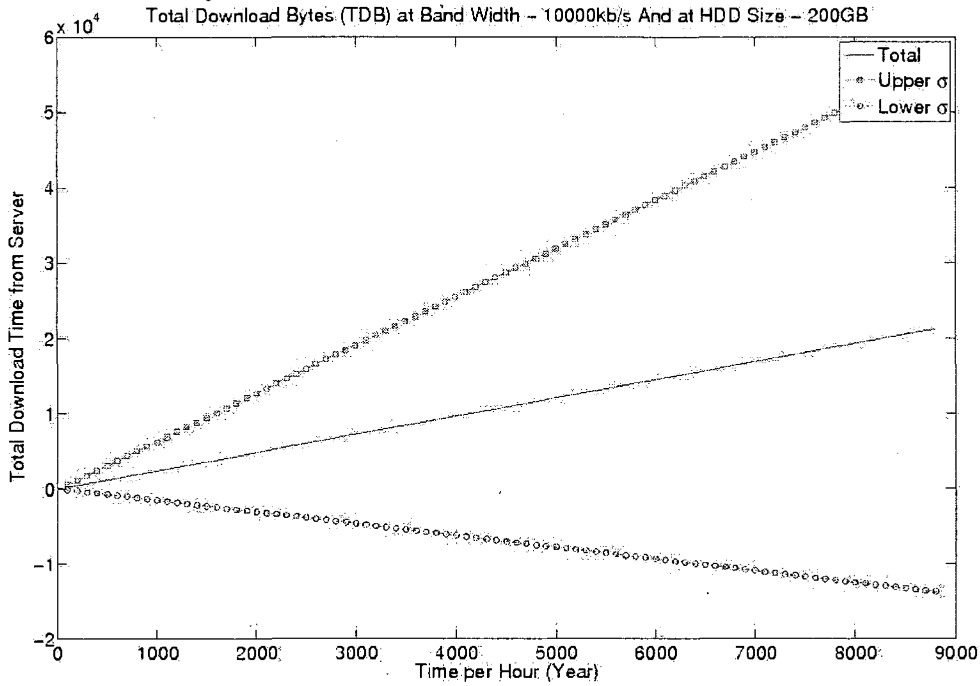


Figure 485: Total Download Bytes for H1 case scenario at hard drive size of 50GB and download bandwidth of 15000kb/s

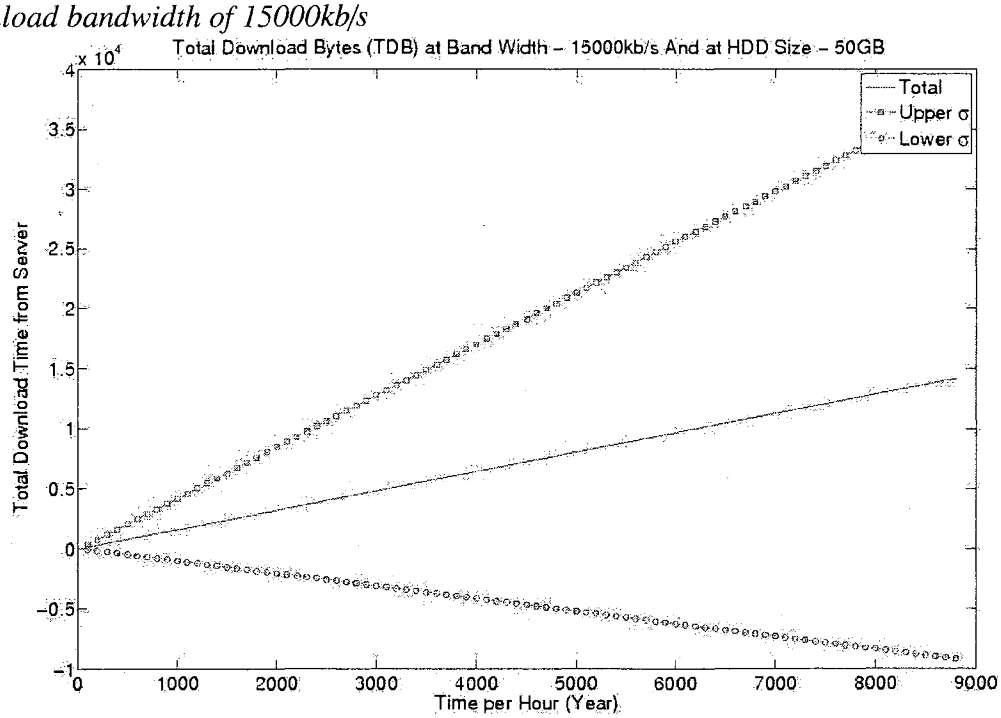


Figure 486: Total Download Bytes for H1 case scenario at hard drive size of 100GB and download bandwidth of 15000kb/s

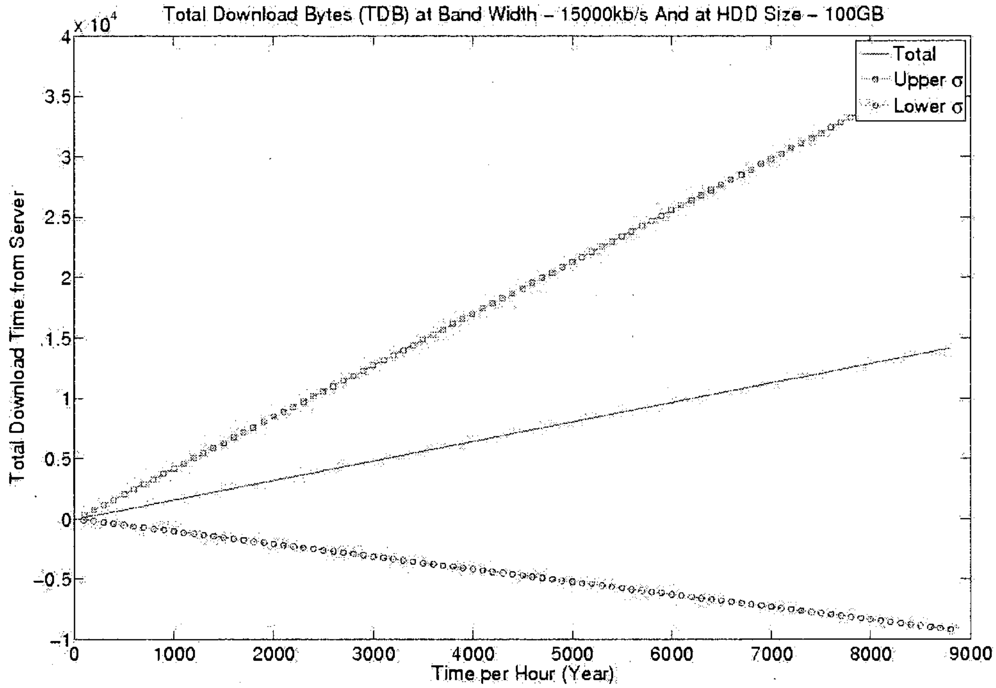


Figure 487: Total Download Bytes for H1 case scenario at hard drive size of 150GB and download bandwidth of 15000kb/s

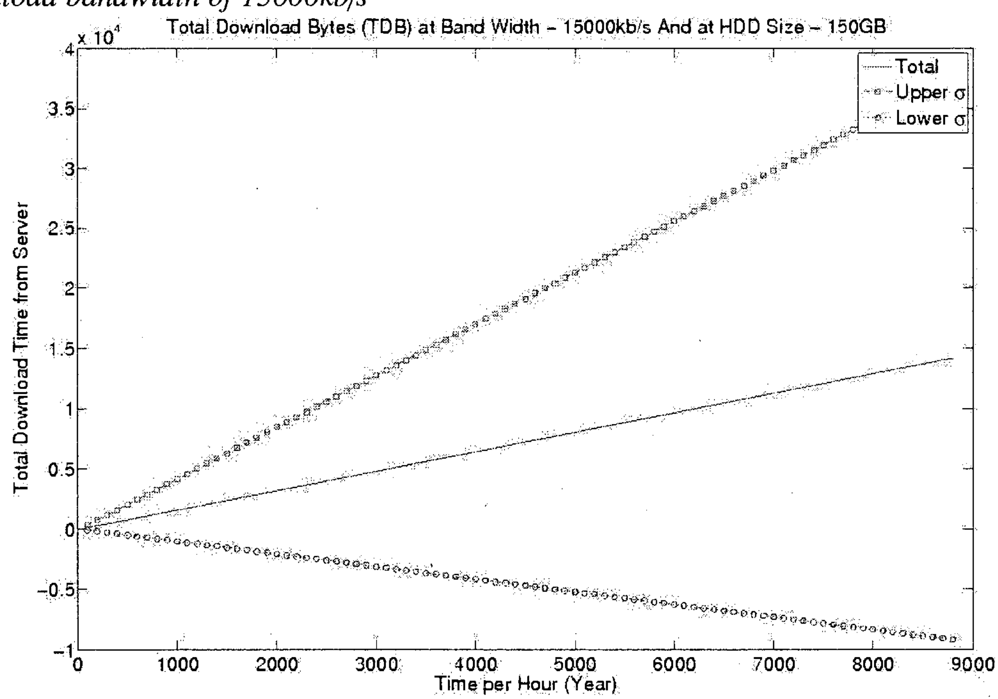


Figure 488: Total Download Bytes for H1 case scenario at hard drive size of 200GB and download bandwidth of 15000kb/s

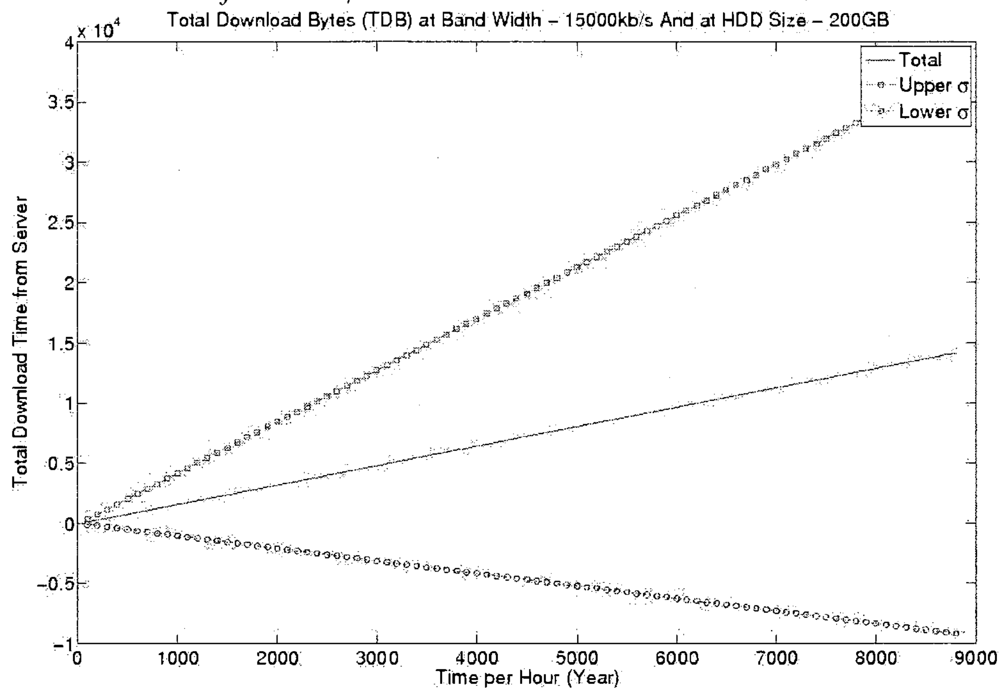


Figure 489: Total Download Bytes for H2 case scenario at hard drive size of 50GB and download bandwidth of 25kb/s

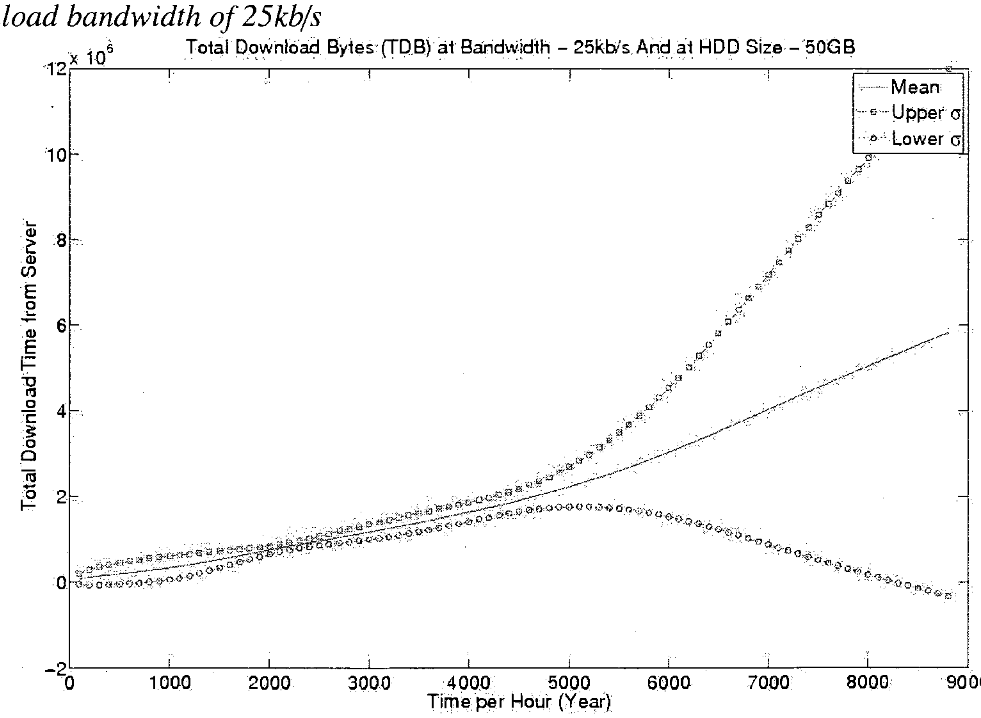


Figure 490: Total Download Bytes for H2 case scenario at hard drive size of 100GB and download bandwidth of 25kb/s

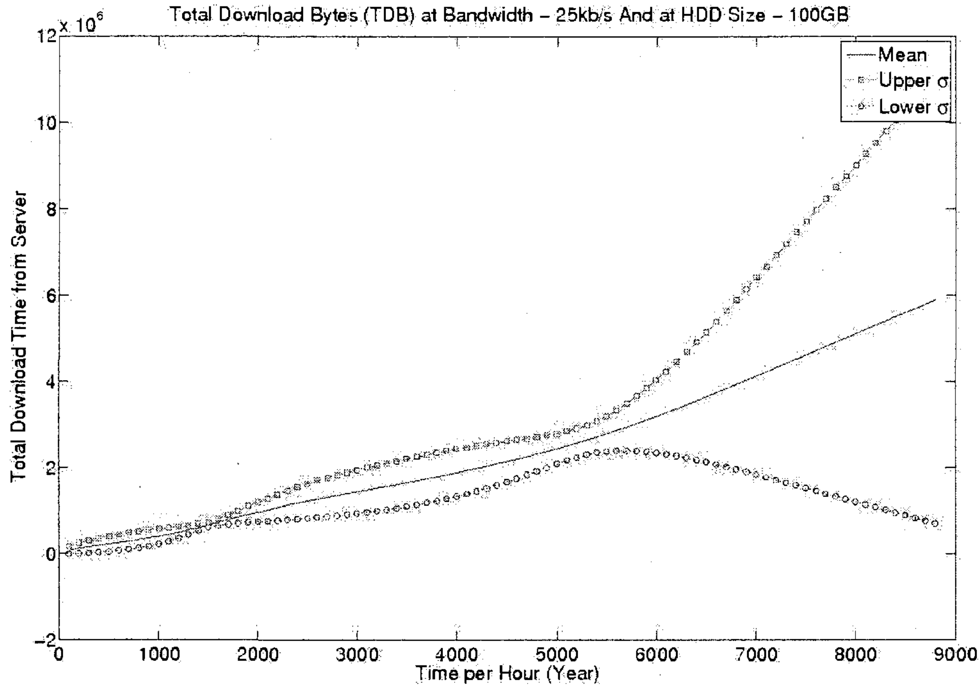


Figure 491: Total Download Bytes for H2 case scenario at hard drive size of 150GB and download bandwidth of 25kb/s

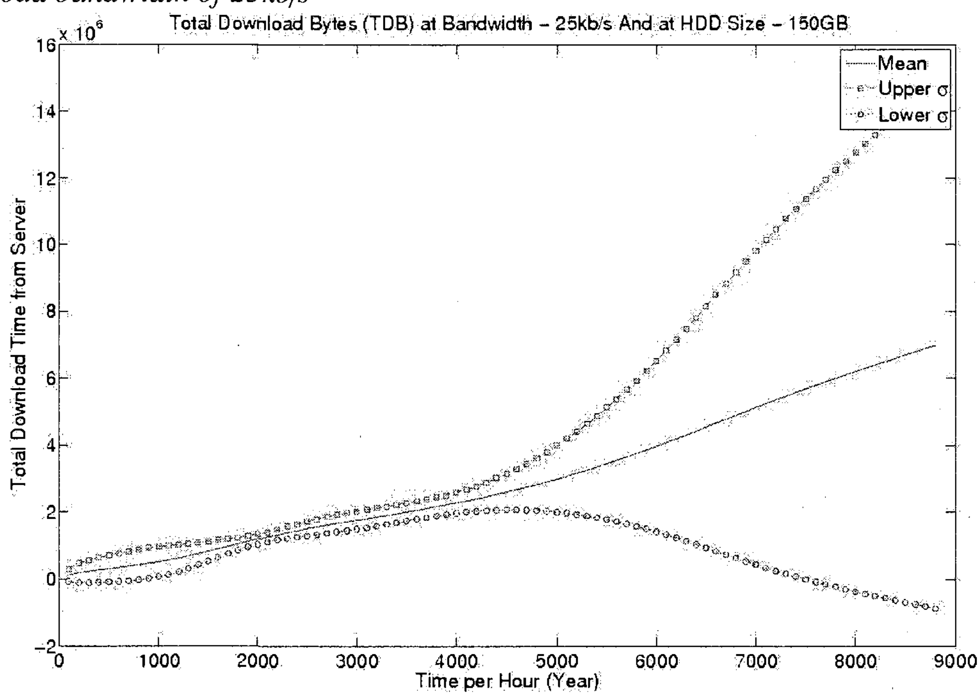


Figure 492: Total Download Bytes for H2 case scenario at hard drive size of 200GB and download bandwidth of 25kb/s

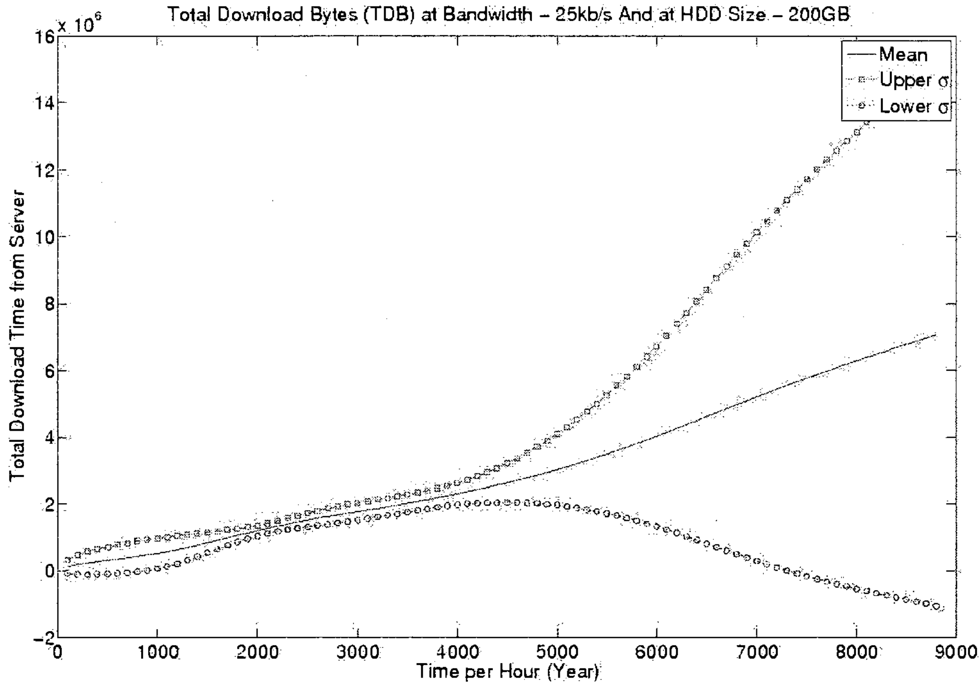


Figure 493: Total Download Bytes for H2 case scenario at hard drive size of 50GB and download bandwidth of 50kb/s

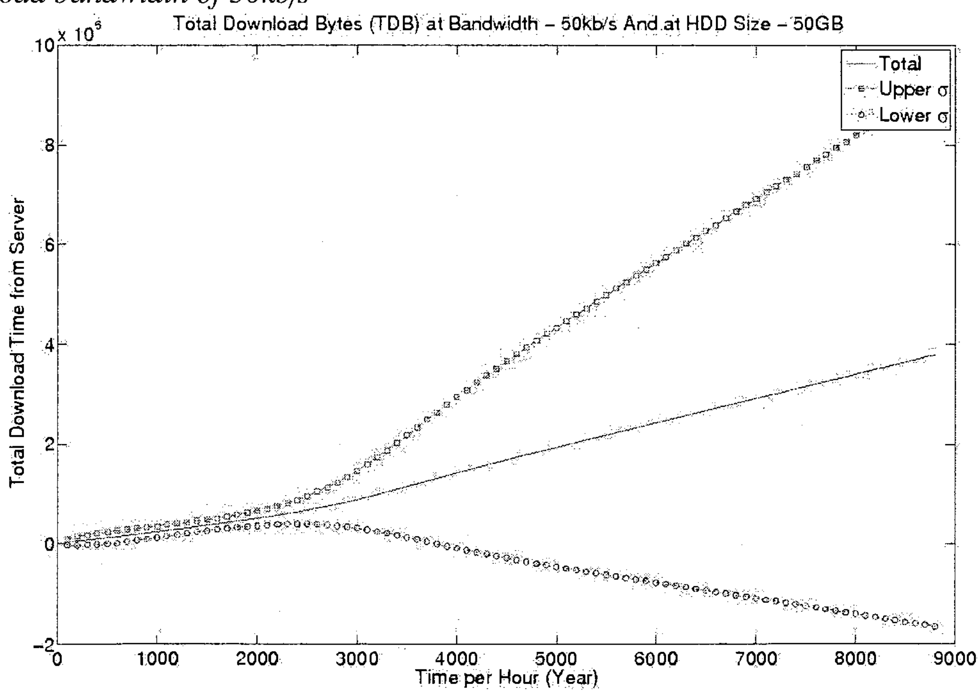


Figure 494: Total Download Bytes for H2 case scenario at hard drive size of 100GB and download bandwidth of 50kb/s

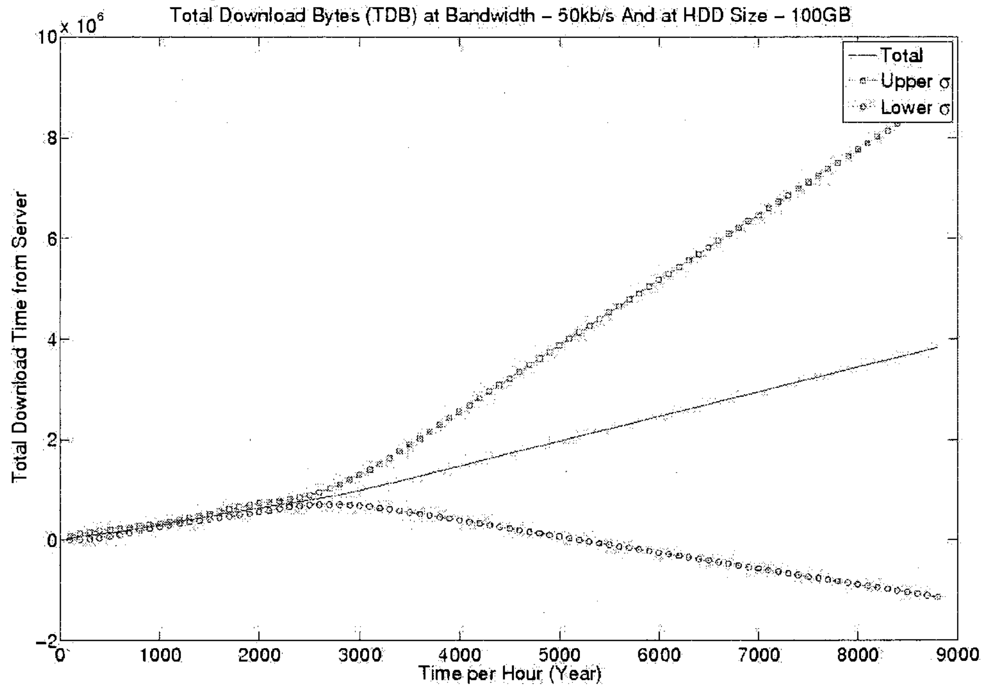


Figure 495: Total Download Bytes for H2 case scenario at hard drive size of 150GB and download bandwidth of 50kb/s

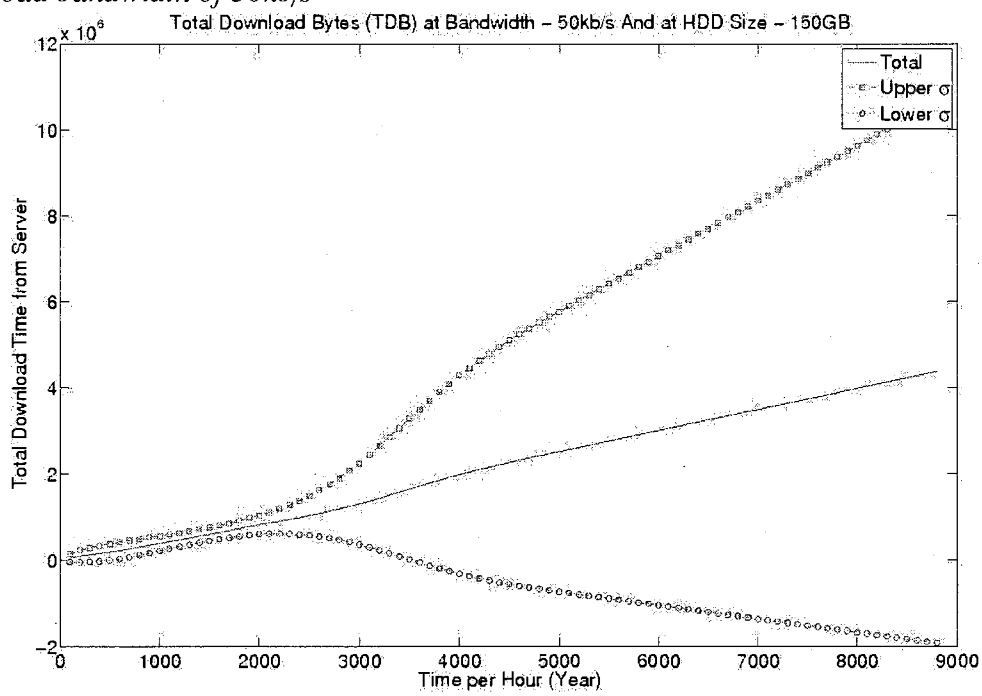


Figure 496: Total Download Bytes for H2 case scenario at hard drive size of 200GB and download bandwidth of 50kb/s

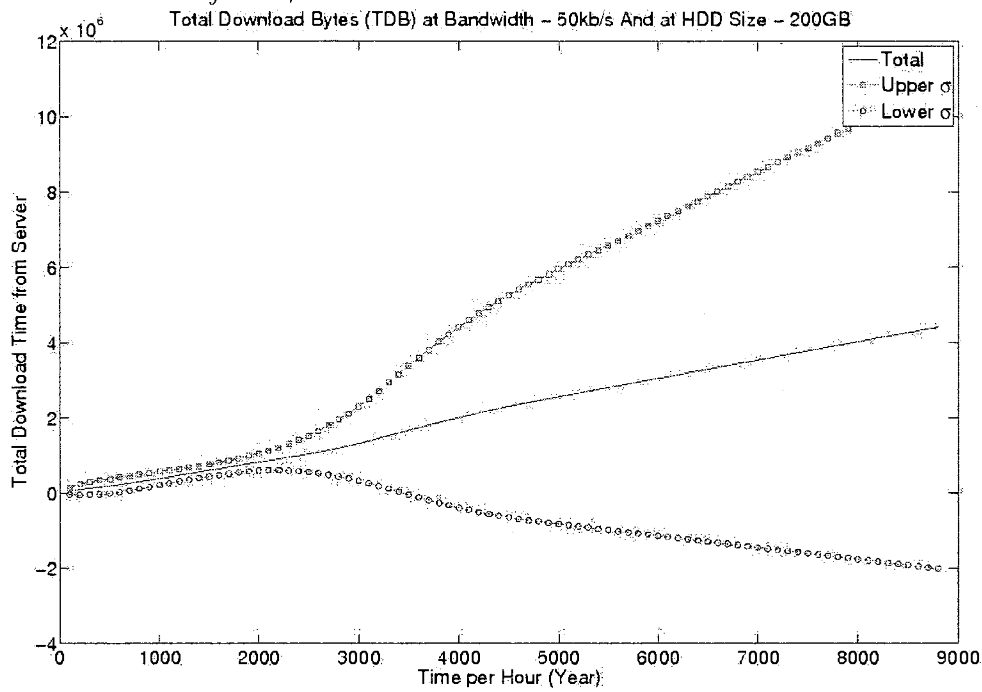


Figure 497: Total Download Bytes for H2 case scenario at hard drive size of 50GB and download bandwidth of 100kb/s

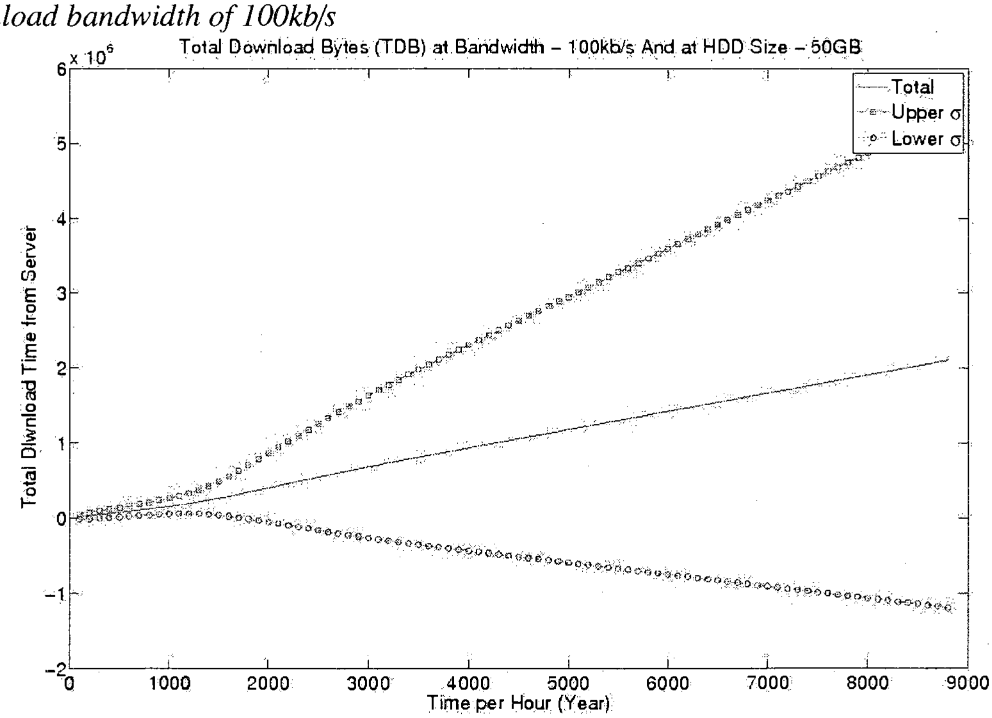


Figure 498: Total Download Bytes for H2 case scenario at hard drive size of 100GB and download bandwidth of 100kb/s

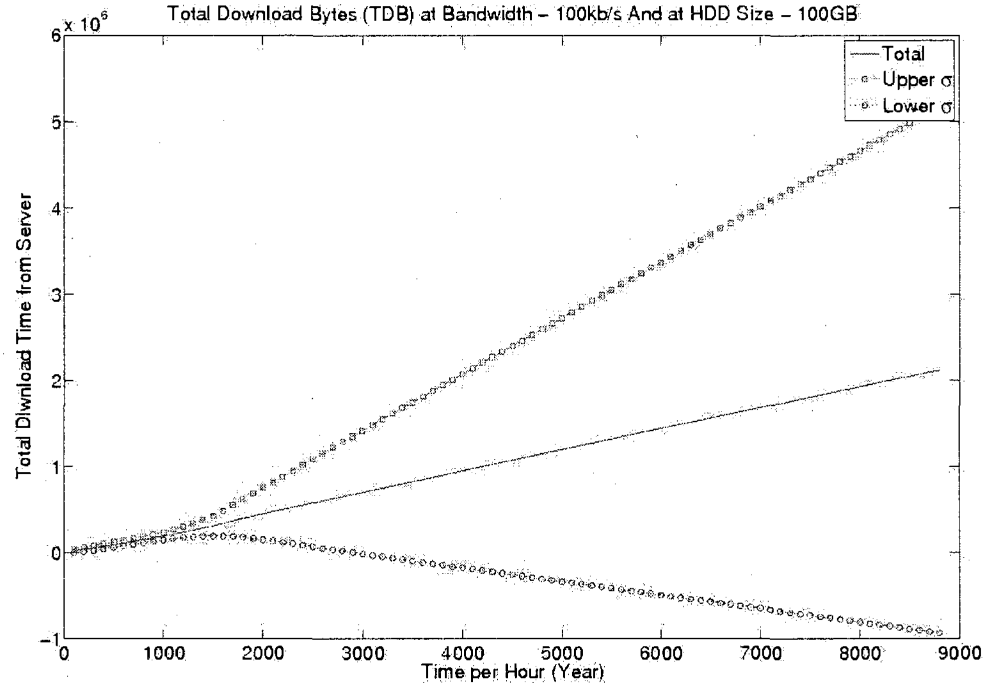


Figure 499: Total Download Bytes for H2 case scenario at hard drive size of 150GB and download bandwidth of 100kb/s

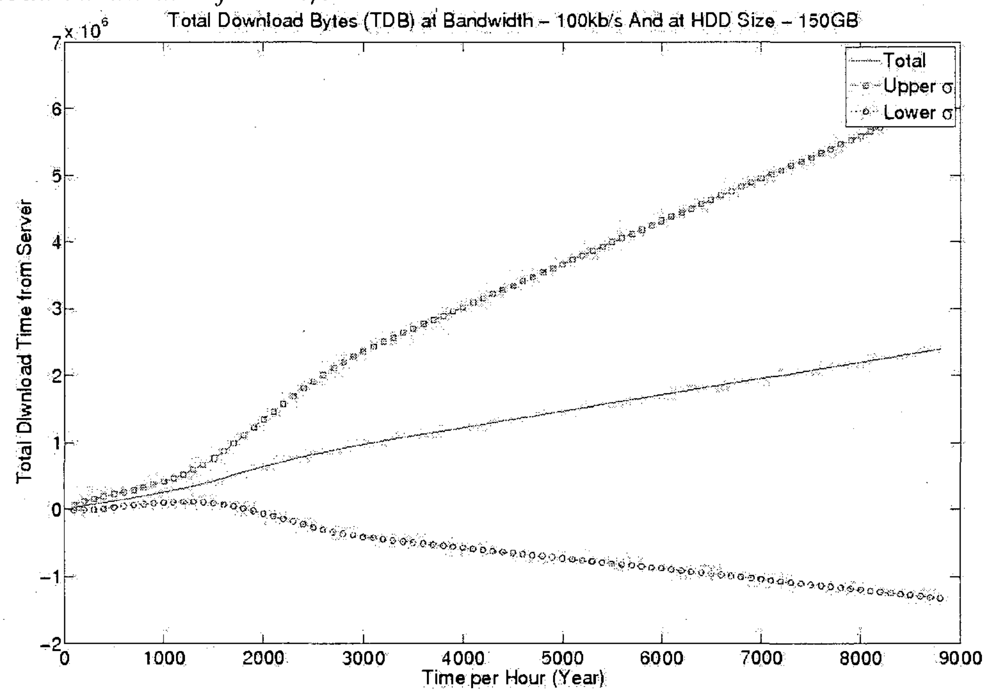


Figure 500: Total Download Bytes for H2 case scenario at hard drive size of 200GB and download bandwidth of 100kb/s

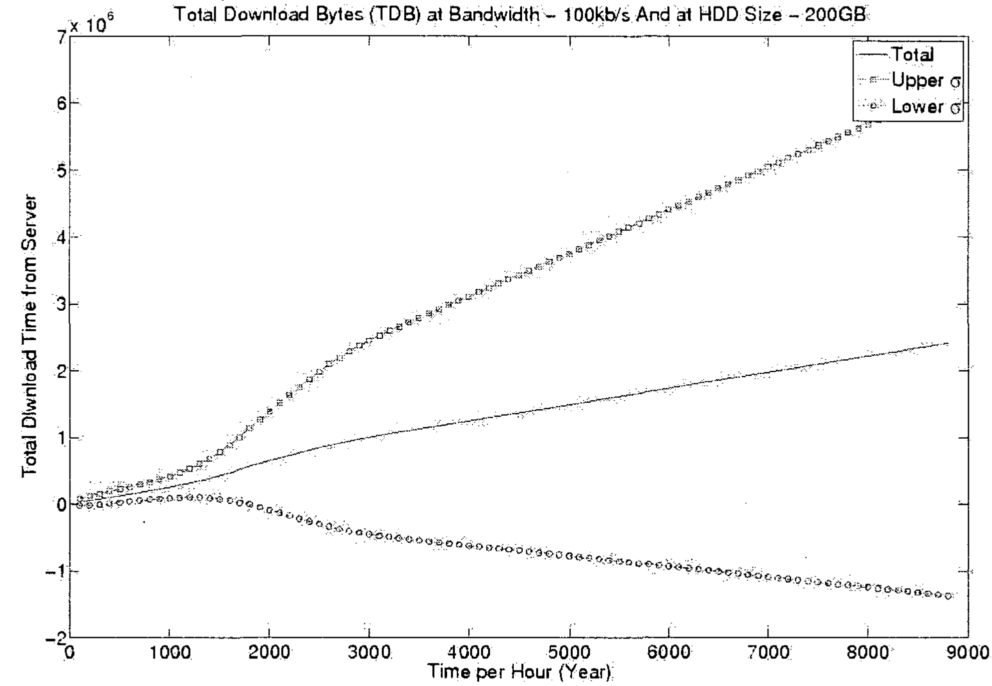


Figure 501: Total Download Bytes for H2 case scenario at hard drive size of 50GB and download bandwidth of 128kb/s

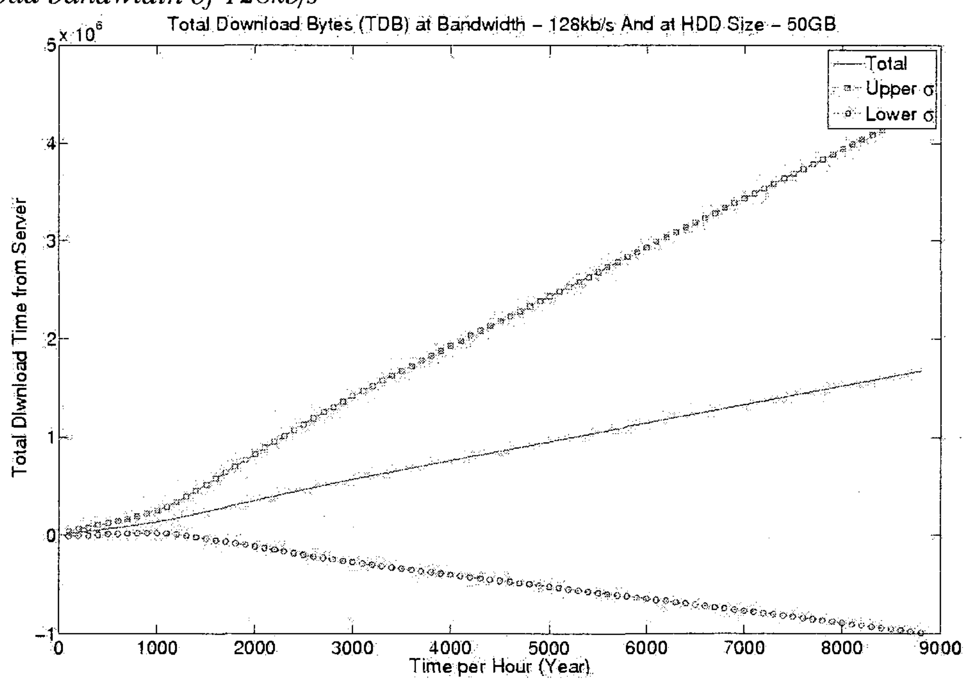


Figure 502: Total Download Bytes for H2 case scenario at hard drive size of 100GB and download bandwidth of 128kb/s

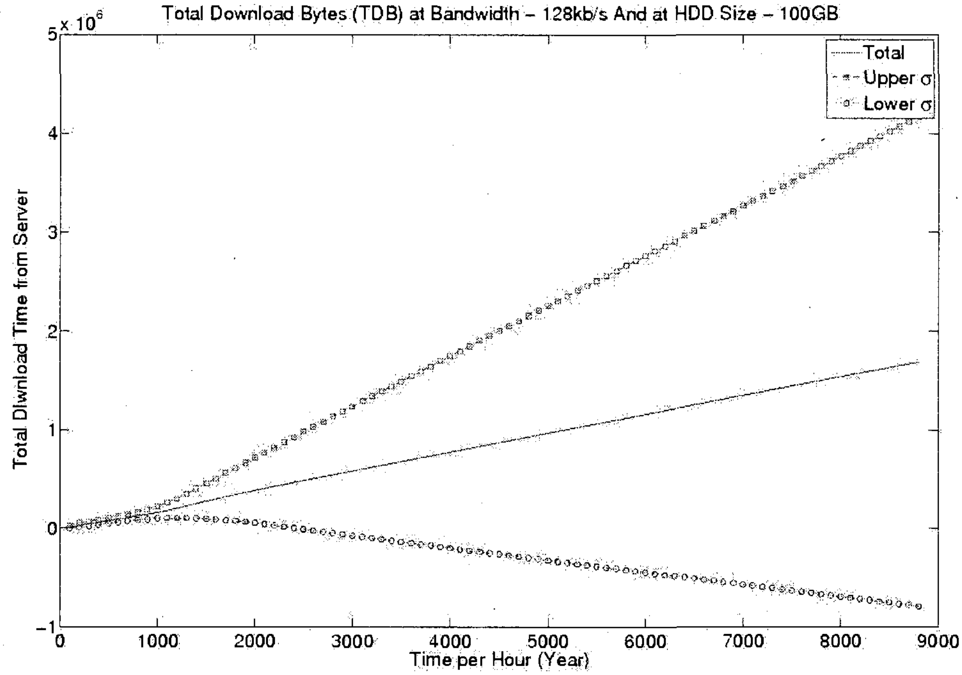


Figure 503: Total Download Bytes for H2 case scenario at hard drive size of 150GB and download bandwidth of 128kb/s

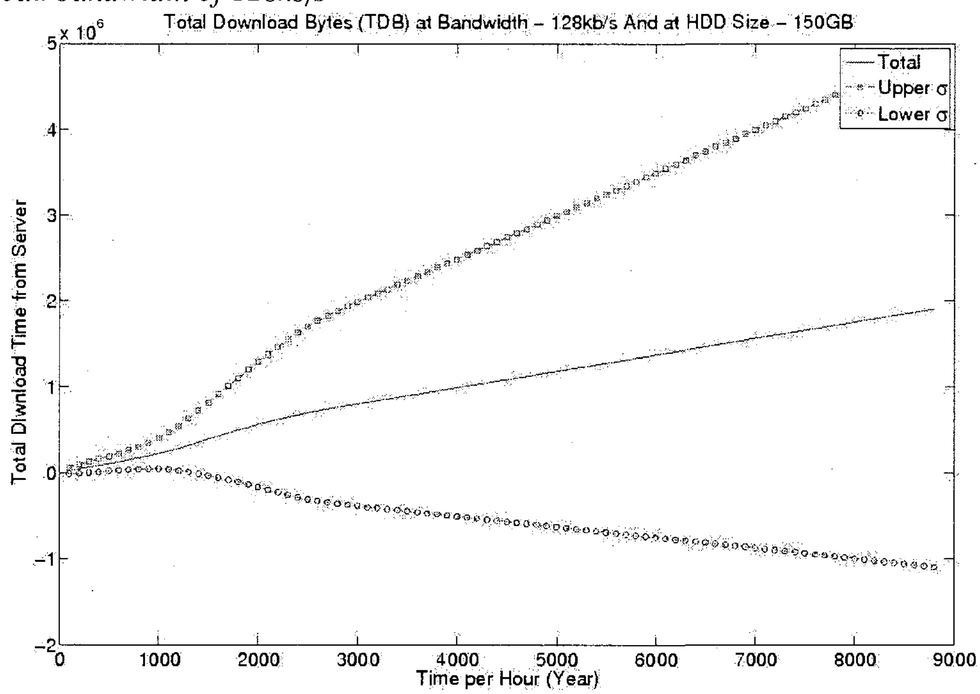


Figure 504: Total Download Bytes for H2 case scenario at hard drive size of 200GB and download bandwidth of 128kb/s

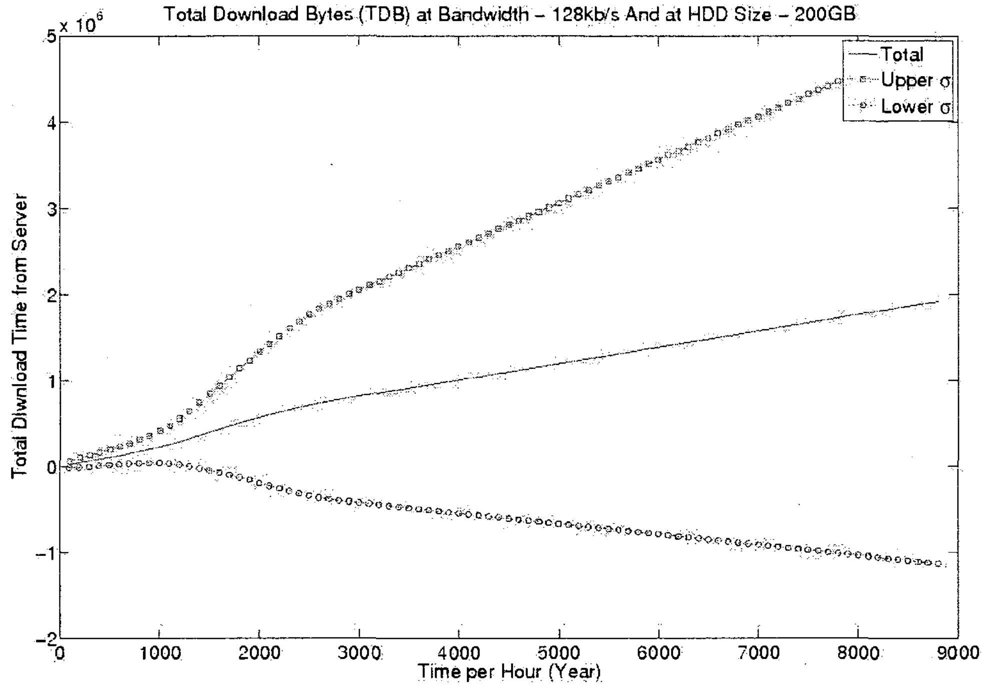


Figure 505: Total Download Bytes for H2 case scenario at hard drive size of 50GB and download bandwidth of 256kb/s

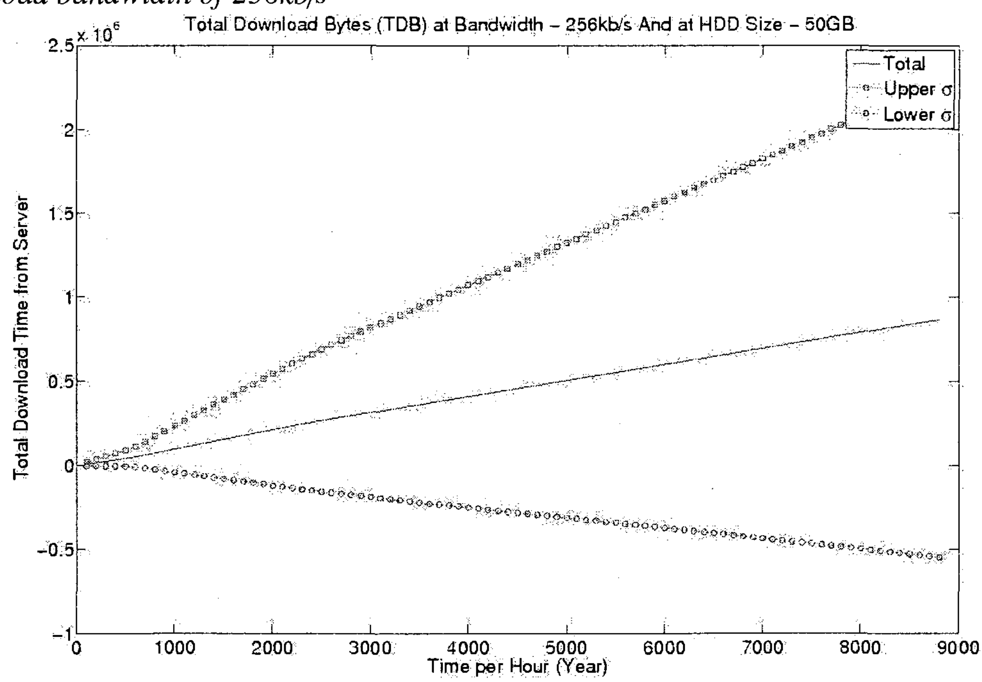


Figure 506: Total Download Bytes for H2 case scenario at hard drive size of 100GB and download bandwidth of 256kb/s

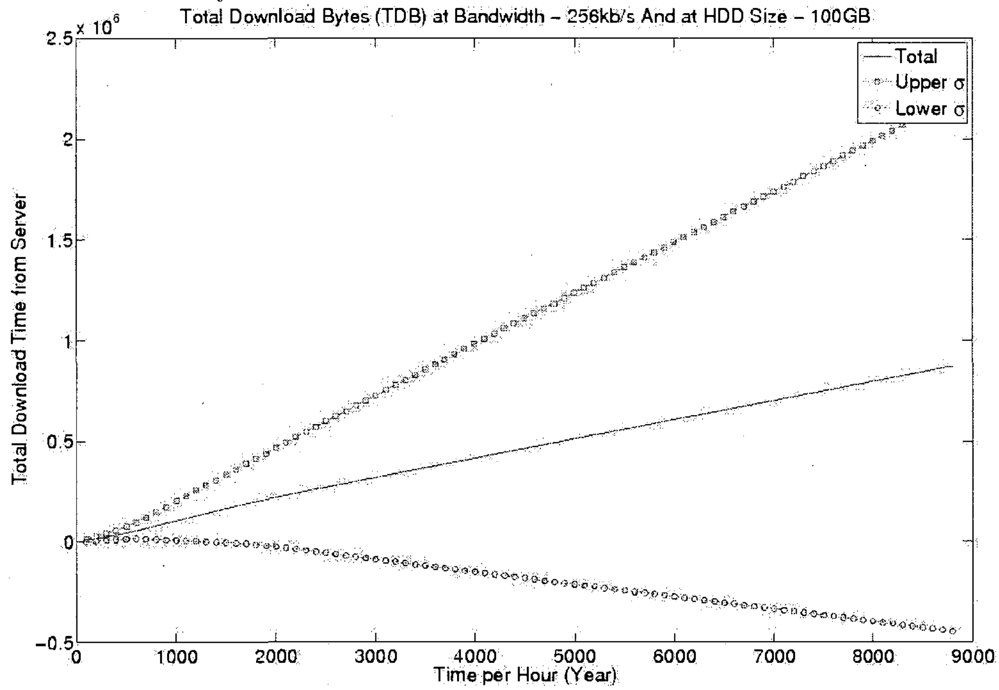


Figure 507: Total Download Bytes for H2 case scenario at hard drive size of 150GB and download bandwidth of 256kb/s

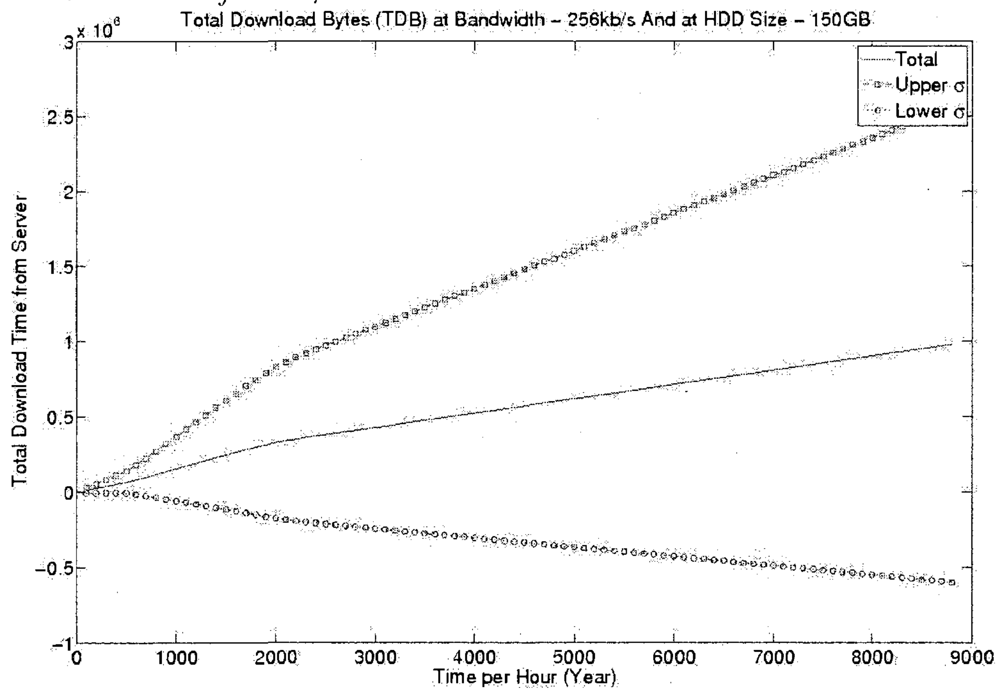


Figure 508: Total Download Bytes for H2 case scenario at hard drive size of 200GB and download bandwidth of 256kb/s

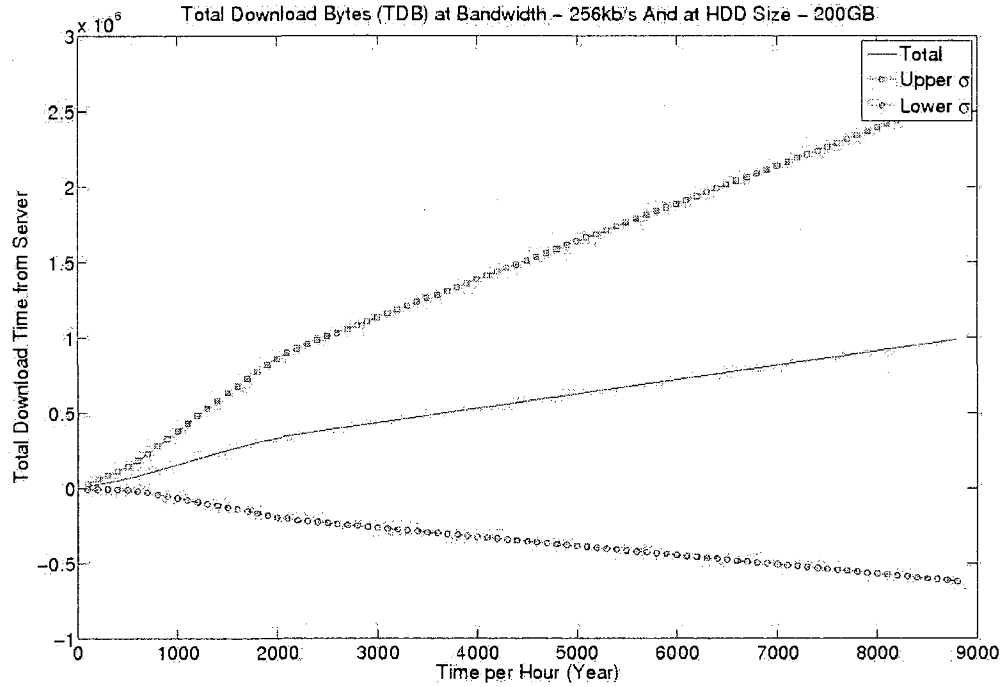


Figure 509: Total Download Bytes for H2 case scenario at hard drive size of 50GB and download bandwidth of 512kb/s

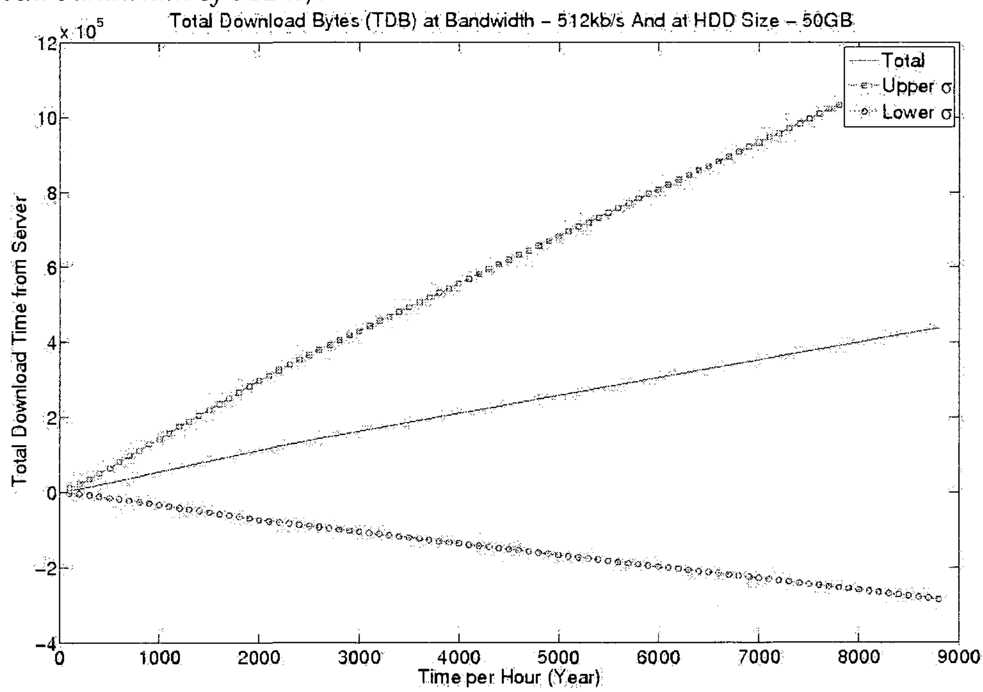


Figure 510: Total Download Bytes for H2 case scenario at hard drive size of 100GB and download bandwidth of 512kb/s

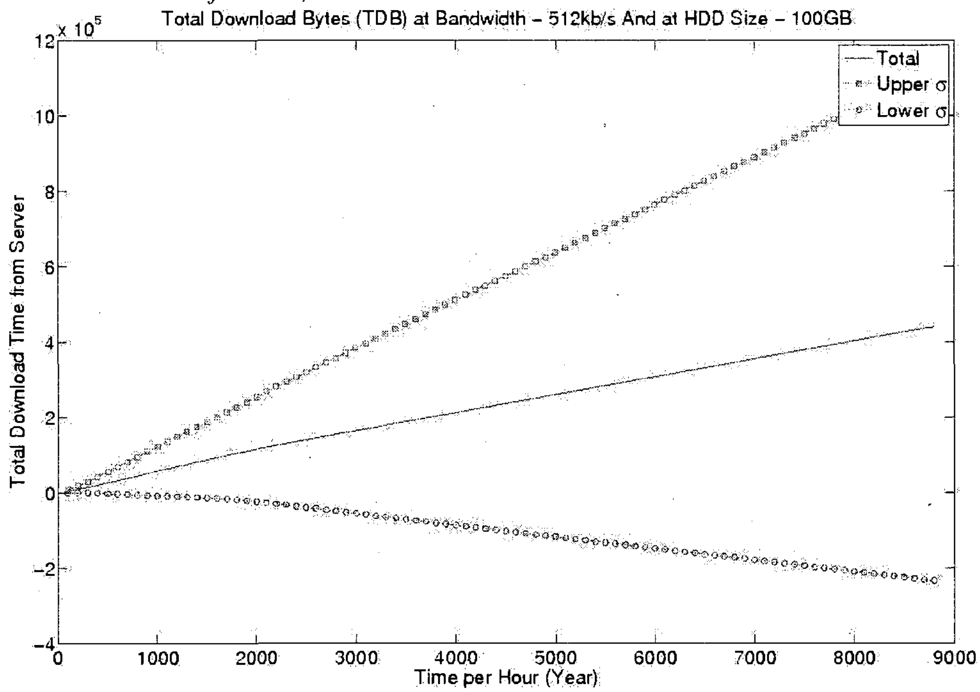


Figure 511: Total Download Bytes for H2 case scenario at hard drive size of 150GB and download bandwidth of 512kb/s

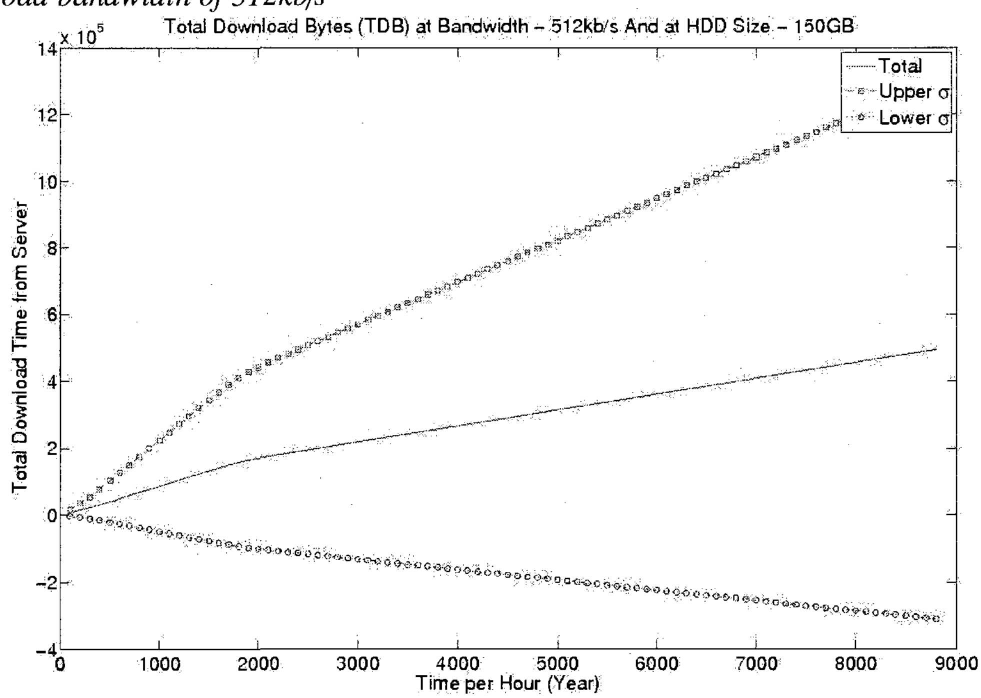


Figure 512: Total Download Bytes for H2 case scenario at hard drive size of 200GB and download bandwidth of 512kb/s

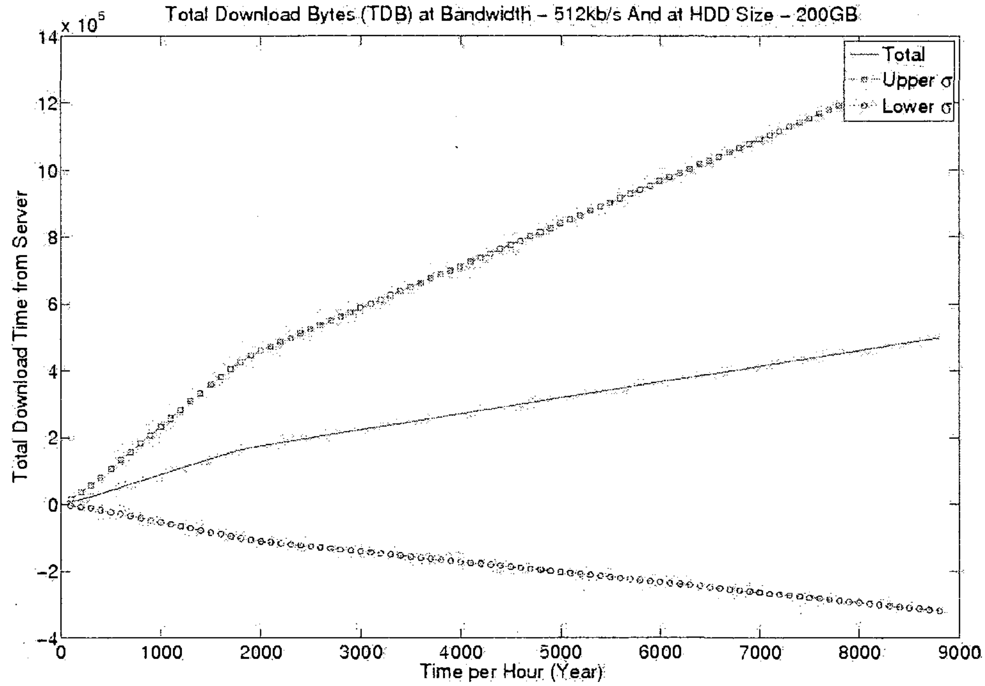


Figure 513: Total Download Bytes for H2 case scenario at hard drive size of 50GB and download bandwidth of 1000kb/s

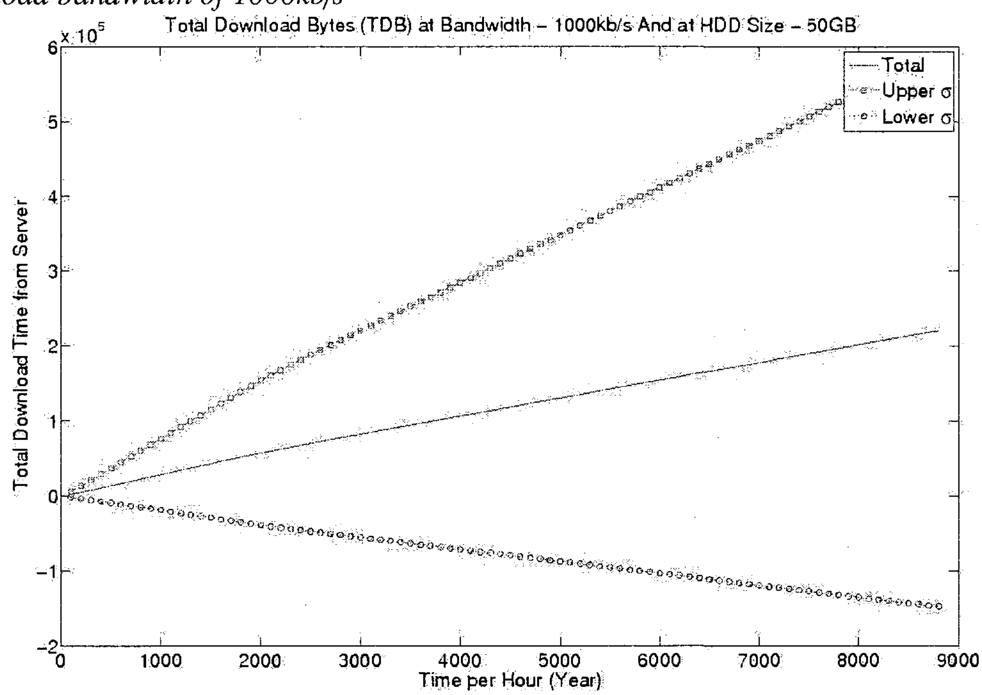


Figure 514: Total Download Bytes for H2 case scenario at hard drive size of 100GB and download bandwidth of 1000kb/s

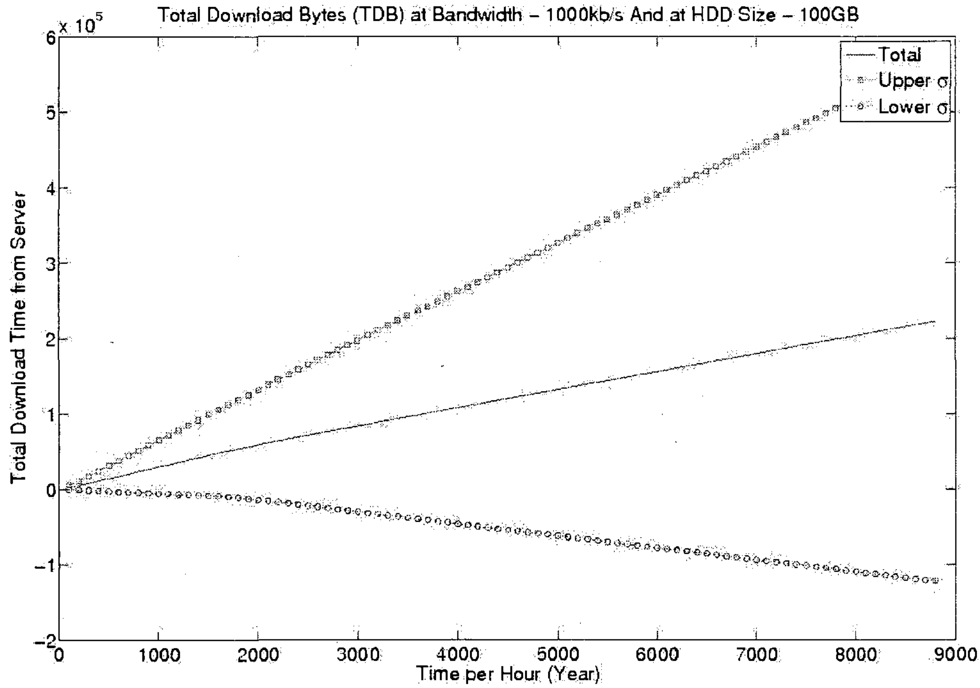


Figure 515: Total Download Bytes for H2 case scenario at hard drive size of 150GB and download bandwidth of 1000kb/s

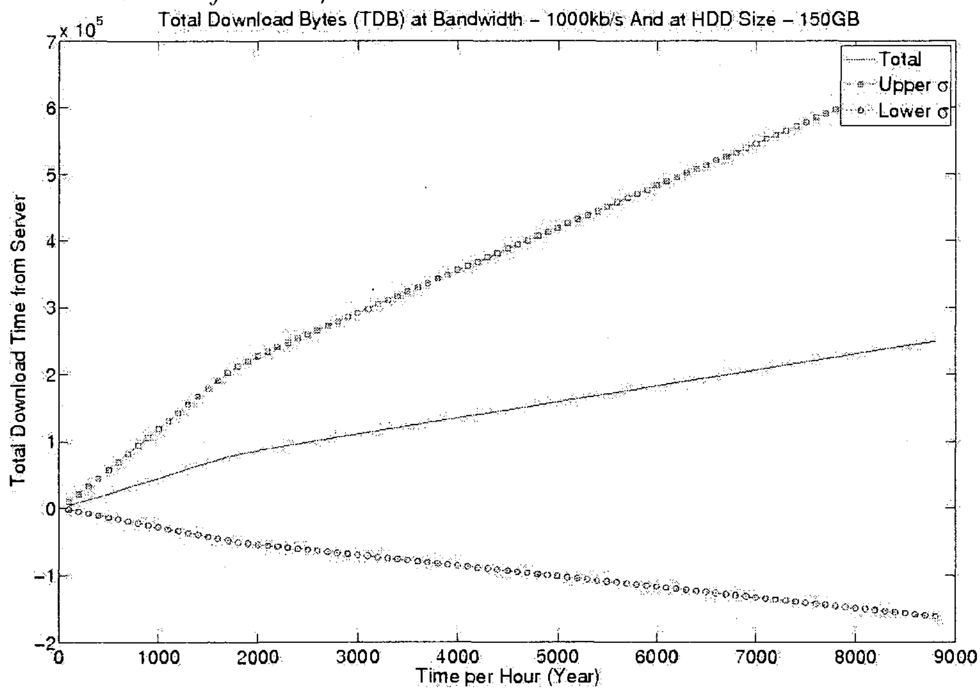


Figure 516: Total Download Bytes for H2 case scenario at hard drive size of 200GB and download bandwidth of 1000kb/s

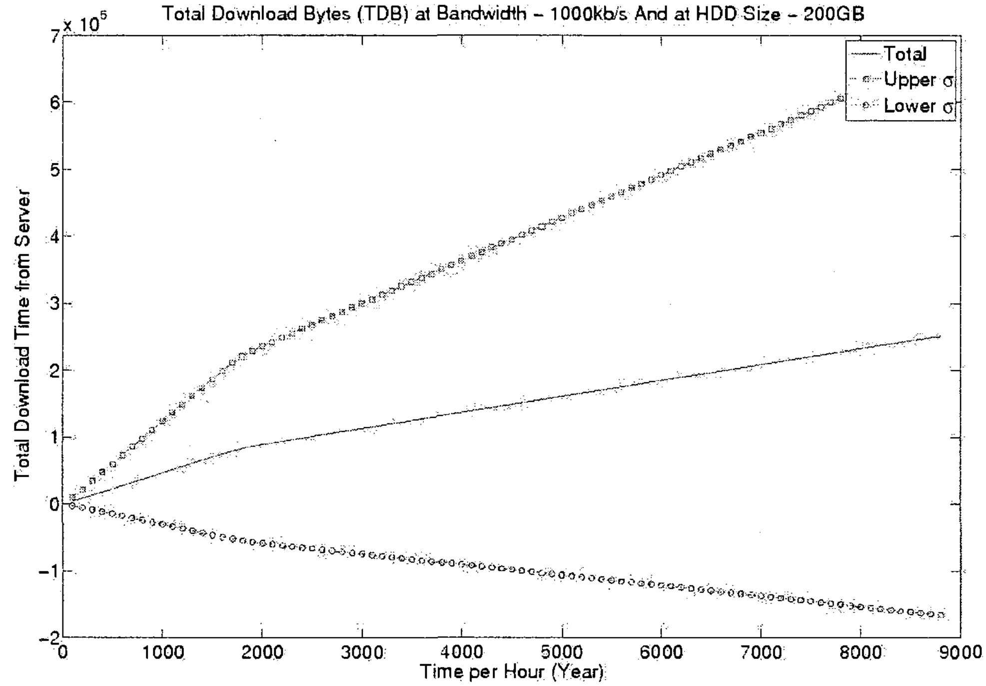


Figure 517: Total Download Bytes for H2 case scenario at hard drive size of 50GB and download bandwidth of 2000kb/s

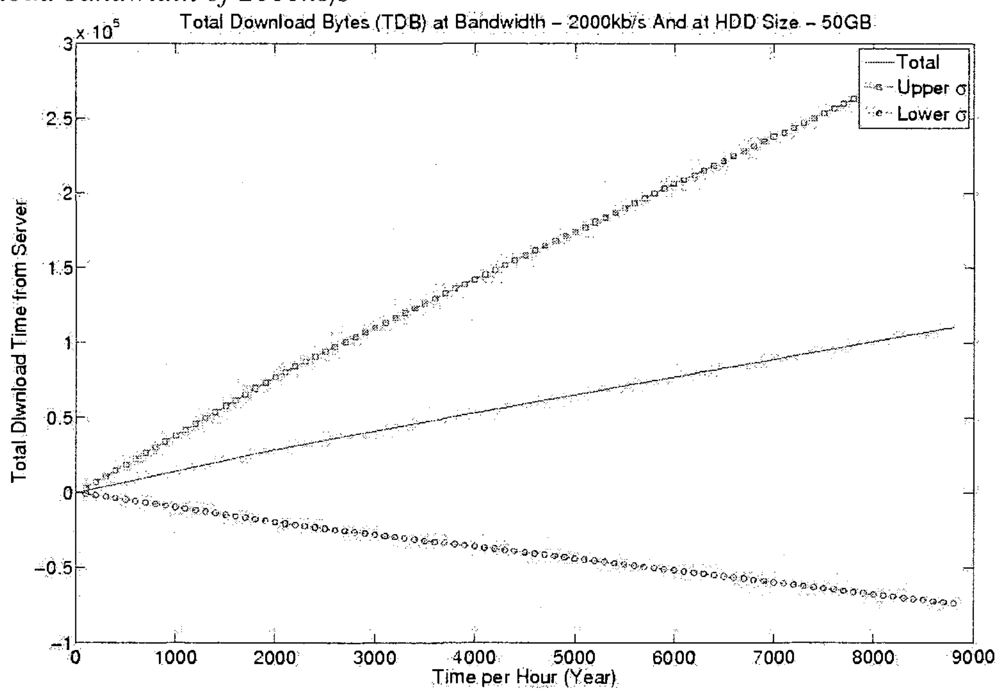


Figure 518: Total Download Bytes for H2 case scenario at hard drive size of 100GB and download bandwidth of 2000kb/s

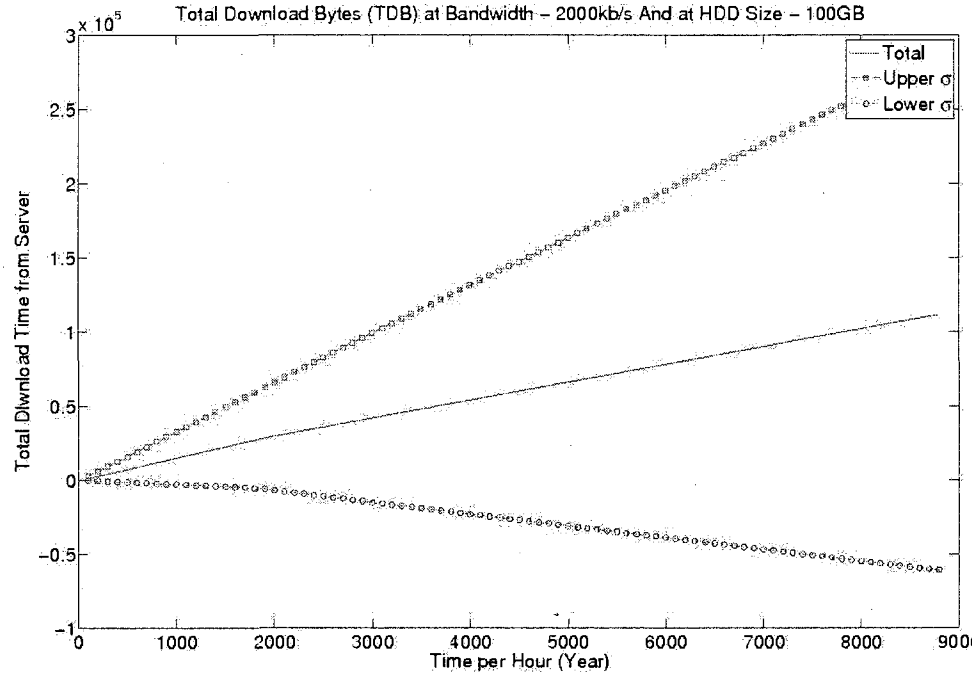


Figure 519: Total Download Bytes for H2 case scenario at hard drive size of 150GB and download bandwidth of 2000kb/s

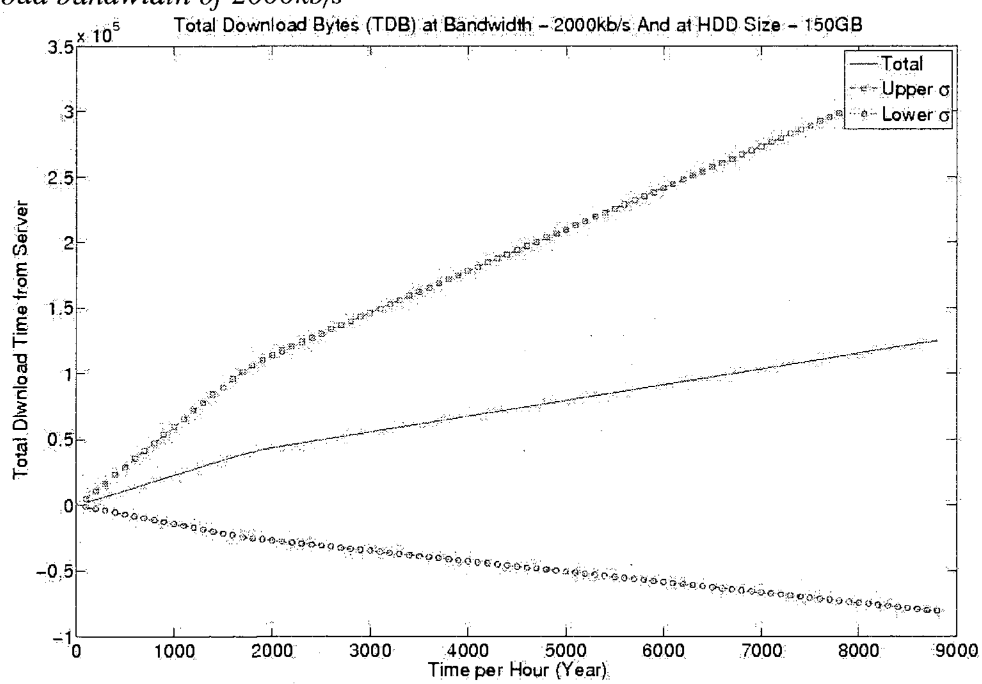


Figure 520: Total Download Bytes for H2 case scenario at hard drive size of 200GB and download bandwidth of 2000kb/s

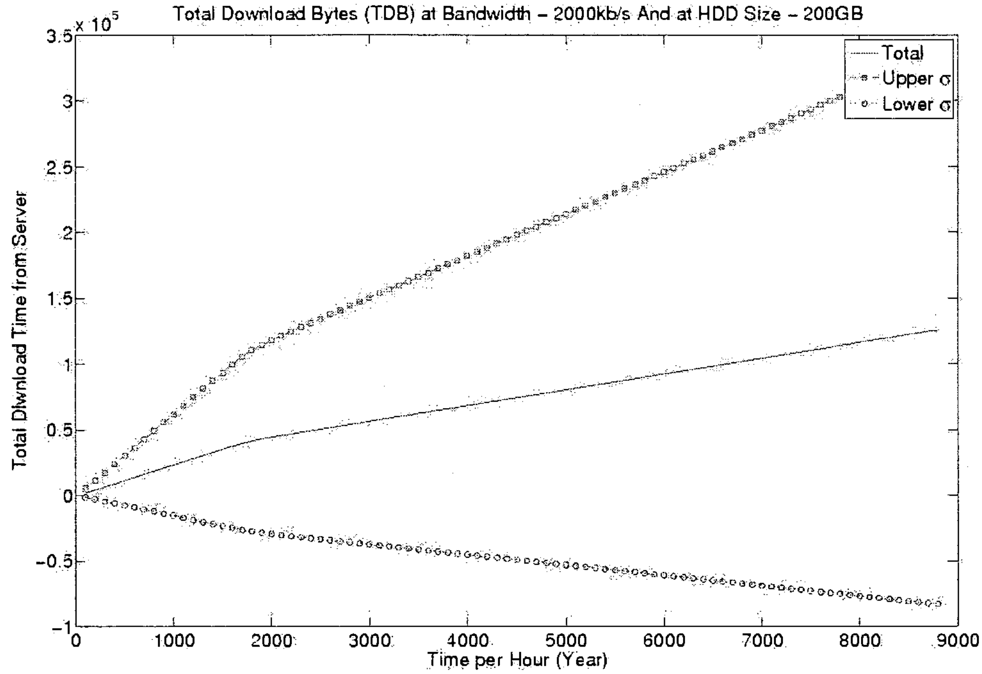


Figure 521: Total Download Bytes for H2 case scenario at hard drive size of 50GB and download bandwidth of 5000kb/s

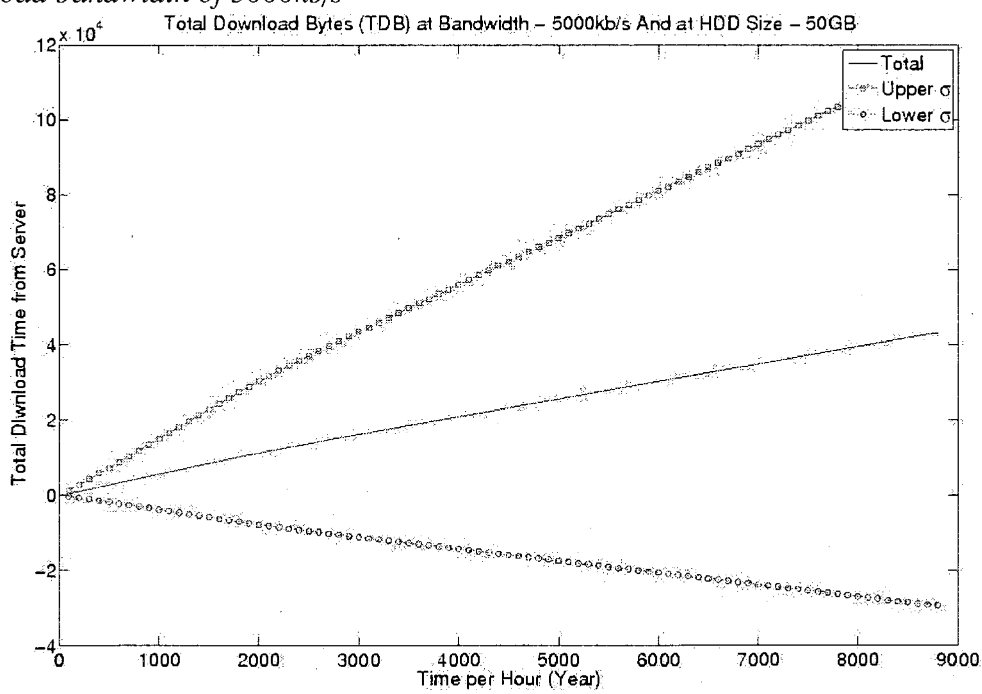


Figure 522: Total Download Bytes for H2 case scenario at hard drive size of 100GB and download bandwidth of 5000kb/s

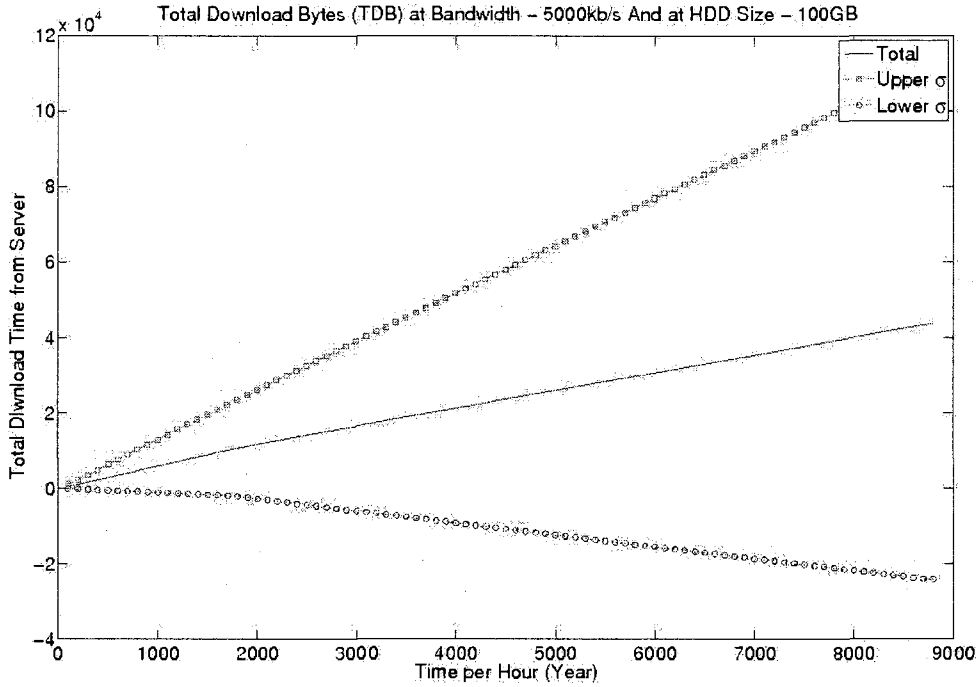


Figure 523: Total Download Bytes for H2 case scenario at hard drive size of 150GB and download bandwidth of 5000kb/s

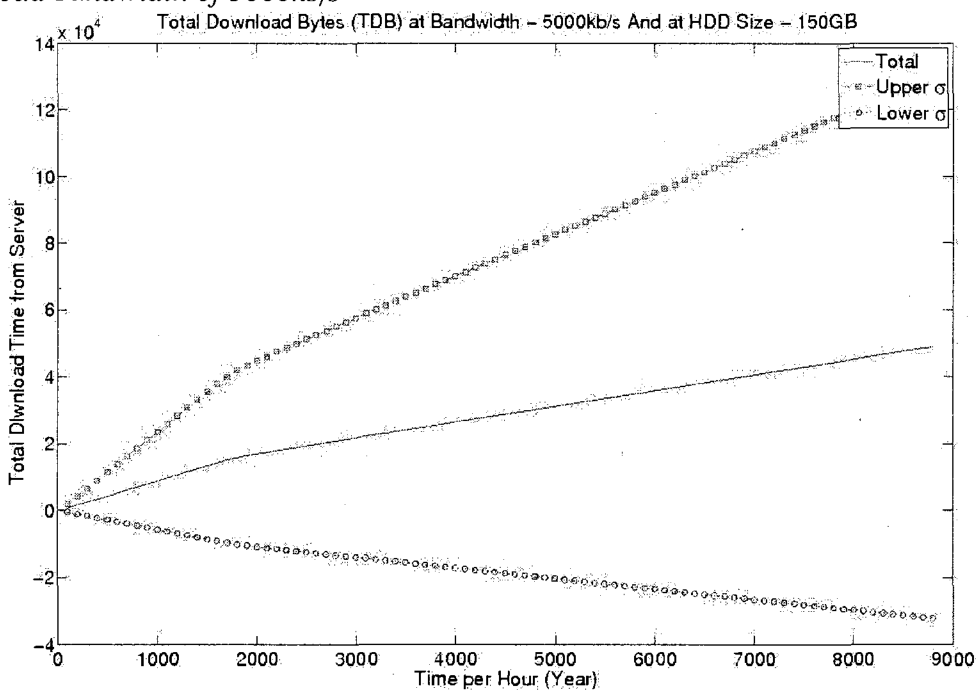


Figure 524: Total Download Bytes for H2 case scenario at hard drive size of 200GB and download bandwidth of 5000kb/s

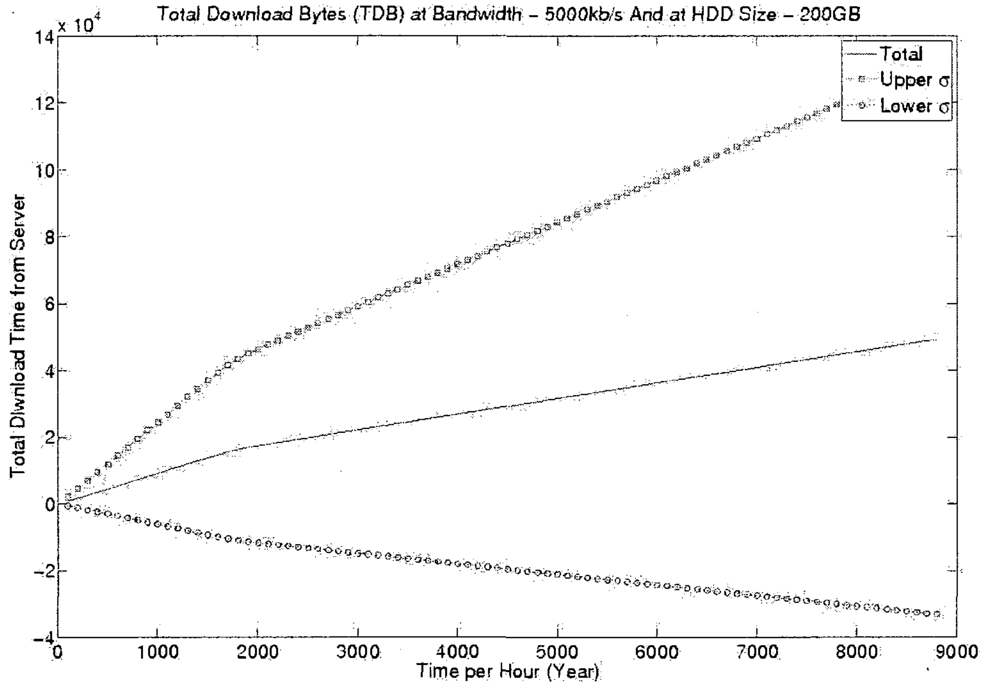


Figure 525: Total Download Bytes for H2 case scenario at hard drive size of 50GB and download bandwidth of 10000kb/s

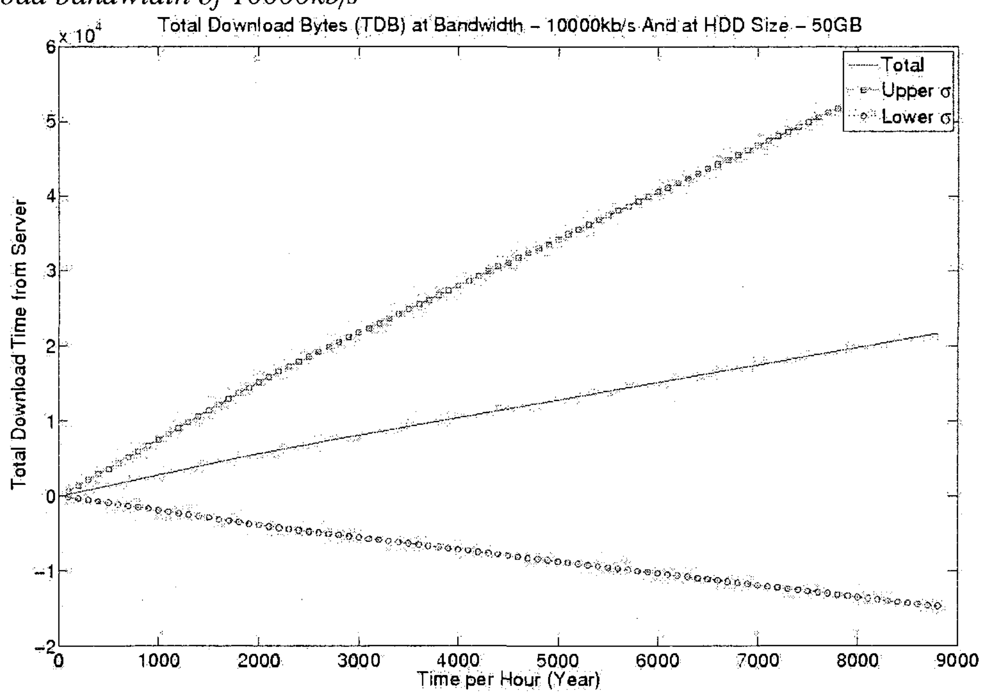


Figure 526: Total Download Bytes for H2 case scenario at hard drive size of 100GB and download bandwidth of 10000kb/s

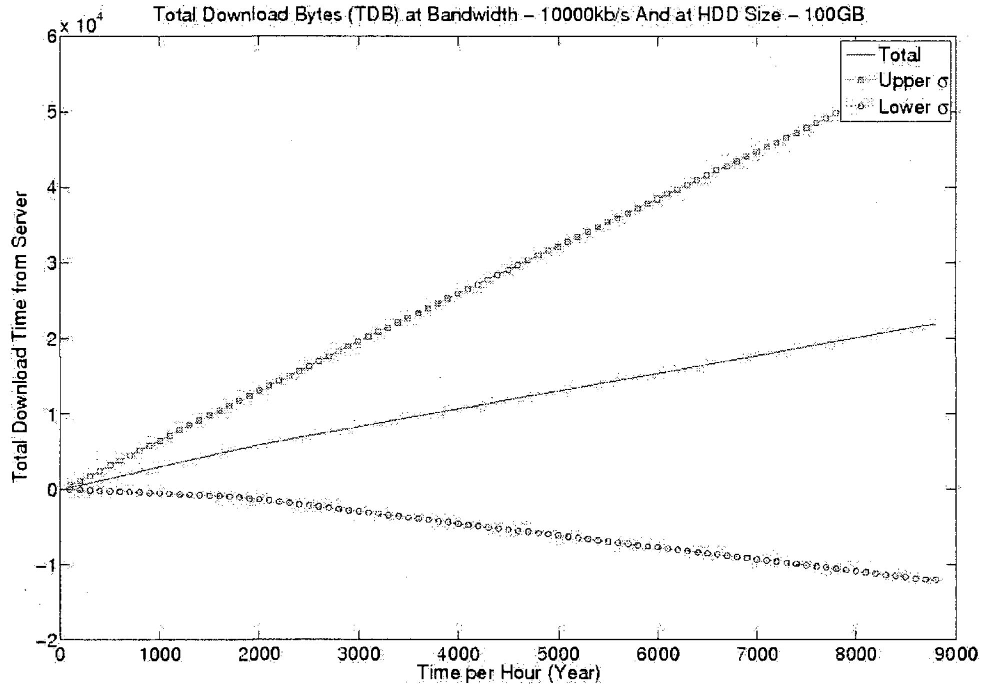


Figure 527: Total Download Bytes for H2 case scenario at hard drive size of 150GB and download bandwidth of 10000kb/s

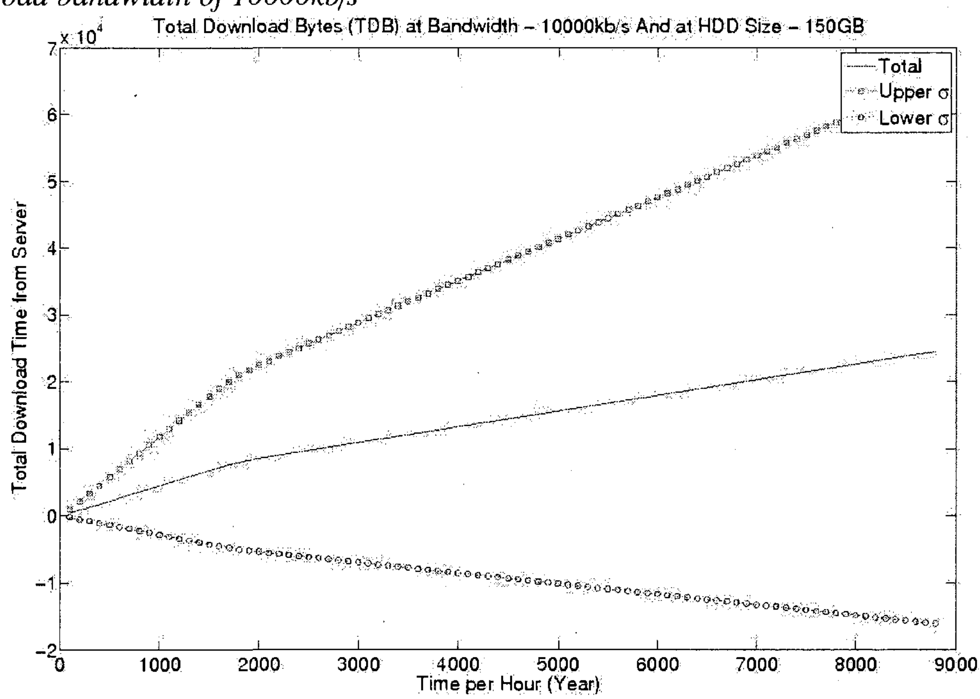


Figure 528: Total Download Bytes for H2 case scenario at hard drive size of 200GB and download bandwidth of 10000kb/s

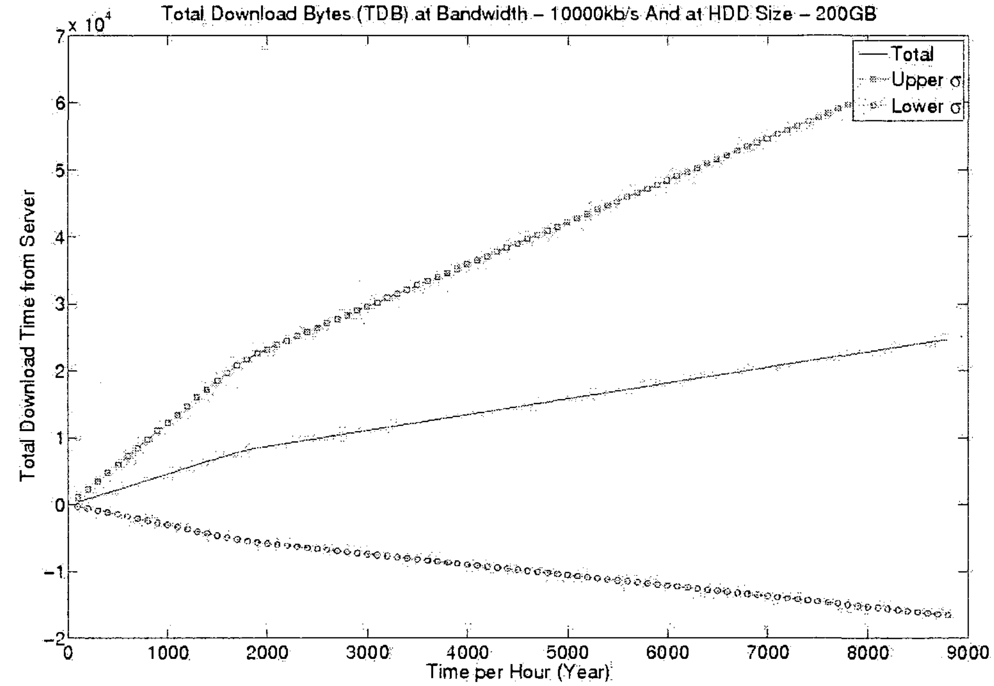


Figure 529: Total Download Bytes for H2 case scenario at hard drive size of 50GB and download bandwidth of 15000kb/s

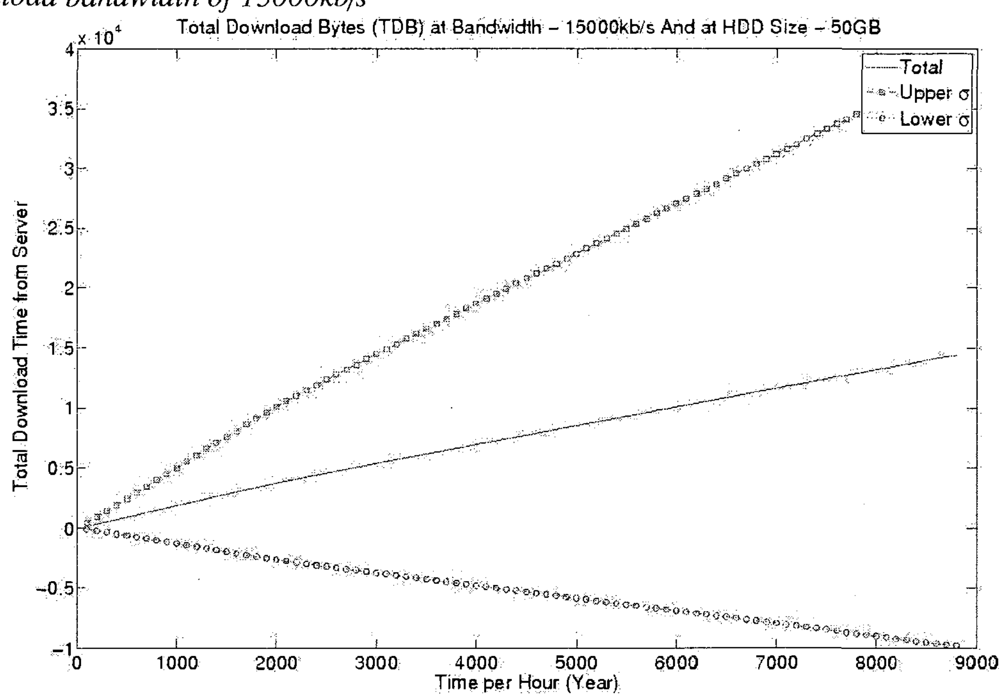


Figure 530: Total Download Bytes for H2 case scenario at hard drive size of 100GB and download bandwidth of 15000kb/s

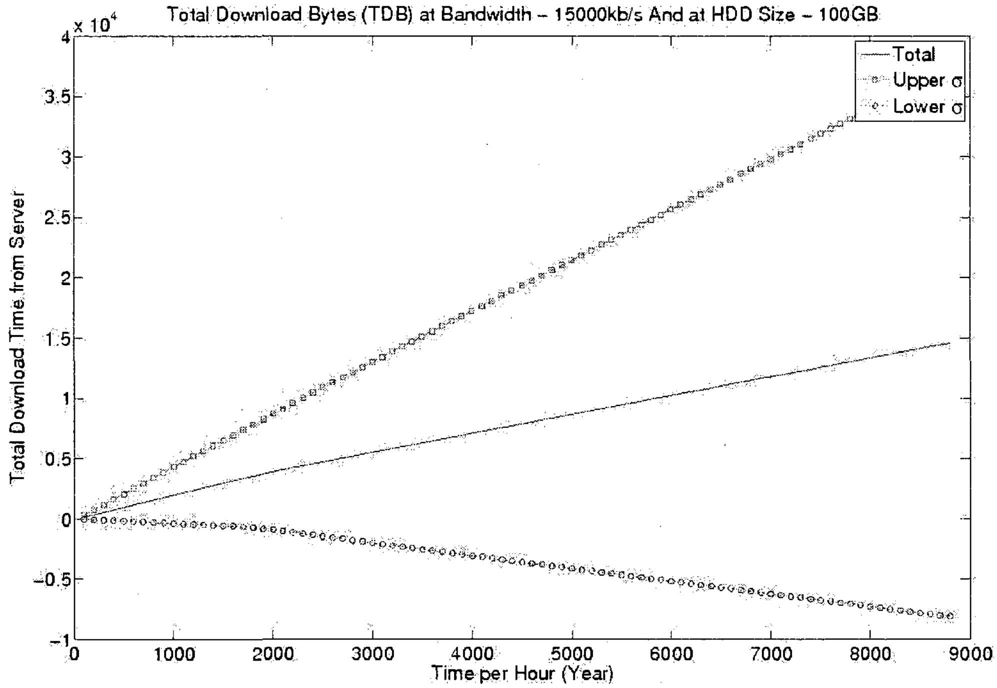


Figure 531: Total Download Bytes for H2 case scenario at hard drive size of 150GB and download bandwidth of 15000kb/s

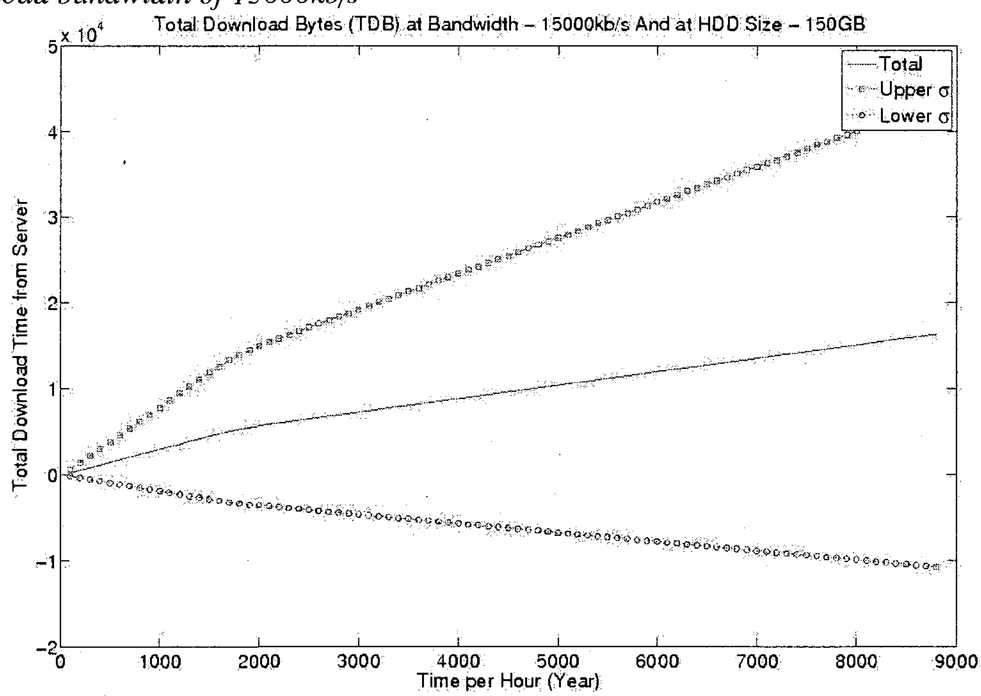


Figure 532: Total Download Bytes for H2 case scenario at hard drive size of 200GB and download bandwidth of 15000kb/s

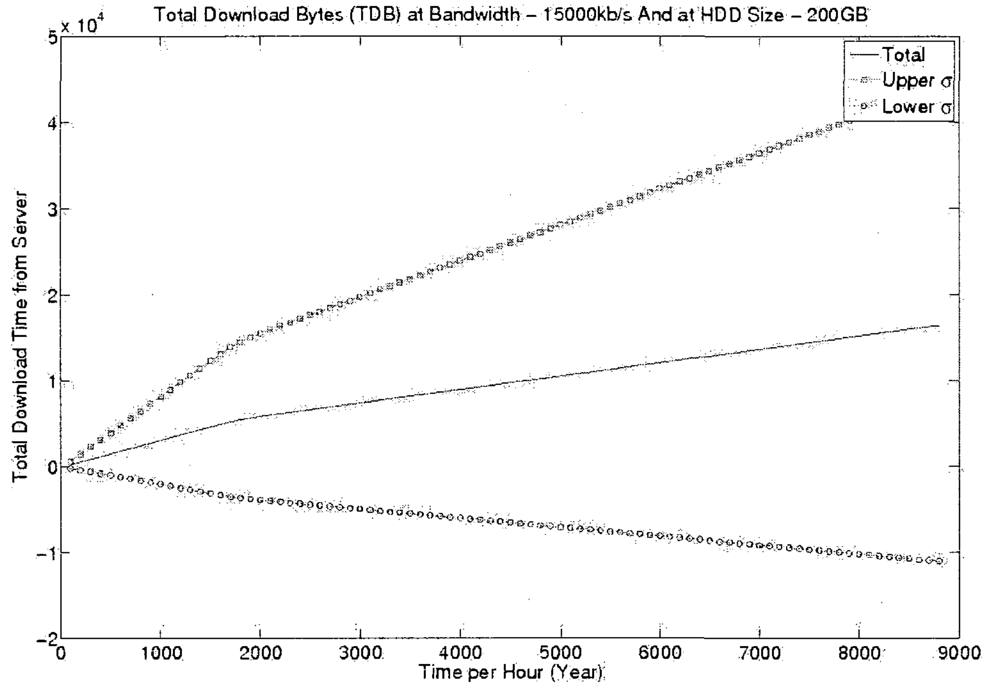


Figure 533: Total Download Bytes for H3 case scenario at hard drive size of 50GB and download bandwidth of 25kb/s

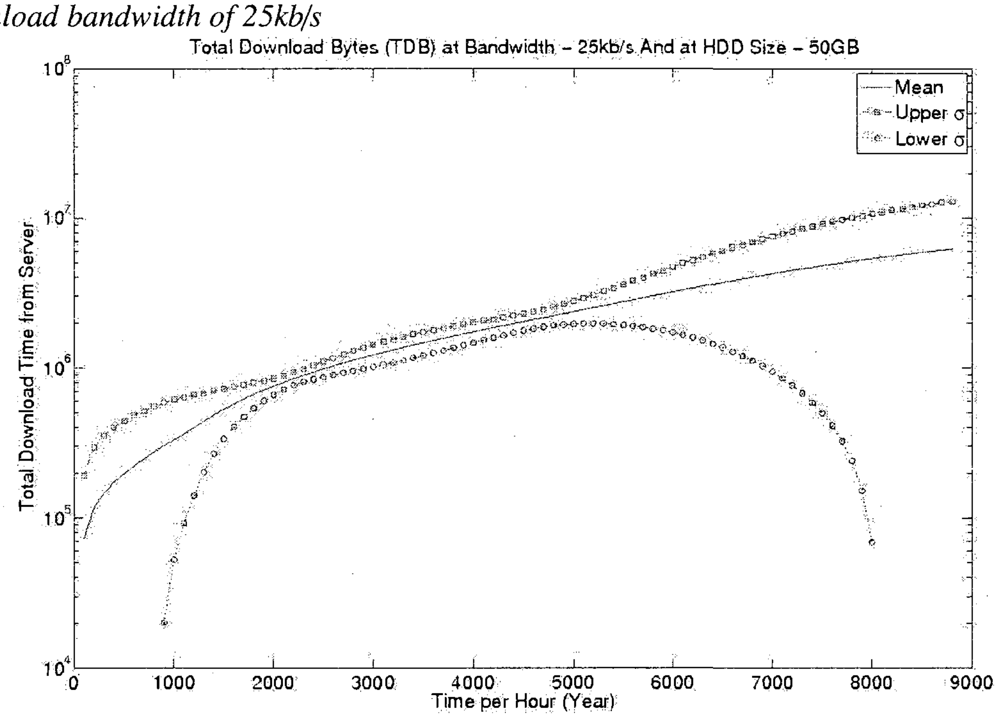


Figure 534: Total Download Bytes for H3 case scenario at hard drive size of 100GB and download bandwidth of 25kb/s

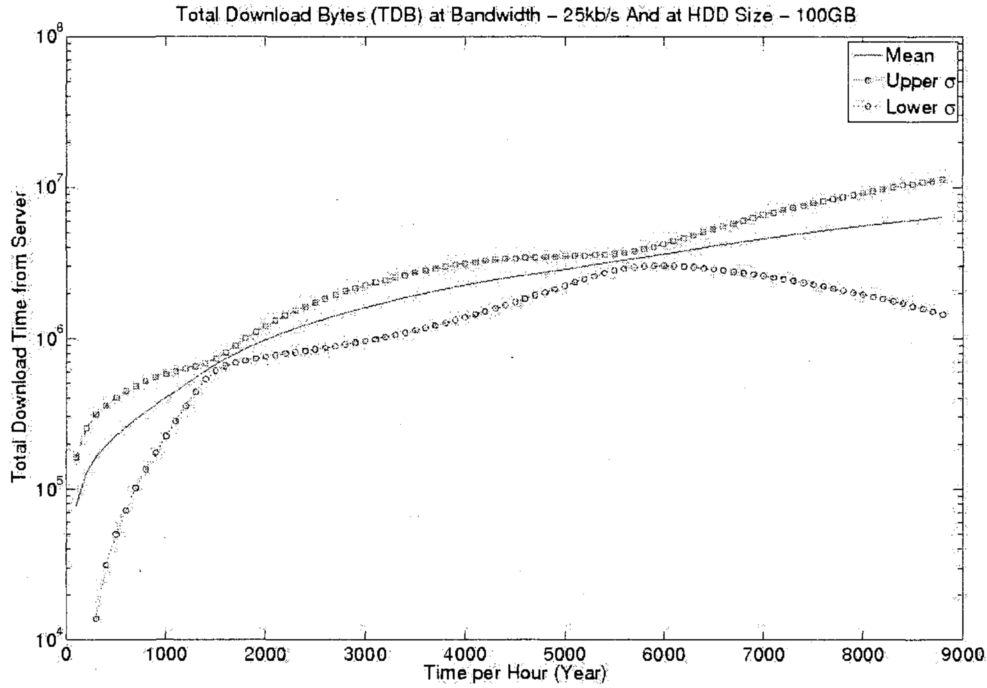


Figure 535: Total Download Bytes for H3 case scenario at hard drive size of 150GB and download bandwidth of 25kb/s

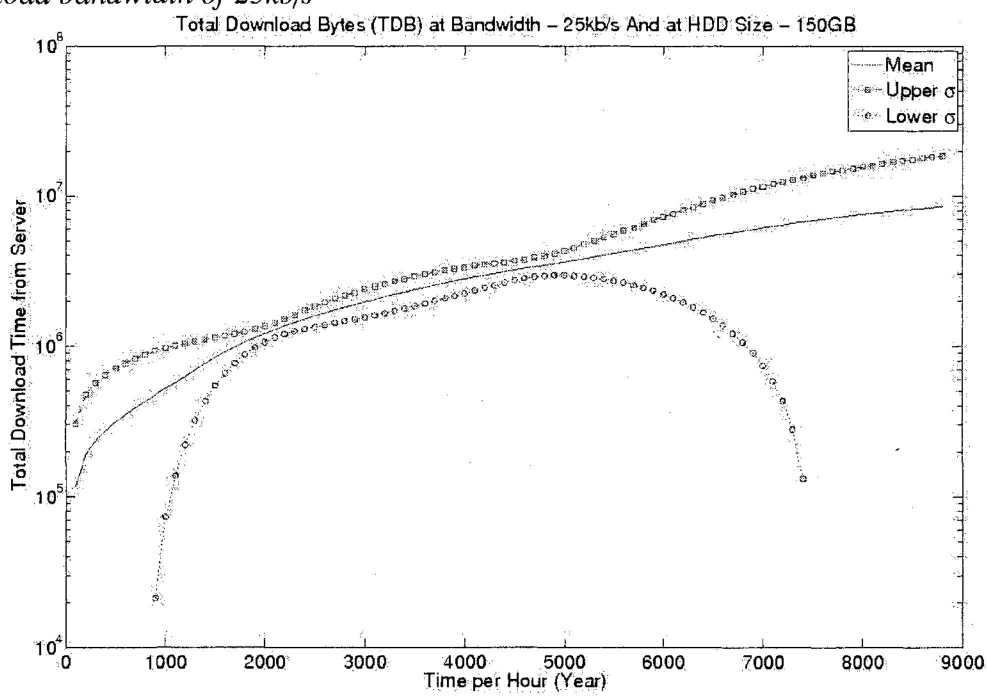


Figure 536: Total Download Bytes for H3 case scenario at hard drive size of 200GB and download bandwidth of 25kb/s

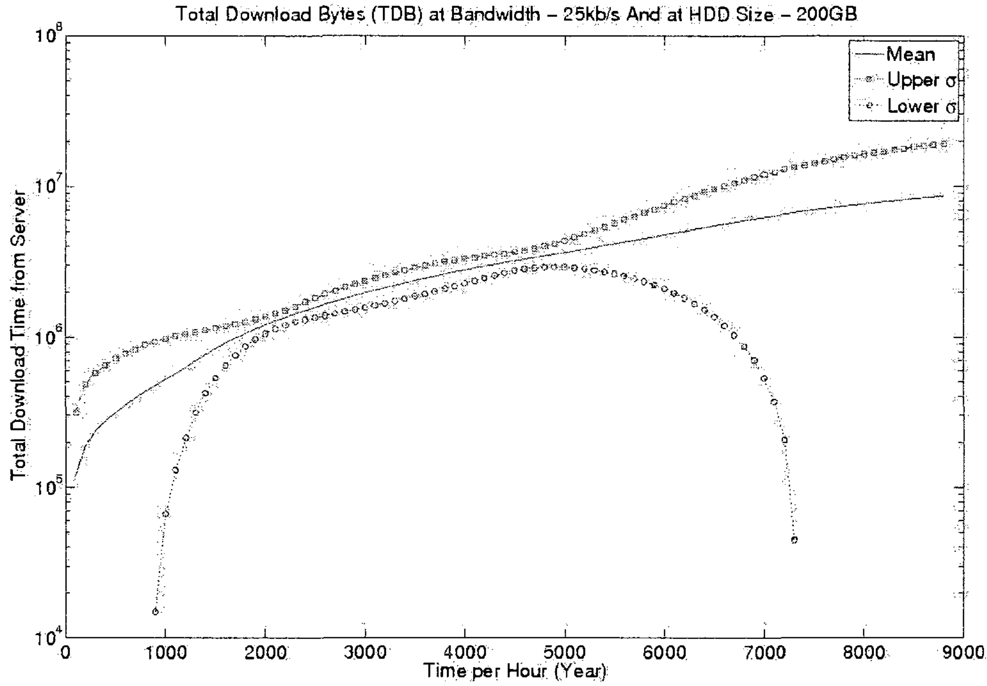


Figure 537: Total Download Bytes for H3 case scenario at hard drive size of 50GB and download bandwidth of 50kb/s

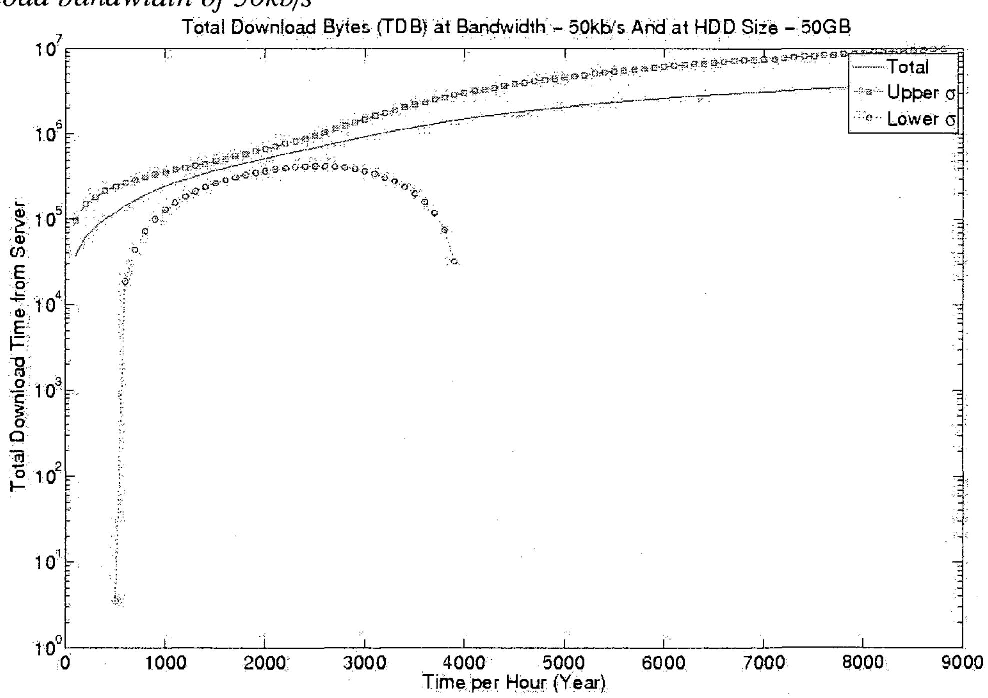


Figure 538: Total Download Bytes for H3 case scenario at hard drive size of 100GB and download bandwidth of 50kb/s

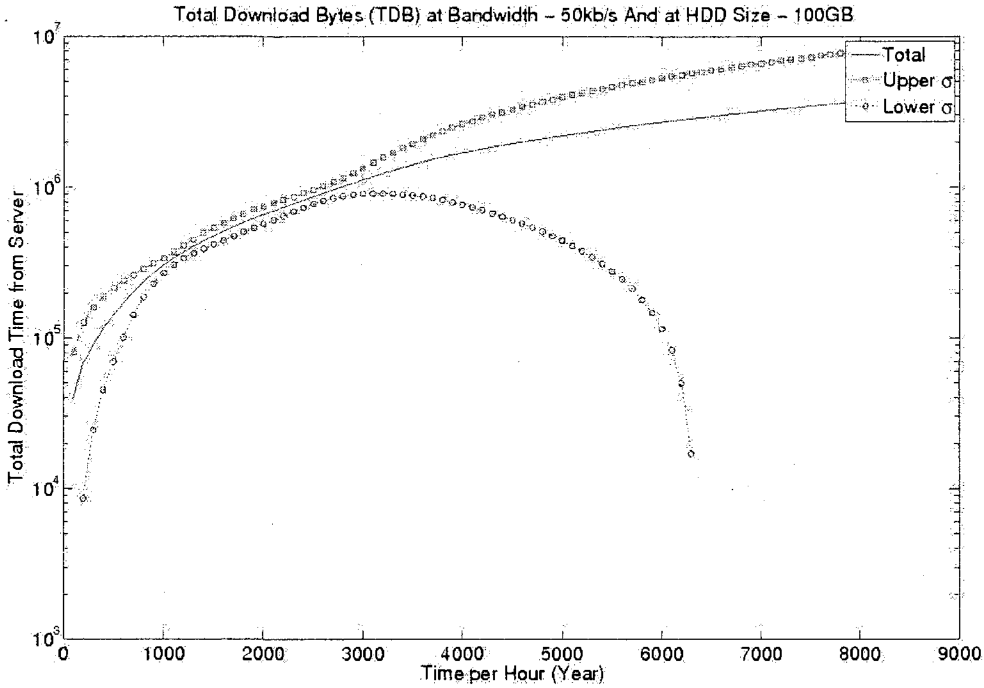


Figure 539: Total Download Bytes for H3 case scenario at hard drive size of 150GB and download bandwidth of 50kb/s

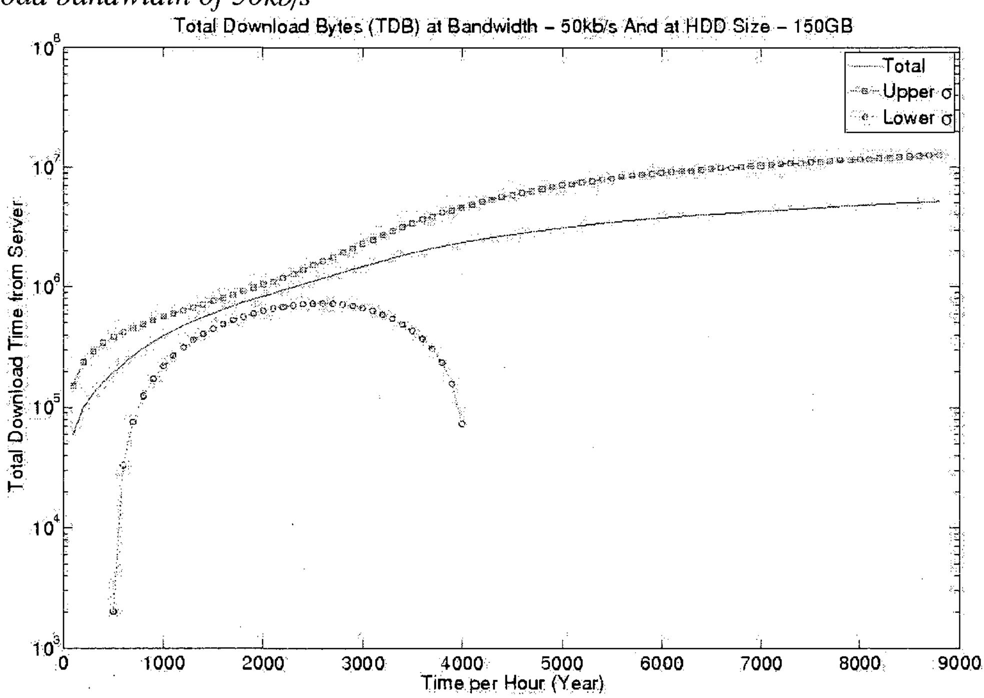


Figure 540: Total Download Bytes for H3 case scenario at hard drive size of 200GB and download bandwidth of 50kb/s

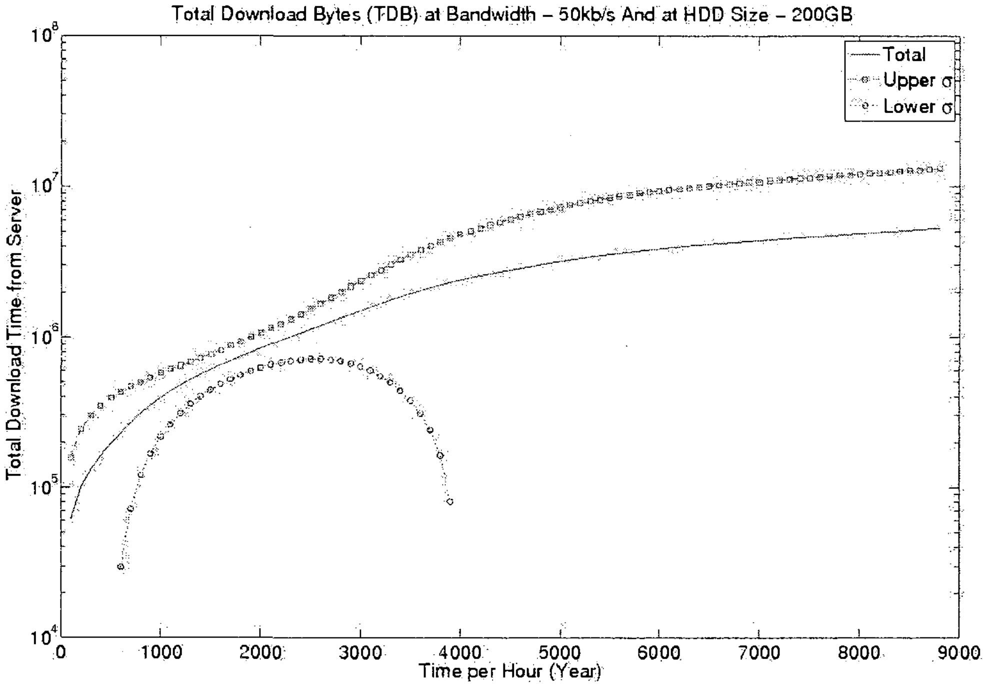


Figure 541: Total Download Bytes for H3 case scenario at hard drive size of 50GB and download bandwidth of 100kb/s

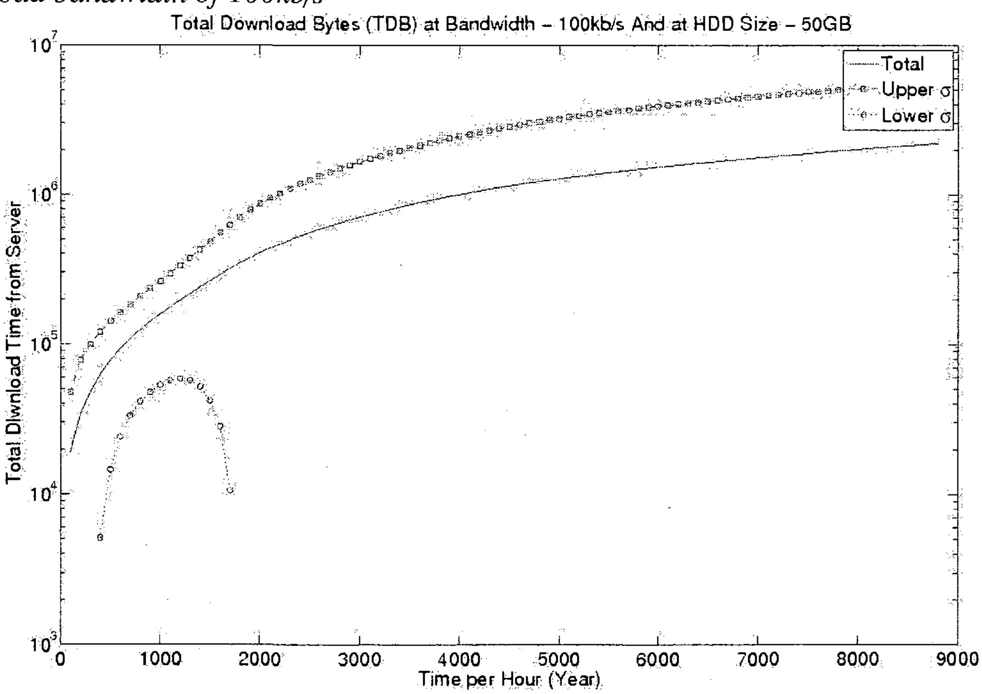


Figure 542: Total Download Bytes for H3 case scenario at hard drive size of 100GB and download bandwidth of 100kb/s

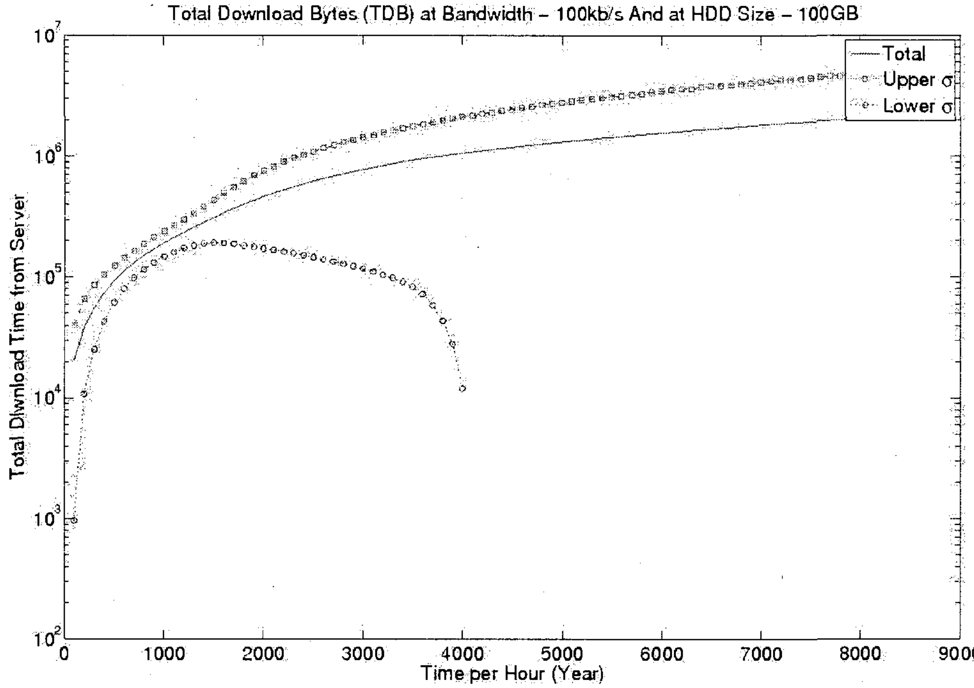


Figure 543: Total Download Bytes for H3 case scenario at hard drive size of 150GB and download bandwidth of 100kb/s

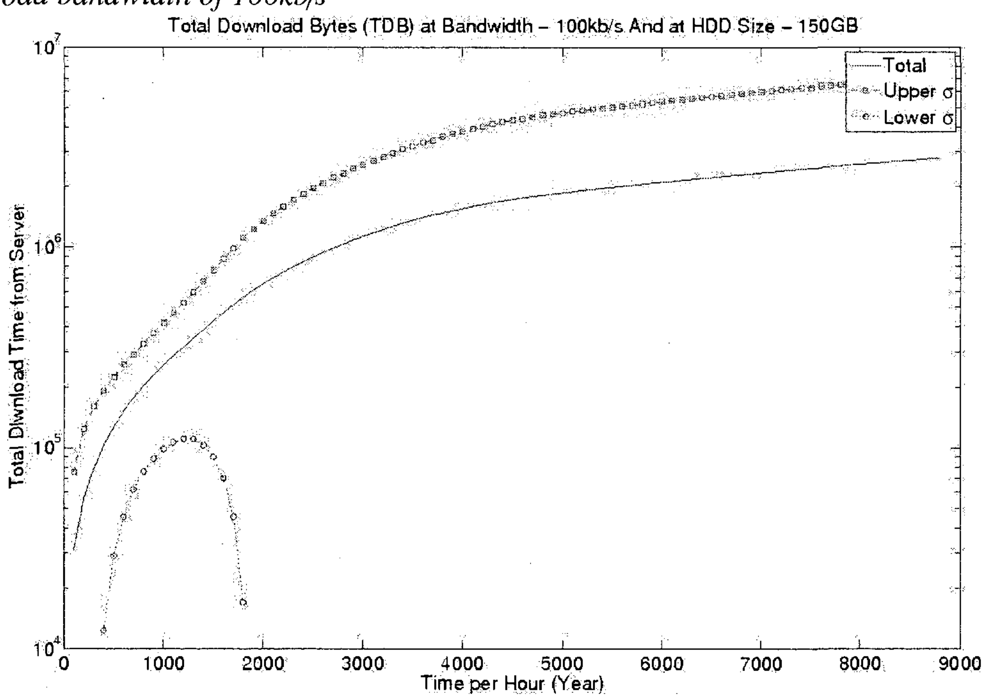


Figure 544: Total Download Bytes for H3 case scenario at hard drive size of 200GB and download bandwidth of 100kb/s

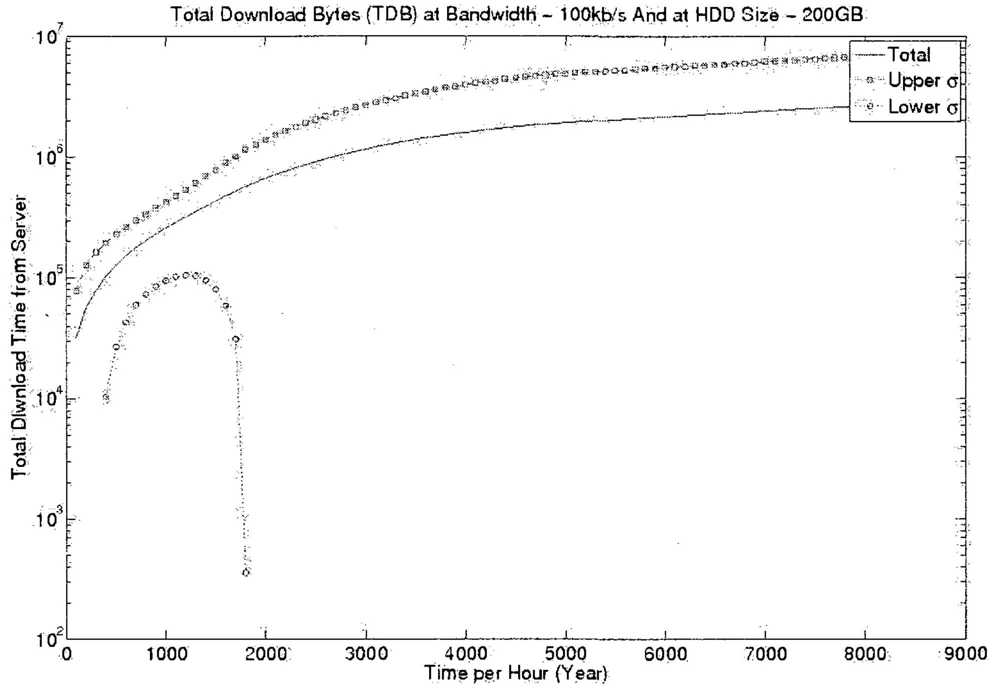


Figure 545: Total Download Bytes for H3 case scenario at hard drive size of 50GB and download bandwidth of 128kb/s

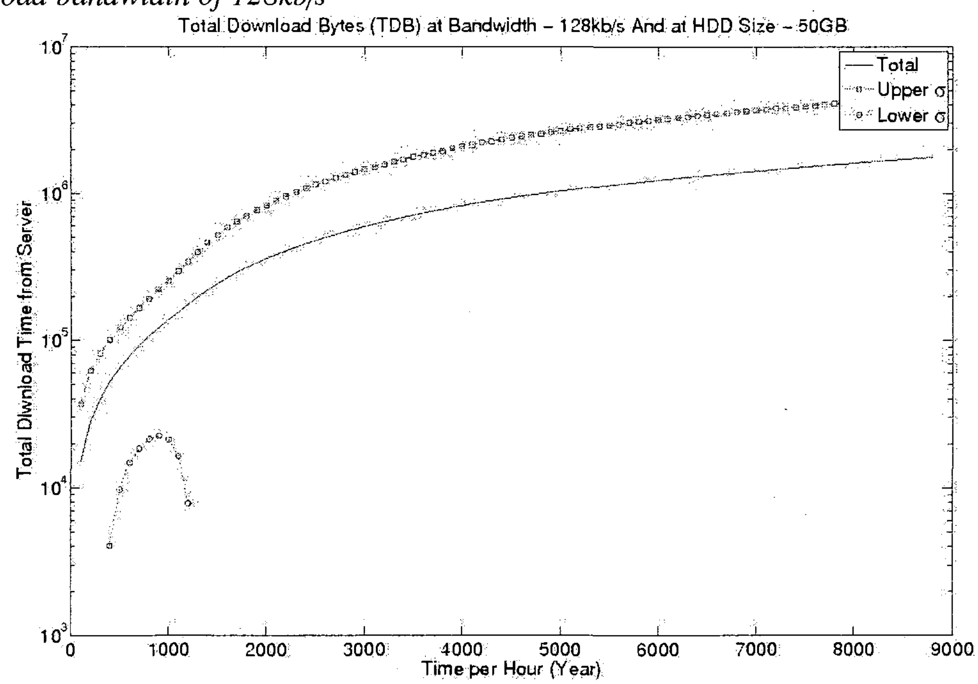


Figure 546: Total Download Bytes for H3 case scenario at hard drive size of 100GB and download bandwidth of 128kb/s

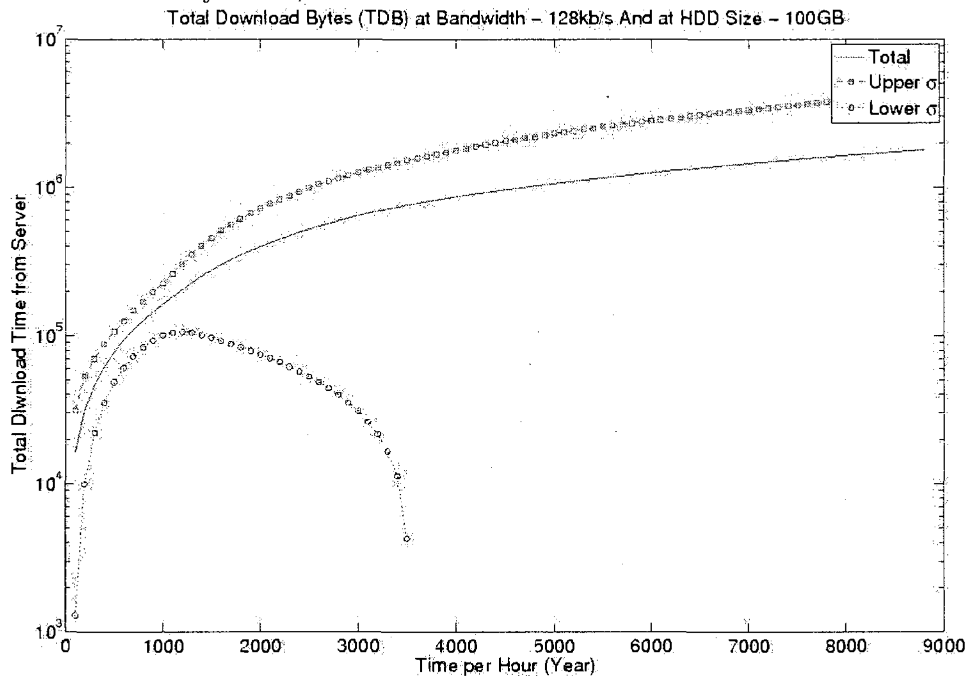


Figure 547: Total Download Bytes for H3 case scenario at hard drive size of 150GB and download bandwidth of 128kb/s

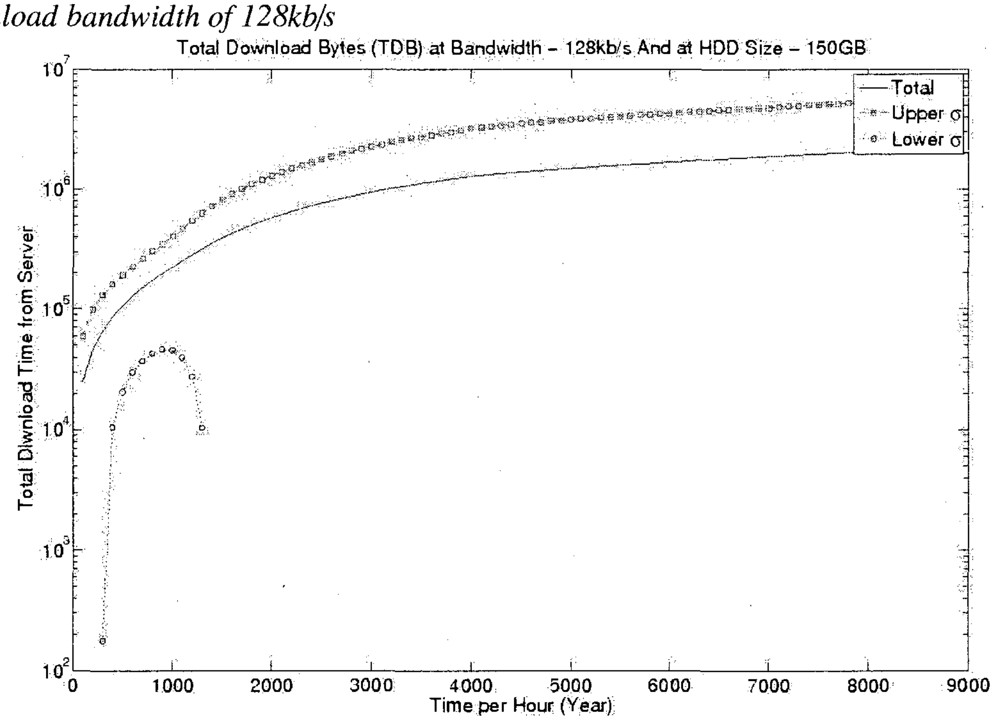


Figure 548: Total Download Bytes for H3 case scenario at hard drive size of 200GB and download bandwidth of 128kb/s

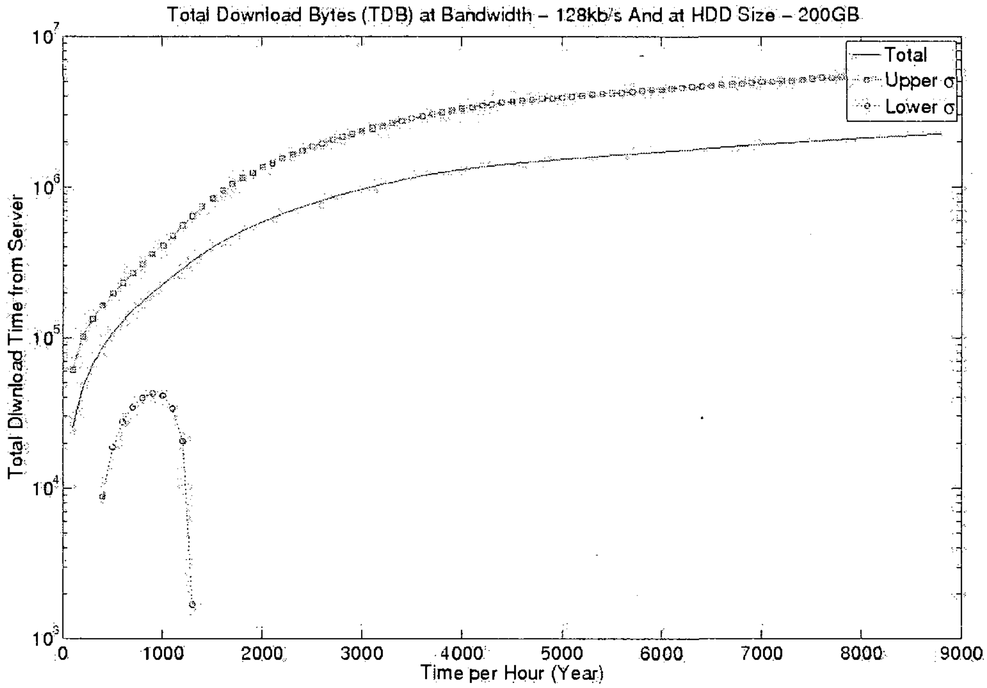


Figure 549: Total Download Bytes for H3 case scenario at hard drive size of 50GB and download bandwidth of 256kb/s

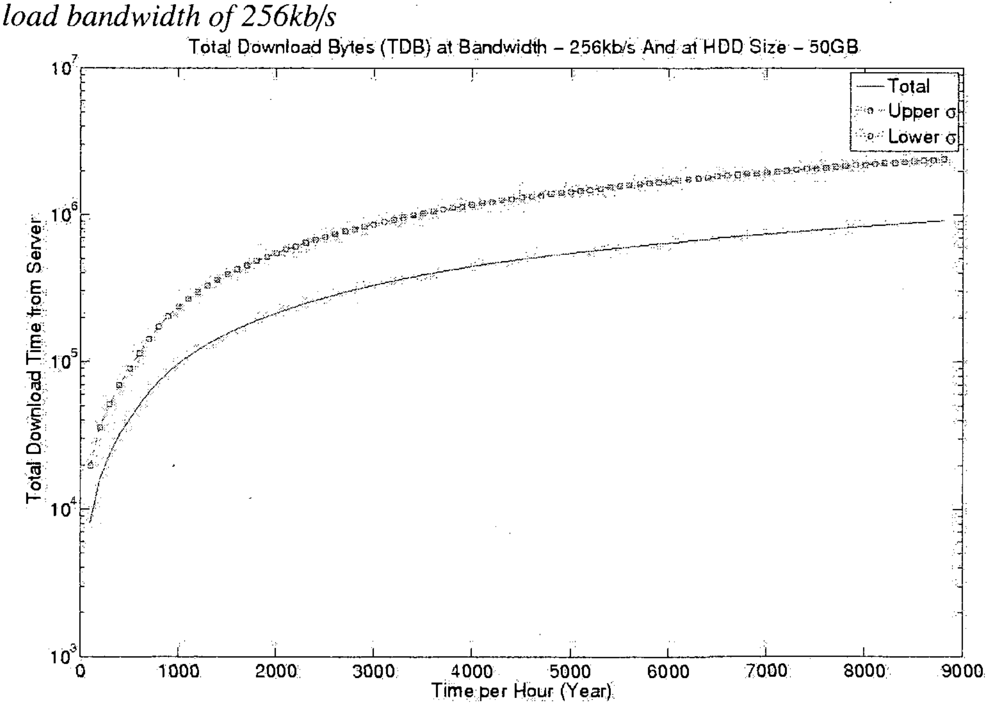


Figure 550: Total Download Bytes for H3 case scenario at hard drive size of 100GB and download bandwidth of 256kb/s

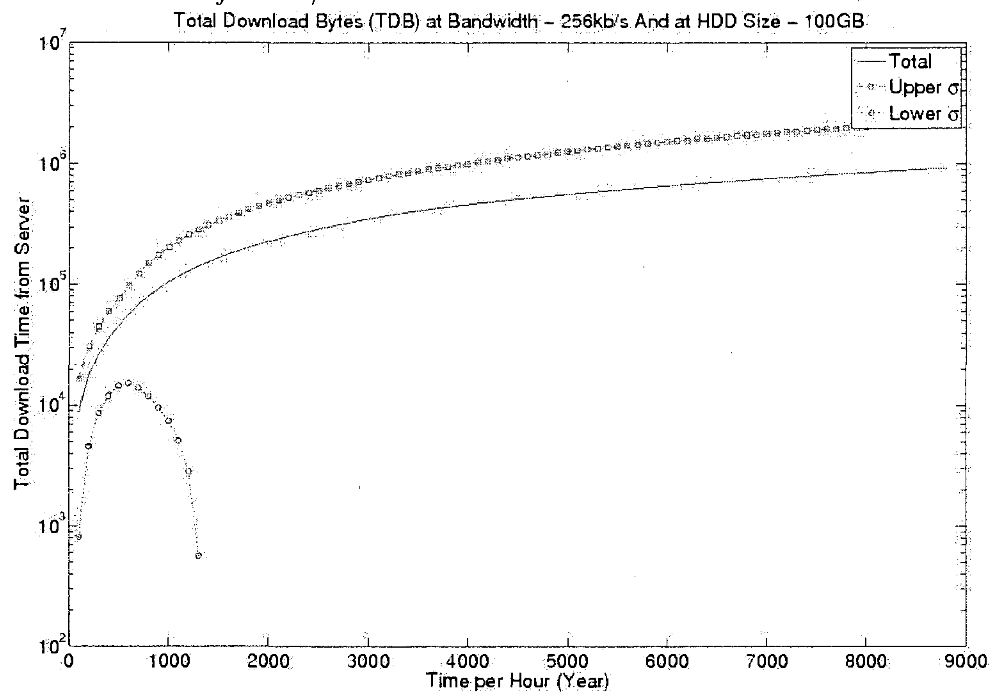


Figure 551: Total Download Bytes for H3 case scenario at hard drive size of 150GB and download bandwidth of 256kb/s

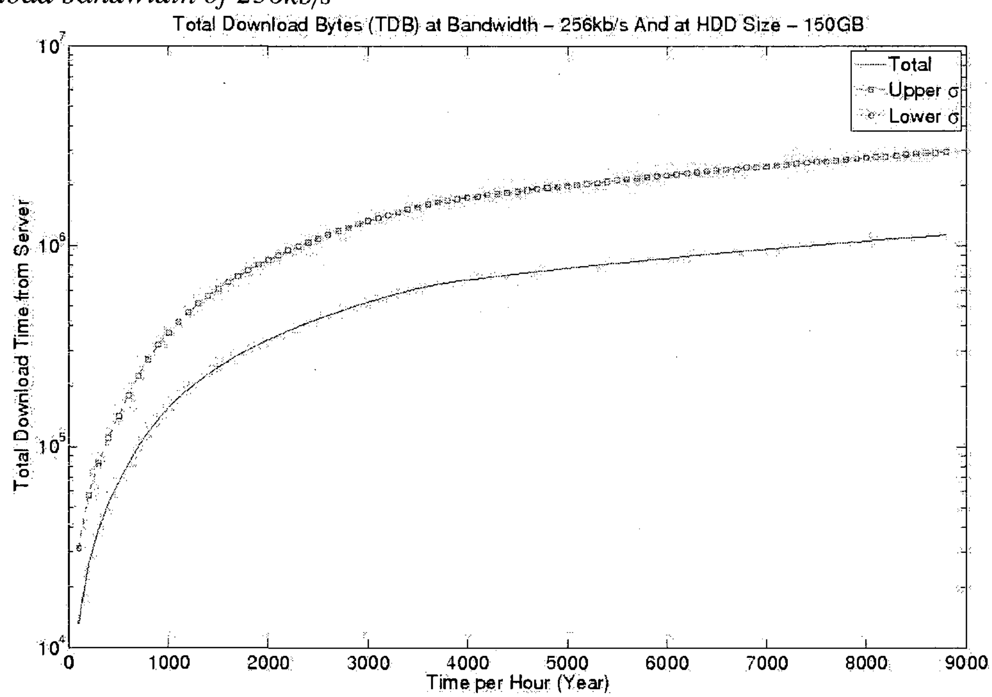


Figure 552: Total Download Bytes for H3 case scenario at hard drive size of 200GB and download bandwidth of 256kb/s

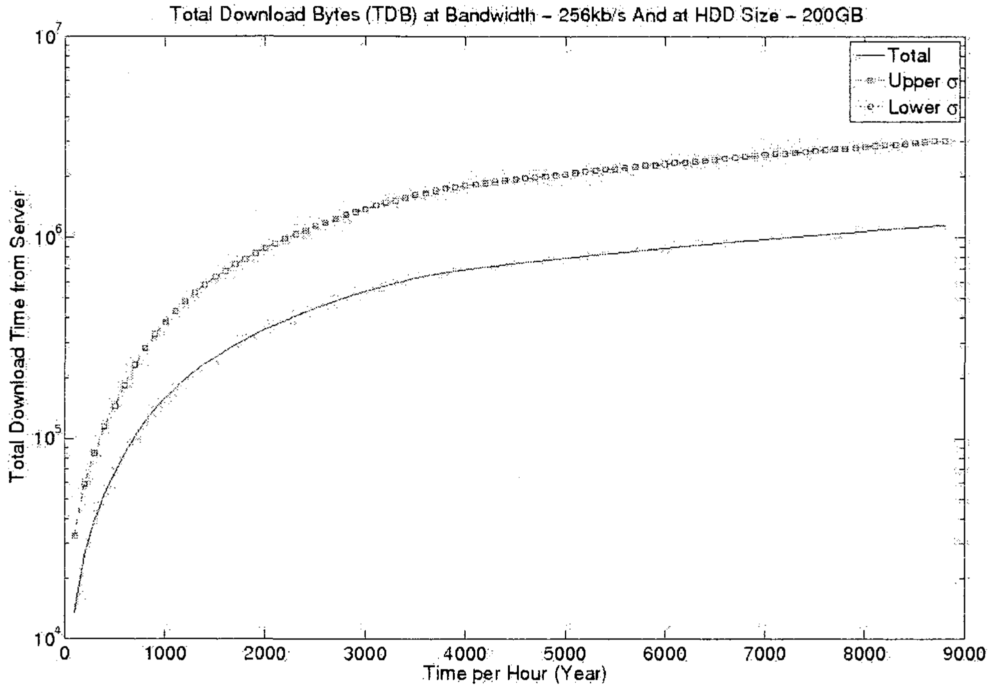


Figure 553: Total Download Bytes for H3 case scenario at hard drive size of 50GB and download bandwidth of 512kb/s

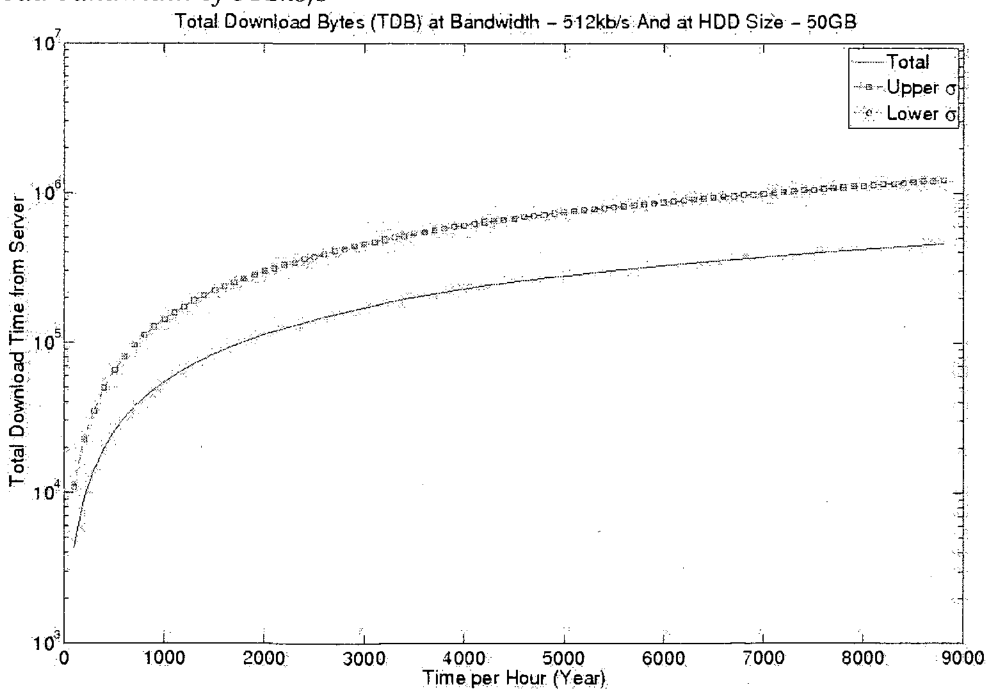


Figure 554: Total Download Bytes for H3 case scenario at hard drive size of 100GB and download bandwidth of 512kb/s

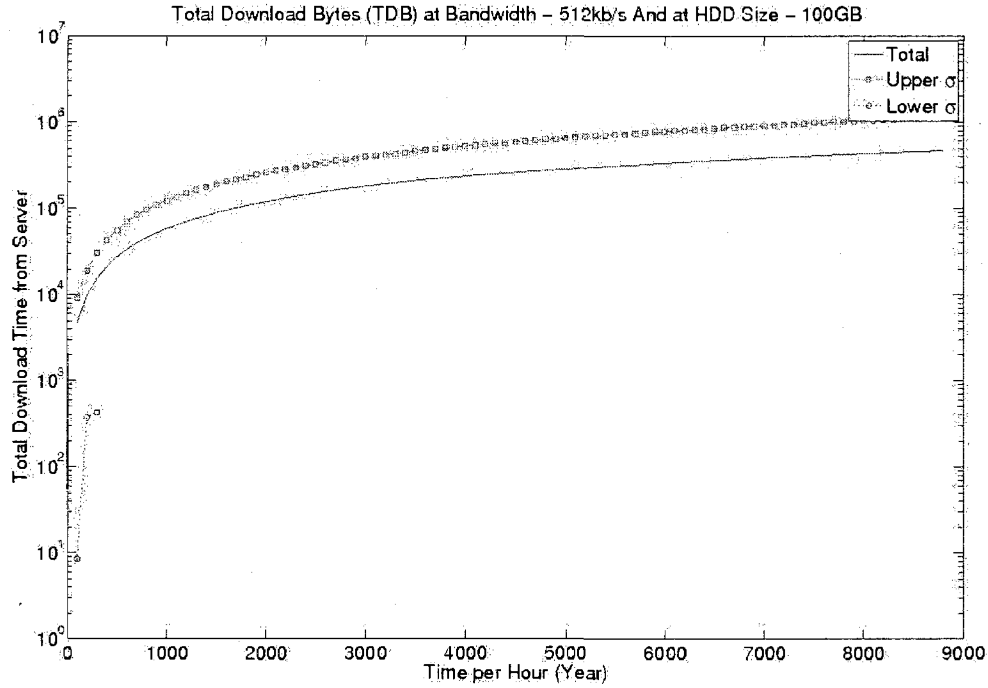


Figure 555: Total Download Bytes for H3 case scenario at hard drive size of 150GB and download bandwidth of 512kb/s

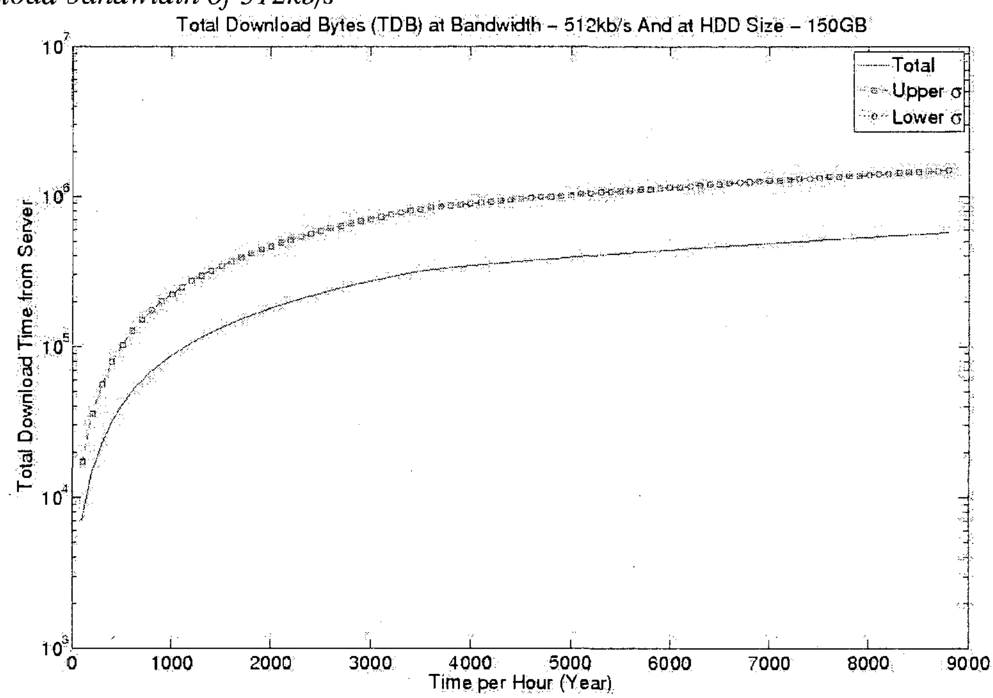


Figure 556: Total Download Bytes for H3 case scenario at hard drive size of 200GB and download bandwidth of 512kb/s

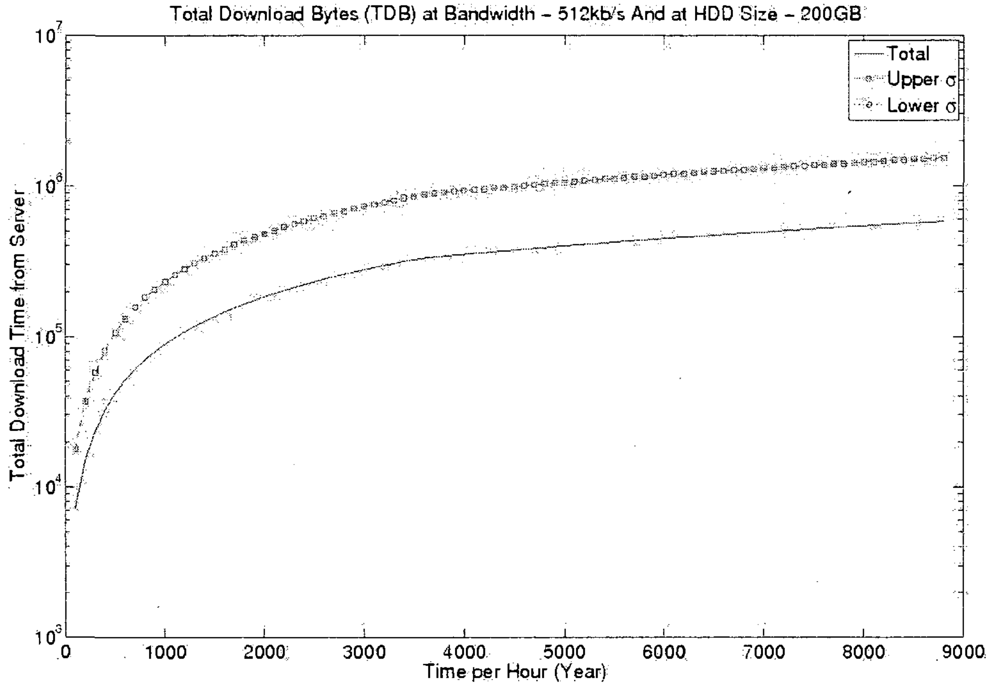


Figure 557: Total Download Bytes for H3 case scenario at hard drive size of 50GB and download bandwidth of 1000kb/s

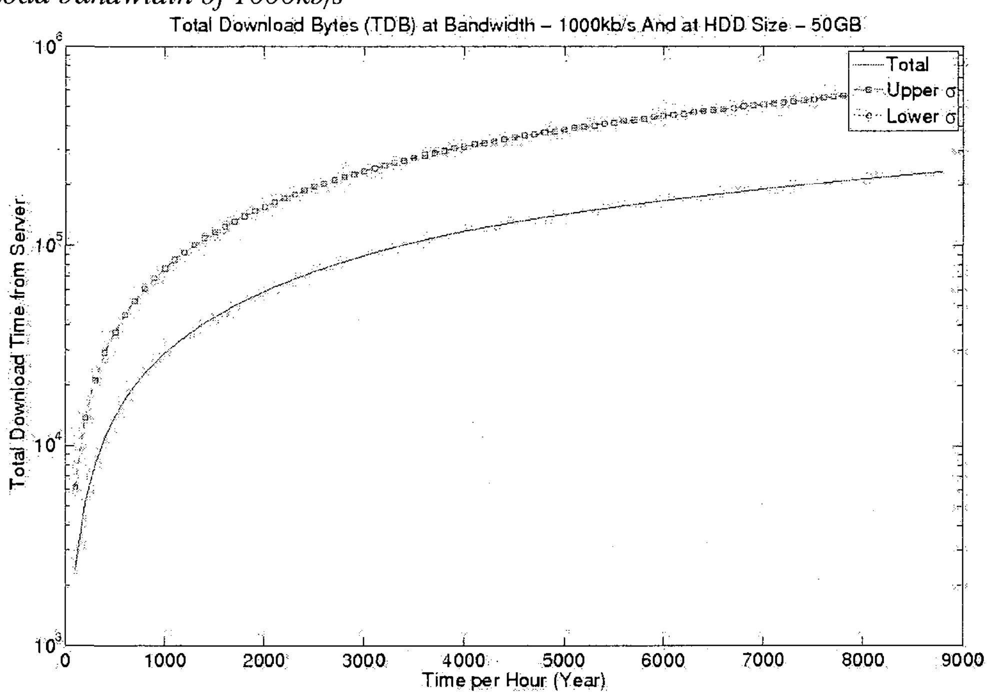


Figure 558: Total Download Bytes for H3 case scenario at hard drive size of 100GB and download bandwidth of 1000kb/s

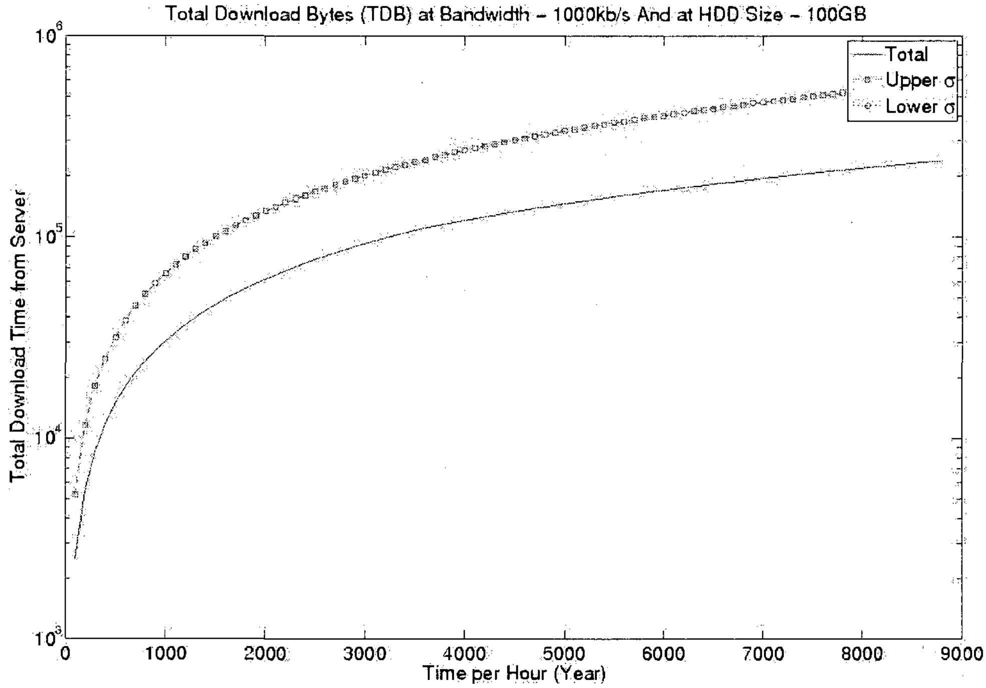


Figure 559: Total Download Bytes for H3 case scenario at hard drive size of 150GB and download bandwidth of 1000kb/s

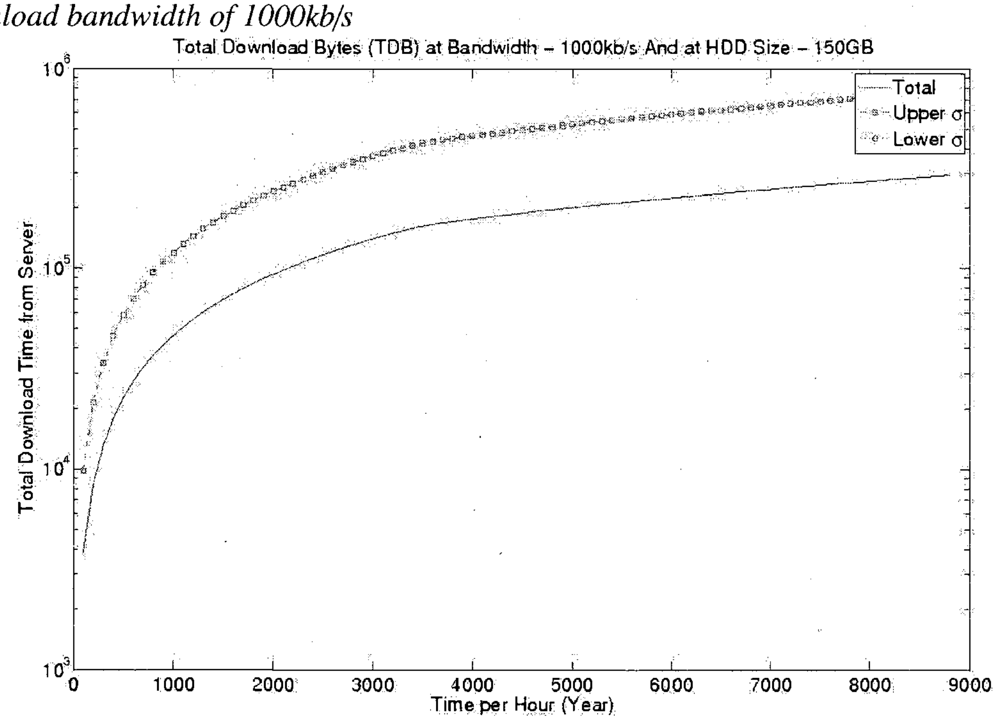


Figure 560: Total Download Bytes for H3 case scenario at hard drive size of 200GB and download bandwidth of 1000kb/s

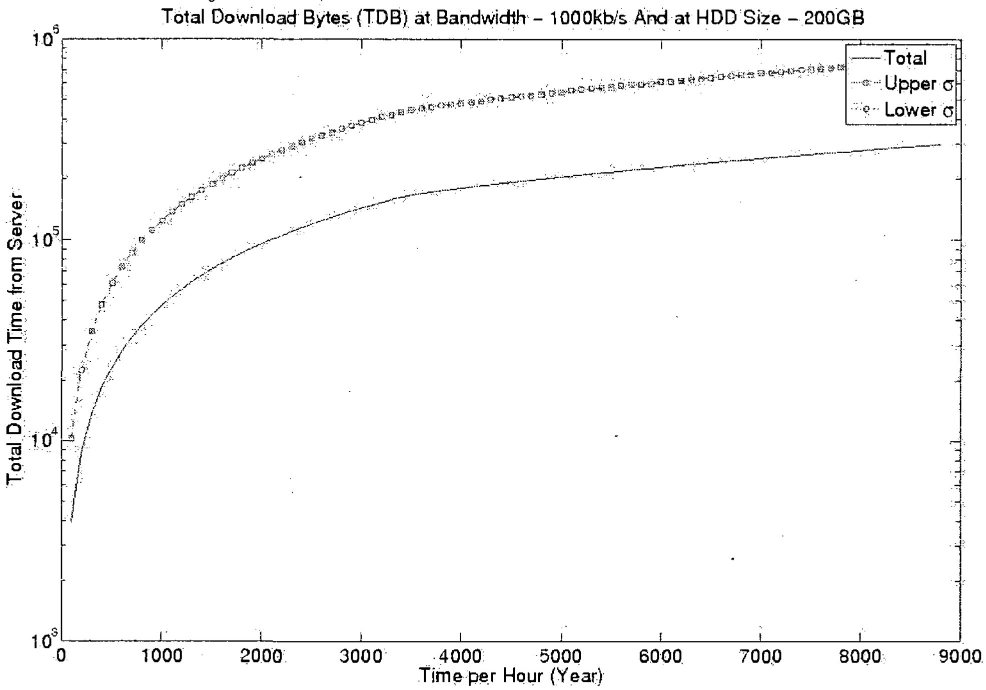


Figure 561: Total Download Bytes for H3 case scenario at hard drive size of 50GB and download bandwidth of 2000kb/s

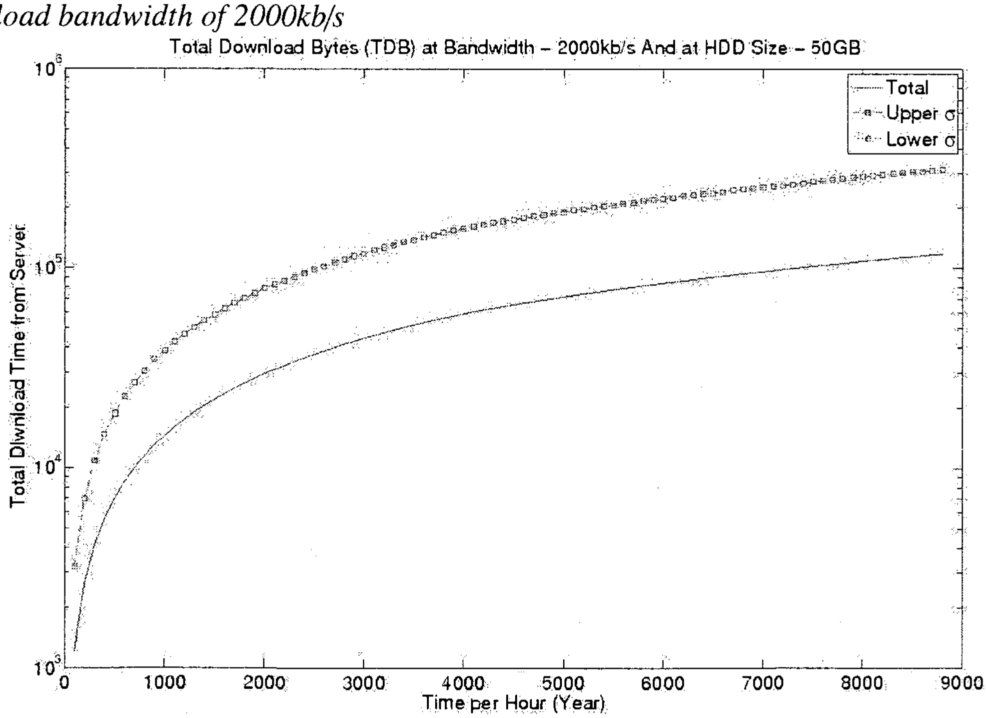


Figure 562: Total Download Bytes for H3 case scenario at hard drive size of 100GB and download bandwidth of 2000kb/s

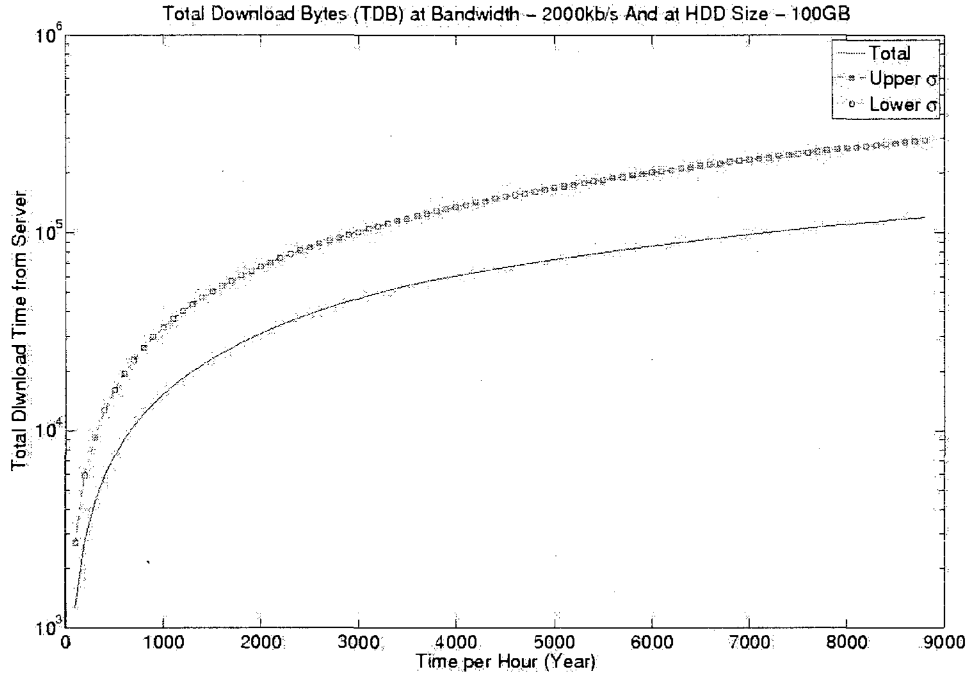


Figure 563: Total Download Bytes for H3 case scenario at hard drive size of 150GB and download bandwidth of 2000kb/s

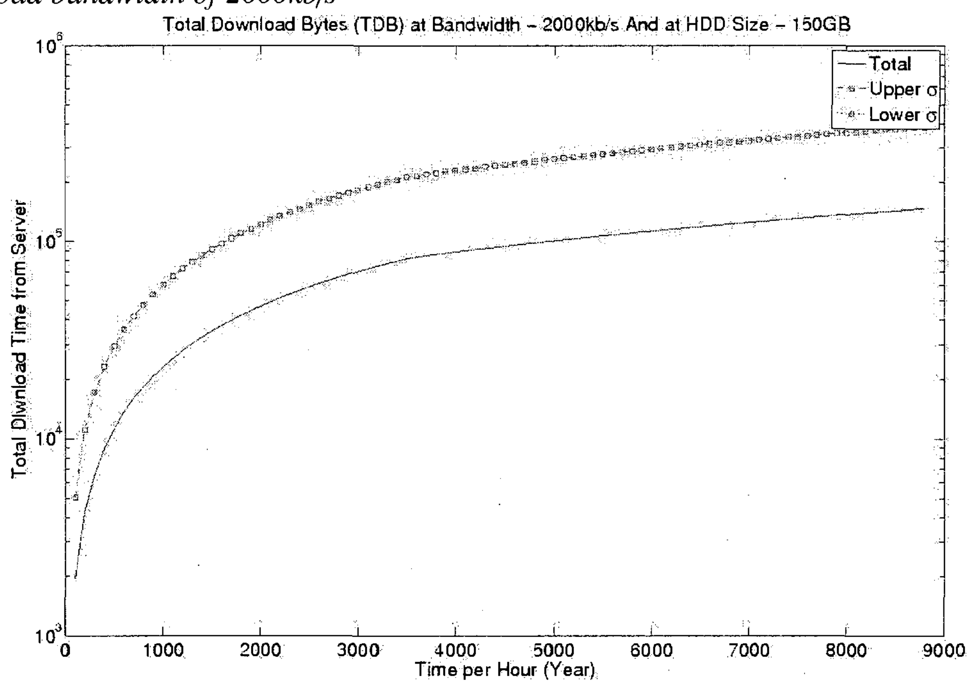


Figure 564: Total Download Bytes for H3 case scenario at hard drive size of 200GB and download bandwidth of 2000kb/s

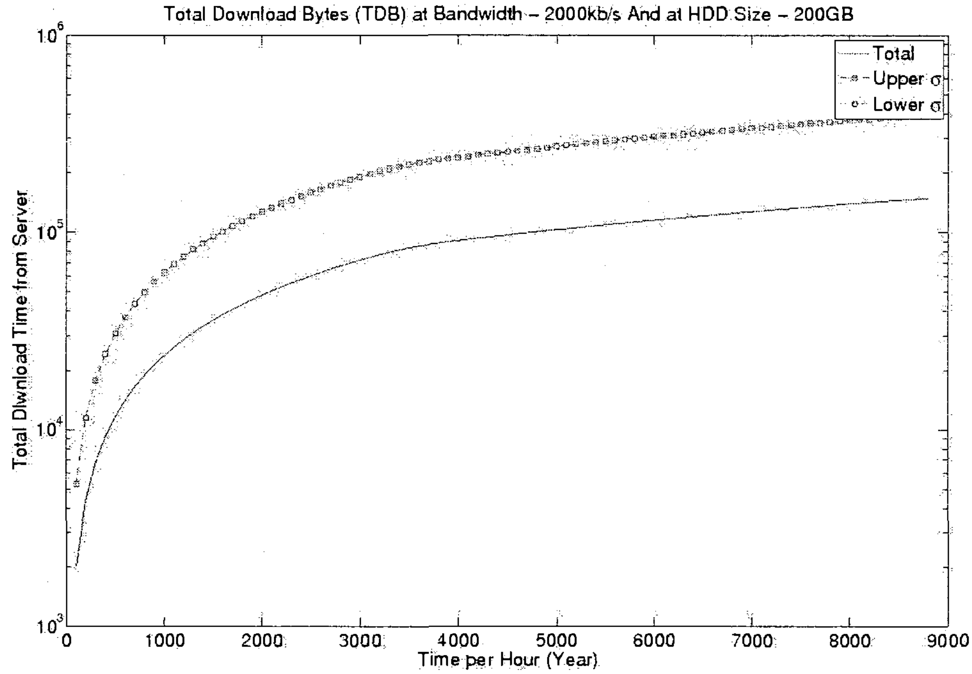


Figure 565: Total Download Bytes for H3 case scenario at hard drive size of 50GB and download bandwidth of 5000kb/s

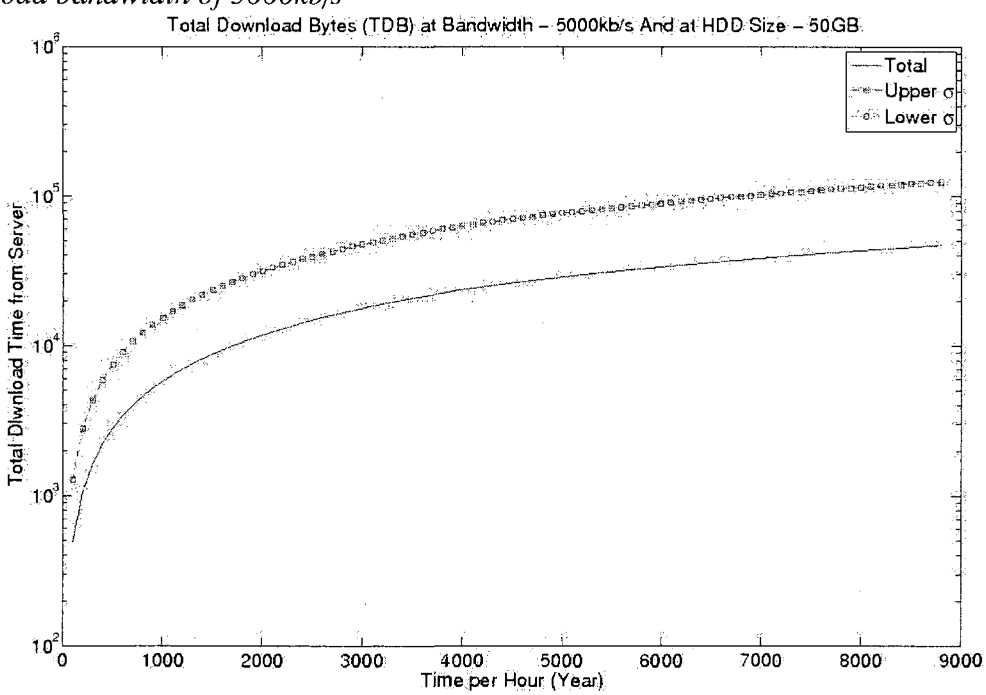


Figure 566: Total Download Bytes for H3 case scenario at hard drive size of 100GB and download bandwidth of 5000kb/s

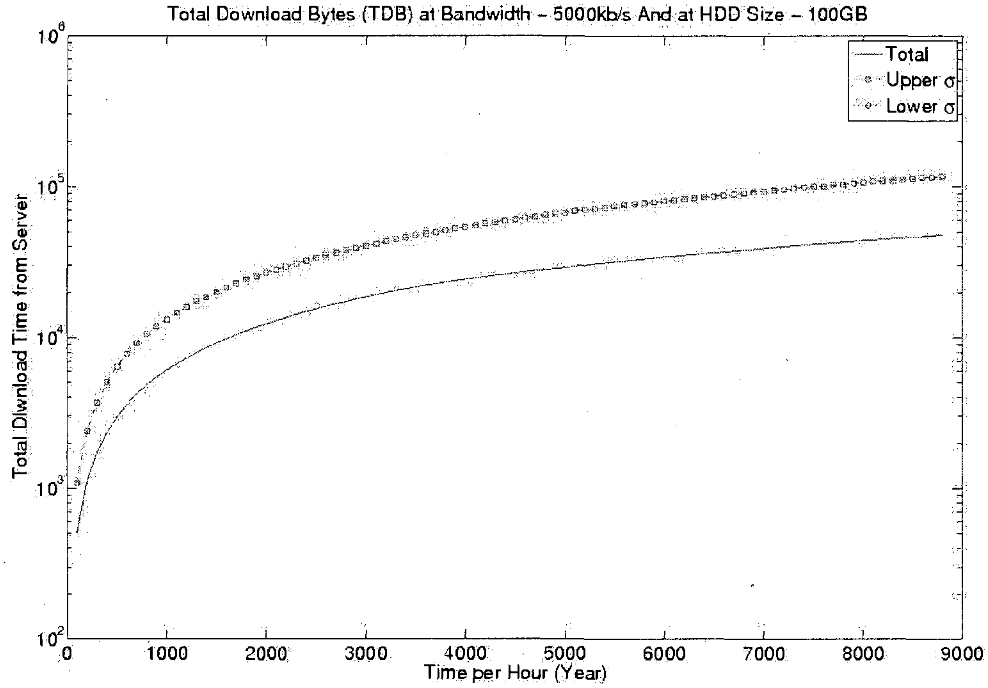


Figure 567: Total Download Bytes for H3 case scenario at hard drive size of 150GB and download bandwidth of 5000kb/s

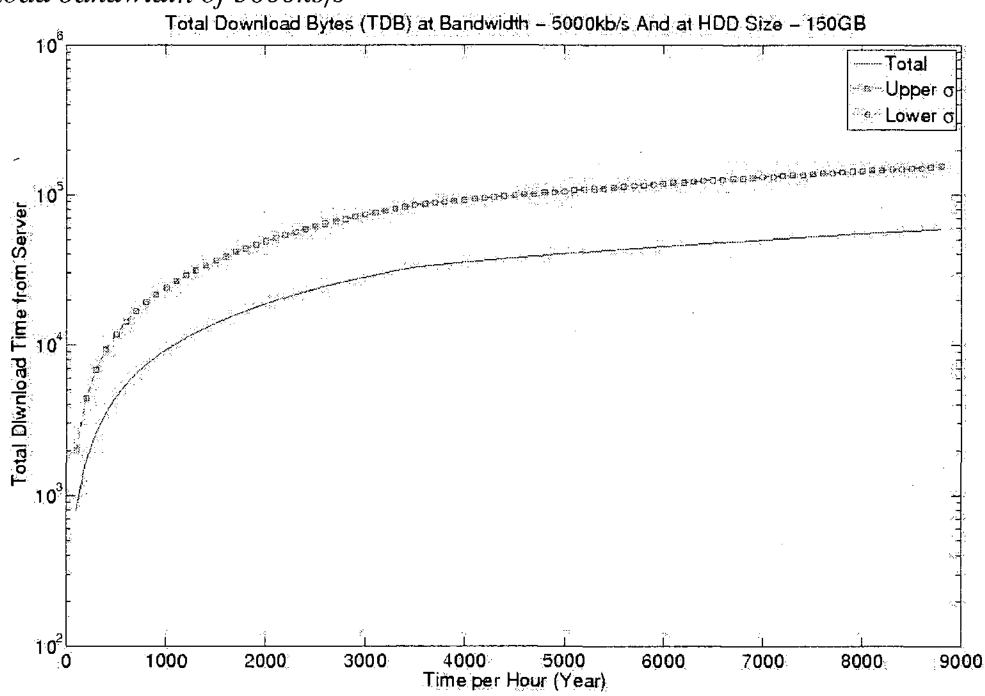


Figure 568: Total Download Bytes for H3 case scenario at hard drive size of 200GB and download bandwidth of 5000kb/s

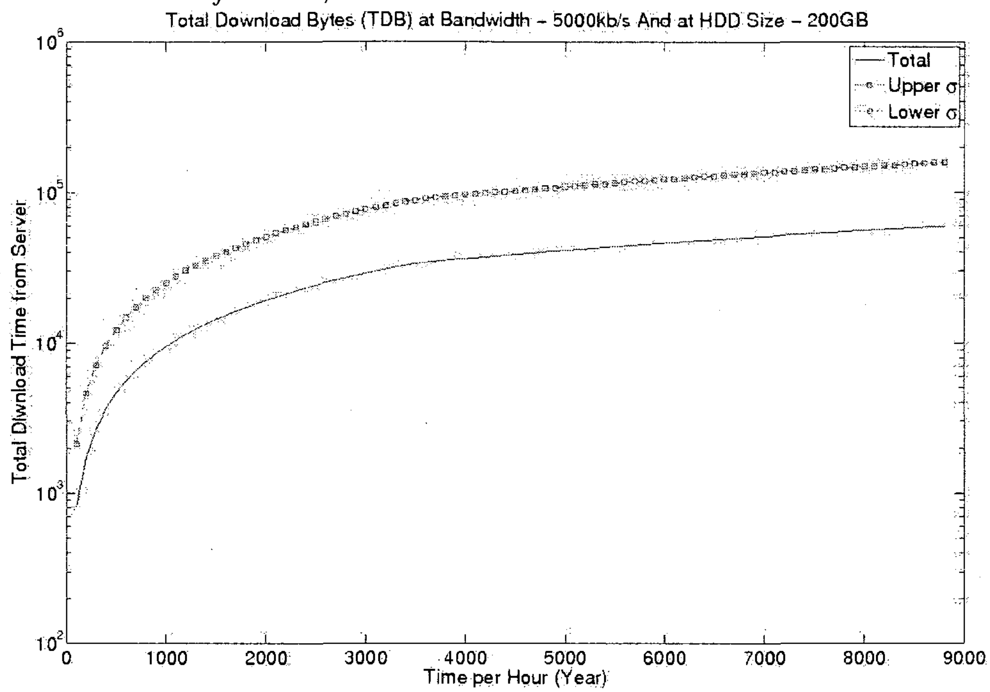


Figure 569: Total Download Bytes for H3 case scenario at hard drive size of 50GB and download bandwidth of 10000kb/s

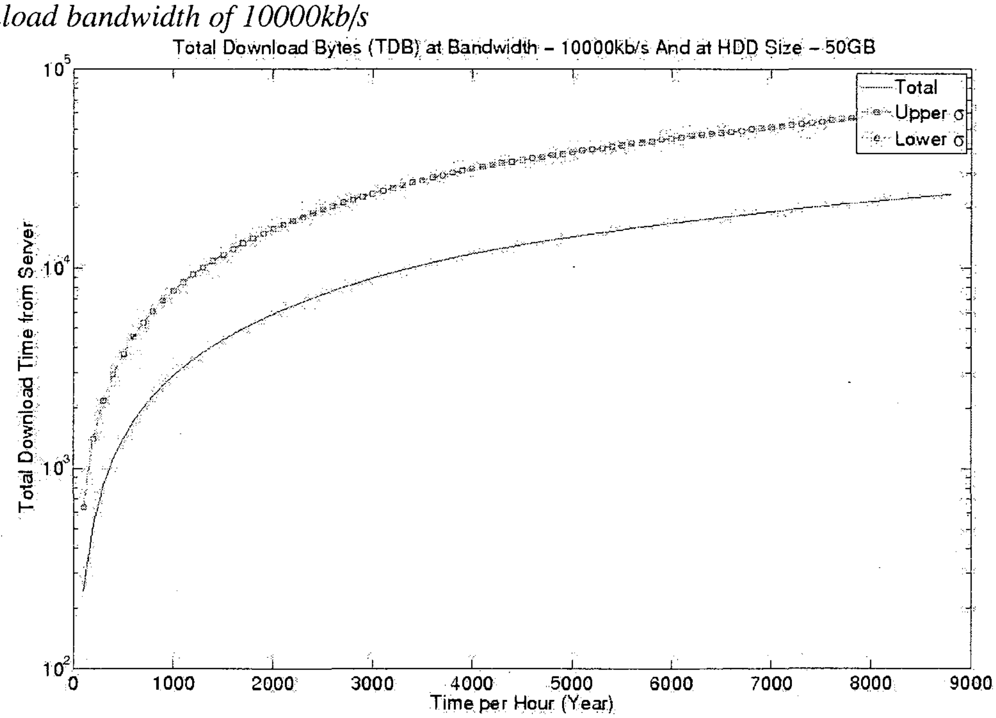


Figure 570: Total Download Bytes for H3 case scenario at hard drive size of 100GB and download bandwidth of 10000kb/s

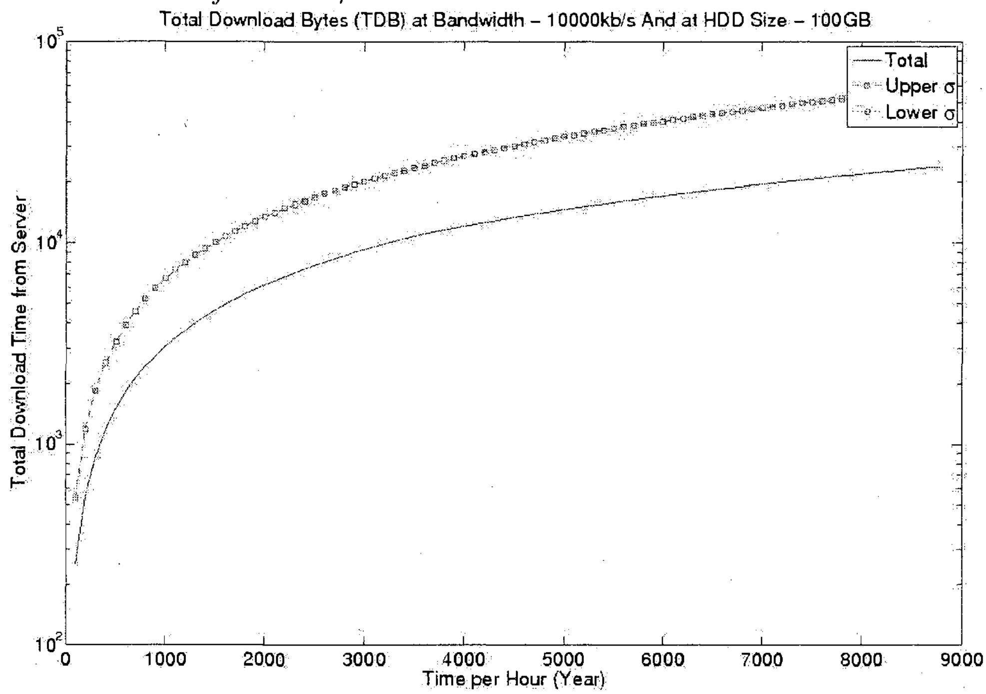


Figure 571: Total Download Bytes for H3 case scenario at hard drive size of 150GB and download bandwidth of 10000kb/s

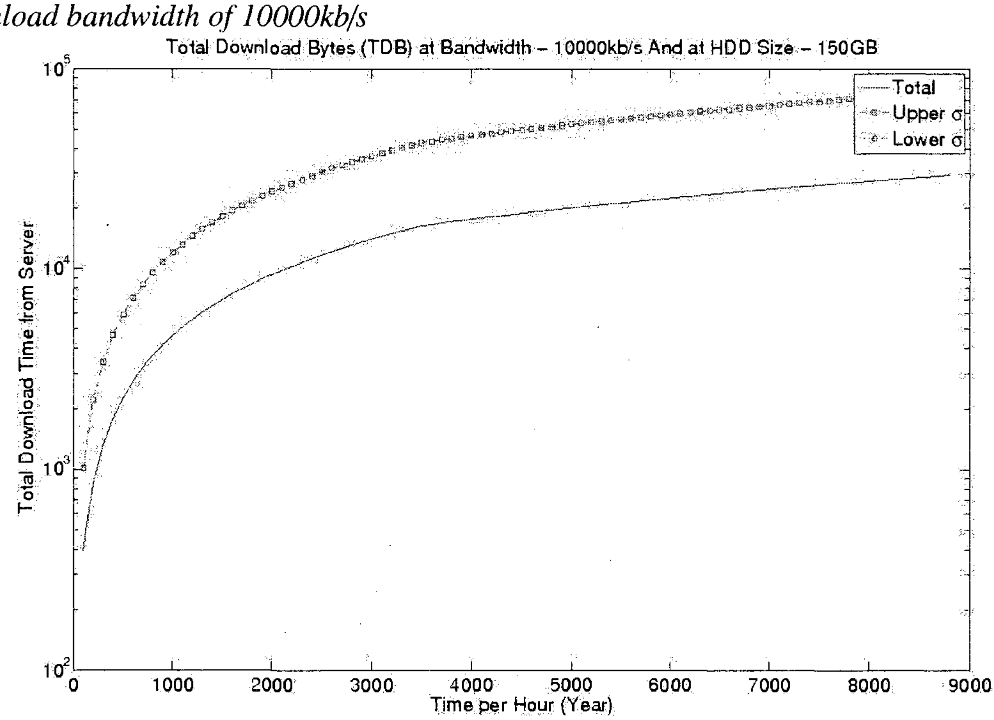


Figure 572: Total Download Bytes for H3 case scenario at hard drive size of 200GB and download bandwidth of 10000kb/s

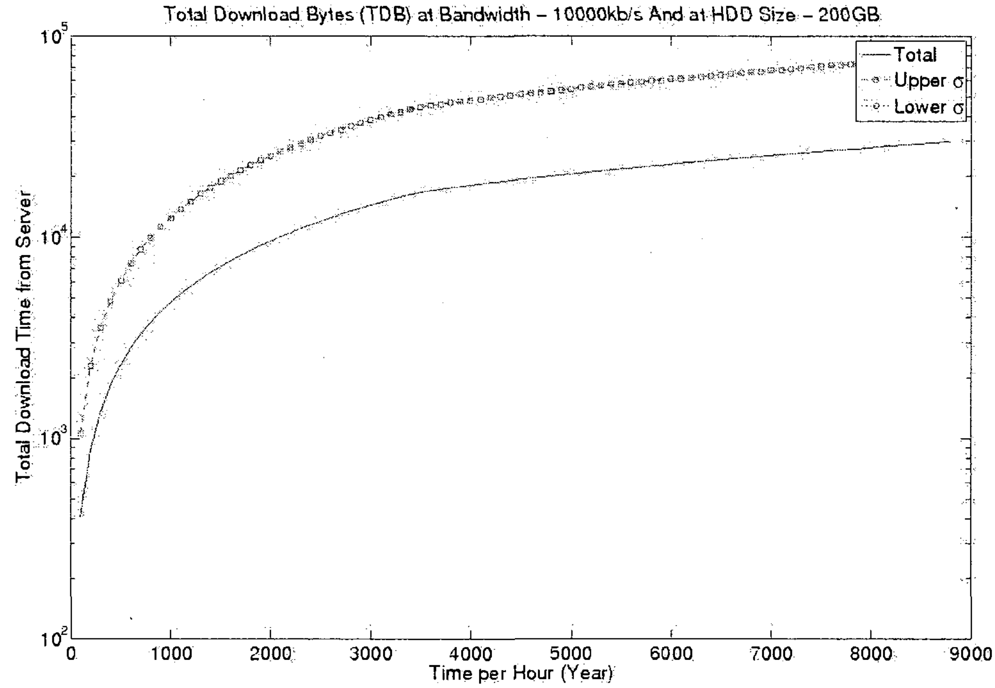


Figure 573: Total Download Bytes for H3 case scenario at hard drive size of 50GB and download bandwidth of 15000kb/s

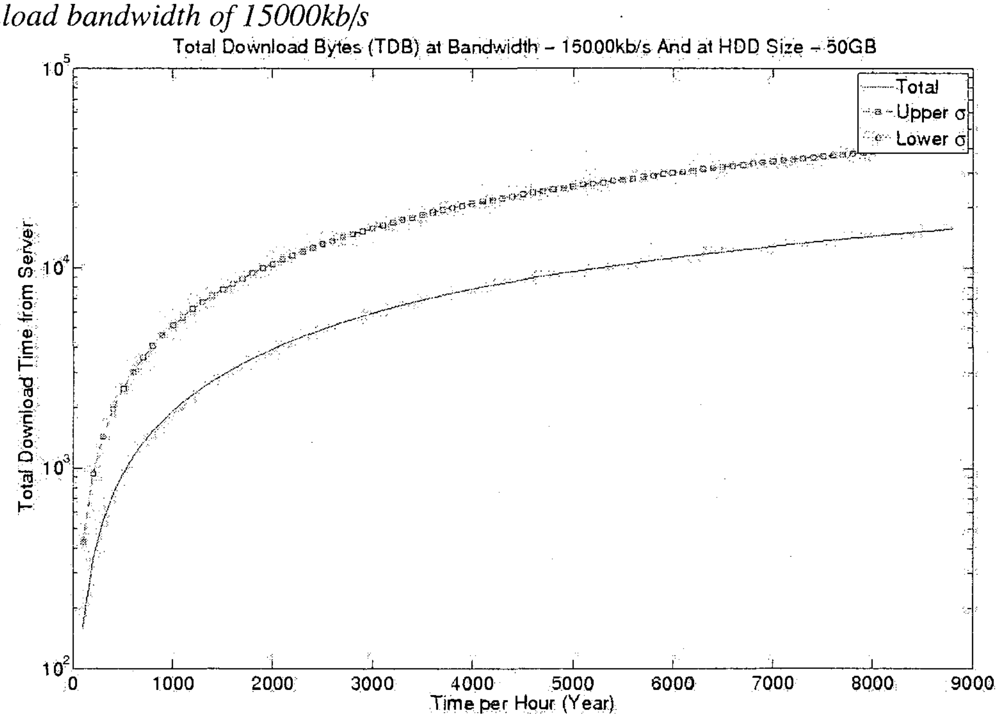


Figure 574: Total Download Bytes for H3 case scenario at hard drive size of 100GB and download bandwidth of 15000kb/s

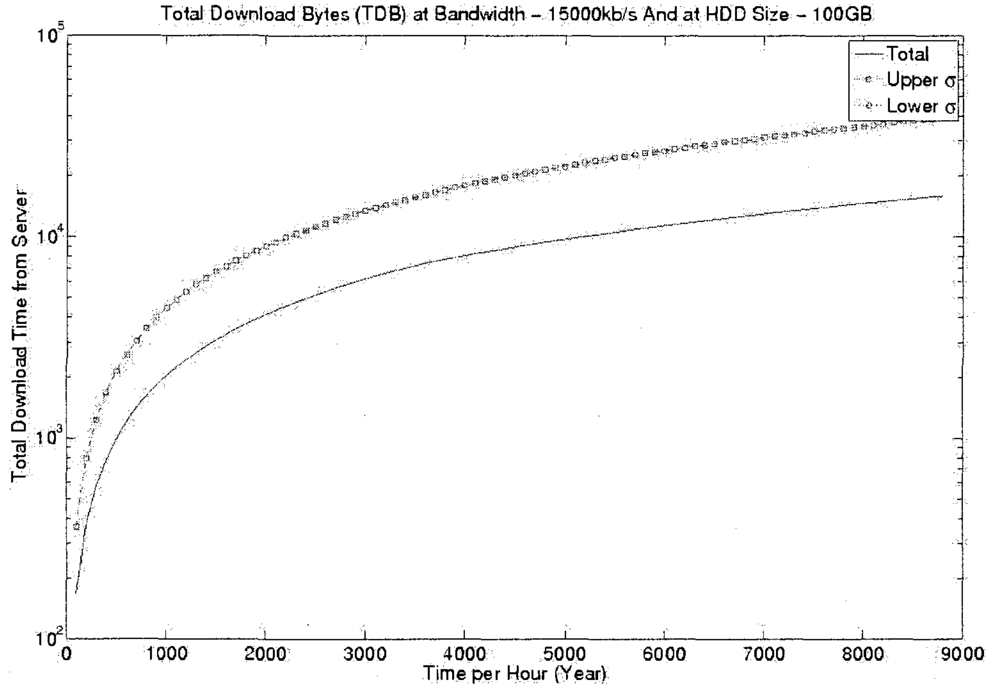


Figure 575: Total Download Bytes for H3 case scenario at hard drive size of 150GB and download bandwidth of 15000kb/s

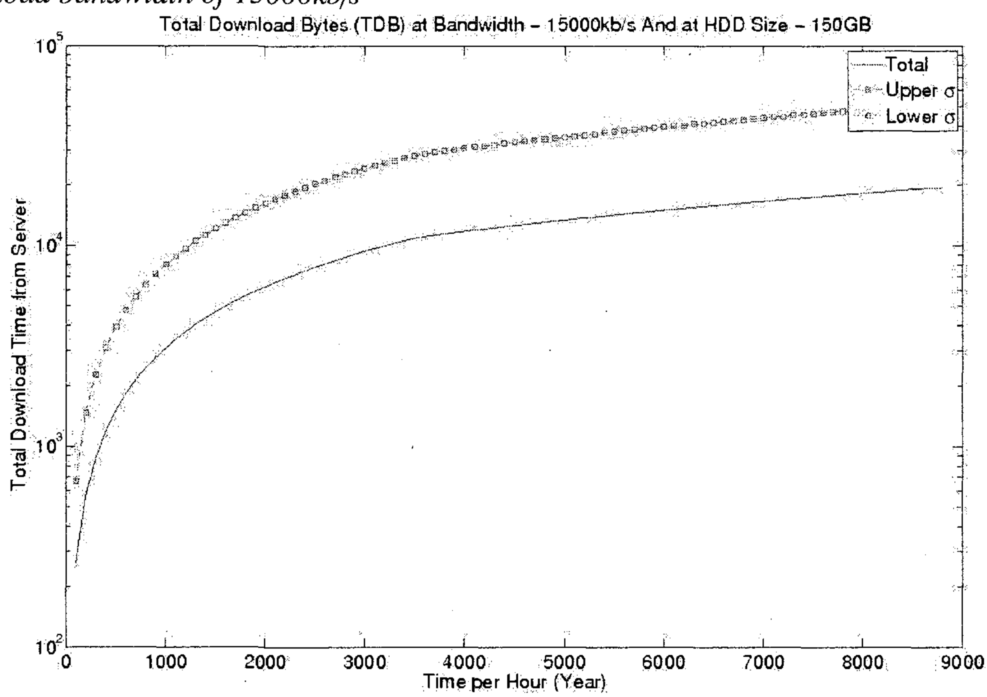


Figure 576: Total Download Bytes for H3 case scenario at hard drive size of 200GB and download bandwidth of 15000kb/s

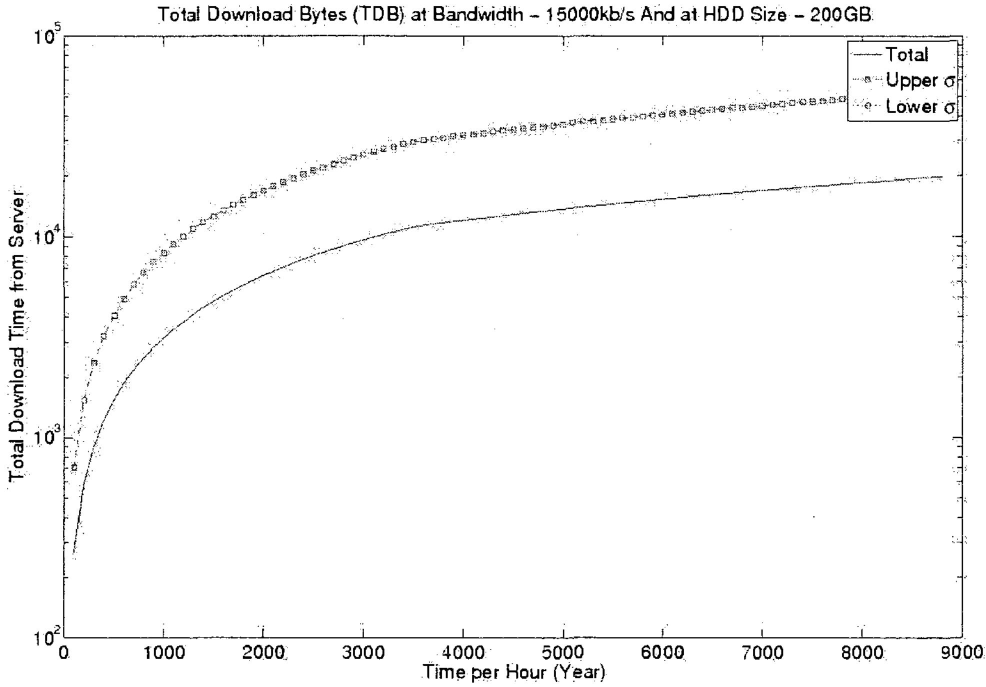


Figure 577: Total Download Bytes for H4 case scenario at hard drive size of 50GB and download bandwidth of 25kb/s

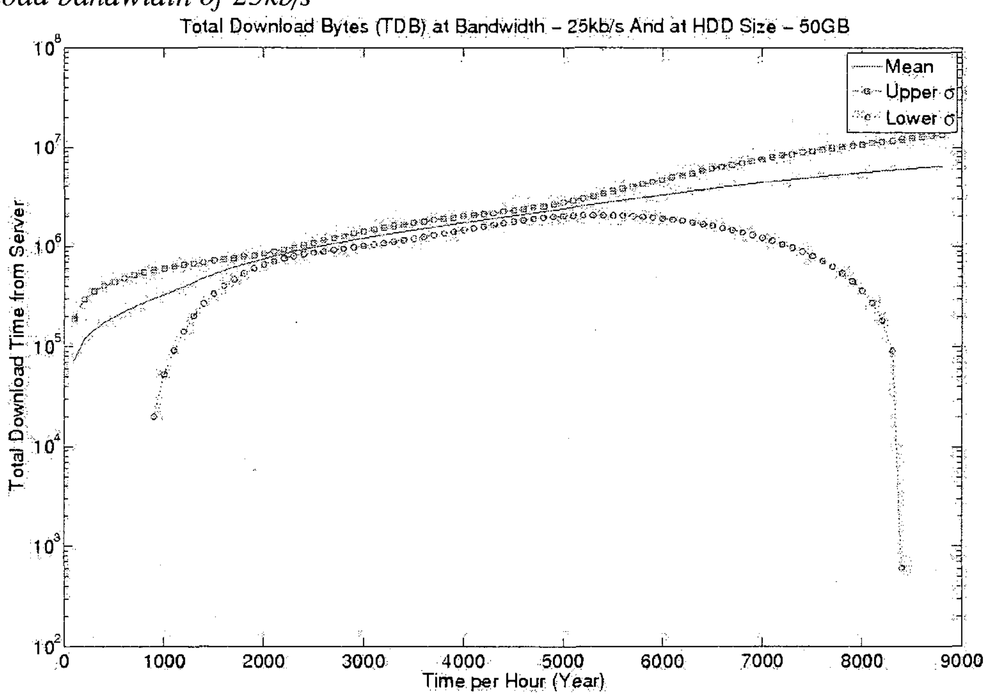


Figure 578: Total Download Bytes for H4 case scenario at hard drive size of 100GB and download bandwidth of 25kb/s

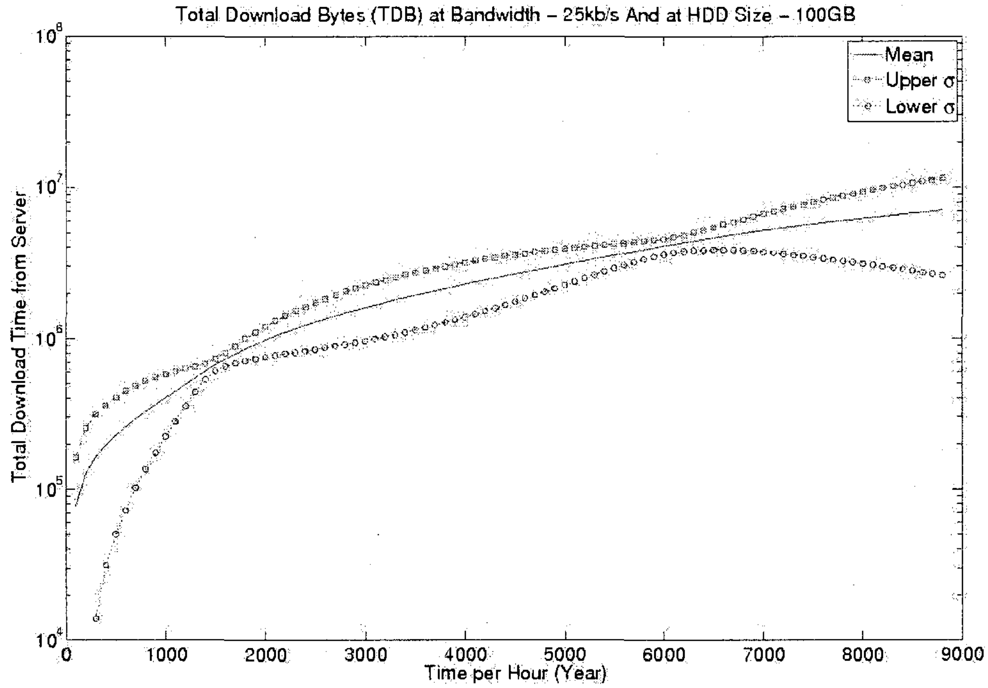


Figure 579: Total Download Bytes for H4 case scenario at hard drive size of 150GB and download bandwidth of 25kb/s

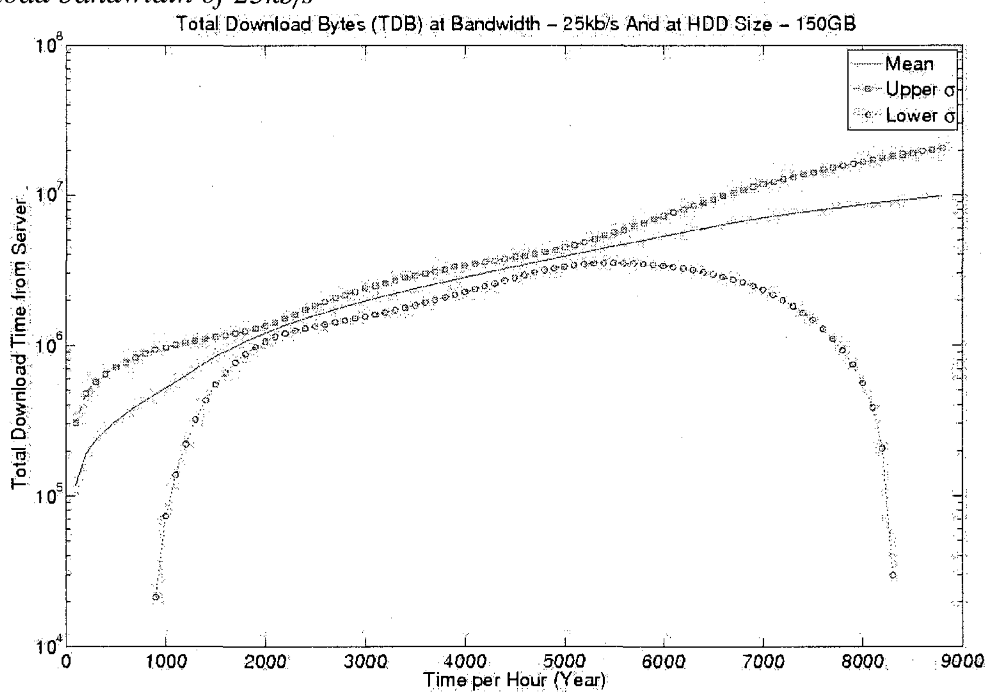


Figure 580: Total Download Bytes for H4 case scenario at hard drive size of 200GB and download bandwidth of 25kb/s

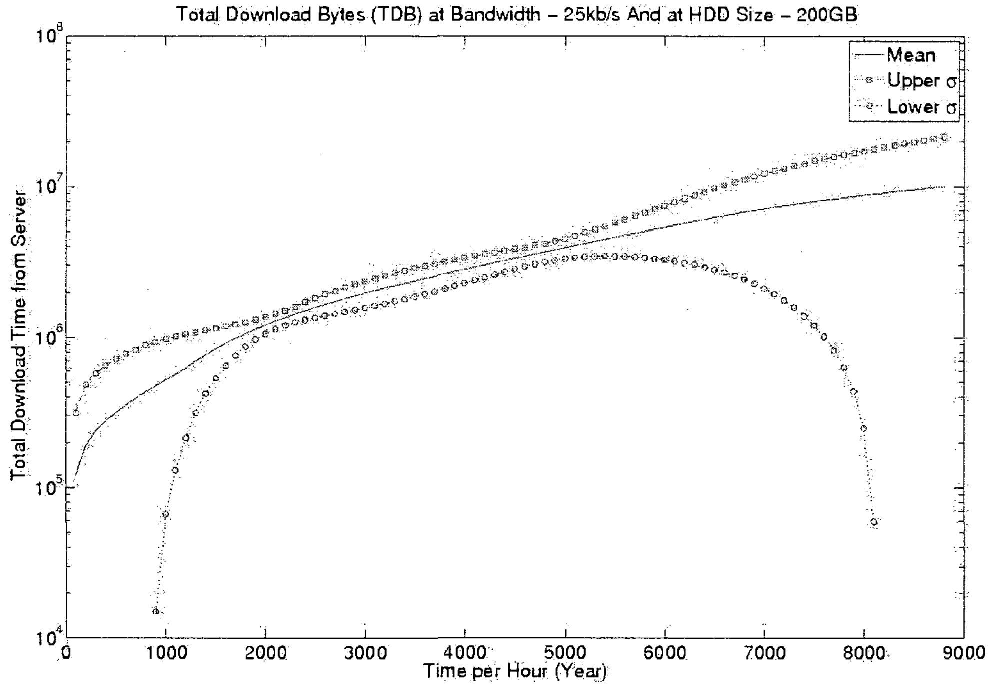


Figure 581: Total Download Bytes for H4 case scenario at hard drive size of 50GB and download bandwidth of 50kb/s

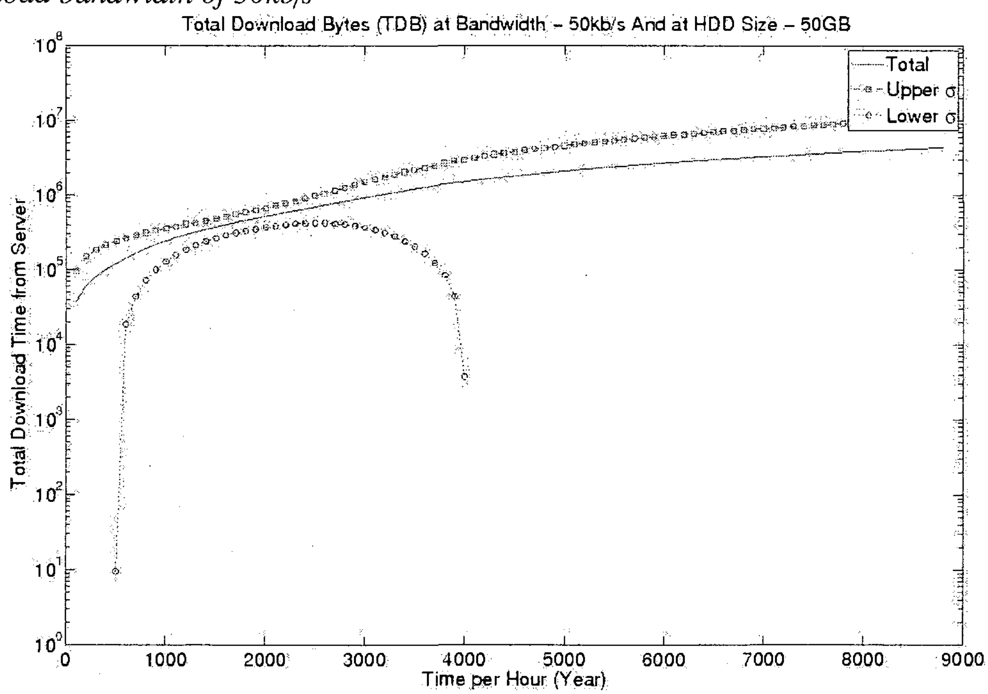


Figure 582: Total Download Bytes for H4 case scenario at hard drive size of 100GB and download bandwidth of 50kb/s

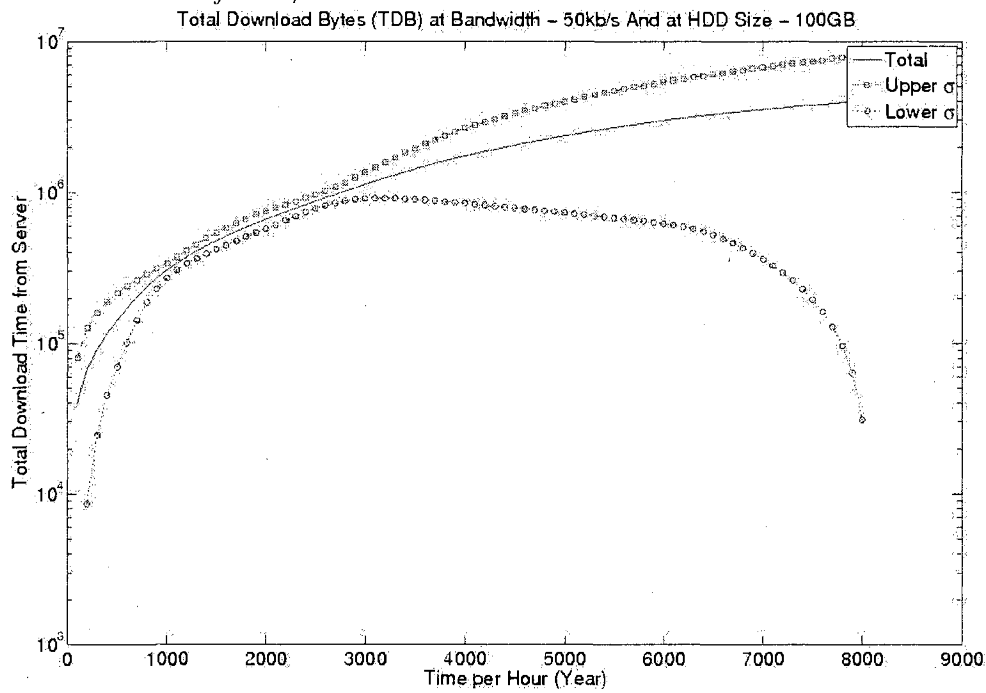


Figure 583: Total Download Bytes for H4 case scenario at hard drive size of 150GB and download bandwidth of 50kb/s

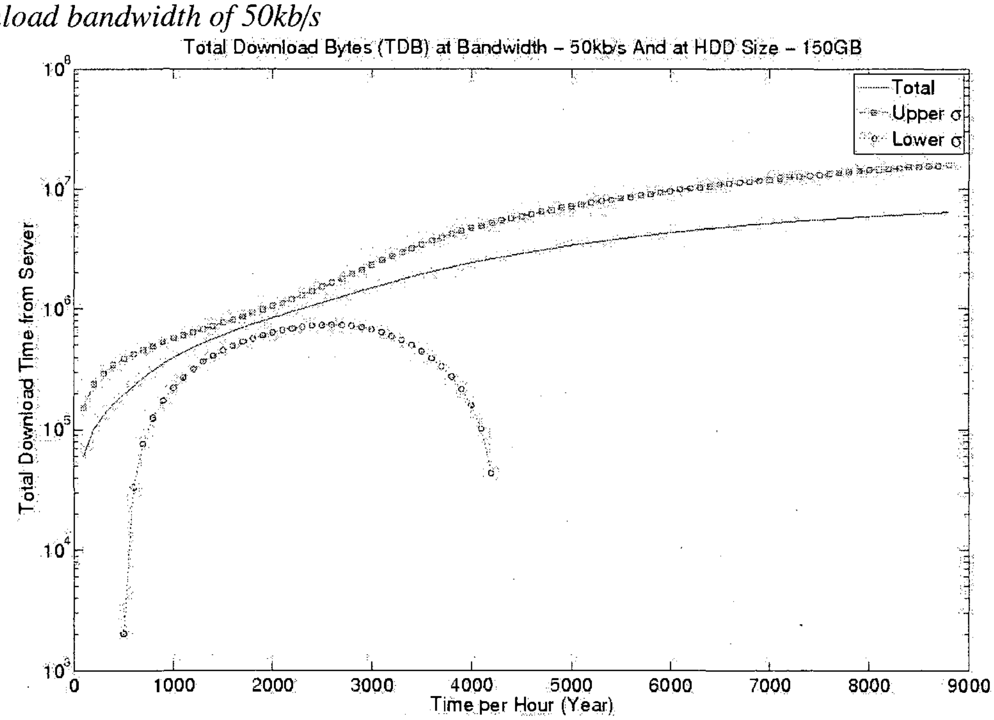


Figure 584: Total Download Bytes for H4 case scenario at hard drive size of 200GB and download bandwidth of 50kb/s

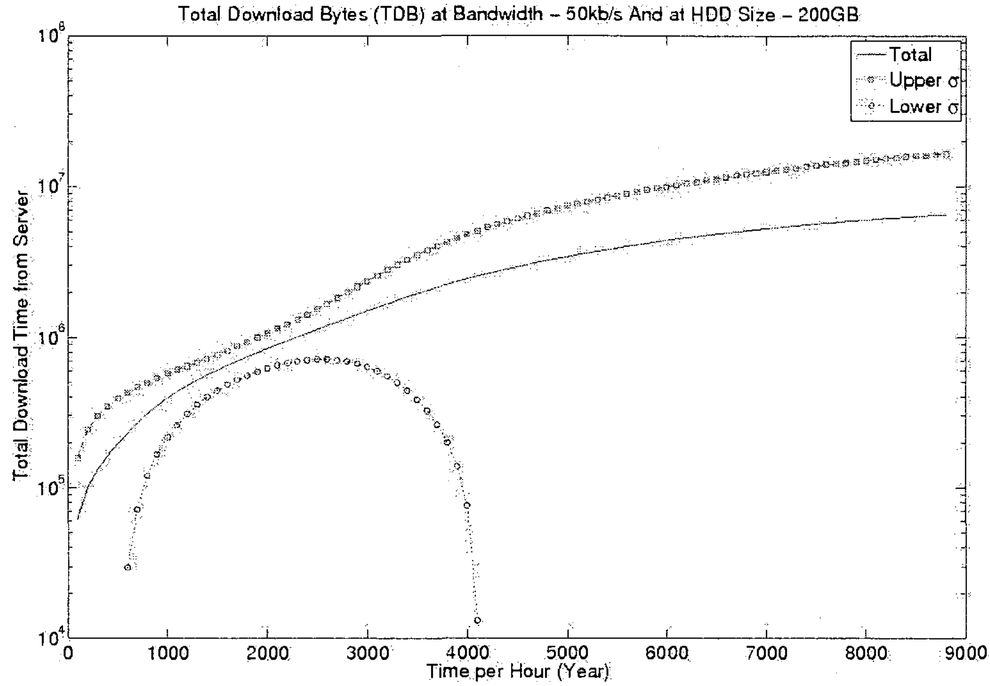


Figure 585: Total Download Bytes for H4 case scenario at hard drive size of 50GB and download bandwidth of 100kb/s

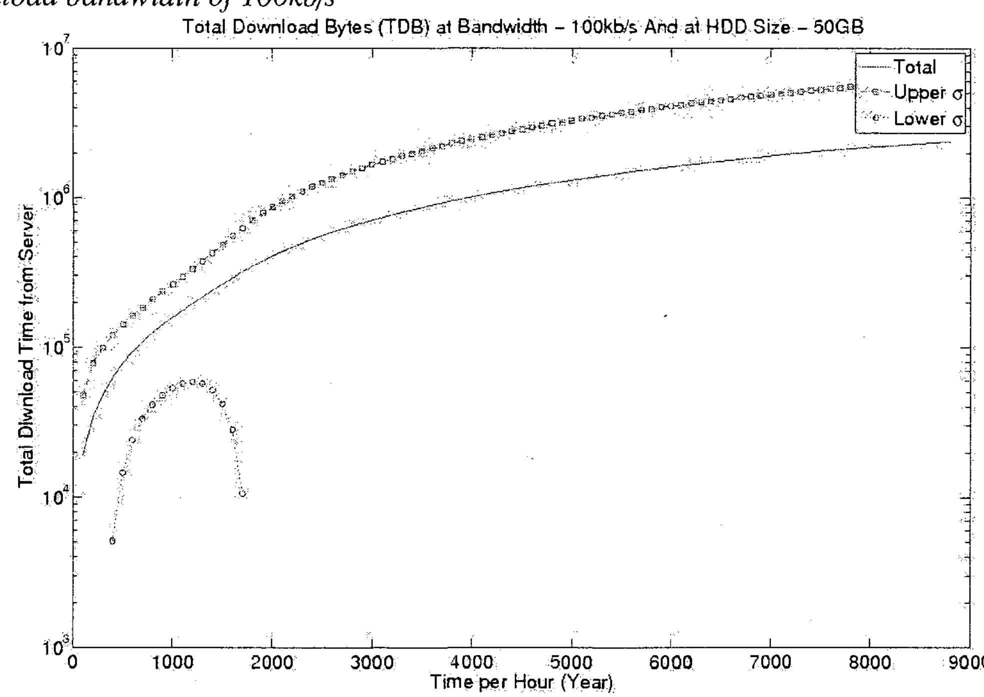


Figure 586: Total Download Bytes for H4 case scenario at hard drive size of 100GB and download bandwidth of 100kb/s

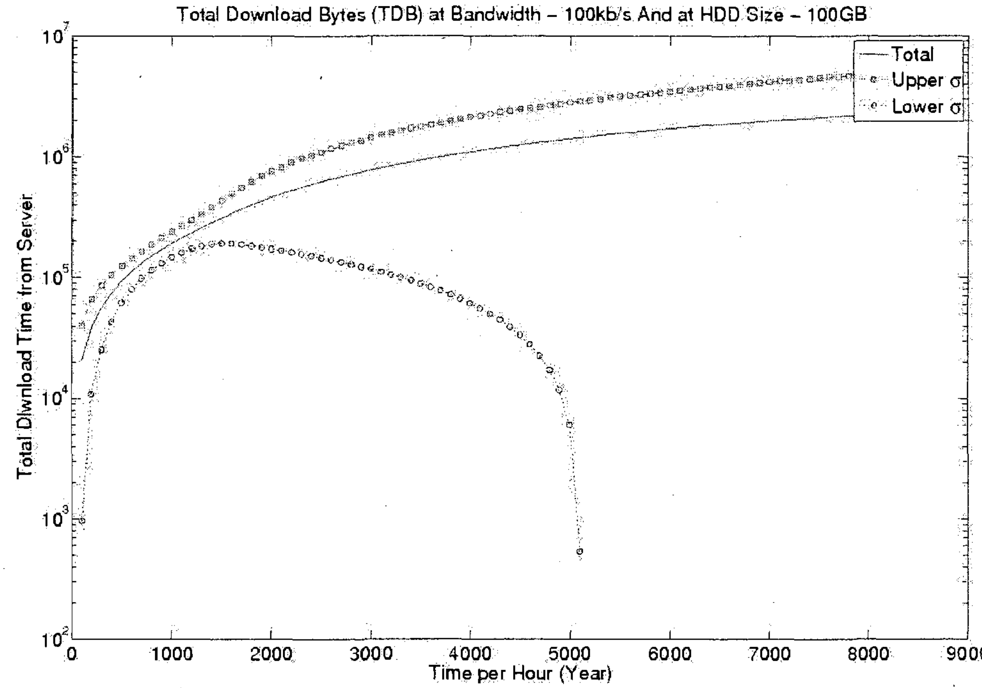


Figure 587: Total Download Bytes for H4 case scenario at hard drive size of 150GB and download bandwidth of 100kb/s

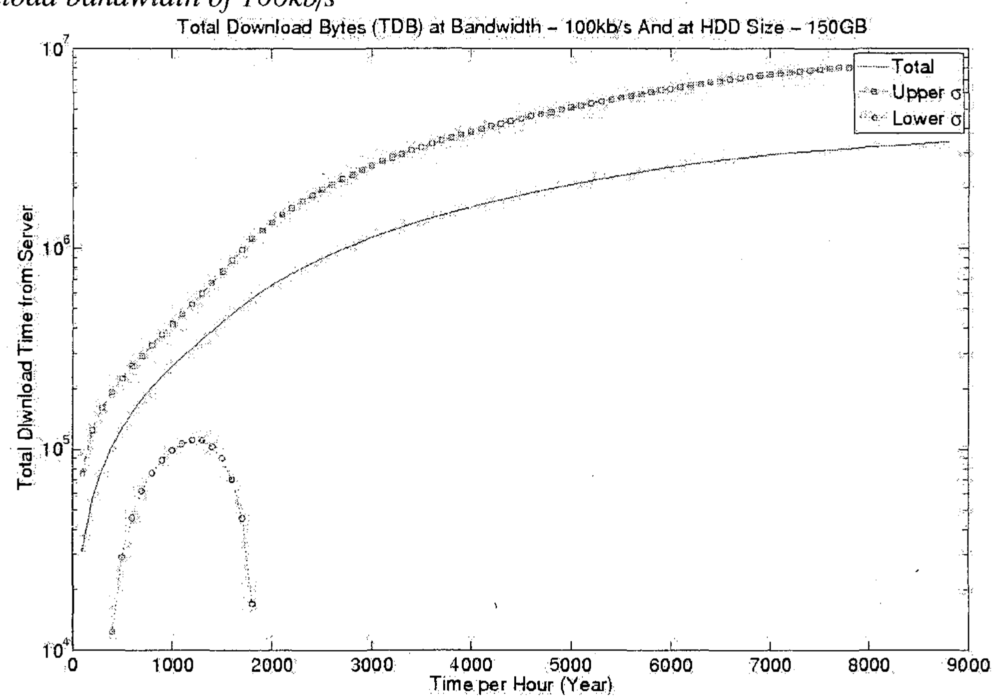


Figure 588: Total Download Bytes for H4 case scenario at hard drive size of 200GB and download bandwidth of 100kb/s

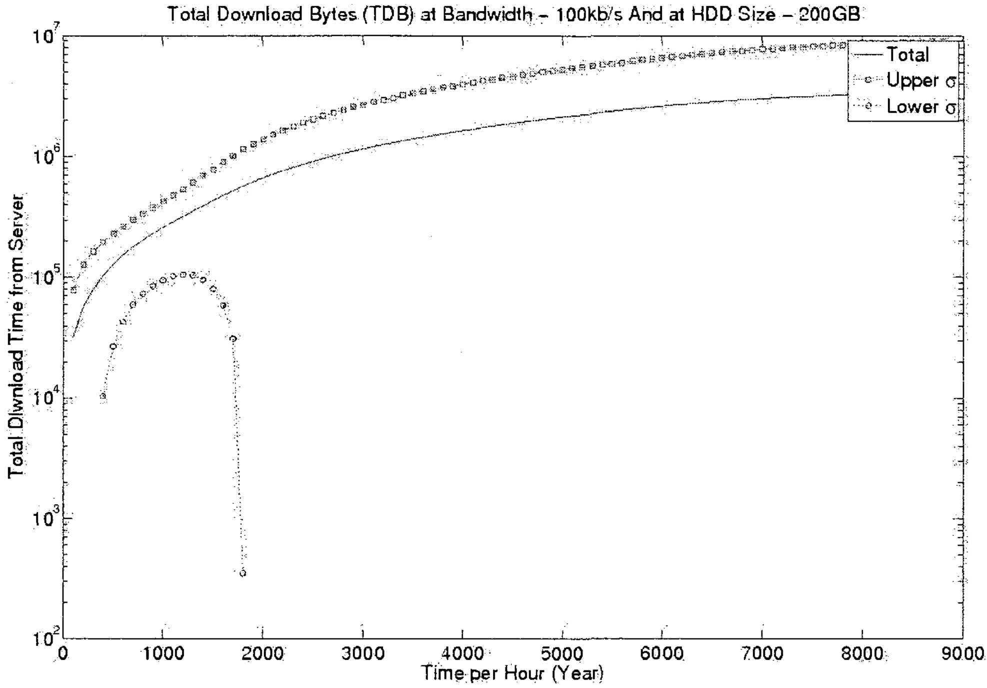


Figure 589: Total Download Bytes for H4 case scenario at hard drive size of 50GB and download bandwidth of 128kb/s

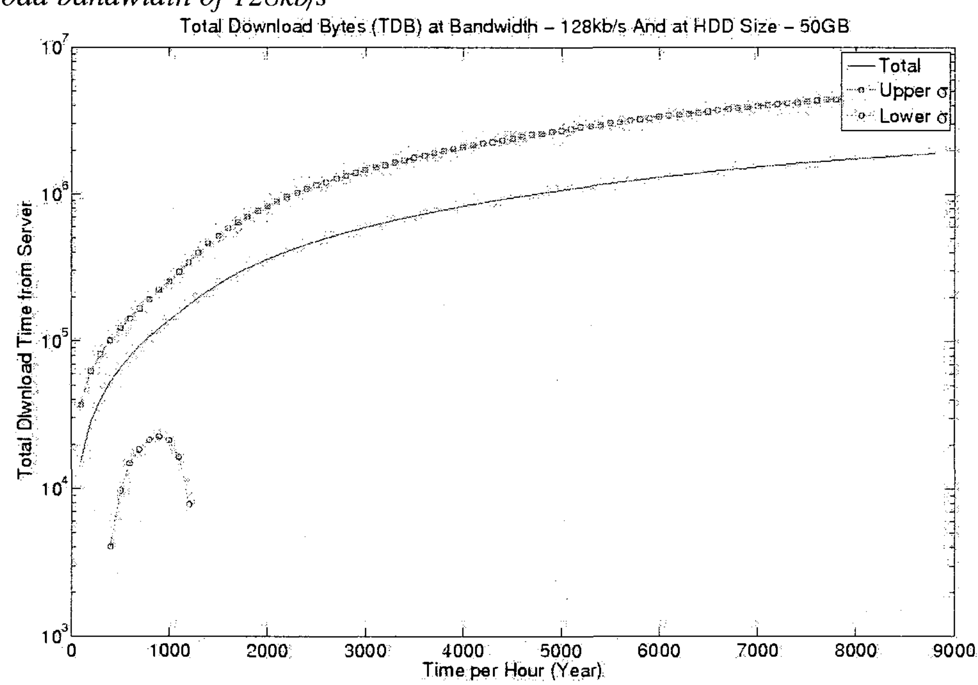


Figure 590: Total Download Bytes for H4 case scenario at hard drive size of 100GB and download bandwidth of 128kb/s

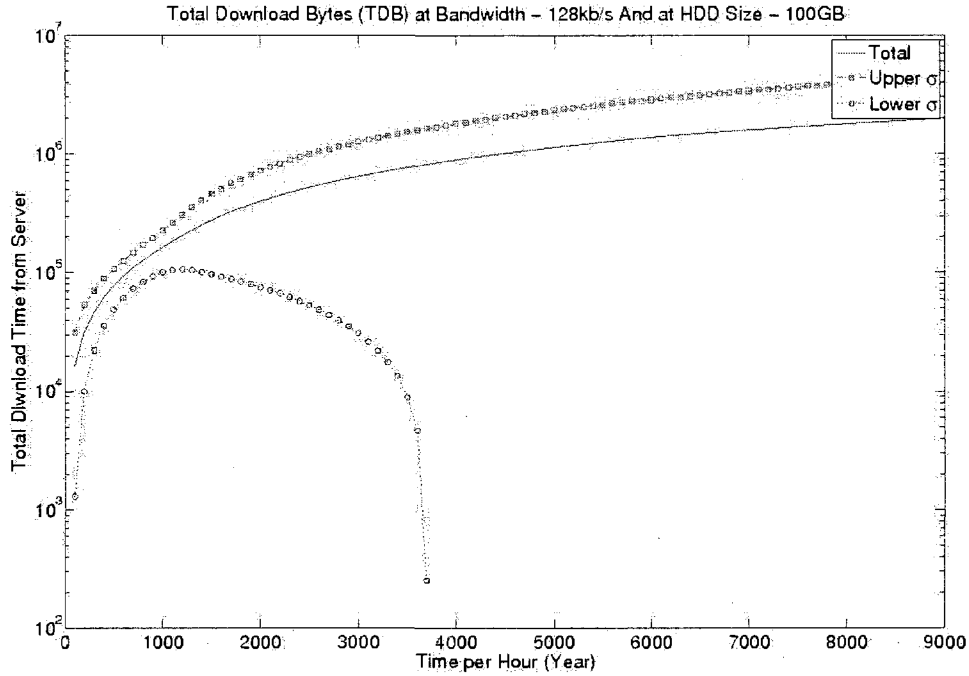


Figure 591: Total Download Bytes for H4 case scenario at hard drive size of 150GB and download bandwidth of 128kb/s

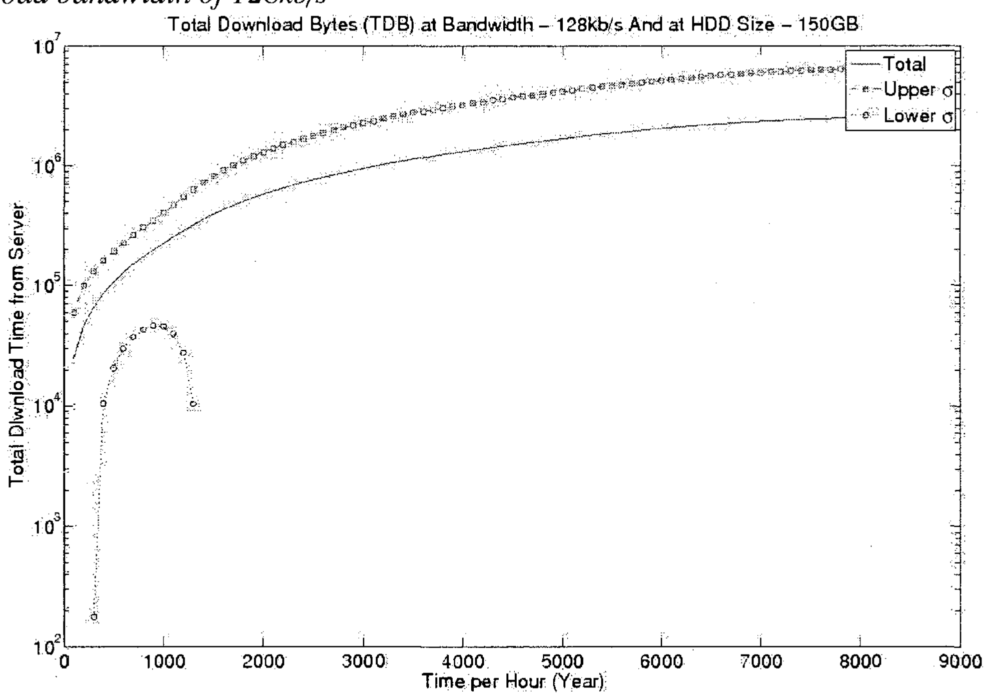


Figure 592: Total Download Bytes for H4 case scenario at hard drive size of 200GB and download bandwidth of 128kb/s

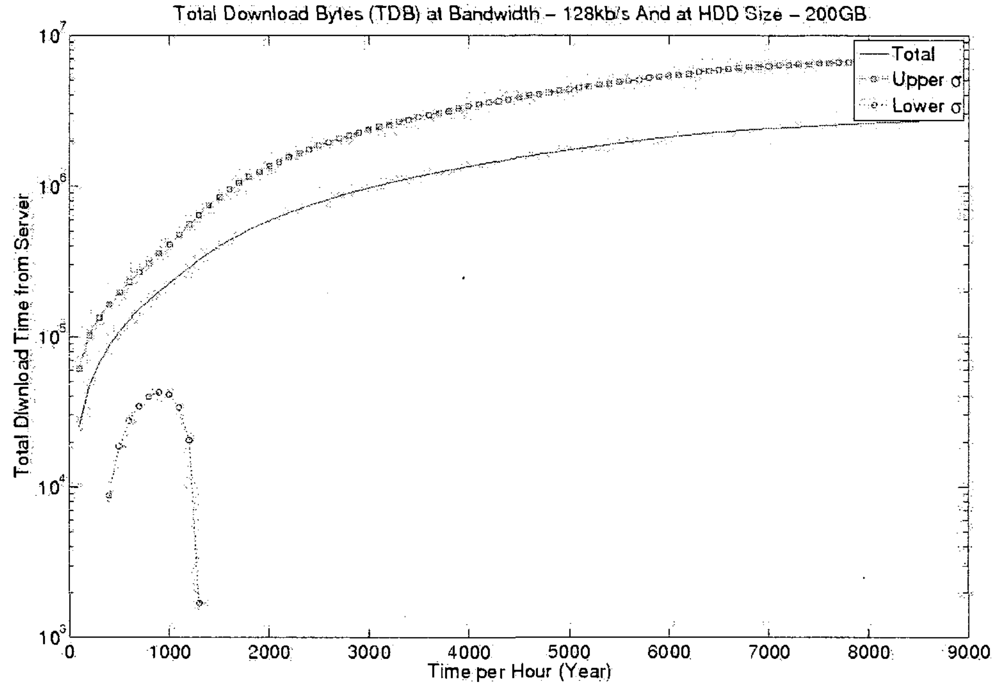


Figure 593: Total Download Bytes for H4 case scenario at hard drive size of 50GB and download bandwidth of 256kb/s

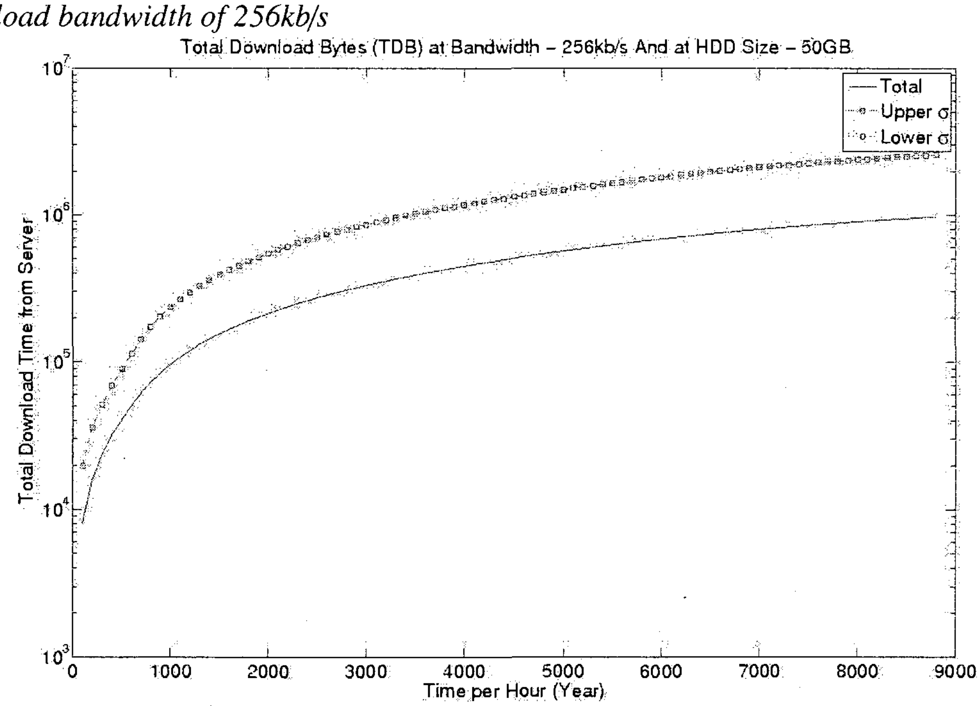


Figure 594: Total Download Bytes for H4 case scenario at hard drive size of 100GB and download bandwidth of 256kb/s

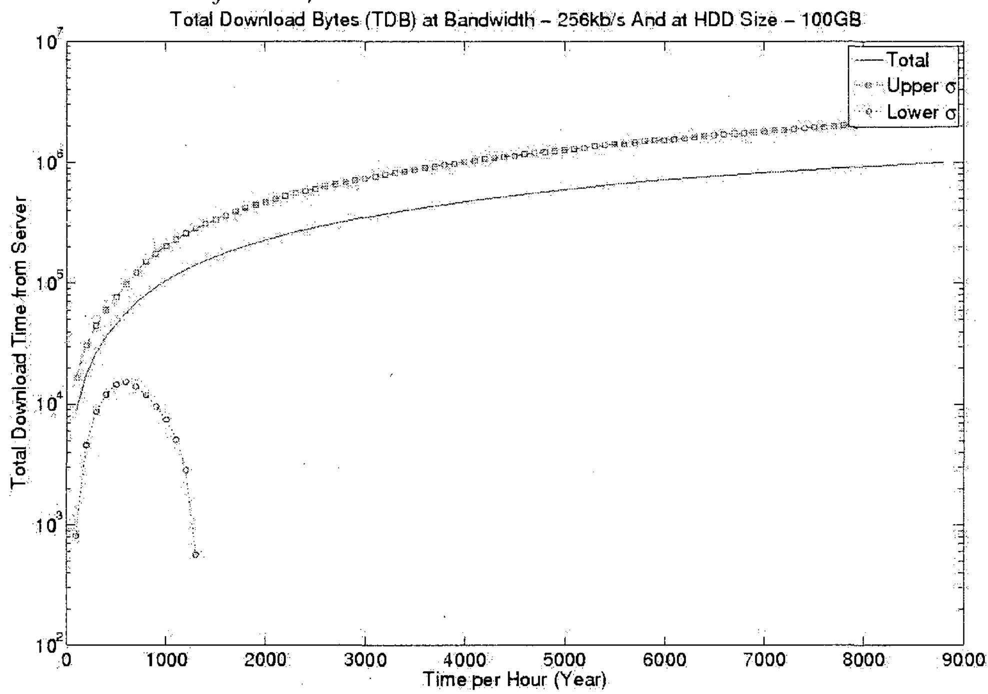


Figure 595: Total Download Bytes for H4 case scenario at hard drive size of 150GB and download bandwidth of 256kb/s

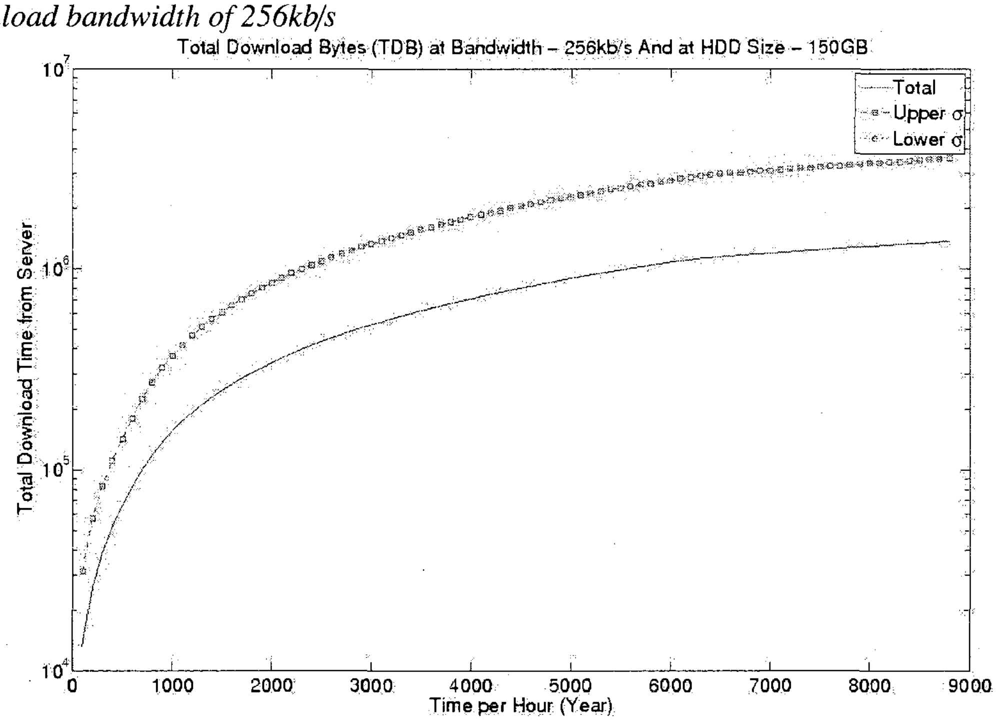


Figure 596: Total Download Bytes for H4 case scenario at hard drive size of 200GB and download bandwidth of 256kb/s

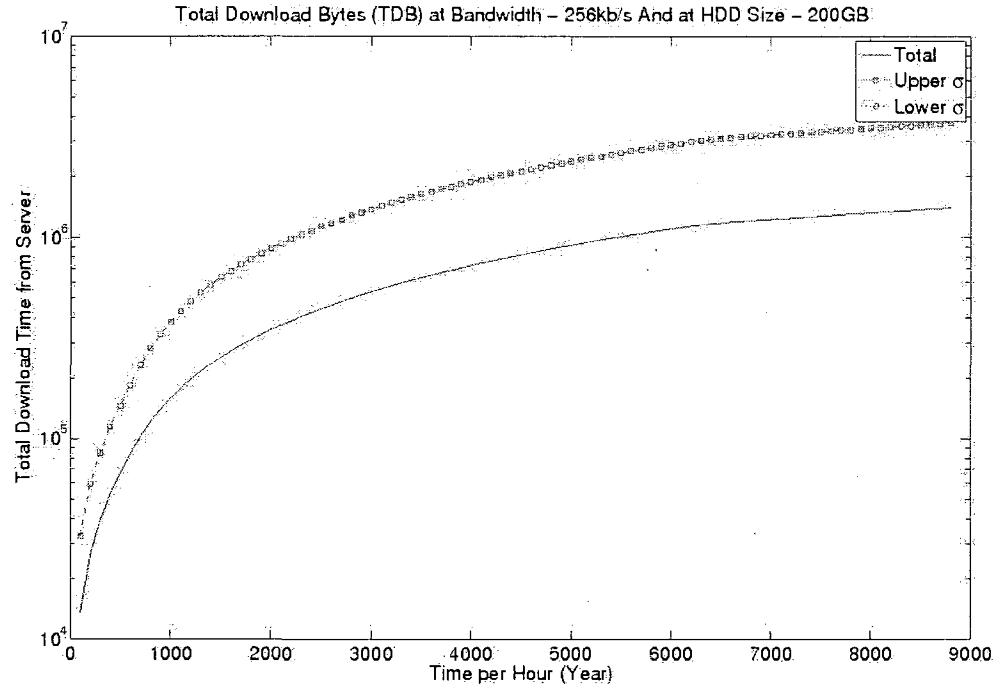


Figure 597: Total Download Bytes for H4 case scenario at hard drive size of 50GB and download bandwidth of 512kb/s

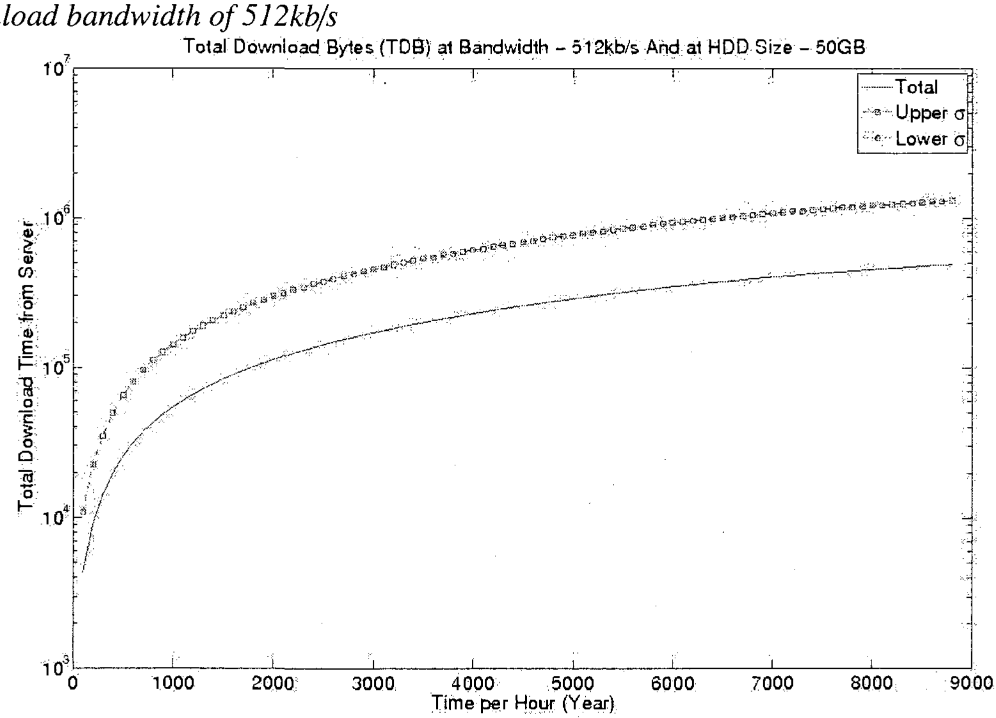


Figure 598: Total Download Bytes for H4 case scenario at hard drive size of 100GB and download bandwidth of 512kb/s

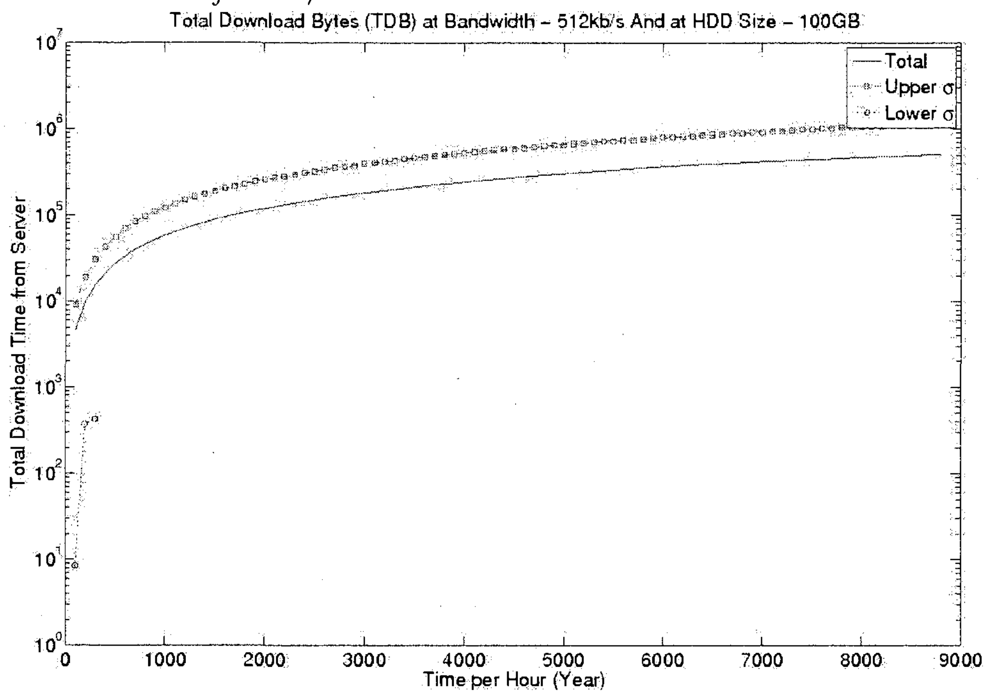


Figure 599: Total Download Bytes for H4 case scenario at hard drive size of 150GB and download bandwidth of 512kb/s

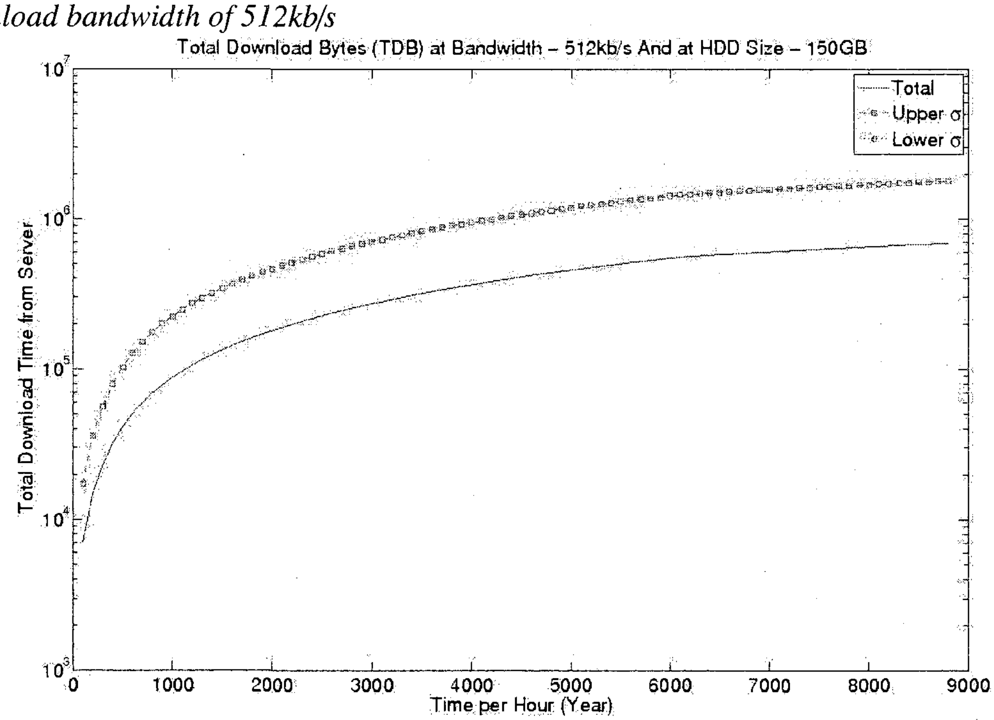


Figure 600: Total Download Bytes for H4 case scenario at hard drive size of 200GB and download bandwidth of 512kb/s

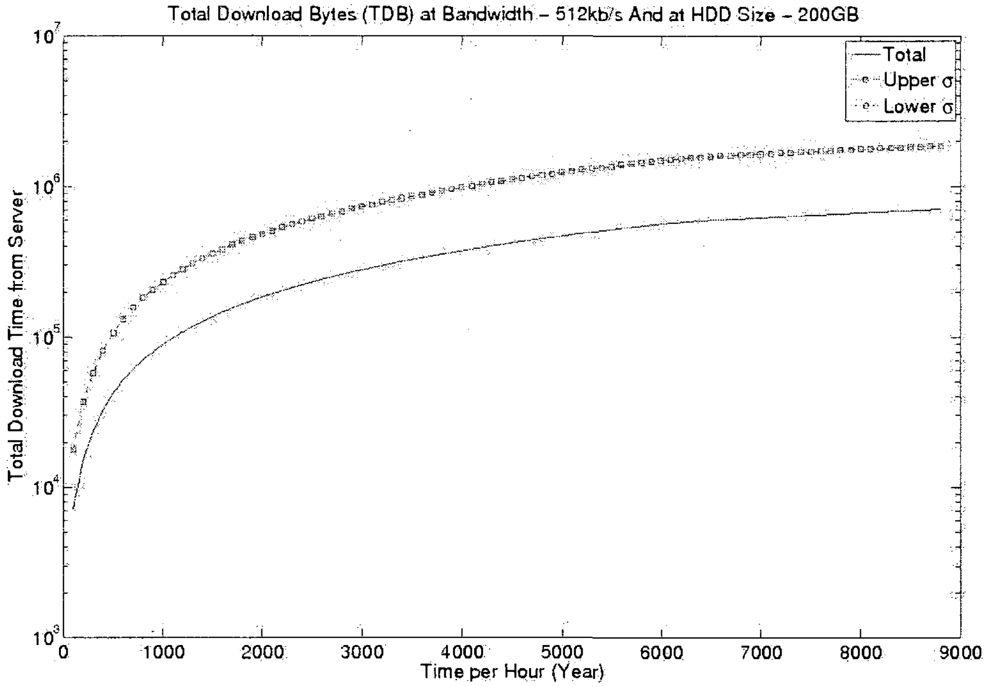


Figure 601: Total Download Bytes for H4 case scenario at hard drive size of 50GB and download bandwidth of 1000kb/s

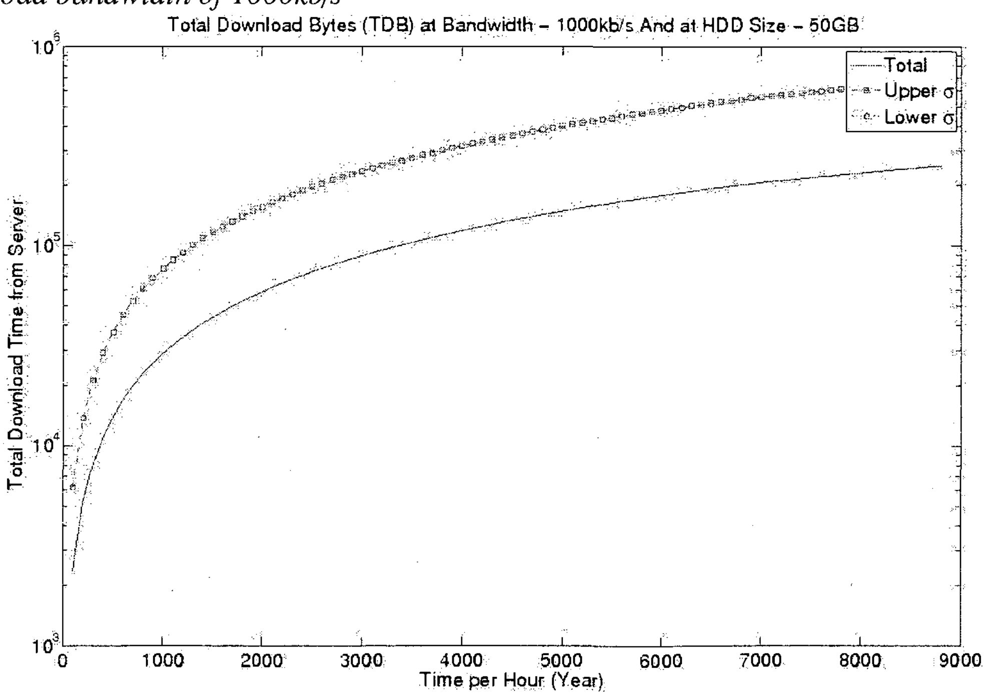


Figure 602: Total Download Bytes for H4 case scenario at hard drive size of 100GB and download bandwidth of 1000kb/s

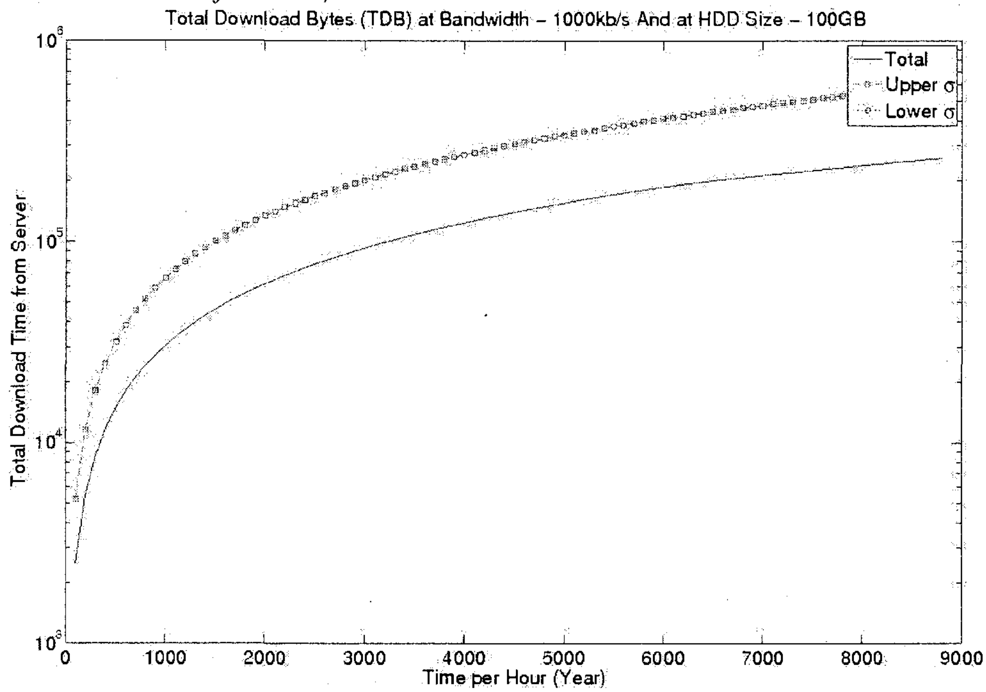


Figure 603: Total Download Bytes for H4 case scenario at hard drive size of 150GB and download bandwidth of 1000kb/s

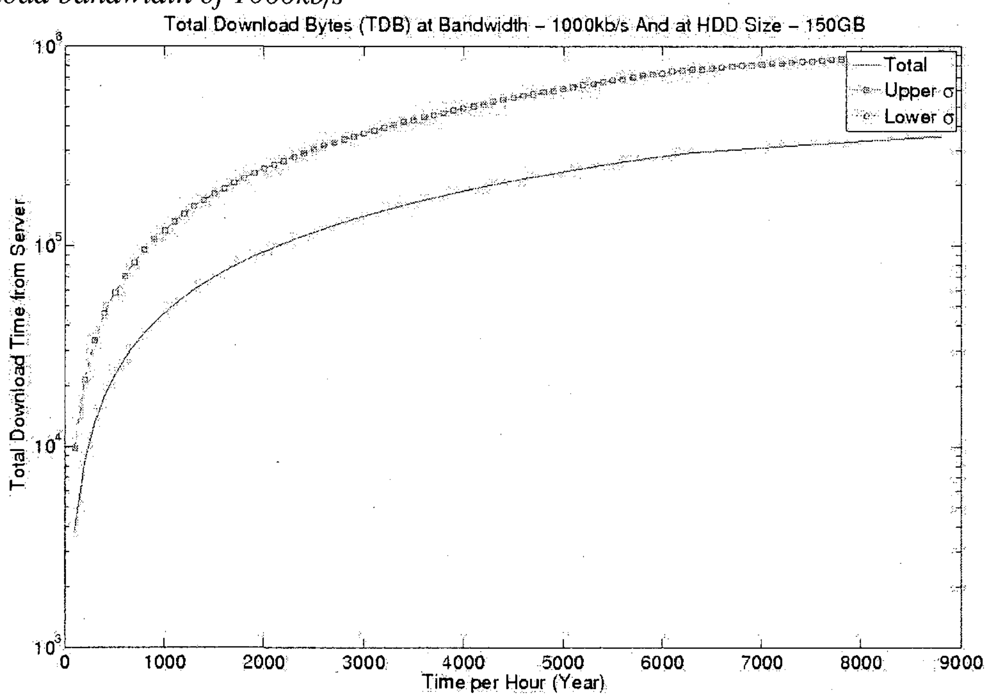


Figure 604: Total Download Bytes for H4 case scenario at hard drive size of 200GB and download bandwidth of 1000kb/s

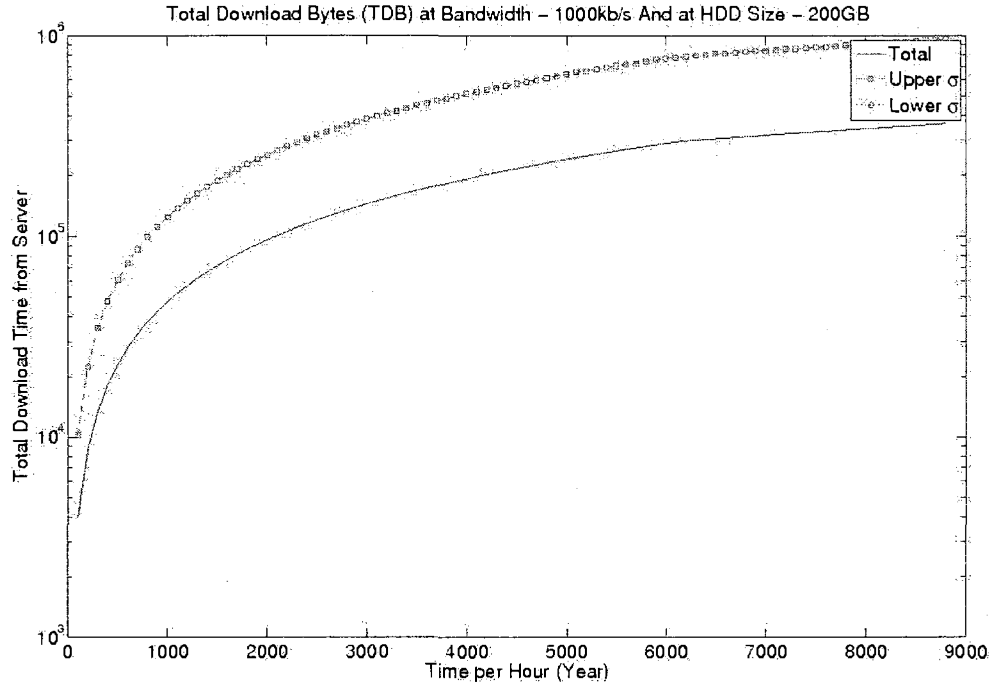


Figure 605: Total Download Bytes for H4 case scenario at hard drive size of 50GB and download bandwidth of 2000kb/s

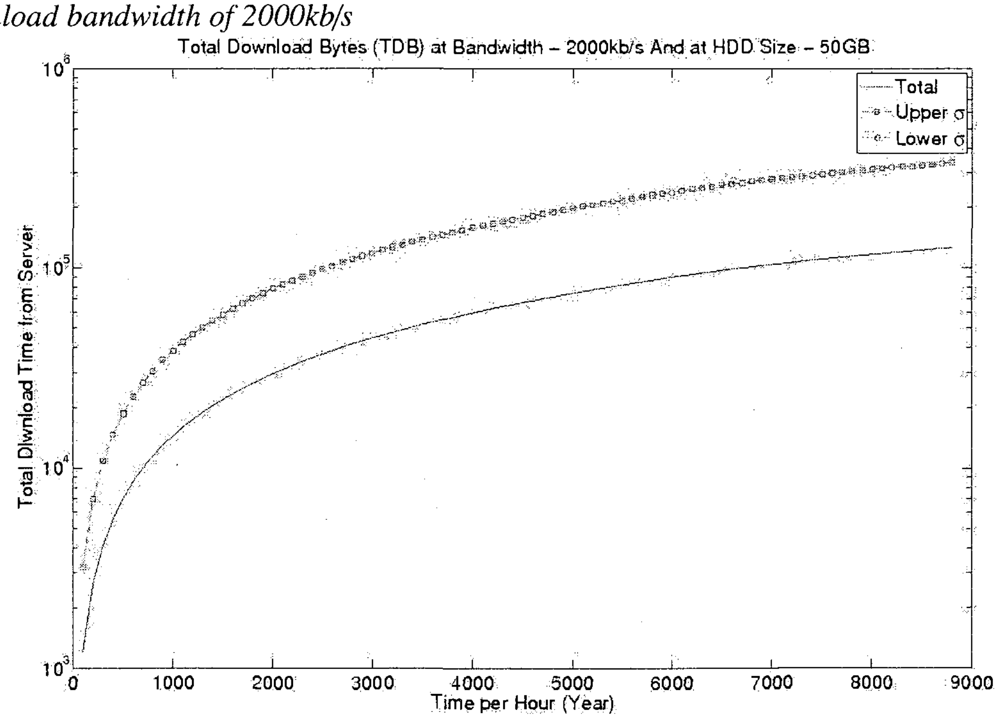


Figure 606: Total Download Bytes for H4 case scenario at hard drive size of 100GB and download bandwidth of 2000kb/s

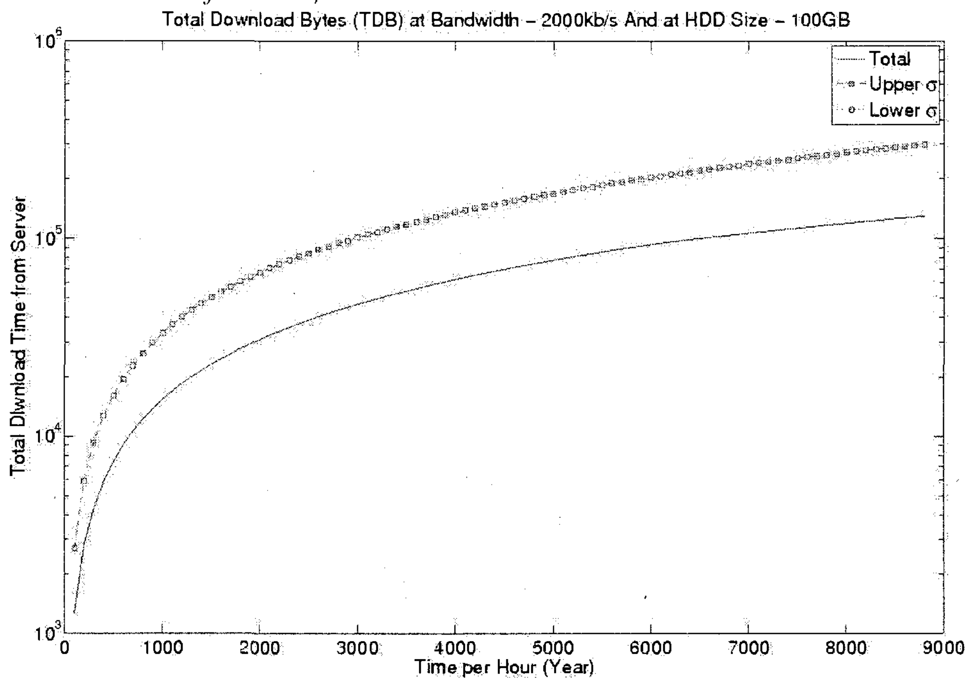


Figure 607: Total Download Bytes for H4 case scenario at hard drive size of 150GB and download bandwidth of 2000kb/s

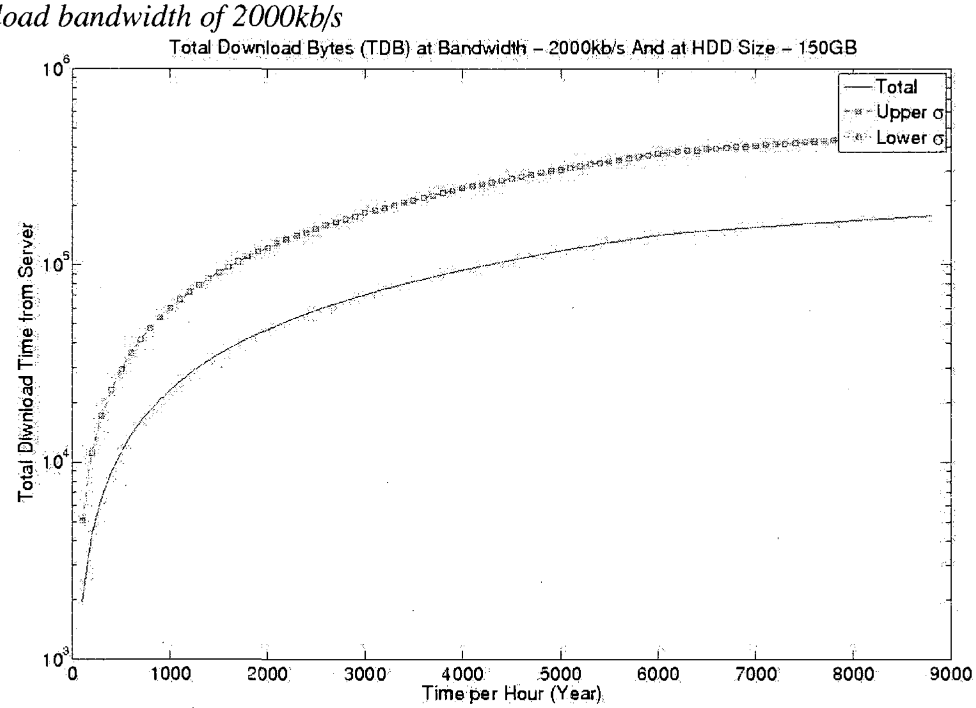


Figure 608: Total Download Bytes for H4 case scenario at hard drive size of 200GB and download bandwidth of 2000kb/s

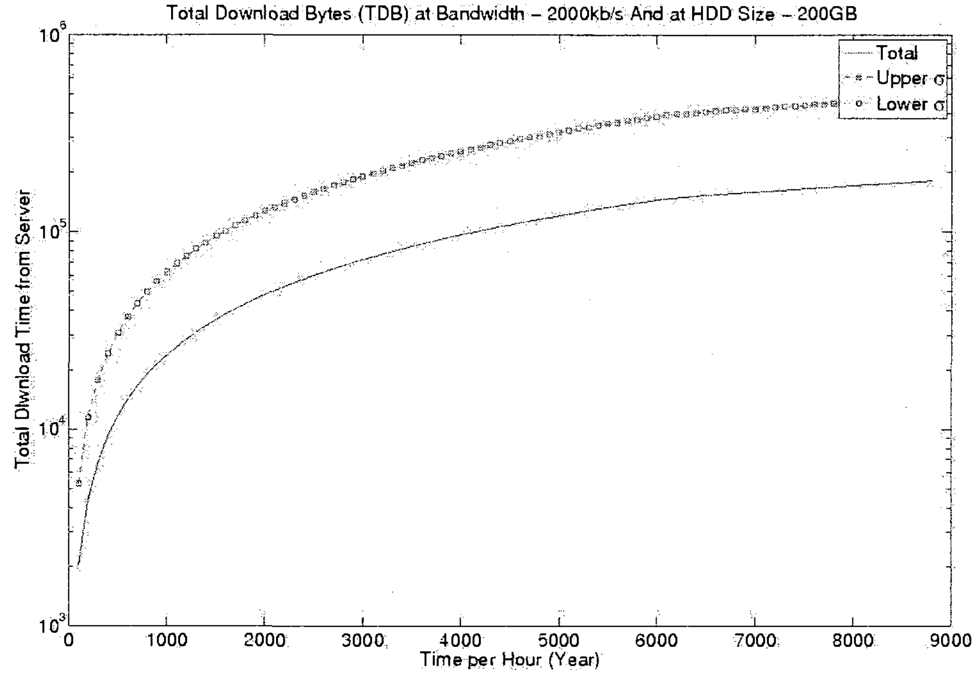


Figure 609: Total Download Bytes for H4 case scenario at hard drive size of 50GB and download bandwidth of 5000kb/s

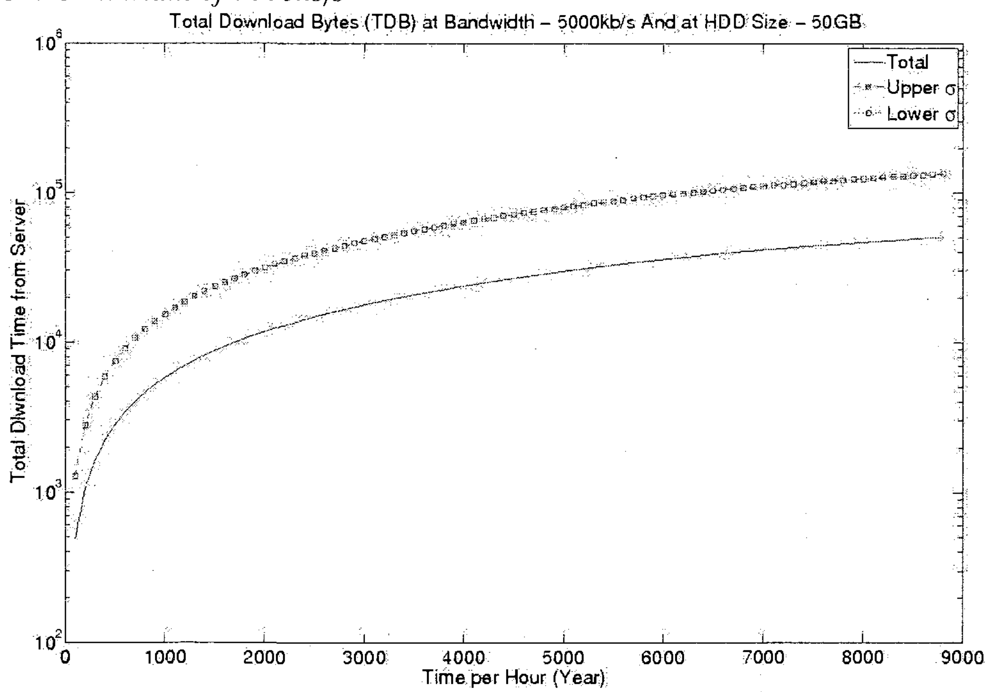


Figure 610: Total Download Bytes for H4 case scenario at hard drive size of 100GB and download bandwidth of 5000kb/s

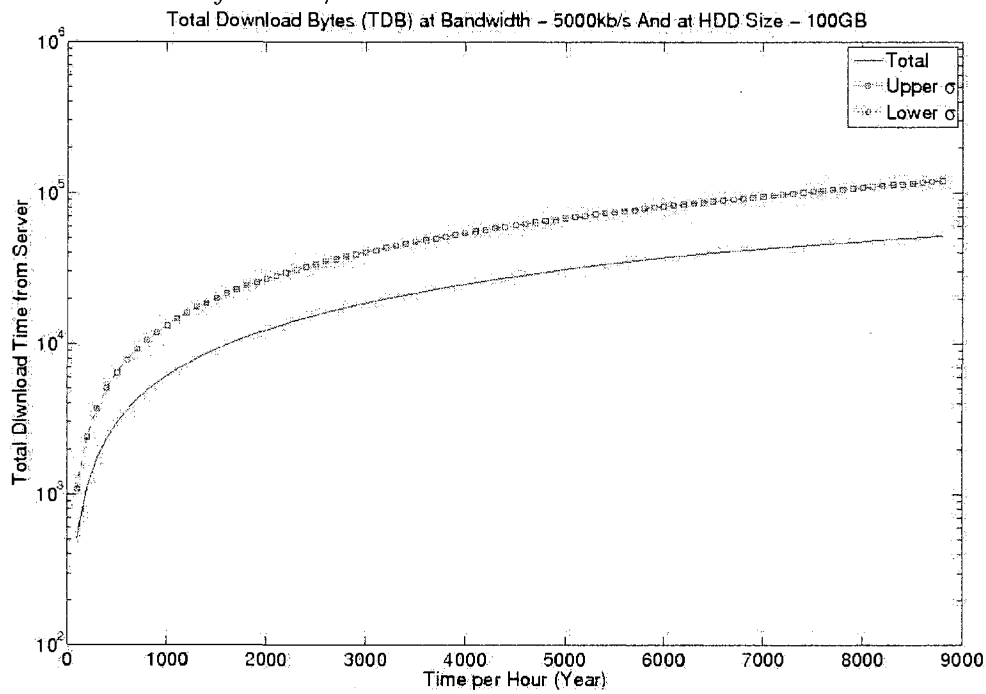


Figure 611: Total Download Bytes for H4 case scenario at hard drive size of 150GB and download bandwidth of 5000kb/s

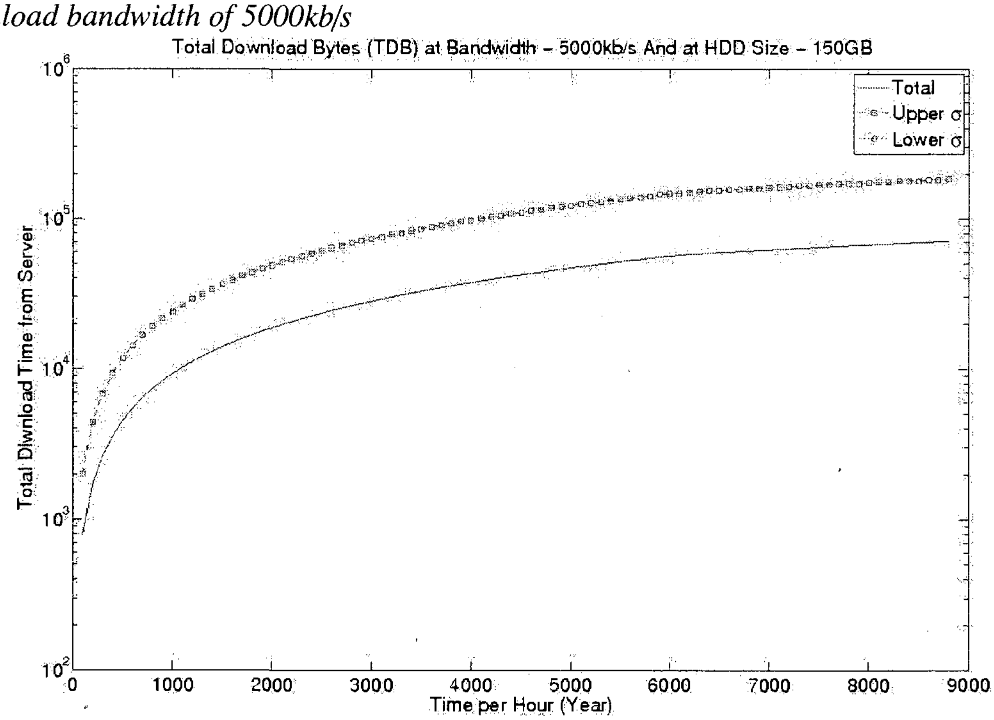


Figure 612: Total Download Bytes for H4 case scenario at hard drive size of 200GB and download bandwidth of 5000kb/s

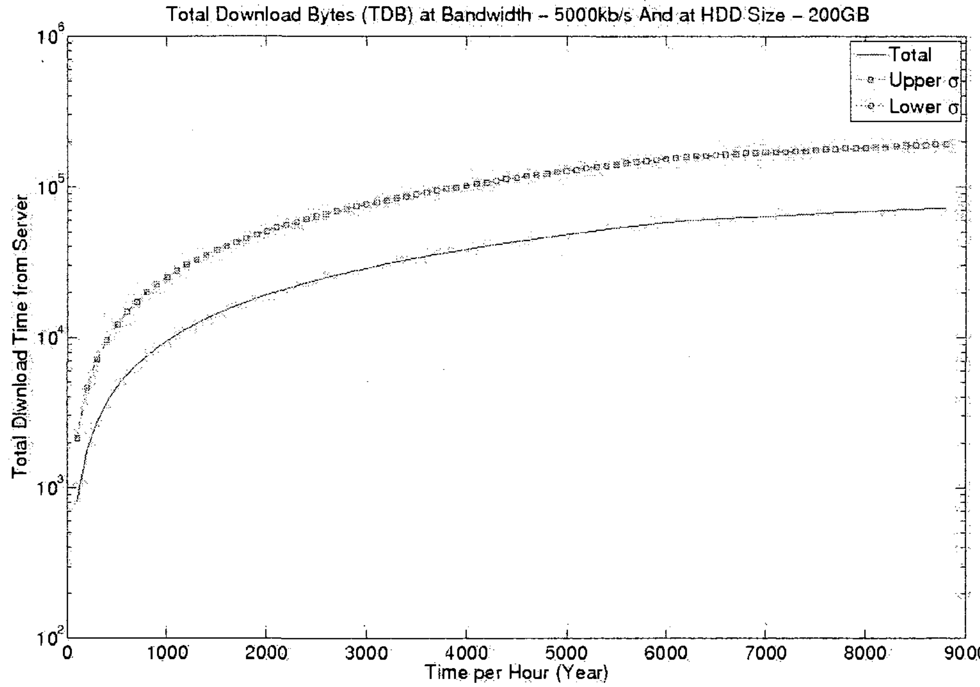


Figure 613: Total Download Bytes for H4 case scenario at hard drive size of 50GB and download bandwidth of 10000kb/s

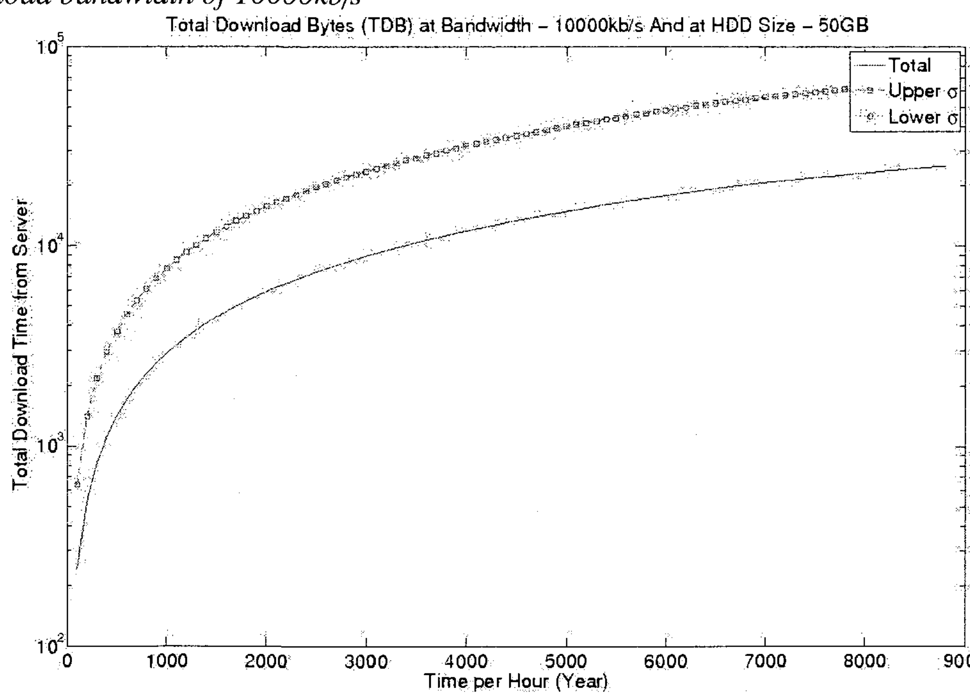


Figure 614: Total Download Bytes for H4 case scenario at hard drive size of 100GB and download bandwidth of 10000kb/s

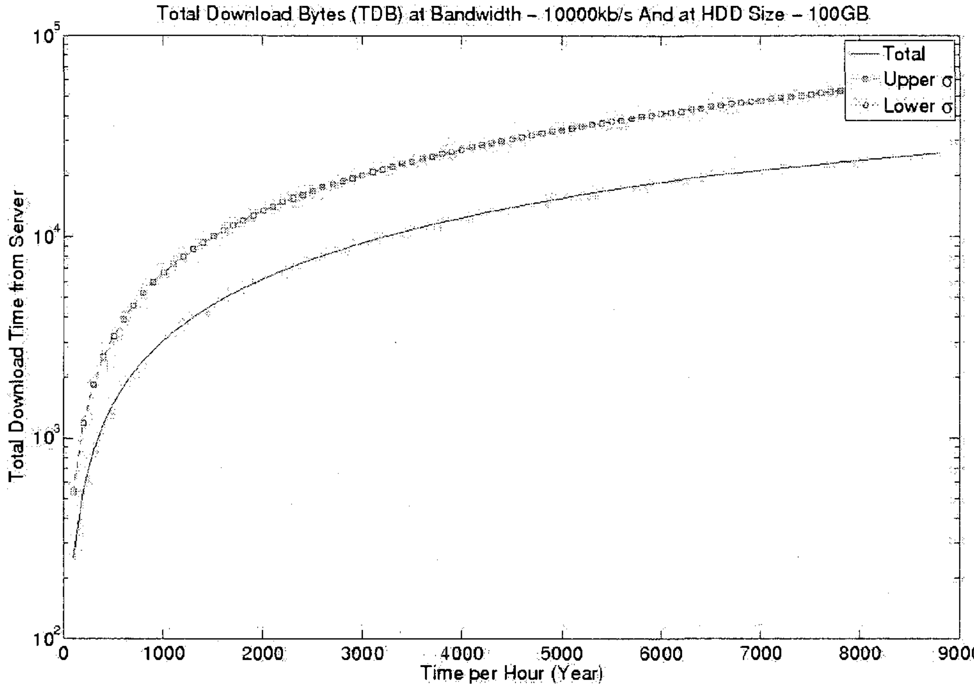


Figure 615: Total Download Bytes for H4 case scenario at hard drive size of 150GB and download bandwidth of 10000kb/s

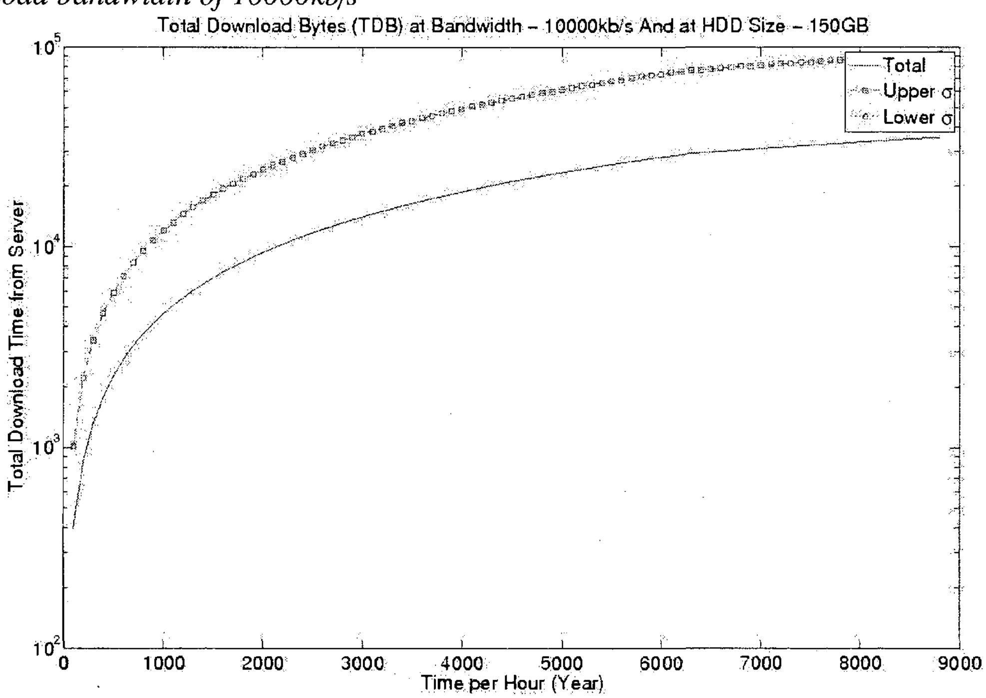


Figure 616: Total Download Bytes for H4 case scenario at hard drive size of 200GB and download bandwidth of 10000kb/s

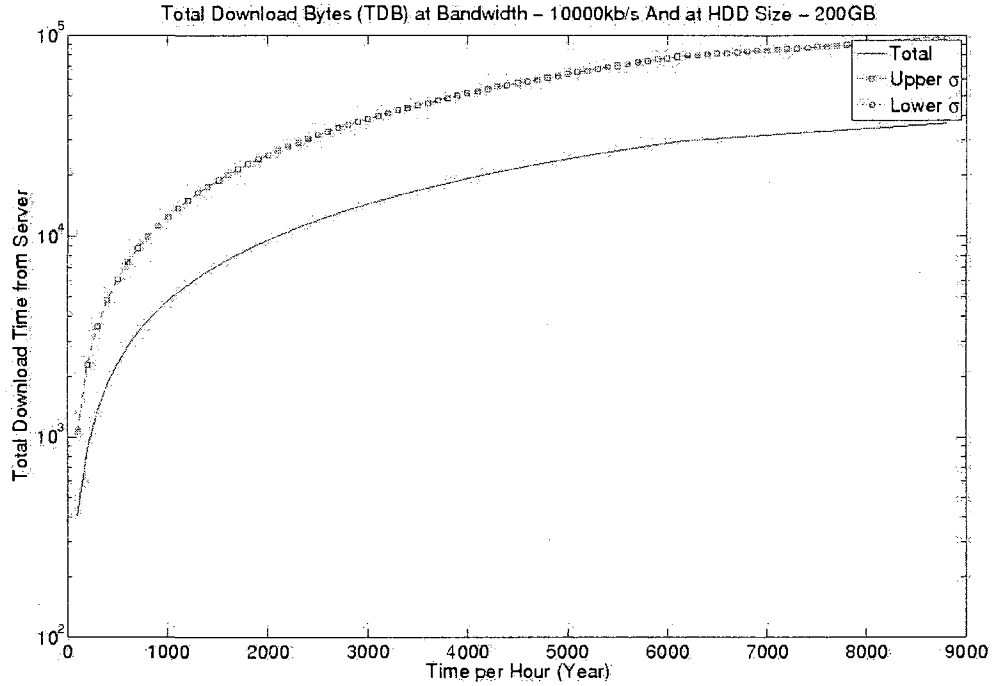


Figure 617: Total Download Bytes for H4 case scenario at hard drive size of 50GB and download bandwidth of 15000kb/s

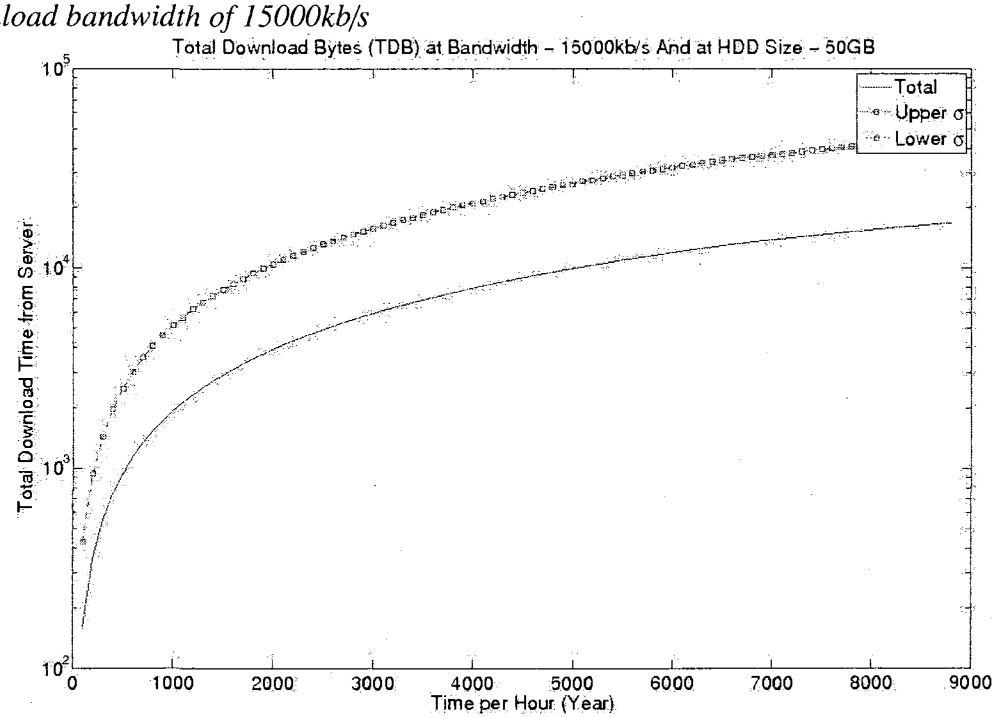


Figure 618: Total Download Bytes for H4 case scenario at hard drive size of 100GB and download bandwidth of 15000kb/s

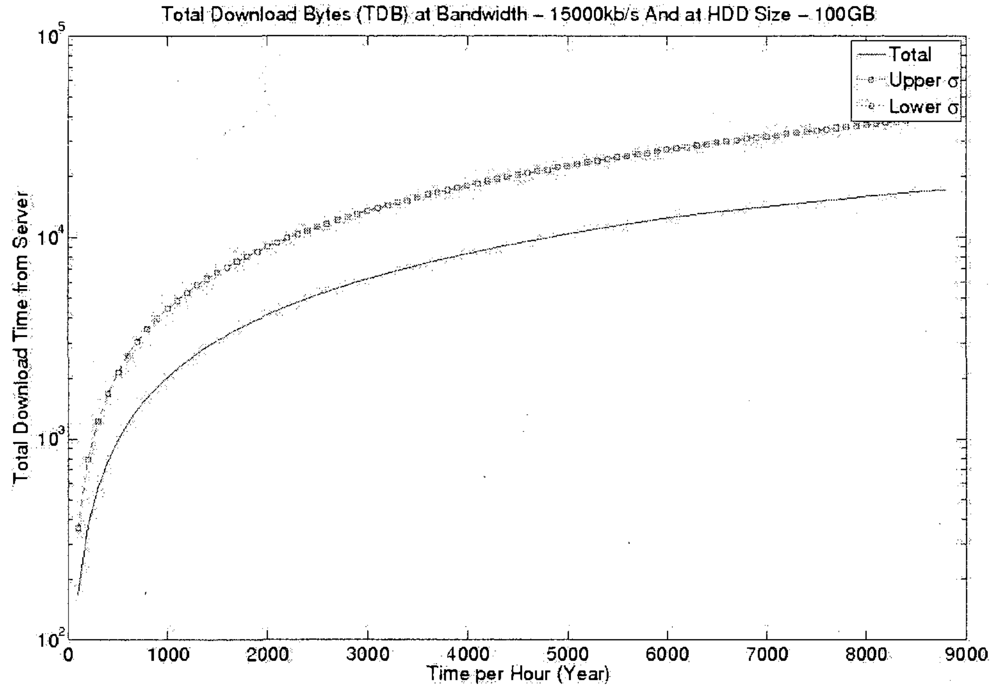


Figure 619: Total Download Bytes for H4 case scenario at hard drive size of 150GB and download bandwidth of 15000kb/s

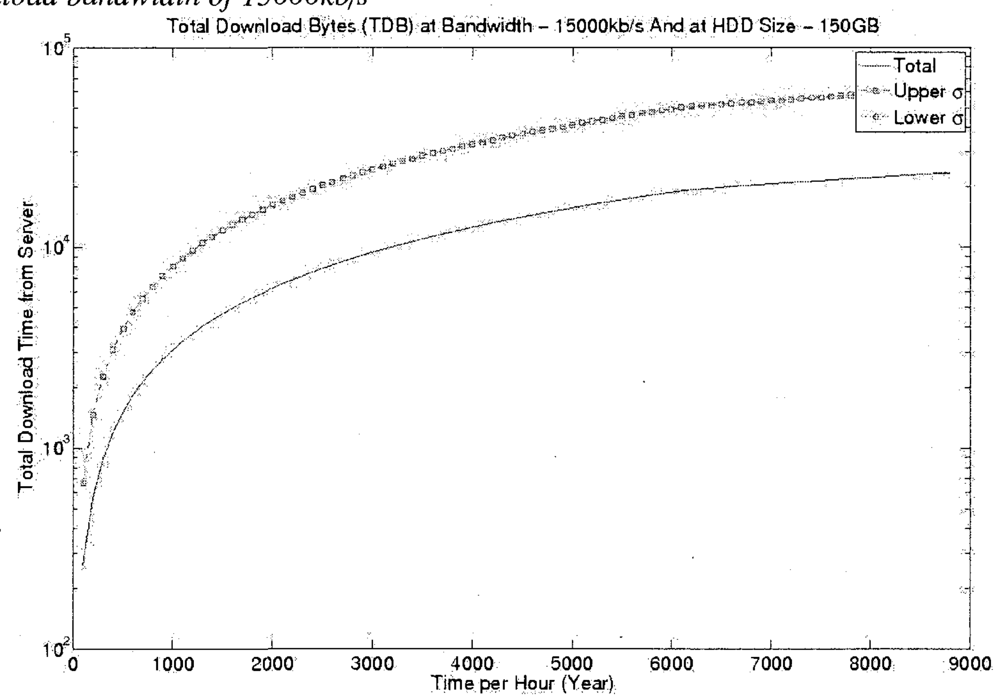


Figure 620: Total Download Bytes for H4 case scenario at hard drive size of 200GB and download bandwidth of 15000kb/s

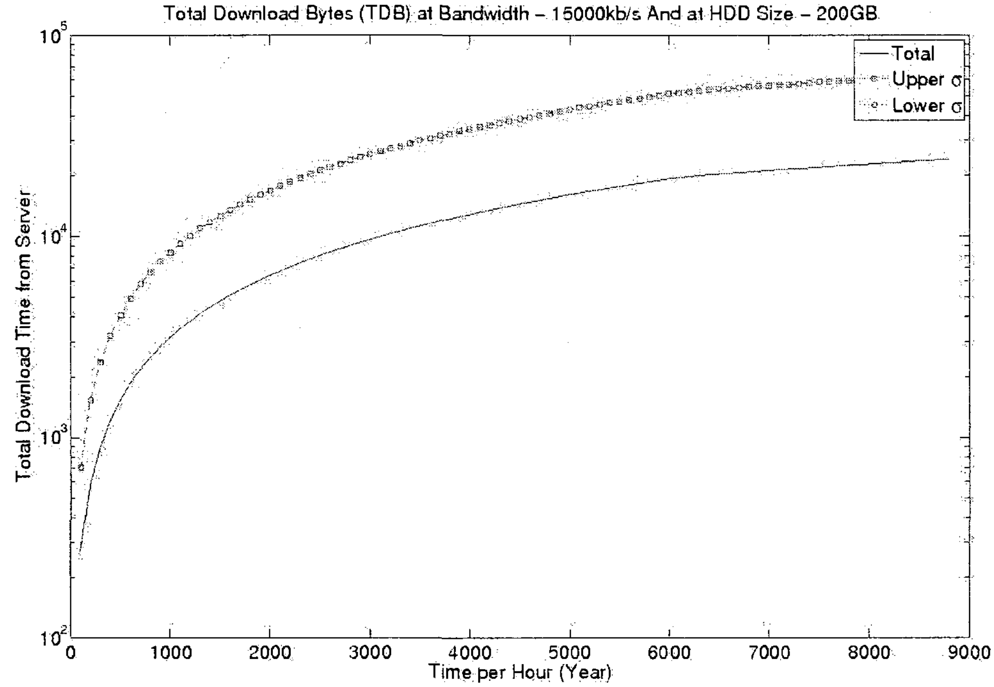


Figure 621: DTA of a difference between H1 and Base Line at download bandwidth of 128kb/s

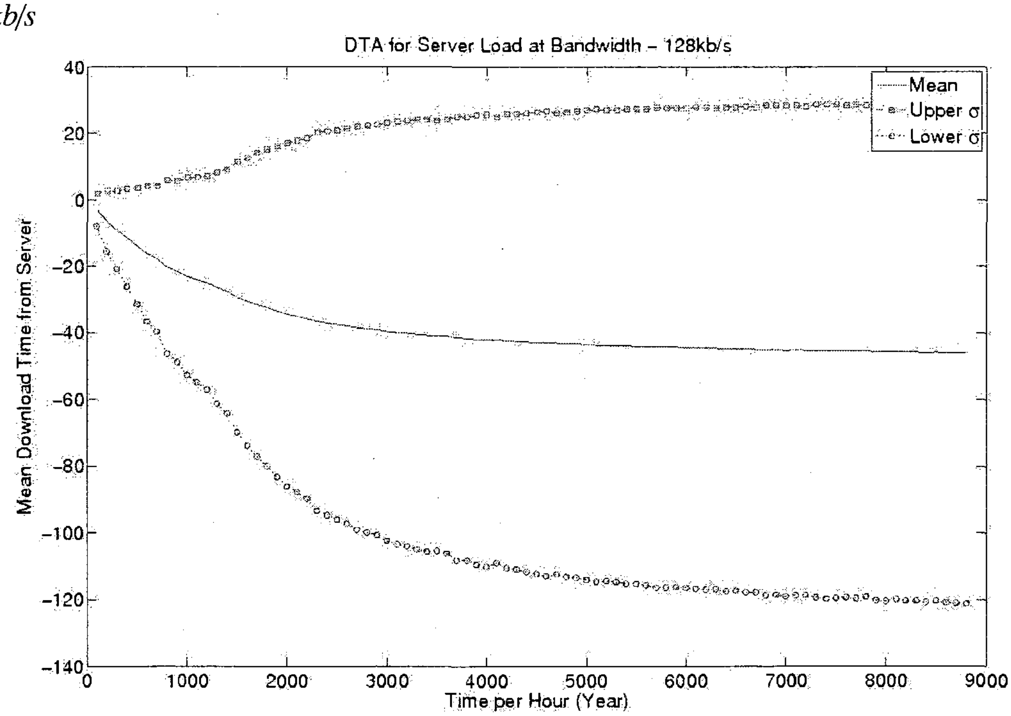


Figure 622: DTA of a difference between H1 and Base Line at download bandwidth of 512kb/s

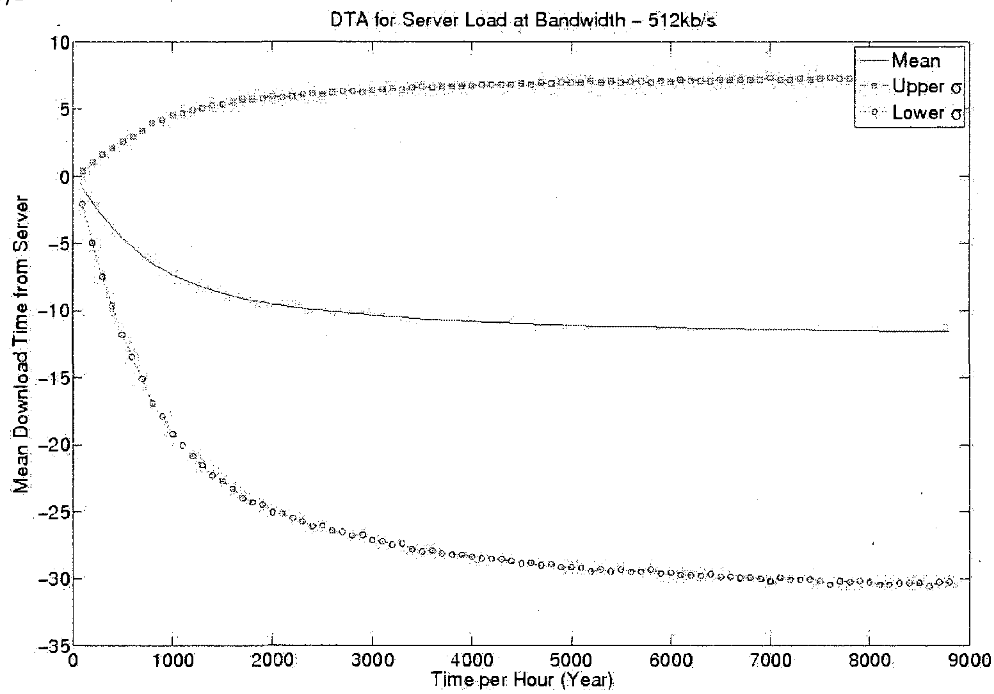


Figure 623: DTA of a difference between H1 and Base Line at download bandwidth of 1000kb/s

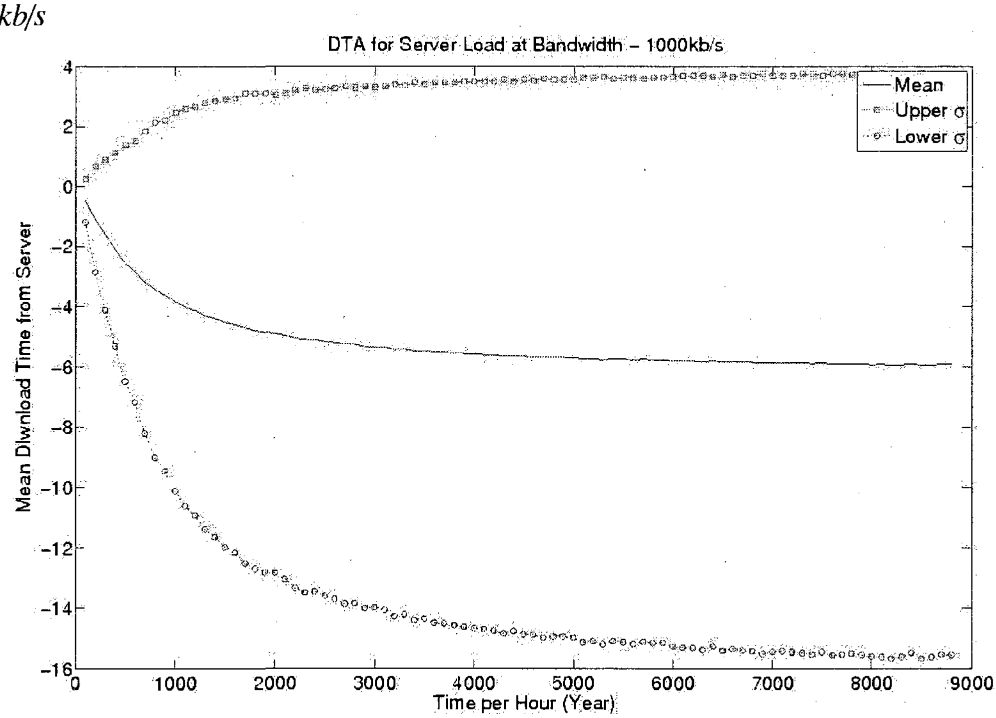


Figure 624: DTA of a difference between H1 and Base Line at download bandwidth of 2000kb/s

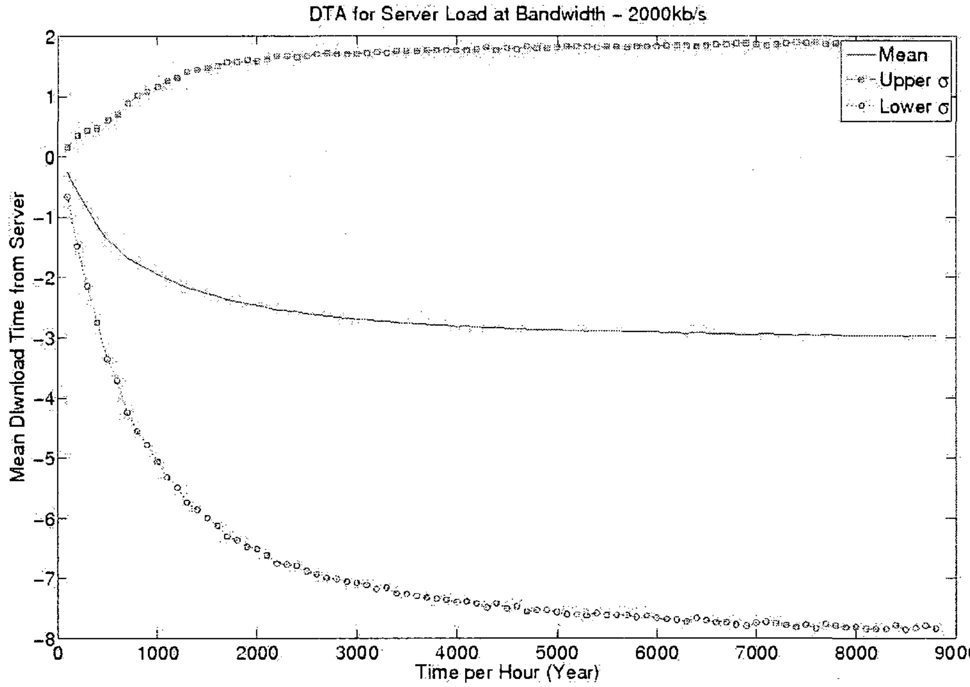


Figure 625: DTA of a difference between H1 and Base Line at download bandwidth of 5000kb/s

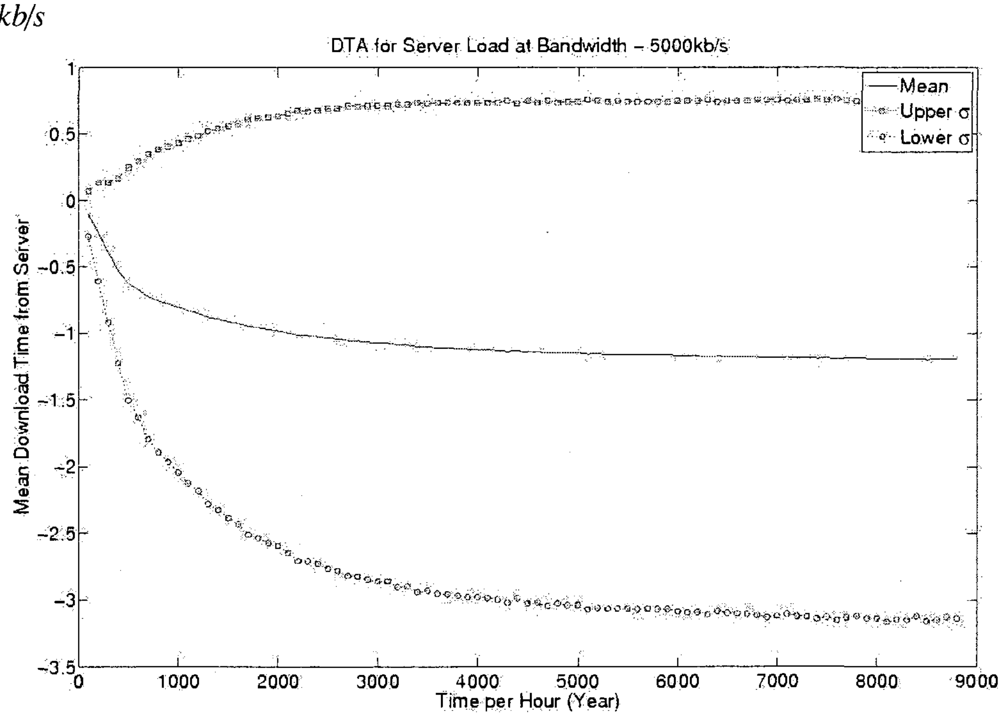


Figure 626: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 25kb/s

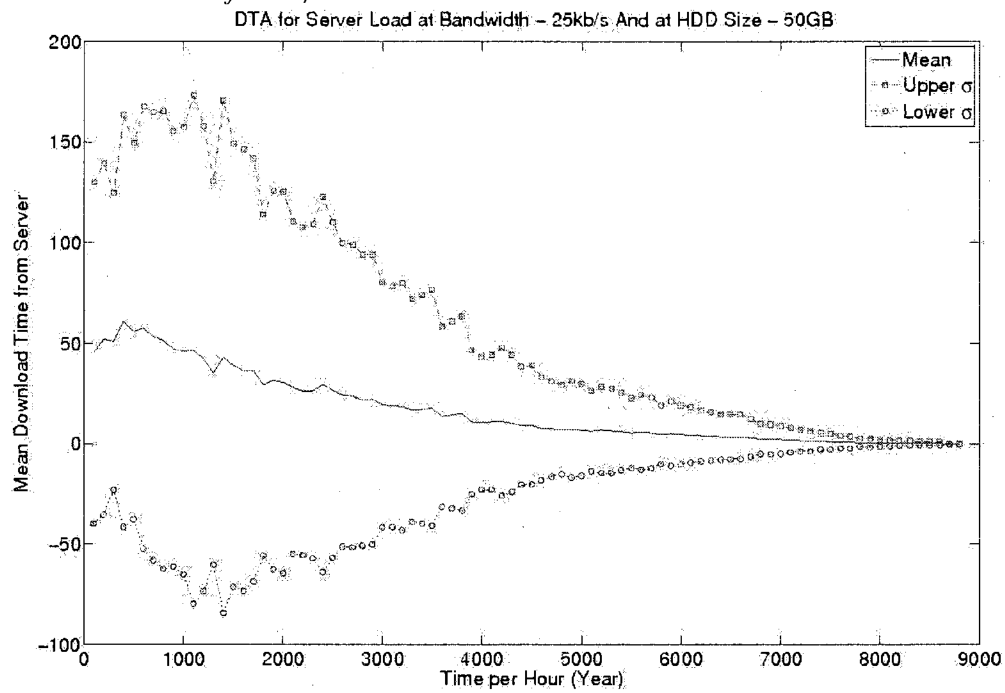


Figure 627: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 25kb/s

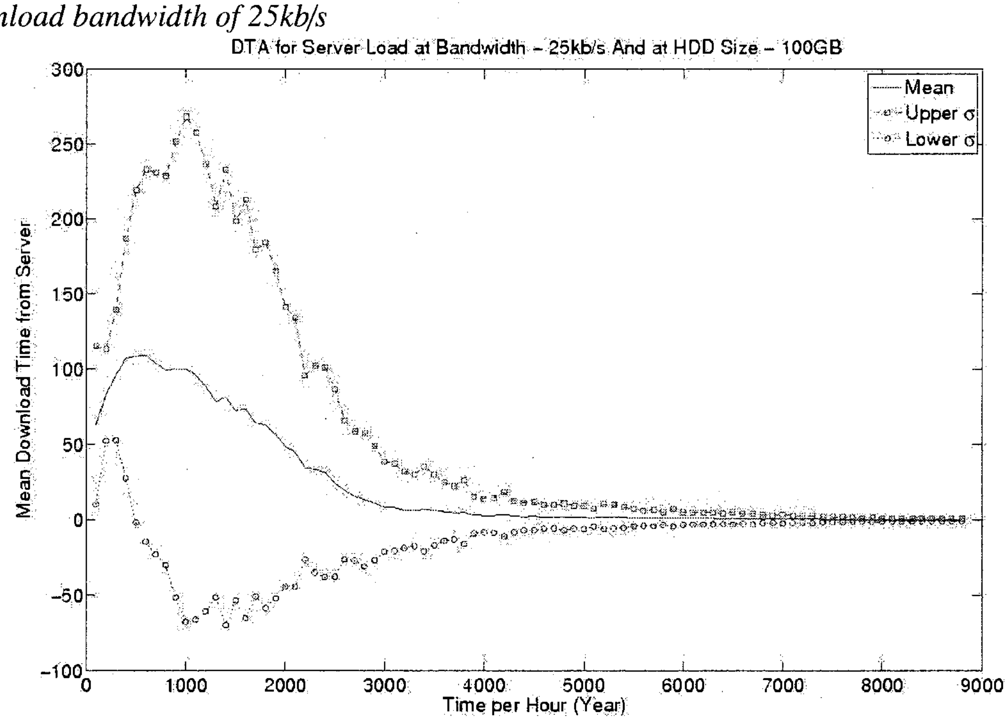


Figure 628: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 25kb/s

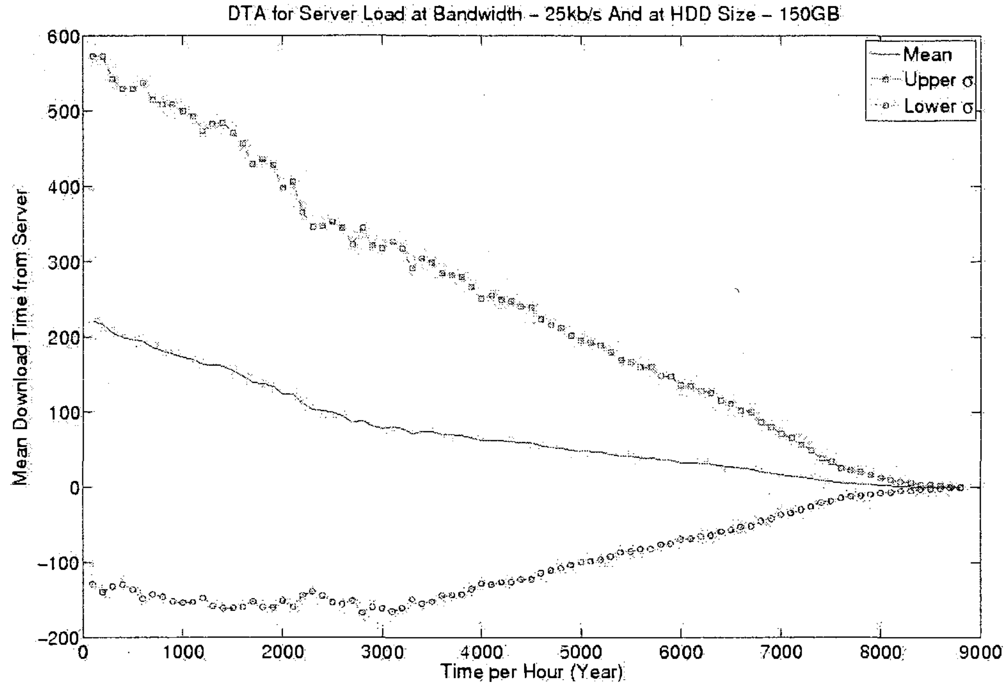


Figure 629: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 25kb/s

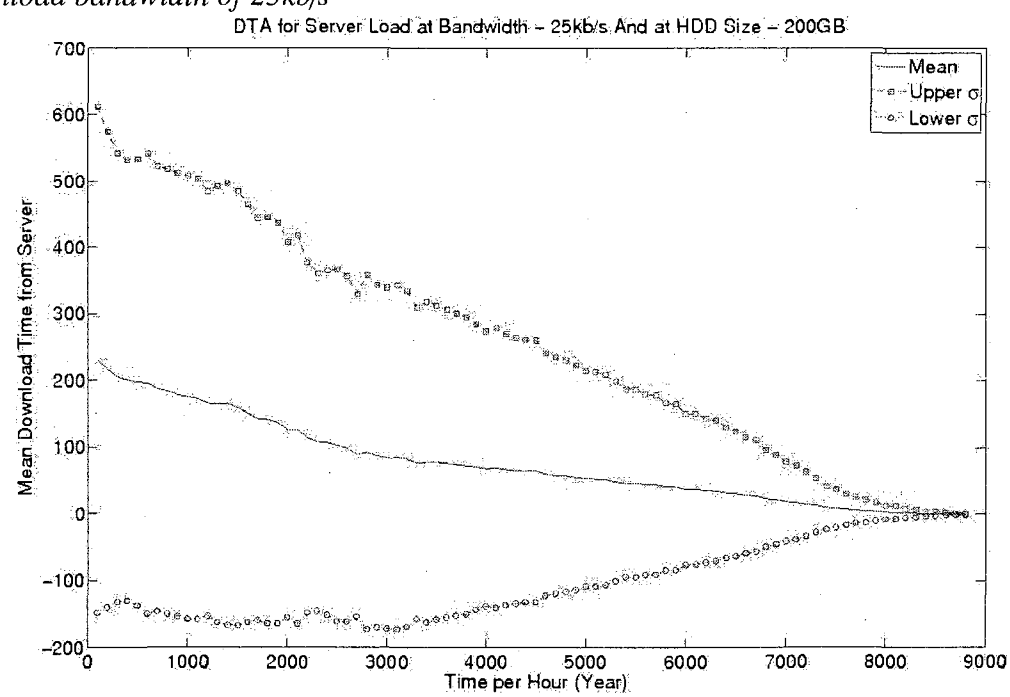


Figure 630: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 50kb/s

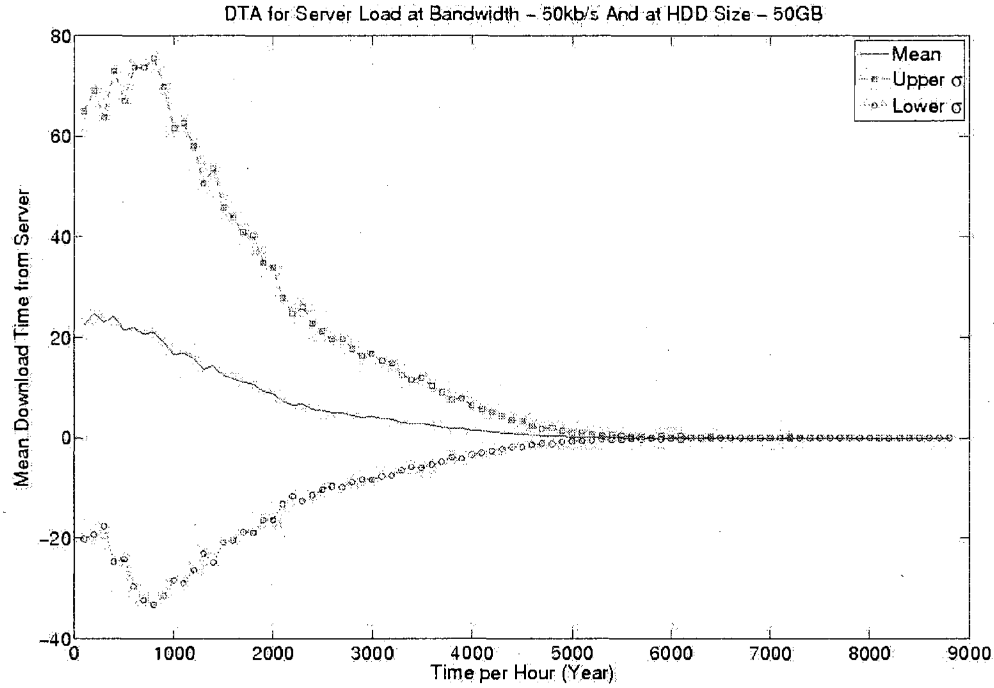


Figure 631: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 50kb/s

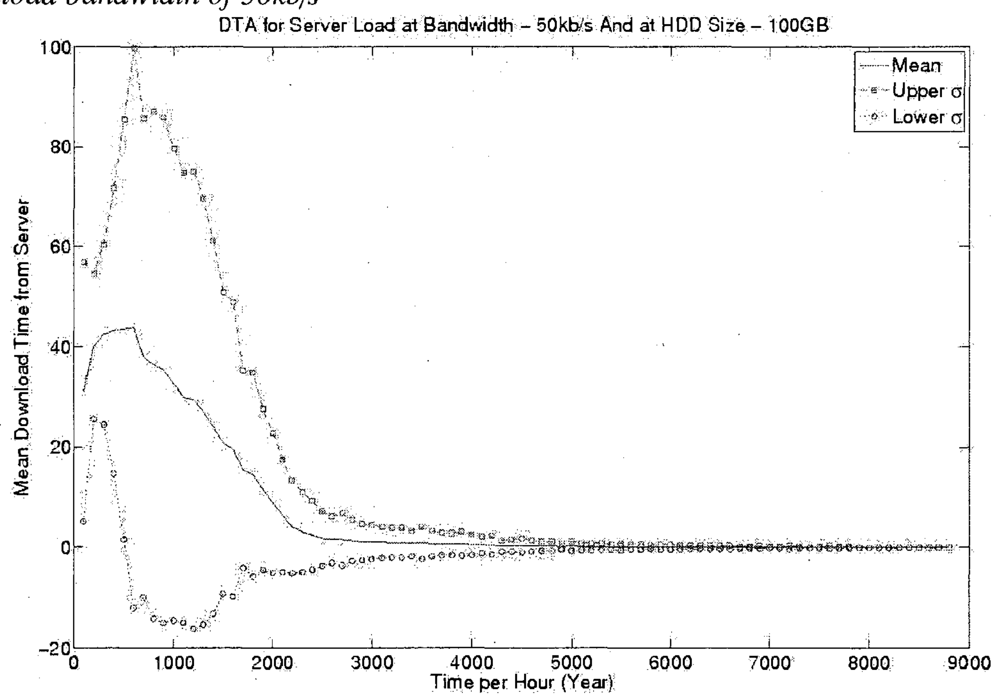


Figure 632: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 50kb/s

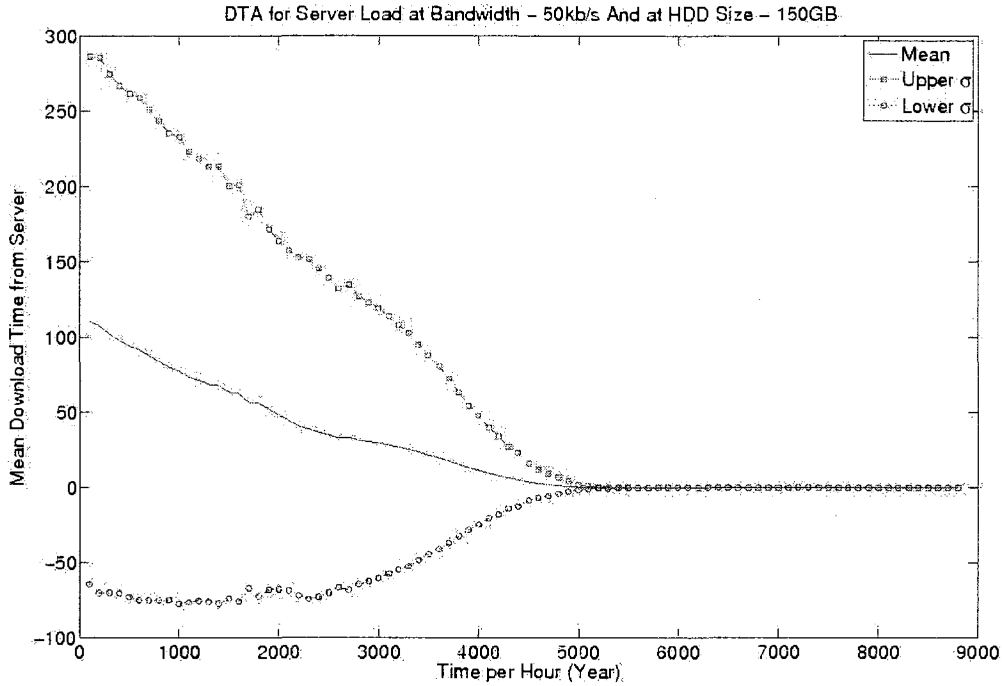


Figure 633: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 50kb/s

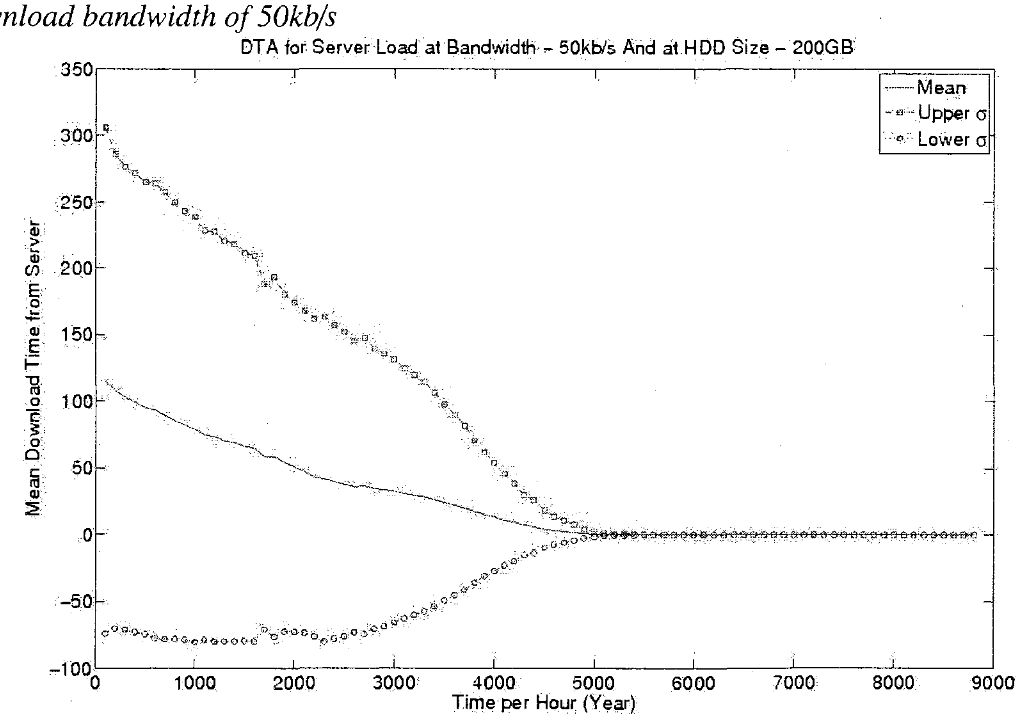


Figure 634: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 100kb/s

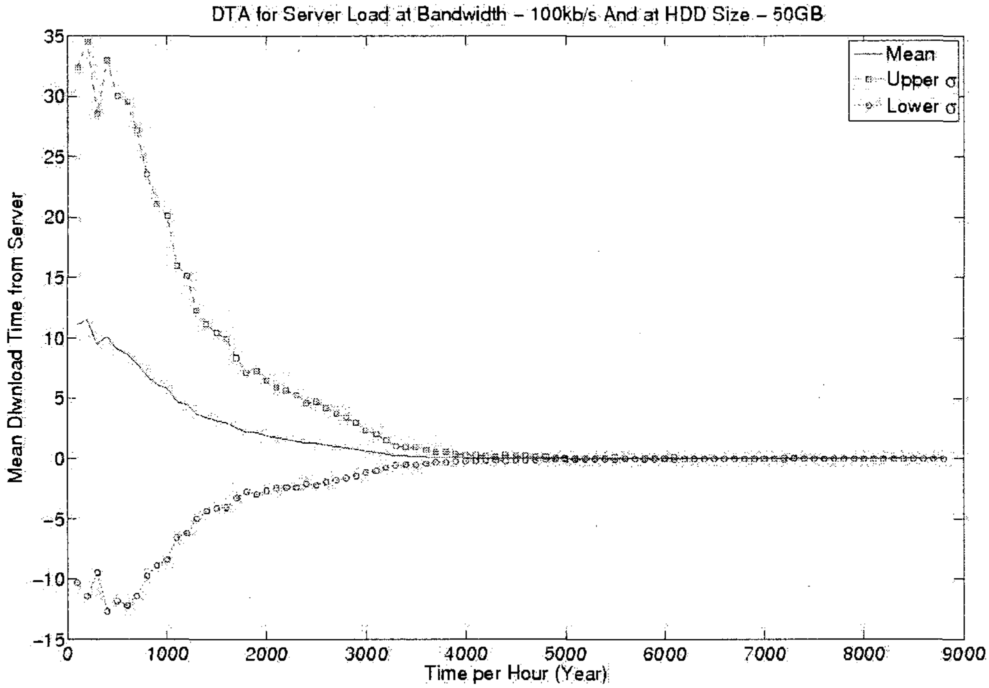


Figure 635: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 100kb/s

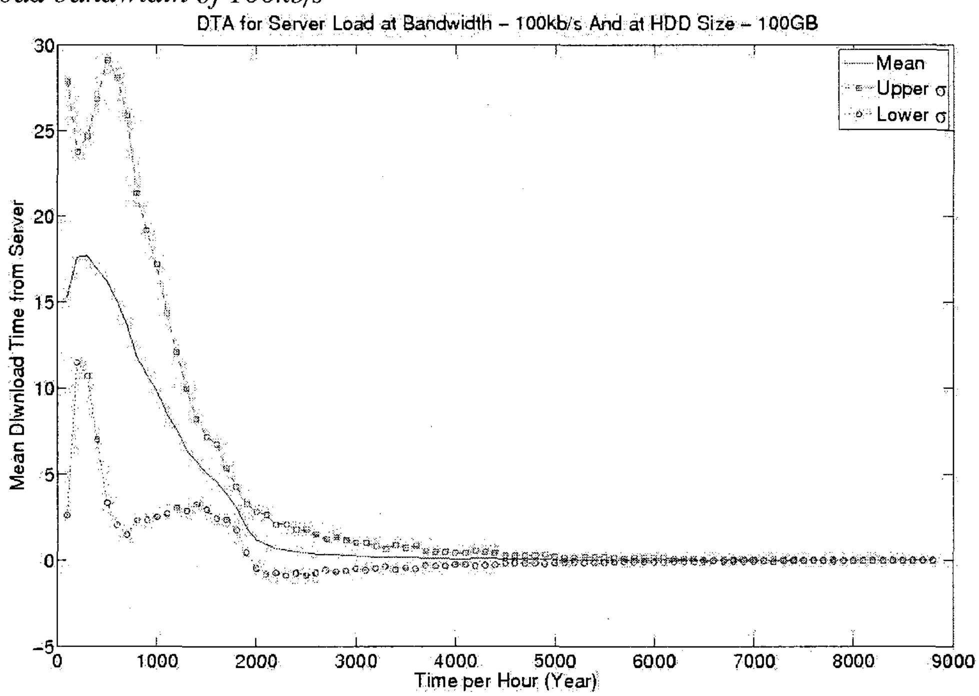


Figure 636: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 100kb/s

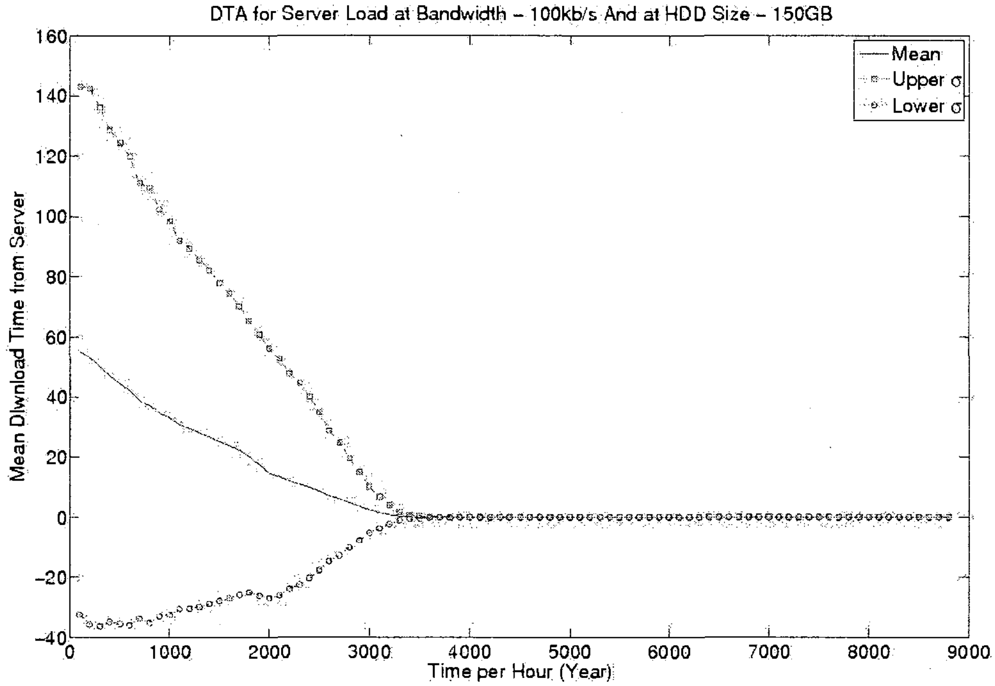


Figure 637: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 100kb/s

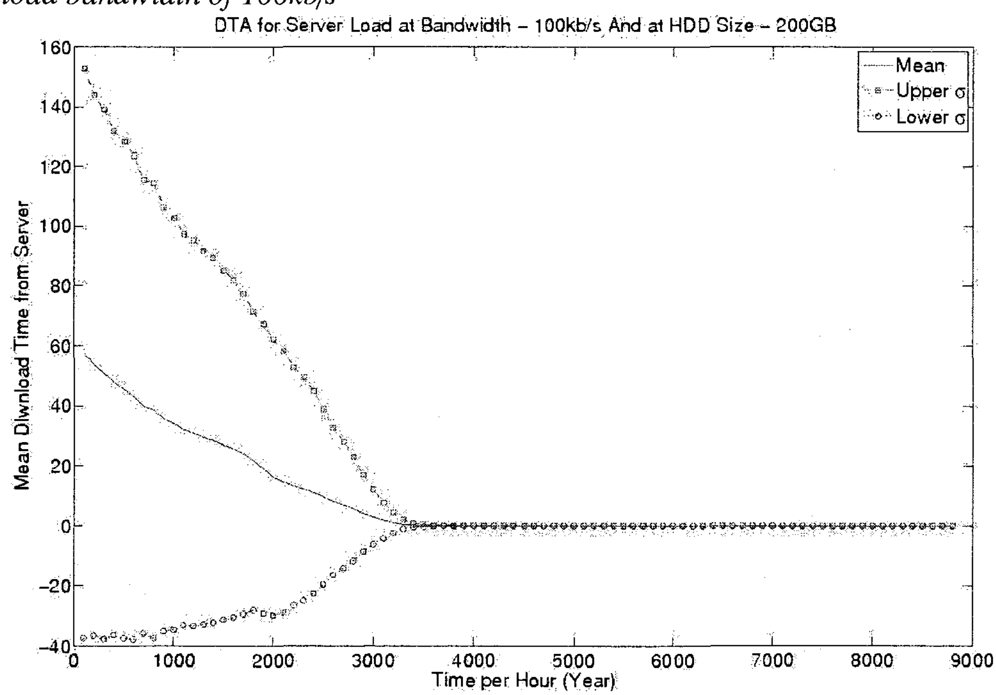


Figure 638: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 128kb/s

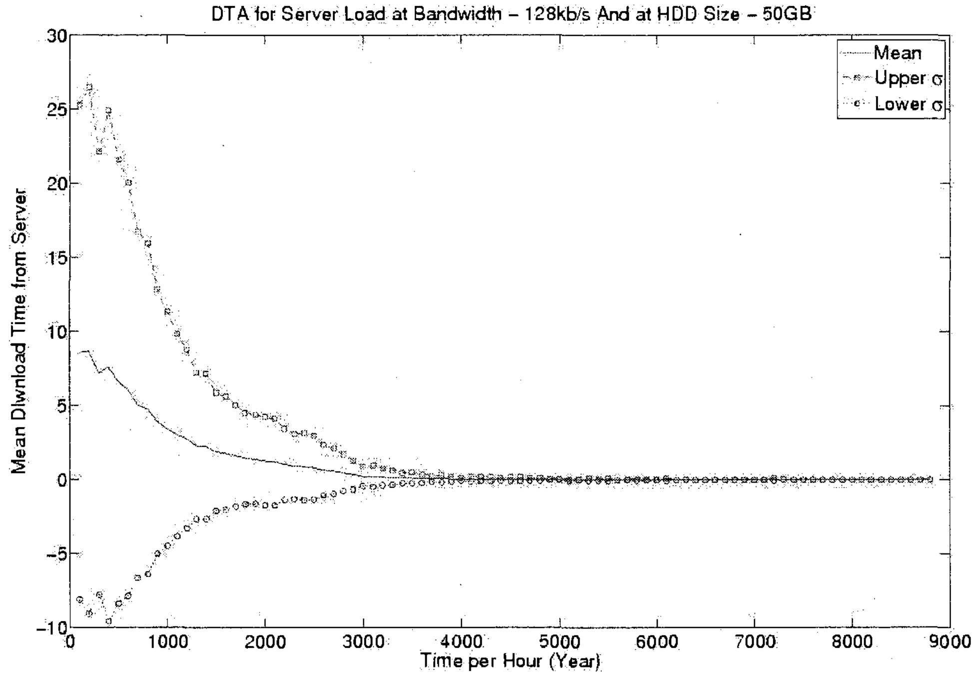


Figure 639: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 128kb/s

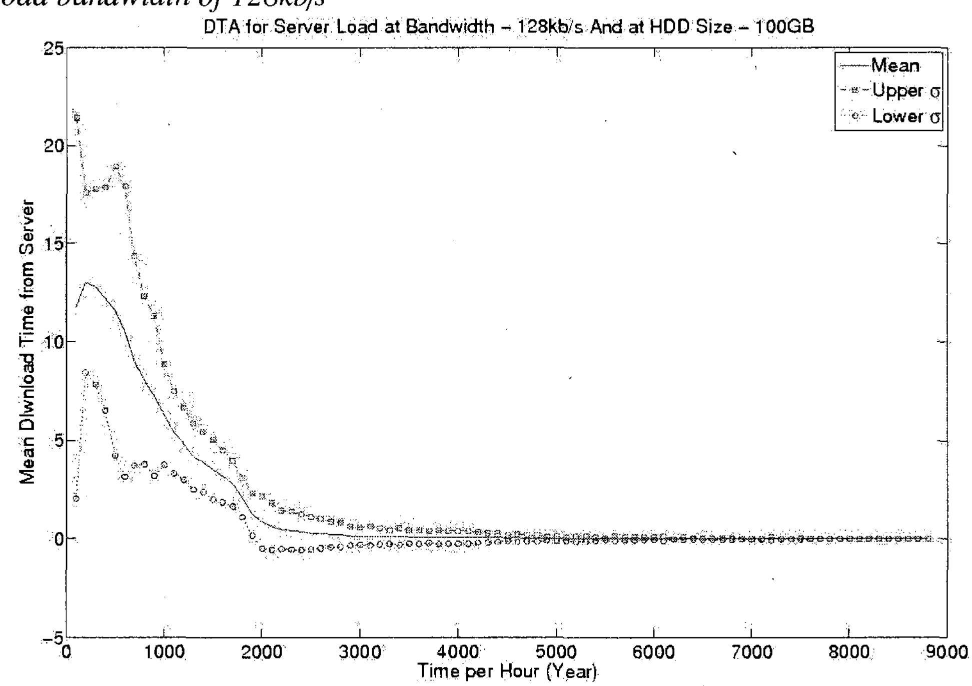


Figure 640: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 128kb/s

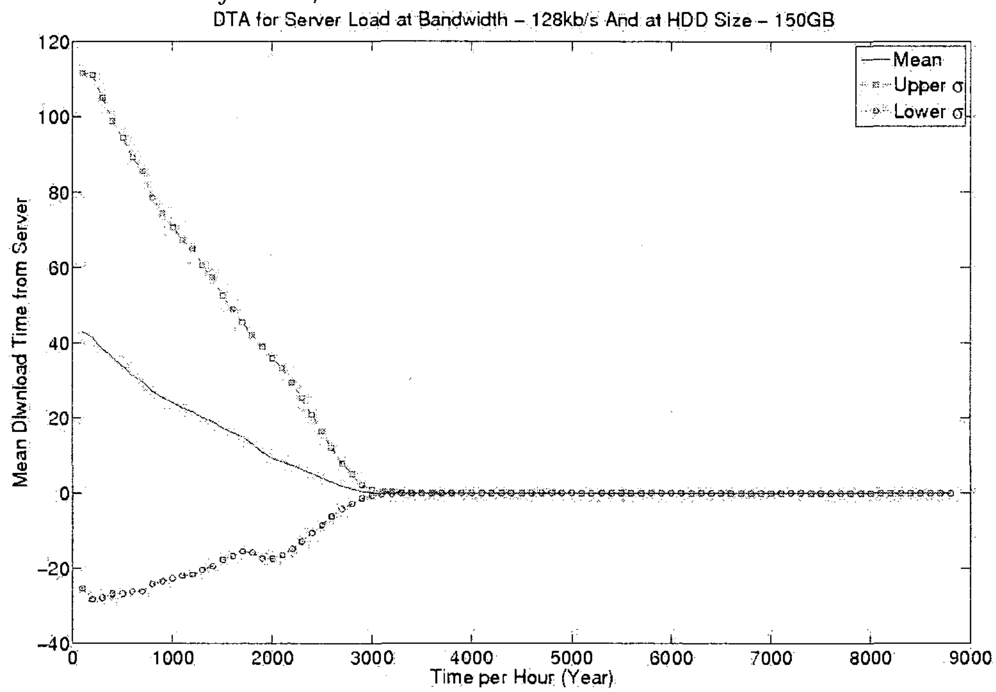


Figure 641: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 128kb/s

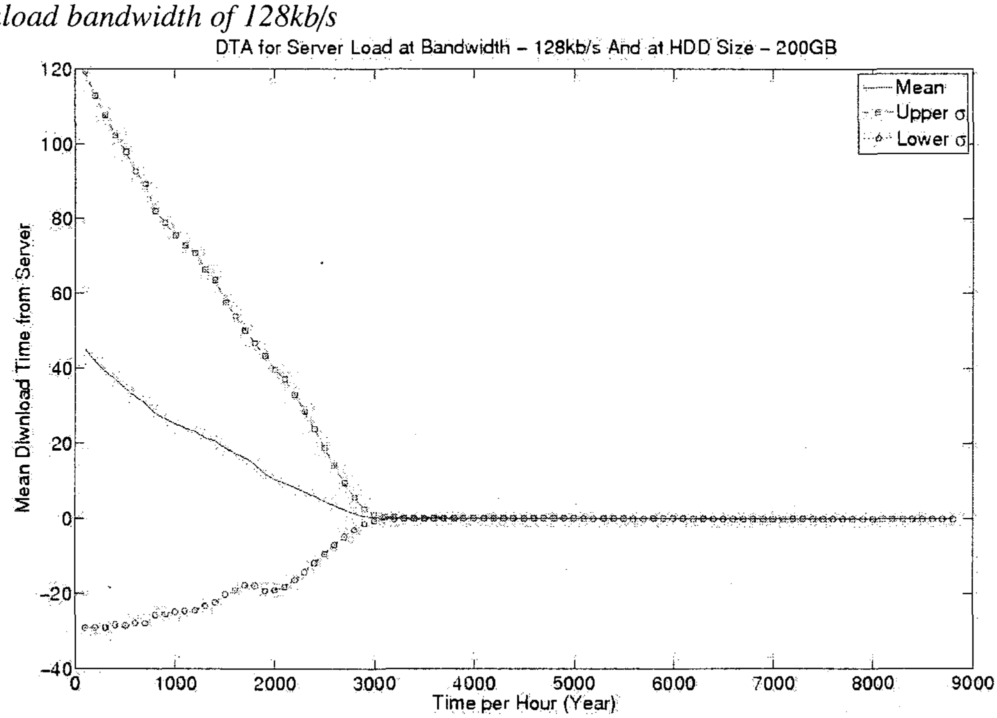


Figure 642: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 256kb/s

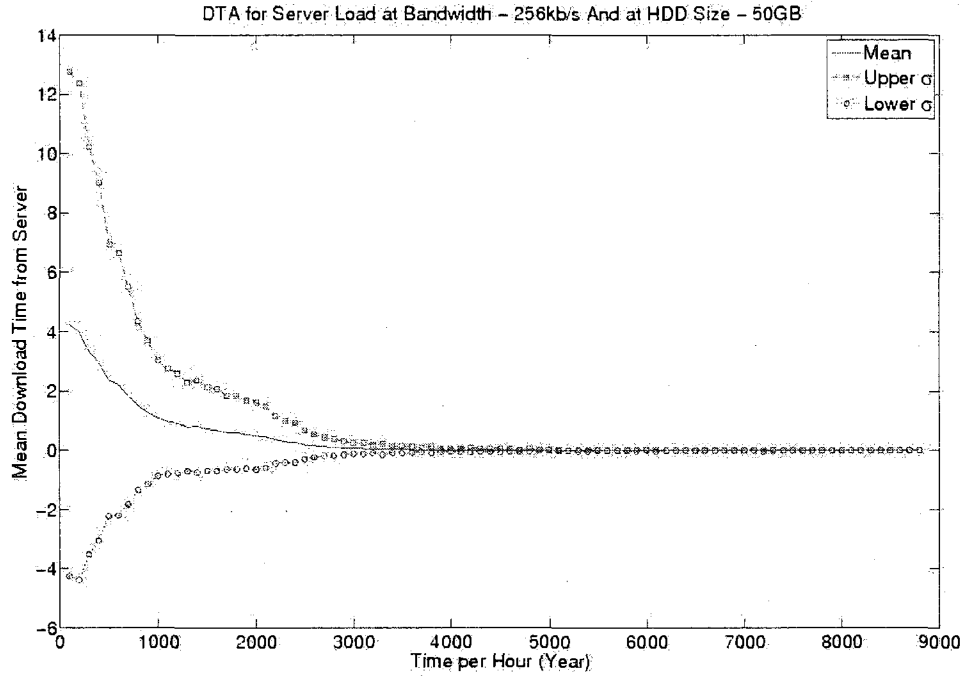


Figure 643: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 256kb/s

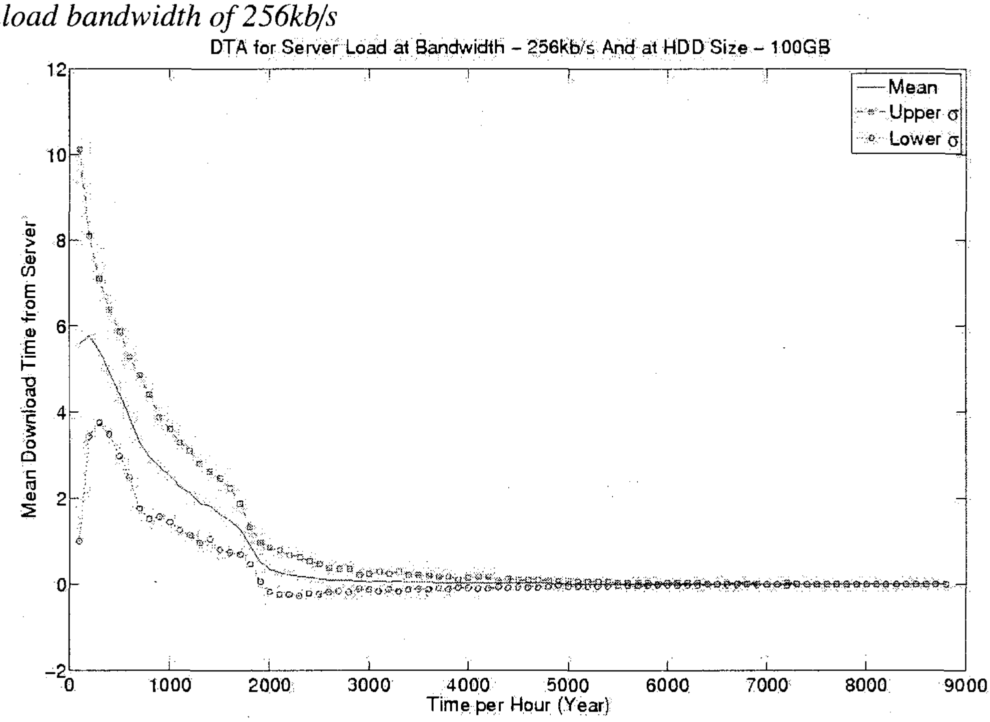


Figure 644: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 256kb/s

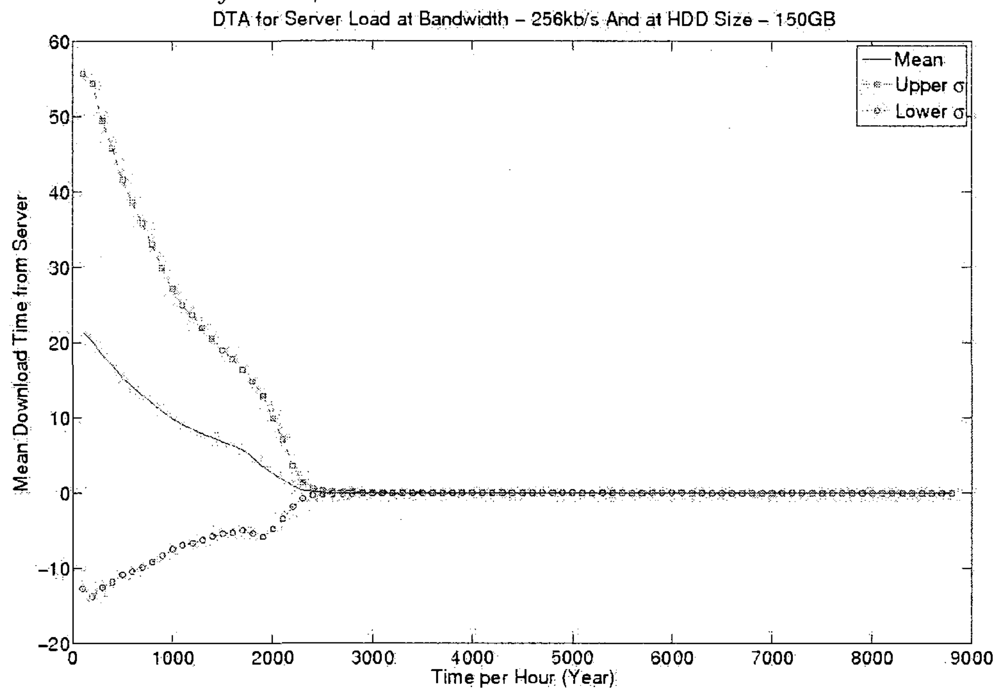


Figure 645: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 256kb/s

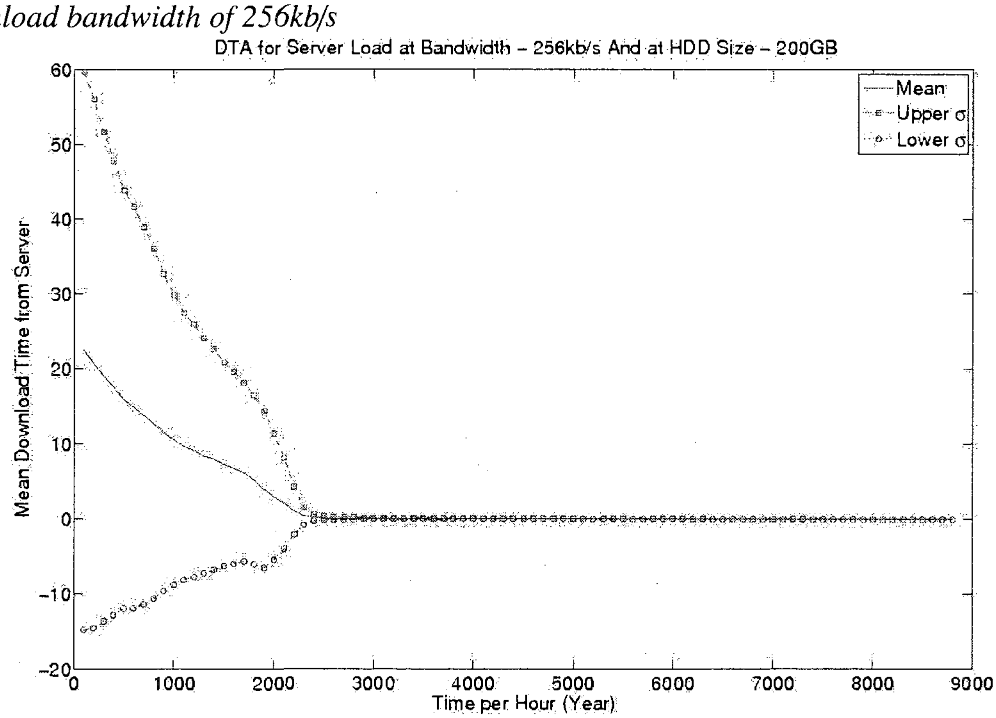


Figure 646: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 512kb/s

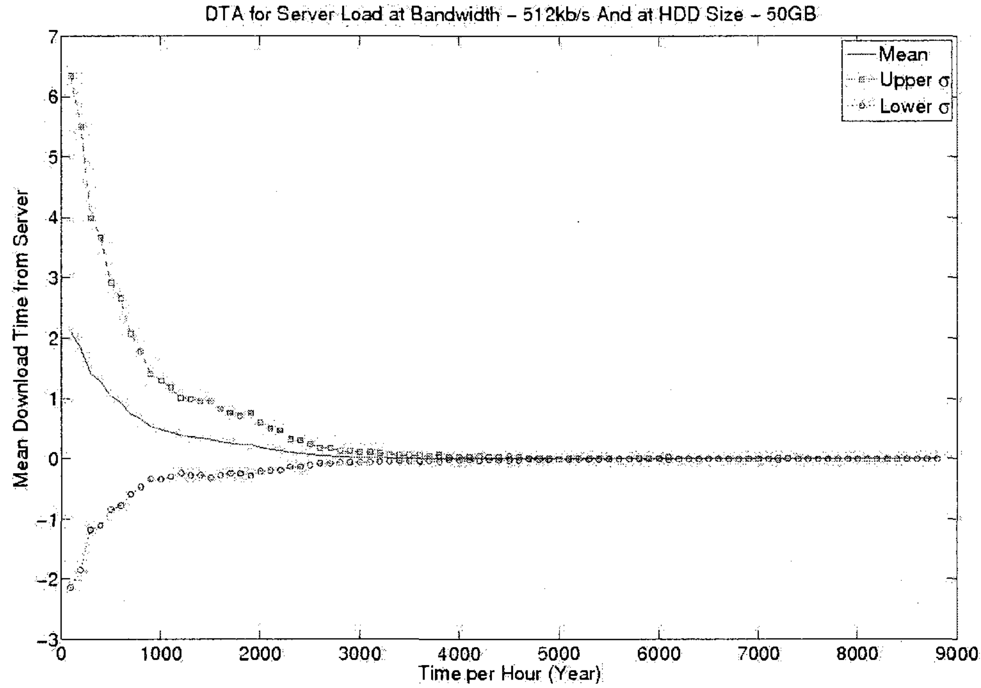


Figure 647: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 512kb/s

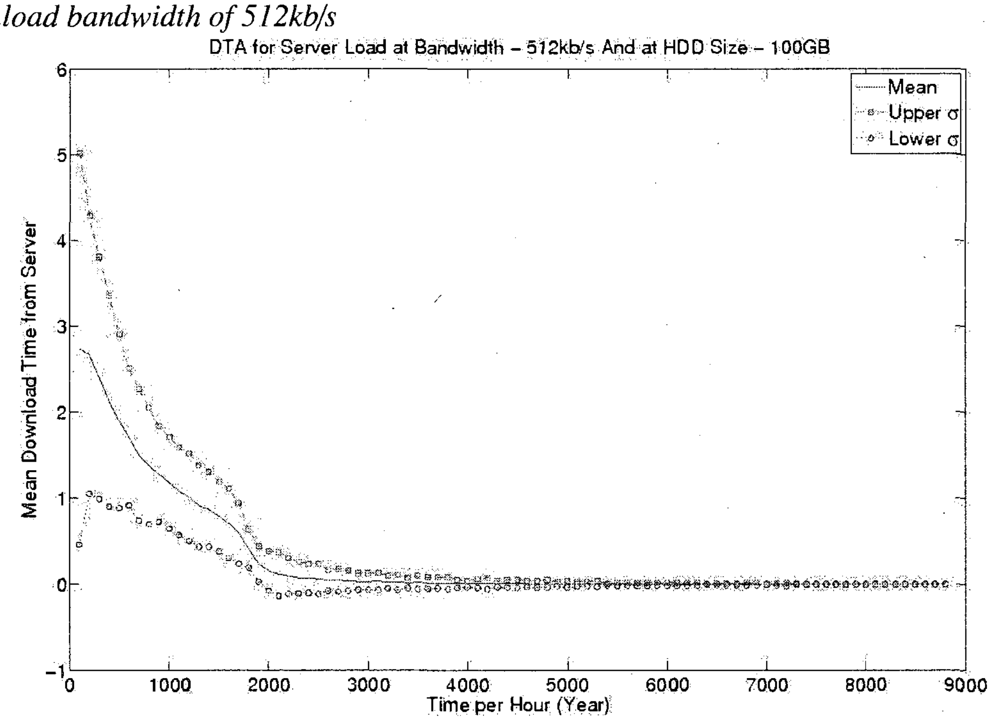


Figure 648: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 512kb/s

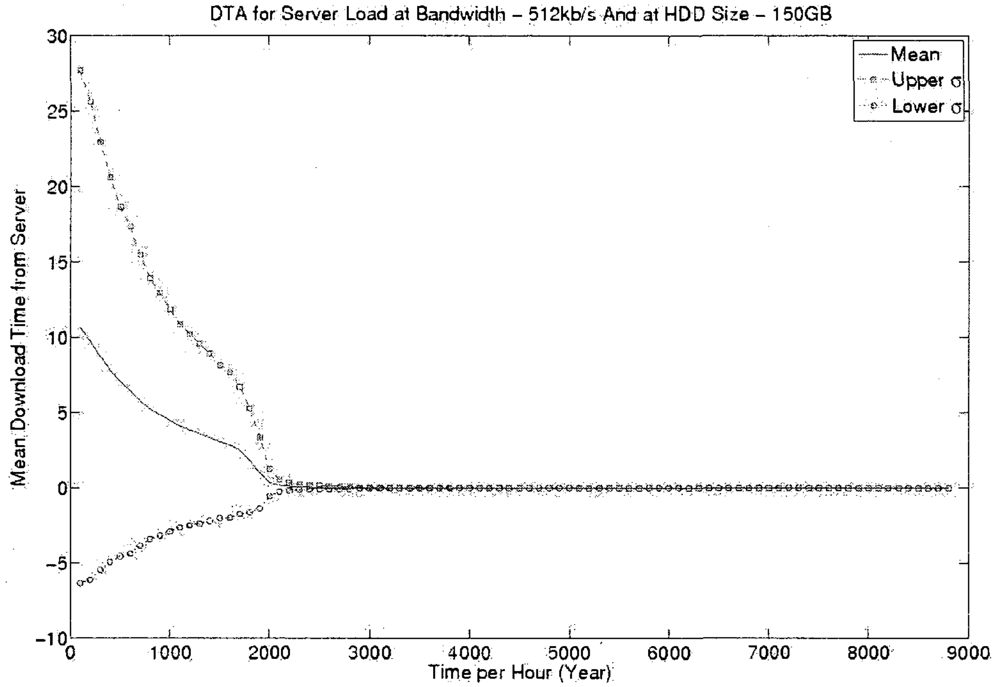


Figure 649: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 512kb/s

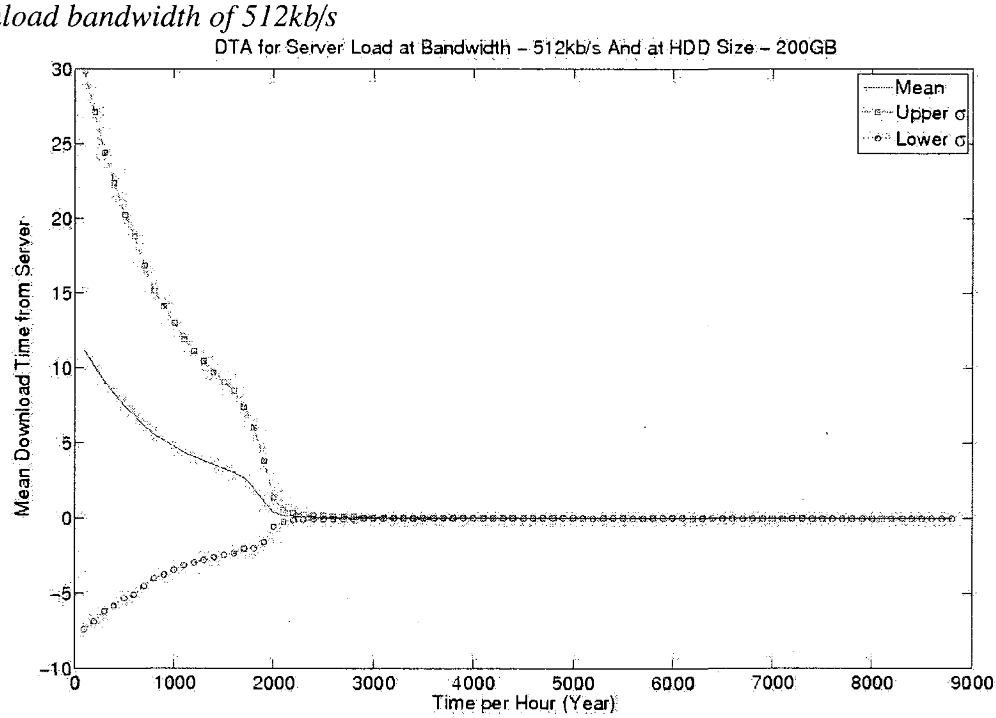


Figure 650: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 1000kb/s

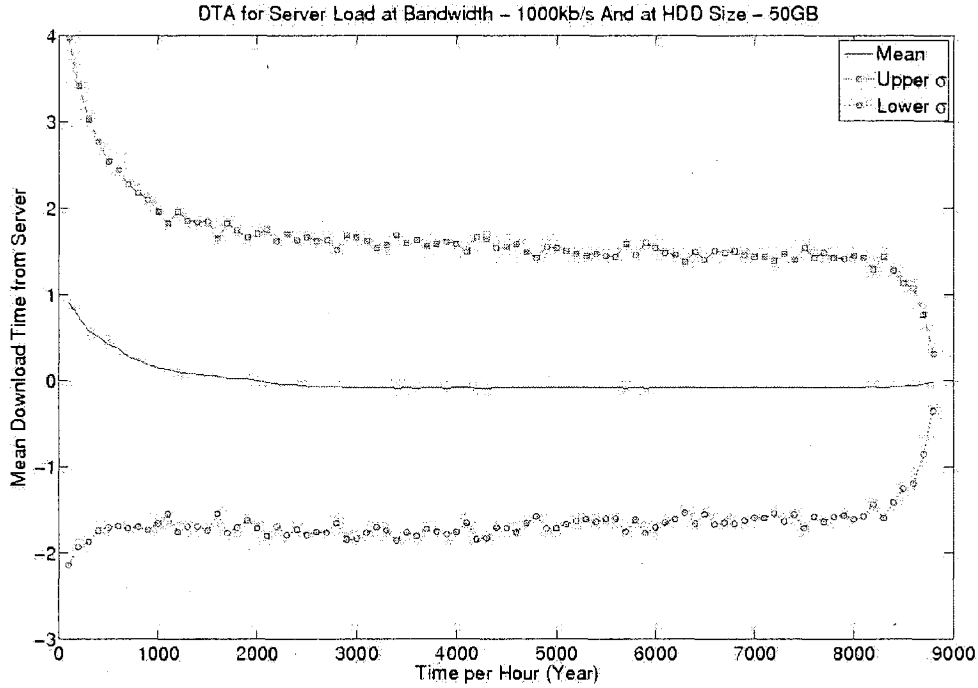


Figure 651: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 1000kb/s

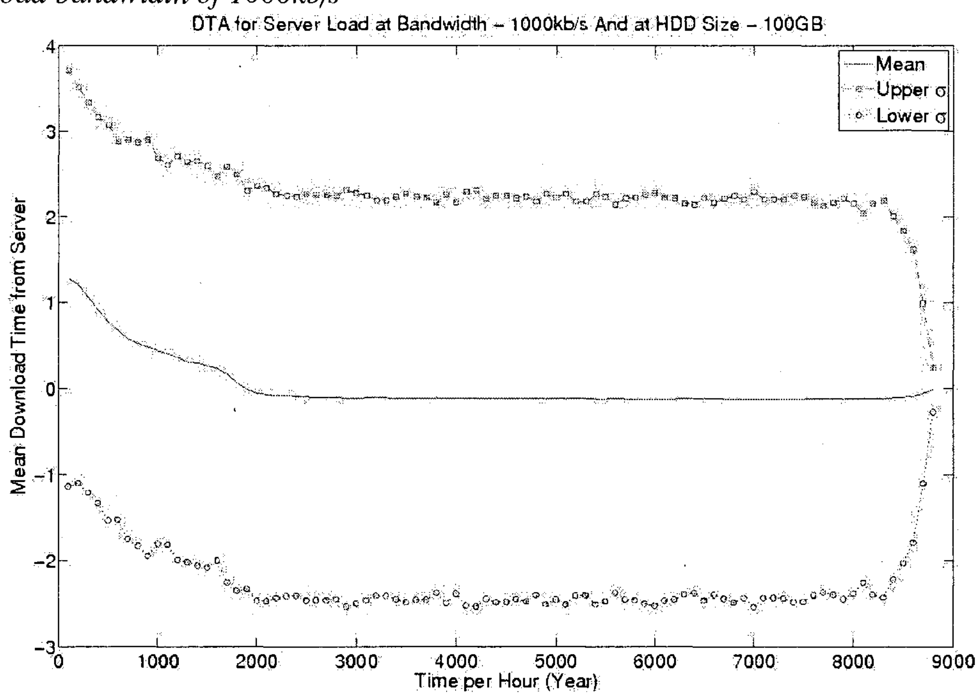


Figure 652: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 1000kb/s

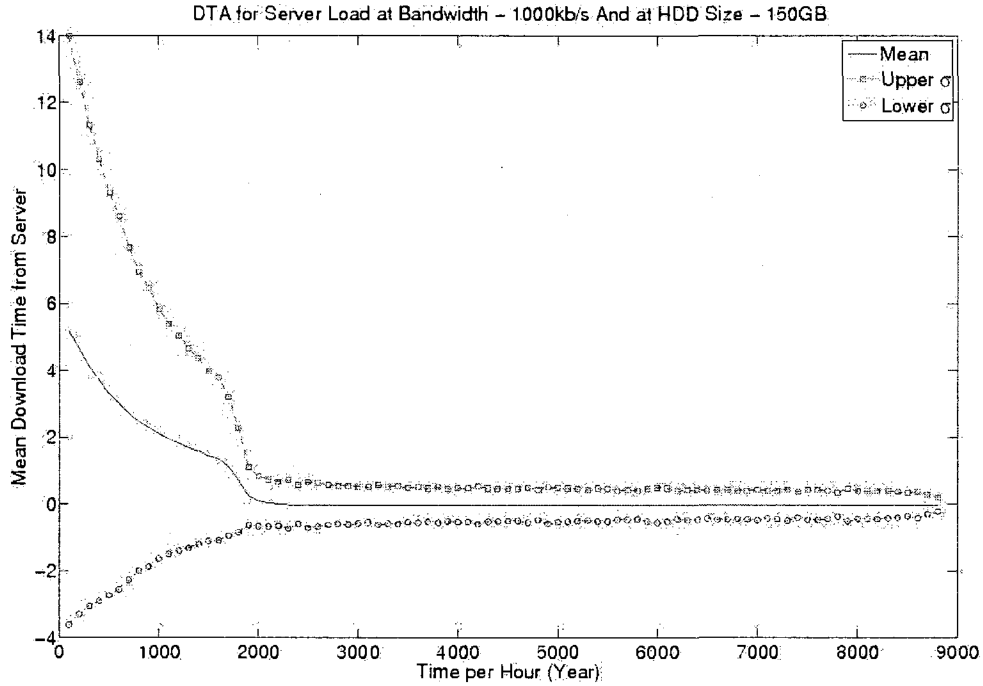


Figure 653: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 1000kb/s

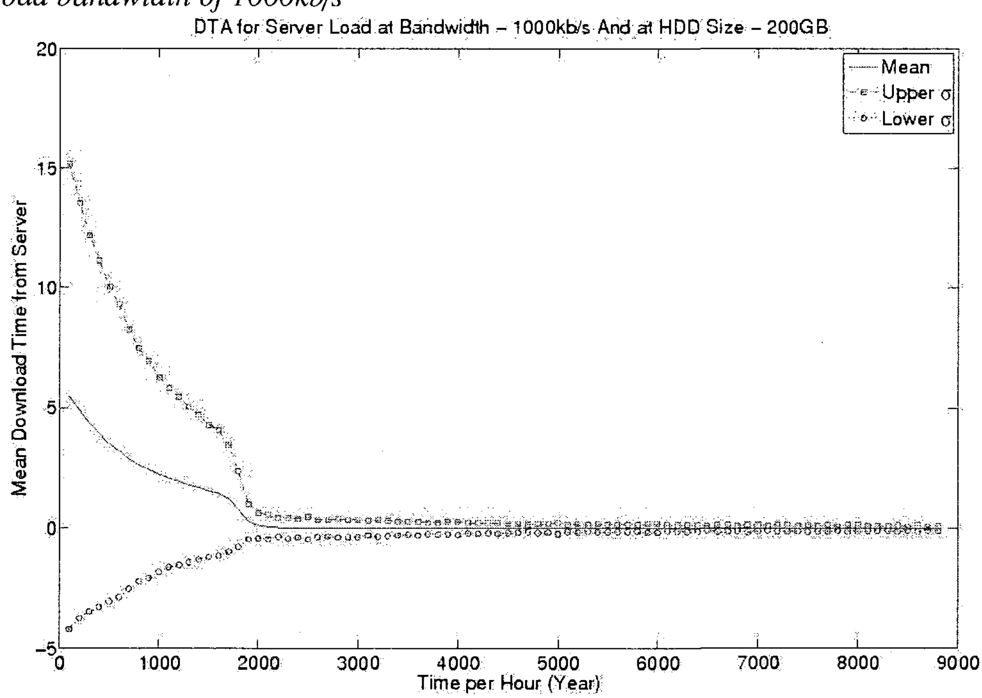


Figure 654: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 2000kb/s

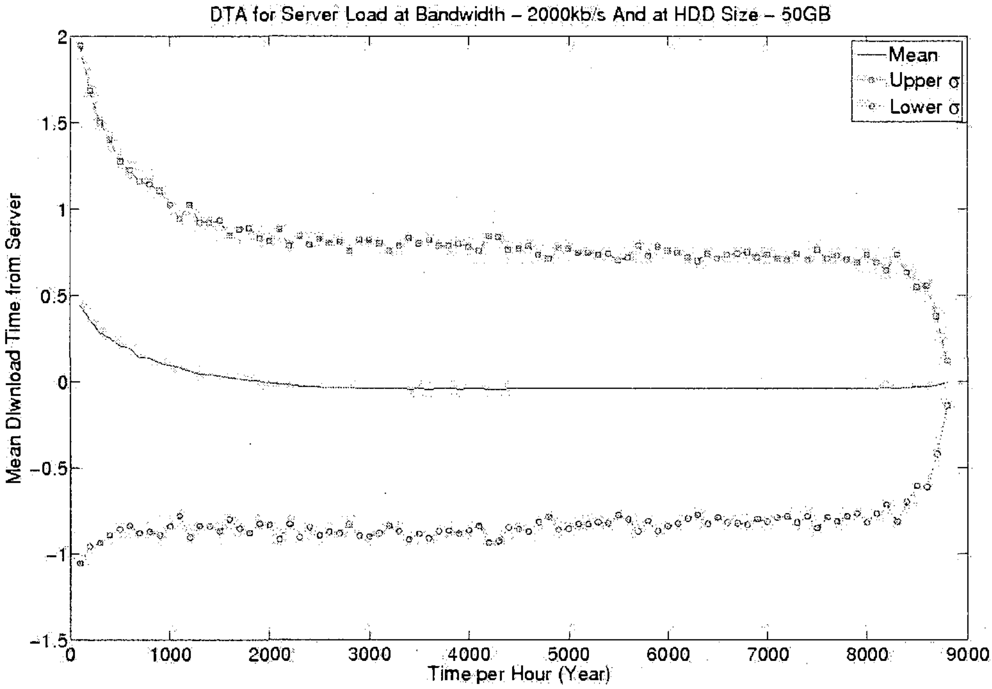


Figure 655: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 2000kb/s

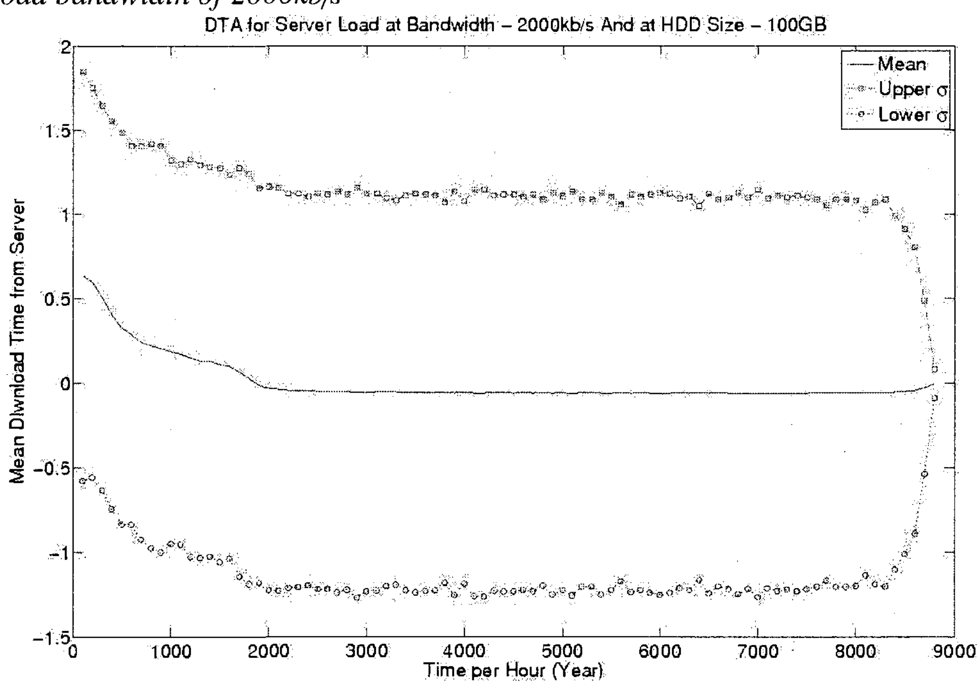


Figure 656: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 2000kb/s

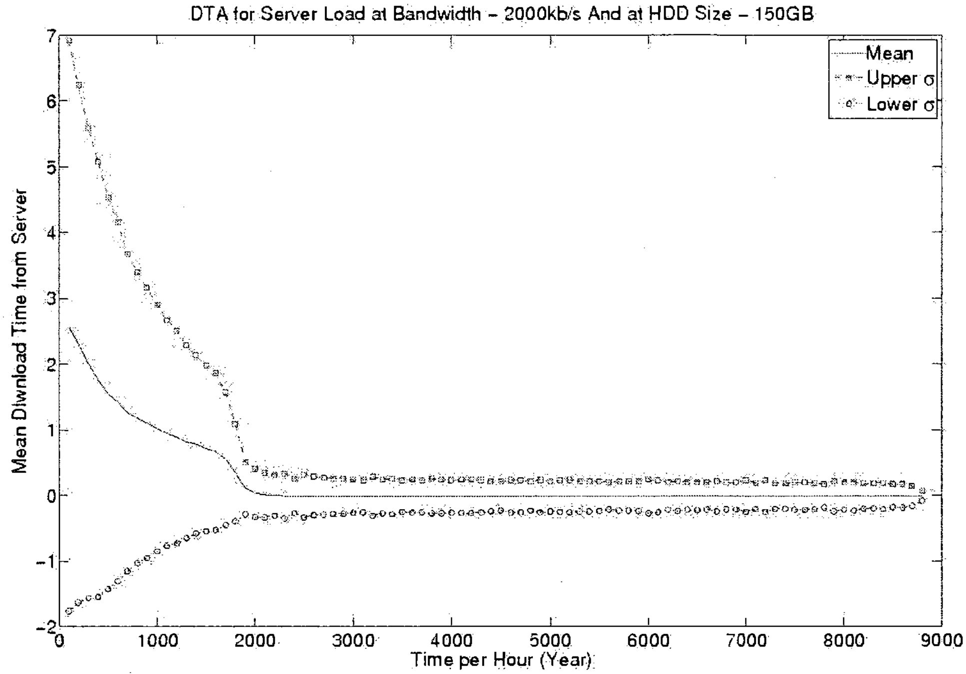


Figure 657: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 2000kb/s

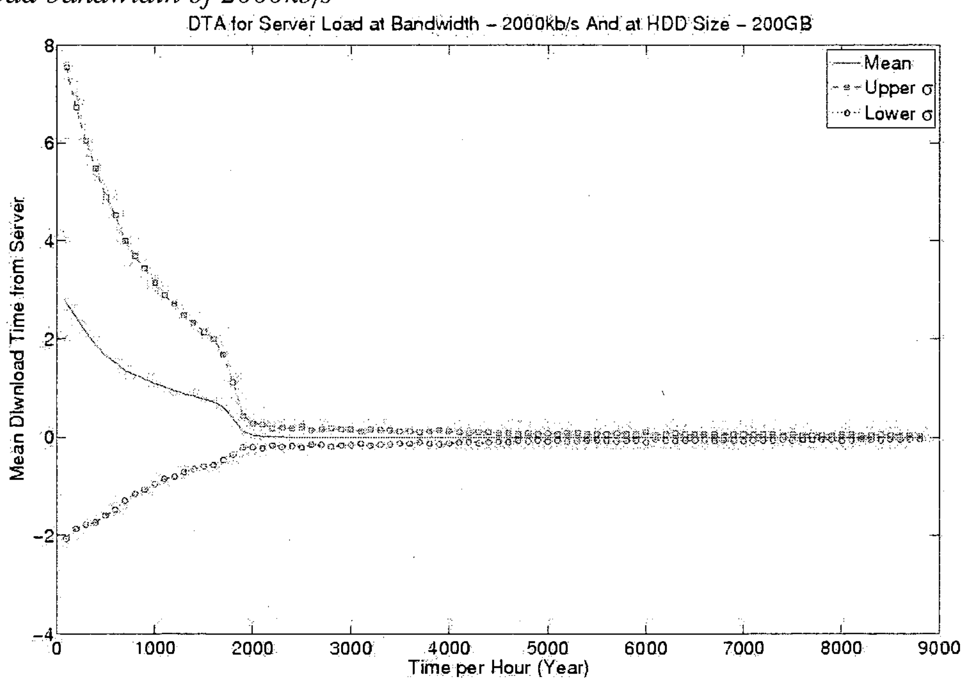


Figure 658: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 5000kb/s

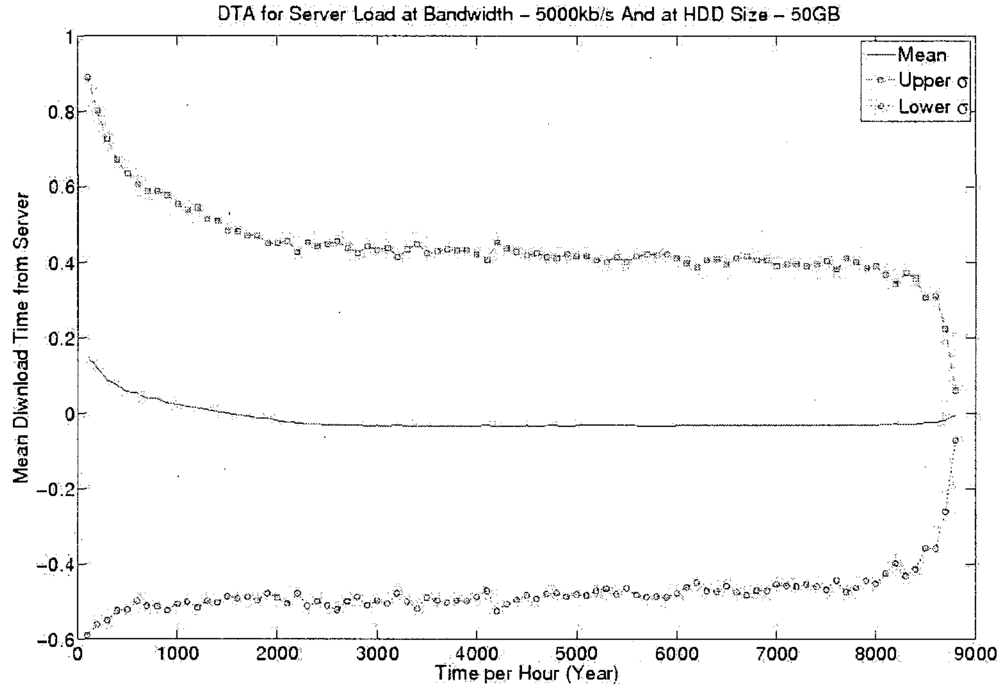


Figure 659: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 5000kb/s

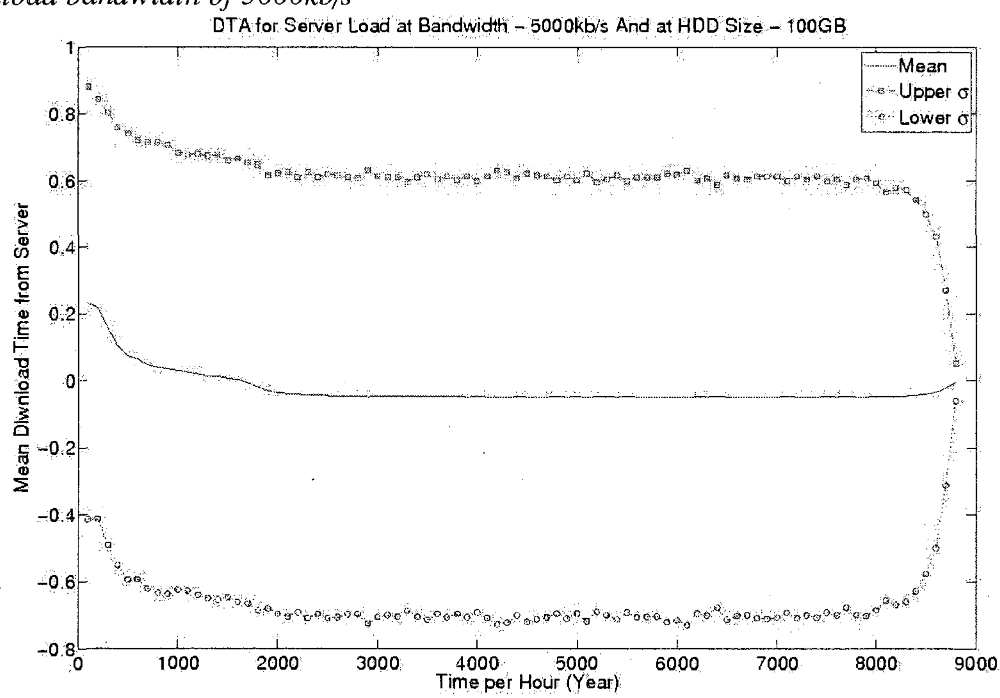


Figure 660: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 5000kb/s

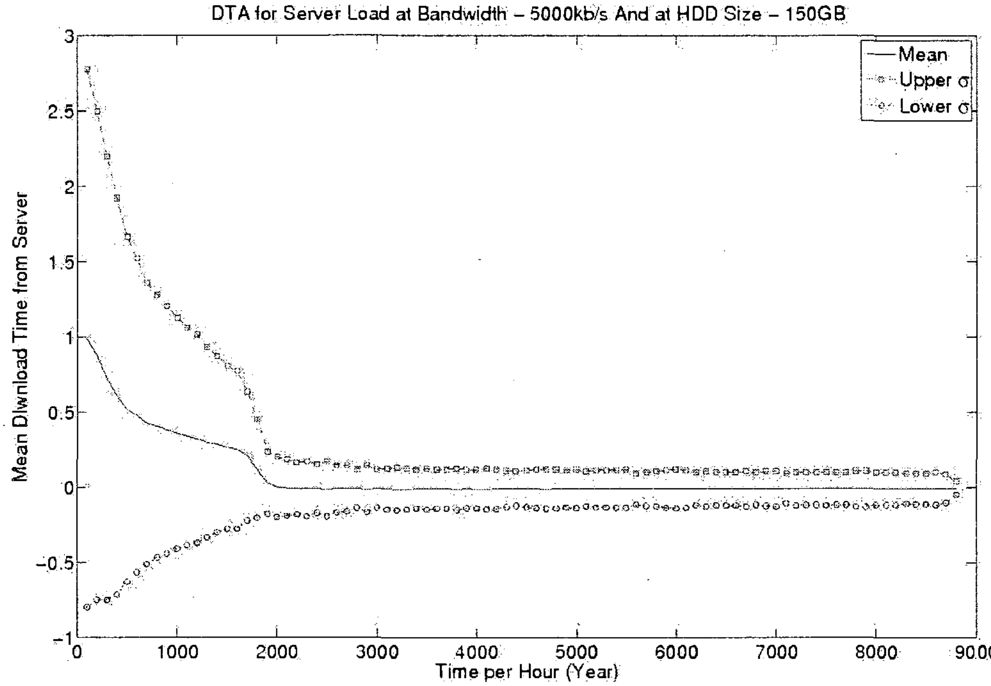


Figure 661: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 5000kb/s

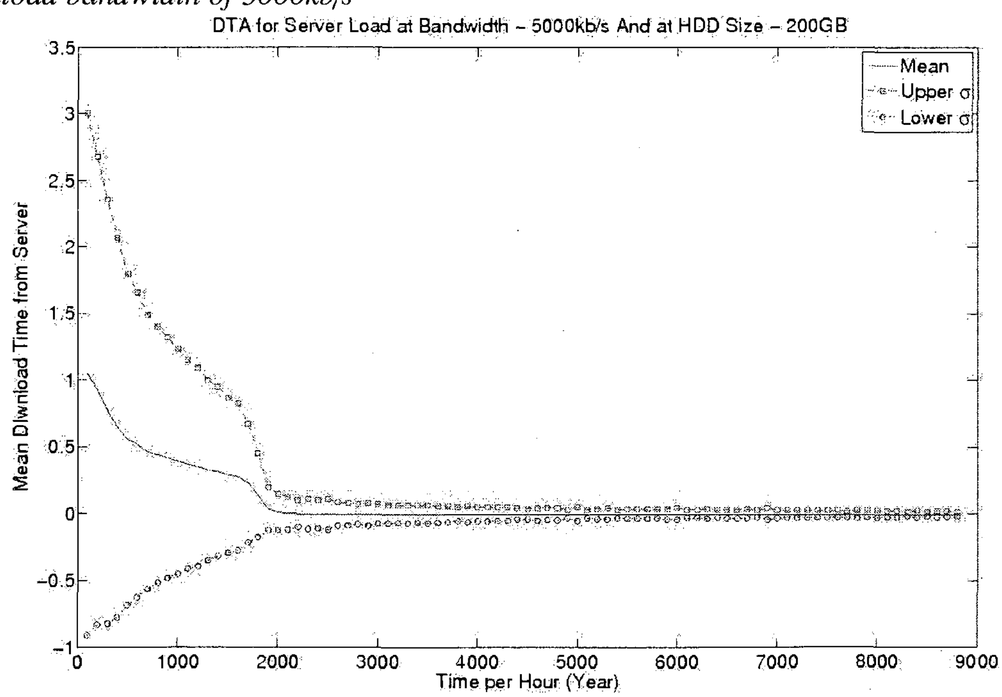


Figure 662: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 10000kb/s

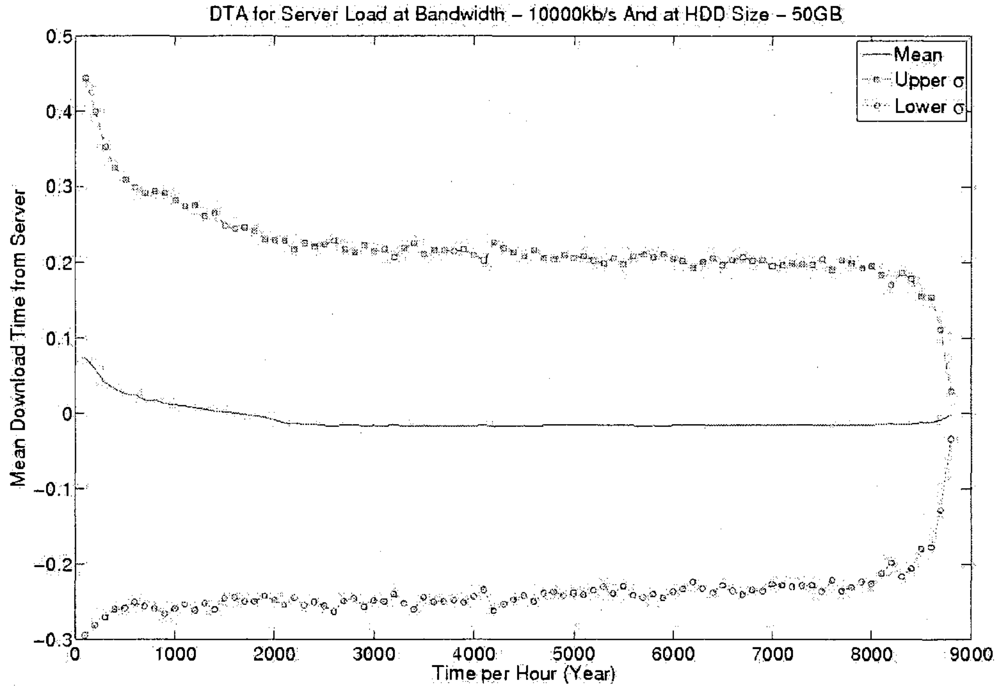


Figure 663: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 10000kb/s

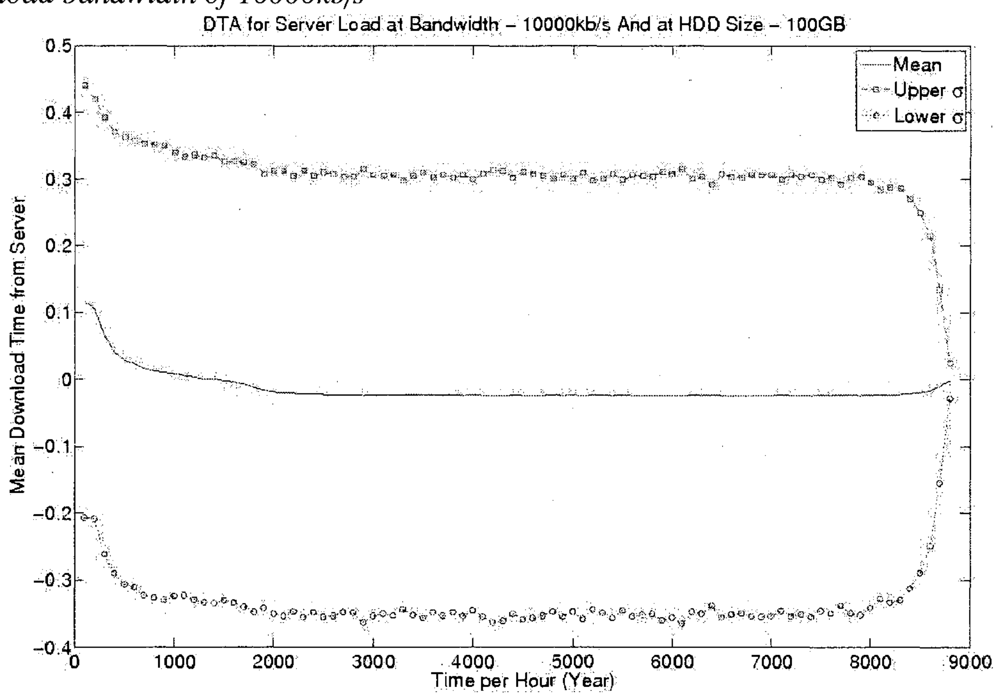


Figure 664: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 10000kb/s

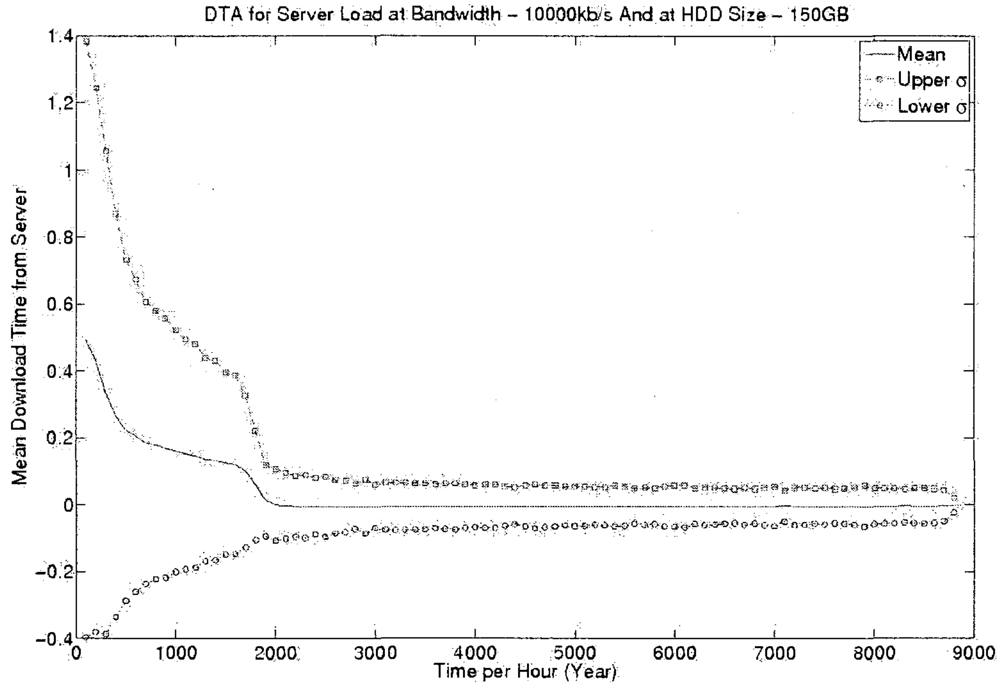


Figure 665: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 10000kb/s

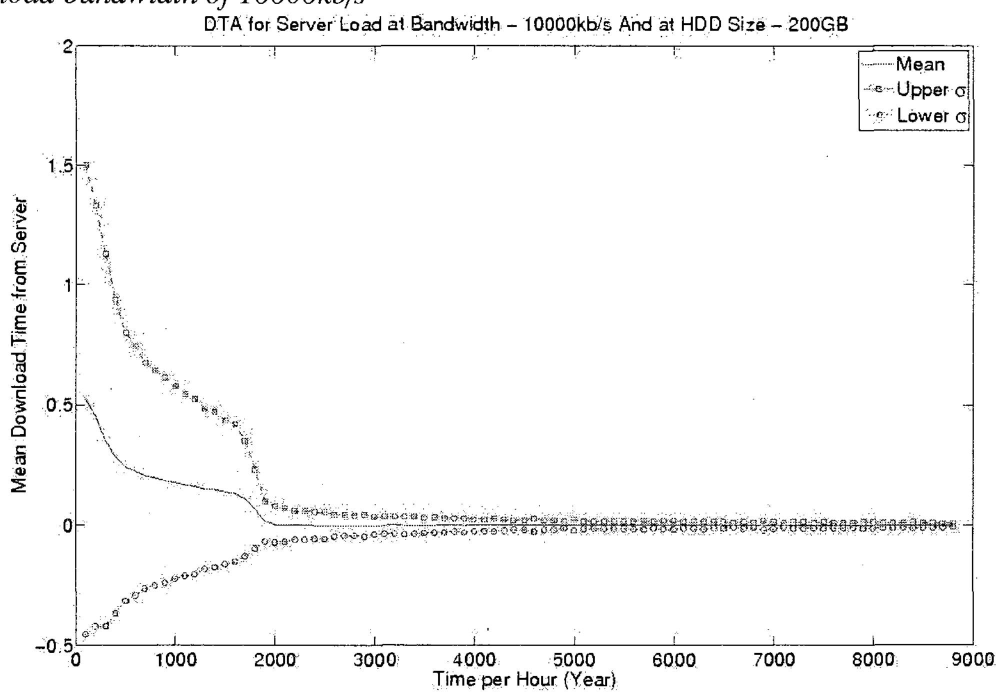


Figure 666: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 15000kb/s

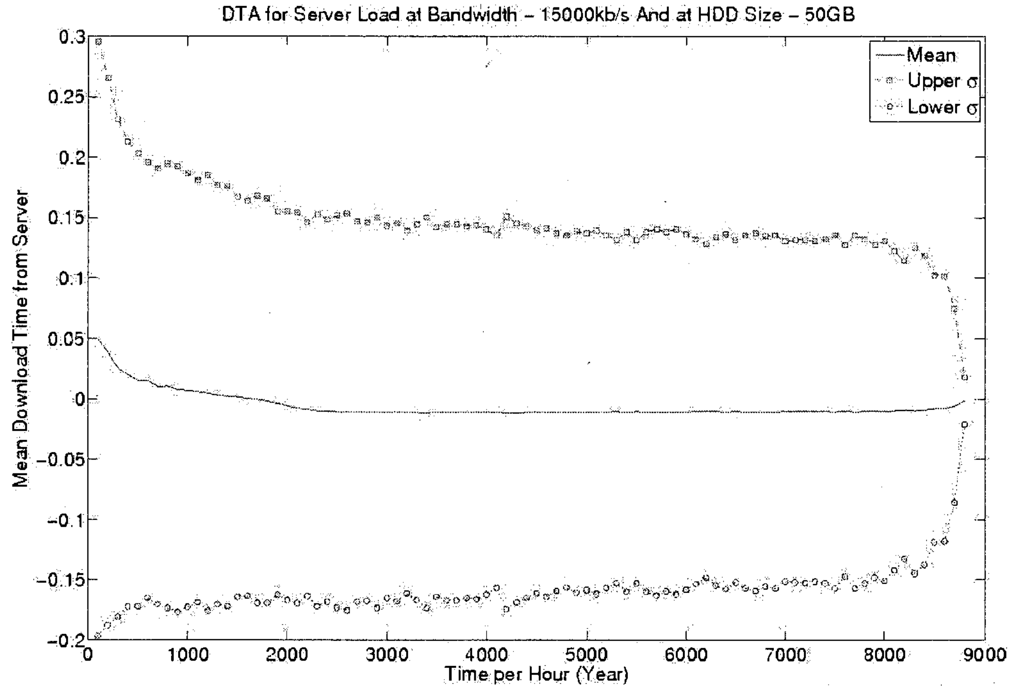


Figure 667: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 15000kb/s

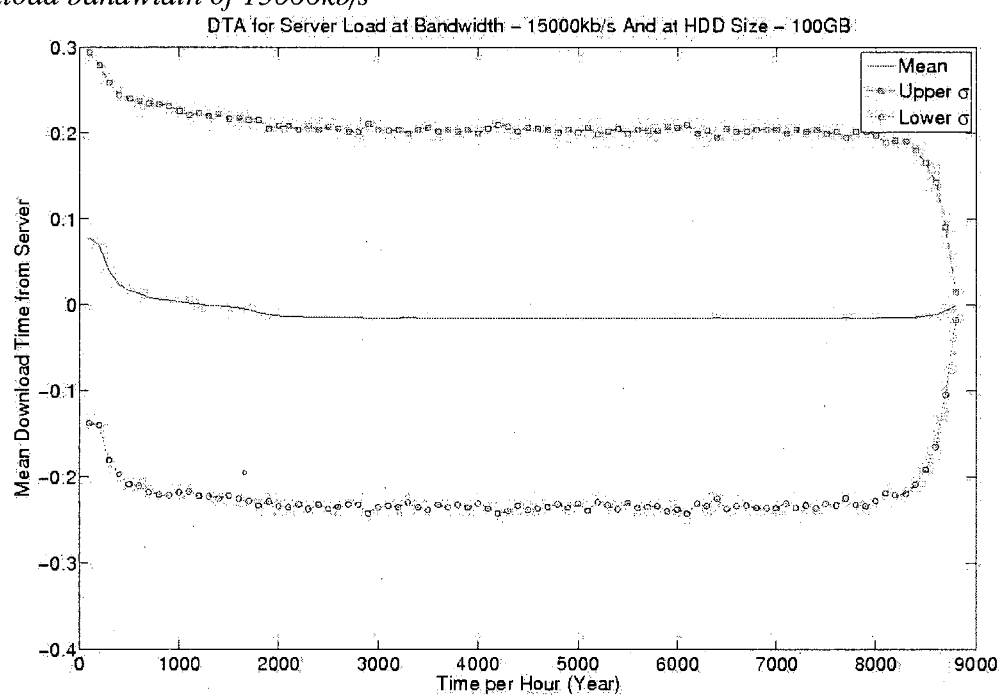


Figure 668: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 15000kb/s

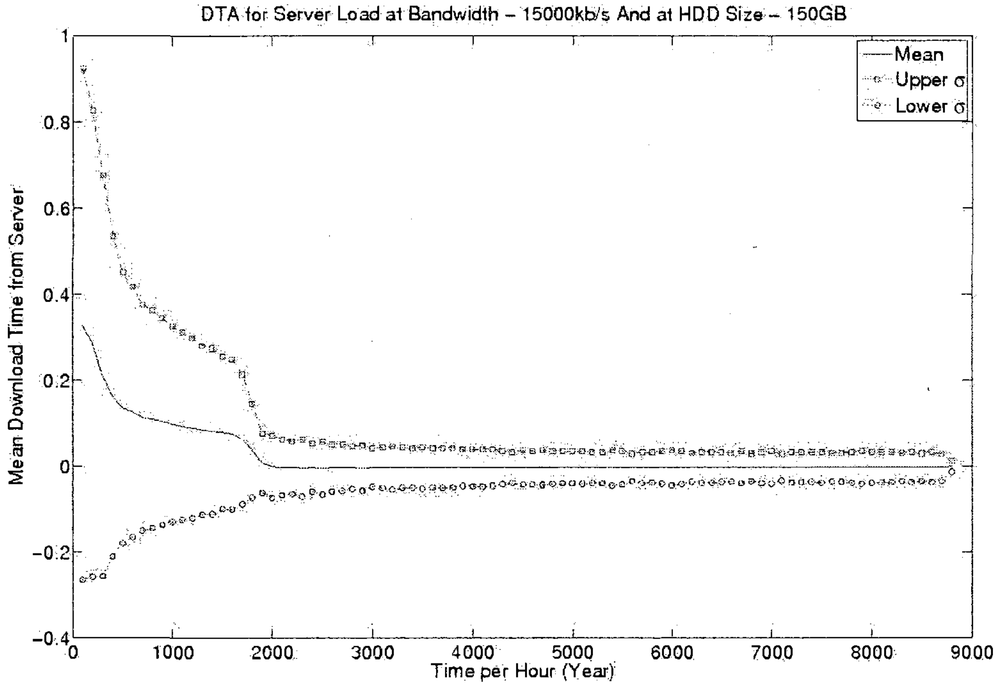


Figure 669: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 15000kb/s

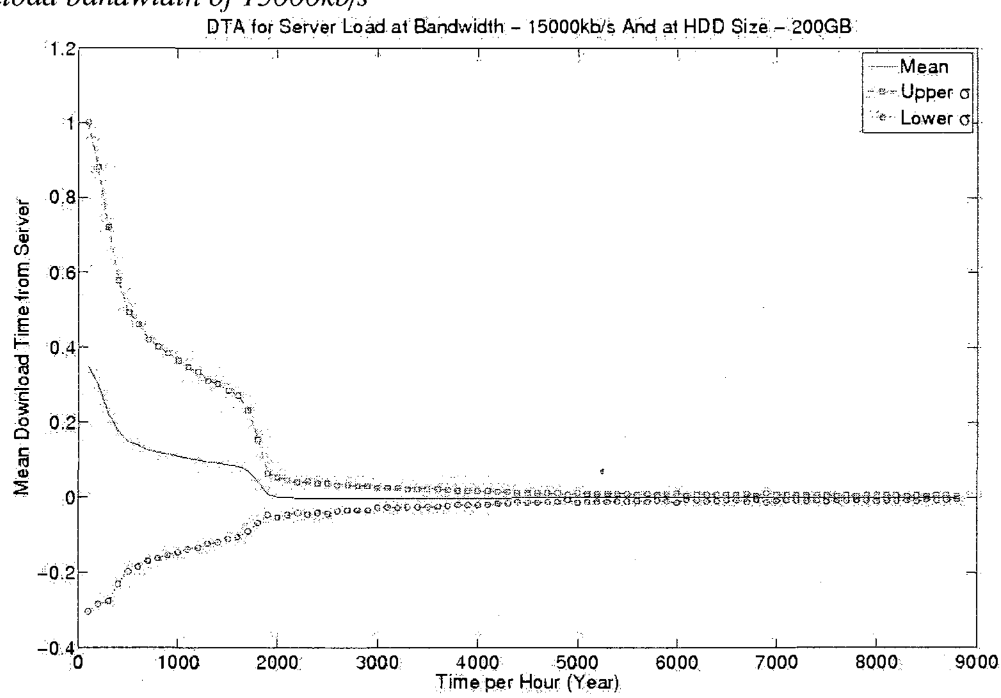


Figure 670: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 25kb/s

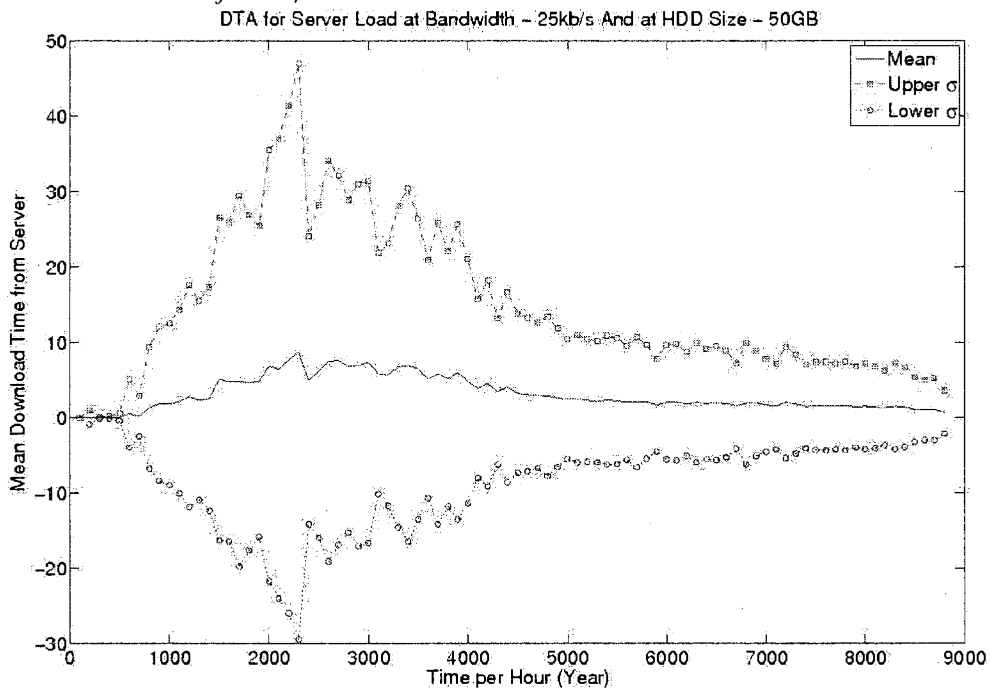


Figure 671: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 25kb/s

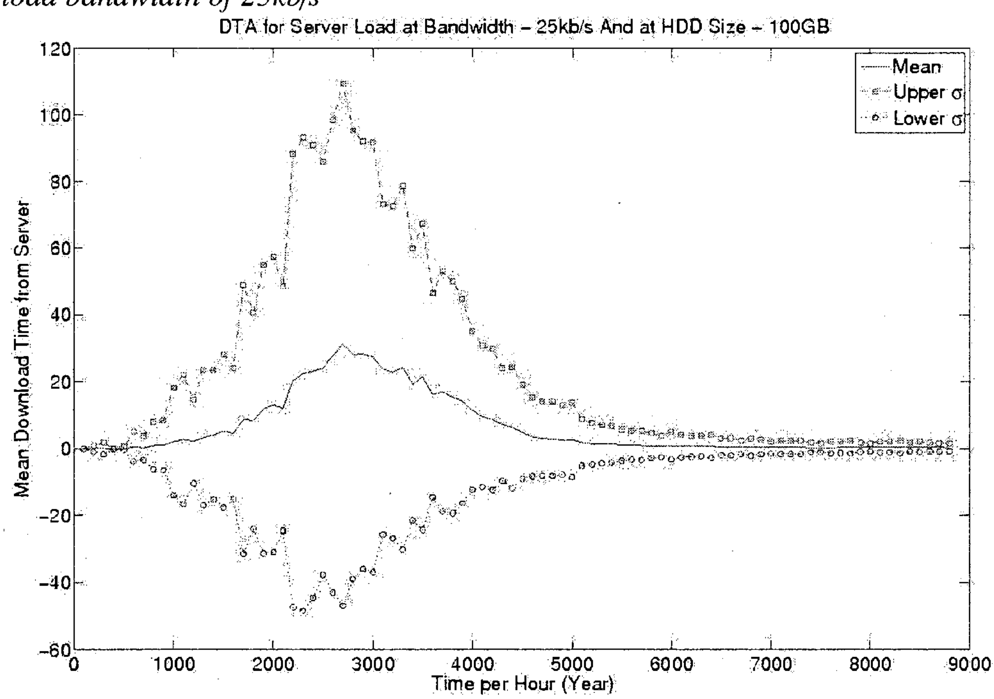


Figure 672: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 25kb/s

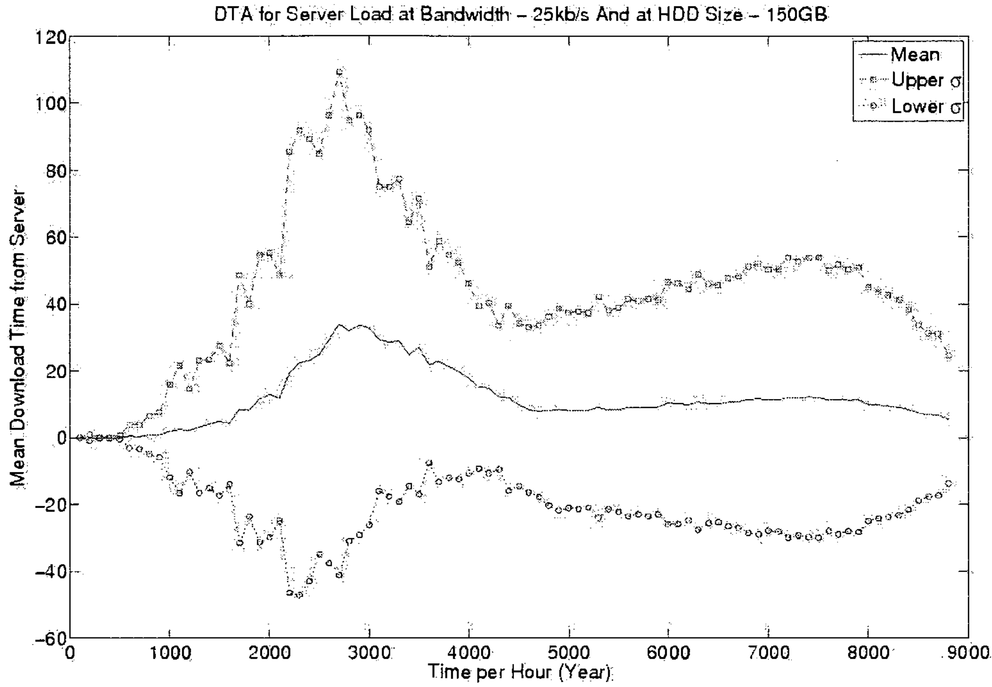


Figure 673: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 25kb/s

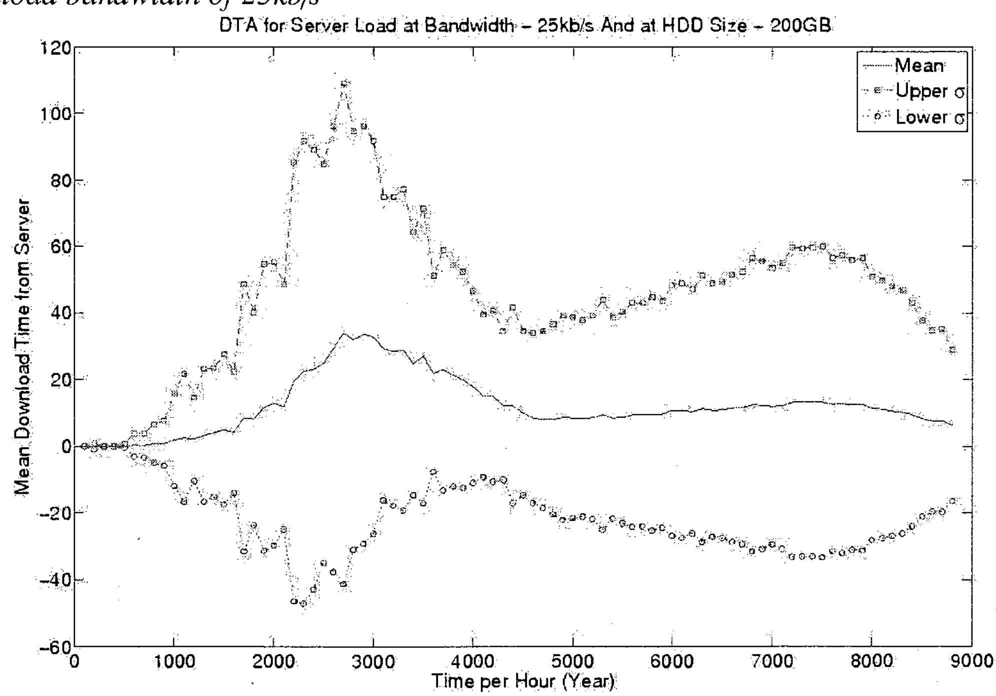


Figure 674: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 50kb/s

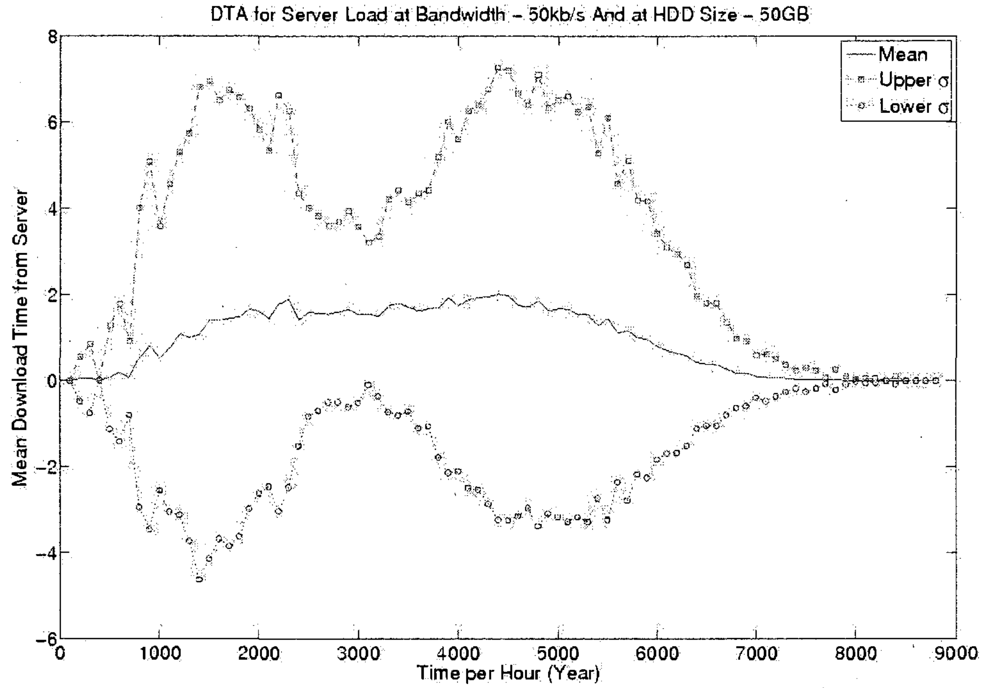


Figure 675: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 50kb/s

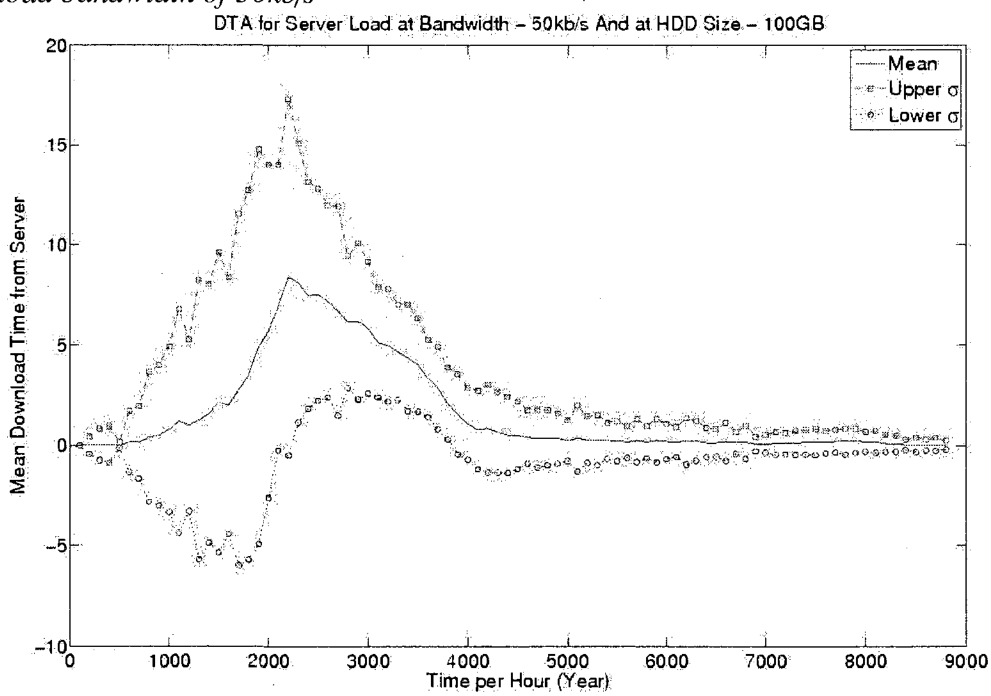


Figure 676: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 50kb/s

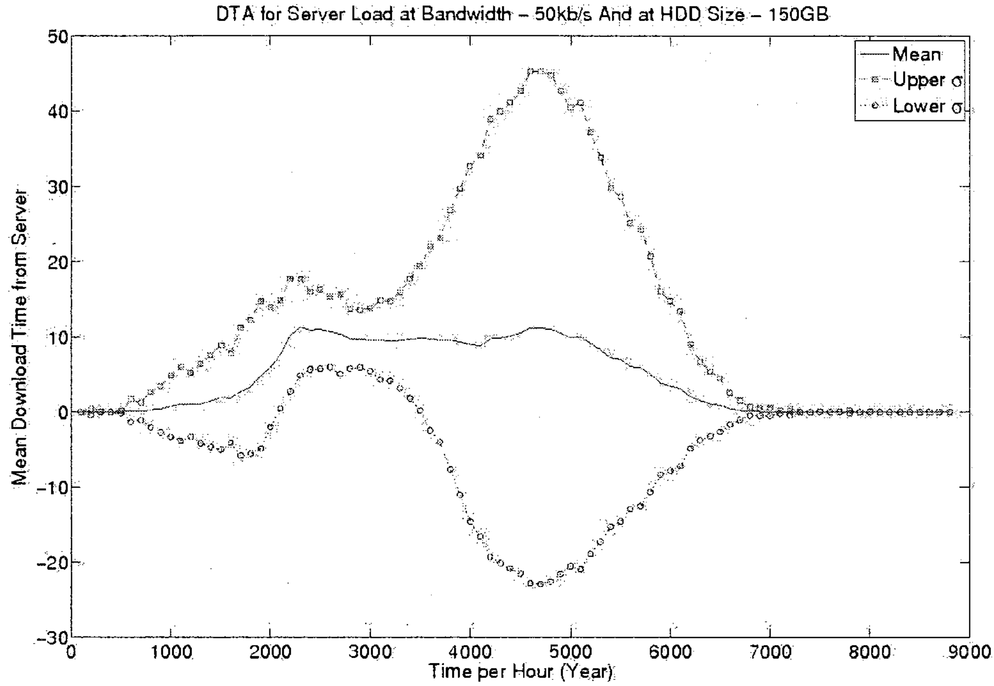


Figure 677: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 50kb/s

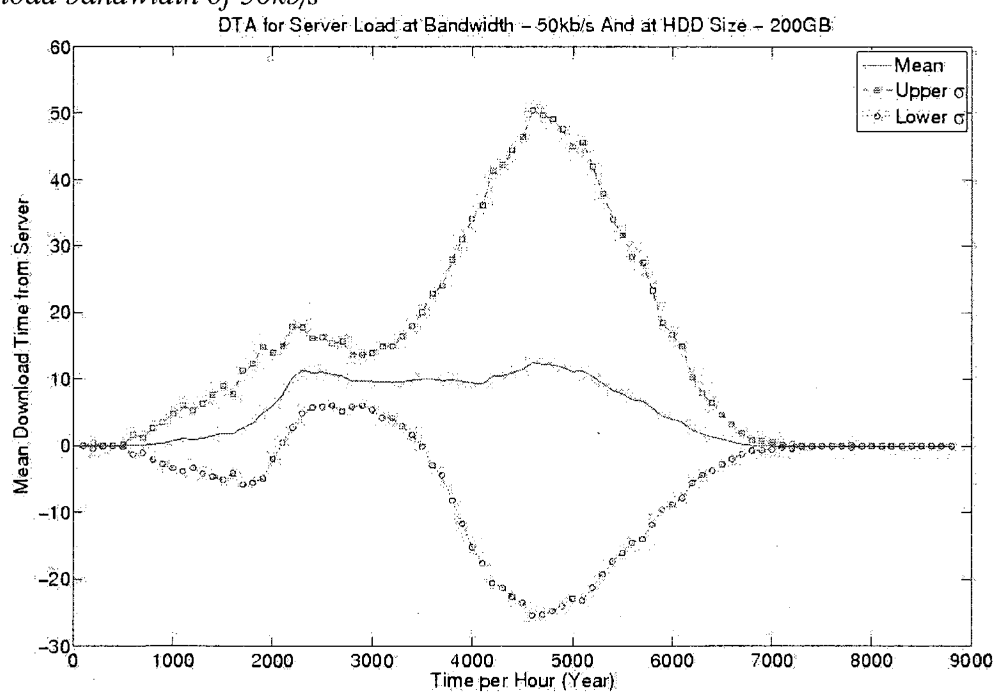


Figure 678: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 100kb/s

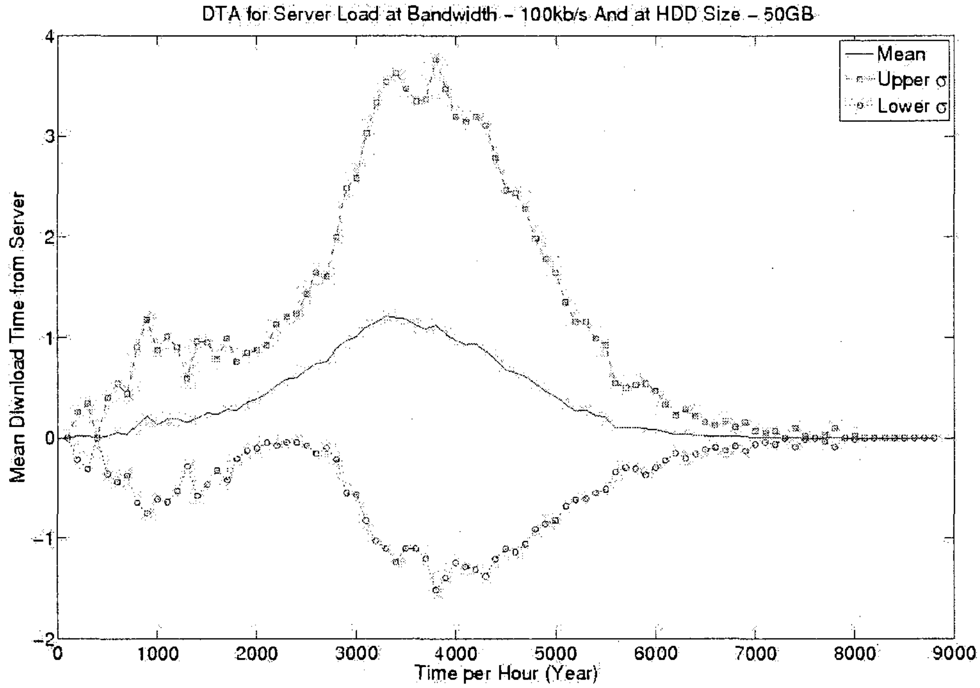


Figure 679: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 100kb/s

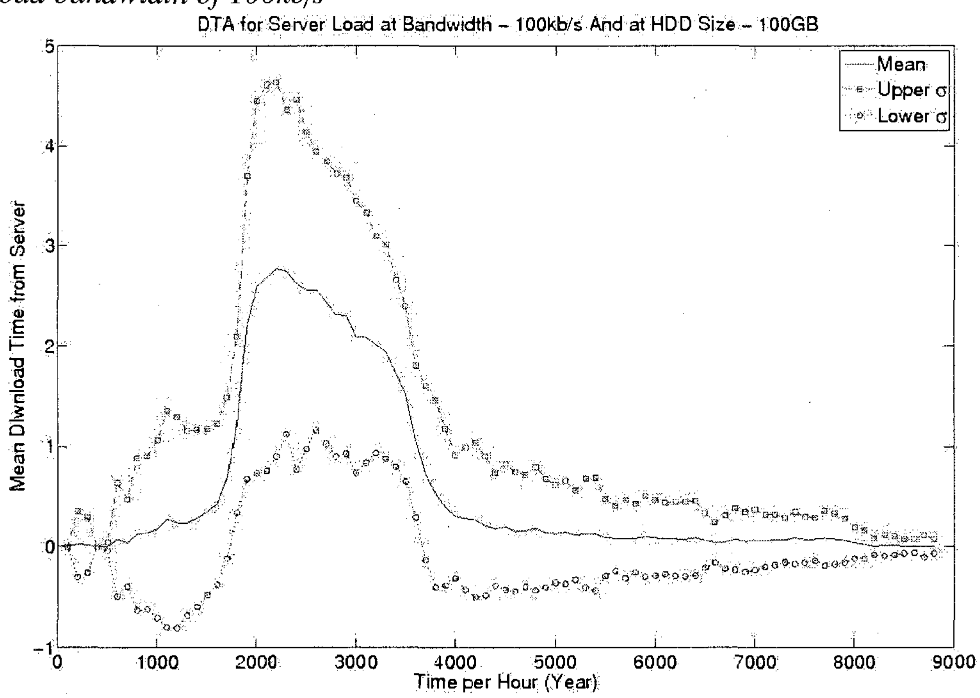


Figure 680: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 100kb/s

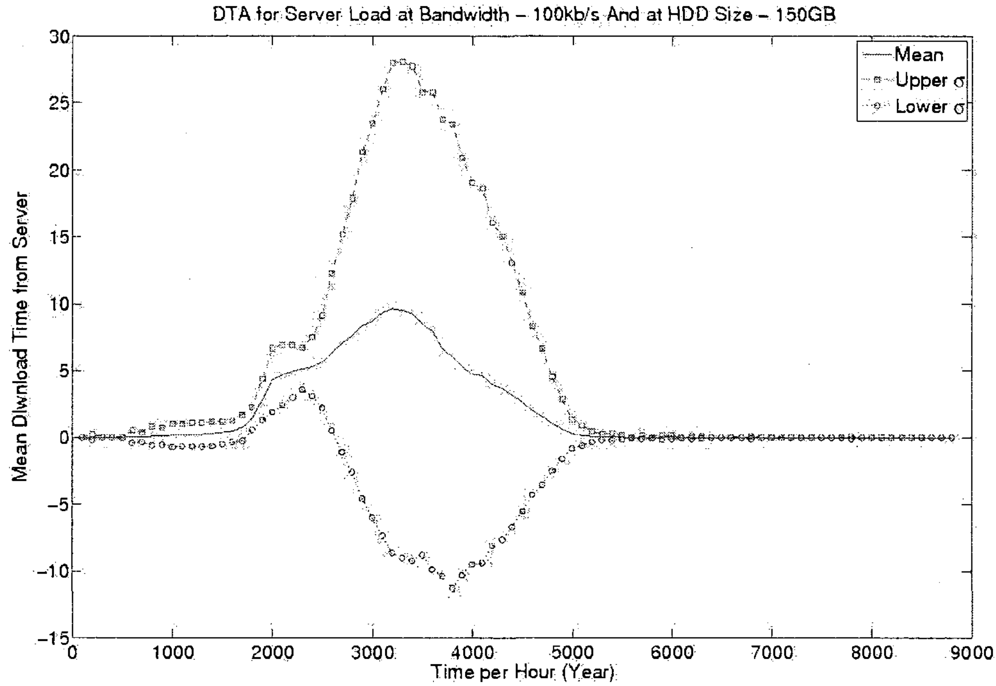


Figure 681: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 100kb/s

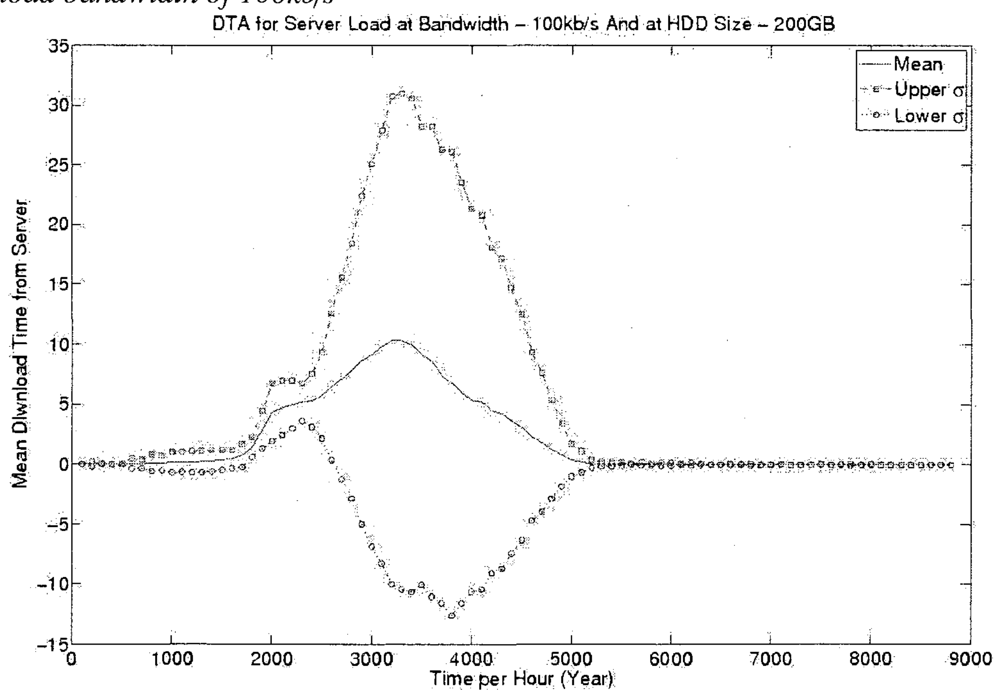


Figure 682: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 128kb/s

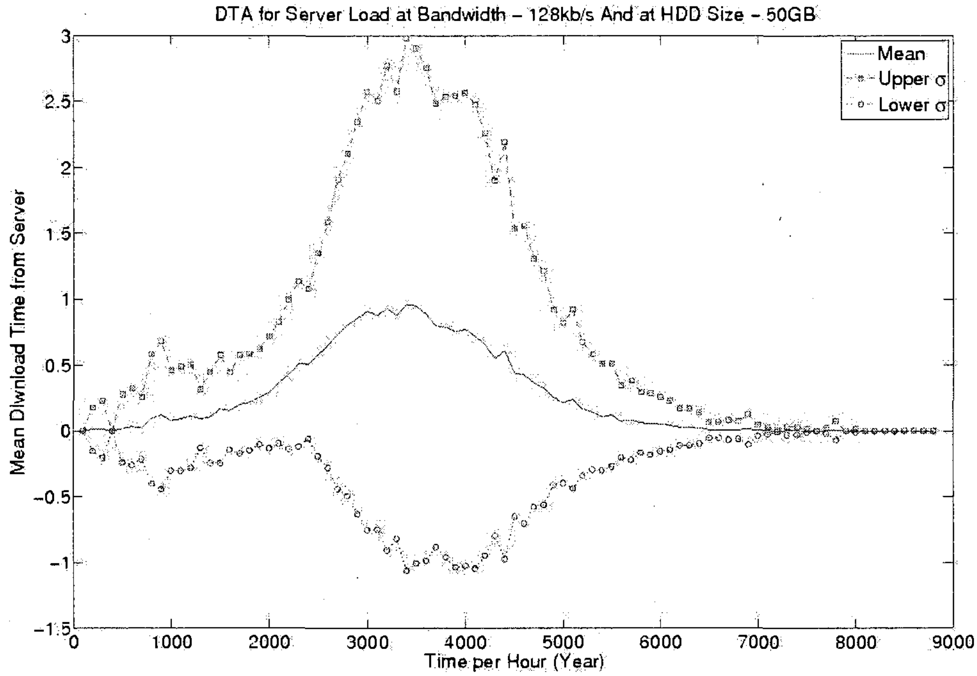


Figure 683: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 128kb/s

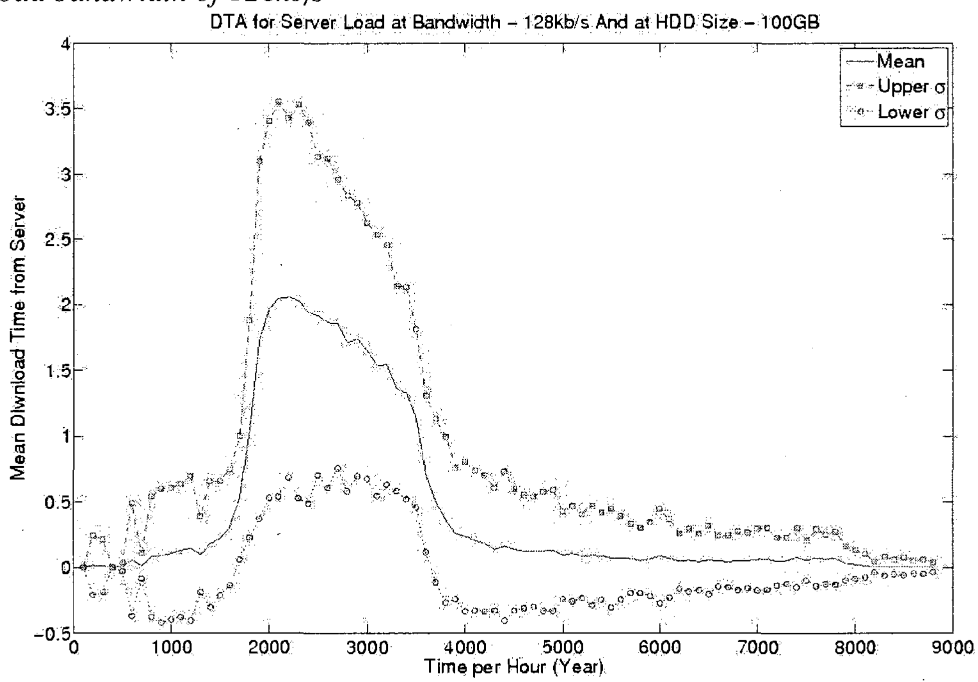


Figure 684: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 128kb/s

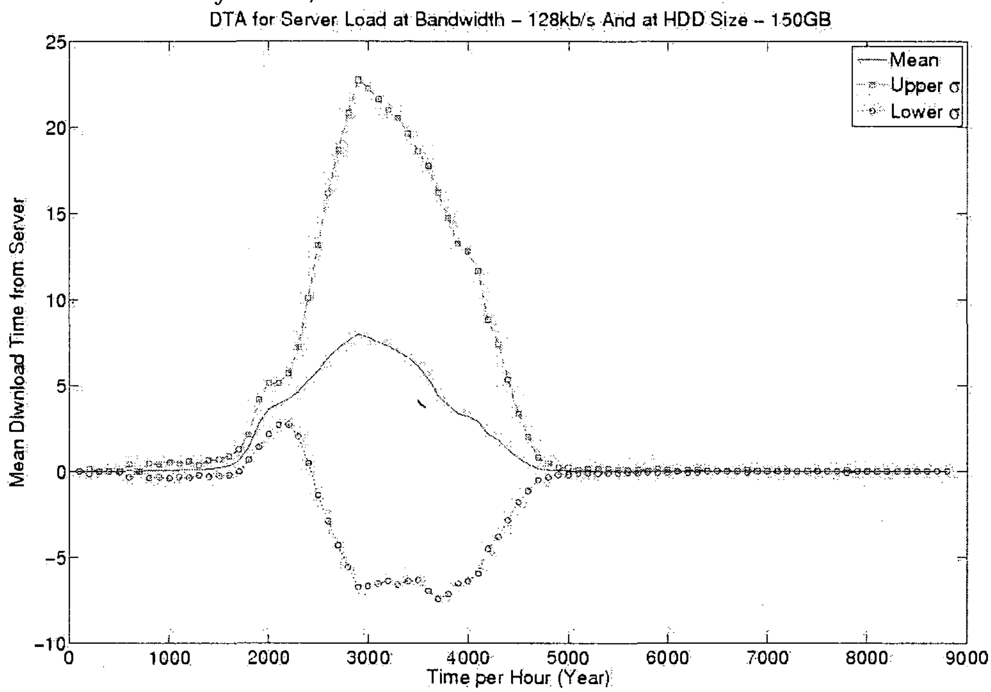


Figure 685: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 128kb/s

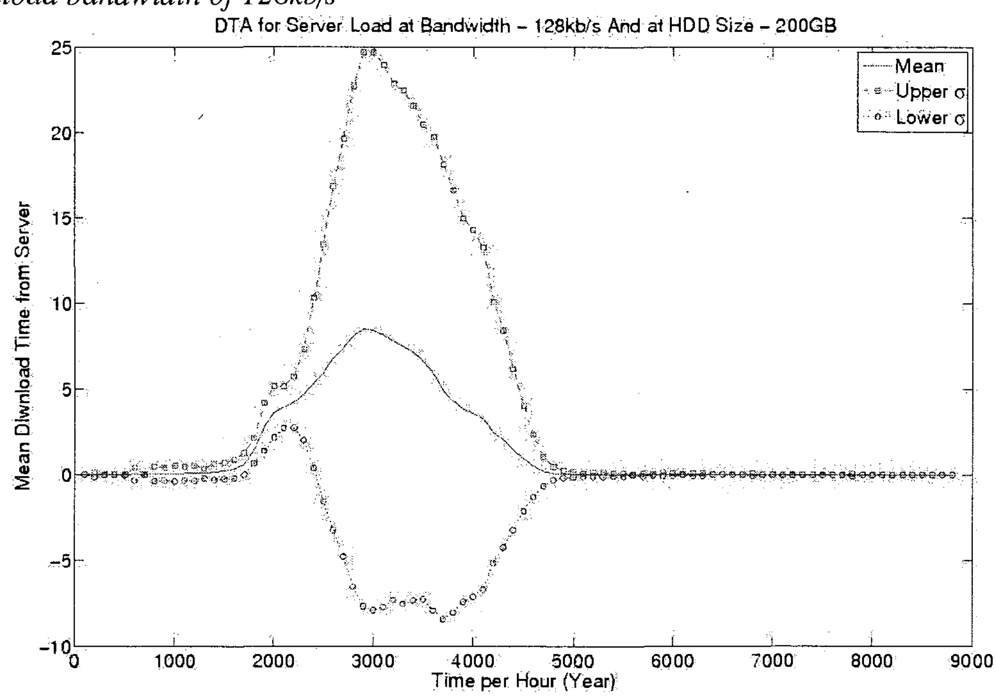


Figure 686: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 256kb/s

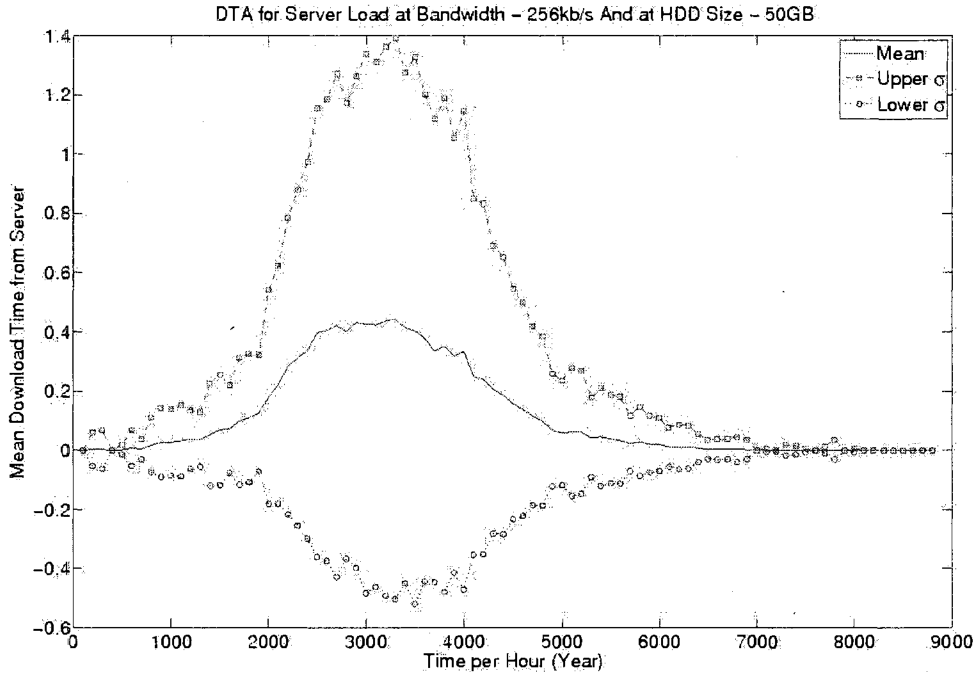


Figure 687: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 256kb/s

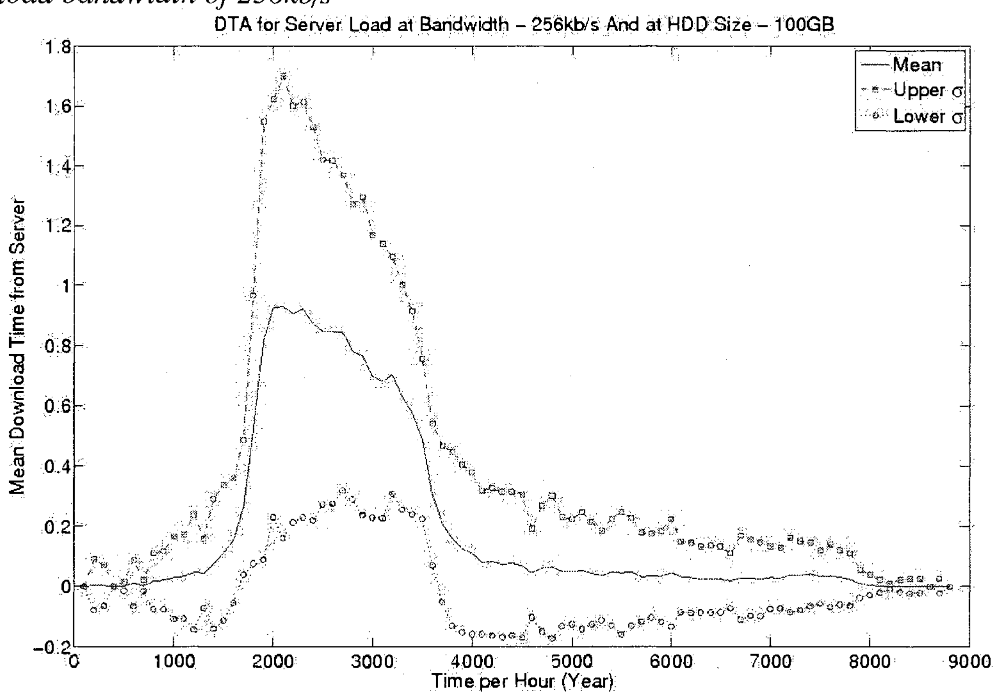


Figure 688: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 256kb/s

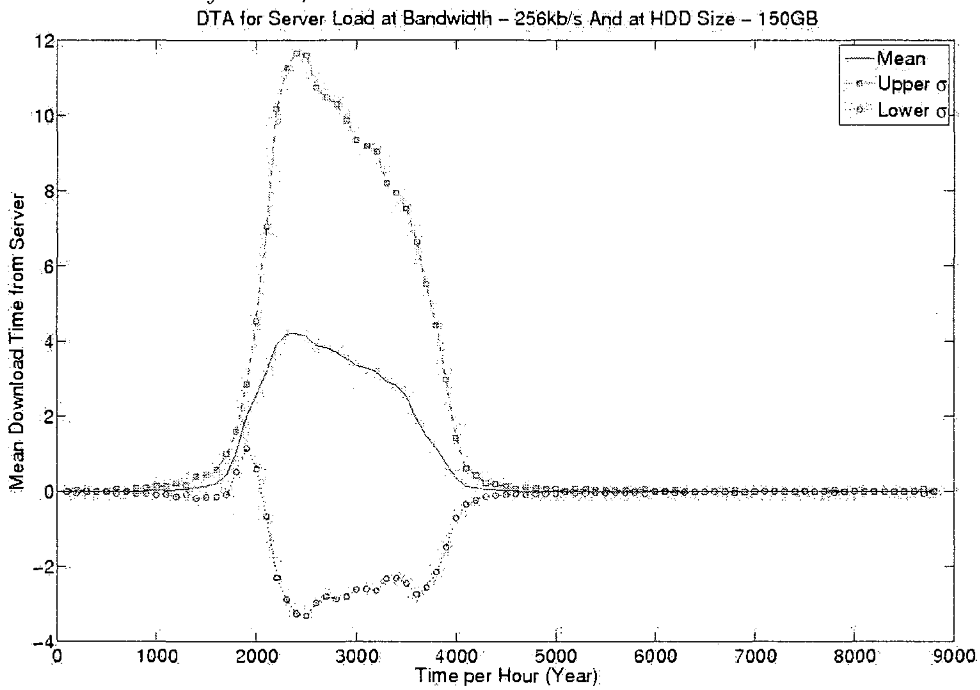


Figure 689: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 256kb/s

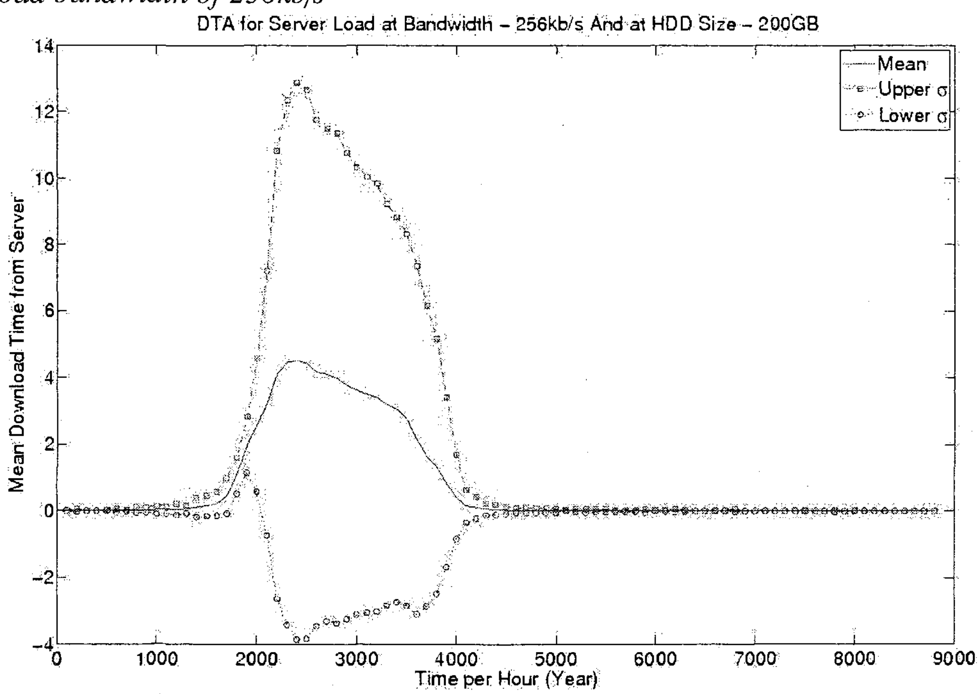


Figure 690: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 512kb/s

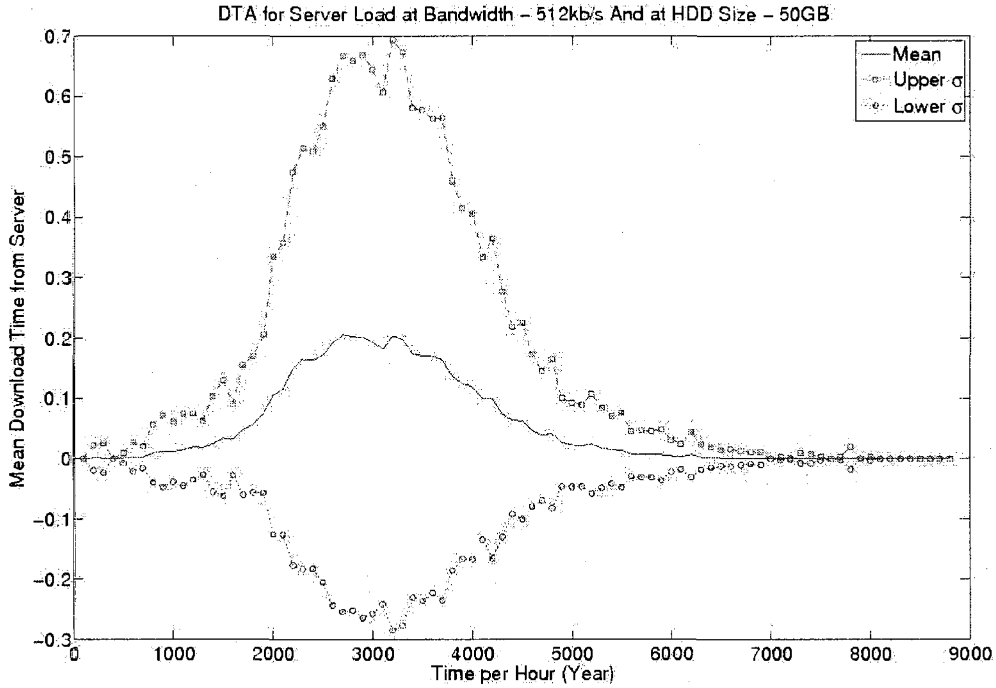


Figure 691: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 512kb/s

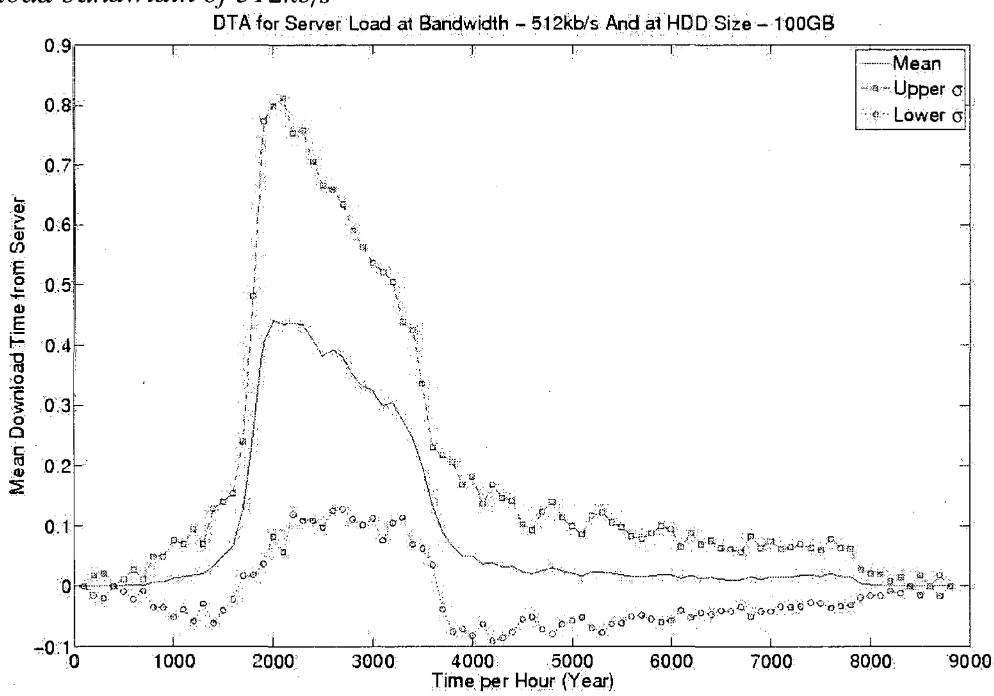


Figure 692: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 512kb/s

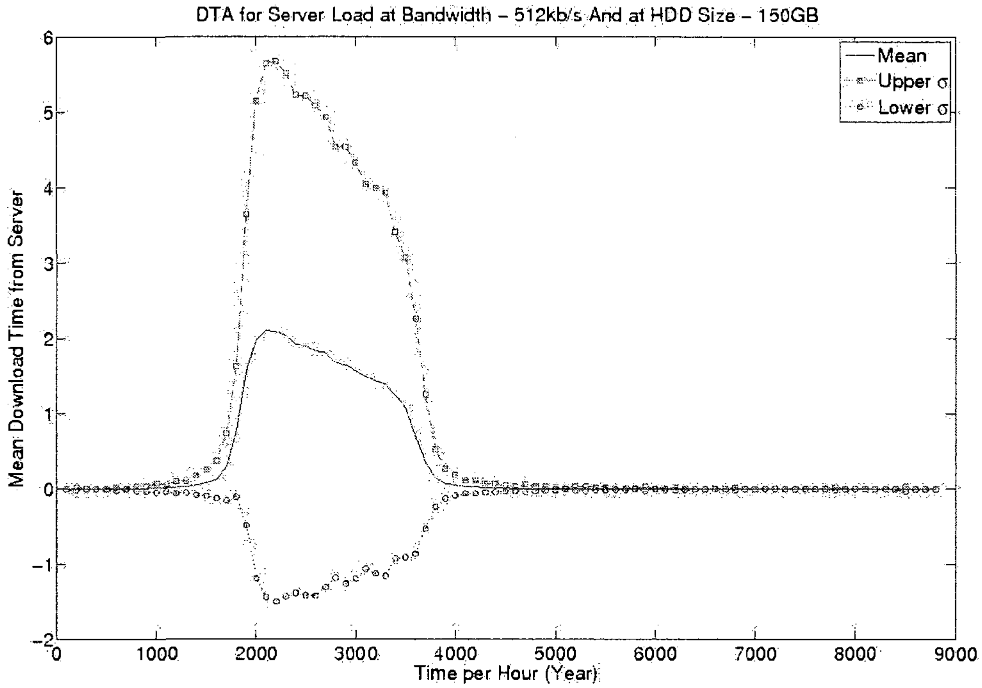


Figure 693: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 512kb/s

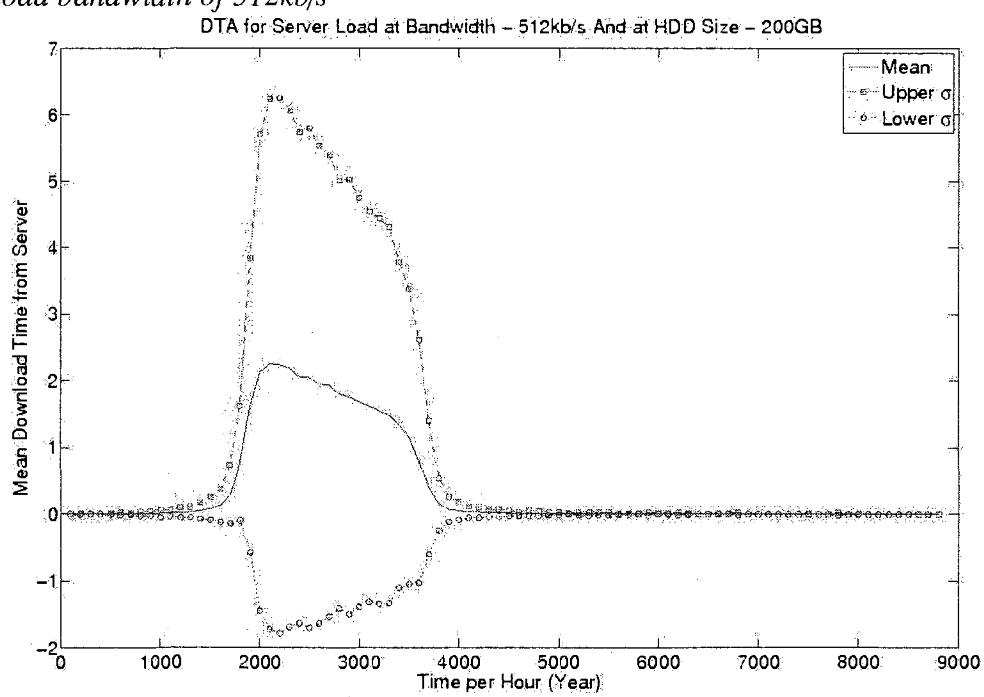


Figure 694: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 1000kb/s

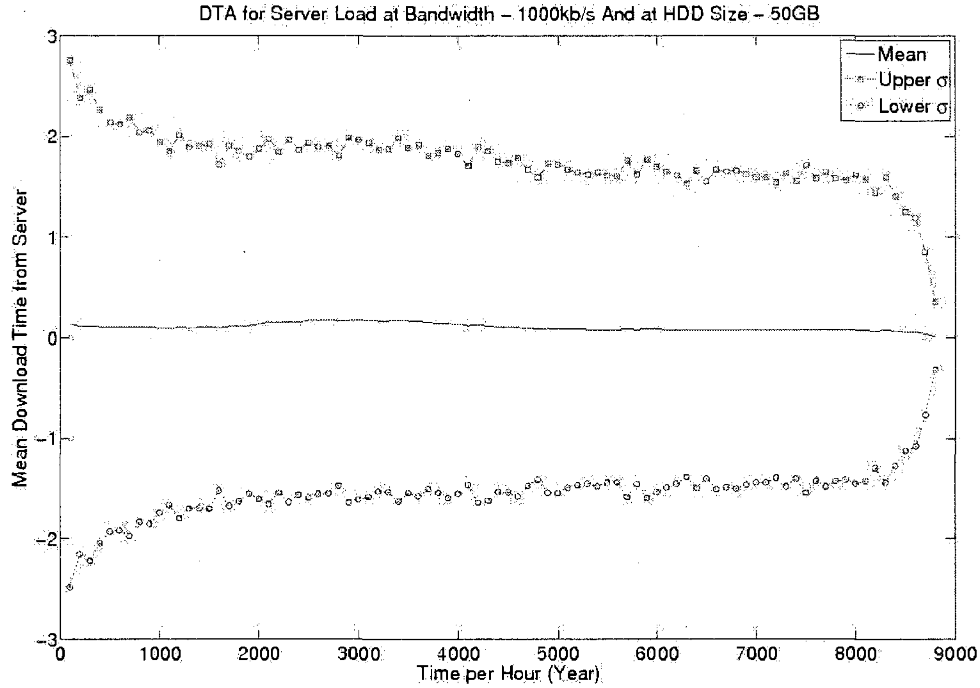


Figure 695: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 1000kb/s

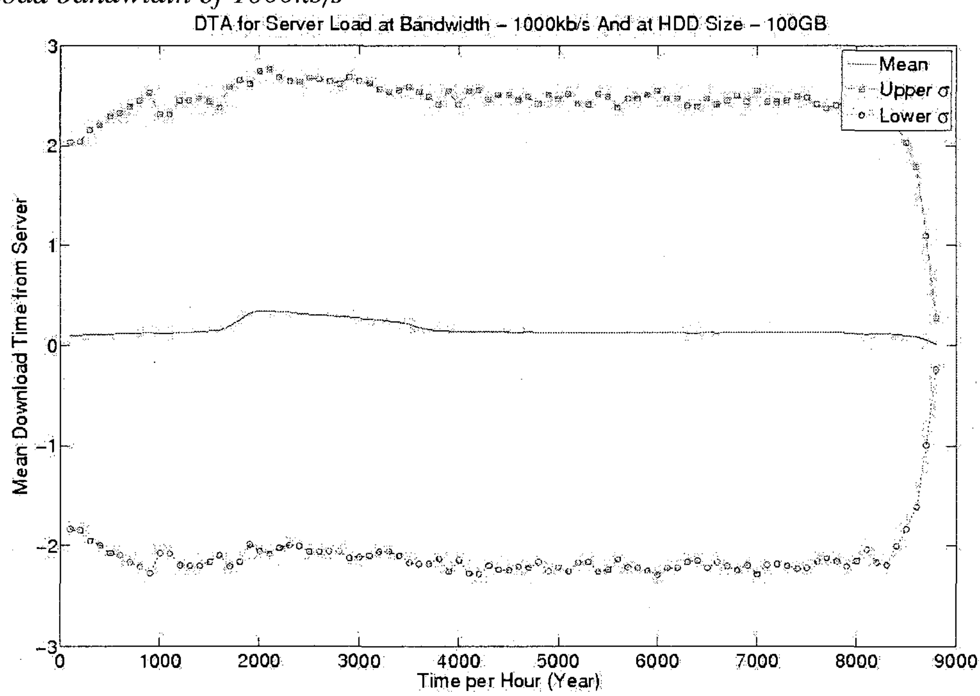


Figure 696: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 1000kb/s

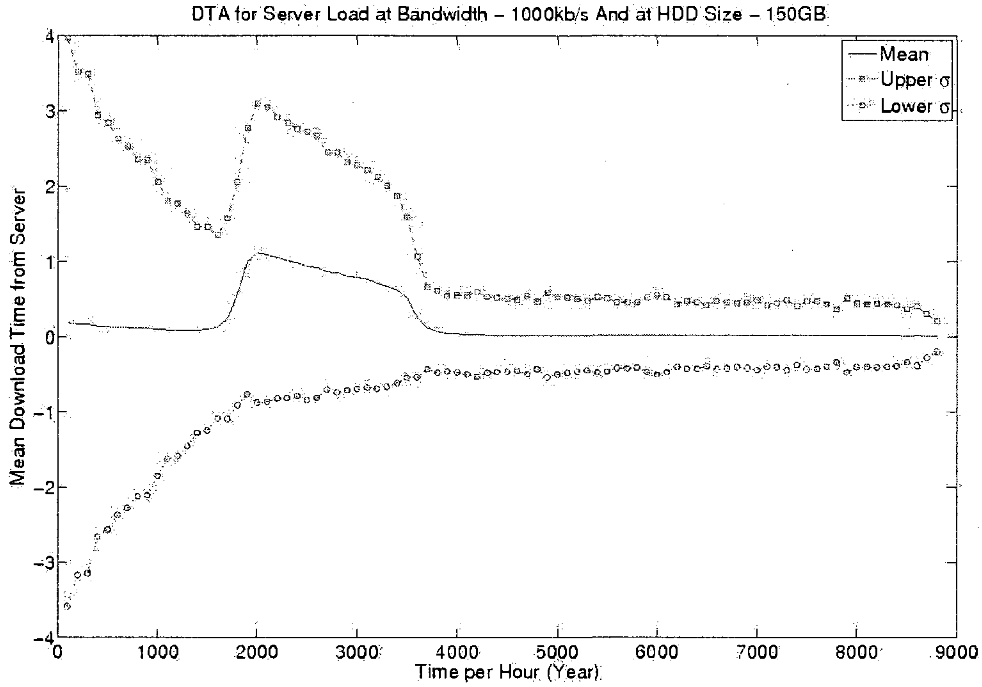


Figure 697: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 1000kb/s

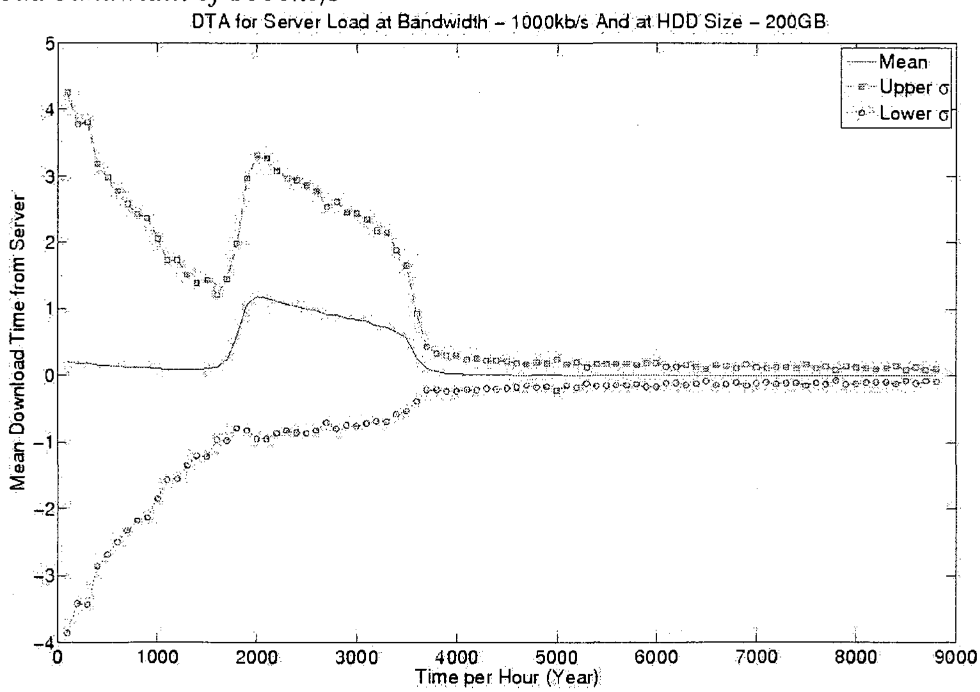


Figure 698: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 2000kb/s

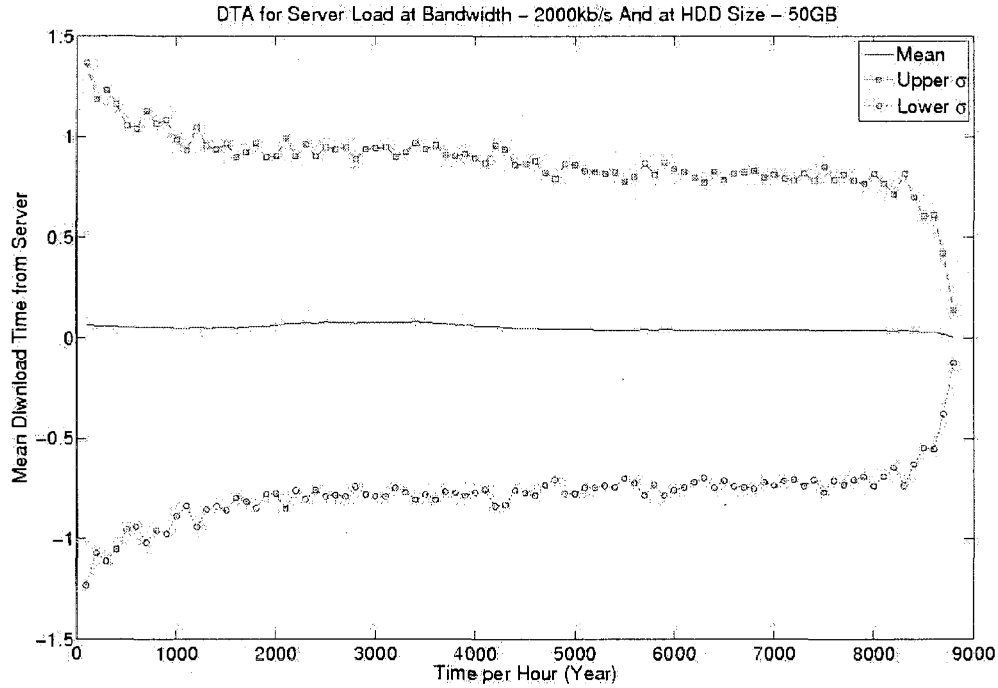


Figure 699: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 2000kb/s

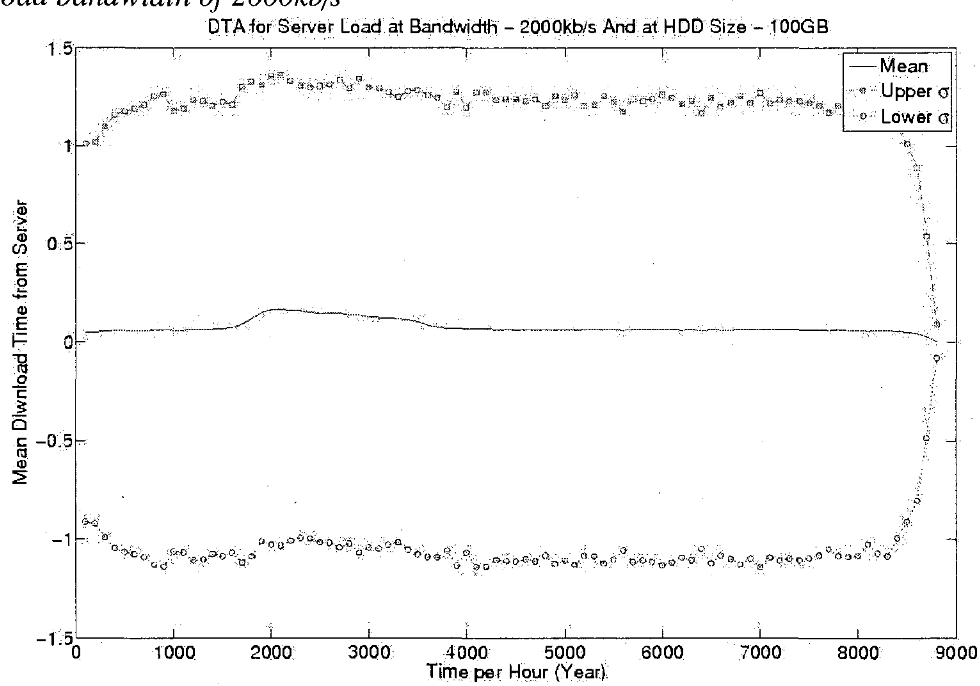


Figure 700: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 2000kb/s

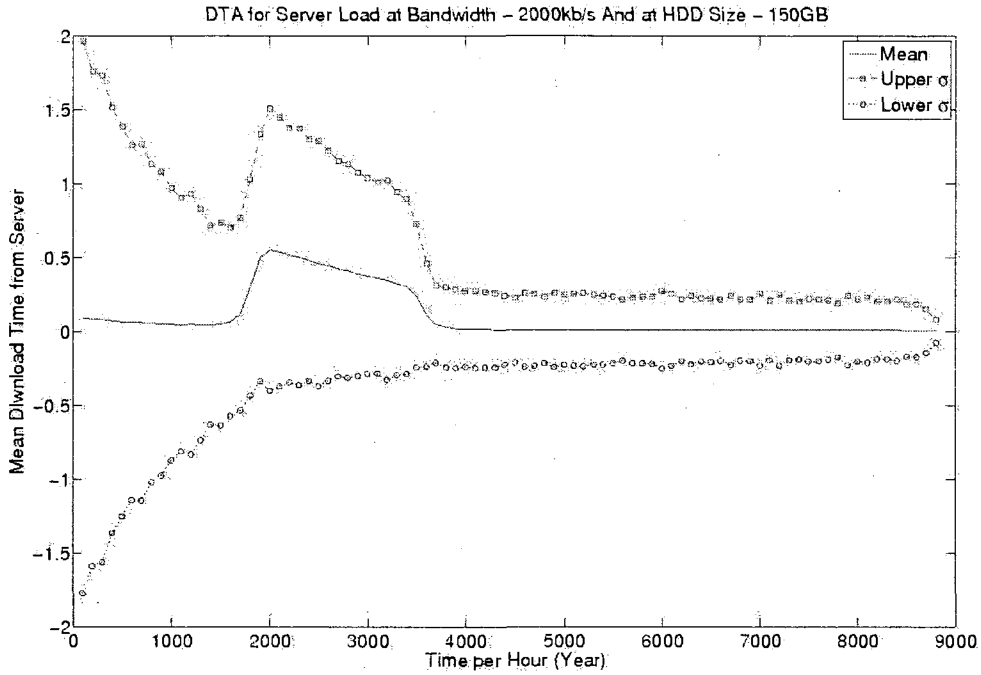


Figure 701: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 2000kb/s

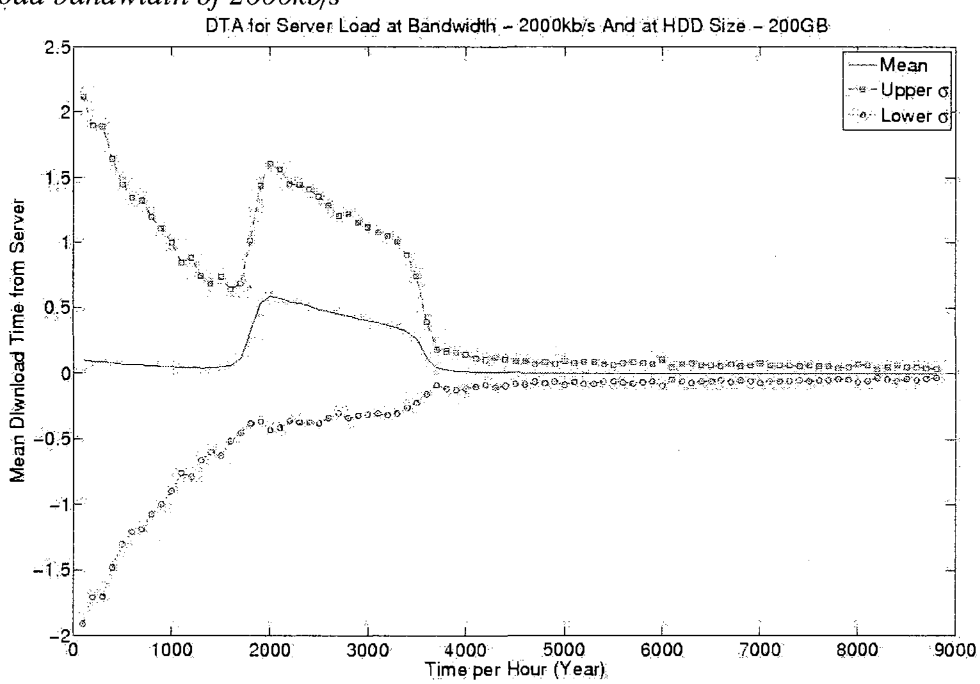


Figure 702: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 5000kb/s

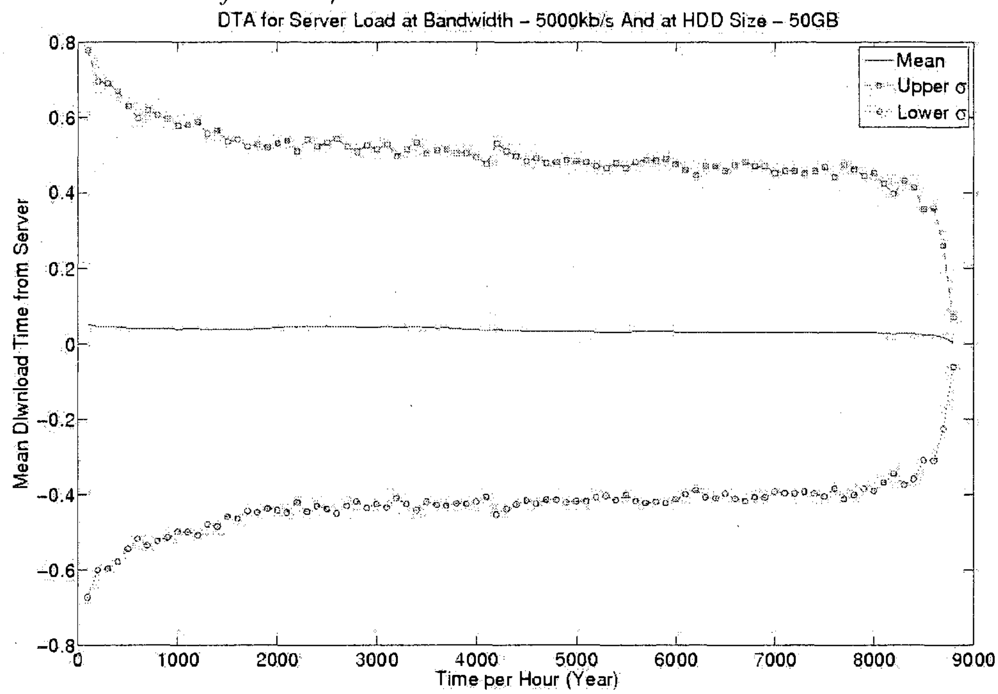


Figure 703: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 5000kb/s

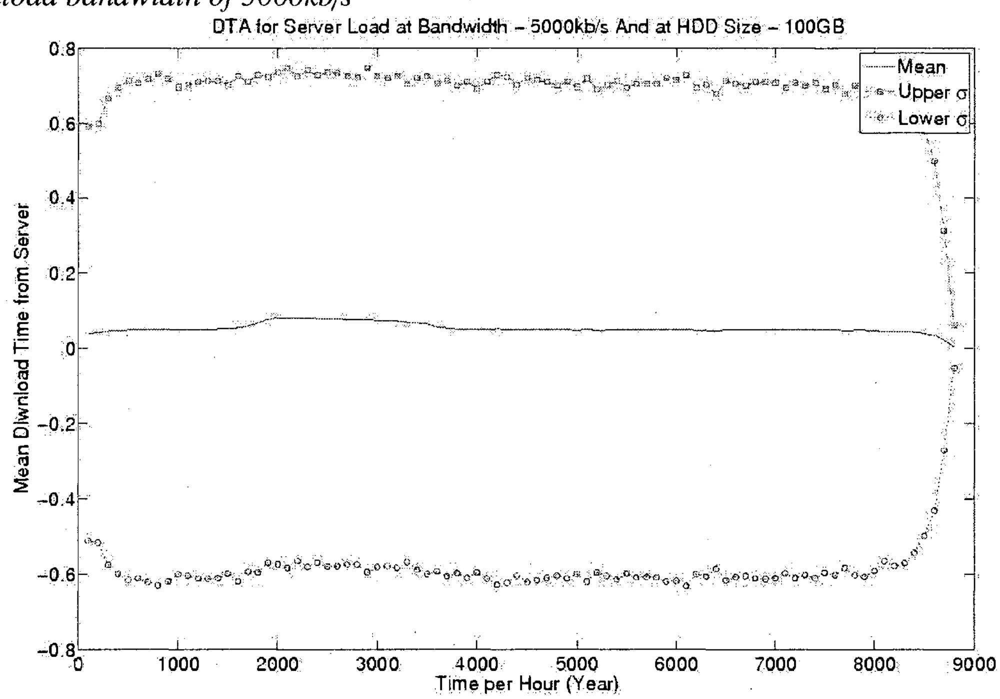


Figure 704: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 5000kb/s

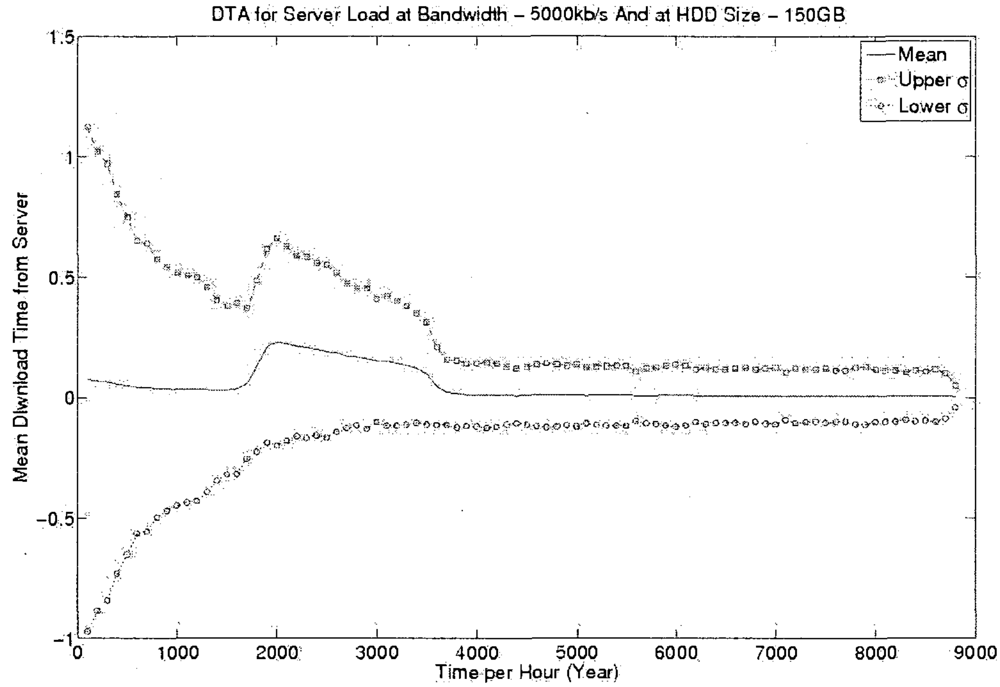


Figure 705: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 5000kb/s

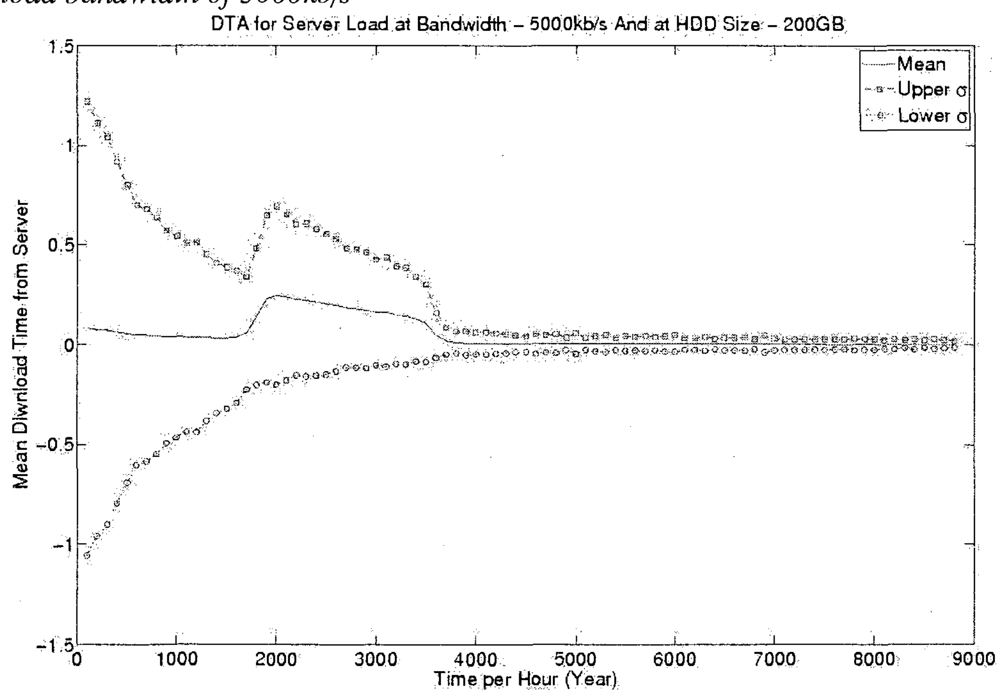


Figure 706: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 10000kb/s

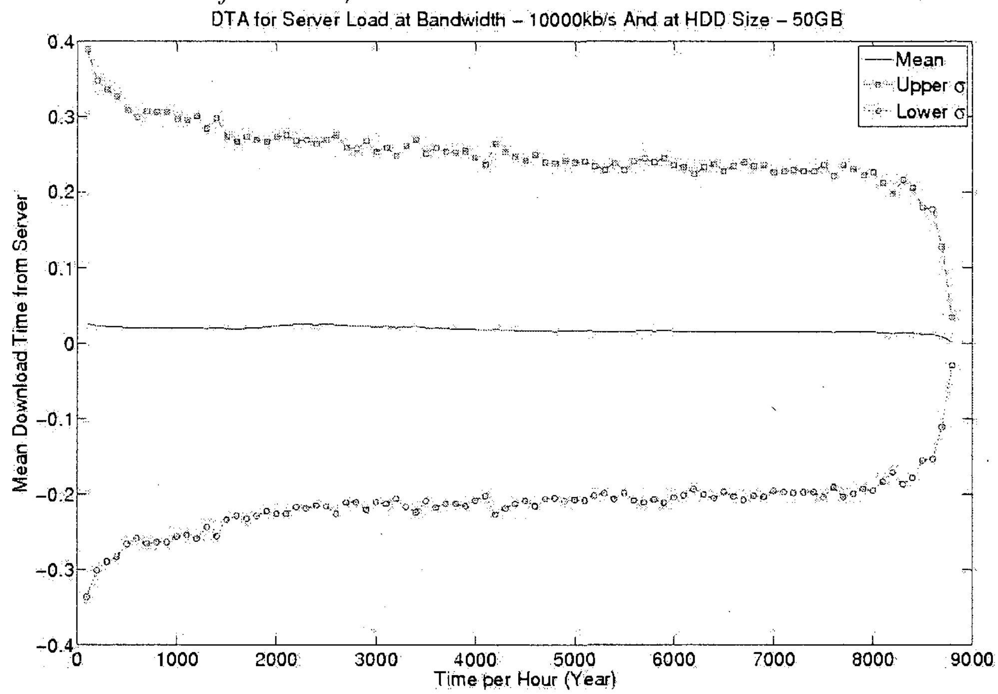


Figure 707: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 10000kb/s

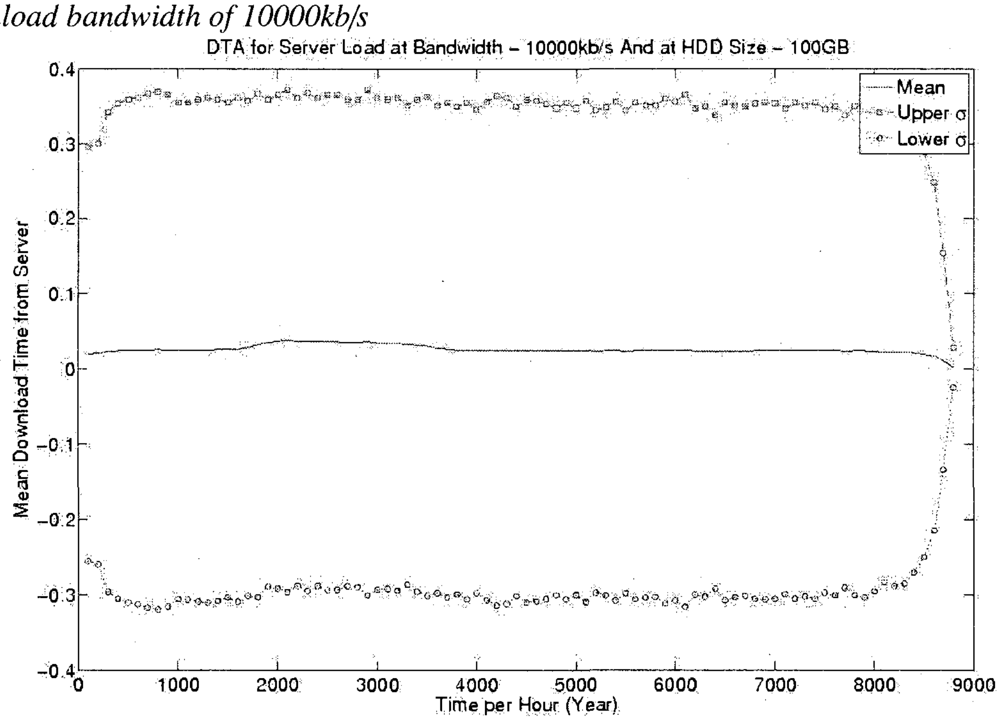


Figure 708: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 10000kb/s

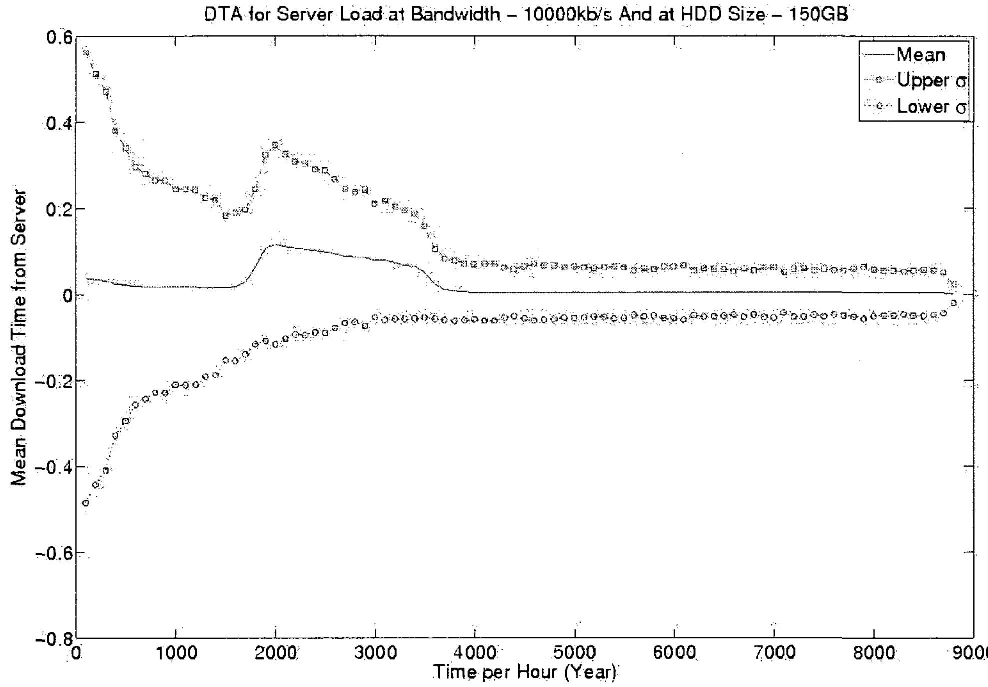


Figure 709: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 10000kb/s

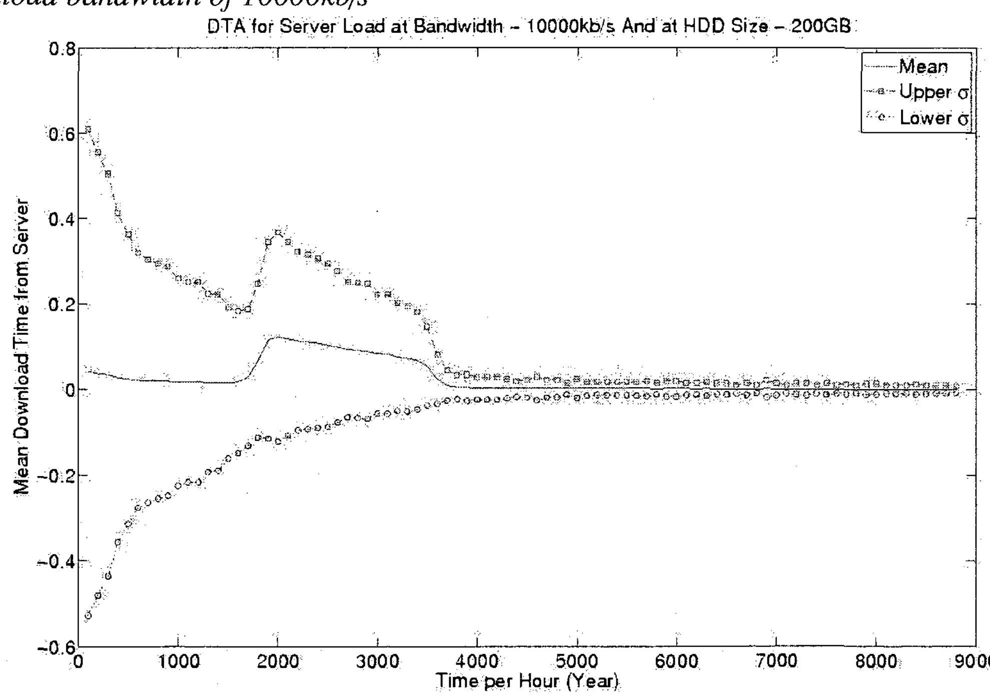


Figure 710: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 15000kb/s

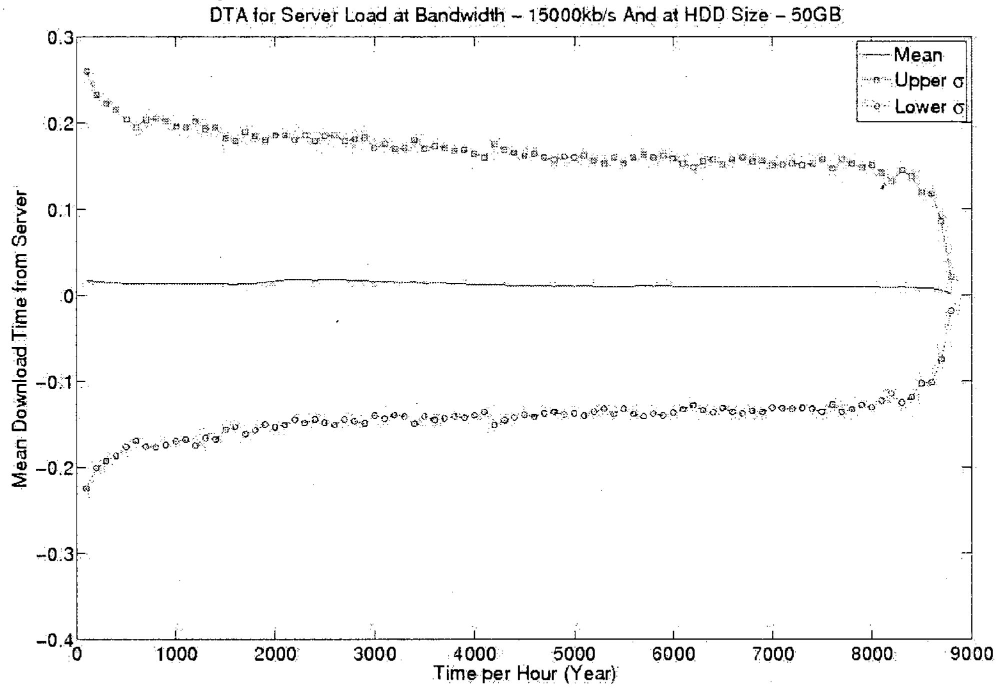


Figure 711: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 15000kb/s

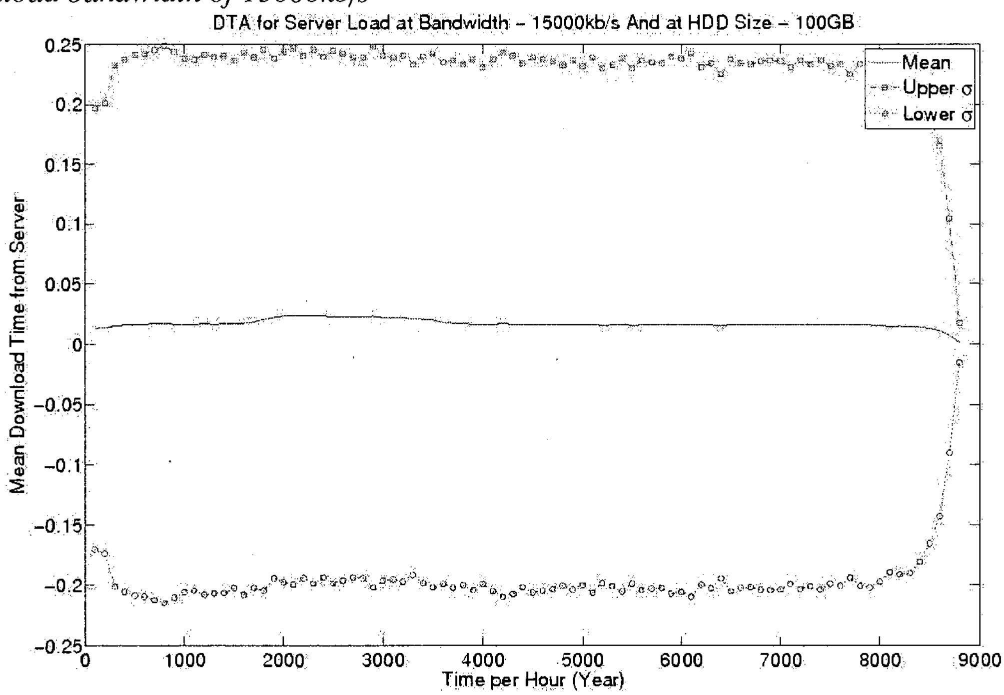


Figure 712: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 15000kb/s

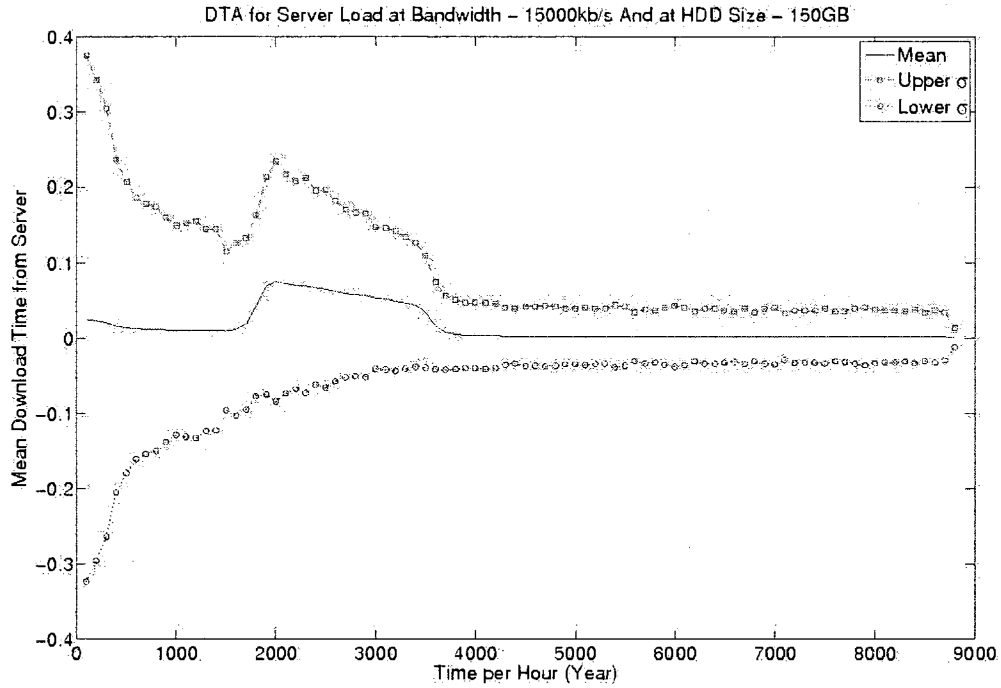


Figure 713: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 15000kb/s

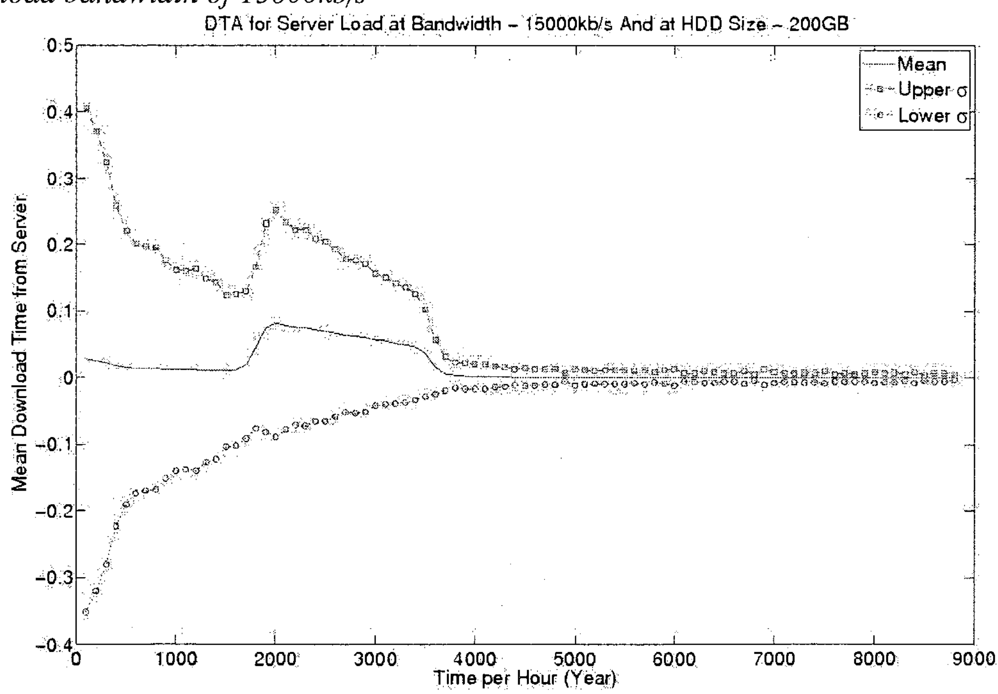


Figure 714: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 25kb/s

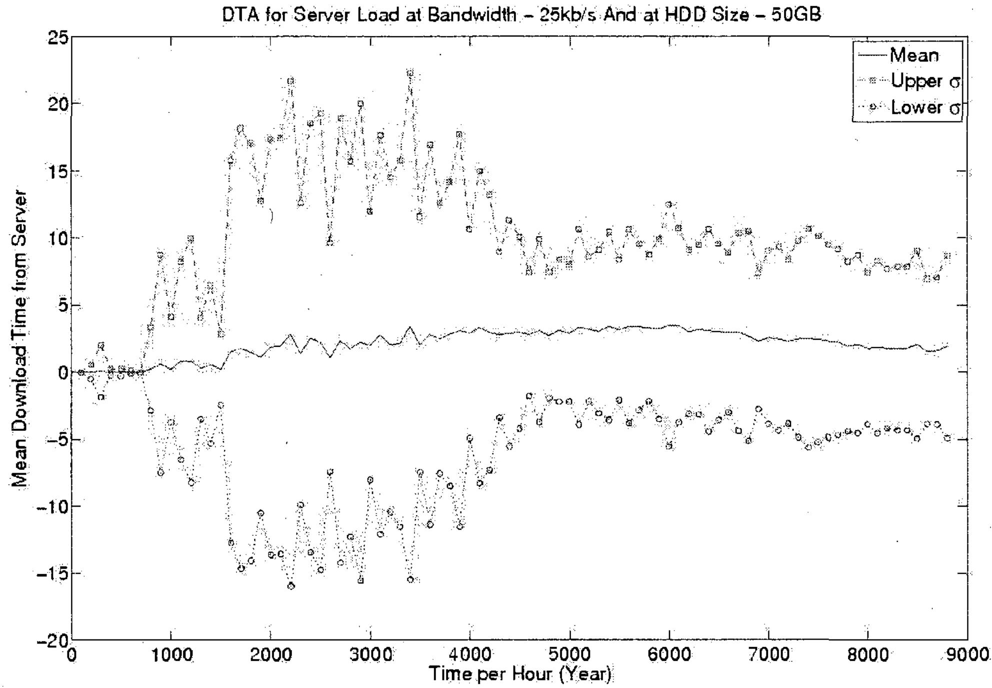


Figure 715: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 25kb/s

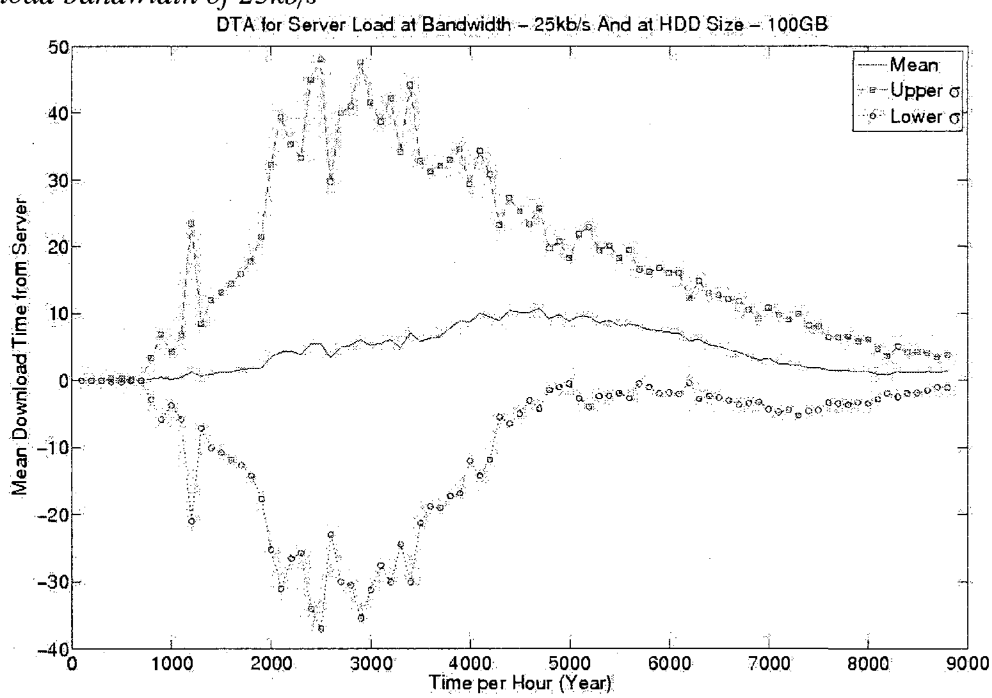


Figure 716: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 25kb/s

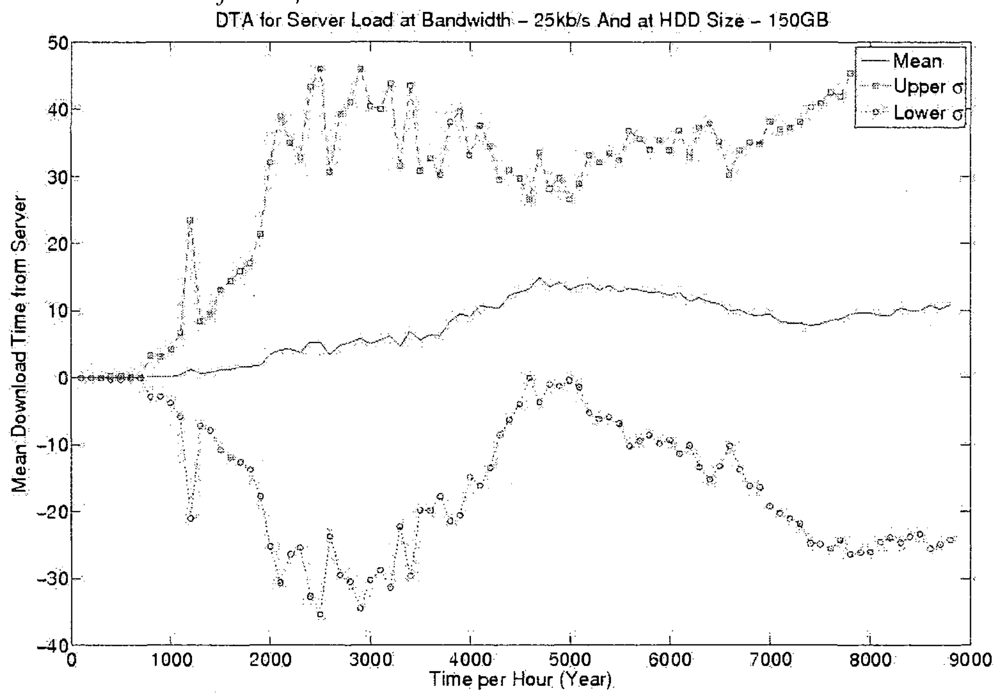


Figure 717: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 25kb/s

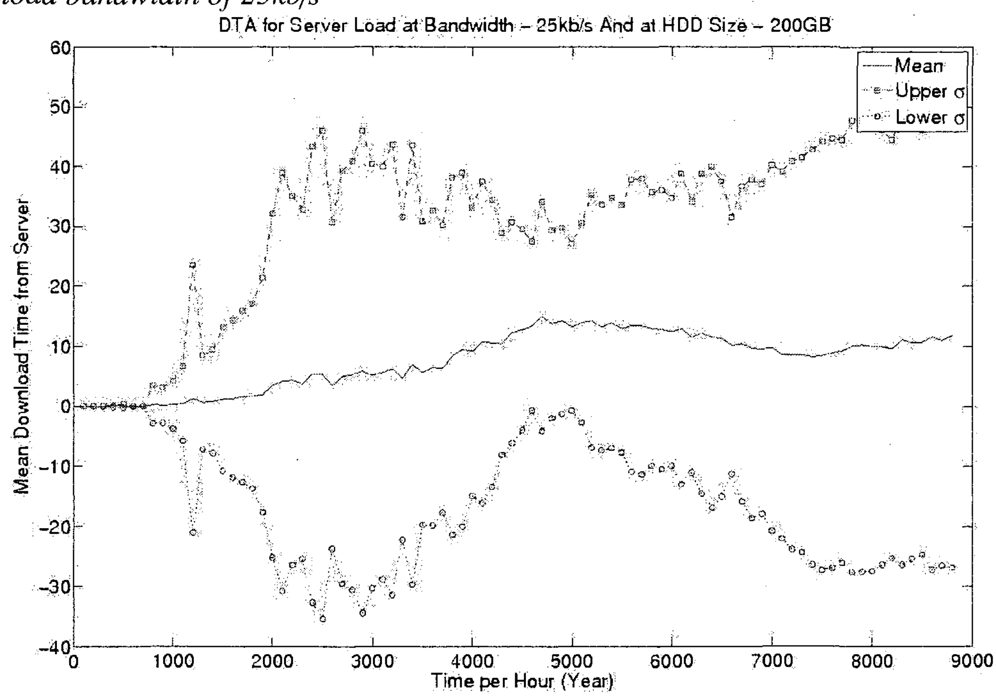


Figure 718: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 50kb/s

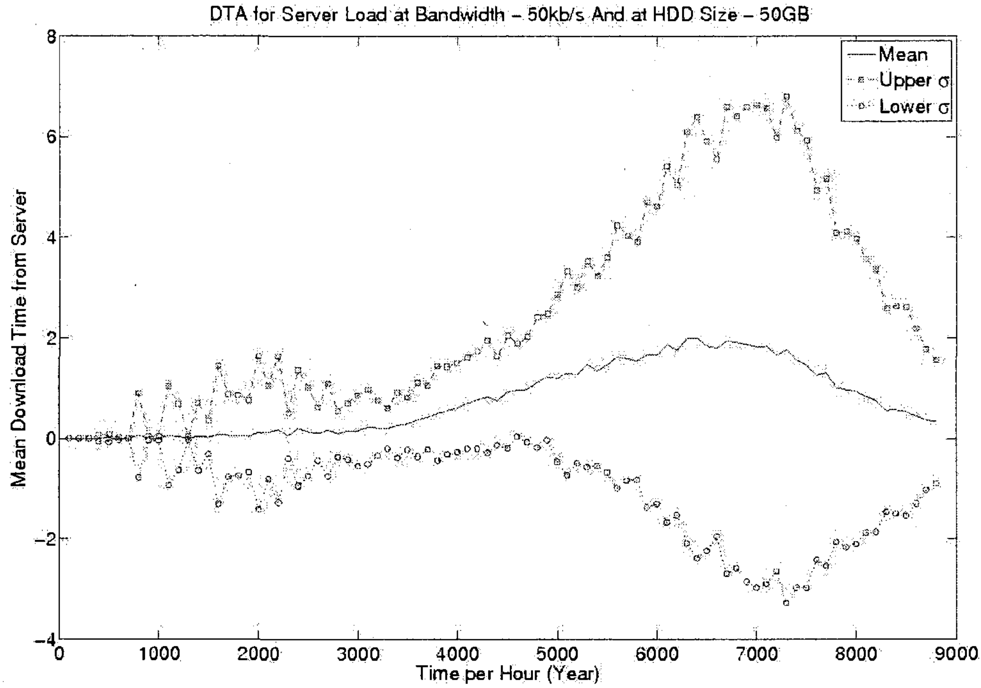


Figure 719: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 50kb/s

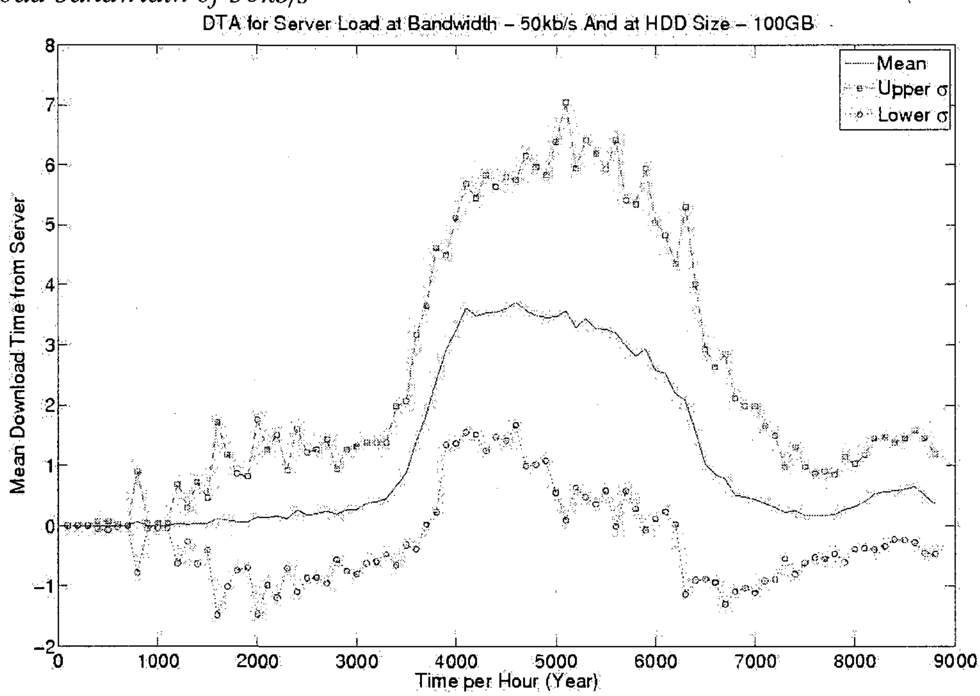


Figure 720: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 50kb/s

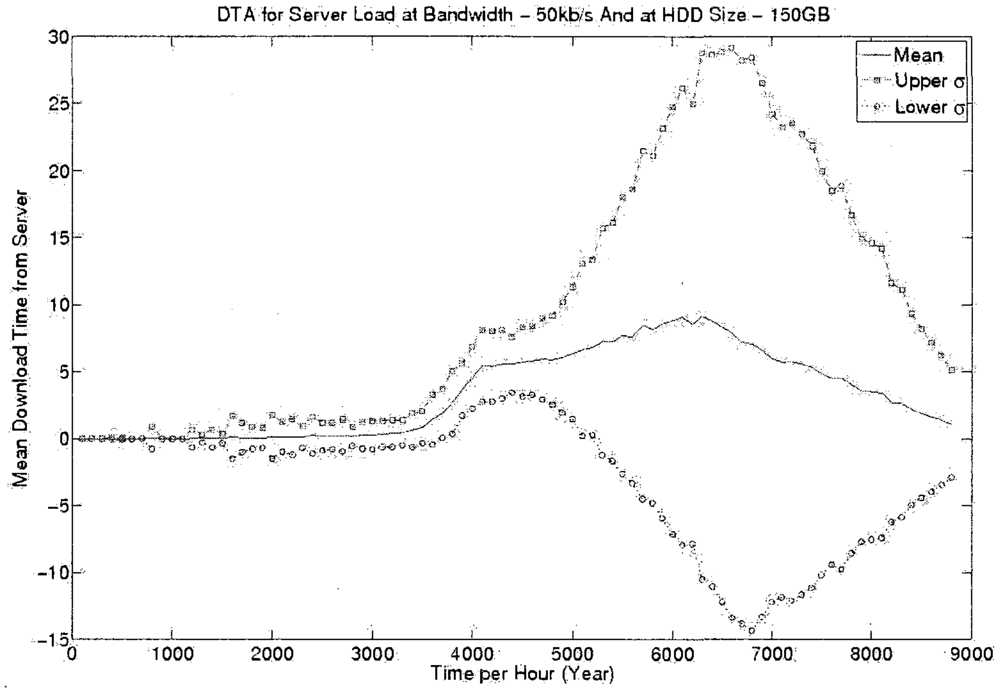


Figure 721: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 50kb/s

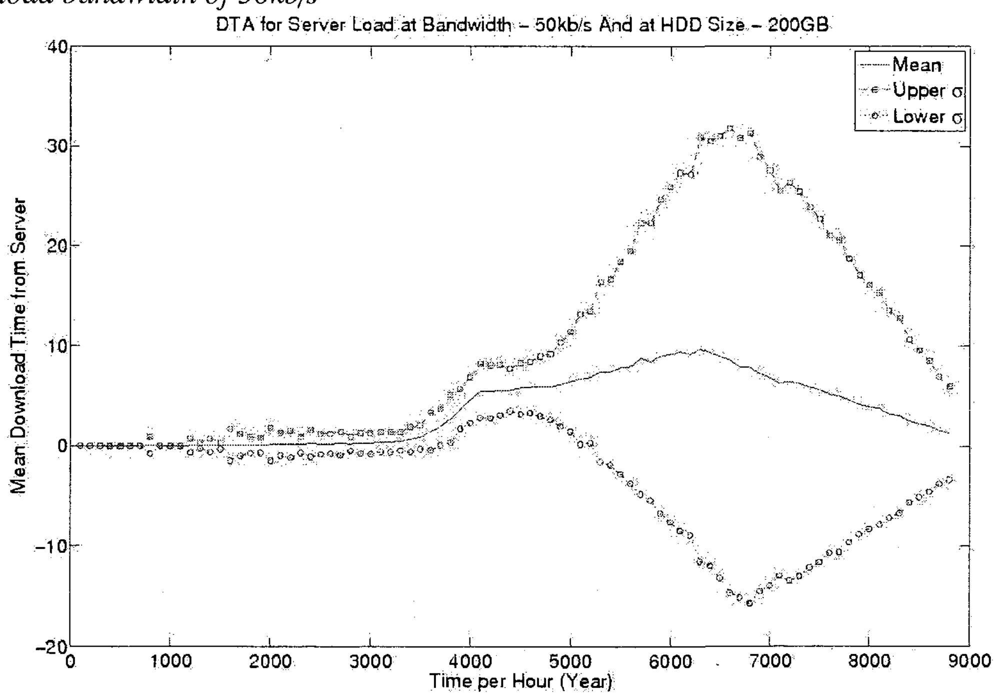


Figure 722: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 100kb/s

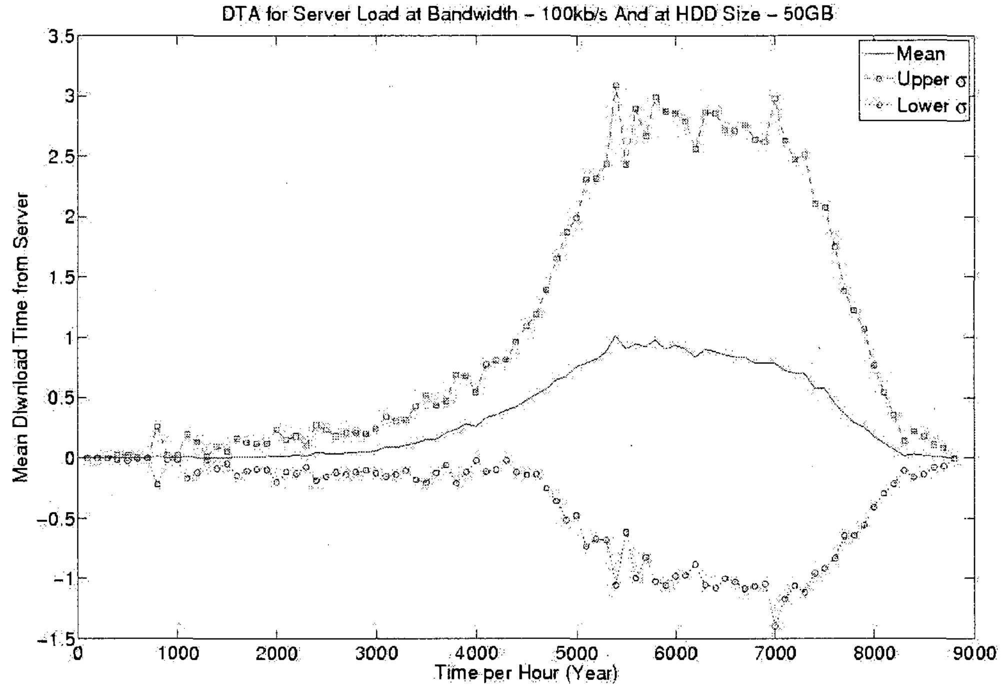


Figure 723: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 100kb/s

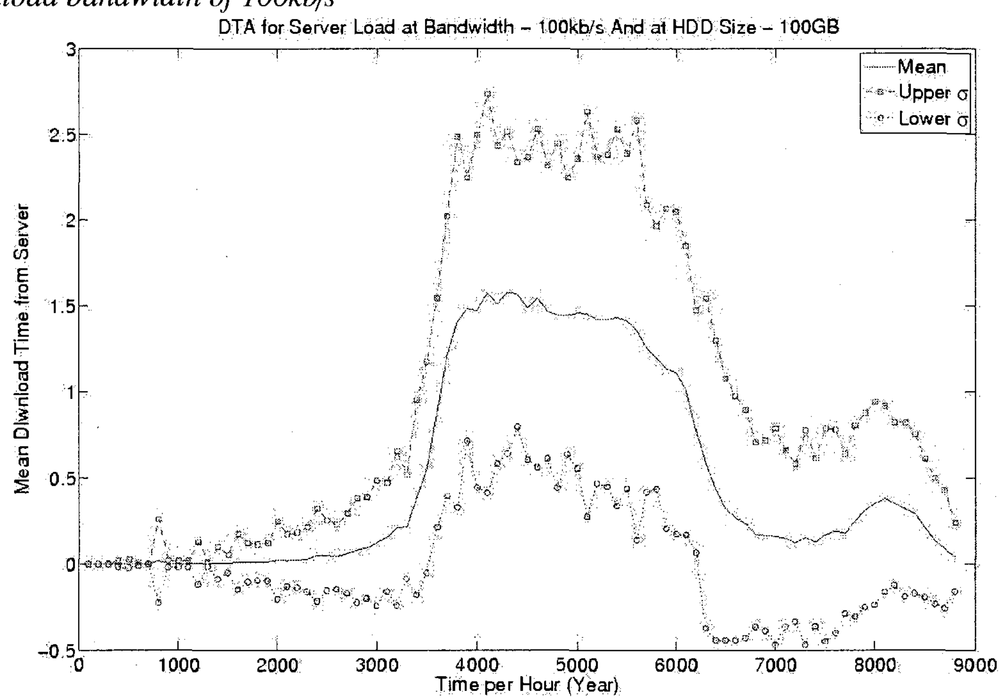


Figure 724: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 100kb/s

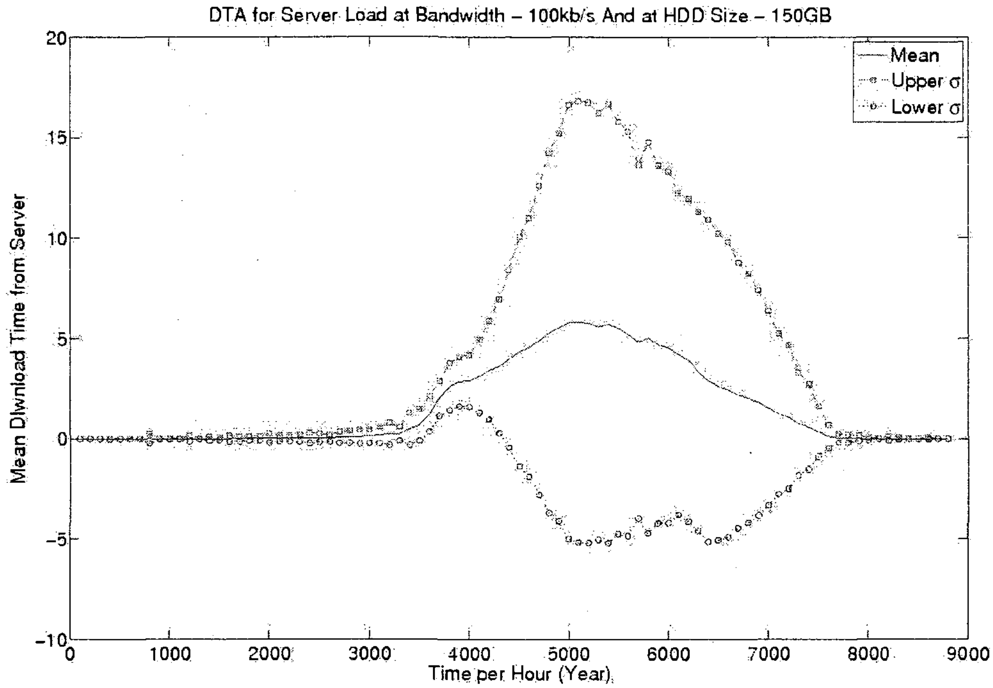


Figure 725: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 100kb/s

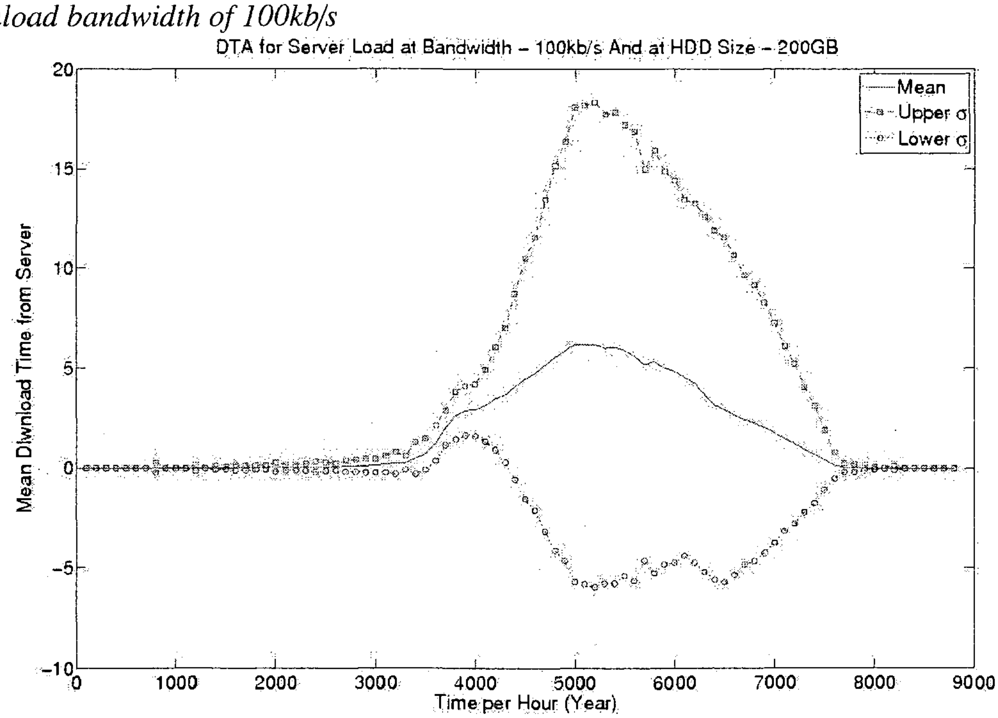


Figure 726: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 128kb/s

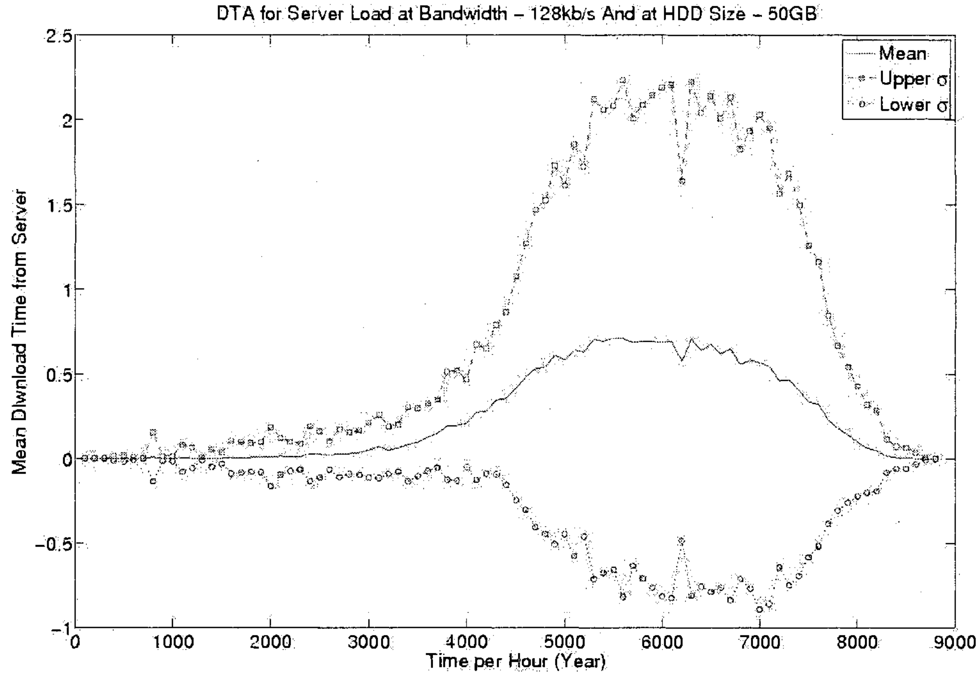


Figure 727: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 128kb/s

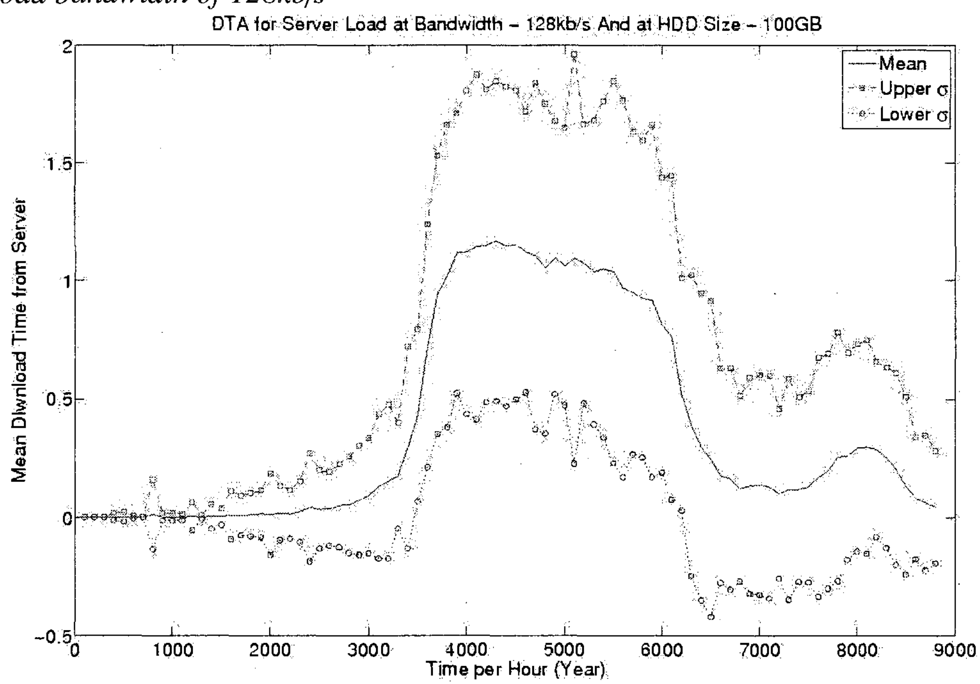


Figure 728: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 128kb/s

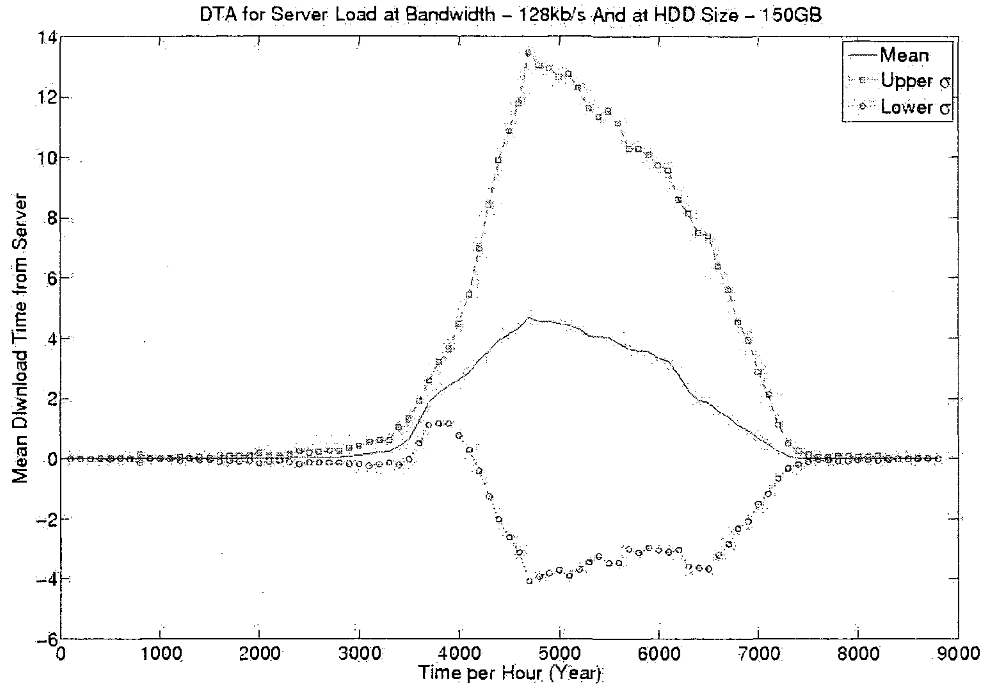


Figure 729: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 128kb/s

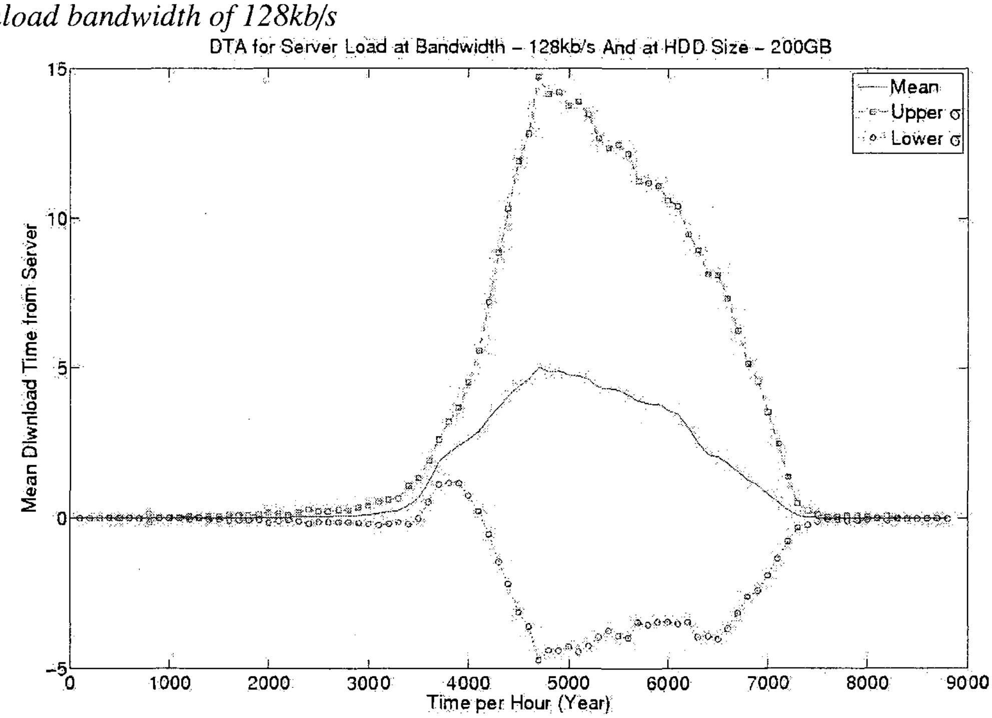


Figure 730: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 256kb/s

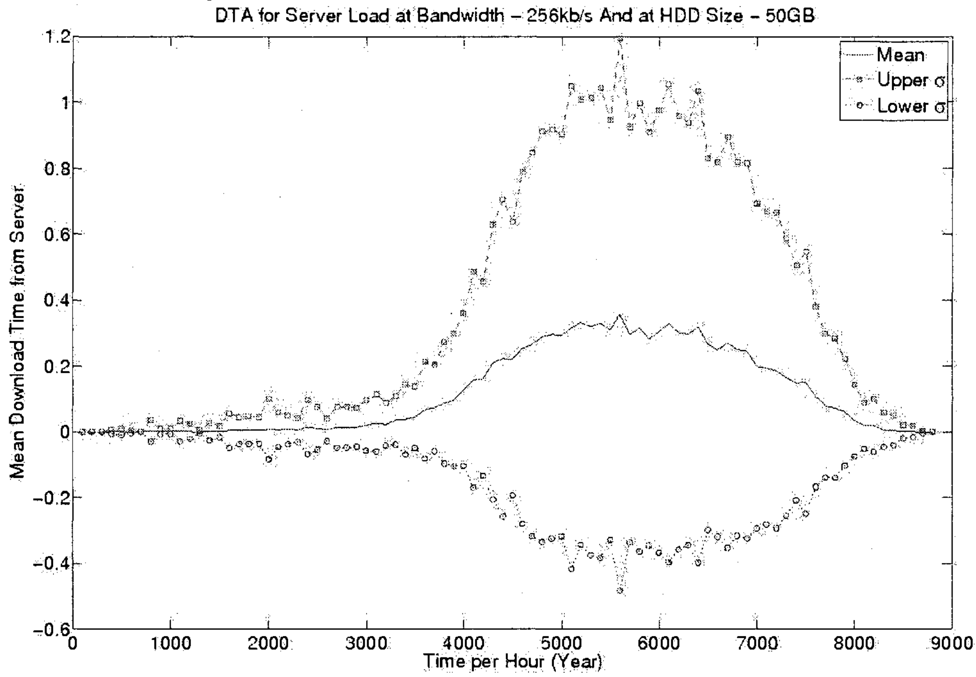


Figure 731: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 256kb/s

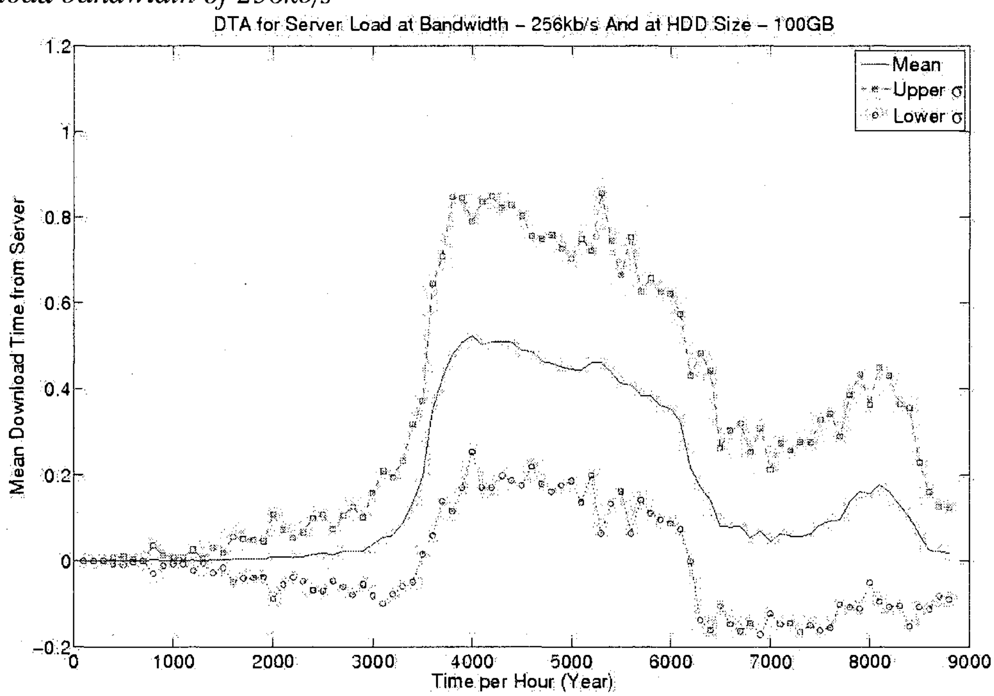


Figure 732: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 256kb/s

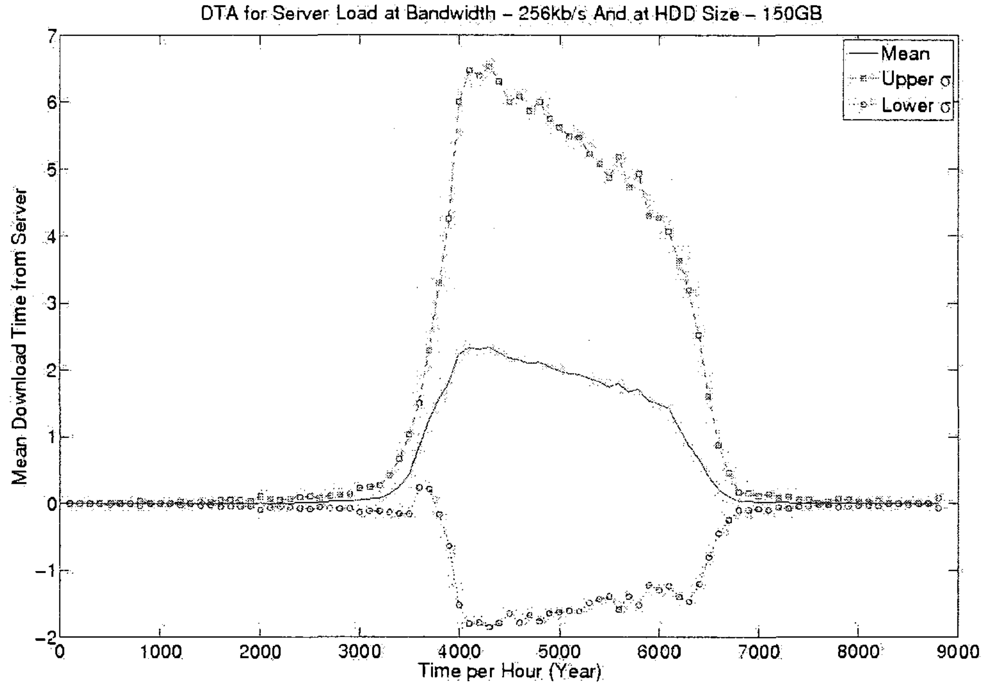


Figure 733: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 256kb/s

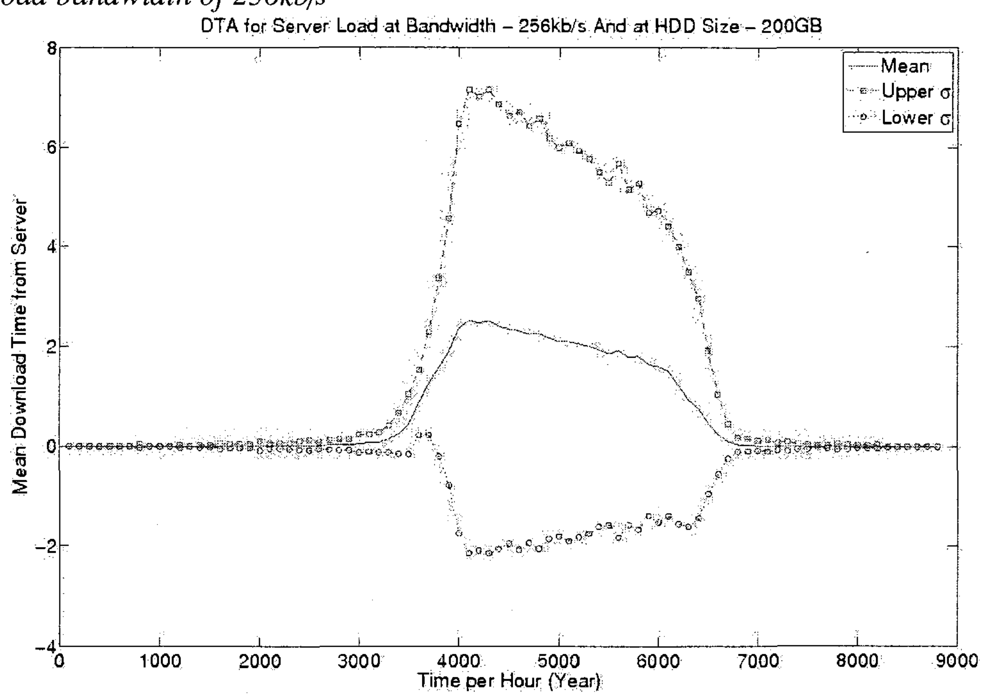


Figure 734: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 512kb/s

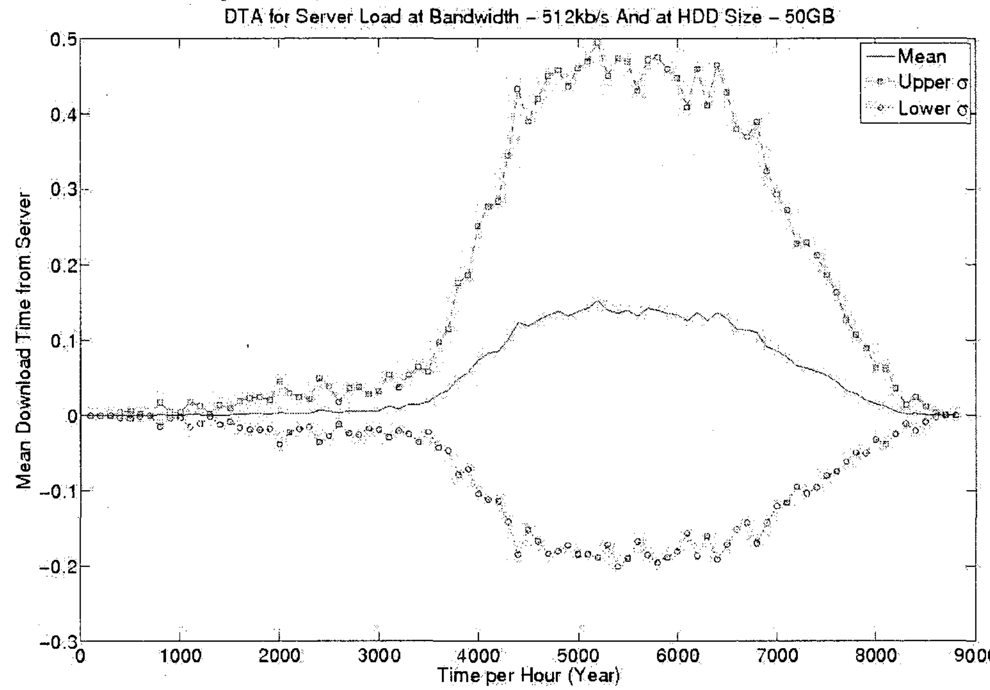


Figure 735: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 512kb/s

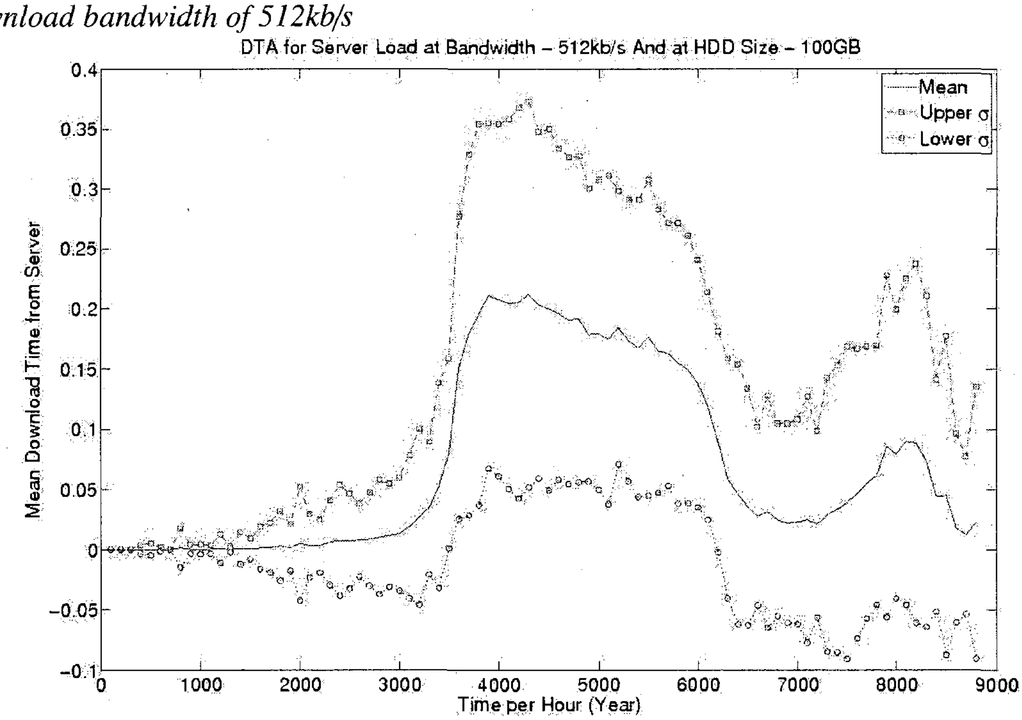


Figure 736: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 512kb/s

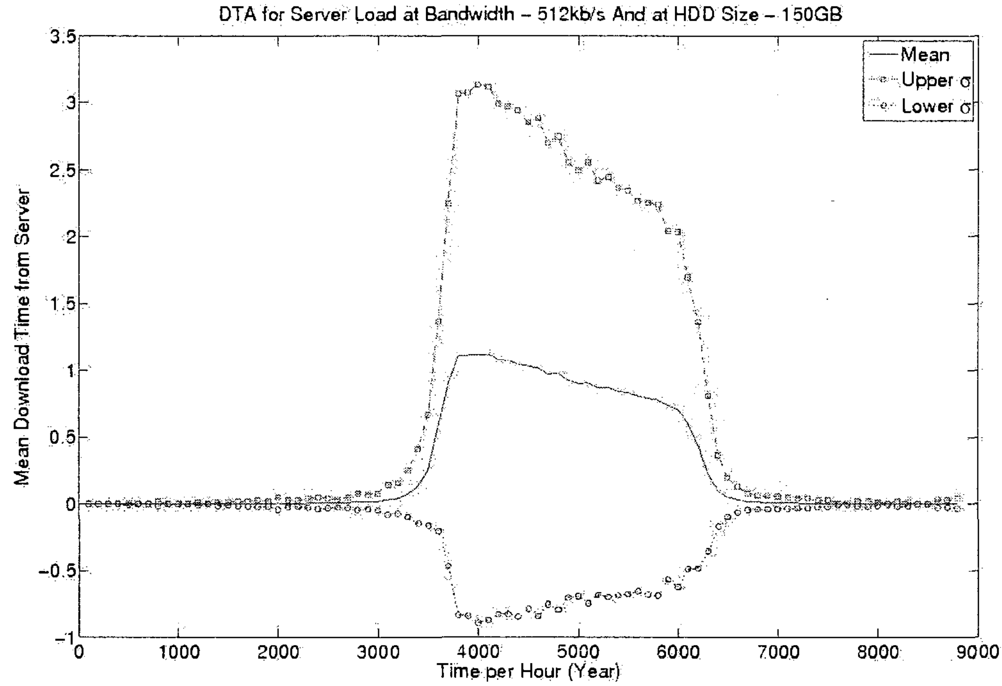


Figure 737: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 512kb/s

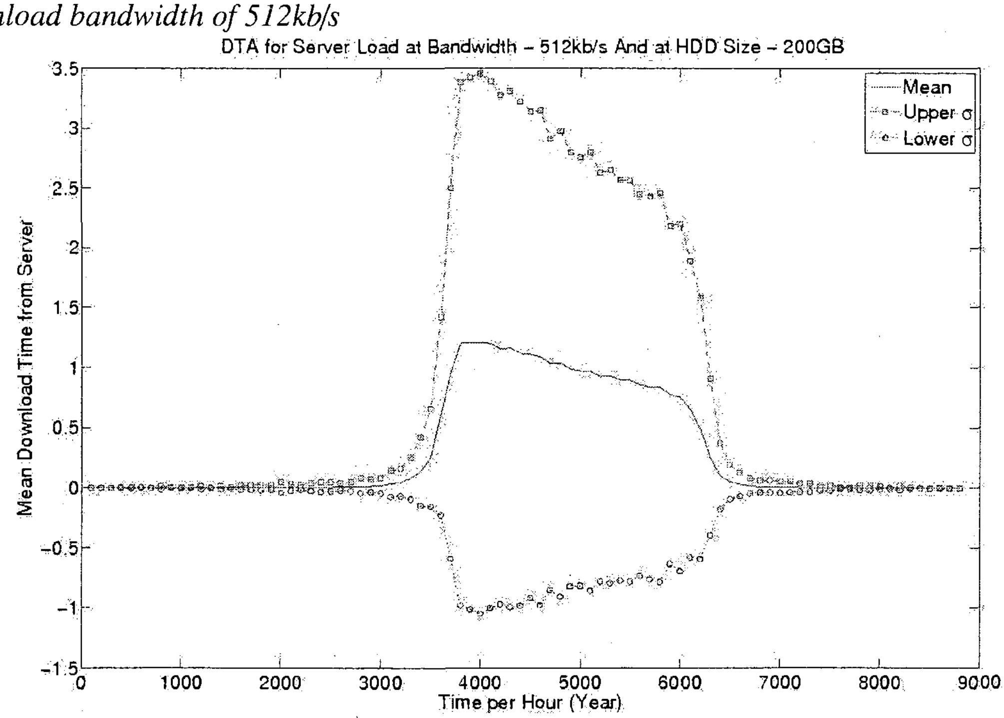


Figure 738: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 1000kb/s

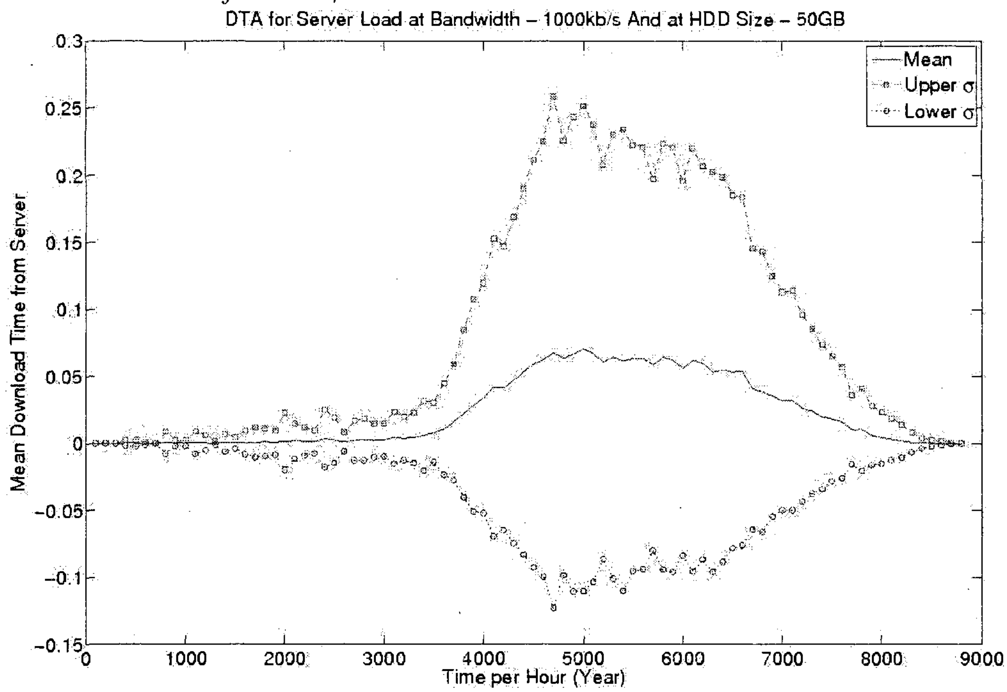


Figure 739: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 1000kb/s

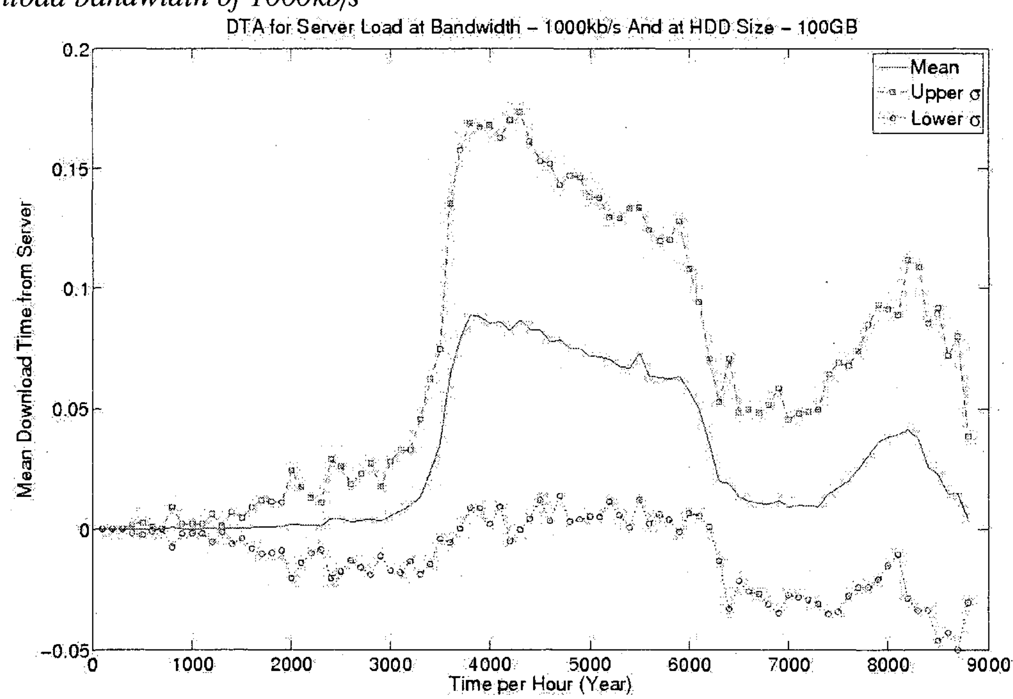


Figure 740: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 1000kb/s

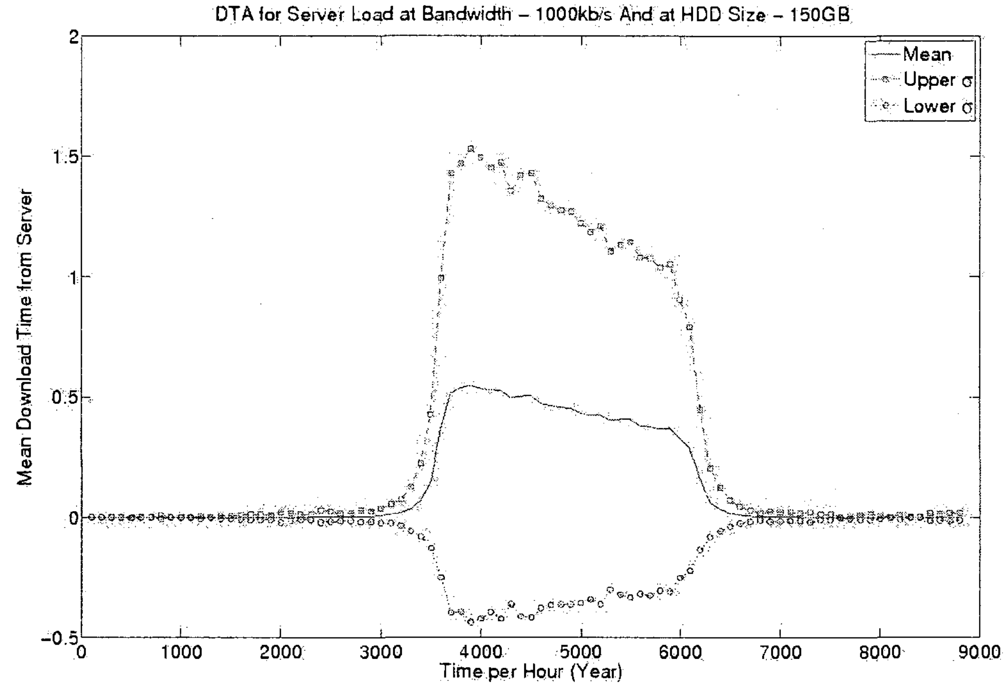


Figure 741: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 1000kb/s

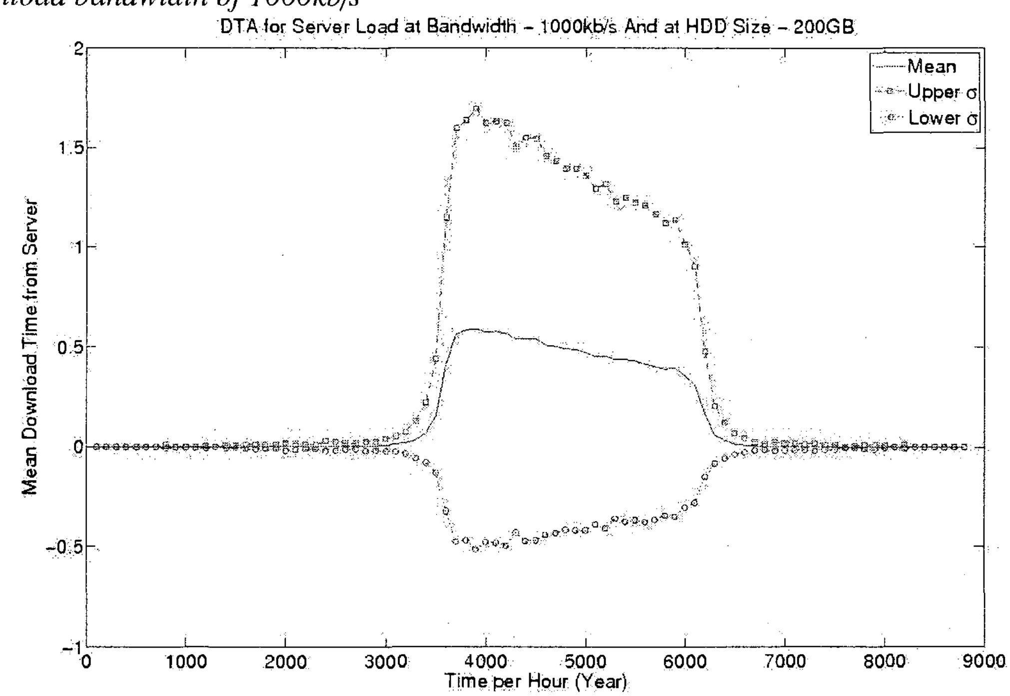


Figure 742: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 2000kb/s

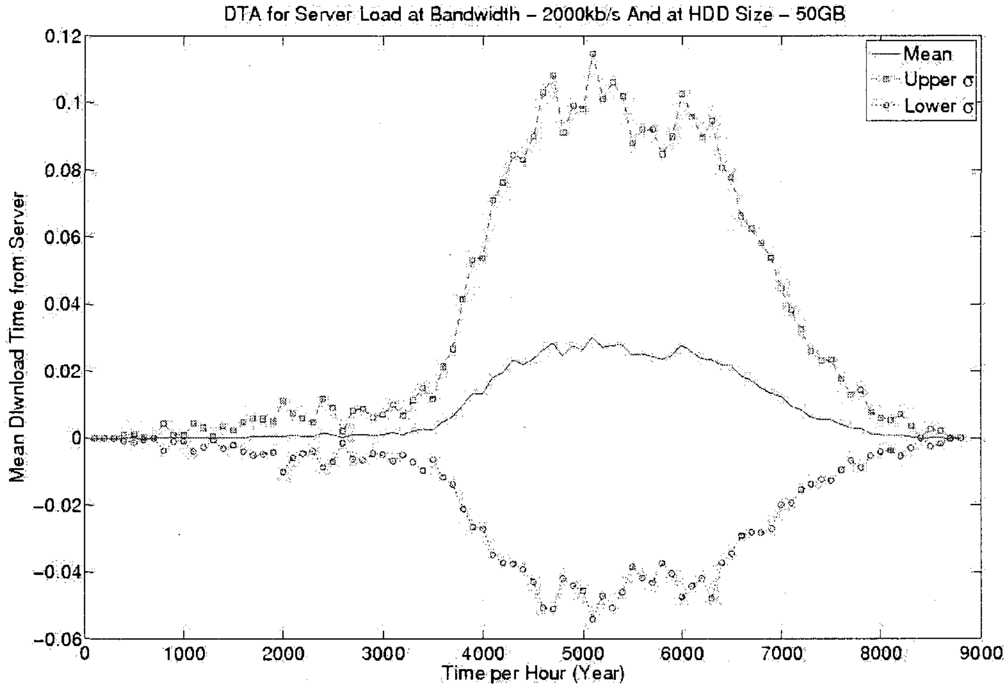


Figure 743: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 2000kb/s

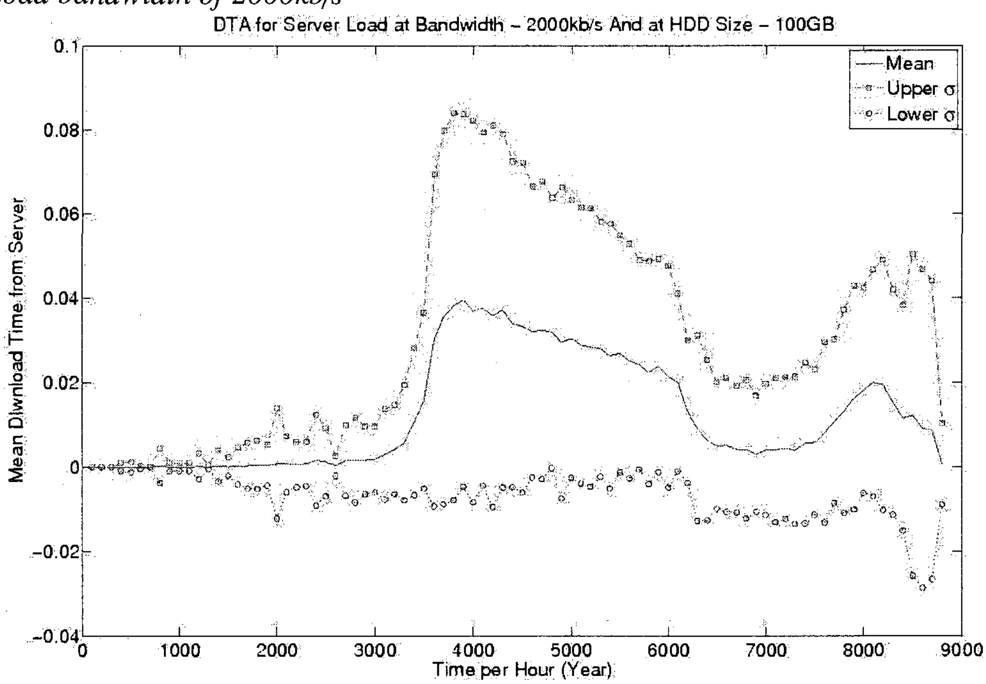


Figure 744: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 2000kb/s

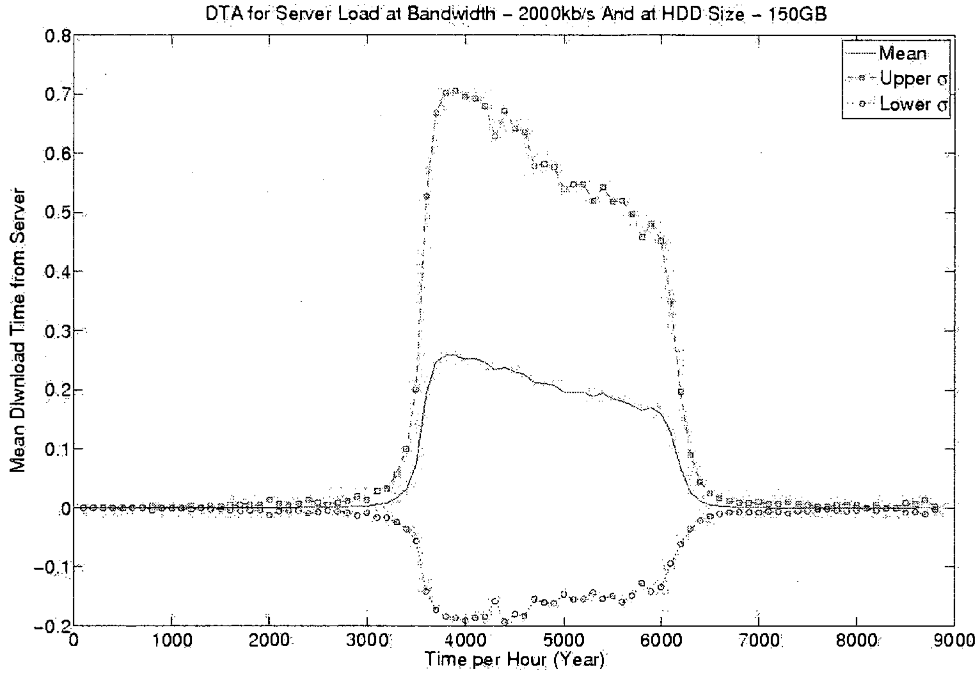


Figure 745: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 2000kb/s

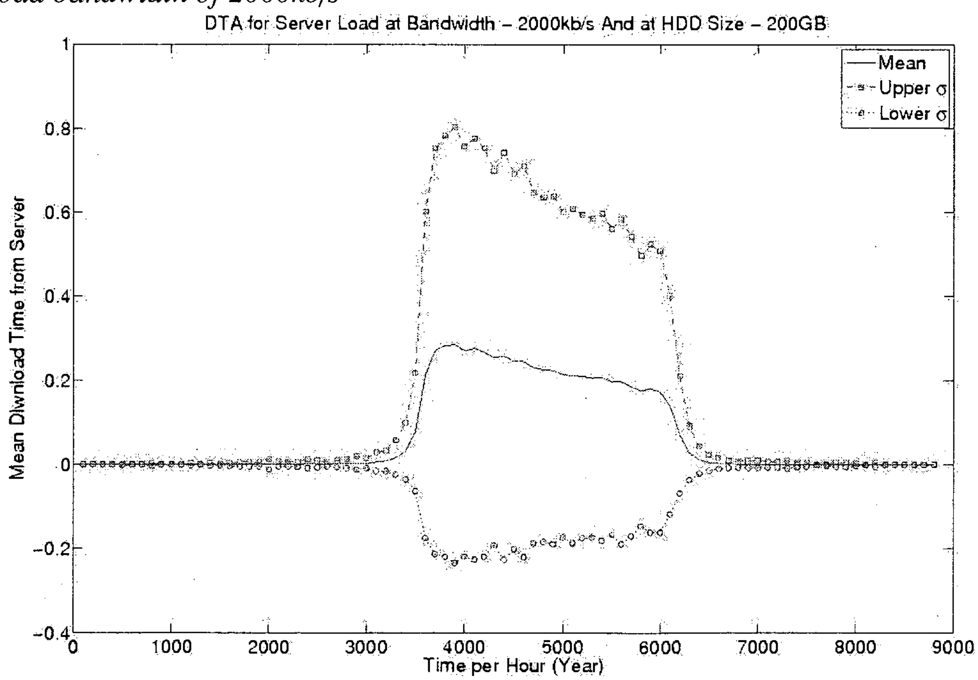


Figure 746: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 5000kb/s

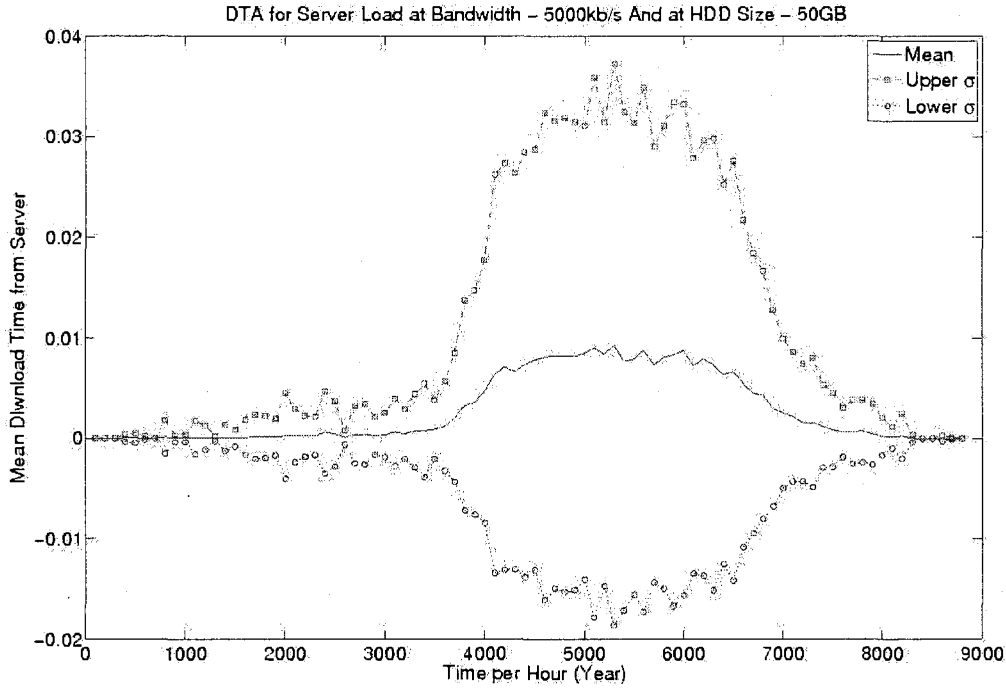


Figure 747: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 5000kb/s

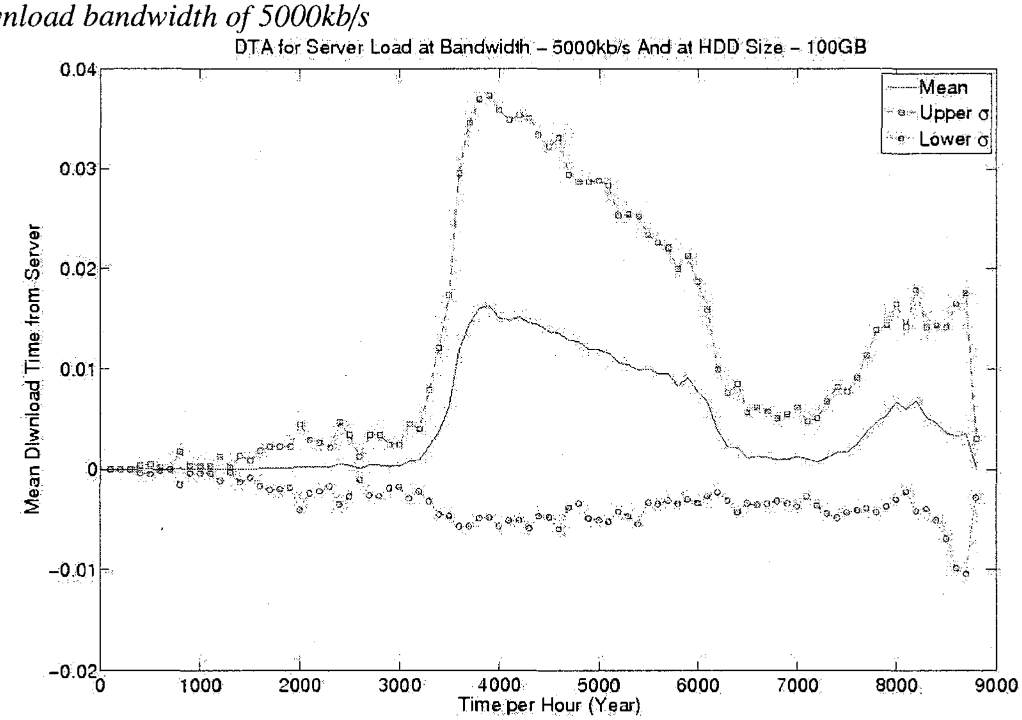


Figure 748: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 5000kb/s

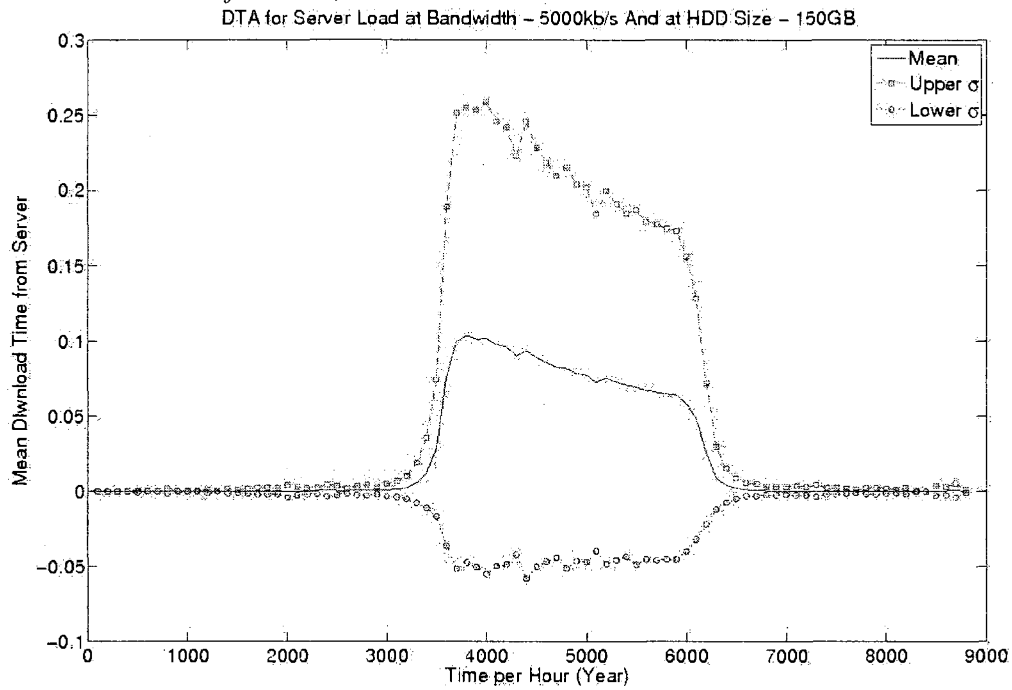


Figure 749: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 5000kb/s

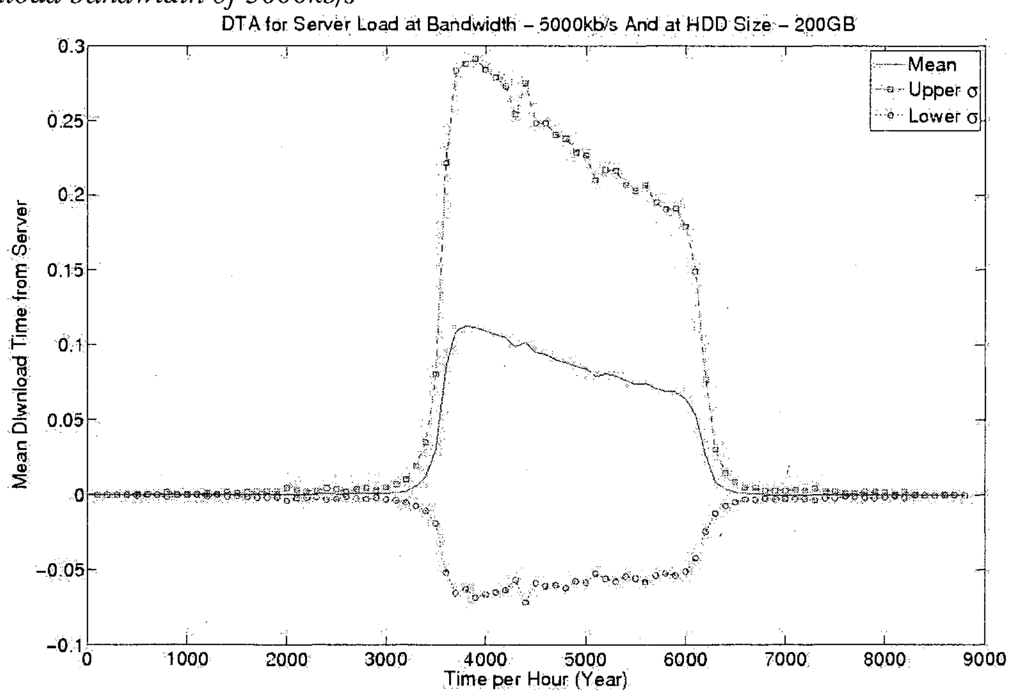


Figure 750: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 10000kb/s

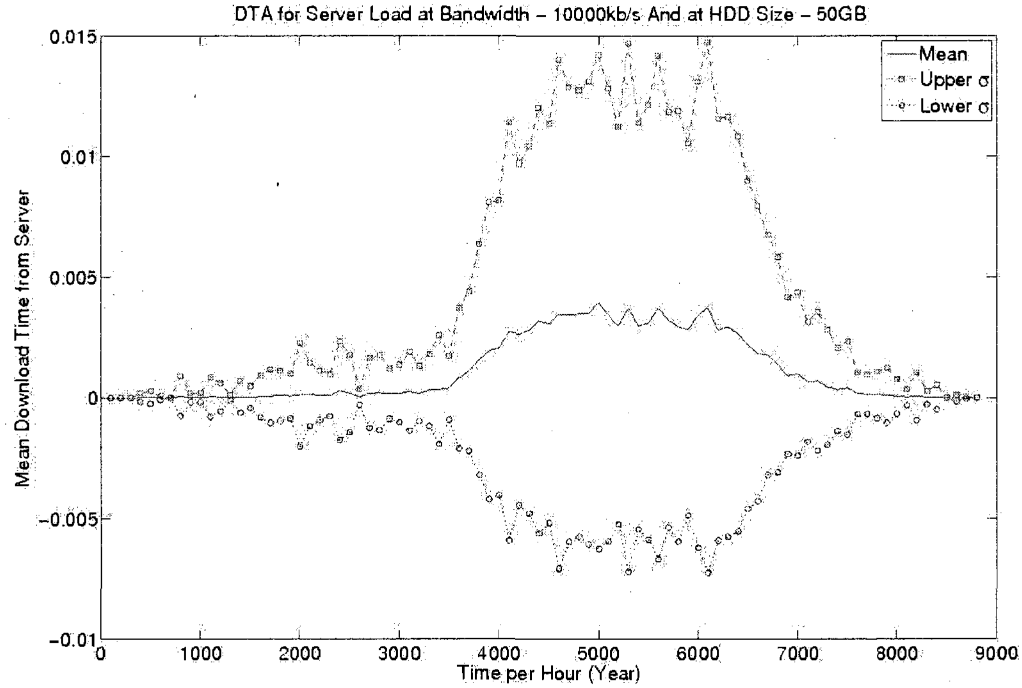


Figure 751: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 10000kb/s

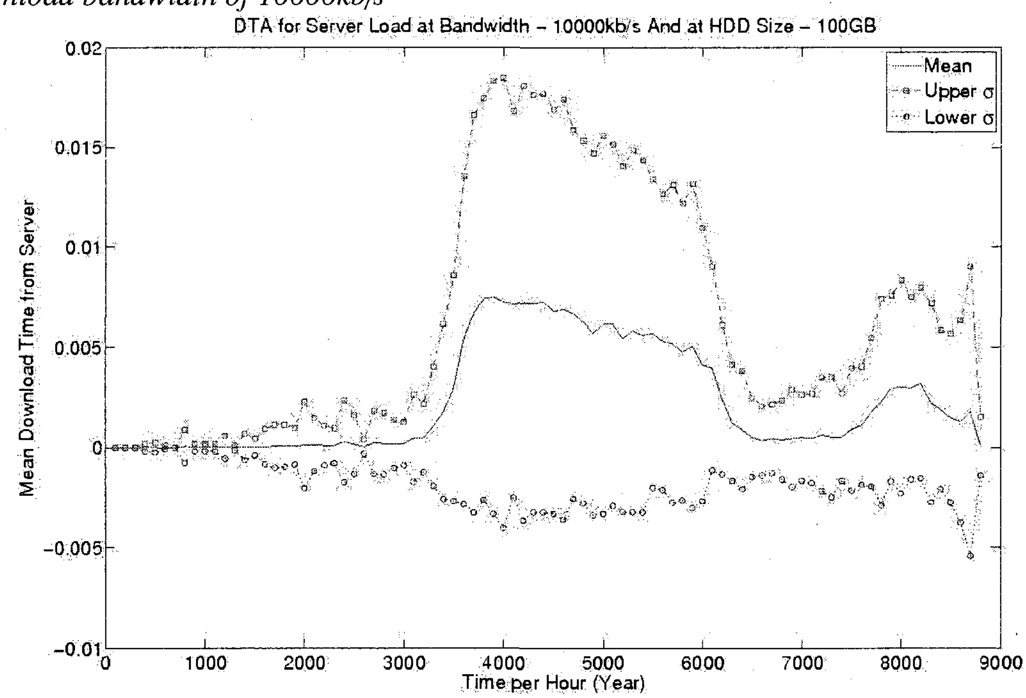


Figure 752: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 10000kb/s

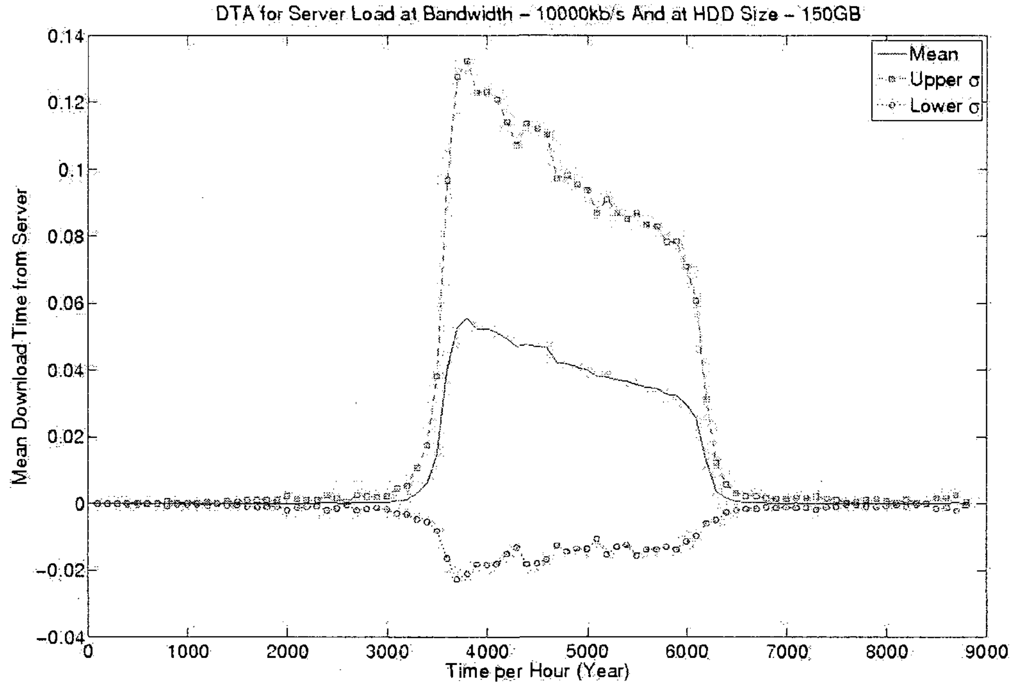


Figure 753: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 10000kb/s

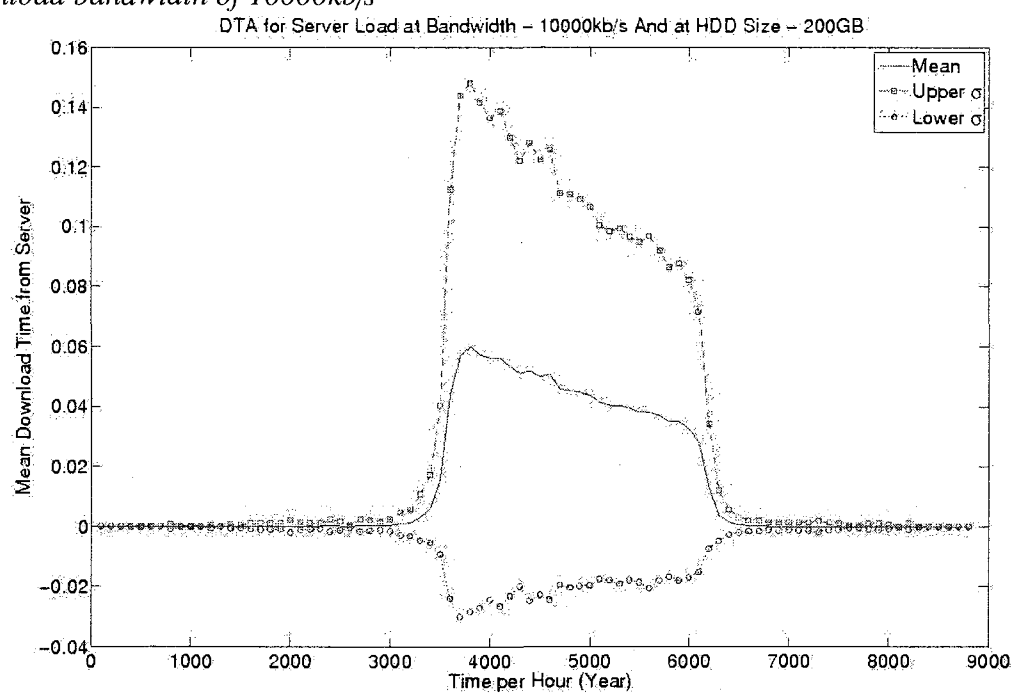


Figure 754: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 15000kb/s

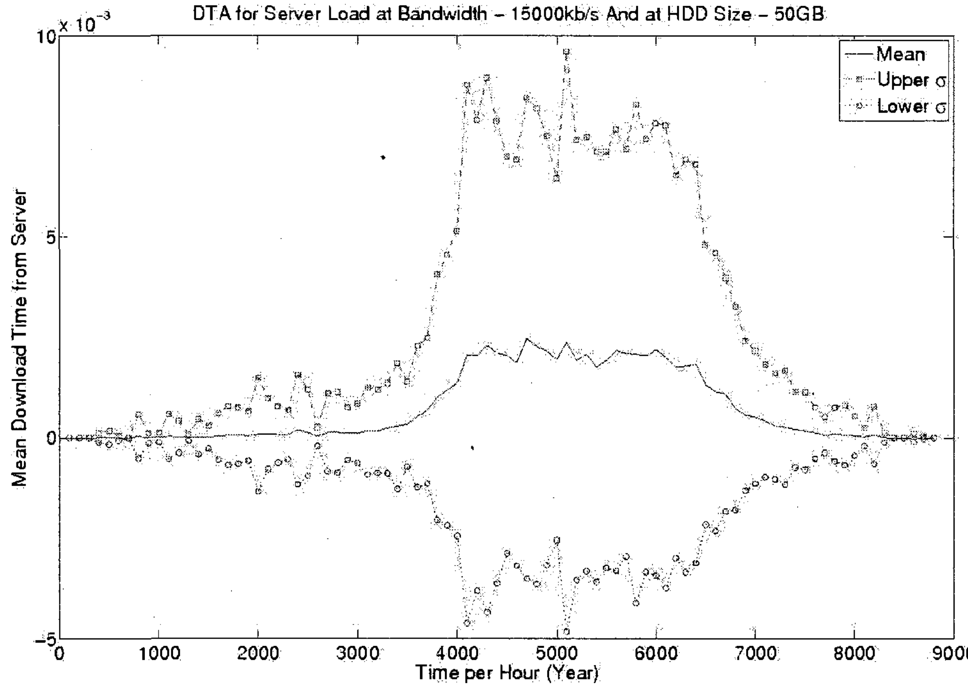


Figure 755: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 15000kb/s

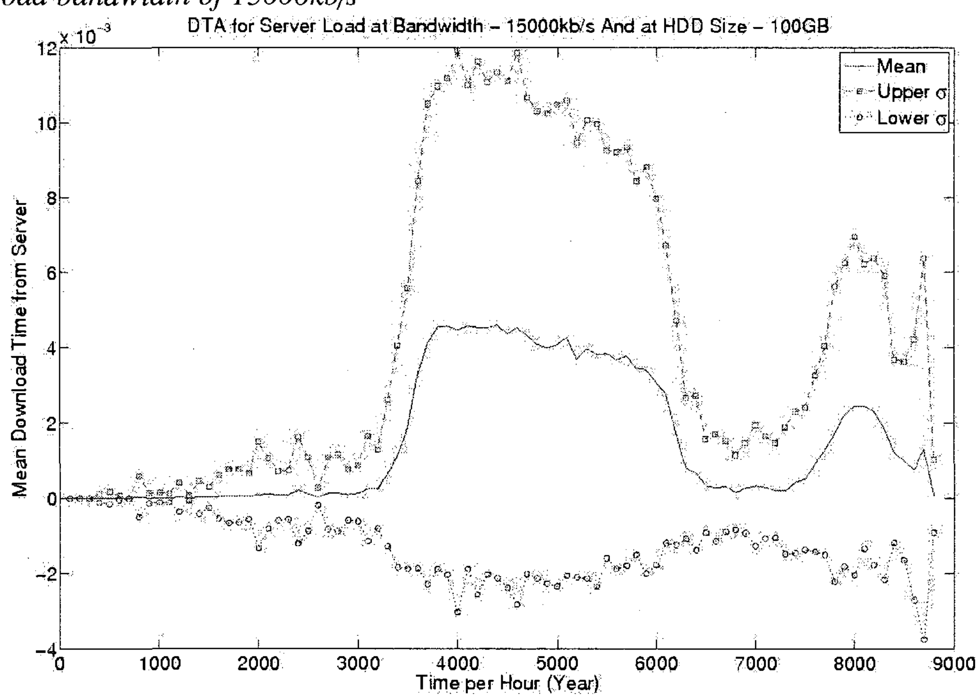


Figure 756: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 15000kb/s

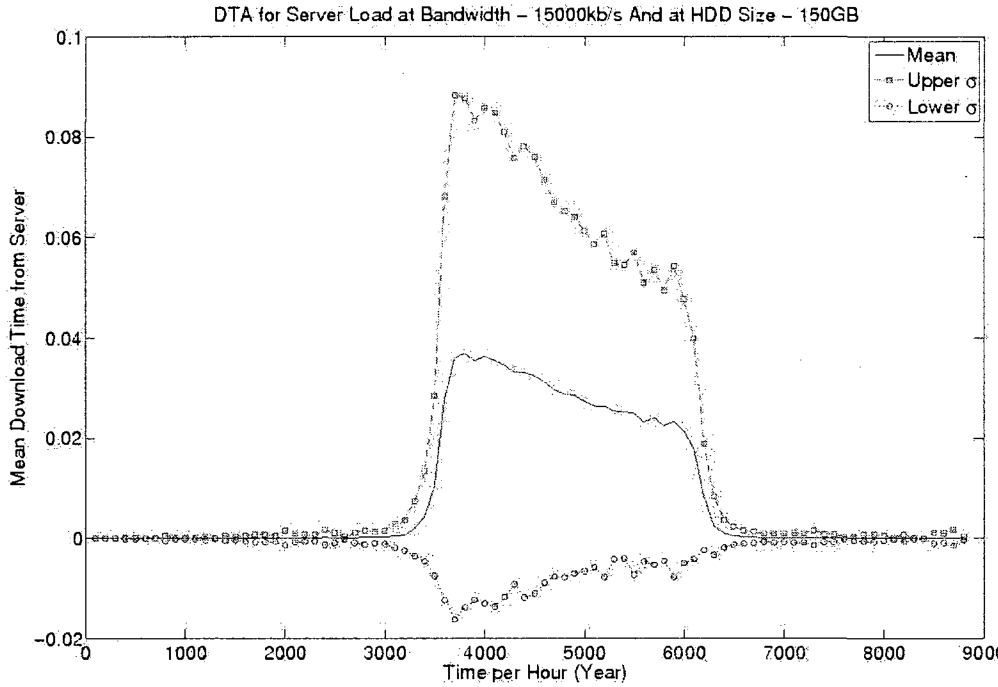


Figure 757: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 15000kb/s

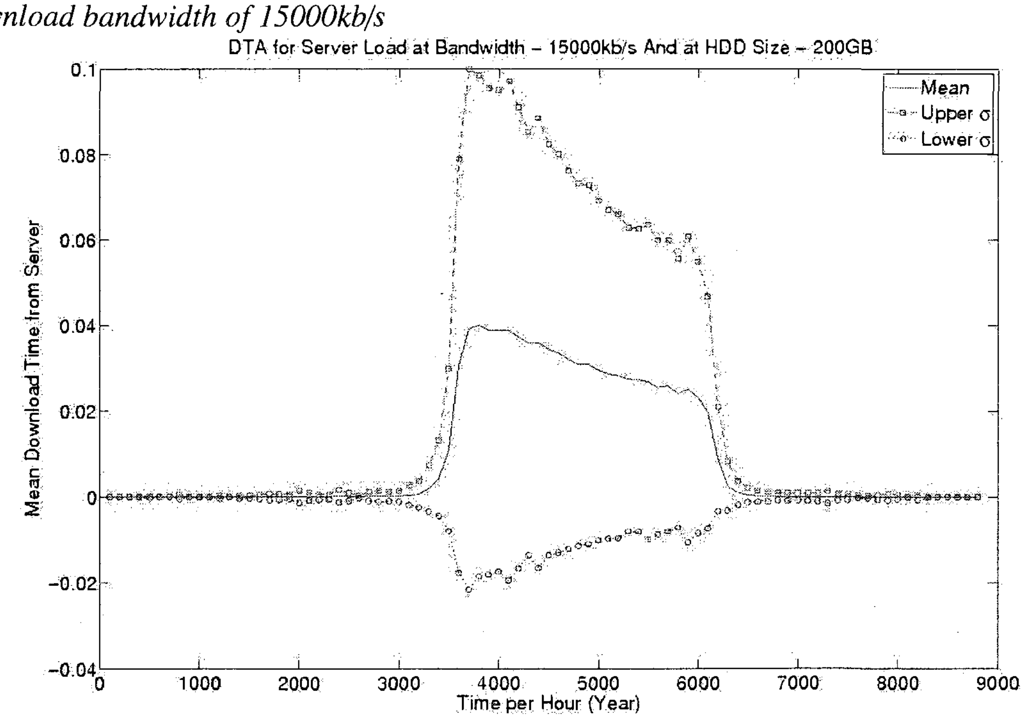


Figure 758: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 25kb/s

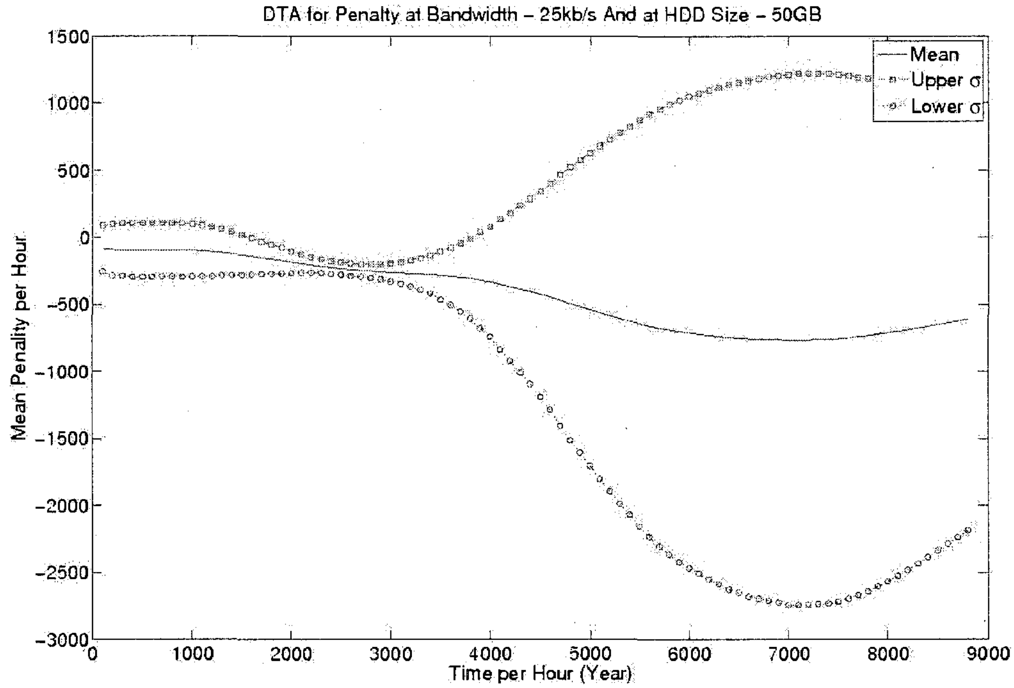


Figure 759: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 25kb/s

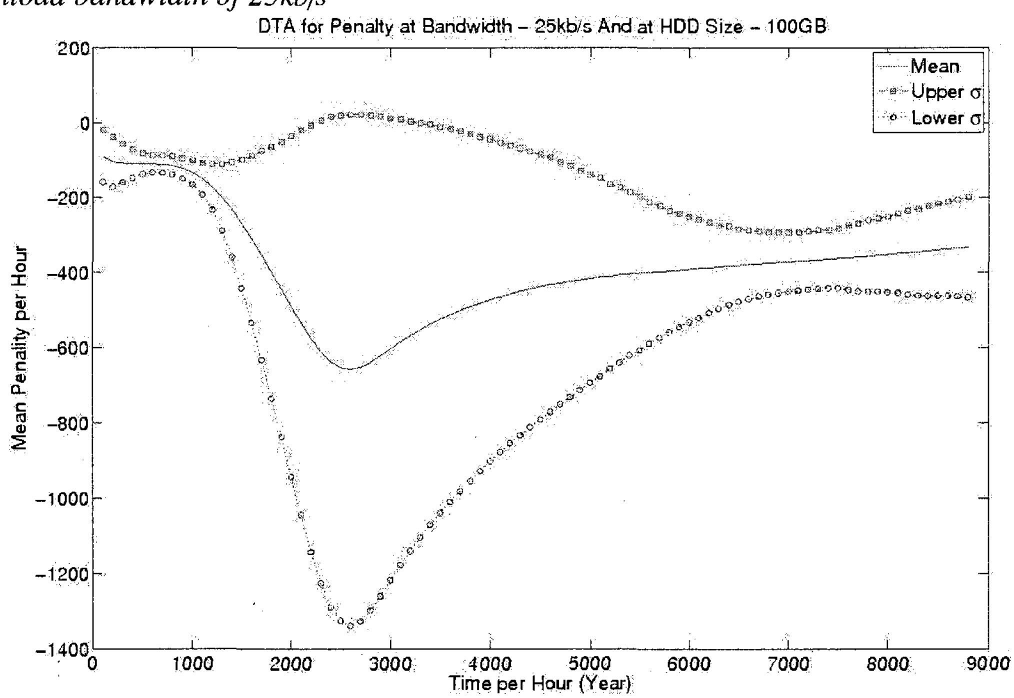


Figure 760: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 25kb/s

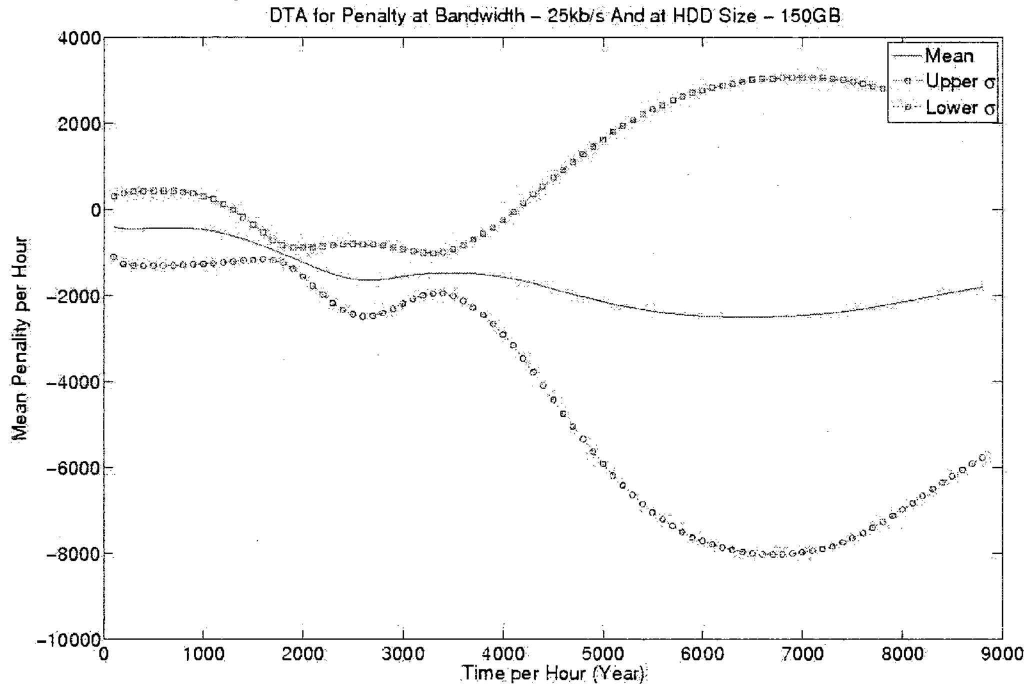


Figure 761: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 25kb/s

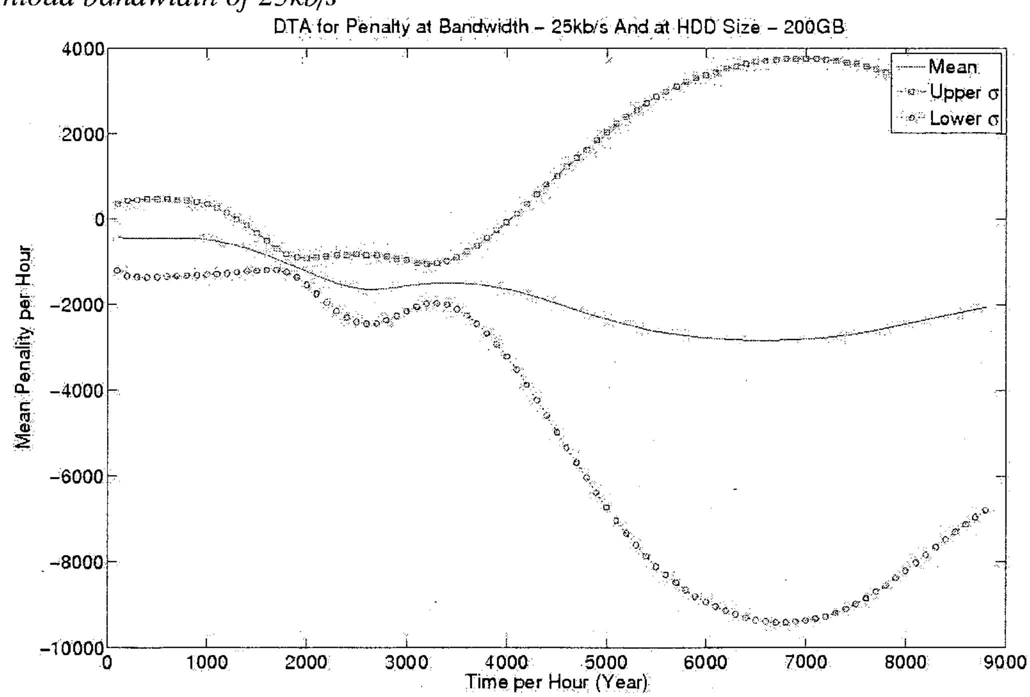


Figure 762: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 50kb/s

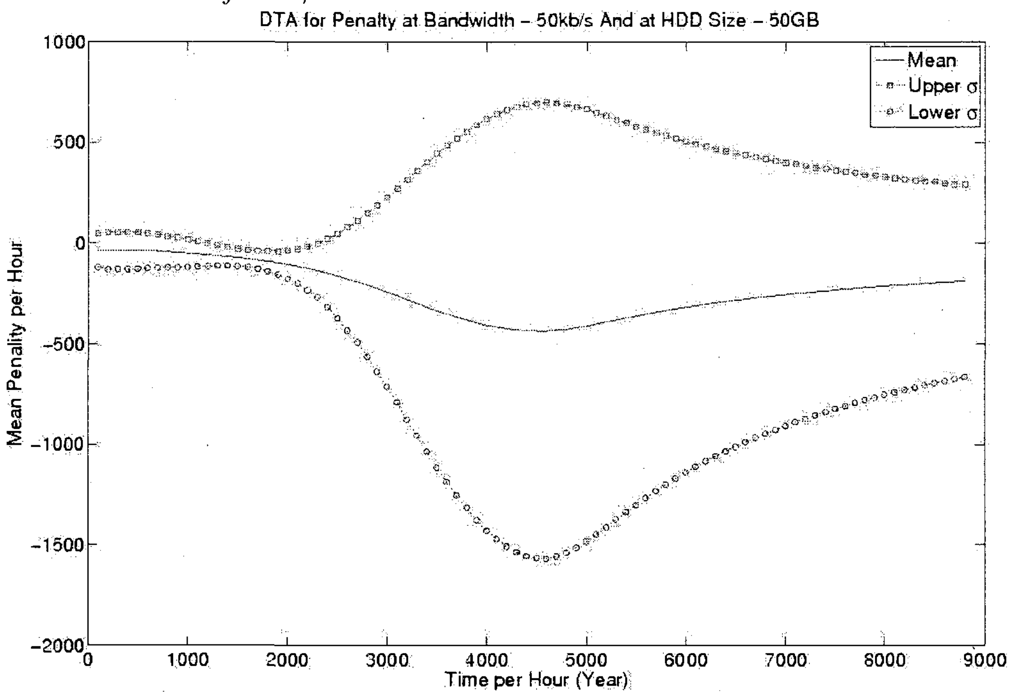


Figure 763: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 50kb/s

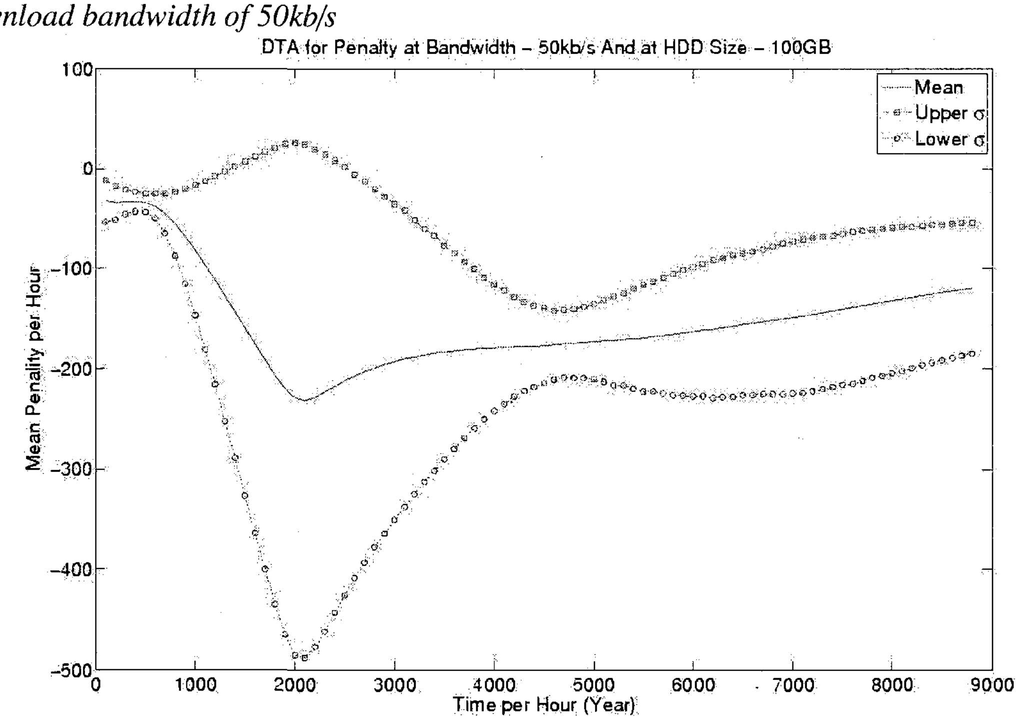


Figure 764: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 50kb/s

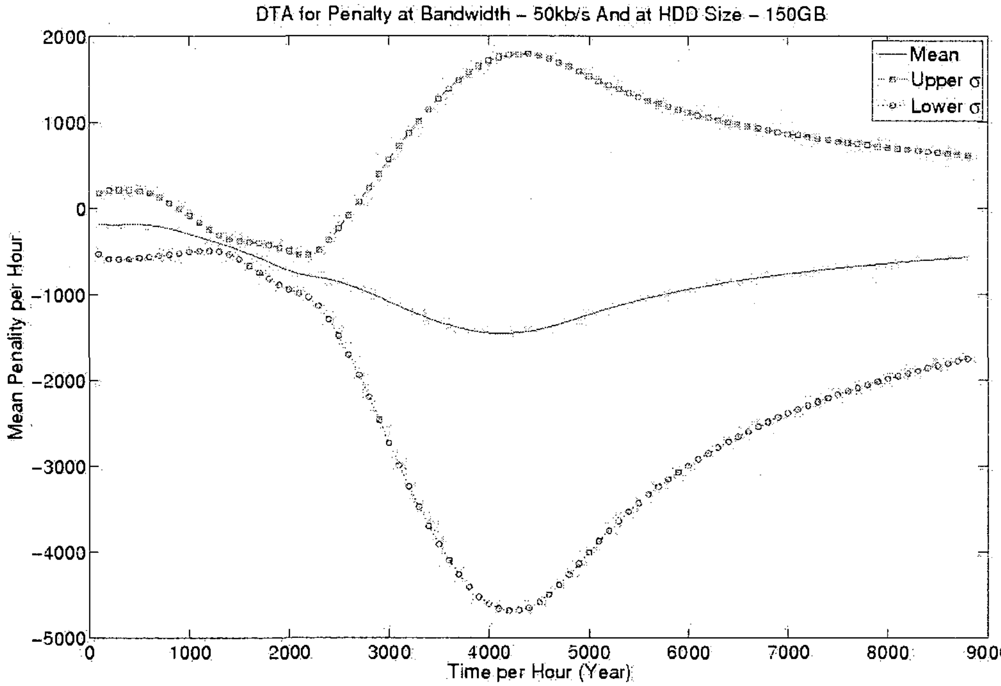


Figure 765: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 50kb/s

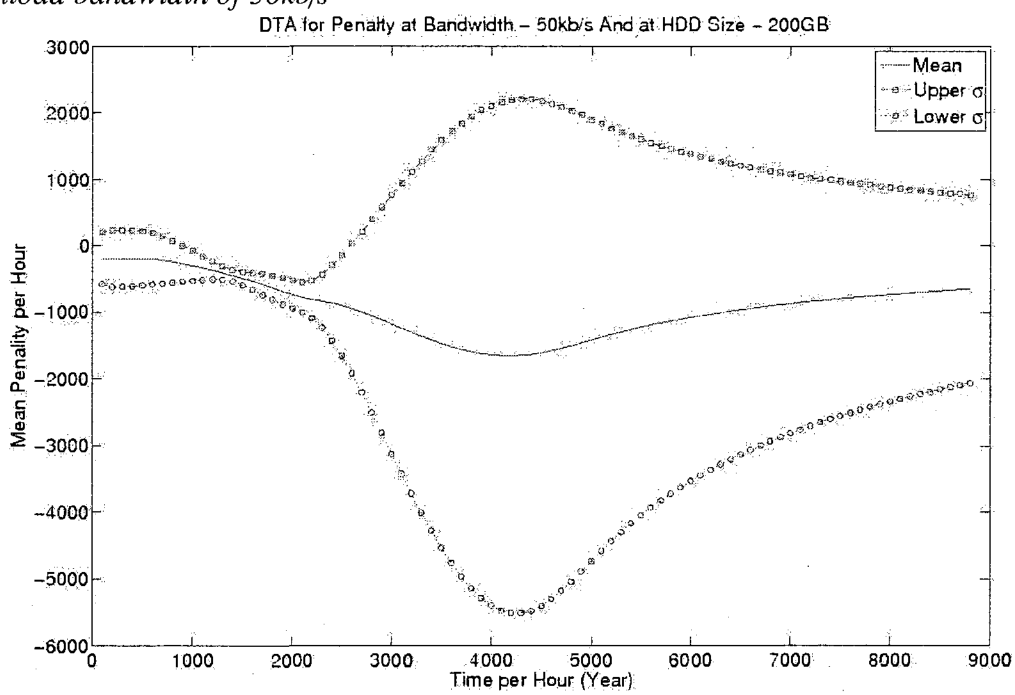


Figure 766: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 100kb/s

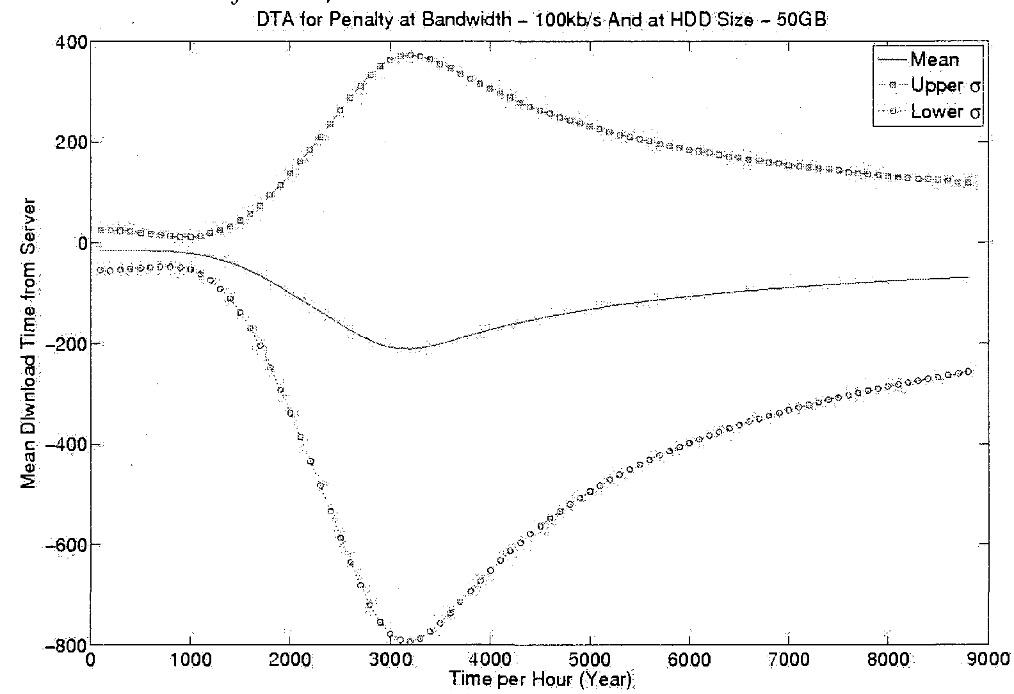


Figure 767: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 100kb/s

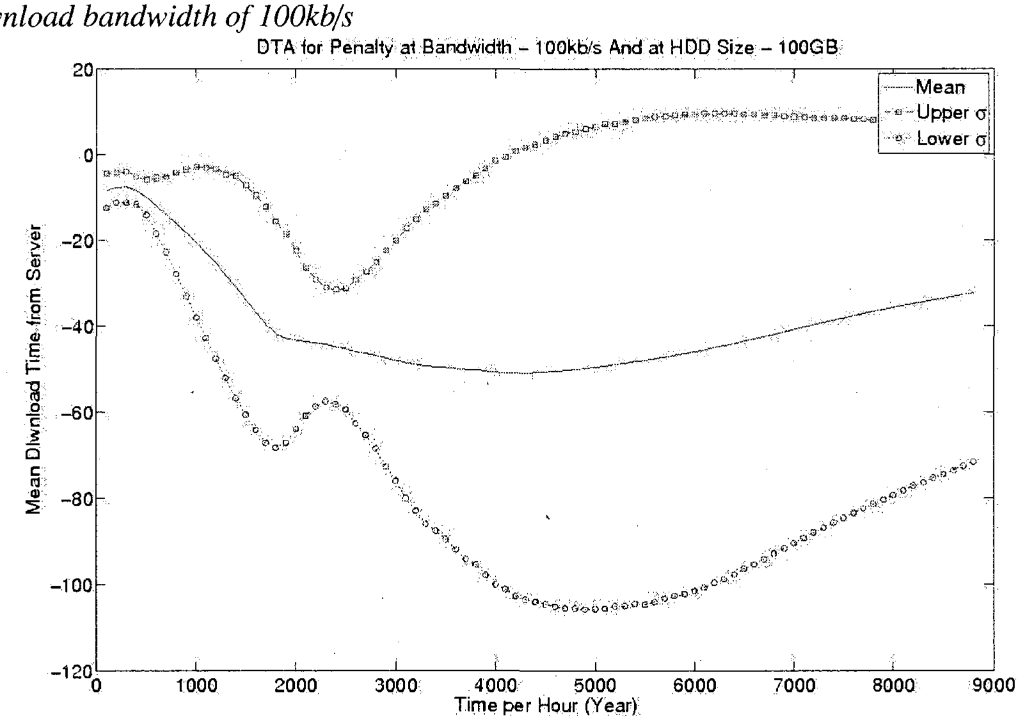


Figure 768: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 100kb/s

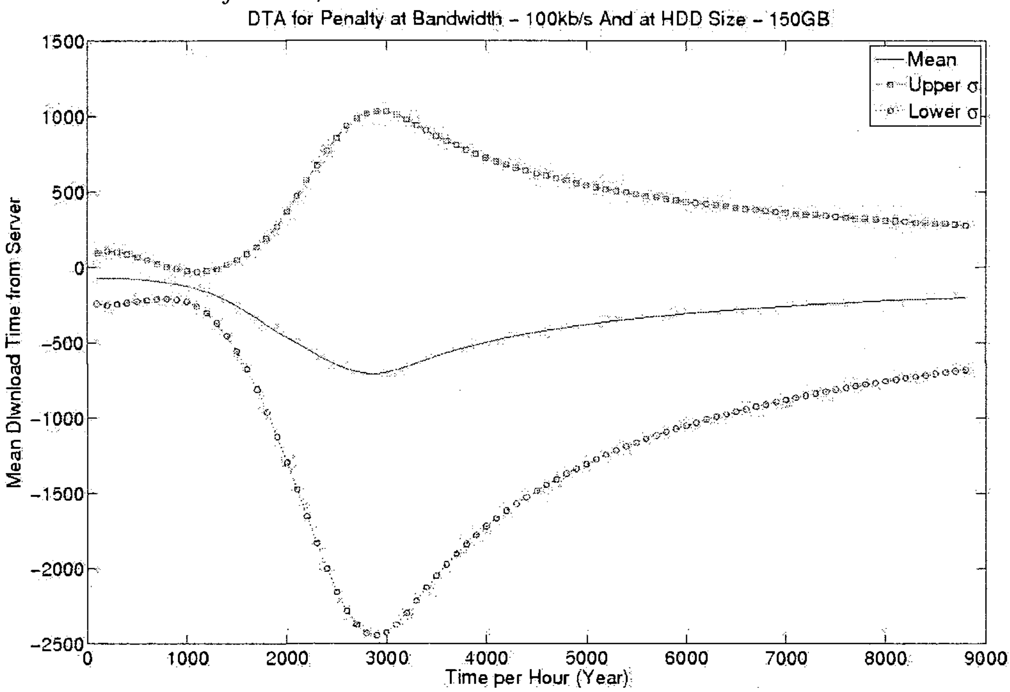


Figure 769: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 100kb/s

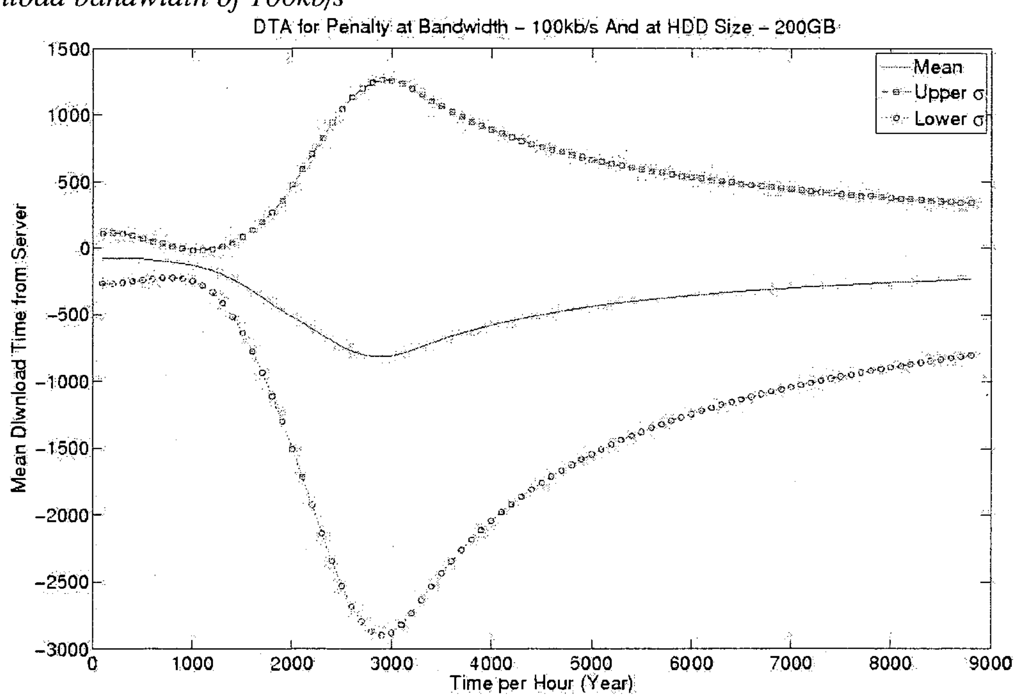


Figure 770: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 128kb/s

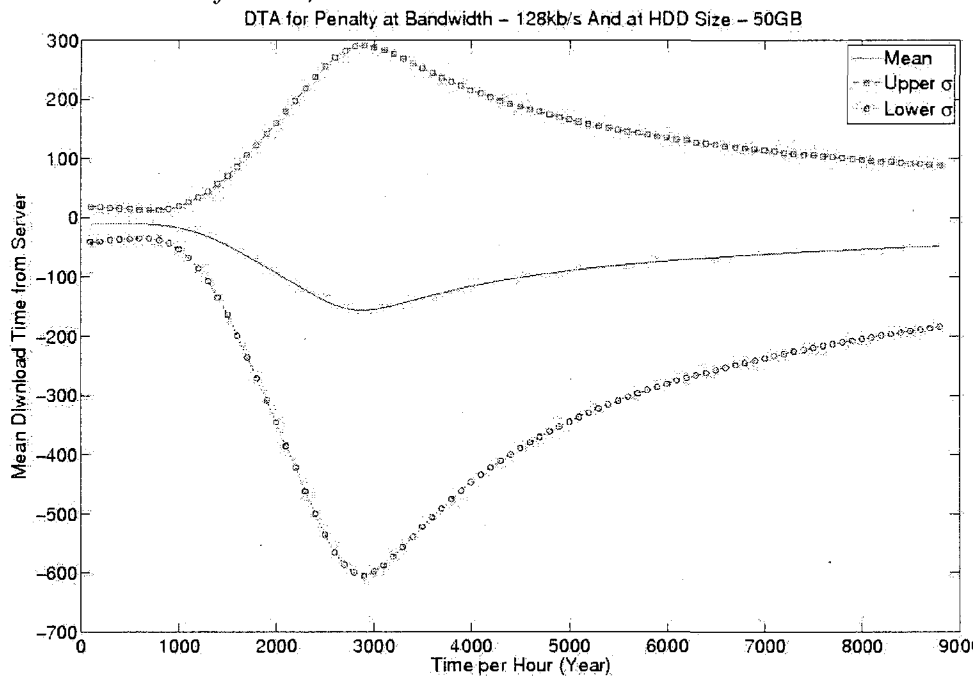


Figure 771: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 128kb/s

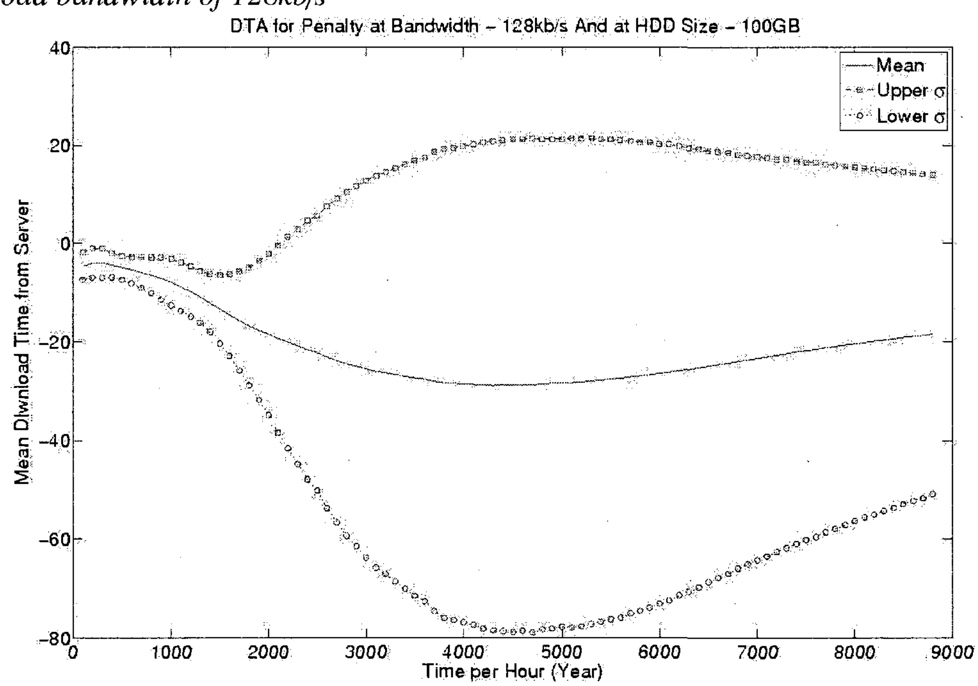


Figure 772: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 128kb/s

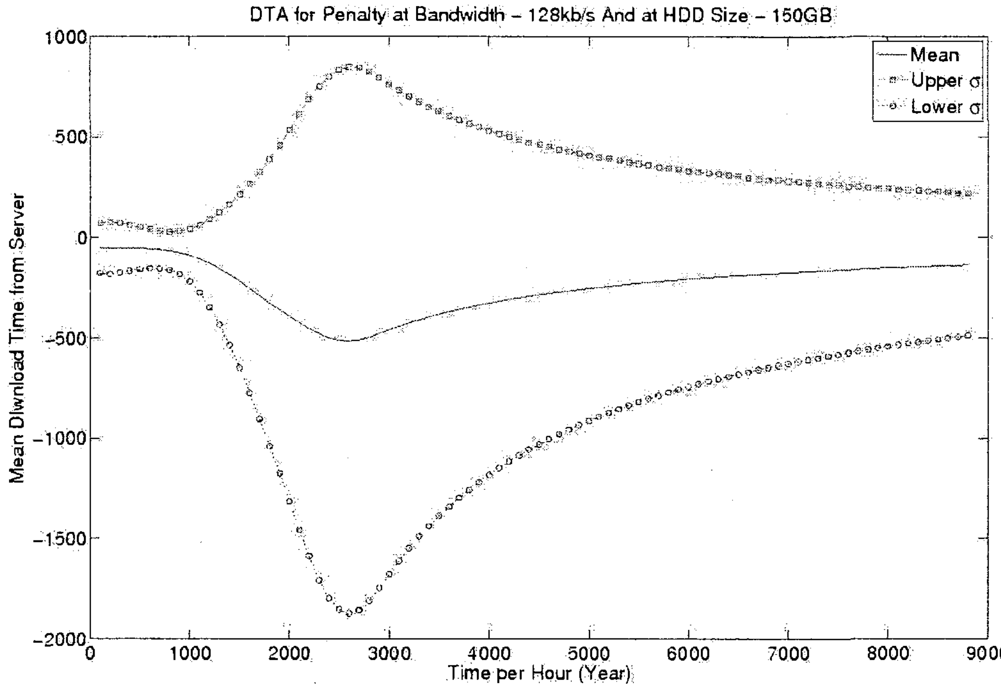


Figure 773: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 128kb/s

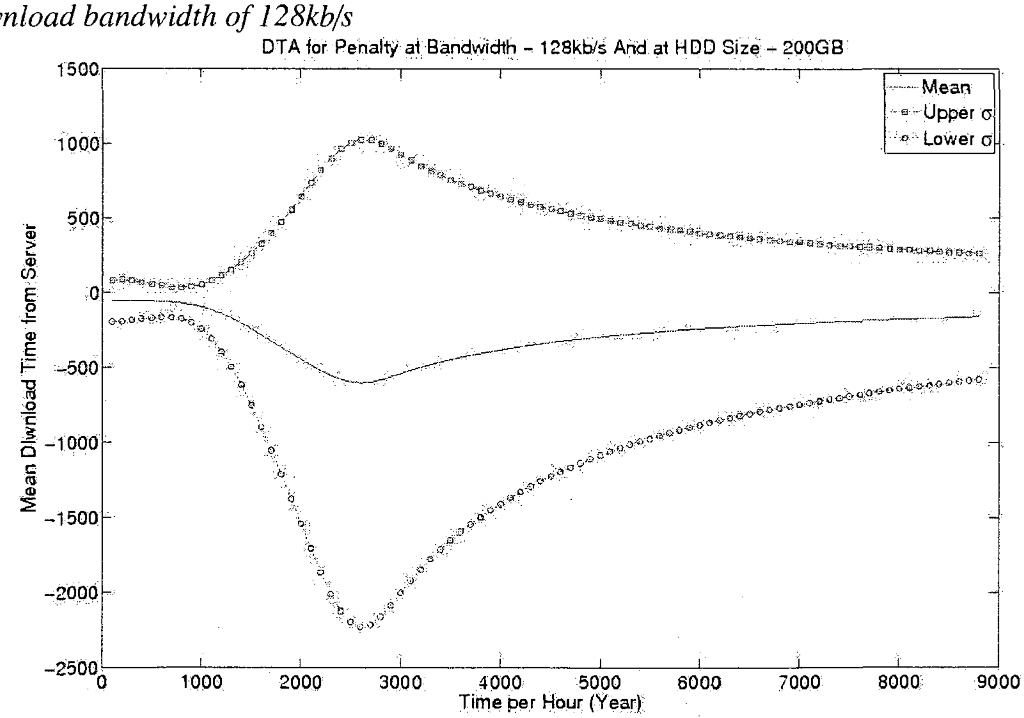


Figure 774: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 256kb/s

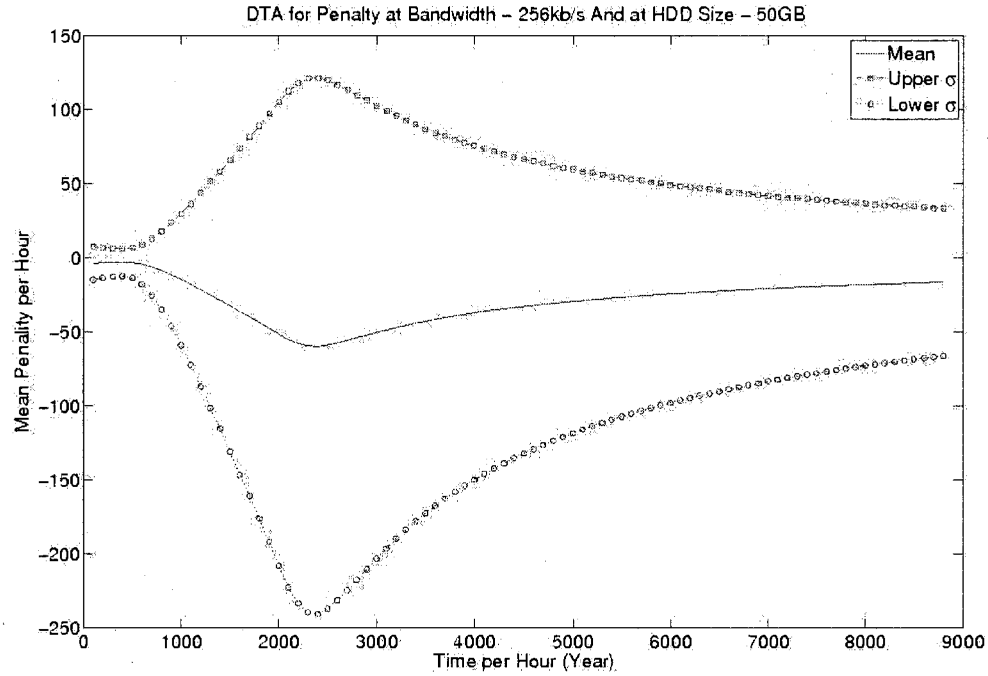


Figure 775: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 256kb/s

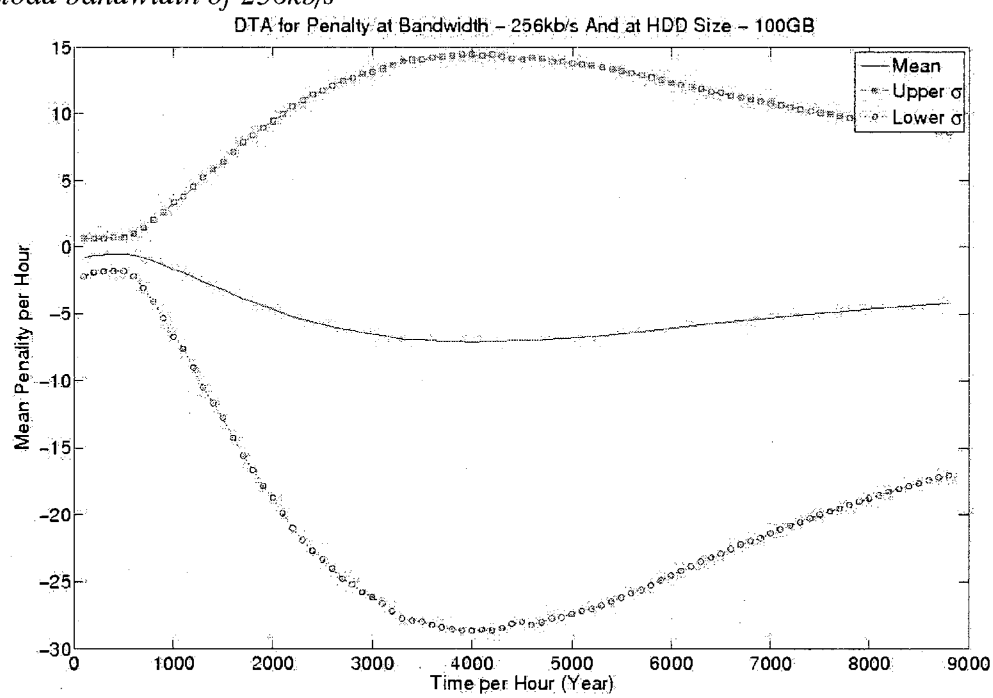


Figure 776: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 256kb/s

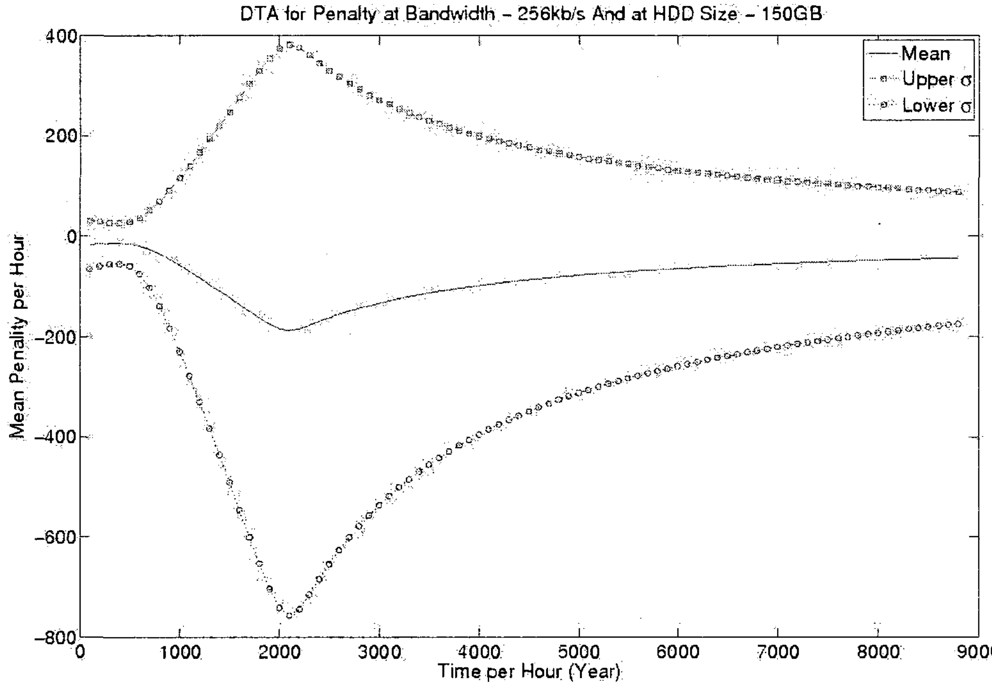


Figure 777: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 256kb/s

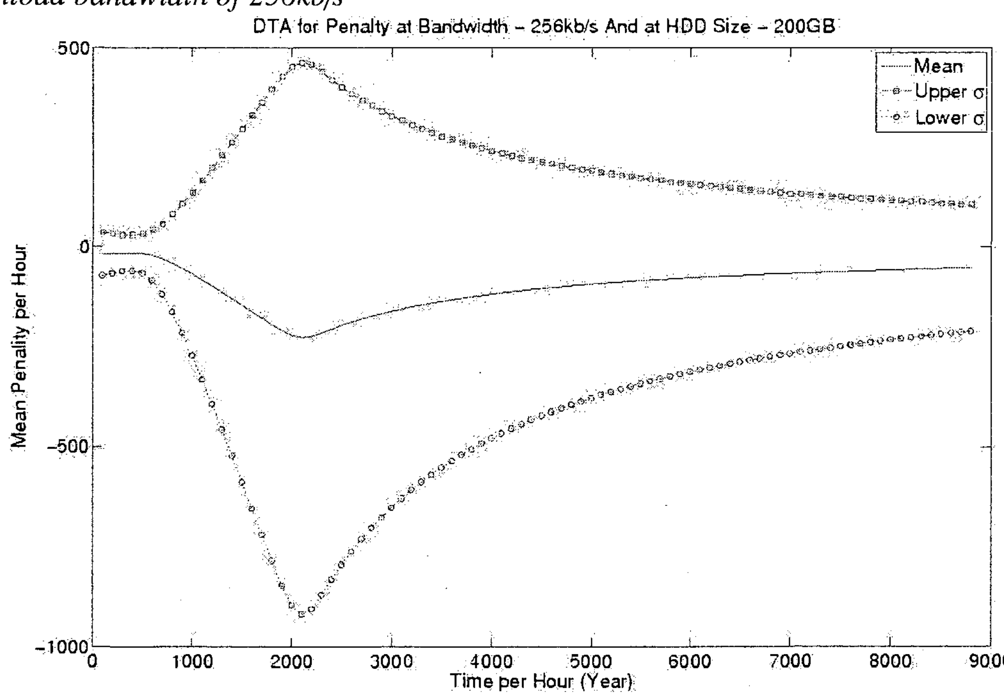


Figure 778: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 512kb/s

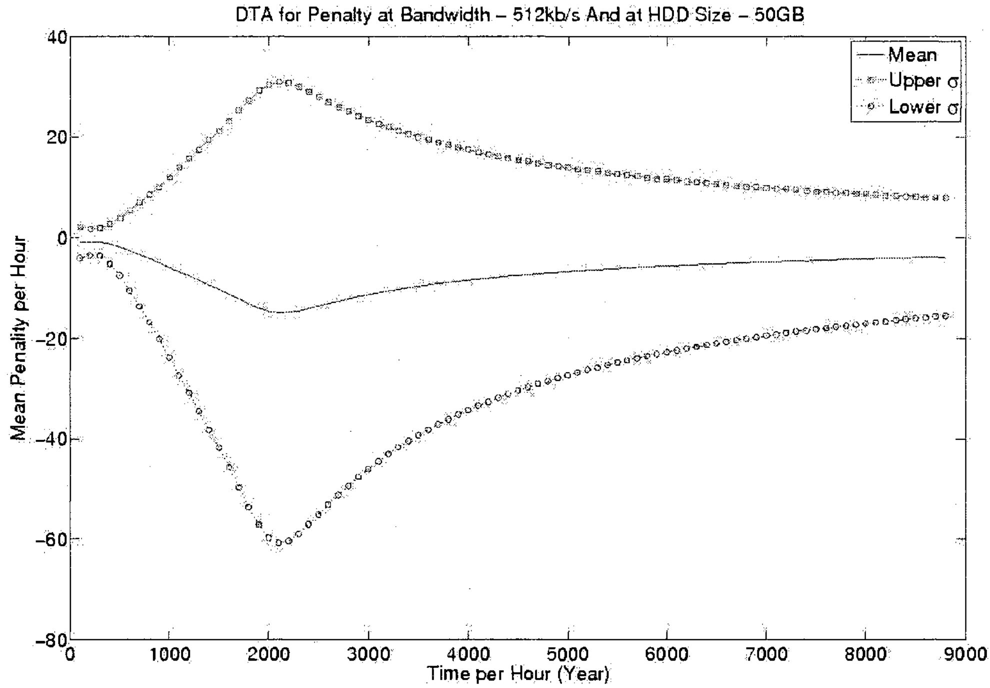


Figure 779: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 512kb/s

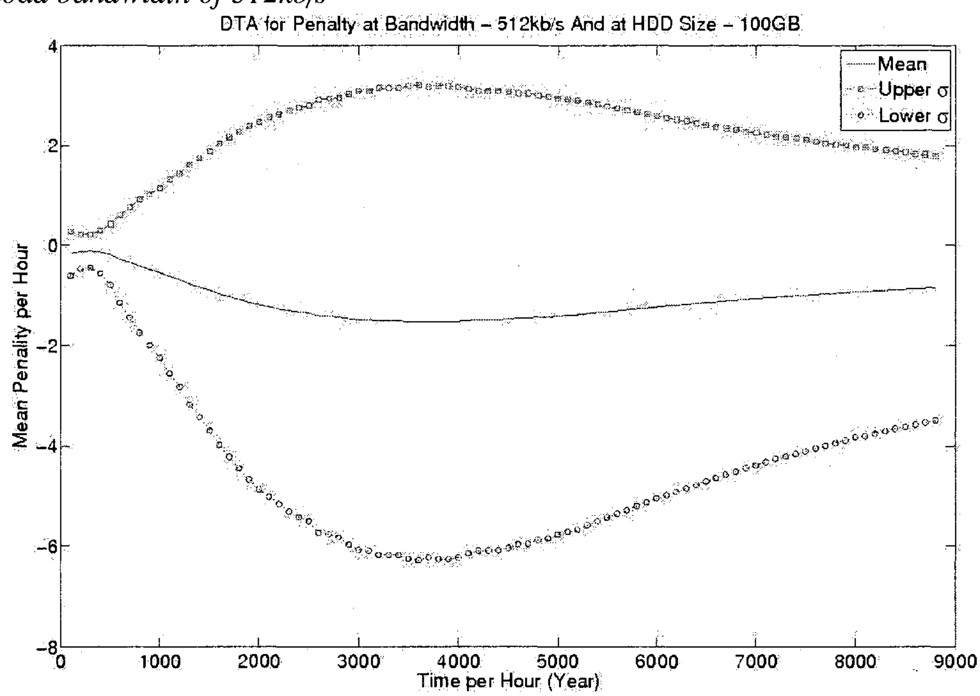


Figure 780: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 512kb/s

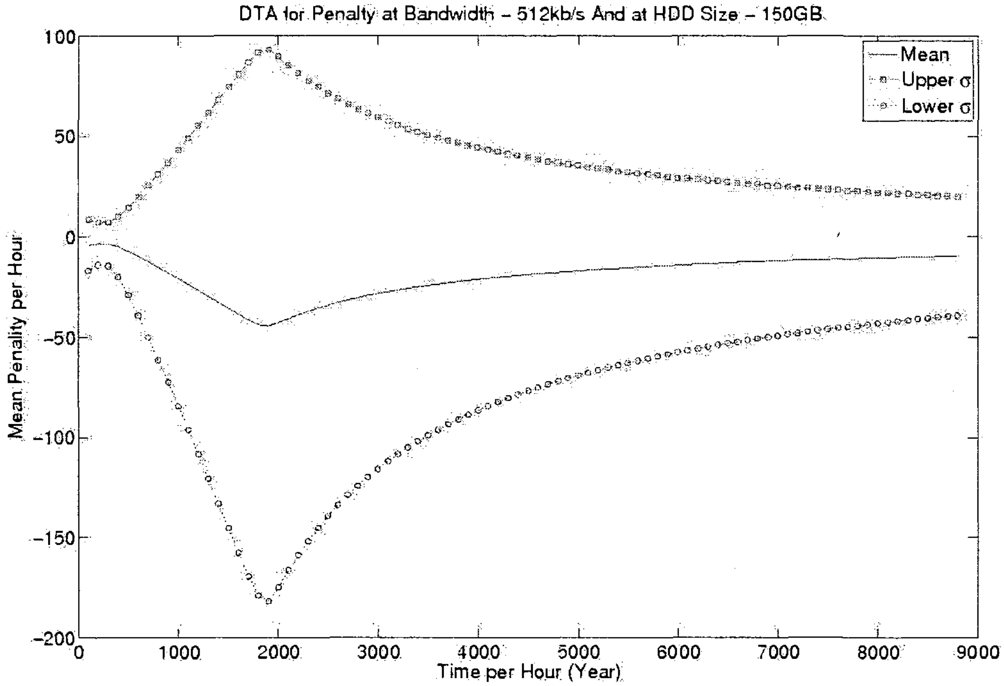


Figure 781: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 512kb/s

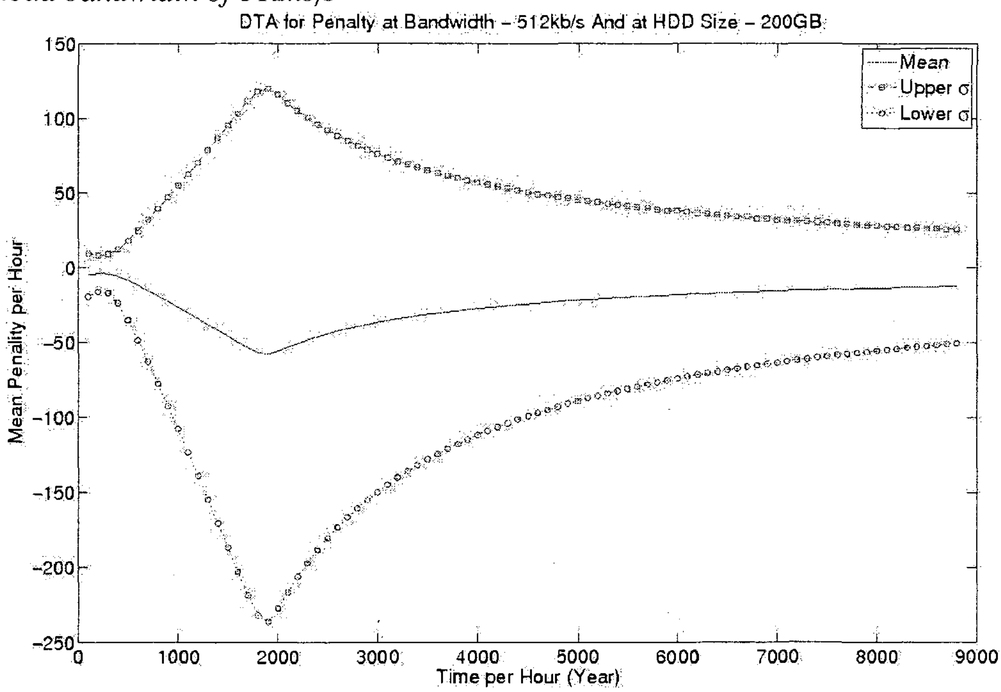


Figure 782: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 1000kb/s

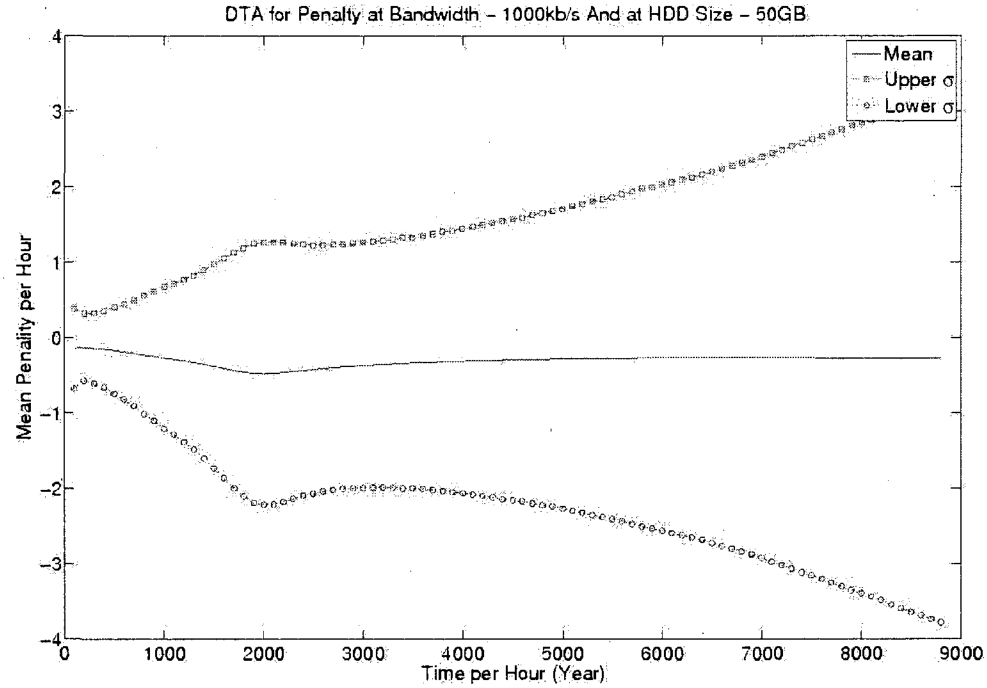


Figure 783: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 1000kb/s

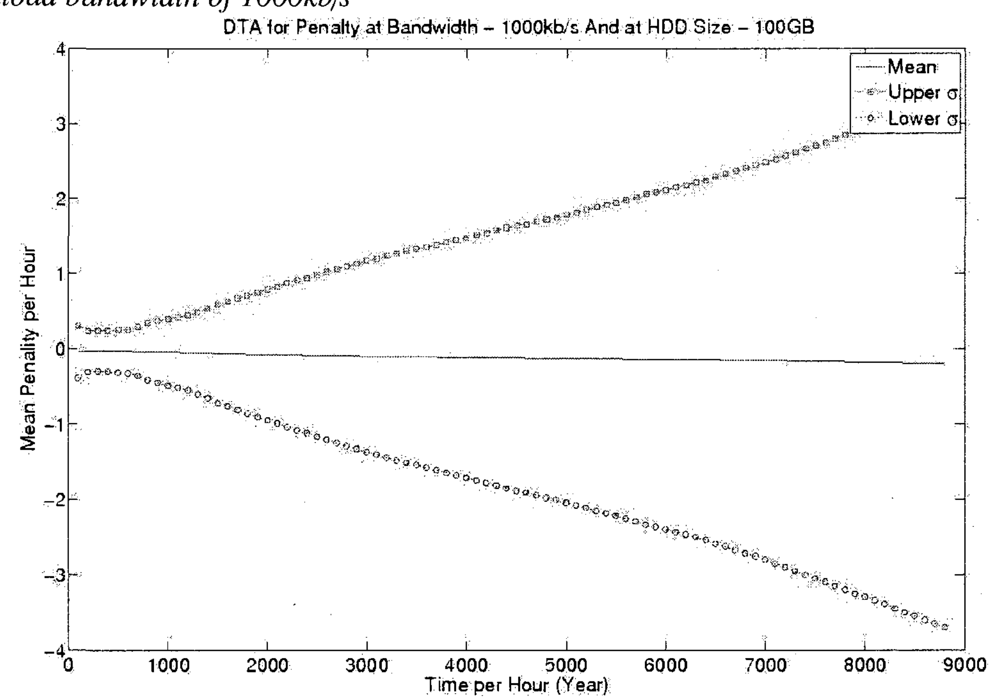


Figure 784: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 1000kb/s

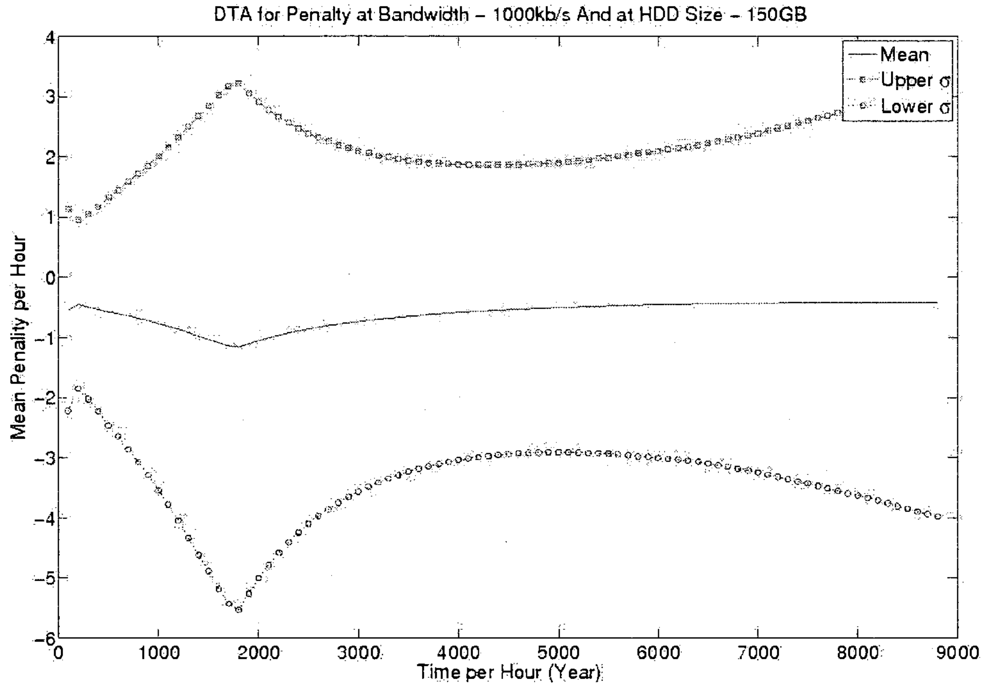


Figure 785: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 1000kb/s

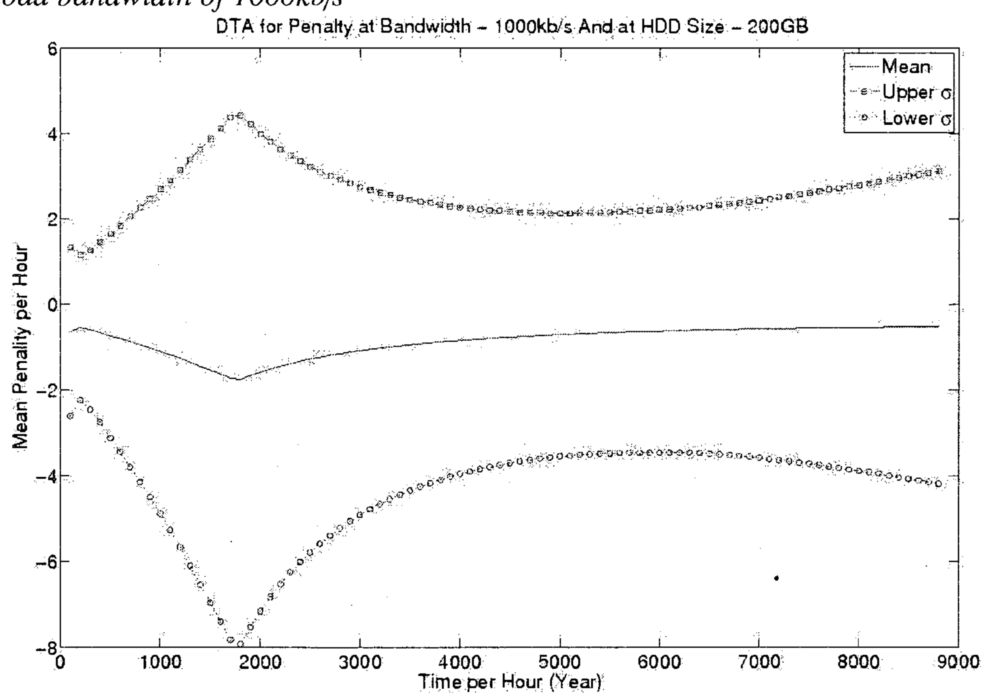


Figure 786: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 2000kb/s

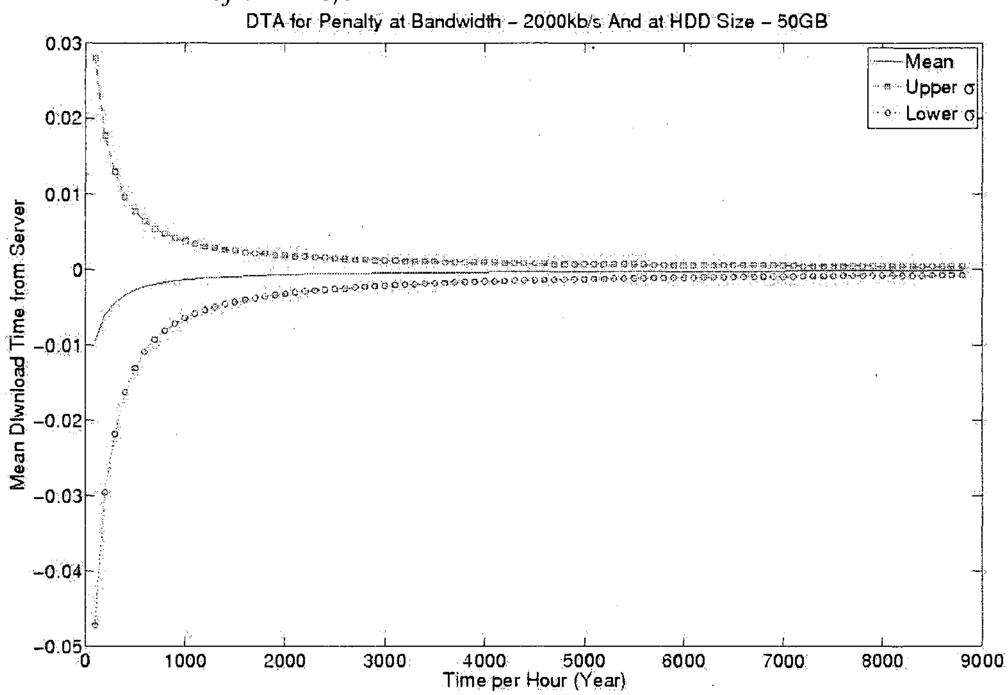


Figure 787: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 2000kb/s

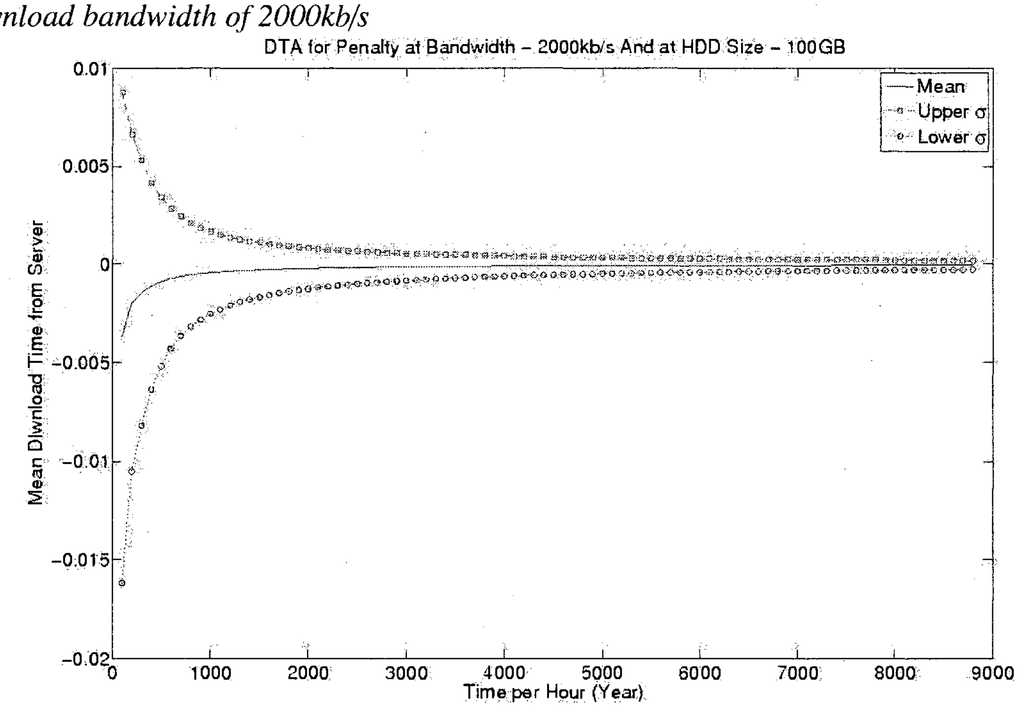


Figure 788: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 2000kb/s

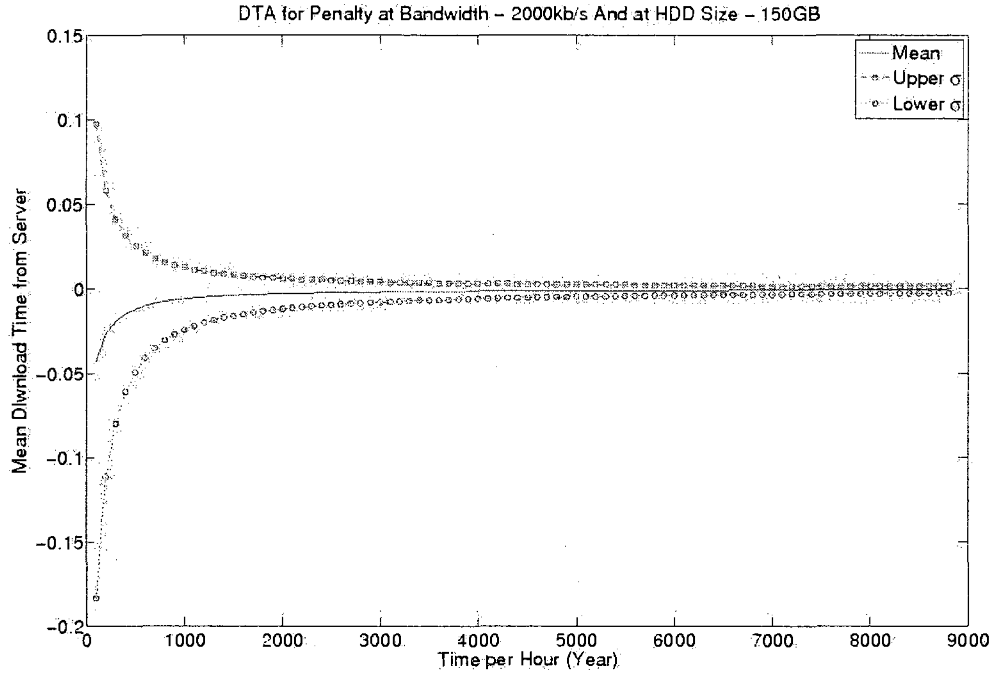


Figure 789: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 2000kb/s

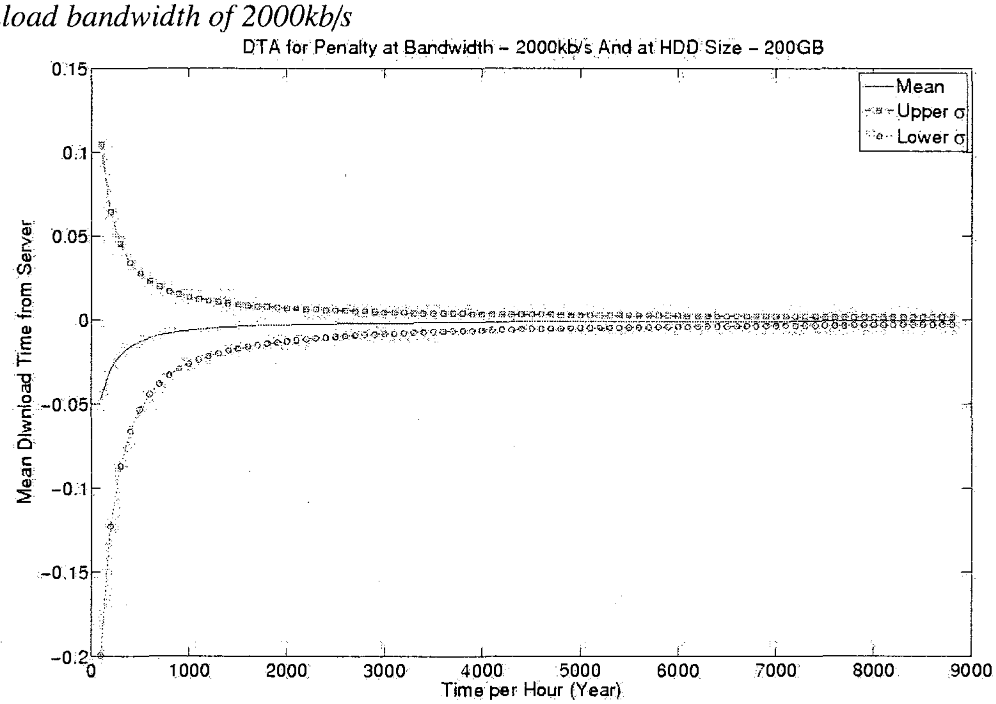


Figure 790: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 5000kb/s

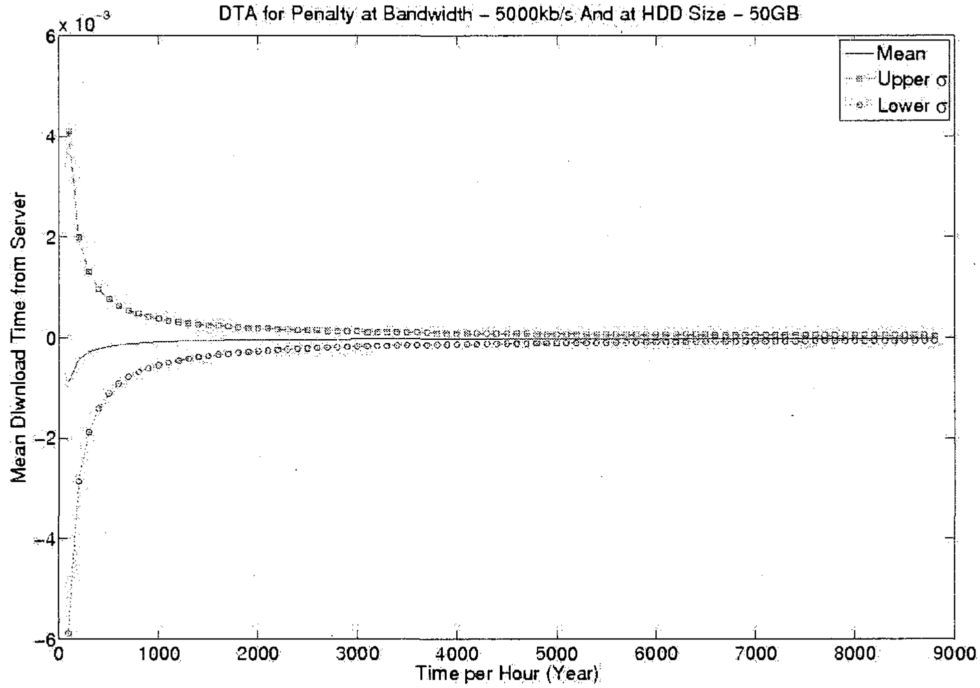


Figure 791: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 5000kb/s

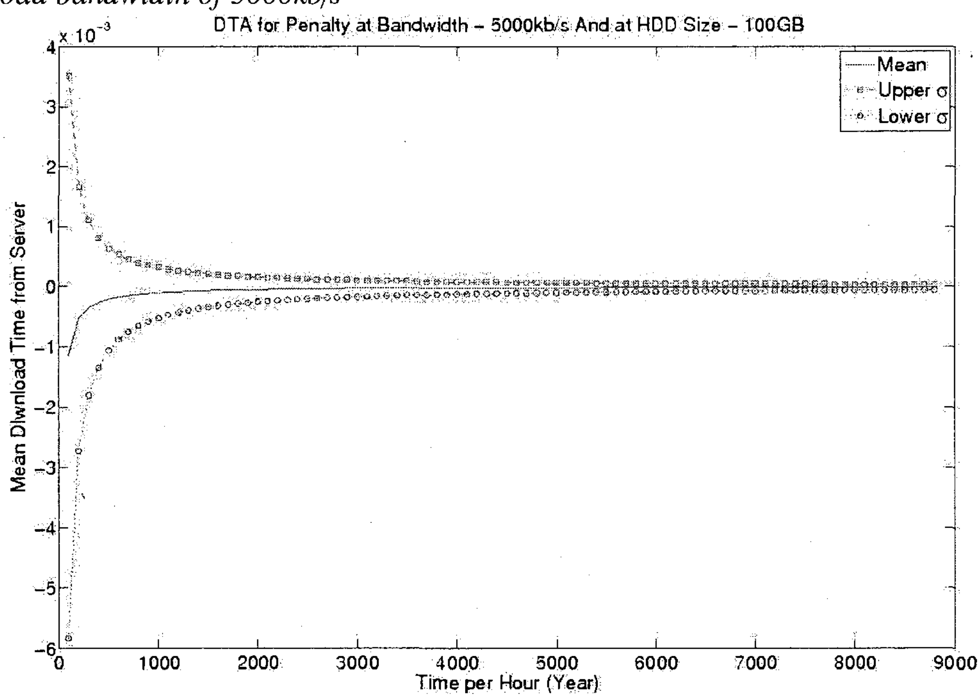


Figure 792: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 5000kb/s

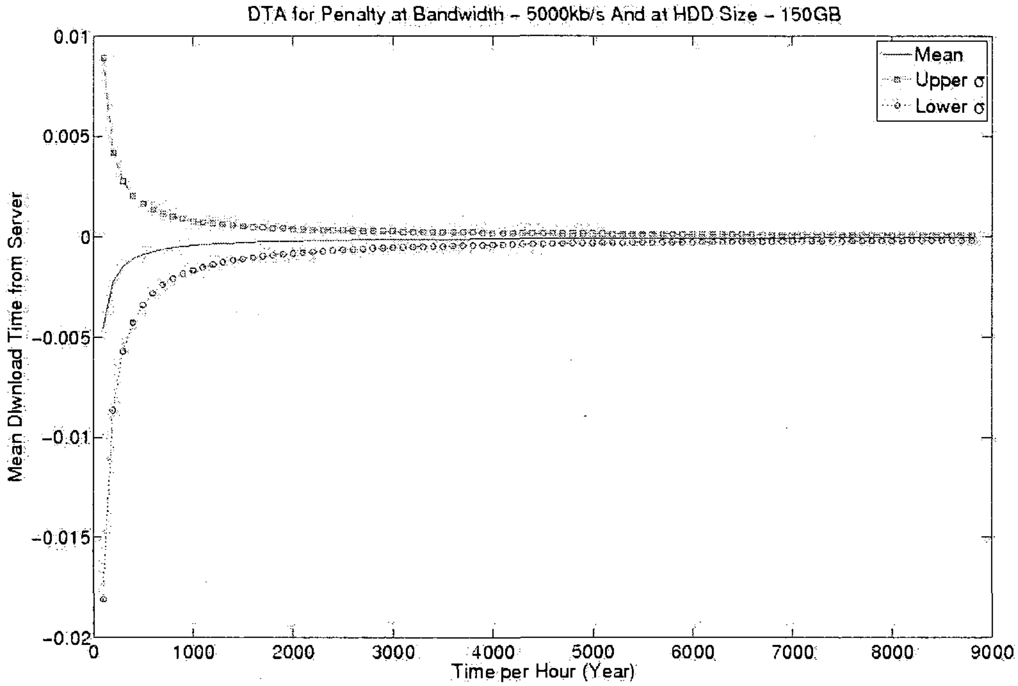


Figure 793: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 5000kb/s

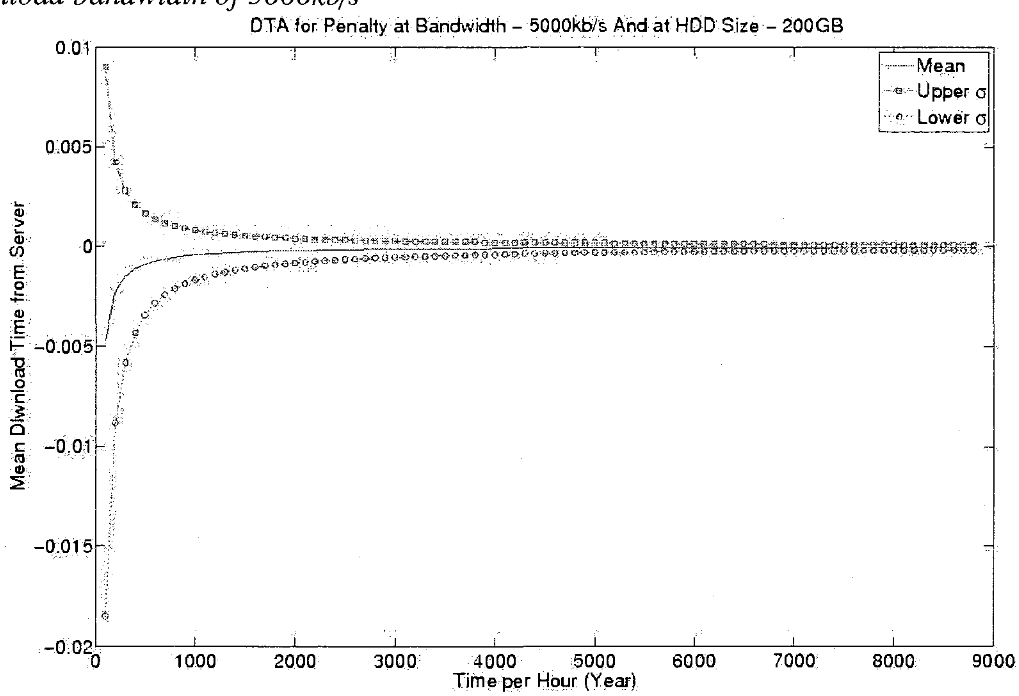


Figure 794: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 10000kb/s

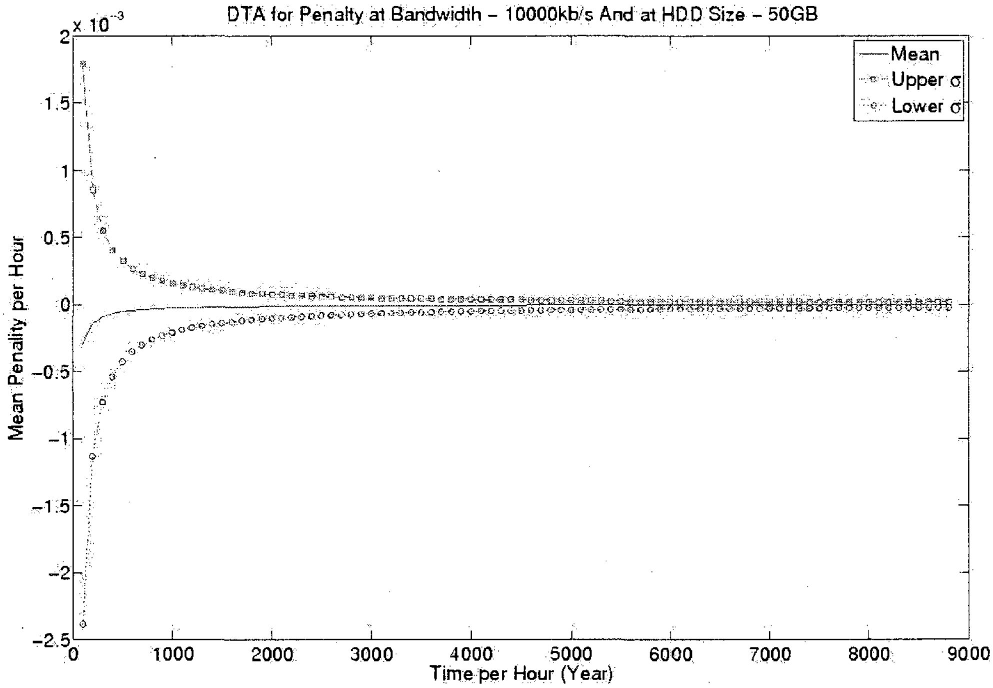


Figure 795: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 10000kb/s

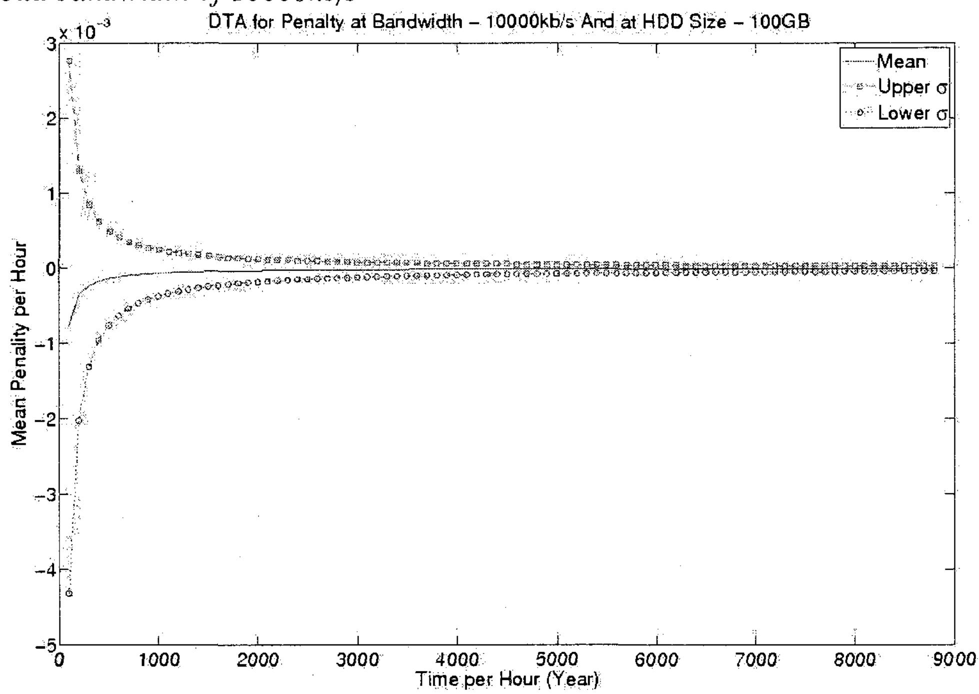


Figure 796: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 10000kb/s

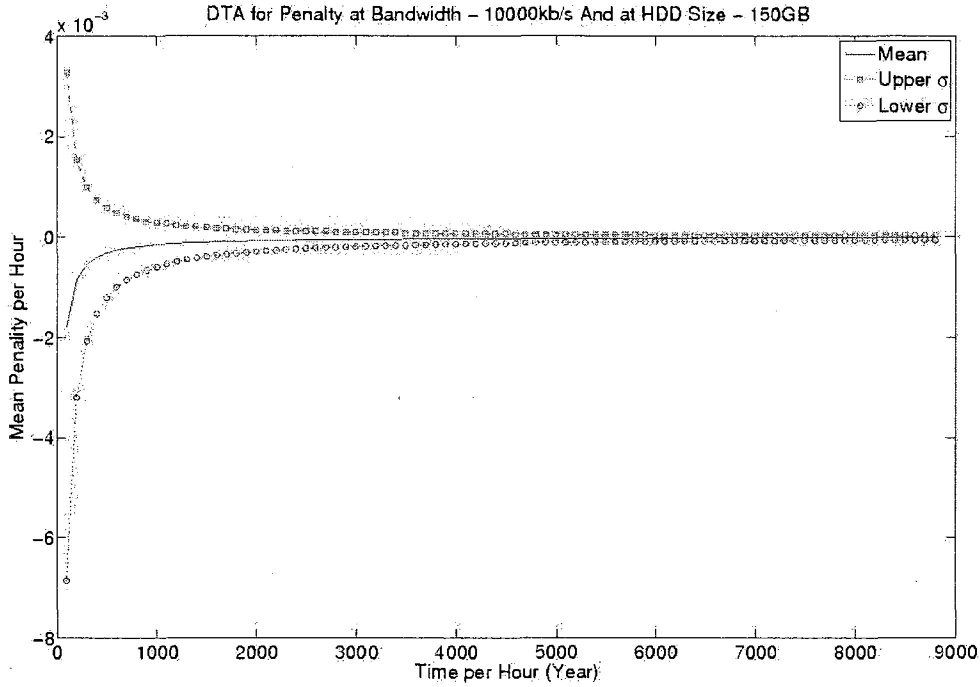


Figure 797: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 10000kb/s

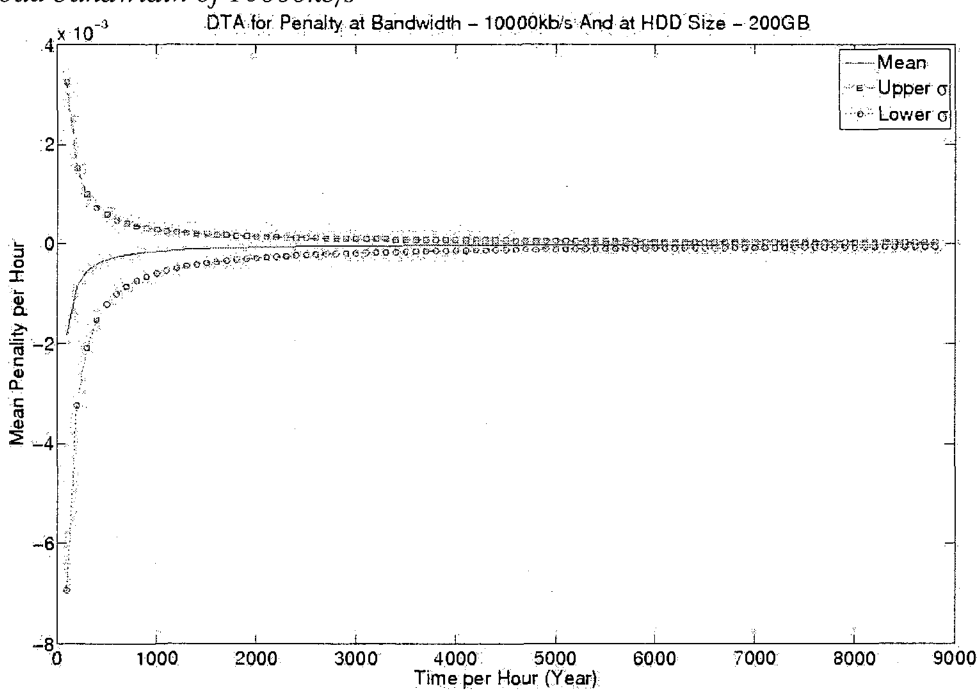


Figure 798: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 15000kb/s

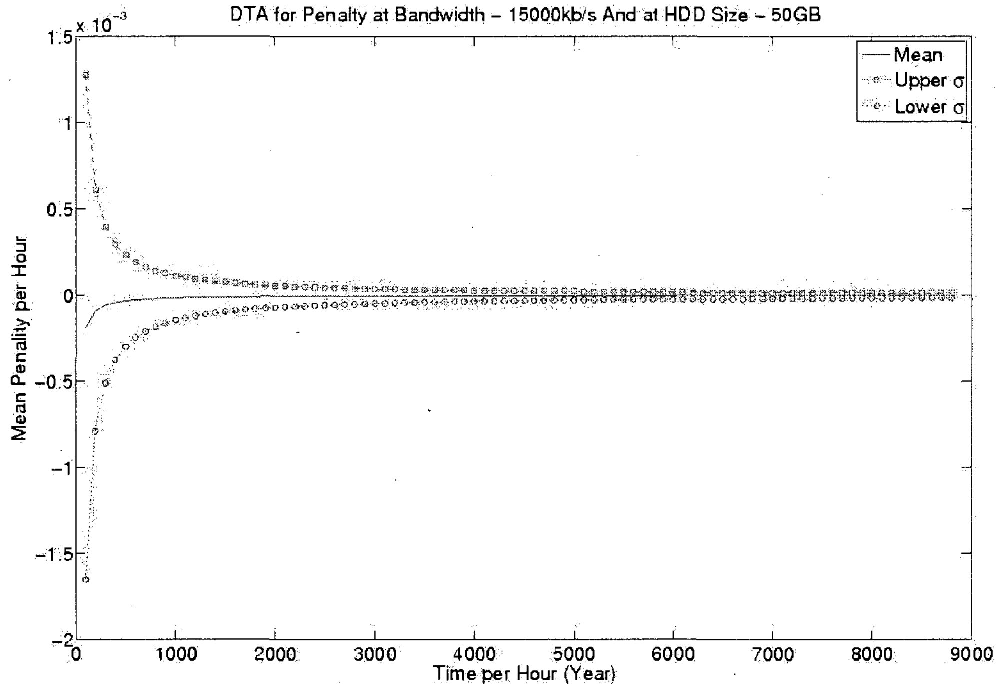


Figure 799: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 15000kb/s

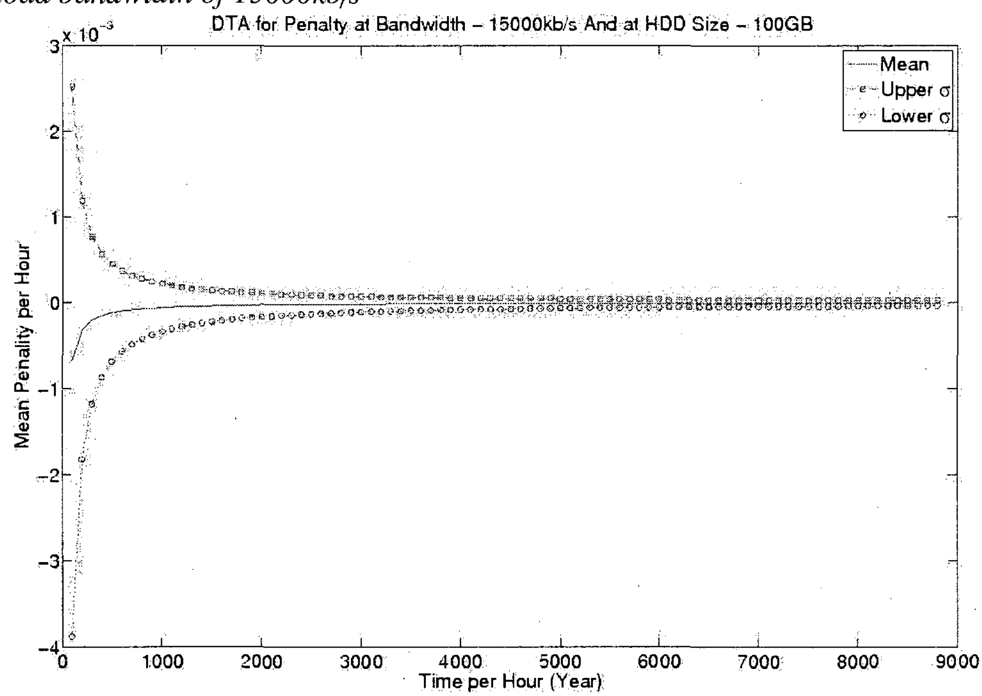


Figure 800: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 15000kb/s

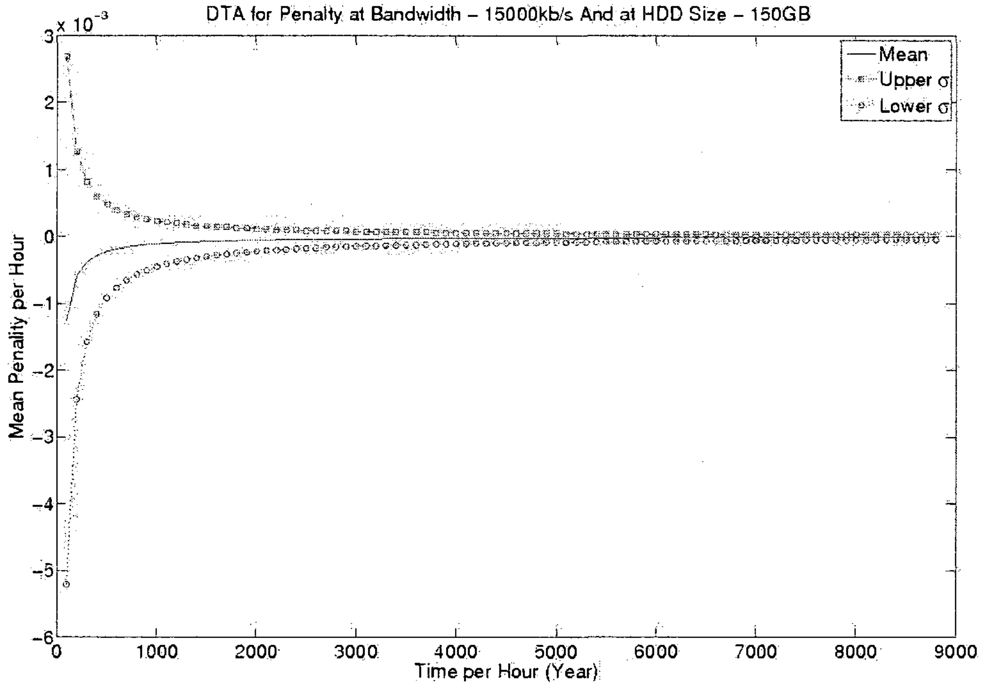


Figure 801: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 15000kb/s

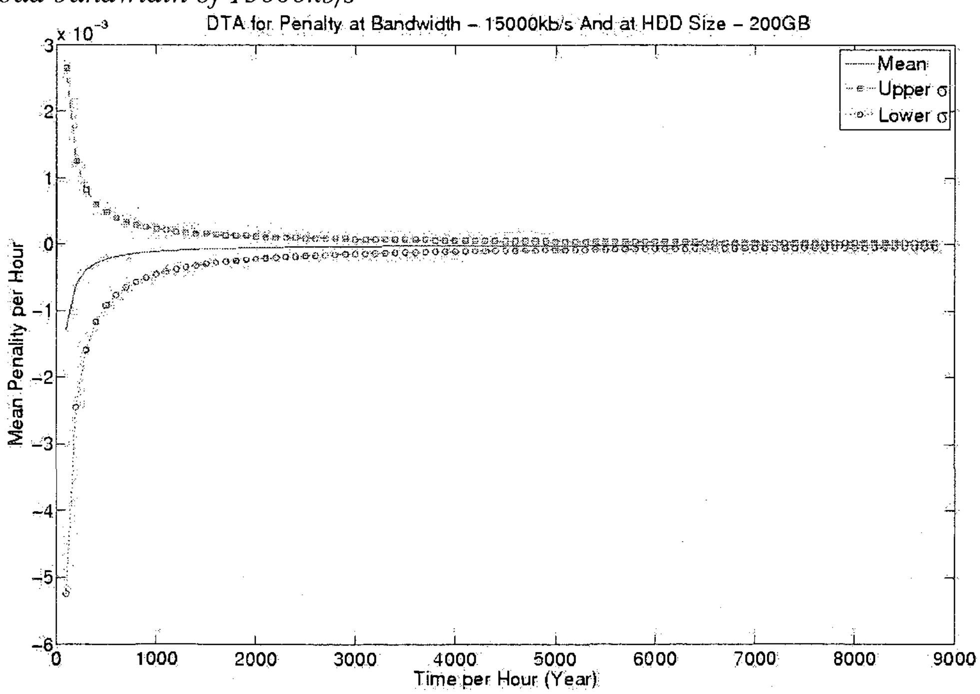


Figure 802: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 25kb/s

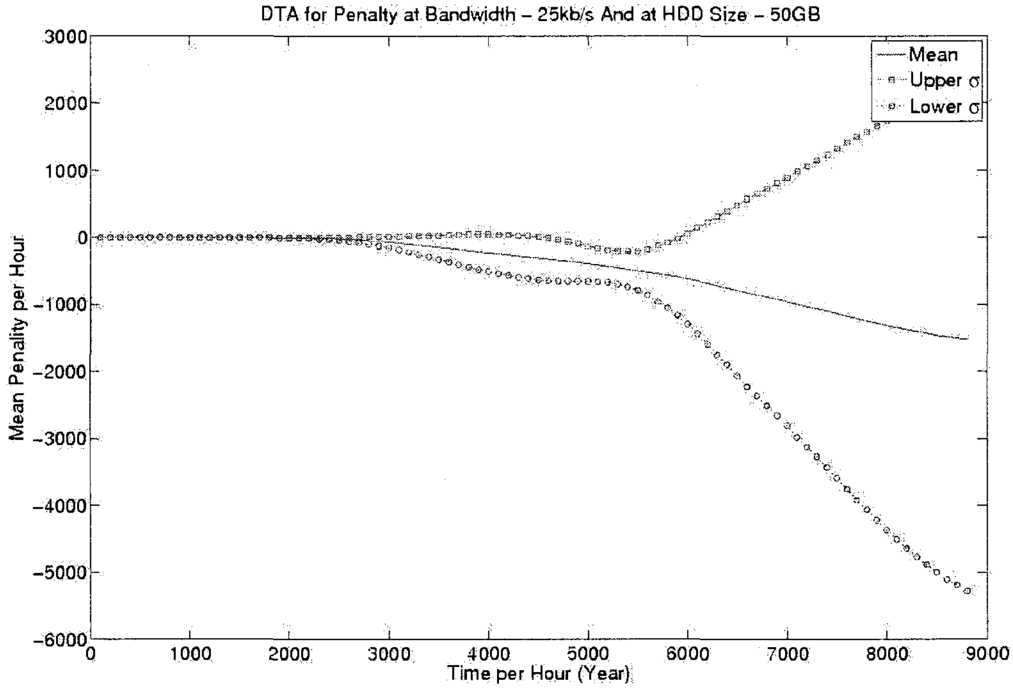


Figure 803: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 25kb/s

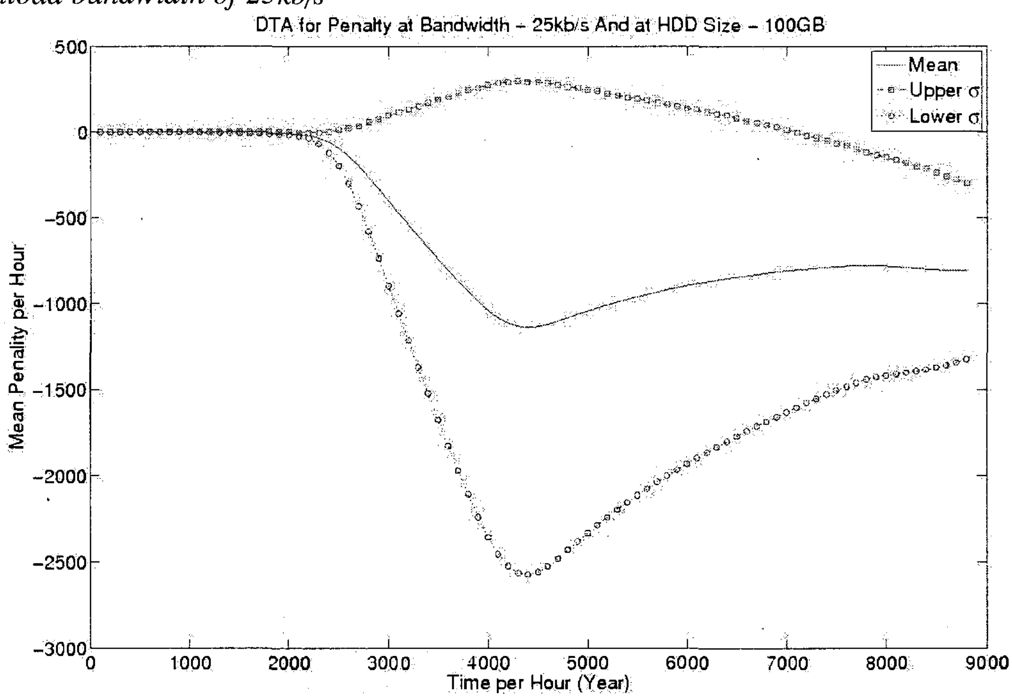


Figure 804: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 25kb/s

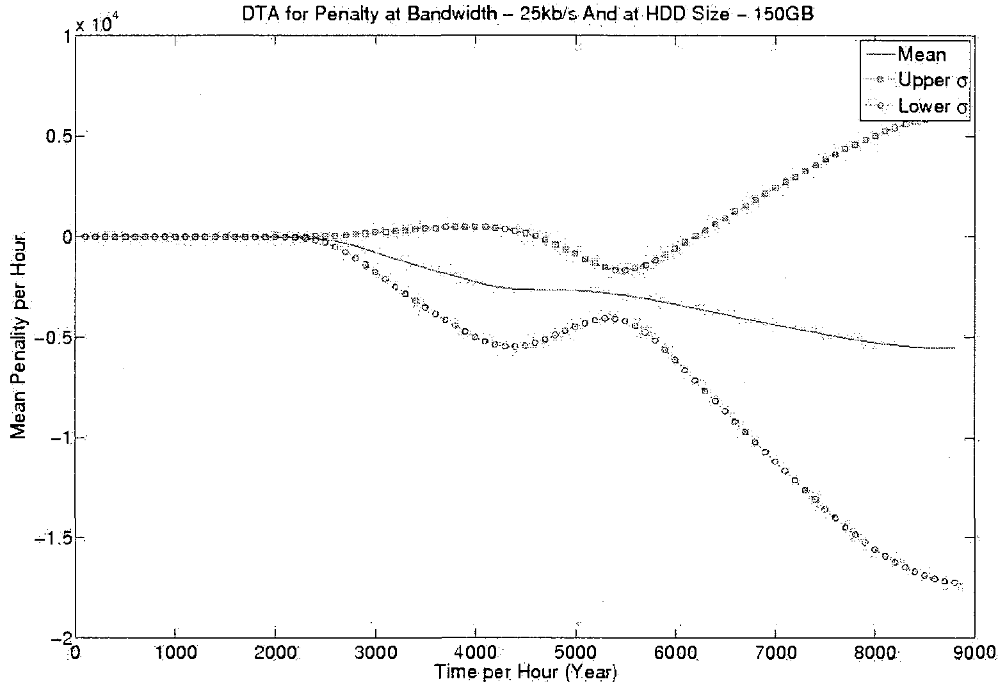


Figure 805: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 25kb/s

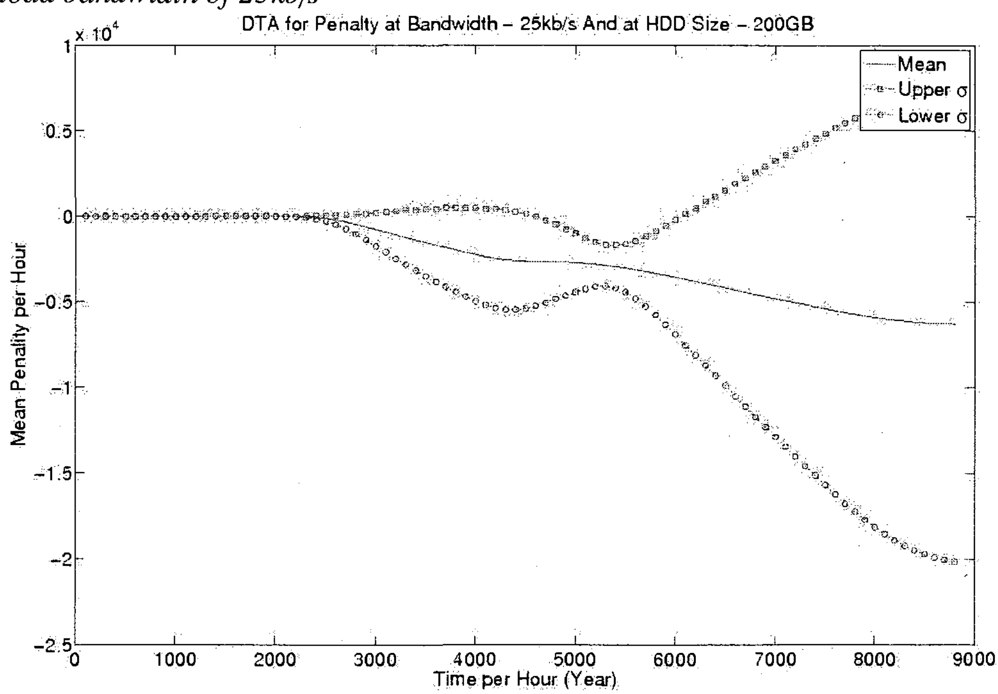


Figure 806: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 50kb/s

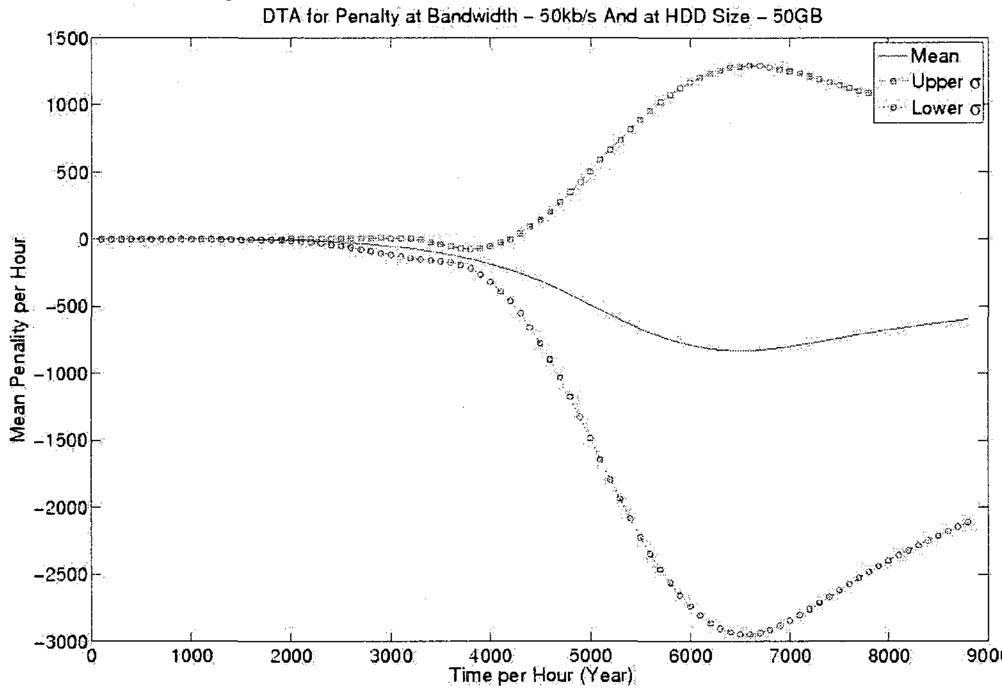


Figure 807: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 50kb/s

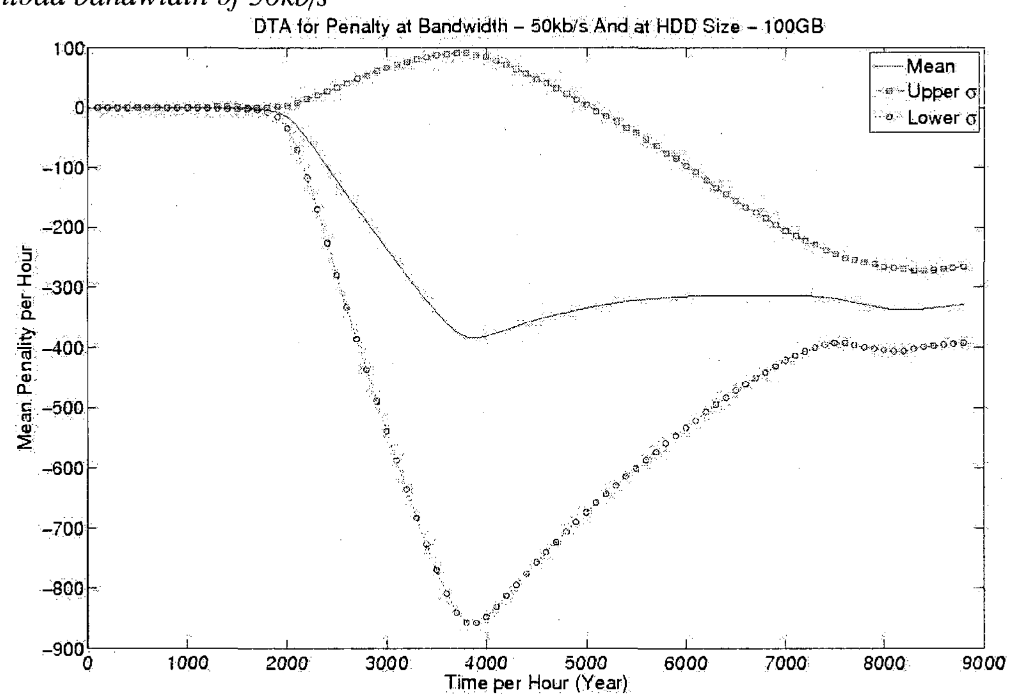


Figure 808: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 50kb/s

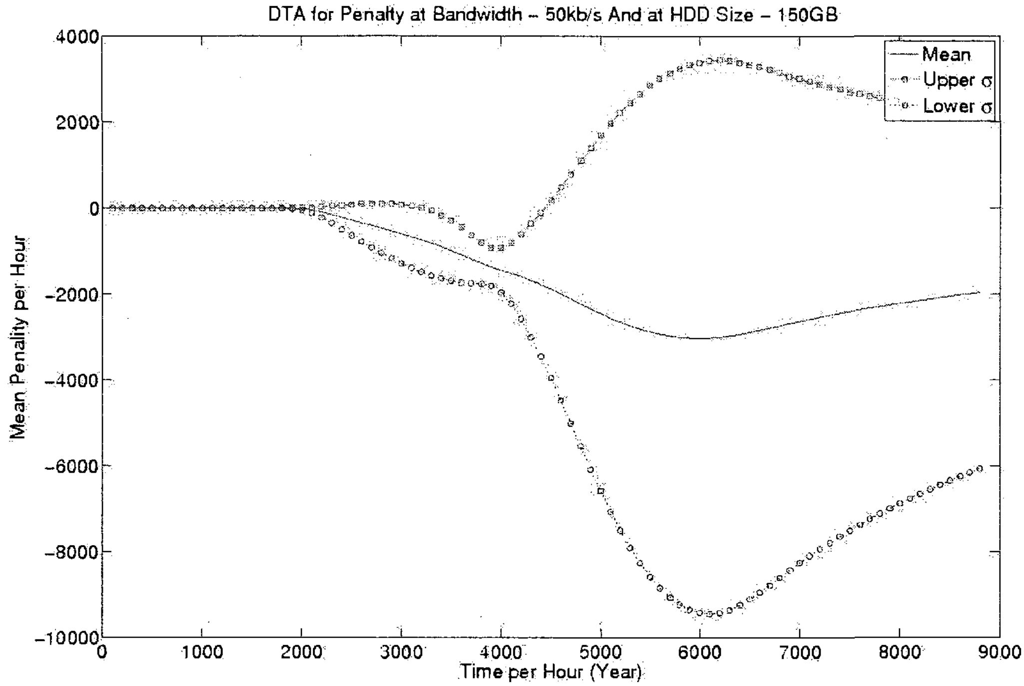


Figure 809: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 50kb/s

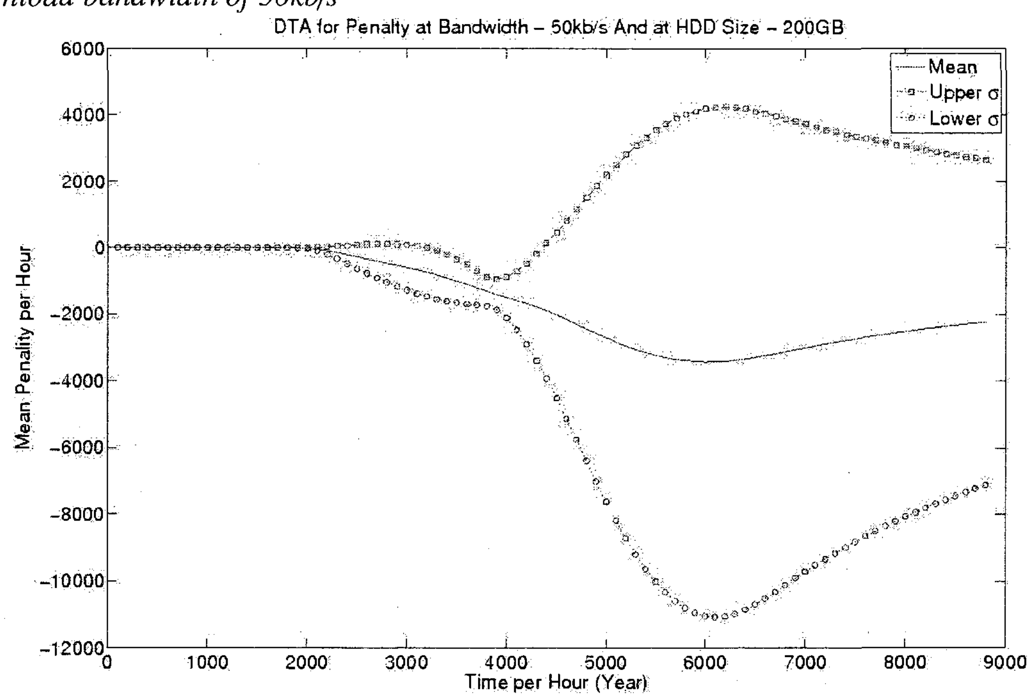


Figure 810: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 100kb/s

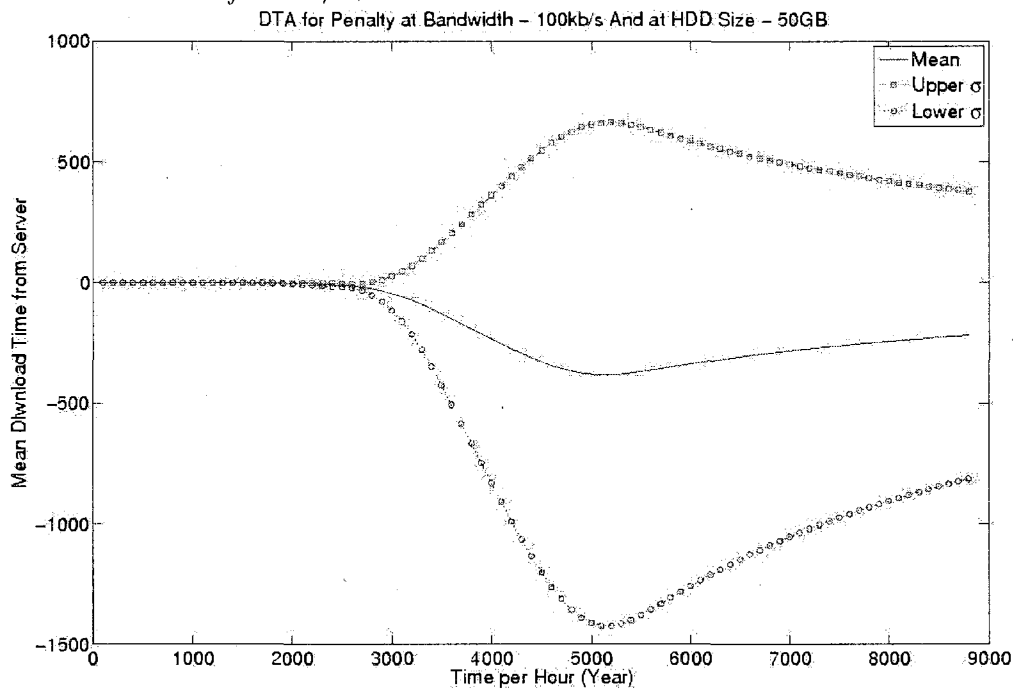


Figure 811: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 100kb/s

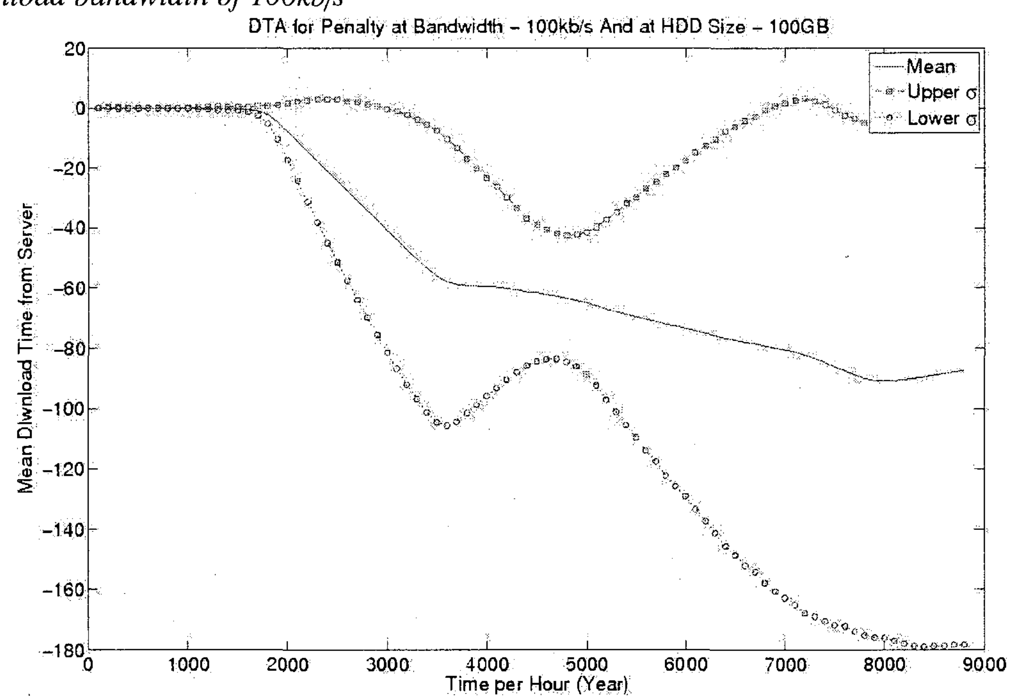


Figure 812: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 100kb/s

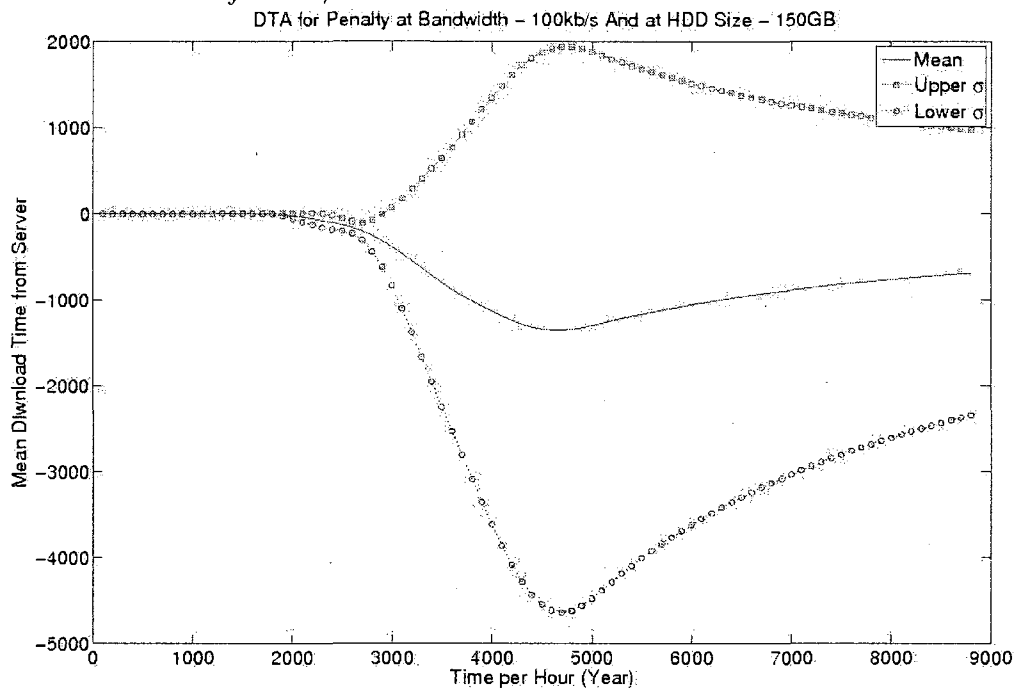


Figure 813: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 100kb/s

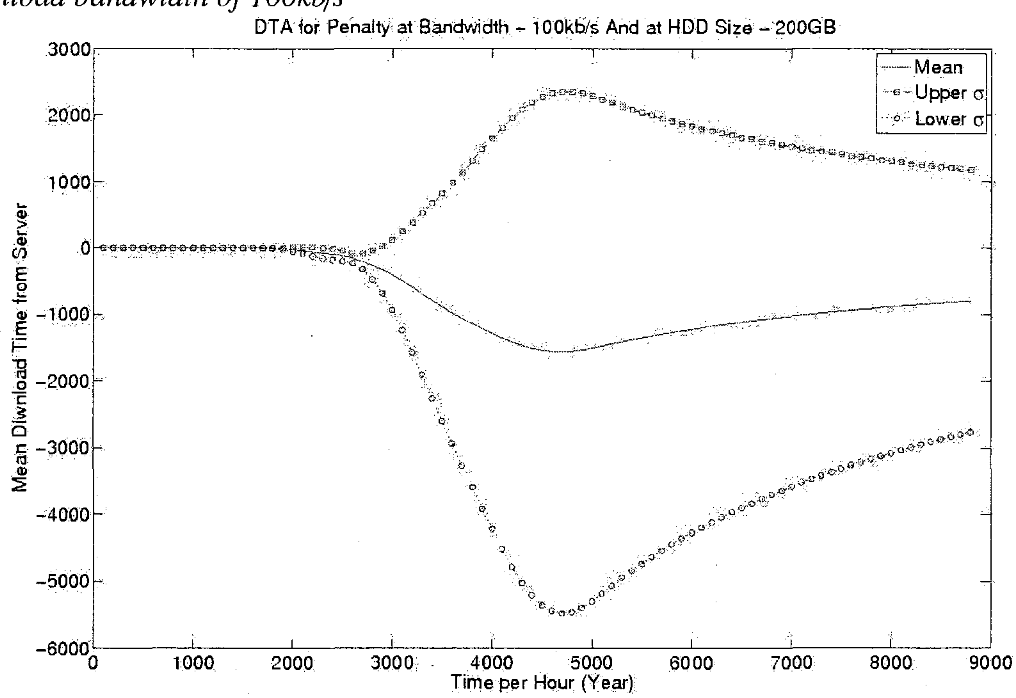


Figure 814: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 128kb/s

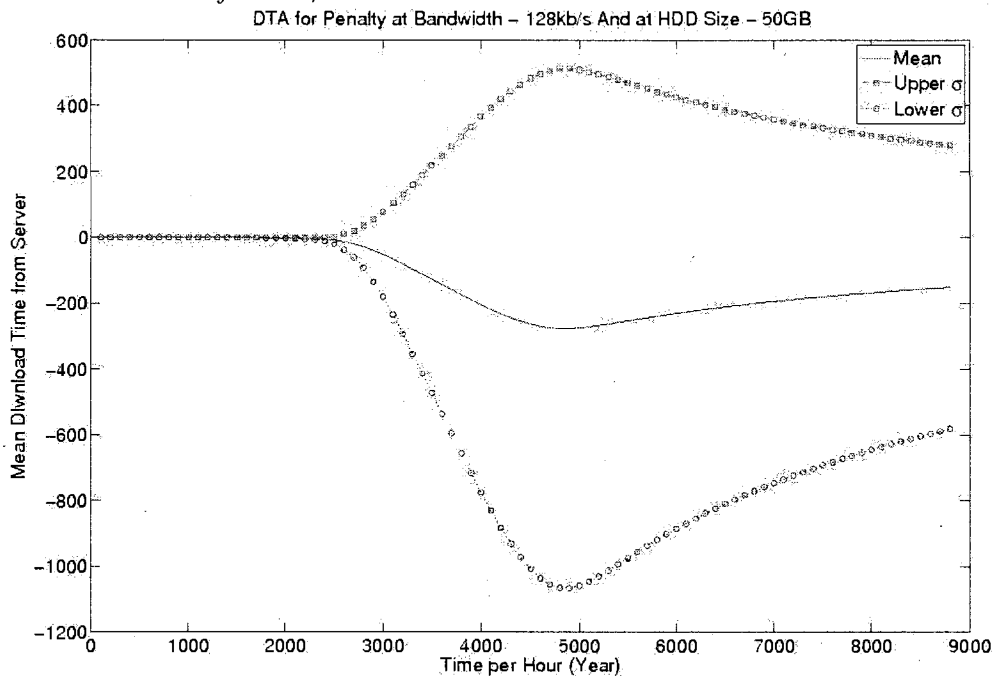


Figure 815: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 128kb/s

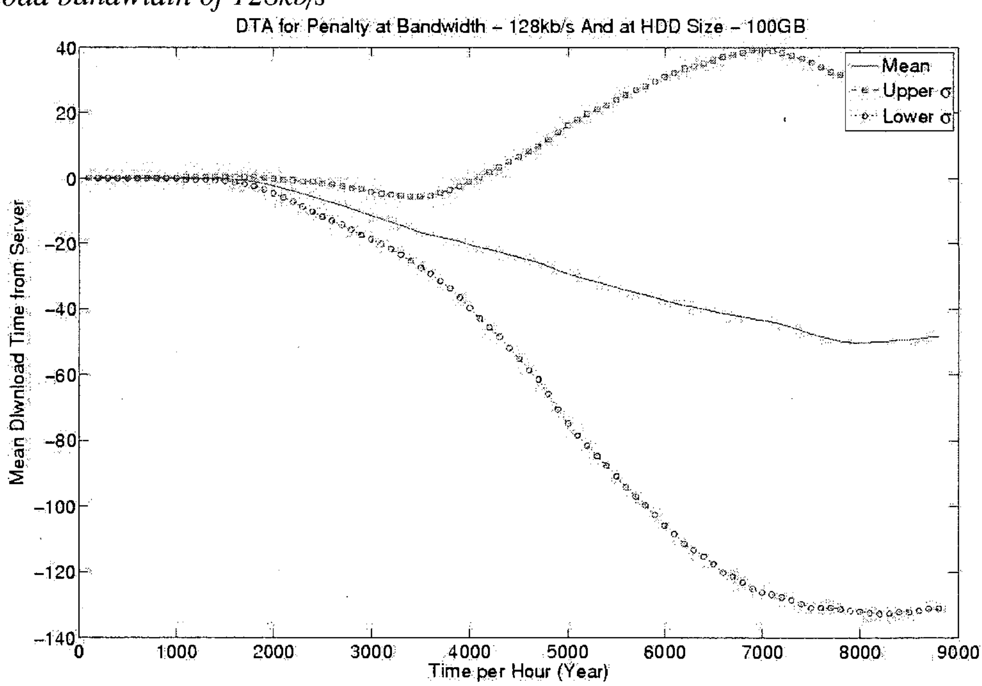


Figure 816: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 128kb/s

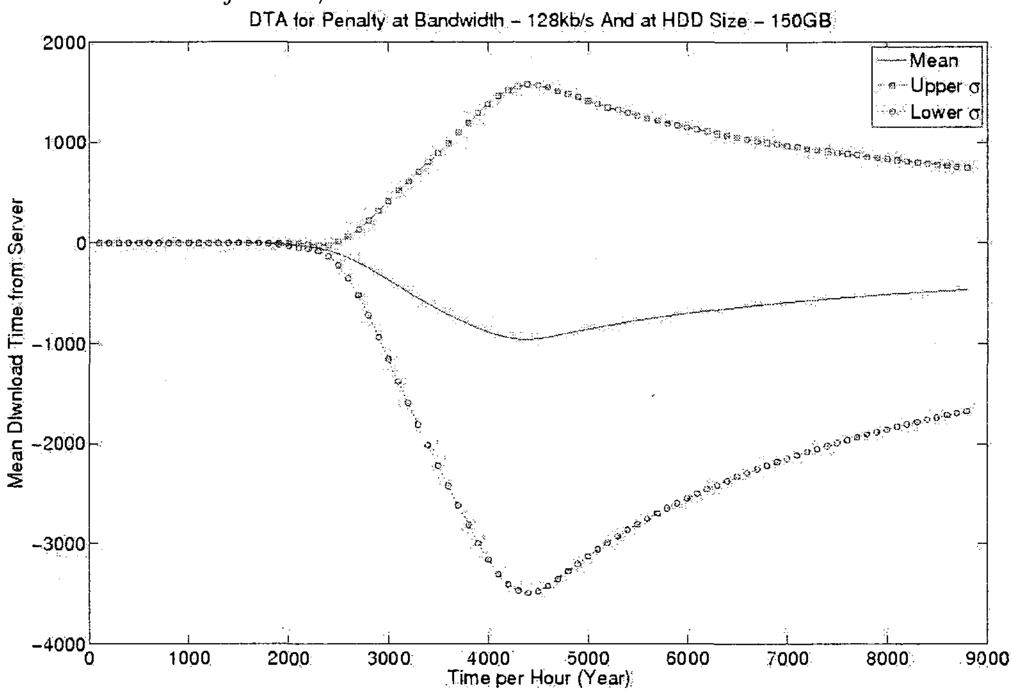


Figure 817: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 128kb/s

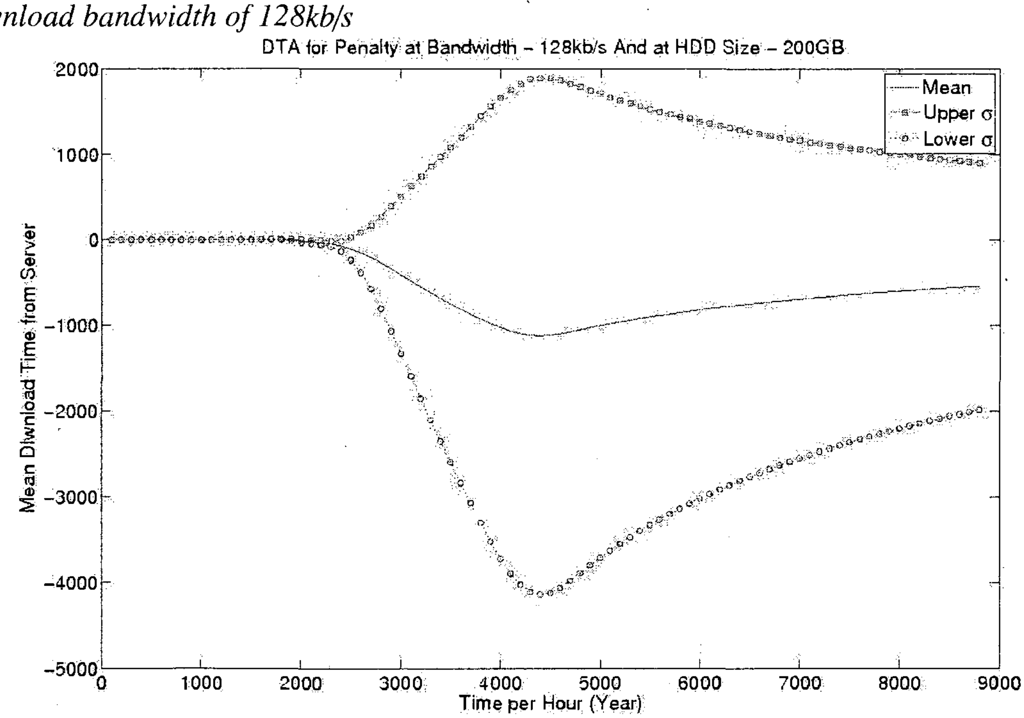


Figure 818: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 256kb/s

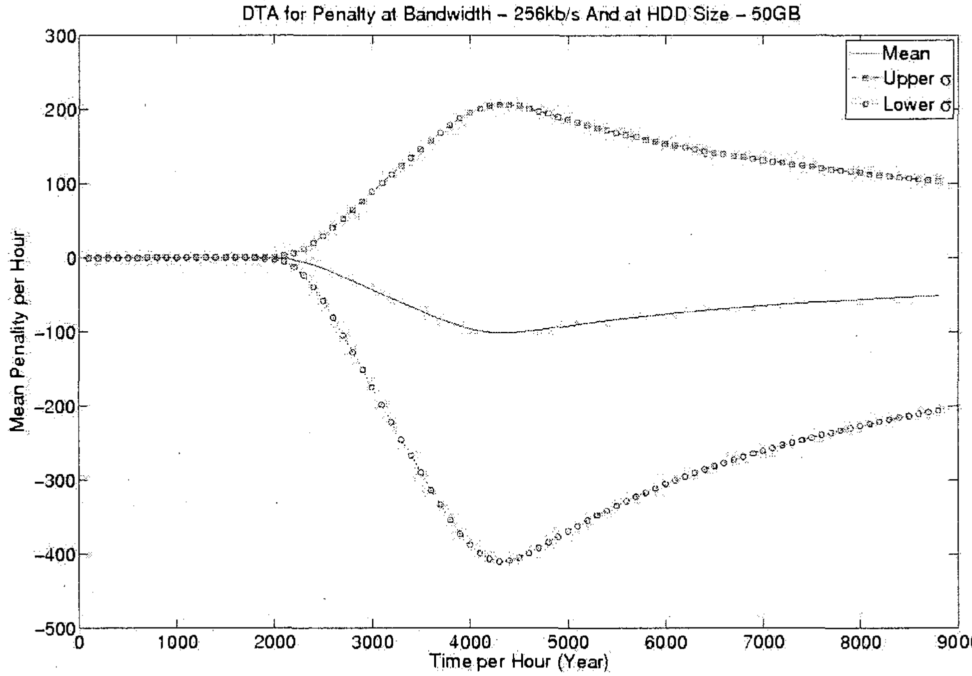


Figure 819: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 256kb/s

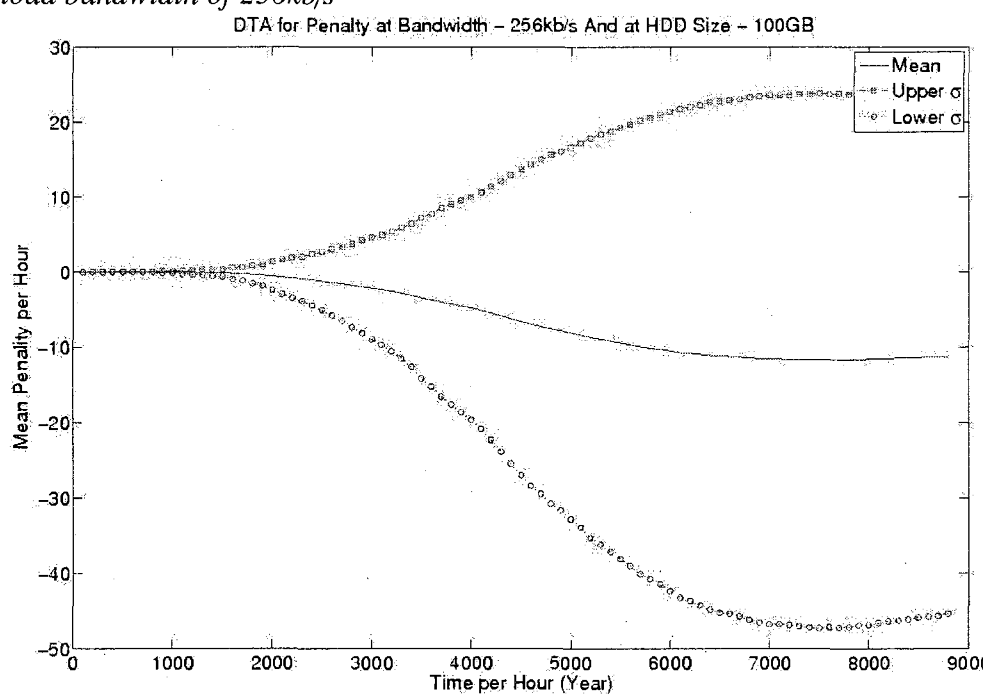


Figure 820: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 256kb/s

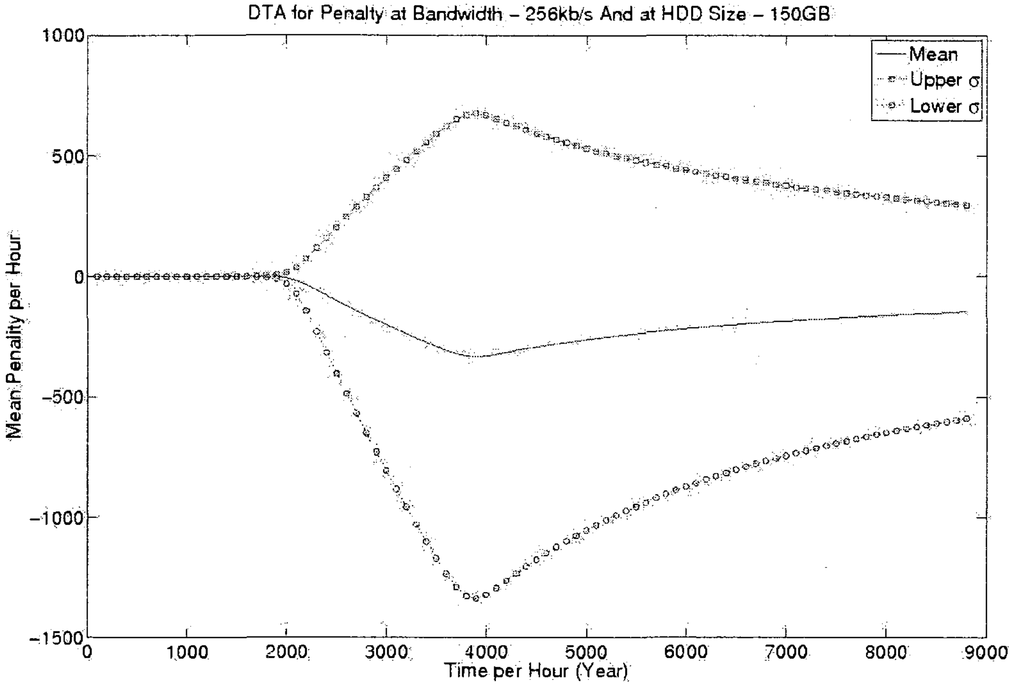


Figure 821: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 256kb/s

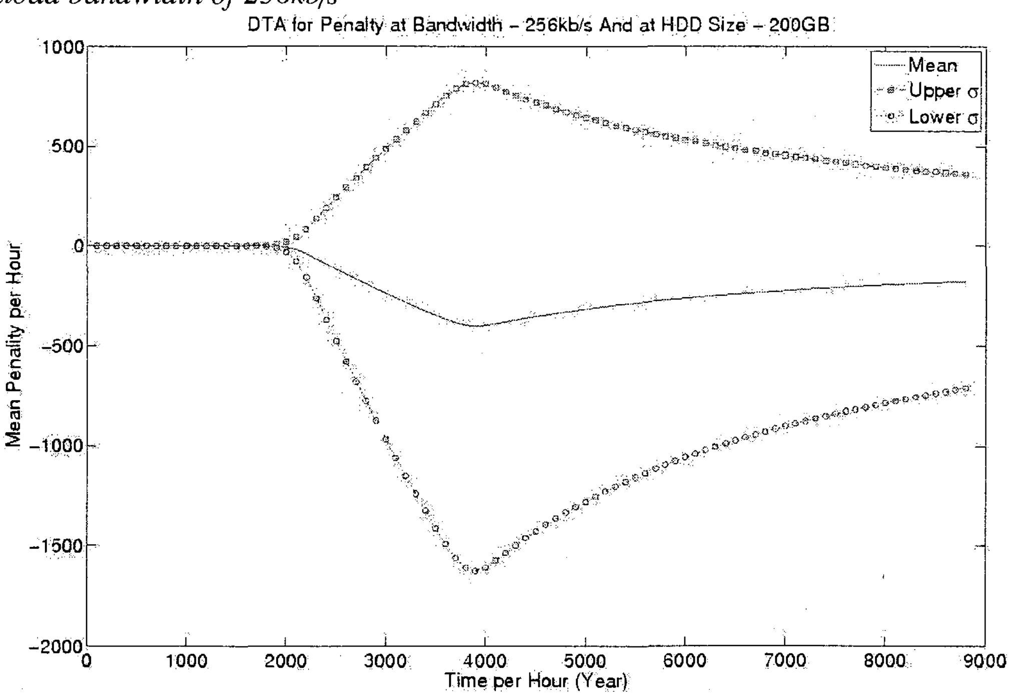


Figure 822: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 512kb/s

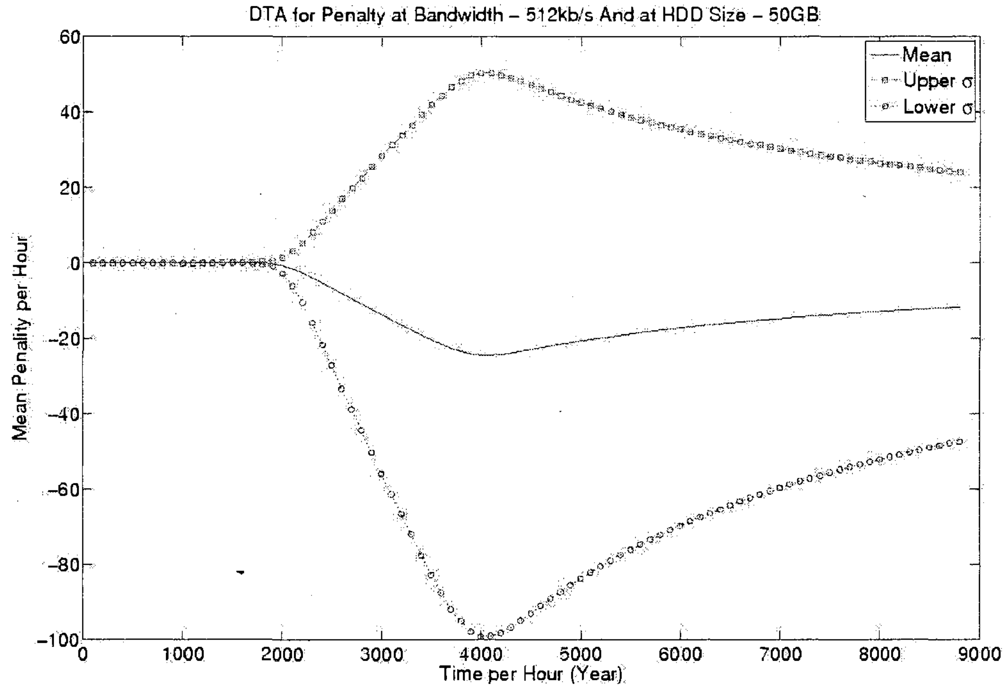


Figure 823: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 512kb/s

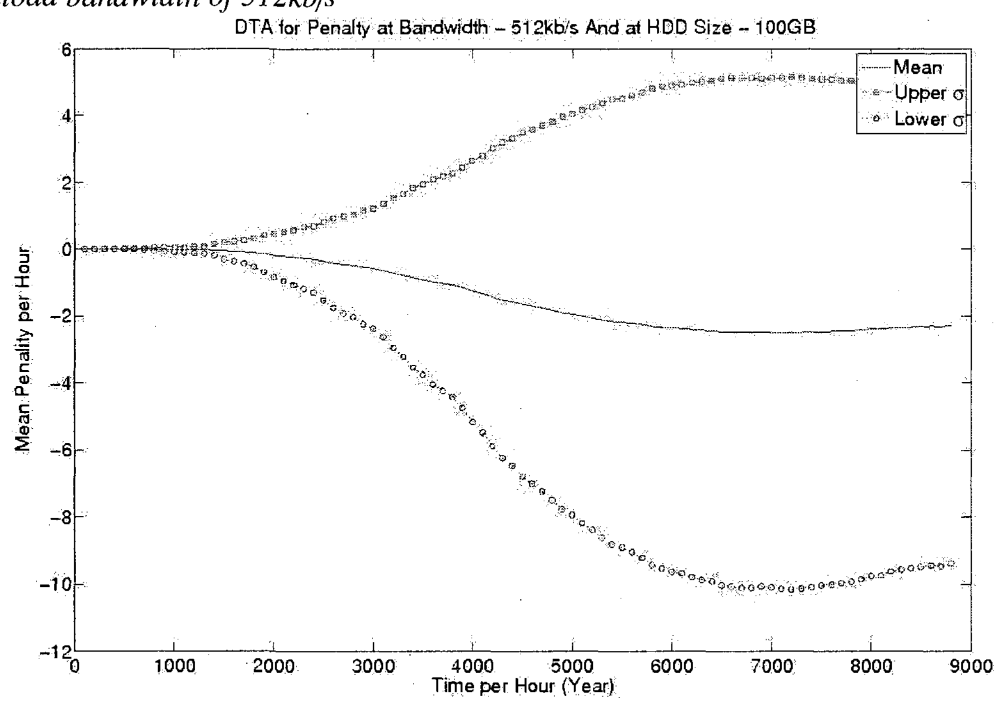


Figure 824: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 512kb/s

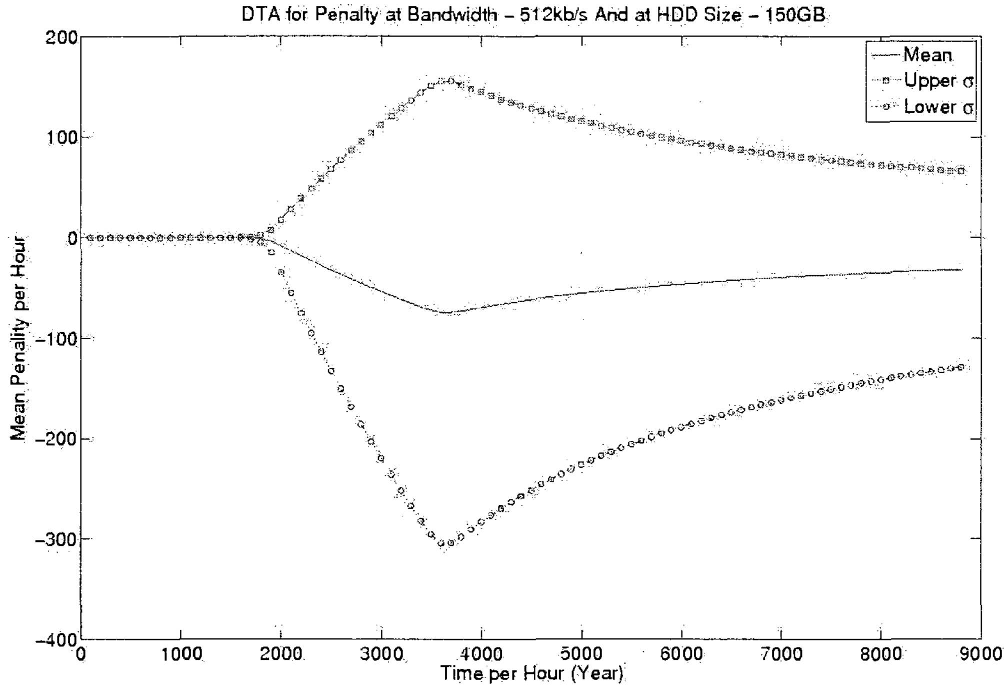


Figure 825: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 512kb/s

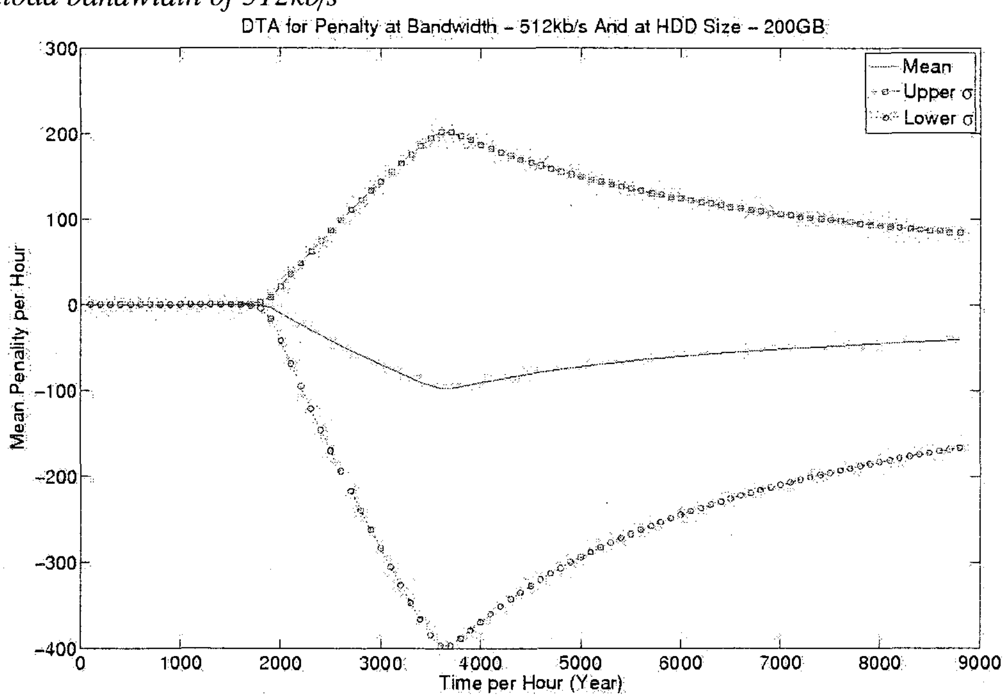


Figure 826: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 1000kb/s

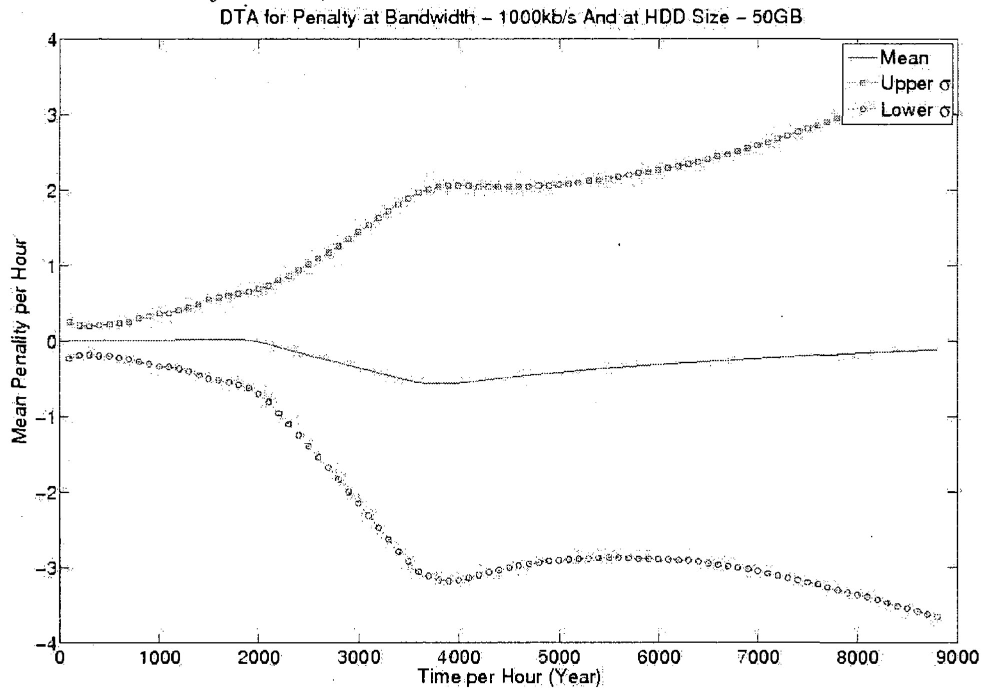


Figure 827: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 1000kb/s

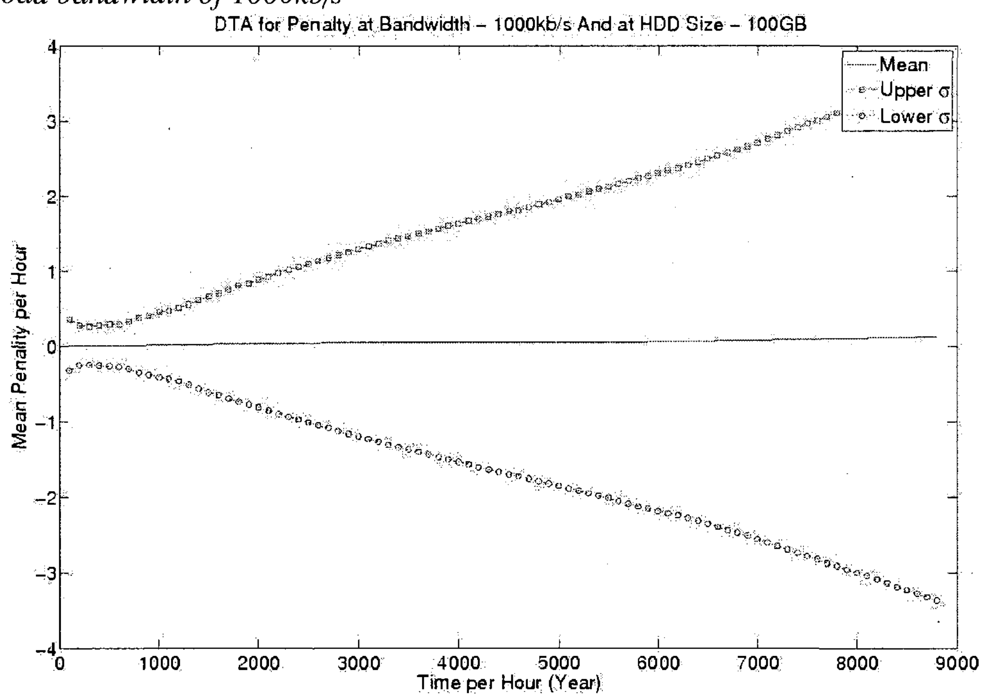


Figure 828: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 1000kb/s

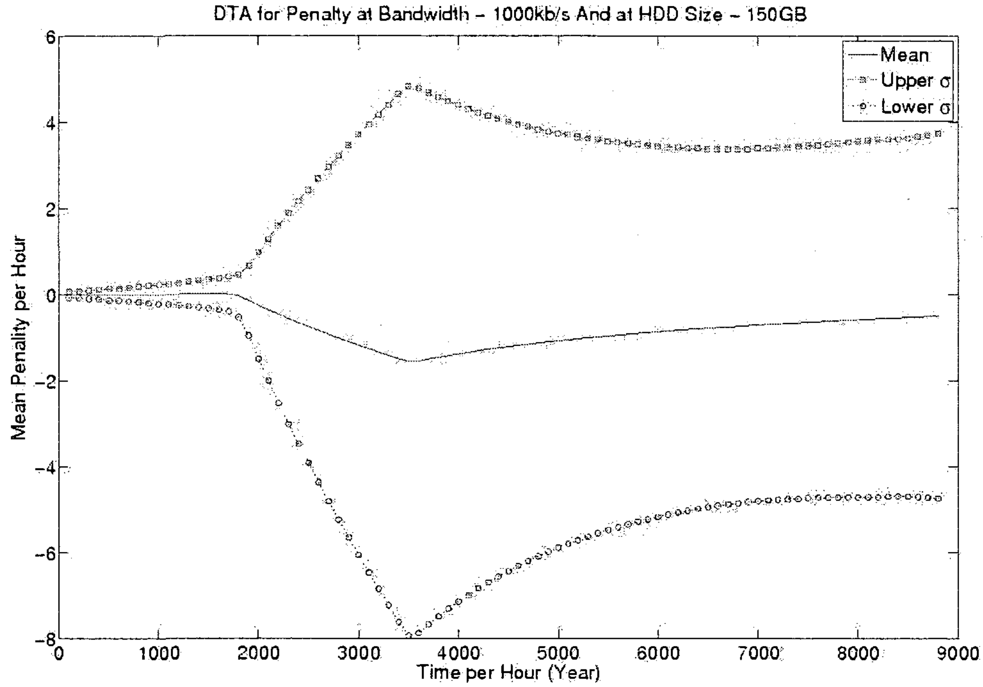


Figure 829: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 1000kb/s

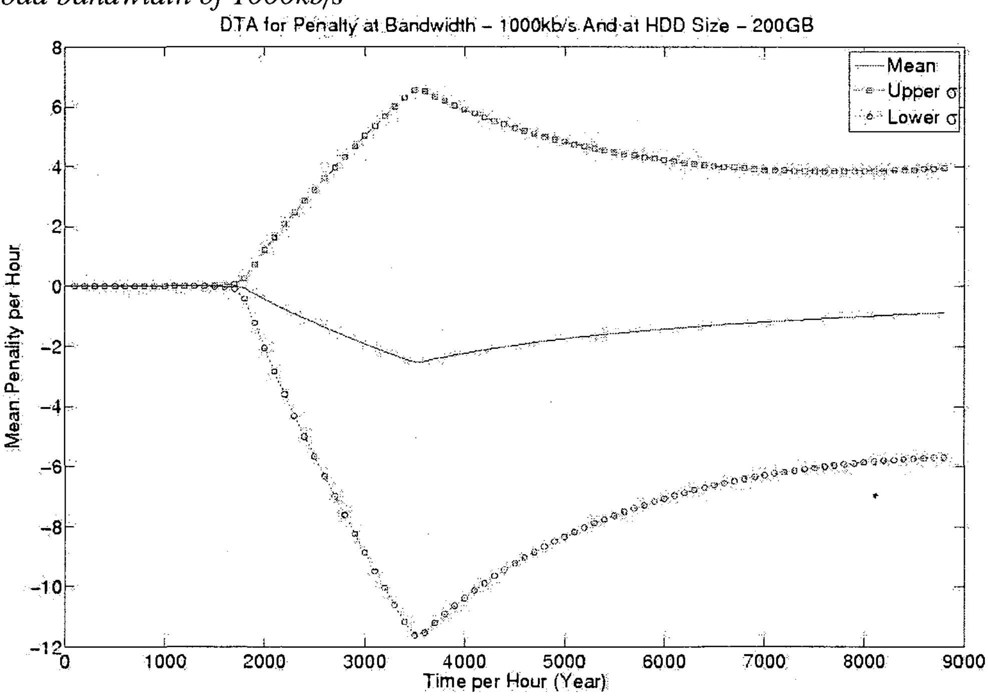


Figure 830: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 2000kb/s

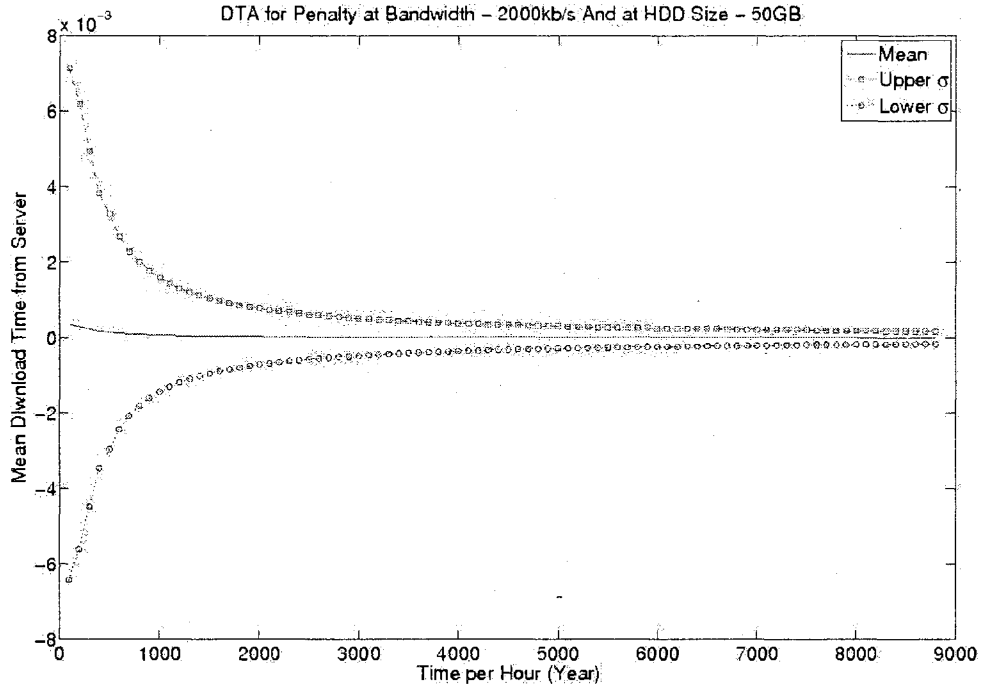


Figure 831: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 2000kb/s

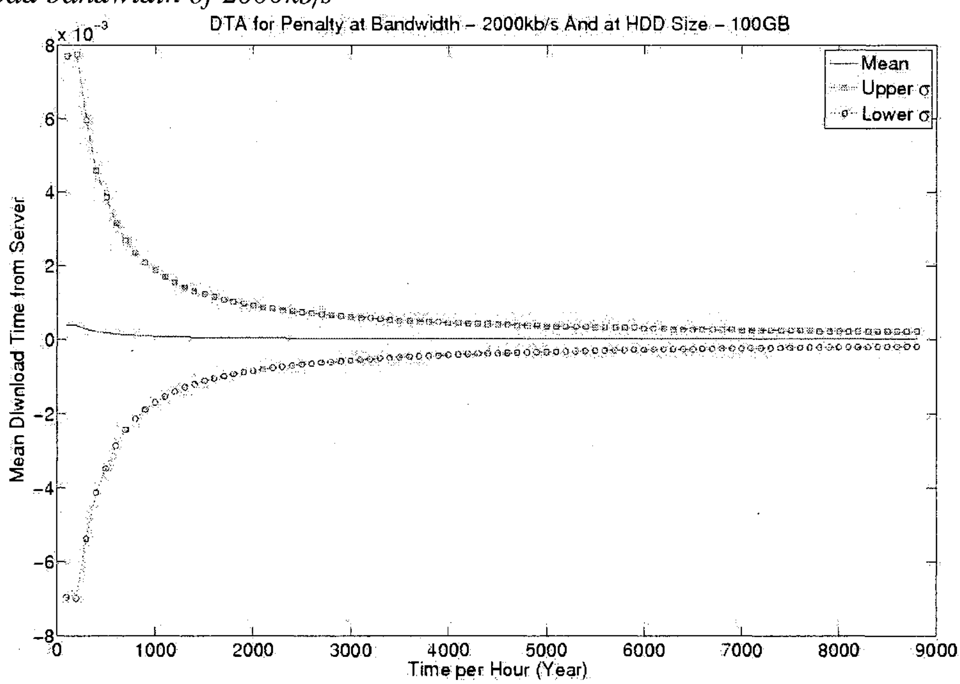


Figure 832: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 2000kb/s

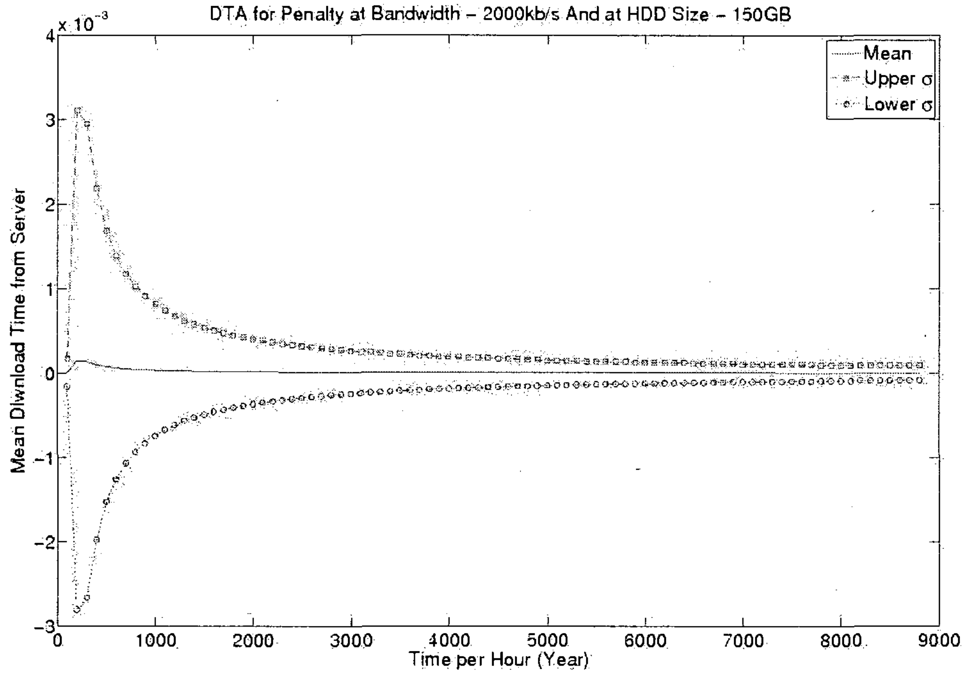


Figure 833: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 2000kb/s

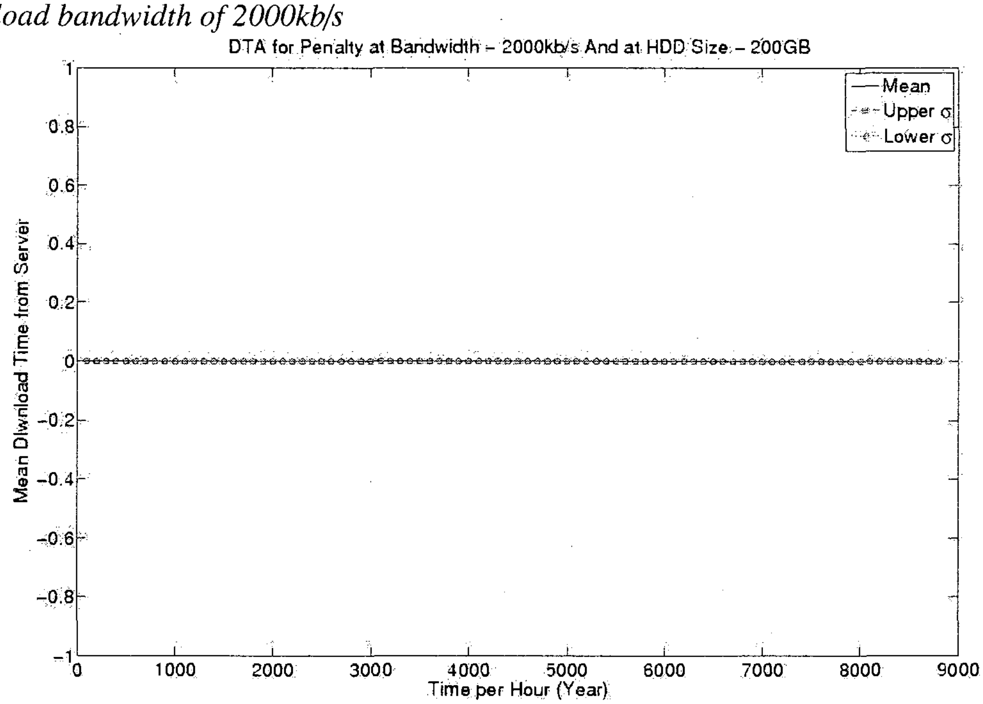


Figure 834: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 5000kb/s

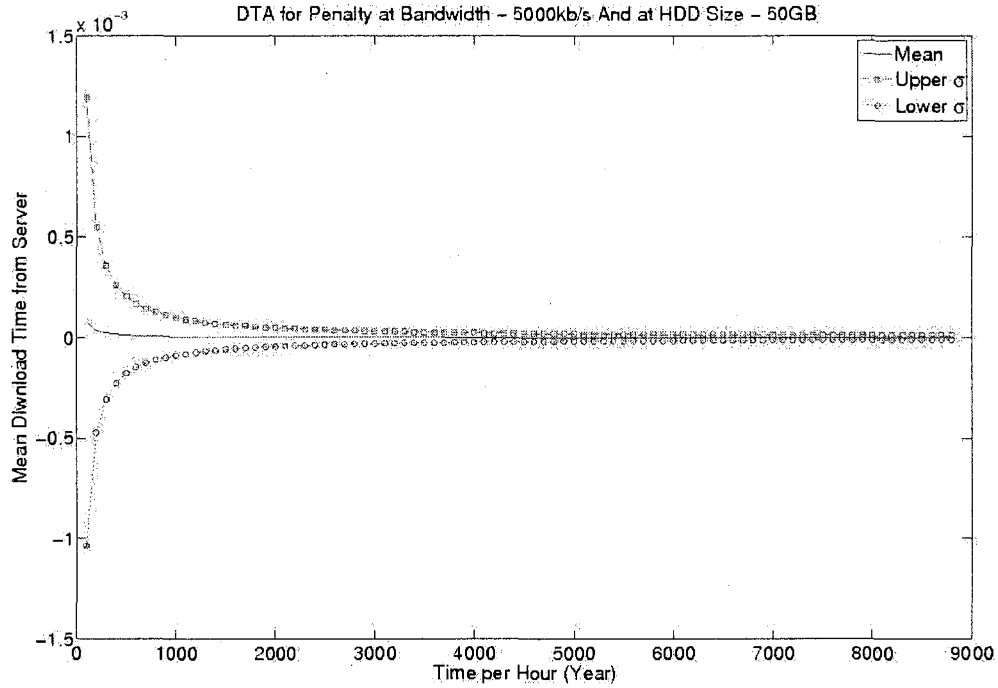


Figure 835: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 5000kb/s

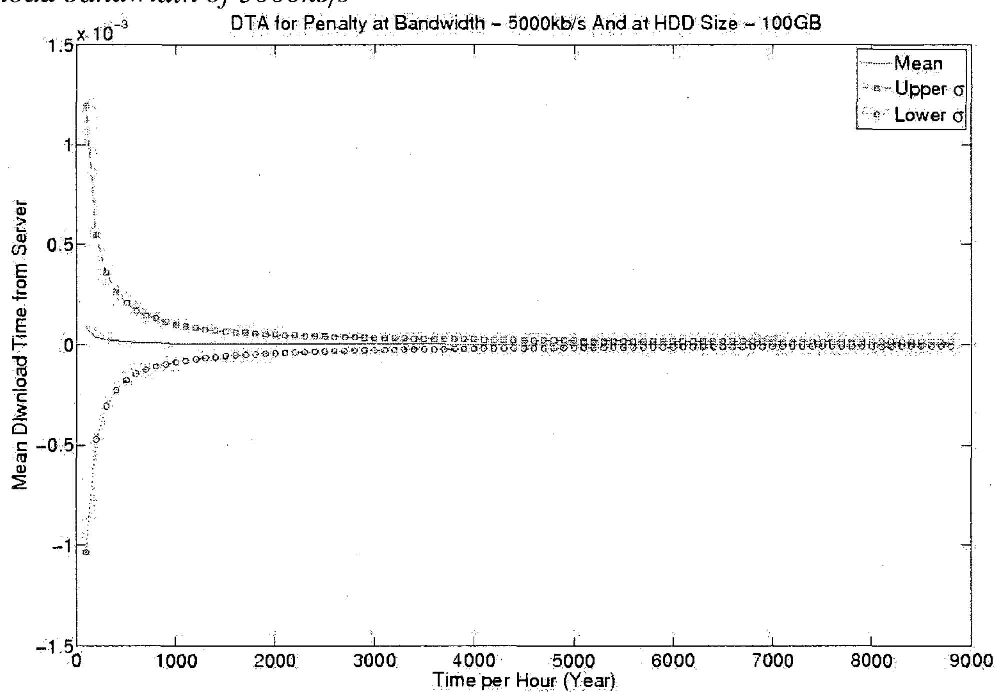


Figure 836: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 5000kb/s

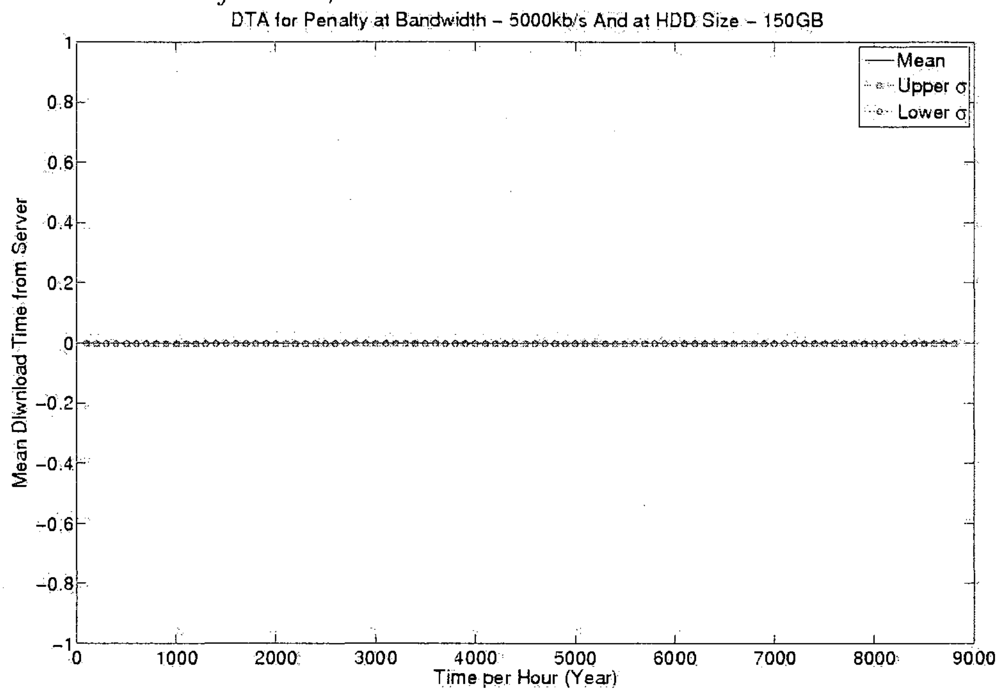


Figure 837: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 5000kb/s

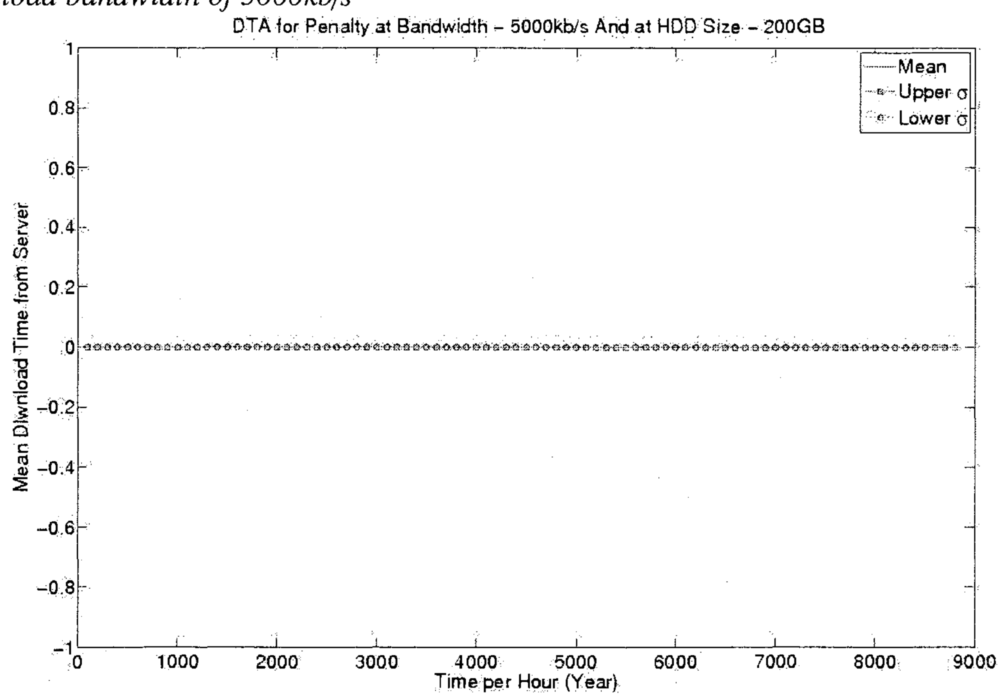


Figure 838: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 10000kb/s

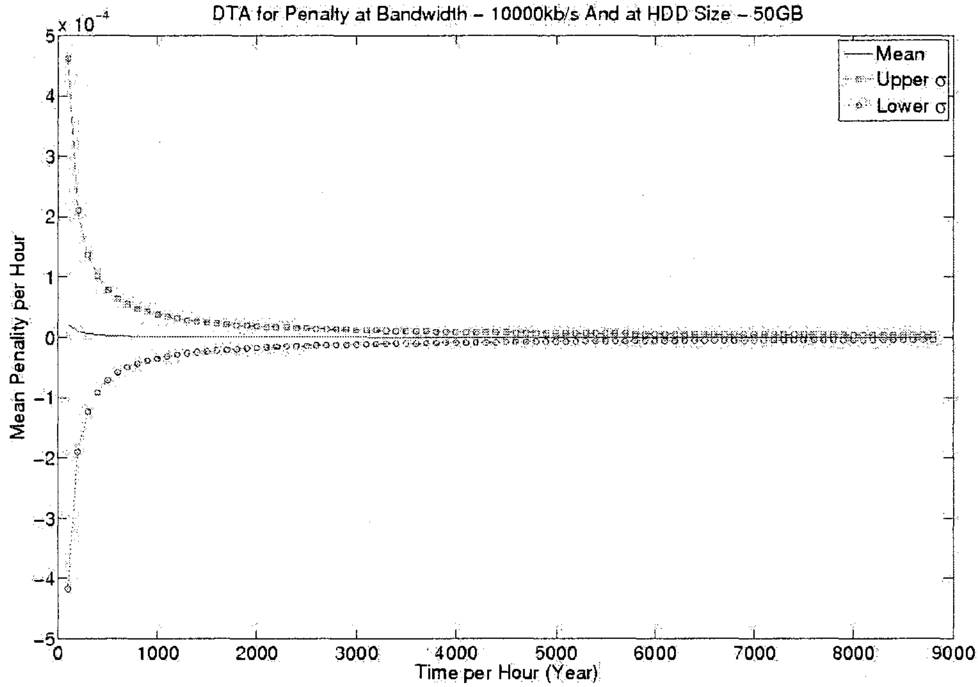


Figure 839: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 10000kb/s

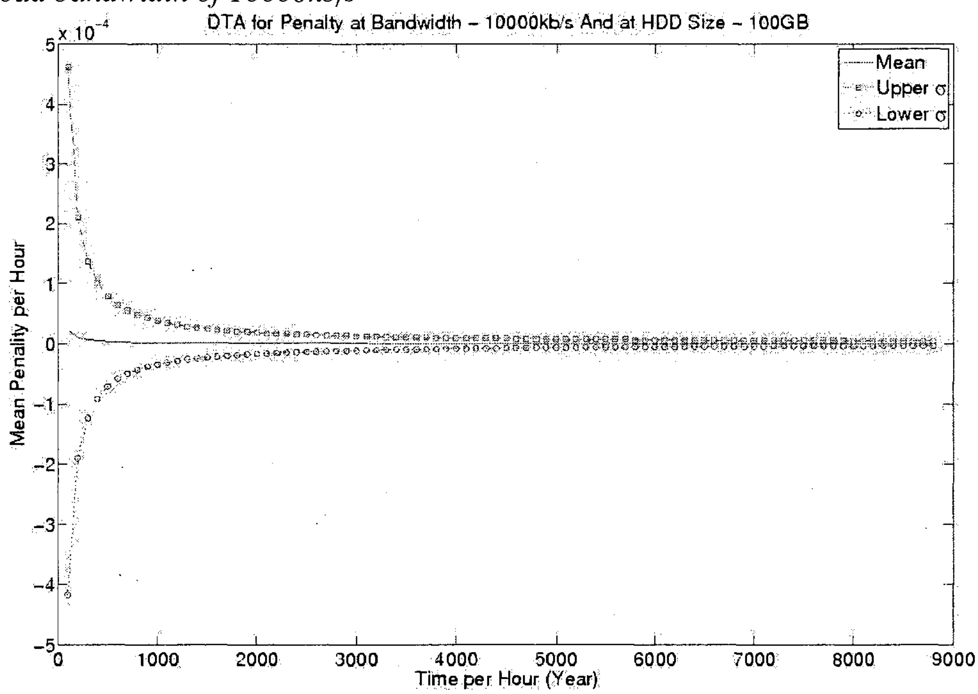


Figure 840: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 10000kb/s

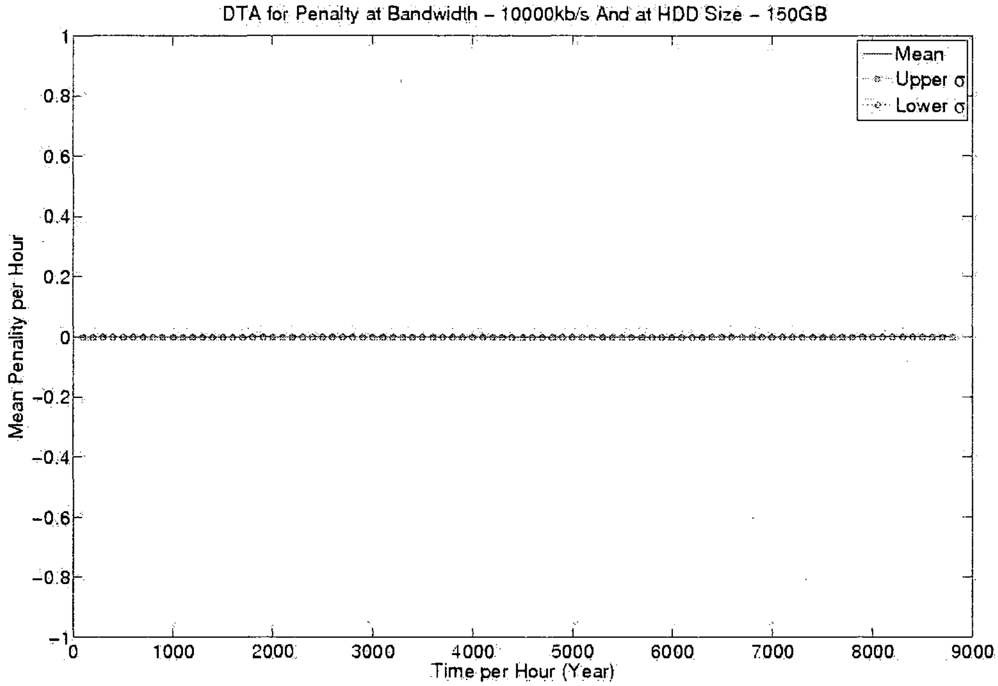


Figure 841: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 10000kb/s

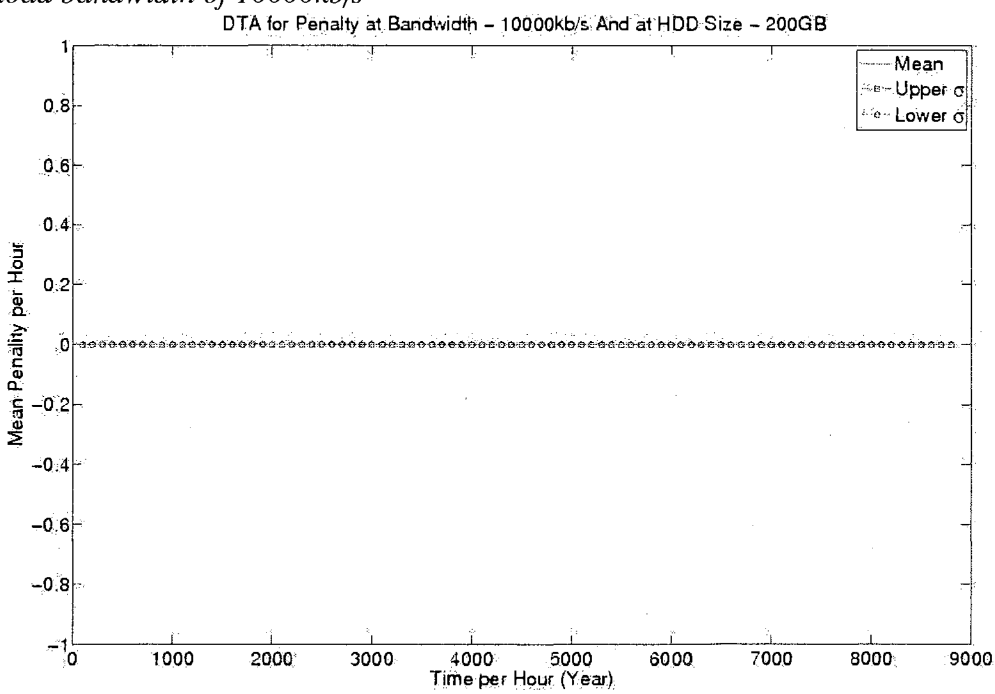


Figure 842: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 15000kb/s

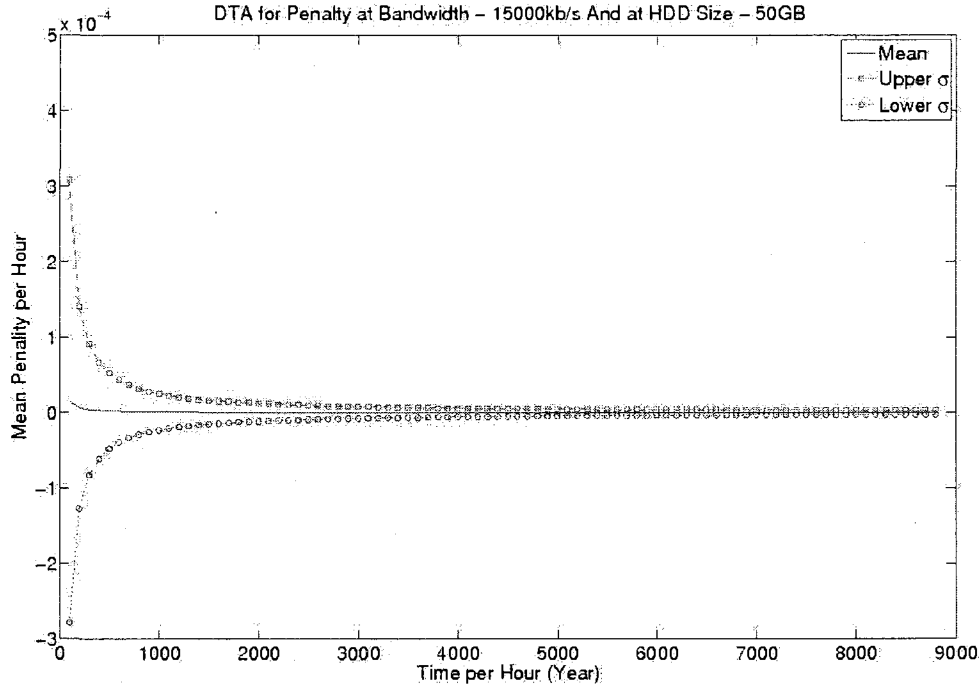


Figure 843: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 15000kb/s

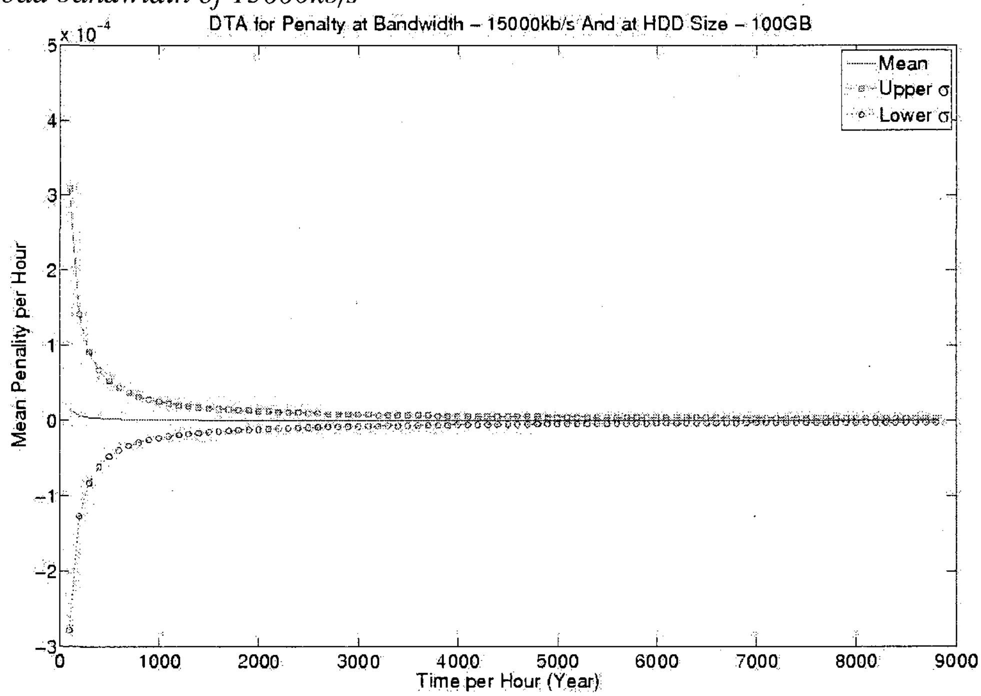


Figure 844: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 15000kb/s

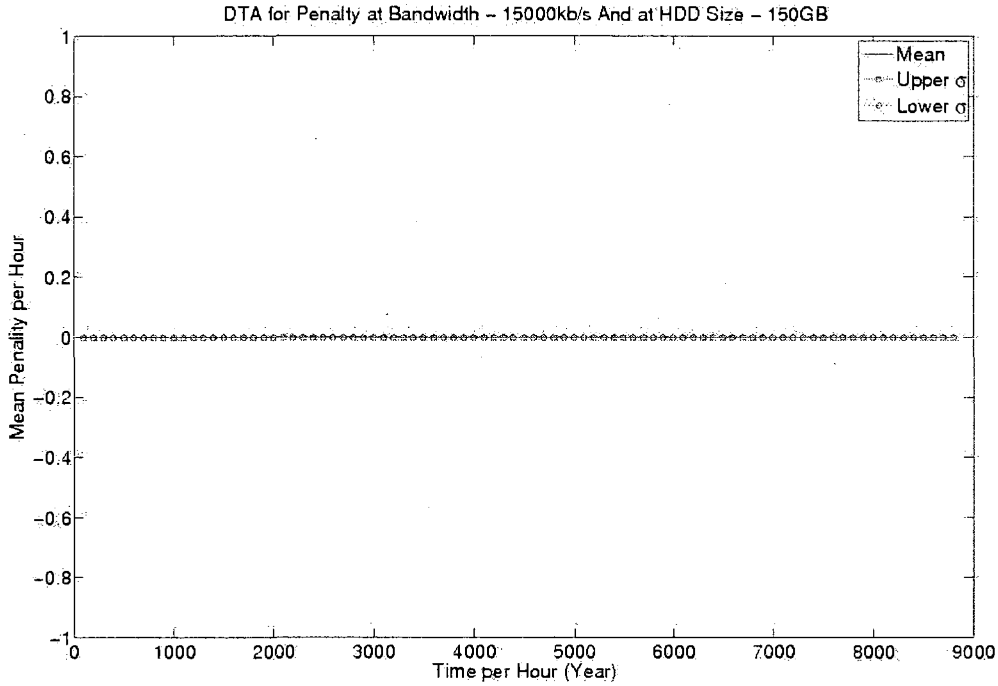


Figure 845: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 15000kb/s

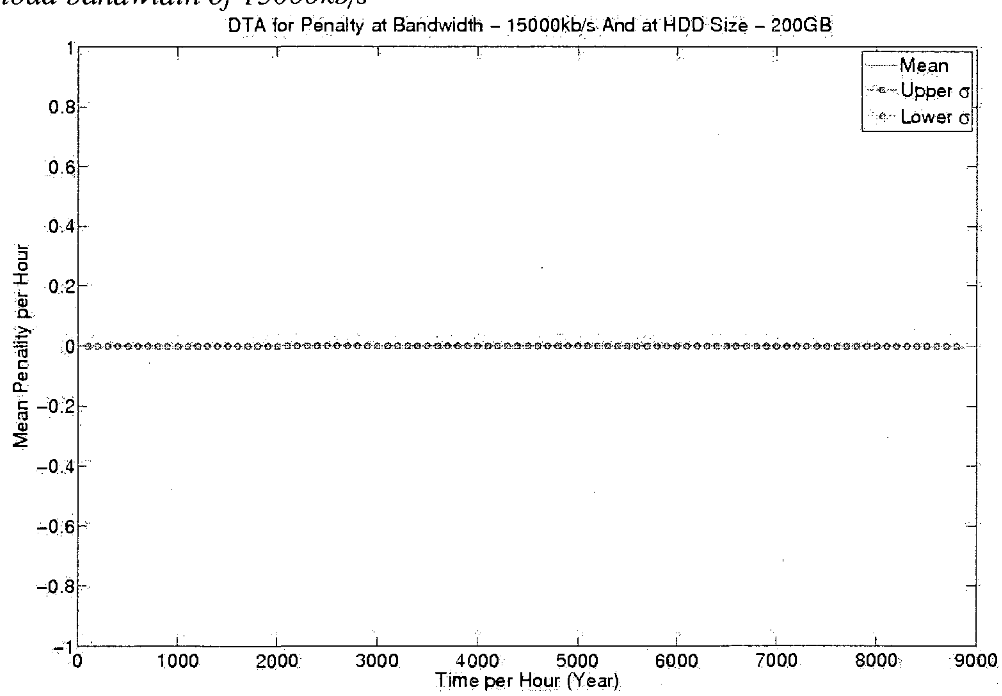


Figure 846: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 25kb/s

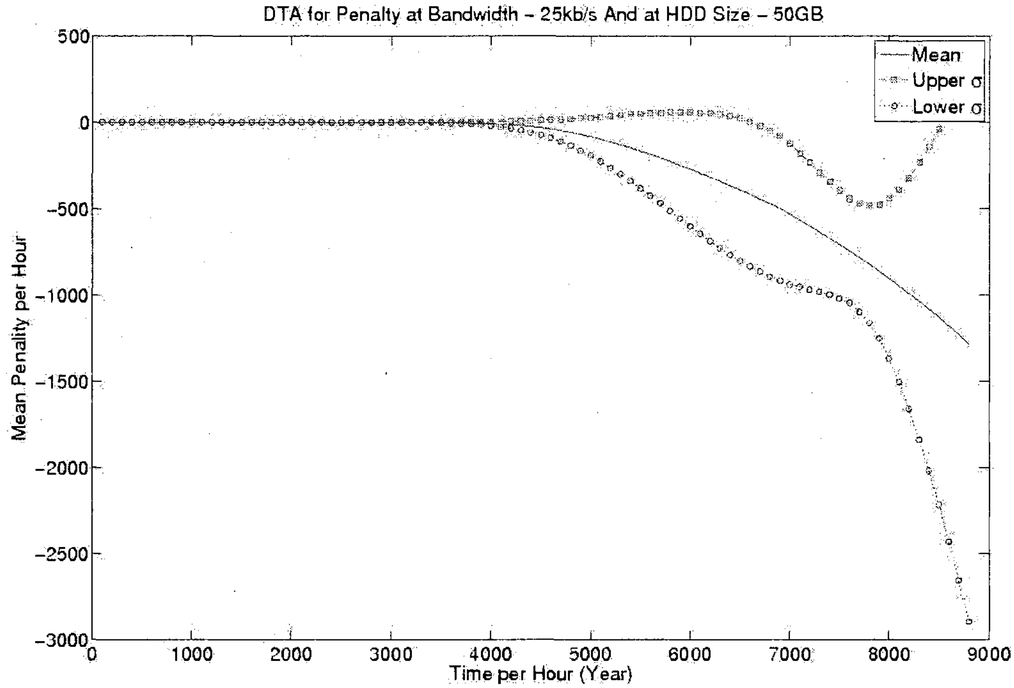


Figure 847: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 25kb/s

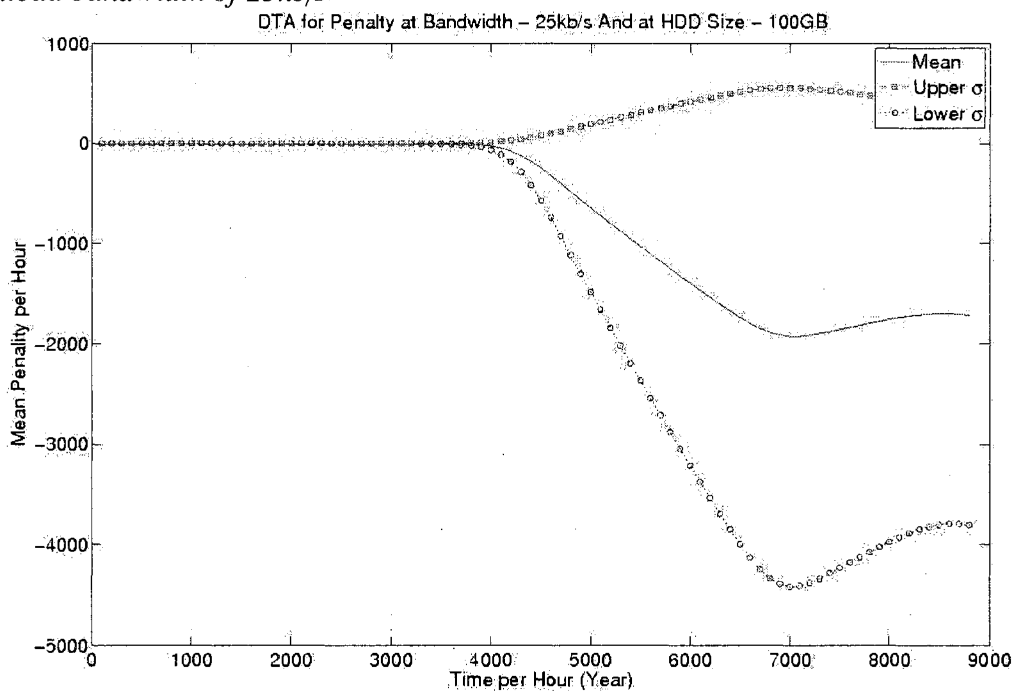


Figure 848: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 25kb/s

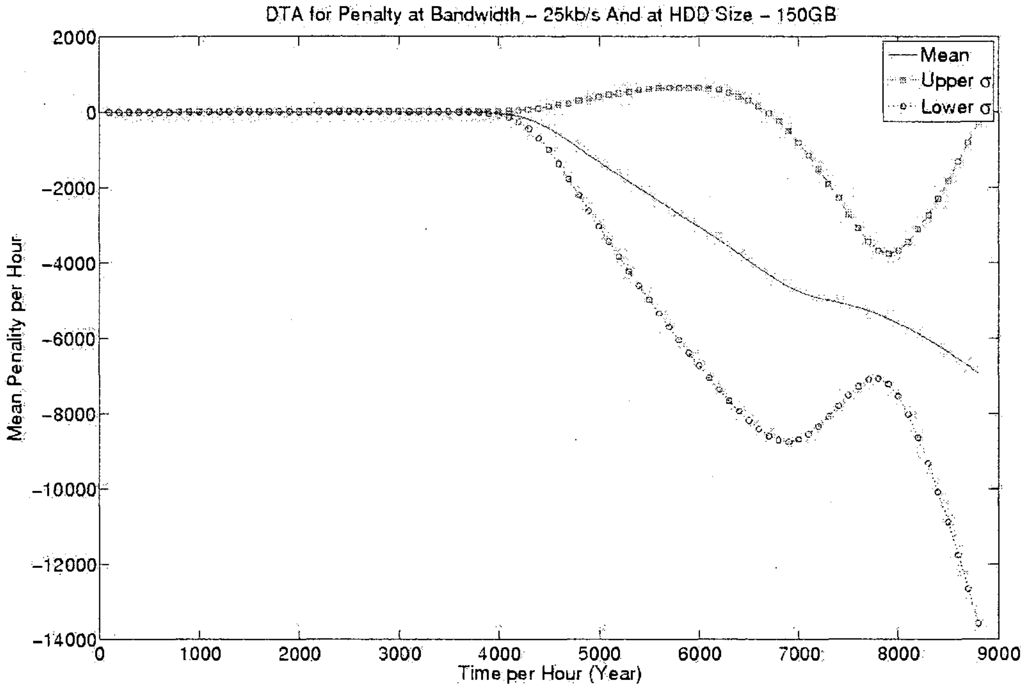


Figure 849: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 25kb/s

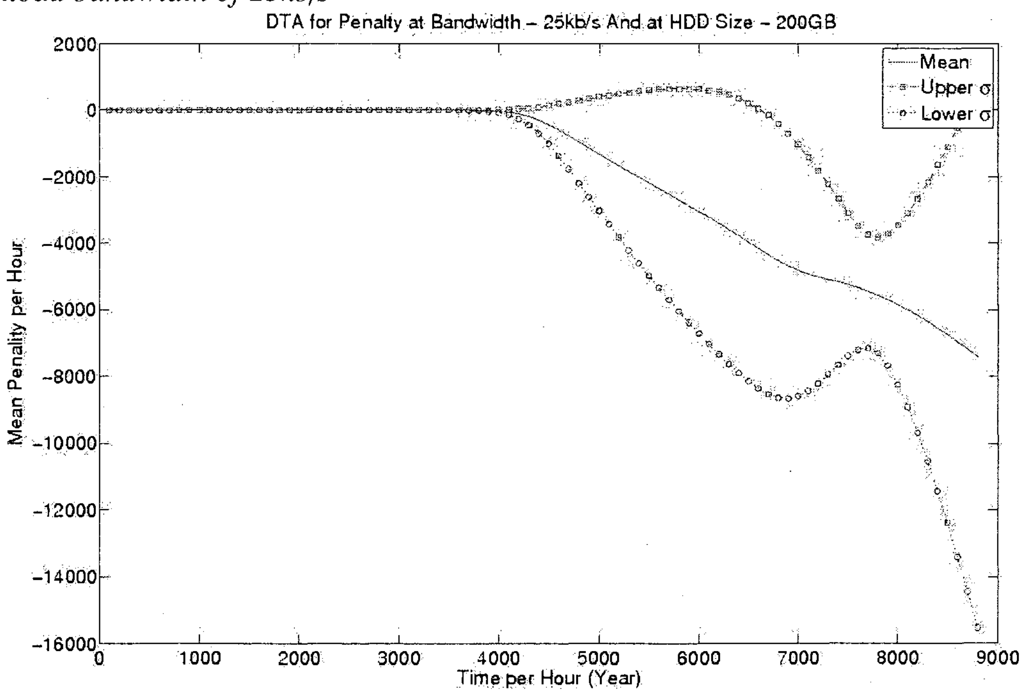


Figure 850: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 50kb/s

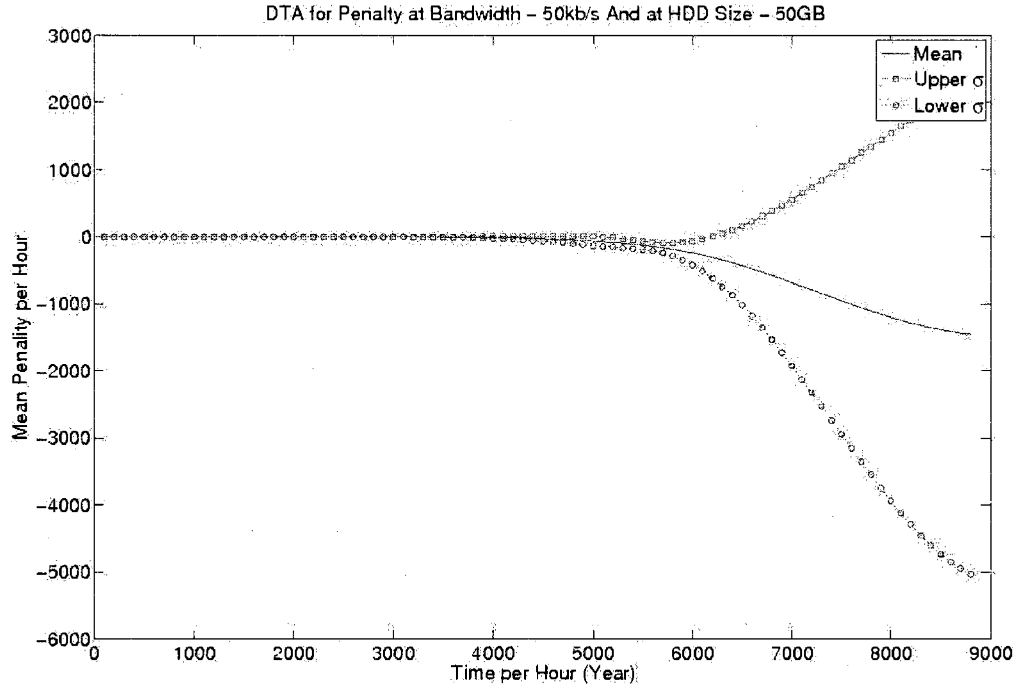


Figure 851: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 50kb/s

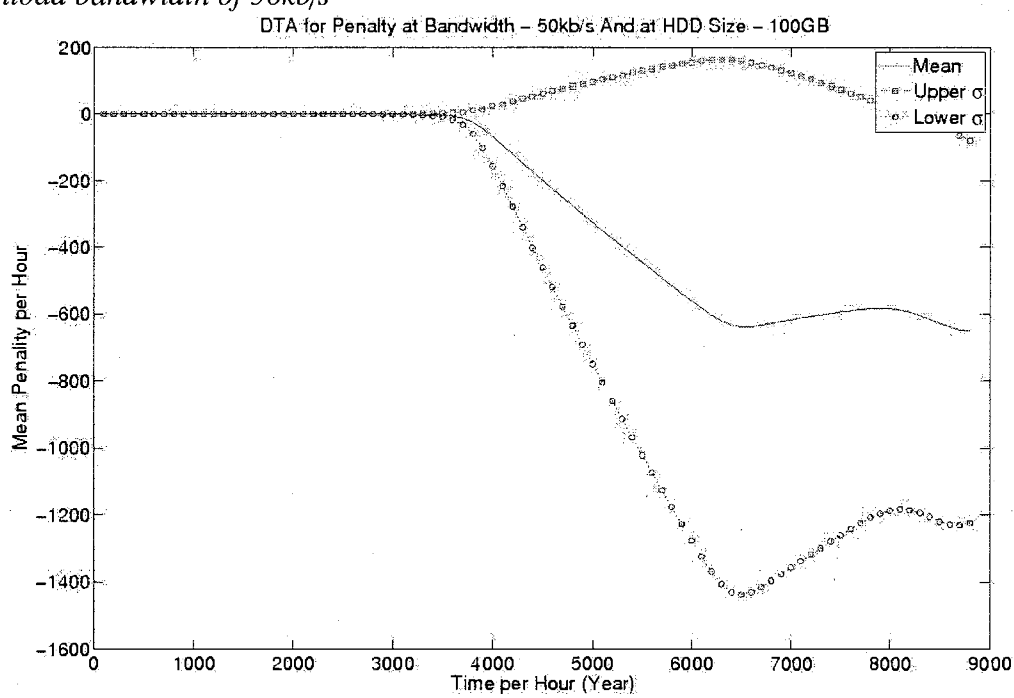


Figure 852: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 50kb/s

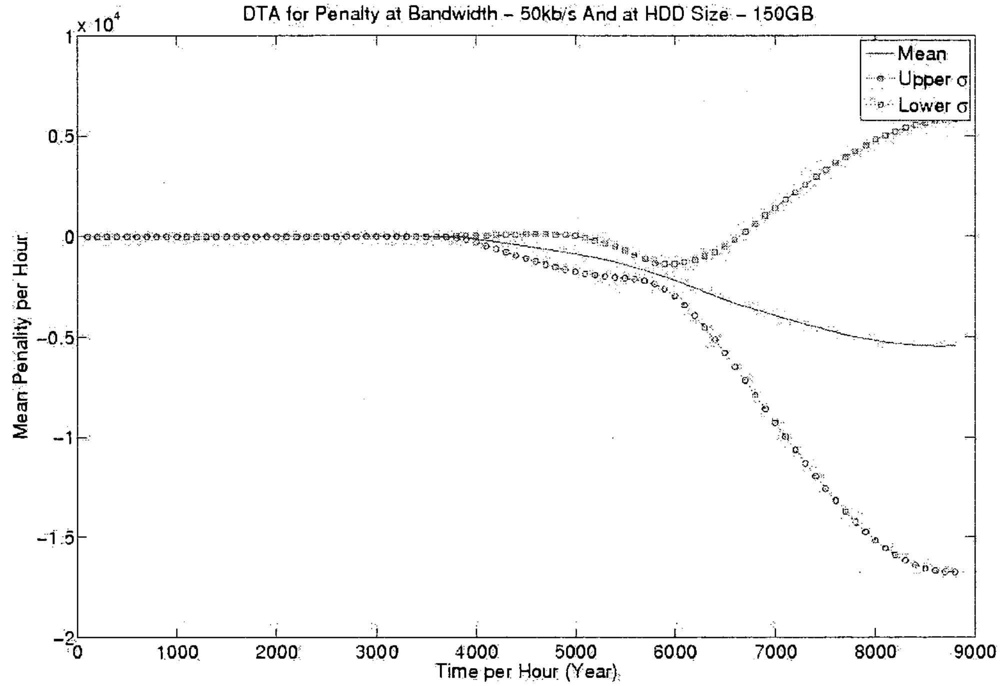


Figure 853: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 50kb/s

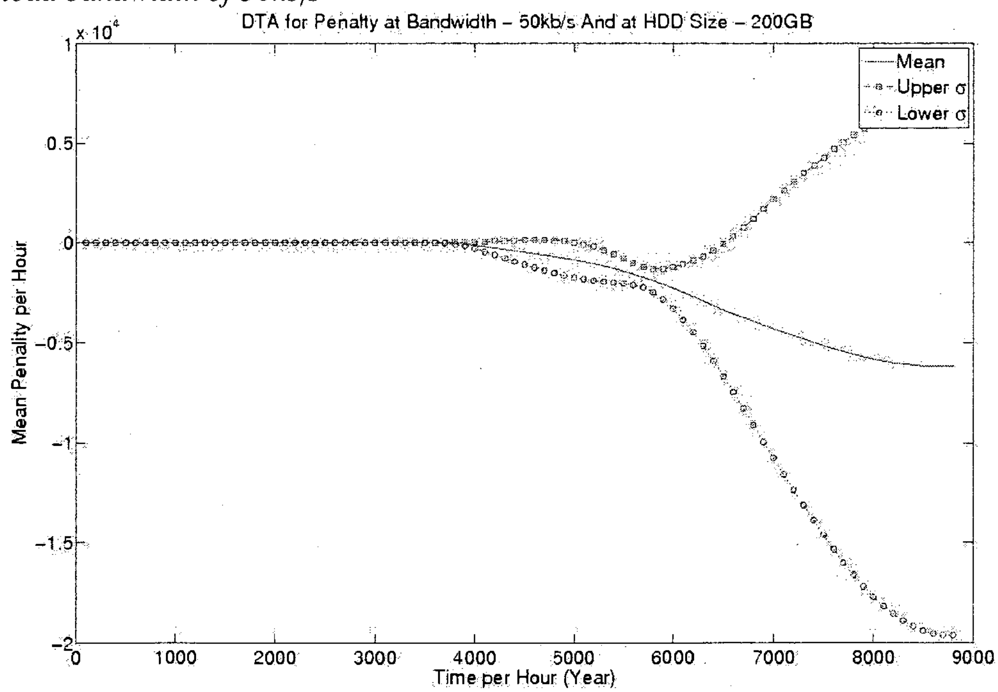


Figure 854: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 100kb/s

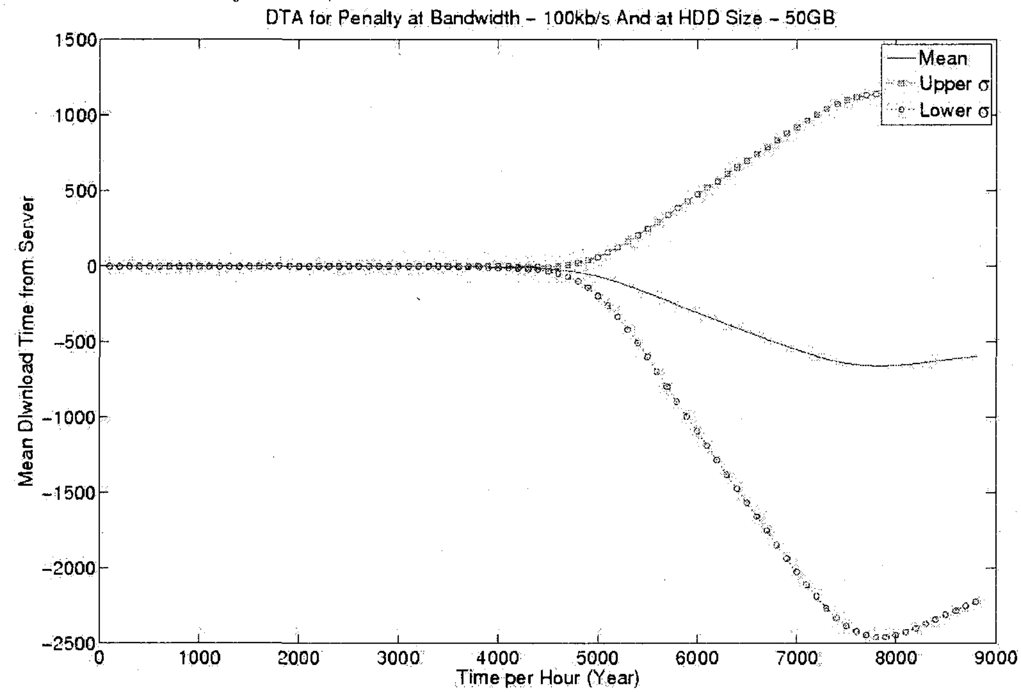


Figure 855: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 100kb/s

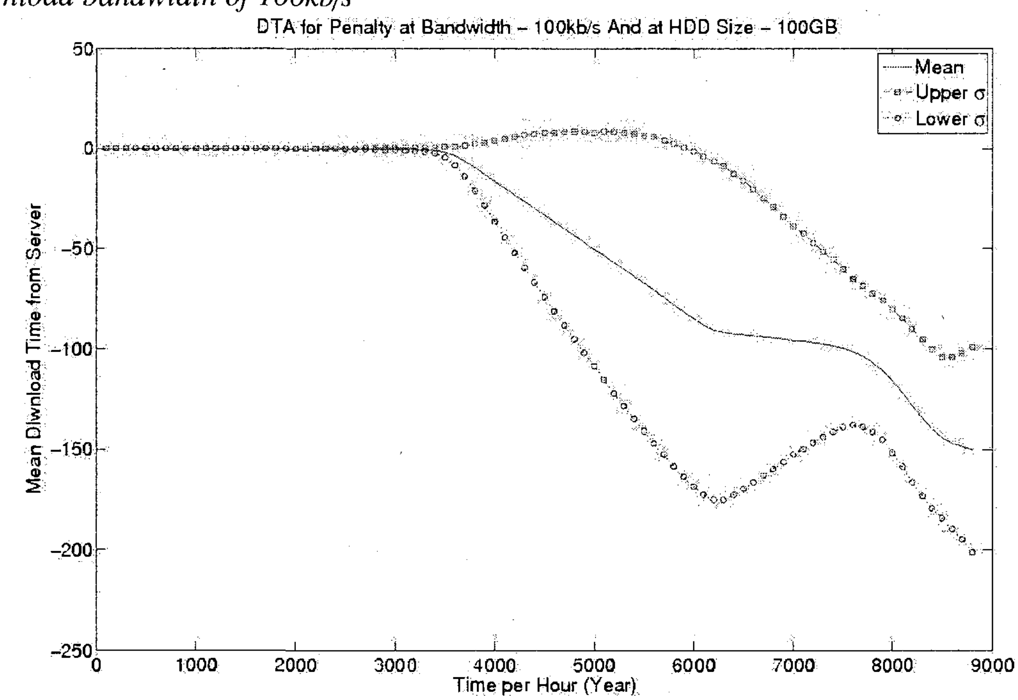


Figure 856: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 100kb/s

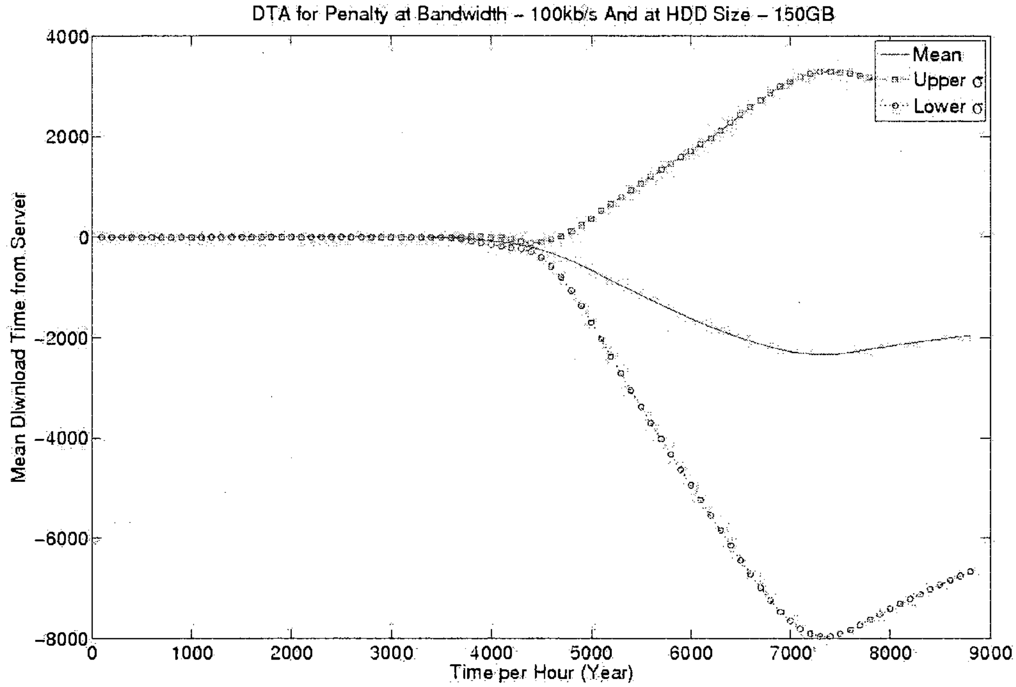


Figure 857: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 100kb/s

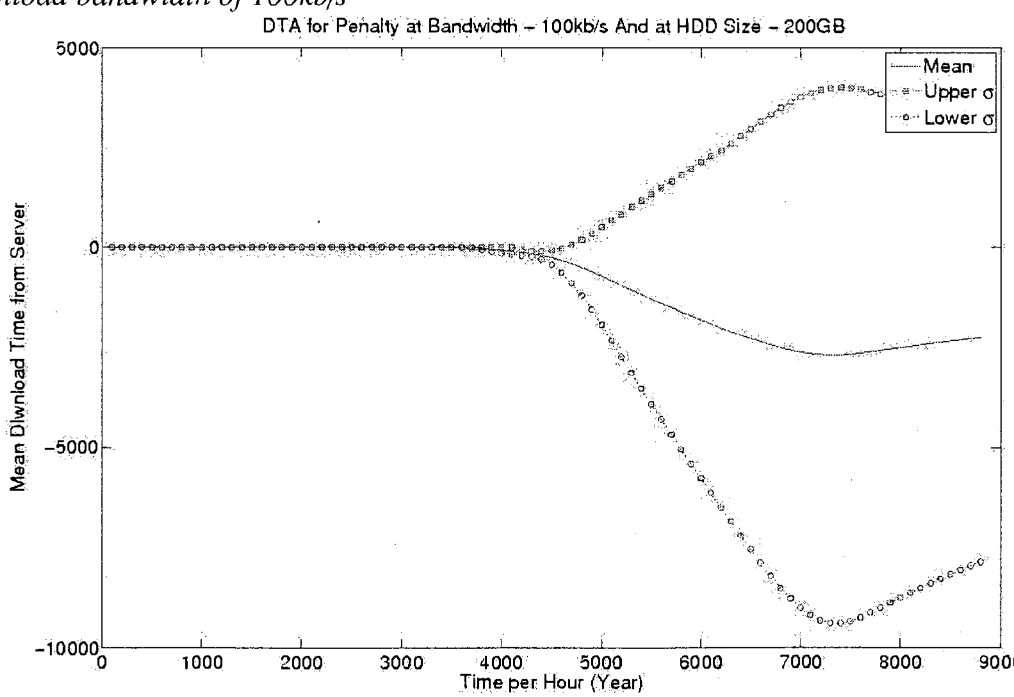


Figure 858: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 128kb/s

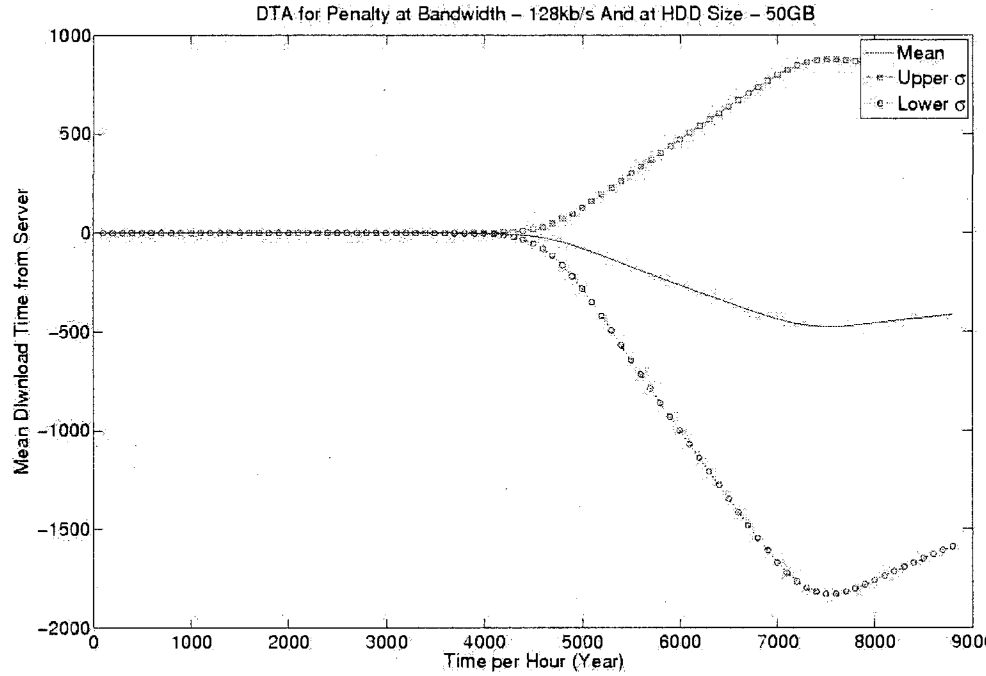


Figure 859: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 128kb/s

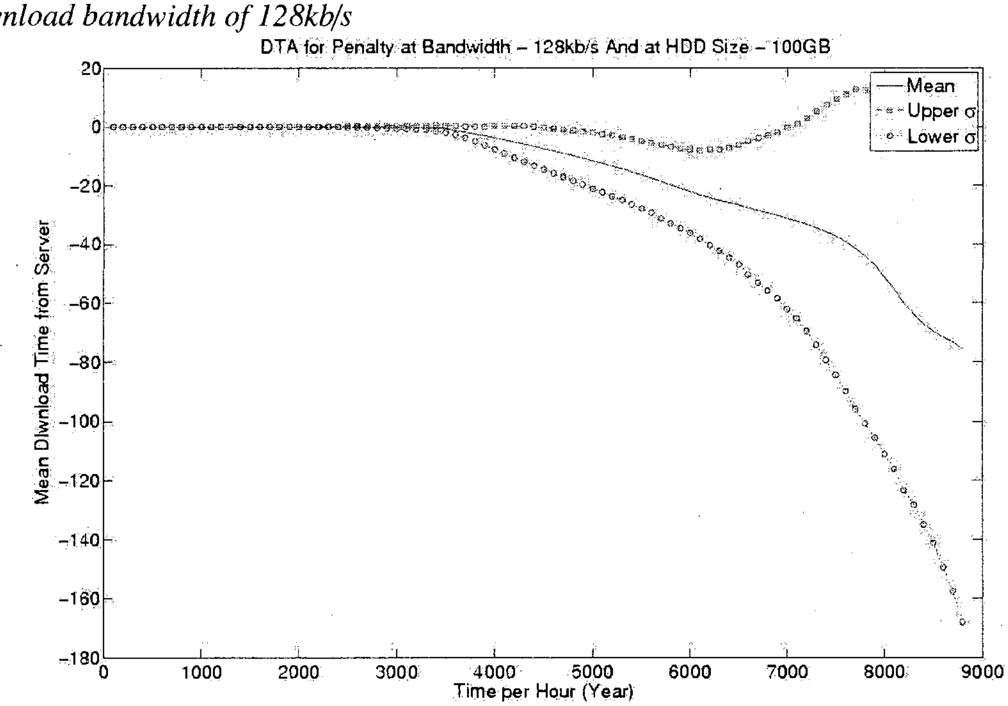


Figure 860: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 128kb/s

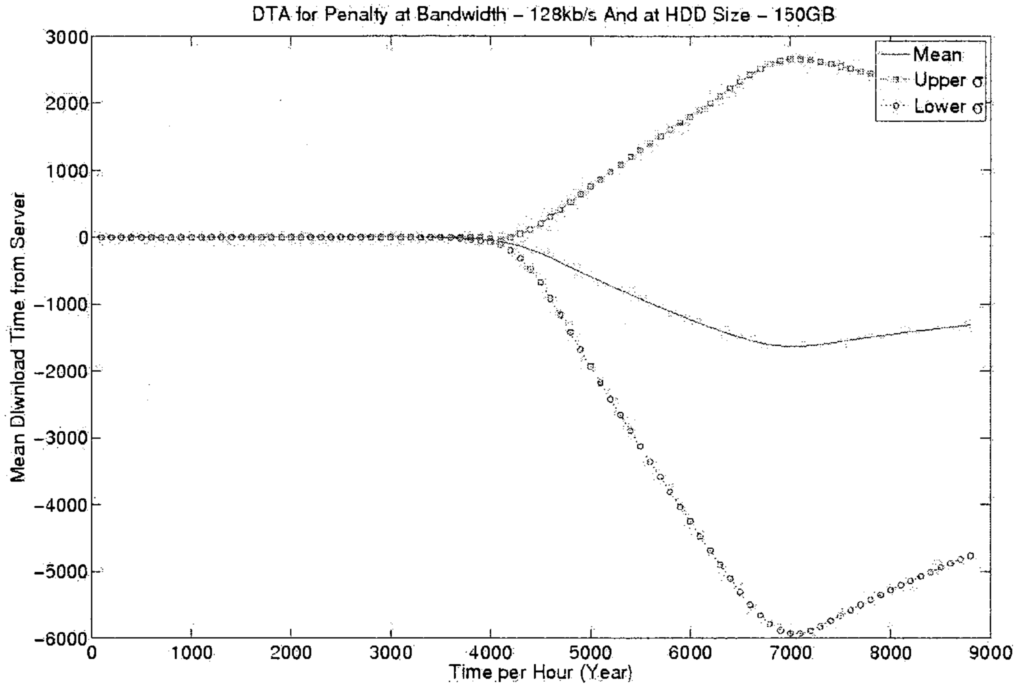


Figure 861: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 128kb/s

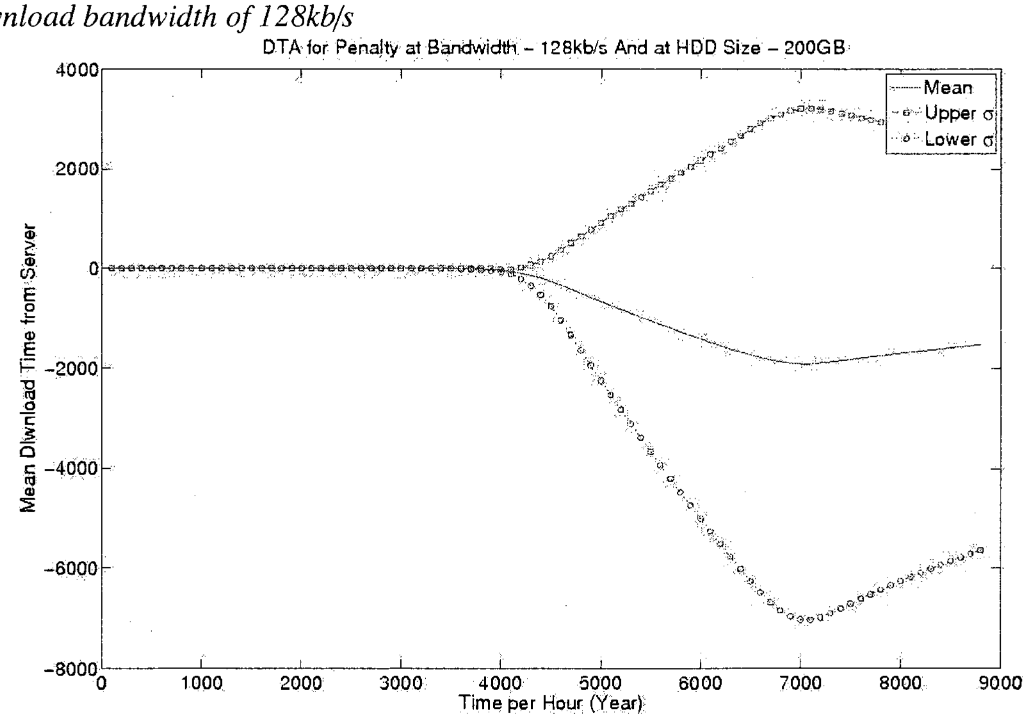


Figure 862: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 256kb/s

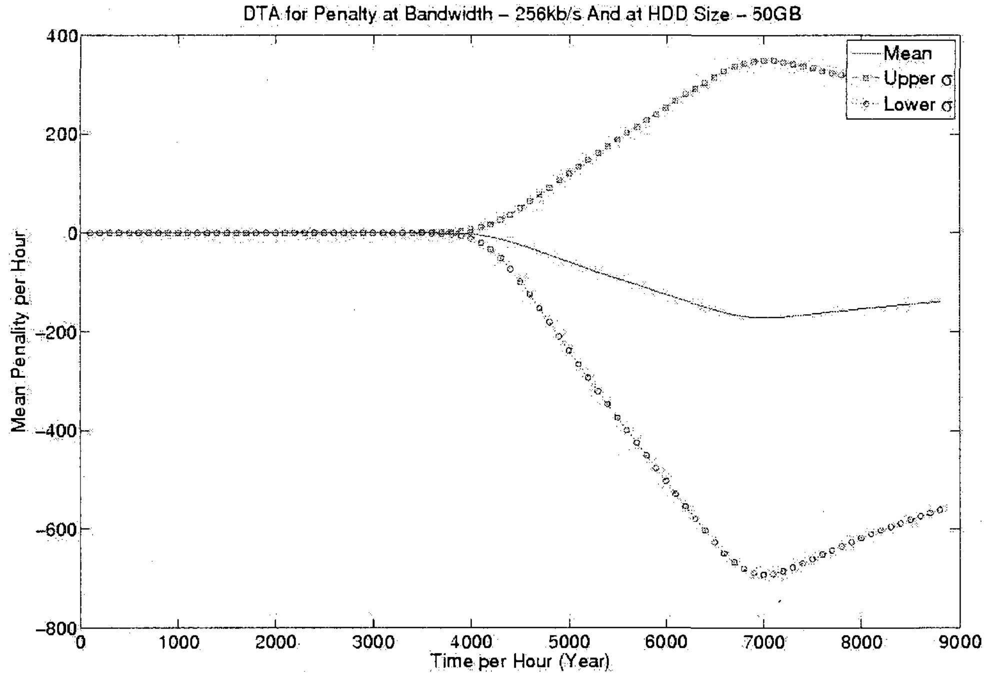


Figure 863: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 256kb/s

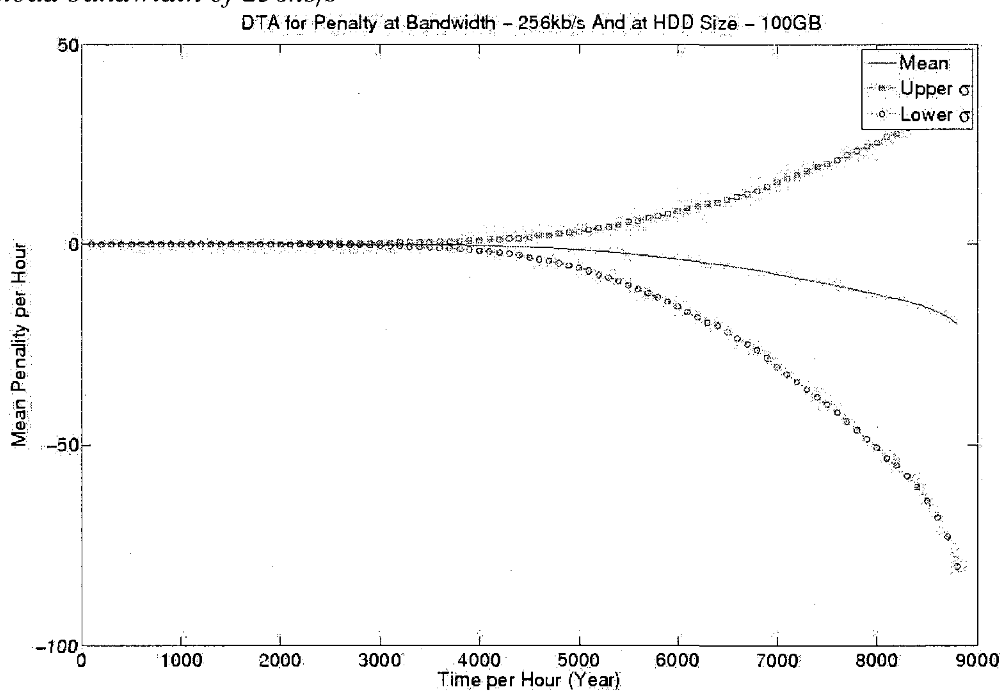


Figure 864: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 256kb/s

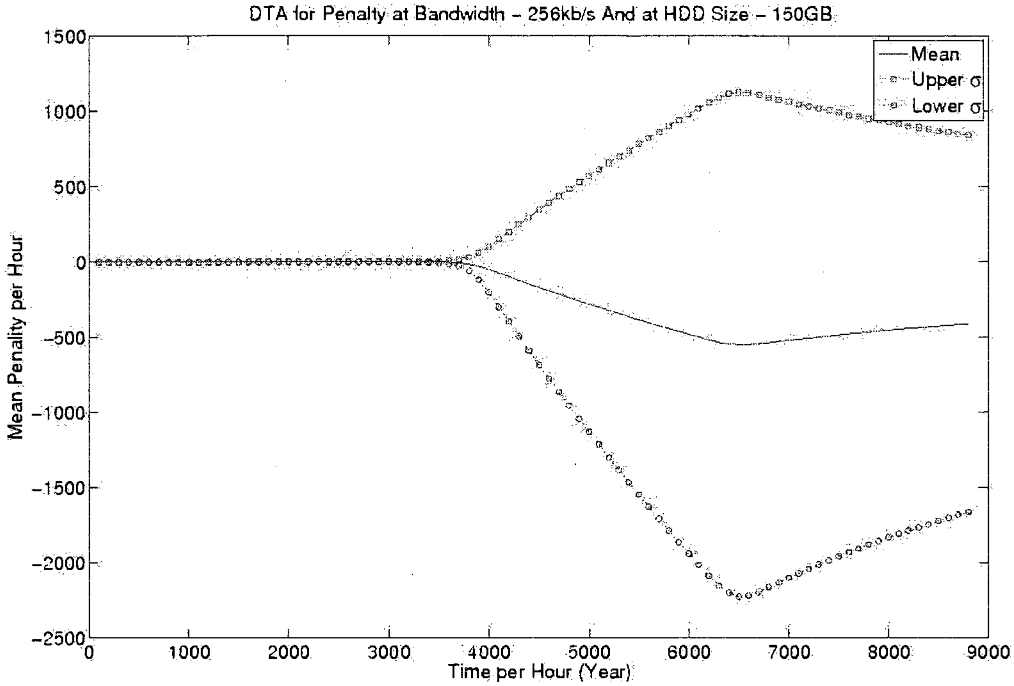


Figure 865: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 256kb/s

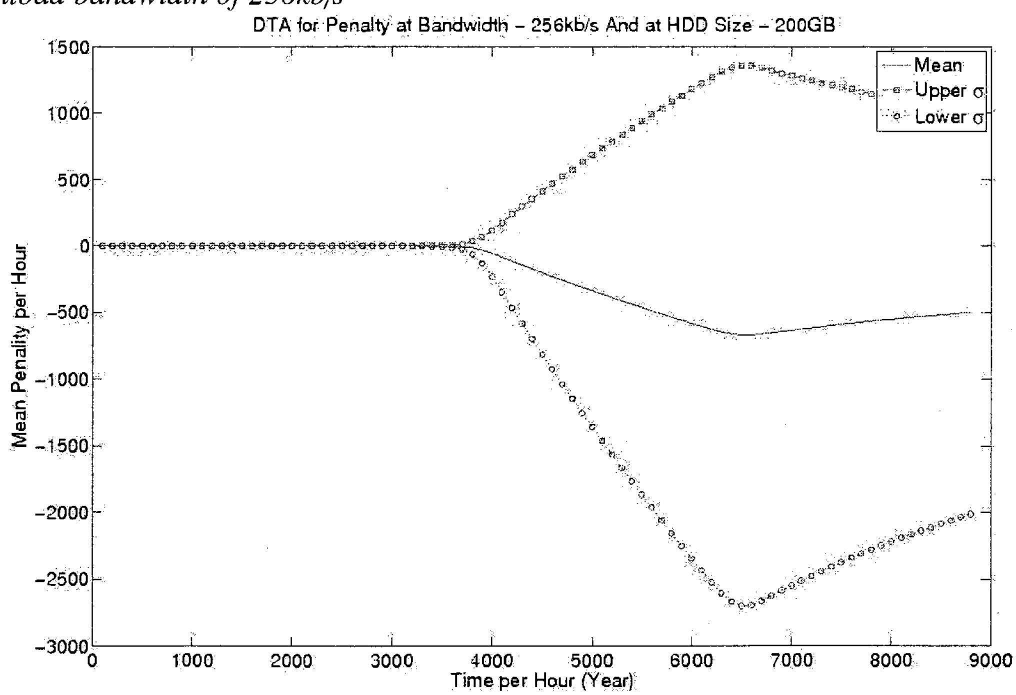


Figure 866: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 512kb/s

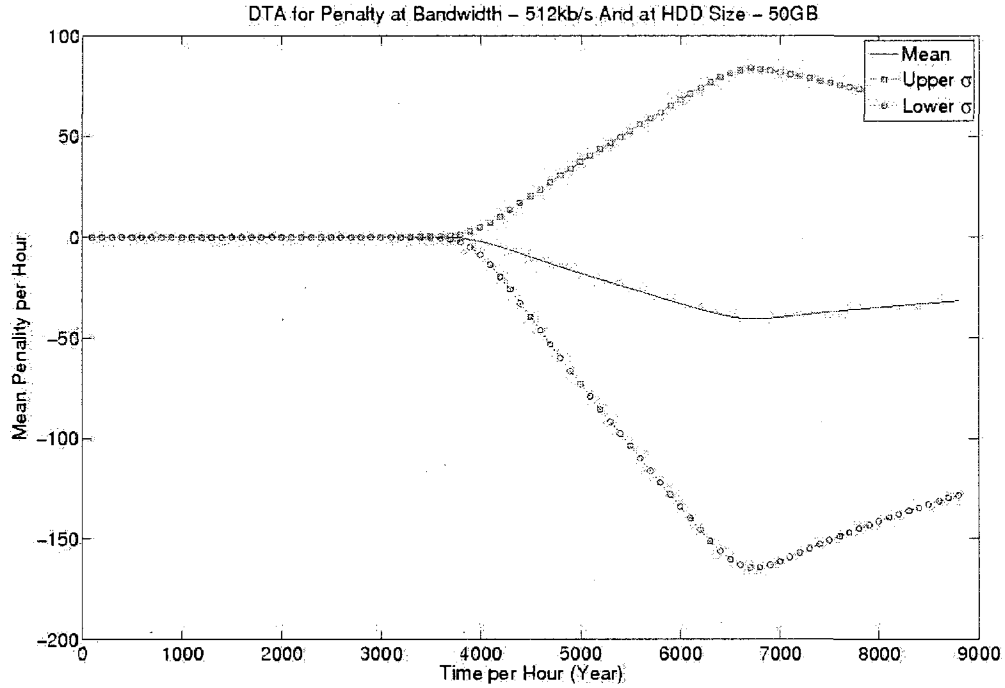


Figure 867: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 512kb/s

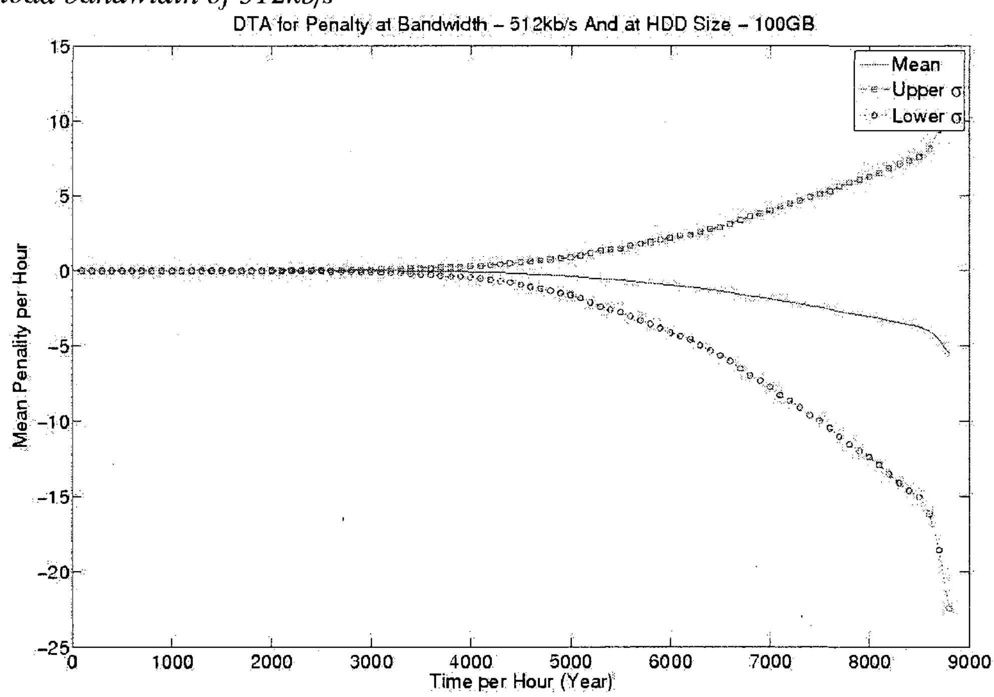


Figure 868: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 512kb/s

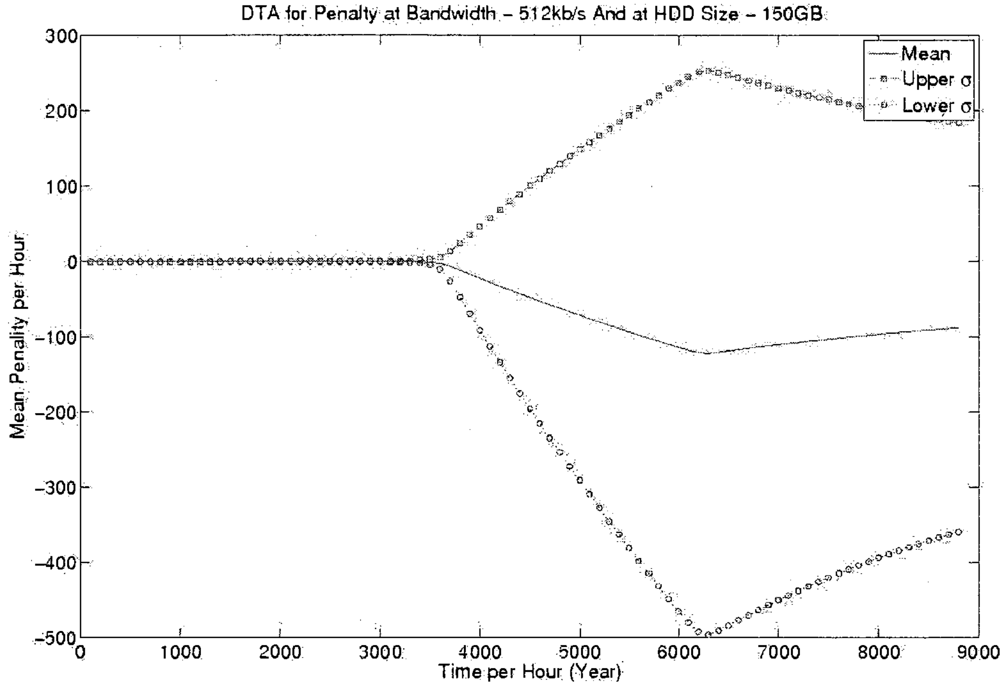


Figure 869: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 512kb/s

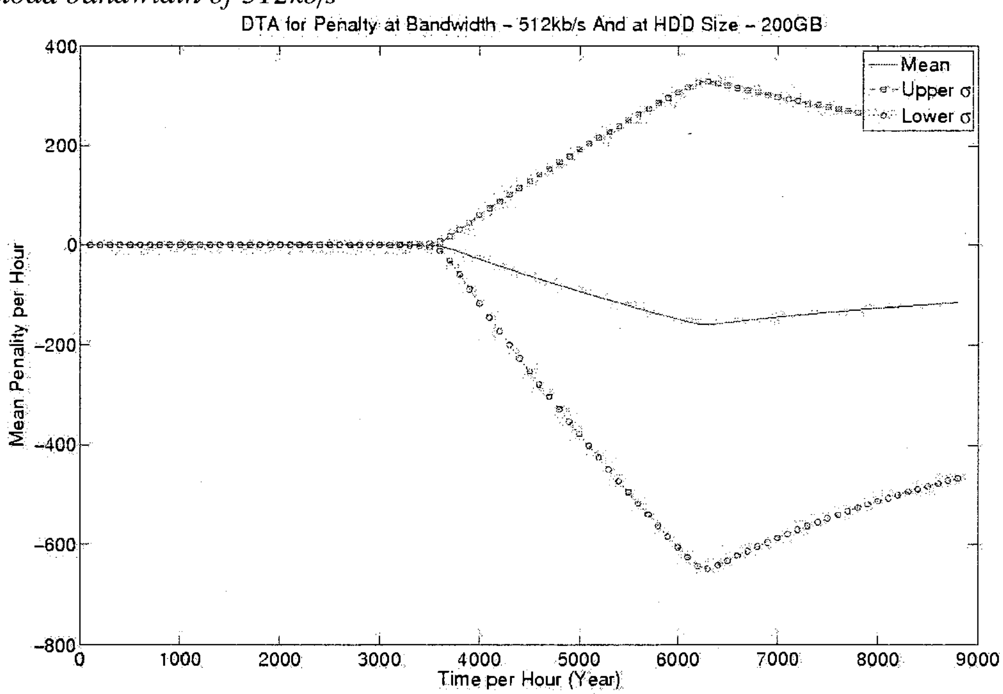


Figure 870: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 1000kb/s

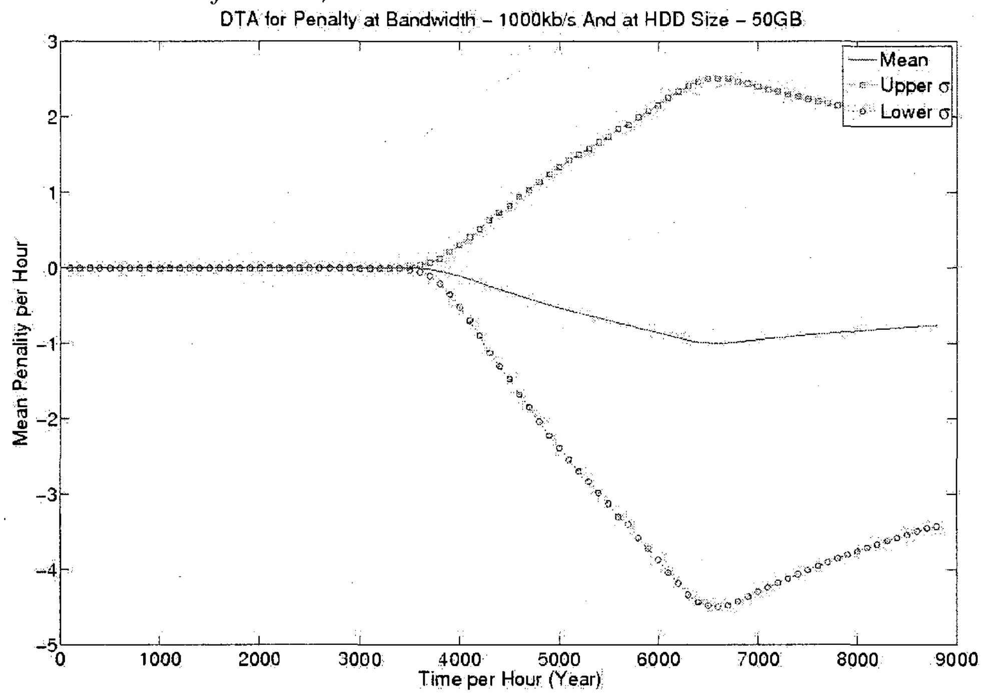


Figure 871: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 1000kb/s

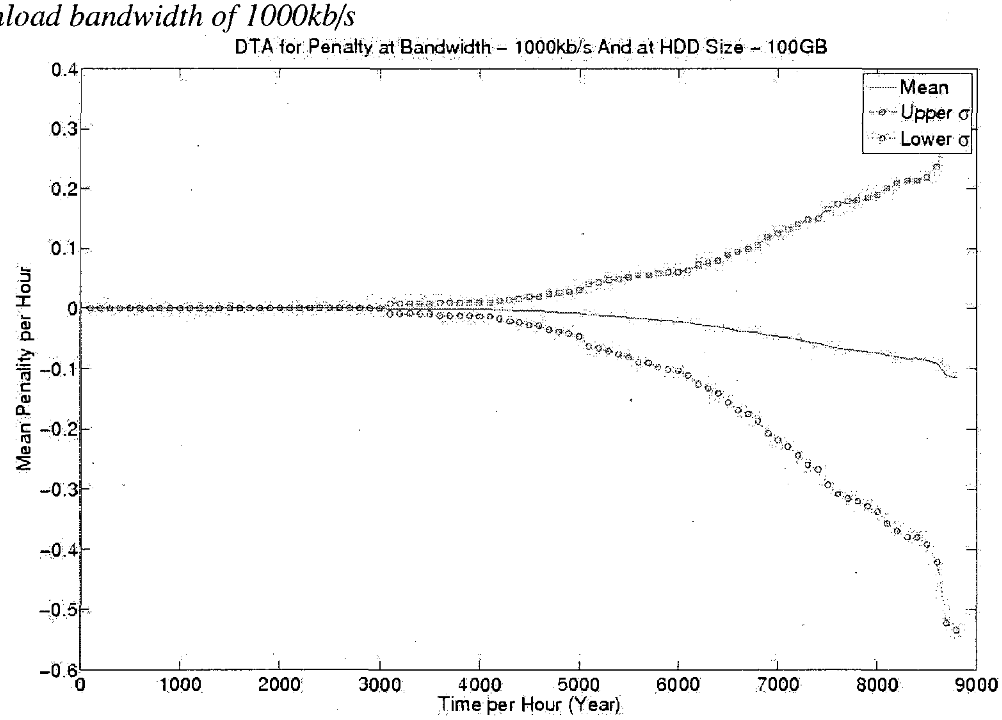


Figure 872: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 1000kb/s

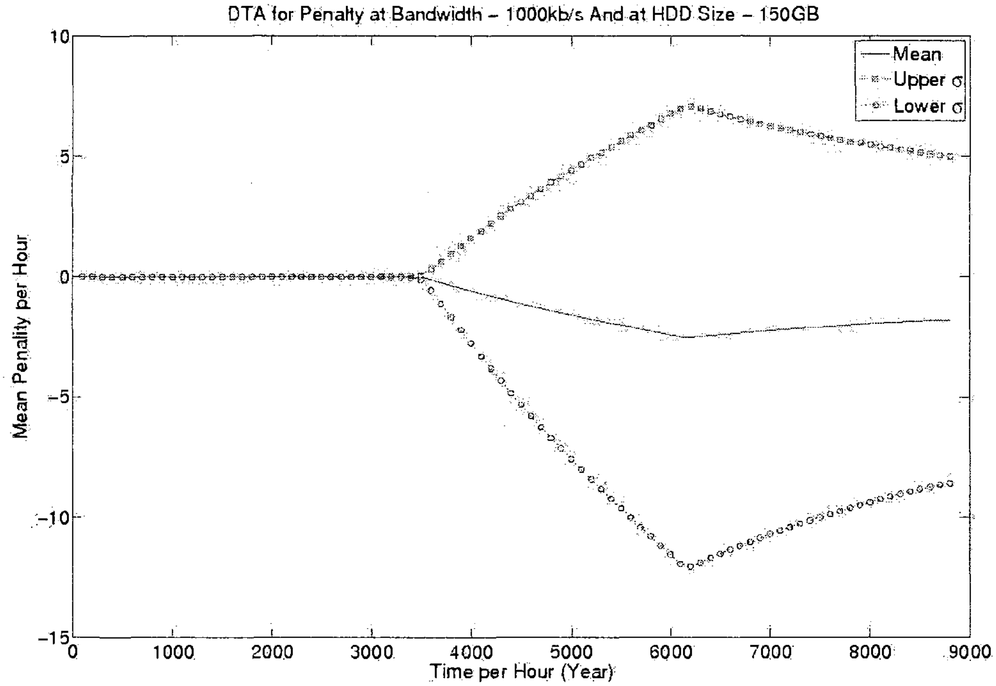


Figure 873: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 1000kb/s

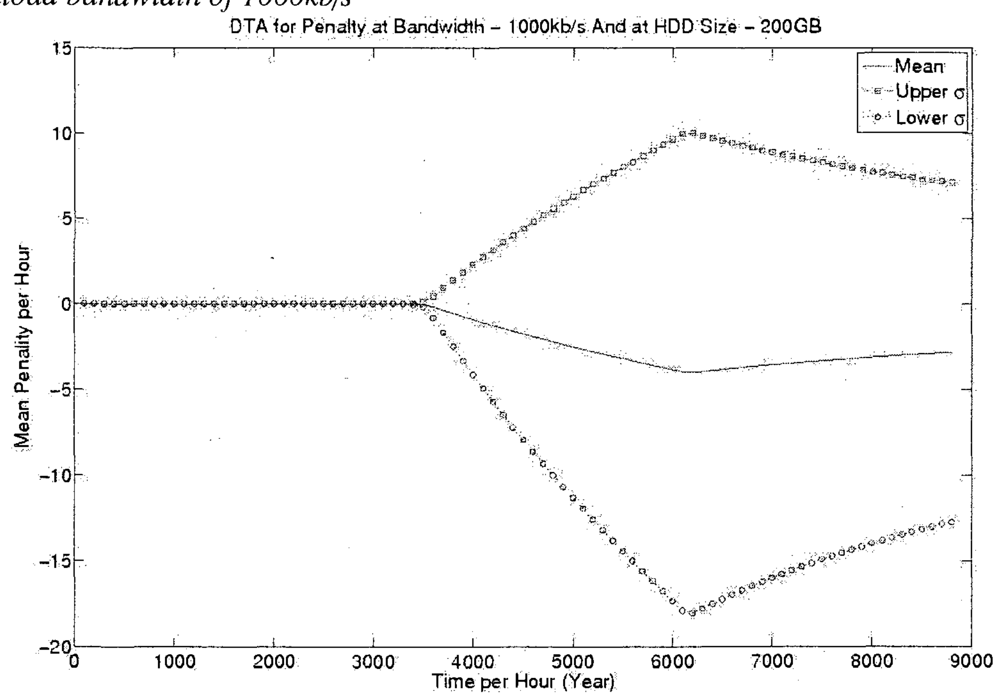


Figure 874: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 2000kb/s

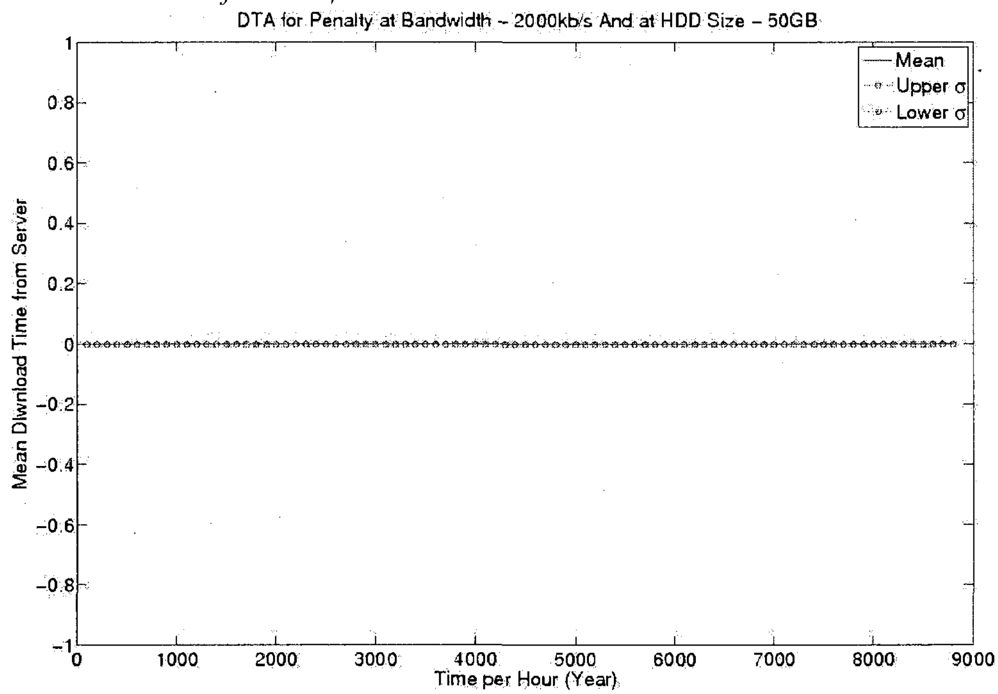


Figure 875: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 2000kb/s

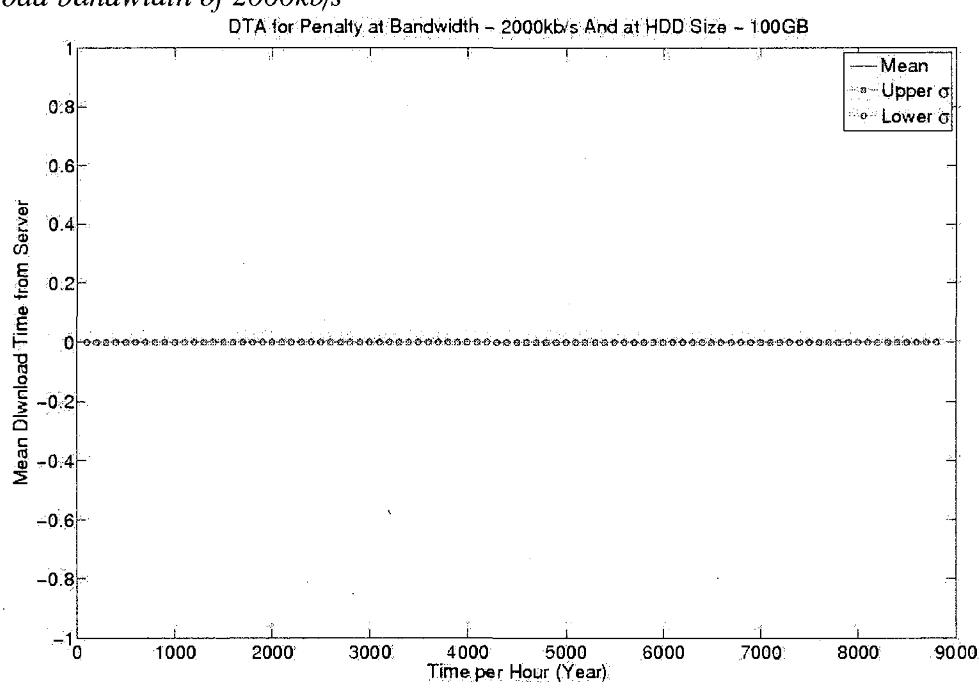


Figure 876: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 2000kb/s

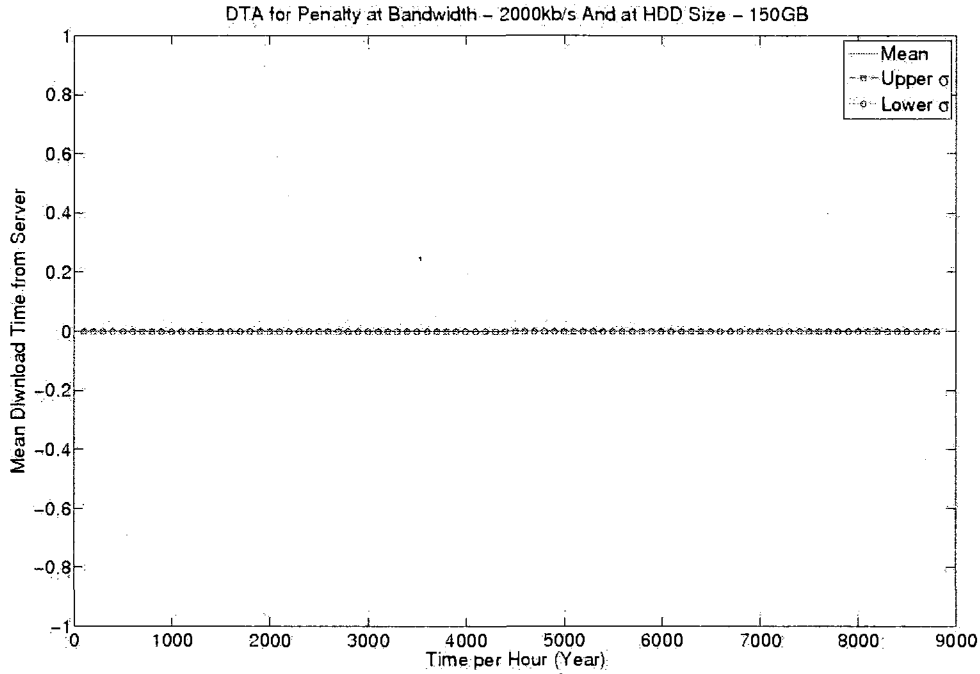


Figure 877: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 2000kb/s

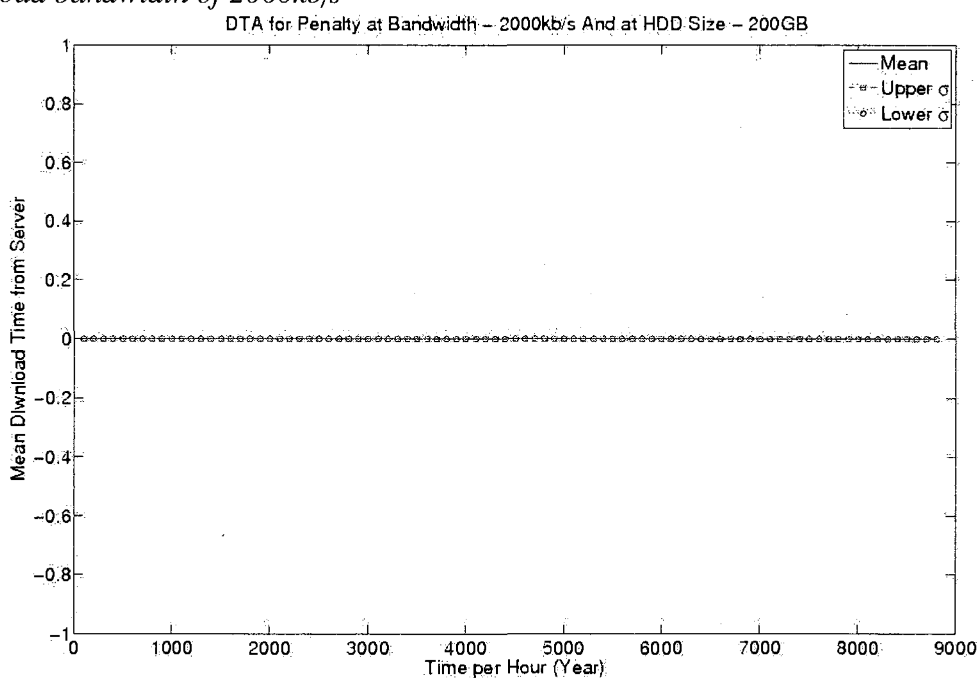


Figure 878: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 5000kb/s

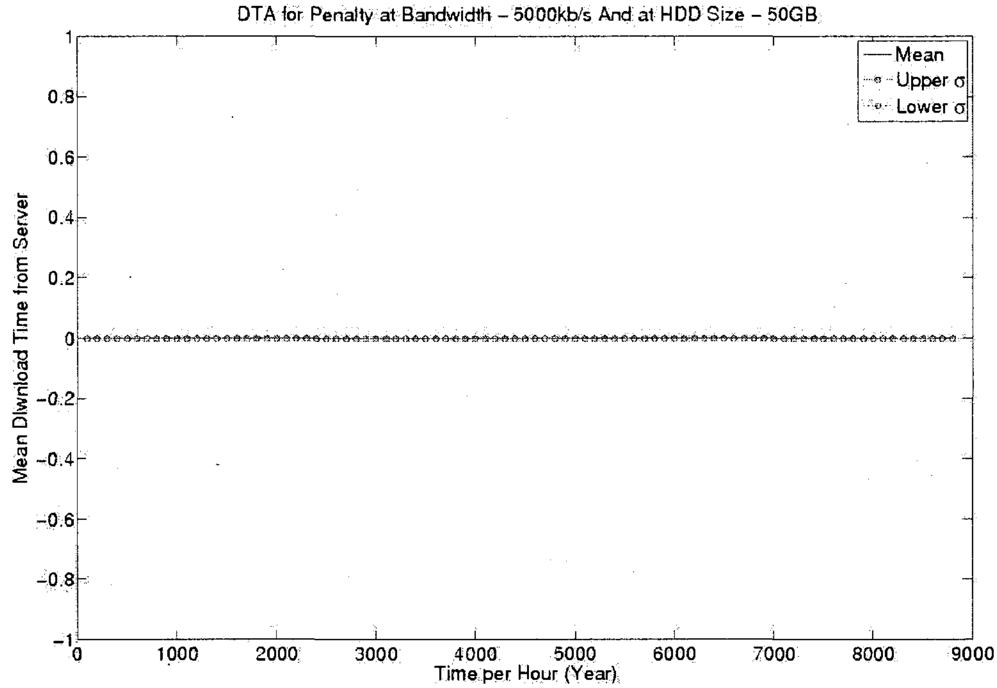


Figure 879: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 5000kb/s

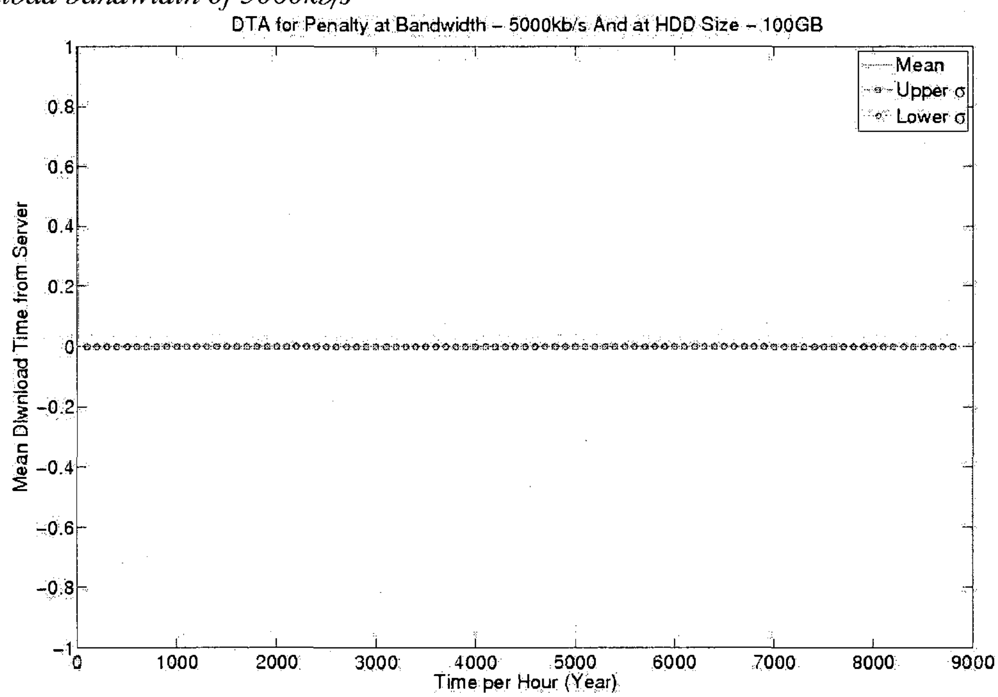


Figure 880: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 5000kb/s

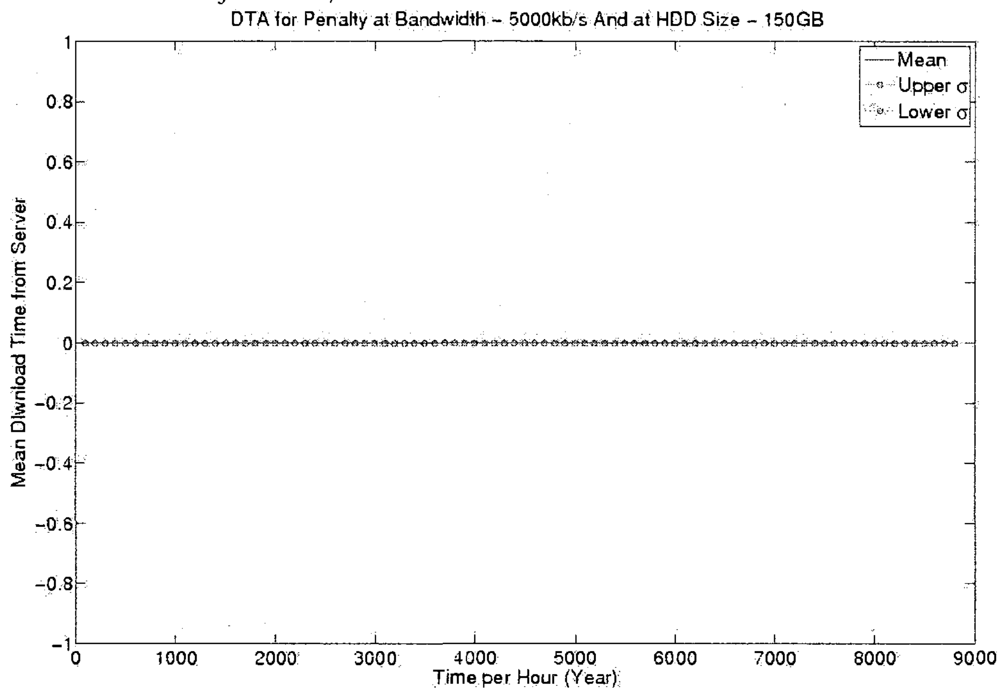


Figure 881: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 5000kb/s

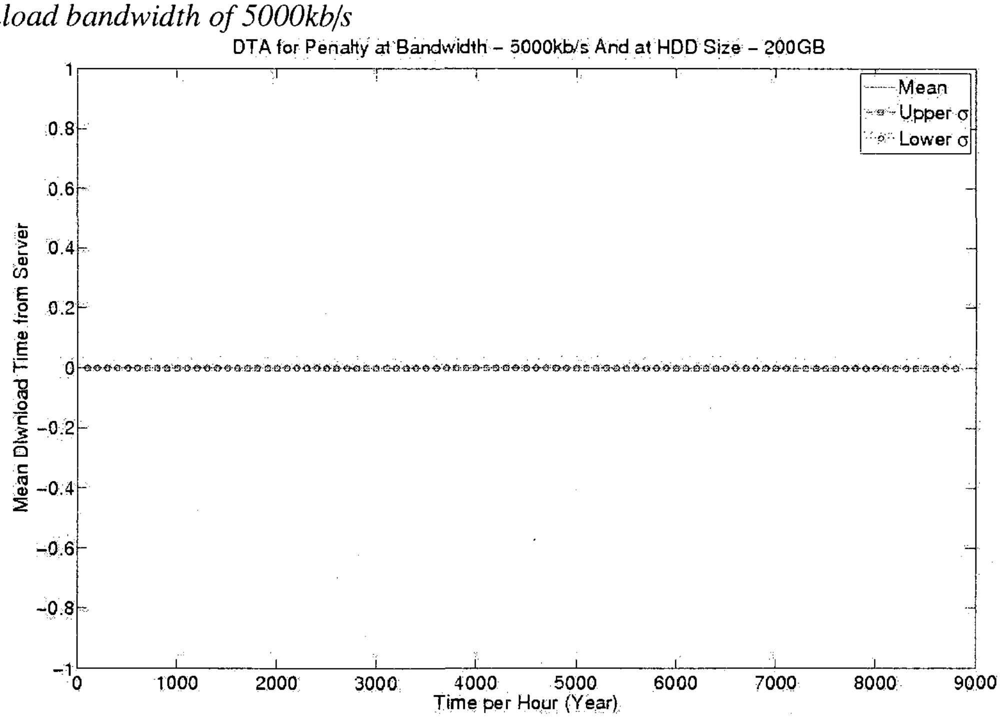


Figure 882: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 10000kb/s

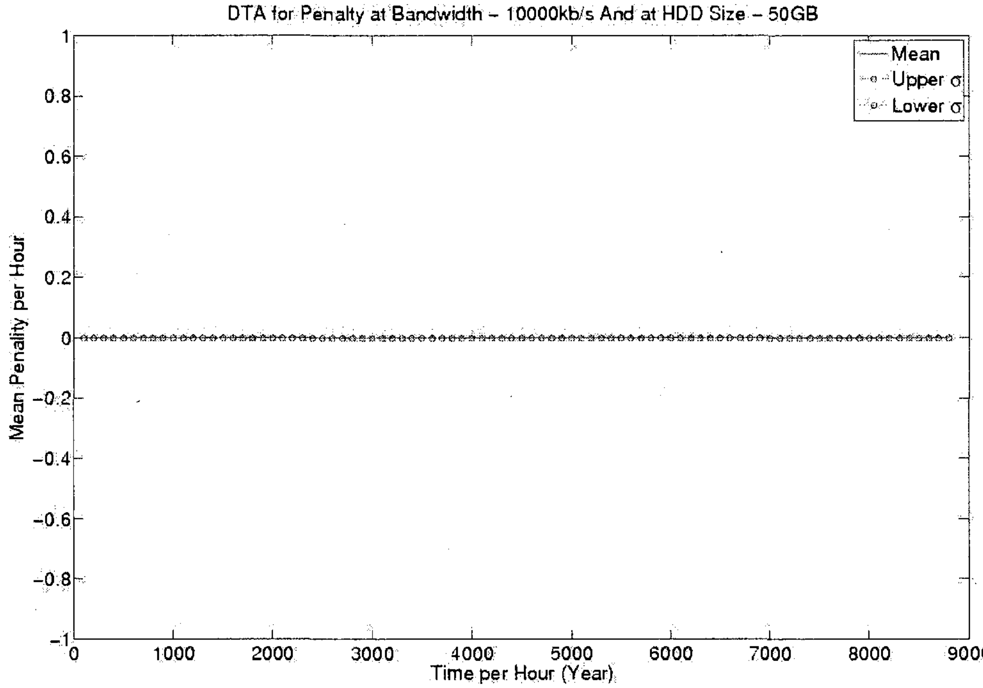


Figure 883: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 10000kb/s

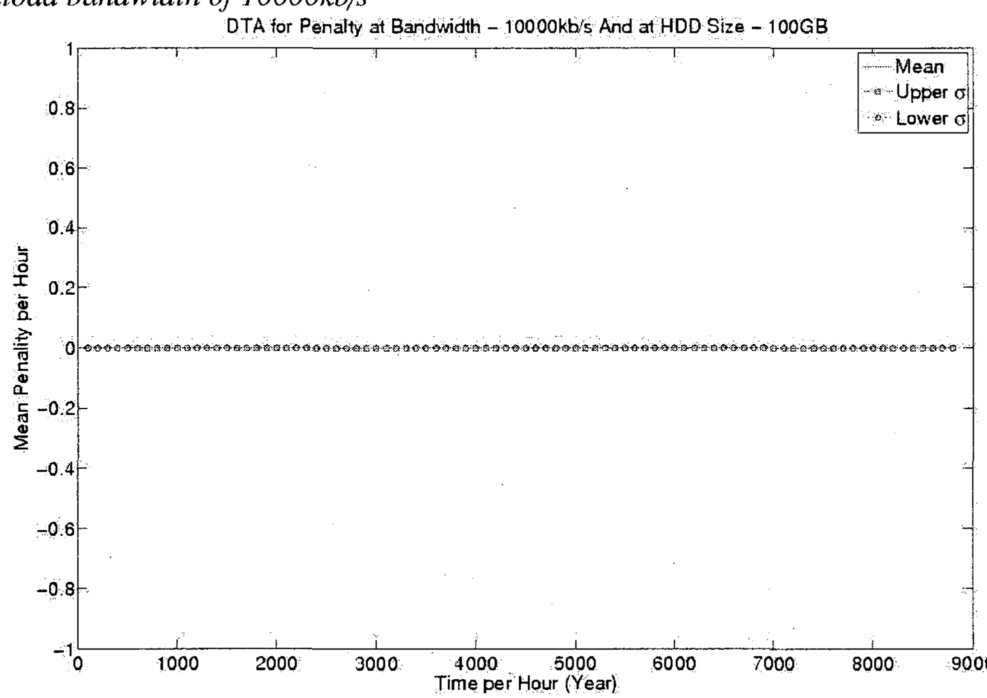


Figure 884: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 10000kb/s

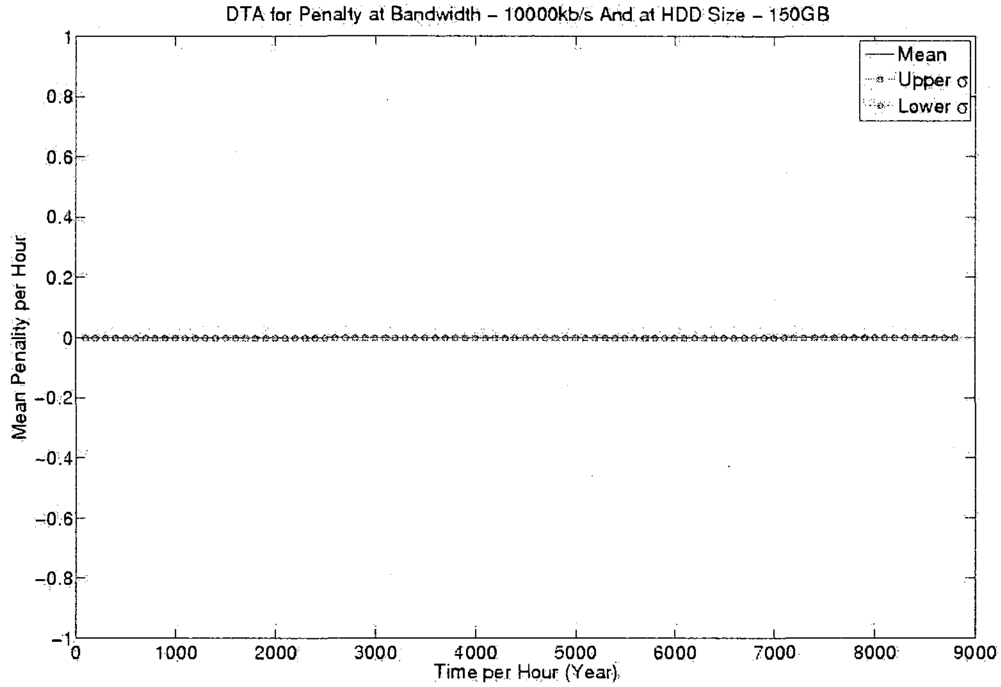


Figure 885: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 10000kb/s

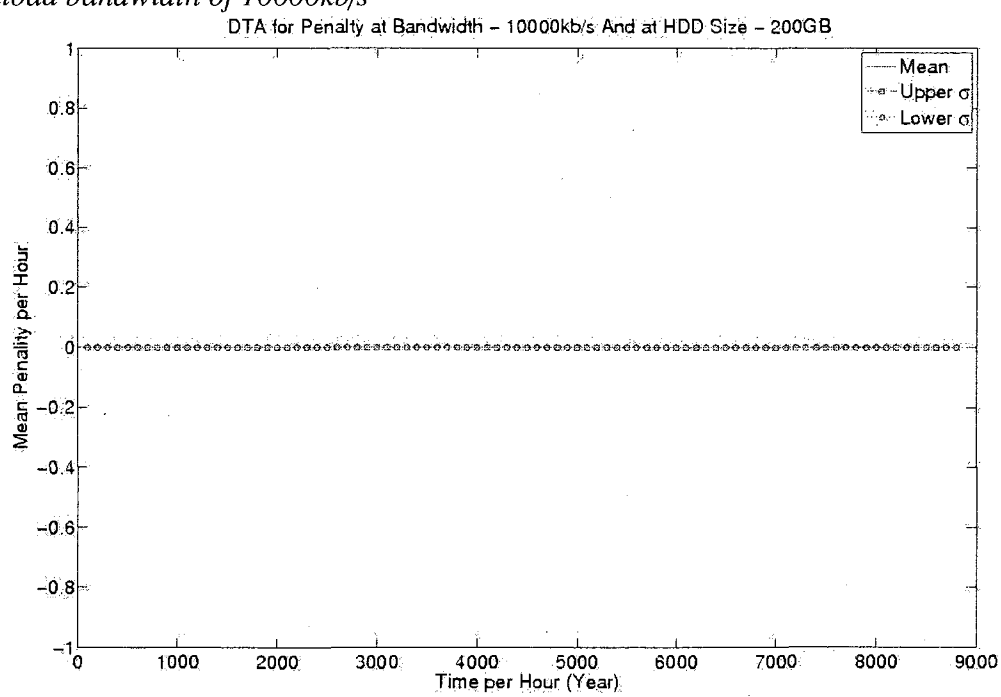


Figure 886: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 15000kb/s

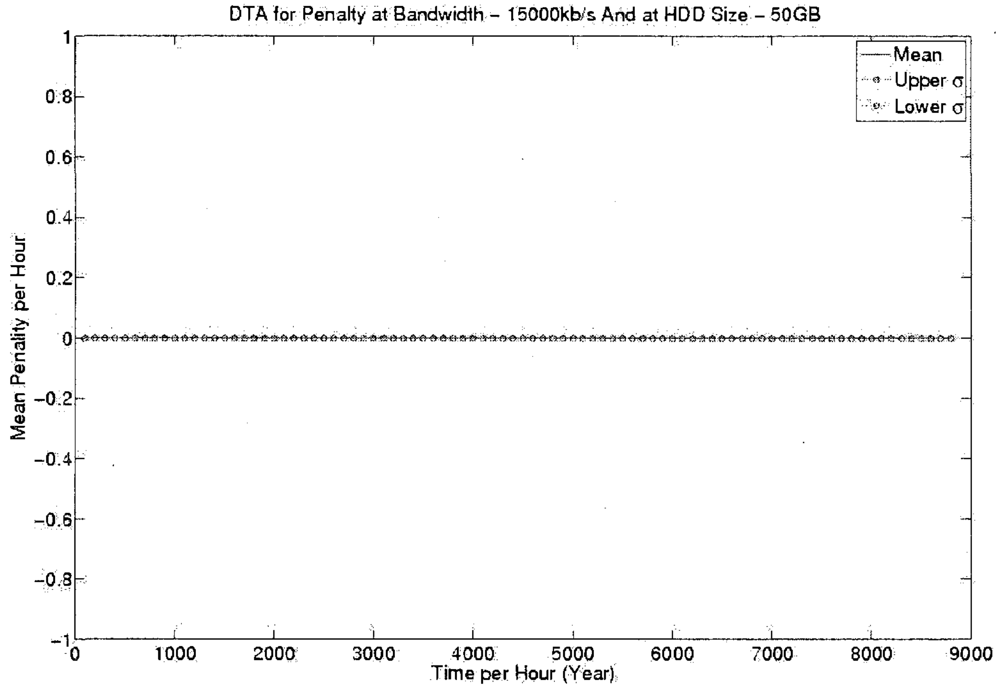


Figure 887: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 15000kb/s

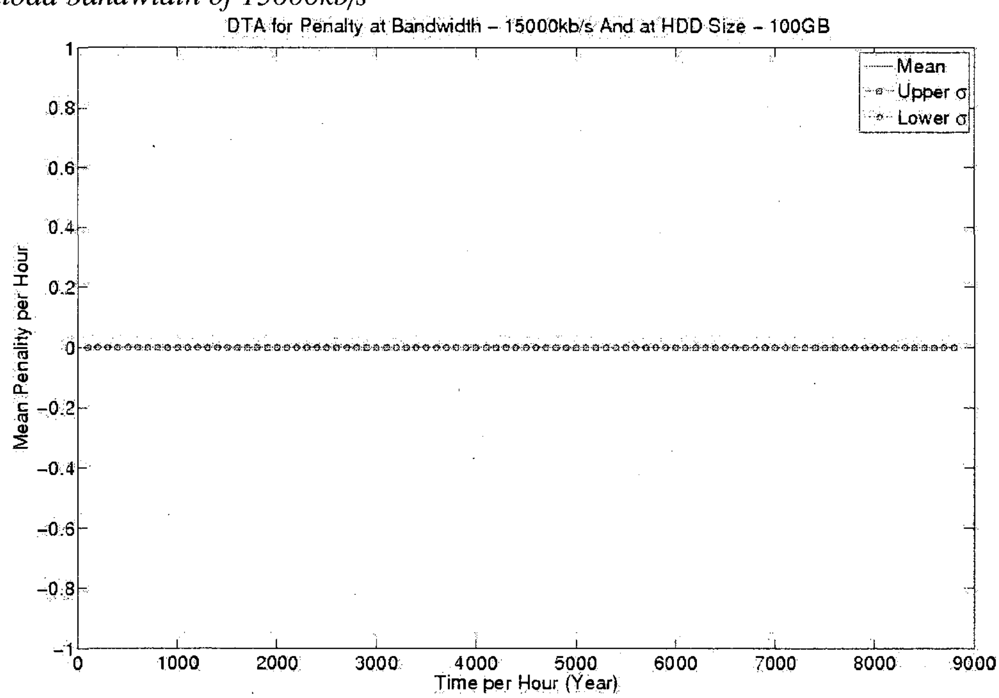


Figure 888: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 15000kb/s

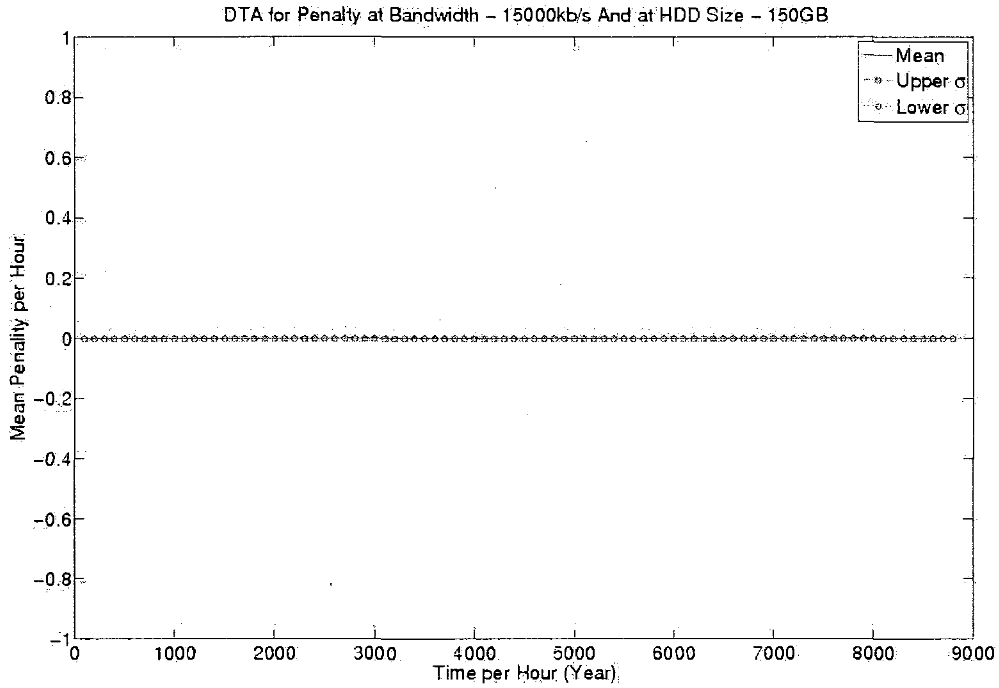


Figure 889: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 15000kb/s

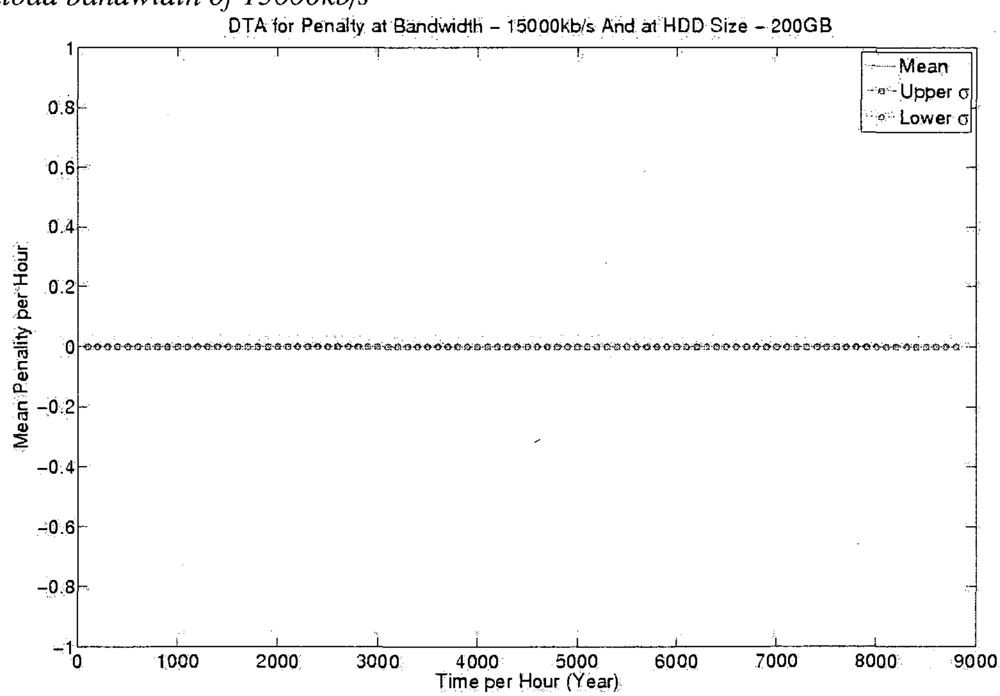


Figure 890: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 25kb/s

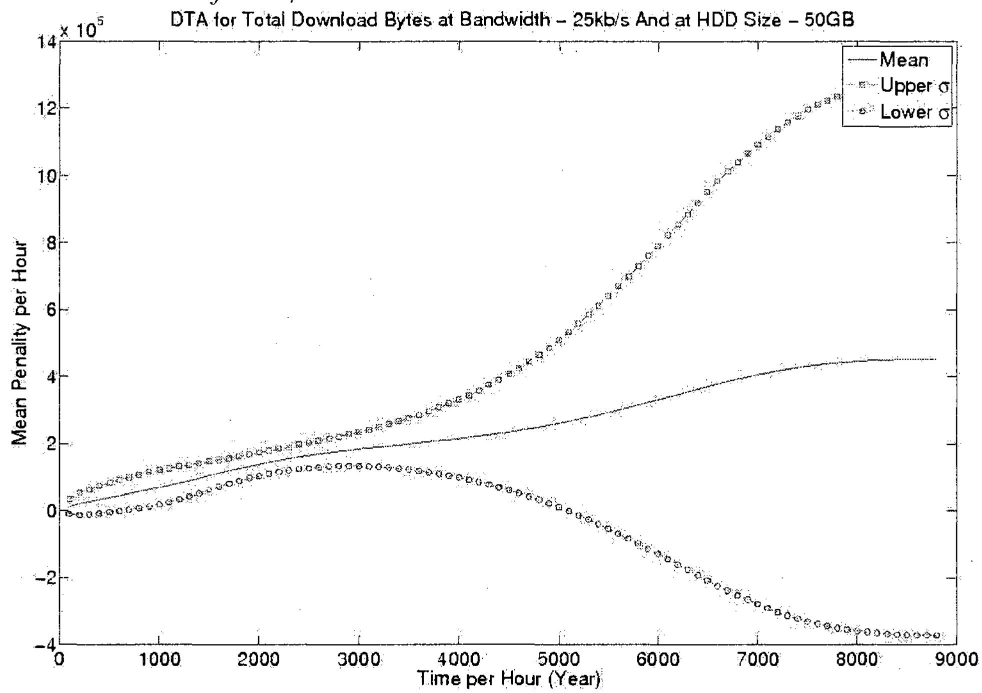


Figure 891: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 25kb/s

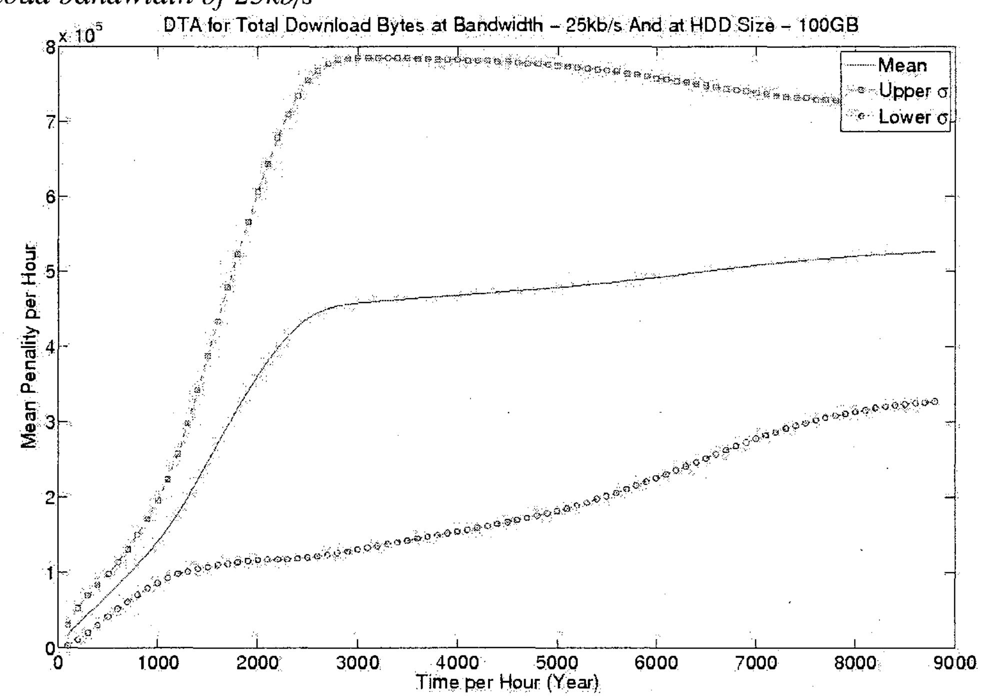


Figure 892: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 25kb/s

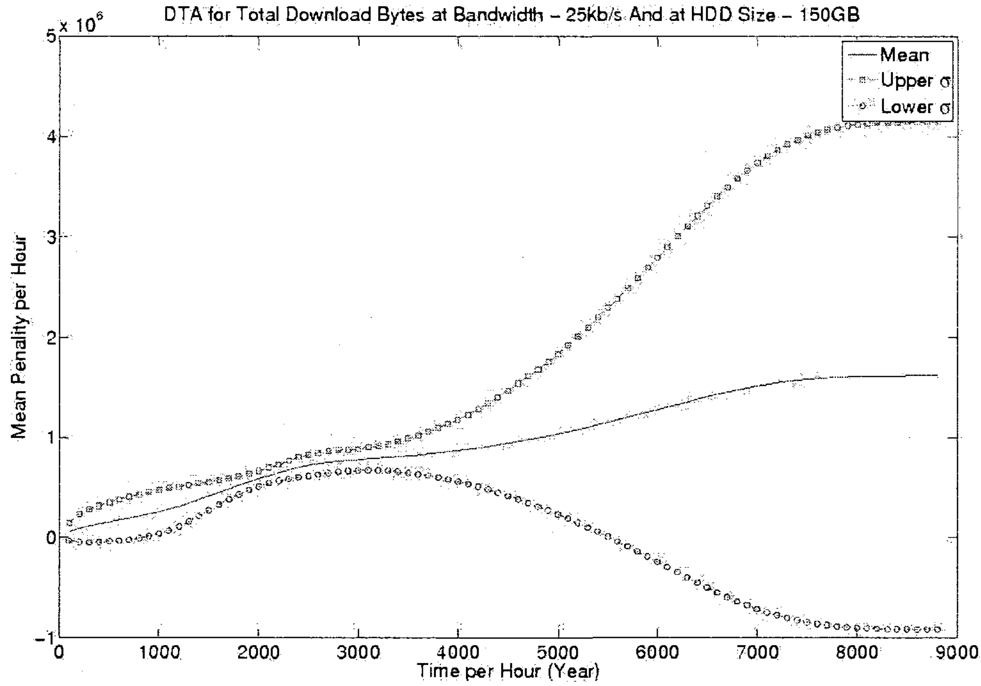


Figure 893: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 25kb/s

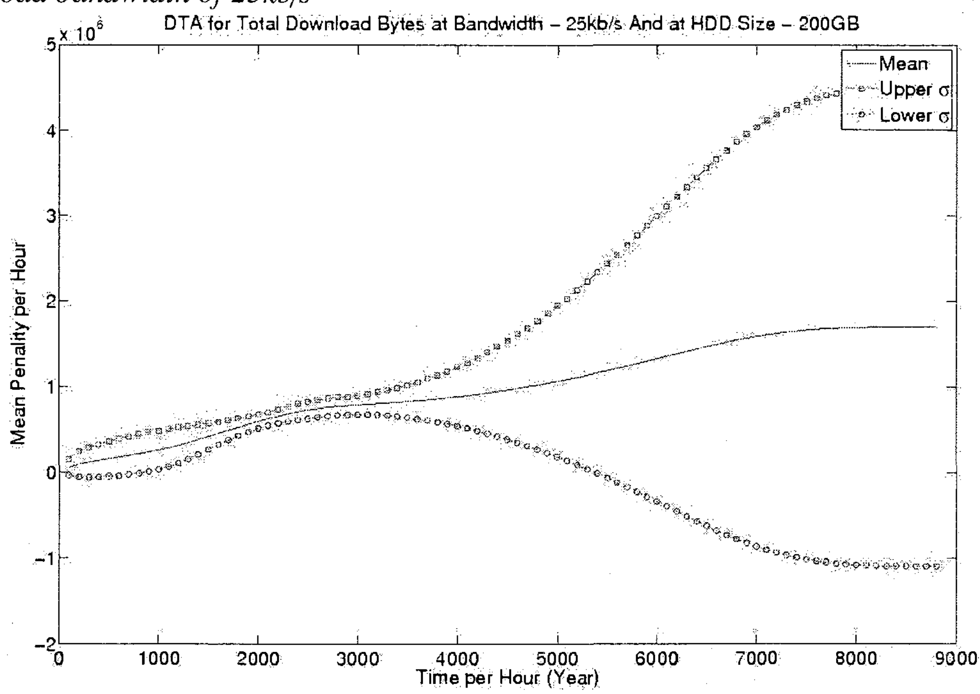


Figure 894: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 50kb/s

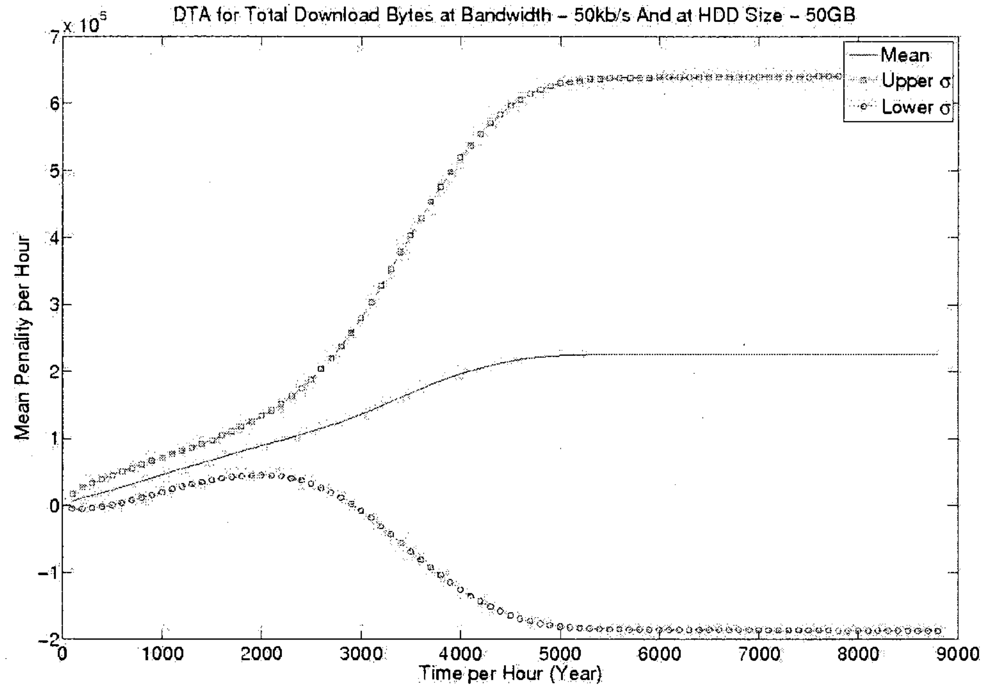


Figure 895: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 50kb/s

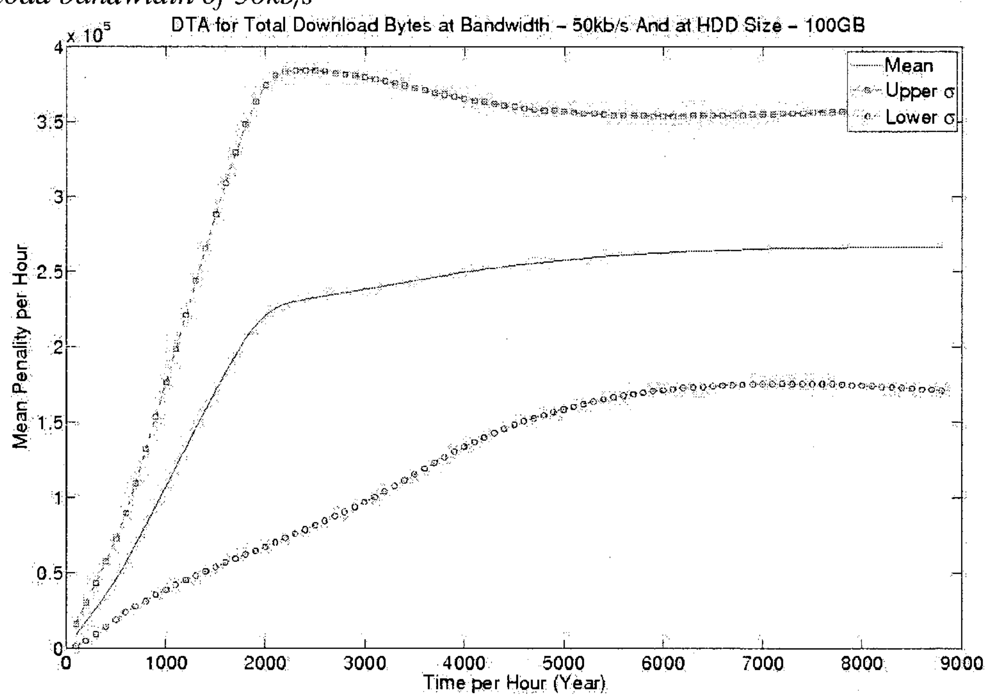


Figure 896: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 50kb/s

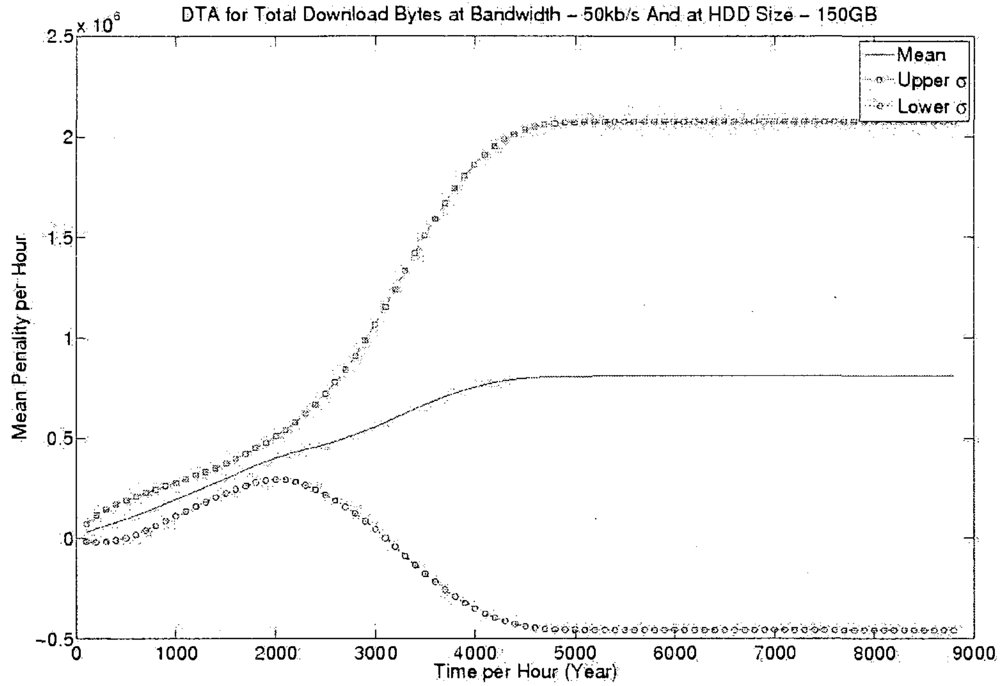


Figure 897: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 50kb/s

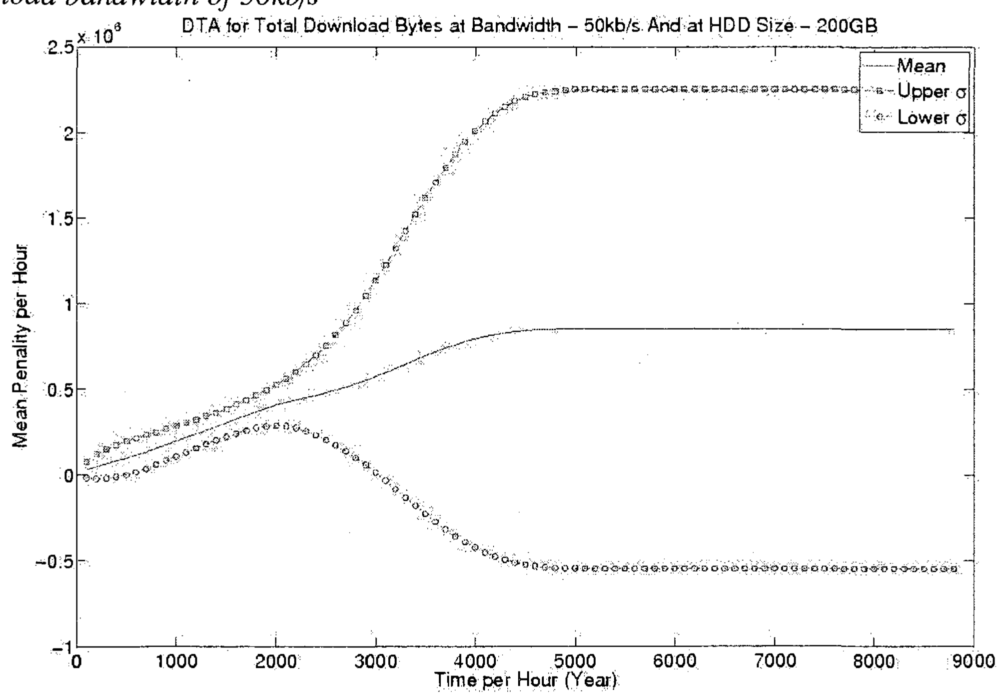


Figure 898: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 100kb/s

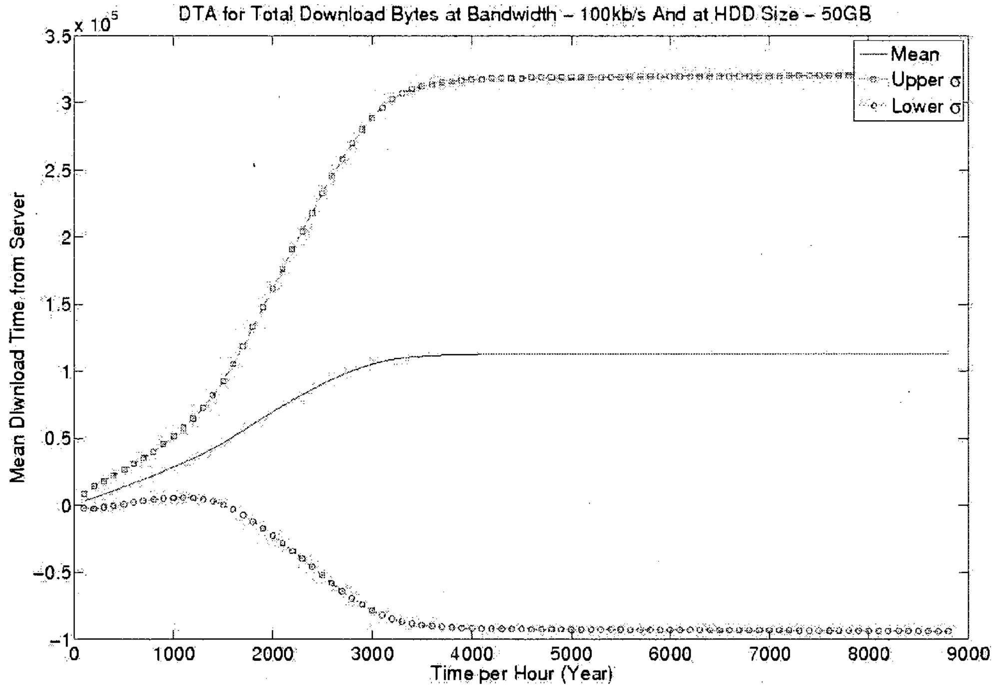


Figure 899: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 100kb/s

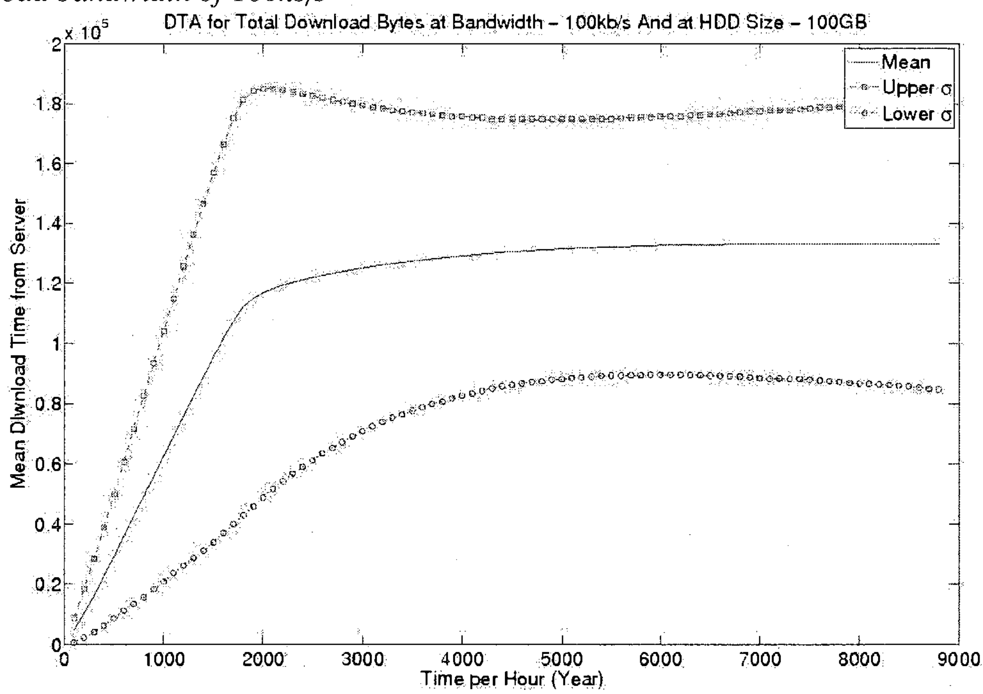


Figure 900: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 100kb/s

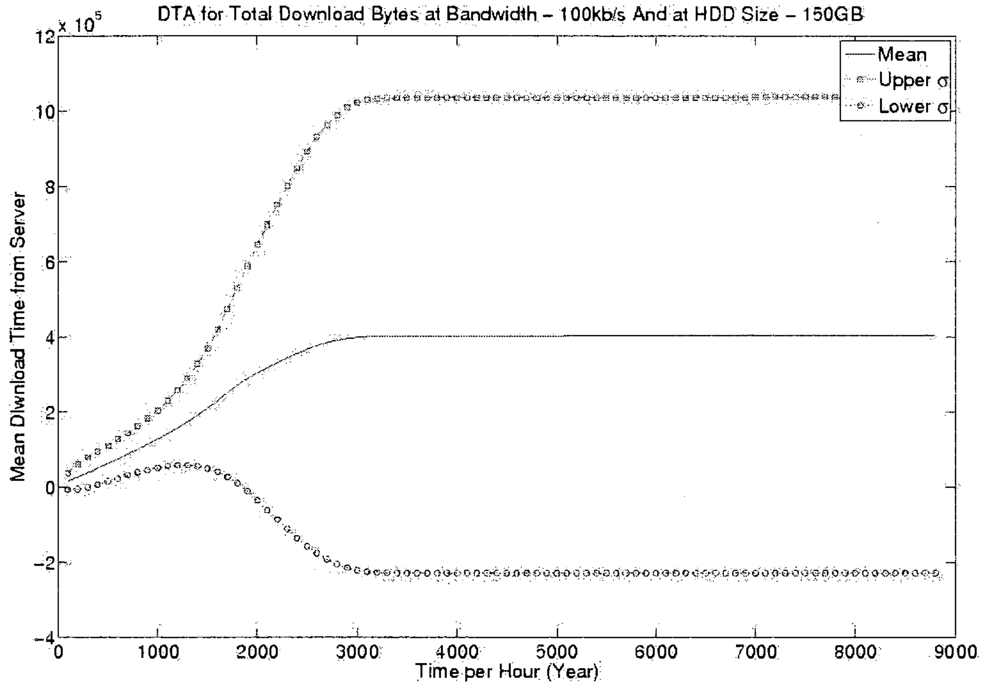


Figure 901: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 100kb/s

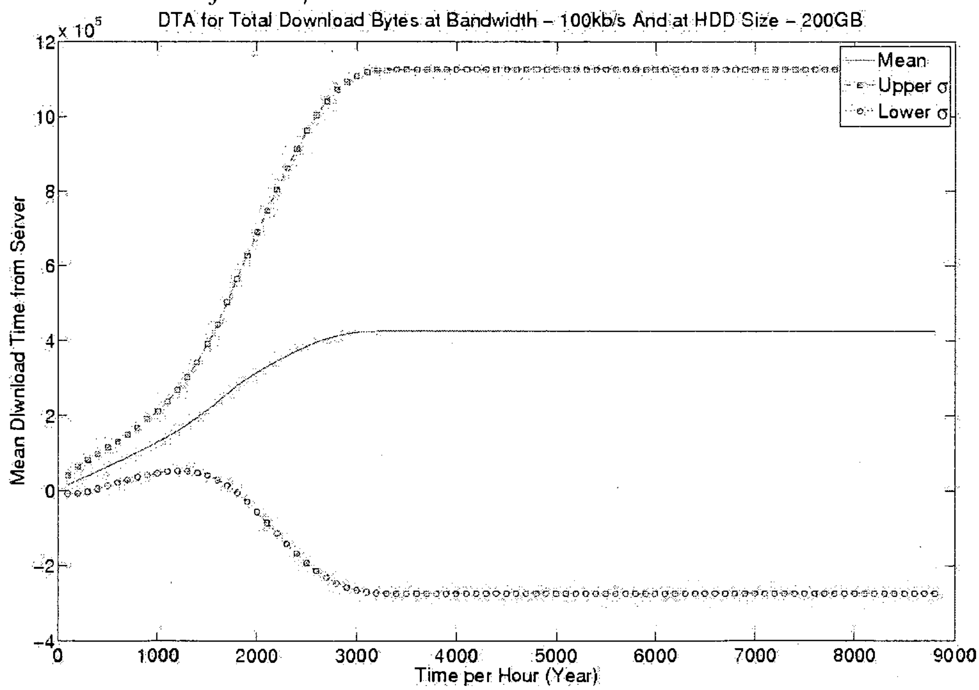


Figure 902: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 128kb/s

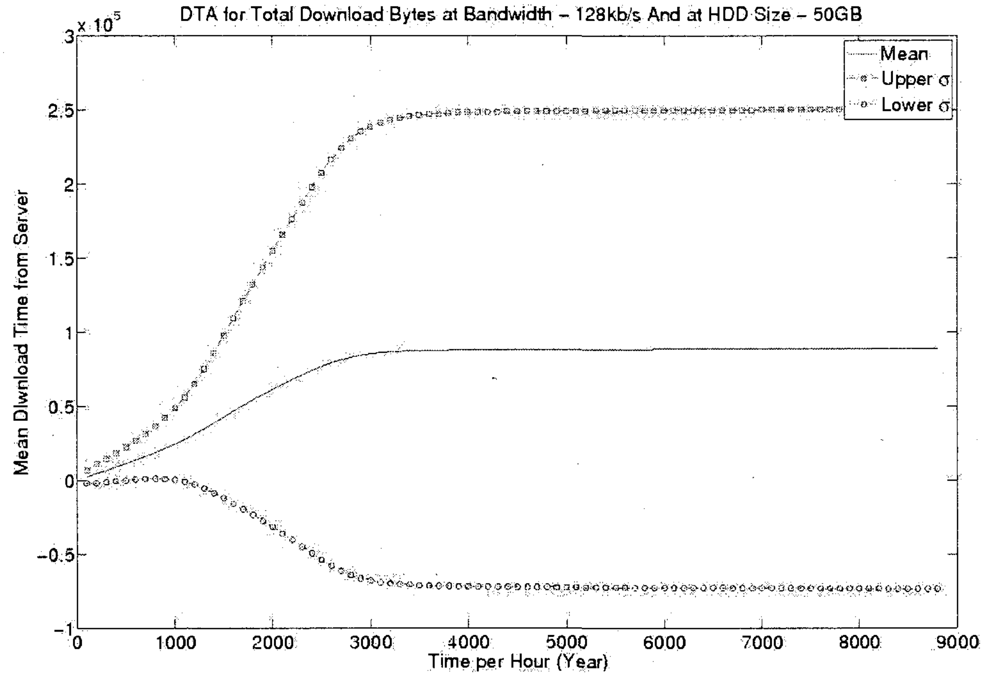


Figure 903: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 128kb/s

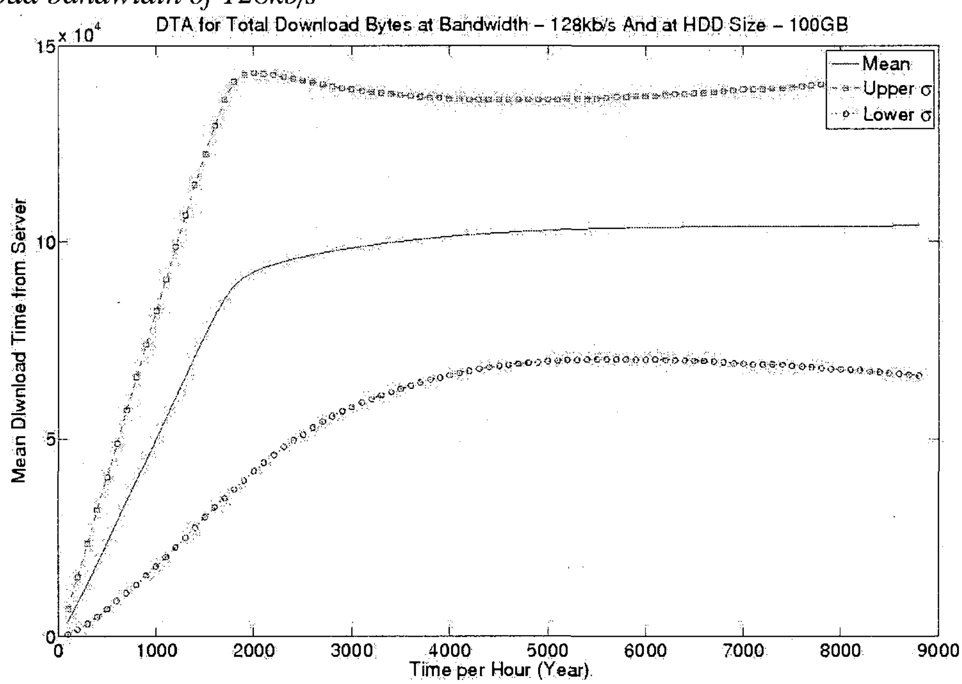


Figure 904: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 128kb/s

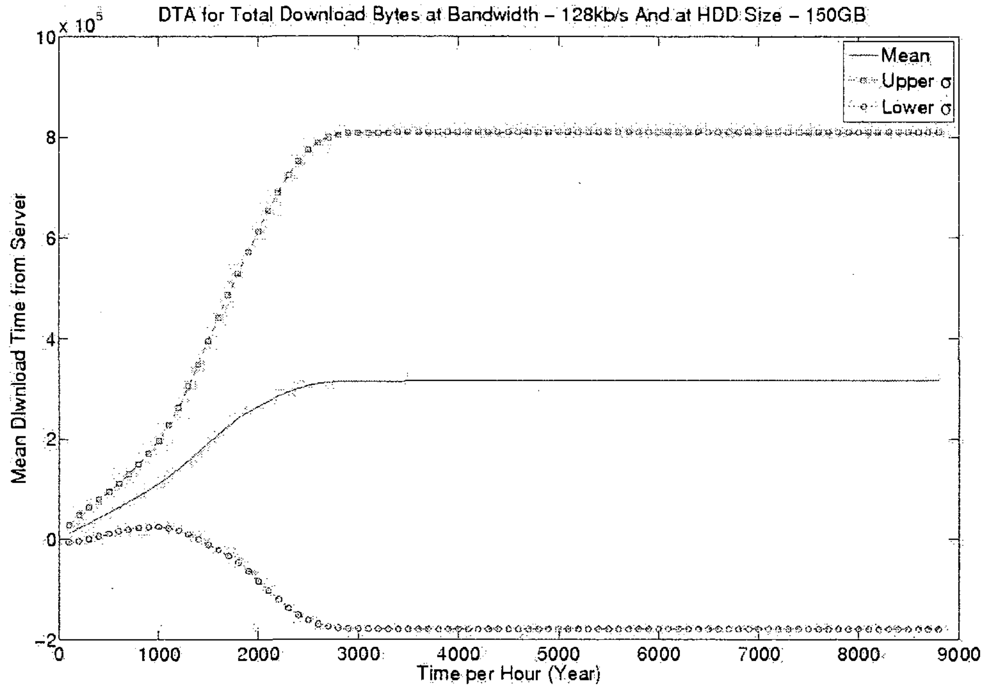


Figure 905: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 128kb/s

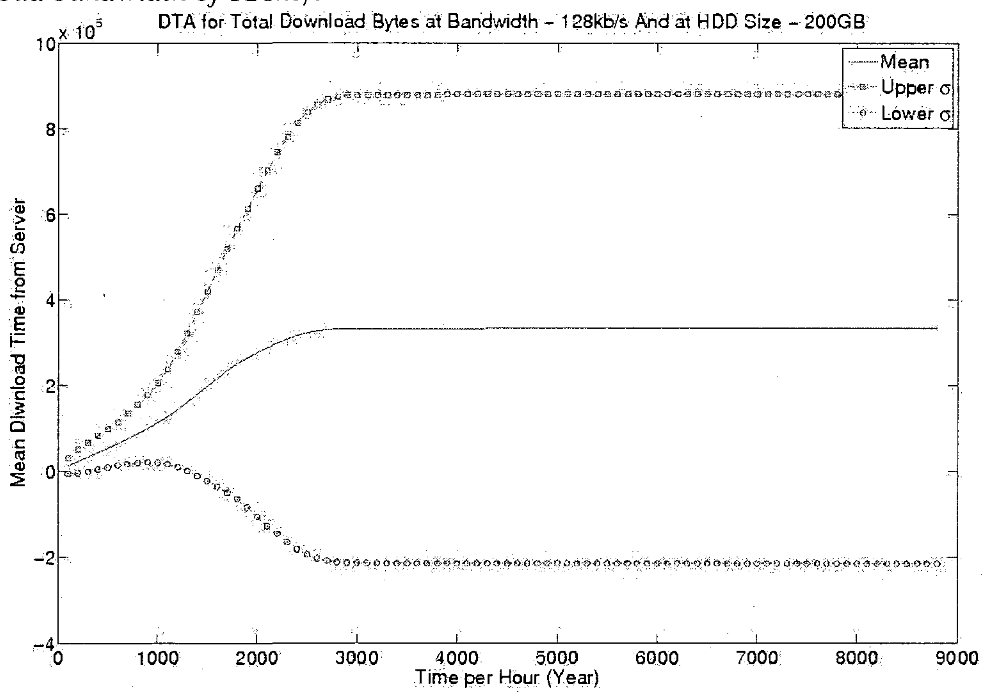


Figure 906: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 256kb/s

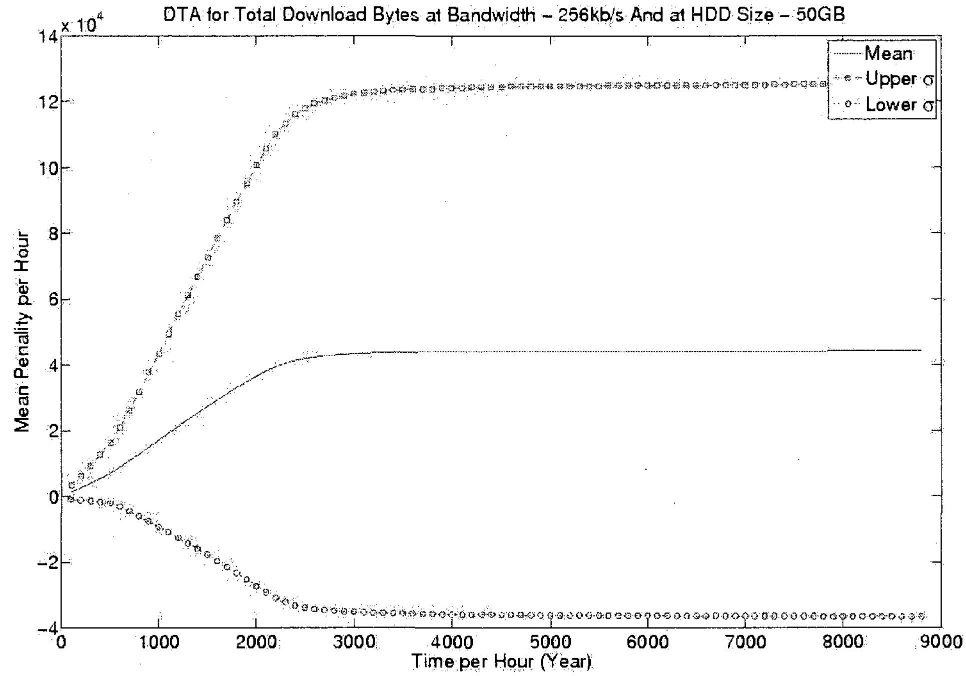


Figure 907: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 256kb/s

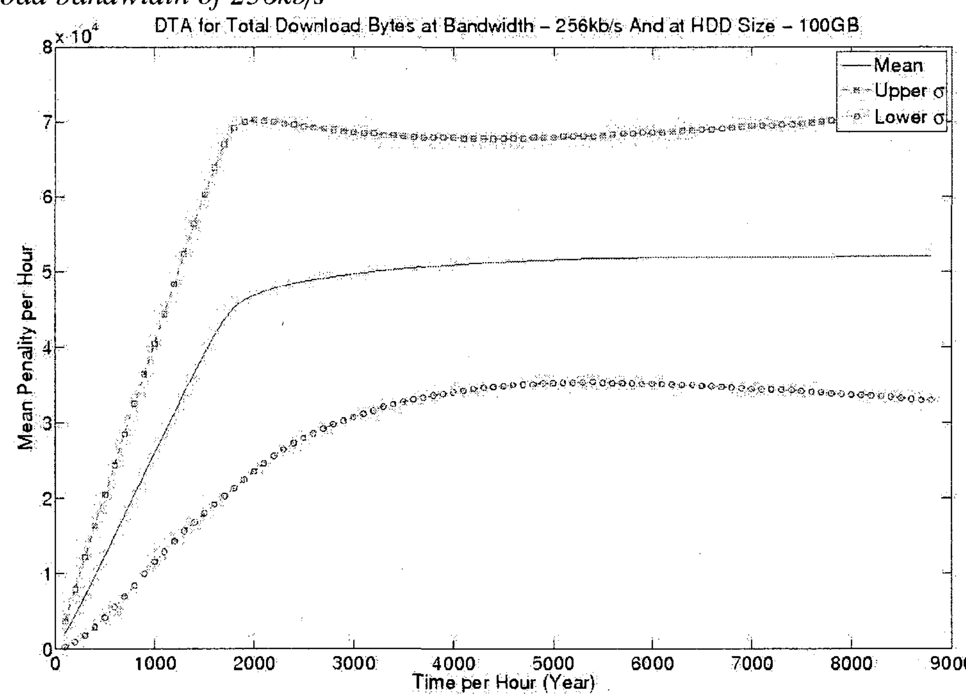


Figure 908: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 256kb/s

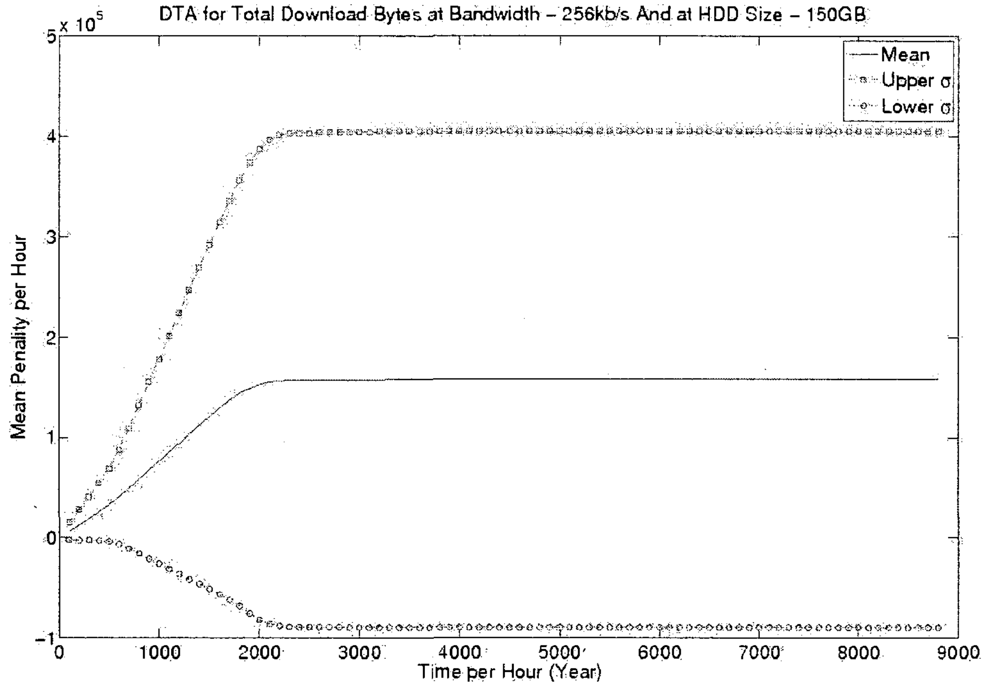


Figure 909: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 256kb/s

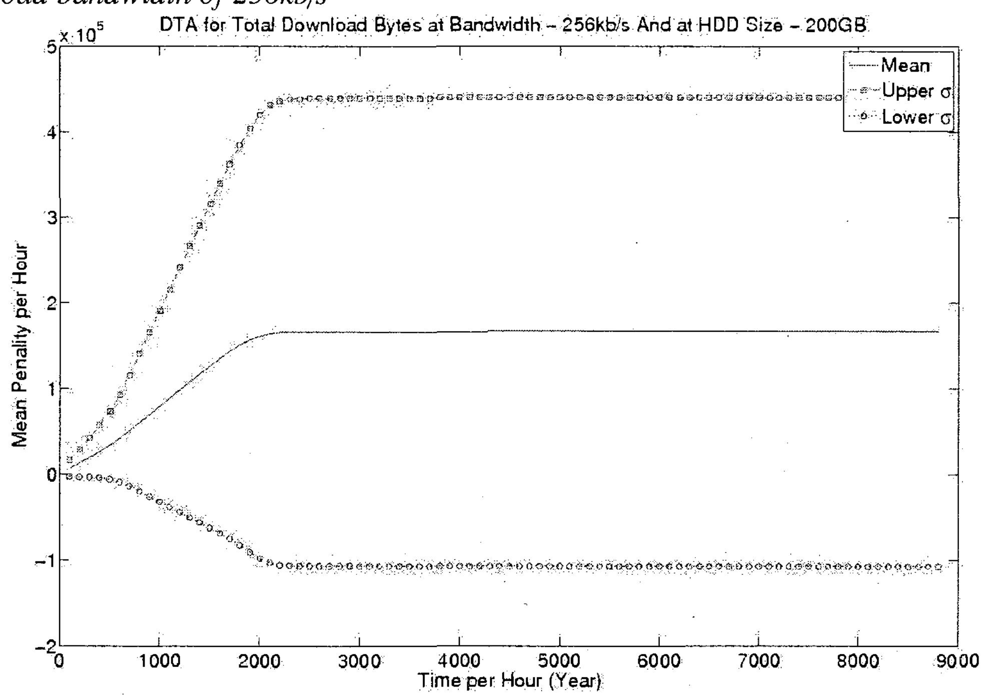


Figure 910: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 512kb/s

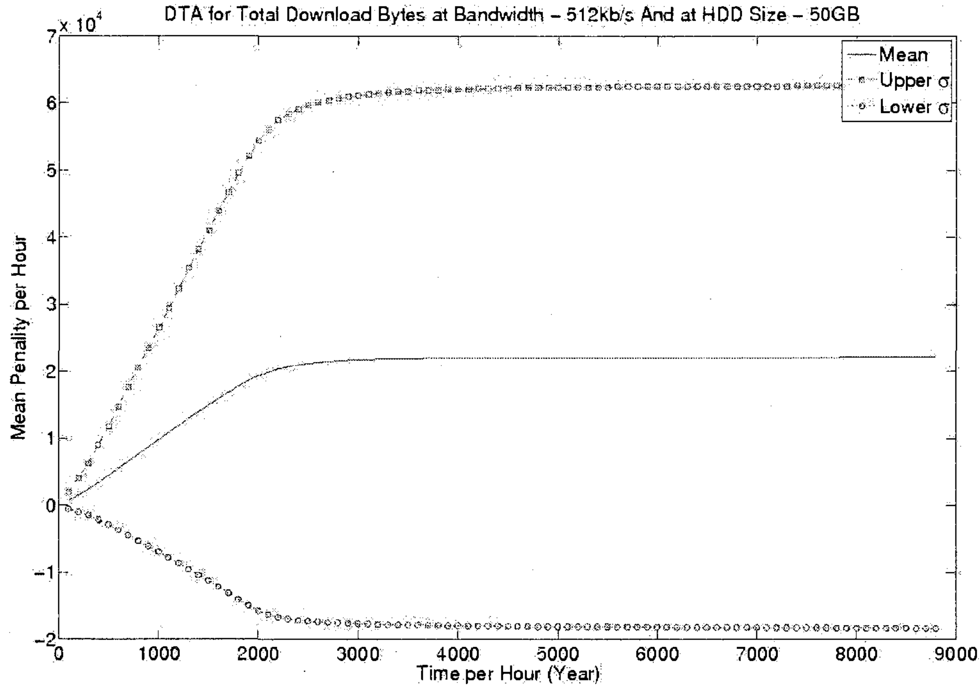


Figure 911: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 512kb/s

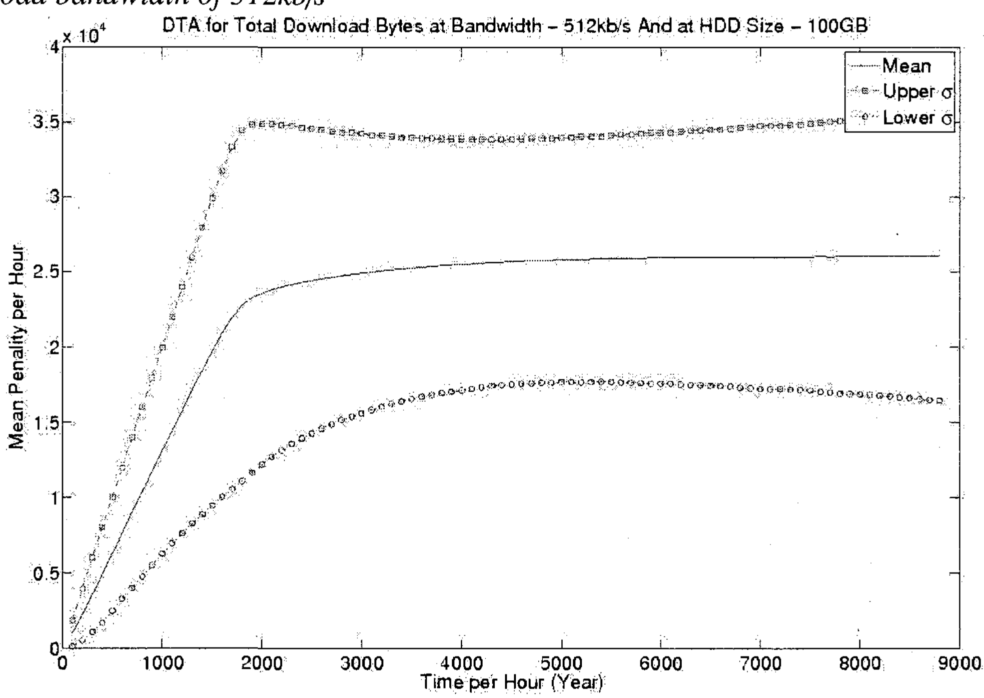


Figure 912: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 512kb/s

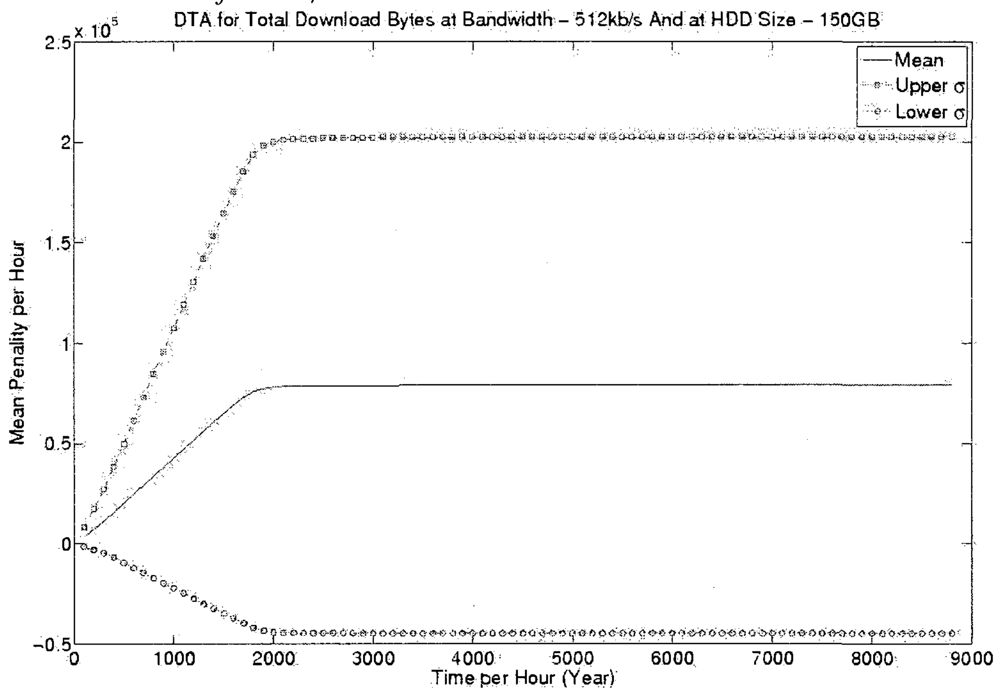


Figure 913: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 512kb/s

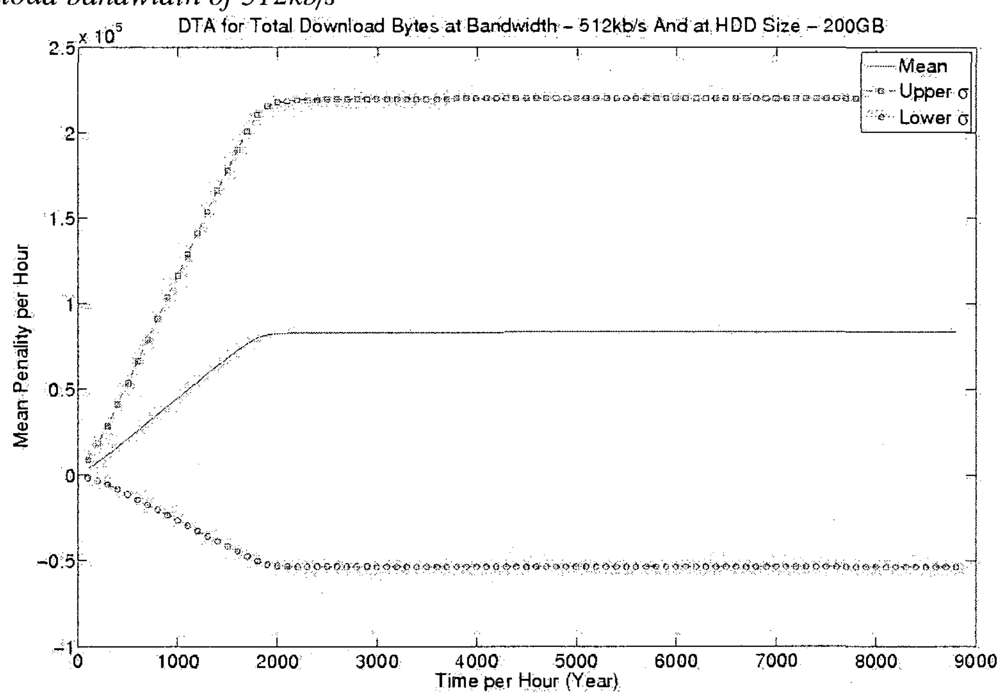


Figure 914: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 1000kb/s

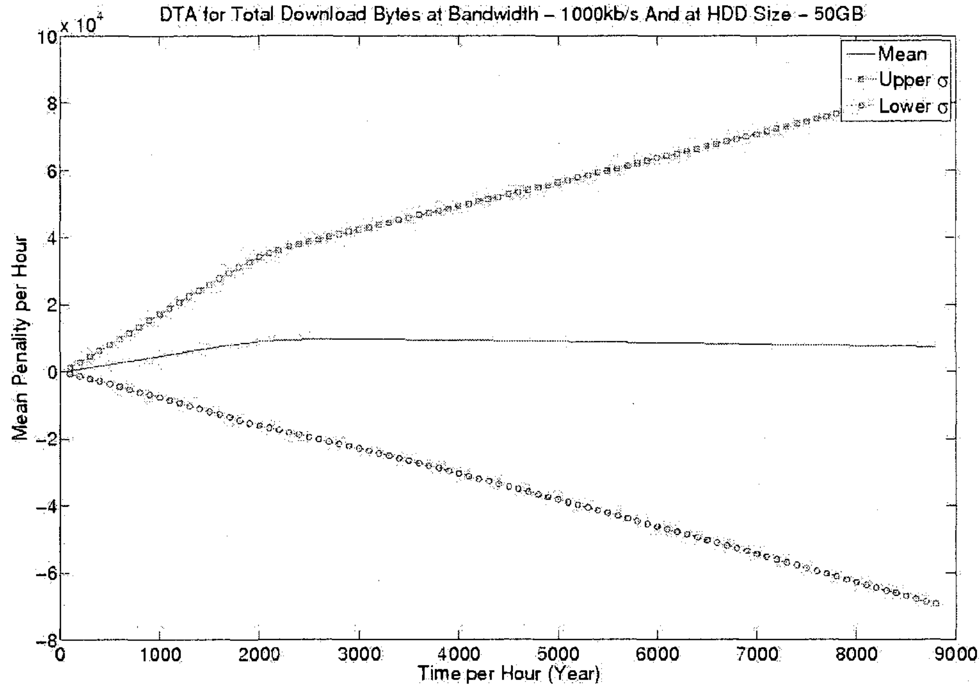


Figure 915: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 1000kb/s

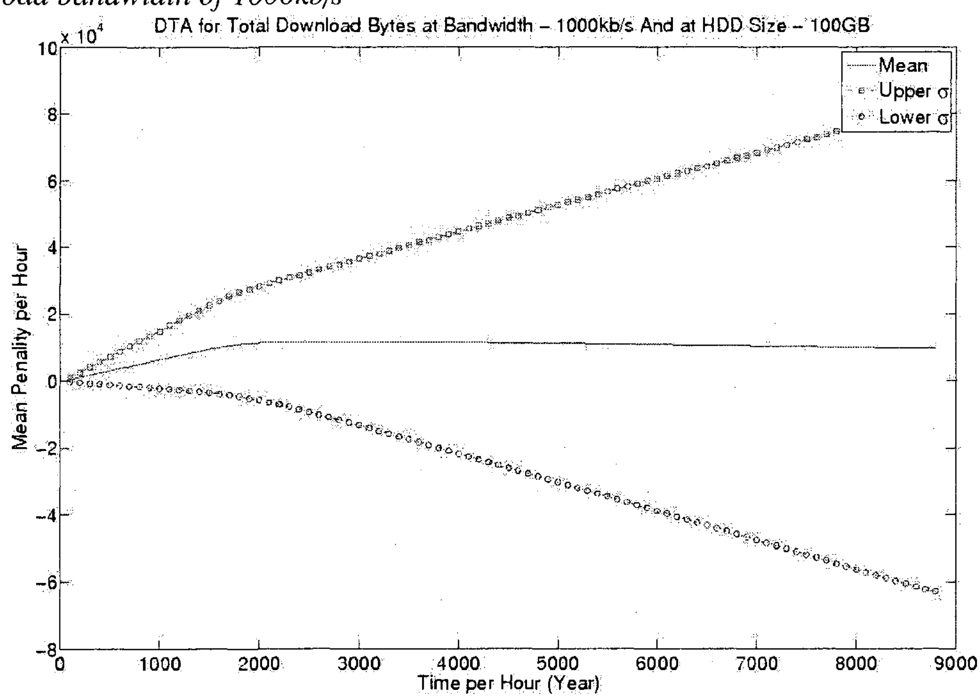


Figure 916: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 1000kb/s

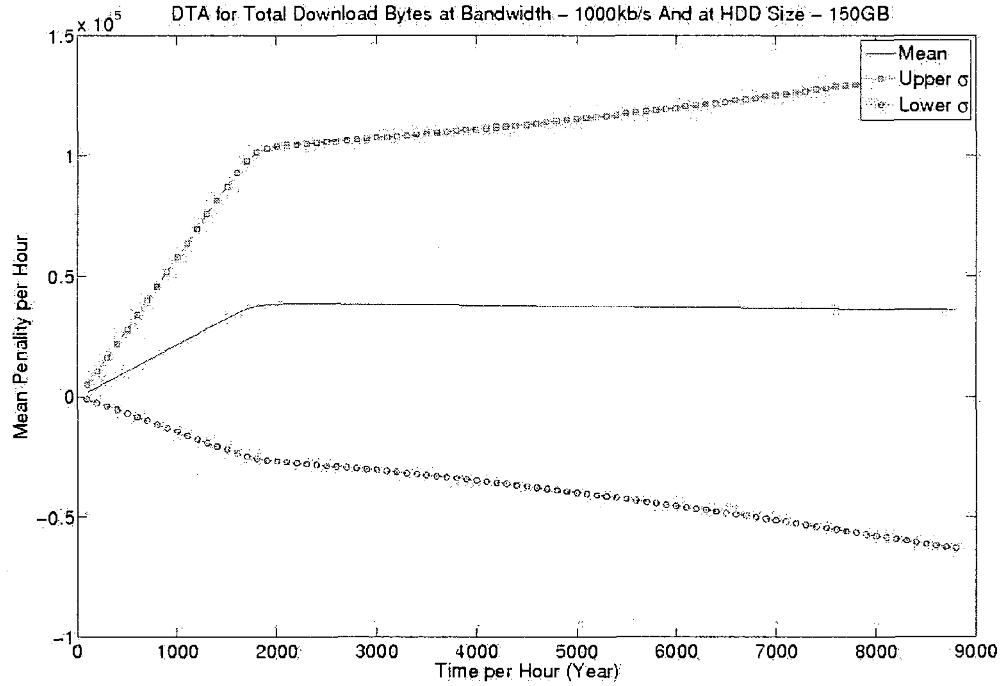


Figure 917: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 1000kb/s

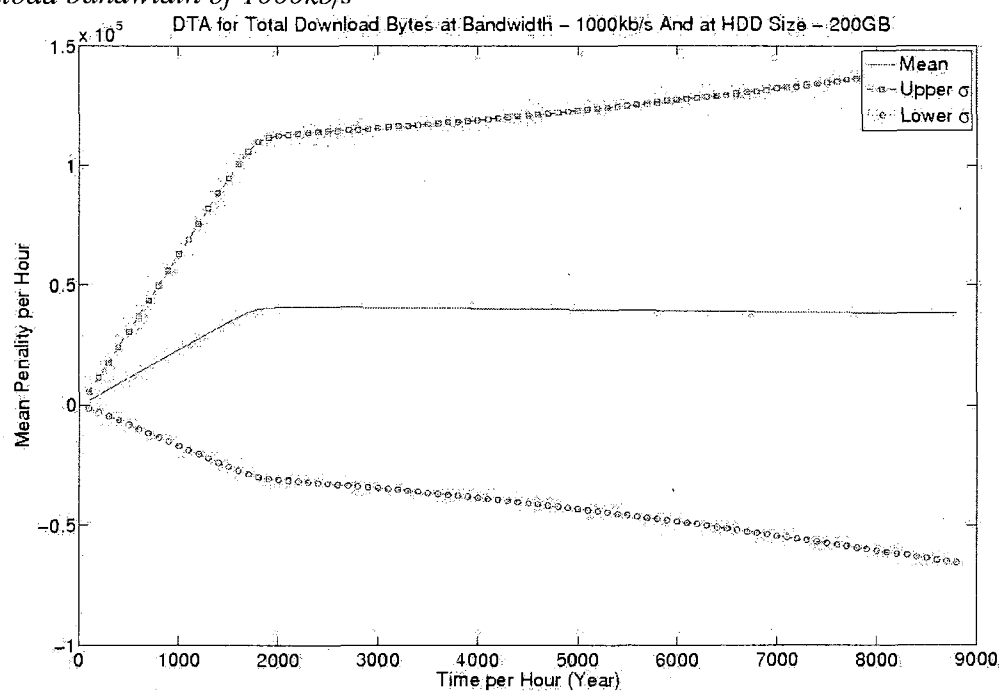


Figure 918: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 2000kb/s

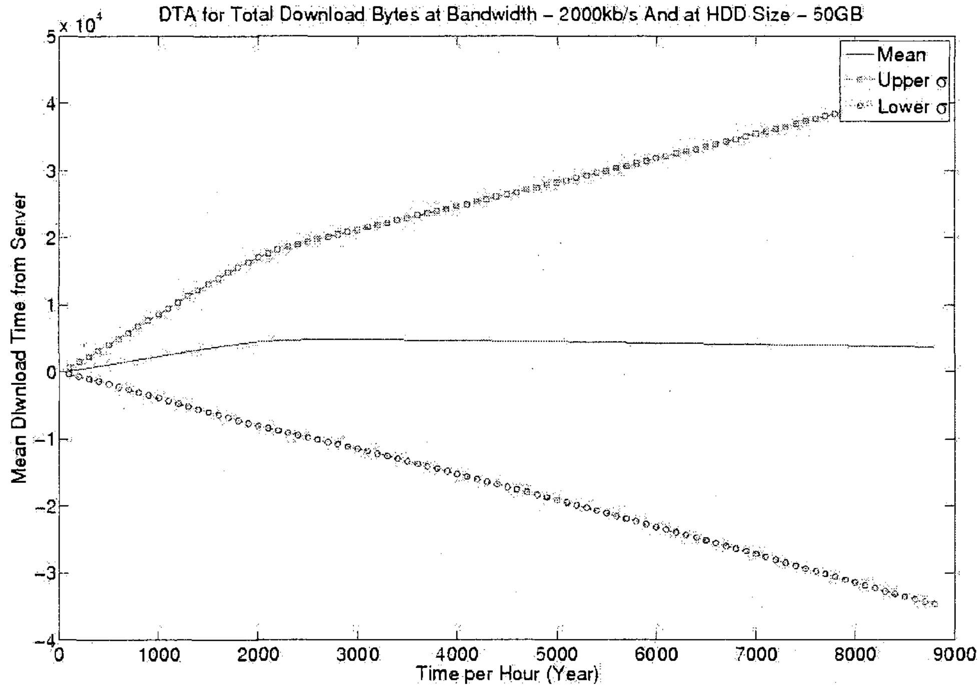


Figure 919: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 2000kb/s

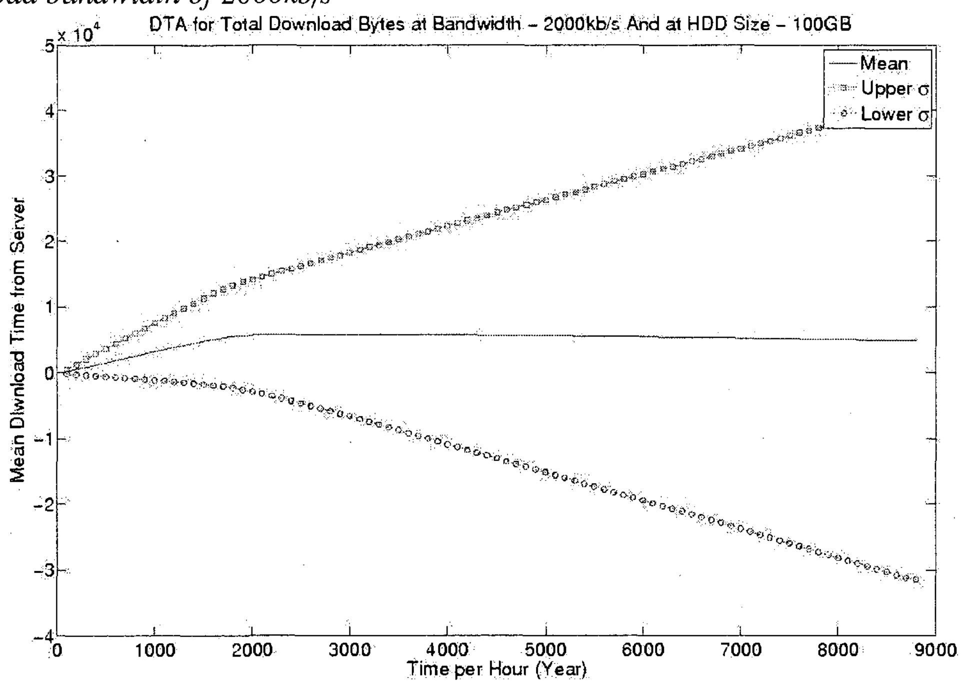


Figure 920: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 2000kb/s

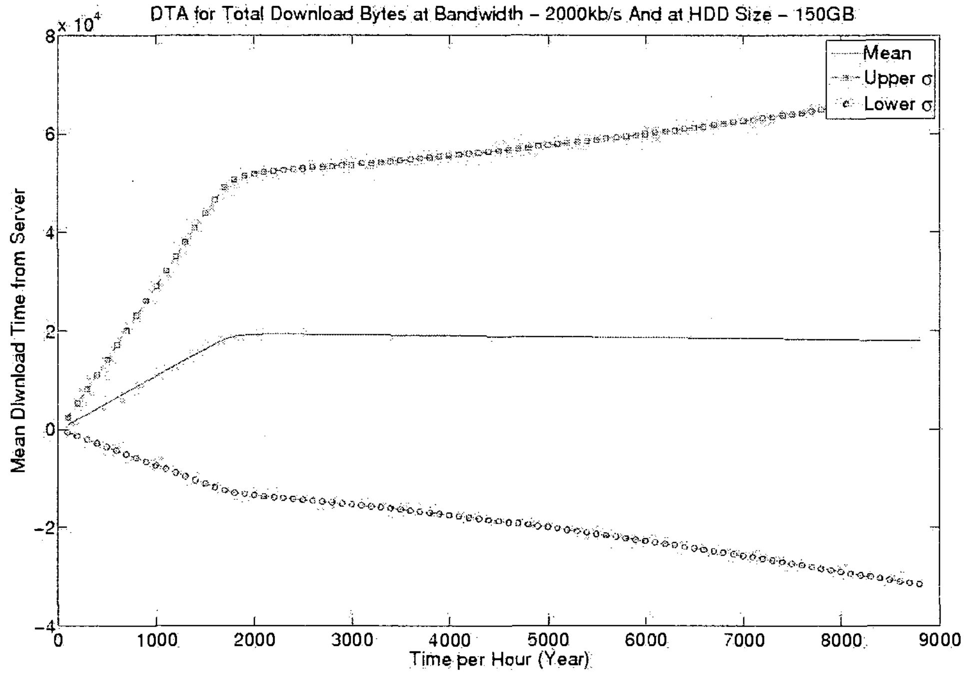


Figure 921: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 2000kb/s

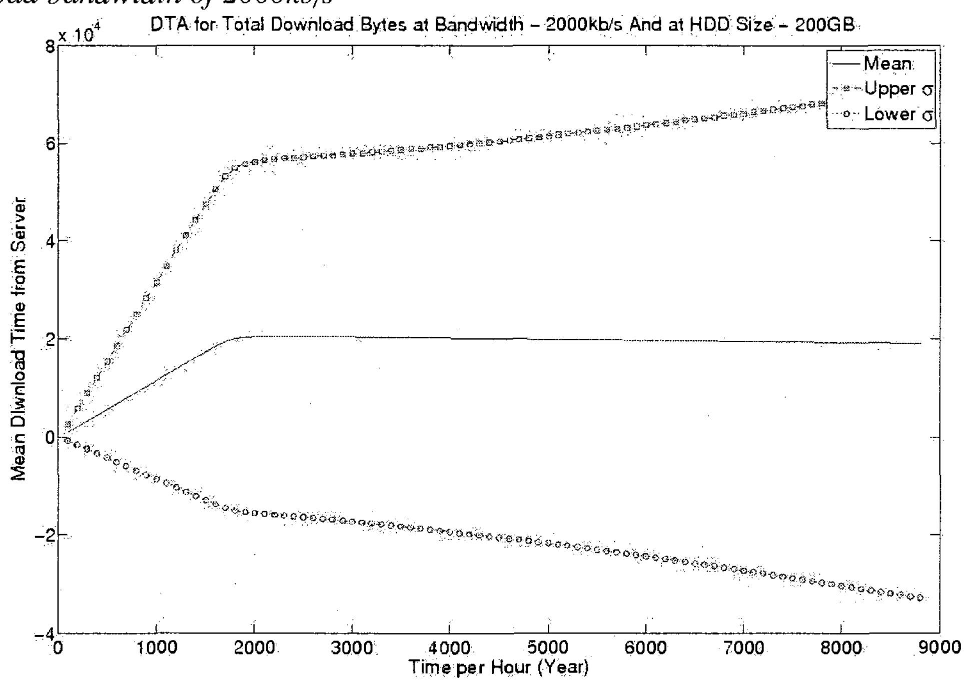


Figure 922: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 5000kb/s

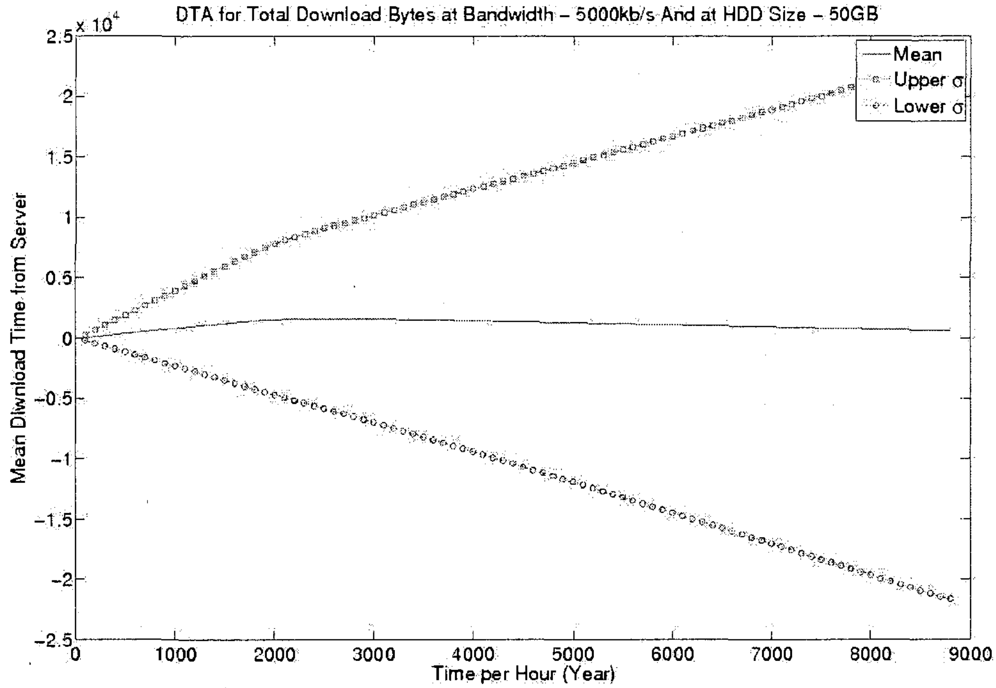


Figure 923: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 5000kb/s

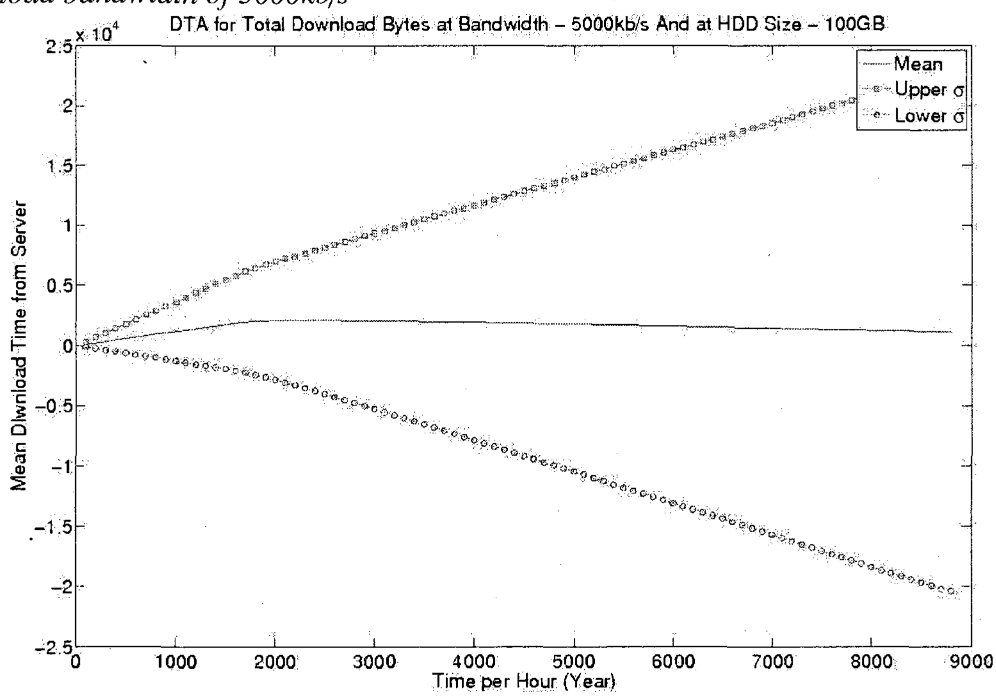


Figure 924: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 5000kb/s

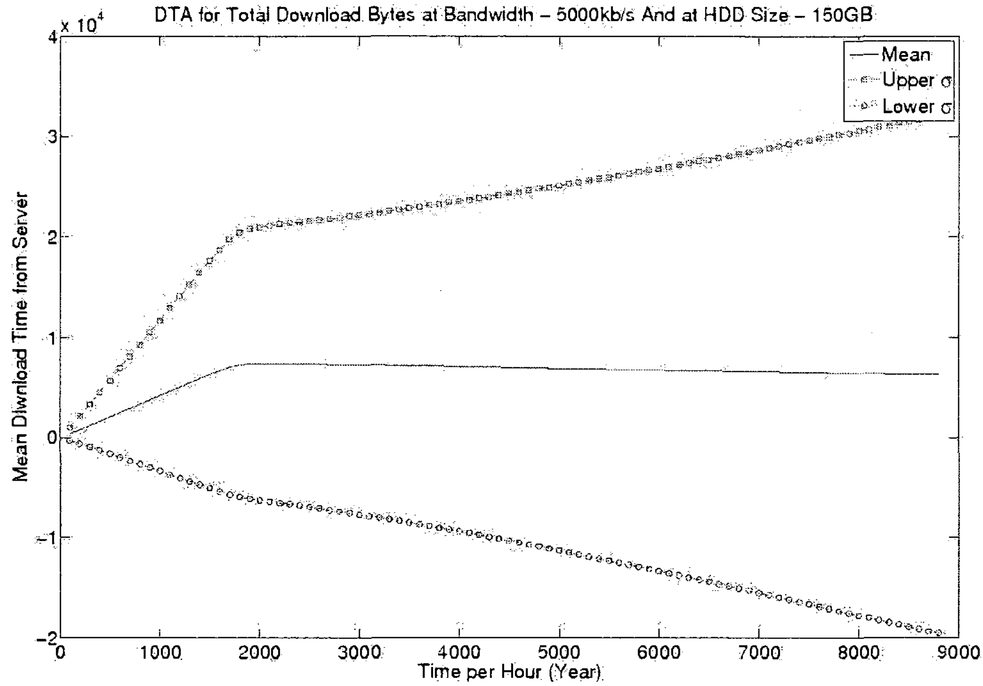


Figure 925: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 5000kb/s

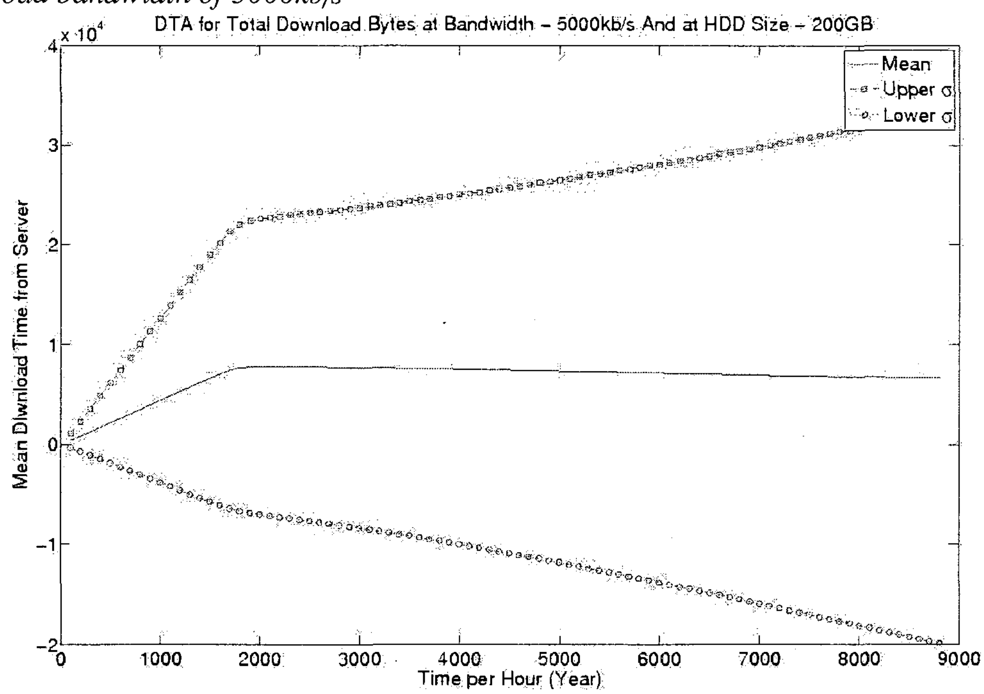


Figure 926: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 10000kb/s

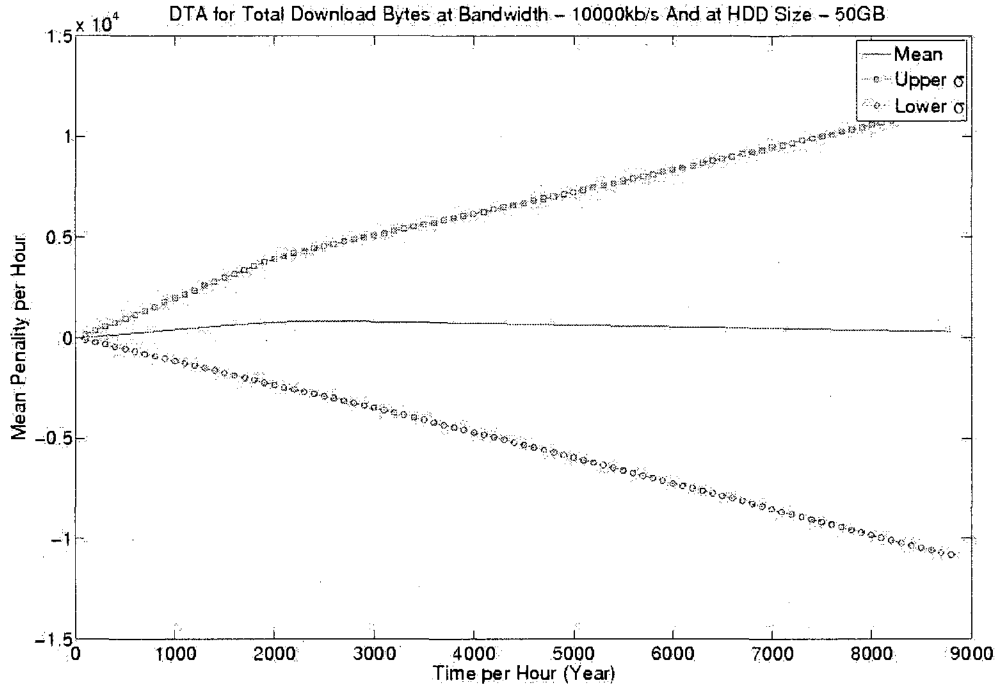


Figure 927: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 10000kb/s

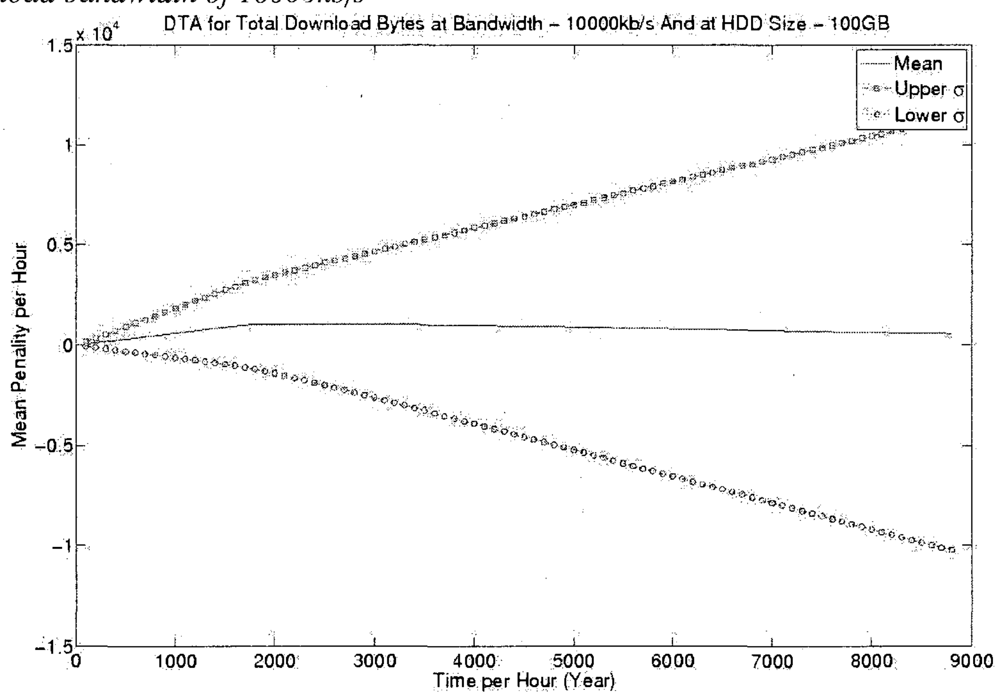


Figure 928: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 10000kb/s

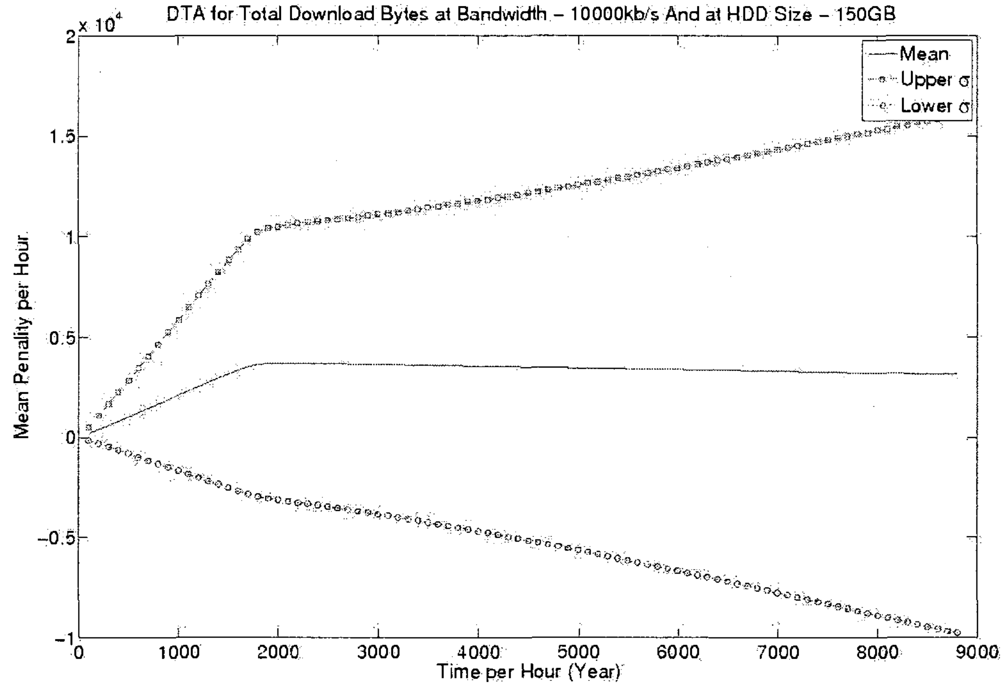


Figure 929: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 10000kb/s

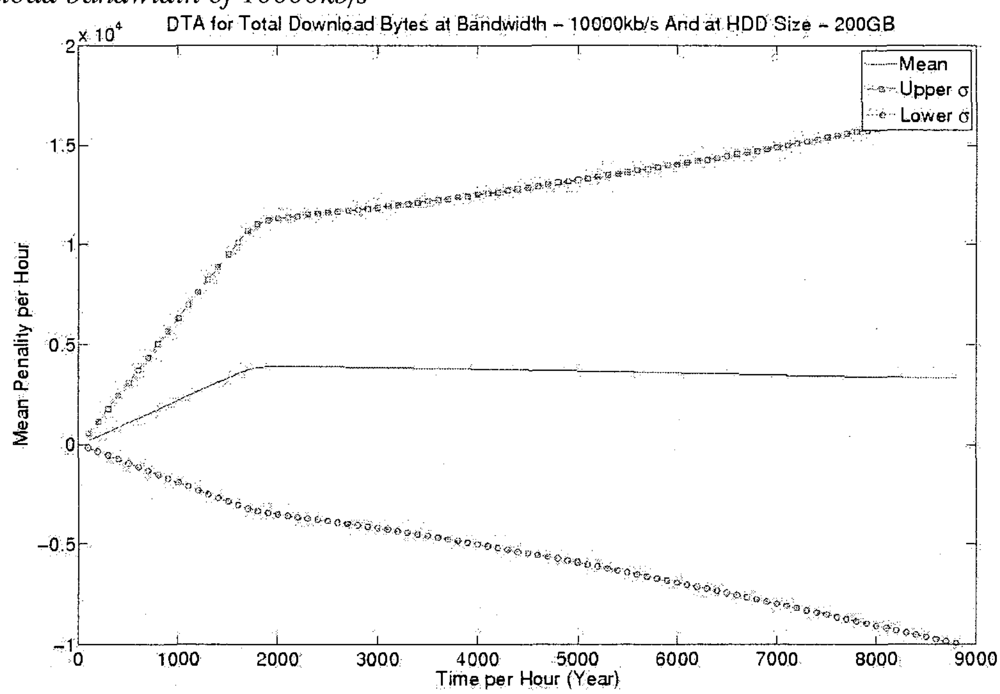


Figure 930: DTA of a difference between H2 and H1 at hard drive size of 50GB and download bandwidth of 15000kb/s

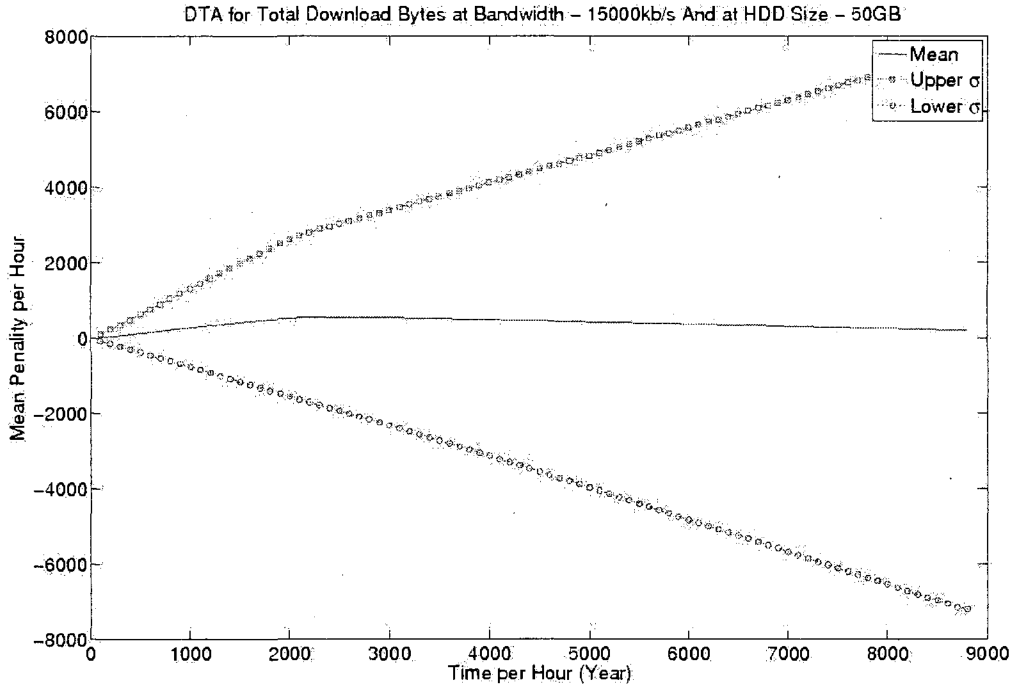


Figure 931: DTA of a difference between H2 and H1 at hard drive size of 100GB and download bandwidth of 15000kb/s

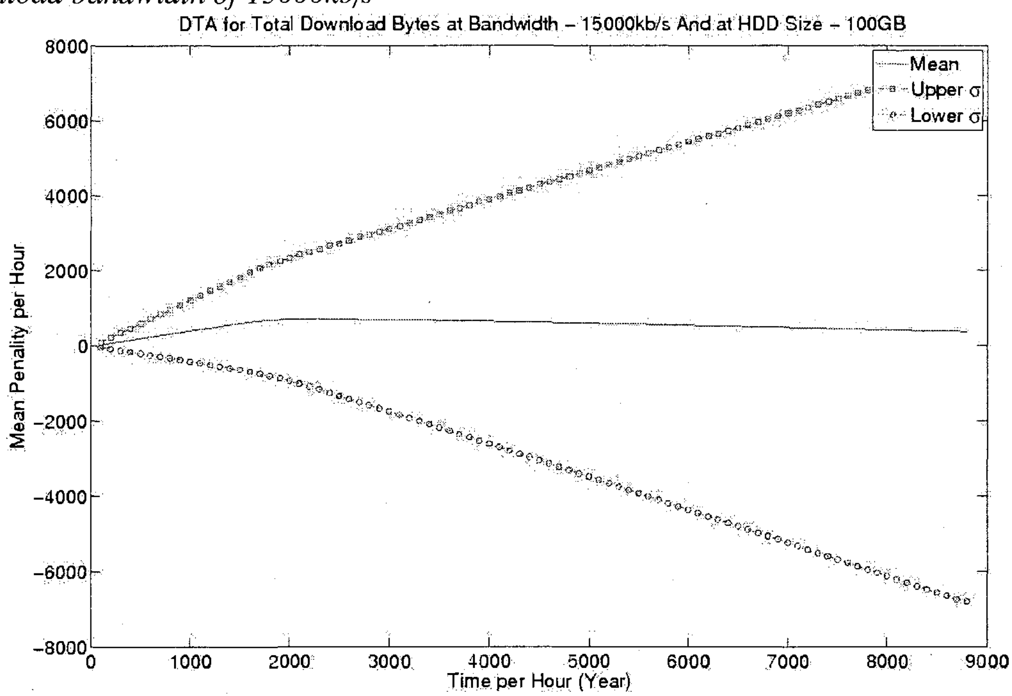


Figure 932: DTA of a difference between H2 and H1 at hard drive size of 150GB and download bandwidth of 15000kb/s

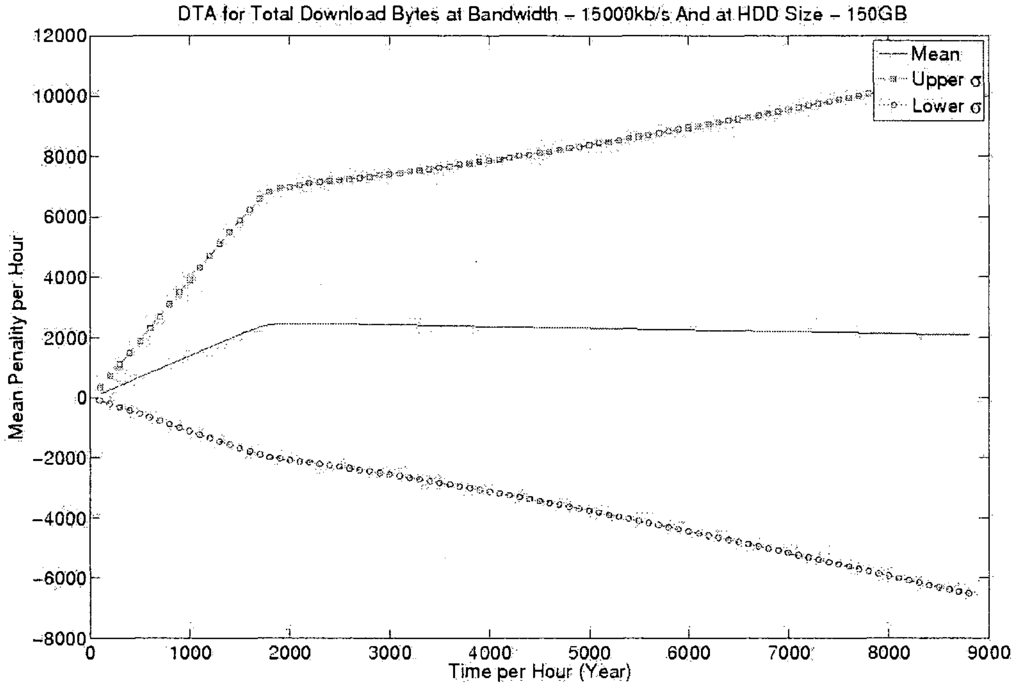


Figure 933: DTA of a difference between H2 and H1 at hard drive size of 200GB and download bandwidth of 15000kb/s

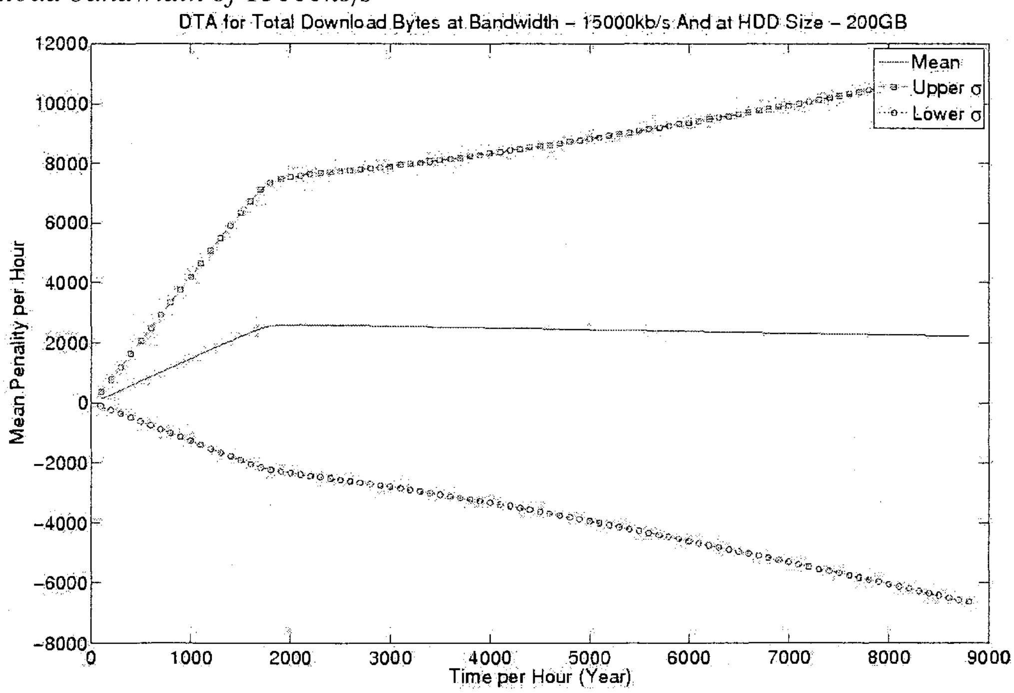


Figure 934: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 25kb/s

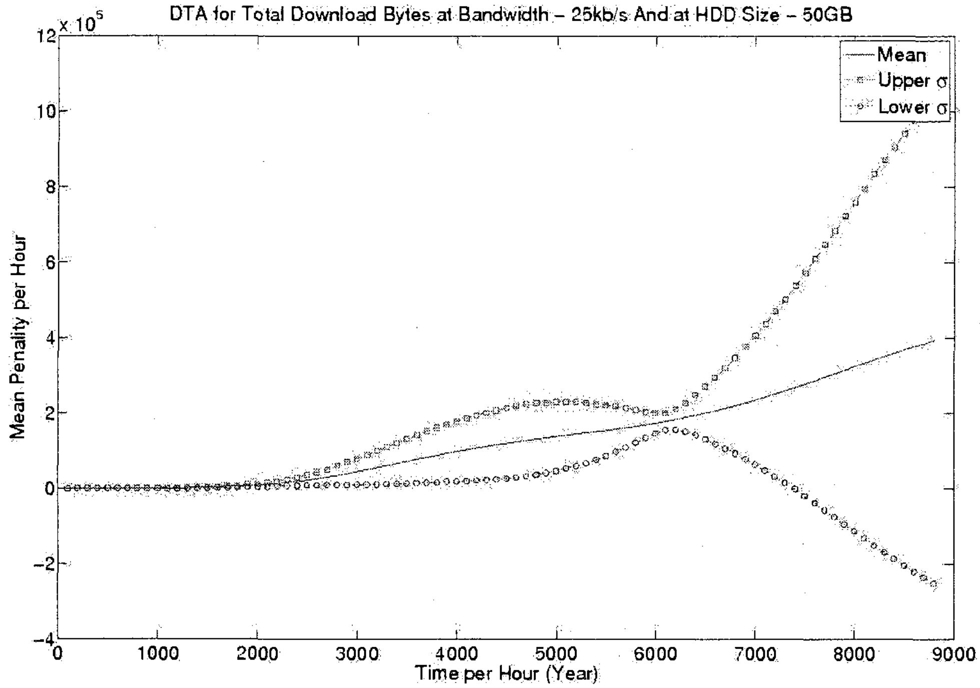


Figure 935: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 25kb/s

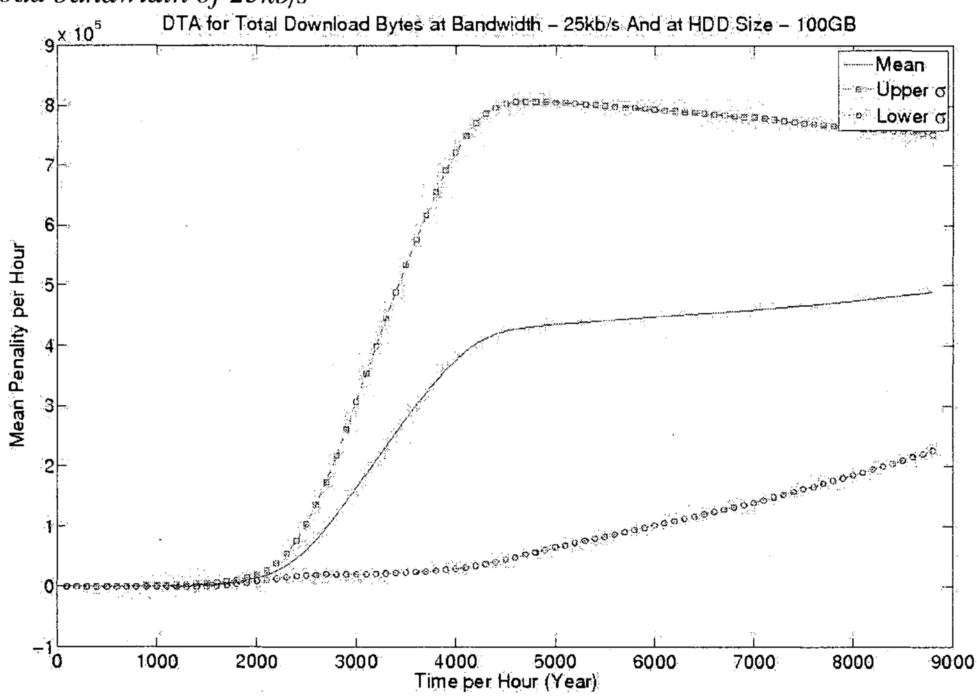


Figure 936: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 25kb/s

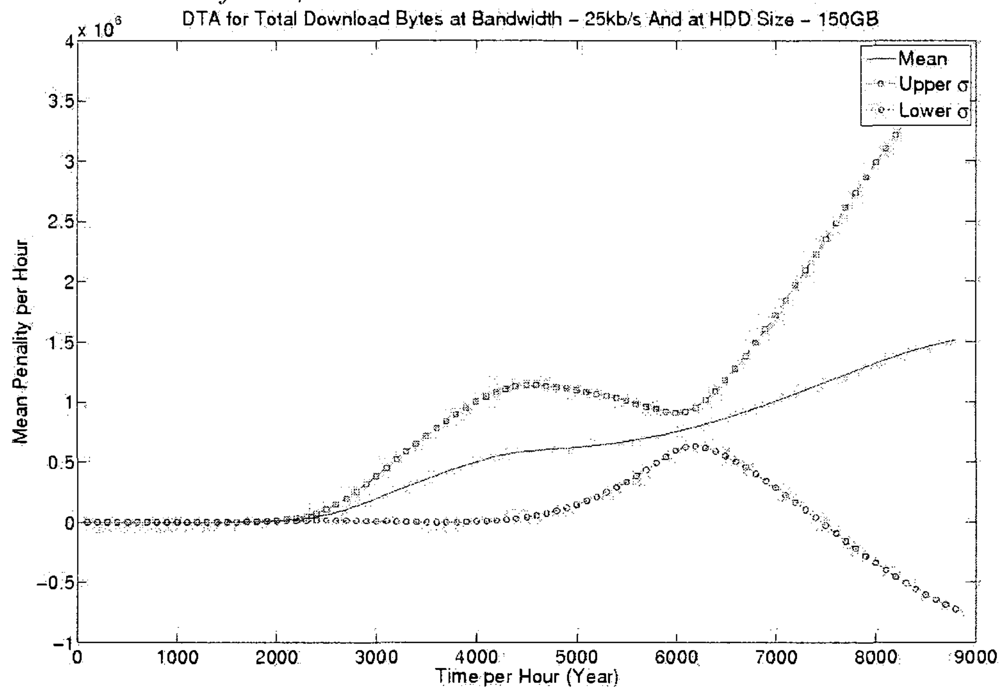


Figure 937: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 25kb/s

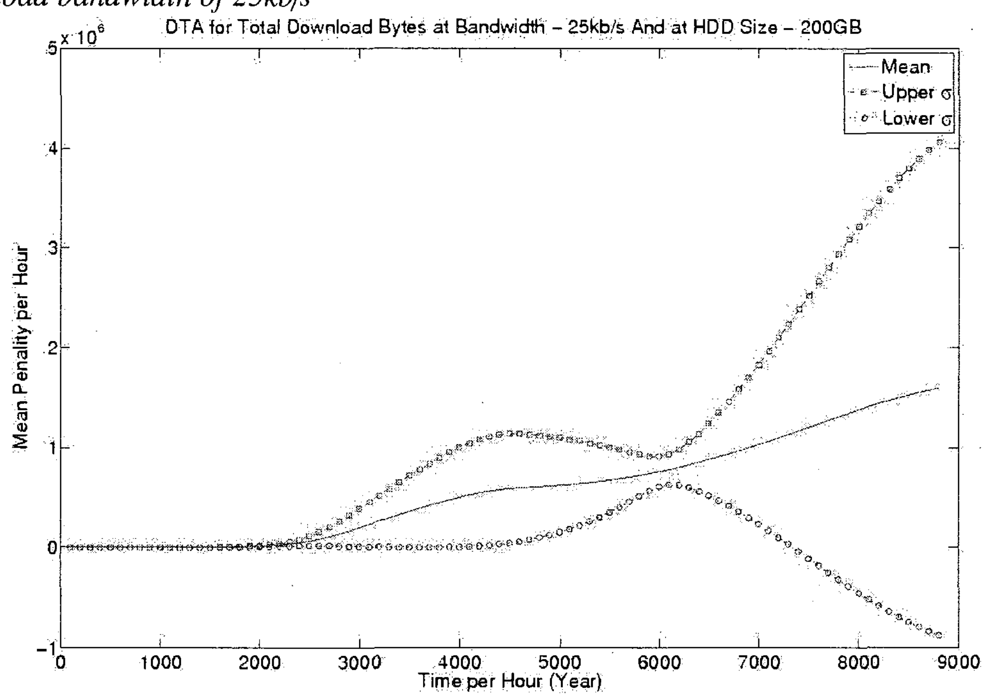


Figure 938: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 50kb/s

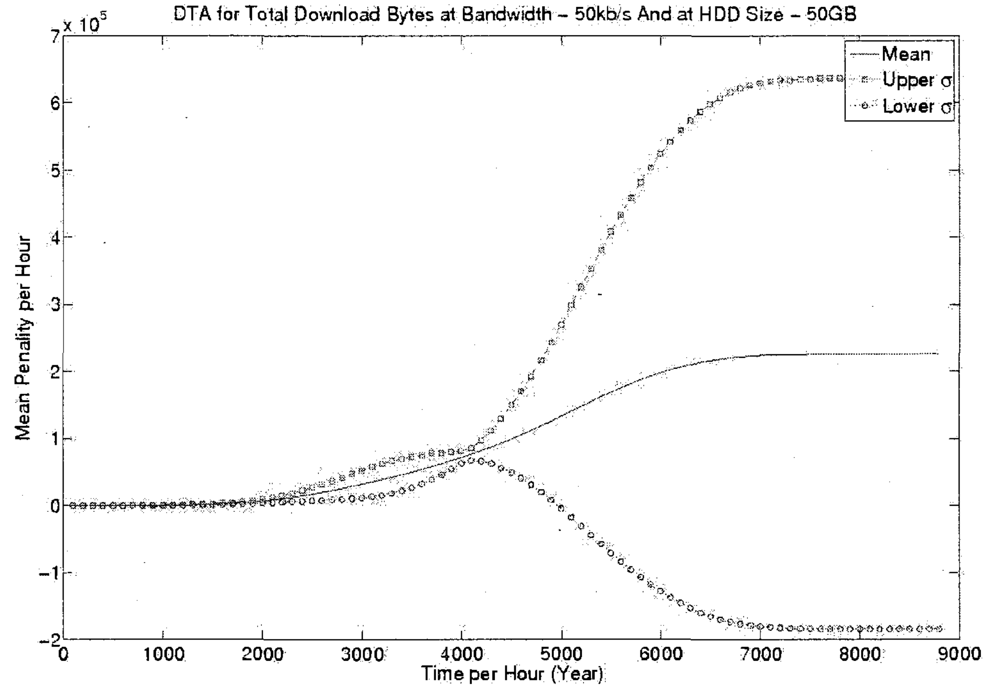


Figure 939: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 50kb/s

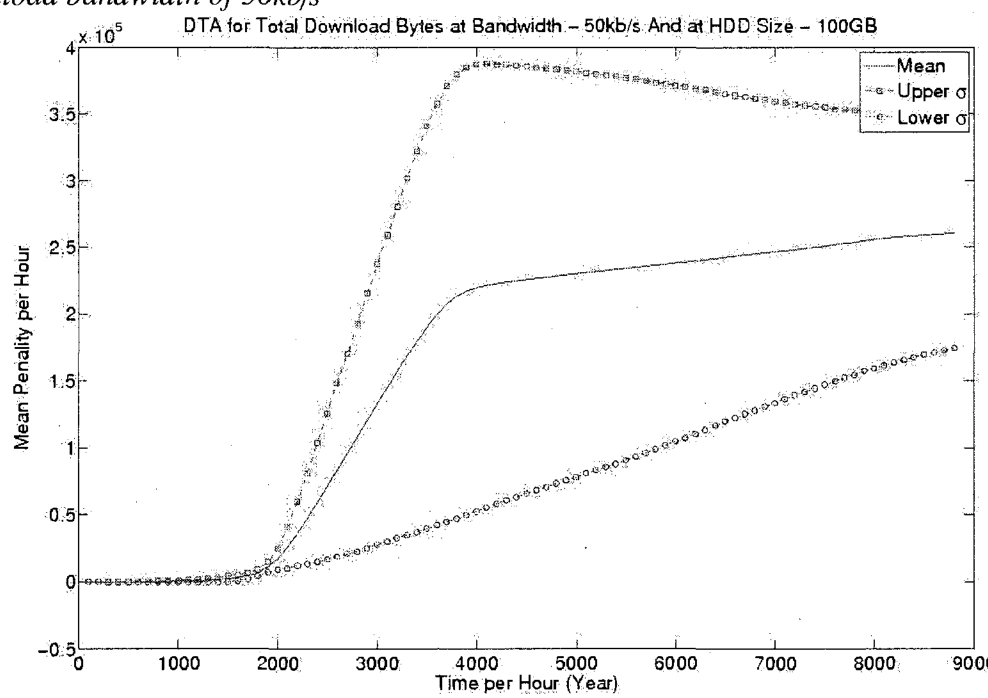


Figure 940: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 50kb/s

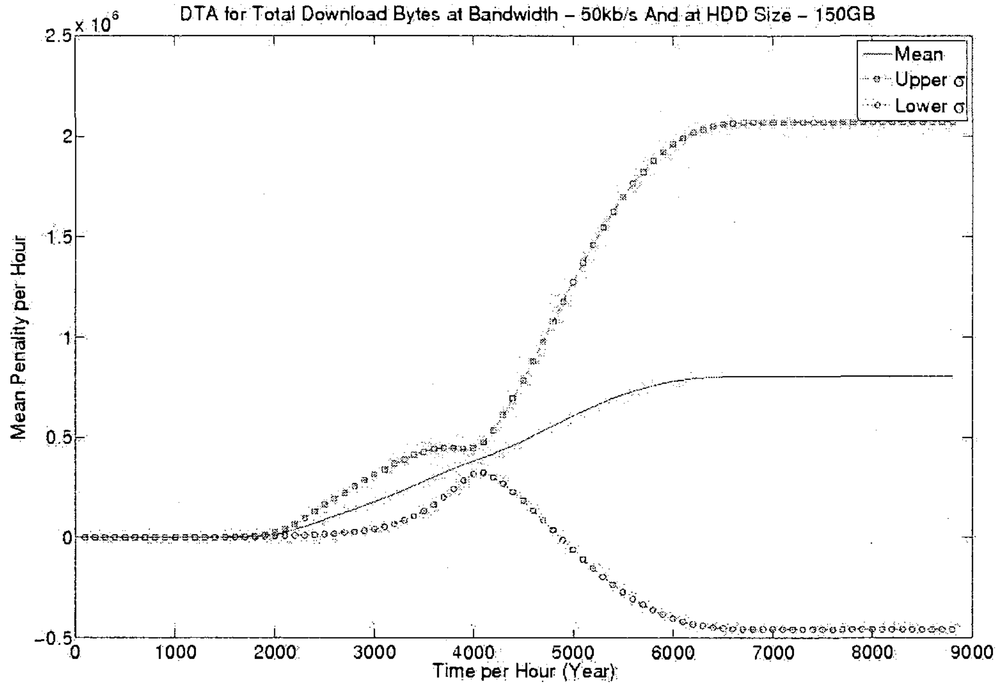


Figure 941: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 50kb/s

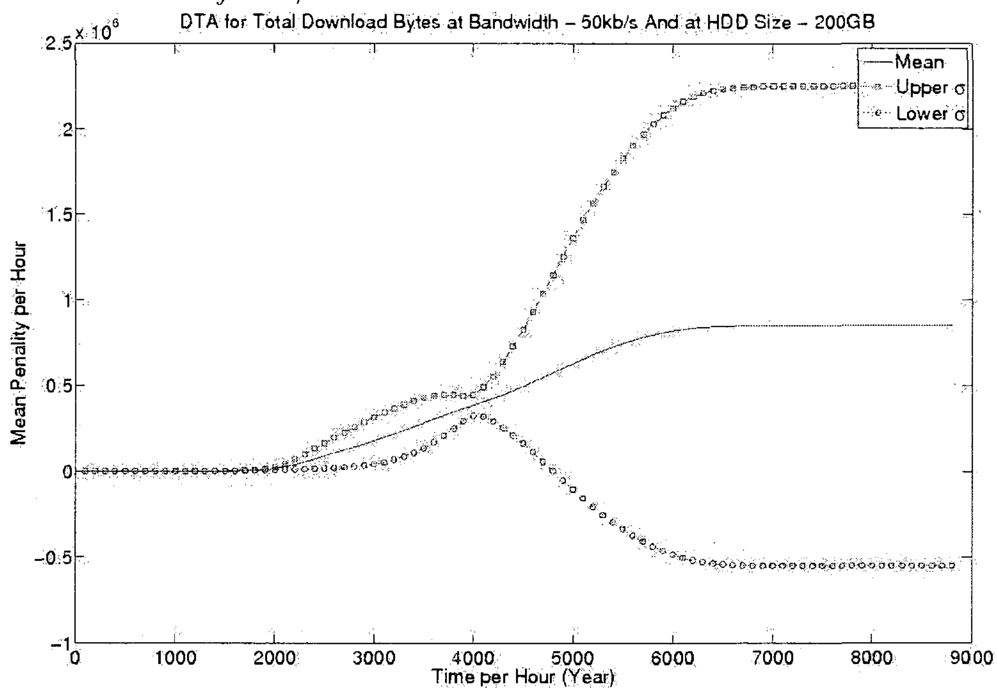


Figure 942: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 100kb/s

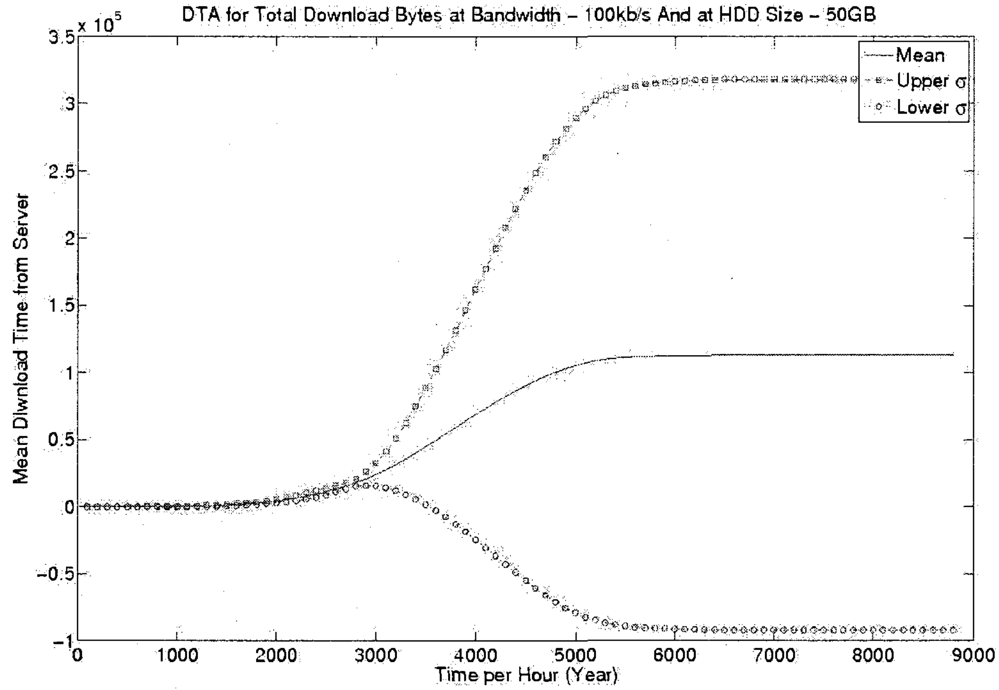


Figure 943: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 100kb/s

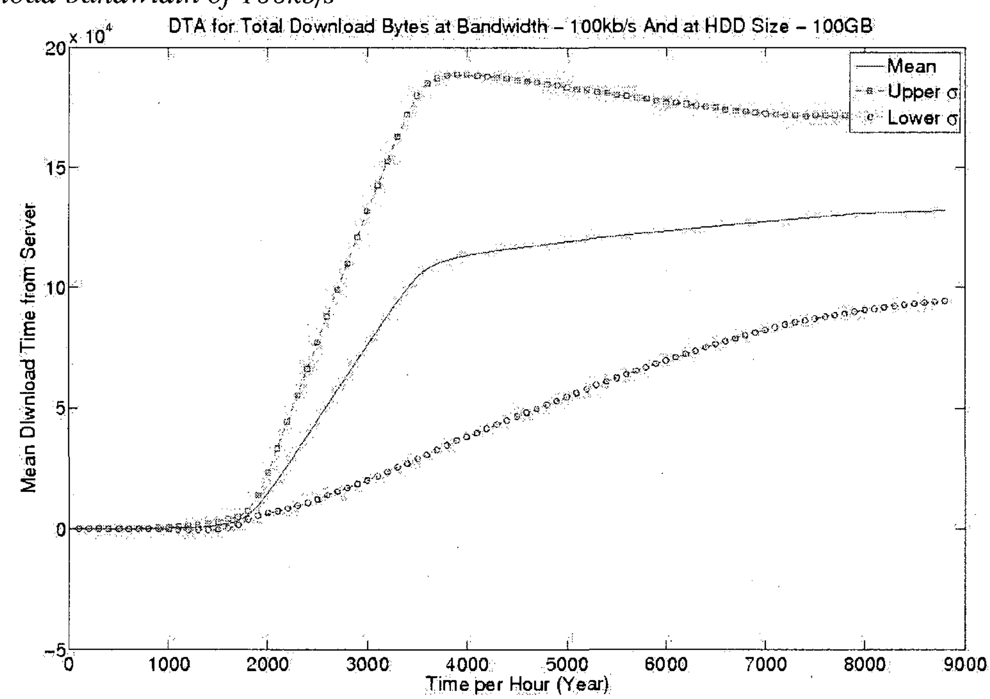


Figure 944: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 100kb/s

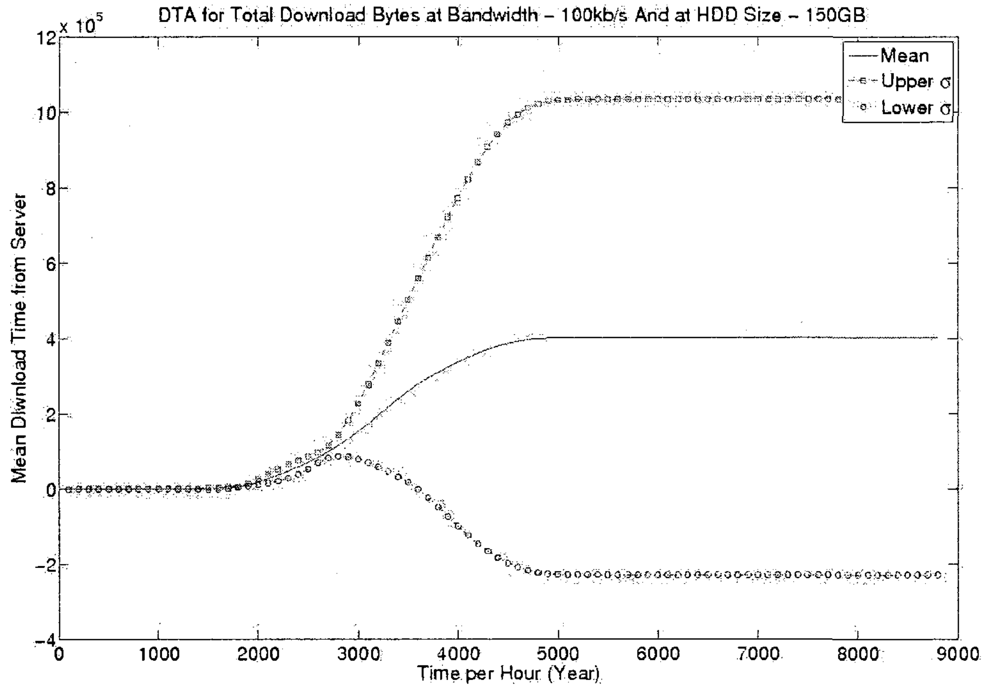


Figure 945: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 100kb/s

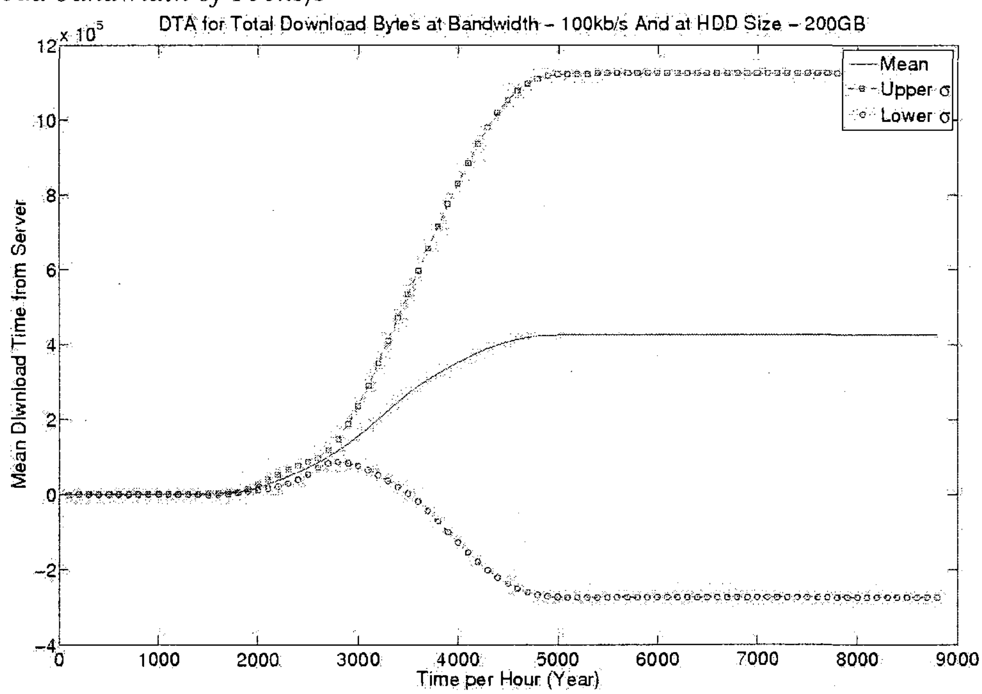


Figure 946: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 128kb/s

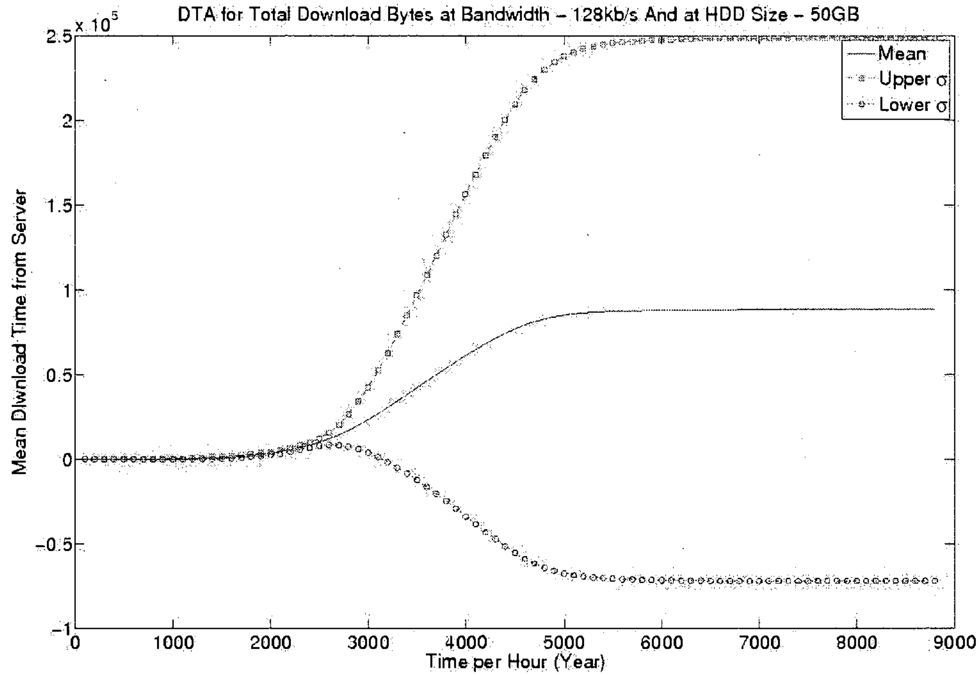


Figure 947: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 128kb/s

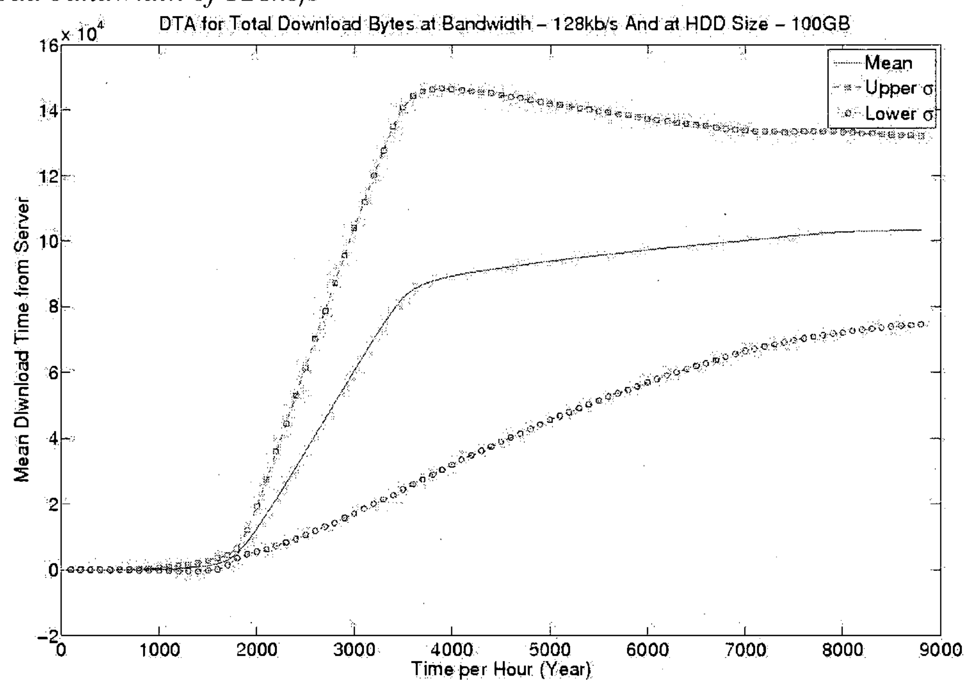


Figure 948: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 128kb/s

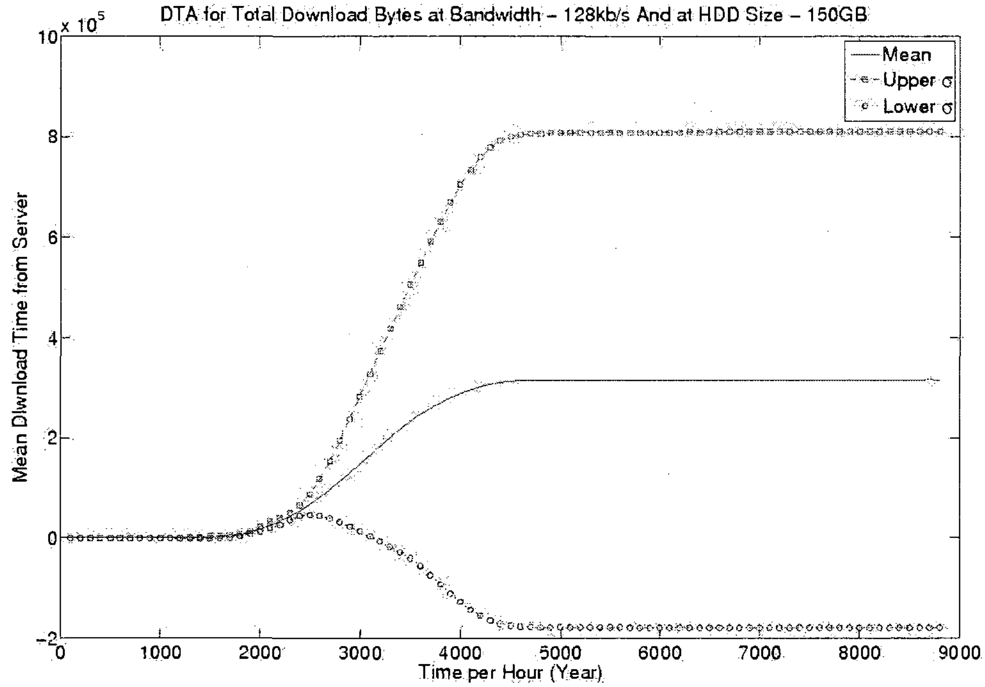


Figure 949: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 128kb/s

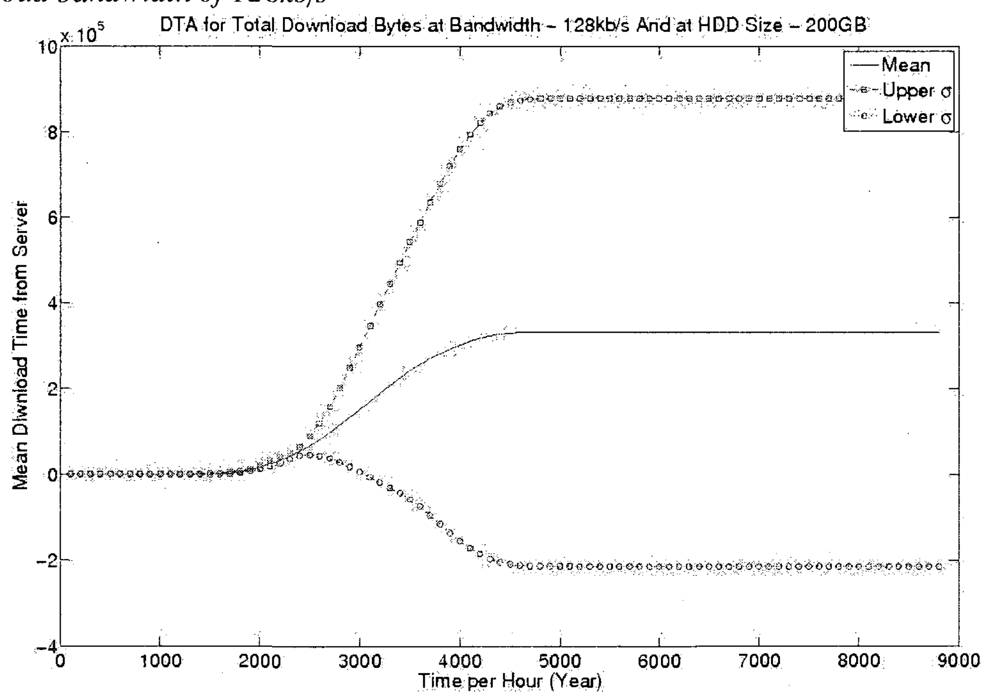


Figure 950: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 256kb/s

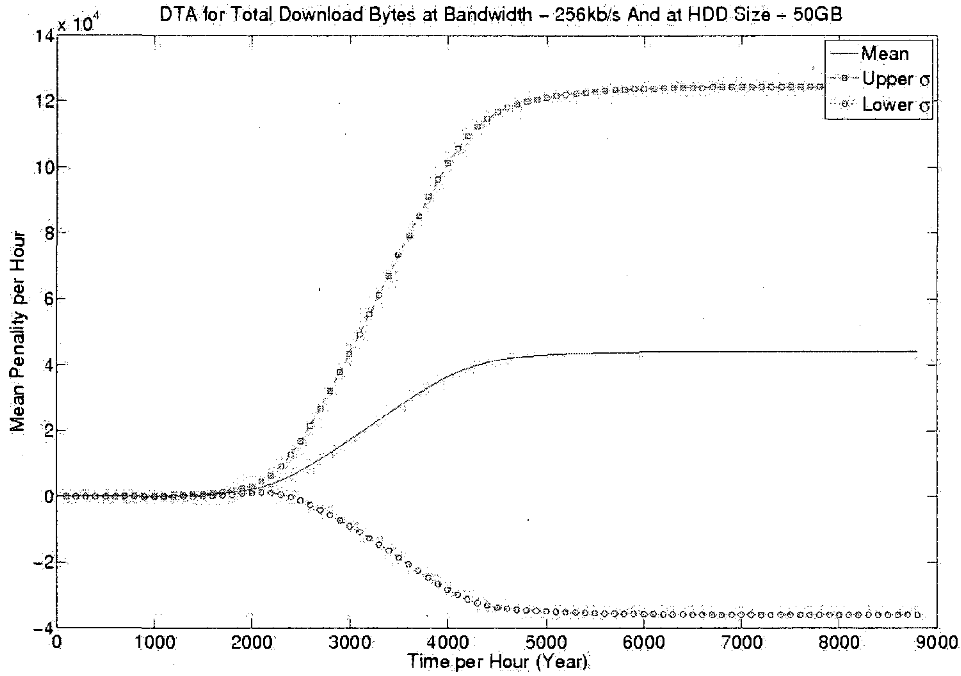


Figure 951: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 256kb/s

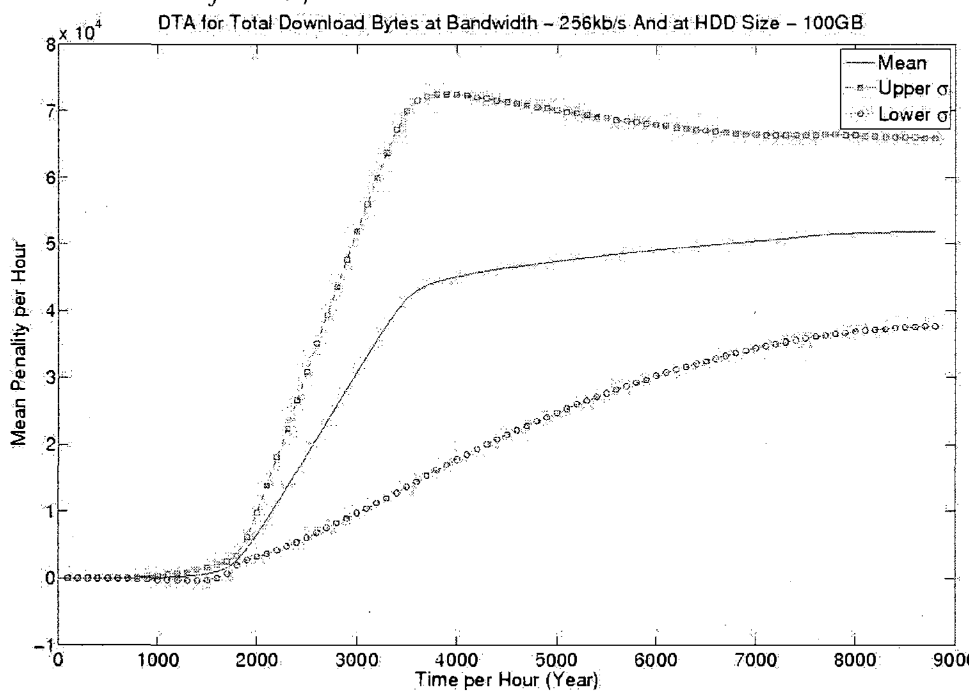


Figure 952: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 256kb/s

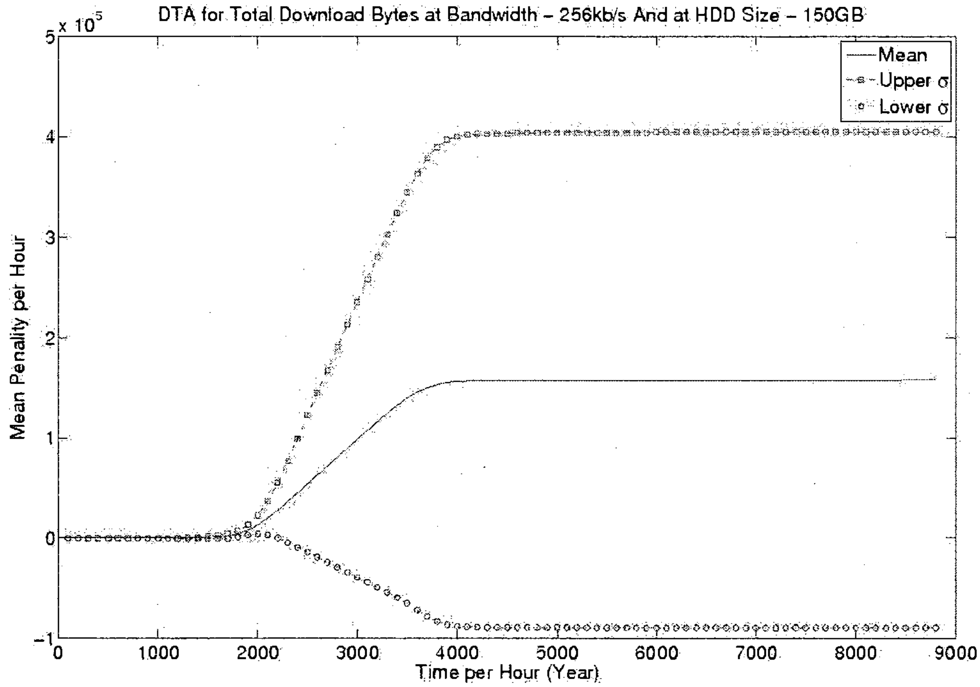


Figure 953: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 256kb/s

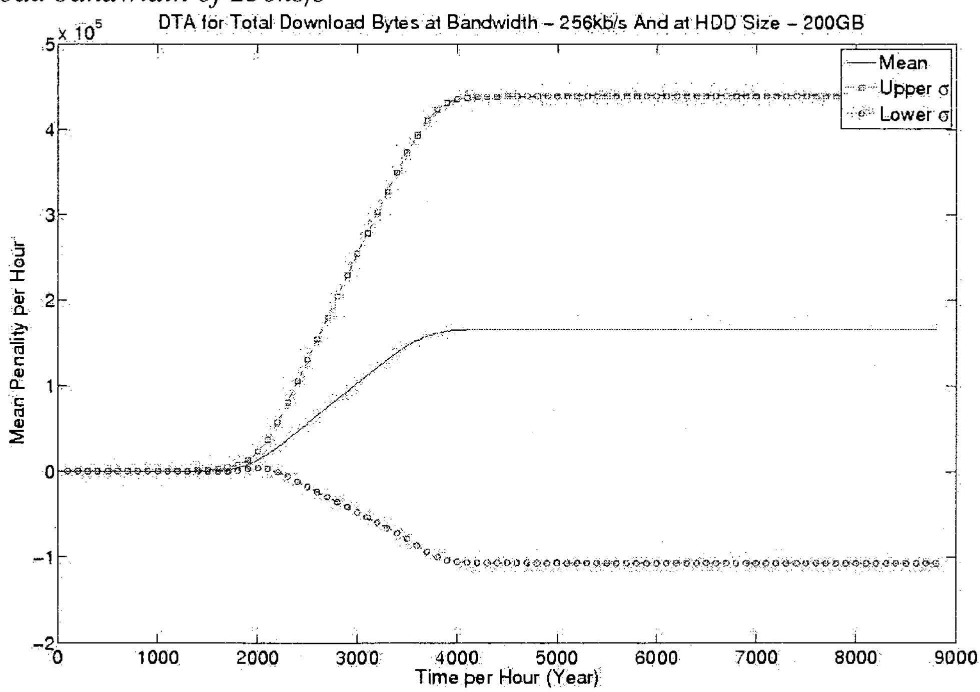


Figure 954: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 512kb/s

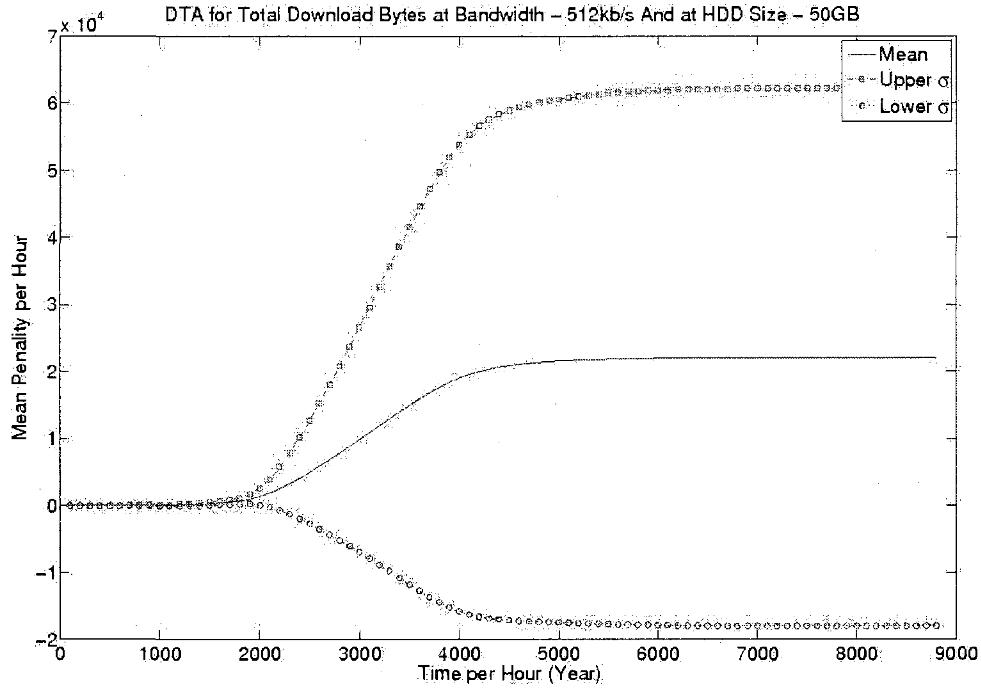


Figure 955: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 512kb/s

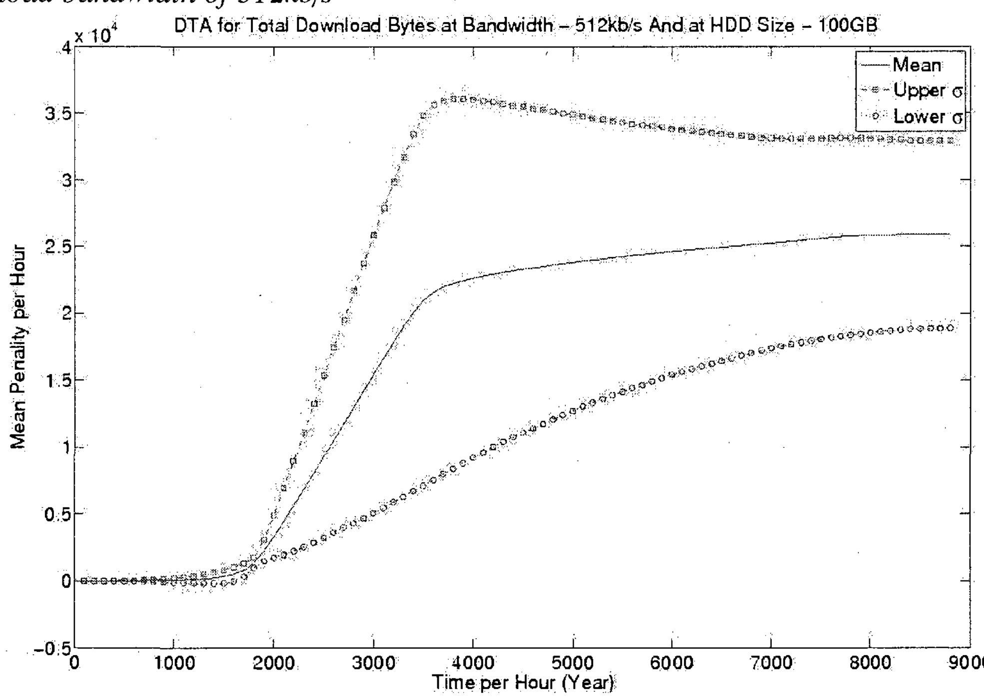


Figure 956: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 512kb/s

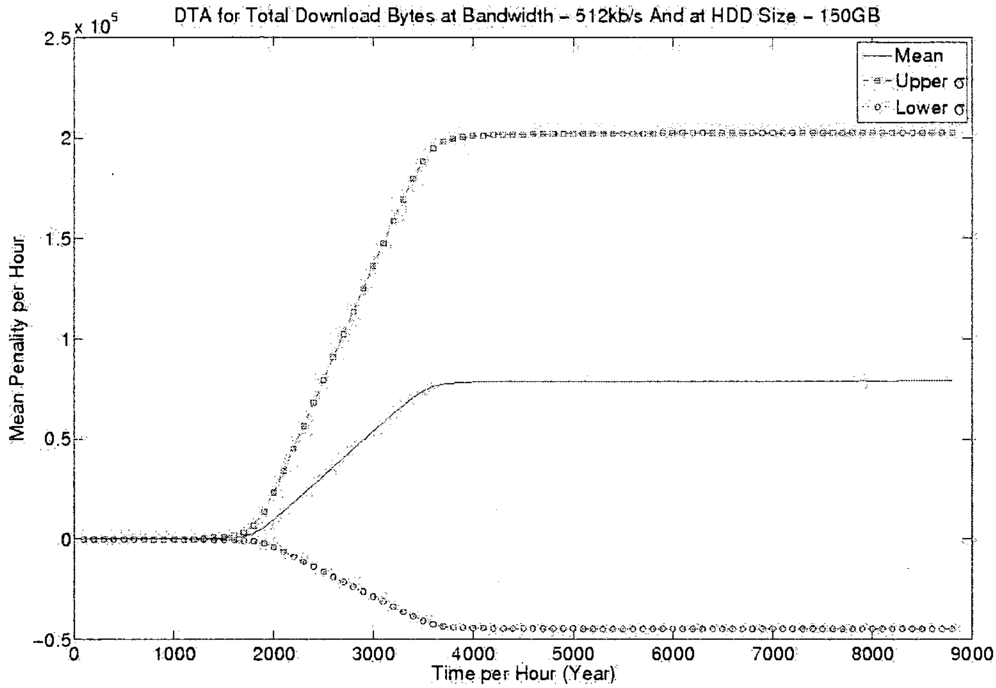


Figure 957: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 512kb/s

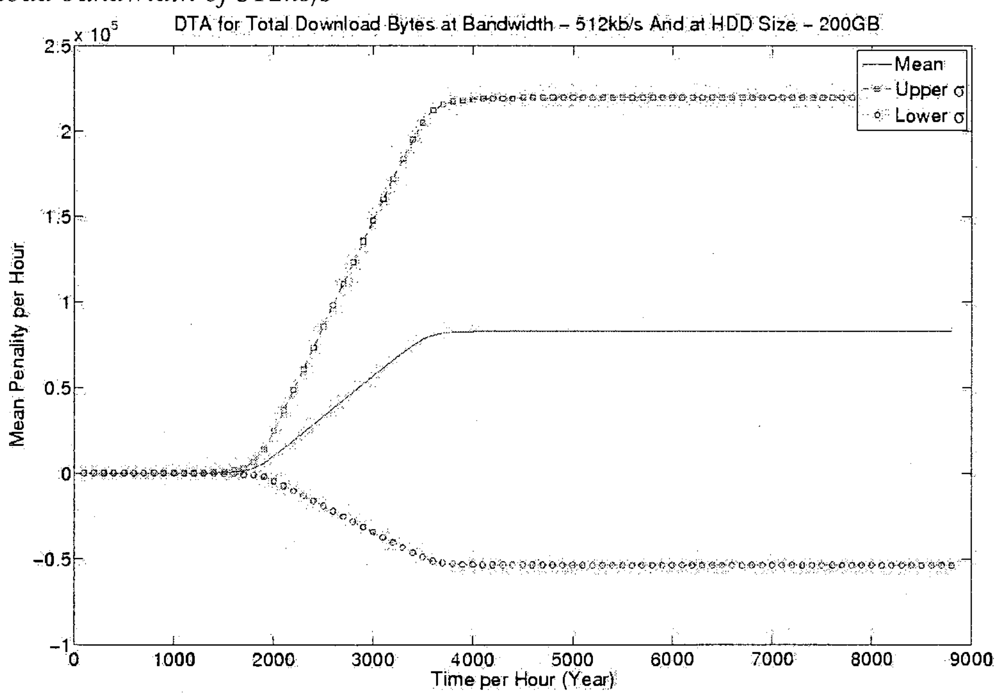


Figure 958: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 1000kb/s

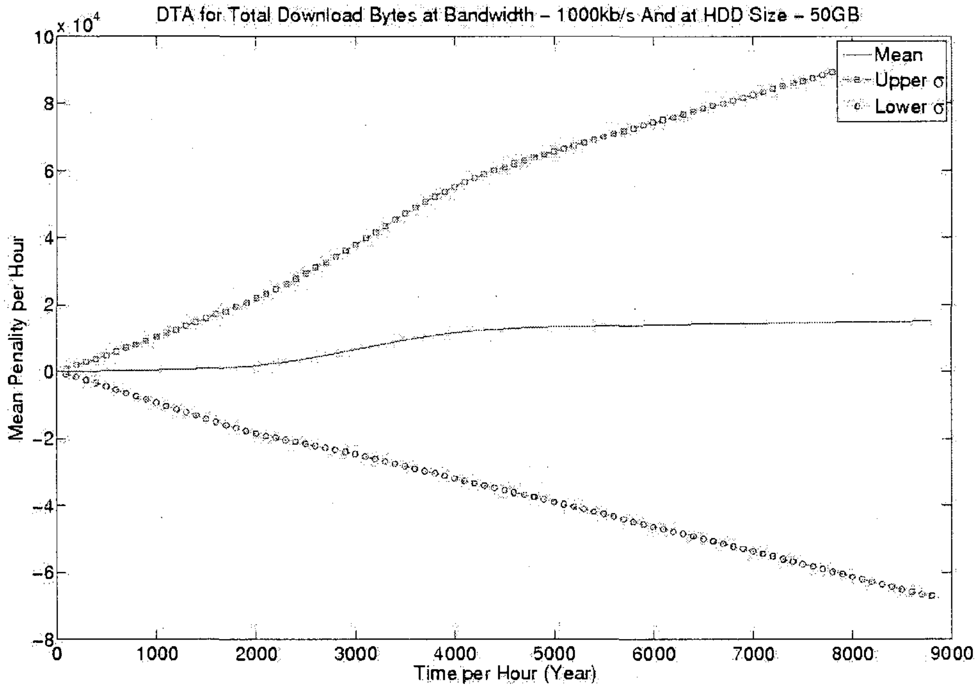


Figure 959: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 1000kb/s

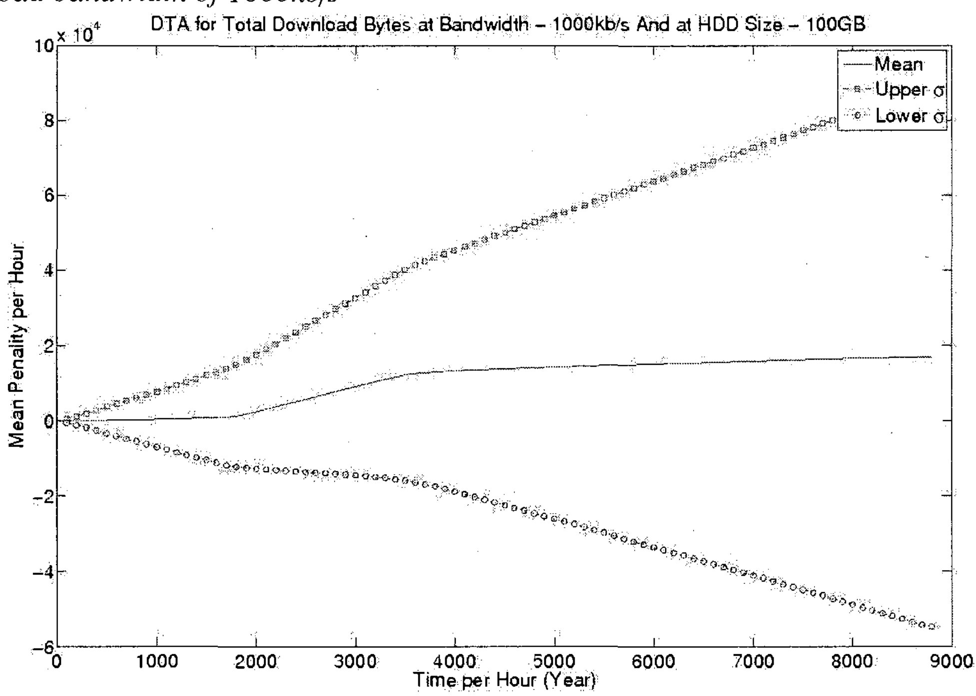


Figure 960: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 1000kb/s

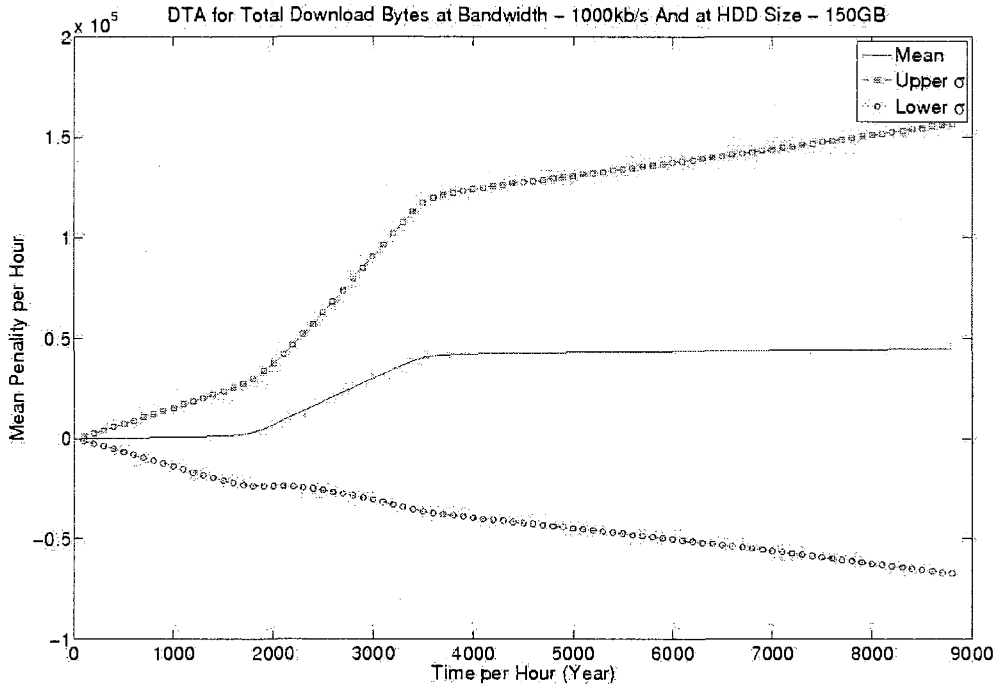


Figure 961: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 1000kb/s

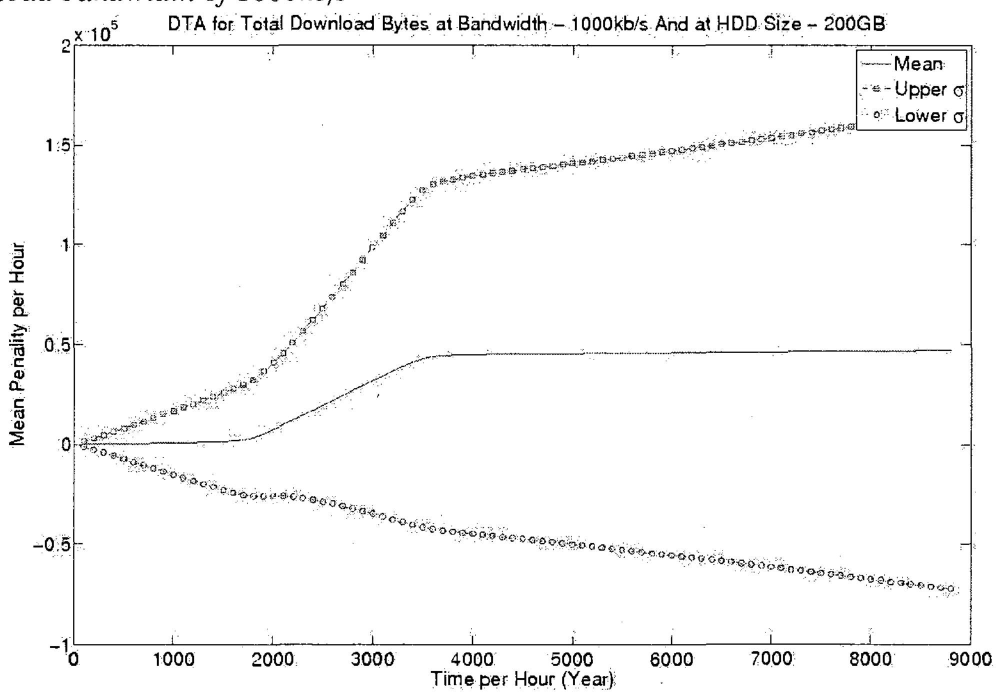


Figure 962: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 2000kb/s

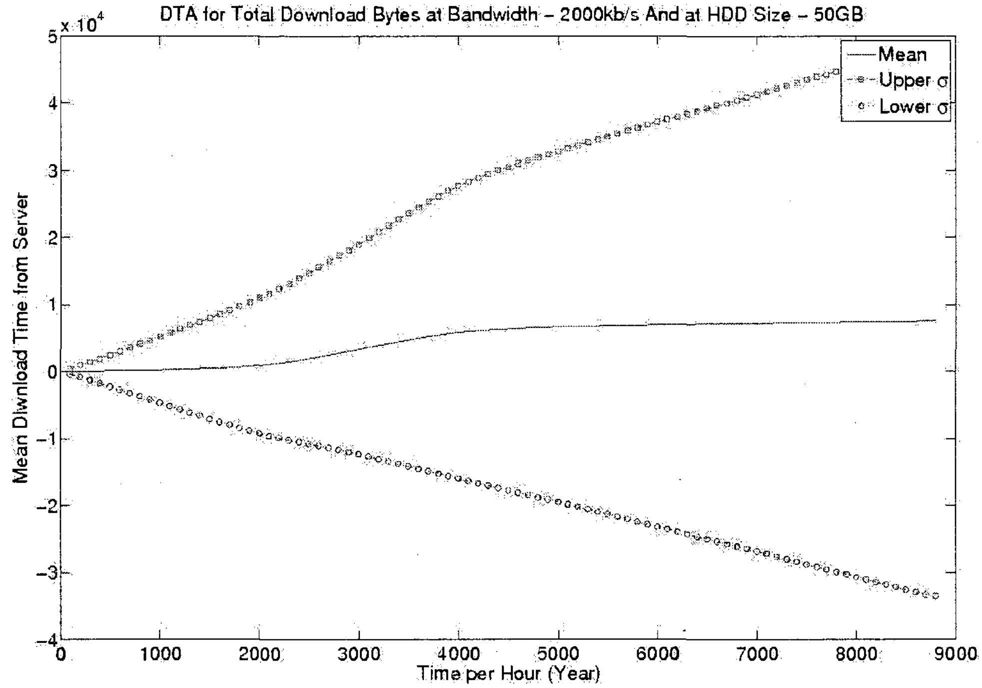


Figure 963: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 2000kb/s

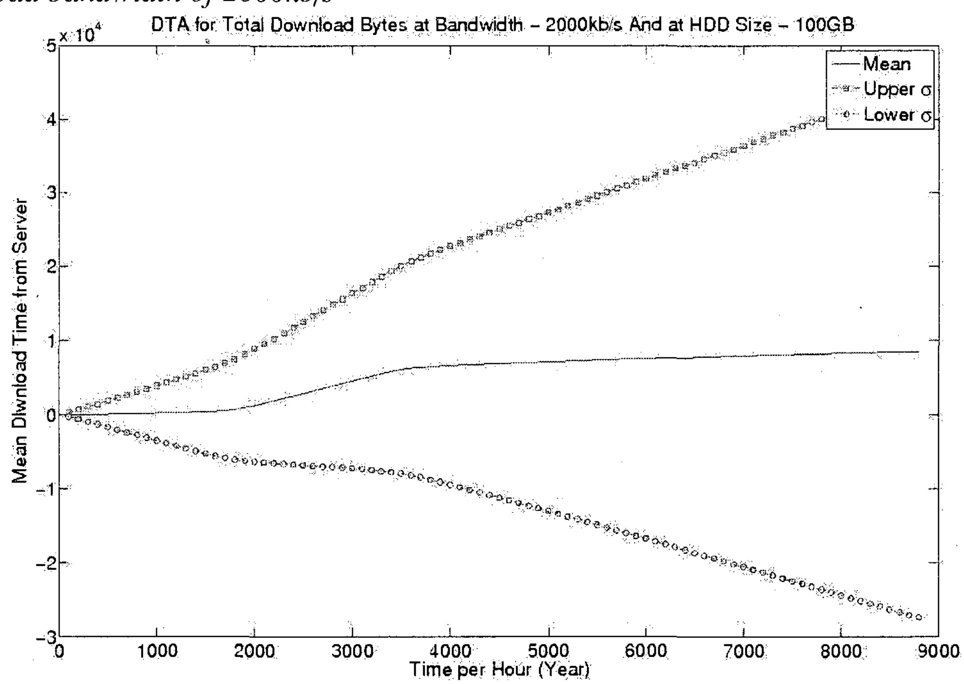


Figure 964: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 2000kb/s

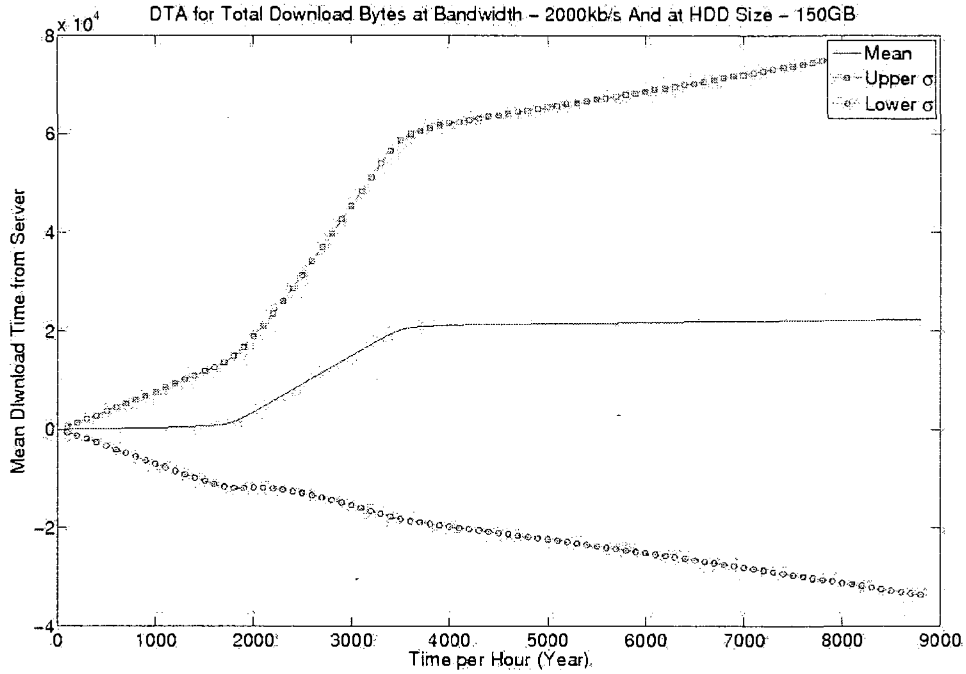


Figure 965: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 2000kb/s

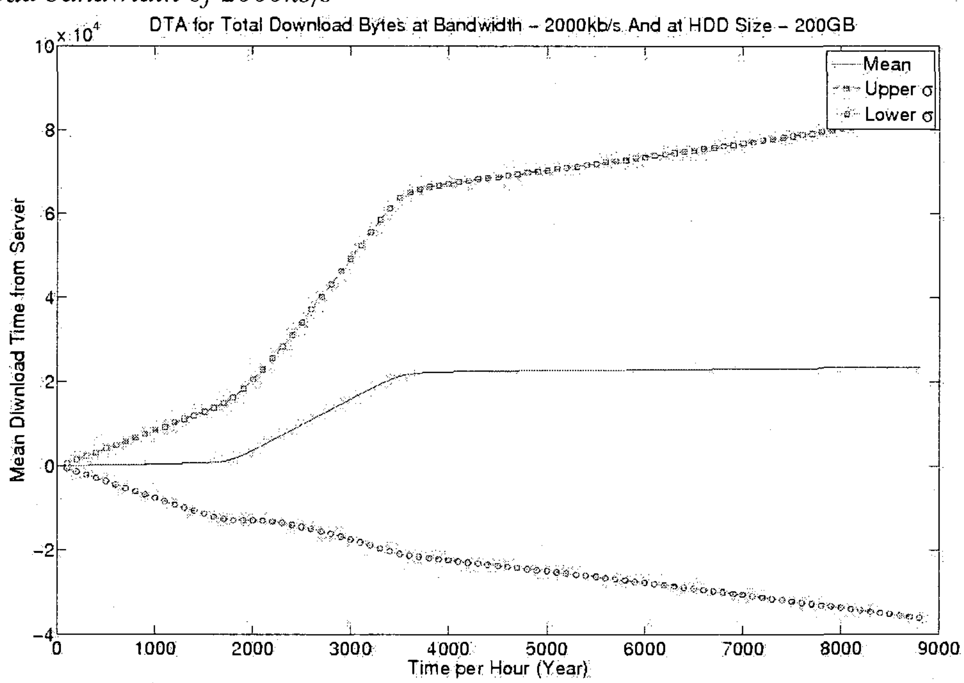


Figure 966: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 5000kb/s

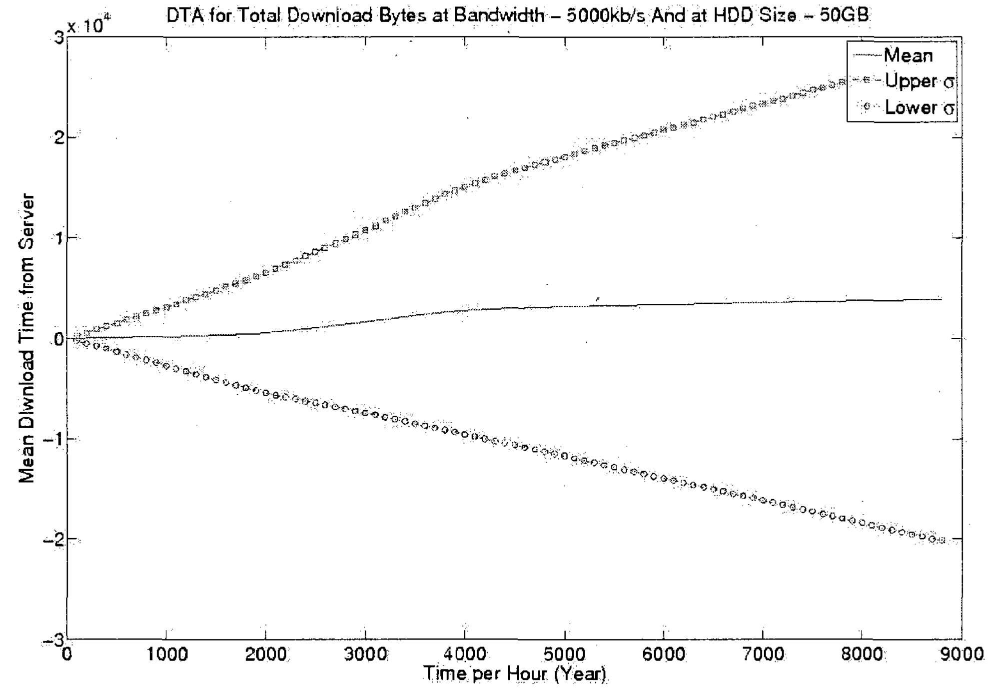


Figure 967: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 5000kb/s

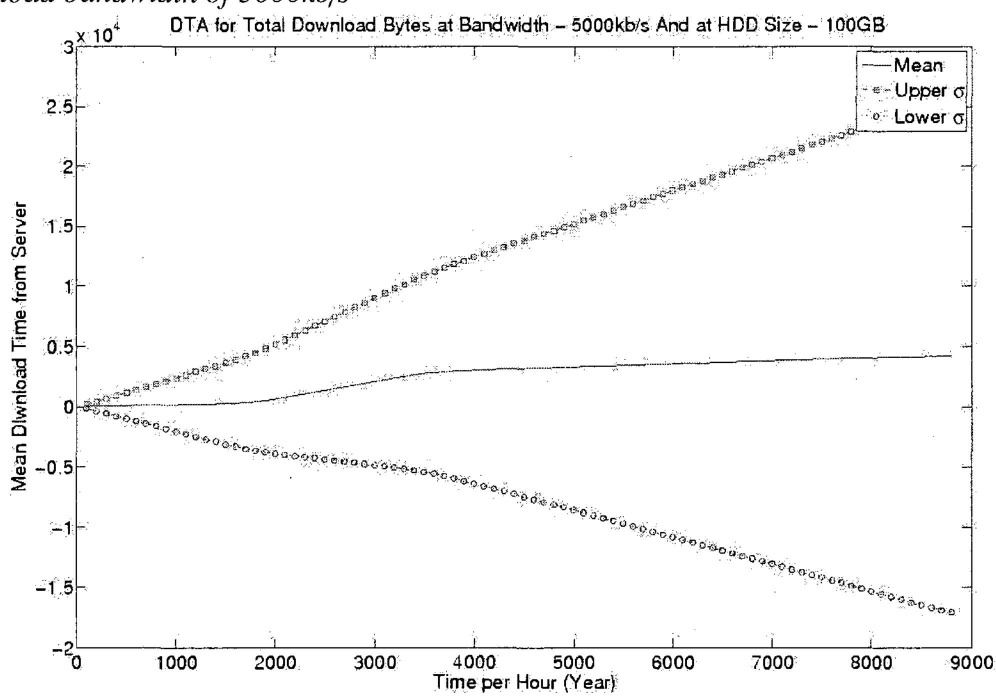


Figure 968: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 5000kb/s

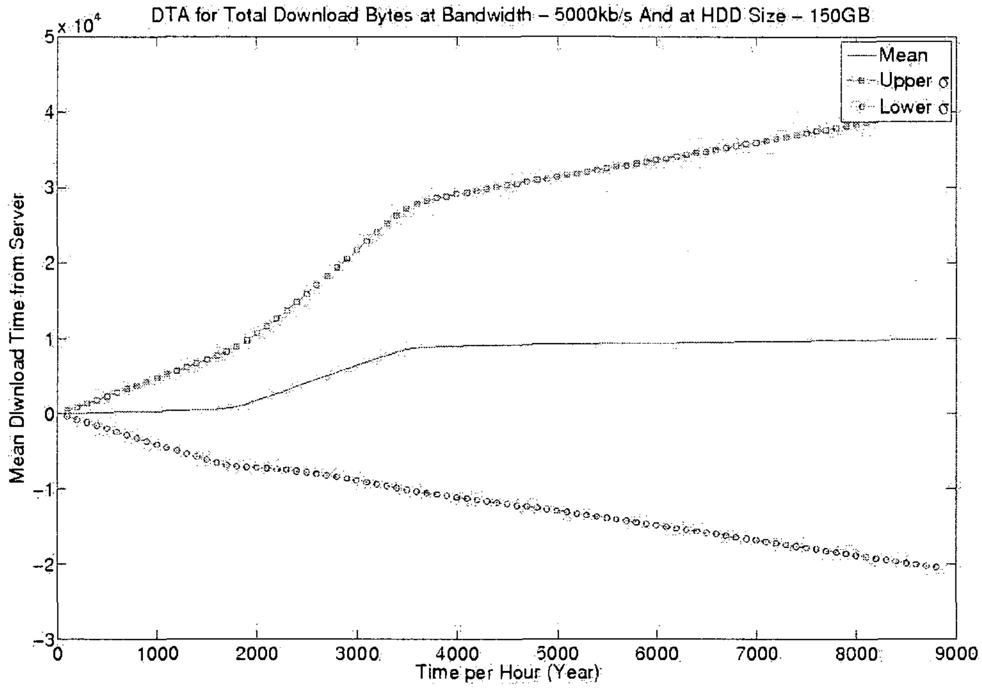


Figure 969: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 5000kb/s

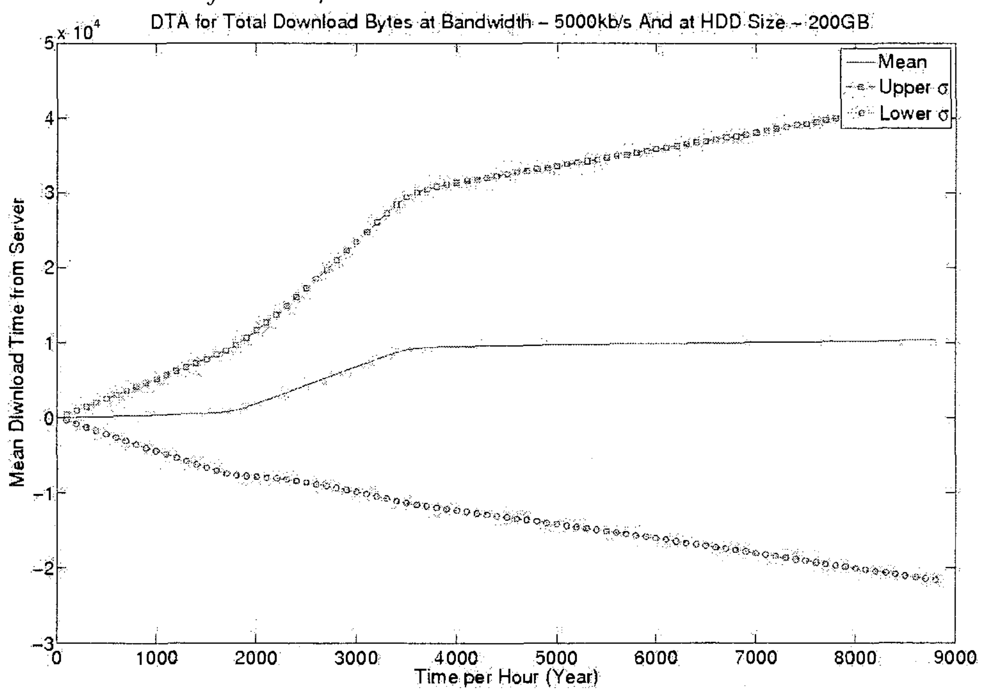


Figure 970: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 10000kb/s

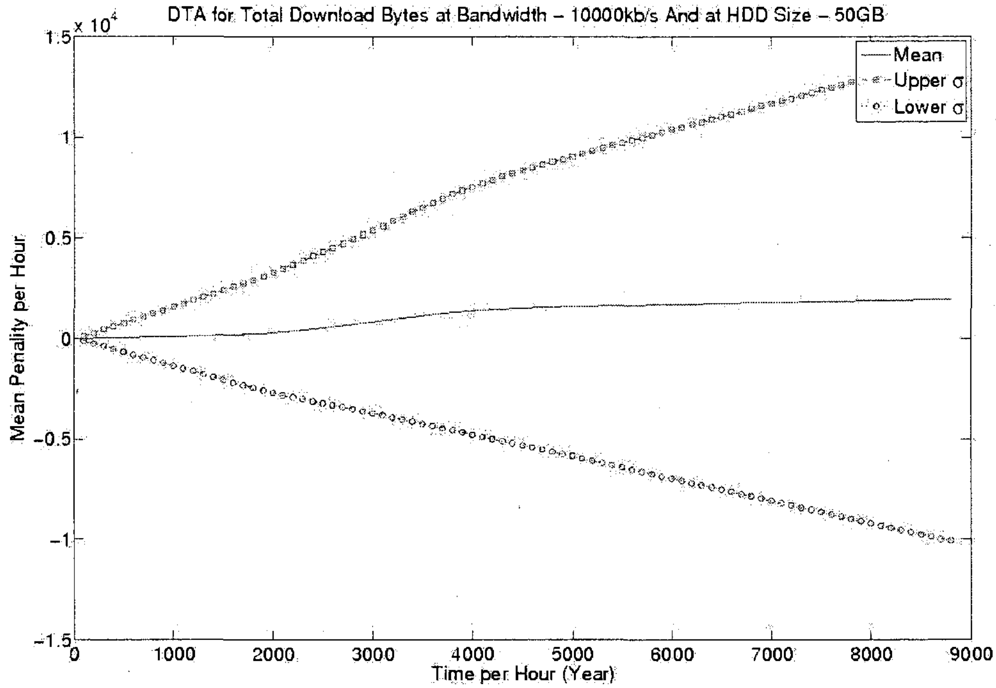


Figure 971: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 10000kb/s

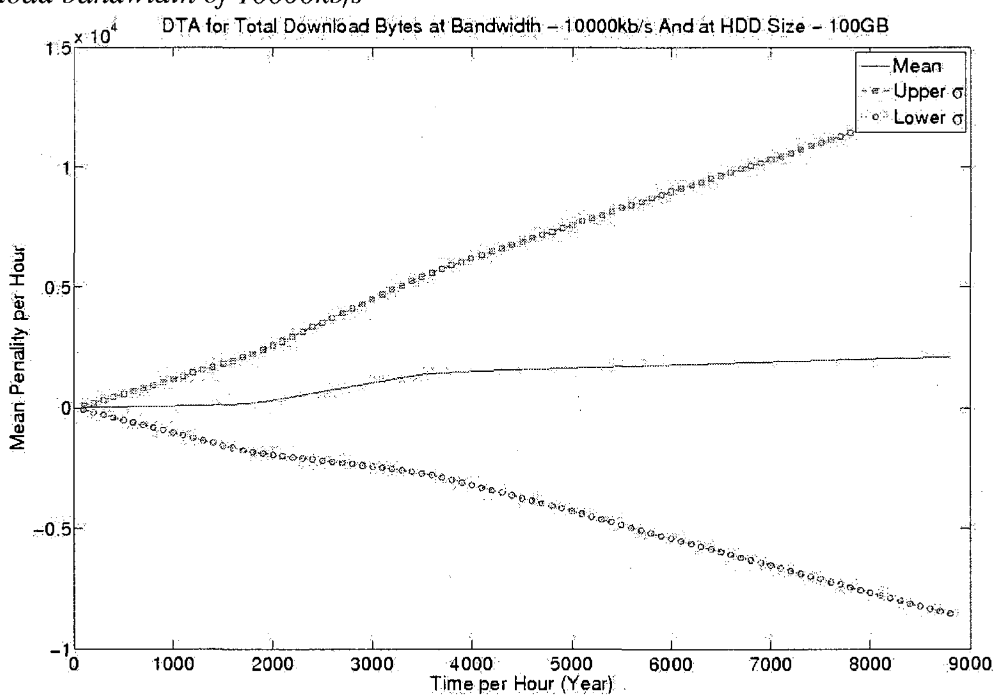


Figure 972: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 10000kb/s

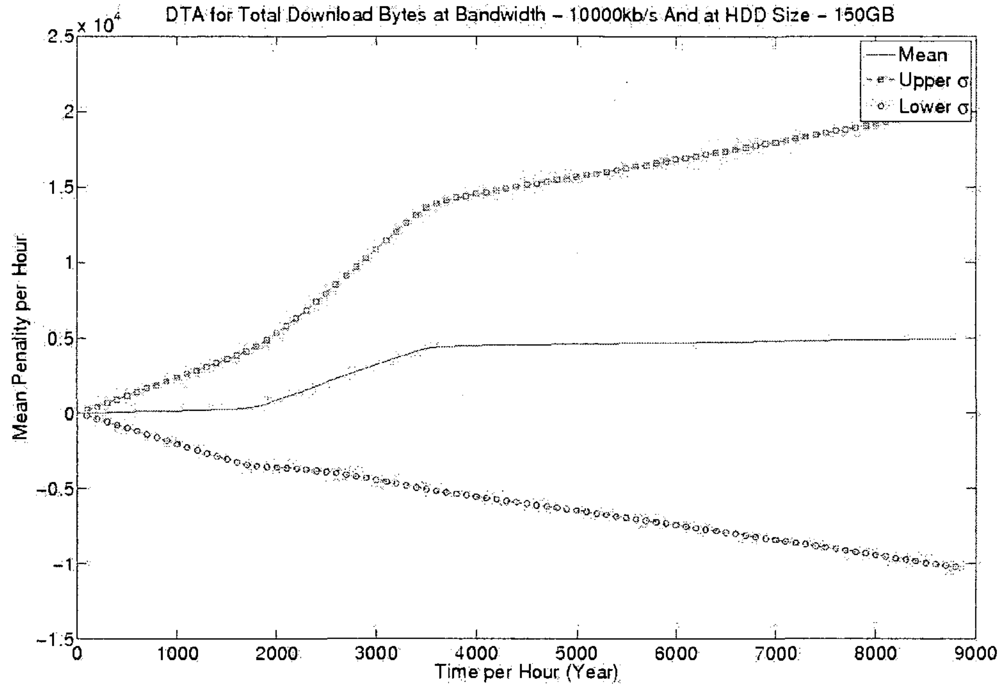


Figure 973: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 10000kb/s

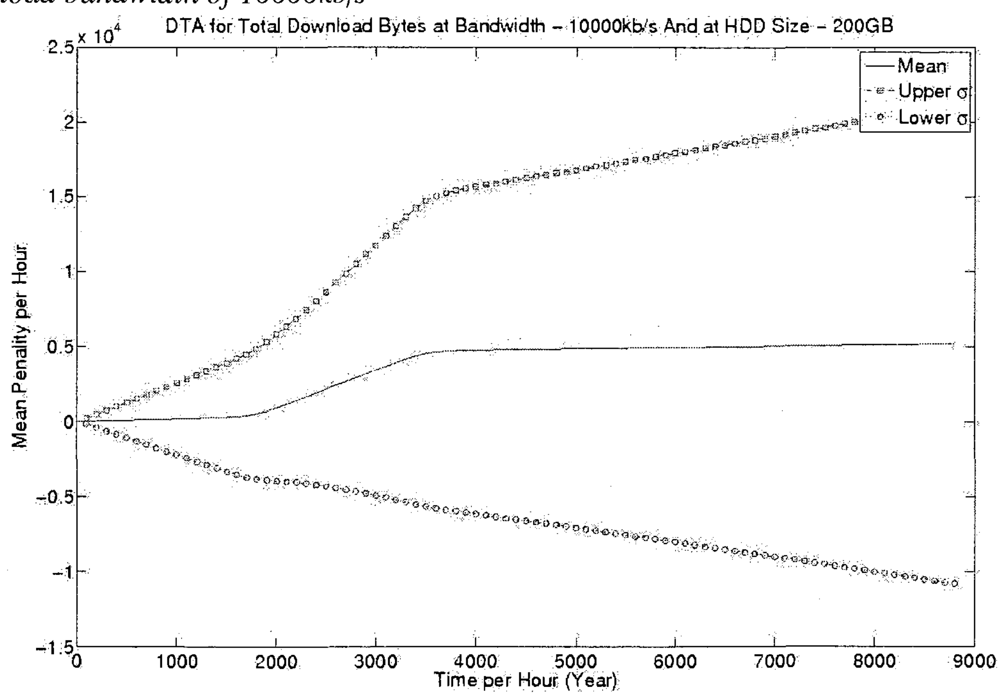


Figure 974: DTA of a difference between H3 and H2 at hard drive size of 50GB and download bandwidth of 15000kb/s

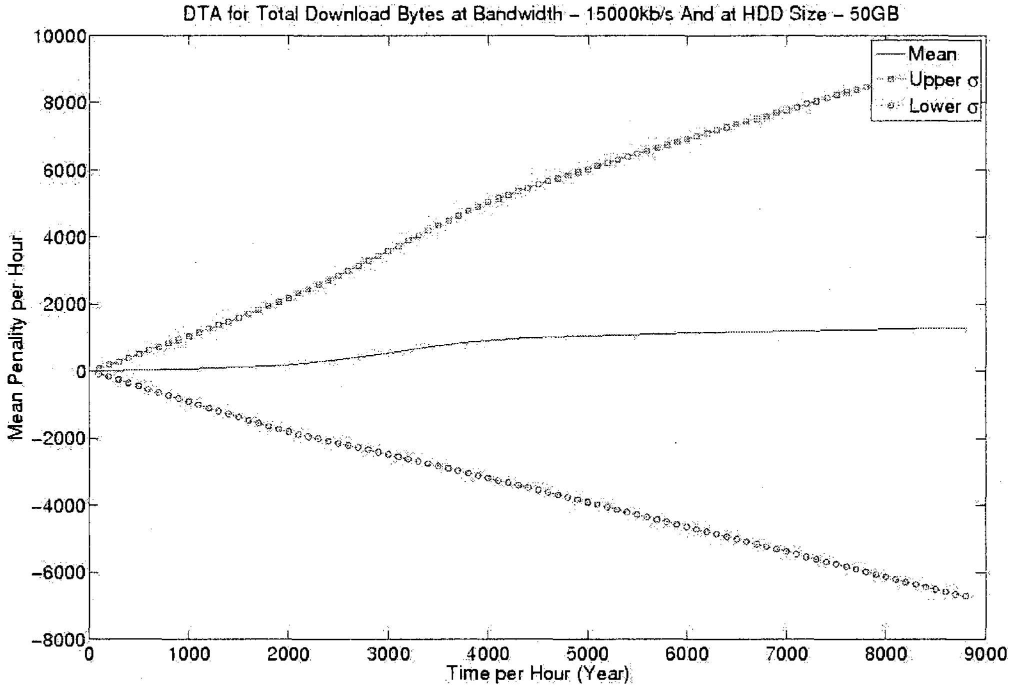


Figure 975: DTA of a difference between H3 and H2 at hard drive size of 100GB and download bandwidth of 15000kb/s

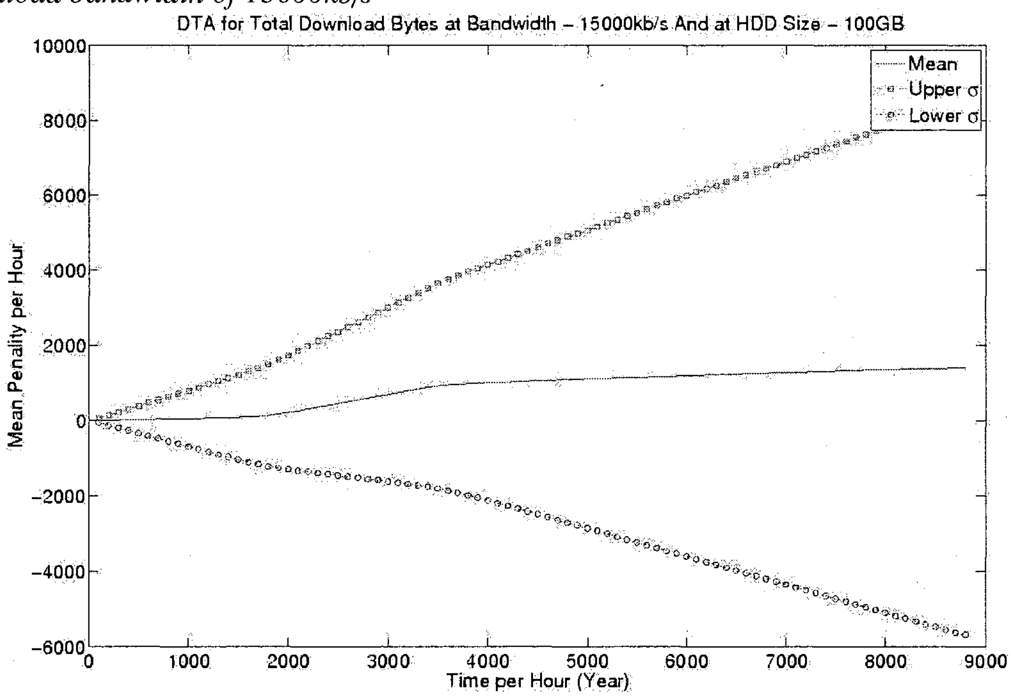


Figure 976: DTA of a difference between H3 and H2 at hard drive size of 150GB and download bandwidth of 15000kb/s

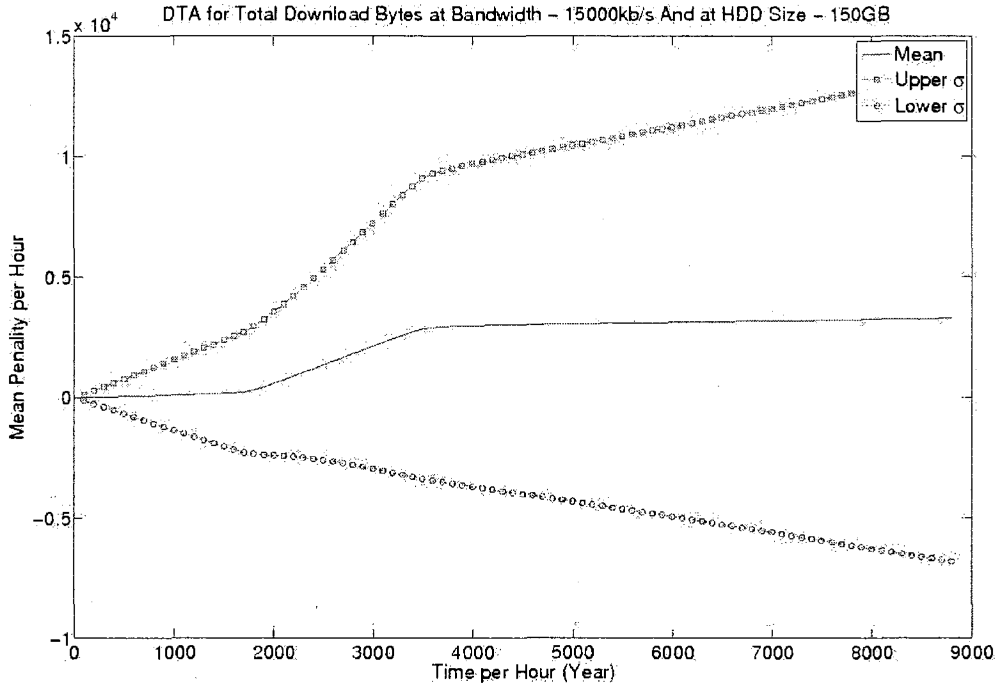


Figure 977: DTA of a difference between H3 and H2 at hard drive size of 200GB and download bandwidth of 15000kb/s

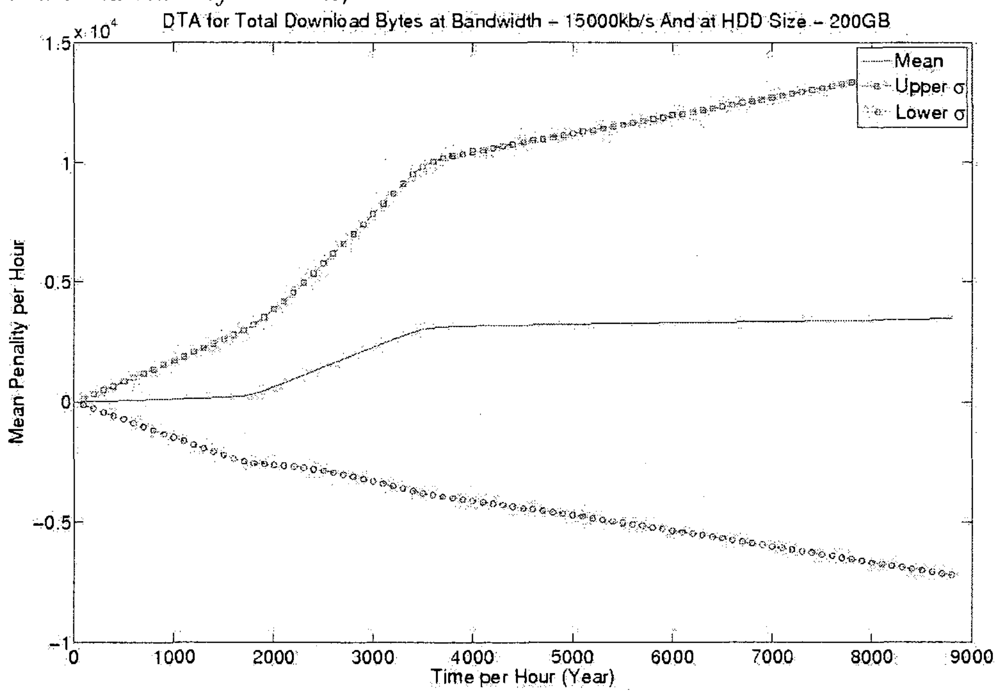


Figure 978: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 25kb/s

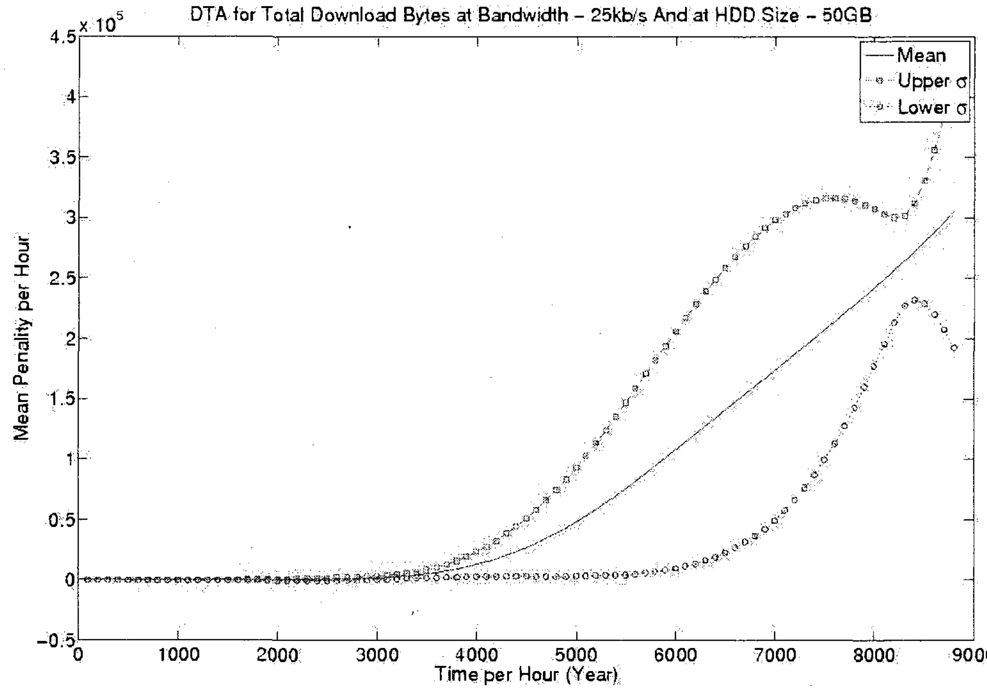


Figure 979: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 25kb/s

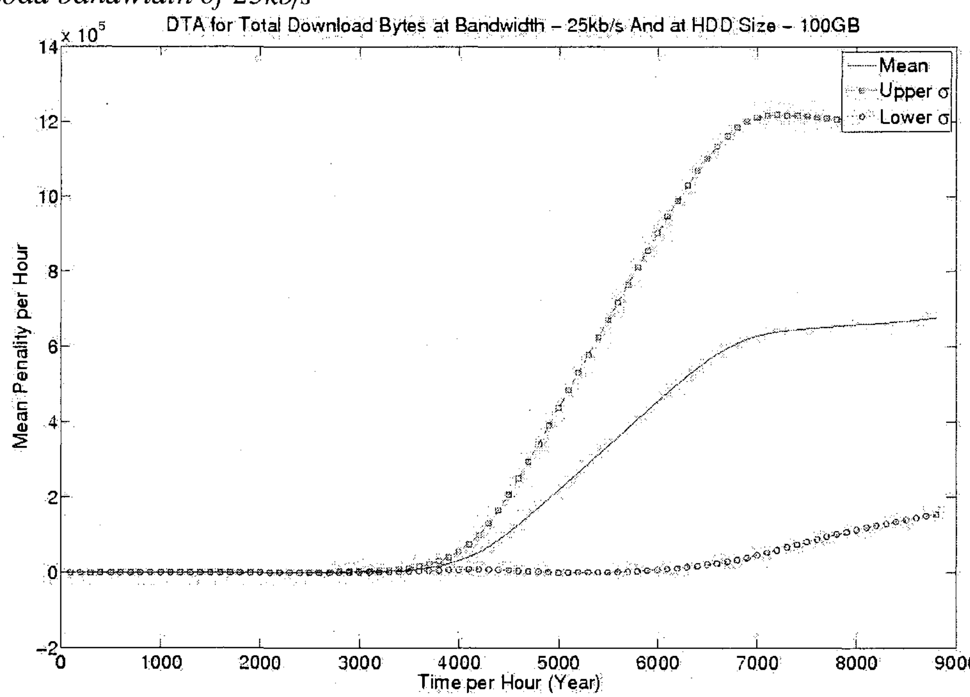


Figure 980: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 25kb/s

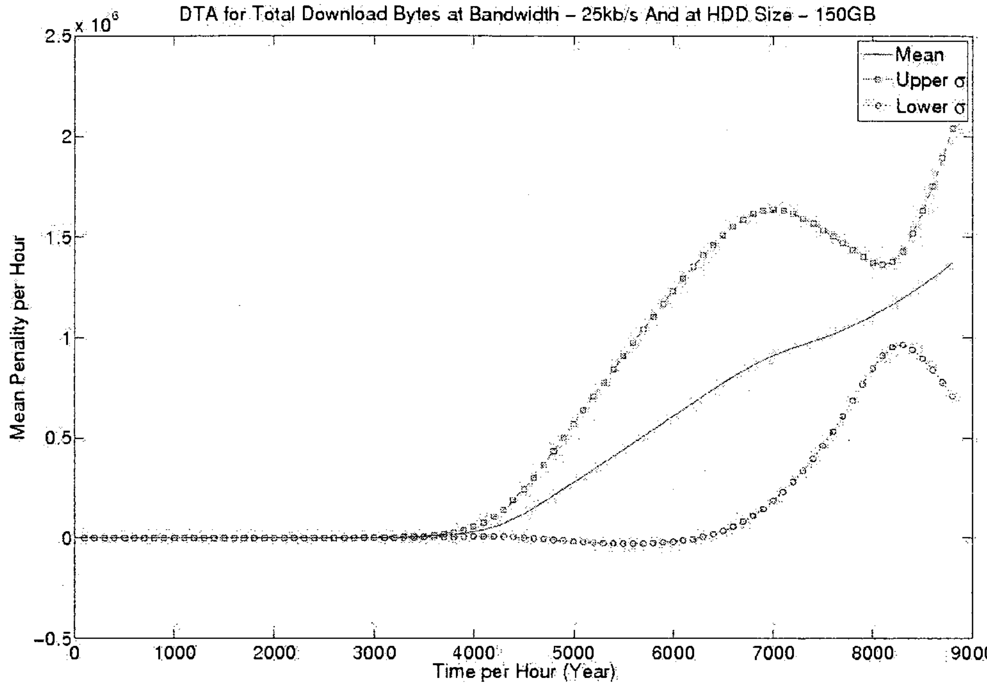


Figure 981: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 25kb/s

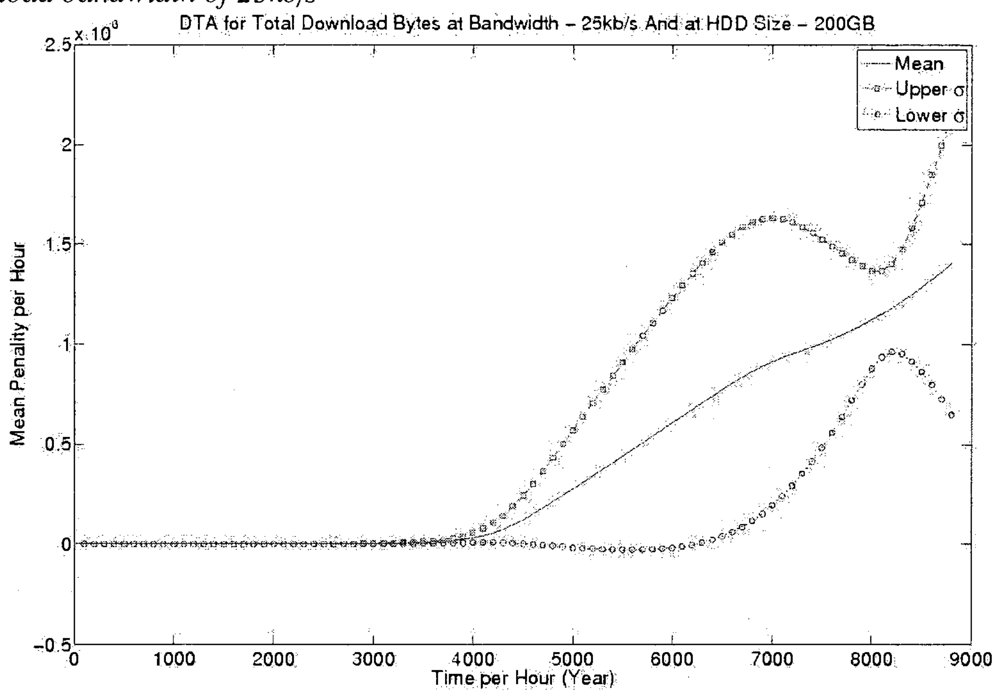


Figure 982: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 50kb/s

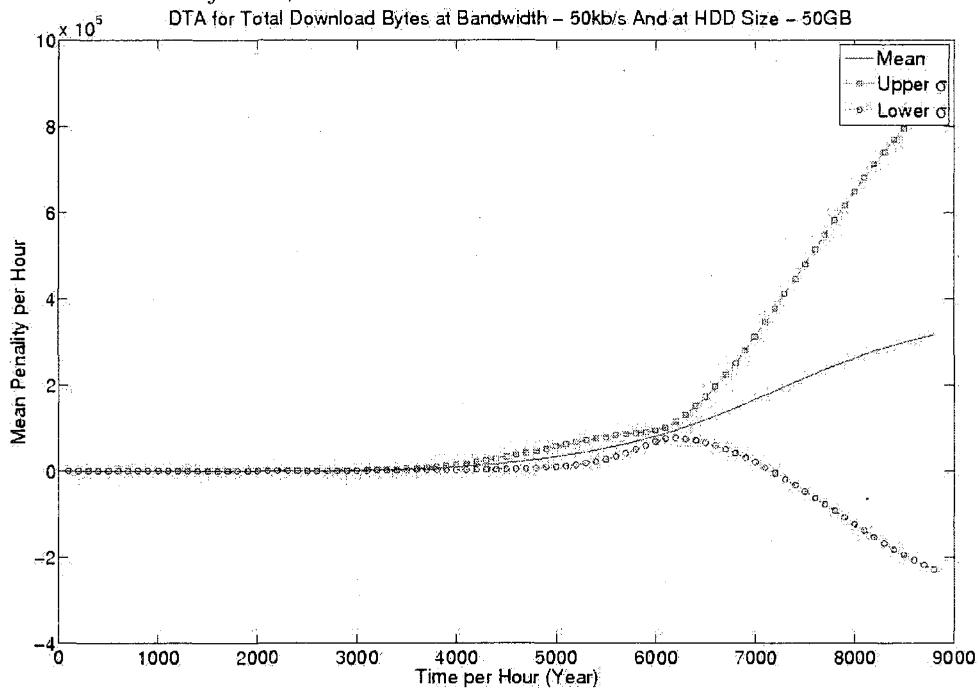


Figure 983: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 50kb/s

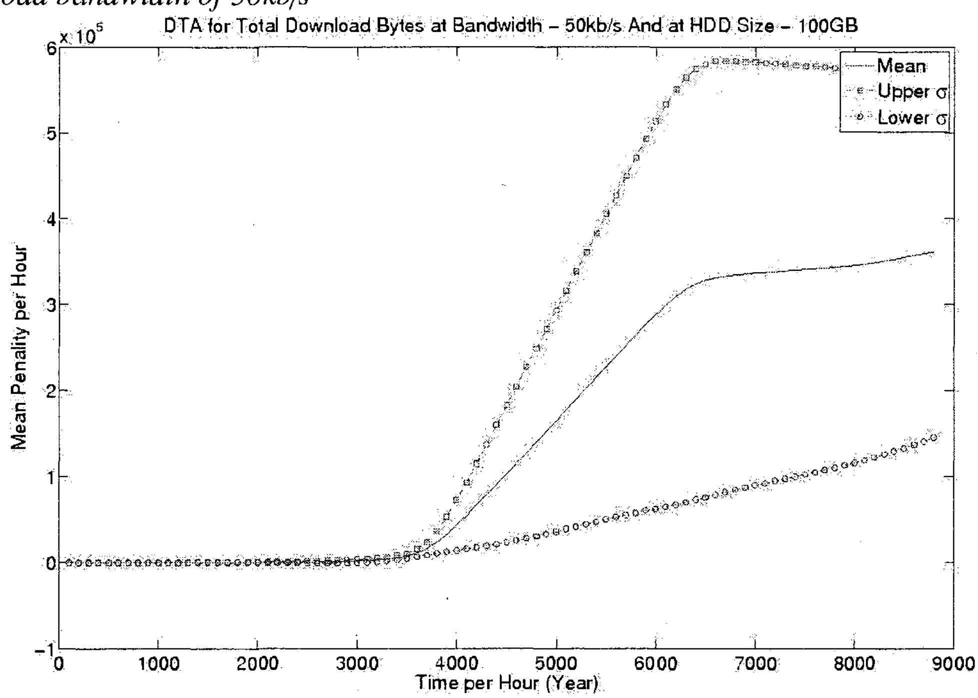


Figure 984: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 50kb/s

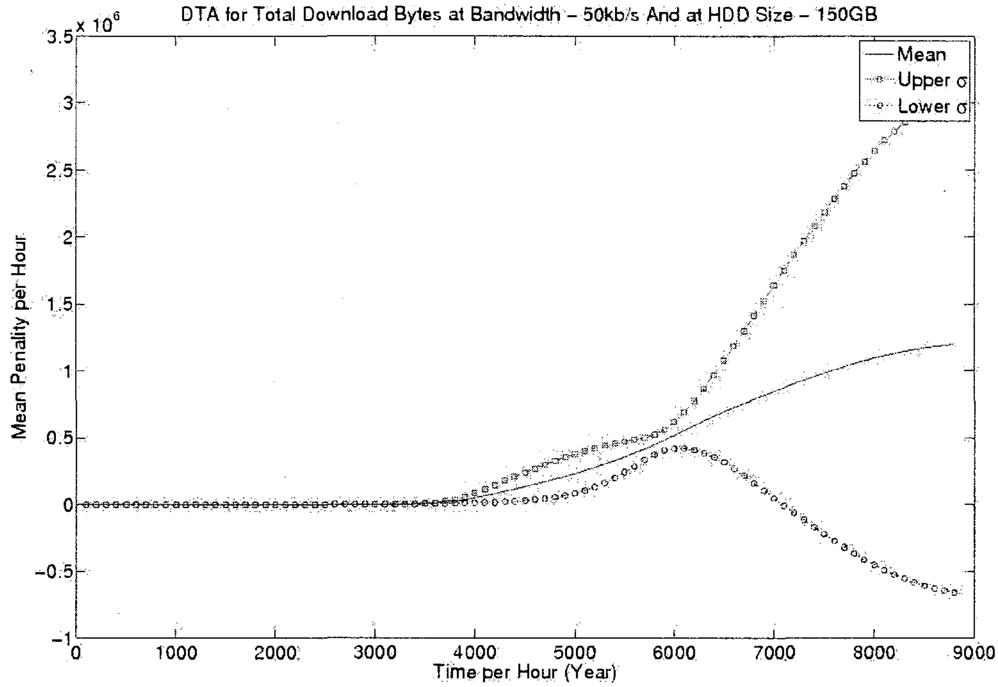


Figure 985: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 50kb/s

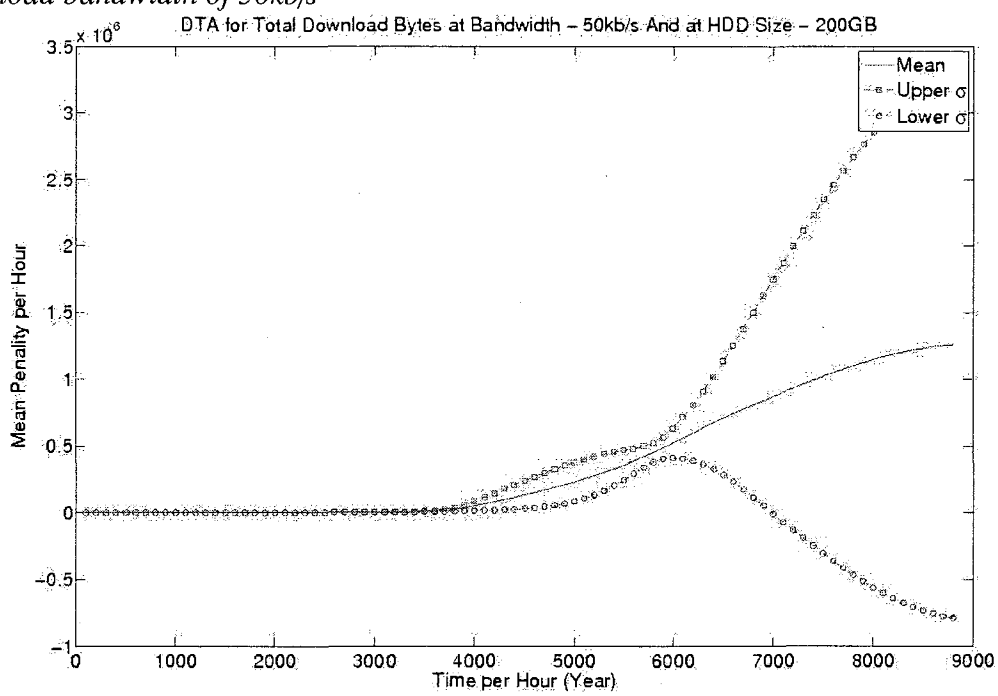


Figure 986: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 100kb/s

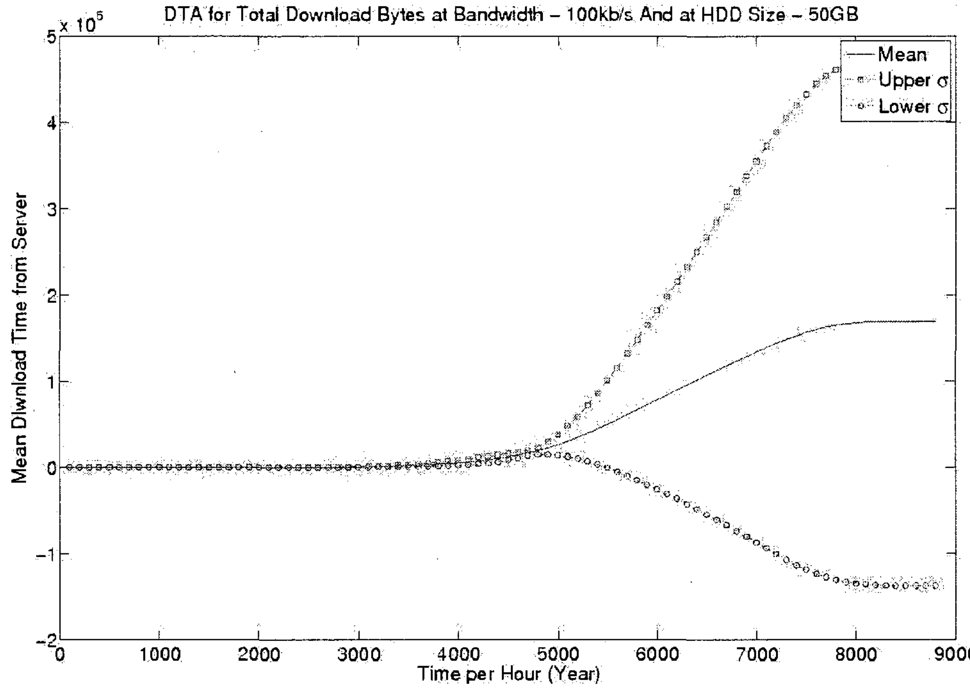


Figure 987: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 100kb/s

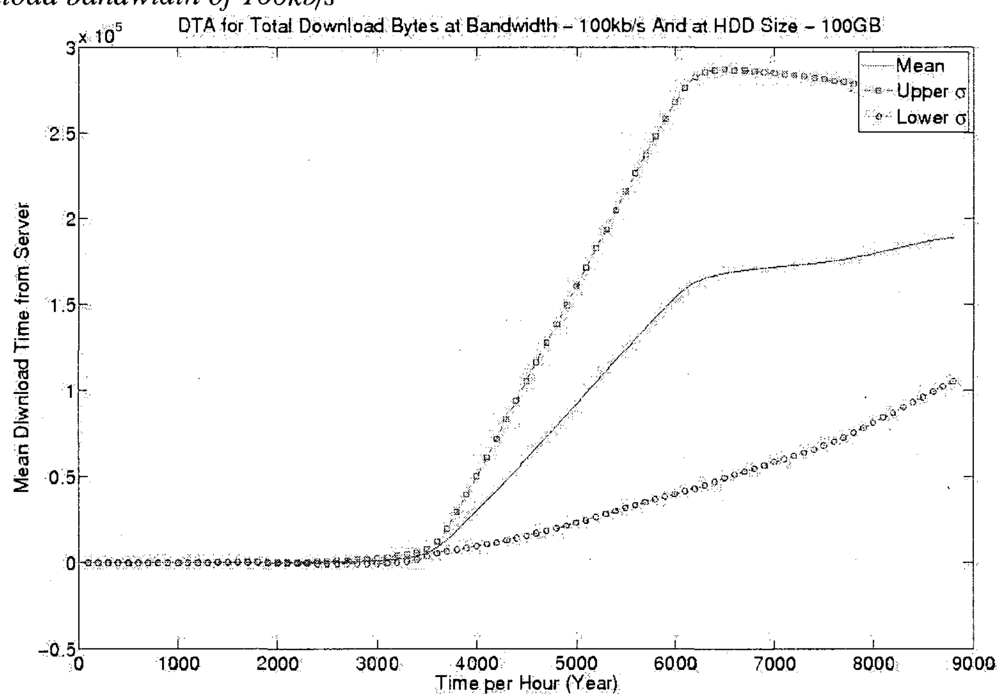


Figure 988: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 100kb/s

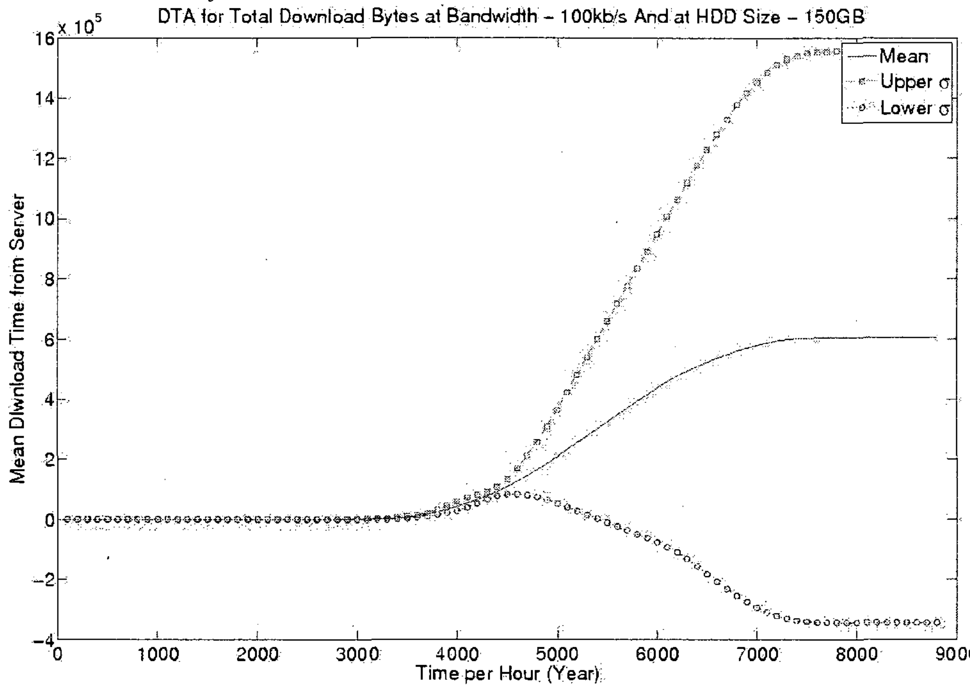


Figure 989: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 100kb/s

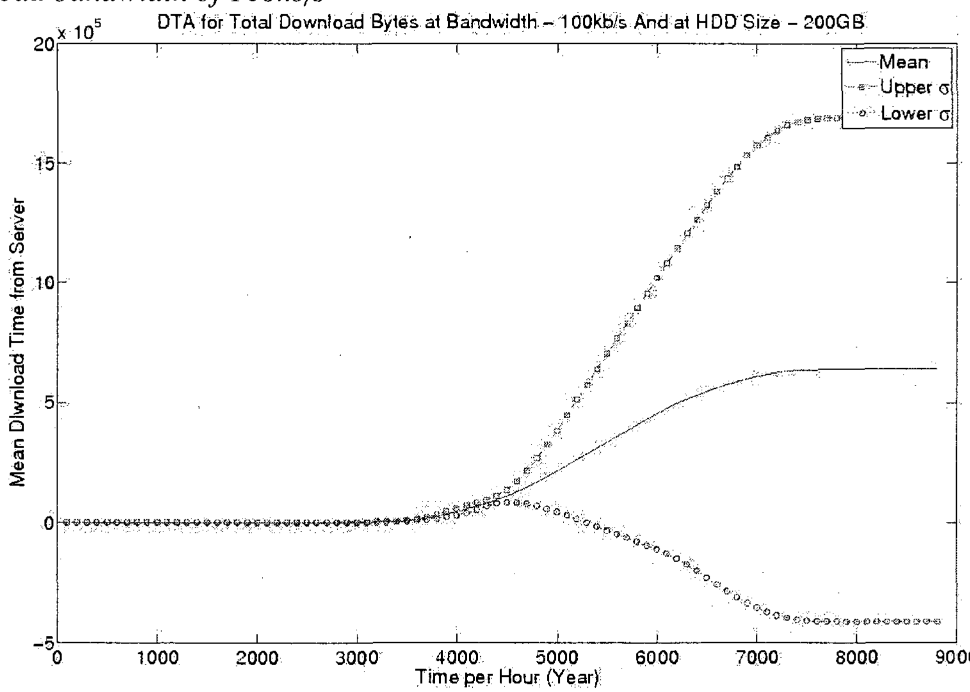


Figure 990: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 128kb/s

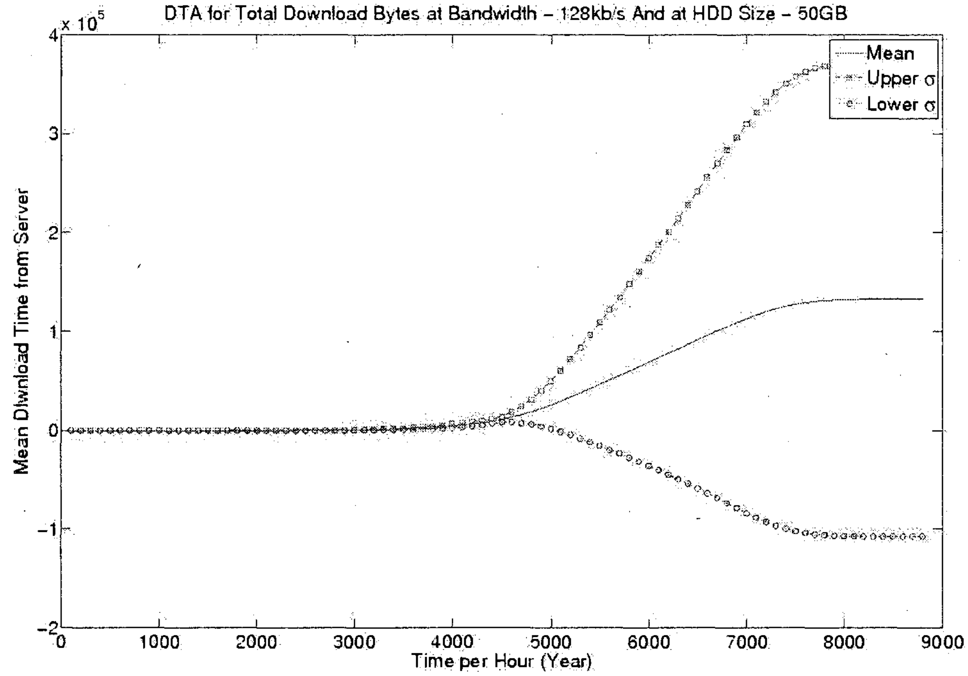


Figure 991: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 128kb/s

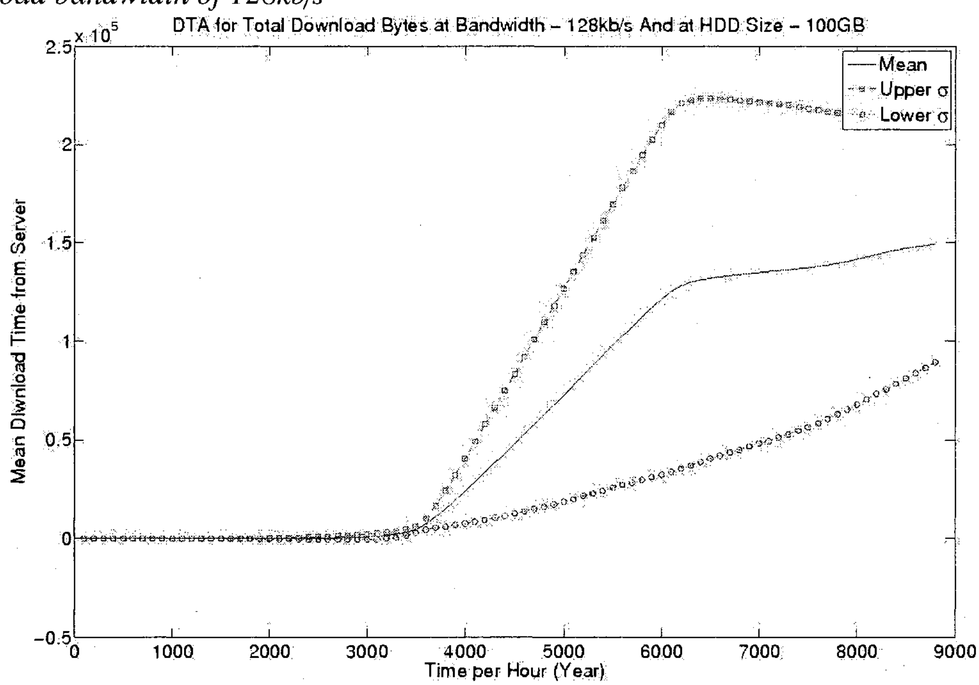


Figure 992: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 128kb/s

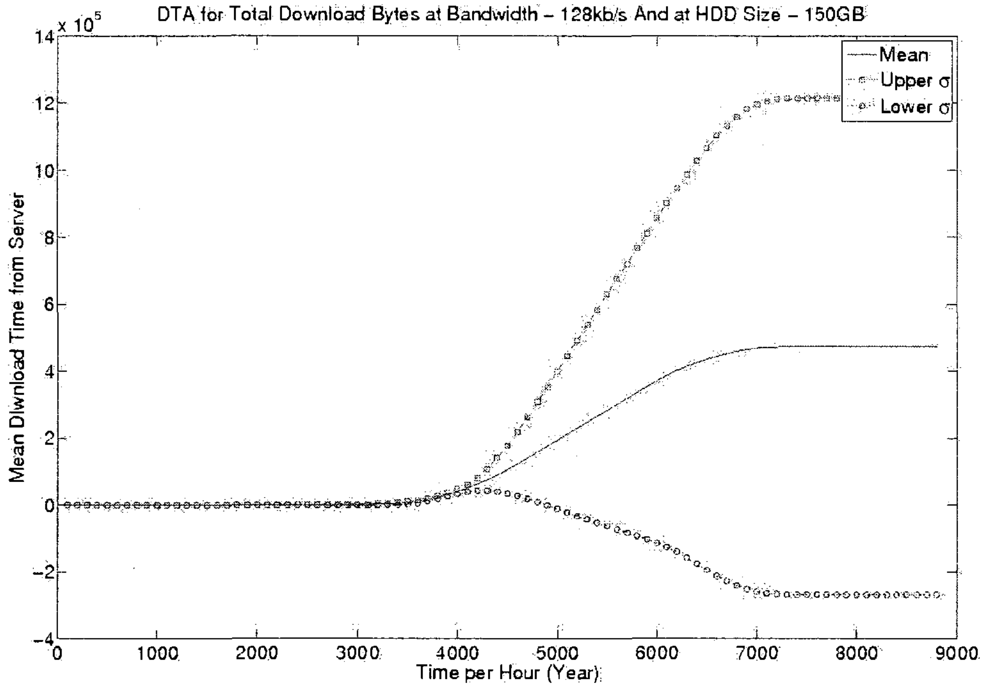


Figure 993: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 128kb/s

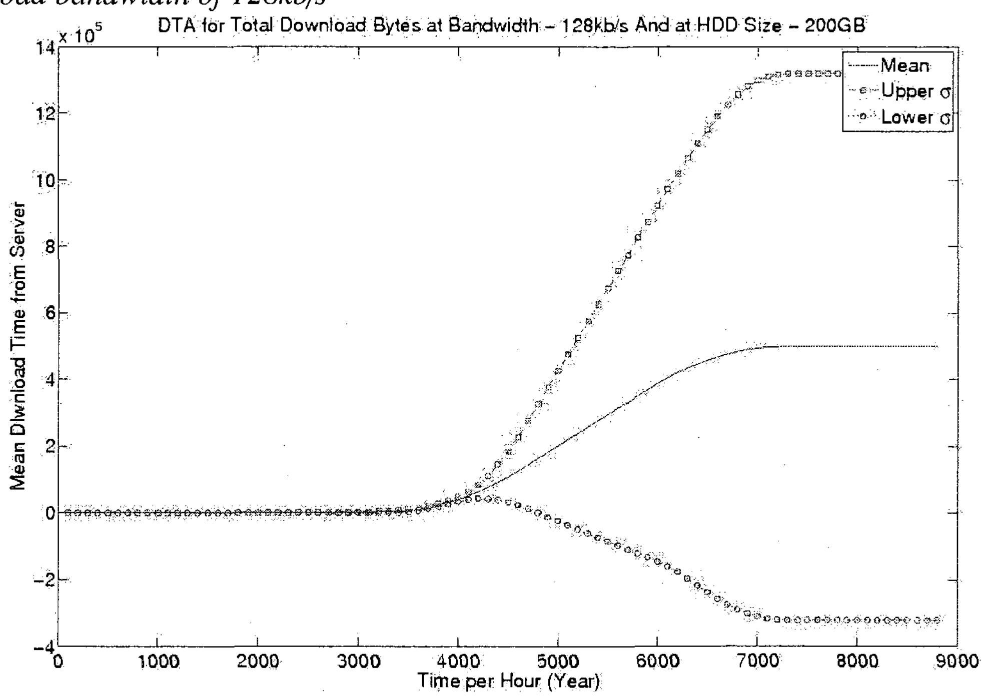


Figure 994: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 256kb/s

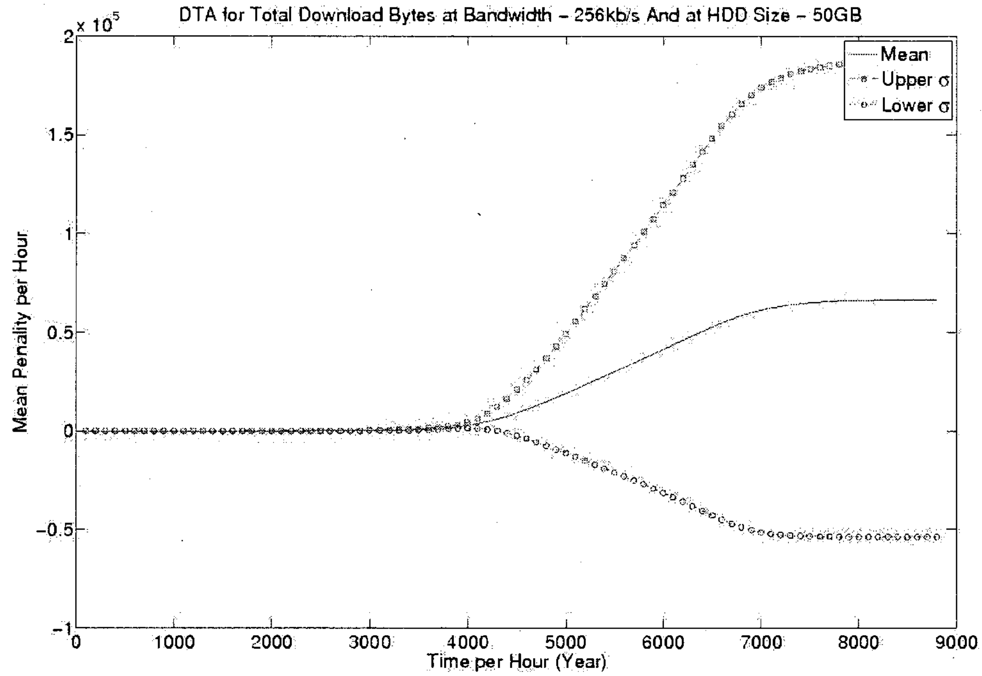


Figure 995: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 256kb/s

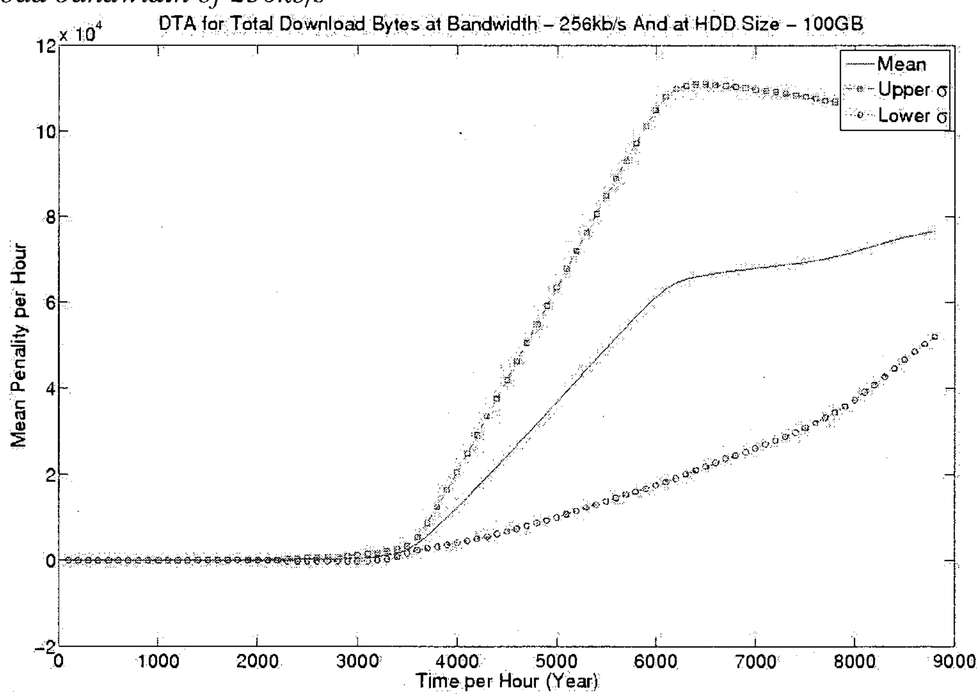


Figure 996: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 256kb/s

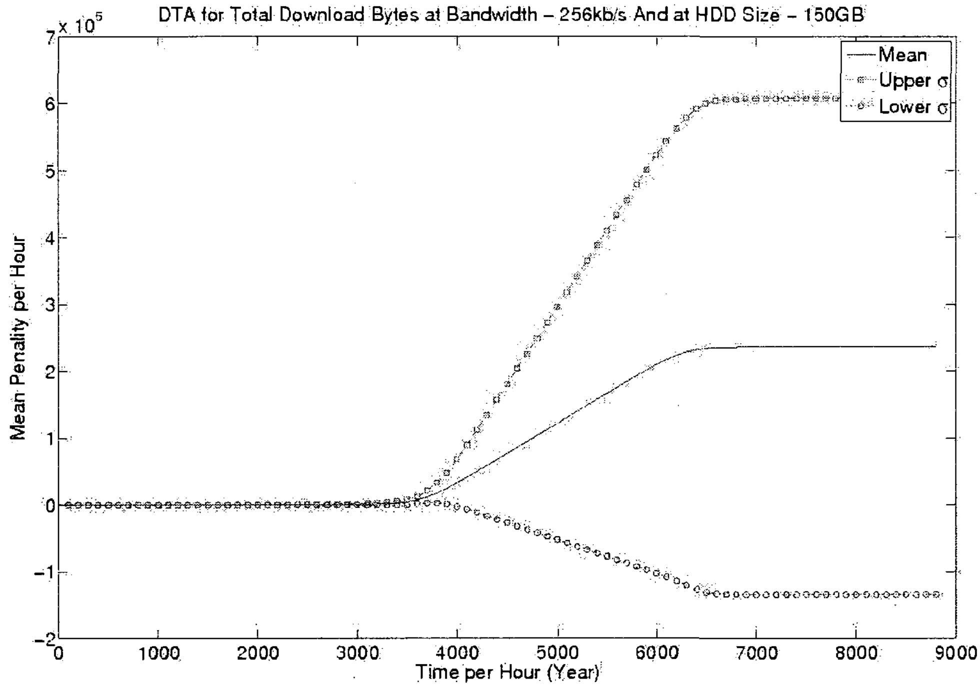


Figure 997: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 256kb/s

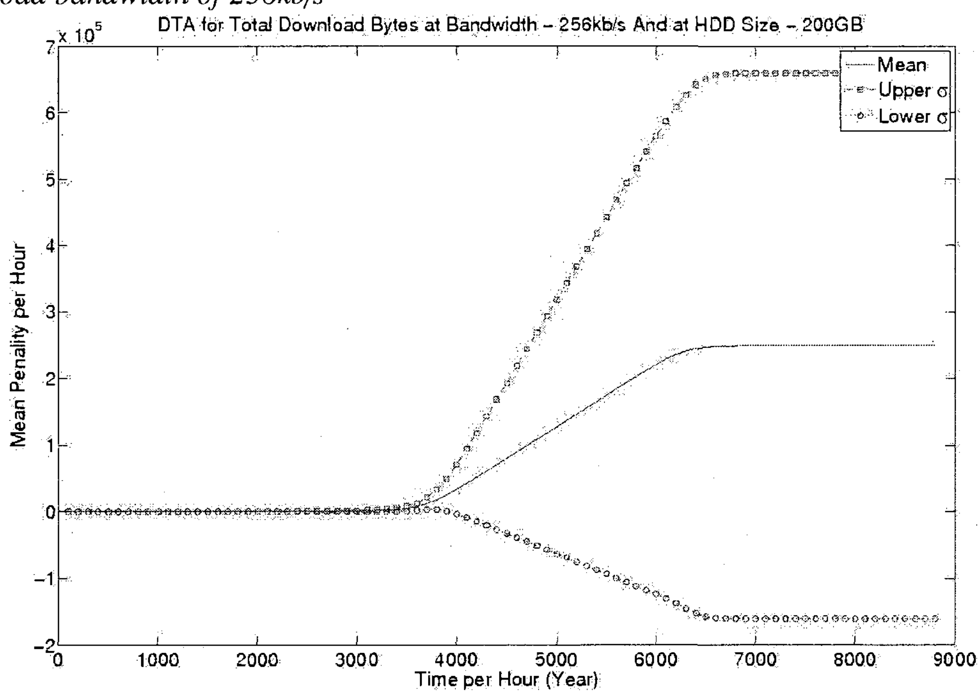


Figure 998: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 512kb/s

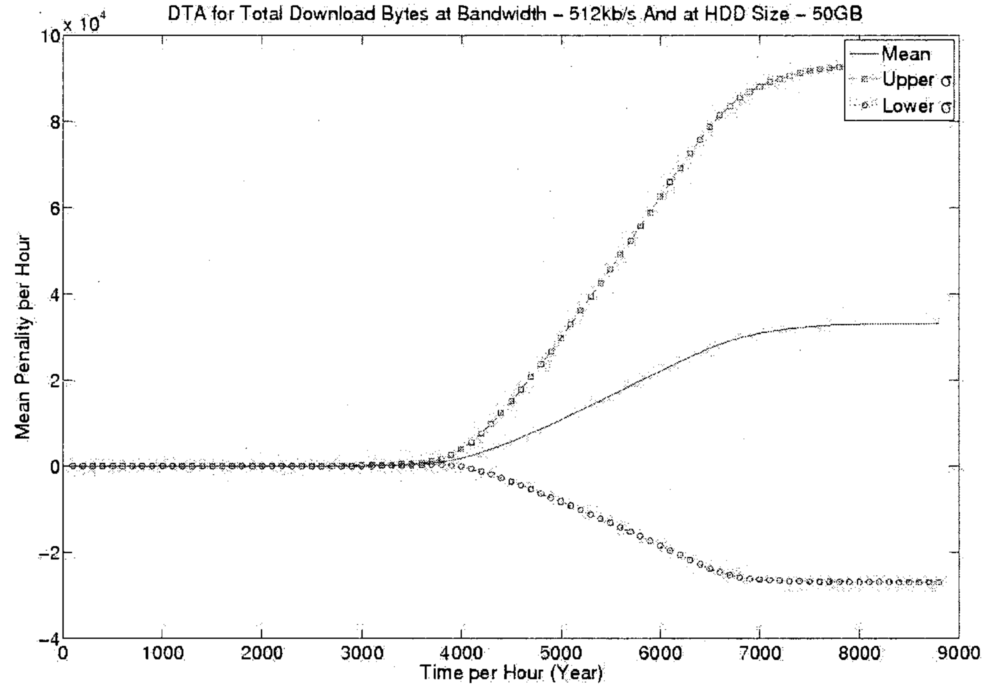


Figure 999: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 512kb/s

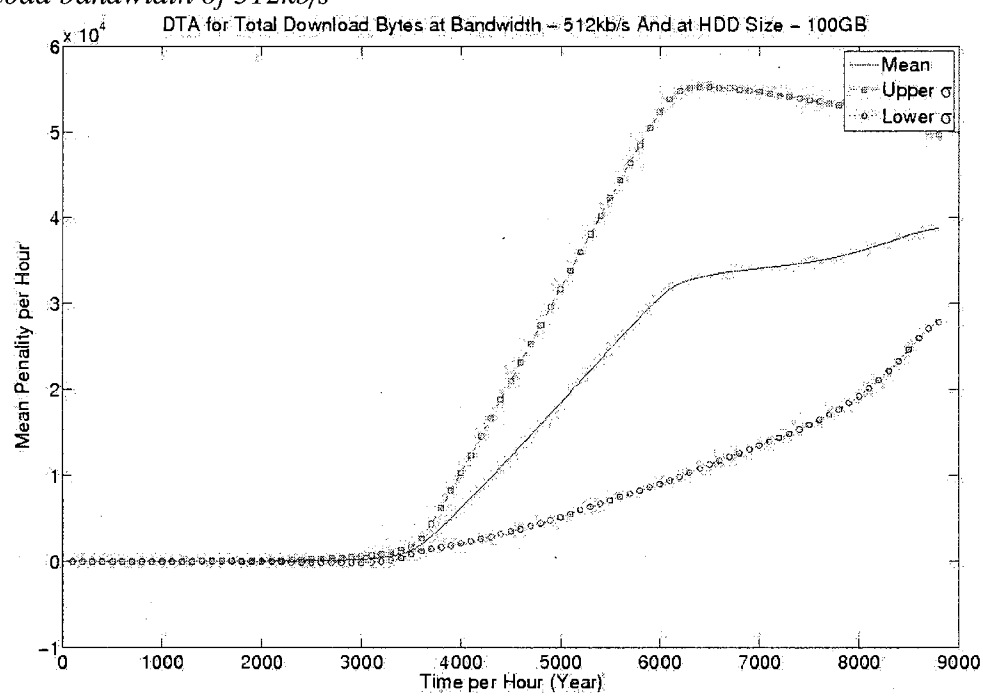


Figure 1000: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 512kb/s

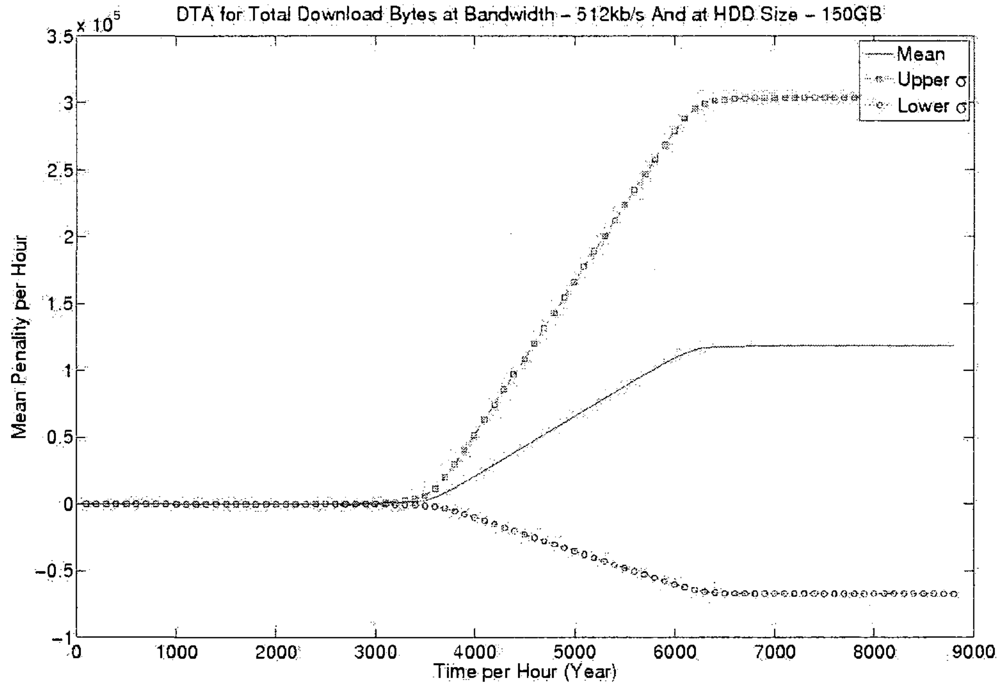


Figure 1001: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 512kb/s

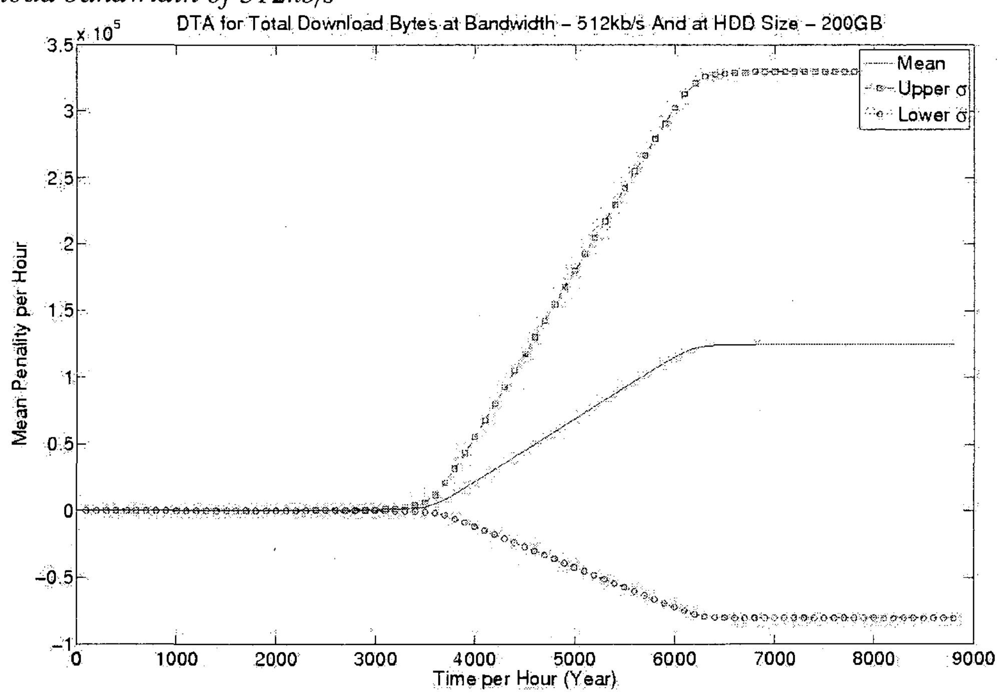


Figure 1002: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 1000kb/s

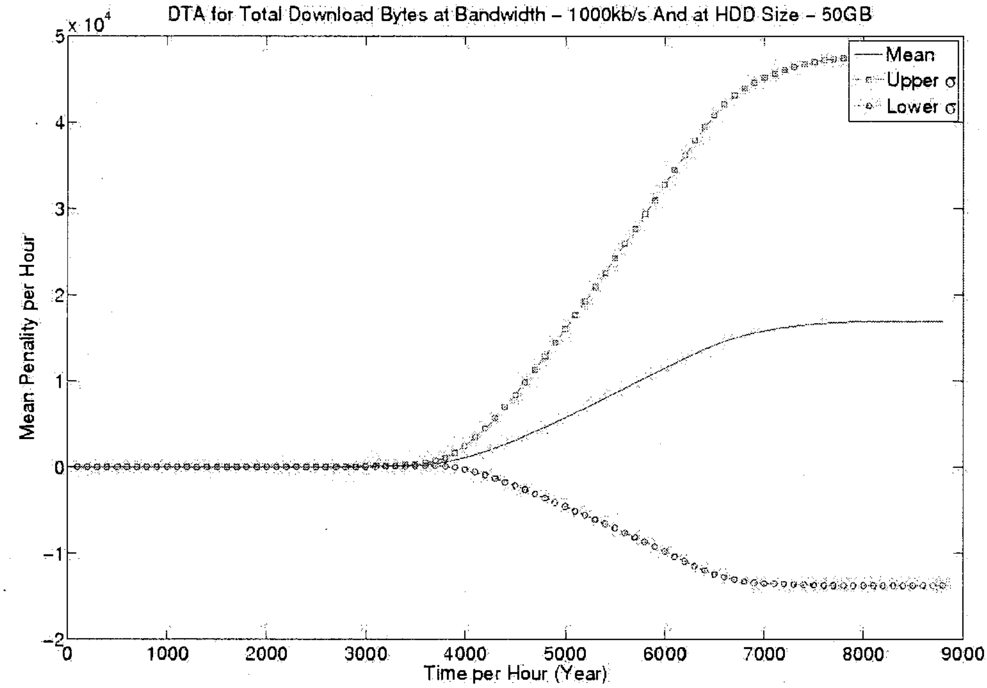


Figure 1003: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 1000kb/s

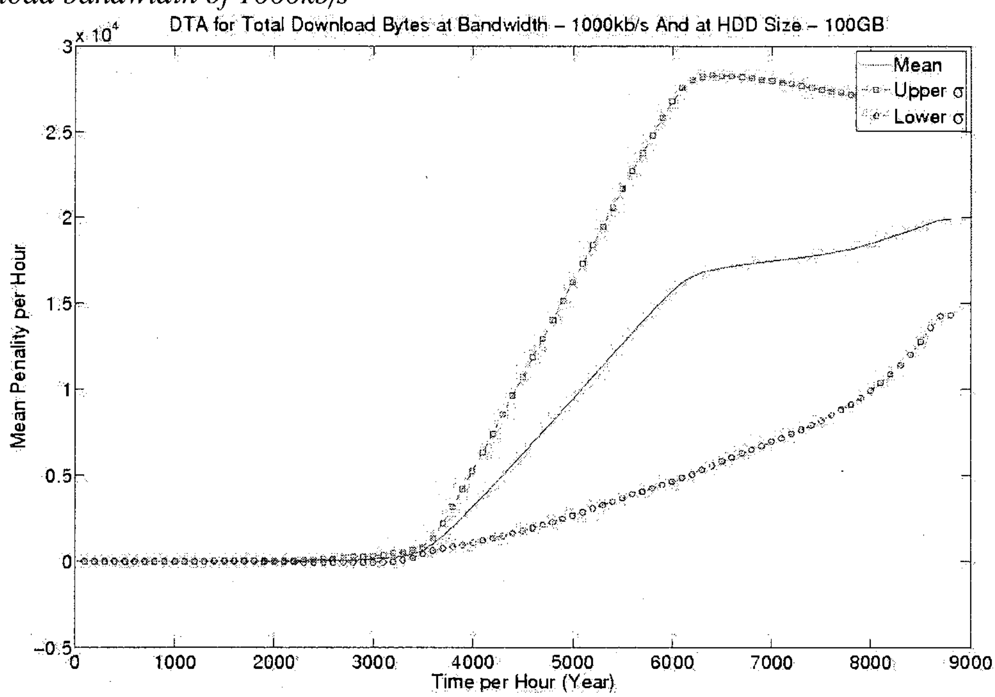


Figure 1004: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 1000kb/s

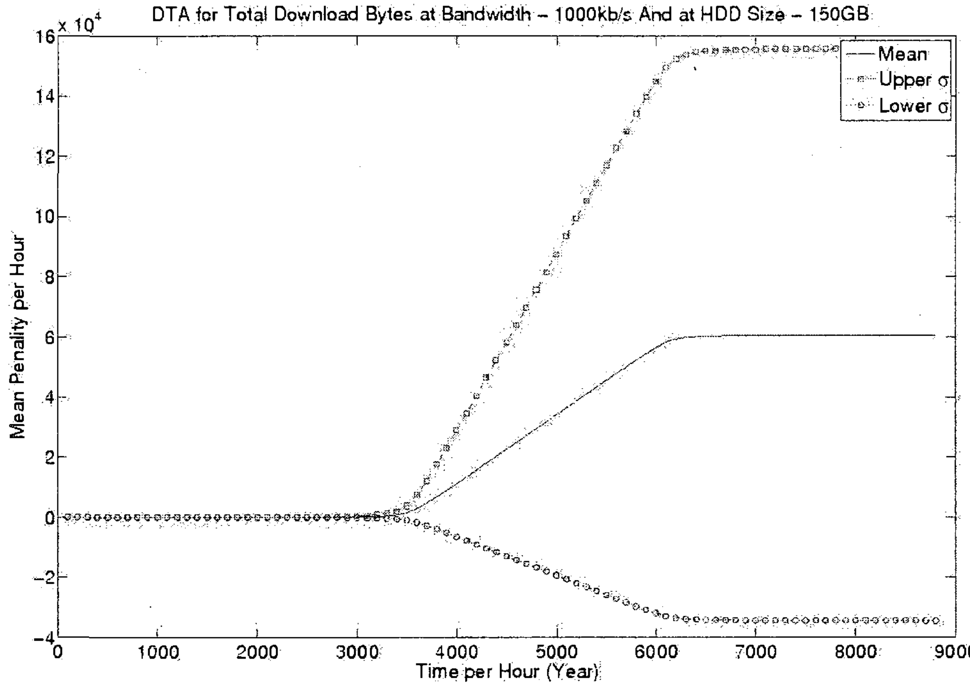


Figure 1005: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 1000kb/s

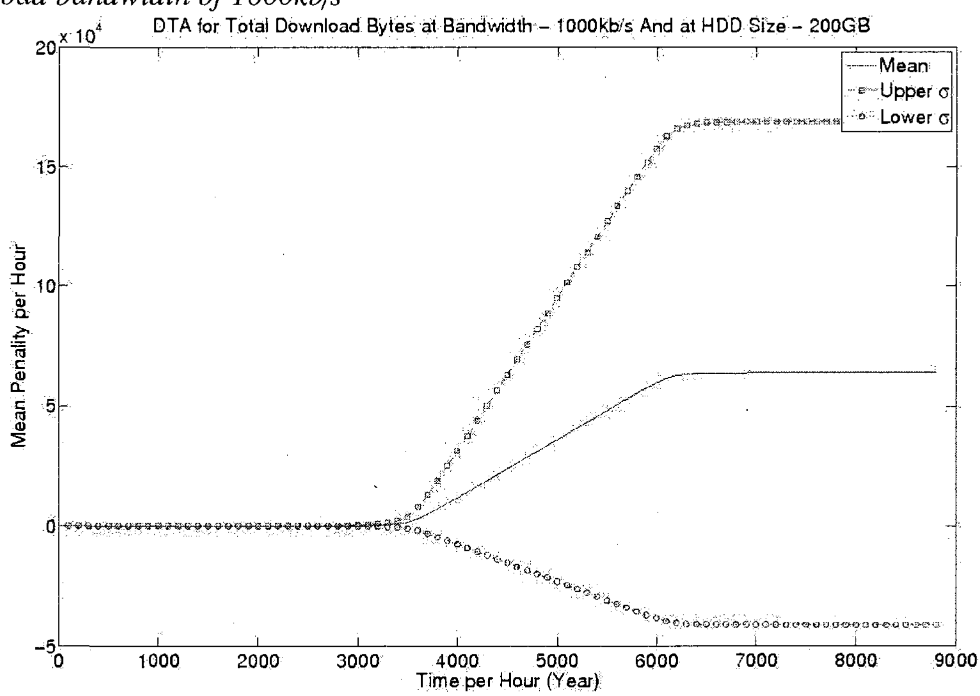


Figure 1006: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 2000kb/s

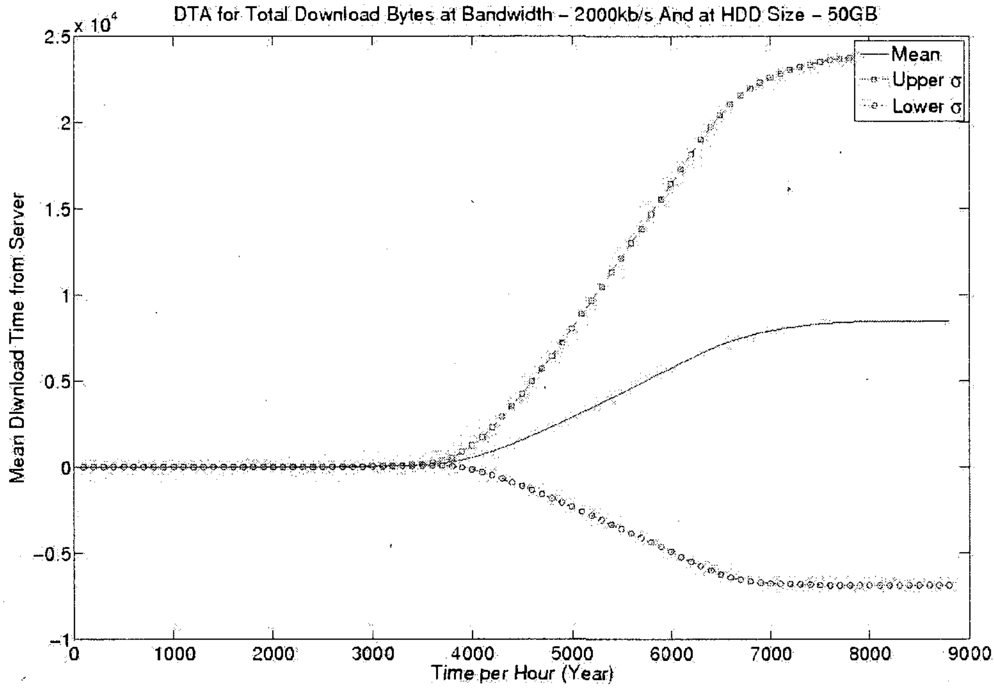


Figure 1007: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 2000kb/s

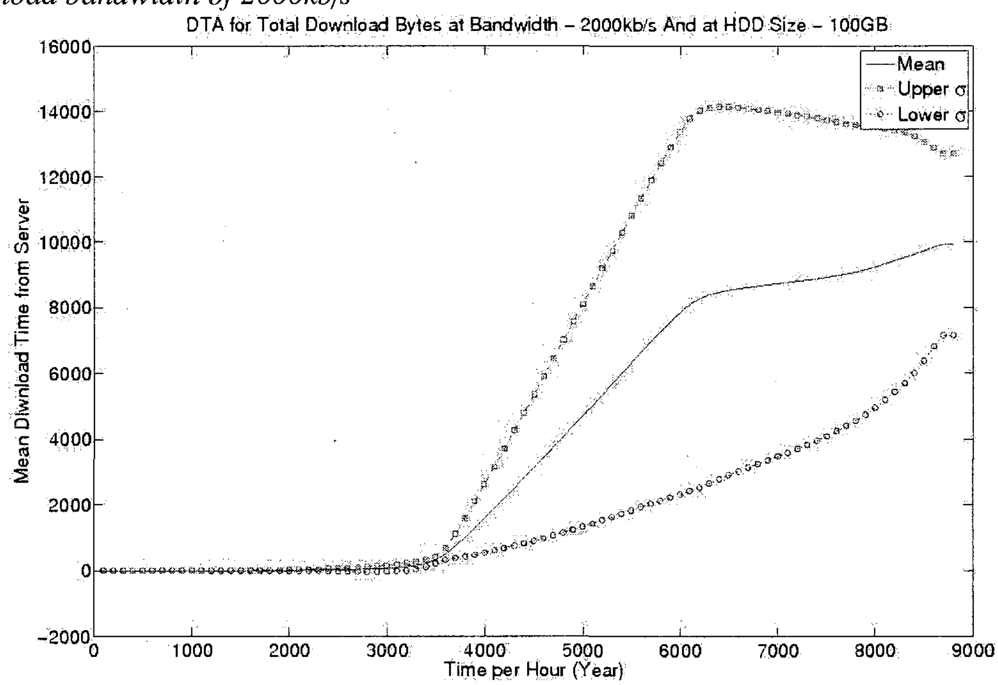


Figure 1008: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 2000kb/s

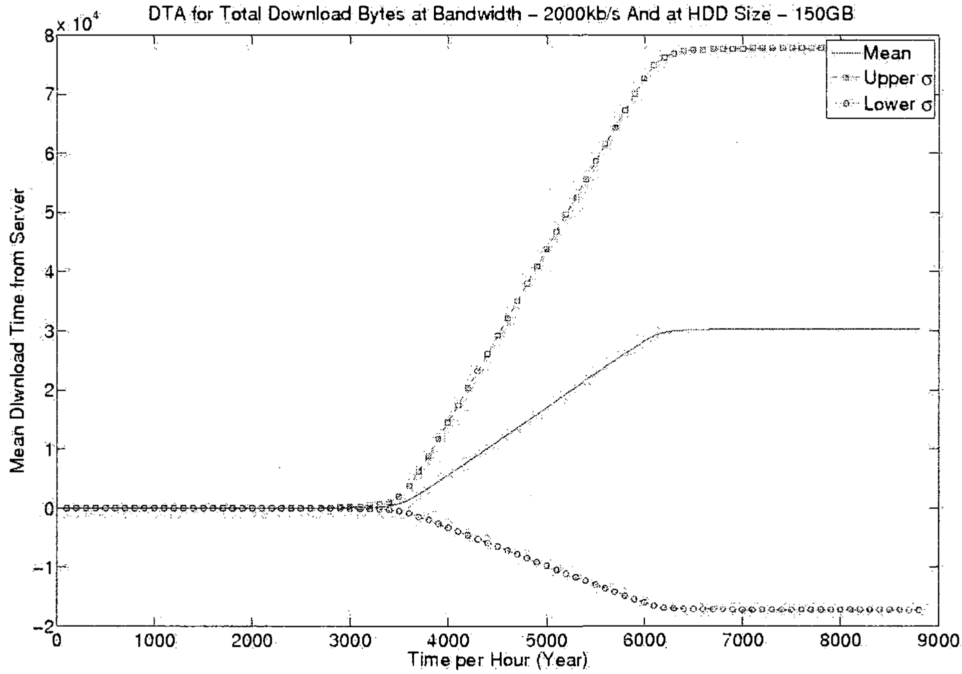


Figure 1009: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 2000kb/s

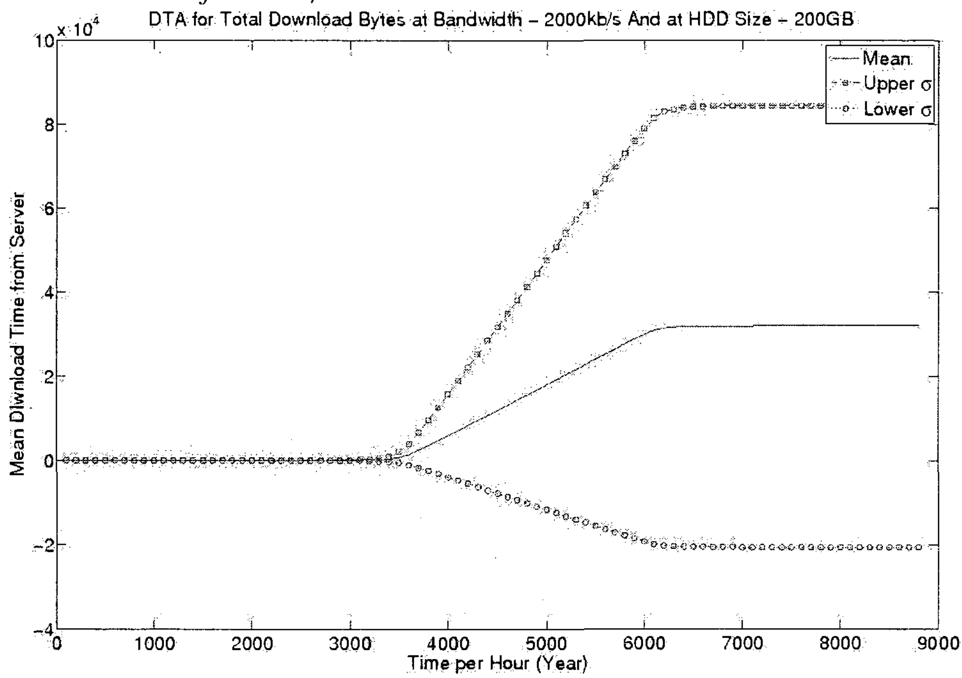


Figure 1010: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 5000kb/s

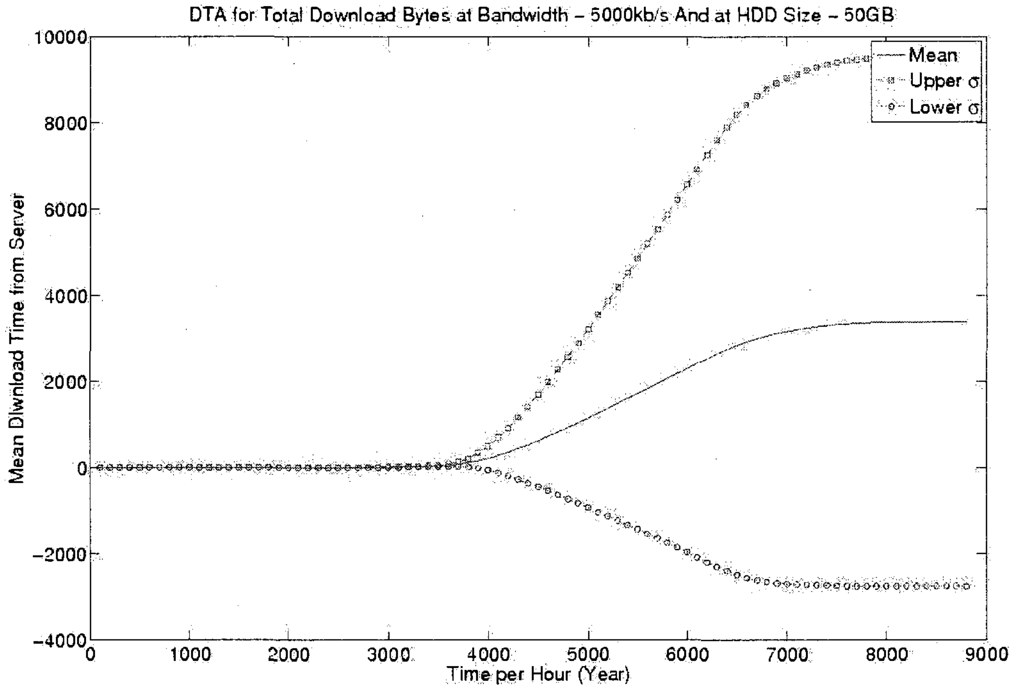


Figure 1011: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 5000kb/s

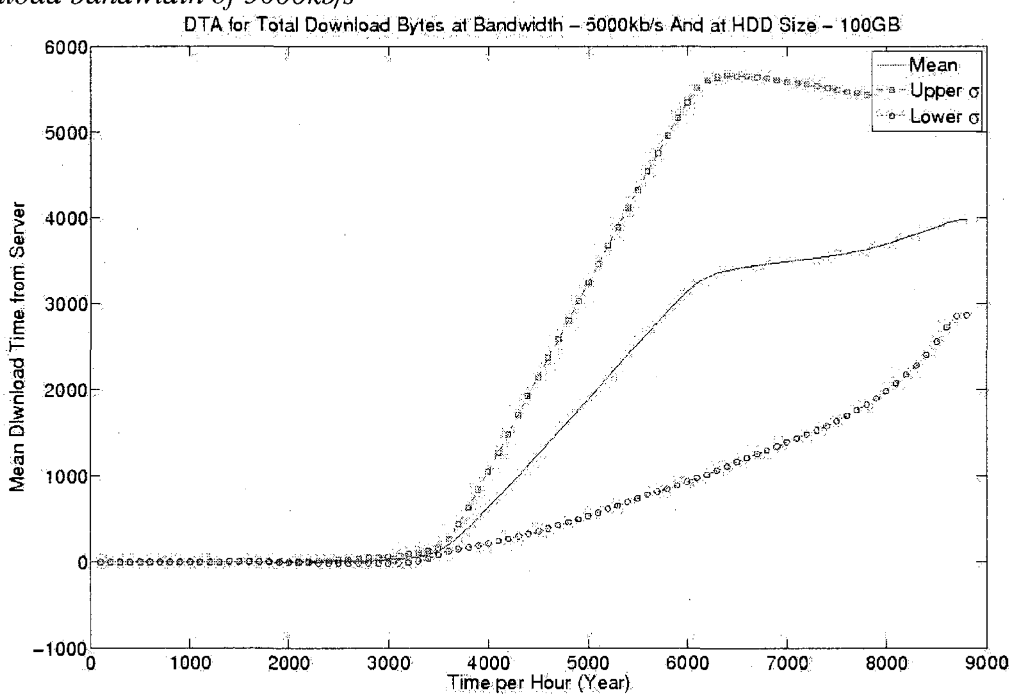


Figure 1012: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 5000kb/s

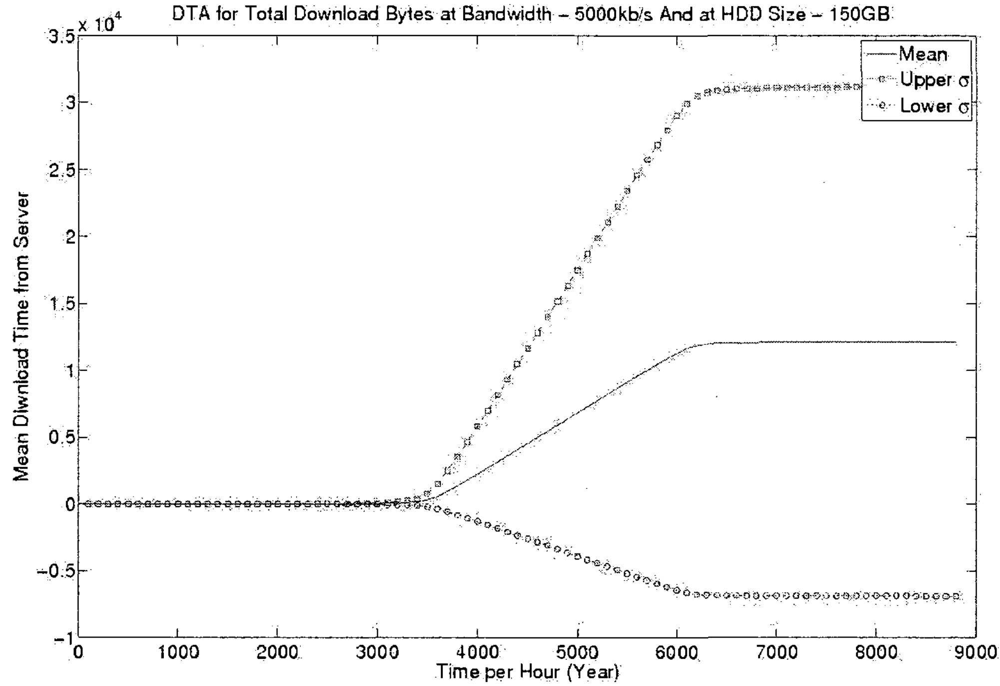


Figure 1013: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 5000kb/s

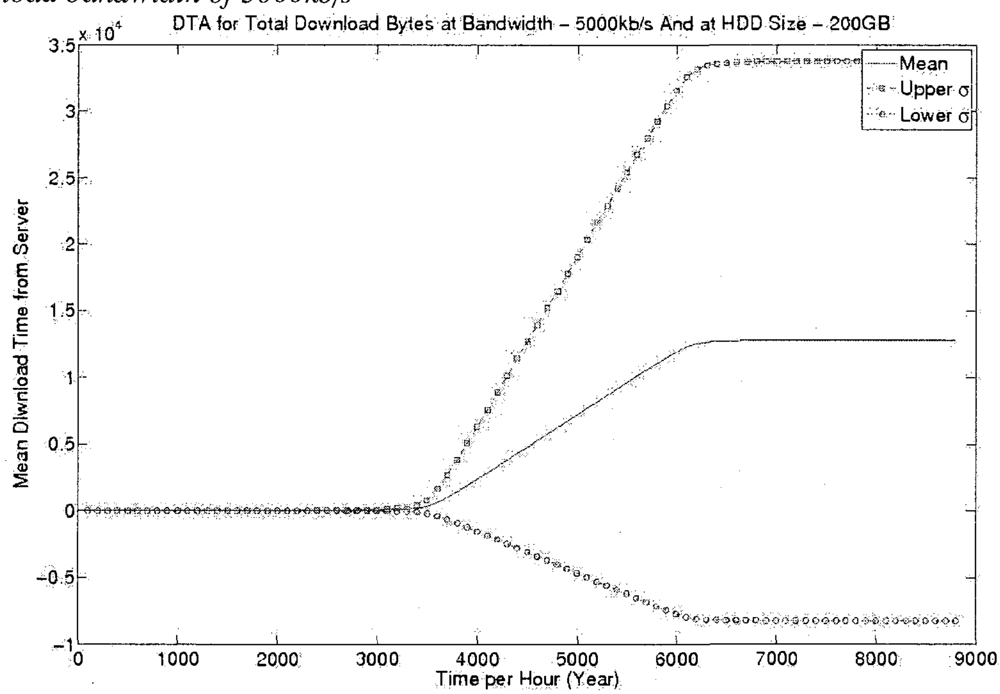


Figure 1014: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 10000kb/s

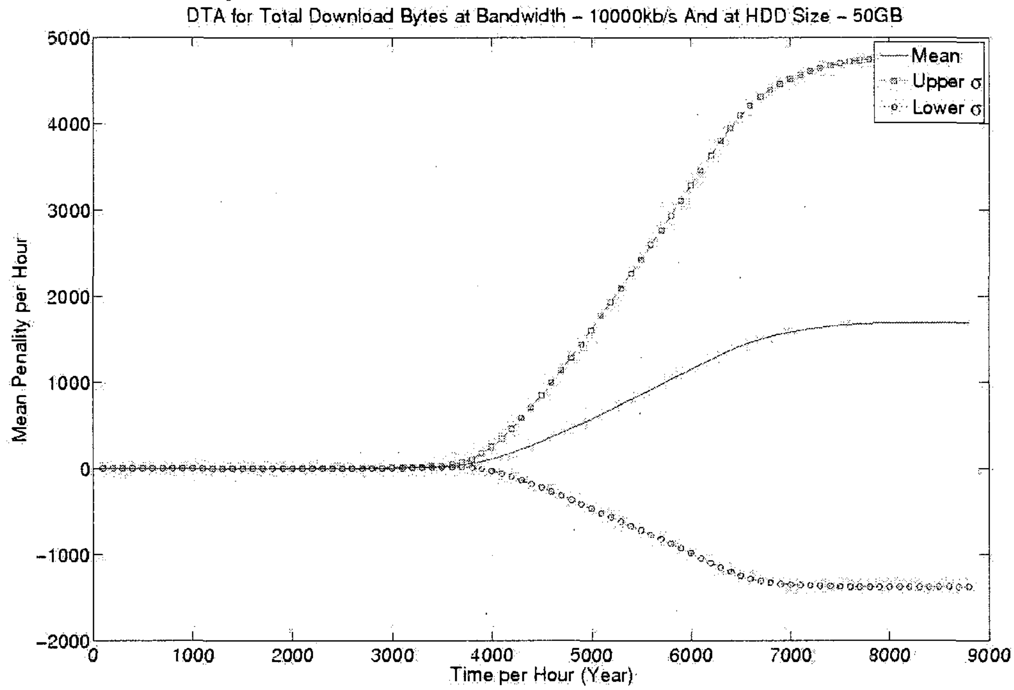


Figure 1015: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 10000kb/s

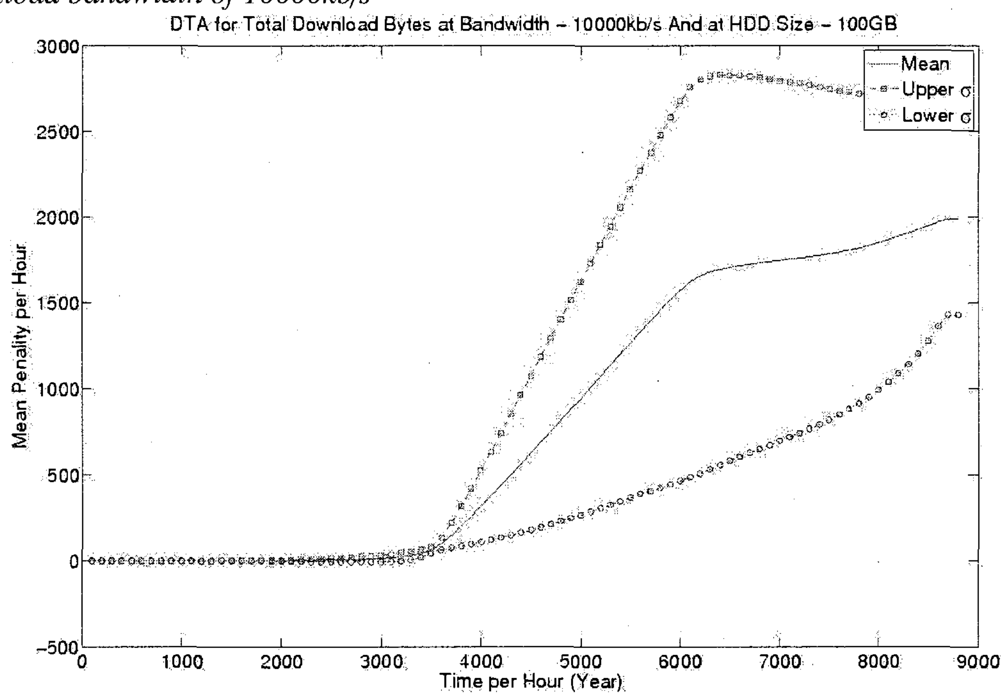


Figure 1016: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 10000kb/s

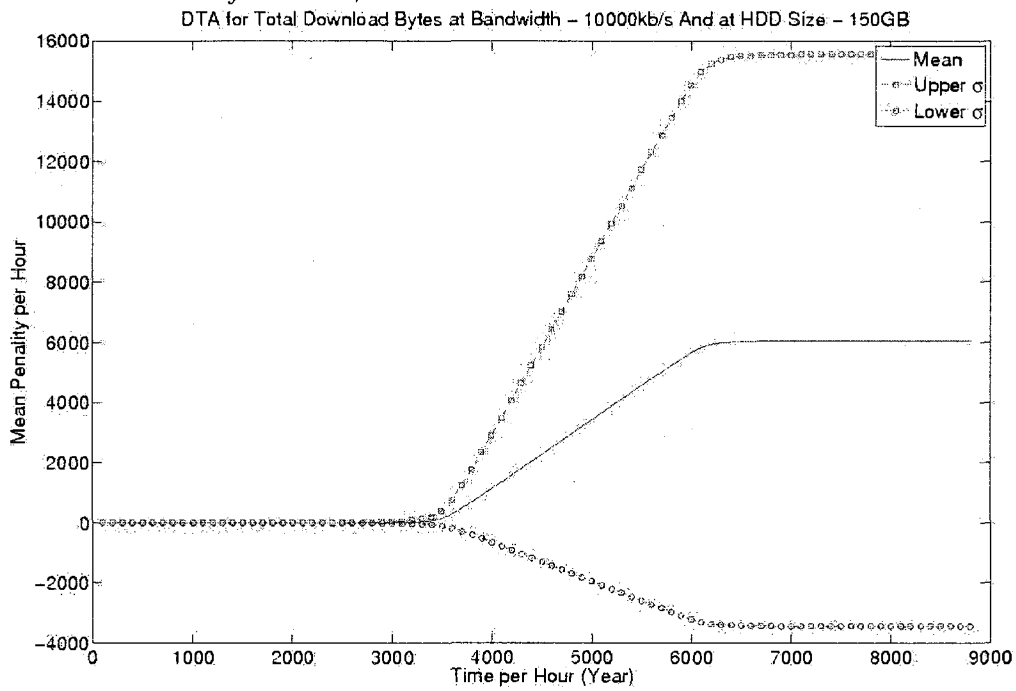


Figure 1017: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 10000kb/s

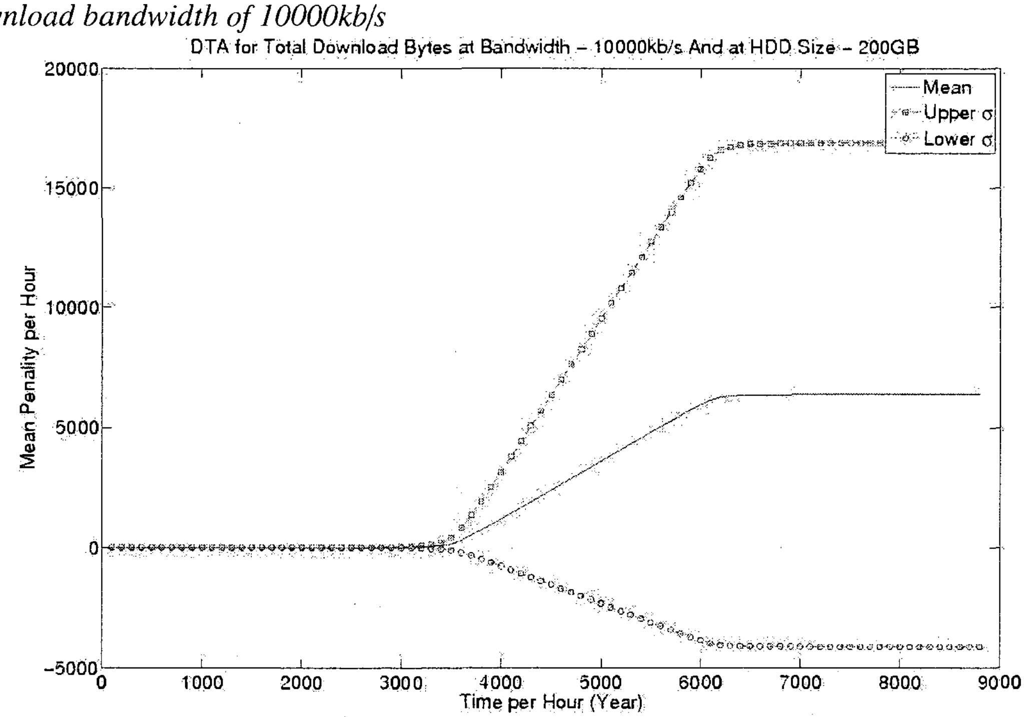


Figure 1018: DTA of a difference between H4 and H3 at hard drive size of 50GB and download bandwidth of 15000kb/s

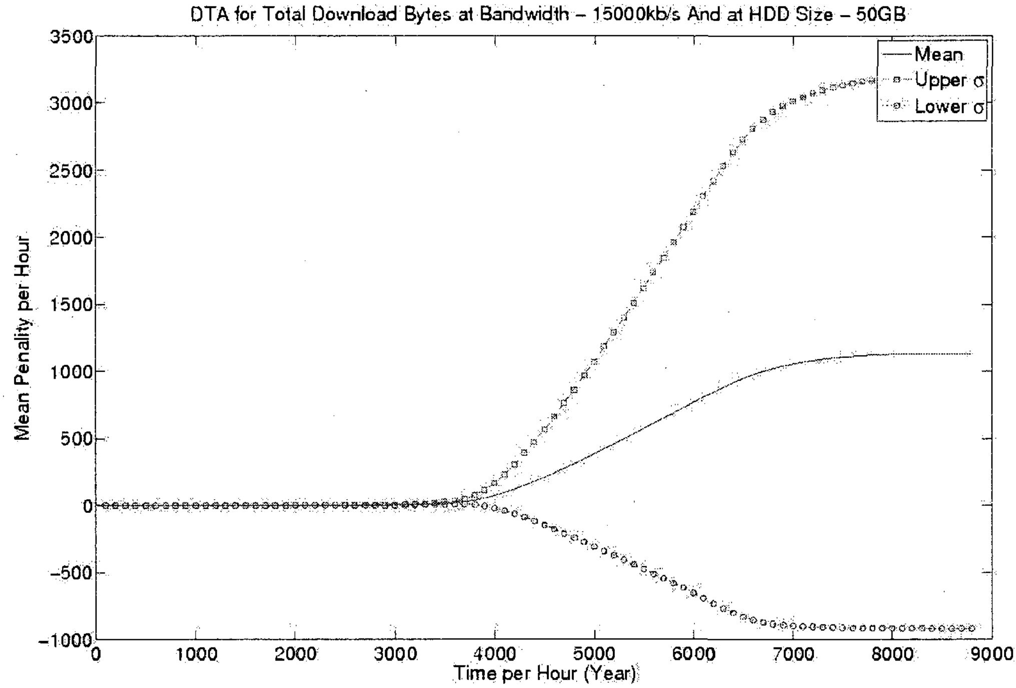


Figure 1019: DTA of a difference between H4 and H3 at hard drive size of 100GB and download bandwidth of 15000kb/s

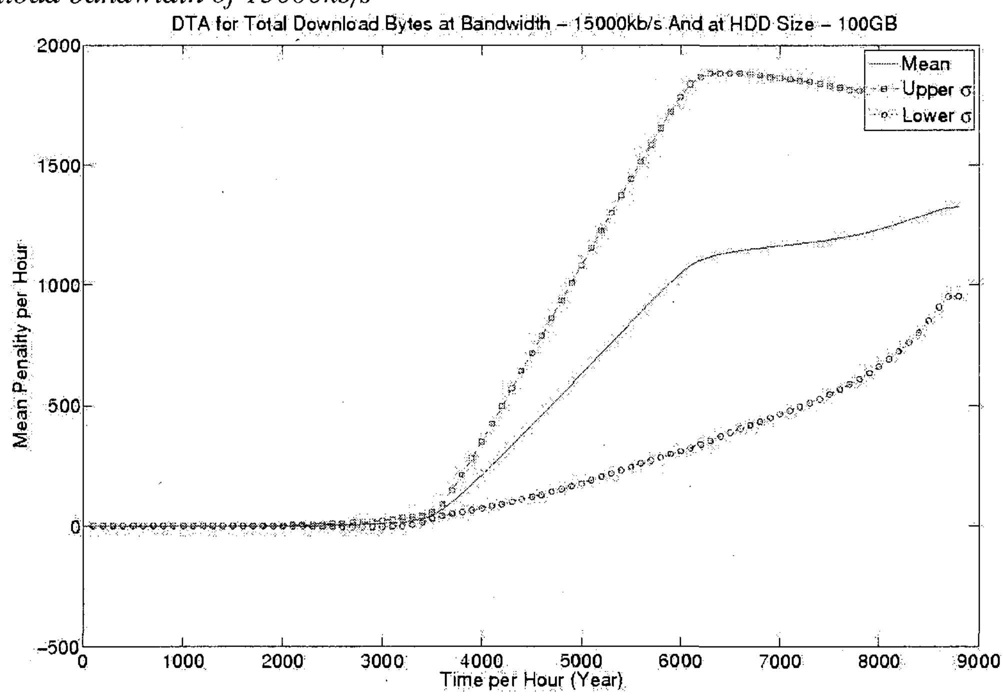


Figure 1020: DTA of a difference between H4 and H3 at hard drive size of 150GB and download bandwidth of 15000kb/s

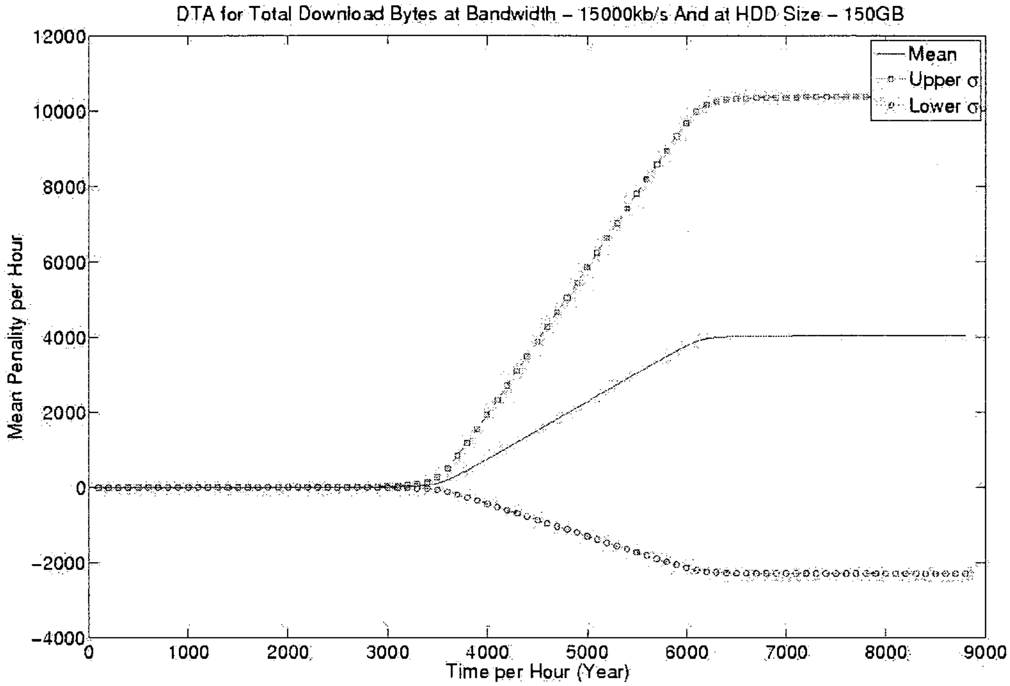


Figure 1021: DTA of a difference between H4 and H3 at hard drive size of 200GB and download bandwidth of 15000kb/s

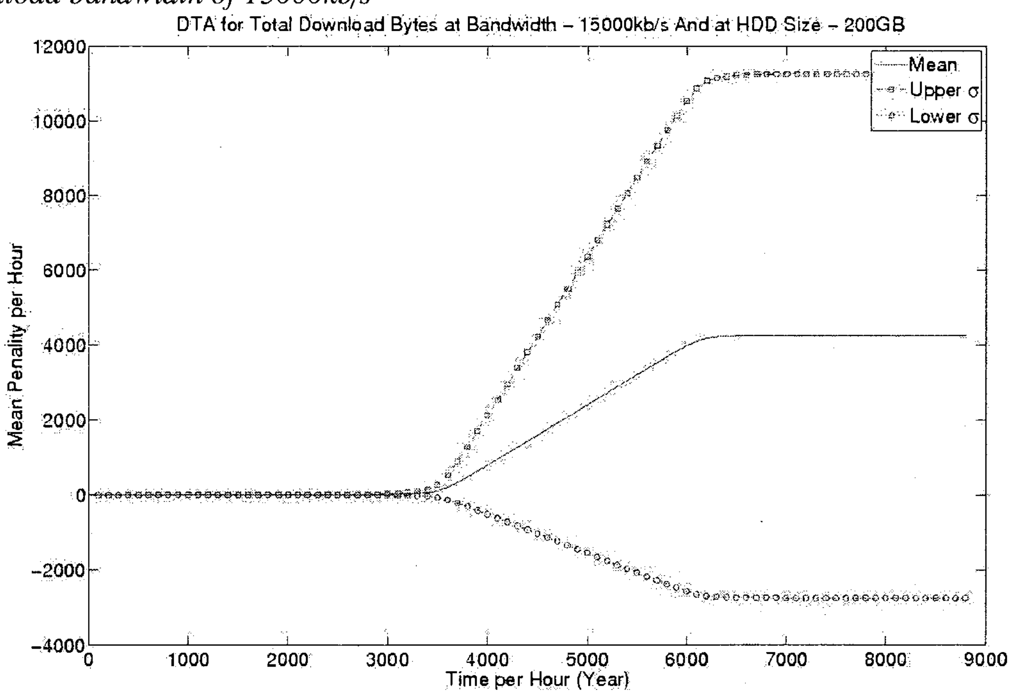


Figure 1022: Server Load for H1 case scenario after interval 100-hour

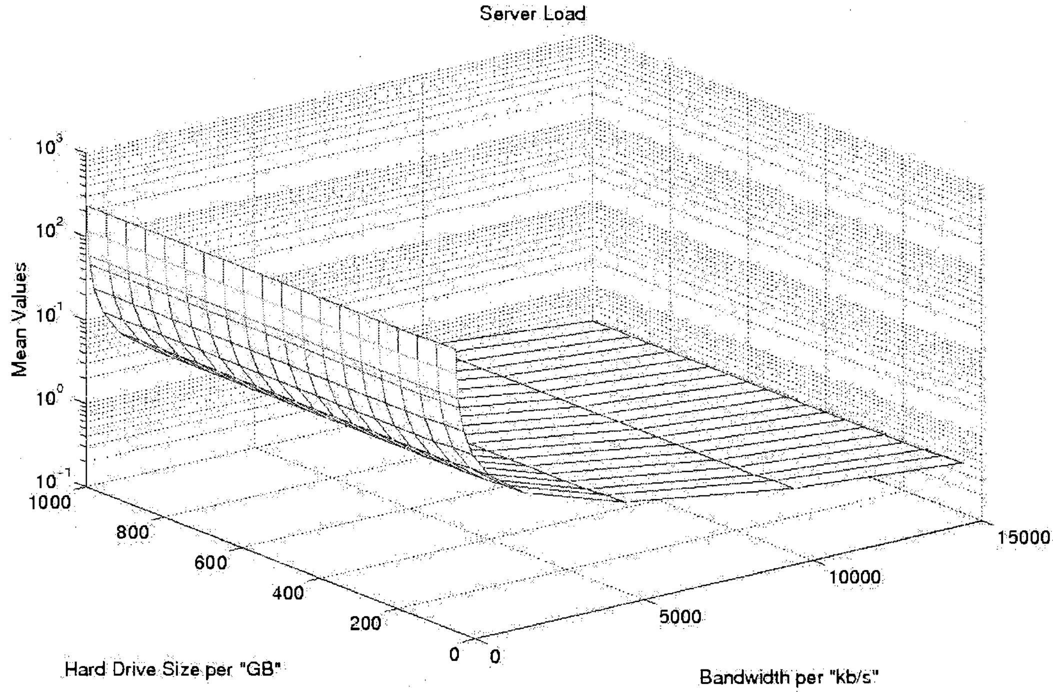


Figure 1023: Server Load for H1 case scenario after interval 1000-hour

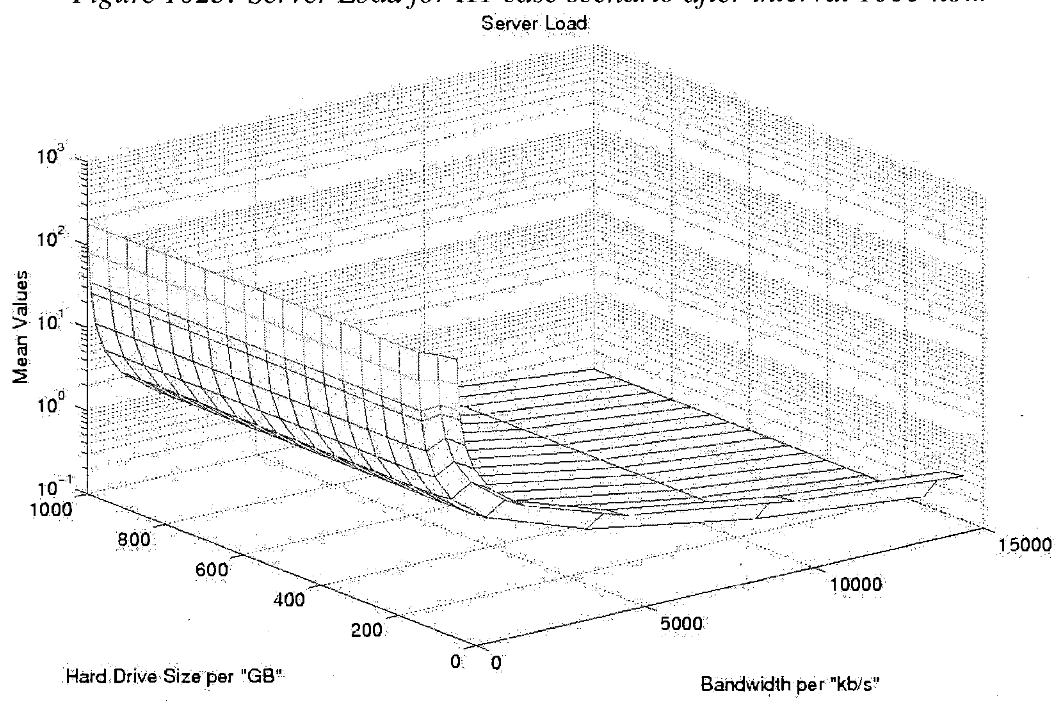


Figure 1024: Server Load for H1 case scenario after interval 1900-hour

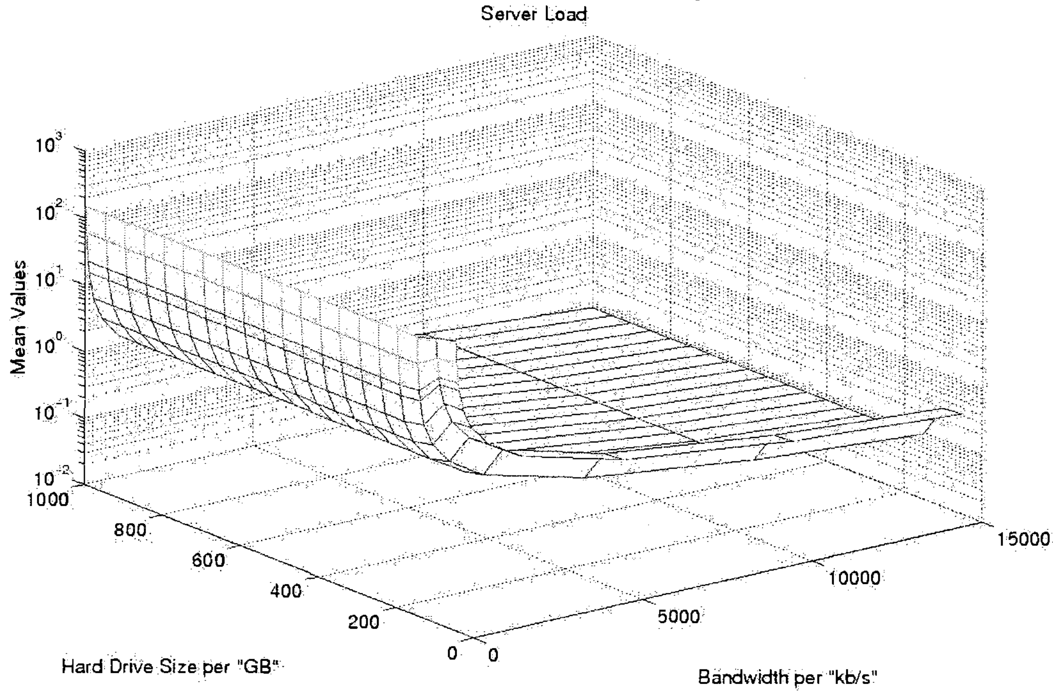


Figure 1025: Server Load for H1 case scenario after interval 2800-hour

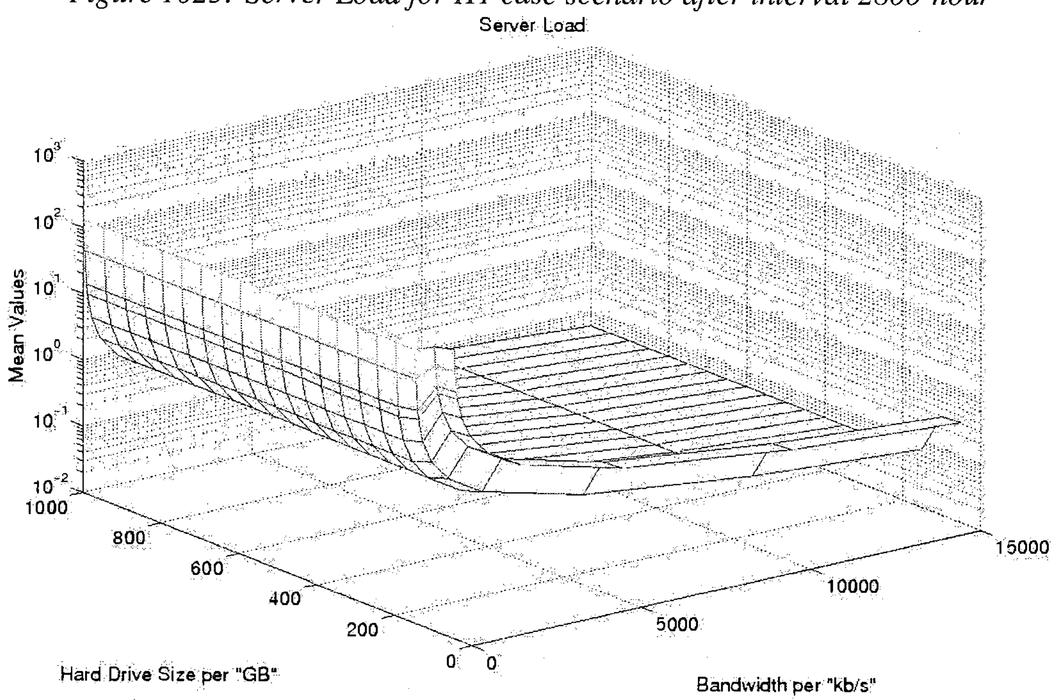


Figure 1026: Server Load for H1 case scenario after interval 3700-hour

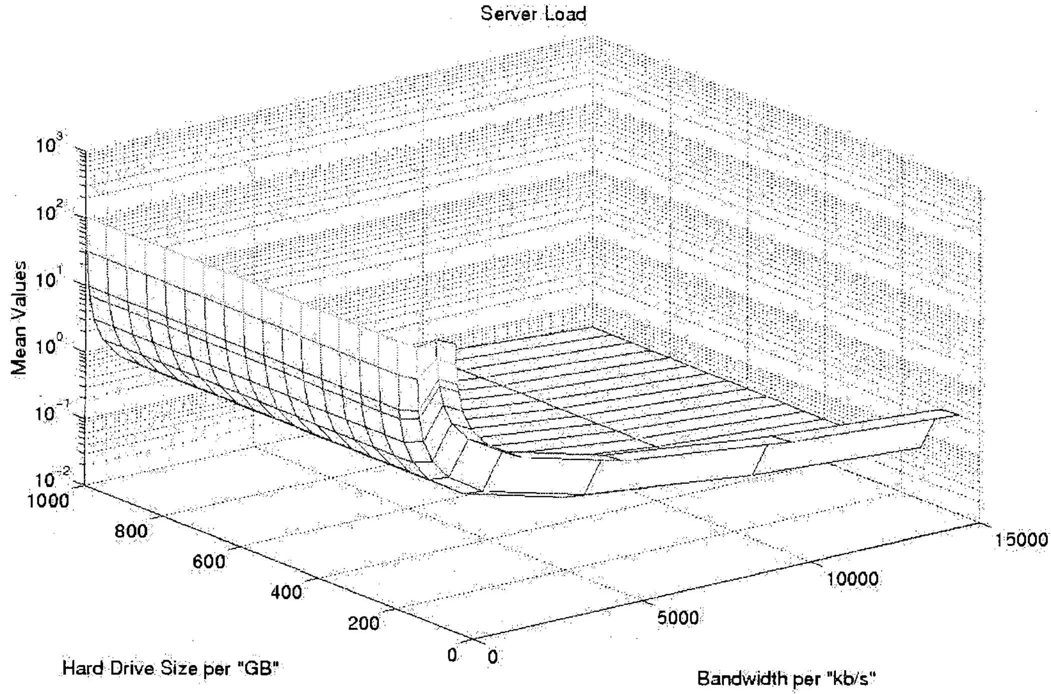


Figure 1027: Server Load for H1 case scenario after interval 4600-hour

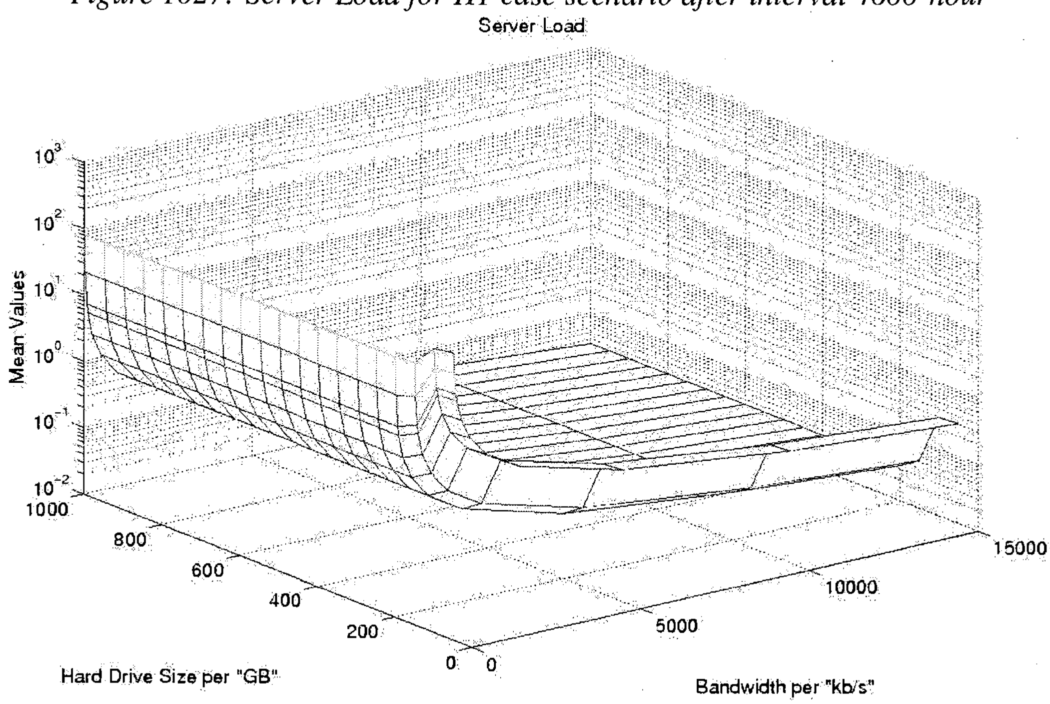


Figure 1028: Server Load for H1 case scenario after interval 5500-hour

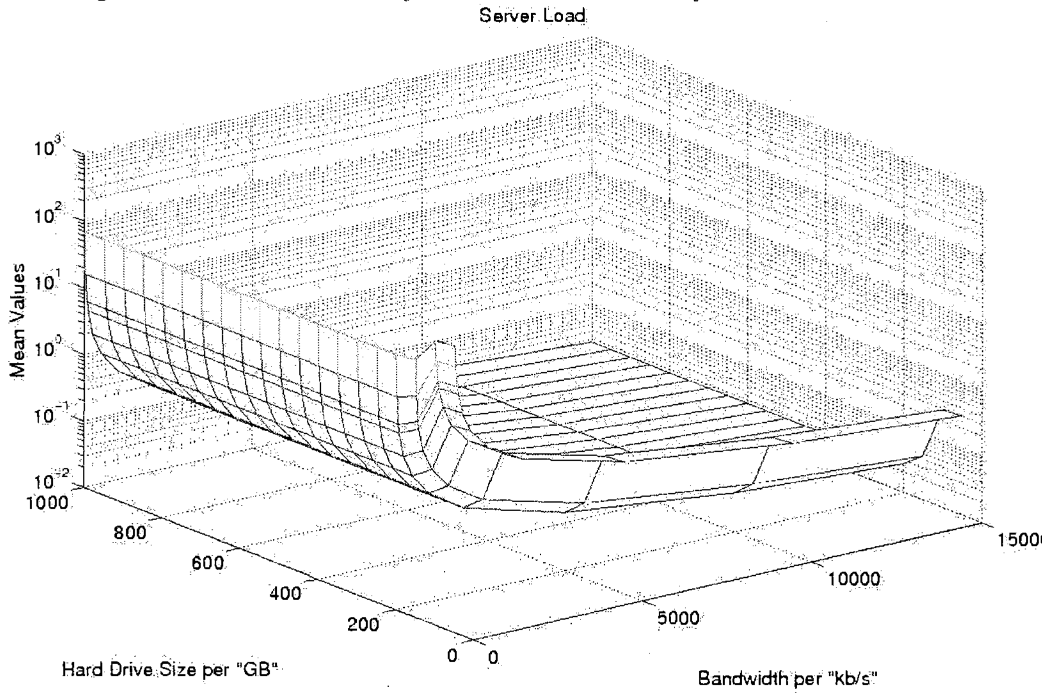


Figure 1029: Server Load for H1 case scenario after interval 6400-hour

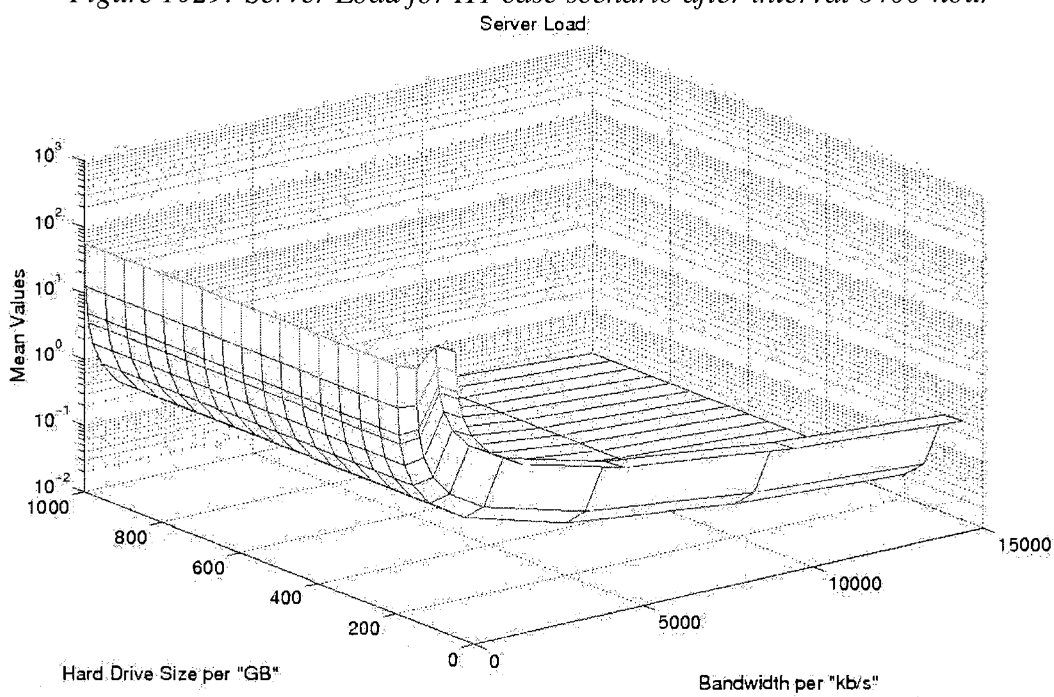


Figure 1030: Server Load for H1 case scenario after interval 7300-hour

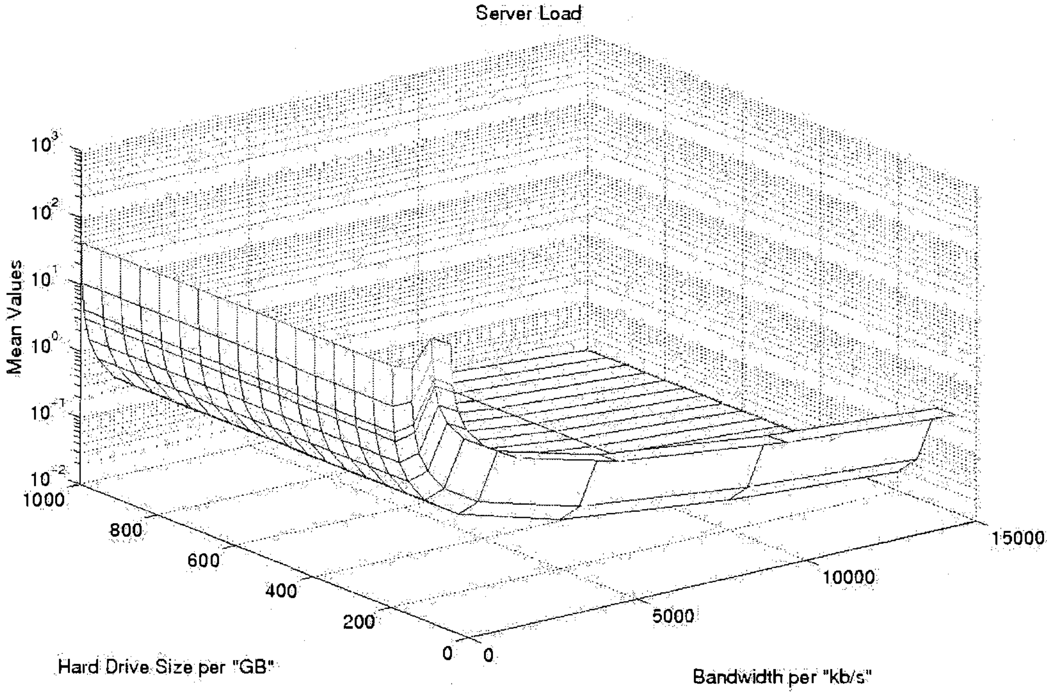


Figure 1031: Server Load for H1 case scenario after interval 8200-hour

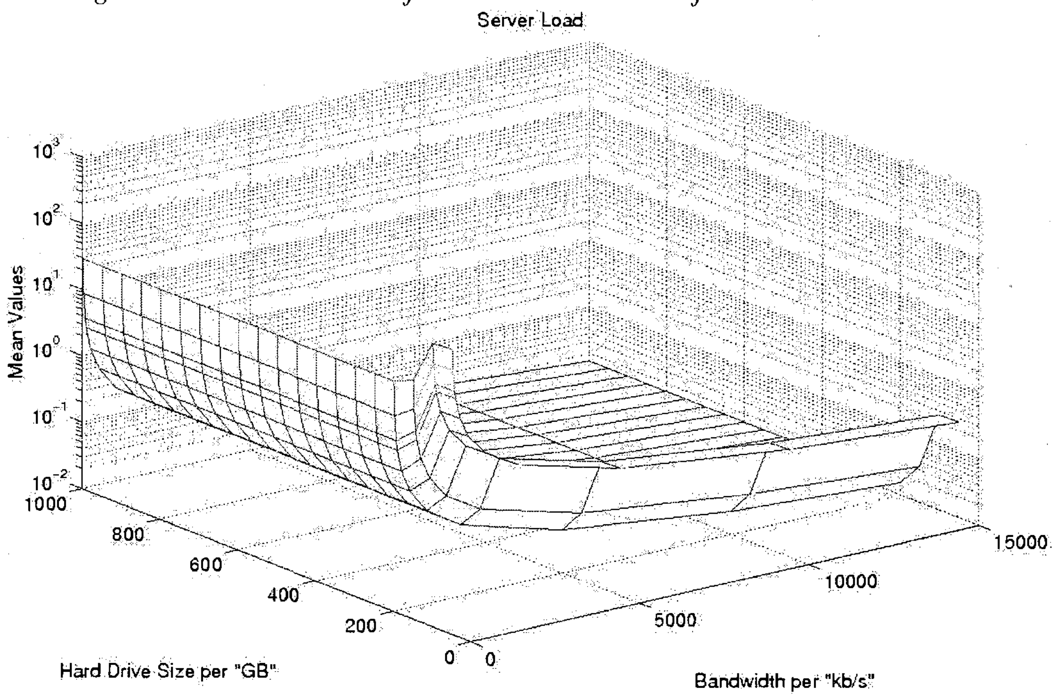


Figure 1032: Server Load for H2 case scenario after interval 100-hour

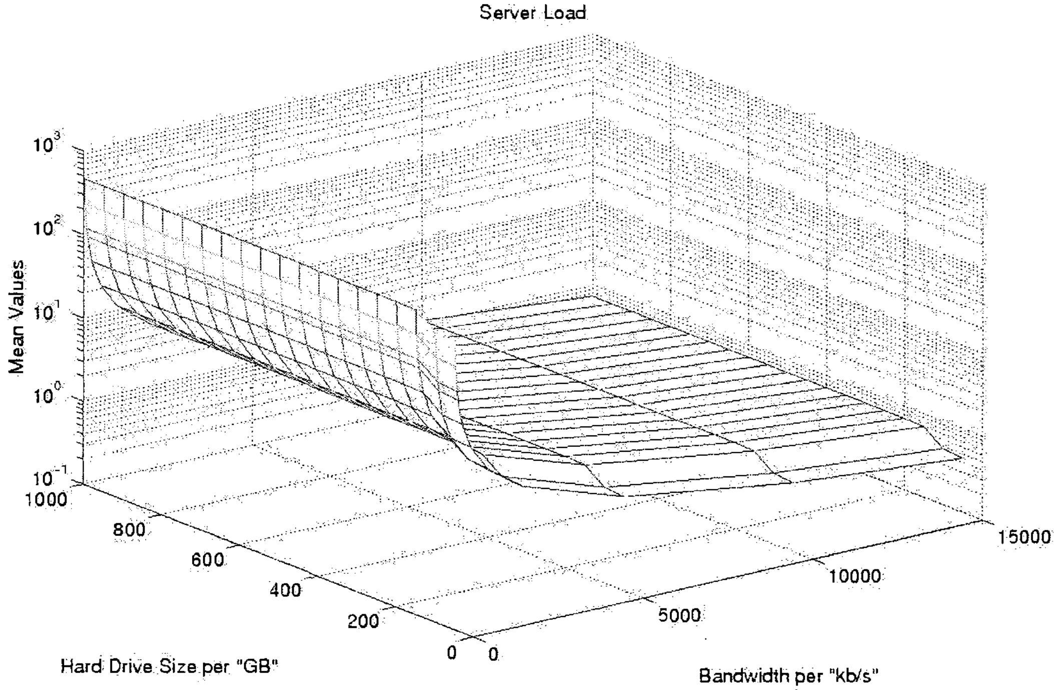


Figure 1033: Server Load for H2 case scenario after interval 1000-hour

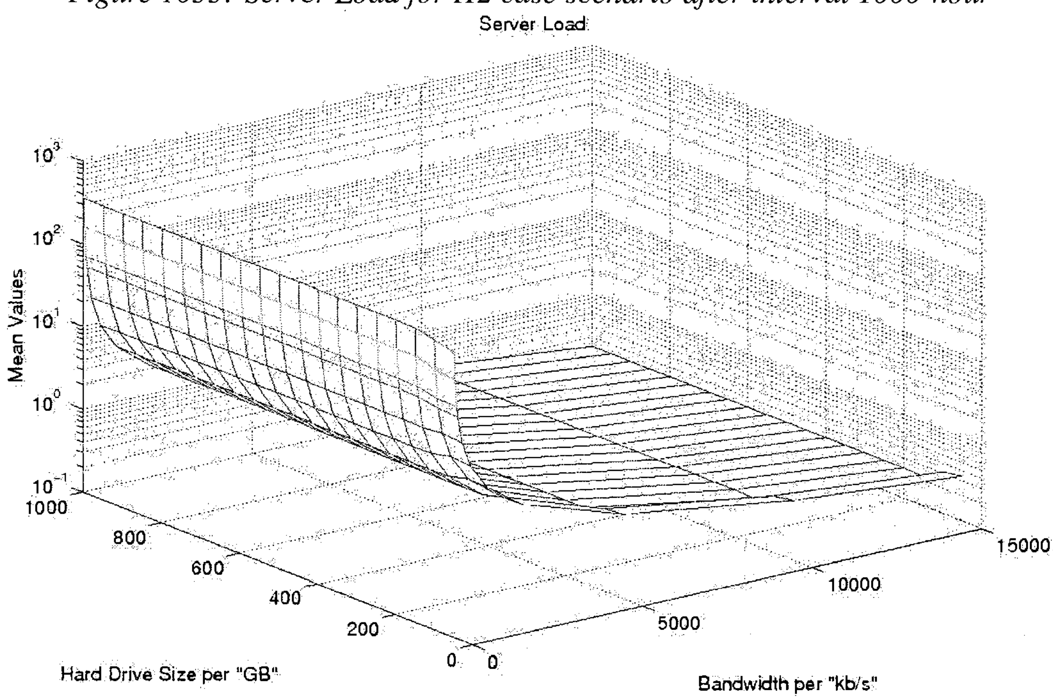


Figure 1034: Server Load for H2 case scenario after interval 1900-hour

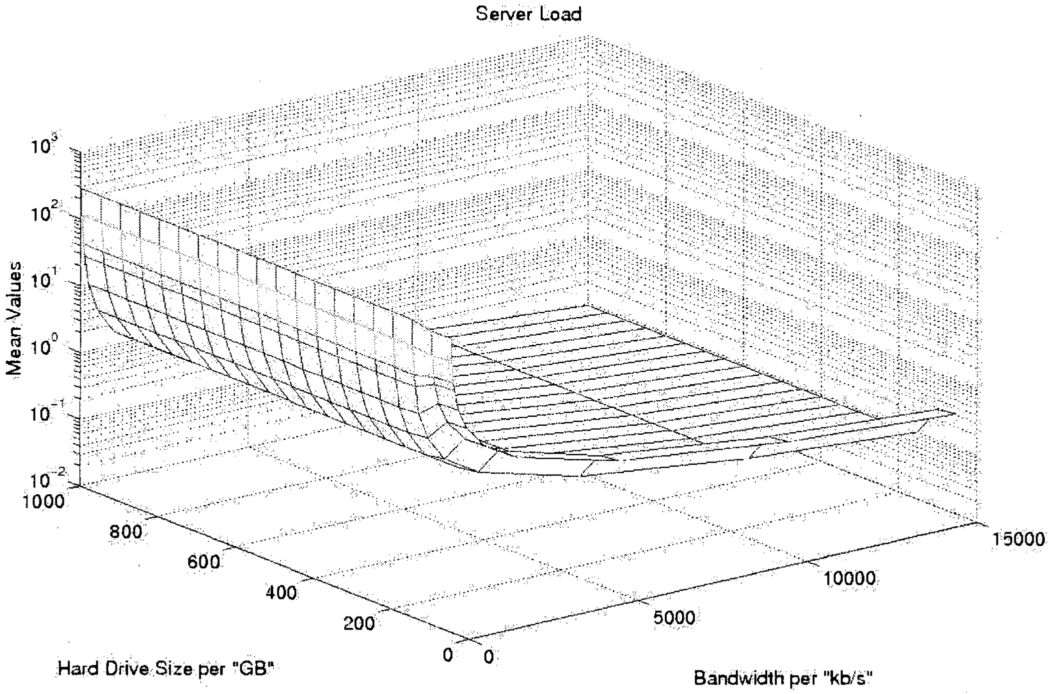


Figure 1035: Server Load for H2 case scenario after interval 2800-hour

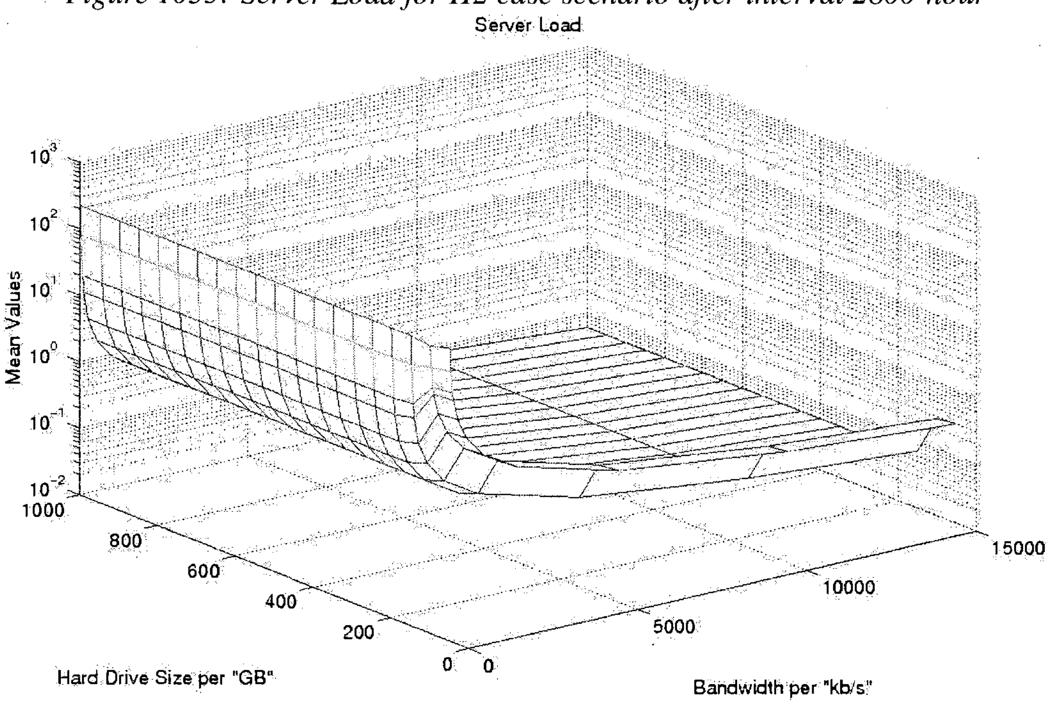


Figure 1036: Server Load for H2 case scenario after interval 3700-hour

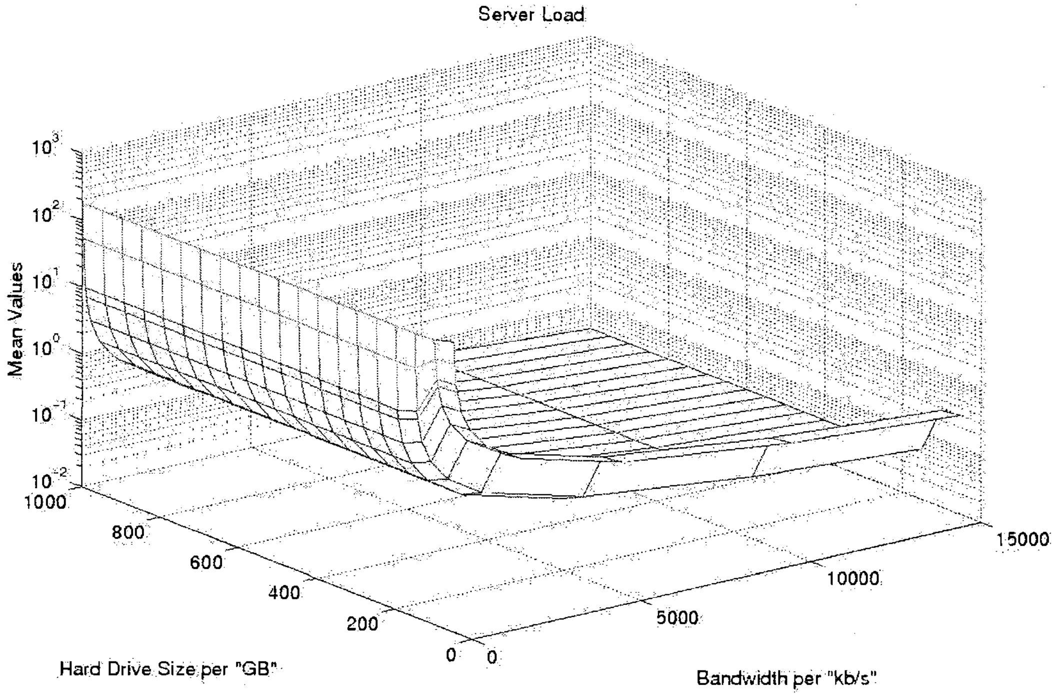


Figure 1037: Server Load for H2 case scenario after interval 4600-hour

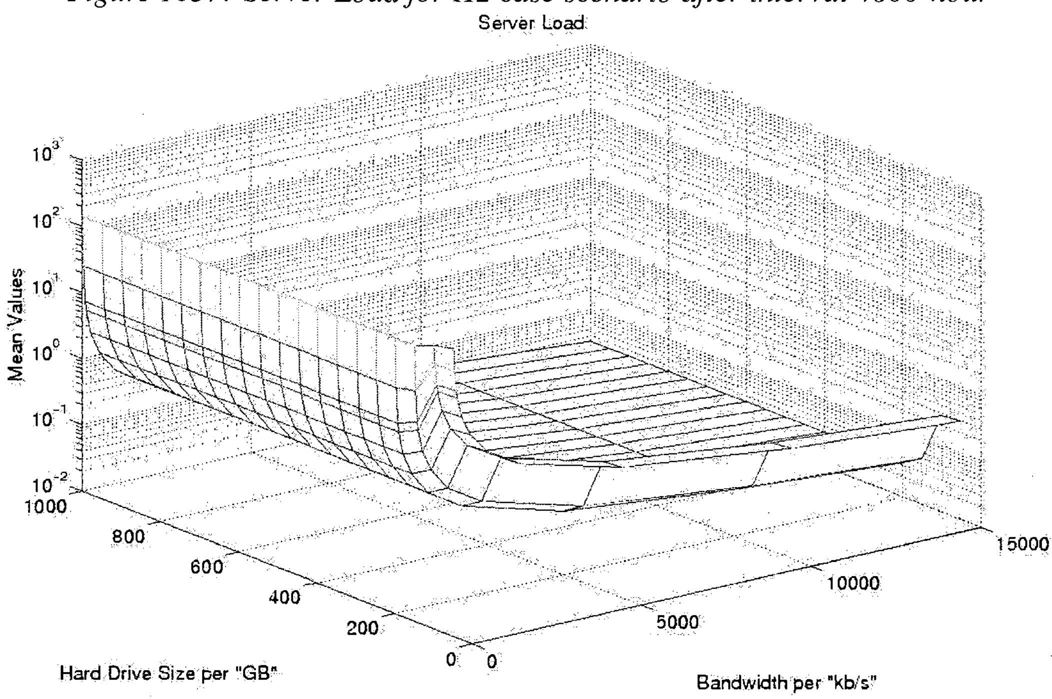


Figure 1038: Server Load for H2 case scenario after interval 5500-hour

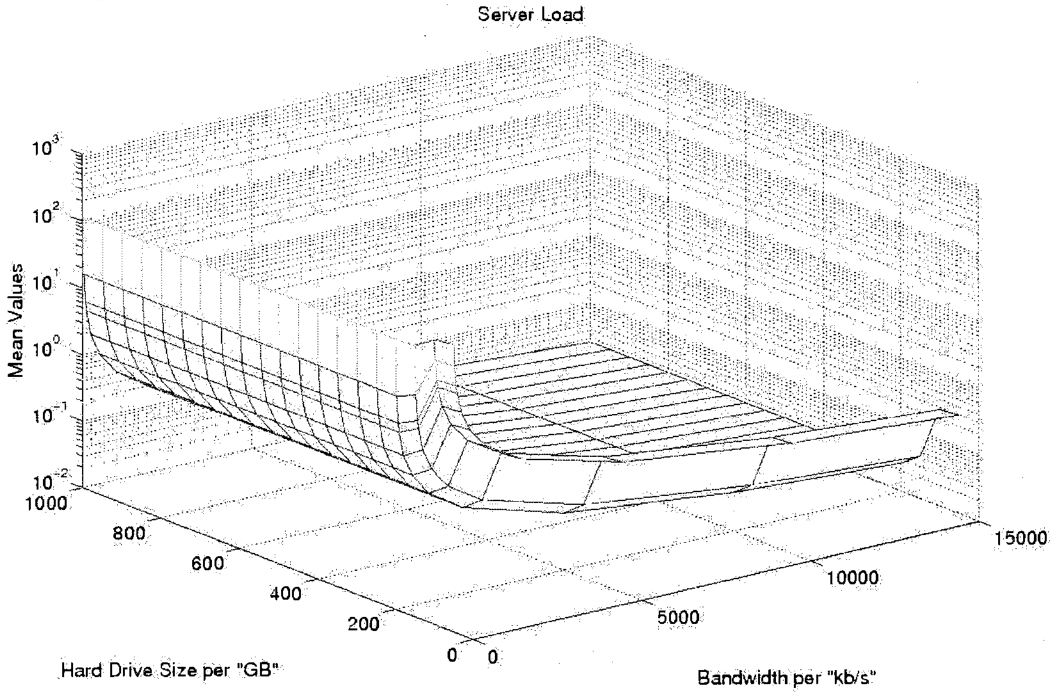


Figure 1039: Server Load for H2 case scenario after interval 6400-hour

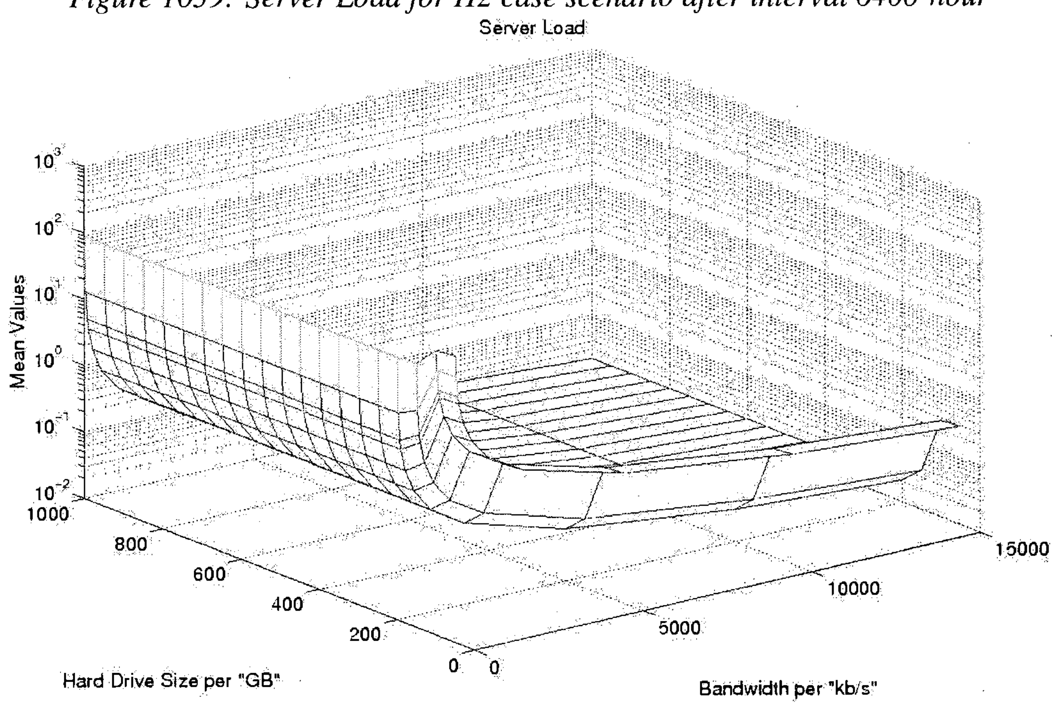


Figure 1040: Server Load for H2 case scenario after interval 7300-hour

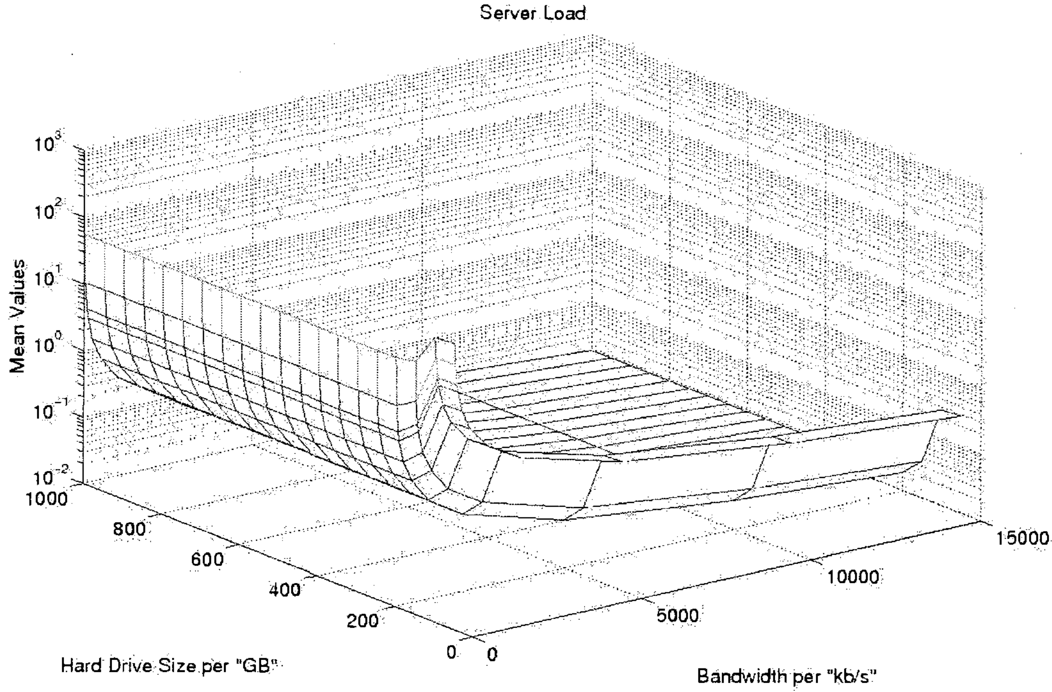


Figure 1041: Server Load for H2 case scenario after interval 8200-hour

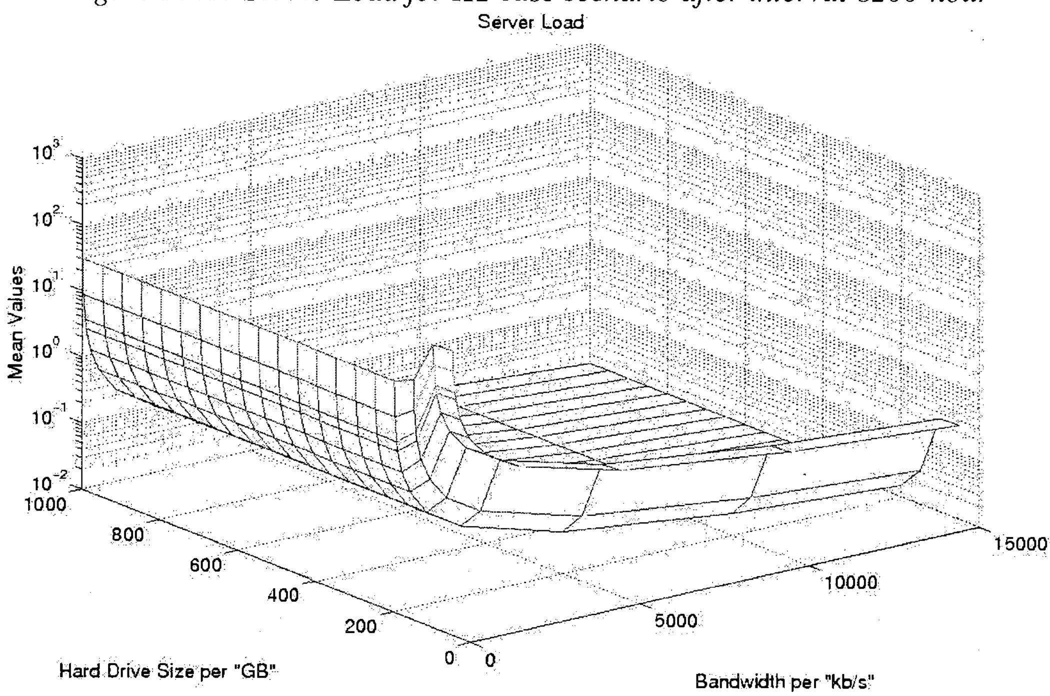


Figure 1042: Server Load for H3 case scenario after interval 100-hour

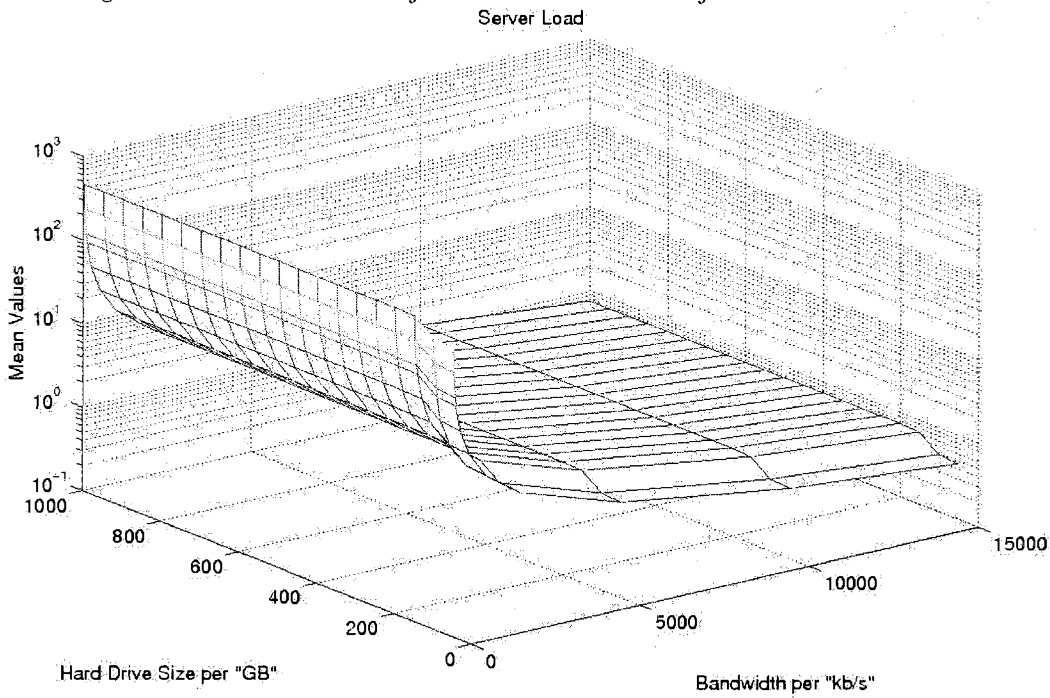


Figure 1043: Server Load for H3 case scenario after interval 1000-hour

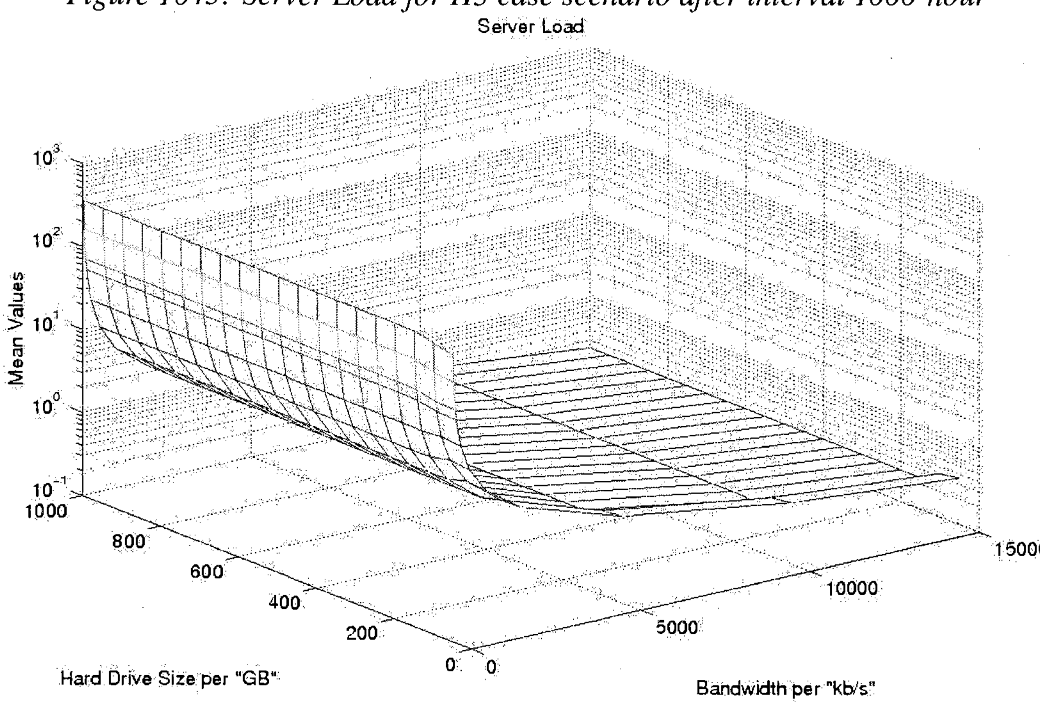


Figure 1044: Server Load for H3 case scenario after interval 1900-hour

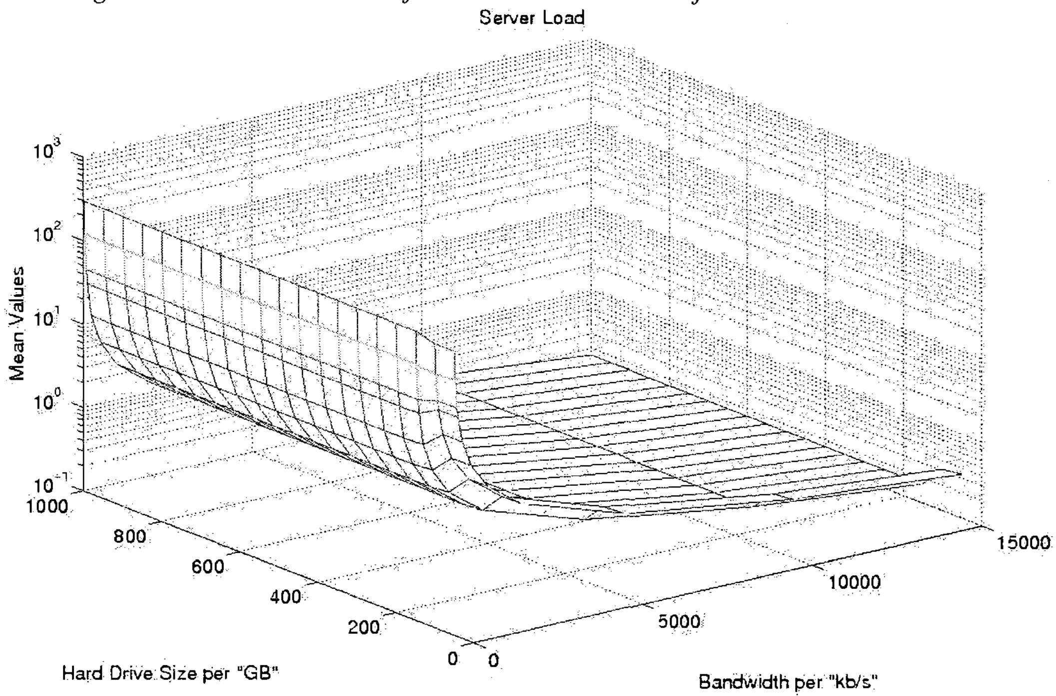


Figure 1045: Server Load for H3 case scenario after interval 2800-hour

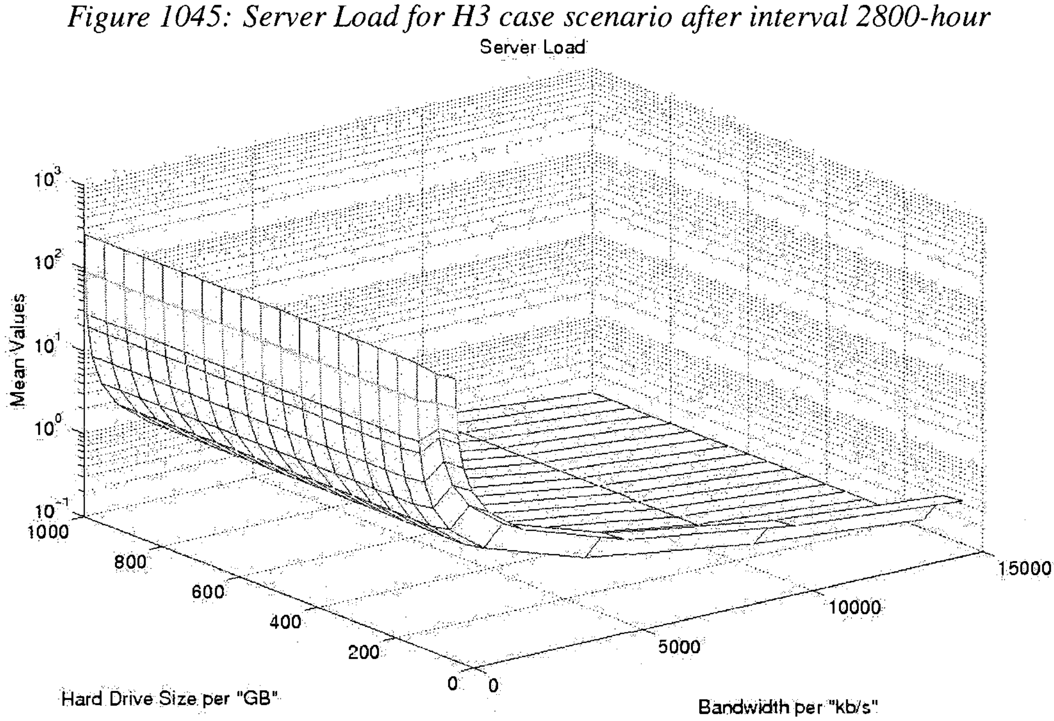


Figure 1046: Server Load for H3 case scenario after interval 3700-hour

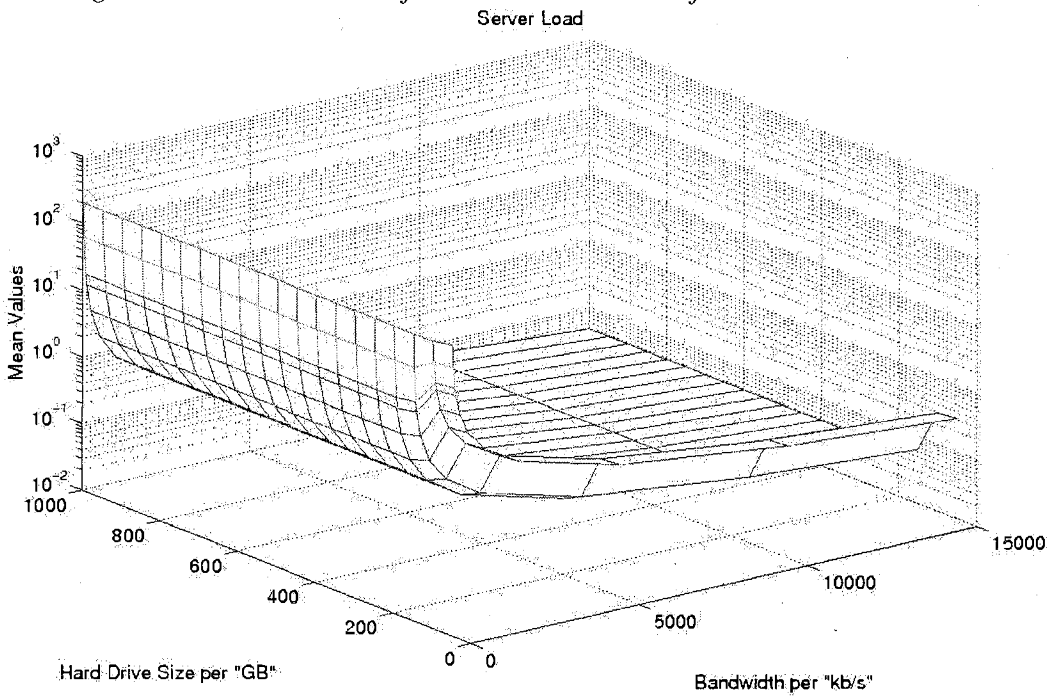


Figure 1047: Server Load for H3 case scenario after interval 4600-hour

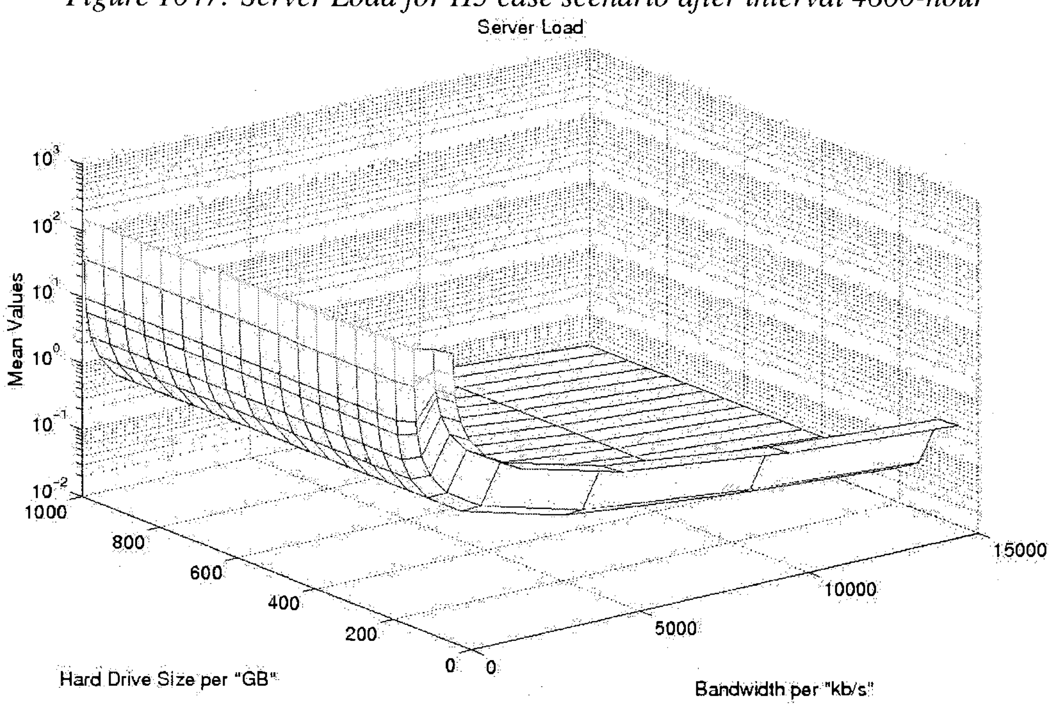


Figure 1048: Server Load for H3 case scenario after interval 5500-hour

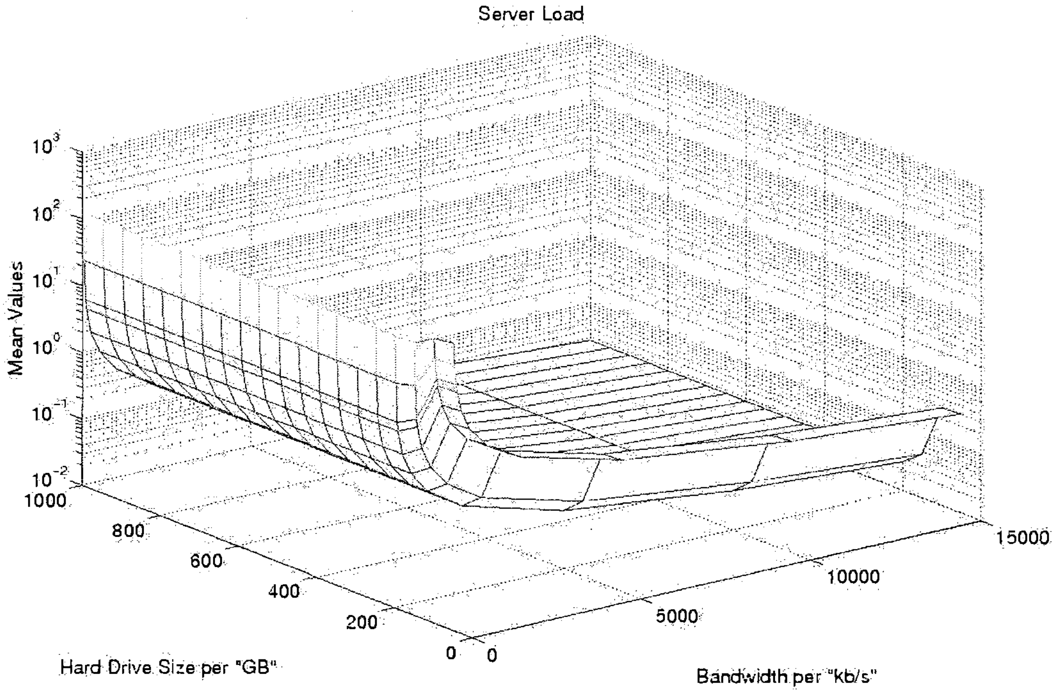


Figure 1049: Server Load for H3 case scenario after interval 6400-hour

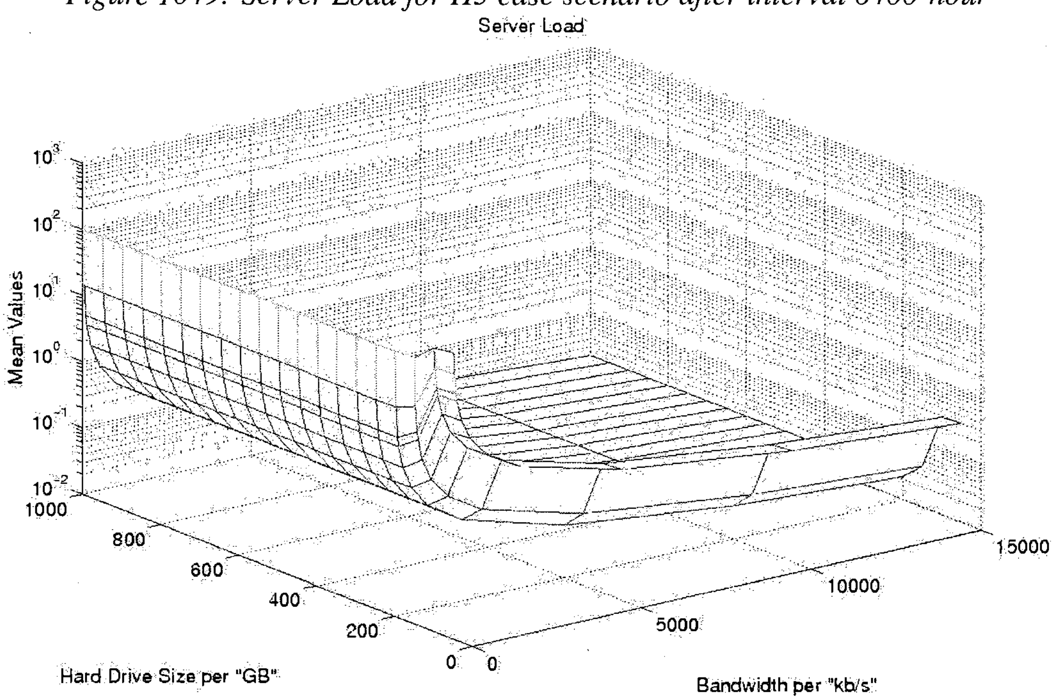


Figure 1050: Server Load for H3 case scenario after interval 7300-hour

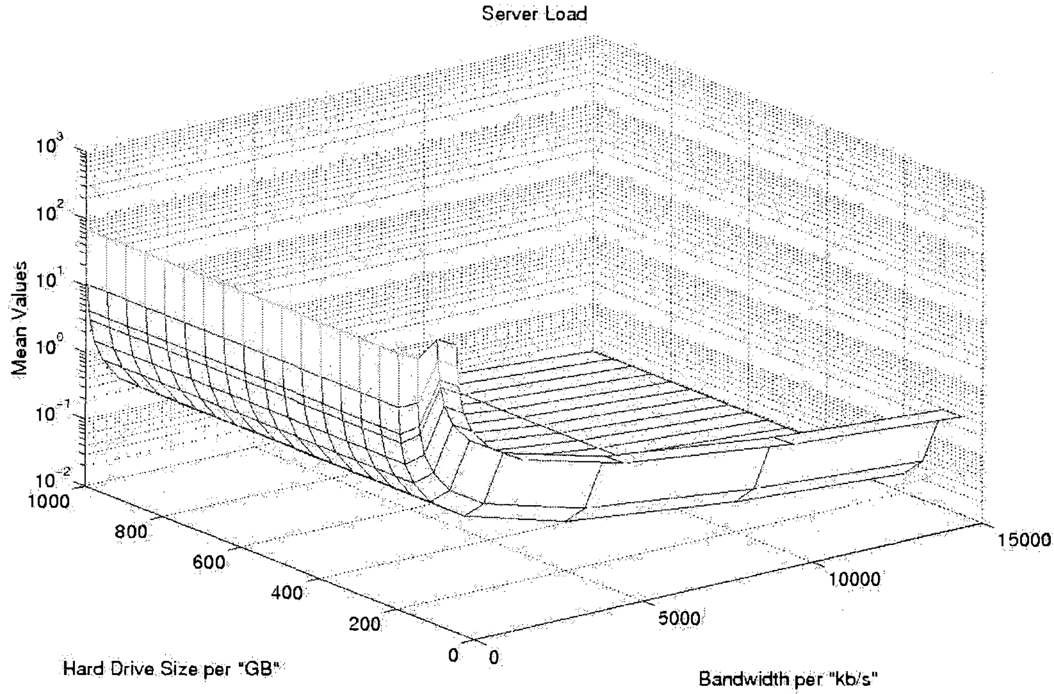


Figure 1051: Server Load for H3 case scenario after interval 8200-hour

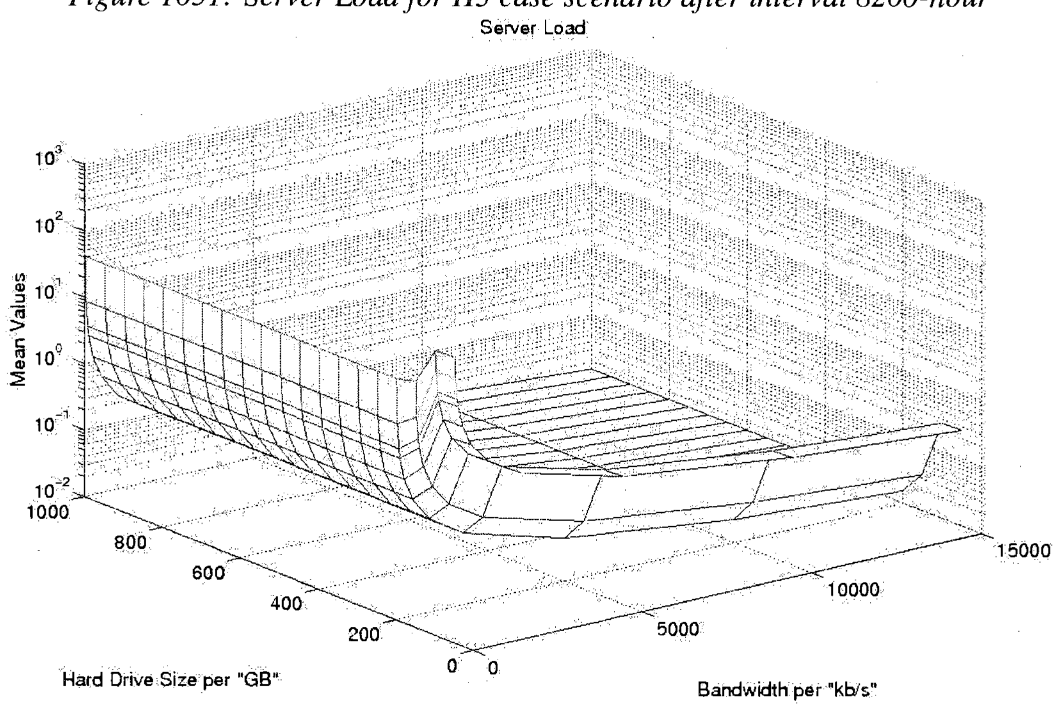


Figure 1052: Server Load for H4 case scenario after interval 100-hour

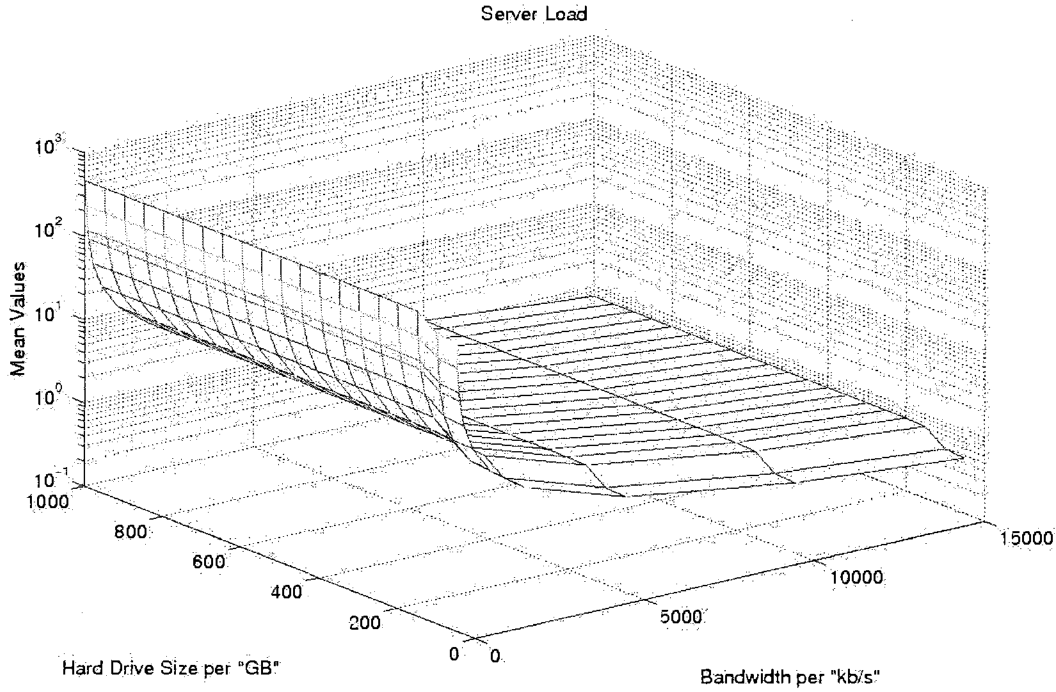


Figure 1053: Server Load for H4 case scenario after interval 1000-hour

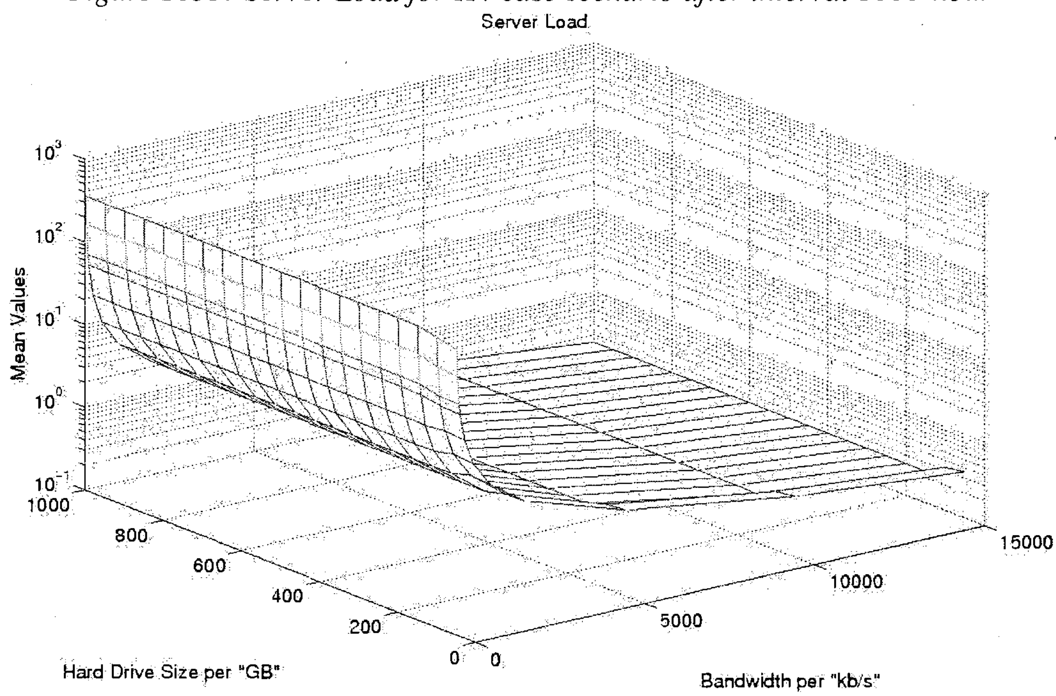


Figure 1054: Server Load for H4 case scenario after interval 1900-hour

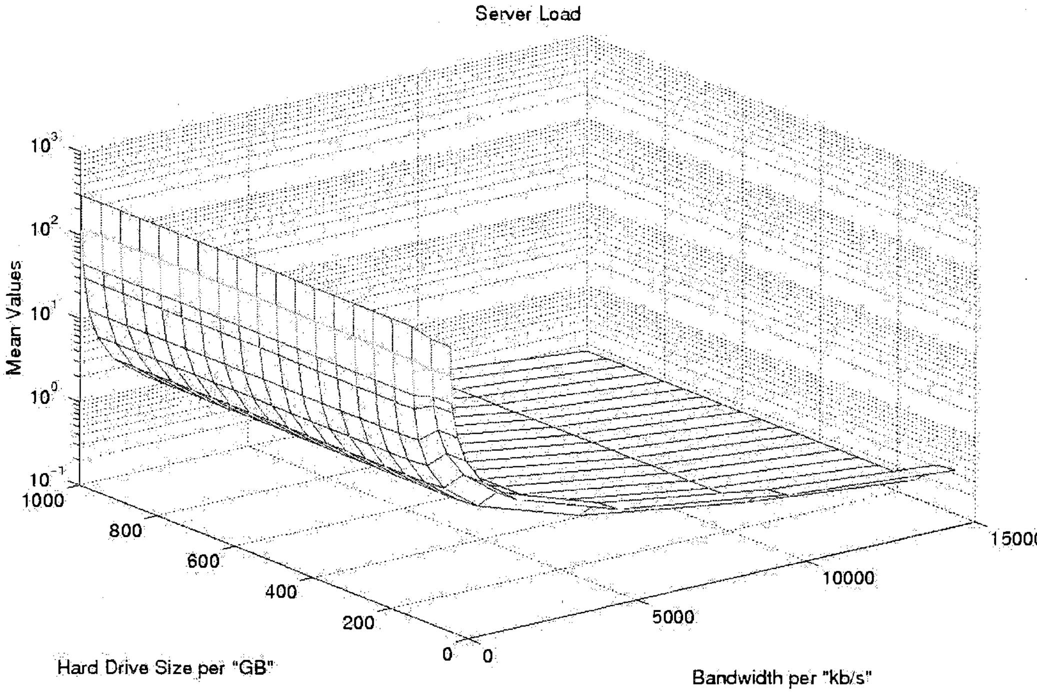


Figure 1055: Server Load for H4 case scenario after interval 2800-hour

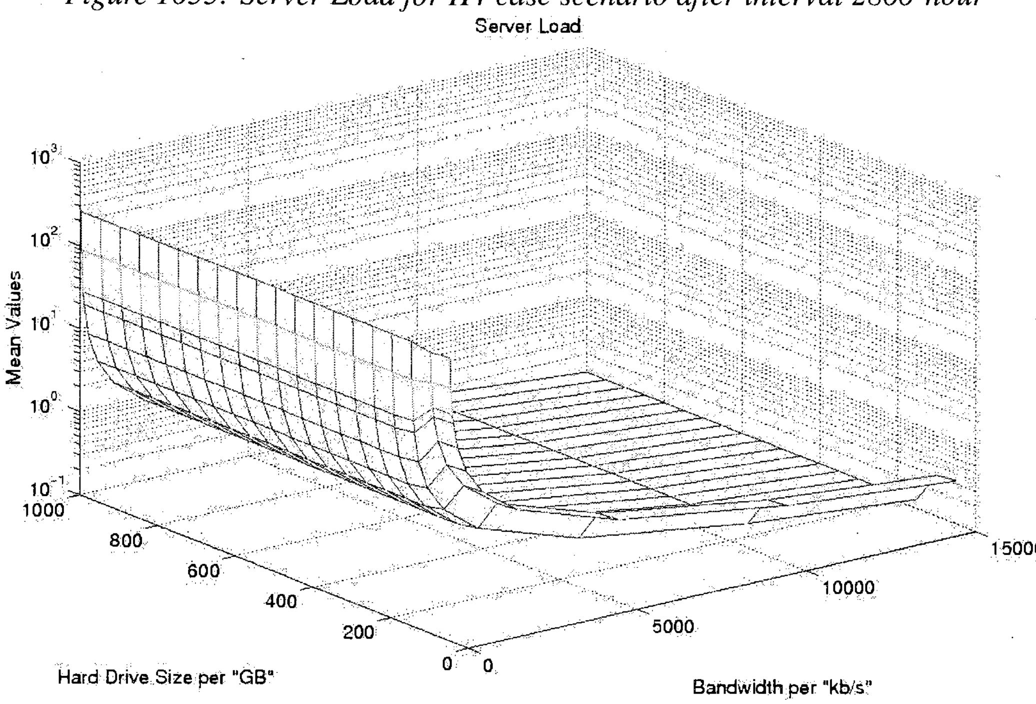


Figure 1056: Server Load for H4 case scenario after interval 3700-hour

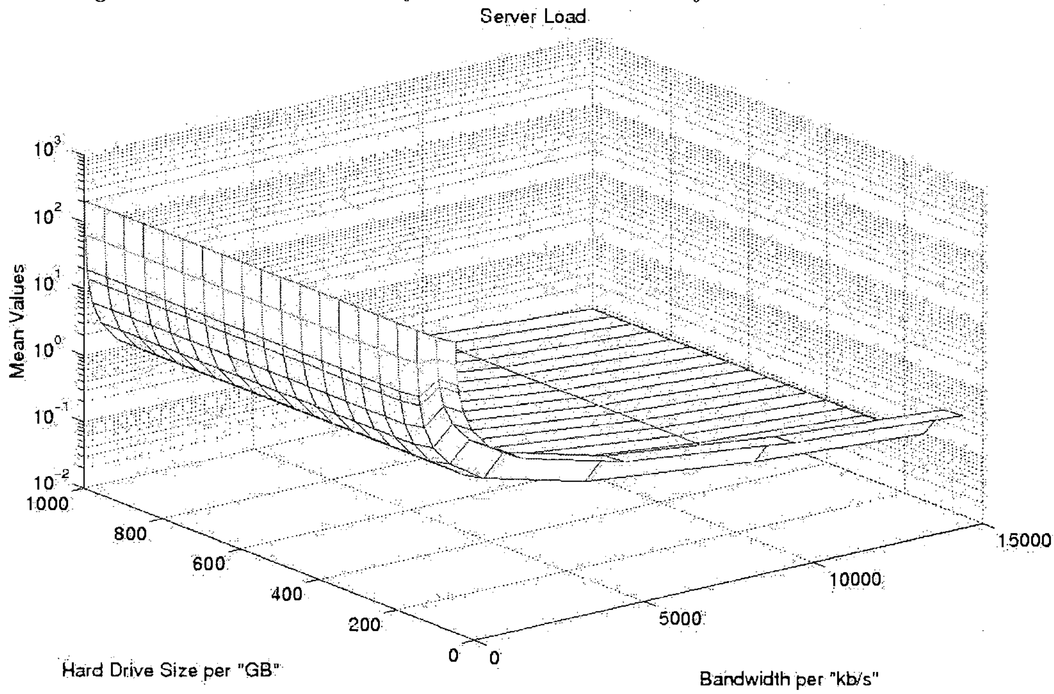


Figure 1057: Server Load for H4 case scenario after interval 4600-hour

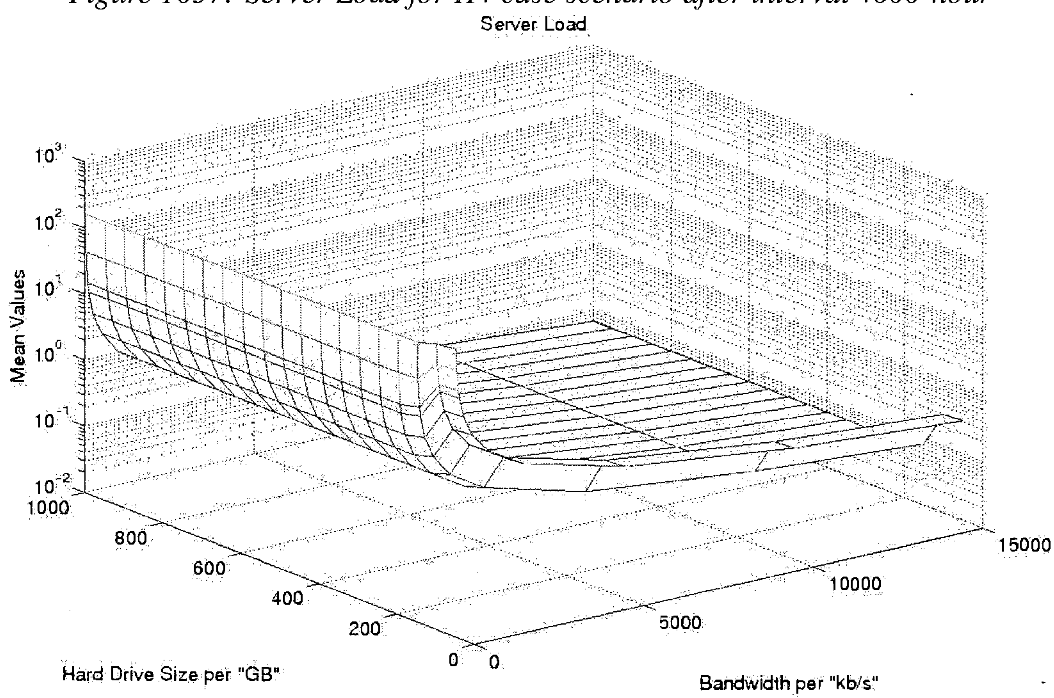


Figure 1058: Server Load for H4 case scenario after interval 5500-hour

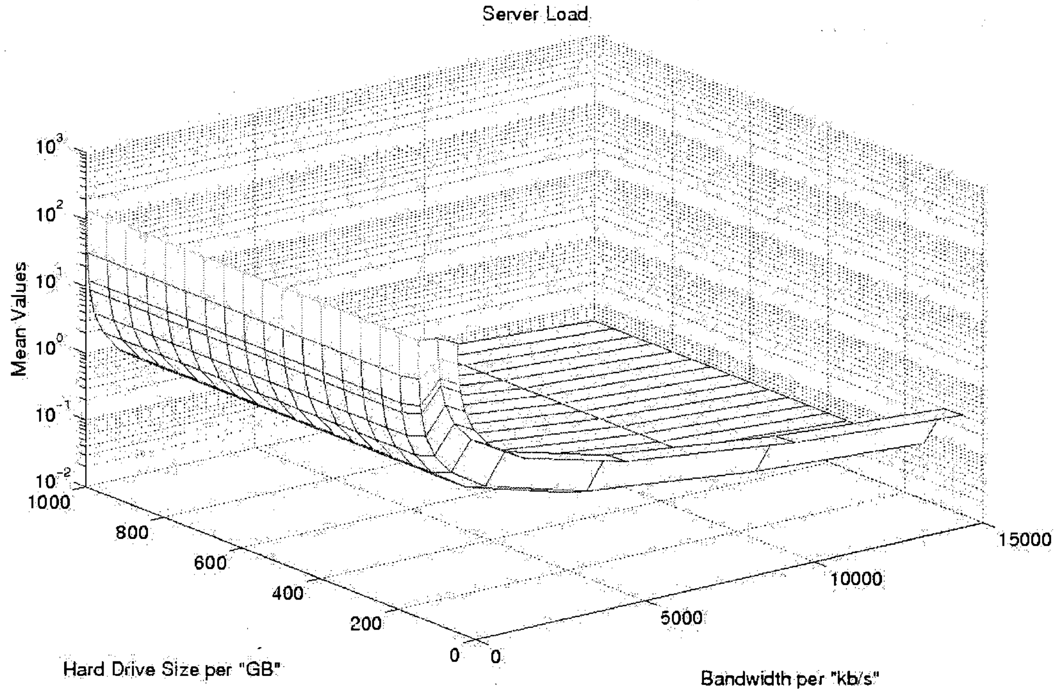


Figure 1059: Server Load for H4 case scenario after interval 6400-hour

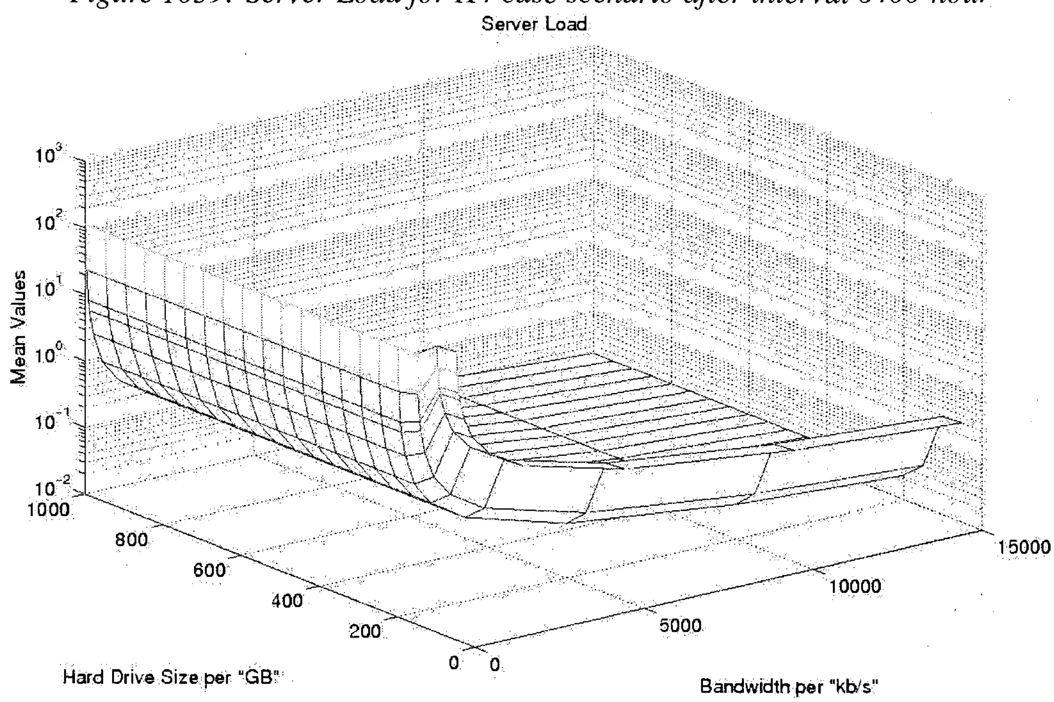


Figure 1060: Server Load for H4 case scenario after interval 7300-hour

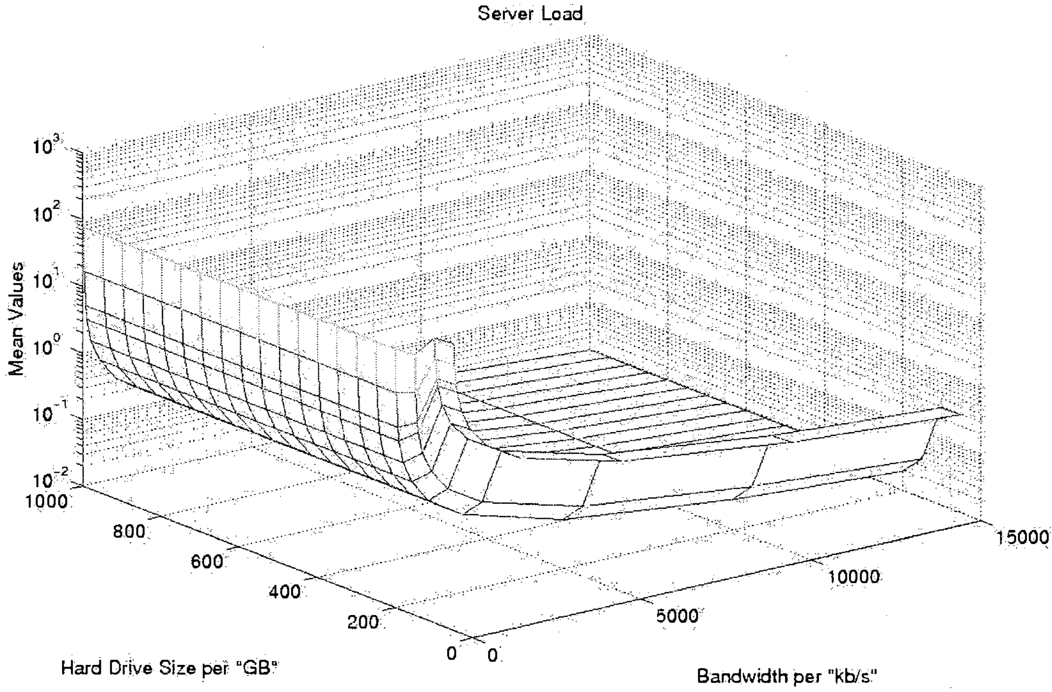


Figure 1061: Server Load for H4 case scenario after interval 8200-hour

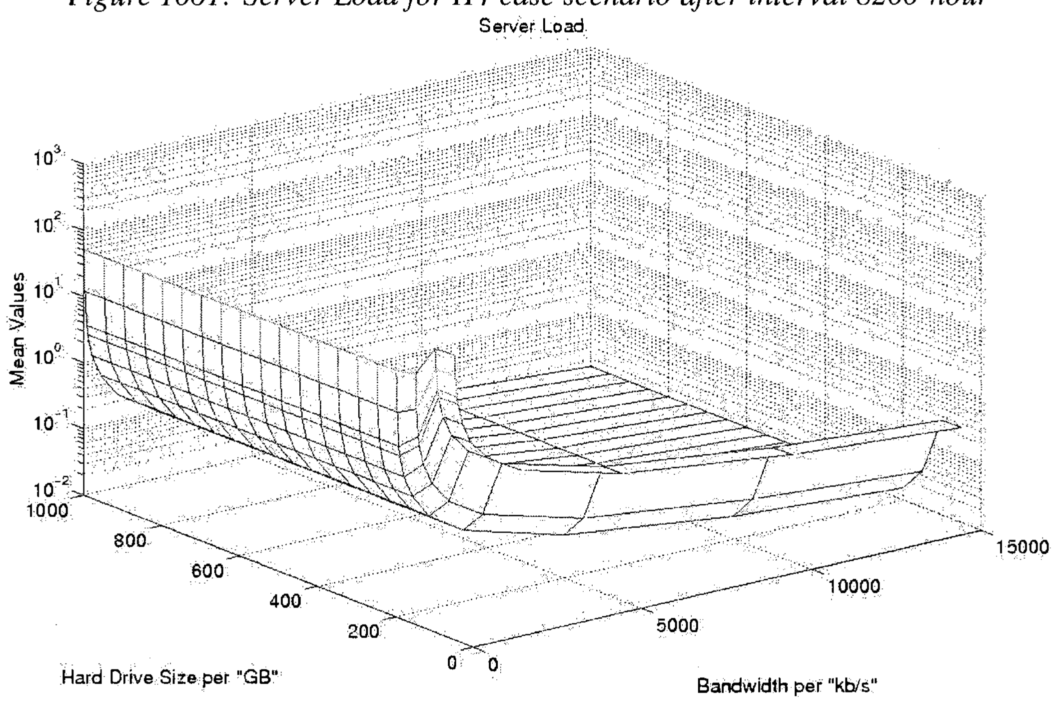


Figure 1062: Penalty for H1 case scenario after interval 100-hour

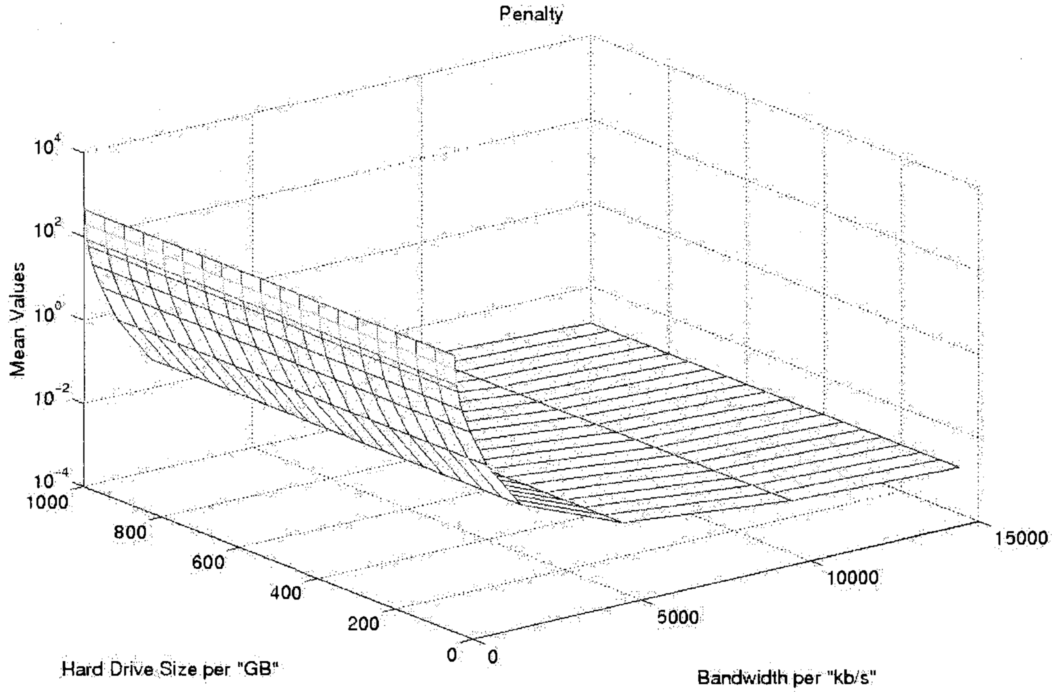


Figure 1063: Penalty for H1 case scenario after interval 1000-hour

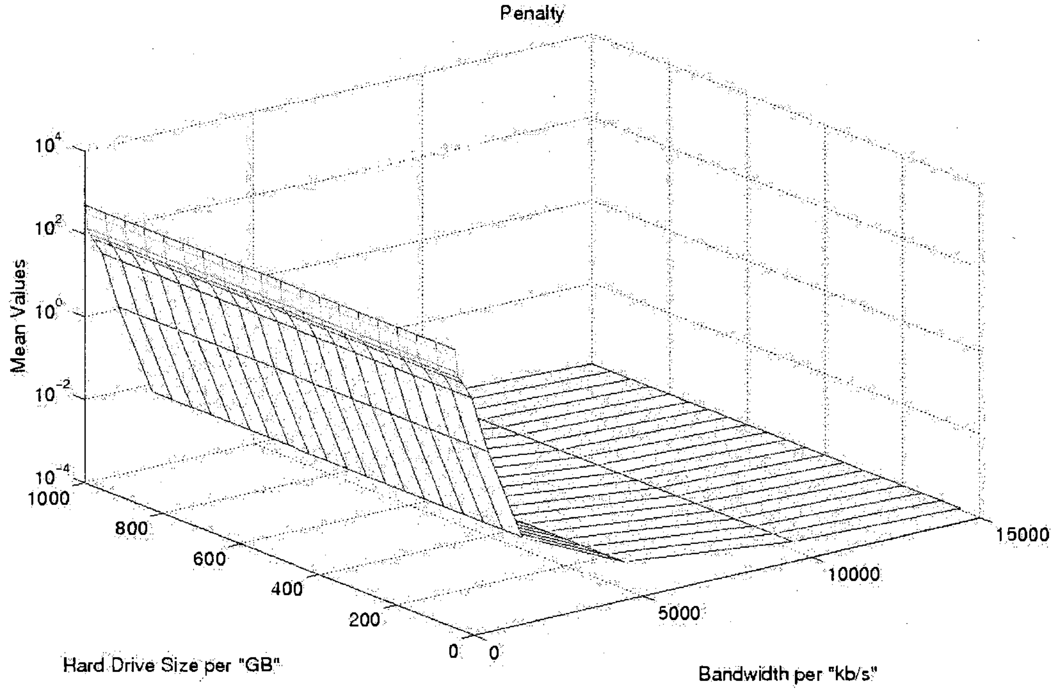


Figure 1064: Penalty for H1 case scenario after interval 1900-hour

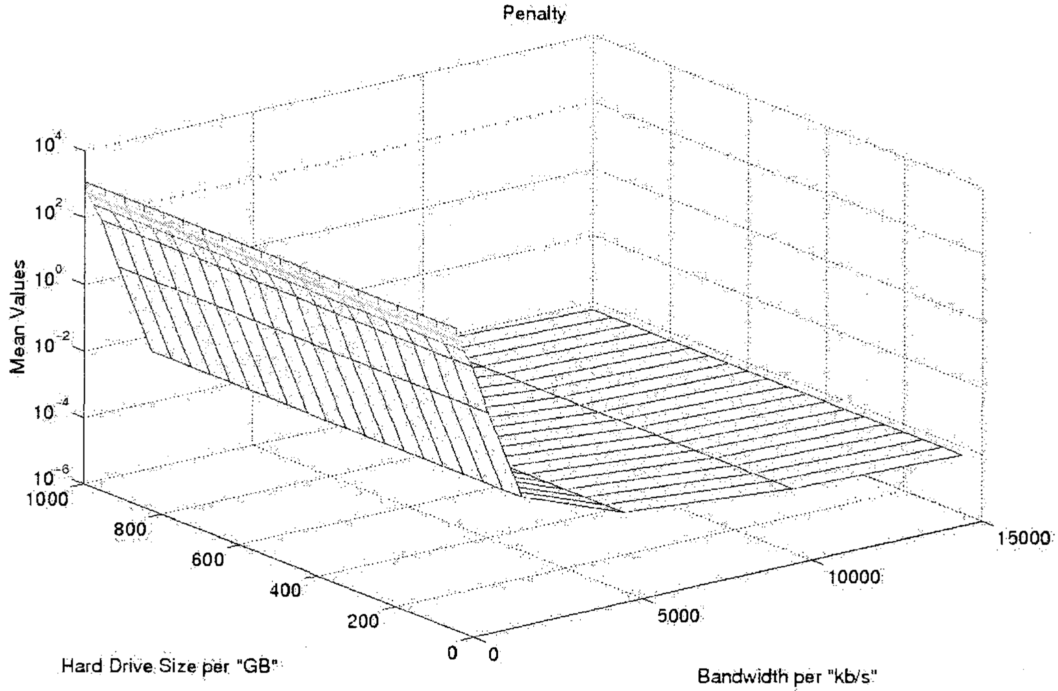


Figure 1065: Penalty for H1 case scenario after interval 2800-hour

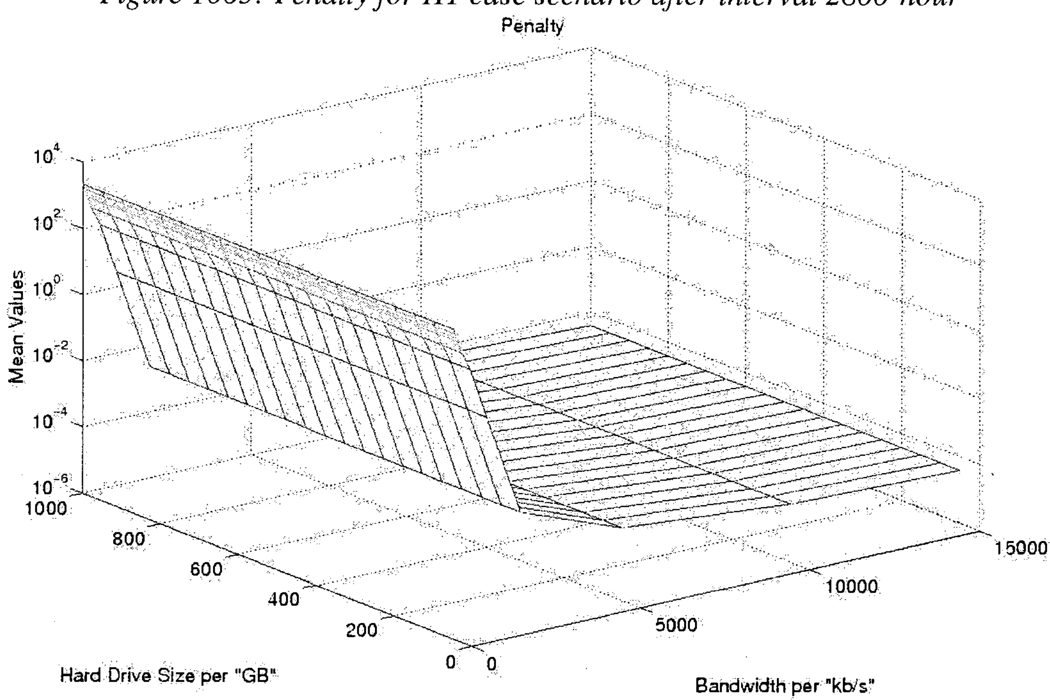


Figure 1066: Penalty for H1 case scenario after interval 3700-hour

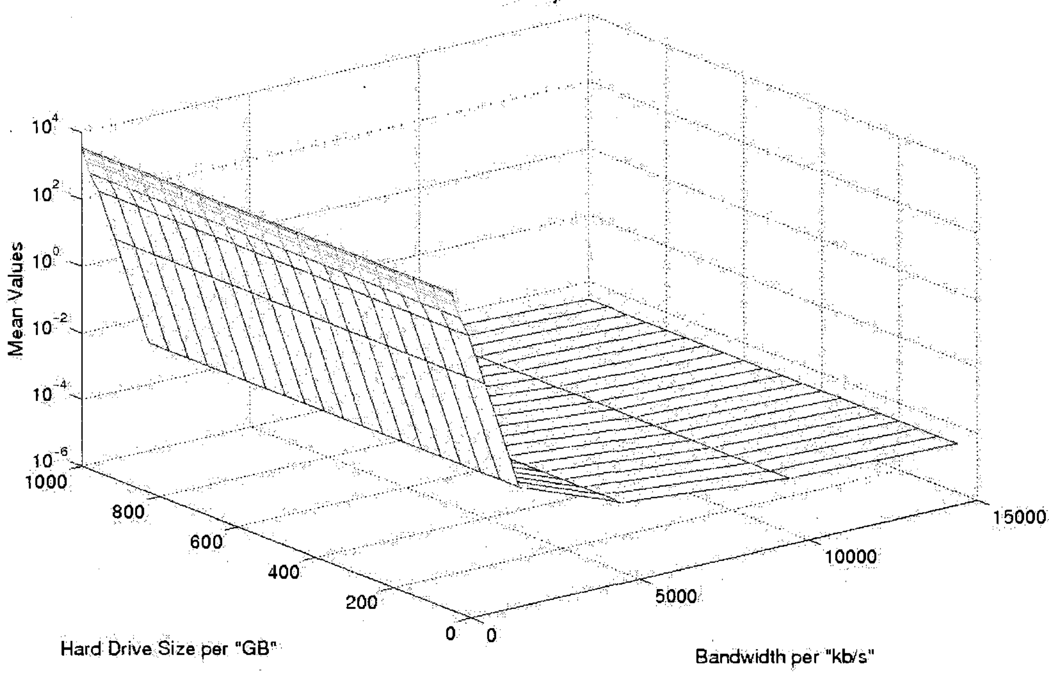


Figure 1067: Penalty for H1 case scenario after interval 4600-hour

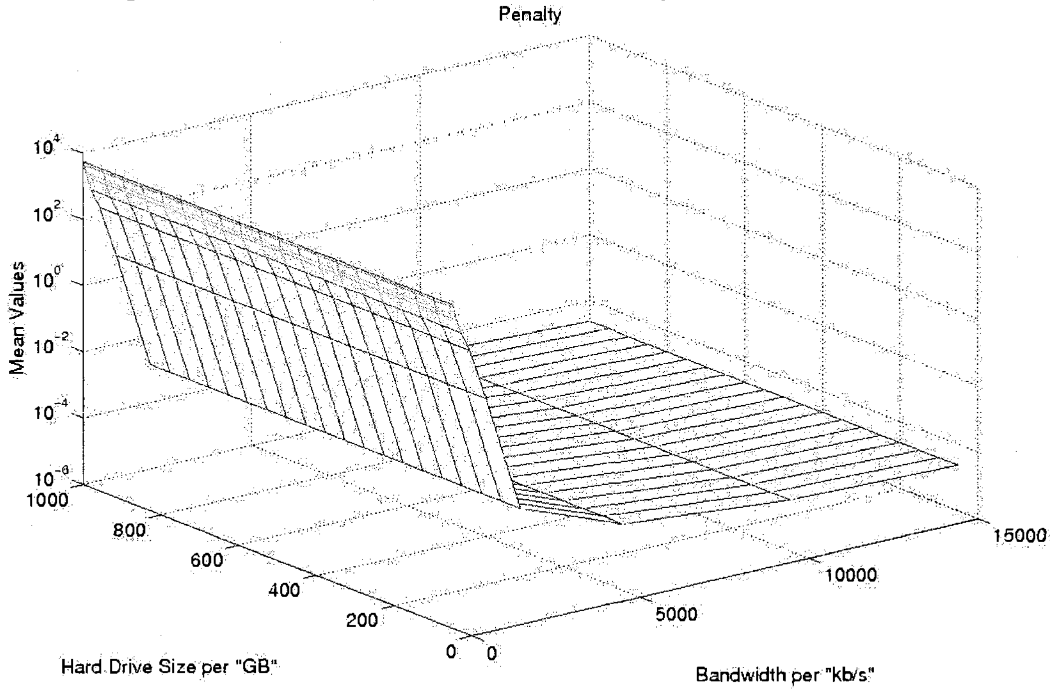


Figure 1068: Penalty for H1 case scenario after interval 5500-hour

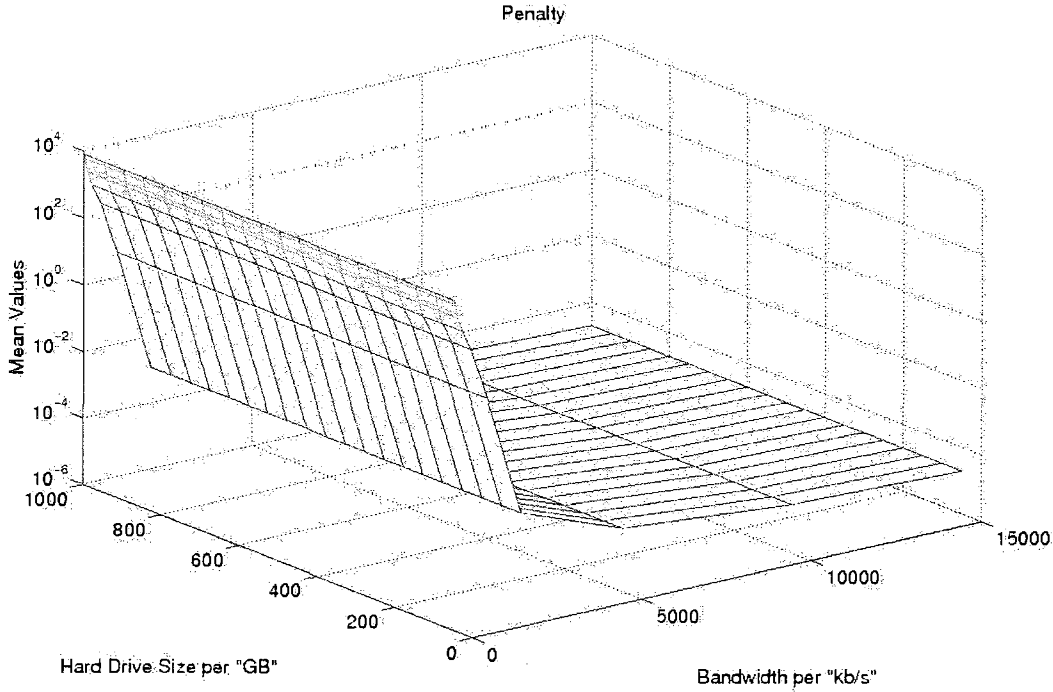


Figure 1069: Penalty for H1 case scenario after interval 6400-hour

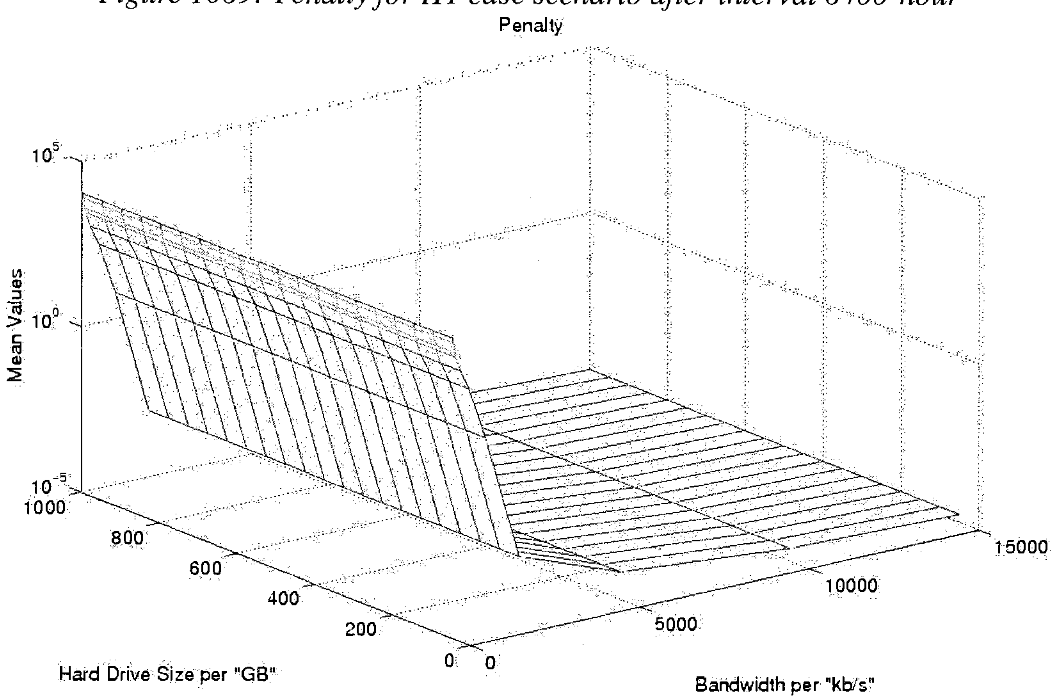


Figure 1070: Penalty for H1 case scenario after interval 7300-hour

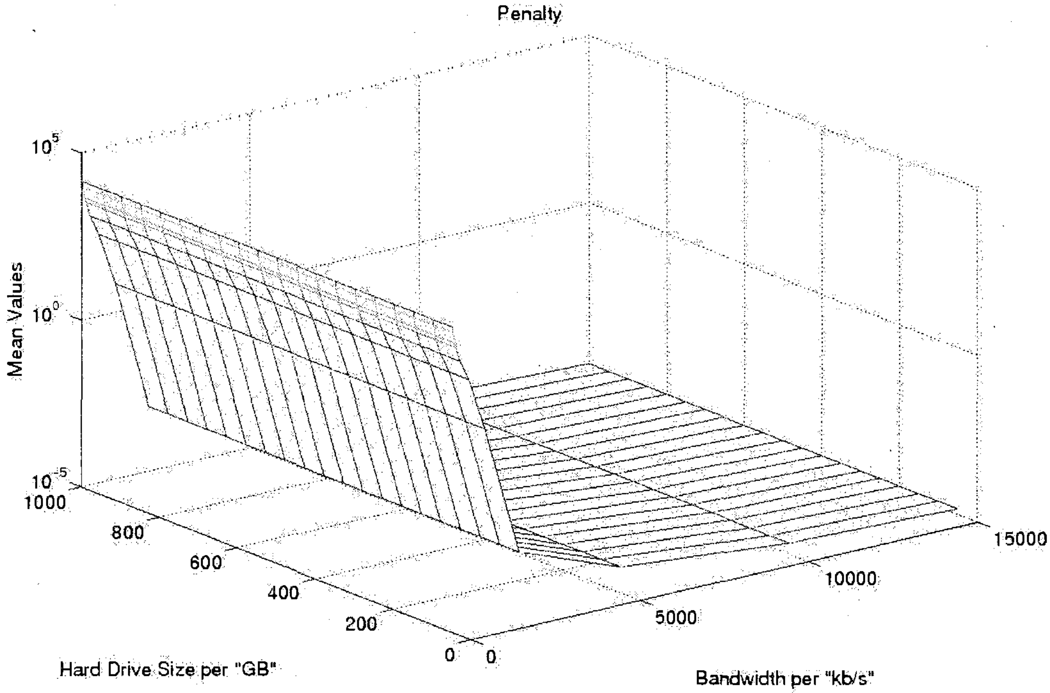


Figure 1071: Penalty for H1 case scenario after interval 8200-hour

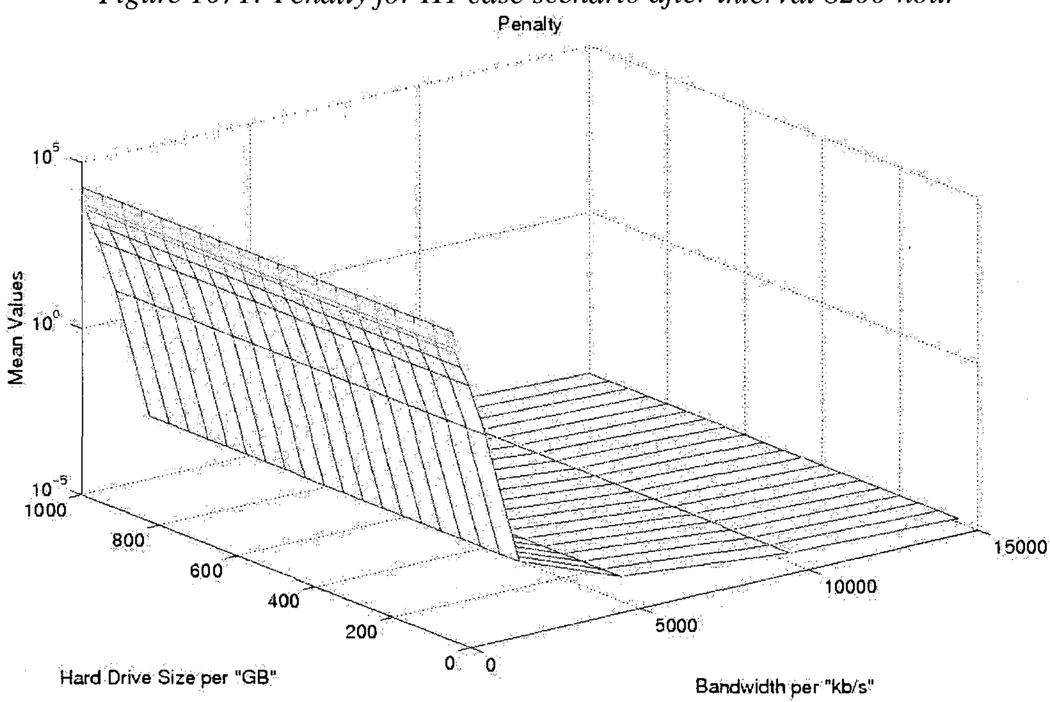


Figure 1072: Penalty for H2 case scenario after interval 100-hour

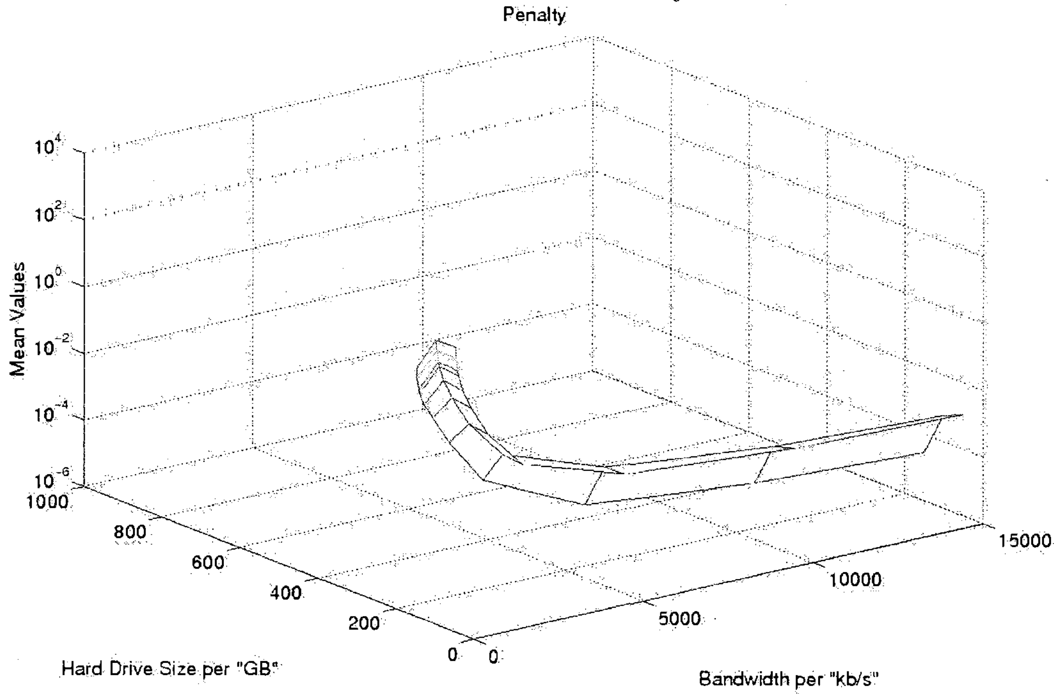


Figure 1073: Penalty for H2 case scenario after interval 1000-hour

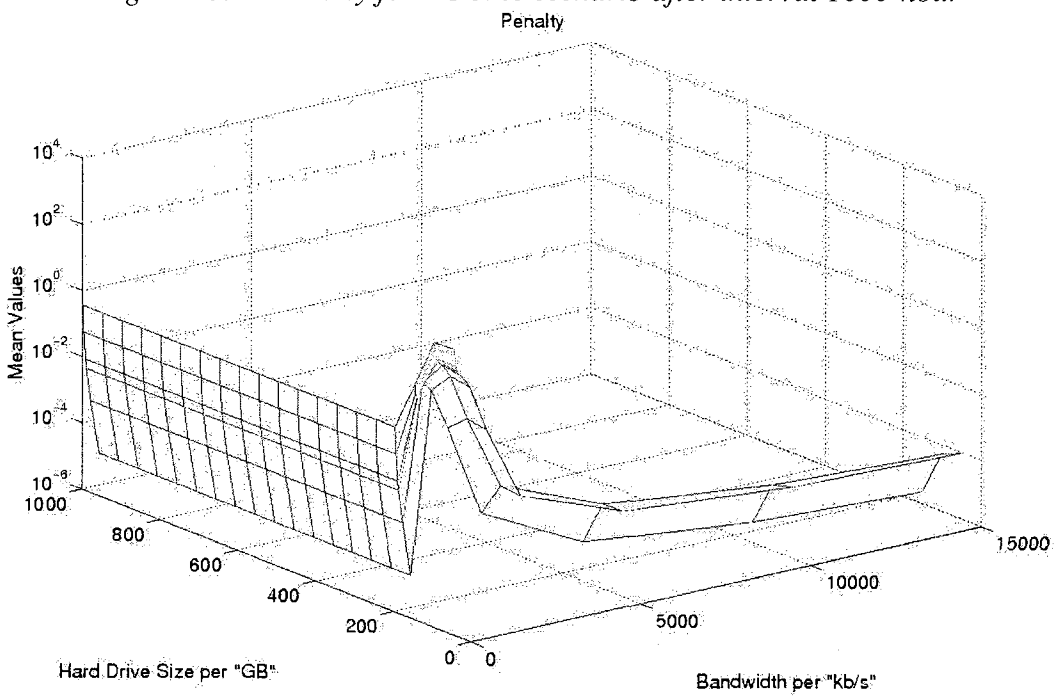


Figure 1074: Penalty for H2 case scenario after interval 1900-hour

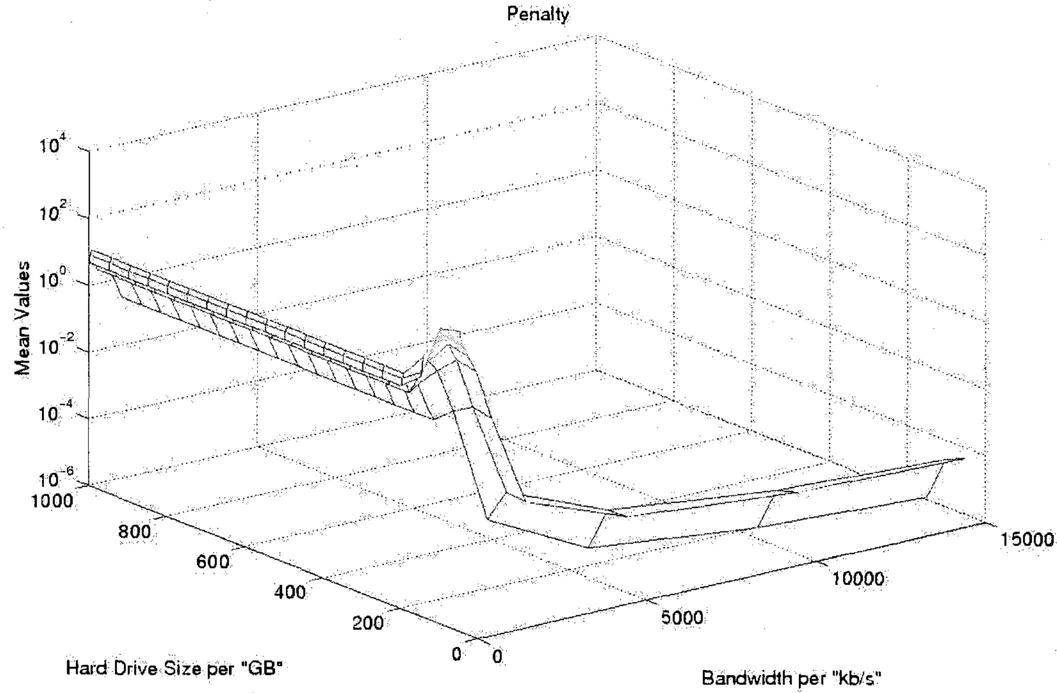


Figure 1075: Penalty for H2 case scenario after interval 2800-hour

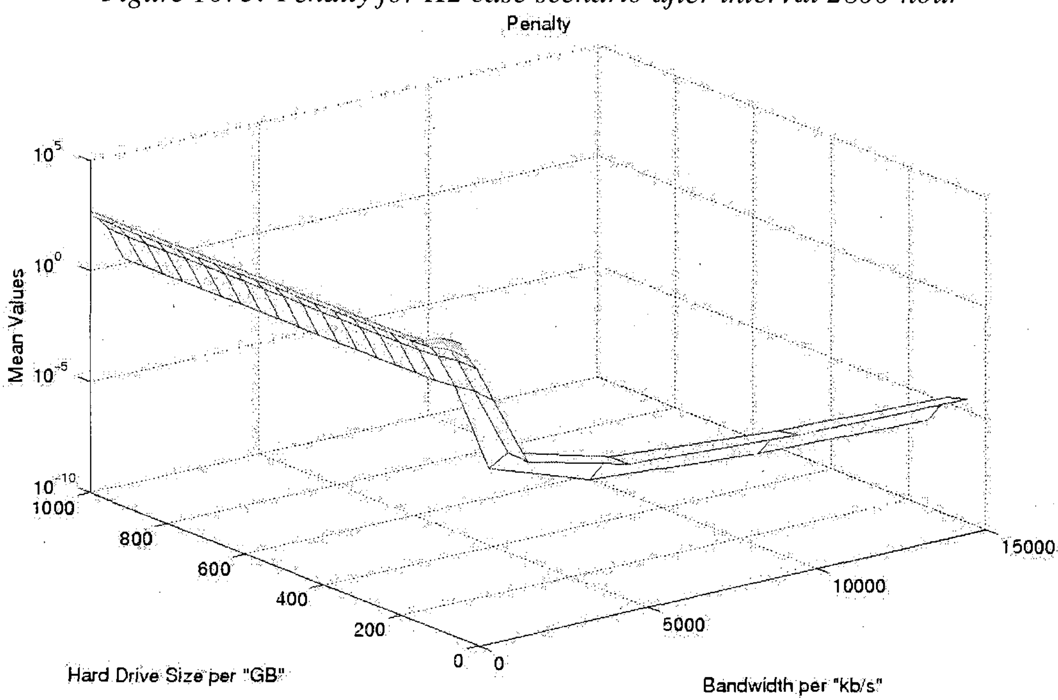


Figure 1076: Penalty for H2 case scenario after interval 3700-hour

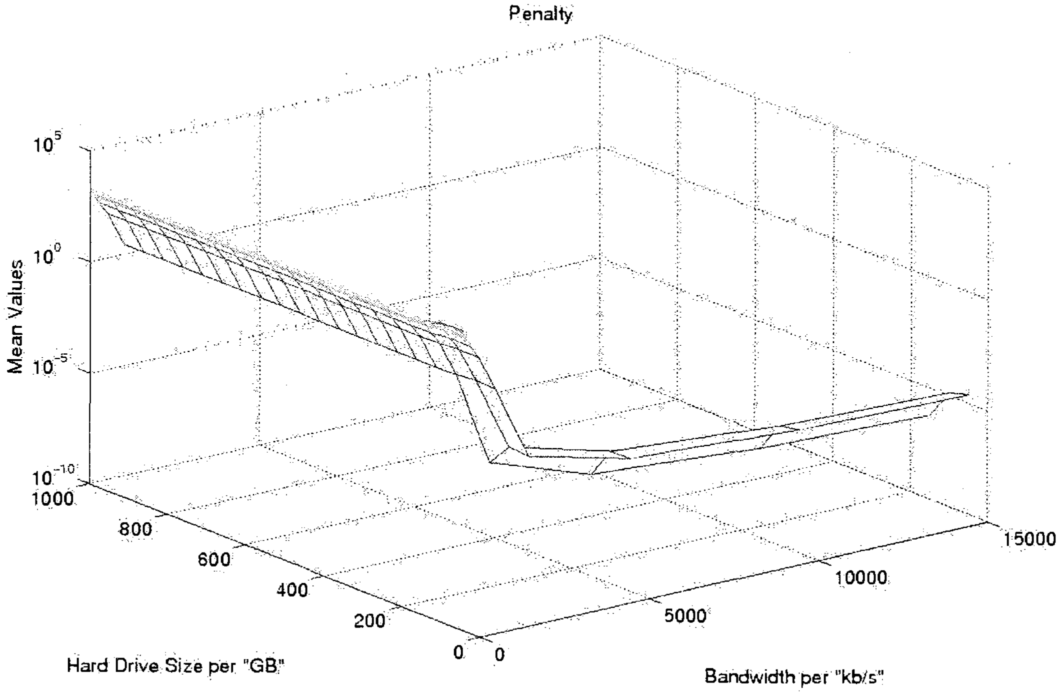


Figure 1077: Penalty for H2 case scenario after interval 4600-hour

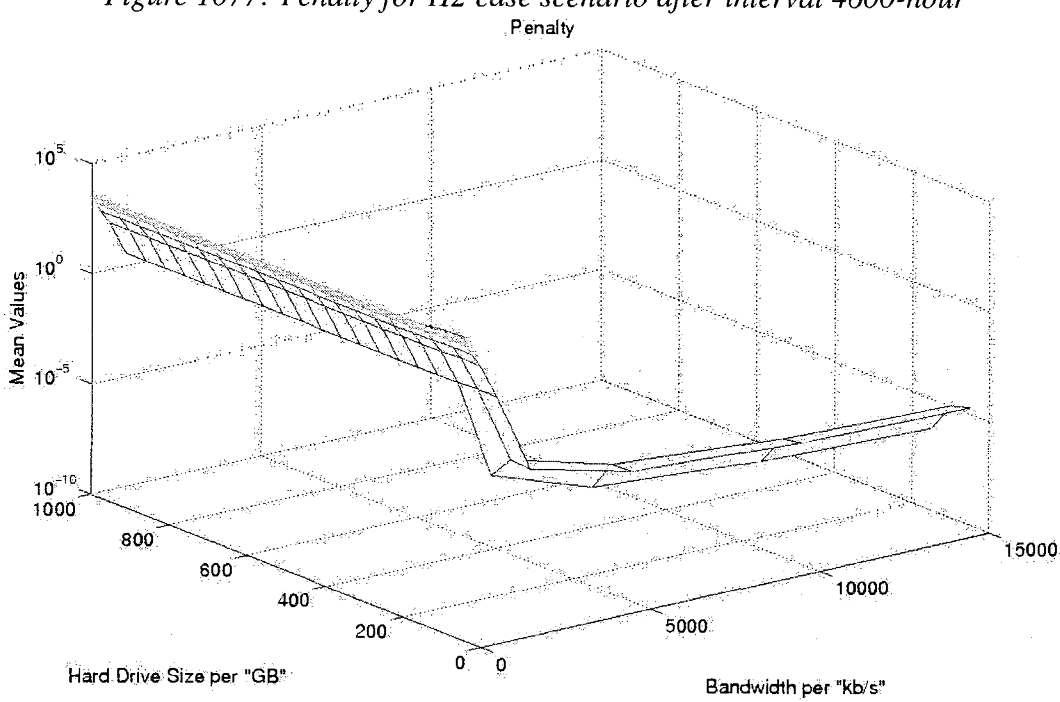


Figure 1078: Penalty for H2 case scenario after interval 5500-hour

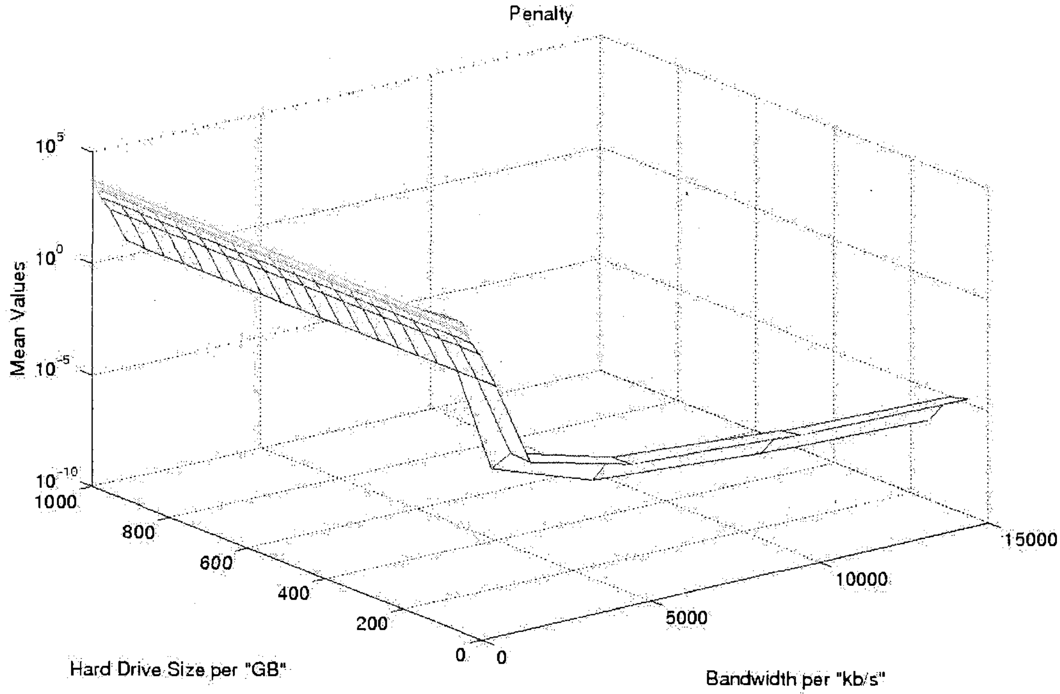


Figure 1079: Penalty for H2 case scenario after interval 6400-hour

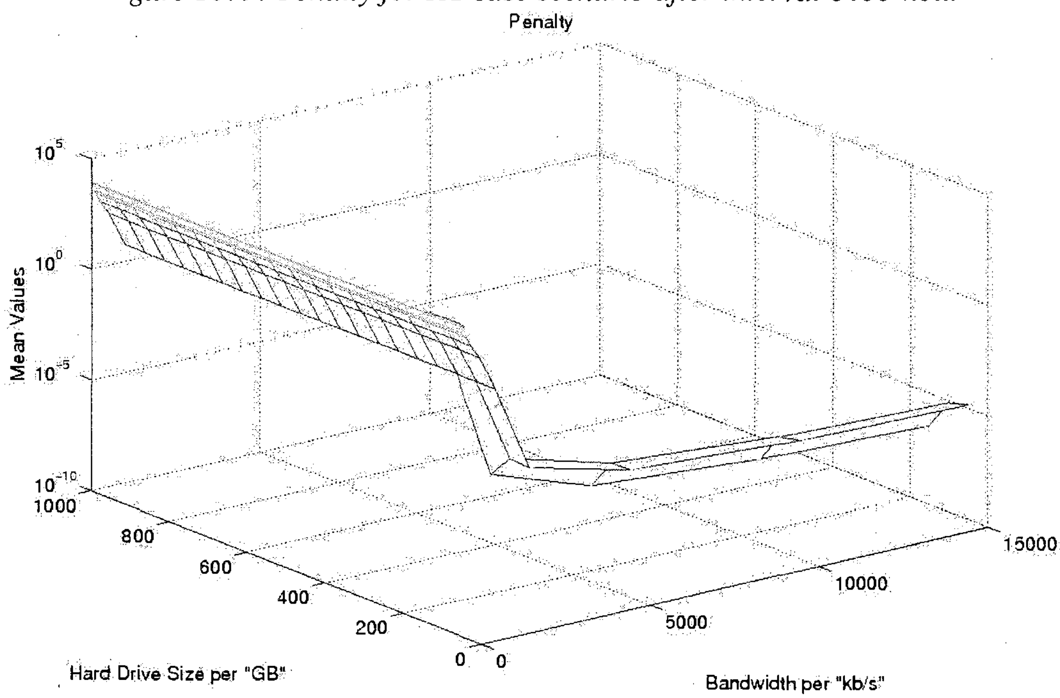


Figure 1080: Penalty for H2 case scenario after interval 7300-hour

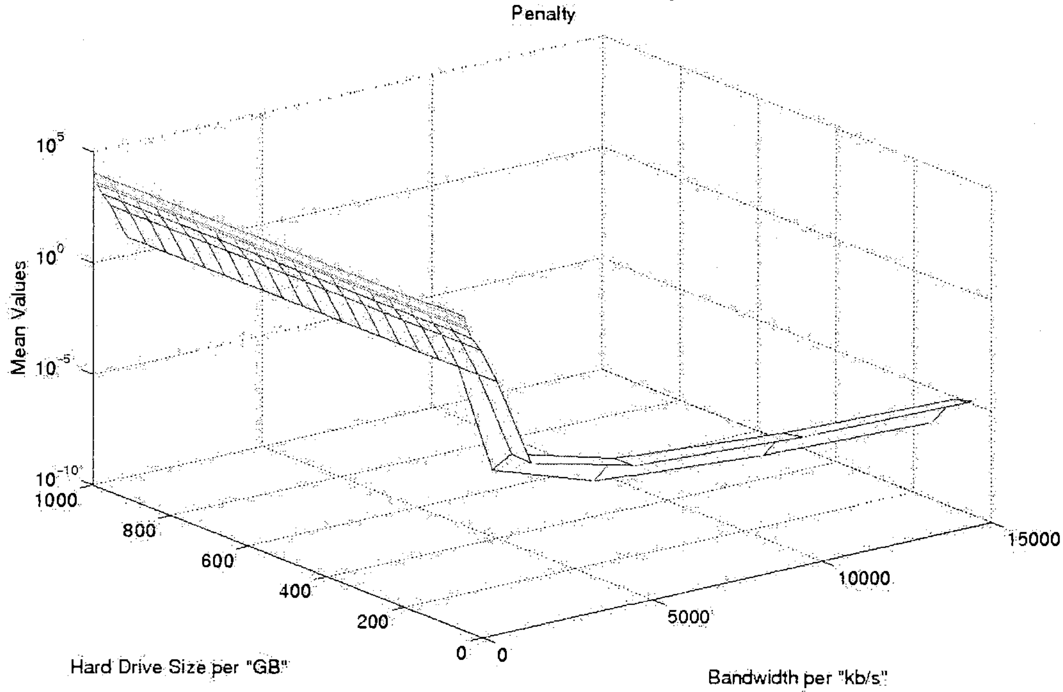


Figure 1081: Penalty for H2 case scenario after interval 8200-hour

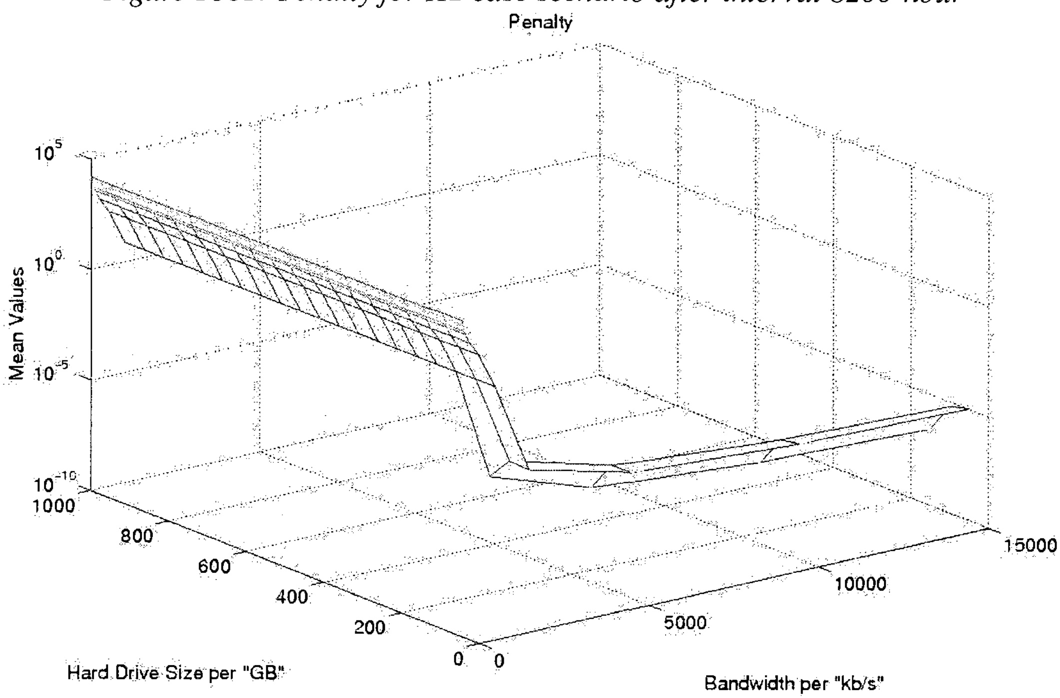


Figure 1082: Penalty for H3 case scenario after interval 100-hour

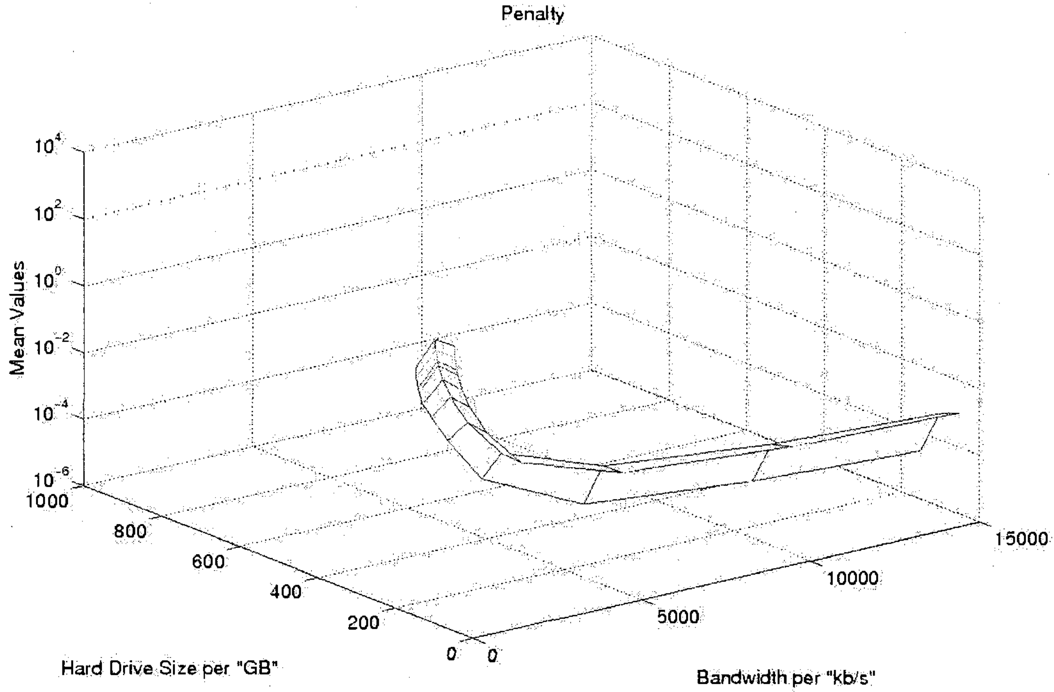


Figure 1083: Penalty for H3 case scenario after interval 1000-hour

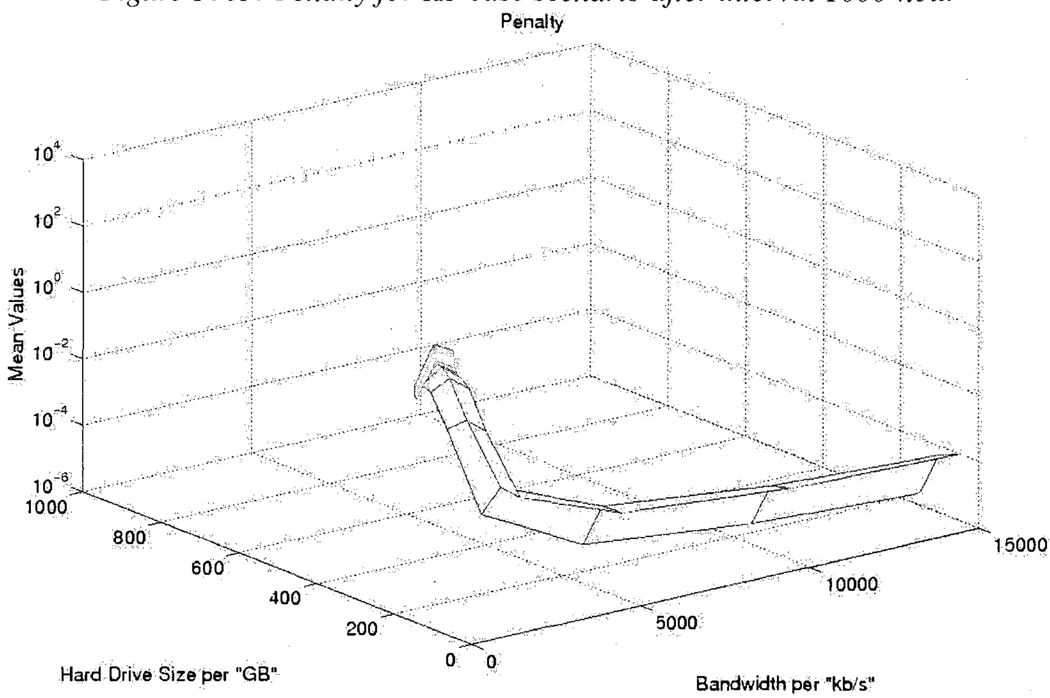


Figure 1084: Penalty for H3 case scenario after interval 1900-hour

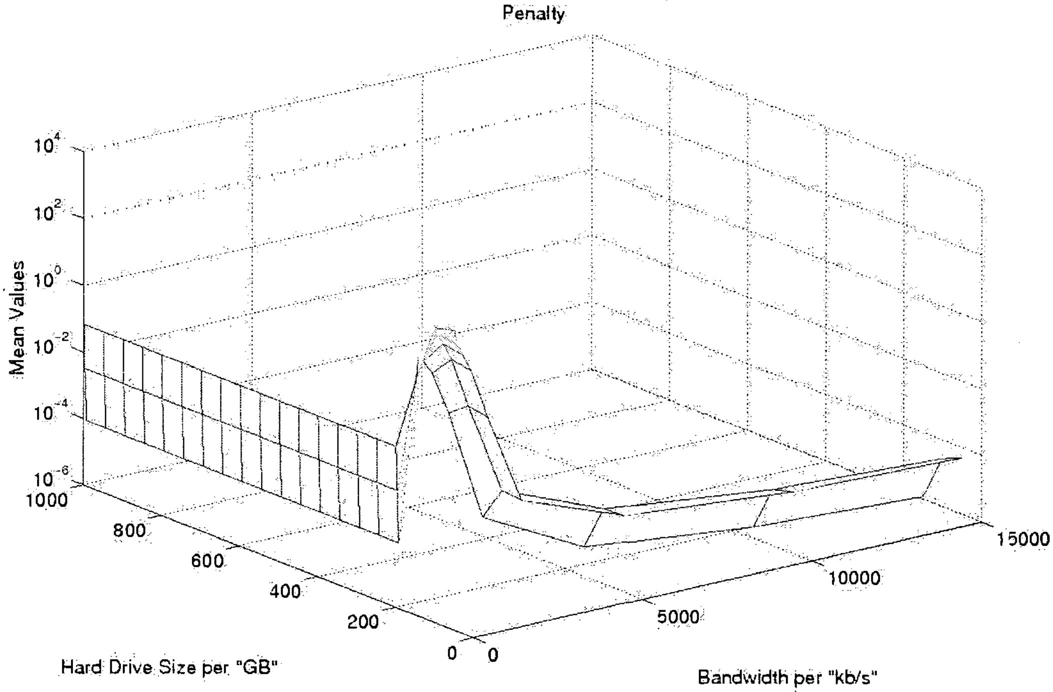


Figure 1085: Penalty for H3 case scenario after interval 2800-hour

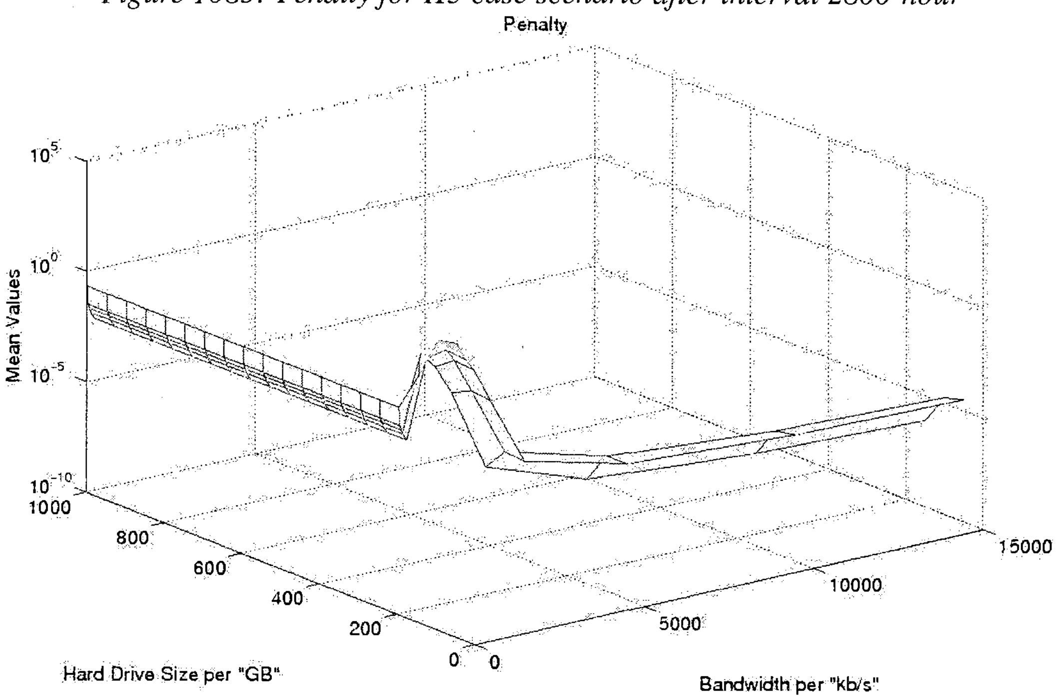


Figure 1086: Penalty for H3 case scenario after interval 3700-hour

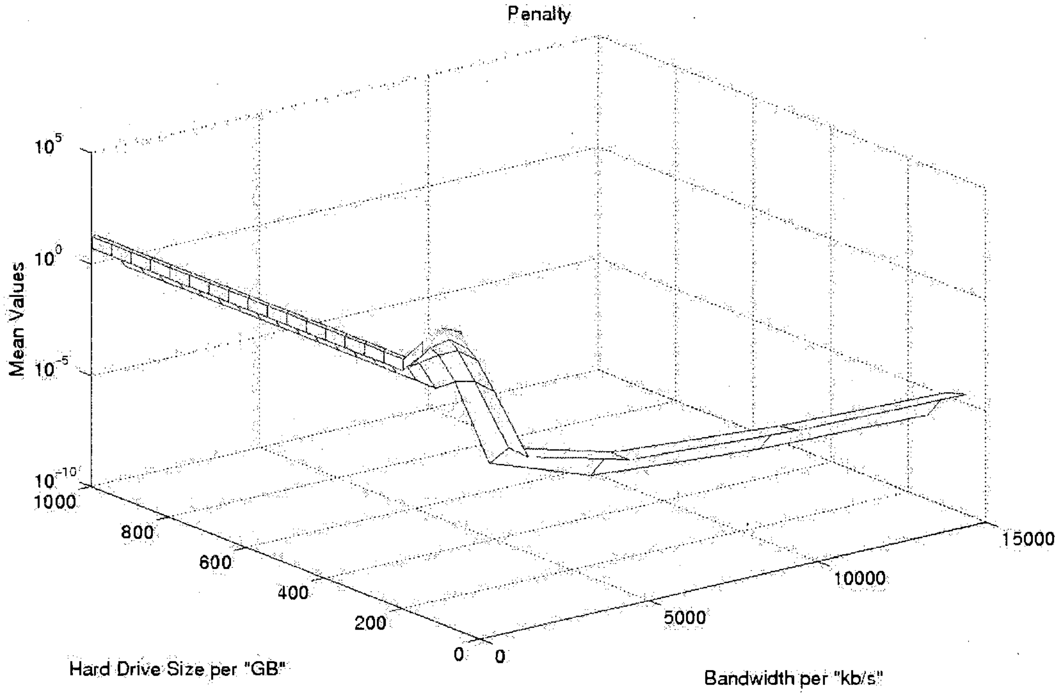


Figure 1087: Penalty for H3 case scenario after interval 4600-hour

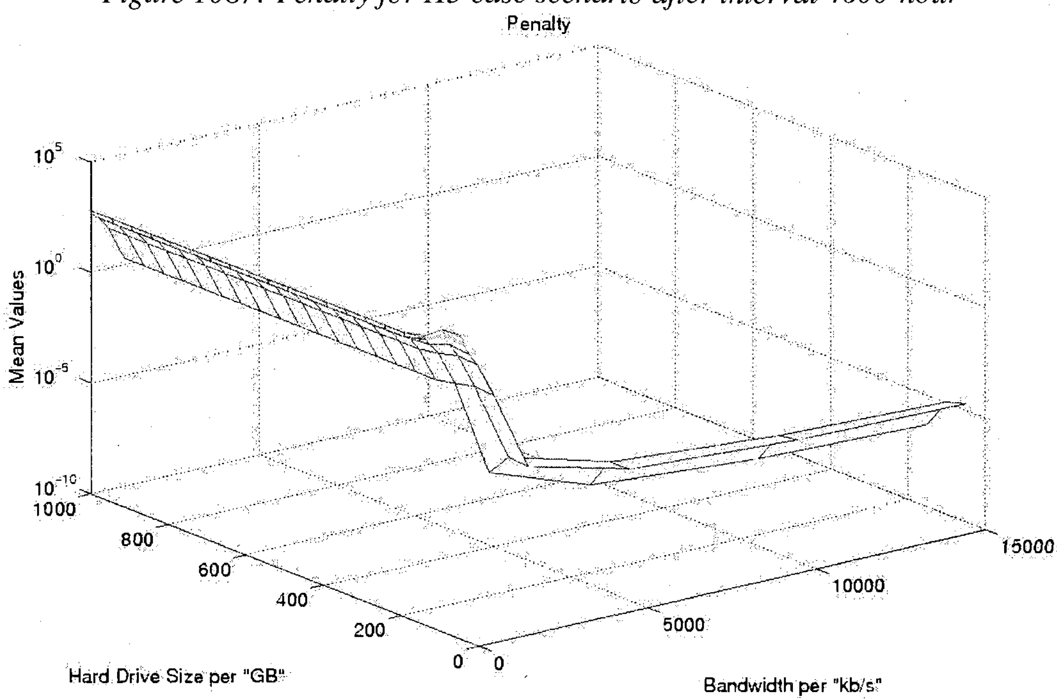


Figure 1088: Penalty for H3 case scenario after interval 5500-hour

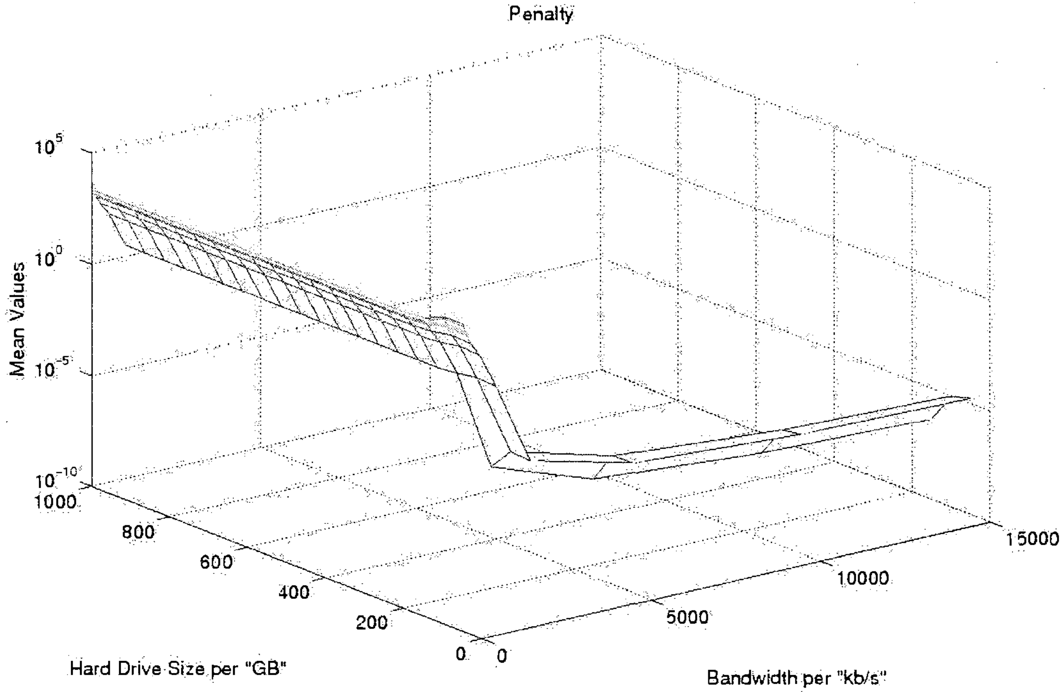


Figure 1089: Penalty for H3 case scenario after interval 6400-hour

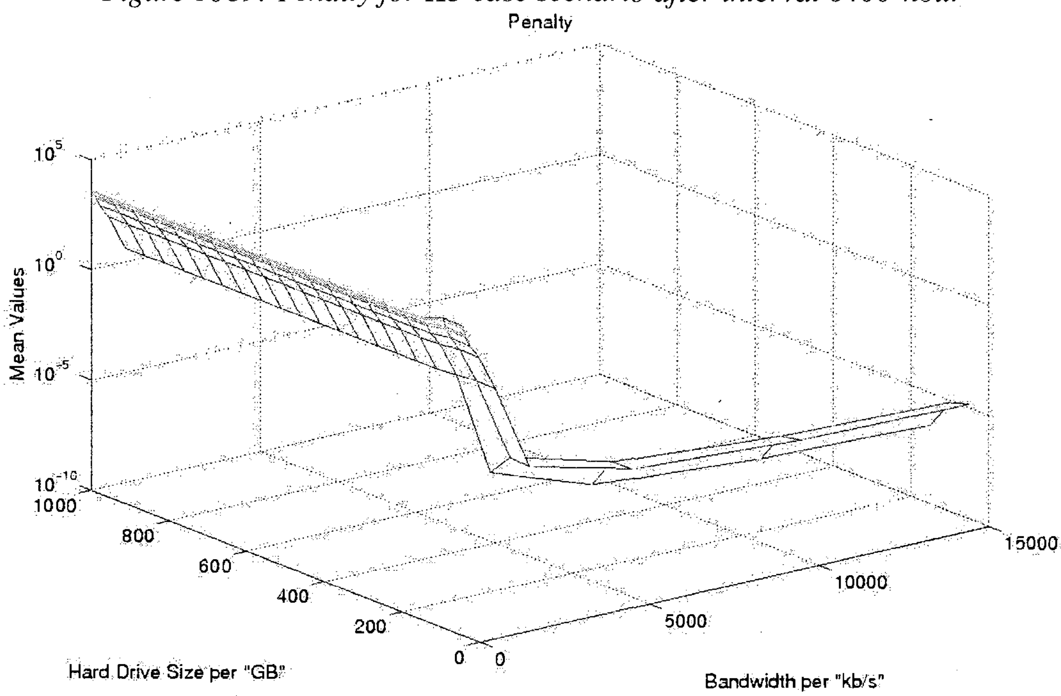


Figure 1090: Penalty for H3 case scenario after interval 7300-hour

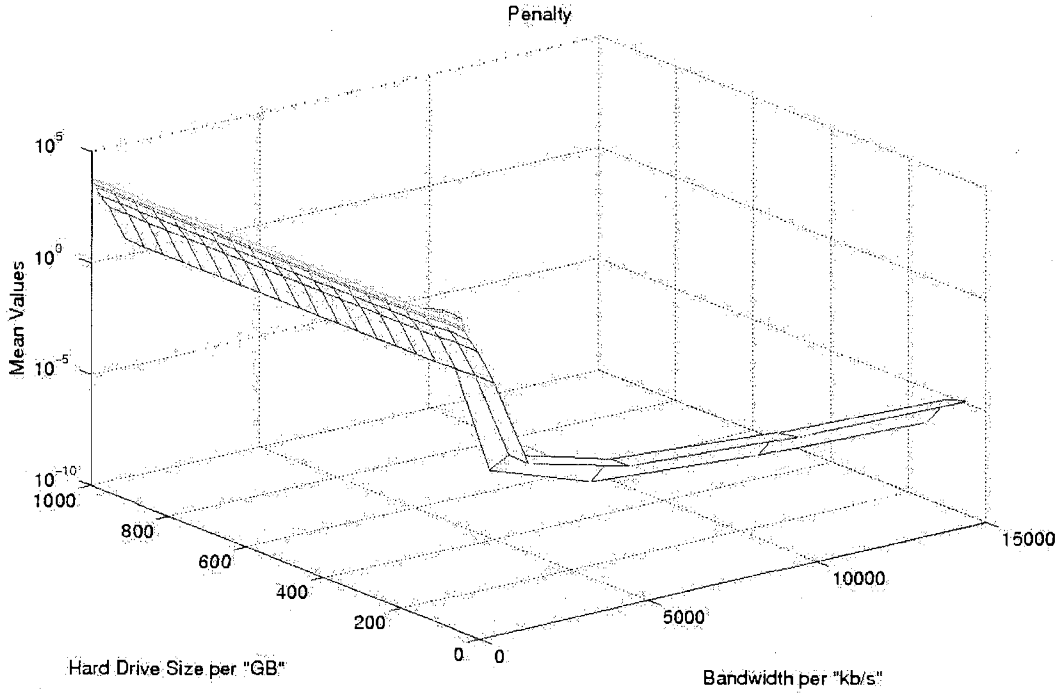


Figure 1091: Penalty for H3 case scenario after interval 8200-hour

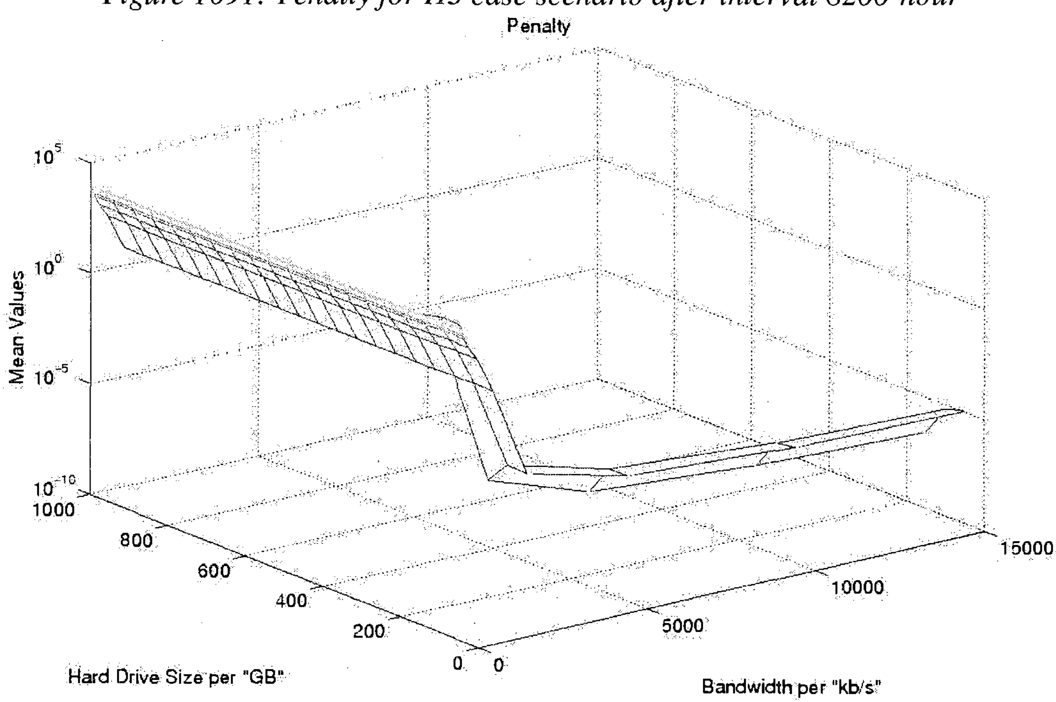


Figure 1092: Penalty for H4 case scenario after interval 100-hour

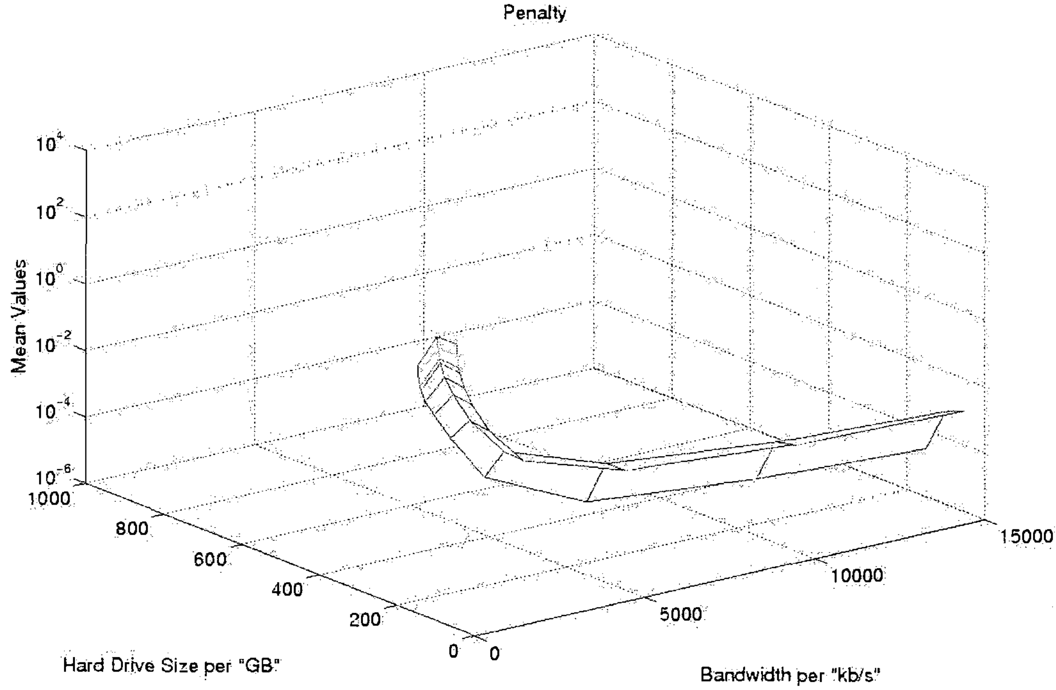


Figure 1093: Penalty for H4 case scenario after interval 1000-hour

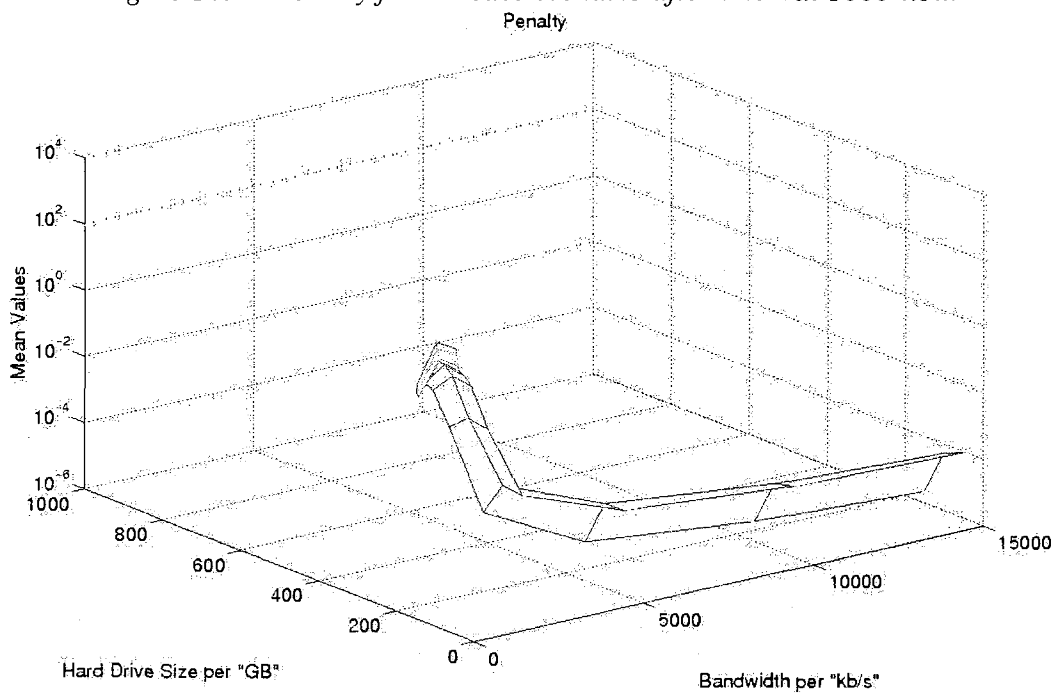


Figure 1094: Penalty for H4 case scenario after interval 1900-hour

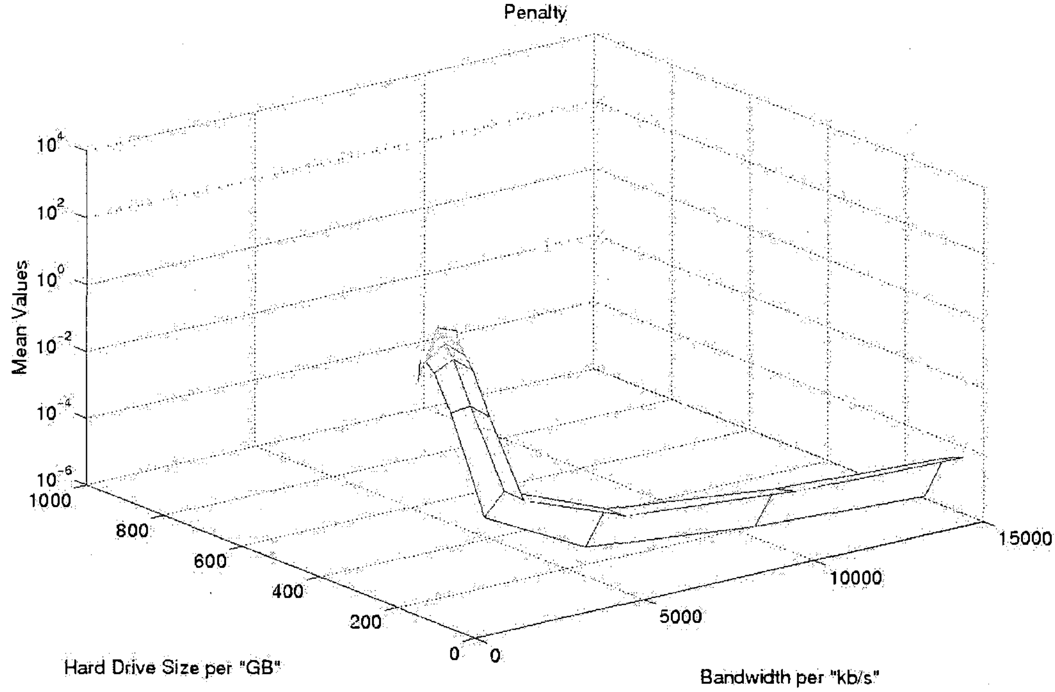


Figure 1095: Penalty for H4 case scenario after interval 2800-hour

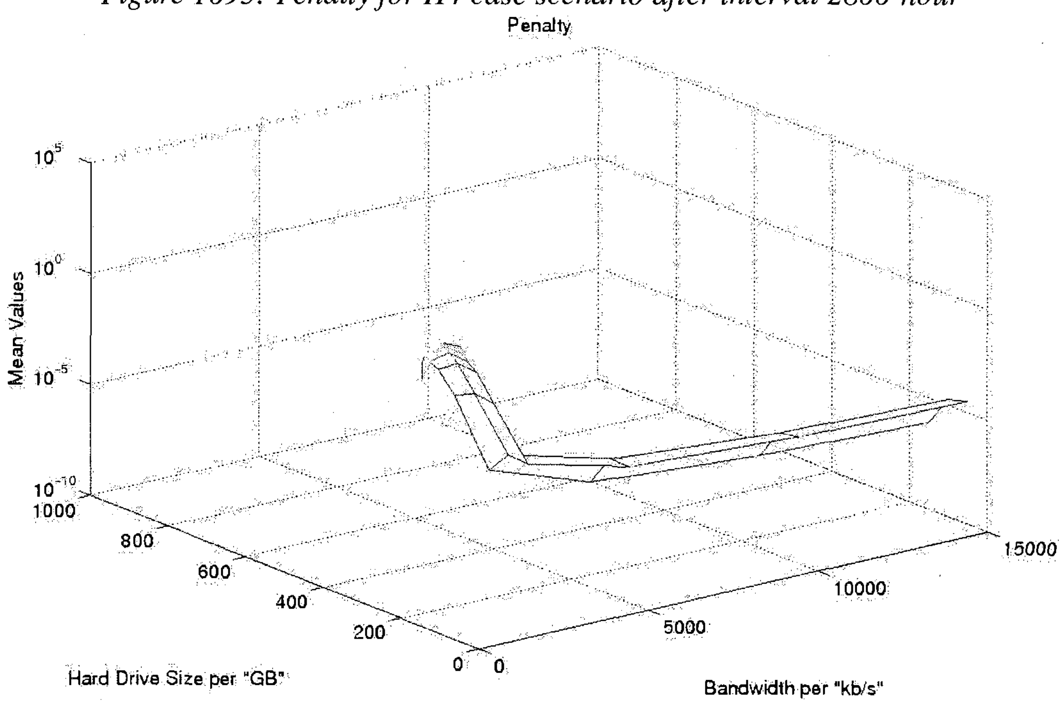


Figure 1096: Penalty for H4 case scenario after interval 3700-hour

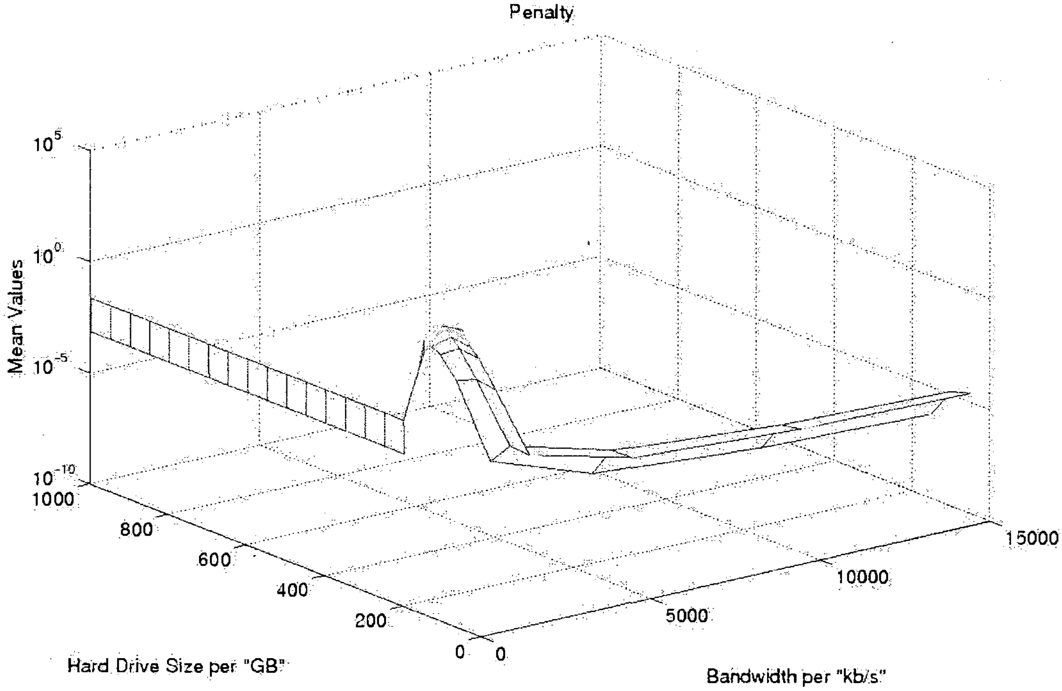


Figure 1097: Penalty for H4 case scenario after interval 4600-hour

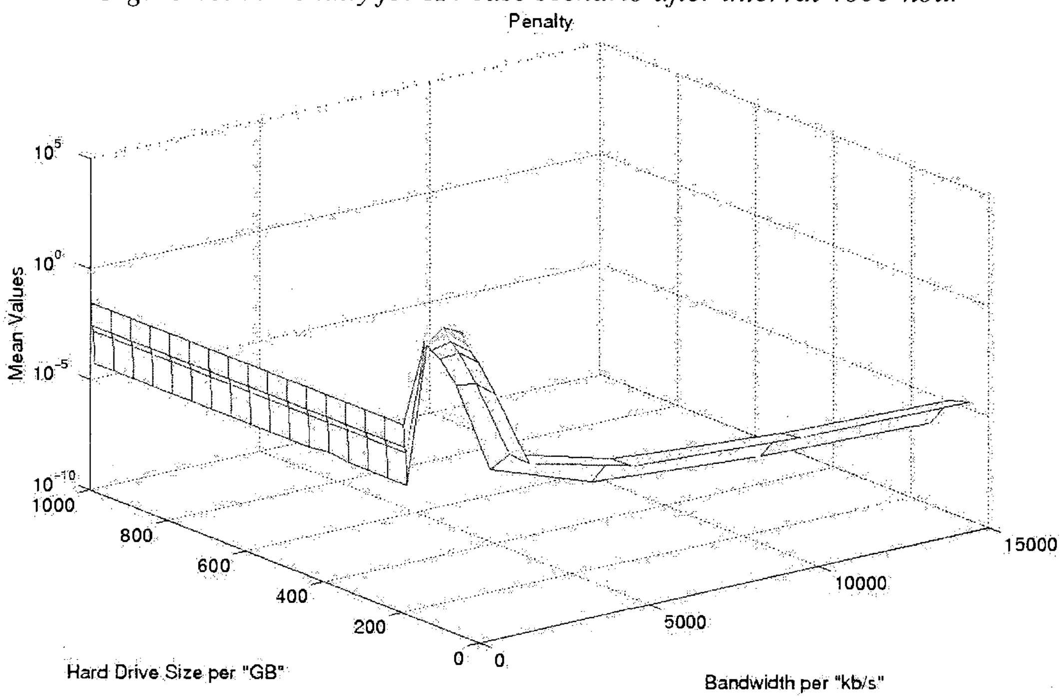


Figure 1098: Penalty for H4 case scenario after interval 5500-hour

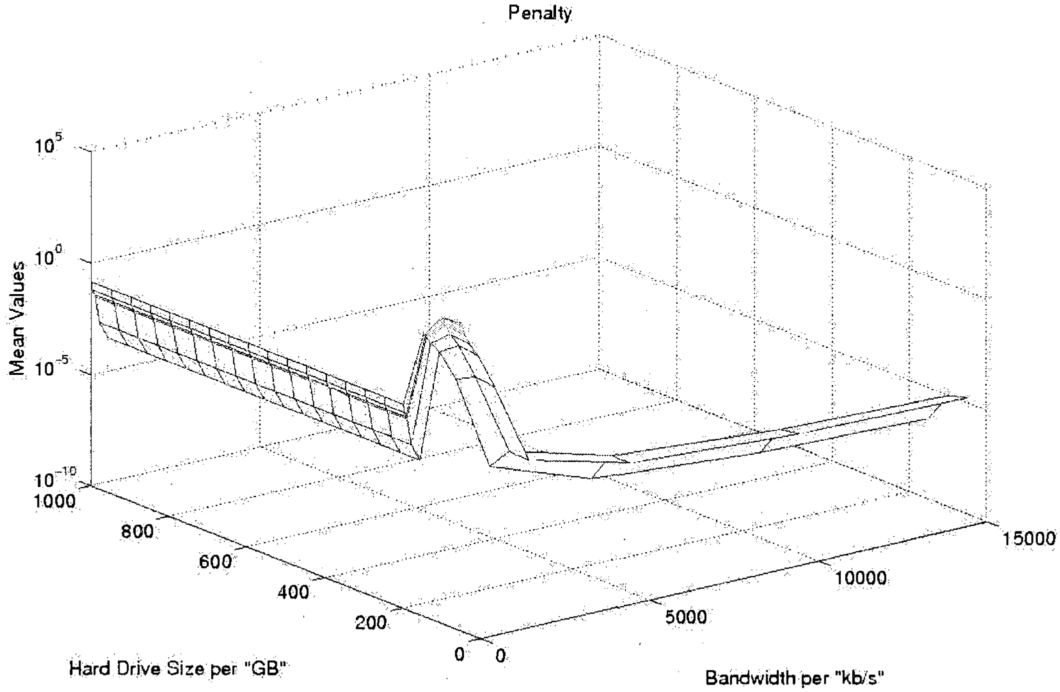


Figure 1099: Penalty for H4 case scenario after interval 6400-hour

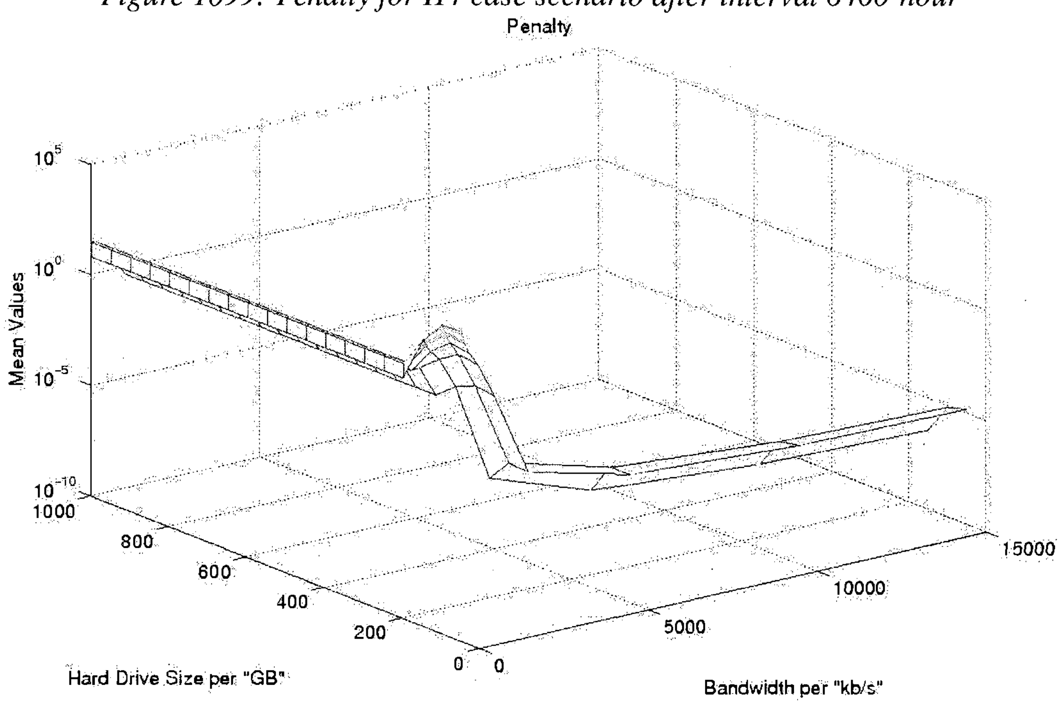


Figure 1100: Penalty for H4 case scenario after interval 7300-hour

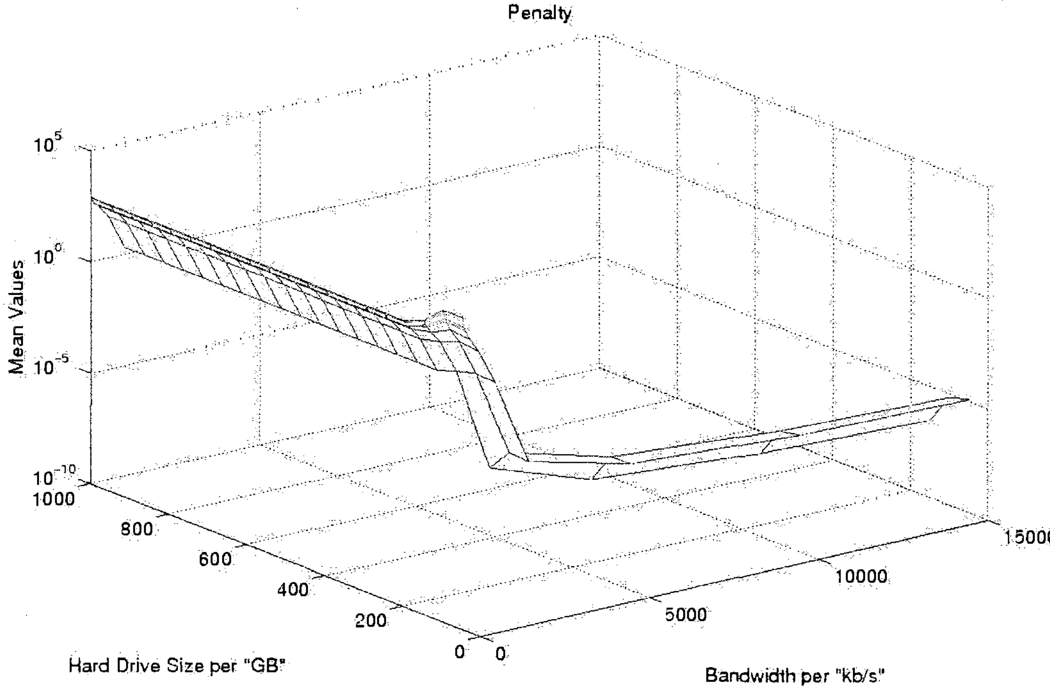


Figure 1101: Penalty for H4 case scenario after interval 8200-hour

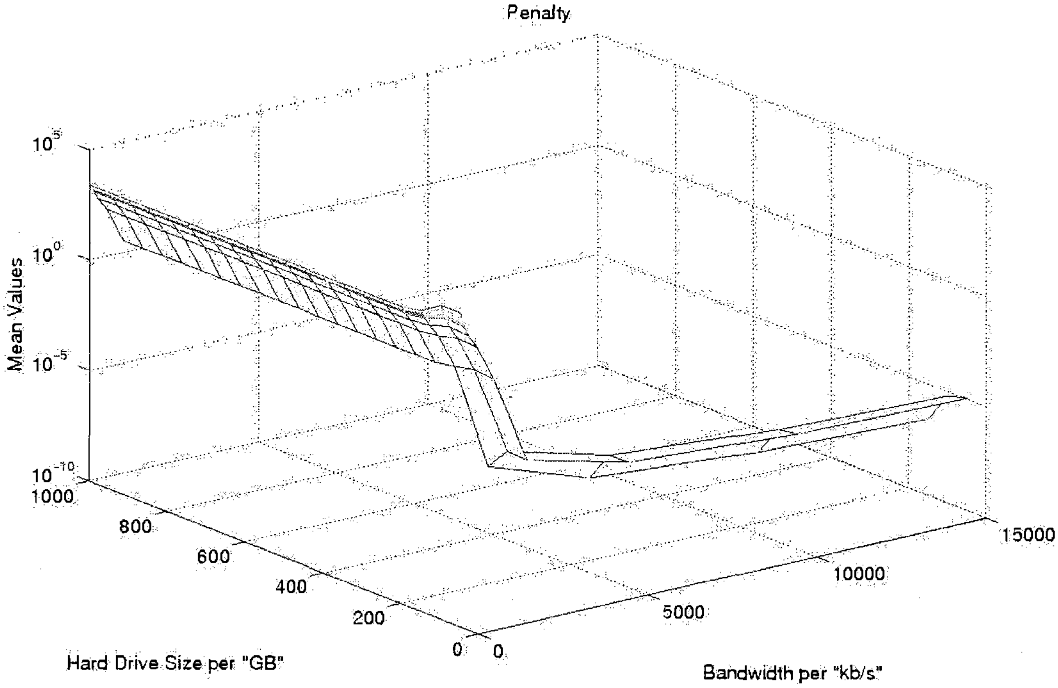


Figure 1102: Total Download Bytes for H1 case scenario after interval 100-hour

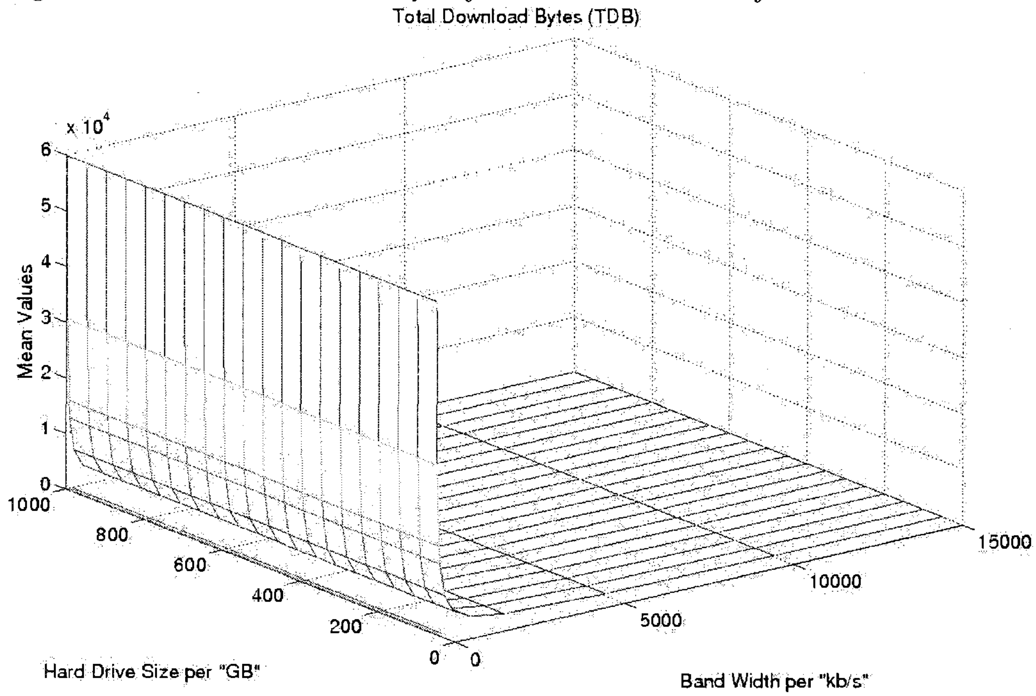


Figure 1103: Total Download Bytes for H1 case scenario after interval 1000-hour

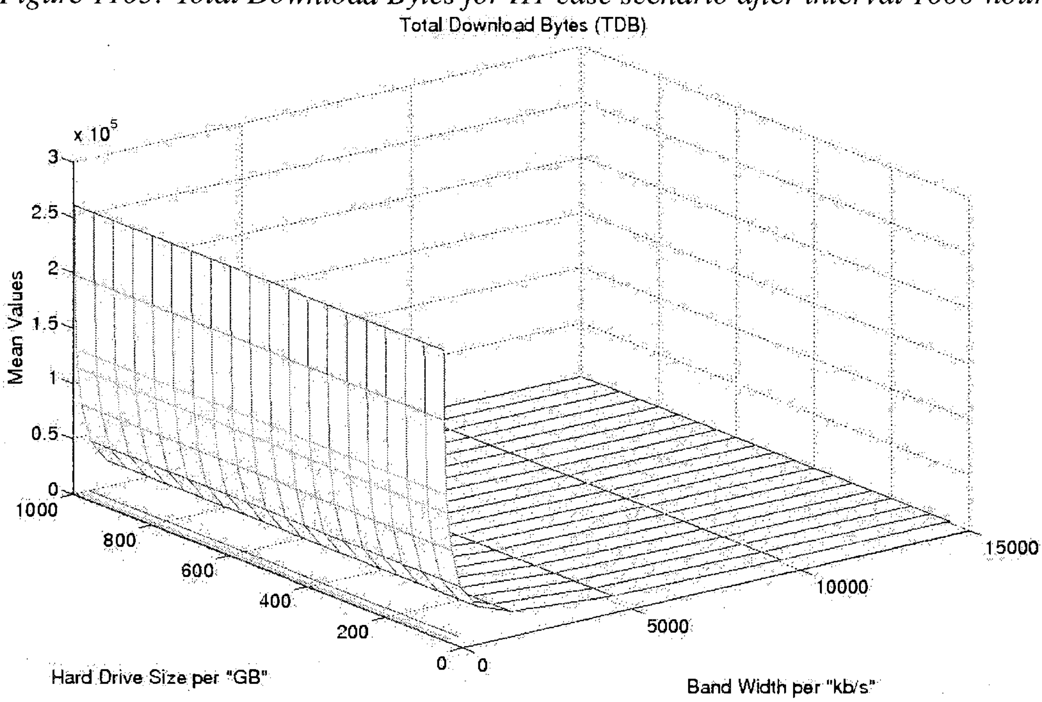


Figure 1104: Total Download Bytes for H1 case scenario after interval 1900-hour

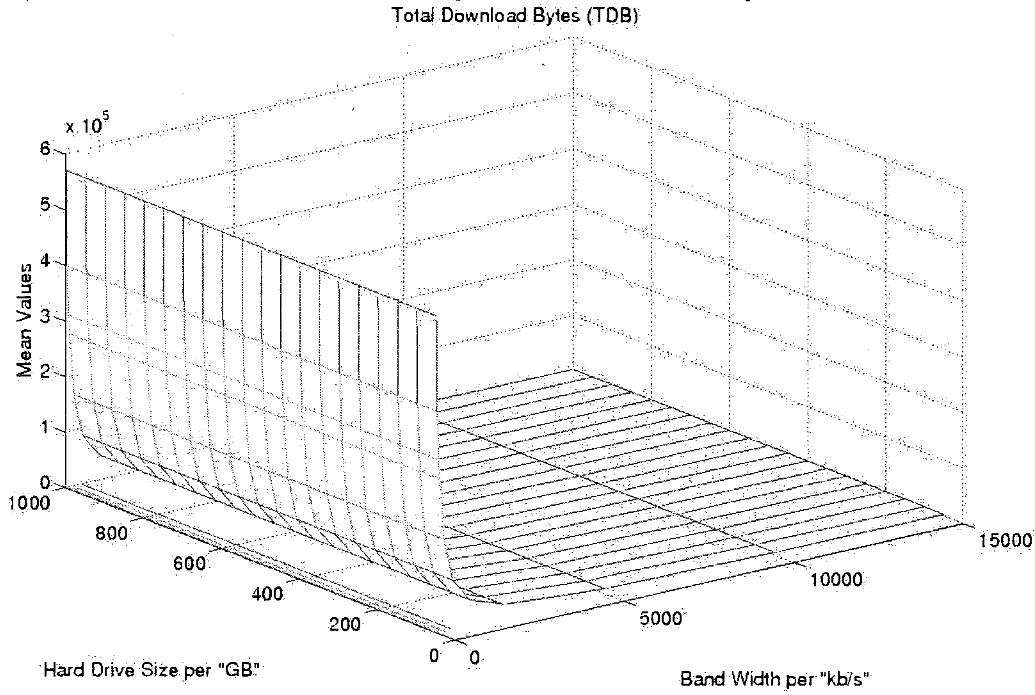


Figure 1105: Total Download Bytes for H1 case scenario after interval 2800-hour

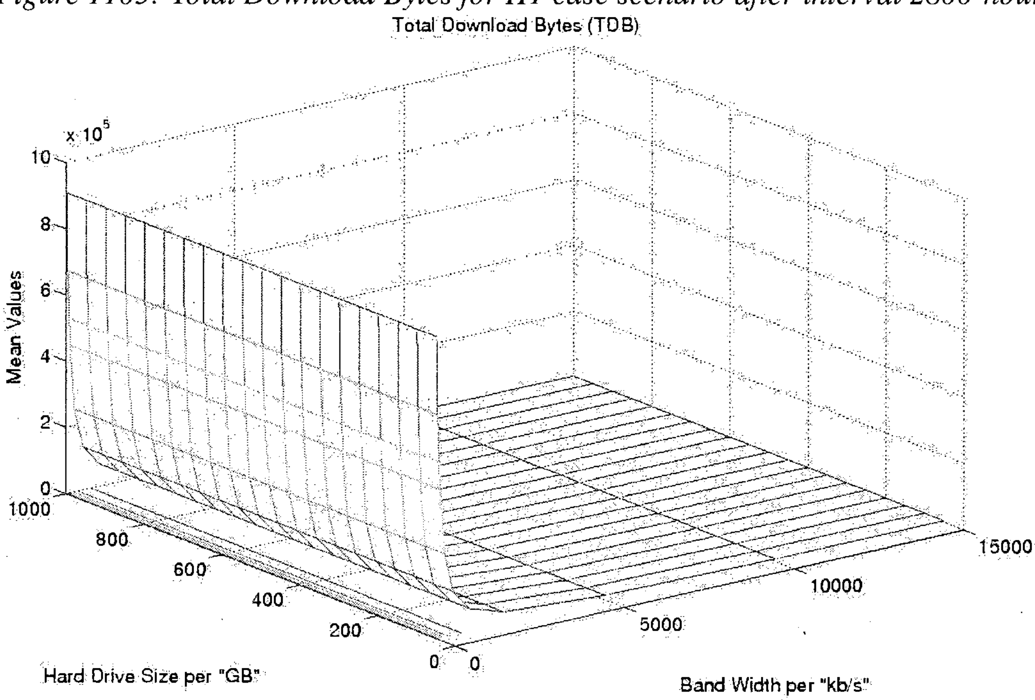


Figure 1106: Total Download Bytes for H1 case scenario after interval 3700-hour

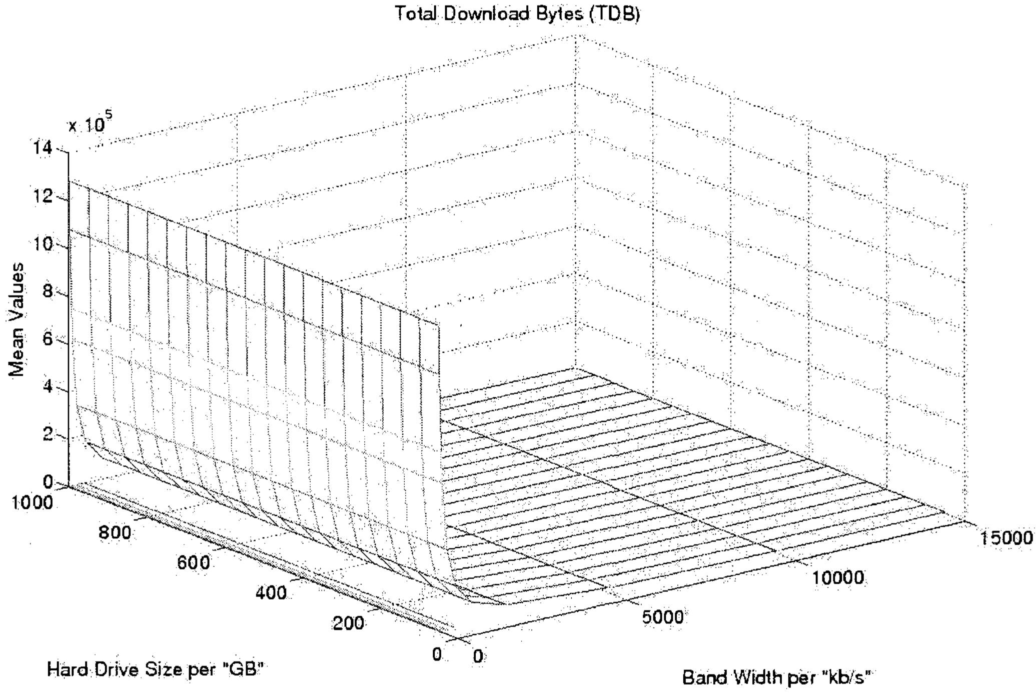


Figure 1107: Total Download Bytes for H1 case scenario after interval 4600-hour

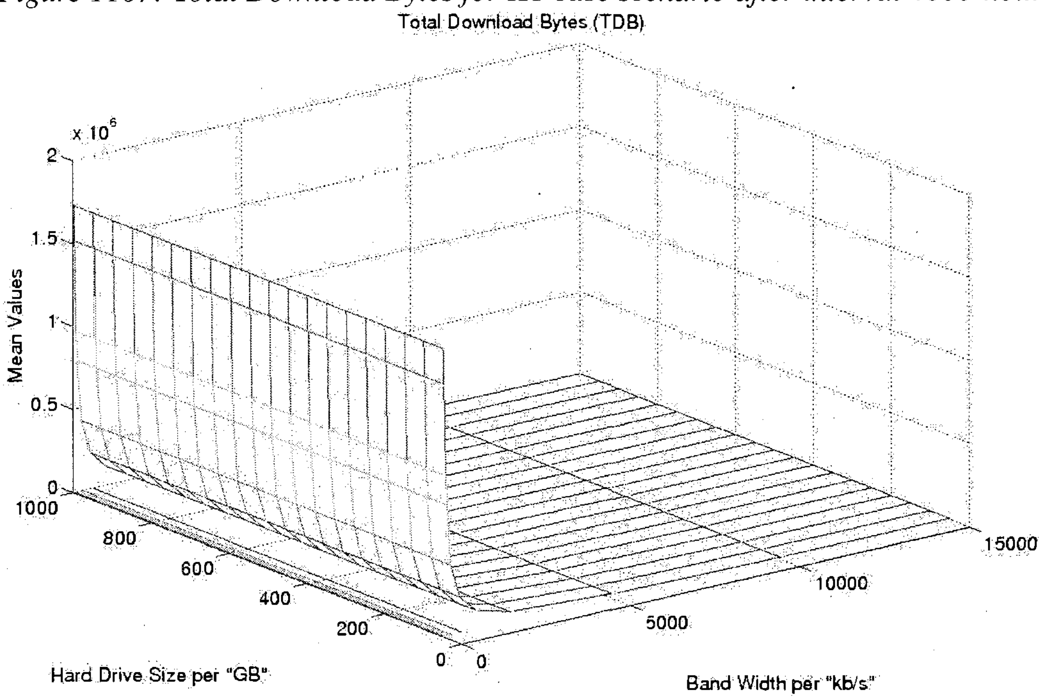


Figure 1108: Total Download Bytes for H1 case scenario after interval 5500-hour

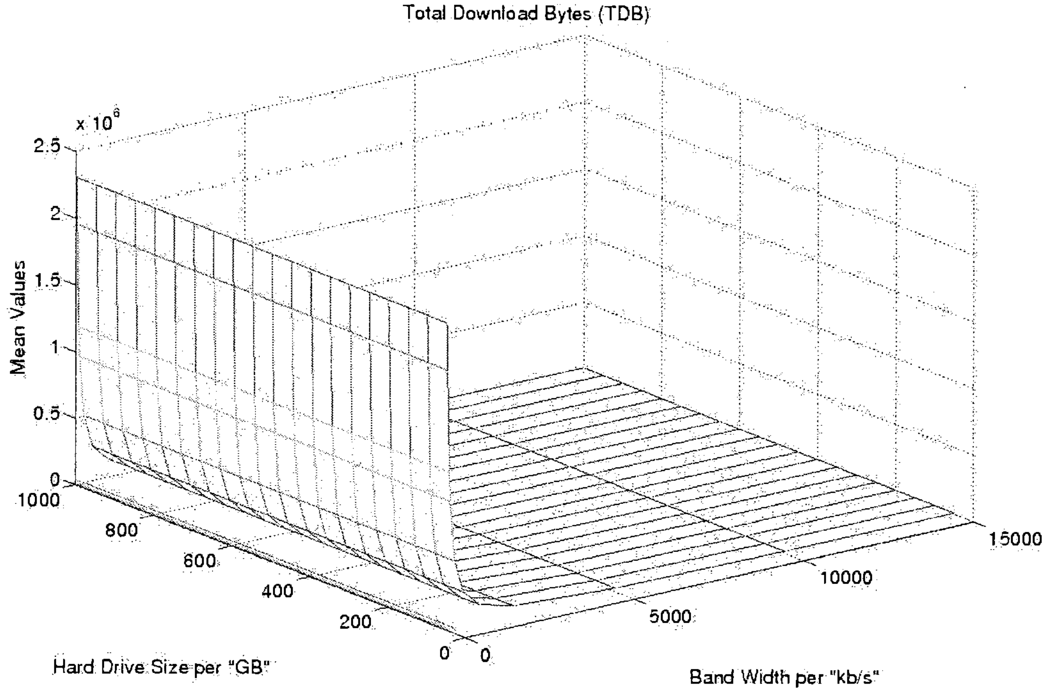


Figure 1109: Total Download Bytes for H1 case scenario after interval 6400-hour

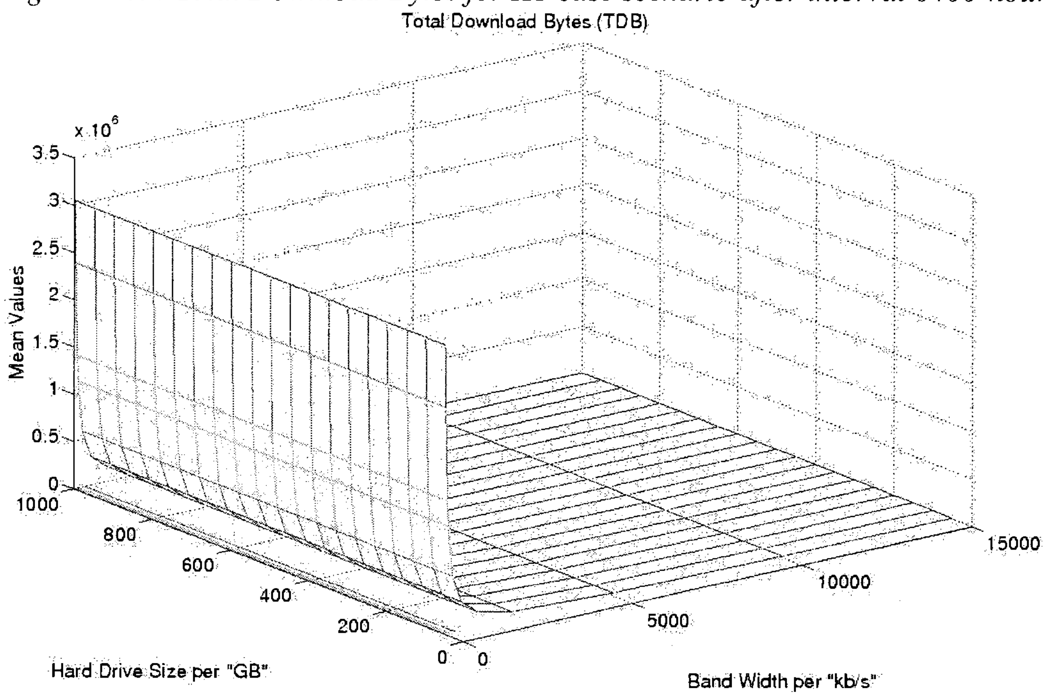


Figure 1110: Total Download Bytes for H1 case scenario after interval 7300-hour

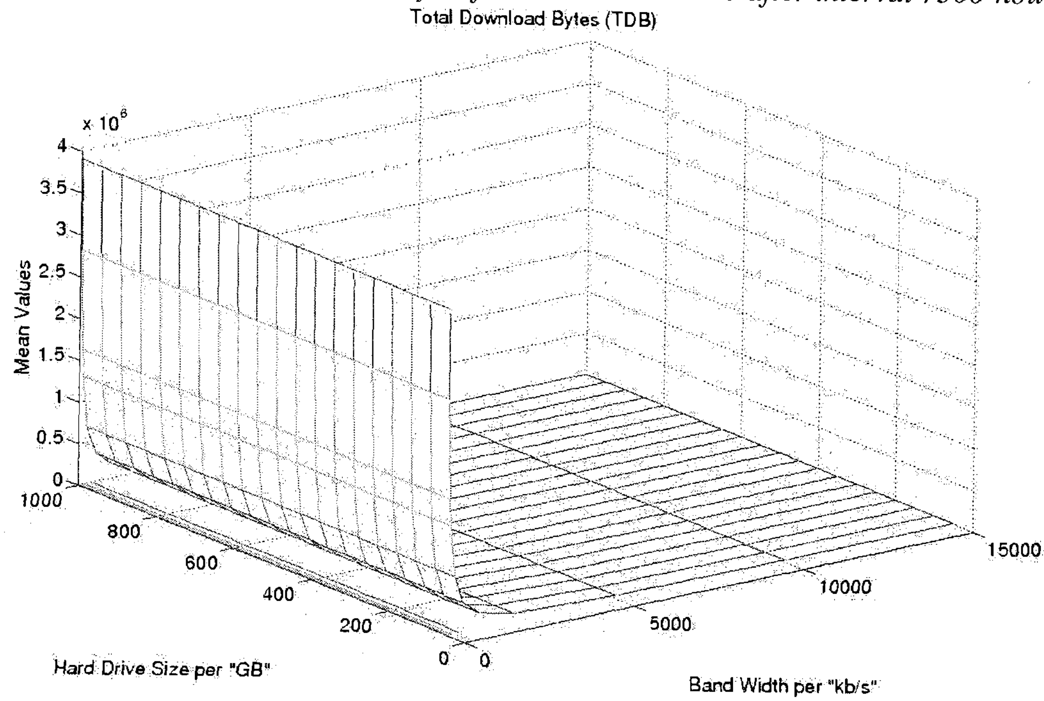


Figure 1111: Total Download Bytes for H1 case scenario after interval 8200-hour

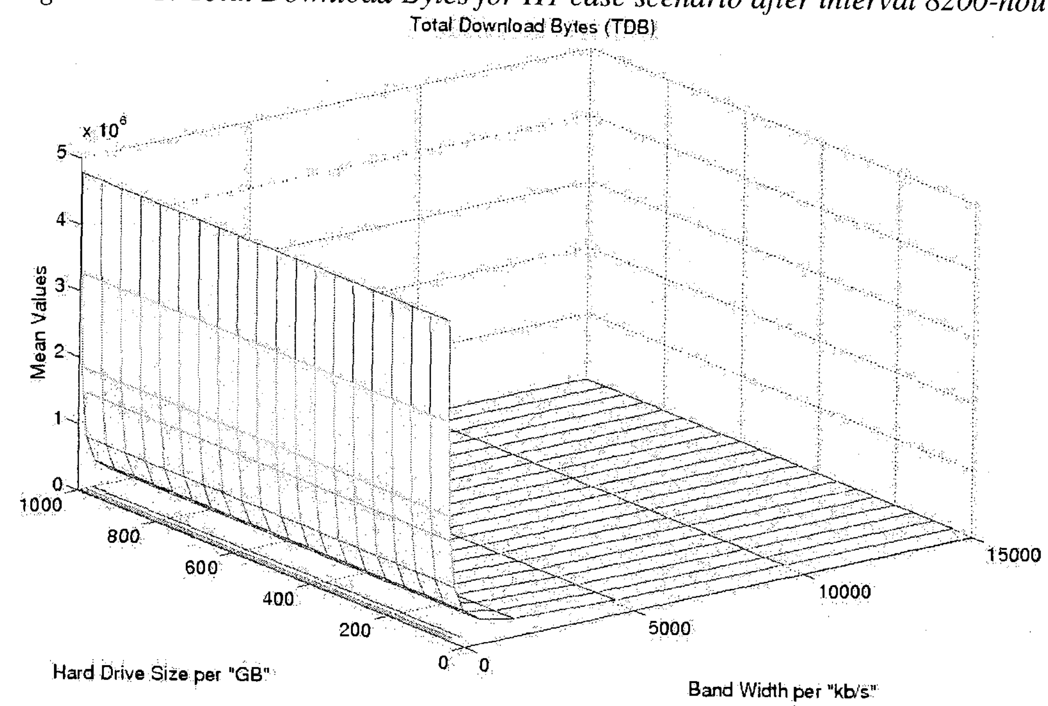


Figure 1112: Total Download Bytes for H2 case scenario after interval 100-hour

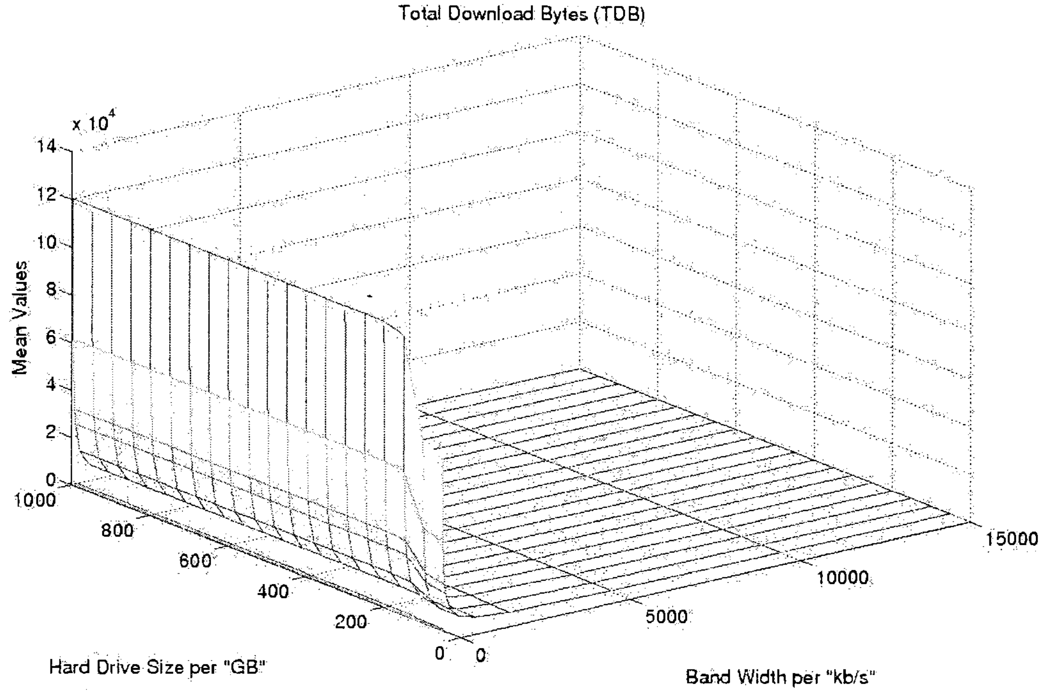


Figure 1113: Total Download Bytes for H2 case scenario after interval 1000-hour

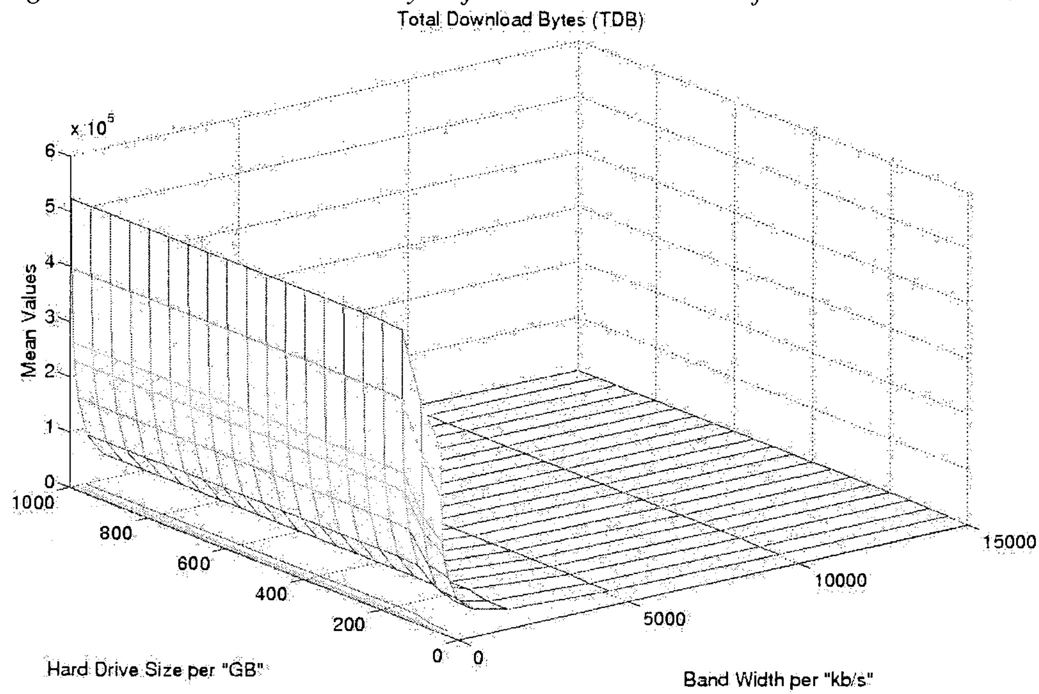


Figure 1114: Total Download Bytes for H2 case scenario after interval 1900-hour

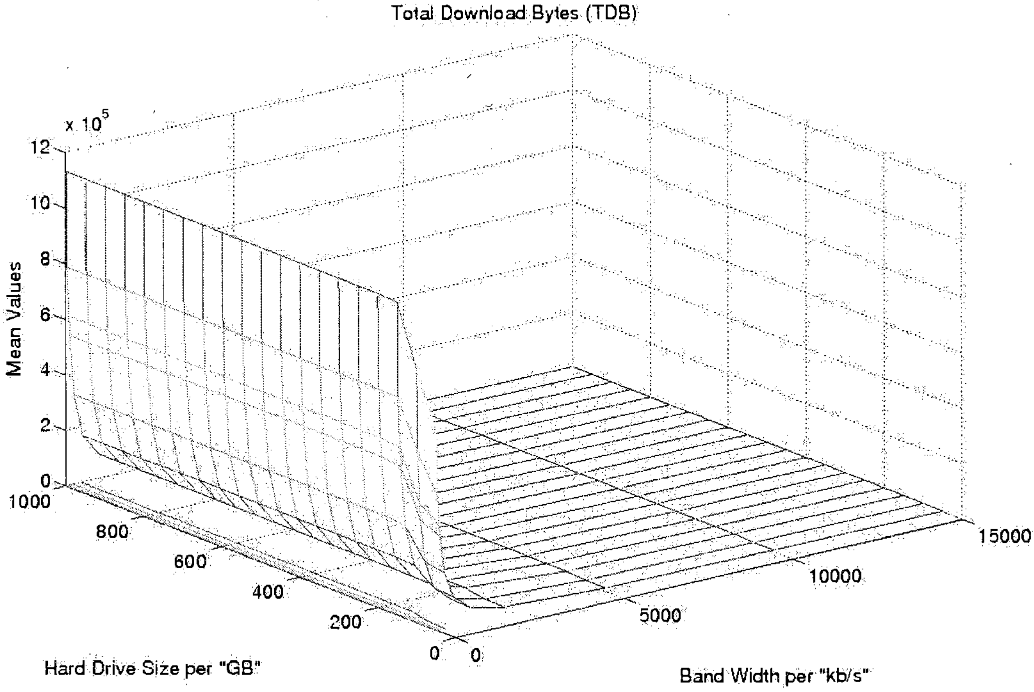


Figure 1115: Total Download Bytes for H2 case scenario after interval 2800-hour

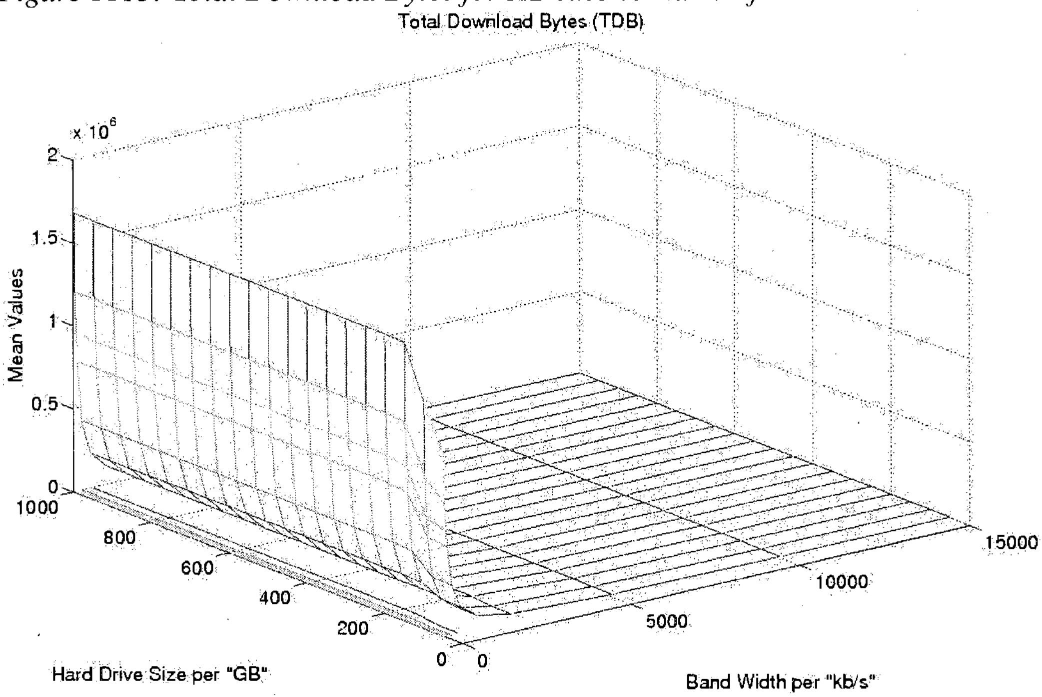


Figure 1116: Total Download Bytes for H2 case scenario after interval 3700-hour

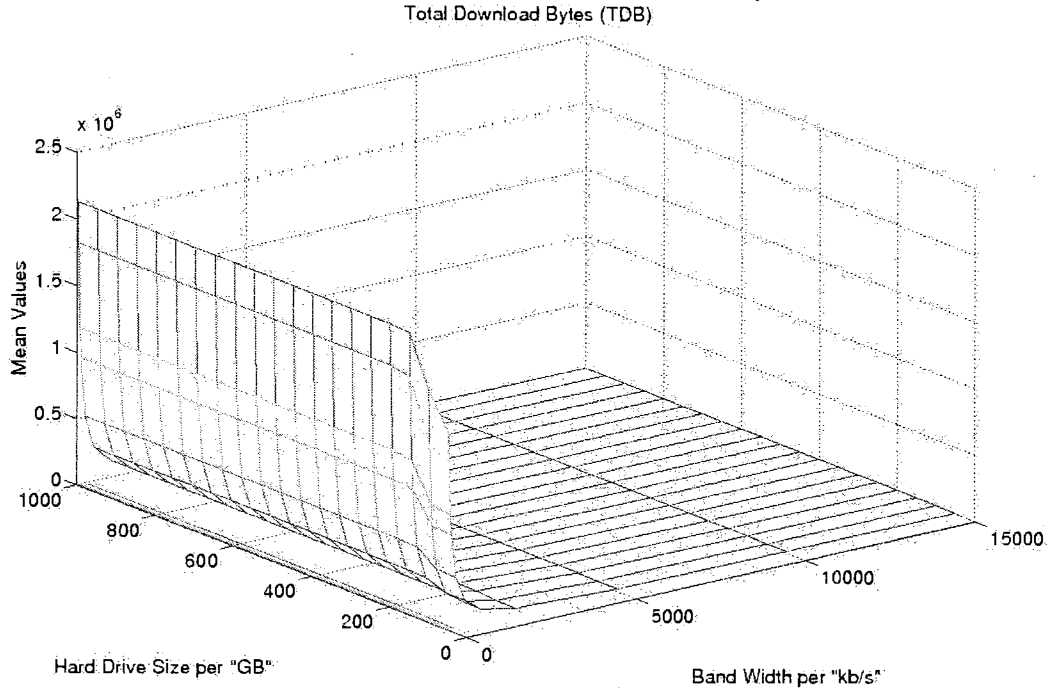


Figure 1117: Total Download Bytes for H2 case scenario after interval 4600-hour

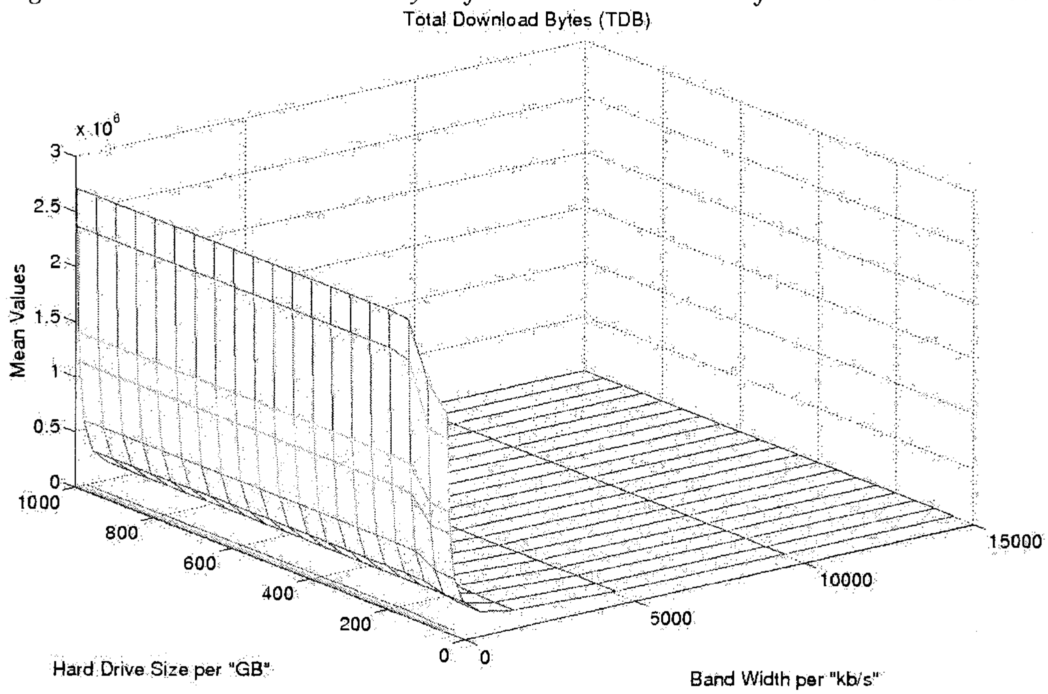


Figure 1118: Total Download Bytes for H2 case scenario after interval 5500-hour

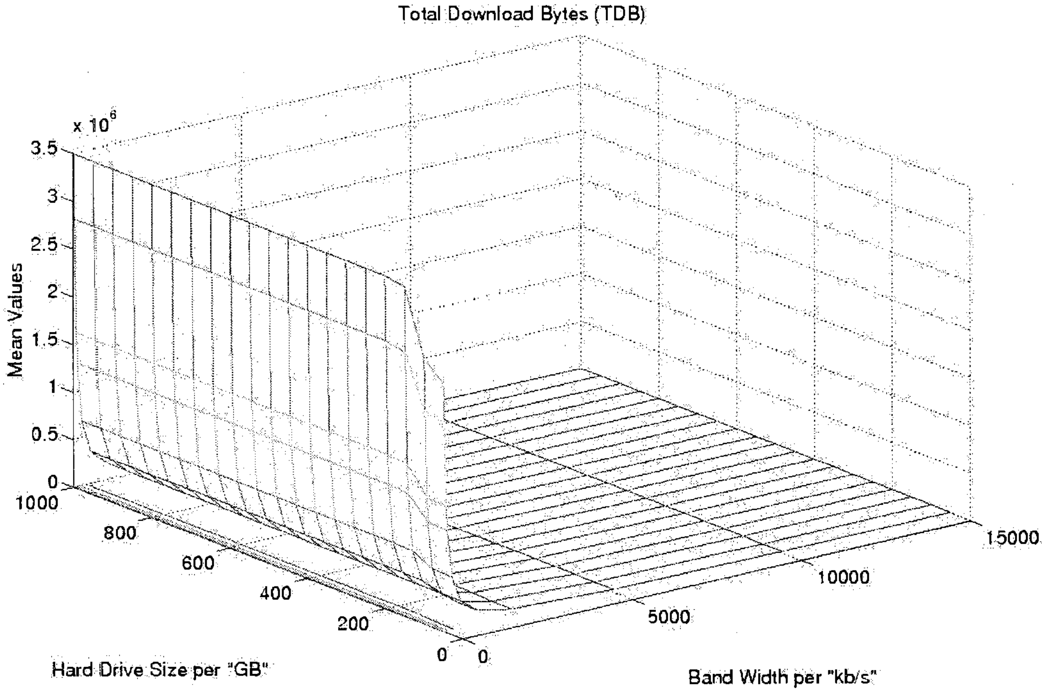


Figure 1119: Total Download Bytes for H2 case scenario after interval 6400-hour

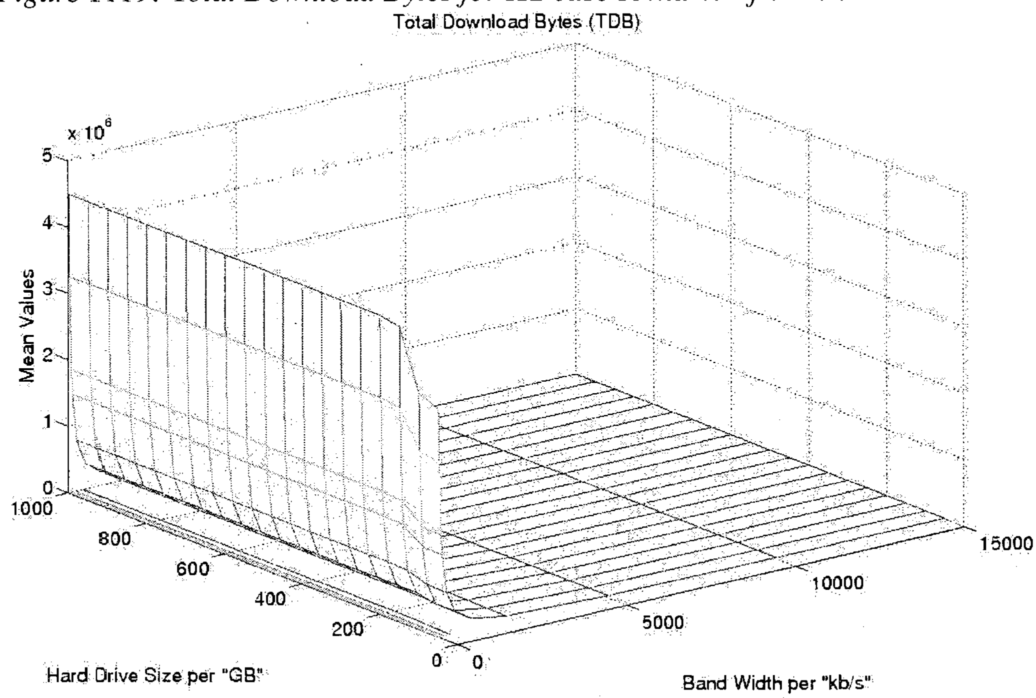


Figure 1120: Total Download Bytes for H2 case scenario after interval 7300-hour

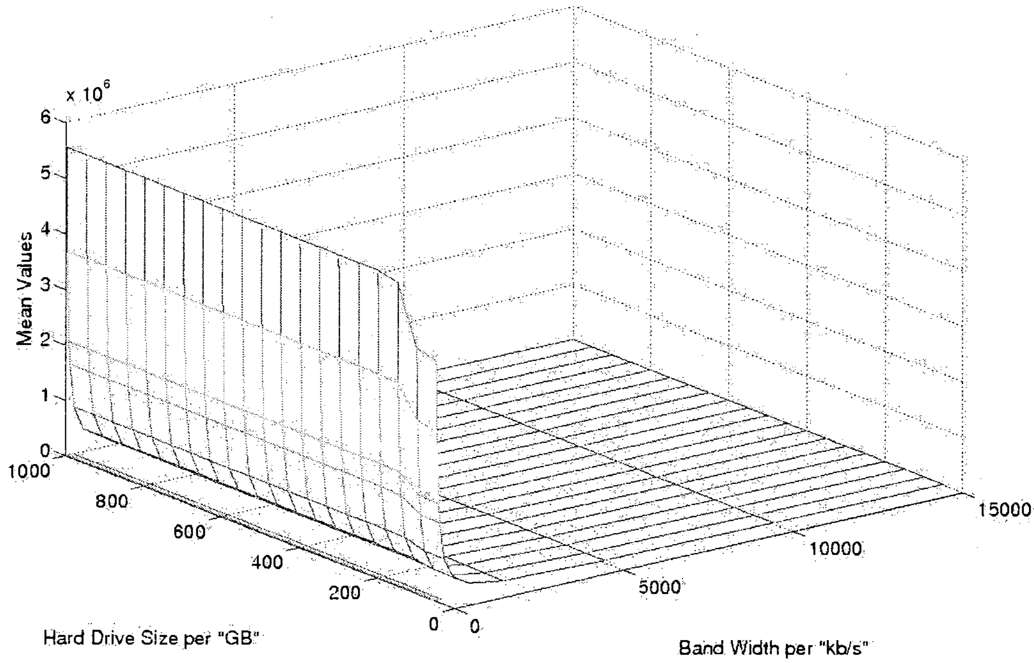


Figure 1121: Total Download Bytes for H2 case scenario after interval 8200-hour

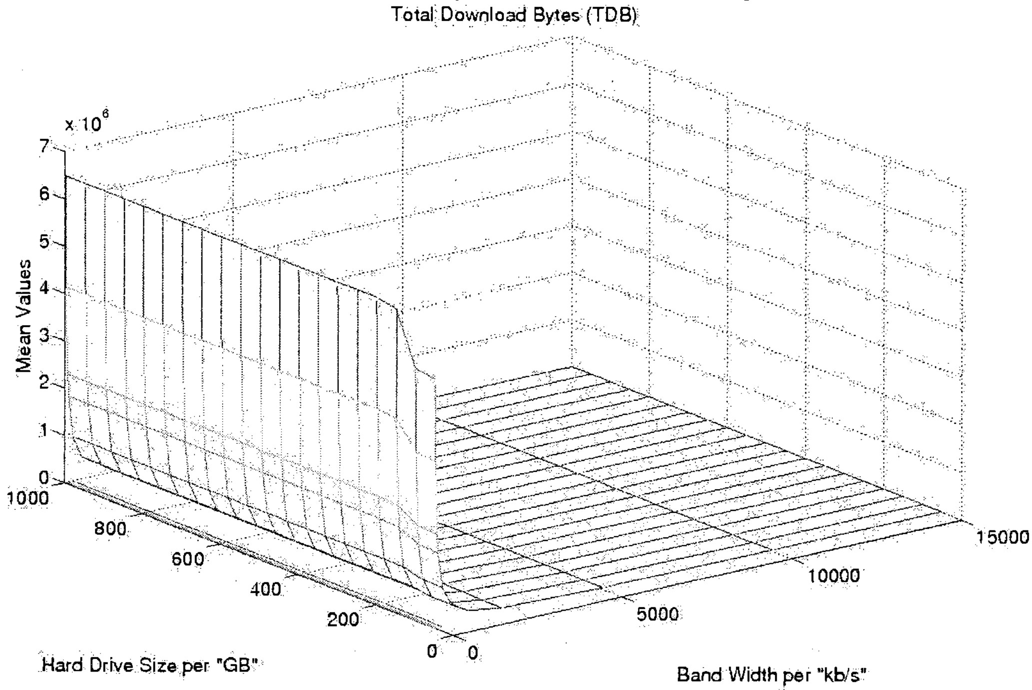


Figure 1122: Total Download Bytes for H3 case scenario after interval 100-hour

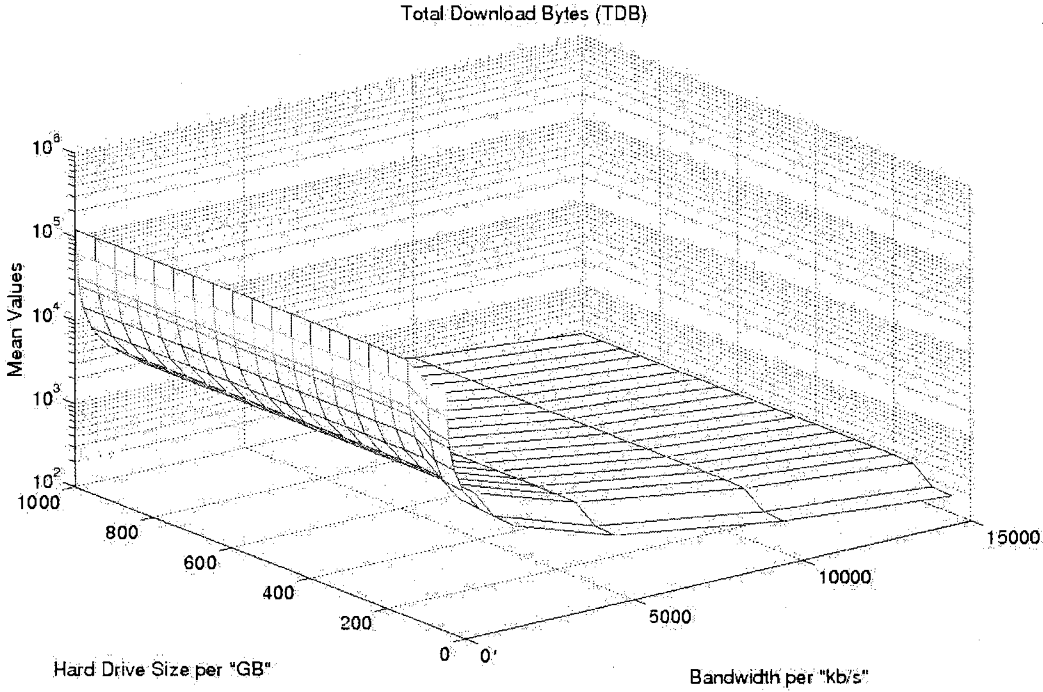


Figure 1123: Total Download Bytes for H3 case scenario after interval 1000-hour

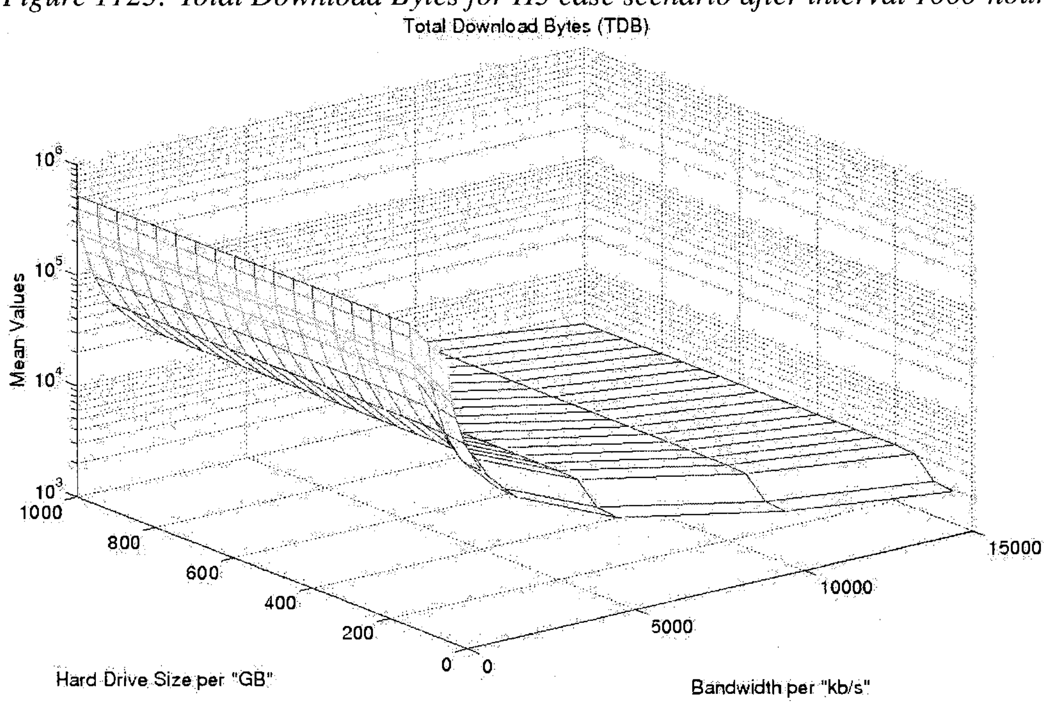


Figure 1124: Total Download Bytes for H3 case scenario after interval 1900-hour

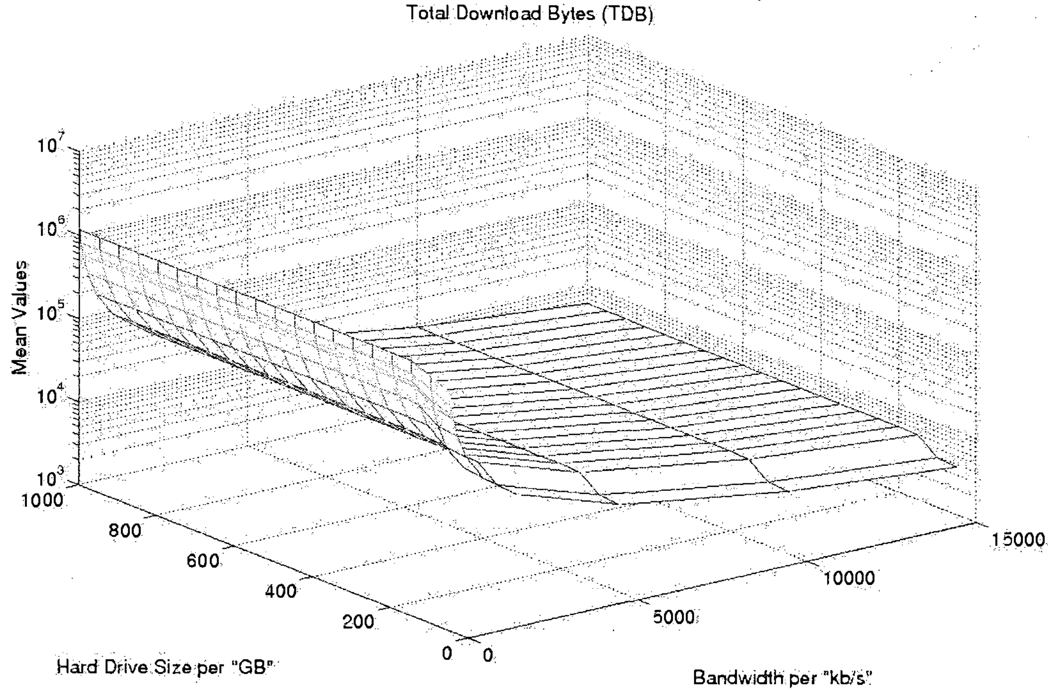


Figure 1125: Total Download Bytes for H3 case scenario after interval 2800-hour

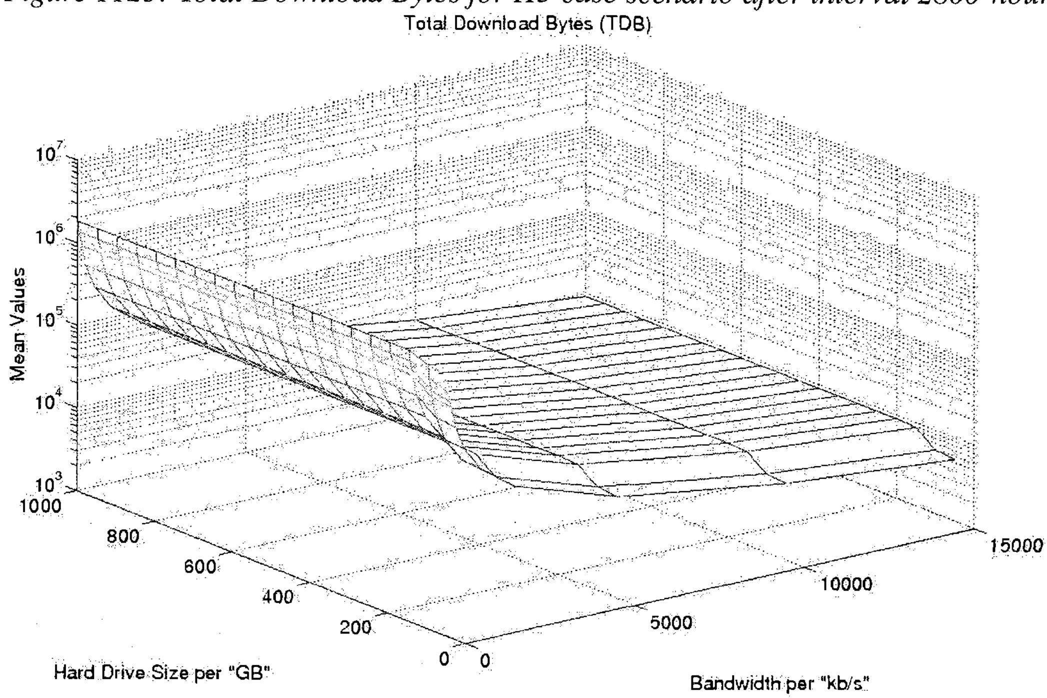


Figure 1126: Total Download Bytes for H3 case scenario after interval 3700-hour

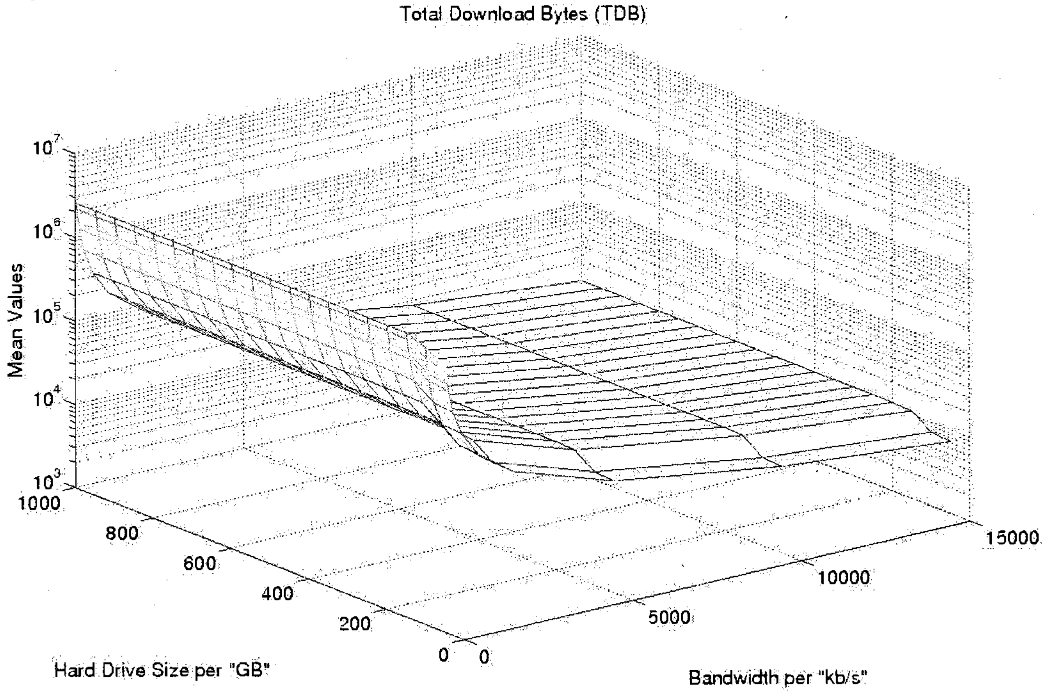


Figure 1127: Total Download Bytes for H3 case scenario after interval 4600-hour

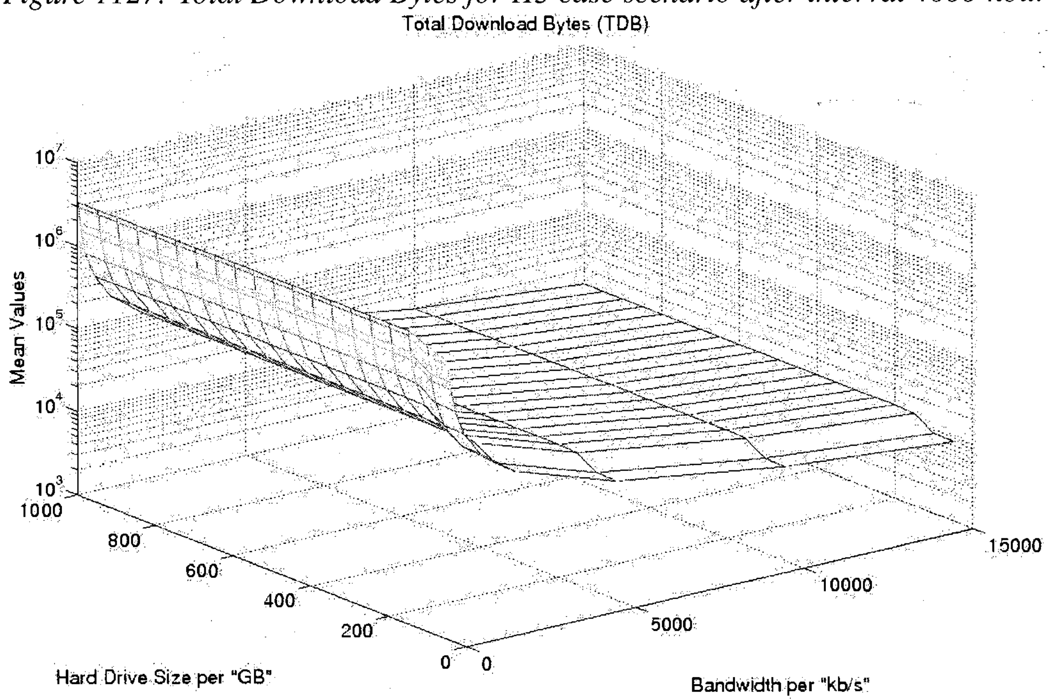


Figure 1128: Total Download Bytes for H3 case scenario after interval 5500-hour

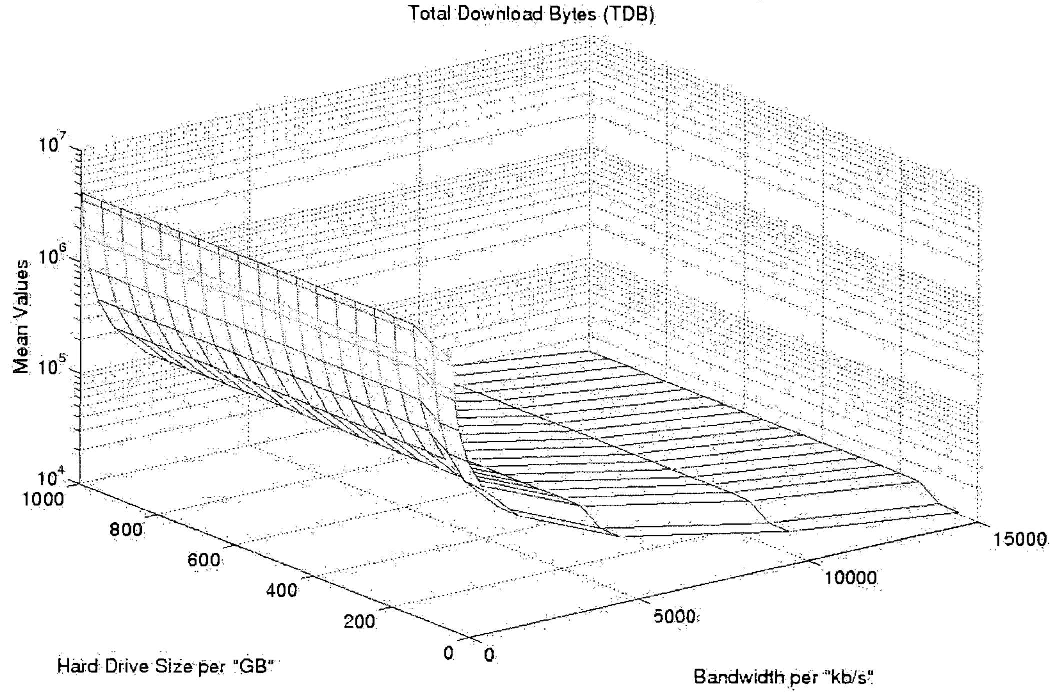


Figure 1129: Total Download Bytes for H3 case scenario after interval 6400-hour

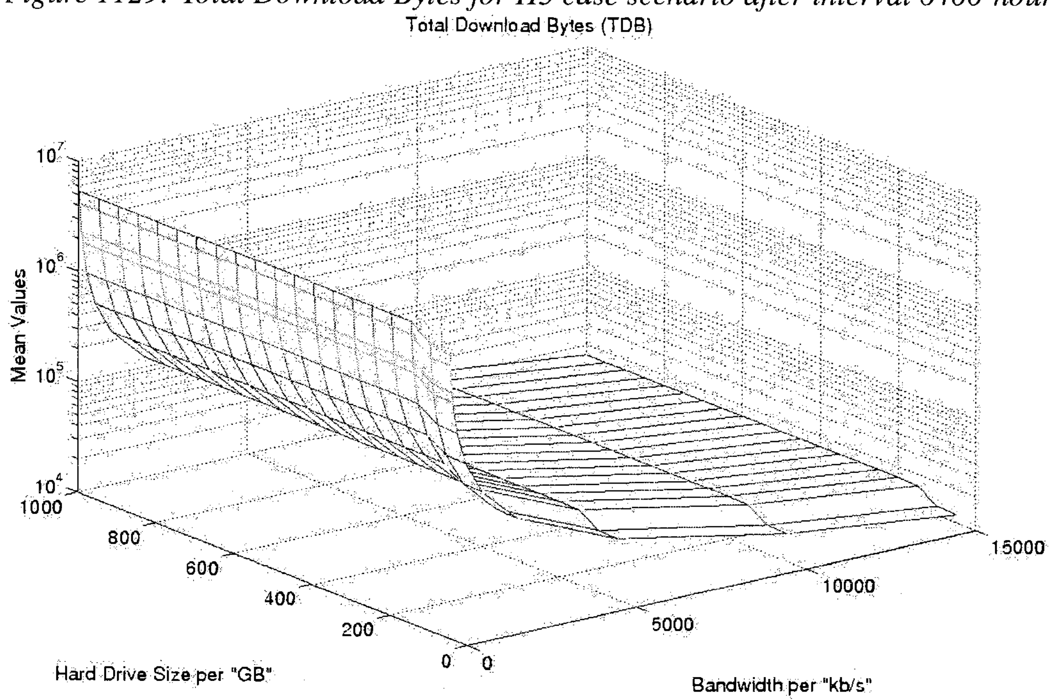


Figure 1130: Total Download Bytes for H3 case scenario after interval 7300-hour

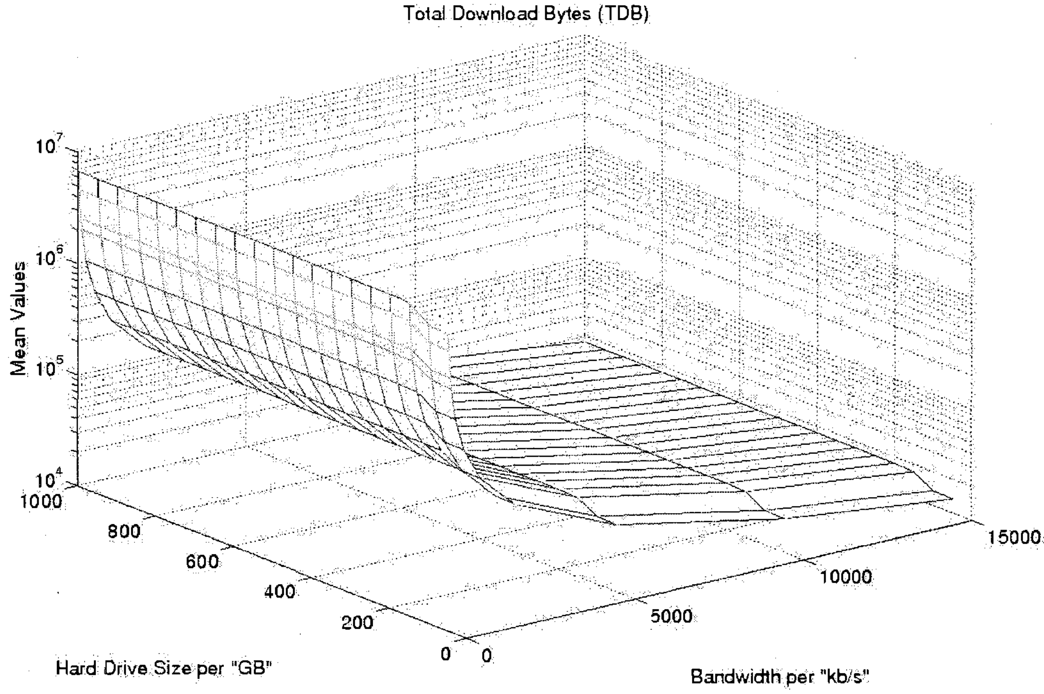


Figure 1131: Total Download Bytes for H3 case scenario after interval 8200-hour

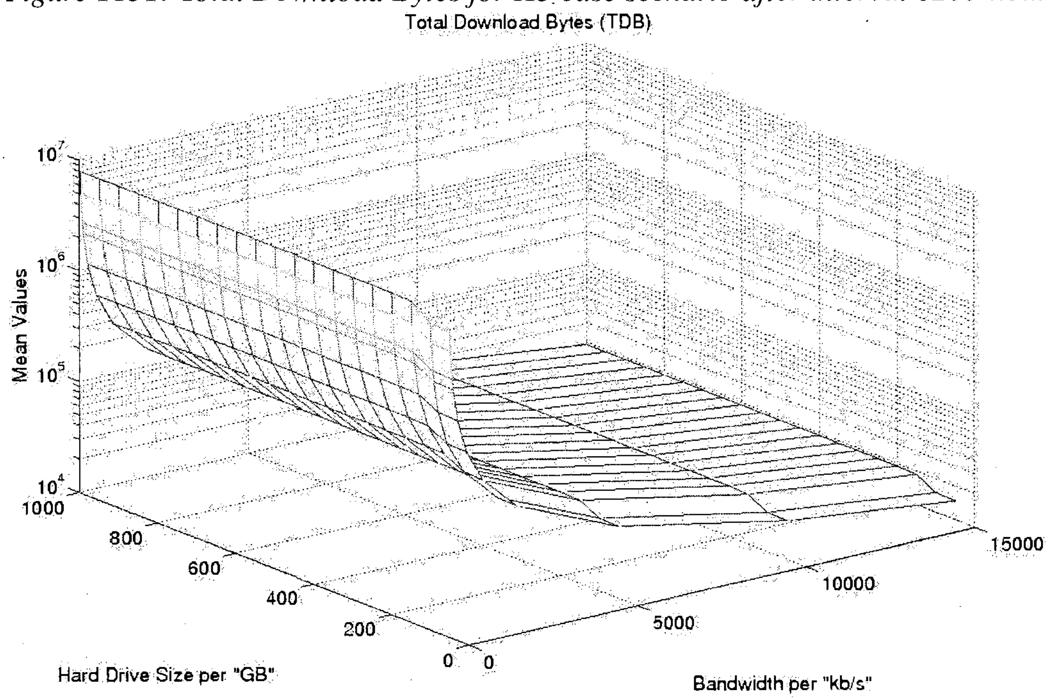


Figure 1132: Total Download Bytes for H4 case scenario after interval 100-hour

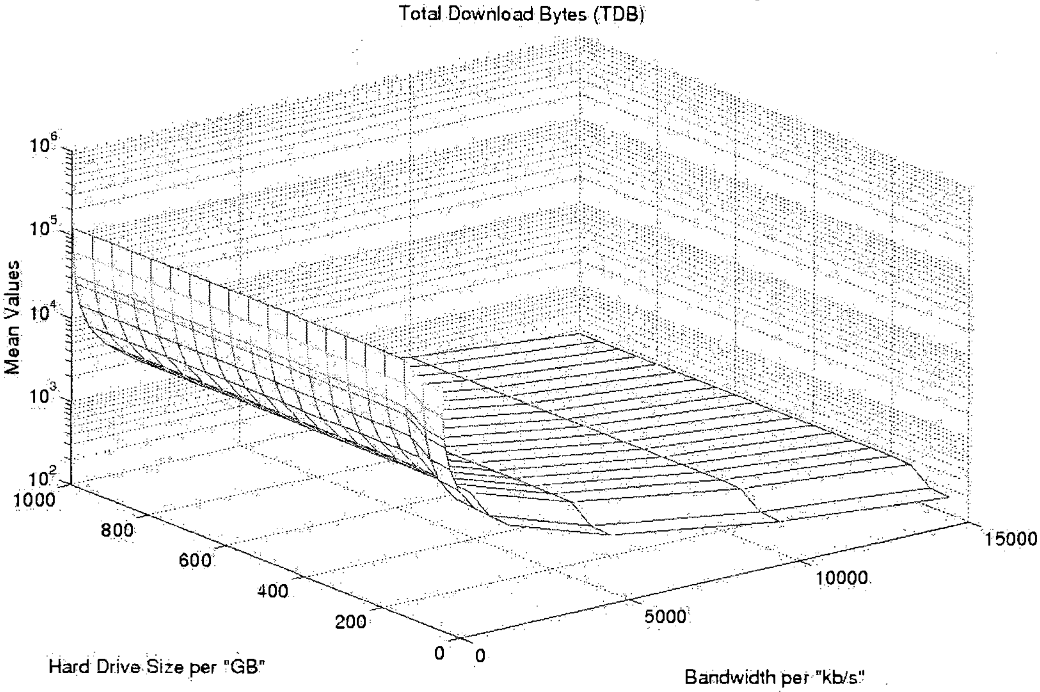


Figure 1133: Total Download Bytes for H4 case scenario after interval 1000-hour

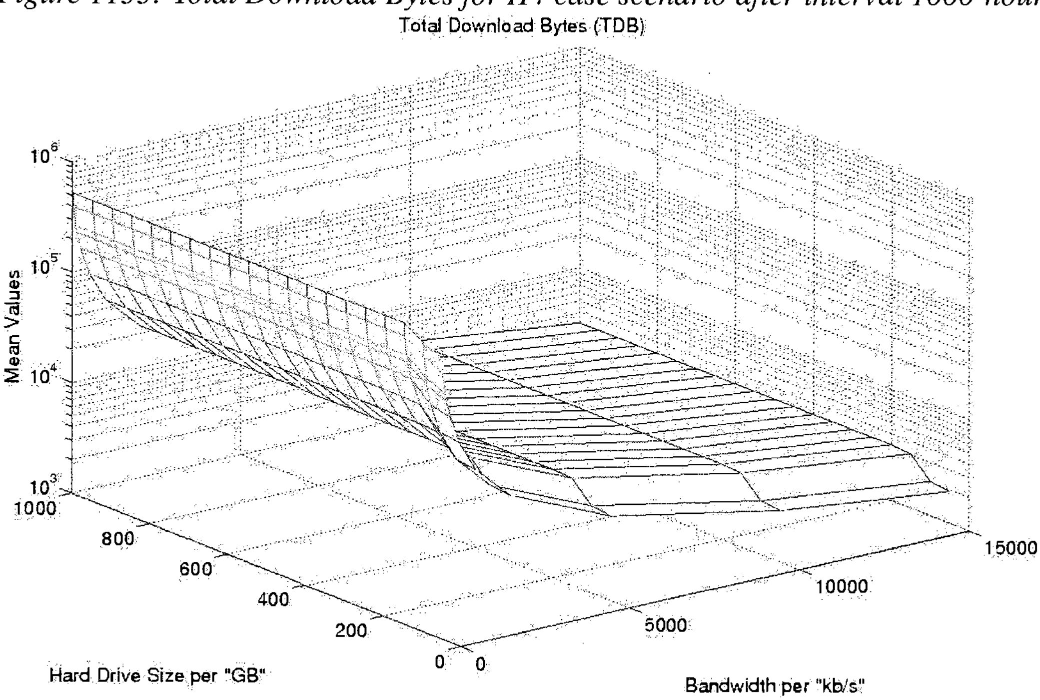


Figure 1134: Total Download Bytes for H4 case scenario after interval 1900-hour

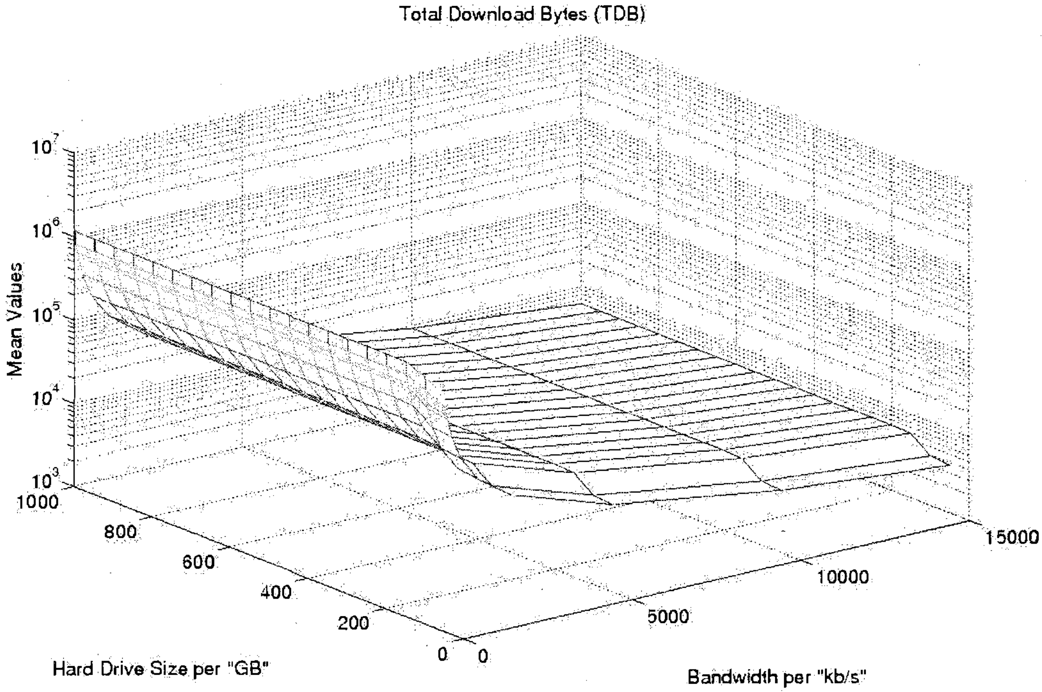


Figure 1135: Total Download Bytes for H4 case scenario after interval 2800-hour

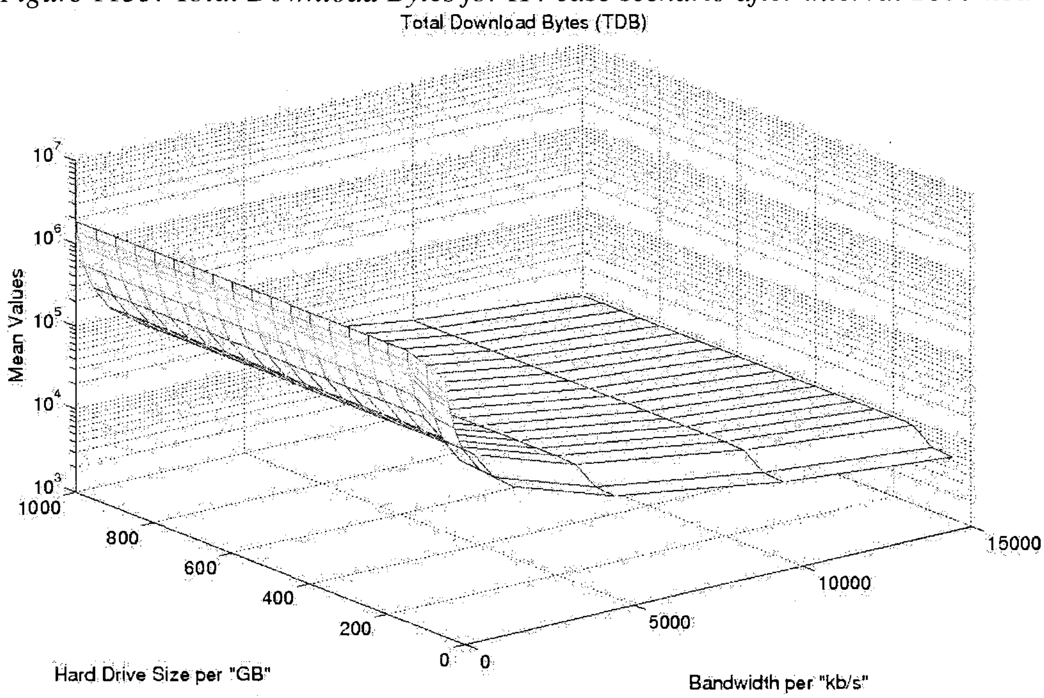


Figure 1136: Total Download Bytes for H4 case scenario after interval 3700-hour

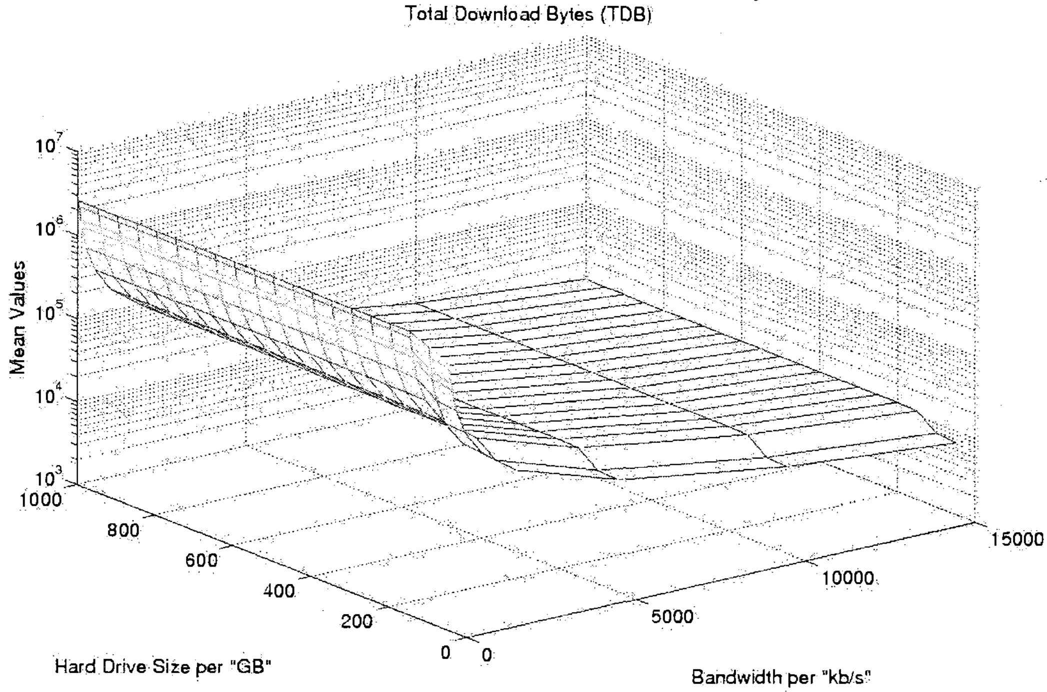


Figure 1137: Total Download Bytes for H4 case scenario after interval 4600-hour

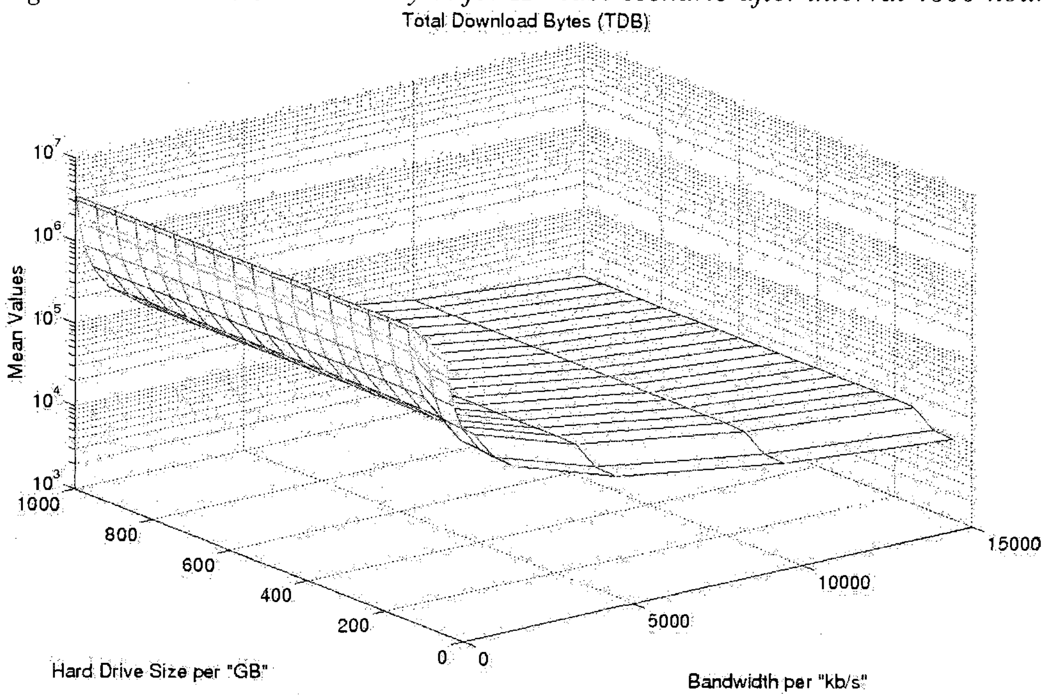


Figure 1138: Total Download Bytes for H4 case scenario after interval 5500-hour

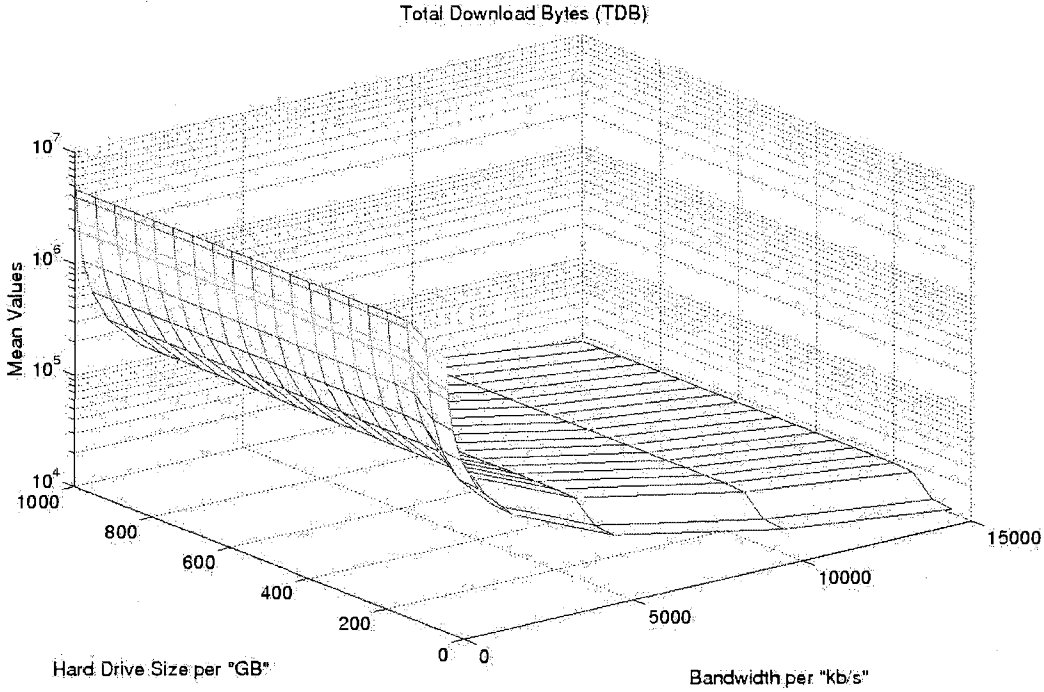


Figure 1139: Total Download Bytes for H4 case scenario after interval 6400-hour

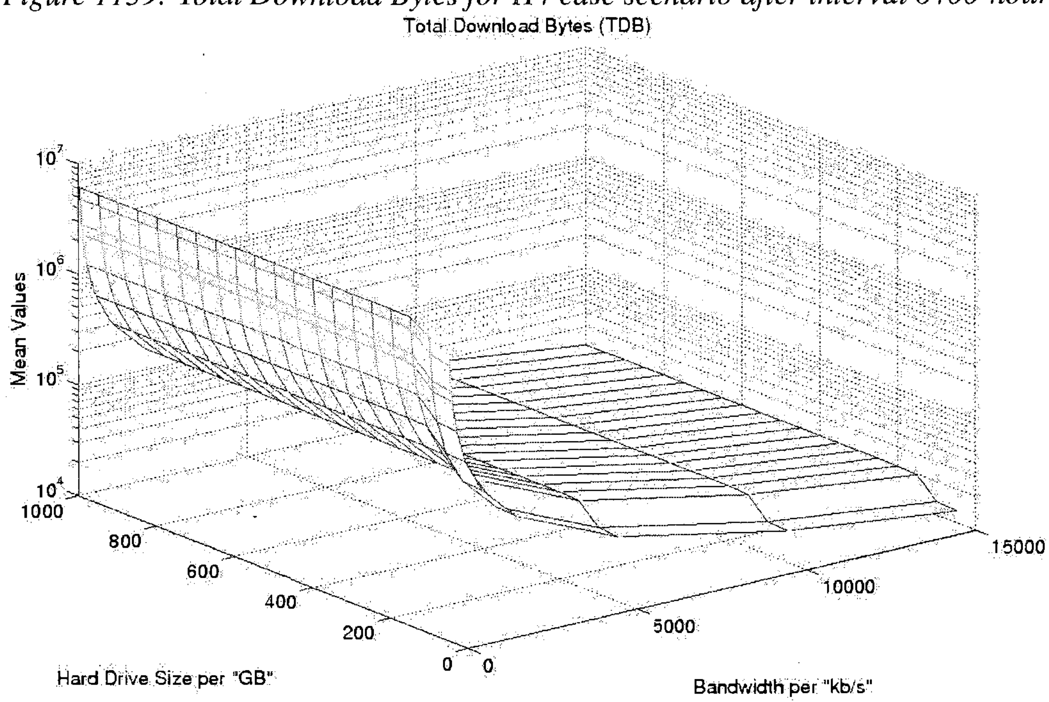


Figure 1140: Total Download Bytes for H4 case scenario after interval 7300-hour

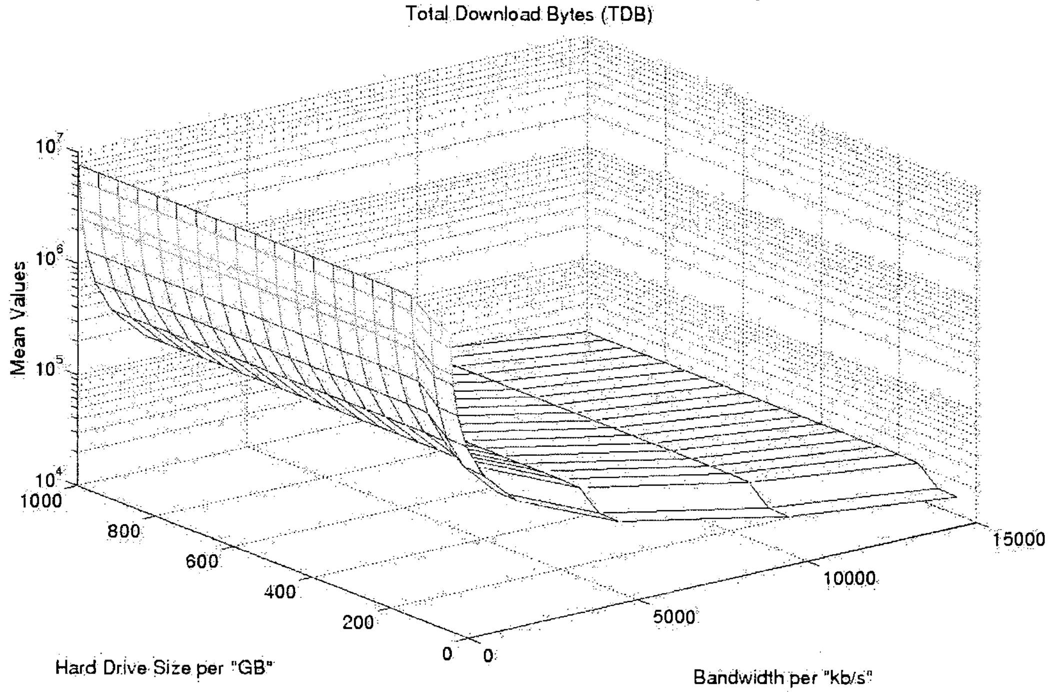
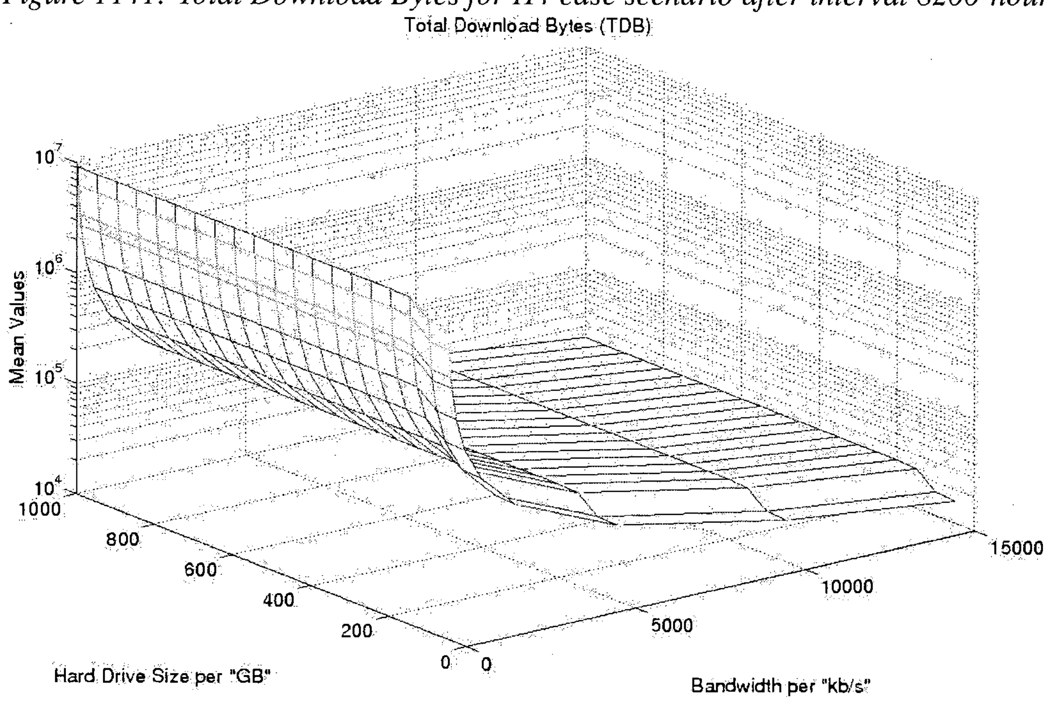


Figure 1141: Total Download Bytes for H4 case scenario after interval 8200-hour



VITA

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Ramez Ahmed Abdel Ghaphar Shamseldin was born in Alexandria, Egypt on November 5, 1974, the son of Dr. Ahmed Abdel Ghaphar Shamseldin and Samya Ali Salama. After completing high school at Gamal Abdel Naser Military High School, Alexandria, Egypt in 1992, he attended Alexandria University in Alexandria, Egypt from 1993-1997. He graduated with a Bachelor of Electrical and Communication Engineering degree in 1997, then he taught at Engineering at Alexandria University in Alexandria, Egypt for two years. From 1998-2000, he worked in a large partnership in Egypt with Caterpillar. After that he left the company to pursue a Master degree at Devry University in Chicago, Illinois. On November 2000, he graduated with a Master of Information System Management degree in May 2004. On December 2004, he joined one of the largest Telecommunication Company in United States which is Verizon and worked in a fiber program as a Senior Network Design Engineer to deliver triple play services to either commercials or residential homes. He attended Old Dominion University in Norfolk, Virginia on January 2005. He graduated with a Doctoral of Philosophy degree on May 2009.

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