A PERFORMANCE EVALUATION OF A HOMOGENEOUS WIRELESS NETWORK USING OPNET IT GURU

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With the advancement of computer technology comes the advancement of methods used to network computers together. One of the newest forms of computer networks is the wireless network. Wireless communication has been around for many years, but only recently has wireless technology become prevalent in computer networking applications.

This study focuses on the factors that have significant impacts on the performance of a wireless network. The network modeled in this study is intended to represent a real-life classroom setting in which students have the ability to transfer and download files, check email, and surf the web.

The tool of evaluation for this study is OPNET IT Guru. OPNET IT Guru is a network simulation tool capable of modeling wired and wireless networks. OPNET will be used to simulate network activity and record performance based on changing the parameters of two main factors. These factors include application load and number of hosts. The sole response that will be used to evaluate the network performance is the mean delay on the network in seconds.

The collected data from the simulations were analyzed using a General Linear Model in Minitab and a two-factor full factorial experimental design. According to

the collected data, it was determined that all factors and combinations of factors were statistically significant. It was also determined that increasing the number of hosts alone on a network has a greater impact on the mean delay than increasing the application load alone.

Accepted by: ____________________, Chair

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CHAPTER I

INTRODUCTION

Computer networks are omnipresent in this age that has been deemed the "Information Age." It is difficult to find an electronic system today that does not contain a computer or a microcontroller. Once this computer or microcontroller is connected to another computer or microcontroller, then a computer network exists.

Computer networks come in several varieties, but the general functioning of them are all the same. The Institute for Electrical and Electronic Engineers (IEEE) has set up a set of standards that govern the way networks should function. Networks can vary by their configuration and the medium by which data is transferred. This Thesis closely examines the use of one of those mediums of transfer, wireless.

Problem Statement

The purpose of this Thesis is to evaluate the performance of a wireless network using the OPNET IT Guru Network Simulator. The study will use the simulator to perform an experimental design of a wireless network in a classroom. The experiment will examine the performance of a wireless network with various numbers of users, and various application loads. Upon completion of the study, the results are hoped to achieve three goals. They are as follows:

1. To demonstrate how OPNET IT Guru can model networks; specifically Wireless Local Area Networks.
2. To demonstrate that increasing the number of hosts and/or the application load of a network will increase the delay.
3. To determine which parameter (if any), application load or number of hosts, causes the mean delay to increase the most.

Chapter 2 of this Thesis presents some of the basic terminology and concepts involved with computer networks. The chapter gives a brief overview of network cabling, network topology, network devices, and MAC and IP addresses. The chapter then goes into more detailed information regarding the problem statement. Examples of wireless research, a historical overview, and the concepts of wireless technology are presented in Chapter 2.

Chapter 3 of this Thesis is entitled "Methodology." The purpose of this chapter is to describe the methods used to achieve the goals in the problem statement. Several methods of experiment and data collection are discussed and analyzed, and reasons for choosing one particular method are given.

Chapter 4 of this Thesis is a Chapter devoted solely to OPNET IT Guru. The purpose of Chapter 4 is to demonstrate the capabilities of the simulation software chosen for this Thesis.

Chapter 5 of this Thesis is entitled "Simulation Setup." This chapter describes how the simulations will be performed. The chapter includes descriptions of factors, responses, assumptions, and limitations.

Chapter 6 presents the results from the performed simulations. This chapter includes graphs and tables that visually represent the collected data. The chapter also contains a General Linear Model created in Minitab and a factorial design of experiments to analyze the percent variation for each factor.

Chapter 7 of this Thesis is the conclusion. This chapter contains information that demonstrates the achievement of the goals listed in the Problem Statement. The chapter also presents solutions and suggestions for improving the performance of various wireless network configurations.

CHAPTER II

REVIEW OF LITERATURE

This chapter will provide a glance at other research done on wireless network modeling and a historical overview of wireless technology. This section will conclude with a review of wireless concepts.

Network Cabling

Coaxial cable is not as commonly used now as it used to be due to slower speeds and the difficulty involved with installation. Some applications of coaxial cable include IEEE 802.3 10Base5 Ethernet LAN, IEEE 802.4 token bus LAN, and Systems Network Architecture. The maximum speed of data through coaxial cable is only 10 Mbps. One advantage of coaxial cable is that it can transfer data over a great distance. The Broadband 75 ohm coaxial cable has a distance limitation of 3600 meters between nodes (Harwood, 2003).

Fiber-optic cable is becoming more common in network applications today. Single-mode fiber and multimode fiber are the two types of available fiber optic cable. Single-mode fiber sends a single beam of light through the cable during transmission. Multi-mode fiber sends many beams of light through the cable during transmission. Speeds of fiber optic transmissions can reach more than 100 Mbps, with distances covering 2 km (Harwood, 2003).

Unshielded twisted pair (UTP) is the most commonly used form of media in current network applications. Unshielded twisted pair has four pairs of wires twisted together in a non-metallic sheath. RJ-45 connecters are used to construct patch cables with UTP cable. Depending on the application, the speeds of UTP can reach 1,544 Mbps over 1950 meters. The application for which UTP cable is intended is identified by its category number. There are seven UTP categories. Category 1 and Category 2 are associated with voice transmissions. Categories 3 through 7 are associated with data transmissions. The most common application has a CAT 5 UTP cable transmitting at 100 Mbps over a distance no greater than 100 meters (Harwood, 2003).

Network Topology

A second distinguishing characteristic of a computer network is the topology of the network. A network's topology refers to the physical and logical layout of the network. The physical layout of the network is what can actually be seen. This is the way the computers, cables, and network devices are laid out in the network. The logical layout of the network refers to the way the network looks to the devices that use it. The most common topologies used in current networking applications are bus, ring, and mesh topologies (Harwood, 2003).

A bus network contains a backbone to which all the computers on the network are linked. Computers are connected to the backbone using T connectors, taps, or splitters. In order to prevent disruptions in data rate transmissions, bus topology requires that each end of the physical bus be terminated. Bus topology is generally very cheap to implement because it requires less cable than other topologies. There are also no special network devices used for bus topology (Harwood, 2003).

Bus topology creates a dilemma when computers must be added to the network. In order to add computers to the network, the entire network must be disrupted because all systems connect to a single backbone. A break in the backbone causes the entire network to go down. A bus network is also extremely difficult to troubleshoot since a fault causes the entire network to shut down rather than just the faulty device(s) (Harwood, 2003).

A network with a ring topology functions exactly as it sounds. The logical topology of the network is a ring. In a ring network, the data will travel in a circle from one computer to another on the same network. The physical layout of a ring network is not the same as the logical network. Physically, a ring network is usually connected in a star configuration (discussed later). As with bus topology, if a computer or a piece of cable is removed from a ring network, the entire network is disrupted. A ring network can be compared to a series circuit in electricity. The ring topology is not a logical choice for network in which computers will need to be constantly added or removed.

The star topology is very common in current network applications. In the star topology, all computers and devices on the network are connected to a centralized hub or switch, with each device connected to the hub or switch individually. This approach prevents the problem of network disruption when adding and removing computers. This configuration also allows the network to remain accessible if a cable or computer is faulty. Due to the amount of cabling needed to implement a star network, the cost is greater than that of other topologies. Another disadvantage of the star topology is that the hub or switch allows for a single point of failure for the entire network. If the hub or switch fails, then the entire network will be inaccessible.

Due to its configuration, the mesh topology is the most reliable topology. In a mesh network, each computer or device on the network is connected to every other computer or device on the network. The mesh topology provides a great amount of redundancy which makes it an extremely fault tolerant topology. If one path in the network fails, the data will always have an alternate path to travel. Mesh networks require an even greater amount of cabling than does the star topology; making this design the most costly to implement.

Network Devices

Now that the cabling and topology of computer networks have been described, the devices that make up the network need to be introduced. A network can contain a number of devices depending on the application and purpose of the network. Some of the more common devices found on smaller networks are hubs, switches, routers, modems, and network interface cards. These devices are generally found on a Local Area Network or LAN. A LAN is simply a network that is restricted in geographic location, and only covers a small area such as an office, classroom, or small building.

Other devices that may be found on larger networks include bridges, gateways, and system area network cards. These devices can be used in Wide Area Network or WAN applications. A WAN is a network that spans over more than one location. A WAN generally connects two or more LANs.

In order for LANs and WANs to function, several devices are required. The most basic necessary device is a hub. Hubs are used to connect computers and devices on a LAN. A hub will send all data to every computer that is connected to it. Two types of hubs are available, the passive hub and the active hub. Passive hubs do nothing but provide a path for electrical signals to travel along. An active hub provides the same path, but it will regenerate a signal before passing it along to the connected devices. A hub does not process the data or check for errors, thus making the hub a highly inefficient device.

Switches are very similar to hubs in providing a connection point and pathway for devices and data. However, a switch performs a task that a hub does not. A switch will only send data to the port that connects to the destination device, rather than sending the data to all connected devices. A switch does this by matching the MAC address of the device to the destination MAC address in the data it receives. A switch is highly efficient in improving network performance. Switches create a direct path between two devices, and reduce the number of times two devices attempt to transmit at exactly the same time on the same network (collisions).

Bridges are devices that are used on large networks to create smaller, more manageable network sections. A bridge is placed between two physical network segments to manage the flow of data between these two segments. A bridge will look at the MAC address of the devices connected to each segment and then either forward the data or block it from crossing. This decision is based on whether the bridge determines that the destination address is on another interface. If the destination address is on another interface, the bridge will forward the data; otherwise the data is blocked. Bridges can be highly complicated to implement correctly.

In order to place a bridge on a network properly, the 80/20 rule must be used. This means that 80% of the data coming to the bridge should transmitted locally (same interface), with the other 20% destined for devices on other interfaces.

Another complication that occurs when implementing bridges is a loop. Bridging loops are common when more than one bridge is placed on a network. Confusion among bridges can occur when one bridge believes that a destination device is located on a segment that it is not. The Spanning Tree protocol is used to prevent bridging loops. The Spanning Tree Protocol allows bridge interfaces to be assigned a value that can be used to control the learning process of the bridge.

There are three types of bridges that are used in network applications: transparent bridges, source route bridges, and translational bridges. A transparent bridge is a bridge that exists on a network without other devices on the network being aware of it. A transparent bridge will block or forward data based on the source MAC address. Source route bridges are most often used in token ring networks. In this application, the path that the data is to take is embedded within the data, and the bridge routes the data to the appropriate path. Translational bridges are used to convert one networking data format to another. For example, if data from an Ethernet network was destined for a Token Ring network, a translational bridge would be used to convert the format of the data from Ethernet format to Token Ring format.

While a bridge can be used to split a network into smaller sections, a router is used to combine two networks to make a larger network. A router has the capability to route information it receives from one network to another. Once a router receives a packet, it reads the header of the packet to determine the destination address. Once the router has determined the destination address, it looks in its routing table to determine whether it knows a path to the destination. If the router knows the path, it will forward the packet to the next hop on the route. The next hop could either be the final destination, or another router. If it is another router, that particular router will perform the same task until the packet reaches its destination. A router sees a network differently than the network is designed, only seeing devices that are one hop away. In other words, a router can only see devices to which it is directly connected. When forwarding a packet, the router will choose the shortest path from those that are directly connected to the router. Each router along the path will perform the same task.

Very similar to a router, a gateway is a device that translates one data format to another. A gateway can be a router that translates data from one network protocol to another. A gateway is only responsible for translating the data format, and not the data itself. It is common to confuse the term gateway with the term default gateway. A default gateway is a router on a network that is connected to another network. If a device on a particular network has a packet to send to a device on another network, the packet will be sent to the default gateway first. The default gateway handles all transmissions that are not destined for the local network. The default gateway will then examine the destination address, and forward the packet appropriately.

In order for the network to be fully functional, there must be some interface between the computer and the network. Two devices that can be used to interface a personal computer with a network are modems and network interface cards.

The term modem is short for modulator/demodulator. A modem converts digital signals generated by a computer into analog signals that are capable of traveling over conventional phone lines. A modem that receives a transmission will convert the analog signal back to a digital signal so that the receiving computer can understand the information.

Modems can either be internal or external devices. In most current applications, modems are internally installed into a computer. This is generally done via PCI expansion cards. Older computers have modems that use the ISA slot; however, computers are being built today without the ISA slots. External modems can either be connected via the serial or USB port of the computer. Proper configuration of the modem depends on if the modem is internal or external.

Internal modems can be very easy to install depending on the operating system of the computer. Most current operating systems will automatically install the modem properly. However, it is important for a user to know the proper procedure for installing the modem. First, the modem must be configured with an interrupt request (IRQ) and a memory I/O address. It is extremely important to make sure these addresses do not conflict with the addresses of another device or the system will not function. If the modem is configured to a serial interface, the resources of that interface will be assigned to the modem. If the operating system does not automatically make these assignments, the user must do so.

In cases where the operating system will not automatically install an internal modem, external modems can be less complicated to configure. External modems connect directly to a port; therefore the resources for that port will be used automatically. Modems that connect to a USB port are considered plug-and-play devices and do not require the user to assign resources. The system will automatically recognize the device. In any installation case, the drivers for the modem must be installed to the computer before the device will be enabled.

A concern in any network is the speed of the network and the devices on the network. There are two factors that can affect the speed of a modem connection. First, the speed of the modem itself, and second, the speed of the Universal Asynchronous Receiver/Transmitter (UART) chip in the computer to which the modem is connected. The UART chip is responsible for controlling the serial communication of the computer. It is important that the speed of the UART chip is sufficient to support the installed modem.

The other interfacing device used to connect computers to a network is the Network Interface Card. Network Interface Cards are usually installed in a PCI expansion slot of a computer. Older Network Interface Cards may use the ISA slot, but this is highly uncommon now. Like a modem or any other device installed on a computer, the Network Interface Card must have an IRQ and a memory I/O address. These addresses can not conflict with any other device on the system or system devices will not function properly. It is also vital to consider the compatibility of the Network Interface Card with the cabling and type of network on which the card is being installed. The vast majority of Network Interface Cards sold in stores are configured to be used with twisted pair cabling with Ethernet. There are cards available for coaxial and fiber-optic, but they must be ordered specifically. Wireless network cards are also becoming a standard in laptop computers and portable devices. Other network types, such as Token Ring, must also be specified. Unlike Ethernet, every network card on a Token Ring network must be configured to transmit at the same speed, or else the network will not function properly.

MAC and IP Addresses

In order for devices to communicate over a network, there must be a means for the devices to identify each other. MAC and IP addresses serve this very purpose. A MAC address is known as an identifier for hardware. The MAC address is burned into each network interface on the network. A MAC address is a 6-byte address that is unique to a network interface and is used to identify each interface on the network. MAC addresses are expressed in hexadecimal form, with each byte of the address separated by either a colon or a hyphen. According to the rules of a hexadecimal number, the values of a MAC address can only take on the numbers 1-9 and the letters A-F. IEEE is responsible for managing the use of MAC addresses. This organization makes sure that each MAC address is unique to the device to which it is assigned.

An example of a valid MAC address would be 12-1F-D3-FF-D5-A1. Examining the address, the first three bytes identify the manufacturer of the device. Therefore, each device that is manufactured by this particular company will contain 12-1F-D3 as the first three bytes of the MAC address. These numbers are called Organizationally Unique Identifiers and are assigned by IEEE. The last three bytes of the address are assigned by the manufacturer. This portion of the address is called the Universal LAN MAC address.

An IP address can be a little more complicated than the MAC address. An IP address is software-based, and is also unique to each device on a network. An IP address is composed of four sets of 8 bits or octets. Each octet is separated by a period. For example, a valid IP address would be 192.168.41.143. This address identifies the individual system as well as the network to which the system is attached. It is possible to determine which part of the address is the device and which part is the network by examining what is called the subnet mask. In a subnet mask, the part of the IP address that refers to the network is assigned a binary value of 1. The node address will be assigned a binary value of 0. For the given address of 192.168.41.143, it will be assumed that 192.168 is the network address. Given the rules of subnet masks, a binary 1 will be assigned to each bit of the network address.

The remaining bytes will be assigned 0. Therefore, the binary subnet mask will appear as 11111111.11111111.00000000.00000000, or 255.255.0.0 (Harwood, 2002).

Wireless Research

Since wireless communication is becoming more widely used, many researchers are evaluating how a wireless network functions. Mineo Takai, Jay Martin, and Rajive Bagrodia (n.d.) of UCLA performed a study on Mobile Ad Hoc Networks. In their paper, "Effects of Wireless Physical Layer Modeling in Mobile Ad Hoc Networks," they show that factors at the physical layer affect the absolute performance of a routing protocol as well as the relative ranking among protocols for the same scenario. This study does not include the use of OPNET IT Guru due to the specificity of the results. Instead, the researchers chose to utilize ns-2 and GloMoSim. These two simulators are commonly used in mobile ad hoc network studies.

Takai et al. (n.d.) studied four modeling factors of the wireless physical layer that were examined. These factors included the physical layer preamble, interference computation and signal reception, fading and path loss, and physical layer models of common simulation tools.

The Takai et al. study examined the packet delivery ratio with different signal reception and fading models. The study also examined the end-to-end delays of the various cases. The experiment was designed to compare the performance of the AODV routing protocol to the DSR routing protocol. Takai et al. used the free space path loss model and the two ray path loss model to conduct the experiment. They determined that the end-to-end delay increased as the estimated channel condition became more severe.

OPNET has been previously used to perform wireless data simulations. Michael Jiang, Stephen Hardy, and Ljiljana Trajkovic (n.d.) performed a study involving a performance evaluation of wireless data using OPNET. Their paper, "Simulating CDPD Networks Using OPNET," describes how they used OPNET to "investigate the impact of self-similar traffic on performance of a cellular digital packet data (CDPD) network." (p. 1)

This study used genuine traffic traces collected from an existing company. According to the results of the paper, genuine traffic traces are responsible for producing longer queues. As a result, these traffic traces require larger buffers in the switching element of the network.

While many studies have been done to evaluate the performance of wireless local area networks, some studies are being done to improve the capacity of wireless networks. Harkirat Singh and Suresh Singh (n.d.) wrote a paper entitled, "Improving Wireless Network Capacity Using Smart Antennas in OPNET." The study developed a "novel slotted ALOHA protocol (Direction-Of-Arrival ALOHA) for use in ad hoc networks where nodes are equipped with smart antennas" (Singh and Singh, n.d.). Singh and Singh exploit the benefits of adaptive array antennas to yield throughputs that are two to four times higher than recent protocols. The final results indicated that by adding 8 Smart Antennae to the wireless network, the throughput is two to three times more than other protocols. When 16 antennae were used, they determined that the throughput was three to four times greater than previous protocols. This study essentially provides a way to increase the amount of data a wireless network will transmit. Therefore, performance is evaluated based on the throughput of the network.

Historical Overview

Wireless communication has been around for more than 60 years. The vast majority of wireless communication has been voice communication for many of these years. Even during World War II, soldiers communicated with wireless communication devices on the battle field. Wireless data access got its start in the mid 1980s. This is when wireless networks such as Ardis and RAM/Mobitex came about. These networks could provide data transfer speeds of 8Kbps-19.2Kbps. By the early 1990s, the necessary hardware became available to connect a laptop modem to an analog cellular phone. These two technologies were not designed specifically to be interfaced with each other; therefore there were several problems that arose. In 1995, CDPD technology began using idle channels in the analog cellular systems to achieve data rates of 19.2Kbps.

GSM and CDMA marked the modern beginning of wireless data transfer. These standards included provisions for data transmission speeds of 9.6Kbps-14.4Kbps. These transmissions were digital rather than analog, and the coverage was better than that of previous wireless networks.

Mainstream Wireless LAN (WLAN) devices and products began with the original 802.11 standard. This standard was developed in 1997 by IEEE. In the years to follow, the standard was enhanced and given letter notations after the 802.11 name. The enhancement standards include 802.11b, 802.11a, and 802.11g. The letter following 802.11 represents the task group that defines the extension to the standard. Enhancements of 802.11 brought forth increases in data rate and functionality. This eventually would lead to the rapid progression of WLAN products. In July of 1999, IEEE ratified 802.11b and 802.11a. Nearly four years later, in June of 2003, 802.11g was ratified by IEEE (WLAN Standards, 2003).

Wireless Technology

In order to begin a discussion on the concepts of wireless technology, it is essential to explore some of the terminology that is used when discussion wireless networks. Two important terms that will be mentioned are complementary code keying modulation (CCK) and orthogonal frequency division multiplexing modulation (OFDM).

CCK was adopted in 1999 to replace the Barker code in wireless digital networks. A complementary code contains a pair of finite bit sequences of equal length, such that the number of pairs of identical elements with any given separation in one sequence is equal to the number of pairs of unlike elements having the same separation in the other sequence. A wireless network that uses CCK is capable of transferring more data per unit time for a given signal bandwidth than wireless network using the outdated Barker code. This is possible because CCK makes more efficient use of the bit sequences.

OFDM is a method of digital modulation in which a signal is split into several narrowband channels. These channels are split at different frequencies. OFDM was first examined in the 1960s when research was performed to discover a way to minimize interference among channels near each other in frequency. OFDM is very similar to frequency division multiplexing (FDM). The main difference between the two is the way in which the signals are modulated and demodulated. Priority is given to minimizing the interference among the channels and symbols comprising the data stream. Less priority is given to perfecting individual channels. OFDM is used in European digital audio broadcast services. OFDM is also being considered as a method of obtaining high-speed digital data transmission over conventional telephone lines (Vaughan-Nichols, 2002).

OFDM has been proven to be a superior technology, but numerous incompatible OFDM standards may prove to limit the usefulness of the technology. The principle driving force behind the increasing popularity of OFDM in the wireless world is the ubiquitous demand for faster data speeds. Multimedia applications are also becoming more prevalent in the communication world. Such applications are data intensive, and require higher bandwidths. OFDM relies on high-speed digital signal processors which make it capable of satisfying the desires of those wishing for higher data rates (Vaughan-Nichols, 2002).

Another sought-after quality of OFDM is the reduced interference. A common form of interference associated with wireless communication is called multipath distortion or delay. This type of delay occurs when a transmitted signal is echoed off objects in a room such as walls, floors, and furniture. As a result of these echoed signals, series of signals reach the receiving antenna at different times because they travel different paths. OFDM protects against this interference through forward error correction. OFDM also transmits each bit relatively slowly. This method simply alters the number of bits sent per second by the transmitter. For example, a system that wished to send 1 Megabit per second could opt to send 1 bit per microsecond. This would give exactly 1 Megabit per second. However, in the case of a delayed transmission of more than 1 microsecond, an overlap would occur and interference would be produced. To combat this, a system can send 1000 bits in parallel over 1000 OFDM subchannels. In this case, one bit can be transmitted every millisecond and the 1 Megabit per second data rate would be achieved. Through this method, a signal delay of more than 1 microsecond would only overlap one-thousandth of the next bit transmission period. This reduces the interference to nearly nothing (Vaughan-Nichols, 2002).

One major issue surrounding the implementation of OFDM is the amount of power it consumes. An OFDM component is designed to run at a system's peak power usage. The problem occurs in battery-powered devices such as laptops and handheld devices. Since wireless technology's major advantage is its convenience, many users wishing to access a wireless network will be using a battery-powered device (Vaughan-Nichols, 2002).

WLANS

Wireless local area networks or WLANs have been around for many years. Only recently has the technology become more understood and prominent in the market. WLANs operate in the Industrial, Scientific, and Medical (ISM) frequency spectrum. Any product can use this spectrum as long as it complies with certain regulatory rules. These regulatory rules include characteristics such as radiated power and modulation methods (Held, 2001).

The two major ISM bands are the 2.4 GHz band and the 5.7 GHZ band. The 5.7 GHz band is also referred to as the National Industrial Infrastructure (NII) band. Several WLAN devices use these bands because the FCC does not require licensing. Microwaves and many portable phones operate on the 2.4 GHz band. Some portable phones can be found to operate on the 5.7 GHz band (Held, 2001).

As mentioned earlier, wireless networks raise concerns about the security of information being sent through the air. The current security standard for WLANs is WEP (Brain, 2005). In WEP, administrators deploy a secret key on both the access point and wireless device. The key is then used to encrypt data and check data integrity. The access point can also use the key to authenticate its clients.

As wireless networks become more widely used in personal and business applications, it is essential for users to have ample information on the devices used to access the wireless networks. When a network administrator implements access points in a wireless network, it is essential to provide ample security measures for the network. In general, wireless access points are shipped by a manufacturer with WEP disabled. An administrator must realize this, and enable WEP before deploying the access points. Other security features with the access point are assigned default values by the manufacturer. It is imperative that these values be changed before the deployment of the access point. Such features include passwords, the simple network management protocol or SNMP parameters, channel selection, dynamic host configuration protocol or DHCP setup, and the firewall configuration.

Wireless Standards

Currently, the IEEE has three standards for wireless local area networks. These standards are identified as 802.11b, 802.11a, and 802.11g.

802.11b

802.11b was ratified by the IEEE in July of 1999. This standard extends the original IEEE 802.11 direct sequence spread spectrum standard to operate up to 11 Mbps. 802.11b operates in the 2.4 GHz spectrum using CCK modulation (Stallings, 2004). One major setback with 802.11b is that it is not interoperable with 802.11a products. However, 802.11b covers a larger area than 802.11a, therefore, less access points are needed. While the specifications of 802.11b indicate data speeds of up to 11 Mbps, the expected maximum throughput of 802.11b is about 5.8 Mbps. This rate decreases as the distance from the access point increases. A user can expect to have speeds of 5.8 Mbps up to 150 feet away from an 802.11b access point. At 200 feet, a user can expect to have a maximum throughput of 3.7 Mbps. At 300 feet, the maximum throughput drops to only 0.9 Mbps (WLAN Standards, 2003).

802.11a

802.11a was ratified by the IEEE at the same time as 802.11b. 802.11a is significantly different than the 802.11b standard. 802.11a products operate in the 5 GHz spectrum. 802.11a was designed for higher bandwidth applications that 802.11b. 802.11a uses OFDM modulation on up to 12 discrete channels (Stallings, 2004). The theoretical maximum data rate of 802.11a is 54Mbps. However, a user can expect a maximum throughput of about 24.7 Mbps. The range of 802.11a is considerably less than that of 802.11b. The maximum expected data rate of 24.7 Mbps can only be reached at distances of 0 to 50 feet from an access point. From 50 to 100 feet, a user can expect a maximum rate of 19.8 Mbps. 802.11a is not capable of transmitting over distances greater than 200 feet (WLAN Standards, 2003).

802.11g

802.11g is the standard that will be used in this experiment. 802.11g is the most recent of the wireless local area network standards to be ratified. In July of 1999, an 802.11g subcommittee was tasked to extend the 2.4 GHz spectrum to data rates faster than 20 Mbps (Stallings, 2004). In June of 2003, the 802.11g standard was ratified as a result of the works of the committee. 802.11g has a theoretical maximum data rate of 54 Mbps, and it is backwards compatible with 802.11b devices. 802.11g specifies OFDM and CCK as the mandatory modulation schemes with 24 Mbps as the maximum mandatory data rate. Optional data rates of 36, 48, and 54 Mbps are also provided.

Figuring out the actual expected throughput of 802.11g networks is slightly more complex than that of 802.11a and 802.11b. The compatibility of 802.11g with 802.11b makes it necessary to consider 802.11b products in the area when determining throughput. Performance is best in environments where an 802.11g access point is only communicating with 802.11g clients in a homogeneous WLAN. In such an environment, the data rate within 75 feet of the access point is 54 Mbps and the throughput is 22-24 Mbps.

As mentioned before, one of the main advantages of 801.11g is its backward compatibility with 802.11b products. 802.11g uses the same radio signaling as 802.11b at the lower four 802.11g data rates. This allows 802.11g networks to support 802.11b devices when migrating to the higher performance standard.

In a mixed environment of 802.11g and 802.11b devices, it is essential to have protection mechanisms to manage the communication. 802.11b devices are not capable of hearing when airspace is busy with 802.11g OFDM signals. Protection devices are used to prevent 802.11b clients from transmitting during the period when 802.11g OFDM signals are being transmitted. This is accomplished by sending a short 802.11b rate message signal to 802.11b devices ordering them not to transmit during a specified period of time (WLAN Standards, 2003).

There are two signaling methods that are used in mixed 802.11g/b environments. These two methods are request to send/clear to send (RTS/CTS), and CTS-to-self. The RTS/CTS is exactly what the term implies. A client will make a request to send a packet, and it will wait for clearance before sending the packet. The CTS-to-self method sends a CTS message using an 802.11b rate to clear the air. This message will immediately be followed with data using an 802.11g data rate (WLAN Standards, 2003).

CHAPTER III

METHODOLOGY

As mentioned in the problem statement, the purpose of this thesis is to determine the factors that have the greatest impact on the performance of a wireless network using OPNET IT Guru as a modeling tool. The most efficient way to determine this is to do an experimental design. The experimental design will consist of combining factors in various ways to determine the.affect on the performance of the network. For the purpose of this thesis, the performance of the network will be based on the total delay (in seconds) that can be anticipated with the given network scenario.

There are various research methods that can be utilized to collect the desired data for and study. These methods include but are not limited to theoretical, experimentation, and simulation.

A theory can be defined as "a set of systematically interrelated concepts, definitions, and propositions that are advanced to explain and predict phenomena (facts)."(Cooper, 2001) Theoretical research is performed in order to explain or predict what goes on around us. Theoretical research is generally complex, abstract, and includes several variables.

Experimentation in research involves intervention by the researcher that goes beyond that required for measurement. In most cases, a researcher will manipulate a variable in a specified setting, and make observations of the effects it has on the studied subjects. Experimentation usually includes independent and dependent variables. Independent variables are the variables that can be changed or manipulated by the researcher. Dependent variables are those variables that change as a response to the changing independent variables.

The method of research chosen for this Thesis is simulation research. Simulations are most commonly used in operations research. Characteristics of various conditions in actual situations can be represented in mathematical models when simulations are performed. Simulation research was chosen for this Thesis because a real-life network needs to be modeled in order to evaluate the performance. It is impractical to perform experimentation because of the number of devices that would be necessary to gather for this research. Theoretical research does not apply to this Thesis because an evaluation is being performed rather than a development of Wireless Technology theory. Therefore, the logical choice of research is simulation research.

Network Simulators

The best way to gain an understanding of how a network will perform and function is to actually set up the network and run various tests. However, this can take valuable time, and cost lots of money. In most cases, it is not practical to run trial and error experiments with network implementations. Therefore, network simulators are the best way to decide the most efficient way to set up a functional network. Simulators allow an administrator to perform various tests using various scenarios in order to obtain optimal performance for a network. Simulators are highly effective in saving time and money in the network implementation and installation phases. The market is currently saturated with network simulators for researchers, network administrators, and universities to use as a tool to implement an efficient network. The choice of simulator is based on what the individual or individuals are looking to gain from the experiments. Some simulators are designed just for wireless networks, while others are designed to evaluate a network's interaction at the physical and MAC layers. This section will give a basic overview of some of the network simulators on the market today, including OPNET IT Guru.

QualNet

In December of 2004, Scalable Network Technologies launched QualNet Version 3.8. This particular program can be used to design and test communication networks. This includes ad-hoc wireless networks as well as other wireless networks and wired networks. QualNet is equipped with the capability to accept packet data traffic from a real network. This capability is made possible through the add-on called the Real-time Interface Module. This add-on gives QualNet the capability to directly support hardware-and-software-in-the-loop simulation (Scalable Networks, 2004). Some of the protocol models for Version 3.8 include the following:

- Policy Based routing
- Session Initiated Protocol
- Routing Information Protocol next generation
- Address Resolution Protocol
- Bordercast Resolution Protocol

The wireless physical models include the following:

- Microwave
- Fast Rayleigh Fading
- Advanced Stand Alone Prediction System Propagation
- Automatic Link Establishment for High Frequency Radios
- Weather Model for Troposphere Fading

QualNet WiFi Network Simulator

In May of 2004, Scalable Network Technologies released QualNet WiFi Network Simulator. This software is a WLAN simulation tool. This software is designed to simulate the interaction between the MAC and physical layers of wireless networks. The software contains a library of wireless protocols. It also contains wireless access points, distributed coordination functions, point coordination functions, power consumption and management analysis, and dynamic association and reassociation analysis (Scalable Networks, 2004).

GloMoSim

GloMoSim is a commonly used network simulator for the performance evaluation of wireless ad hoc routing protocols. GloMoSim contains a scalable simulation environment for both wireless and wired network systems. This software was designed using parallel discrete event simulation capability. This software currently supports protocols for purely wireless network environments. The designers of GloMoSim designed their software using a layered approach similar to the OSI layered network architecture. The layers used in GloMoSim include the following:

- Mobility
- Rapid Propagation
- Radio model
- Packet Reception Models
- Data Link (MAC)
- Network (Routing)
- Transport
- Application

While GloMoSim is an extremely powerful network simulator, it has one major disadvantage. The range of users that can use GloMoSim is very narrow, and it may not be practical for some applications. In order to run GloMoSim, a user must have what is known as the Parsec compiler. The user also must be familiar with the parsec compiler in order to develop protocols in GloMoSim. The user must also have knowledge of C code; as Parsec is a C-based simulation language. It is also necessary to write code in C when developing protocols (GloMoSim, 1999).

CHAPTER IV

OPNET IT GURU

The network simulator chosen for this experiment is OPNET IT Guru. OPNET IT Guru has the ability to model an entire network including routers, switches, protocols, servers, as well as the individual applications they support. IT Guru is capable of simulating the performance of wireless networks as well as wired networks and hybrid networks. The OPNET environment is extremely user friendly, and provides a sense of reality that makes it easier to set up modeled networks. Figure 4.1 shows a screen capture from OPNET IT Guru.

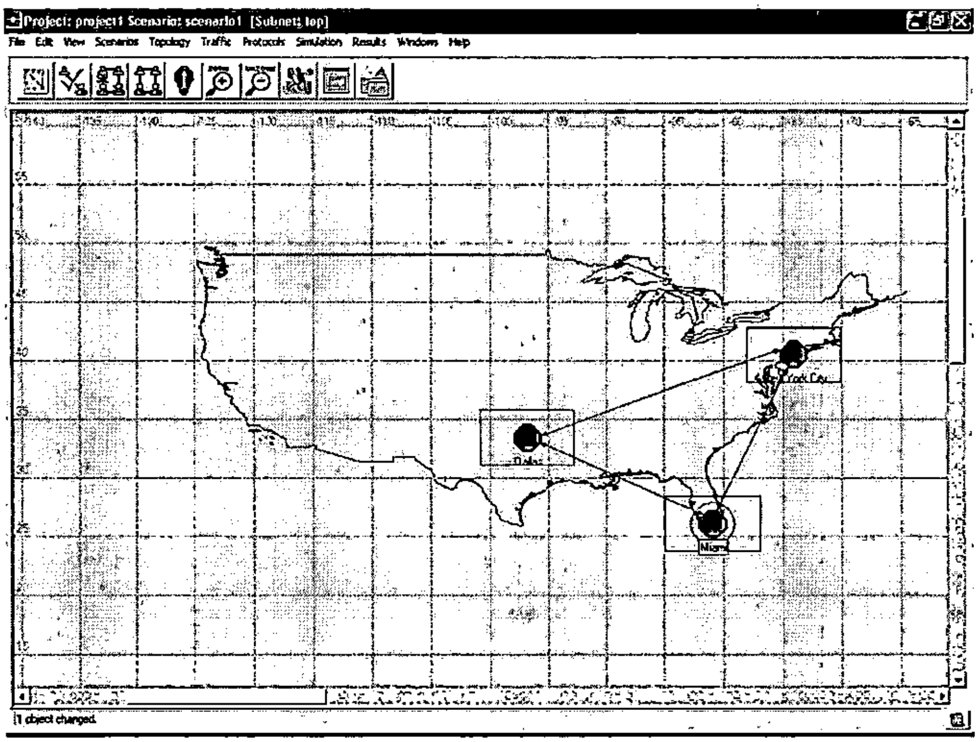

Figure 4.1. Virtual Private Network in OPNET IT Guru

Figure 4.1 shows a very basic image in OPNET. The capture shows a map of the United States with three subnets placed in the cities of New York, Dallas, and Miami. OPNET allows you to choose various scales of the networks you wish to simulate. These scales include World, Enterprise, Campus, Office, and Logical. There is also a "choose from maps" option. This option allows you to choose a map from one of the several that are stored in OPNET's database. As in Figure 4.1, the user can choose the map of a country, and place subnets or networks in various locations around the country. This particular scenario may simulate a franchise that has corporate headquarters in Dallas, New York, and Miami. It is beneficial to the franchise to have all of its headquarter locations directly connected to each other to expedite communication and data transfer. For such applications, many companies choose to use what is called a Virtual Private Network (VPN). A private network is a network which is composed of company computers and leased telephone lines. These networks are very secure, and they work perfectly fine. Someone wishing to intrude on the company's information transfers must physically wiretap the telephone lines. The major problem with this concept is the extreme cost. In order to lease these lines, companies must pay thousands of dollars per month (Tanenbaum, 2003).

Once public data networks came about, many companies figured it would be more economical to place their data traffic on public networks. However, this brought about security concerns. This is when the Virtual Private Network was invented. A VPN is an overlay network on top of public networks. VPNs have most of the properties of private networks. In Figure 4.1 there are three subnets or offices.

Within each office are several computers that are placed behind a firewall. Between each of the offices or subnets is a link. The links are connected to the firewall in each office. In this situation, a firewall is a router that is set up to only allow traffic from specific networks to flow to the other side. All other traffic will be blocked (Tanenbaum, 2003).

OPNET IT Guru also has options that allow a user to configure a network based on its topology. Once OPNET is opened, the user can choose the "Topology" menu from the toolbar. This menu contains an option called "Rapid Configuration." The Rapid Configuration option allows a user to choose the topology of the modeled network from an array of topologies. Once the topology is chosen, the user is then able to choose the type of nodes and number of hosts to be placed on the network. In network topologies such as the Star topology, the user is able to choose the radius of the network. Rapid Configuration is a useful tool that assists in keeping the uniformity of a modeled network. If a user wishes to model a network that is irregular, then he/she cannot use the rapid configuration option. Figure 4.2 shows the Rapid Configuration window in OPNET IT Guru.

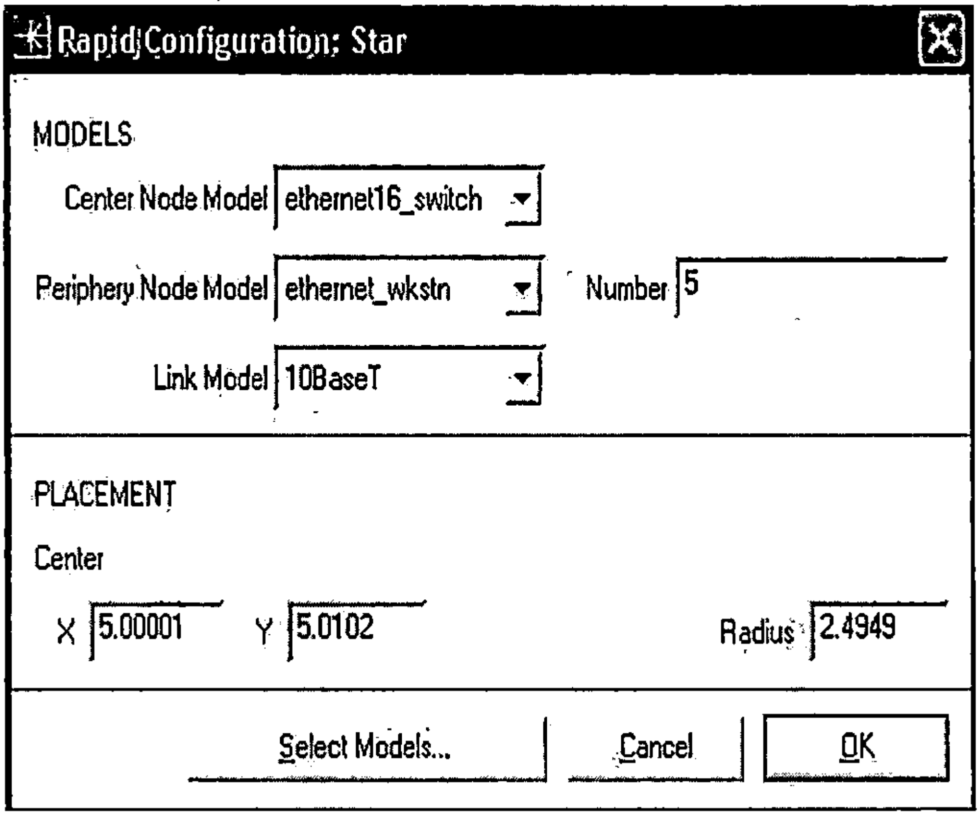

Figure 4.2. Rapid Configuration Window in OPNET IT Guru

Once a user determines the devices and manner in which to organize the network, he/she must configure the network. Configuration of a network model in OPNET IT Guru consists of setting up tasks, applications, and profiles that will be used on the modeled network.

In OPNET IT Guru, a task is something that a user wishes to be performed when an application is run. There are example tasks contained with OPNET IT Guru, or a user can define his/her own tasks. When defining a task, a user must configure various phases for the task. For example, if a user wants to create an application to read the temperature from a remote microcontroller the user must define the steps that need to be taken to acquire the temperature reading. The user might choose for a server and client to contact each other before the temperature reading takes place. This is the first phase of the task. The next phase will be for a client to actually take the reading. The third stage will be for the client to send the reading to the server or another computer. Finally, the server or other computer will acknowledge the receipt of the temperature reading. Within the task configuration menu, a user can specify when a specific phase will begin, how much information is transmitted during the phase, and how long the phase will last.

The next vital component to configuring a network model in OPNET IT Guru is defining applications. Applications are programs that a user wishes to run on a modeled network during a simulation. Applications include Email, File Transfer Protocol, Web Browsing, Print, Telnet, Database, Video Conferencing, and Voice. A user can also create custom applications by defining tasks to be performed within an application. When configuring an application, a user has the option of choosing the amount of data being transferred during the execution of the application, the duration of the application, and how often the application is executed.

In order for OPNET to know which hosts will perform which applications, the Profile configuration tool must be used. Profile configuration allows a user to assign various applications to various hosts on the network. A user can create a number of profiles by defining the applications used for a particular profile. A user will then assign a profile to the desired host or hosts on the modeled network. For example, in a classroom, there is a teacher and many students. In order to model the traffic on a classroom network in OPNET, the user must setup a profile for the teacher and the student. The teacher might have access to File Transfer, Web Browsing, and Email; while the student will only have access to File Transfer. An OPNET user will configure a profile for a teacher which will include the File Transfer, Web Browsing, and Email applications. The user will configure a separate profile for the student which will only include the File Transfer application. The OPNET user will then assign these profiles to the appropriate hosts on the modeled network. Figure 4.3 shows the wireless network that will be modeled for this Thesis.

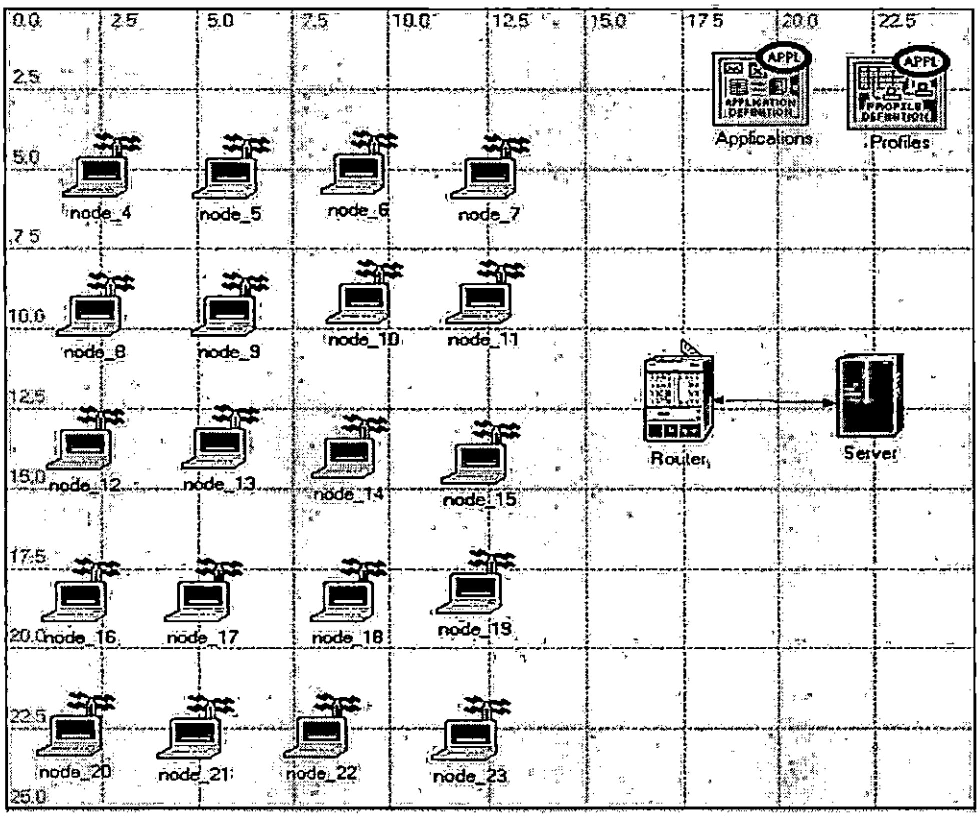

Figure 4.3. Wireless Local Area Network in OPNET IT Guru

Once a user has configured the network, the actual simulation of the network can take place. Prior to running a simulation in OPNET IT Guru, it is essential to tell OPNET IT Guru what to record from the simulation. A user must go to the "Choose Individual Statistics" menu in OPNET in order to do this. The three types of statistics that can be recorded in OPNET are Global Statistics, Node Statistics, and Link Statistics. Global Statistics show results from the entire network. Node Statistics will only show information about a selected node on the modeled network. Link Statistics will only show information about a selected link on the modeled network.

Subsequent to selecting statistics to gather from a simulation, the actual event simulation can be performed. In order to perform a simulation, OPNET needs to know the duration of the simulated model, the value for each statistic, the update interval, and the seed of the simulation. The seed is a value OPNET uses to tell the register when to begin counting. This value is merely used to add statistical confidence to various simulation runs. Figure 4.4 shows the Simulation Configuration window in OPNET IT Guru.

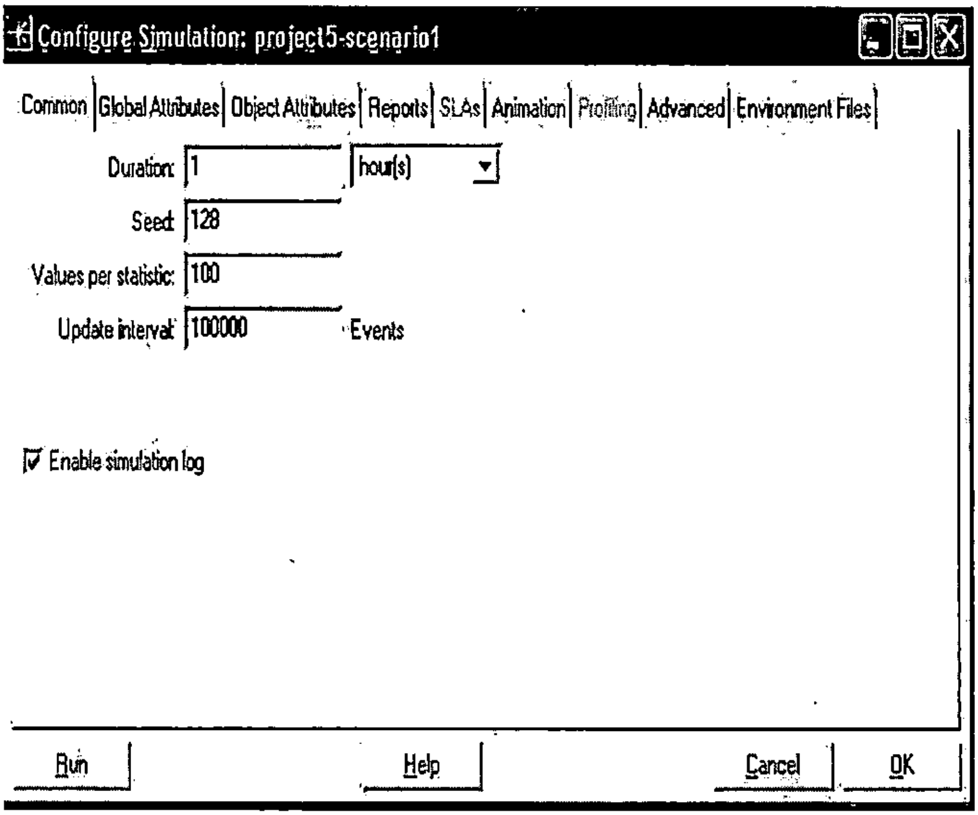

Figure 4.4. Simulation Configuration Window in OPNET IT Guru

CHAPTER V

SIMULATION SETUP

Factors

The factors chosen for this experiment are application load and number of hosts. An application is a program that a user will be running on the computer that will require access to the server on the network. Applications that will be examined for this experiment will include Email, Web Browsing, and File Transfer Protocol (FTP). OPNET IT Guru allows a user to specify the load that will be expected from each of these applications. There are options for light and heavy loads. The experiment will consist of testing the network performance for light and heavy loads of each of the mentioned applications. The second factor is the number of hosts on the network. The number of hosts will take on the discrete values of 10, 20, and 30.

Response

The sole response that will be examined in this experiment is the total delay in seconds. The delay will be used to evaluate the overall performance of the WLAN. Delay was chosen as the evaluating response due to the nature in which network simulators model network performance. The most accurate response that can be examined is the delay of the traffic over the network. Other responses such as data rate are extremely unpredictable in the wireless environment. The routing of packets in a wireless network is different than the routing of packets in a wired network, and this variation makes the data rates of wireless networks unpredictable.

Assumptions of Study

Wireless networks are extremely difficult to model using a network simulator. The transport medium for wireless networks is the atmosphere. Therefore, it is difficult to predict how a wireless network will perform because the performance can vary based on changing atmospheric conditions and surroundings. For this experiment, it is necessary to make some assumptions to facilitate the results of the experiment.

The first assumption that will be made is that each device on the network will be an 802.11g device. As mentioned earlier, the 802.11g standard requires that 802.11g products be backward compatible with 802.11b products. When an environment is mixed with 802.11b and 802.11g products, the performance of the network will diminish. Therefore, this experiment will assume that there are no 802.11b devices or products within transmitting range of the modeled network. It is also assumed that the speed of the processors for each computer on the network is the same. Processor speed of a computer is important because the computer can only operate as fast as the processor can process the information. If the network were to include computers with different processing speeds, the network can only be as fast as the slowest computer connected to the network. Realistically, the network will actually be slower than the slowest computer due to the bottleneck that will be created by the different speeds of the processors. Therefore, for simplicity and practicality, this experiment will assume that all computers on the network will have the same processor speed.

Limitations of Simulator

There is one major limitation that comes from performing this experiment with OPNET IT Guru. The only version of the software available for this Thesis is the Academic version of OPNET IT Guru. Inherent to this version are some designed limitations of features. The major limitation that will affect this experiment is the number of events that can be simulated for any given setup. The Academic version only allows 50,000,000 events to be simulated for any one simulation run. This means some of the parameters for the experiment will need to be altered to stay under this limit. This also means that some of the simulations will be run for less than a simulated hour while others will be run for an entire simulated hour. In the "Results" section of this thesis, it will be noted when an experiment was run for less than an hour. Results from experiments running less than an hour will only be compared with results in the same time frame of other experiments. For example, if one experiment ran for 25 minutes while another ran for an hour, only the results from 25 minutes will be used for the latter experiment.

Setup

Table 5.1 shows the parameters and their values that will be used for each simulation in the research. The first column shows the number of hosts or computers involved in the particular simulation. The discrete values for this column are 10, 20, 30, and 40. The second column is labeled "seed". OPNET uses this value to initialize the state of the random number generator. Using different seed values for a simulation with all other parameters the same will allow for statistical confidence to be established. This column can take on discrete values of 64, 128, or 1024. The final three columns show the applications that will be used in this research. The applications are Web Browsing (Web), File Transfer Protocol (FTP), and Email. The values in these columns will either be heavy or light. Heavy and light refer to the loads at which the applications will be executed. In Web and Email, the main different between heavy and light is how often the application is accessed in a given amount of time by any one host. For FTP, the file size on a light load is 1.5 MB as opposed to the 2.0 MB size of the file for the heavy load. Like Email and Web, the number of times the application is executed during a given amount of time by any one host also varies between light and heavy.

Each parameter and factor was chosen to simulate real-world applications. The models are intended to simulate a typical classroom environment. The file size was chosen based on the size of a typical PowerPoint presentation with 30-40 slides. In a typical classroom setting, students will need to download these particular presentations from an instructor's website in order to follow the lecture. The seeds were chosen to simply add statistical confidence to the data. The actual value of the seed is not important for this experiment; however it is important to choose values that are significantly different.

Number of Hosts	**Seed**	**Web**	**FTP**	**Email**
10, 20, 30	64, 128, 1024	Light	Light	Light
10, 20, 30	64, 128, 1024	Heavy	Light	Light
10,20,30	64, 128, 1024	Heavy	Heavy	Heavy

Table 5.1. Simulation Parameters

Chapter VI

RESULTS

The purpose of this thesis was to determine the factors that have the greatest effect on the performance of a Wireless Local Area Network. Specifically, the research used factors such as application load and number of hosts to determine one response, delay. Through the use of OPNET IT Guru, several simulations were performed to model a Wireless Local Area Network using different combinations of parameters. This chapter will present the data and analysis that came from those experiments.

To begin, various graphs will be examined from the simulations that were performed in OPNET IT Guru. After that, a General Linear Model from Minitab will be presented. Finally, all given data will be analyzed using full factorial design of experiments to show the parameters that had the greatest affect on the delay.

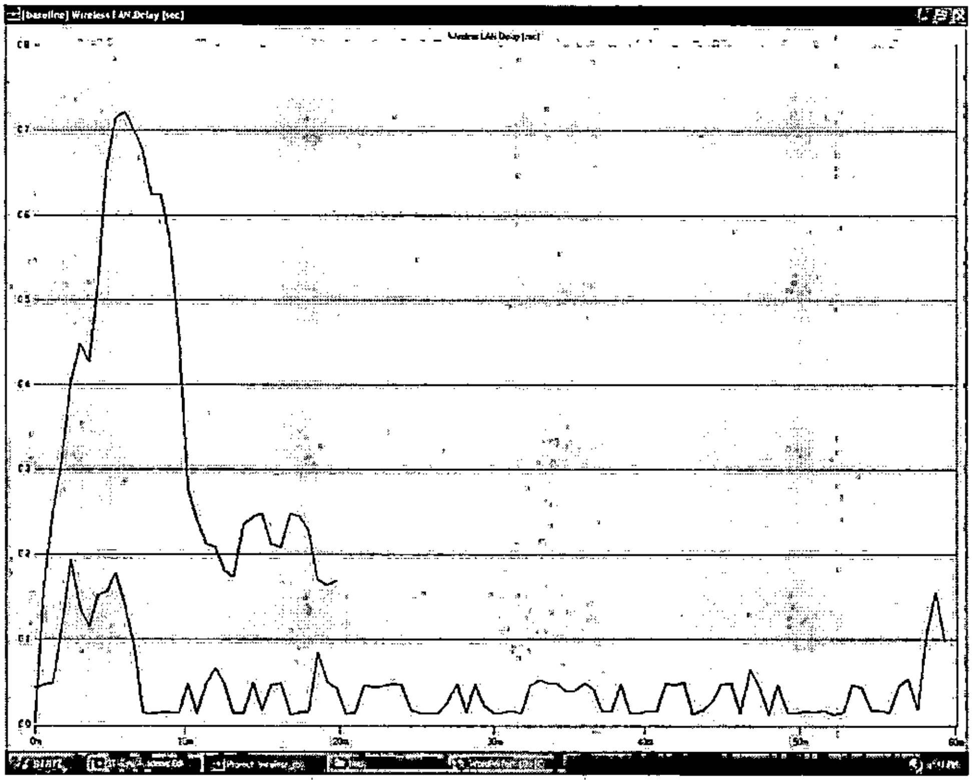

Figure 4.7. Overlaid statistics 30 Hosts Heavy Loads vs. 10 Hosts Heavy Loads

Figure 4.7 shows overlaid statistics of two separate simulations. The top line indicates a simulation with 30 hosts and heavy loads on all applications. The bottom line shows the same heavy load on applications, but for only 10 hosts. It is only necessary to compare the data up until the point where the red line ends. This is when the simulation was halted due to limitations in the software. Up until this point, a great difference can be seen between the delays of the two scenarios.

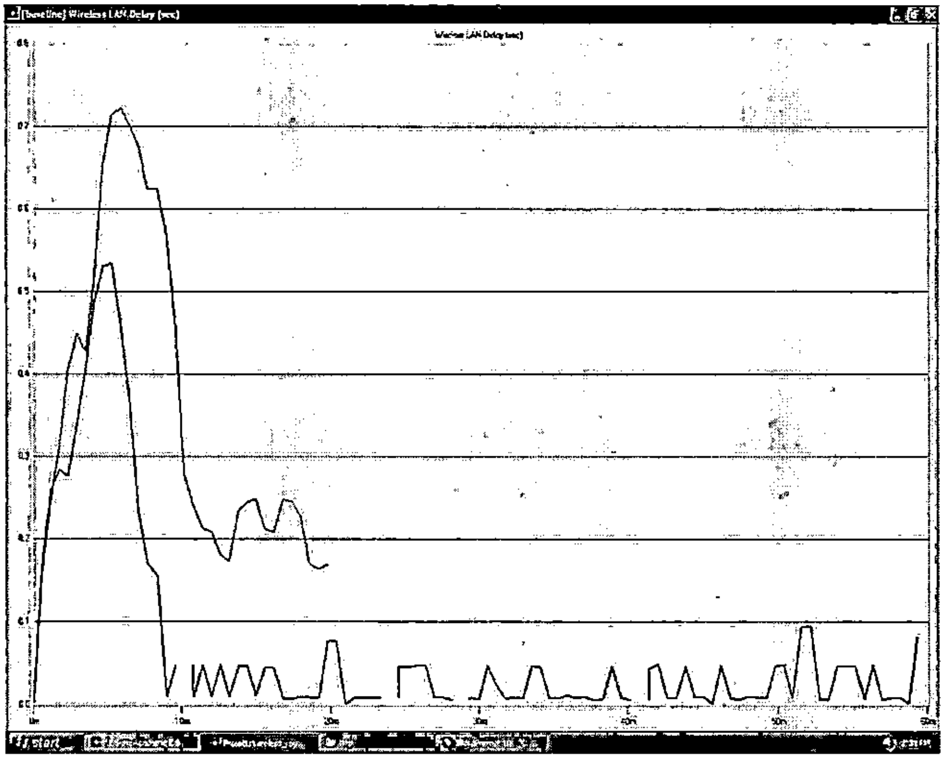

Figure 4.8. 30 Hosts Heavy Loads vs. 30 Hosts Light Loads

While Figure 4.7 examined the factor of number of hosts, Figure 4.8 examines the factor of application load. The top line indicates a scenario in which load for all applications is heavy, and the number of hosts is 30. The bottom line indicates a scenario with 30 hosts, and a light load for all applications. It is easy to see that there is a great difference between the delays for each scenario; however it is not easy to determine if this difference is greater than the difference in Figure 4.7. This will be determined using other statistical means.

Analysis

In order to provide a proper analysis of the data, a statistical model must be presented. A general linear model was created using Minitab in order to achieve statistical confidence in the acquired data. The model shows the statistical significance of number of hosts and amount of application load in relation to the response of delay. Table 6.1 shows the analysis of variance for delay. The factors used to perform this analysis are number of hosts and application load.

Source	P Value
Hosts	0.000
Load	0.000
Host*Load	0.000

Table 6.1. Analysis of Variance P-values

The table lists the statistical significance of hosts, load, and the interaction of hosts and load. Minitab yielded a p-value of less than 0.00001 for each of these factors. Therefore, it can be determined that each of the factors in the table have a significant effect on the delay. The next step is to determine which parameters of these factors have the most significant effect on the delay. In order to determine this, it is essential to perform a design of experiment analysis. For this particular application, a two-factor, full factorial design with replications is used. The following model is applicable to this case.

$$yijk = \mu + \alpha_j + \beta_i + \gamma_{ij} + e_{ijk}$$

In this situation,

yijk= response (observation) in the kth replication of experiment with factor A at level j and factor B at level i

μ= mean response

α_j=effect of factor A at level j

β_i=effect of factor B at level i

γ_{ij}=effect of interaction between factor A at level j and factor B at level i

e_{ijk}=experimental error

Table 6.2 shows the collected mean delay from each simulation. The results from each seed are displayed in the table.

FACTORS	10	20	30
LLL	0.02036	0.04476	0.06072
	0.02744	0.03844	0.06895
	0.02105	0.04563	0.0806
HLL	0.02277	0.0402	0.05772
	0.02536	0.03625	0.07031
	0.01966	0.04892	0.07331
HHH	0.03288	0.07021	0.5031
	0.04279	0.0981	0.3505
	0.03892	0.08919	0.364

Table 6.2. Mean Delays for Various Interactions

Table 6.2 shows the mean delay for each interaction. Each interaction has three means due to the three seeds used for each simulation run. Table 6.3 shows the averages of these simulation runs.

FACTOR	**10**	**20**	**30**
LLL	0.02295	0.042943	0.07009
HLL	0.022597	0.04179	0.067113
HHH	0.038197	0.085833	0.405867

Table 6.3. Mean Delays of All interactions and Seeds

Table 6.3 shows the mean delay for all interactions and all seeds. The next step is to determine which factor has the greatest impact on the mean delay on the network. This is done by a simple factorial design of experiment calculation. By using the sum of squares calculation for each factor and their interaction, the percent variation can be determined. The variation percentage will show which factor or interaction of factors have the greatest impact on the mean delay of the network. Table 6.4 shows the sum of squares calculation results and the variation percentage for the various factors.

Interaction	Variation Percentage
Sum of Square for Load (SSA)	28.58246
Sum of Squares for Hosts (SSB)	32.53149
Sum of Square for Hosts and Load (SSAB)	34.72681
Error (SSE)	4.159248

Table 6.3. DOE Results

The allocation for variation is computed by using Equation 6.1 listed below.

$$\underbrace{\sum_{ijk} y^2 ijk}_{SSY} = \underbrace{abr\mu^2}_{SSO} + \underbrace{br\sum_{j} \alpha^2 j}_{SSA} + \underbrace{ar\sum_{i} \beta^2 i}_{SSB} + \underbrace{r\sum_{ij} \gamma^2 ij}_{SSAB} + \underbrace{\sum_{ijk} e^2 ijk}_{SSE}$$

Equation 6.1. Allocation of Variation Equation

The final analysis step is to determine the confidence interval for the presented calculations. Table 6.4 shows each factor individually, along with the calculated confidence interval. In order for the factors to be considered statistically significant, the confidence interval must not contain zero.

Factor	Confidence Interval
LLL	(-0.02979, -0.05675)
HLL	(-0.3128, -0.05825)
HHH	(0.101515, 0.074554)
10	(-0472, -0.07416)
20	(-0.01826, -0.04522)
30	(0.105906, 0.078945)

Table 6.6. Confidence intervals for given factors

In order to compute these values, an F-value must be computed for each factor. This value is computed by dividing the mean square of the factor by the mean square of the error. The F-value is used because the degree of freedom is less than 30. Once this F-value is calculated, any statistical software can produce an interval based on the amount of confidence the researcher desires. The figures in Table 4.6 are based on the 0.95 quantile.

CHAPTER VII

CONCLUSION

This Thesis research had three main goals. They were as follows:

1. To demonstrate how OPNET IT Guru can model networks; specifically Wireless Local Area Networks.
2. To demonstrate that increasing the number of hosts and/or the application load of a network will increase the delay.
3. To determine which parameter (if any), application load or number of hosts, causes delay to increase the most.

In order to achieve these goals, several simulations were performed to model a Wireless Local Area Network. The modeled network was to simulate a classroom setting in which students would access a Wireless Local Area Network in order to download presentations, check Email, or browse the web for resources. In order to demonstrate that OPNET could model this environment, it was necessary to perform simulations and provide graphs and data from the simulations. The graphs from the modeled network can be found in Appendix A, and the data spreadsheets can be found in Appendix B. The spreadsheets show a breakdown of the delay at each recorded interval during the simulation run. The graphs are a visual representation of the spreadsheets.

The second goal of this research was achieved by altering the parameters of each simulation. In order to demonstrate that application load and number of hosts caused an increase in delay, it was necessary to control the number of hosts and application load throughout each simulation. Table 5.1 in Chapter 5 demonstrates how the various parameters of the simulations were altered. By comparing Table 5.1 to the graphs and spreadsheets, it is clear that as the number of hosts and/or the application load was increased, the delay also increased.

The third goal of this research was achieved in the same manner as the second. However, an analysis tool other than graphs and spreadsheets was necessary to achieve the third goal. Therefore, a powerful statistical software program, Minitab, was used to create a General Linear Model of the collected data. In order to create the model, it was necessary to enter the data from the spreadsheets into the Minitab software.

The p-value of any given set of data is used to determine the statistical significance of the data. In Chapter 6, this value was used to determine how significant the collected data was. The tests concluded that the following factors and interactions were statistically significant.

Factor Interaction	P-Value
Hosts	0.0000
Load	0.0000
Hosts*Load	0.0000

Table 7.1. Factor Interaction and P-values for Collected Data

The table demonstrates that the given factor interactions have a p-value of 0.0000 or less than 0.00001. All tests were performed using 95% confidence. Therefore, a p-value less than 0.05 would indicate that the data is statistically significant.

Once statistical significance was determined for the data, it was essential to demonstrate which of the factors had the greatest impact on the mean delay. This was determined by performing a full factorial design model. The following table from Chapter 6 shows the results of this analysis.

Interaction	Variation Percentage
Sum of Square for Load (SSA)	28.58246
Sum of Squares for Hosts (SSB)	32.53149
Sum of Square for Hosts and Load (SSAB)	34.72681
Error (SSE)	4.159248

Table 6.3. DOE Results

Table 6.3 is the most conclusive evidence of which factor has the greatest impact on the mean delay of the network. Using the variation percentage column, it is evident that the number of hosts has a greater impact on the delay than the application load. An even greater impact is shown by increasing both the number of hosts and the application loads together. However, the data demonstrates that increasing only the number of hosts alone will have a greater affect on the mean delay than increasing only the application loads alone.

Solutions

Due to the nature of the modeled network, it is difficult to offer a solution to the presented problem. The collected data and analysis show that increasing the number of hosts on the modeled network had a greater impact on the mean delay than increasing the application load on the network. If the modeled network was a wired network, the solution would be simple. In order to decrease the number of hosts on the network, an administrator could simply divide one network into two by adding another server. However, the modeled network is a wireless network, and adding another server would not solve the problem. The communication medium for a wireless network is the atmosphere. Therefore if you place two wireless routers in the same room, they will interfere with each other whether they are on a separate network or not. The only way to prevent the wireless routers from interfering with each other is to place them in a separate room, or out of transmitting range of each other. This solution is not practical to this Thesis because the network is modeled for a single classroom. Therefore there is no feasible way to combat the problem of increasing delay due to increasing the number of hosts on the network other than reducing the number of hosts on the network.

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Appendix A
Graph Results from OPNET Simulations

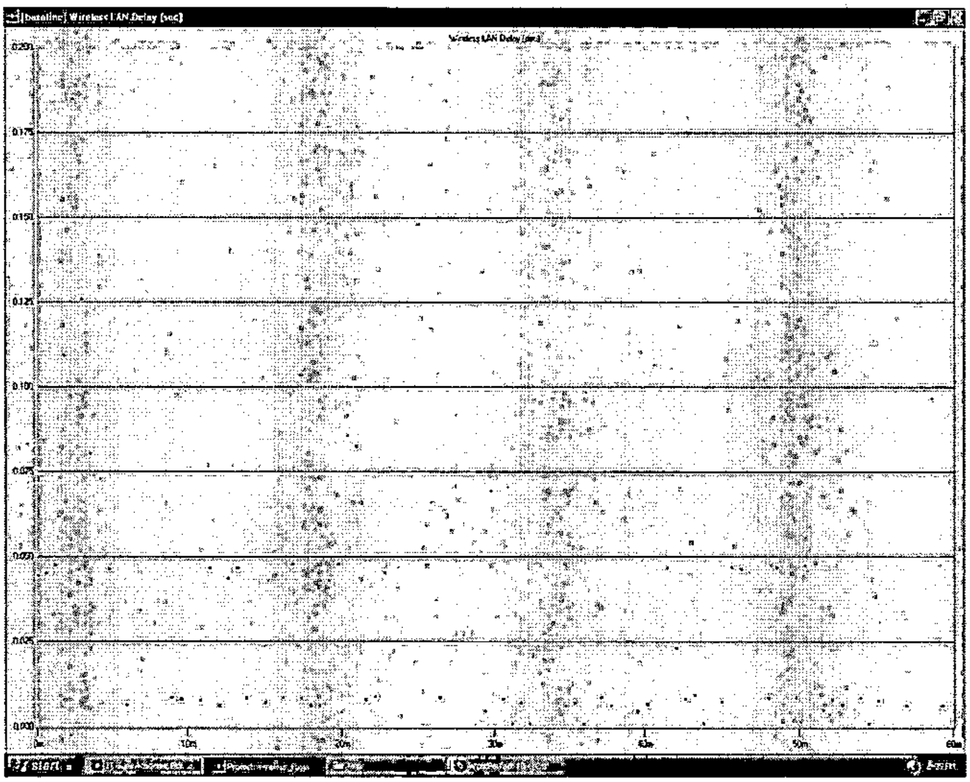

Figure A-1. Results from 10 Hosts, Light Application Loads, Seed 64

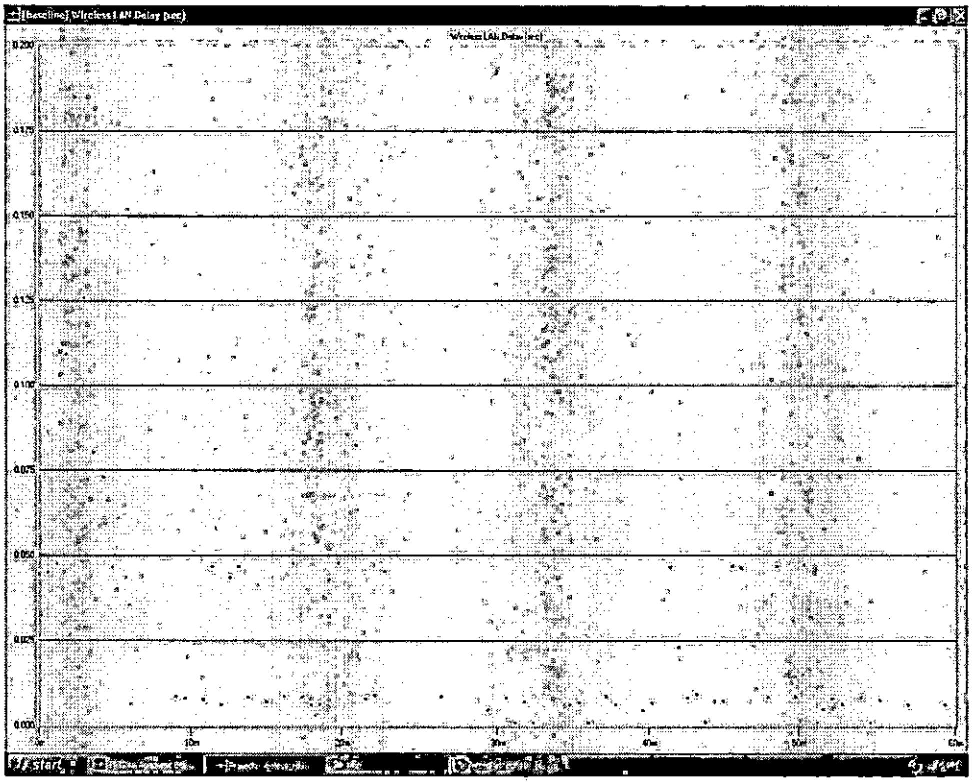

Figure A-2. Results from 10 Hosts, Light Application Loads, Seed 128

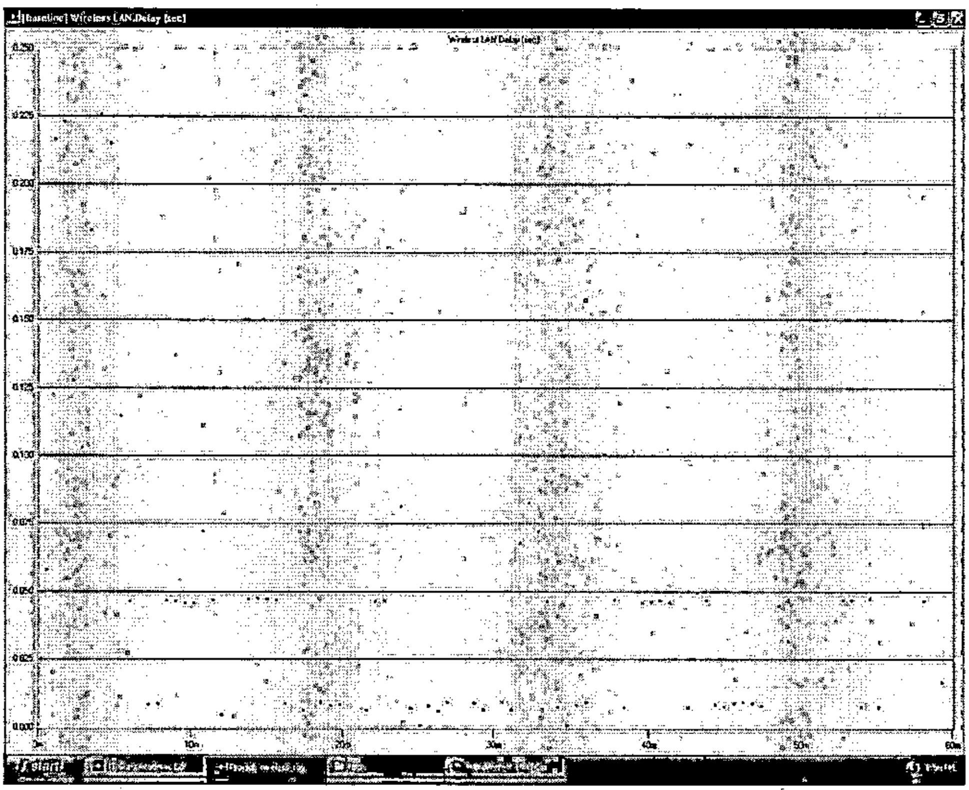

Figure A-3. Results from 10 Hosts, Light Application Loads, Seed 1024

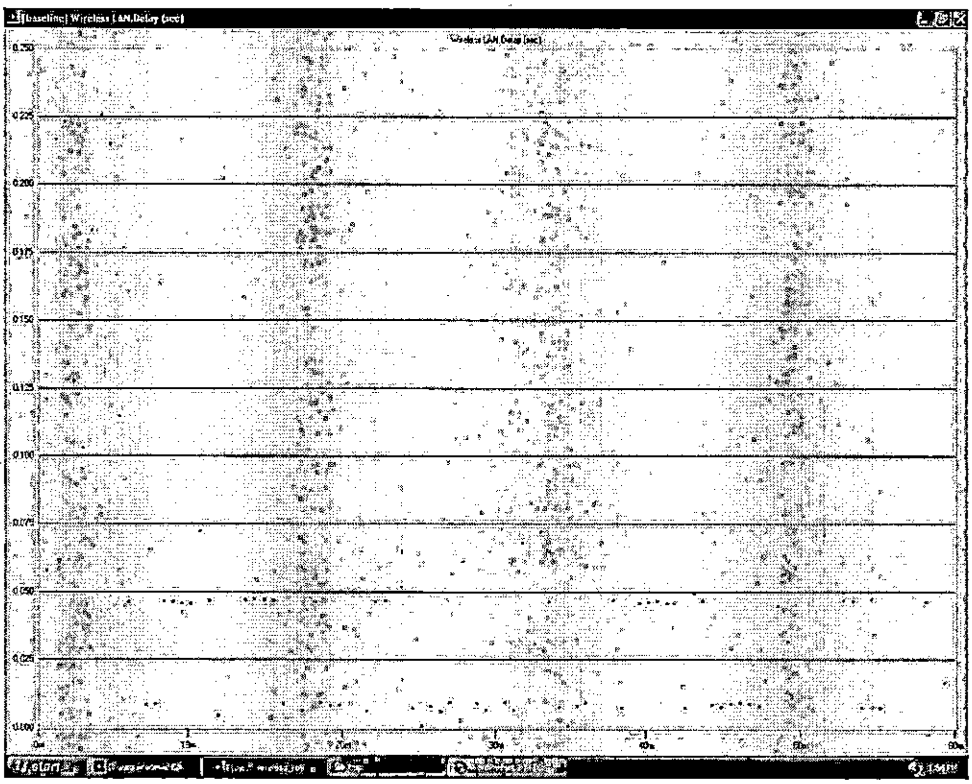

Figure A-4. Results from 20 Hosts, Light Application Loads, Seed 64

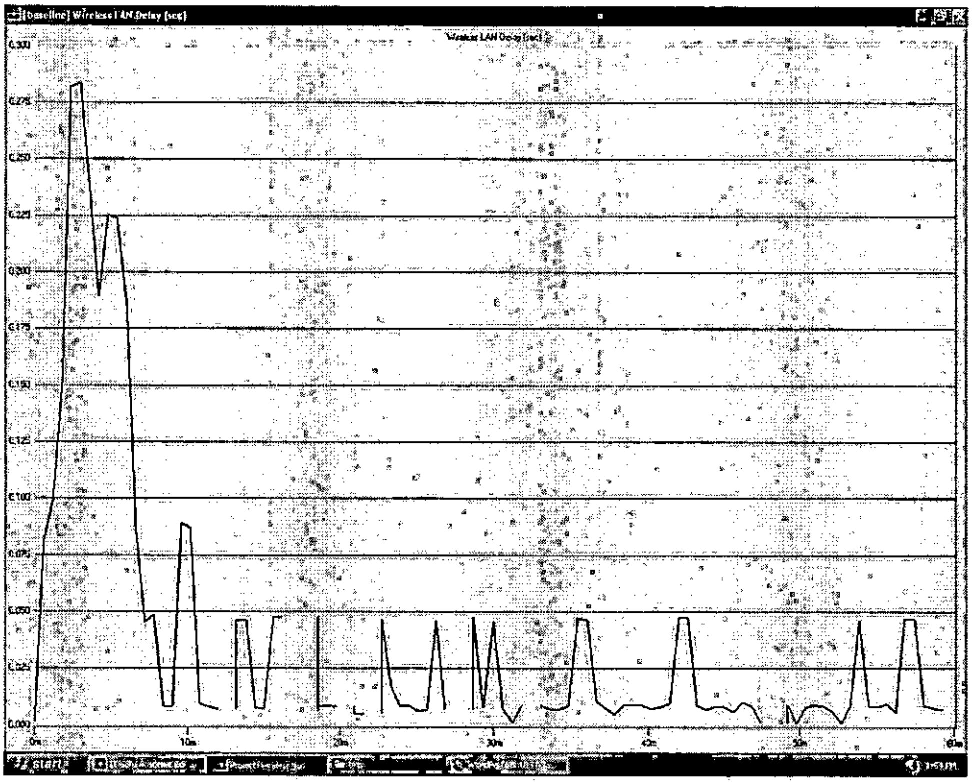

Figure A-5. Results from 20 Hosts, Light Application Loads, Seed 128

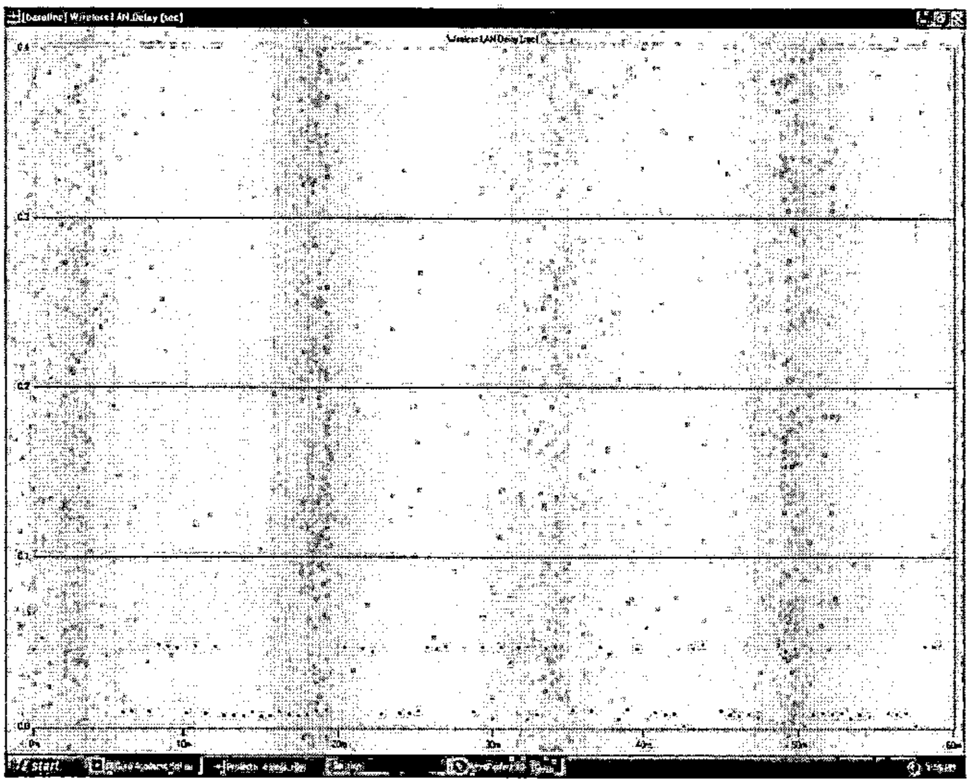

Figure A-6. Results from 20 Hosts, Light Application Loads, Seed 1024

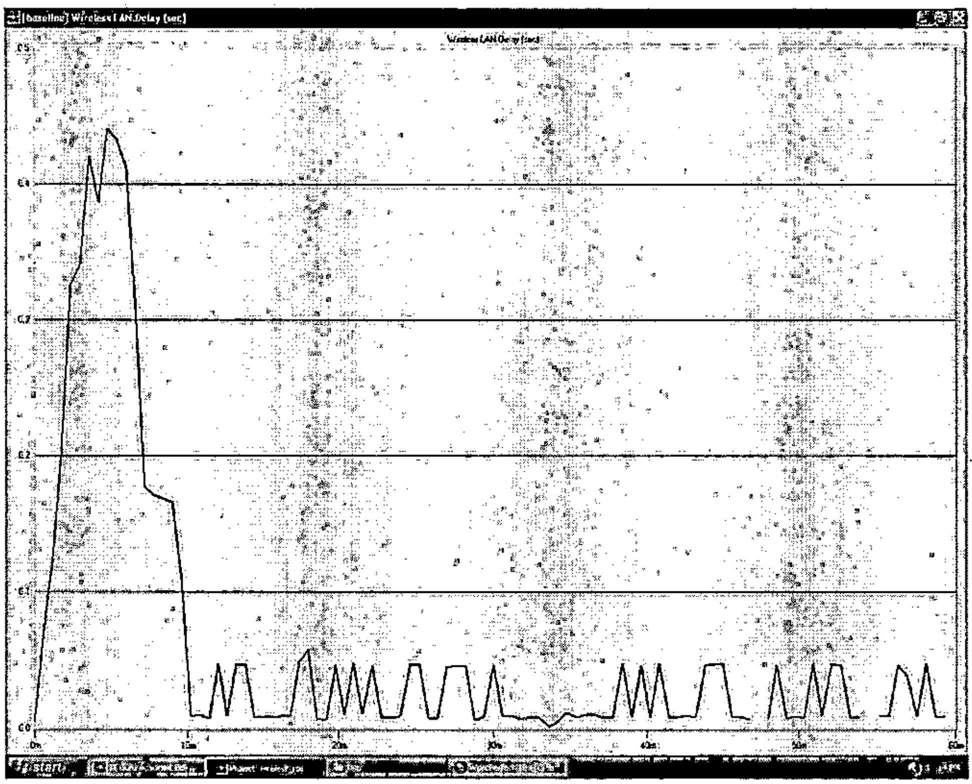

Figure A-7. Results from 30 Hosts, Light Application Loads, Seed 64

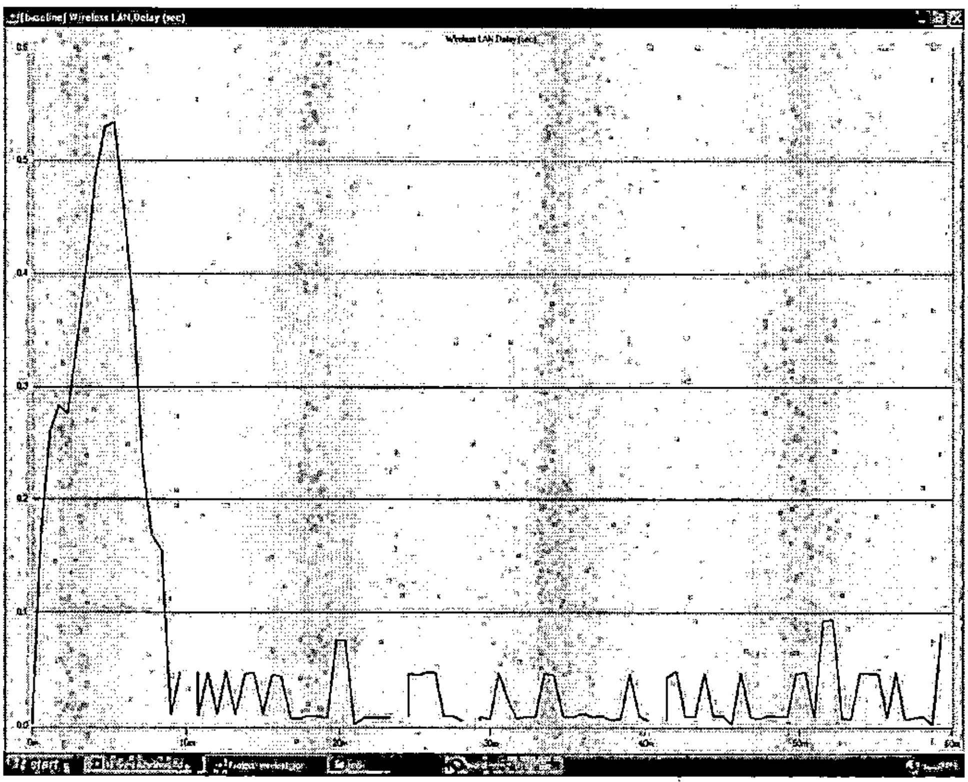

Figure A-8. Results from 30 Hosts, Light Application Loads, Seed 128

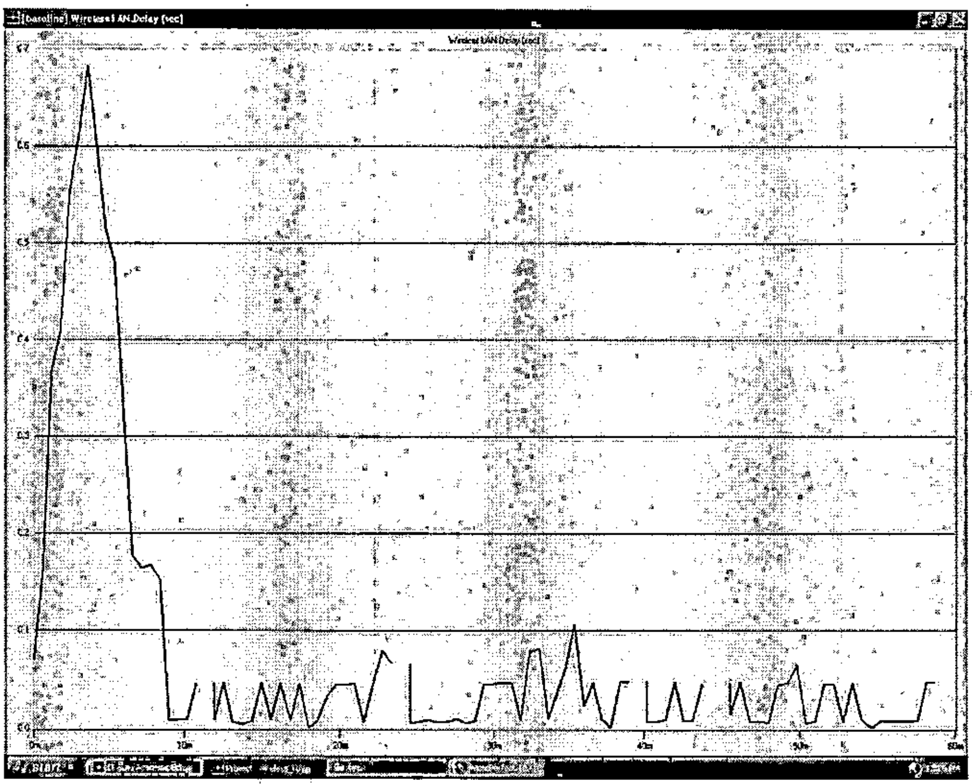

Figure A-9. ***Results from 30 Hosts, Light Application Load, Seed 1024***

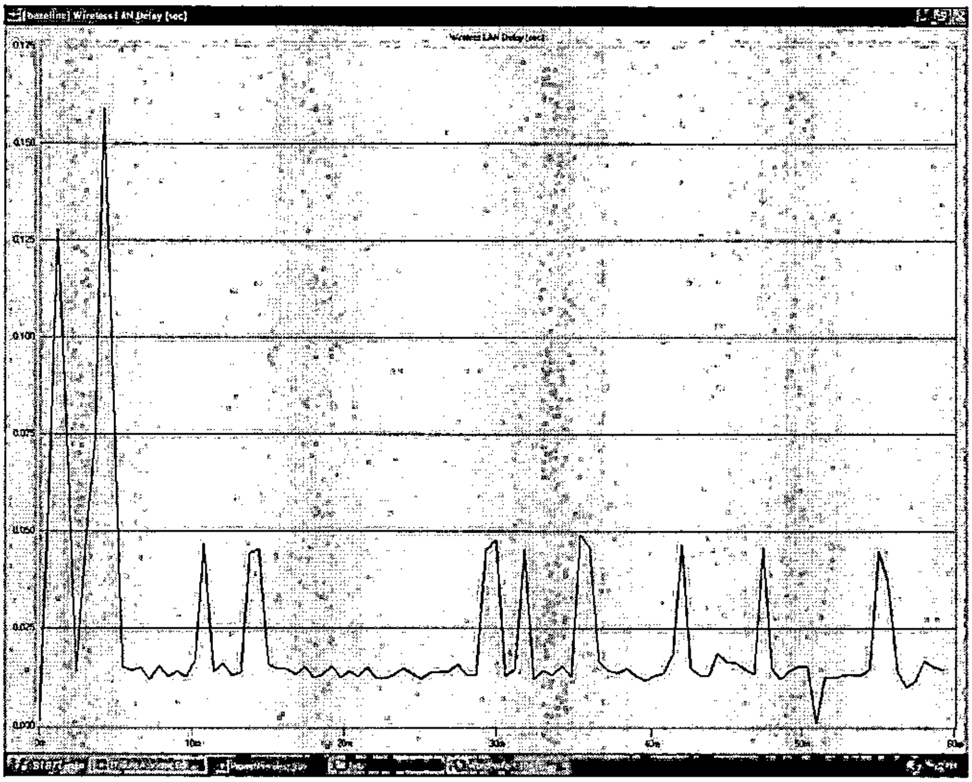

Figure A-10. Results from 10 Hosts, Heavy Web, Seed 64

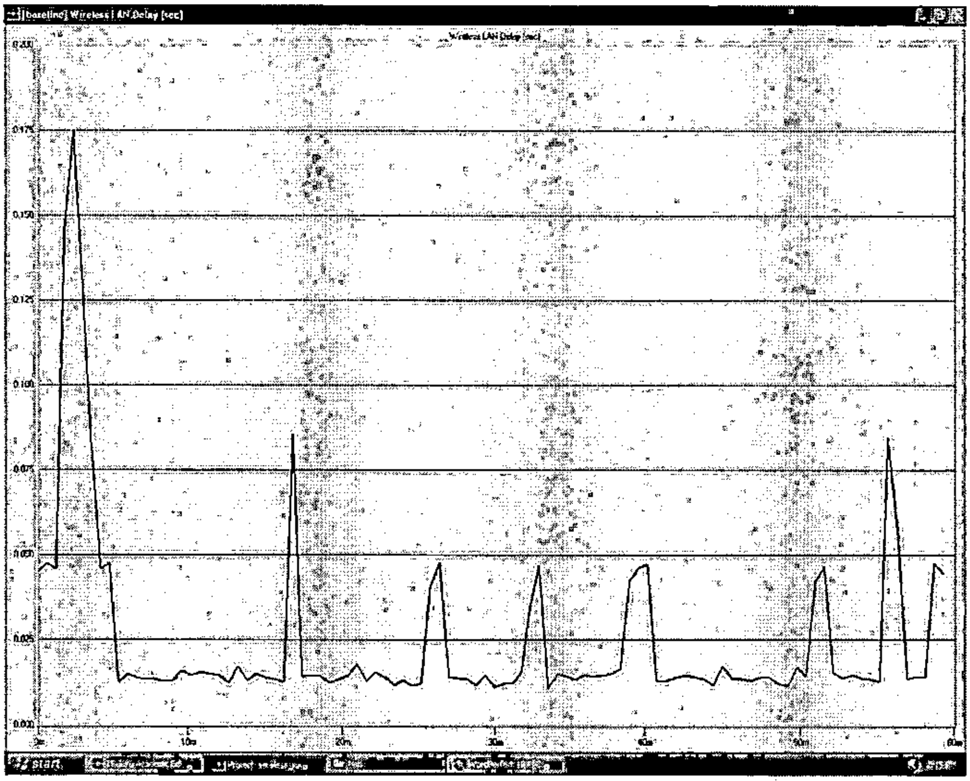

Figure A-11. Results from 10 Hosts, Heavy Web, Seed 128

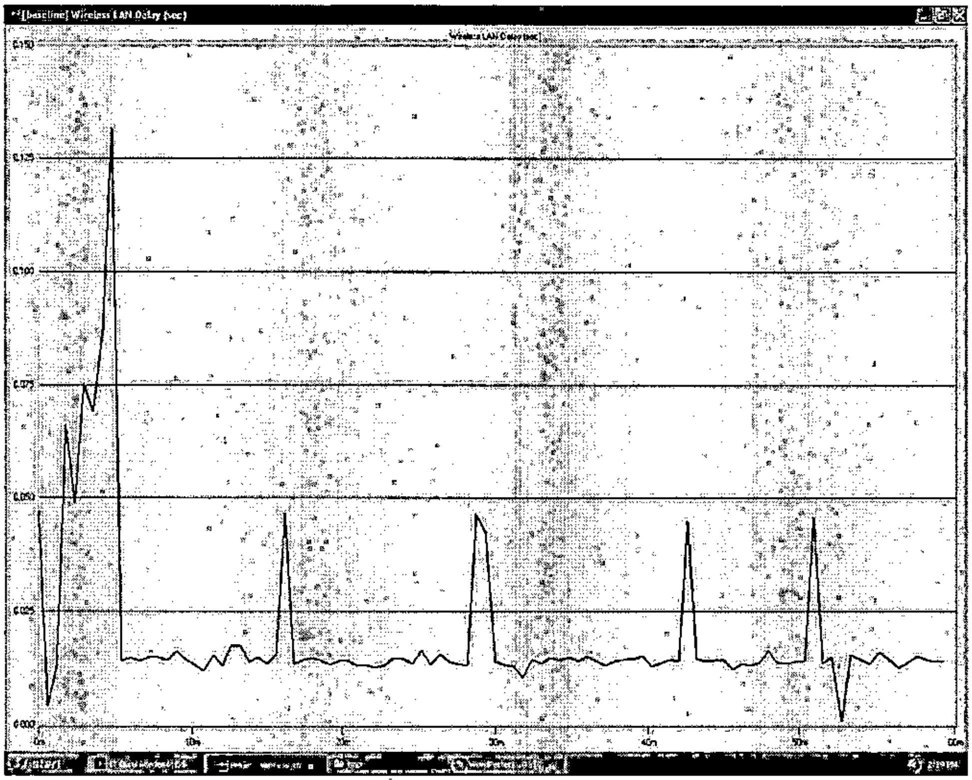

Figure A-12. Results from 10 Hosts, Heavy Web, Seed 1024

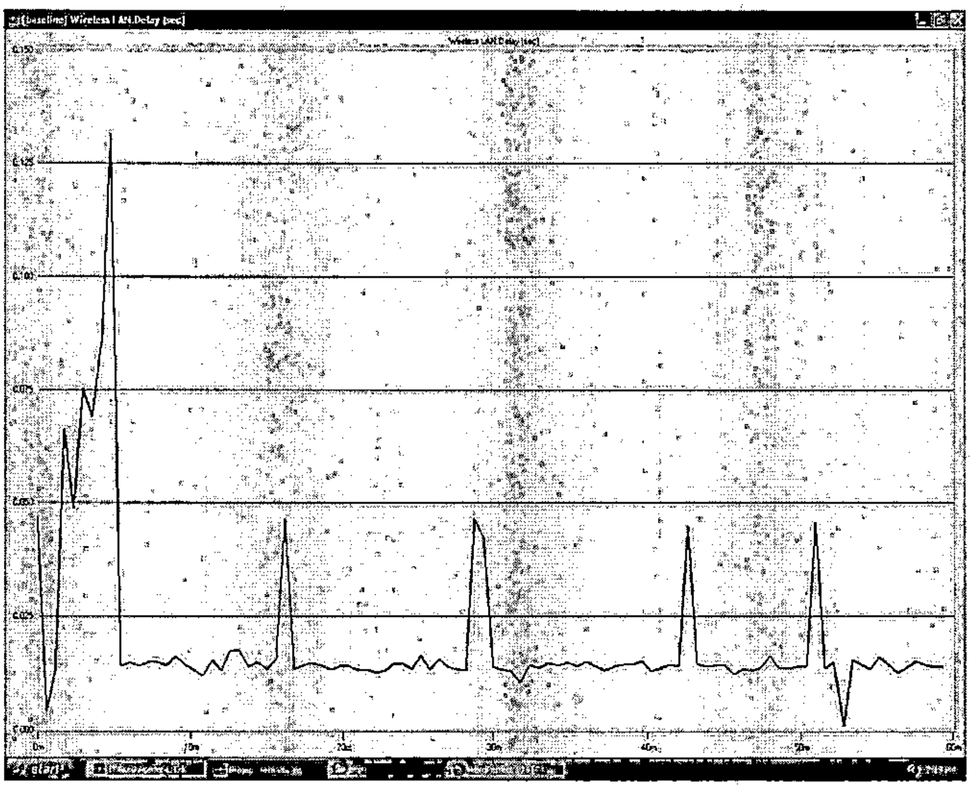

Figure A-13. Results from 20 Hosts, Heavy Web, Seed 64

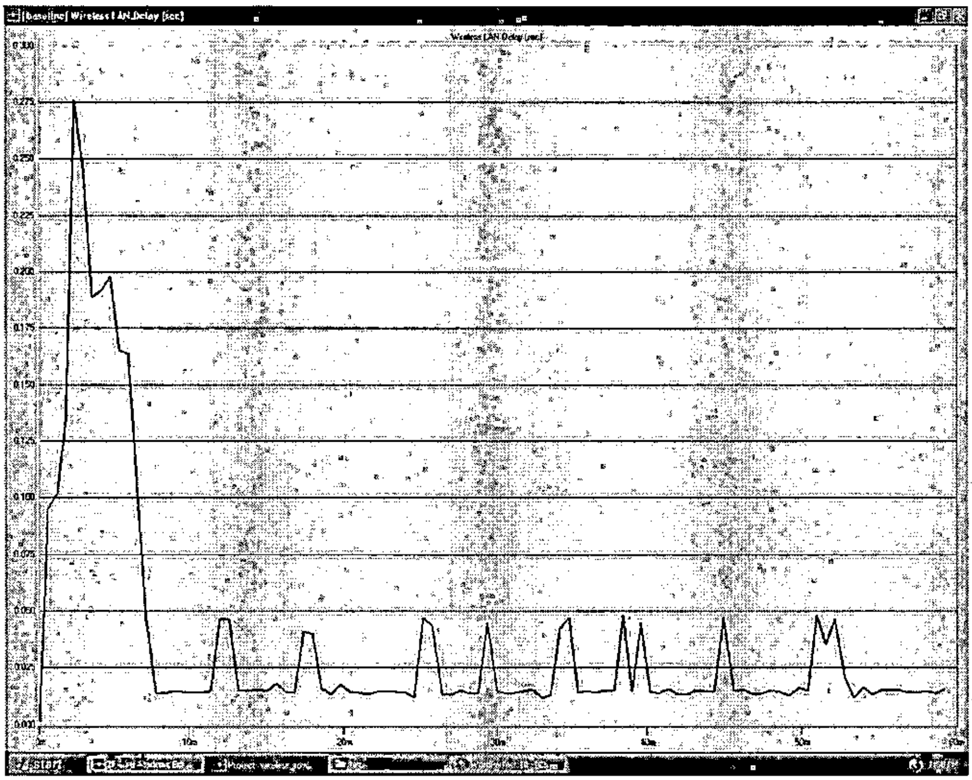

Figure A-14. Results from 20 Hosts, Heavy Web, Seed 128

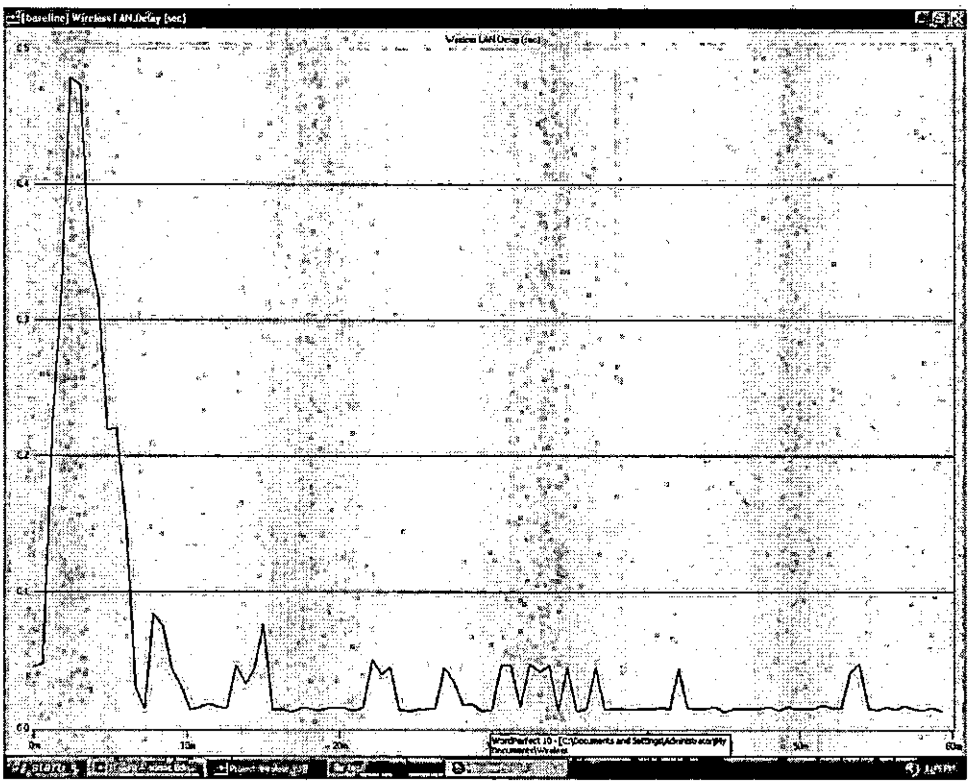

Figure A-15. Results from 20 Hosts, Heavy Web, Seed 1024

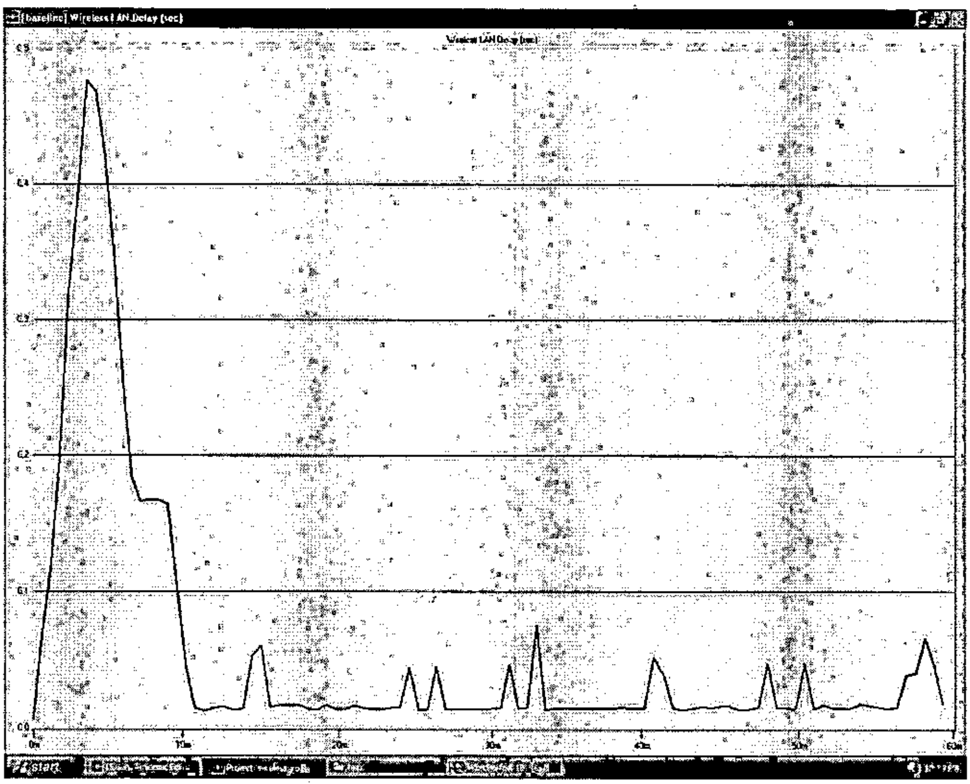

Figure A-16. Results from 30 Hosts, Heavy Web, Seed 64

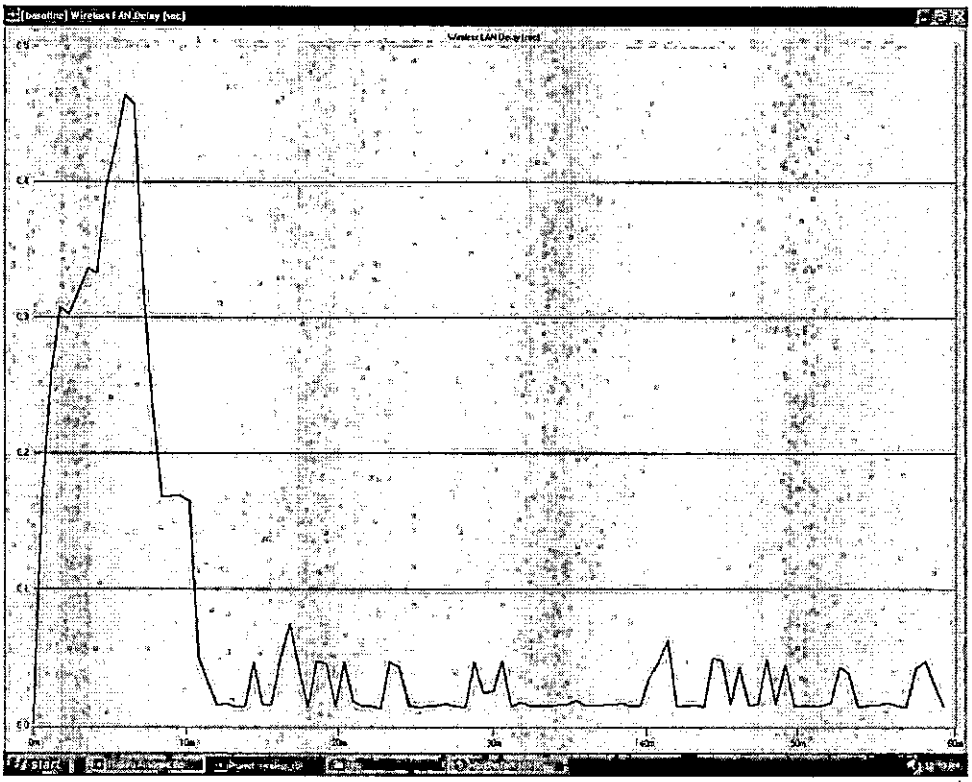

Figure A-17. Results from 30 Hosts, Heavy Web, Seed 128

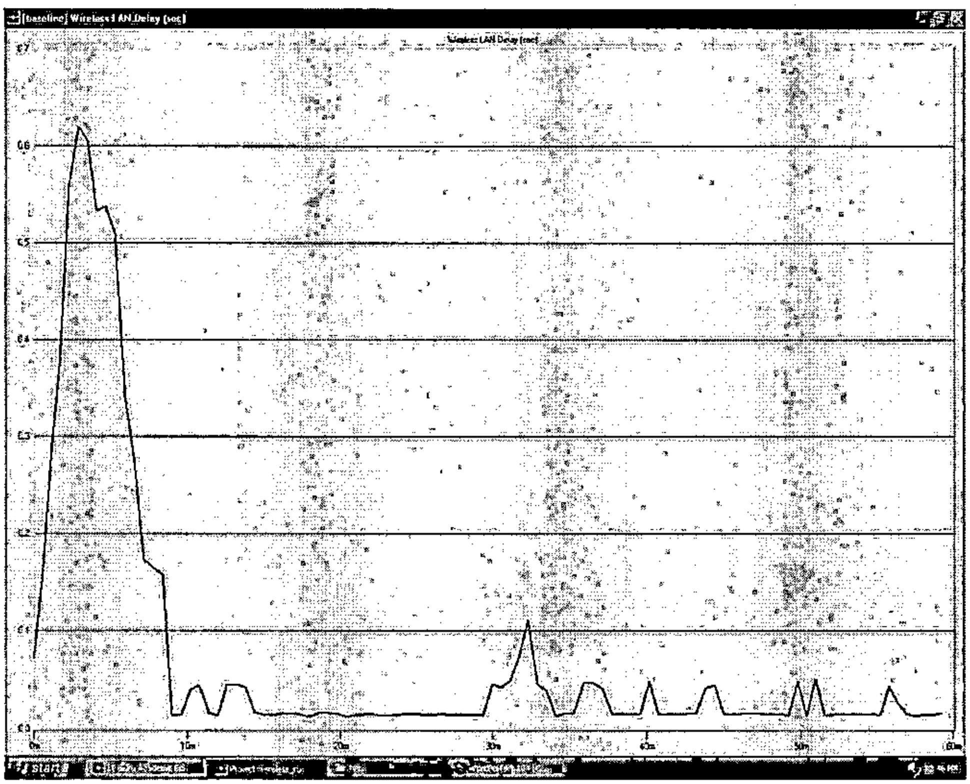

Figure A-18. Result from 30 Hosts, Heavy Web, Seed 1024

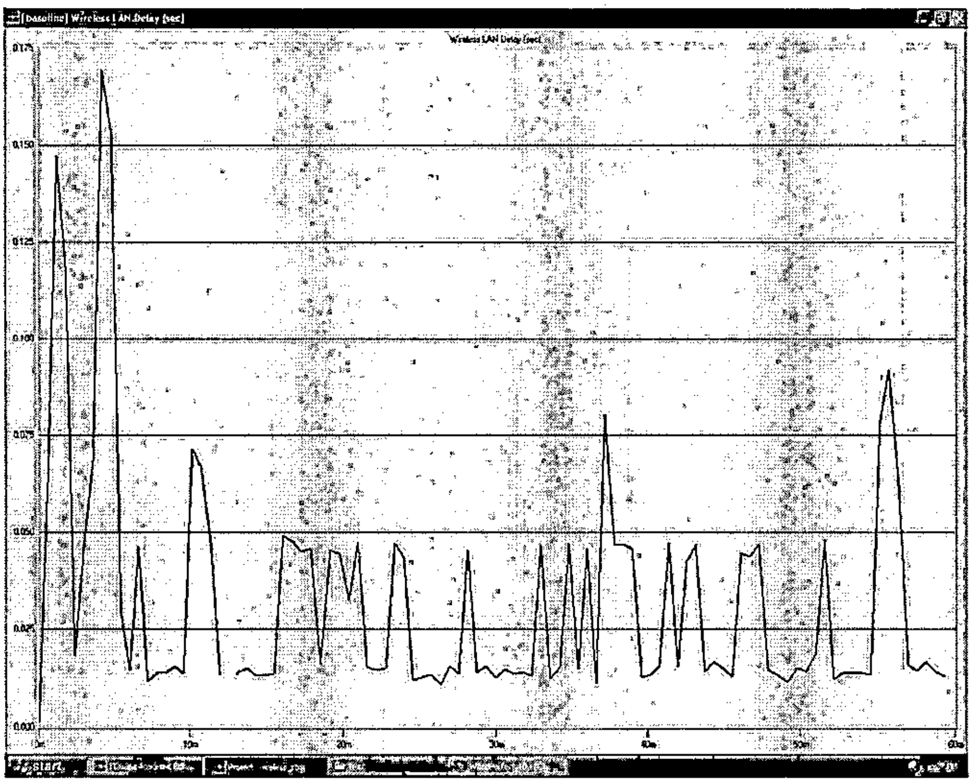

Figure A-19. Results from 10 Hosts, Heavy Application Loads, Seed 64

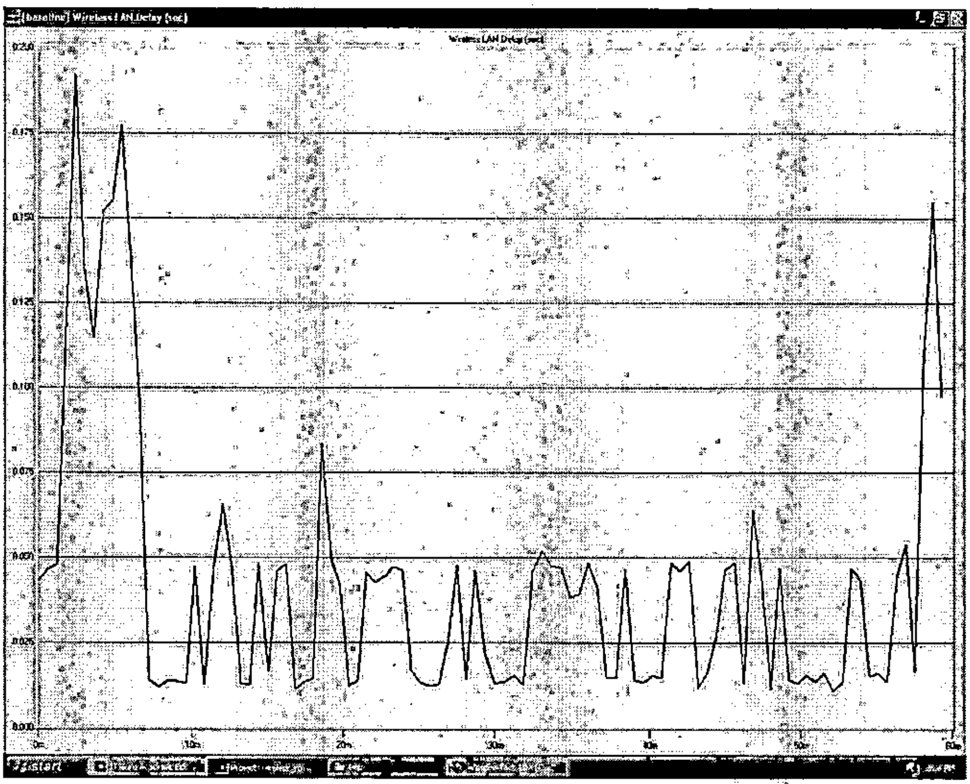

Figure A-20. Results from 10 Hosts, Heavy Application Loads, Seed 128

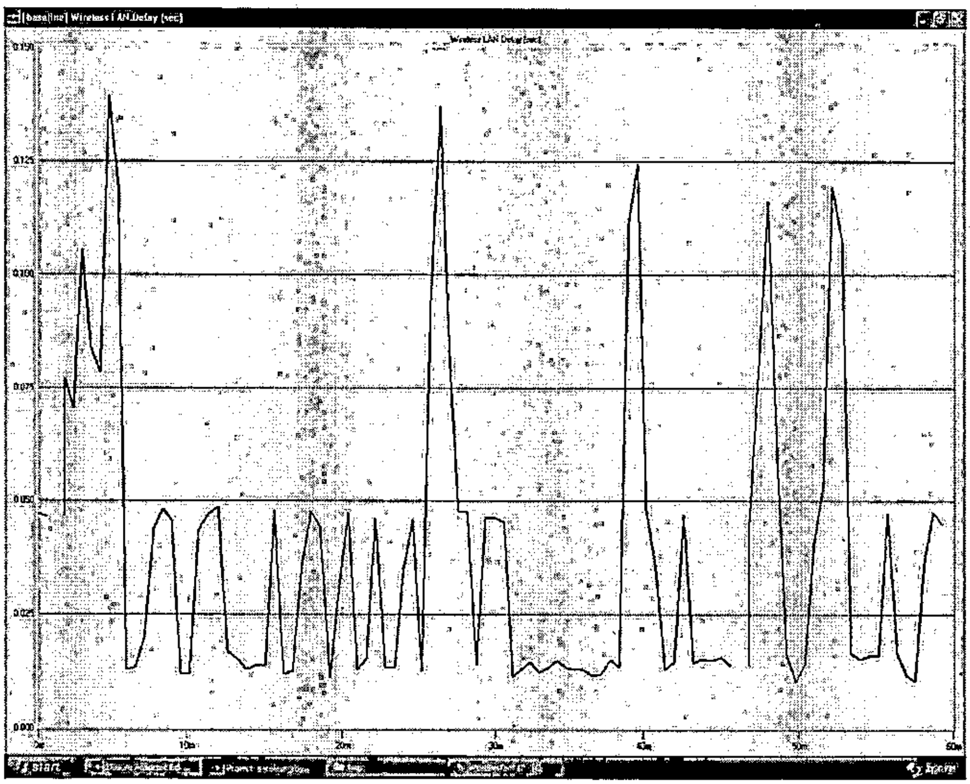

Figure A-21. Results from 10 Hosts, Heavy Application Loads, Seed 1024

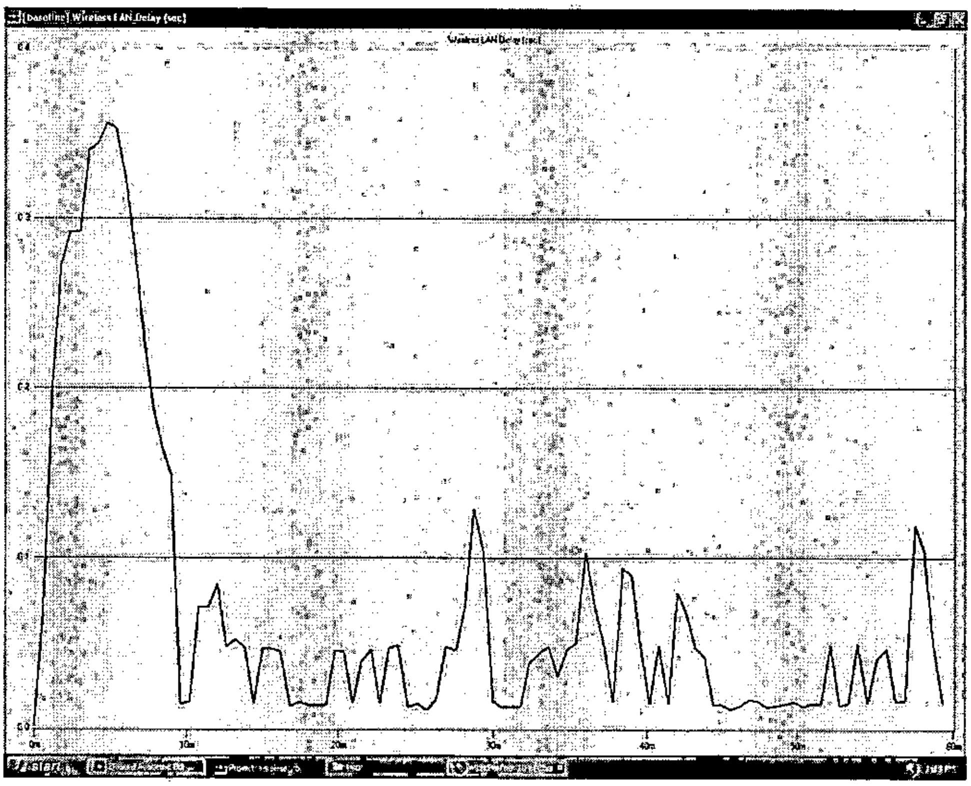

Figure A-22. Results from 20 Hosts, Heavy Application Loads, Seed 64

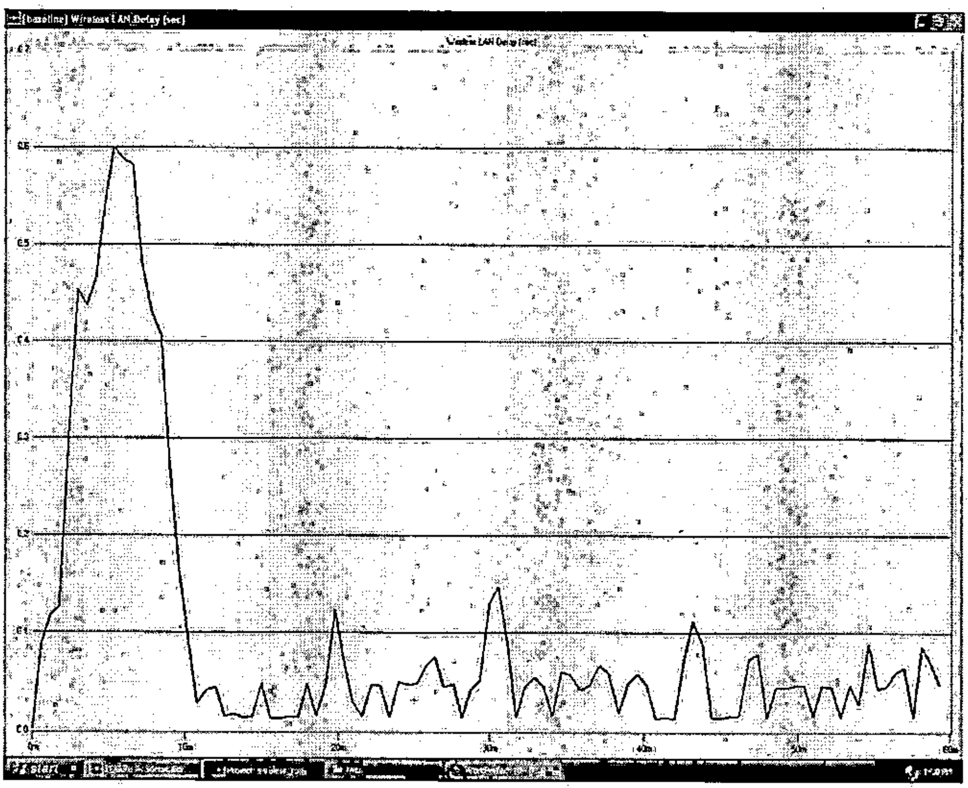

Figure A-23. Results from 20 Hosts, Heavy Application Loads, Seed 128

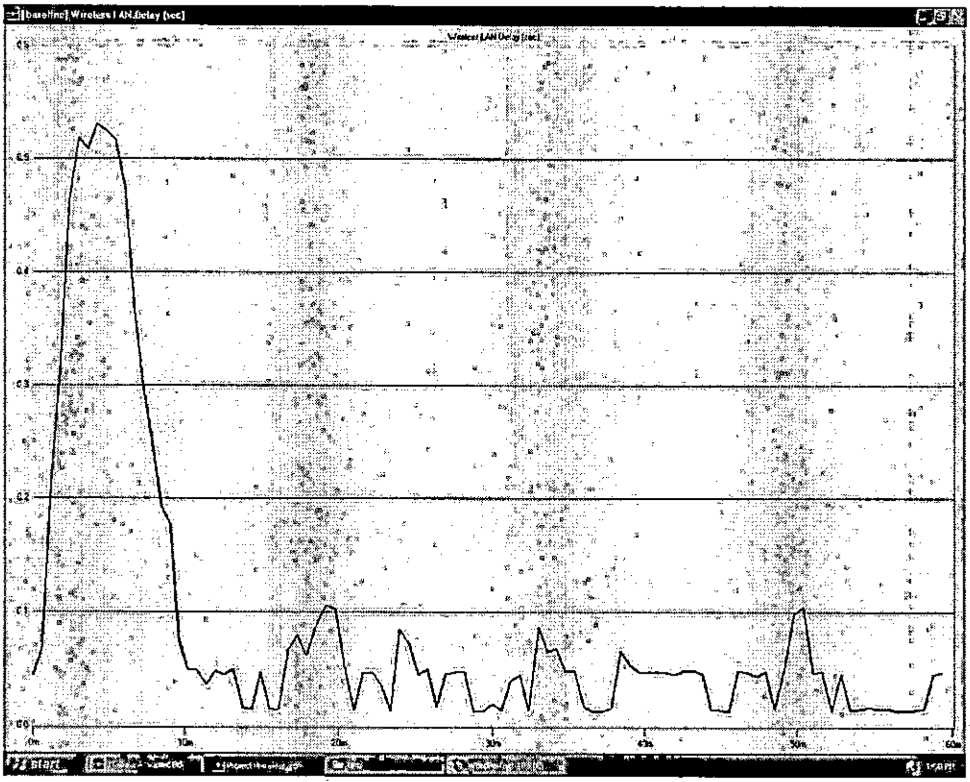

Figure A-24. Results from 20 Hosts, Heavy Application Loads, Seed 1024

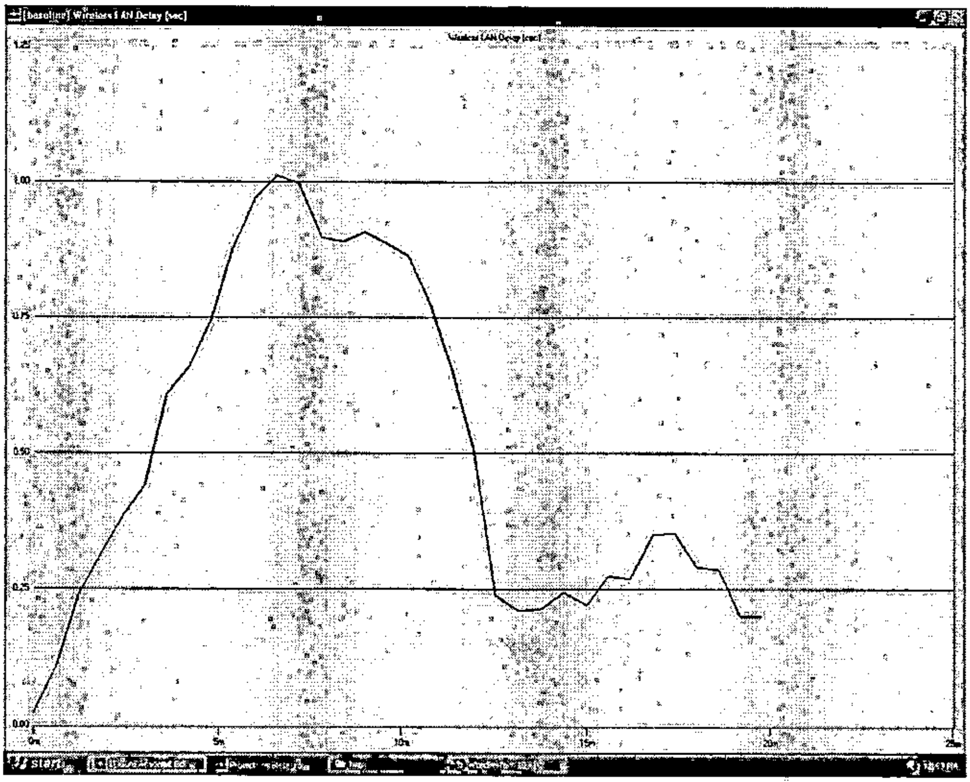

Figure A-25. Results from 30 Hosts, Heavy Application Loads, Seed 64

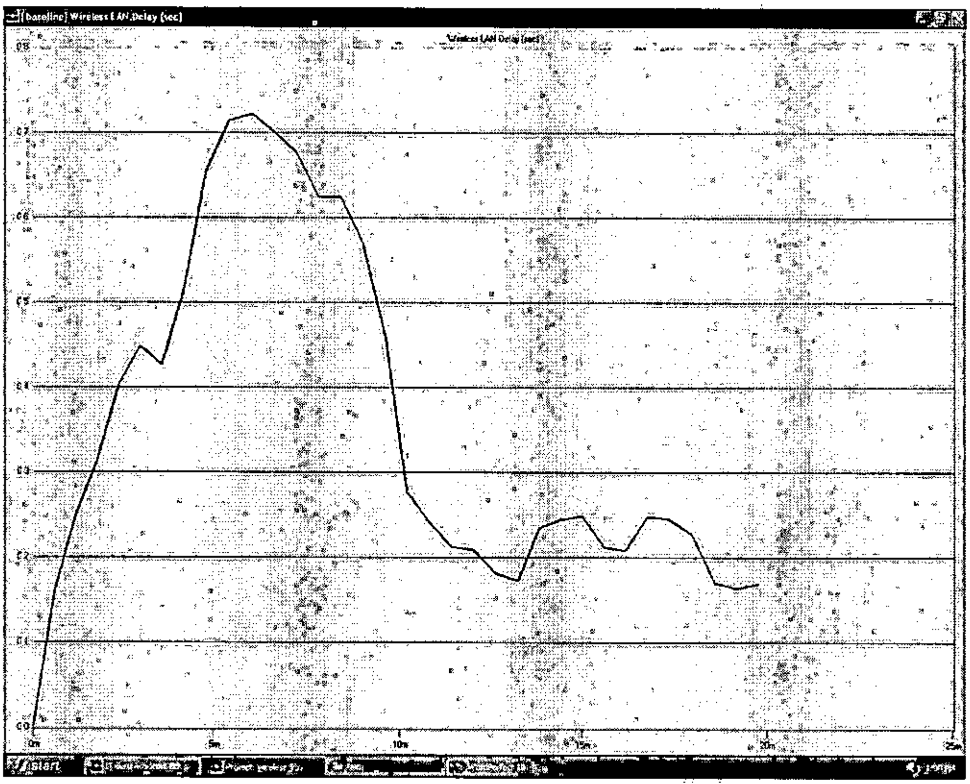

Figure A-26. Results from 30 Hosts, Heavy Application Loads, Seed 128

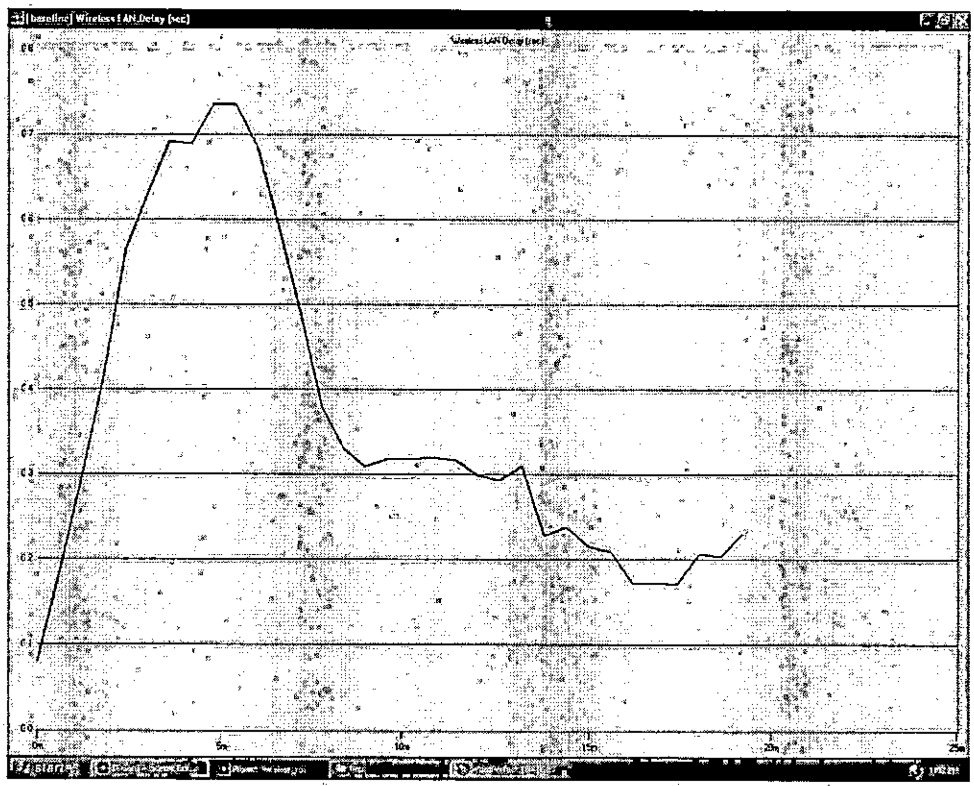

Figure A-27. Results from 30 Hosts, Heavy Application Loads, Seed 1024

Appendix B
Data Spreadsheets

Results from 10 Hosts, Light Application Loads, Seed 64

Time (sec)	Delay (sec)	Time (sec)	Delay (sec	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay(sec)
0	0.001088	576	0.008788	1296	0.0463861	2376	0.0065348	3276	0.008391
0	0.001088	576	0.008788	1296	0.0463861	2376	0.0065348	3276	0.008391
36	0.0633271	612	0.00711	1332	0.0462233	2412	0.0097637	3348	0.008092
36	0.0633271	612	0.00711	1332	0.0462233	2412	0.0097637	3348	0.008092
72	0.1520328	648	0.010935	1404	0.0096235	2448	0.008997	3384	0.00805
72	0.1520328	648	0.010935	1404	0.0096235	2448	0.008997	3384	0.00805
108	0.0901439	720	0.009553	1548	0.0078047	2484	0.000672	3420	0.000672
108	0.0901439	720	0.009553	1548	0.0078047	2484	0.000672	3420	0.000672
180	0.0453899	756	0.007603	1656	0.0046876	2520	0.0092858	3456	0.009314
180	0.0453899	756	0.007603	1656	0.0046876	2520	0.0092858	3456	0.009314
216	0.0725138	792	0.000672	1800	0.008624	2556	0.0055596	3492	0.004353
216	0.0725138	792	0.000672	1800	0.008624	2556	0.0055596	3492	0.004353
252	0.1666555	864	0.007334	1872	0.0090268	2736	0.0429722	3528	0.00947
252	0.1666555	864	0.007334	1872	0.0090268	2736	0.0429722	3528	0.00947
288	0.0939236	900	0.008577	1944	0.0088924	2772	0.0479297		
288	0.0939236	900	0.008577	1944	0.0088924	2772	0.0479297		
324	0.0079704	936	0.000672	1980	0.0080896	2844	0.0082029		
324	0.0079704	936	0.000672	1980	0.0080896	2844	0.0082029		
360	0.0081855	972	0.00826	2052	0.0065197	2880	0.0045934		
360	0.0081855	972	0.00826	2052	0.0065197	2880	0.0045934		
396	0.0469315	1080	0.010132	2088	0.0088164	3024	0.0061638		
396	0.0469315	1080	0.010132	2088	0.0088164	3024	0.0061638		
432	0.008803	1116	0.008659	2160	0.0083047	3168	0.0080267		
432	0.008803	1116	0.008659	2160	0.0083047	3168	0.0080267		
468	0.0087561	1152	0.006431	2196	0.0080026	3204	0.0076091		
468	0.0087561	1152	0.006431	2196	0.0080026	3204	0.0076091		
540	0.0060201	1188	0.007587	2340	0.008442	3240	0.0043792		
540	0.0060201	1188	0.007587	2340	0.008442	3240	0.0043792		

Table A-1. Results from 10 Hosts, Light Loads, Seed 64

Results from 10 Hosts, Light Application Loads, Seed 128

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.0443188	720	0.0060393	1296	0.0079456	2376	0.0045113	3096	0.0048295
0	0.0443188	720	0.0060393	1296	0.0079456	2376	0.0045113	3096	0.0048295
36	0.0451186	756	0.0434575	1332	0.0086535	2412	0.0066229	3132	0.0078773
36	0.0451186	756	0.0434575	1332	0.0086535	2412	0.0066229	3132	0.0078773
72	0.0474957	792	0.0464966	1368	0.0452126	2484	0.0465144	3168	0.0062729
72	0.0474957	792	0.0464966	1368	0.0452126	2484	0.0465144	3168	0.0062729
108	0.1092586	828	0.0082862	1584	0.00859	2520	0.022969	3240	0.0081999
108	0.1092586	828	0.0082862	1584	0.00859	2520	0.022969	3240	0.0081999
144	0.1849133	900	0.006949	1764	0.0045185	2556	0.0081009	3276	0.000672
144	0.1849133	900	0.006949	1764	0.0045185	2556	0.0081009	3276	0.000672
180	0.1256939	972	0.0084789	1836	0.0080583	2592	0.0092755	3312	0.0074728
180	0.1256939	972	0.0084789	1836	0.0080583	2592	0.0092755	3312	0.0074728
216	0.0802299	1008	0.0476142	1872	0.000672	2628	0.000672	3420	0.0061677
216	0.0802299	1008	0.0476142	1872	0.000672	2628	0.000672	3420	0.0061677
252	0.0728121	1044	0.0082195	1908	0.0070095	2700	0.0072822	3564	0.0061932
252	0.0728121	1044	0.0082195	1908	0.0070095	2700	0.0072822	3564	0.0061932
288	0.0463077	1080	0.0059971	1944	0.000672	2736	0.0468884		
288	0.0463077	1080	0.0059971	1944	0.000672	2736	0.0468884		
360	0.0062831	1116	0.0061278	2088	0.0060355	2772	0.0463165		
360	0.0062831	1116	0.0061278	2088	0.0060355	2772	0.0463165		
540	0.008557	1152	0.0427597	2124	0.0066727	2880	0.0081881		
540	0.008557	1152	0.0427597	2124	0.0066727	2880	0.0081881		
576	0.0079735	1188	0.0477842	2160	0.000672	2916	0.0468261		
576	0.0079735	1188	0.0477842	2160	0.000672	2916	0.0468261		
648	0.0076805	1224	0.0855122	2232	0.0085378	2988	0.0085893		
648	0.0076805	1224	0.0855122	2232	0.0085378	2988	0.0085893		

Table A-2. Results from 10 Hosts, Light Loads, Seed 128

Results from 10 Hosts, Heavy Application Loads, Seed 1024

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay(sec)
0	0.0470624	648	0.000672	1584	0.0462314	2484	0.0061138	3420	0.0082497
0	0.0470624	648	0.000672	1584	0.0462314	2484	0.0061138	3420	0.0082497
36	0.0091292	684	0.006174	1728	0.0067242	2664	0.0079869	3564	0.0092615
36	0.0091292	684	0.006174	1728	0.0067242	2664	0.0079869	3564	0.0092615
72	0.000672	720	0.0099393	1764	0.010081	2736	0.0080155		
72	0.000672	720	0.0099393	1764	0.010081	2736	0.0080155		
108	0.0819496	756	0.0086259	1800	0.000672	2772	0.0084322		
108	0.0819496	756	0.0086259	1800	0.000672	2772	0.0084322		
144	0.0648341	828	0.0461745	1872	0.0080561	2808	0.000672		
144	0.0648341	828	0.0461745	1872	0.0080561	2808	0.000672		
180	0.0755311	864	0.0459916	1908	0.0463216	2880	0.0083935		
180	0.0755311	864	0.0459916	1908	0.0463216	2880	0.0083935		
216	0.0764307	936	0.0083029	1944	0.0085072	2952	0.0089183		
216	0.0764307	936	0.0083029	1944	0.0085072	2952	0.0089183		
252	0.0831627	1008	0.0092266	2016	0.0085763	2988	0.000672		
252	0.0831627	1008	0.0092266	2016	0.0085763	2988	0.000672		
288	0.1515312	1152	0.0352915	2052	0.0066666	3060	0.0099151		
288	0.1515312	1152	0.0352915	2052	0.0066666	3060	0.0099151		
324	0.000672	1188	0.0466637	2088	0.0408867	3096	0.0056537		
324	0.000672	1188	0.0466637	2088	0.0408867	3096	0.0056537		
396	0.0062292	1224	0.0046626	2124	0.0477067	3132	0.0062921		
396	0.0062292	1224	0.0046626	2124	0.0477067	3132	0.0062921		
432	0.0045876	1296	0.0067624	2268	0.0083393	3204	0.0087373		
432	0.0045876	1296	0.0067624	2268	0.0083393	3204	0.0087373		
468	0.0080432	1368	0.0084632	2304	0.000672	3240	0.0080245		
468	0.0080432	1368	0.0084632	2304	0.000672	3240	0.0080245		

Table A-3. Results from 10 Hosts, Heavy Loads, Seed 1024

Results from 20 Hosts, Light Application Loads, Seed 64

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.001088	540	0.0463185	1188	0.0083129	1944	0.0825811	2556	0.0072836	3276	0.0471092
0	0.001088	540	0.0463185	1188	0.0083129	1944	0.0825811	2556	0.0072836	3276	0.0471092
36	0.0580177	576	0.0457696	1296	0.006224	1980	0.0719045	2592	0.0492553	3312	0.0072259
36	0.0580177	576	0.0457696	1296	0.006224	1980	0.0719045	2592	0.0492553	3312	0.0072259
72	0.2167462	612	0.0458206	1332	0.0462532	2016	0.0464486	2628	0.0465483	3492	0.0464478
72	0.2167462	612	0.0458206	1332	0.0462532	2016	0.0464486	2628	0.0465483	3492	0.0464478
108	0.2229396	648	0.0723043	1368	0.0466574	2052	0.0077369	2664	0.0084007	3564	0.0163964
108	0.2229396	648	0.0723043	1368	0.0466574	2052	0.0077369	2664	0.0084007	3564	0.0163964
144	0.1276392	684	0.0468983	1476	0.0071818	2088	0.000672	2700	0.0075714		
144	0.1276392	684	0.0468983	1476	0.0071818	2088	0.000672	2700	0.0075714		
180	0.1029749	720	0.0045792	1512	0.000672	2124	0.0081451	2736	0.008738		
180	0.1029749	720	0.0045792	1512	0.000672	2124	0.0081451	2736	0.008738		
216	0.1832159	828	0.0470797	1548	0.0078805	2160	0.0091452	2772	0.0091797		
216	0.1832159	828	0.0470797	1548	0.0078805	2160	0.0091452	2772	0.0091797		
252	0.225927	864	0.0473739	1584	0.0060701	2232	0.1002832	2808	0.0088427		
252	0.225927	864	0.0473739	1584	0.0060701	2232	0.1002832	2808	0.0088427		
288	0.2151321	900	0.0470143	1620	0.0093046	2268	0.0470016	2844	0.0079843		
288	0.2151321	900	0.0470143	1620	0.0093046	2268	0.0470016	2844	0.0079843		
324	0.1145142	936	0.0467588	1728	0.0091032	2304	0.007404	2916	0.0446152		
324	0.1145142	936	0.0467588	1728	0.0091032	2304	0.007404	2916	0.0446152		
360	0.0462879	972	0.0087158	1764	0.0063869	2376	0.045811	2952	0.0316641		
360	0.0462879	972	0.0087158	1764	0.0063869	2376	0.045811	2952	0.0316641		
432	0.008297	1044	0.0061355	1836	0.0092443	2412	0.045988	3168	0.0469264		
432	0.008297	1044	0.0061355	1836	0.0092443	2412	0.045988	3168	0.0469264		
468	0.0087765	1116	0.0091854	1872	0.0065951	2448	0.0465677	3204	0.0466487		

Table A-4. Results from 20 Hosts, Light Loads, Seed 64

Results from 20 Hosts, Light Application Loads, Seed 128

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.0451283	540	0.0469752	1044	0.0063138	1728	0.009163	2304	0.0047197	2844	0.0056238	3456	0.000672
0	0.0451283	540	0.0469752	1044	0.0063138	1728	0.009163	2304	0.0047197	2844	0.0056238	3456	0.000672
36	0.0520032	576	0.0462461	1080	0.0074297	1764	0.0468676	2340	0.0102592	2952	0.0445948	3492	0.0472561
36	0.0520032	576	0.0462461	1080	0.0074297	1764	0.0468676	2340	0.0102592	2952	0.0445948	3492	0.0472561
72	0.2052504	612	0.0083709	1116	0.0095464	1800	0.0045769	2376	0.0458143	2988	0.0461466	3528	0.0469819
72	0.2052504	612	0.0083709	1116	0.0095464	1800	0.0045769	2376	0.0458143	2988	0.0461466	3528	0.0469819
108	0.3217561	648	0.0472697	1152	0.0100846	1836	0.0467207	2412	0.0581673	3024	0.000672		
108	0.3217561	648	0.0472697	1152	0.0100846	1836	0.0467207	2412	0.0581673	3024	0.000672		
144	0.370657	684	0.0078682	1224	0.0467765	1872	0.0378917	2448	0.0086279	3060	0.0072576		
144	0.370657	684	0.0078682	1224	0.0467765	1872	0.0378917	2448	0.0086279	3060	0.0072576		
180	0.3677891	720	0.0469366	1296	0.0459377	1908	0.0465241	2484	0.0072898	3096	0.0080934		
180	0.3677891	720	0.0469366	1296	0.0459377	1908	0.0465241	2484	0.0072898	3096	0.0080934		
216	0.2721738	756	0.0069186	1332	0.0440367	1944	0.0047626	2520	0.007871	3132	0.0075907		
216	0.2721738	756	0.0069186	1332	0.0440367	1944	0.0047626	2520	0.007871	3132	0.0075907		
252	0.2452152	792	0.0069148	1368	0.0079274	1980	0.0073932	2556	0.000672	3168	0.0082146		
252	0.2452152	792	0.0069148	1368	0.0079274	1980	0.0073932	2556	0.000672	3168	0.0082146		
288	0.2803344	828	0.0062492	1440	0.0082572	2016	0.0464108	2592	0.0463012	3204	0.0049723		
288	0.2803344	828	0.0062492	1440	0.0082572	2016	0.0464108	2592	0.0463012	3204	0.0049723		
324	0.1887153	864	0.0085582	1476	0.0082759	2052	0.047319	2628	0.0483185	3240	0.0074164		
324	0.1887153	864	0.0085582	1476	0.0082759	2052	0.047319	2628	0.0483185	3240	0.0074164		
360	0.0086456	900	0.0058838	1512	0.0096533	2124	0.0100862	2700	0.0093017	3276	0.0059108		
360	0.0086456	900	0.0058838	1512	0.0096533	2124	0.0100862	2700	0.0093017	3276	0.0059108		
396	0.0091723	936	0.0066221	1548	0.0465541	2196	0.0093476	2736	0.0070806	3348	0.0081157		
396	0.0091723	936	0.0066221	1548	0.0465541	2196	0.0093476	2736	0.0070806	3348	0.0081157		
468	0.0090051	972	0.0090734	1584	0.0458829	2232	0.0466745	2772	0.0070148	3384	0.0078264		
468	0.0090051	972	0.0090734	1584	0.0458829	2232	0.0466745	2772	0.0070148	3384	0.0078264		

Table A-5. Results from 20 Hosts, Light Loads, Seed 128

Results from 20 Hosts, Light Application Loads, Seed 1024

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.001088	504	0.0081433	1116	0.0080033	1764	0.0074728	2304	0.0091261	2808	0.0083411	3384	0.005588
0	0.001088	504	0.0081433	1116	0.0080033	1764	0.0074728	2304	0.0091261	2808	0.0083411	3384	0.005588
36	0.0816759	540	0.0084707	1152	0.0087525	1800	0.0456568	2340	0.0087212	2844	0.000672	3420	0.046826
36	0.0816759	540	0.0084707	1152	0.0087525	1800	0.0456568	2340	0.0087212	2844	0.000672	3420	0.046826
72	0.0995809	576	0.0891592	1188	0.0080315	1836	0.0074415	2376	0.0088428	2952	0.0092388	3456	0.046752
72	0.0995809	576	0.0891592	1188	0.0080315	1836	0.0074415	2376	0.0088428	2952	0.0092388	3456	0.046752
108	0.1509371	612	0.0868488	1260	0.0048055	1872	0.0011131	2412	0.007191	2988	0.000672	3492	0.008874
108	0.1509371	612	0.0868488	1260	0.0048055	1872	0.0011131	2412	0.007191	2988	0.000672	3492	0.008874
144	0.2819252	648	0.0094331	1296	0.0050152	1908	0.009196	2448	0.0079861	3024	0.0076531	3528	0.00741
144	0.2819252	648	0.0094331	1296	0.0050152	1908	0.009196	2448	0.0079861	3024	0.0076531	3528	0.00741
180	0.2835009	684	0.0080872	1368	0.0467117	1980	0.0083379	2484	0.0096925	3060	0.0090444	3564	0.006792
180	0.2835009	684	0.0080872	1368	0.0467117	1980	0.0083379	2484	0.0096925	3060	0.0090444	3564	0.006792
216	0.2359174	720	0.0070425	1404	0.0175609	2016	0.0070865	2520	0.0472555	3096	0.0084312		
216	0.2359174	720	0.0070425	1404	0.0175609	2016	0.0070865	2520	0.0472555	3096	0.0084312		
252	0.1890775	792	0.0459778	1440	0.0084292	2052	0.0068978	2556	0.0473595	3132	0.0060415		
252	0.1890775	792	0.0459778	1440	0.0084292	2052	0.0068978	2556	0.0473595	3132	0.0060415		
288	0.2251781	828	0.0460546	1476	0.0086804	2088	0.0087568	2592	0.0086747	3168	0.000672		
288	0.2251781	828	0.0460546	1476	0.0086804	2088	0.0087568	2592	0.0086747	3168	0.000672		
324	0.2237268	864	0.0076707	1512	0.0062952	2124	0.0468078	2628	0.006952	3204	0.0088336		
324	0.2237268	864	0.0076707	1512	0.0062952	2124	0.0468078	2628	0.006952	3204	0.0088336		
360	0.1851834	900	0.0070969	1548	0.0066854	2160	0.0461915	2664	0.0083602	3240	0.0462817		
360	0.1851834	900	0.0070969	1548	0.0066854	2160	0.0461915	2664	0.0083602	3240	0.0462817		
396	0.0874474	936	0.0473634	1584	0.0458677	2196	0.0103224	2700	0.0080144	3276	0.0083564		
396	0.0874474	936	0.0473634	1584	0.0458677	2196	0.0103224	2700	0.0080144	3276	0.0083564		
432	0.0452875	972	0.0476401	1620	0.0068252	2232	0.007595	2736	0.0058144	3312	0.0082484		

Table A-6. Results from 20 Hosts, Light Loads, Seed 1024

Results from 30 Hosts, Light Application Loads, Seed 64

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.0042807	504	0.1685723	1008	0.0085463	1512	0.0461671	2016	0.000672	2520	0.0080523	3060	0.0474875
0	0.0042807	504	0.1685723	1008	0.0085463	1512	0.0461671	2016	0.000672	2520	0.0080523	3060	0.0474875
36	0.070867	540	0.1658721	1044	0.048266	1548	0.0066778	2052	0.0044542	2556	0.0088576	3096	0.0093474
36	0.070867	540	0.1658721	1044	0.048266	1548	0.0066778	2052	0.0044542	2556	0.0088576	3096	0.0093474
72	0.1252375	576	0.1094567	1080	0.0575106	1584	0.0072751	2088	0.0110871	2592	0.0080029	3132	0.0466471
72	0.1252375	576	0.1094567	1080	0.0575106	1584	0.0072751	2088	0.0110871	2592	0.0080029	3132	0.0466471
108	0.206716	612	0.0087103	1116	0.0066888	1620	0.0444163	2124	0.0081969	2628	0.0458688	3168	0.0455261
108	0.206716	612	0.0087103	1116	0.0066888	1620	0.0444163	2124	0.0081969	2628	0.0458688	3168	0.0455261
144	0.3262114	648	0.0097434	1152	0.0056381	1656	0.0457737	2160	0.0094979	2664	0.046548	3204	0.0077147
144	0.3262114	648	0.0097434	1152	0.0056381	1656	0.0457737	2160	0.0094979	2664	0.046548	3204	0.0077147
180	0.3408617	684	0.0070756	1188	0.046343	1692	0.0452353	2196	0.0099296	2700	0.0473248	3240	0.0079789
180	0.3408617	684	0.0070756	1188	0.046343	1692	0.0452353	2196	0.0099296	2700	0.0473248	3240	0.0079789
216	0.4205215	720	0.0473075	1224	0.0088572	1728	0.0060124	2232	0.0076086	2736	0.0088372	3312	0.0085489
216	0.4205215	720	0.0473075	1224	0.0088572	1728	0.0060124	2232	0.0076086	2736	0.0088372	3312	0.0085489
252	0.3864253	756	0.0082989	1260	0.0479025	1764	0.0079973	2268	0.0081432	2772	0.0082297	3348	0.0086379
252	0.3864253	756	0.0082989	1260	0.0479025	1764	0.0079973	2268	0.0081432	2772	0.0082297	3348	0.0086379
288	0.4403298	792	0.04607	1296	0.0102464	1800	0.0462278	2304	0.0472572	2808	0.0061355	3384	0.0459683
288	0.4403298	792	0.04607	1296	0.0102464	1800	0.0462278	2304	0.0472572	2808	0.0061355	3384	0.0459683
324	0.4331729	828	0.046409	1332	0.0453868	1836	0.0086022	2340	0.0082865	2880	0.0071386	3420	0.0380343
324	0.4331729	828	0.046409	1332	0.0453868	1836	0.0086022	2340	0.0082865	2880	0.0071386	3420	0.0380343
360	0.4119597	864	0.0080879	1368	0.0076596	1872	0.0093329	2376	0.0458086	2916	0.0459116	3456	0.0085757
360	0.4119597	864	0.0080879	1368	0.0076596	1872	0.0093329	2376	0.0458086	2916	0.0459116	3456	0.0085757
396	0.3079868	900	0.0080358	1404	0.0075375	1908	0.0062407	2412	0.0076218	2952	0.0068752	3492	0.0470214
396	0.3079868	900	0.0080358	1404	0.0075375	1908	0.0062407	2412	0.0076218	2952	0.0068752	3492	0.0470214
432	0.1774455	936	0.0082011	1440	0.0087881	1944	0.0082592	2448	0.0471989	2988	0.008777	3528	0.00798
432	0.1774455	936	0.0082011	1440	0.0087881	1944	0.0082592	2448	0.0471989	2988	0.008777	3528	0.00798

Table A-7. Results from 30 Hosts, Light Loads, Seed 64

Results from 30 Hosts, Light Application Loads, Seed 128

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.001088	504	0.1548693	1044	0.0062932	1584	0.0465213	2124	0.0074137	2664	0.0084058	3168	0.006828
0	0.001088	504	0.1548693	1044	0.0062932	1584	0.0465213	2124	0.0074137	2664	0.0084058	3168	0.006828
36	0.1686546	540	0.0091159	1080	0.0091411	1620	0.0083927	2160	0.0106479	2700	0.0090217	3204	0.0059381
36	0.1686546	540	0.0091159	1080	0.0091411	1620	0.0083927	2160	0.0106479	2700	0.0090217	3204	0.0059381
72	0.2601318	576	0.0469086	1116	0.0084805	1656	0.0081302	2196	0.0074661	2736	0.000672	3240	0.0458572
72	0.2601318	576	0.0469086	1116	0.0084805	1656	0.0081302	2196	0.0074661	2736	0.000672	3240	0.0458572
108	0.2833534	648	0.0088013	1152	0.0071684	1692	0.0045543	2232	0.008878	2772	0.0462771	3276	0.0462926
108	0.2833534	648	0.0088013	1152	0.0071684	1692	0.0045543	2232	0.008878	2772	0.0462771	3276	0.0462926
144	0.2755427	684	0.0470796	1188	0.0755872	1764	0.0079891	2268	0.004709	2808	0.0078754	3312	0.0457253
144	0.2755427	684	0.0470796	1188	0.0755872	1764	0.0079891	2268	0.004709	2808	0.0078754	3312	0.0457253
180	0.3400359	720	0.0096611	1224	0.0759896	1800	0.0056648	2304	0.0065478	2844	0.0060673	3348	0.0068156
180	0.3400359	720	0.0096611	1224	0.0759896	1800	0.0056648	2304	0.0065478	2844	0.0060673	3348	0.0068156
216	0.4066213	756	0.0479668	1260	0.000672	1836	0.0464188	2340	0.0458305	2880	0.0088591	3384	0.0471623
216	0.4066213	756	0.0479668	1260	0.000672	1836	0.0464188	2340	0.0458305	2880	0.0088591	3384	0.0471623
252	0.4862742	792	0.0094559	1296	0.0072373	1872	0.0238813	2376	0.0087274	2916	0.0084383	3420	0.0057917
252	0.4862742	792	0.0094559	1296	0.0072373	1872	0.0238813	2376	0.0087274	2916	0.0084383	3420	0.0057917
288	0.5300527	828	0.0457319	1332	0.0077608	1908	0.0065157	2412	0.004634	2952	0.0079475	3456	0.0072907
288	0.5300527	828	0.0457319	1332	0.0077608	1908	0.0065157	2412	0.004634	2952	0.0079475	3456	0.0072907
324	0.5338031	864	0.0465092	1368	0.0071519	1944	0.0080033	2484	0.0428142	2988	0.045499	3492	0.0085896
324	0.5338031	864	0.0465092	1368	0.0071519	1944	0.0080033	2484	0.0428142	2988	0.045499	3492	0.0085896
360	0.4565634	900	0.0102629	1404	0.0076774	1980	0.0079562	2520	0.0478884	3024	0.0474682	3528	0.000672
360	0.4565634	900	0.0102629	1404	0.0076774	1980	0.0079562	2520	0.0478884	3024	0.0474682	3528	0.000672
396	0.3652008	936	0.0449124	1476	0.0459451	2016	0.0463254	2556	0.0084788	3060	0.0076677	3564	0.0813348
396	0.3652008	936	0.0449124	1476	0.0459451	2016	0.0463254	2556	0.0084788	3060	0.0076677	3564	0.0813348
432	0.2302678	972	0.0436469	1512	0.0450847	2052	0.044799	2592	0.0079533	3096	0.0923062		
432	0.2302678	972	0.0436469	1512	0.0450847	2052	0.044799	2592	0.0079533	3096	0.0923062		

Table A-8. Results from 30 Hosts, Light Loads, Seed 128

Results from 30 Hosts, Light Application Loads, Seed 1024

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.0702	504	0.1529547	1044	0.0459207	1584	0.0058144	2088	0.0626715	2628	0.0462848	3204	0.0469572
0	0.0702	504	0.1529547	1044	0.0459207	1584	0.0058144	2088	0.0626715	2628	0.0462848	3204	0.0469572
36	0.1617814	540	0.0081074	1080	0.000672	1620	0.0064441	2124	0.1064513	2736	0.0145492	3240	0.0093829
36	0.1617814	540	0.0081074	1080	0.000672	1620	0.0064441	2124	0.1064513	2736	0.0145492	3240	0.0093829
72	0.3681812	576	0.0091688	1116	0.0084215	1656	0.0092947	2160	0.0229055	2772	0.0474143	3276	0.000672
72	0.3681812	576	0.0091688	1116	0.0084215	1656	0.0092947	2160	0.0229055	2772	0.0474143	3276	0.000672
108	0.4096822	612	0.0087401	1152	0.0339679	1692	0.0046863	2196	0.0469234	2808	0.0067909	3312	0.0070275
108	0.4096822	612	0.0087401	1152	0.0339679	1692	0.0046863	2196	0.0469234	2808	0.0067909	3312	0.0070275
144	0.5511291	648	0.046269	1188	0.0456479	1728	0.0076047	2232	0.0097265	2844	0.0074342	3348	0.0081113
144	0.5511291	648	0.046269	1188	0.0456479	1728	0.0076047	2232	0.0097265	2844	0.0074342	3348	0.0081113
180	0.6139831	720	0.0089108	1224	0.0446827	1764	0.0447658	2268	0.000672	2880	0.005449	3384	0.007513
180	0.6139831	720	0.0089108	1224	0.0446827	1764	0.0447658	2268	0.000672	2880	0.005449	3384	0.007513
216	0.6828123	756	0.0466165	1260	0.0458411	1800	0.04554	2304	0.0475121	2916	0.0446611	3420	0.0081872
216	0.6828123	756	0.0466165	1260	0.0458411	1800	0.04554	2304	0.0475121	2916	0.0446611	3420	0.0081872
252	0.5987616	792	0.0064978	1296	0.006898	1836	0.046508	2340	0.0482465	2952	0.0466663	3456	0.0073162
252	0.5987616	792	0.0064978	1296	0.006898	1836	0.046508	2340	0.0482465	2952	0.0466663	3456	0.0073162
288	0.5145016	828	0.0046019	1332	0.0468239	1872	0.0461393	2412	0.0072407	2988	0.0656641	3492	0.0464611
288	0.5145016	828	0.0046019	1332	0.0468239	1872	0.0461393	2412	0.0072407	2988	0.0656641	3492	0.0464611
324	0.4804316	864	0.007189	1368	0.079183	1908	0.0082984	2448	0.0062792	3024	0.004834	3528	0.0468771
324	0.4804316	864	0.007189	1368	0.079183	1908	0.0082984	2448	0.0062792	3024	0.004834	3528	0.0468771
360	0.3153966	900	0.0467186	1404	0.0658414	1944	0.0784445	2484	0.0086719	3060	0.0070164		
360	0.3153966	900	0.0467186	1404	0.0658414	1944	0.0784445	2484	0.0086719	3060	0.0070164		
396	0.1769968	936	0.0092336	1476	0.0048116	1980	0.0816565	2520	0.0478627	3096	0.0464172		
396	0.1769968	936	0.0092336	1476	0.0048116	1980	0.0816565	2520	0.0478627	3096	0.0464172		
432	0.16478	972	0.0457838	1512	0.0065493	2016	0.0095335	2556	0.0075026	3132	0.0456366		
432	0.16478	972	0.0457838	1512	0.0065493	2016	0.0095335	2556	0.0075026	3132	0.0456366		
468	0.1677706	1008	0.0078645	1548	0.008709	2052	0.0358068	2592	0.0071441	3168	0.0064923		

Table A-9. Results from 30 Hosts, Light Loads, Seed 1024

Results from 10 Hosts, Heavy Web, Seed 64

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.001088	504	0.0127213	1008	0.0132341	1512	0.0120528	2016	0.0130386	2520	0.0466158	3024	0.0152248
0	0.001088	504	0.0127213	1008	0.0132341	1512	0.0120528	2016	0.0130386	2520	0.0466158	3024	0.0152248
36	0.059098	540	0.014115	1044	0.0151636	1548	0.0135552	2052	0.0154758	2556	0.0148901	3060	0.000672
36	0.059098	540	0.014115	1044	0.0151636	1548	0.0135552	2052	0.0154758	2556	0.0148901	3060	0.000672
72	0.1278977	576	0.0126392	1080	0.012487	1584	0.0138081	2088	0.0127296	2592	0.0131394	3096	0.0127002
72	0.1278977	576	0.0126392	1080	0.012487	1584	0.0138081	2088	0.0127296	2592	0.0131394	3096	0.0127002
108	0.0719016	612	0.0168374	1116	0.0130191	1620	0.0140305	2124	0.0490664	2628	0.0128981	3132	0.0123003
108	0.0719016	612	0.0168374	1116	0.0130191	1620	0.0140305	2124	0.0490664	2628	0.0128981	3132	0.0123003
144	0.0137849	648	0.0468325	1152	0.0154242	1656	0.0158705	2160	0.046065	2664	0.0186023	3168	0.0129923
144	0.0137849	648	0.0468325	1152	0.0154242	1656	0.0158705	2160	0.046065	2664	0.0186023	3168	0.0129923
180	0.0465642	684	0.0140764	1188	0.0124522	1692	0.0130187	2196	0.0165429	2700	0.0164837	3204	0.0130577
180	0.0465642	684	0.0140764	1188	0.0124522	1692	0.0130187	2196	0.0165429	2700	0.0164837	3204	0.0130577
216	0.0731141	720	0.016055	1224	0.0141079	1728	0.0129796	2232	0.014288	2736	0.0160829	3240	0.0131075
216	0.0731141	720	0.016055	1224	0.0141079	1728	0.0129796	2232	0.014288	2736	0.0160829	3240	0.0131075
252	0.1591137	756	0.0131111	1260	0.0126432	1764	0.0451496	2268	0.0135535	2772	0.014589	3276	0.0146333
252	0.1591137	756	0.0131111	1260	0.0126432	1764	0.0451496	2268	0.0135535	2772	0.014589	3276	0.0146333
288	0.0864069	792	0.0136429	1296	0.0150055	1800	0.0479409	2304	0.0148116	2808	0.0131912	3312	0.0449094
288	0.0864069	792	0.0136429	1296	0.0150055	1800	0.0479409	2304	0.0148116	2808	0.0131912	3312	0.0449094
324	0.0151865	828	0.0444271	1332	0.0124779	1836	0.0128542	2340	0.0129432	2844	0.0460361	3348	0.0373545
324	0.0151865	828	0.0444271	1332	0.0124779	1836	0.0128542	2340	0.0129432	2844	0.0460361	3348	0.0373545
360	0.0141884	864	0.0454496	1368	0.0122765	1872	0.0146833	2376	0.0116636	2880	0.0148897	3384	0.0142759
360	0.0141884	864	0.0454496	1368	0.0122765	1872	0.0146833	2376	0.0116636	2880	0.0148897	3384	0.0142759
396	0.0149436	900	0.0158171	1404	0.0132931	1908	0.0454556	2412	0.0128842	2916	0.0121433	3420	0.0099482
396	0.0149436	900	0.0158171	1404	0.0132931	1908	0.0454556	2412	0.0128842	2916	0.0121433	3420	0.0099482
432	0.0119862	936	0.0146425	1440	0.0147709	1944	0.0121627	2448	0.0134683	2952	0.0143094	3456	0.011543
432	0.0119862	936	0.0146425	1440	0.0147709	1944	0.0121627	2448	0.0134683	2952	0.0143094	3456	0.011543
468	0.0154821	972	0.0146993	1476	0.013488	1980	0.0141985	2484	0.0185429	2988	0.0154773	3492	0.016679

Table A-10. Results from 10 Hosts, Heavy Web, Seed 64

Results from 10 Hosts, Heavy Web, Seed 128

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.0449447	504	0.0126921	1008	0.0856115	1512	0.0120571	2016	0.010772	2520	0.0137219	3024	0.0141821
0	0.0449447	504	0.0126921	1008	0.0856115	1512	0.0120571	2016	0.010772	2520	0.0137219	3024	0.0141821
36	0.0474793	540	0.0128821	1044	0.0141031	1548	0.0401446	2052	0.0148653	2556	0.0145845	3060	0.0418942
36	0.0474793	540	0.0128821	1044	0.0141031	1548	0.0401446	2052	0.0148653	2556	0.0145845	3060	0.0418942
72	0.0457	576	0.0158449	1080	0.0145256	1584	0.0476872	2088	0.014312	2592	0.0140391	3096	0.0466727
72	0.0457	576	0.0158449	1080	0.0145256	1584	0.0476872	2088	0.014312	2592	0.0140391	3096	0.0466727
108	0.1466791	612	0.0144635	1116	0.0143547	1620	0.0139941	2124	0.0132211	2628	0.0133198	3132	0.015097
108	0.1466791	612	0.0144635	1116	0.0143547	1620	0.0139941	2124	0.0132211	2628	0.0133198	3132	0.015097
144	0.1750225	648	0.0153237	1152	0.0122237	1656	0.0137112	2160	0.0148046	2664	0.0116148	3168	0.0136831
144	0.1750225	648	0.0153237	1152	0.0122237	1656	0.0137112	2160	0.0148046	2664	0.0116148	3168	0.0136831
180	0.1310463	684	0.0149066	1188	0.0133687	1692	0.0133316	2196	0.0140454	2700	0.0170625	3204	0.0146102
180	0.1310463	684	0.0149066	1188	0.0133687	1692	0.0133316	2196	0.0140454	2700	0.0170625	3204	0.0146102
216	0.0831726	720	0.0144329	1224	0.0144394	1728	0.0115614	2232	0.0144144	2736	0.0135697	3240	0.0135387
216	0.0831726	720	0.0144329	1224	0.0144394	1728	0.0115614	2232	0.0144144	2736	0.0135697	3240	0.0135387
252	0.0459317	756	0.0123393	1260	0.0175811	1764	0.0144301	2268	0.0149414	2772	0.0134593	3276	0.0133536
252	0.0459317	756	0.0123393	1260	0.0175811	1764	0.0144301	2268	0.0149414	2772	0.0134593	3276	0.0133536
288	0.0474354	792	0.0171651	1296	0.0126162	1800	0.0109264	2304	0.016408	2808	0.0130346	3312	0.012399
288	0.0474354	792	0.0171651	1296	0.0126162	1800	0.0109264	2304	0.016408	2808	0.0130346	3312	0.012399
324	0.0124633	828	0.0128956	1332	0.0154068	1836	0.012123	2340	0.0421483	2844	0.0138107	3348	0.0843747
324	0.0124633	828	0.0128956	1332	0.0154068	1836	0.012123	2340	0.0421483	2844	0.0138107	3348	0.0843747
360	0.0150223	864	0.0149023	1368	0.0139283	1872	0.0121599	2376	0.0461427	2880	0.0140189	3384	0.0561594
360	0.0150223	864	0.0149023	1368	0.0139283	1872	0.0121599	2376	0.0461427	2880	0.0140189	3384	0.0561594
396	0.0137494	900	0.0138389	1404	0.011601	1908	0.0152729	2412	0.0471252	2916	0.0120928	3420	0.0134768
396	0.0137494	900	0.0138389	1404	0.011601	1908	0.0152729	2412	0.0471252	2916	0.0120928	3420	0.0134768
432	0.0133428	936	0.0133855	1440	0.0128462	1944	0.0350214	2448	0.0128073	2952	0.011288	3456	0.0140837
432	0.0133428	936	0.0133855	1440	0.0128462	1944	0.0350214	2448	0.0128073	2952	0.011288	3456	0.0140837
468	0.0132896	972	0.0124439	1476	0.0114275	1980	0.0467378	2484	0.0129277	2988	0.0168344	3492	0.0138199

Table A-11. Results from 10 Hosts, Heavy Web, Seed 128

Results from 10 Hosts, Heavy Web, Seed 1024

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.0469865	504	0.0142532	1008	0.0133032	1512	0.0162669	2016	0.0147353	2520	0.0140178	3024	0.014009
0	0.0469865	504	0.0142532	1008	0.0133032	1512	0.0162669	2016	0.0147353	2520	0.0140178	3024	0.014009
36	0.0041421	540	0.016142	1044	0.0141156	1548	0.0131527	2052	0.0142068	2556	0.0449084	3060	0.0456931
36	0.0041421	540	0.016142	1044	0.0141156	1548	0.0131527	2052	0.0142068	2556	0.0449084	3060	0.0456931
72	0.0131965	576	0.0143508	1080	0.0147492	1584	0.015567	2088	0.014925	2592	0.0144841	3096	0.0135953
72	0.0131965	576	0.0143508	1080	0.0147492	1584	0.015567	2088	0.014925	2592	0.0144841	3096	0.0135953
108	0.0663689	612	0.0131868	1116	0.014208	1620	0.0139069	2124	0.0140097	2628	0.0140604	3132	0.0148538
108	0.0663689	612	0.0131868	1116	0.014208	1620	0.0139069	2124	0.0140097	2628	0.0140604	3132	0.0148538
144	0.0486217	648	0.011874	1152	0.0132257	1656	0.013382	2160	0.0149359	2664	0.0141641	3168	0.000672
144	0.0486217	648	0.011874	1152	0.0132257	1656	0.013382	2160	0.0149359	2664	0.0141641	3168	0.000672
180	0.0752921	684	0.0153616	1188	0.0140253	1692	0.01306	2196	0.0140954	2700	0.014405	3204	0.0153855
180	0.0752921	684	0.0153616	1188	0.0140253	1692	0.01306	2196	0.0140954	2700	0.014405	3204	0.0153855
216	0.0689077	720	0.0130886	1224	0.0139945	1728	0.0463992	2232	0.0130181	2736	0.0121323	3240	0.0142711
216	0.0689077	720	0.0130886	1224	0.0139945	1728	0.0463992	2232	0.0130181	2736	0.0121323	3240	0.0142711
252	0.086951	756	0.0173255	1260	0.013056	1764	0.0423789	2268	0.0139441	2772	0.0132837	3276	0.0134354
252	0.086951	756	0.0173255	1260	0.013056	1764	0.0423789	2268	0.0139441	2772	0.0132837	3276	0.0134354
288	0.1316087	792	0.0174642	1296	0.0131889	1800	0.0137779	2304	0.0144195	2808	0.0130645	3312	0.0160552
288	0.1316087	792	0.0174642	1296	0.0131889	1800	0.0137779	2304	0.0144195	2808	0.0130645	3312	0.0160552
324	0.0140388	828	0.0138492	1332	0.0125132	1836	0.0132425	2340	0.0144168	2844	0.013617	3348	0.0142972
324	0.0140388	828	0.0138492	1332	0.0125132	1836	0.0132425	2340	0.0144168	2844	0.013617	3348	0.0142972
360	0.0148555	864	0.0147934	1368	0.013005	1872	0.0129263	2376	0.0151688	2880	0.0163928	3384	0.0125294
360	0.0148555	864	0.0147934	1368	0.013005	1872	0.0129263	2376	0.0151688	2880	0.0163928	3384	0.0125294
396	0.0141036	900	0.0134126	1404	0.0147233	1908	0.0103261	2412	0.0129383	2916	0.0134513	3420	0.0137625
396	0.0141036	900	0.0134126	1404	0.0147233	1908	0.0103261	2412	0.0129383	2916	0.0134513	3420	0.0137625
432	0.014801	936	0.0154433	1440	0.0144646	1944	0.0144079	2448	0.0134479	2952	0.0135632	3456	0.0149974
432	0.014801	936	0.0154433	1440	0.0144646	1944	0.0144079	2448	0.0134479	2952	0.0135632	3456	0.0149974
468	0.0147678	972	0.0464624	1476	0.0133807	1980	0.0135906	2484	0.0143011	2988	0.0138982	3492	0.0143855

Table A-12. Results from 10 Hosts, Heavy Web, Seed 1024

Results from 20 Hosts, Heavy Web, Seed 64

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.001088	504	0.0137417	1008	0.0153827	1512	0.0165378	2016	0.013694	2520	0.0126312	3024	0.0145574
0	0.001088	504	0.0137417	1008	0.0153827	1512	0.0165378	2016	0.013694	2520	0.0126312	3024	0.0145574
36	0.0612301	540	0.0145318	1044	0.01342	1548	0.0112239	2052	0.012921	2556	0.0143022	3060	0.01371
36	0.0612301	540	0.0145318	1044	0.01342	1548	0.0112239	2052	0.012921	2556	0.0143022	3060	0.01371
72	0.2168479	576	0.0127127	1080	0.0464936	1584	0.0468043	2088	0.0152328	2592	0.0138182	3096	0.0145883
72	0.2168479	576	0.0127127	1080	0.0464936	1584	0.0468043	2088	0.0152328	2592	0.0138182	3096	0.0145883
108	0.2047665	612	0.0140682	1116	0.0146962	1620	0.0403639	2124	0.0143913	2628	0.01377	3132	0.0154656
108	0.2047665	612	0.0140682	1116	0.0146962	1620	0.0403639	2124	0.0143913	2628	0.01377	3132	0.0154656
144	0.1604879	648	0.0150315	1152	0.0133906	1656	0.0425007	2160	0.0346003	2664	0.0132204	3168	0.0139254
144	0.1604879	648	0.0150315	1152	0.0133906	1656	0.0425007	2160	0.0346003	2664	0.0132204	3168	0.0139254
180	0.1395334	684	0.0132571	1188	0.0139158	1692	0.0383938	2196	0.0466293	2700	0.0435163	3204	0.0151564
180	0.1395334	684	0.0132571	1188	0.0139158	1692	0.0383938	2196	0.0466293	2700	0.0435163	3204	0.0151564
216	0.2450138	720	0.014587	1224	0.0142446	1728	0.062957	2232	0.0140553	2736	0.0452483	3240	0.0135674
216	0.2450138	720	0.014587	1224	0.0142446	1728	0.062957	2232	0.0140553	2736	0.0452483	3240	0.0135674
252	0.2994331	756	0.0130848	1260	0.0363753	1764	0.0492766	2268	0.0154897	2772	0.0141465	3276	0.015773
252	0.2994331	756	0.0130848	1260	0.0363753	1764	0.0492766	2268	0.0154897	2772	0.0141465	3276	0.015773
288	0.2896902	792	0.0473997	1296	0.0435824	1800	0.0132512	2304	0.0139926	2808	0.0155887	3312	0.0138054
288	0.2896902	792	0.0473997	1296	0.0435824	1800	0.0132512	2304	0.0139926	2808	0.0155887	3312	0.0138054
324	0.2088578	828	0.0467485	1332	0.0131433	1836	0.01473	2340	0.014146	2844	0.040009	3348	0.0139022
324	0.2088578	828	0.0467485	1332	0.0131433	1836	0.01473	2340	0.014146	2844	0.040009	3348	0.0139022
360	0.0742056	864	0.0147599	1368	0.0150608	1872	0.016307	2376	0.0361924	2880	0.0450714	3384	0.047403
360	0.0742056	864	0.0147599	1368	0.0150608	1872	0.016307	2376	0.0361924	2880	0.0450714	3384	0.047403
396	0.0464434	900	0.0340487	1404	0.0134931	1908	0.0146081	2412	0.0476727	2916	0.0490728	3420	0.0485341
396	0.0464434	900	0.0340487	1404	0.0134931	1908	0.0146081	2412	0.0476727	2916	0.0490728	3420	0.0485341
432	0.0144815	936	0.0438076	1440	0.0150168	1944	0.01436	2448	0.0151261	2952	0.015707	3456	0.0460706
432	0.0144815	936	0.0438076	1440	0.0150168	1944	0.01436	2448	0.0151261	2952	0.015707	3456	0.0460706
468	0.0141756	972	0.0142841	1476	0.014857	1980	0.0456202	2484	0.0473087	2988	0.0178461	3492	0.0130254
468	0.0141756	972	0.0142841	1476	0.014857	1980	0.0456202	2484	0.0473087	2988	0.0178461	3492	0.0130254

Table A-13. Results from 20 Hosts, Heavy Web, Seed 64

Results from 20 Hosts, Heavy Web, Seed 128

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.001088	504	0.0136854	1008	0.0140417	1512	0.0470097	2016	0.0131927	2520	0.0133039	3024	0.0146535
0	0.001088	504	0.0136854	1008	0.0140417	1512	0.0470097	2016	0.0131927	2520	0.0133039	3024	0.0146535
36	0.0952149	540	0.014914	1044	0.0409211	1548	0.043465	2052	0.0424403	2556	0.0131882	3060	0.0479522
36	0.0952149	540	0.014914	1044	0.0409211	1548	0.043465	2052	0.0424403	2556	0.0131882	3060	0.0479522
72	0.1015856	576	0.0144868	1080	0.0400961	1584	0.0133305	2088	0.0468942	2592	0.0152275	3096	0.035433
72	0.1015856	576	0.0144868	1080	0.0400961	1584	0.0133305	2088	0.0468942	2592	0.0152275	3096	0.035433
108	0.1335935	612	0.0139833	1116	0.015601	1620	0.0130537	2124	0.0142423	2628	0.014836	3132	0.0464535
108	0.1335935	612	0.0139833	1116	0.015601	1620	0.0130537	2124	0.0142423	2628	0.014836	3132	0.0464535
144	0.2757751	648	0.0141296	1152	0.0134656	1656	0.0150377	2160	0.0149067	2664	0.0143867	3168	0.0204569
144	0.2757751	648	0.0141296	1152	0.0134656	1656	0.0150377	2160	0.0149067	2664	0.0143867	3168	0.0204569
180	0.2460394	684	0.014743	1188	0.0178047	1692	0.0136652	2196	0.0140141	2700	0.047263	3204	0.0118192
180	0.2460394	684	0.014743	1188	0.0178047	1692	0.0136652	2196	0.0140141	2700	0.047263	3204	0.0118192
216	0.1886856	720	0.0462683	1224	0.0145053	1728	0.0136809	2232	0.0151713	2736	0.0146936	3240	0.0165602
216	0.1886856	720	0.0462683	1224	0.0145053	1728	0.0136809	2232	0.0151713	2736	0.0146936	3240	0.0165602
252	0.1919574	756	0.046438	1260	0.0140847	1764	0.0449158	2268	0.0149163	2772	0.0155275	3276	0.0135777
252	0.1919574	756	0.046438	1260	0.0140847	1764	0.0449158	2268	0.0149163	2772	0.0155275	3276	0.0135777
288	0.1979807	792	0.0146512	1296	0.0133548	1800	0.0147364	2304	0.0478027	2808	0.0134328	3312	0.0150248
288	0.1979807	792	0.0146512	1296	0.0133548	1800	0.0147364	2304	0.0478027	2808	0.0134328	3312	0.0150248
324	0.1652195	828	0.0146772	1332	0.0144592	1836	0.0138724	2340	0.0143088	2844	0.0138633	3348	0.0149707
324	0.1652195	828	0.0146772	1332	0.0144592	1836	0.0138724	2340	0.0143088	2844	0.0138633	3348	0.0149707
360	0.1638408	864	0.0153339	1368	0.01452	1872	0.0140946	2376	0.0447604	2880	0.0150198	3384	0.0150972
360	0.1638408	864	0.0153339	1368	0.01452	1872	0.0140946	2376	0.0447604	2880	0.0150198	3384	0.0150972
396	0.1045168	900	0.0149056	1404	0.0143498	1908	0.0148802	2412	0.0146644	2916	0.0143958	3420	0.0142075
396	0.1045168	900	0.0149056	1404	0.0143498	1908	0.0148802	2412	0.0146644	2916	0.0143958	3420	0.0142075
432	0.0456223	936	0.0179503	1440	0.0140519	1944	0.0154714	2448	0.0136437	2952	0.0127981	3456	0.0142255
432	0.0456223.	936	0.0179503	1440	0.0140519	1944	0.0154714	2448	0.0136437	2952	0.0127981	3456	0.0142255

Table A-14. Results from 20 Hosts, Heavy Web, Seed 128

Results from 20 Hosts, Heavy Web, Seed 1024

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.0448149	504	0.0743678	1008	0.0116231	1512	0.0133129	2016	0.0463411	2520	0.0434904	3024	0.0142963
0	0.0448149	504	0.0743678	1008	0.0116231	1512	0.0133129	2016	0.0463411	2520	0.0434904	3024	0.0142963
36	0.0471638	540	0.0434489	1044	0.0145754	1548	0.0143776	2052	0.0130587	2556	0.0151293	3060	0.0146278
36	0.0471638	540	0.0434489	1044	0.0145754	1548	0.0143776	2052	0.0130587	2556	0.0151293	3060	0.0146278
72	0.2199388	576	0.0305905	1080	0.0148567	1584	0.0146716	2088	0.0445713	2592	0.0140101	3096	0.0166805
72	0.2199388	576	0.0305905	1080	0.0148567	1584	0.0146716	2088	0.0445713	2592	0.0140101	3096	0.0166805
108	0.3195493	612	0.0136858	1116	0.0128895	1620	0.0442857	2124	0.0126977	2628	0.0149259	3132	0.0144355
108	0.3195493	612	0.0136858	1116	0.0128895	1620	0.0442857	2124	0.0126977	2628	0.0149259	3132	0.0144355
144	0.478436	648	0.0153362	1152	0.0146172	1656	0.0332729	2160	0.0142674	2664	0.0158841	3168	0.0145557
144	0.478436	648	0.0153362	1152	0.0146172	1656	0.0332729	2160	0.0142674	2664	0.0158841	3168	0.0145557
180	0.4734042	684	0.017833	1188	0.0145738	1692	0.0170559	2196	0.0446589	2700	0.0120009	3204	0.0406643
180	0.4734042	684	0.017833	1188	0.0145738	1692	0.0170559	2196	0.0446589	2700	0.0120009	3204	0.0406643
216	0.3480181	720	0.0156337	1224	0.0148654	1728	0.0182322	2232	0.0137324	2736	0.0140853	3240	0.047238
216	0.3480181	720	0.0156337	1224	0.0148654	1728	0.0182322	2232	0.0137324	2736	0.0140853	3240	0.047238
252	0.3178462	756	0.014509	1260	0.0128187	1764	0.0121991	2268	0.0148839	2772	0.0139746	3276	0.0145734
252	0.3178462	756	0.014509	1260	0.0128187	1764	0.0121991	2268	0.0148839	2772	0.0139746	3276	0.0145734
288	0.2192254	792	0.0462322	1296	0.0151727	1800	0.0133779	2304	0.0142489	2808	0.0140404	3312	0.0127948
288	0.2192254	792	0.0462322	1296	0.0151727	1800	0.0133779	2304	0.0142489	2808	0.0140404	3312	0.0127948
324	0.2205907	828	0.0324015	1332	0.0499177	1836	0.0456926	2340	0.0137957	2844	0.0144403	3348	0.0155626
324	0.2205907	828	0.0324015	1332	0.0499177	1836	0.0456926	2340	0.0137957	2844	0.0144403	3348	0.0155626
360	0.1482213	864	0.0439392	1368	0.0397259	1872	0.0463143	2376	0.0146194	2880	0.0157849	3384	0.0136393
360	0.1482213	864	0.0439392	1368	0.0397259	1872	0.0463143	2376	0.0146194	2880	0.0157849	3384	0.0136393
396	0.0299706	900	0.0762764	1404	0.0444462	1908	0.0151159	2412	0.0138752	2916	0.0131491	3420	0.0164747
396	0.0299706	900	0.0762764	1404	0.0444462	1908	0.0151159	2412	0.0138752	2916	0.0131491	3420	0.0164747
432	0.0143103	936	0.0137283	1440	0.0136358	1944	0.0474261	2448	0.015206	2952	0.0157979	3456	0.0142976
432	0.0143103	936	0.0137283	1440	0.0136358	1944	0.0474261	2448	0.015206	2952	0.0157979	3456	0.0142976

Table A-15. Results from 20 Hosts, Heavy Web, Seed 1024

Results from 30 Hosts, Heavy Web, Seed 64

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.0055792	504	0.1670999	1008	0.0161302	1512	0.0134115	2016	0.0131688	2520	0.0147692	3024	0.0473833
0	0.0055792	504	0.1670999	1008	0.0161302	1512	0.0134115	2016	0.0131688	2520	0.0147692	3024	0.0473833
36	0.0688939	540	0.1638404	1044	0.016992	1548	0.0127334	2052	0.0140465	2556	0.0130065	3060	0.0137353
36	0.0688939	540	0.1638404	1044	0.016992	1548	0.0127334	2052	0.0140465	2556	0.0130065	3060	0.0137353
72	0.1183307	576	0.1061369	1080	0.0143499	1584	0.0450575	2088	0.0138572	2592	0.0140297	3096	0.0171172
72	0.1183307	576	0.1061369	1080	0.0143499	1584	0.0450575	2088	0.0138572	2592	0.0140297	3096	0.0171172
108	0.2012358	612	0.0456151	1116	0.0131659	1620	0.0141791	2124	0.0147426	2628	0.0155356	3132	0.0145238
108	0.2012358	612	0.0456151	1116	0.0131659	1620	0.0141791	2124	0.0147426	2628	0.0155356	3132	0.0145238
144	0.318291	648	0.0148002	1152	0.0168773	1656	0.0137152	2160	0.014028	2664	0.0143852	3168	0.0140062
144	0.318291	648	0.0148002	1152	0.0168773	1656	0.0137152	2160	0.014028	2664	0.0143852	3168	0.0140062
180	0.393337	684	0.0126291	1188	0.0133188	1692	0.0135543	2196	0.0148824	2700	0.0158293	3204	0.0146676
180	0.393337	684	0.0126291	1188	0.0133188	1692	0.0135543	2196	0.0148824	2700	0.0158293	3204	0.0146676
216	0.4766166	720	0.0148912	1224	0.0137374	1728	0.0133412	2232	0.0142837	2736	0.0155441	3240	0.0176786
216	0.4766166	720	0.0148912	1224	0.0137374	1728	0.0133412	2232	0.0142837	2736	0.0155441	3240	0.0176786
252	0.4679671	756	0.015672	1260	0.016043	1764	0.0134797	2268	0.0140686	2772	0.0132201	3276	0.0160756
252	0.4679671	756	0.015672	1260	0.016043	1764	0.0134797	2268	0.0140686	2772	0.0132201	3276	0.0160756
288	0.4234833	792	0.0131221	1296	0.0146024	1800	0.0141029	2304	0.0145421	2808	0.0135431	3312	0.0153625
288	0.4234833	792	0.0131221	1296	0.0146024	1800	0.0141029	2304	0.0145421	2808	0.0135431	3312	0.0153625
324	0.3550415	828	0.01415	1332	0.0133854	1836	0.0147237	2340	0.0144302	2844	0.0153368	3348	0.0140389
324	0.3550415	828	0.01415	1332	0.0133854	1836	0.0147237	2340	0.0144302	2844	0.0153368	3348	0.0140389
360	0.2554556	864	0.0530044	1368	0.0134867	1872	0.0462333	2376	0.0143115	2880	0.0472587	3384	0.0153196
360	0.2554556	864	0.0530044	1368	0.0134867	1872	0.0462333	2376	0.0143115	2880	0.0472587	3384	0.0153196
396	0.1844948	900	0.060814	1404	0.0146495	1908	0.0143231	2412	0.0140099	2916	0.0151259	3420	0.0386772
396	0.1844948	900	0.060814	1404	0.0146495	1908	0.0143231	2412	0.0140099	2916	0.0151259	3420	0.0386772
432	0.1660279	936	0.0154682	1440	0.0147215	1944	0.0141412	2448	0.0515615	2952	0.0144369	3456	0.0398597
432	0.1660279	936	0.0154682	1440	0.0147215	1944	0.0141412	2448	0.0515615	2952	0.0144369	3456	0.0398597

Table A-16. Results from 30 Hosts, Heavy Web, Seed 64

Results from 30 Hosts, Heavy Web, Seed 128

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.001088	504	0.1677822	1008	0.0741745	1512	0.0131765	2016	0.0140847	2520	0.0139563	3024	0.0141583
0	0.001088	504	0.1677822	1008	0.0741745	1512	0.0131765	2016	0.0140847	2520	0.0139563	3024	0.0141583
36	0.1676227	540	0.1681929	1044	0.0406227	1548	0.0138359	2052	0.0153923	2556	0.0142885	3060	0.0143177
36	0.1676227	540	0.1681929	1044	0.0406227	1548	0.0138359	2052	0.0153923	2556	0.0142885	3060	0.0143177
72	0.2580705	576	0.1687859	1080	0.0135478	1584	0.0144955	2088	0.0151684	2592	0.0149607	3096	0.0148625
72	0.2580705	576	0.1687859	1080	0.0135478	1584	0.0144955	2088	0.0151684	2592	0.0149607	3096	0.0148625
108	0.3075337	612	0.1646245	1116	0.0466081	1620	0.0159711	2124	0.0184301	2628	0.013783	3132	0.0162514
108	0.3075337	612	0.1646245	1116	0.0466081	1620	0.0159711	2124	0.0184301	2628	0.013783	3132	0.0162514
144	0.3020937	648	0.0503082	1152	0.0451418	1656	0.0140344	2160	0.0148124	2664	0.0494942	3168	0.0429236
144	0.3020937	648	0.0503082	1152	0.0451418	1656	0.0140344	2160	0.0148124	2664	0.0494942	3168	0.0429236
180	0.3202892	684	0.0304332	1188	0.0137396	1692	0.013141	2196	0.014816	2700	0.0480233	3204	0.0378738
180	0.3202892	684	0.0304332	1188	0.0137396	1692	0.013141	2196	0.014816	2700	0.0480233	3204	0.0378738
216	0.3365229	720	0.0147135	1224	0.0460003	1728	0.0464476	2232	0.015355	2736	0.0157551	3240	0.0137817
216	0.3365229	720	0.0147135	1224	0.0460003	1728	0.0464476	2232	0.015355	2736	0.0157551	3240	0.0137817
252	0.3324777	756	0.0162315	1260	0.0175595	1764	0.0238563	2268	0.0153451	2772	0.0427089	3276	0.0146886
252	0.3324777	756	0.0162315	1260	0.0175595	1764	0.0238563	2268	0.0153451	2772	0.0427089	3276	0.0146886
288	0.3961917	792	0.0134826	1296	0.0140341	1800	0.0250816	2304	0.0160523	2808	0.0144724	3312	0.0145289
288	0.3961917	792	0.0134826	1296	0.0140341	1800	0.0250816	2304	0.0160523	2808	0.0144724	3312	0.0145289
324	0.4255617	828	0.0137641	1332	0.014056	1836	0.0473682	2340	0.0142104	2844	0.0160042	3348	0.0167746
324	0.4255617	828	0.0137641	1332	0.014056	1836	0.0473682	2340	0.0142104	2844	0.0160042	3348	0.0167746
360	0.464351	864	0.0463628	1368	0.0119129	1872	0.0141432	2376	0.0148031	2880	0.0486029	3384	0.0145008
360	0.464351	864	0.0463628	1368	0.0119129	1872	0.0141432	2376	0.0148031	2880	0.0486029	3384	0.0145008
396	0.4576105	900	0.0148413	1404	0.0460049	1908	0.0166387	2412	0.0352169	2916	0.0158799	3420	0.0133535
396	0.4576105	900	0.0148413	1404	0.0460049	1908	0.0166387	2412	0.0352169	2916	0.0158799	3420	0.0133535
432	0.3242341	936	0.0150538	1440	0.0430863	1944	0.0144398	2448	0.0463415	2952	0.0447492	3456	0.0414875
432	0.3242341	936	0.0150538	1440	0.0430863	1944	0.0144398	2448	0.0463415	2952	0.0447492	3456	0.0414875

Table A-17. Results from 30 Hosts, Heavy Web, Seed 128

Results from 30 Hosts, Heavy Web, Seed 1024

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.0707192	504	0.1573707	1008	0.0155284	1512	0.0140825	2016	0.0393264	2520	0.0140076	3024	0.0138771
0	0.0707192	504	0.1573707	1008	0.0155284	1512	0.0140825	2016	0.0393264	2520	0.0140076	3024	0.0138771
36	0.1580615	540	0.0143689	1044	0.0139794	1548	0.0137637	2052	0.0128029	2556	0.0147184	3060	0.0505101
36	0.1580615	540	0.0143689	1044	0.0139794	1548	0.0137637	2052	0.0128029	2556	0.0147184	3060	0.0505101
72	0.2857582	576	0.0138284	1080	0.0123194	1584	0.0147093	2088	0.0149877	2592	0.0154681	3096	0.0132497
72	0.2857582	576	0.0138284	1080	0.0123194	1584	0.0147093	2088	0.0149877	2592	0.0154681	3096	0.0132497
108	0.3790392	612	0.0399743	1116	0.0156874	1620	0.0143584	2124	0.015048	2628	0.0412424	3132	0.0142474
108	0.3790392	612	0.0399743	1116	0.0156874	1620	0.0143584	2124	0.015048	2628	0.0412424	3132	0.0142474
144	0.5591668	648	0.0444512	1152	0.0157107	1656	0.0137564	2160	0.0464984	2664	0.0442316	3168	0.0147006
144	0.5591668	648	0.0444512	1152	0.0157107	1656	0.0137564	2160	0.0464984	2664	0.0442316	3168	0.0147006
180	0.6202194	684	0.0156421	1188	0.0151769	1692	0.0141883	2196	0.0467244	2700	0.0150027	3204	0.0153654
180	0.6202194	684	0.0156421	1188	0.0151769	1692	0.0141883	2196	0.0467244	2700	0.0150027	3204	0.0153654
216	0.6056804	720	0.013645	1224	0.0121939	1728	0.013754	2232	0.040793	2736	0.0139758	3240	0.0139399
216	0.6056804	720	0.013645	1224	0.0121939	1728	0.013754	2232	0.040793	2736	0.0139758	3240	0.0139399
252	0.532935	756	0.0443462	1260	0.0139136	1764	0.0137895	2268	0.0147682	2772	0.0152687	3276	0.0149486
252	0.532935	756	0.0443462	1260	0.0139136	1764	0.0137895	2268	0.0147682	2772	0.0152687	3276	0.0149486
288	0.5374122	792	0.0449575	1296	0.0142346	1800	0.045317	2304	0.0139963	2808	0.0148593	3312	0.0135384
288	0.5374122	792	0.0449575	1296	0.0142346	1800	0.045317	2304	0.0139963	2808	0.0148593	3312	0.0135384
324	0.5110545	828	0.0419596	1332	0.0143081	1836	0.0425358	2340	0.0146164	2844	0.0150831	3348	0.0432161
324	0.5110545	828	0.0419596	1332	0.0143081	1836	0.0425358	2340	0.0146164	2844	0.0150831	3348	0.0432161
360	0.3402703	864	0.0164539	1368	0.0125895	1872	0.0488804	2376	0.0152829	2880	0.0144539	3384	0.025798
360	0.3402703	864	0.0164539	1368	0.0125895	1872	0.0488804	2376	0.0152829	2880	0.0144539	3384	0.025798
396	0.2732922	900	0.0141543	1404	0.0139326	1908	0.0736898	2412	0.0486965	2916	0.0152283	3420	0.0152677
396	0.2732922	900	0.0141543	1404	0.0139326	1908	0.0736898	2412	0.0486965	2916	0.0152283	3420	0.0152677
432	0.1727844	936	0.0137149	1440	0.0140736	1944	0.1110094	2448	0.0144325	2952	0.0132132	3456	0.0128549
432	0.1727844	936	0.0137149	1440	0.0140736	1944	0.1110094	2448	0.0144325	2952	0.0132132	3456	0.0128549

Table A-18. Results from 30 Hosts, Heavy Web, Seed 1024

Results from 10 Hosts, Heavy Application Loads, Seed 64

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.001088	504	0.0138897	1044	0.0450934	1548	0.013496	2052	0.0153697	2556	0.0424212	3060	0.0189452
0	0.001088	504	0.0138897	1044	0.0450934	1548	0.013496	2052	0.0153697	2556	0.0424212	3060	0.0189452
36	0.0628897	540	0.0155337	1080	0.0458341	1584	0.0108563	2088	0.0470511	2592	0.0467203	3096	0.048009
36	0.0628897	540	0.0155337	1080	0.0458341	1584	0.0108563	2088	0.0470511	2592	0.0467203	3096	0.048009
72	0.1471447	576	0.0136322	1116	0.0159223	1620	0.0156598	2124	0.0148346	2628	0.0141971	3132	0.0123836
72	0.1471447	576	0.0136322	1116	0.0159223	1620	0.0156598	2124	0.0148346	2628	0.0141971	3132	0.0123836
108	0.1187749	612	0.0714425	1152	0.0454224	1656	0.0135739	2160	0.045904	2664	0.0167111	3168	0.0139793
108	0.1187749	612	0.0714425	1152	0.0454224	1656	0.0135739	2160	0.045904	2664	0.0167111	3168	0.0139793
144	0.0181885	648	0.0665987	1188	0.0444426	1692	0.0453928	2196	0.0111292	2700	0.0151831	3204	0.0139253
144	0.0181885	648	0.0665987	1188	0.0444426	1692	0.0453928	2196	0.0111292	2700	0.0151831	3204	0.0139253
180	0.0461571	684	0.0475579	1224	0.0324384	1728	0.0140821	2232	0.0804728	2736	0.0129329	3240	0.0138402
180	0.0461571	684	0.0475579	1224	0.0324384	1728	0.0140821	2232	0.0804728	2736	0.0129329	3240	0.0138402
216	0.0682672	720	0.013286	1260	0.047558	1764	0.0155223	2268	0.0468158	2772	0.0446589	3276	0.0134438
216	0.0682672	720	0.013286	1260	0.047558	1764	0.0155223	2268	0.0468158	2772	0.0446589	3276	0.0134438
252	0.1693647	792	0.0140975	1296	0.0154424	1800	0.0126324	2304	0.046914	2808	0.0438654	3312	0.0779195
252	0.1693647	792	0.0140975	1296	0.0154424	1800	0.0126324	2304	0.046914	2808	0.0438654	3312	0.0779195
288	0.1531234	828	0.0149687	1332	0.0146988	1836	0.0148048	2340	0.0457878	2844	0.046906	3348	0.0918329
288	0.1531234	828	0.0149687	1332	0.0146988	1836	0.0148048	2340	0.0457878	2844	0.046906	3348	0.0918329
324	0.0292245	864	0.0133565	1368	0.0149709	1872	0.0136973	2376	0.0129221	2880	0.0147074	3384	0.0621721
324	0.0292245	864	0.0133565	1368	0.0149709	1872	0.0136973	2376	0.0129221	2880	0.0147074	3384	0.0621721
360	0.0143699	900	0.0133271	1404	0.0471839	1908	0.0140035	2412	0.0134739	2916	0.0134008	3420	0.0158884
360	0.0143699	900	0.0133271	1404	0.0471839	1908	0.0140035	2412	0.0134739	2916	0.0134008	3420	0.0158884
396	0.046447	936	0.0135682	1440	0.0436008	1944	0.0132366	2448	0.015871	2952	0.0114376	3456	0.014382
396	0.046447	936	0.0135682	1440	0.0436008	1944	0.0132366	2448	0.015871	2952	0.0114376	3456	0.014382
432	0.0117449	972	0.0492273	1476	0.0119373	1980	0.0468209	2484	0.0472975	2988	0.0152882	3492	0.0168271
432	0.0117449	972	0.0492273	1476	0.0119373	1980	0.0468209	2484	0.0472975	2988	0.0152882	3492	0.0168271

Table A-19. Results from 10 Hosts, Heavy Loads, Seed 64

Results from 10 Hosts, Heavy Application Loads, Seed 128

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.0429825	504	0.0138565	1008	0.0112854	1512	0.013173	2016	0.0474134	2520	0.0459852	3024	0.0154801
0	0.0429825	504	0.0138565	1008	0.0112854	1512	0.013173	2016	0.0474134	2520	0.0459852	3024	0.0154801
36	0.0464174	540	0.0136366	1044	0.0134476	1548	0.0122431	2052	0.0470805	2556	0.0488721	3060	0.0132867
36	0.0464174	540	0.0136366	1044	0.0134476	1548	0.0122431	2052	0.0470805	2556	0.0488721	3060	0.0132867
72	0.0479245	576	0.01293	1080	0.0145473	1584	0.0127385	2088	0.0382424	2592	0.0116423	3096	0.0161227
72	0.0479245	576	0.01293	1080	0.0145473	1584	0.0127385	2088	0.0382424	2592	0.0116423	3096	0.0161227
108	0.1175685	612	0.0472576	1116	0.083442	1620	0.0251387	2124	0.0392386	2628	0.016016	3132	0.0107746
108	0.1175685	612	0.0472576	1116	0.083442	1620	0.0251387	2124	0.0392386	2628	0.016016	3132	0.0107746
144	0.1920732	648	0.0125957	1152	0.0495423	1656	0.0476253	2160	0.0484151	2664	0.026387	3168	0.0134378
144	0.1920732	648	0.0125957	1152	0.0495423	1656	0.0476253	2160	0.0484151	2664	0.026387	3168	0.0134378
180	0.1346291	684	0.0475521	1188	0.0417471	1692	0.0141542	2196	0.040927	2700	0.0463723	3204	0.0467494
180	0.1346291	684	0.0475521	1188	0.0417471	1692	0.0141542	2196	0.040927	2700	0.0463723	3204	0.0467494
216	0.1145621	720	0.0656319	1224	0.0121875	1728	0.0460254	2232	0.014818	2736	0.0483839	3240	0.0433437
216	0.1145621	720	0.0656319	1224	0.0121875	1728	0.0460254	2232	0.014818	2736	0.0483839	3240	0.0433437
252	0.1521188	756	0.0473893	1260	0.0137699	1764	0.0219595	2268	0.0145645	2772	0.0128039	3276	0.0151786
252	0.1521188	756	0.0473893	1260	0.0137699	1764	0.0219595	2268	0.0145645	2772	0.0128039	3276	0.0151786
288	0.1552606	792	0.0129002	1296	0.0453883	1800	0.013037	2304	0.0466802	2808	0.0639212	3312	0.0161017
288	0.1552606	792	0.0129002	1296	0.0453883	1800	0.013037	2304	0.0466802	2808	0.0639212	3312	0.0161017
324	0.1773086	828	0.0124294	1332	0.0425573	1836	0.0133652	2340	0.0140927	2844	0.0432596	3348	0.0132906
324	0.1773086	828	0.0124294	1332	0.0425573	1836	0.0133652	2340	0.0140927	2844	0.0432596	3348	0.0132906
360	0.1387634	864	0.0481412	1368	0.0443592	1872	0.0152843	2376	0.0131673	2880	0.0111196	3384	0.0444146
360	0.1387634	864	0.0481412	1368	0.0443592	1872	0.0152843	2376	0.0131673	2880	0.0111196	3384	0.0444146
396	0.0928695	900	0.0162092	1404	0.0472612	1908	0.0125782	2412	0.0154293	2916	0.0467517	3420	0.0538167
396	0.0928695	900	0.0162092	1404	0.0472612	1908	0.0125782	2412	0.0154293	2916	0.0467517	3420	0.0538167
432	0.014158	936	0.0458117	1440	0.0462384	1944	0.0458221	2448	0.0144317	2952	0.0141186	3456	0.0163525
432	0.014158	936	0.0458117	1440	0.0462384	1944	0.0458221	2448	0.0144317	2952	0.0141186	3456	0.0163525

Table A-20. Results from 10 Hosts, Heavy Loads, Seed 128

Results from 10 Hosts, Heavy Application Loads, Seed 1024

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.0472035	540	0.0457937	1044	0.035888	1548	0.0944092	2052	0.0148761	2556	0.0470586	3096	0.05317
0	0.0472035	540	0.0457937	1044	0.035888	1548	0.0944092	2052	0.0148761	2556	0.0470586	3096	0.05317
36	0.0465443	576	0.0120593	1080	0.0477149	1584	0.1372268	2088	0.0133585	2592	0.0144055	3132	0.1196275
36	0.0465443	576	0.0120593	1080	0.0477149	1584	0.1372268	2088	0.0133585	2592	0.0144055	3132	0.1196275
108	0.0770641	612	0.0118384	1116	0.0441994	1620	0.0821074	2124	0.0128188	2628	0.0152486	3168	0.1074242
108	0.0770641	612	0.0118384	1116	0.0441994	1620	0.0821074	2124	0.0128188	2628	0.0152486	3168	0.1074242
144	0.070435	648	0.043658	1152	0.0110628	1656	0.0476436	2160	0.0129319	2664	0.0148683	3204	0.016275
144	0.070435	648	0.043658	1152	0.0110628	1656	0.0476436	2160	0.0129319	2664	0.0148683	3204	0.016275
180	0.1055914	684	0.0472361	1188	0.0314596	1692	0.0474957	2196	0.0114873	2700	0.0155136	3240	0.0151951
180	0.1055914	684	0.0472361	1188	0.0314596	1692	0.0474957	2196	0.0114873	2700	0.0155136	3240	0.0151951
216	0.0836669	720	0.0486232	1224	0.0474093	1728	0.0138312	2232	0.0118074	2736	0.0137219	3276	0.0159195
216	0.0836669	720	0.0486232	1224	0.0474093	1728	0.0138312	2232	0.0118074	2736	0.0137219	3276	0.0159195
252	0.0783934	756	0.0168689	1260	0.0127938	1764	0.0462697	2268	0.0149367	2808	0.0455309	3312	0.0158769
252	0.0783934	756	0.0168689	1260	0.0127938	1764	0.0462697	2268	0.0149367	2808	0.0455309	3312	0.0158769
288	0.1393932	792	0.0152393	1296	0.0151533	1800	0.0462611	2304	0.0134177	2844	0.0799343	3348	0.0472364
288	0.1393932	792	0.0152393	1296	0.0151533	1800	0.0462611	2304	0.0134177	2844	0.0799343	3348	0.0472364
324	0.1199019	828	0.0128513	1332	0.0462912	1836	0.0453499	2340	0.1116018	2880	0.1164303	3384	0.0163506
324	0.1199019	828	0.0128513	1332	0.0462912	1836	0.0453499	2340	0.1116018	2880	0.1164303	3384	0.0163506
360	0.0128238	864	0.0137546	1368	0.0132928	1872	0.0112563	2376	0.124517	2916	0.0620636	3420	0.0117217
360	0.0128238	864	0.0137546	1368	0.0132928	1872	0.0112563	2376	0.124517	2916	0.0620636	3420	0.0117217
396	0.0134094	900	0.0136092	1404	0.0131947	1908	0.0130158	2412	0.048063	2952	0.0160701	3456	0.0101465
396	0.0134094	900	0.0136092	1404	0.0131947	1908	0.0130158	2412	0.048063	2952	0.0160701	3456	0.0101465
432	0.0197829	936	0.0479315	1440	0.0350426	1944	0.0145855	2448	0.0362556	2988	0.0102855	3492	0.0364118
432	0.0197829	936	0.0479315	1440	0.0350426	1944	0.0145855	2448	0.0362556	2988	0.0102855	3492	0.0364118
468	0.0440687	972	0.0118686	1476	0.0459226	1980	0.0122498	2484	0.012883	3024	0.0140194	3528	0.0475711
468	0.0440687	972	0.0118686	1476	0.0459226	1980	0.0122498	2484	0.012883	3024	0.0140194	3528	0.0475711

Table A-21. Results from 10 Hosts, Heavy Loads, Seed 1024

Results from 20 Hosts, Heavy Application Loads, Seed 64

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.001088	504	0.1640195	1008	0.0126648	1512	0.0144442	2016	0.0476216	2520	0.0792689	3024	0.0125019
0	0.001088	504	0.1640195	1008	0.0126648	1512	0.0144442	2016	0.0476216	2520	0.0792689	3024	0.0125019
36	0.0655253	540	0.1486086	1044	0.0150799	1548	0.0105586	2052	0.0301317	2556	0.0671879	3060	0.0145953
36	0.0655253	540	0.1486086	1044	0.0150799	·1548	0.0105586	2052	0.0301317	2556	0.0671879	3060	0.0145953
72	0.1979458	576	0.0139792	1080	0.0132914	1584	0.0171138	2088	0.0454102	2592	0.0471466	3096	0.0140603
72	0.1979458	576	0.0139792	1080	0.0132914	1584	0.0171138	2088	0.0454102	2592	0.0471466	3096	0.0140603
108	0.2729608	612	0.0152543	1116	0.0130124	1620	0.0474183	2124	0.0500194	2628	0.0415659	3132	0.0479576
108	0.2729608	612	0.0152543	1116	0.0130124	1620	0.0474183	2124	0.0500194	2628	0.0415659	3132	0.0479576
144	0.2917168	648	0.0709457	1152	0.0131321	1656	0.0453822	2160	0.1029249	2664	0.0134742	3168	0.0128963
144	0.2917168	648	0.0709457	1152	0.0131321	1656	0.0453822	2160	0.1029249	2664	0.0134742	3168	0.0128963
180	0.2916159	684	0.0706198	1188	0.0453531	1692	0.069927	2196	0.0700762	2700	0.0133726	3204	0.0144356
180	0.2916159	684	0.0706198	1188	0.0453531	1692	0.069927	2196	0.0700762	2700	0.0133726	3204	0.0144356
216	0.3399223	720	0.0844472	1224	0.0442735	1728	0.1286074	2232	0.0484539	2736	0.0110292	3240	0.0493921
216	0.3399223	720	0.0844472	1224	0.0442735	1728	0.1286074	2232	0.0484539	2736	0.0110292	3240	0.0493921
252	0.3438542	756	0.0469468	1260	0.0138005	1764	0.1042404	2268	0.0153094	2772	0.0128861	3276	0.0143852
252	0.3438542	756	0.0469468	1260	0.0138005	1764	0.1042404	2268	0.0153094	2772	0.0128861	3276	0.0143852
288	0.3561063	792	0.051895	1296	0.0389482	1800	0.0158848	2304	0.0942261	2808	0.0165419	3312	0.0406136
288	0.3561063	792	0.051895	1296	0.0389482	1800	0.0158848	2304	0.0942261	2808	0.0165419	3312	0.0406136
324	0.3529421	828	0.0468665	1332	0.0458051	1836	0.0123687	2340	0.0892196	2844	0.015879	3348	0.0463256
324	0.3529421	828	0.0468665	1332	0.0458051	1836	0.0123687	2340	0.0892196	2844	0.015879	3348	0.0463256
360	0.3232168	864	0.0139083	1368	0.0142827	1872	0.012346	2376	0.0472035	2880	0.0121555	3384	0.0151844
360	0.3232168	864	0.0139083	1368	0.0142827	1872	0.012346	2376	0.0472035	2880	0.0121555	3384	0.0151844
396	0.2811134	900	0.0464548	1404	0.0466512	1908	0.012267	2412	0.0146	2916	0.0131758	3420	0.0162633
396	0.2811134	900	0.0464548	1404	0.0466512	1908	0.012267	2412	0.0146	2916	0.0131758	3420	0.0162633
432	0.2300576	936	0.0463938	1440	0.0485649	1944	0.0382139	2448	0.0478103	2952	0.0138482	3456	0.1188123
432	0.2300576	936	0.0463938	1440	0.0485649	1944	0.0382139	2448	0.0478103	2952	0.0138482	3456	0.1188123

Table A-22. Results from 20 Hosts, Heavy Loads, Seed 64

Results from 20 Hosts, Heavy Application Loads, Seed 128

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.001088	504	0.4058968	1008	0.0145379	1512	0.0480578	2016	0.0454683	2520	0.0116866	3024	0.0469671
0	0.001088	504	0.4058968	1008	0.0145379	1512	0.0480578	2016	0.0454683	2520	0.0116866	3024	0.0469671
36	0.0888399	540	0.2664867	1044	0.0139207	1548	0.0663745	2052	0.0153769	2556	0.0700052	3060	0.0150479
36	0.0888399	540	0.2664867	1044	0.0139207	1548	0.0663745	2052	0.0153769	2556	0.0700052	3060	0.0150479
72	0.117366	576	0.1629103	1080	0.0472896	1584	0.0753137	2088	0.0598048	2592	0.1118771	3096	0.0461293
72	0.117366	576	0.1629103	1080	0.0472896	1584	0.0753137	2088	0.0598048	2592	0.1118771	3096	0.0461293
108	0.1266538	612	0.0933922	1116	0.0151785	1620	0.04477	2124	0.0571753	2628	0.0884039	3132	0.0443801
108	0.1266538	612	0.0933922	1116	0.0151785	1620	0.04477	2124	0.0571753	2628	0.0884039	3132	0.0443801
144	0.2953092	648	0.0275202	1152	0.0468282	1656	0.0476553	2160	0.0414068	2664	0.0136032	3168	0.0138464
144	0.2953092	648	0.0275202	1152	0.0468282	1656	0.0476553	2160	0.0414068	2664	0.0136032	3168	0.0138464
180	0.4530474	684	0.041352	1188	0.1240674	1692	0.013187	2196	0.0471644	2700	0.0127496	3204	0.046699
180	0.4530474	684	0.041352	1188	0.1240674	1692	0.013187	2196	0.0471644	2700	0.0127496	3204	0.046699
216	0.4367389	720	0.0441632	1224	0.0707194	1728	0.042213	2232	0.0670981	2736	0.0146827	3240	0.0268372
216	0.4367389	720	0.0441632	1224	0.0707194	1728	0.042213	2232	0.0670981	2736	0.0146827	3240	0.0268372
252	0.4647927	756	0.0145329	1260	0.0293078	1764	0.0517787	2268	0.0586334	2772	0.0149091	3276	0.0885173
252	0.4647927	756	0.0145329	1260	0.0293078	1764	0.0517787	2268	0.0586334	2772	0.0149091	3276	0.0885173
288	0.5408234	792	0.0163018	1296	0.0145516	1800	0.1302167	2304	0.0182386	2808	0.0733807	3312	0.0429796
288	0.5408234	792	0.0163018	1296	0.0145516	1800	0.1302167	2304	0.0182386	2808	0.0733807	3312	0.0429796
324	0.6001555	828	0.0126566	1332	0.0461765	1836	0.1477758	2340	0.0481579	2844	0.0787214	3348	0.045265
324	0.6001555	828	0.0126566	1332	0.0461765	1836	0.1477758	2340	0.0481579	2844	0.0787214	3348	0.045265
360	0.5871679	864	0.0145647	1368	0.0459644	1872	0.0921729	2376	0.0573518	2880	0.0135511	3384	0.0593572
360	0.5871679	864	0.0145647	1368	0.0459644	1872	0.0921729	2376	0.0573518	2880	0.0135511	3384	0.0593572
396	0.5821793	900	0.0476369	1404	0.013879	1908	0.0136837	2412	0.0470662	2916	0.0449051	3420	0.0649045
396	0.5821793	900	0.0476369	1404	0.013879	1908	0.0136837	2412	0.0470662	2916	0.0449051	3420	0.0649045
432	0.4802391	936	0.0129427	1440	0.0502581	1944	0.0443028	2448	0.01196	2952	0.0440235	3456	0.013352
432	0.4802391	936	0.0129427	1440	0.0502581	1944	0.0443028	2448	0.01196	2952	0.0440235	3456	0.013352
468	0.4305505	972	0.0121188	1476	0.0465612	1980	0.0546392	2484	0.0135374	2988	0.046412	3492	0.086008

Table A-23. Results from 20 Hosts, Heavy Loads, Seed 128

Results from 20 Hosts, Heavy Application Loads, Seed 1024

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.0441729	504	0.1924844	1008	0.0660115	1512	0.0446597	2016	0.0645214	2520	0.0445004	3024	0.1038754
0	0.0441729	504	0.1924844	1008	0.0660115	1512	0.0446597	2016	0.0645214	2520	0.0445004	3024	0.1038754
36	0.0672316	540	0.1771163	1044	0.0790195	1548	0.0494391	2052	0.0682373	2556	0.0479992	3060	0.0462041
36	0.0672316	540	0.1771163	1044	0.0790195	1548	0.0494391	2052	0.0682373	2556	0.0479992	3060	0.0462041
72	0.2168046	576	0.0755916	1080	0.0614715	1584	0.016655	2088	0.0472417	2592	0.0486893	3096	0.0475952
72	0.2168046	576	0.0755916	1080	0.0614715	1584	0.016655	2088	0.0472417	2592	0.0486893	3096	0.0475952
108	0.3164521	612	0.0488444	1116	0.0867001	1620	0.0453893	2124	0.0479698	2628	0.0451641	3132	0.0130668
108	0.3164521	612	0.0488444	1116	0.0867001	1620	0.0453893	2124	0.0479698	2628	0.0451641	3132	0.0130668
144	0.4618235	648	0.0485221	1152	0.1060329	1656	0.046661	2160	0.0160915	2664	0.0138418	3168	0.0457683
144	0.4618235	648	0.0485221	1152	0.1060329	1656	0.046661	2160	0.0160915	2664	0.0138418	3168	0.0457683
180	0.5185408	684	0.0364819	1188	0.1022991	1692	0.0465052	2196	0.0124899	2700	0.0134282	3204	0.0133514
180	0.5185408	684	0.0364819	1188	0.1022991	1692	0.0465052	2196	0.0124899	2700	0.0134282	3204	0.0133514
216	0.5085681	720	0.0483271	1224	0.0511276	1728	0.0131556	2232	0.0128351	2736	0.0122833	3240	0.0144034
216	0.5085681	720	0.0483271	1224	0.0511276	1728	0.0131556	2232	0.0128351	2736	0.0122833	3240	0.0144034
252	0.5308224	756	0.0449831	1260	0.0137796	1764	0.0126056	2268	0.0148977	2772	0.0479263	3276	0.0159818
252	0.5308224	756	0.0449831	1260	0.0137796	1764	0.0126056	2268	0.0148977	2772	0.0479263	3276	0.0159818
288	0.5253559	792	0.0493667	1296	0.0462719	1800	0.0187332	2304	0.0656726	2808	0.0469225	3312	0.0145896
288	0.5253559	792	0.0493667	1296	0.0462719	1800	0.0187332	2304	0.0656726	2808	0.0469225	3312	0.0145896
324	0.5164811	828	0.0157065	1332	0.0468464	1836	0.0136369	2340	0.0531725	2844	0.043157	3348	0.0148453
324	0.5164811	828	0.0157065	1332	0.0468464	1836	0.0136369	2340	0.0531725	2844	0.043157	3348	0.0148453
360	0.4727644	864	0.0144923	1368	0.0349311	1872	0.0386818	2376	0.0473011	2880	0.047154	3384	0.0126193
360	0.4727644	864	0.0144923	1368	0.0349311	1872	0.0386818	2376	0.0473011	2880	0.047154	3384	0.0126193
396	0.3678807	900	0.0467638	1404	0.0129814	1908	0.0448023	2412	0.0454772	2916	0.0146971	3420	0.0132423
396	0.3678807	900	0.0467638	1404	0.0129814	1908	0.0448023	2412	0.0454772	2916	0.0146971	3420	0.0132423
432	0.2988065	936	0.015158	1440	0.0849275	1944	0.012875	2448	0.0469345	2952	0.0507631	3456	0.0134438
432	0.2988065	936	0.015158	1440	0.0849275	1944	0.012875	2448	0.0469345	2952	0.0507631	3456	0.0134438
468	0.2500117	972	0.0134836	1476	0.0716057	1980	0.0866633	2484	0.0467045	2988	0.0988068	3492	0.0147259

Table A-24. Results from 20 Hosts, Heavy Loads, Seed 1024

Results from 30 Hosts, Heavy Application Loads, Seed 64

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.0211934	504	0.8896089	1008	0.3510942
0	0.0211934	504	0.8896089	1008	0.3510942
36	0.1074476	540	0.9084398	1044	0.3534921
36	0.1074476	540	0.9084398	1044	0.3534921
72	0.2387885	576	0.8866328	1080	0.2915073
72	0.2387885	576	0.8866328	1080	0.2915073
108	0.3127575	612	0.8637647	1116	0.2854892
108	0.3127575	612	0.8637647	1116	0.2854892
144	0.3857014	648	0.7765579	1152	0.1993977
144	0.3857014	648	0.7765579	1152	0.1993977
180	0.4400805	684	0.6524245	1188	0.1992497
180	0.4400805	684	0.6524245	1188	0.1992497
216	0.6081129	720	0.5060237		
216	0.6081129	720	0.5060237		
252	0.6591514	756	0.2381315		
252	0.6591514	756	0.2381315		
288	0.7443224	792	0.20898		
288	0.7443224	792	0.20898		
324	0.8767833	828	0.212961		
324	0.8767833	828	0.212961		
360	0.9702456	864	0.2443335		
360	0.9702456	864	0.2443335		
396	1.0115749	900	0.2210013		
396	1.0115749	900	0.2210013		
432	0.9981666	936	0.2744255		
432	0.9981666	936	0.2744255		

Table A-25. Results from 30 Hosts, Heavy Loads, Seed 64

Results from 30 Hosts, Heavy Application Loads, Seed 128

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.001088	504	0.6239585	1008	0.2471079
0	0.001088	504	0.6239585	1008	0.2471079
36	0.1607322	540	0.5701482	1044	0.244457
36	0.1607322	540	0.5701482	1044	0.244457
72	0.2488195	576	0.4604299	1080	0.2269823
72	0.2488195	576	0.4604299	1080	0.2269823
108	0.3116622	612	0.2763838	1116	0.1693531
108	0.3116622	612	0.2763838	1116	0.1693531
144	0.4031782	648	0.2408484	1152	0.1636254
144	0.4031782	648	0.2408484	1152	0.1636254
180	0.4481101	684	0.2118623	1188	0.168824
180	0.4481101	684	0.2118623	1188	0.168824
216	0.4257901	720	0.2082434		
216	0.4257901	720	0.2082434		
252	0.5161765	756	0.1805658		
252	0.5161765	756	0.1805658		
288	0.6546294	792	0.1724967		
288	0.6546294	792	0.1724967		
324	0.7139752	828	0.2337369		
324	0.7139752	828	0.2337369		
360	0.7218058	864	0.2434542		
360	0.7218058	864	0.2434542		
396	0.7008185	900	0.2478348		
396	0.7008185	900	0.2478348		
432	0.6769626	936	0.2122493		
432	0.6769626	936	0.2122493		

Table A-26. Results from 30 Hosts, Heavy Loads, Seed 128

Results from 30 Hosts, Heavy Application Loads, Seed 1024

Time (sec)	Delay (sec)	Time (sec)	Delay (sec)	Time (sec)	Delay (sec)
0	0.0791965	504	0.32928	1008	0.172009
0	0.0791965	504	0.32928	1008	0.172009
36	0.1835665	540	0.3082717	1044	0.1705658
36	0.1835665	540	0.3082717	1044	0.1705658
72	0.2954557	576	0.3171612	1080	0.2055388
72	0.2954557	576	0.3171612	1080	0.2055388
108	0.4136896	612	0.3169084	1116	0.2033179
108	0.4136896	612	0.3169084	1116	0.2033179
144	0.5637197	648	0.3194093	1152	0.2298925
144	0.5637197	648	0.3194093	1152	0.2298925
180	0.629904	684	0.3161155		
180	0.629904	684	0.3161155		
216	0.6913806	720	0.2986862		
216	0.6913806	720	0.2986862		
252	0.6889622	756	0.2925985		
252	0.6889622	756	0.2925985		
288	0.7348878	792	0.3094749		
288	0.7348878	792	0.3094749		
324	0.7360039	828	0.2266834		
324	0.7360039	828	0.2266834		
360	0.6842808	864	0.2379442		
360	0.6842808	864	0.2379442		
396	0.5914214	900	0.2149434		
396	0.5914214	900	0.2149434		
432	0.4915079	936	0.2087102		
432	0.4915079	936	0.2087102		

Table A-27. Results from 30 Hosts, Heavy Loads, Seed 1024