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Puredata Systems for Analytics: Concurrency and Workload Management

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by

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Abstract

PureData^{TM} System for Analytics also called as Netezza is a data warehouse server handling analytic operations capable of providing throughput 1000 times greater and faster than traditional database servers. Impressively, it requires minimal system tuning thereby providing high-end performance as well as requiring a low total cost of ownership (TCO). Database performance is directly linked to the allocation of system resources on a database management system. The heart of the Netezza appliance, Field-Programmable Gate Array (FPGA) plays a key role in boosting the overall performance of a server. I/O operations are always a bottleneck in any database server and it is the FPGA that eradicates the I/O problem in Netezza by filtering the data across each snippet processing unit (SPU), processing and running the queries faster thereby pumping server’s performance greatly.

This paper describes the current problems the companies face in a “big data” environment which includes concurrency handling and query performance. There are various factors which affect a query's performance, which includes bad data distribution, stale statistics, server load and uneven system resources. Since this paper is restricted to only the system resources, an in-depth analysis of system resources and its components will be analyzed in this research. A database server’s performance is directly related to its underlying allocation of system resources. Work Load Management (WLM) and each of its features are described in this paper which gives the reader a clear notion of how a query's performance is altered using various mechanisms. The paper describes the current performance problems that exist on the traditional database servers and how the Work Load Management components can be tweaked along with the predefined system configurations to process a query to run faster on a Netezza machine.

Acknowledgement

Though the following paper is an individual work, I could have never reached the heights without the support, efforts and guidance of certain people.

First and foremost, I would like to thank my advisor and mentor Dr. Jim Q Chen for providing me endless guidance throughout the project tenure.

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List of Acronyms

BI	Business Intelligence
DBA	Database Administrator
DBMS	Database Management System
FPGA	Field Programmable Gate Arrays
GRA	Guaranteed Resource Allocation
NPS	Netezza performance Server
OLTP	Online Transaction Processing
PQE	Priority Query Execution
SLA	Service Level Agreement
SPA	Snippet Processing Array
SPU	Snippet Processing Unit
SQB	Short Query Bias
SQL	Structured Query Language
WLM	Workload Management

Chapter I

INTRODUCTION

Overview

The challenge for any data warehouse environment is to access and process large volumes of data in a very short span of time. Apart from leveraging hardware components there is always a need to tweak the system resources in order to have the database groups and users achieve the edge to gain more performance. There are a few traditional databases which provide good support in handling large amount of data. But the question is how much volume can these databases accommodate and how well does the query optimization and execution is carried out. Healthcare and banking industries often come across hassle situations where in the database freezes or corrupts because of the large volumes of data being processed at the same time. Database Administrators are required to work round the clock to tune system configurations and resources. In order to address these issues, Netezza was developed in the year 1999 by Foster Hinshaw and Jit Saxena. International Business Machines Corporation (IBM) acquired the product in the year 2010 for $1.7 billion (IBM, 2010a).Netezza is now a part of IBM's PureDataSystems^{TM} family (IBM, 2010b). Netezza is also known as PureData^{TM} System for Analytics. Netezza provides faster response to business users compared to the current traditional databases in the market. With simple deployment, no additional tuning, minimal maintenance and creative optimization technique, Netezza stands out among other competitors. Netezza supports Hadoop, Java, C++, Python and MapReduce programming models. Netezza's customer base is widely spread across the globe which is estimated to be about 500+ clients. It is estimated that Netezza provides 10-100 times greater throughput compared to Oracle with minimal amount of tuning required when compared to Oracle.

Improper utilization of system resources can lead to significant problems. It is always a challenging task for a database administrator to allocate and adjust the numerous system resources to a job or a user group with a strong justification. In this paper, the features of workload management are reviewed along with the various methods to address the performance issues by implementing more than one workload features in parallel.

Problem Statement

With the growing size of users and data there is always a need to address and adjust the resource management of a database server. Companies are thriving to achieve a better performance each day with minimal amount of tweaking and monitoring. Inefficient workload management is the biggest concern the conventional databases servers face today. Database Administrators are required to put in extra efforts due to the change in system catalogs and database size. Performance of a database server is directly related to the allocation of system resources. The better the resources are allocated the better the database server performs yielding faster run time of a query. Netezza comes with a handful amount of enriched workload management features which provides throughput incredibly faster than current conventional DBMS. One needs to know the right combination of implementing the workload features. This is based on several factors ranging from application teams, data volume, number of users and resource groups, performance factors etc.

Nature and Significance of the Problem

Inadequate planning of utilization and allocation of system resources leads to a disaster in a database server. Queries submitted to the server are of various sizes and complexity. With no workload management configured each query obtains same share of system resources, termed as 'fair-sharing model' (IBM, n.d.b). System resources are divided equally based on the number of active jobs running given that each job has equal priority. However, the drawback in having such a model arises when there is no predefined feature to set priorities. With no priorities set each query gets the same share of resources. This can cause a huge drawback to any data warehouse environment when you have analytic operations running concurrently along with the user submitted jobs. Higher priority queries should grasp an extra edge in performance and system resources. Conventional database system fails to produce that extra edge in performance due to the lack of workload management features and an inadequate variety of system configurations. This can cause a delay in missing business SLA's. This is a huge loss in terms of time and money for a company, where additional efforts are required to put in to achieve a performance gain.

Objective of Paper

The objective is to lay out the role of Netezza's workload management features along with the predefined system configurations it comes with. In this paper, a brief explanation is provided on how the performance of a query can be improvised by tweaking and mixing the system configurations along with the work load management parameters to make a complex query run faster.

Study Questions

Upon completion of this paper, the following questions can be answered and explained on how the workload management feature can leverage the performance of a query.

1. How can the workload management feature enhance the Netezza system to handle concurrent queries of various complexities without hassle?
2. The tools and bash scripts required to configure the workload management and how the predefined system configurations can be tweaked on the lines of workload management to achieve improvised performance?
3. On what basis the workload management features needs to be assigned and allocated to? How the workload management is configured based upon the role of a database user or a database group?

Limitations of the Study

This paper is limited to only the design and study of workload management features along with server performance, though a brief explanation will be covered on data design and maintenance. The project results and conclusions cannot be generalized to all kinds of data warehouse environments since the factors and attributes vary for different companies.

Summary

Companies are thriving to adapt and set up “big data” environment but fail to reach the end users expectation. This could be either due to bad data architectural planning or bad configurations on their database servers. Inadequate features and lack of predefined system configurations are the biggest drawbacks in the current conventional DBMS models. The following chapter explains the problems and drawbacks of the current conventional database servers.

Chapter II

BACKGROUND AND REVIEW OF LITERATURE

Introduction

Database servers are expected to meet the needs of the business, market and end users by providing tremendous performance. Since, companies are moving towards “big data” technology to support larger audience there is always a need to have a performance enriched data warehouse server running behind to accommodate the needs of end clients. A traditional database server is capable of handling gigabytes of data, providing a minimal amount of performance. This is due to the restricted amount of predefined configurations and parameters the servers are equipped with. A traditional database server cannot match up the performance of a data warehouse server running on a massively parallel asymmetrical engine.

Background

A data warehouse environment needs to be configured with high end hardware components and high performance software programs to make it run faster and also capable of handling large volumes of data with no repeated problems. Netezza is capable of handling concurrent queries of various complexities. Current traditional database servers lack the ability to handle large number of concurrent queries at any given time, resulting in a server crash, loss in time, value and money. Businesses today are shifting more and more towards data warehouses providing multiple parallel processing (MPP) architecture because of the multiple jobs being run on the data warehouse appliance concurrently.

Current traditional database servers lack the ability to produce potential performance. Inefficient and limited workload management features and lack of system configuration parameters are the biggest reasons. With no workload management enabled, and having concurrent queries running, there is always a possibility of network congestion resulting in loss of time. This is a very big drawback and loss to any company wherein activities and jobs are run round the clock against a data warehouse system. Netezza, unlike other conventional database servers provides 10-100 times faster query response by providing 5 level workload management, which includes the gate keeper, the guaranteed resource allocation, the snippet scheduler, scheduling rules and the resource allocation scheduler. In addition, there are other features and configurations – priority query execution, and short query bias, which IBM provides to enhance the workload management of a Netezza server much more effectively.

Literature Review

Most researchers have considered dealing performance issues through resource tweaking which involves tuning the memory and swab space on a disk or a storage unit. Performance issues were dealt manually rather relying on the workload management policies. Benoit (2000) proposed a model which illustrates how the performance of a database system can be impacted by tuning the available resources. Tweaking system resources based on the business needs and priorities can largely impact the SLA’s. The model also states the interdependency relationship among various resources in a database system. The aim of demonstrating such a model is to enhance the overall functionality and performance of a database system by tweaking the system configurations and resource parameters.

Various attributes contribute to the overall performance of a database system which includes both software and hardware. A database administrator is responsible to track the performance of a system by tuning system configurations and resource parameters at various levels. Weikum, Hasse, M¨onkeberg, and Zabback (1994) described the factors which contribute to the performance of a system and how they can be measured. The research paper describes tweaking the parameters at various levels of a database system including system configurations, workload management policies, resource parameters adjustments, database level configurations, application configurations and operational parameters.

Concurrent queries on any database system are limited in number. It is critical to hardcode the number of concurrent sessions that can run on a database system in order to avoid congestion, thereby, affecting performance and throughput. Since each concurrent query shares the available amount of resources while running, it is always important to set priorities to a query wherein the higher priority query is allocated more resources than the other active queries. Schroeder, Harchol-Balter, Iyengar, and Nahum (2006) built a model which states each SLA designed for a business requires having a query response time criteria to be specified. For a large data warehouse environment, there is large number of users connected at any given time running concurrent queries of various complexities. With no dynamic allocation and continuous tweaking, performance can be impacted slowing the query runtime eventually affecting the business. To achieve performance and throughput, Schroeder et al. (2006) stated that a feedback control loop is designed to dynamically tweak the number of active concurrent sessions by re-allocating the available system resources and re-assigning the priorities.

The problem with such theories and research is that only the resource management is considered as a factor for performance. There are other factors which need to be considered such as killing bad queries which abuses databases and system resources. Such queries need to be addressed and re-written. Apart from this, the above works are restricted only up to OLTP. We do need to consider SAS and BI if we are illustrating the same research from a data warehouse environment point of view.

Literature Review Related to Methodology

Databases servers have come along a long way over the years due to the increase in the volume of data, concurrent users, business needs, business urgencies, and real time analytics. In order to meet the success requirements, new workload features have been implemented and the existing ones were carved repeatedly to make the database servers perform more efficiently. Workload is the concept of running the daily scheduled jobs such as SQL queries, data loads, and maintenance jobs along with a few system triggered action jobs. Assessing a workload is called workload management. In the below sections, a brief explanation is covered about the workload management aspects on traditional DBMS followed by workload management and resource management on a netezza appliance, illustrating each workload management feature. The last section summarizes the entire scenario of workload management and how it has evolved over the years and the best practices to implement it.

PureData System for Analytics: Design

Data loaded into a netezza machine is run through multiple snippets before finally settling on the storage disks. Data stored in a netezza machine is of compressed format. Resultant data retrieved from tables on a regular basis are usually stored in a cache memory using a smart algorithm. This is to boost the performance of the netezza machine by returning results directly from the cache memory instead of requiring disk storage access. Field Programmable Gate Arrays (FPGAs) are known as the core components of a netezza machine. Netezza is designed on the lines of Asymmetric Massively Parallel Processing™ (AMPP™) architecture consisting of multi-core CPUs. These CPUs combined with FPGA Accelerated Stream Technology (FAST^{TM}) boosts the system to run 10-1000 times faster than the traditional DBMS machines. FAST engines' running in parallel uncompresses and filters the data which is irrelevant to the query. The relevant data is served through the multiple CPU cores which run in parallel.

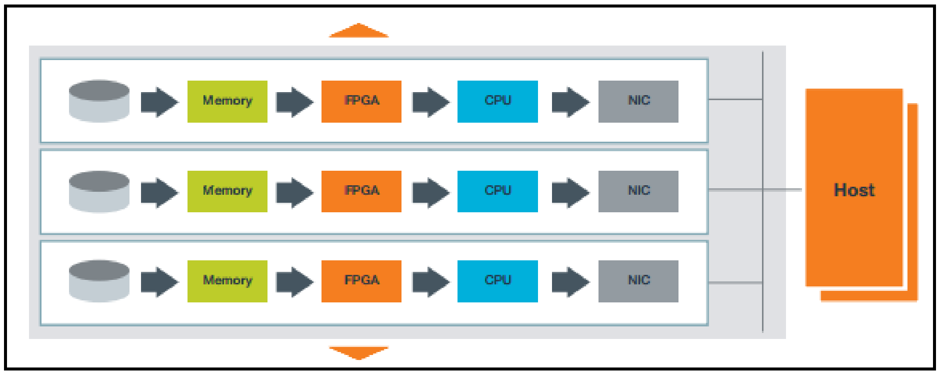


Figure 1. IBM's Massively Parallel Processing Architecture (IBM, n.d.a)

FPGA is considered as the heart of the netezza system due to its ability to produce tremendous performance. FPGA acts as an auxiliary CPU to a netezza system. Similarly, there are multiple FPGA engines which process data at a very high speed thereby providing throughput incredibly faster. FPGAs can be (re)configured dynamically. Each FPGA engine performs filter and transformation mechanisms which assist in performance boost. FPGA engine consists of three components–Direct Memory Access (DMA), Compress Engine (CRC check), and filter and transformation functions.

Filter and Transformation Functions. The filter and transformation functions compromise of the following components.

- Compress Engine: Responsible in compressing and decompressing the data during processing to and fro disks. Due to this, the performance of a netezza system is boosted further by four to eight times the average performance.
- Filter Function—Project and Restrict Engine: Filters out irrelevant data based on the “select” and “where” clauses in an executed query.
- Visibility Engine: Plays a key role in maintaining ACID properties at faster speeds. Filters out the irrelevant data. Data relevant to the query is only visible.

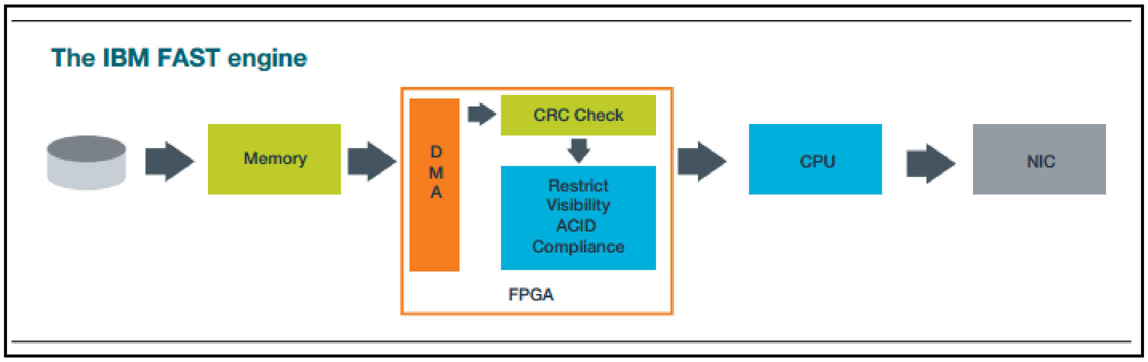


Figure 2. Netezza Software Components (IBM, n.d.a)

Software components of a Netezza system include:

- Multiple optimizers running in parallel to ensure queries are running efficiently and that each node is fully occupied with a task.
- A smart scheduler which is capable of providing maximum throughput irrespective of how busy the system is.
- Snippet processors which are responsible to analyze and run queries.
- A network channel to move the data across the appliance at streaming speeds.

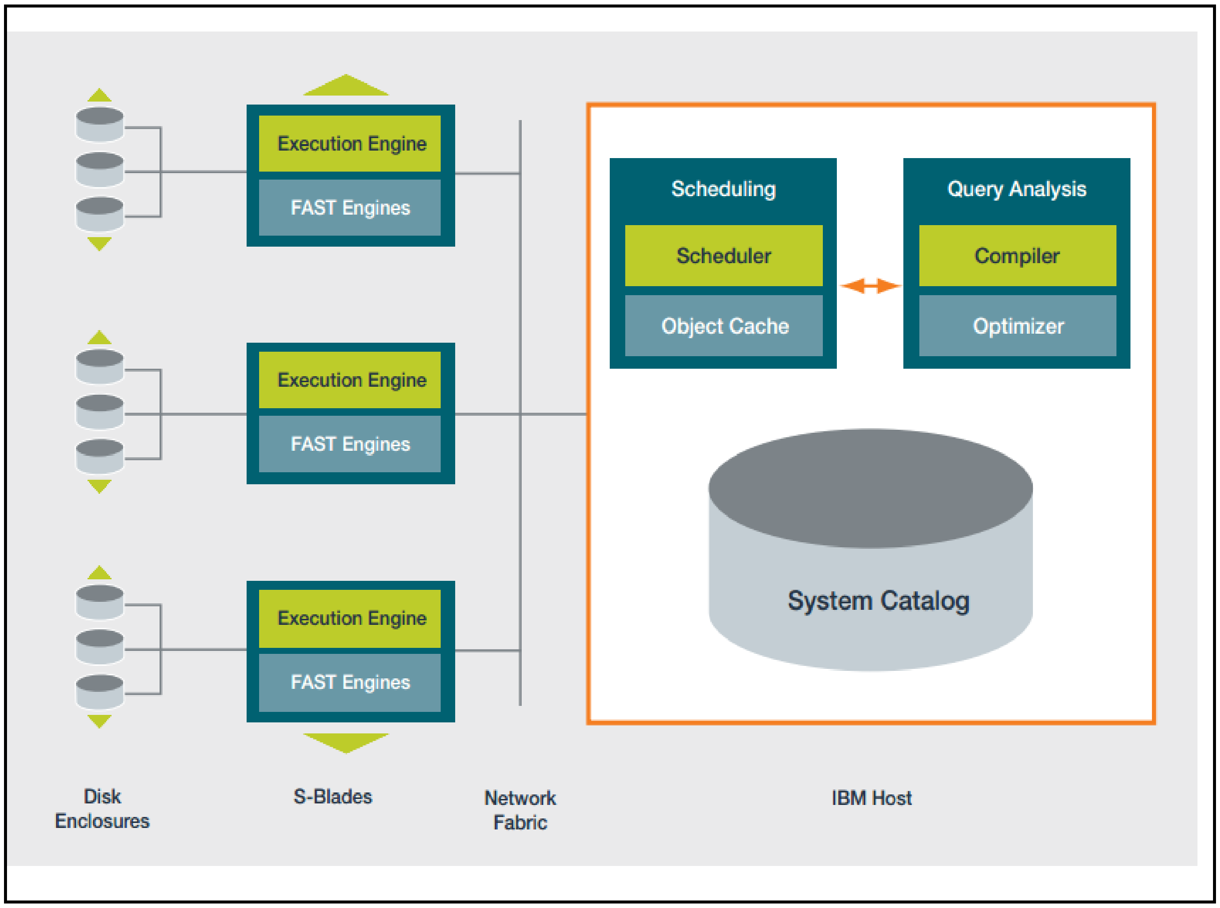


Figure 3. Software Architecture (IBM, n.d.a)

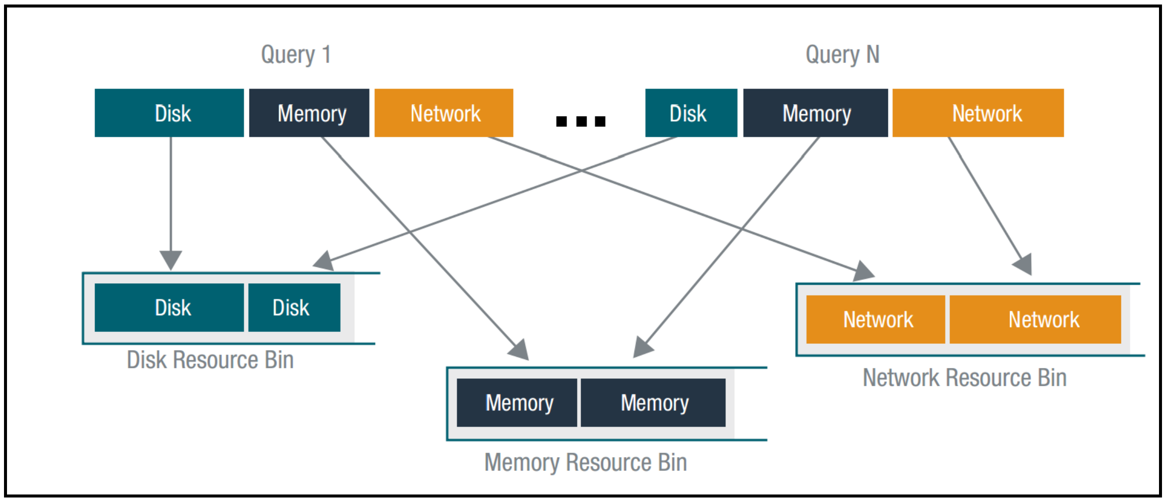


Figure 4. Concurrent Query Resource Allocation (IBM, n.d.a)

PureData System for Analytics: Workload Management

In a data warehouse environment where there are concurrent jobs running round the clock, there is always a need to have smart configured workload settings which is capable of providing real time analytics with no hindrance to user jobs. In implementing the workload management on a DBMS server, e.g., Oracle Database Resource Manager, Microsoft SQL Server Resource and Query Governor, IBM DB2 Workload Manager, Teradata Active System Management, there are certain key factors one needs to consider.

- Performance criteria based on business requirements.
- Segregate and identify user initiated jobs.
- Implications of workload management over queries.

Performance criteria and business compliance. Jobs submitted to a Netezza system are assigned with a minimum amount of system resource along with other attributes pertaining to performance and business needs. There is a wide range of queries submitted to a database server ranging from user initiated jobs, application initiated jobs, business priority jobs, and system initiated jobs. The performance of each query is generated based on the implications of workload features it needs to run through along with the priorities set by the business. Based on the SLA's set by the business and end-clients, the workload needs to be tweaked to adjust the runtime of a query. Performance of a query can be asserted through the following metrics: (a) query runtime, (b) throughput, and (c) query runtime velocity.

Runtime of a query is the elapsed time duration from query submission to query completion. Throughput is defined as the number of requests completed in a defined unit of time. Query Runtime Velocity is defined as the execution speed of the query irrespective of server status (idle or busy). This is calculated as a ratio of average query runtime to the actual time the query ran in the system. Based on the result outcome, the delay factor can be calculated for a respective query. If the ratio is closer to 0, it indicates a drastic delay in performance. Various factors contribute to a delay in performance levels–high priority queries running concurrently, bad workload management, disk storage space issues, poor memory allocation design etc.

Based on the priorities set by the business, higher priority queries generating business revenue are allocated with large amount of memory resources. These queries take precedence over the rest of the queries running concurrently in the system. Queries submitted to the system are allocated with the available system memory resources and a priority factor based on the importance it has for the business. The workload parameters and system configurations defined on a database server contribute towards the performance of each query submitted to the system. These parameters control the behavior of a query from the point it gets submitted to the system until the result execution time. Workload rules defines the amount of available resources a query needs to be allocated when it is submitted on a system along with the priority of a query.

Each query or job submitted to a system is defined as work and a group of such is termed as workload. Performance of a query or a workload is usually calculated in terms of percentiles or ratios. In simple terms, it is defined as the x% percent of queries in a workload running in y units of time. Queries submitted by the business are usually of high priority and are expected to attain a higher value of x% with respect to smaller y value in time metrics. Apart, other non-business/non-critical queries are usually not set with any performance policies since they do not implicate any business needs. Hence, they do not need to be tagged with a higher priority.

Furthermore, scheduling rules comes into place to set restriction on the allocation of memory resources for non-critical queries or workloads (Chen et al., 2008).

Identify and segregate user initiated jobs. Jobs submitted to a system needs to be identified and segregated based on the nature of the query as well as its impact on business or end-user. Queries with higher priority needs to be addressed at first place since they are the one generating revenues for business. Any factors causing hindrance to such high priority queries can cause a huge negative impact on business. Workload rules are configured to identify the jobs submitted to the system. Based on the query attributes workload management policies kicks in (Chen et al., 2008). Various attributes of a query contributing towards the priority assignment depends on the user who submitted the query, group name the user belongs to, against which database and objects the query is running against, rowset return, and impact on business. Any query submitted to the system will need to be identified and assigned a priority based on the business needs and SLA's set by the business. Queries prioritized based on business needs are supposed to be run at schedule times and in a stipulated amount of time. Non-critical queries are supposed to be run during the times the system is idle or little busy.

Queries submitted to the system are supposed to be grouped into workloads based on priority levels and attributes of a query. This gives a clear picture with the amount of system resources an entire workload is running on a system, thereby providing visibility (Chen et al., 2008; Microsoft Corp., 2015). Using user-defined rules and policies, similar queries can be grouped together to run under a single workload. Query commencement and query type contributes towards the key factors in deciding if they come under a single workload. This depends on who is initiating and running the query such as user name, application name, application type, and session ID. Apart, it also depends on the query characteristics. Query characteristics include the type of SQL query a user is running, estimated costs, skew factor.

Implications of workload management over queries. A query submitted to a database system undergoes through the workload policies before the execution phase begins. A query submitted to the system is allocated system memory out of the available resources followed by a priority level (low, medium, high, critical) tagged to it. Workload management involves three different types of controls – admission control, scheduling control, and execution control (Krompass, Kuno, Dayal, & Kemper, n.d.; Krompass et al., 2008). Each of the workload controls have system configurations pertained to it. These system configurations can be modified based on the business needs and criteria.

Admission control acts as a gatekeeper to a database system which determines if a submitted query needs to be passed on to next phase or not. This is to avoid the network and database congestion. A query submitted to a database system undergoes through the workload management policies before moving into the execution phase. Optimizer plays a key role is calculating the estimated cost of a query. The workload management determines if the given query submitted is a long running or a short query (<2s runtime). Short queries are assigned with a reserved amount of memory resources when it is run in concurrency with large complex queries.

The next set of workload management control, scheduling control, determines the similar requests of queries and bundles them into a single workload. Based on the priority levels, workloads are created and queued. The workload management policies decide which queries or jobs needs to be sent for execution. It is the responsibility of the database server’s workload management to keep the system in optimal state and meet the business SLA's. In order to meet this requirement, the scheduling mechanism needs to determine the attributes of a query such as query characteristics, query priority, estimated cost of a query, resource allocated to the query. A database system's threshold is responsible in maintaining the overall health of a system. If the threshold is too high, the system is over utilized and underutilized if the threshold is too low. The number of concurrent sessions needs to be defined in order to gain control over the queries that can run in parallel. The maximum value on a Netezza system for this is 48.

Execution phase controls the runtime attributes of a query. The workload management policy under this phase dynamically controls the running query to restrict its impact on the system and other concurrent queries. It is the primary responsibility of the execution phase to determine the availability of system resources to allocate the newly submitted queries. Re-allocation of memory resources occurs when an existing running query completes.

Workload Management Structure

Over the years', workload management has come along a long way in adding new parameters and reconfiguring the existing ones to enhance the overall functionality and performance of a database system. This section covers the brief illustration of the components of a workload management.

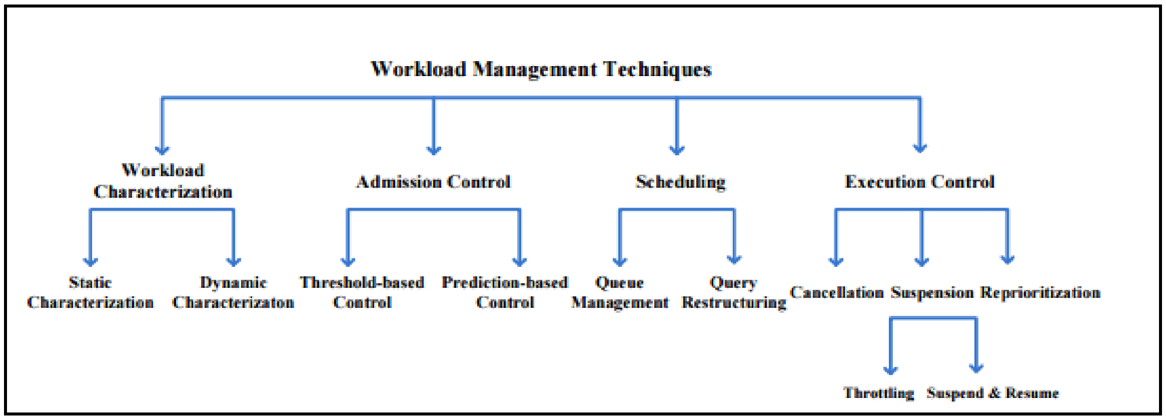


Figure 5. Workload Management Structure (Zhang, 2014)

- *Workload Characterization*–Provides vital information about workload (queries and jobs) to its controllers and sub-ordinates. Information related to costs, resources, demands, business priorities, business SLA's, and performance metrics are passed on to controllers.
    - *Static Characterization*–This type of workload is usually observed in traditional database systems where in the system resources are allocated before the requests are arrived.
    - *Dynamic Characterization*–Dynamically identifies the arriving workloads and allocates shared system memory based on the arriving loads.
- *Admission Control*–Restricts the number of concurrent sessions running against a database system. This helps in maintaining ideal throughput and adequate allocation of available resources. If more number of connections are accepted, beyond the defined threshold value, the throughput of a system decreases marginally.
    - *Threshold Based Admission Control*–Defines the threshold parameter above which no query is allowed to submit and execute on a database system. The

threshold parameters can be defined in terms of estimated query cost, query runtime, session runtime, and concurrent sessions.

    - *Prediction Based Admission Control*–Predicts the behavior of a query before it is submitted to a database system. Based on a query's behavior – type of the query, estimated cost of the query, query runtime, performance of a query can be calculated.

- *Scheduling*–Scheduling mechanisms acts as a gatekeeper to a database system. It is responsible to schedule the order in which the new requests are supposed to be arrived. Based on the priority of new requests, higher priority queries are scheduled to be submitted first followed by the medium and low priority requests.
    - *Query Management*–Execution order of a query is based on the attributes of a query that is submitted on a database system. After passing through the admission control mechanism, the similar queries are piled together into a single workload based on the attributes.
    - *Query Restructuring*–Breaks down a large complex query into smaller pieces and executes them in a scheduled order. In this way, large queries will not have to rely on shorter queries and vice versa.
- *Execution Control*–Places control mechanisms on different workloads to execute concurrent requests without being biased to any of the active requests.
    - *Query Cancellation*–Process of killing an active query that is currently running on a database system. Killing an active query releases the system resources allocated to the query.

- *Request Suspension*–Slows down or suspends an active request’s execution.
    - *Query Suspend and Resume*–Any active query can be suspended or killed, and the intermediate results are stored in a cache memory. The suspended query can be scheduled to run at a later time during off business hours. In this way the resource is reallocated to higher priority queries.
    - *Request Throttling techniques*–holds the same functionality as the previous subclass mechanism except that this functionality does not suspend an active request rather it pauses it there by releasing network bandwidth. CPU usage and I/O bottlenecks can be diagnosed using this subclass functionality.
- *Query Re-prioritization*–Dynamically adjusts the priority of a query in the middle of running state thereby resulting in resource reallocation of system memory. High priority gets higher amount of shared available system resources compared to low priority requests. Business requests submitted to a system can be dynamically tweaked to alter the priority based on the SLA.

Summary

In this chapter, some brief concepts were introduced about the workload management and its background. This chapter also covered the critical components of workload management policies including Performance criteria based on business requirements, Segregate and identify user initiated jobs, and Implications of workload management over queries. The existing (and previous) research works are still insufficient in diagnosing a performance issue on a database system. The previous works are limited to resource management and priority execution and does not talk about how a bad query abusing a database is supposed to be dealt. Despite having dynamically changing resource management and priority optimization, it is often the bad queries that affect the performance of a system. Troubleshooting a bad query, either re-writing or killing it can cause adverse effects on a database system.

Chapter III

METHODOLOGY

Introduction

A Netezza server is bundled with server, database and storage unit into a single architectural system. Netezza is upgraded by leveraging its hardware unlike other traditional databases wherein software is upgraded. It is capable of providing rapid results claiming to be 10-100 times faster than Oracle and this is because of the server’s asymmetric massively parallel processing (AMPP) architecture along with the efficient use of five level workload management features it offers. Going through the paper an in-depth description is explained about the workload management along with an introduction to netezza’s concepts and theories in addition to the usage of various syntaxes and tools the server supports.

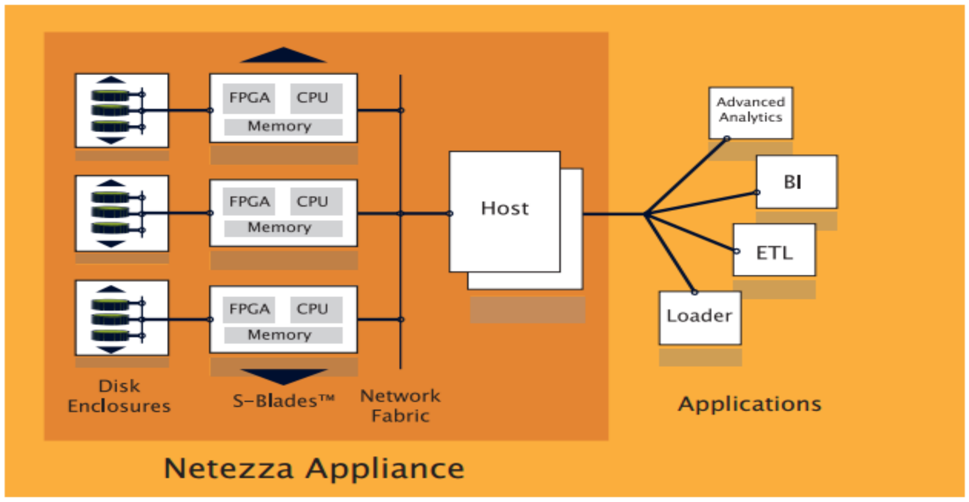


Figure 6. Netezza TwinFin Architecture

Design of the Study

In this section, a brief explanation is driven about the core components of a netezza’s TwinFin architecture. Netezza’s released its TwinFin model in the year 2009 as an advanced model of its previous machine, Mustang. In the following year, 2010, Netezza released a new model, skimmer, as a trimmed down version of TwinFin. Since the TwinFin release Netezza has opened up about supporting programming languages such as JAVA, C, C++, Hadoop and R.

Netezza: TwinFin Architecture

TwinFin model architecture of a Netezza system is displayed in Figure 6 (IBM, n.d.b). Following described are the core components of a Netezza system.

Host: Netezza host acts as an interface cum mediator between the appliance system and the application tools external to the environment. A Netezza system comes with two red hat Linux operating system wherein one act as primary and the other secondary which is usually a backup. The backup comes into the role when the primary OS fails or corrupts. An end user will not notice any difference in the performance when the primary disk fails in the middle of query execution or any job operations. Backup OS immediately takes over the processing of queries or any other jobs. External tools load data into the appliance through data loading tools such as ETL or any other supporting data loader tool. Also, NzLoad is a feature in Netezza where in the data can be loaded from external sources into the appliance. The queries submitted to the appliance through the external tools are converted into the code called snippets, which is read by the Netezza system. Each query submitted to the Netezza system, host creates a plan to optimize it to pace up the performance. The snippets and the query plan are created by the host and sent to the multiple parallel processing units where in the data is processed in parallel by multiple disks.

Snippet Blades (S – Blades): Snippet blades consists the core components of a Netezza system. Each S-Blade comes with a multi-engine FPGA, high processing CPU, which is designed to provide complex algorithms to handle large volumes of data, and a RAM memory.

Overall, snippets are the processing nodes where in the query optimization takes place and the jobs are split into multiple lines and processed by each of the MPP engines. On a TwinFin appliance, there are eight MPP nodes. Each MPP node consists of 2GB RAM, one FPGA core, and one CPU processor core. Query processing and optimization takes place on each of these snippets by the FPGA. Queries received by the Host are forwarded to these snippet processing units (SPU) for query execution and optimization. A SPU is a combination of the memory units ALONG with the FPGA. Unification of all the SPU's on the appliance is called Snippet processing Array (SPA).

Disk Enclosures: Large volumes of data loaded into the appliance finally end up in to disk storage. Each disk is RAID protected and is connected to the S-Blades through a network stream. Each SPU has a hard drive storage space to accommodate data, which is otherwise called as data slice. Data is split on these data slices based upon the distribution key. A distribution key is a column in the table definition. The data loaded on to the primary disk is copied on to the mirror (aka secondary) disk. Replication of data ensures that if the primary disk fails, then the secondary disk can act as primary until the primary is resolved.

Network Fabric: The Netezza appliance comes up with a Network fabric which connects all the components in the appliance. The bandwidth of the network is high enough to accommodate a thousand nodes with no difference in performance drop even when each and every node is communicating and transferring data among themselves. Network fabric runs a customized IP based protocol.

Netezza: Features and Benefits

Following described are the features and benefits of the Netezza system over other current conventional data warehouse appliances.

Speed: The Netezza System for Analytics, is said to provide 10-100 times faster response to query execution and other performance aspects, with about 128 gigabytes per second scan rate. This is because of netezza’s asymmetric massively parallel processing (AMPP) architecture which is capable of running multiple jobs concurrently, thereby providing rapid response to the end clients without any hassle. Field Programmable Gate Arrays (FPGA) is the heart and brain of Netezza system which filters the data apart from making sensible and smart decisions to improve the overall performance of the system. Over the years, Netezza has come up with various models with much rapid growth in performance. Of late, IBM has come up with a new algorithm – Directed Data Processing algorithm, integrating it with the Netezza system, thereby achieving a throughput of about 20 times greater than the previous Netezza models.

Simplicity. Netezza provides faster performance with no indexing or tablespaces required. Also, Netezza does not rely on the key constraints. As said earlier, Netezza system in ready-to-go state can be immediately started with taking up jobs and query execution thereby providing instant responses to the clients’ right away. Netezza system easily integrates with the BI tools and other data loading tools such as ETL through netezza’s supporting interfaces, JDBC, ODBC and OLE. Netezza supports redundancy of data, wherein failures of one of the nodes or disk will not impact system’s performance. Netezza does not require any additional tuning to the hardware components.

Scalable. Based on the size of the environment required to build a database to store large amounts of data, Netezza is capable of providing great response irrespective of the volume of data being loaded or stored on the appliance. A Netezza appliance holds server storage space ranging from 8 terabytes to 300 terabytes. Also, additional system can be deployed without any hassle if data volume increases beyond the initially installed server. As said earlier, minimal amount of administrative tasks are required to maintain a Netezza system, therefore loading large amount of data into the storage unit will not affect the performance nor will require any additional tasks to be performed.

Netezza: Users and Objects

Netezza system by default has a database user and a group – ADMIN and PUBLIC Administrator, also, is the super user of a database who has all the privileges right from creating databases to granting/revoking object privileges on a user. Admin has access to all the objects on a database server. An administrator has several responsibilities for carrying out various tasks and managing them altogether efficiently like managing databases, backing up/restoring databases, providing access control.

Always advisable to create a service account for the database administrators who have all the admin level privileges. Usage of the ADMIN account for database object deployment is not permissible unless the job activity is critical which involves system related activities. Any object deployed by the database administrators on a database should be under the ADMIN account. Once the object is deployed, ALTER the owner to admin. Queries run by admin occupy at least 50% of system resources.

By default, user is allocated to the PUBLIC resource group. The name and attributes of a PUBLIC group cannot be altered. ADMIN owns the group PUBLIC. Each user has a limited set of permissions. Database groups are created and permissions are granted to the group and the users who require a similar set of permissions are added on to a single group rather than granting permissions to each user explicitly. In Netezza, the users are usually authenticated using LDAP. Admin user always uses local authentication.

- Create User using LDAP authentication

```
CREATE USER MMUDDU;
CREATE USER MMUDDU WITH PASSWORD ‘MMUDDU’;
```

- Create User using LOCAL authentication

```
CREATE USER MMUDDU WITH PASSWORD ‘MMUDDUNYBOY’ AUTH LOCAL;
```

User or group attributes can be altered using the ‘ALTER’ syntax; also the admin can drop a group or a user using a simple ‘DROP’ command.

Netezza: Security Model

The security model illustrates the level of privileges a user is assigned to. Typically, there are two types of privileges—administrative level privileges and objects level privileges.

Administrative level privileges include creating database objects and execute global objects. Object level privileges are restricted only up to a particular object like a database, a table and so on. A database user inherits the access level privileges from a database group they are assigned to, provided the group has been granted the necessary privileges. In simple terms, permissions granted to a group are allocated to the users belonging to the group. It is not a good practice to grant/revoke permissions to a user explicitly when the user belongs to a database group.

Table 1

Netezza SQL Commands for Displaying Privileges

Command	Description
\du	Displays database users.
\dU	Displays database users and the groups in which they belong to.
\dpU	Displays all the privileges pertaining to a database user.
\dg	Displays the database groups.
\dG	Displays database groups and the users belonging to each group.
\dpg	Displays all the privileges pertaining to a database group.
\dp	Displays all the privileges of a database user through direct assigning or through inheriting privileges from a database group the user belongs to.

Authenticating using LDAP. User authentication is either ‘local’ or LDAP authentication. Under local authentication, password needs to be defined while creating a user.

```
CREATE USER MMUDDU with PASSWORD ‘Bikerboy’ AUTH LOCAL;
```

Netezza admin has the privileges to alter the login credentials of any ‘local’ authenticated user. In LDAP authentication, Netezza admin need not define any user password while creating a database user.

```
CREATE USER MMUDDU;
```

Netezza has an inbuilt centralized LDAP server that authenticates any newly created database user. Netezza system adopts Pluggable Authentication Module (PAM) to authenticate users on an LDAP name server. LDAP assigned credentials differ from the UNIX account.

In LDAP authentication, the system looks up the system catalog to check the LDAP authenticated user and returns an error if a user does not exist. Every successful and failed login attempts on a Netezza appliance is recorded on to a log file which can be found on the UNIX host machine under */nz/kit/log/postgres/pg.log*. The end user sees no difference between local and LDAP authentication.

There are extensive aspects which include parameter tweaking as well as writing additional parameters to a LDAP configuration file, but, this is beyond our project scope.

Netezza: Optimizer and Query Plans

Netezza appliance is designed with an inbuilt optimizer which elects the best scenario for query join operation, the order of join operations and most importantly the regulation of data between SPUs which in turn decides the best way to distribute data over the SPUs either through redistribution(HASH or RANDOM) or broadcast. The Netezza planner indicates the criteria the data is distributed on the SPUs. Netezza planner optimizes a query in a way the larger tables are not redistributed. This could make an impact on performance. When two or more tables are used in a join condition, the Netezza optimizer and planner initially checks the validity of the join conditions inside a given query. A smaller table has to precede a larger table in any join statement. During data distribution, larger tables are distributed initially followed by smaller tables. Vice versa would result in a bad skew, which could impact performance and also improper utilization of available SPU resources.

Planner and optimizer decide the order of tables that needs to be redistributed initially, although this is based on the size of a table. Optimizer plays a key role in improving the system’s performance by rewriting queries without any database administrator intervention. A database administrator can do an ‘EXPLAIN VERBOSE’ command on an active running query to check the criteria planner has chosen to redistribute the data. An admin can check this either through a query plan file or query explain plan.

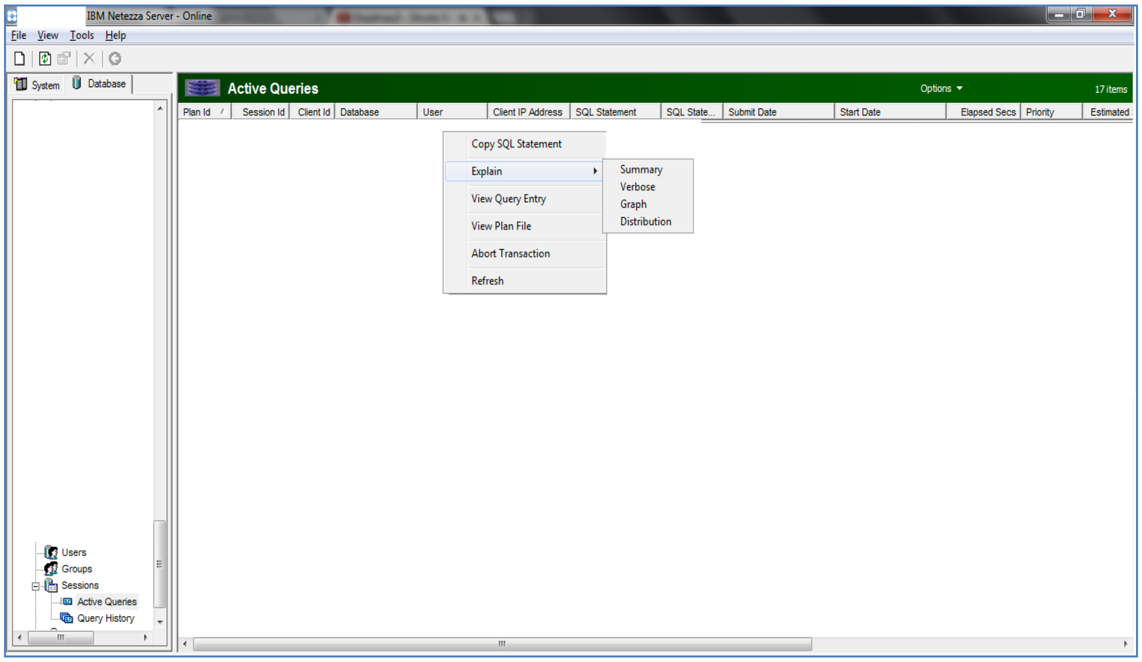


Figure 7. NzAdmin Tool Interface–Query Explain Plan

Performance of an optimizer relies on the table statistics. Optimizer plans and runs efficiently if the table statistics are updated on a regular basis. Stale statistics bring down the performance of an optimizer. Generate the table statistics when data is loaded onto a table, or when data is deleted from a table, or when a table structure is altered. Statistics are updated using the command GENERATE STATISTICS. Statistics can not only be generated on a table, but can also be generated on a database, and a table column(s). Optimizer relies on the last updated statistics information to optimize a query. Statistics information is stored in the system catalog table under the system database. Running statistics generates the count of duplicate values in a column, the maximum and minimum values in a column, unique data in a column and also the null values.

```
GENERATE STATISTICS ON TABLE_NAME/DATABASE_NAME;
```

In order to analyze an active running query following plans are generated.

EXPLAIN PLAN syntax

- *EXPLAIN PLANGRAPH SELECT * FROM TABLE_NAME;*

HTML PLAN syntax

-
  ```
  SET enable_print_plan_html=1;
  SELECT * FROM TABLE_NAME;
  ```

'SET' command writes the *plangraph* output to the /tmp directory on the host machine. The plan.html file represents a query in the form of a tree with each 'where' clause represented as a single node.

The queries are run on the command terminal. Alternatively, a plan file can looked up on the netezza admin tool.

Concurrency

Often, large numbers of queries run concurrently at the same time on a Netezza appliance. Netezza has the capability of handling the multiple concurrent queries running at the same time. But how many queries can run concurrently is the question here. Netezza has a limit of 48 concurrent queries. That is Netezza can service all the 48 queries which run at the same time. However, Netezza commits that the limit of the number of concurrent queries can be increased if only required. It is important that queries submitted or running concurrently must run efficiently and meet the end user requirements without any hindrance. On the Netezza host machine, the postgres configuration file (postgres.conf) can be modified to alter the number of queries an appliance can take up concurrently, but this number cannot exceed 48.

Queries are queued up to wait for the initial queries to run. Queries which are queued up are in the ‘Active’ state but are waiting for the other queries to finish running. Also, when any operation is going on a specific table, then any other query having that table name will have to wait until the former query finishes running. No two queries can run simultaneously on a table. Often when multiple queries try to run on a single table concurrently then the operation would result in a SPU swap partition error where the appliance says that the temporary work space is full. There is no solution for this problem rather an alternative way is to reduce the number of concurrent queries running or the SQL query has to be rewritten.

Workload Management (WLM)

Queries submitted to a database system will need minimum amount of system resources to have it run. When you have equally assigned resources to each of the resource groups, priority needs to be assigned to each user group or to an individual user. This is to give an extra edge in performance to have the query run faster than the average runtime. Often, there are large complex queries running round the clock pertained to business needs and criticality. These types of queries consume large amount of resources and ultimately affects the performance of smaller (and simpler) queries whose runtime is about a second or less in average. Netezza addresses this problem with the use of Short Query Bias feature. The following sections drive through the components of a workload management on a netezza machine.

Guaranteed Resource Allocation (GRA) and Resource Sharing Groups (RSG)

Before GRA is introduced, a brief explanation is described on the Resource Sharing Groups. Resource Sharing Groups unlike access groups have resources allocated to them disproportionately. Priorities are allocated to the Resource Sharing Groups based on the role the application is assigned to it. A database user cannot belong to more than one resource group. Admin possesses several controls over the Resource Sharing Groups such as

- *Resource minimum and Resource maximum*–Minimum and maximum percentage of system resources can be granted to a RSG for the queries being run by the users belonging to a RSG.
- *Job Maximum*–Number of concurrent queries the users belonging to a RSG can run. Typically, not more than 48 should be set.
- *Querytimeout*–Mhe maximum time the queries can run before being kicked out by the appliance.
- *Sessiontimeout*–The idle time before session drops.
- *Rowsetlimit*–Mhe number of rows to be returned on executing a query.
- *Defpriority and Maxpriority*–Four levels of priority given to a user in a RSG - critical, high, normal, low.

Often, *Resource minimum* and *Resource maximum* are the only options which are set for the RSGs. *Querytimeout* should not be set because there are certain queries run by a user which supposedly return about a billion of rows and this operation will take hours or even days but the information returned is valuable in some means to the user. *Rowsetlimit* is also one such option that is not set by the admin while defining a RSG, because there are certain queries which would return about a million or a billion rows. *Job Maximum* is left to its default value. And the rest parameters are used accordingly with respect to the environment the appliance is being used in.

Netezza SQL commands to create a RSG

```
SYSTEM (ADMIN) => CREATE GROUP DEVELOPERS WITH RESOURCE MINIMUM 50
RESOURCE MAXIMUM 100;
```

To change the resource minimum of a group to 30% from 50%

```
SYSTEM (ADMIN) => ALTER GROUP DEVELOPER WITH RESOURCE MINIMUM 30%;
```

Add user ‘mmuddu’ to the group DEVELOPERS

```
SYSTEM (ADMIN) => ALTER GROUP DEVELOPERS ADD USER MMUDDU;
```

For a given RSG, say the resource minimum is defined as 30%, then the group get at least 30% of the system resources irrespective of the other groups or users running queries concurrently. A RSG cannot receive more than the allocated system resources no matter if it is the only group (or a user belonging to the RSG) running queries on the Netezza appliance. Say, a RSG, has Resource maximum defined as 60%, then the maximum resources the group gets is not more than 60% at any given situation.

The resources parameters can be defined on either through the NzAdmin interface or it can be done through the Netezza SQL commands.

Once the RSGs are defined, it is now the responsibility of the GRA scheduler to schedule the plans for different RSGs on the Netezza appliance. GRA is enabled by default on a Netezza server but it does not come into effect until the resource groups are created and defined with their respective minimum percentage allocations.

GRA setting can be found on the Netezza system registry settings. GRA can be enabled(if disabled) or disabled using the Netezza ‘*`nzsystem set`*’ command by changing the value of *`host.schedGRAEnabled`* setting to yes, for enabling and no, for disabling GRA.

On each group, the GRA maintains the list of short and long queries. Every RSG has priority of queries defined such as short queries having higher priority than the long queries and priorities of critical to low within a set of queries. GRA scheduler schedules to make sure that the shorter queries are run before the longer queries and high priority ones before the lower ones. This is done in order to maintain compliance on the Netezza server.

GRA scheduler computes the allocation of system resources on the fly. Let’s take a scenario where in there are four RSGs defined on a Netezza server. Group A has 40% resources, Group B has 30% resources, Group C has 20% resources and Group D has 10% resources. All the groups are defined with their respective resource minimum and consider each group to be having Resource maximum as 100%.

Resource allocations for an ADMIN take up at least half of available system resources at any given time. As the ADMIN consumes lot of resources, it is therefore not advisable to run any queries or perform any operations as ADMIN unless there is a critical need. An alternate approach to this is to create a resource group for the administrators.

Priority Query Execution

As said earlier, multiple queries are run concurrently on a Netezza server and there is a probability that one or more users out the multiple users have critical jobs running along with the lower priority at the same time. Multiple users belonging to a single resource sharing group runs queries simultaneously and not necessary that all the users are running equal priority jobs wherein one of the users runs a critical job and the other users running low priority jobs. Though the GRA is enabled and the resource minimum is being shared among the multiple users of the group, the high priority jobs cannot finish quicker than the low priority ones. In this situation the GRA needs to be reallocated among the different users in a group based on the priority of the jobs. Netezza has a solution to this situation and that is to assign the priorities among the jobs being run by multiple users belonging to a single resource sharing group. Netezza calls this as Priority Query Execution (PQE). Priorities are assigned to the jobs based on the level of criticality. Once the priorities are assigned to the users on a RSG, the GRA gradually reallocates the system resources based on the priority level of jobs and the higher priority jobs are allocated with more percentage of resources compared to the lower ones. Also, Netezza schedules to run the jobs based on the priority level where in high priority is run before the lower one.

Netezza altogether has six different levels of priority for query execution where in four are at user level and two specifically designed for Netezza system.

Table 2

Query Priority Levels

System Critical	Top most system priority operations
Critical	Highest user priority
High	Priority jobs
Normal	Default level jobs
Low	Lowest priority job not affecting others
System Background	Lowest priority system jobs

Priority Query Execution can be assigned to a single user among multiple users on a RSG, or even to a RSG. User’s priority overrides the groups’ priority when priorities are defined to both the user (of a group) and the group. Default priority is Normal. Priority levels can be altered. Apart from allocating the priorities to the users and groups, Netezza also allows the admin to allocate priority to the entire Netezza system, but this not recommended and left to its default value, NULL or NONE. Users inherits the priority level from the group and group inherits from the system settings and in turn the system inherits from the system default priority setting which is usually set as Normal. The priorities can be assigned using either Netezza SQL commands or through NzADMIN interface.

The most important point an admin needs to note down is to not assign many jobs as critical or high because this may lead to a standstill of lower priority jobs (NORMAL and LOW priority).

Gate Keeper

Gate keeper in Netezza schedules the query for execution. The gate keeper is also called as Dynamic Cost-Based Queuing. The gateway is a queuing control system. In simple terms, it is the responsibility of the gate keeper to manage and schedule the number of concurrent queries that should run on a Netezza system. Gate Keeper can also schedule the number of concurrent jobs to run for each of the four different user priority levels. Each priority level has its own schedule of queued queries. By default, the gate keeper is disabled. Any jobs which are scheduled, goes directly to the GRA if the gate keeper is disabled. Responsibility of the gate keeper is to manage the jobs by creating queues before passing the jobs on to the GRA scheduler. When Priority Query Execution (PQE) is enabled, then the gate keeper creates individual queues for each of the four different priority levels before passing it on to the GRA and then further on to the SPU's. The gate keeper can control the number of the each priority jobs that can run concurrently on the Netezza system.

The gate keeper has hardcoded configuration setting which restricts the maximum number of concurrent critical priority level jobs to 36. At any given time, maximum number of critical jobs that can run concurrently on the Netezza system is 36 and this value cannot be changed on the gate keeper registry setting.

Apart from configuring the gate keeper to schedule the number of concurrent queries based on the priority levels, the gate keeper can also be configured based on the estimated run time of a query. This impacts the overall performance of the Netezza system wherein the gate keeper can be configured to run more number of shorter queries than the queries which comparatively takes more time to run.

Short Query Bias (SQB)

Netezza categorizes the queries into two types–Short and Long. Short queries typically run very fast and Netezza defines a short query as the one with the run time less than two seconds. Long queries on the other side takes many seconds, minutes or hours to run depending upon factors ranging from the amount of data being pulled by the business intelligence team to complex queries having many joins and conditions. With SQB enabled, users running short queries are not impacted by the complex queries run by other users.

Netezza favors the shorter queries over the longer queries, with the SQB enabled on the system. SQB is enabled by default on the Netezza system. With SQB enabled, Netezza reserves memory and system resources so that the shorter queries are run with no hindrance from the longer queries. This affect can make a large impact on performance. A short query typically includes a query which does either a quick look up to retrieve data or dimensional data lookups. The run time duration of a short query can be changed but this change will require a system pause and resume operation. Long queries a said include multiple join operations which takes large amount of time for the system to process it.

Netezza is smart enough to differentiate the run of different queries. And this is because of Netezza' s internal feature 'prep' snippet which analyzes the run time of a query much before it is run on the system. Not only are the prep snippets but there other factors Netezza system relies on to distinguish run time of queries–Just-In-Time stats and zone maps. The queries usually go through the GRA and Snippet scheduler by forming queues. When the queues are occupied with no more queries being accepted by the scheduler, the scheduler then releases the additional allocated memory for the shorter queries, which is nothing but a separate queue for the shorter queries. Each of the schedulers, GRA and Snippet, reserves slots for the shorter queries.

As described earlier that changes made to alter the estimated run time of a query requires system pause using the *nzsystem pause* command. After the registry changes are completed, resume the system using the command *nzsystem resume.*

Tools and Technology

Following are tools and technology that have been used to design, implement and test the complete research. Performance of a system can be calculated and estimated with the help of netezza's graphical user interface tools, NzAdmin, and NZ web portal. Similarly, "nzsqa schedqueues" is a powerful inbuilt script on a Netezza machine which tends to provide the current running queries along with the consumption of resources.

Netezza Inbuilt tool–'nzsqa schedqueues'. An inbuilt command tool which displays the current running queries along with the amount of resources the query is running with.

The nzsqa schedqueues command displays the following parameters.

- Displays the current system date and time.

```
SCHED TIME:  2015-12-04 01:17:35.887 EST
```

- Displays the scheduler policy, which includes the parameters defined for each of the workload management settings.

```
SCHEDULER POLICY:
    Gatekeeper     Disabled  max slots = 2048
    GRA            Enabled  max slots =   48    SQB slots =  10
    Snippet        Enabled  max slots =   40    SQB slots =  10
    SQB (< 2s)     Enabled
    SN Limiting    Enabled   baseline =    8
    GRALoad        Enabled
    Null I/O -> Ceilings:on Available:on Expected:on SNLimit:on
```

- Displays the respective resource groups on a system along with the defined minimum and maximum resource group attributes. This section illustrates 'JobMax' parameter, which is nothing but the maximum number of jobs a resource group can run concurrently.

```
KNOWN RESOURCE GROUPS:
    OID=    4900  Min 100  Max 100%  JobMax  0 (off)     "ADMIN"
    OID=    4901  Min   5  Max 100%  JobMax  0 (off)     "PUBLIC"
    OID=  203683  Min  60  Max 100%  JobMax  0 (off)     "resource_batch_grp"
    OID=27433791  Min  20  Max 100%  JobMax  0 (off)     "resource_app_grp"
    OID=27433792  Min  15  Max 100%  JobMax  0 (off)     "resource_misc_grp"
```

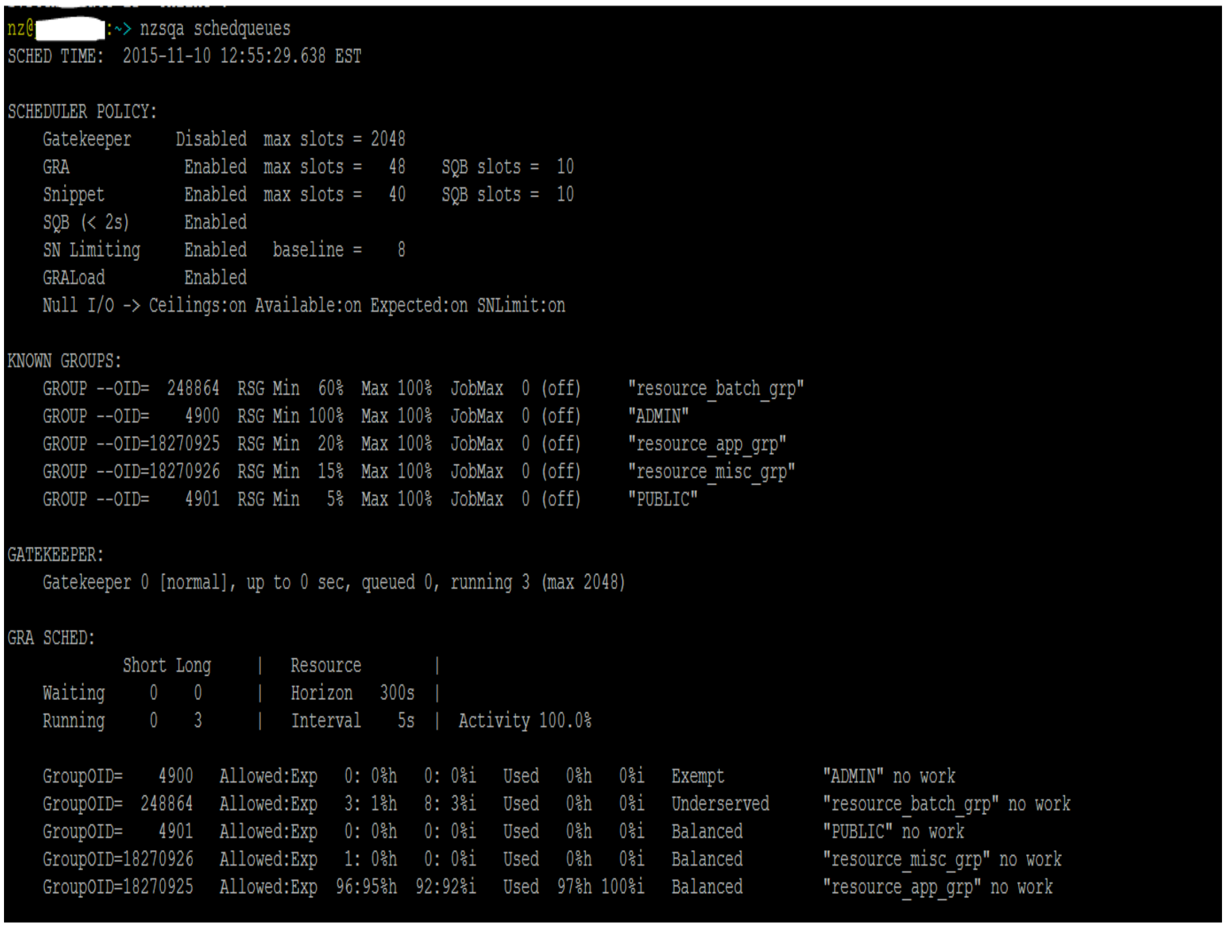
- Next is the GRA scheduler parameter. This section displays the number of queries in "waiting" and "running" state along with the level of activity for each resource group on the system.

```
GRA SCHED:

             Short Long     |   Resource        |
          Waiting     0    0      |   Horizon   300s  |
          Running     0    1      |   Interval    5s  |  Activity   0.0%

    GroupOID=    4900   Allowed:Exp   1:  0%h  33:  9%i   Used   0%h   0%i
Exempt "ADMIN"
    GroupOID=    4901   Allowed:Exp   0:  0%h   0:  0%i   Used   0%h   0%i
Balanced "PUBLIC"
    GroupOID=27433792   Allowed:Exp   0:  0%h   0:  0%i   Used   0%h   0%i
Balanced "resource_misc_grp"
    GroupOID=27433791   Allowed:Exp   0:  0%h   0:  0%i   Used   0%h   0%i
Balanced "resource_app_grp"
    GroupOID=  203683   Allowed:Exp   0:  0%h   0:  0%i   Used   0%h   0%i

Balanced "resource_batch_grp"
```

- Following section, snippet scheduler, displays the host memory, blade memory, channels, distributes, spu2hosts, broadcasts. This section displays each of the above parameters for short and long queries. This section concludes with a wide range of information which includes the attributes of a query–Plan-ID, type of SQL, current data slice number the query is running on, snippet number, resource memory etc.

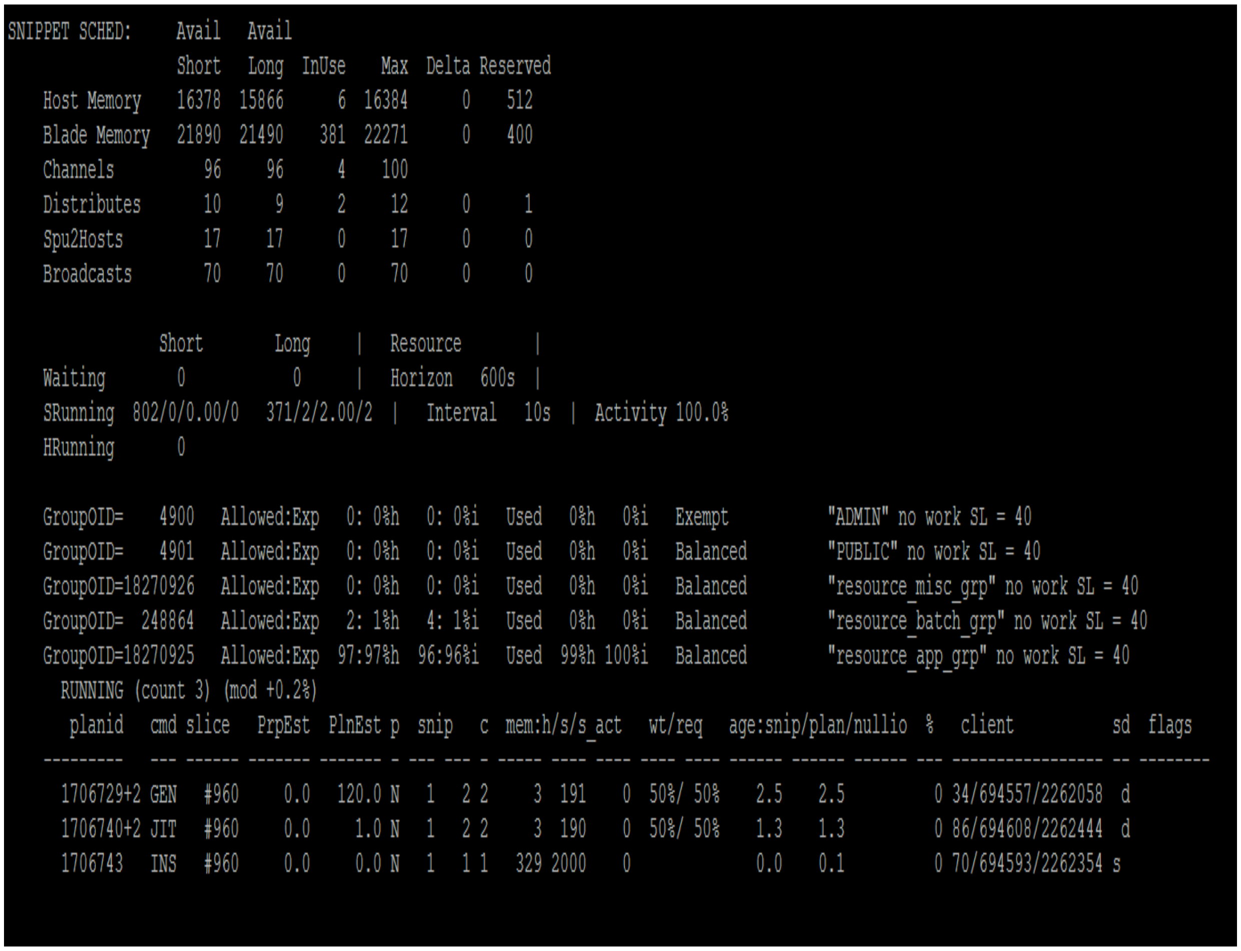
```
SNIPPET SCHED:     Avail   Avail
                   Short   Long  InUse    Max  Delta Reserved
    Host Memory    16084  15572    300  16384      0    512
    Blade Memory   10437  10037     13  10450      0    400
    Channels          99     99      1    100
    Distributes       50     49      0     50      0      1
    Spu2Hosts         99     99      1    100      0      0
    Broadcasts        99     99      0    100      0      0

                  Short     Long     |   Resource        |
    Waiting         0        0       |   Horizon   600s  |
    SPU  Running   0.0/0    1.0/1    |   Interval   10s  | Activity 0.0%
    Host Running    0        0


    GroupOID=    4900   Allowed:Exp   0:  0%h   0:  0%i   Used   0%h   0%i
Exempt "ADMIN" no work
      RUNNING (count 1)
       planid   cmd slice  est:plan/sched  p  snip   c  mem:h/s/s_act   temp
wt/req   age:snip/plan/nullio  scan  %  client           sd rules  flags
```

```
    ---------   --- ------ ------- ------- - --- --- - ----- ---- ---- -------
---- ---- ------ ------ ------ -- -- --- ----------------- -- ------ --------
        56118   SEL    #92   208.3    49.1 N    2    2 1    300   13     3       0
100%/100%    5.4    5.4         1  1    0 446/140549/353391           Rnj

    GroupOID=    4901   Allowed:Exp   0:  0%h   0:  0%i   Used   0%h   0%i
Balanced "PUBLIC" no work
    GroupOID=27433792   Allowed:Exp   0:  0%h   0:  0%i   Used   0%h   0%i
Balanced "resource_misc_grp" no work
    GroupOID=27433791   Allowed:Exp   0:  0%h   0:  0%i   Used   0%h   0%i
Balanced "resource_app_grp" no work
    GroupOID=  203683   Allowed:Exp   0:  0%h   0:  0%i   Used   0%h   0%i
Balanced "resource_batch_grp" no work
```



```
nz@[redacted]:~> nzsqa schedqueues
SCHED TIME:  2015-11-10 12:55:29.638 EST

SCHEDULER POLICY:
    Gatekeeper     Disabled  max slots = 2048
    GRA             Enabled  max slots =   48    SQB slots =  10
    Snippet         Enabled  max slots =   40    SQB slots =  10
    SQB (< 2s)      Enabled
    SN Limiting     Enabled   baseline =    8
    GRALoad         Enabled
    Null I/O -> Ceilings:on Available:on Expected:on SNLimit:on

KNOWN GROUPS:
    GROUP --OID=  248864  RSG Min  60%  Max 100%  JobMax  0 (off)     "resource_batch_grp"
    GROUP --OID=    4900  RSG Min 100%  Max 100%  JobMax  0 (off)     "ADMIN"
    GROUP --OID=18270925  RSG Min  20%  Max 100%  JobMax  0 (off)     "resource_app_grp"
    GROUP --OID=18270926  RSG Min  15%  Max 100%  JobMax  0 (off)     "resource_misc_grp"
    GROUP --OID=    4901  RSG Min   5%  Max 100%  JobMax  0 (off)     "PUBLIC"

GATEKEEPER:
    Gatekeeper 0 [normal], up to 0 sec, queued 0, running 3 (max 2048)

GRA SCHED:
            Short Long     |   Resource        |
    Waiting     0    0     |   Horizon   300s  |
    Running     0    3     |   Interval    5s  |  Activity 100.0%

    GroupOID=    4900   Allowed:Exp   0: 0%h   0: 0%i   Used   0%h   0%i   Exempt          "ADMIN" no work
    GroupOID=  248864   Allowed:Exp   3: 1%h   8: 3%i   Used   0%h   0%i   Underserved     "resource_batch_grp" no work
    GroupOID=    4901   Allowed:Exp   0: 0%h   0: 0%i   Used   0%h   0%i   Balanced        "PUBLIC" no work
    GroupOID=18270926   Allowed:Exp   1: 0%h   0: 0%i   Used   0%h   0%i   Balanced        "resource_misc_grp" no work
    GroupOID=18270925   Allowed:Exp  96:95%h  92:92%i   Used  97%h 100%i   Balanced        "resource_app_grp" no work
```

Figure 8. “nzsqa schedqueues”–1



```
SNIPPET SCHED:    Avail   Avail
                  Short    Long  InUse    Max  Delta Reserved
    Host Memory   16378   15866      6  16384      0    512
    Blade Memory  21890   21490    381  22271      0    400
    Channels         96      96      4    100
    Distributes      10       9      2     12      0      1
    Spu2Hosts        17      17      0     17      0      0
    Broadcasts       70      70      0     70      0      0

                Short        Long      |   Resource       |
    Waiting       0            0       |   Horizon   600s |
    SRunning  802/0/0.00/0   371/2/2.00/2  |   Interval   10s  |  Activity 100.0%
    HRunning      0

    GroupOID=    4900   Allowed:Exp   0: 0%h   0: 0%i   Used   0%h   0%i   Exempt          "ADMIN" no work SL = 40
    GroupOID=    4901   Allowed:Exp   0: 0%h   0: 0%i   Used   0%h   0%i   Balanced        "PUBLIC" no work SL = 40
    GroupOID=18270926   Allowed:Exp   0: 0%h   0: 0%i   Used   0%h   0%i   Balanced        "resource_misc_grp" no work SL = 40
    GroupOID=  248864   Allowed:Exp   2: 1%h   4: 1%i   Used   0%h   0%i   Balanced        "resource_batch_grp" no work SL = 40
    GroupOID=18270925   Allowed:Exp  97:97%h  96:96%i   Used  99%h 100%i   Balanced        "resource_app_grp" no work SL = 40
      RUNNING (count 3) (mod +0.2%)
       planid   cmd slice   PrpEst  PlnEst p  snip   c  mem:h/s/s_act   wt/req   age:snip/plan/nullio  %   client          sd  flags
    ---------   --- ------ ------- ------- - --- --- - ----- ---- ---- ---- ---- ------ ------ ------ --- ---------------- -- --------
      1706729+2 GEN   #960     0.0   120.0 N   1   2 2     3  191    0  50%/ 50%    2.5    2.5         0 34/694557/2262058  d
      1706740+2 JIT   #960     0.0     1.0 N   1   2 2     3  190    0  50%/ 50%    1.3    1.3         0 86/694608/2262444  d
      1706743   INS   #960     0.0     0.0 N   1   1 1   329 2000    0              0.0    0.1         0 70/694593/2262354 s
```

Figure 9. “nzsqa schedqueues”–2

Netezza Admin Graphical User Interface

NzAdmin is a windows client tool for the netezza machine. It provides an interface to easily manage the interactions of database objects. It is through this interface hardware information about a netezza machine can be gathered and diagnosed along with other aspects such as active sessions, active queries, database users, database objects, database groups, backup and restore information.

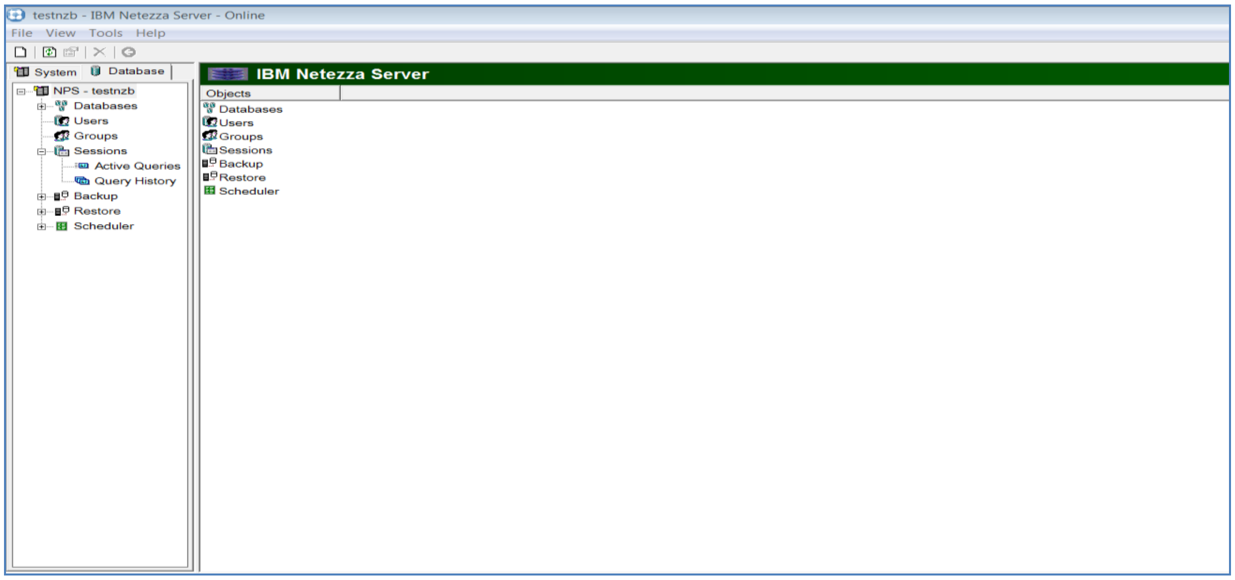
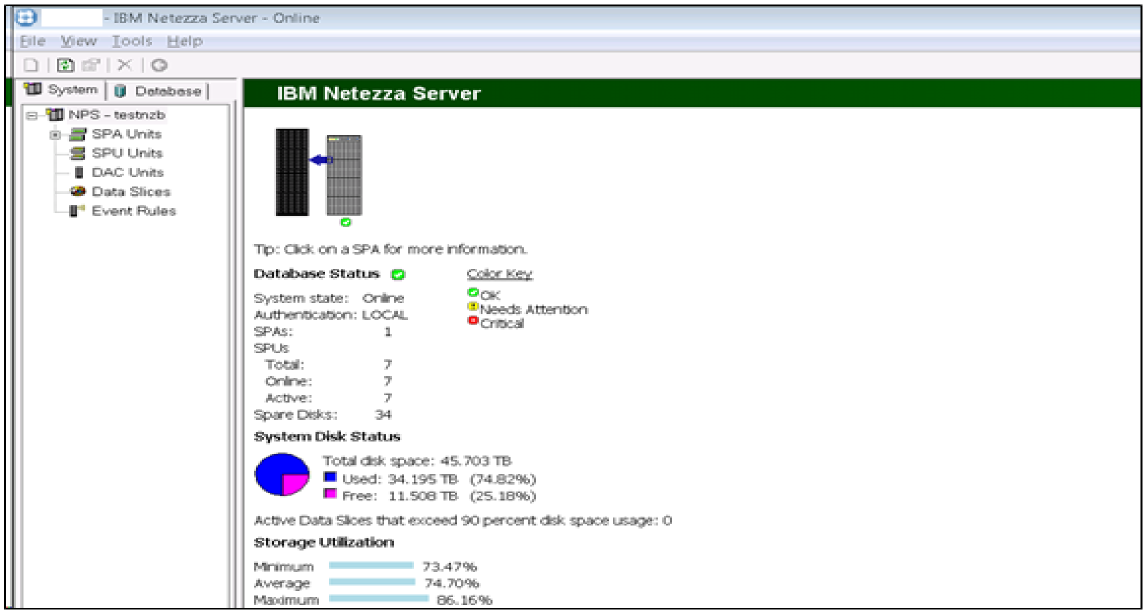


Figure 10. NzAdmin Tool Interface

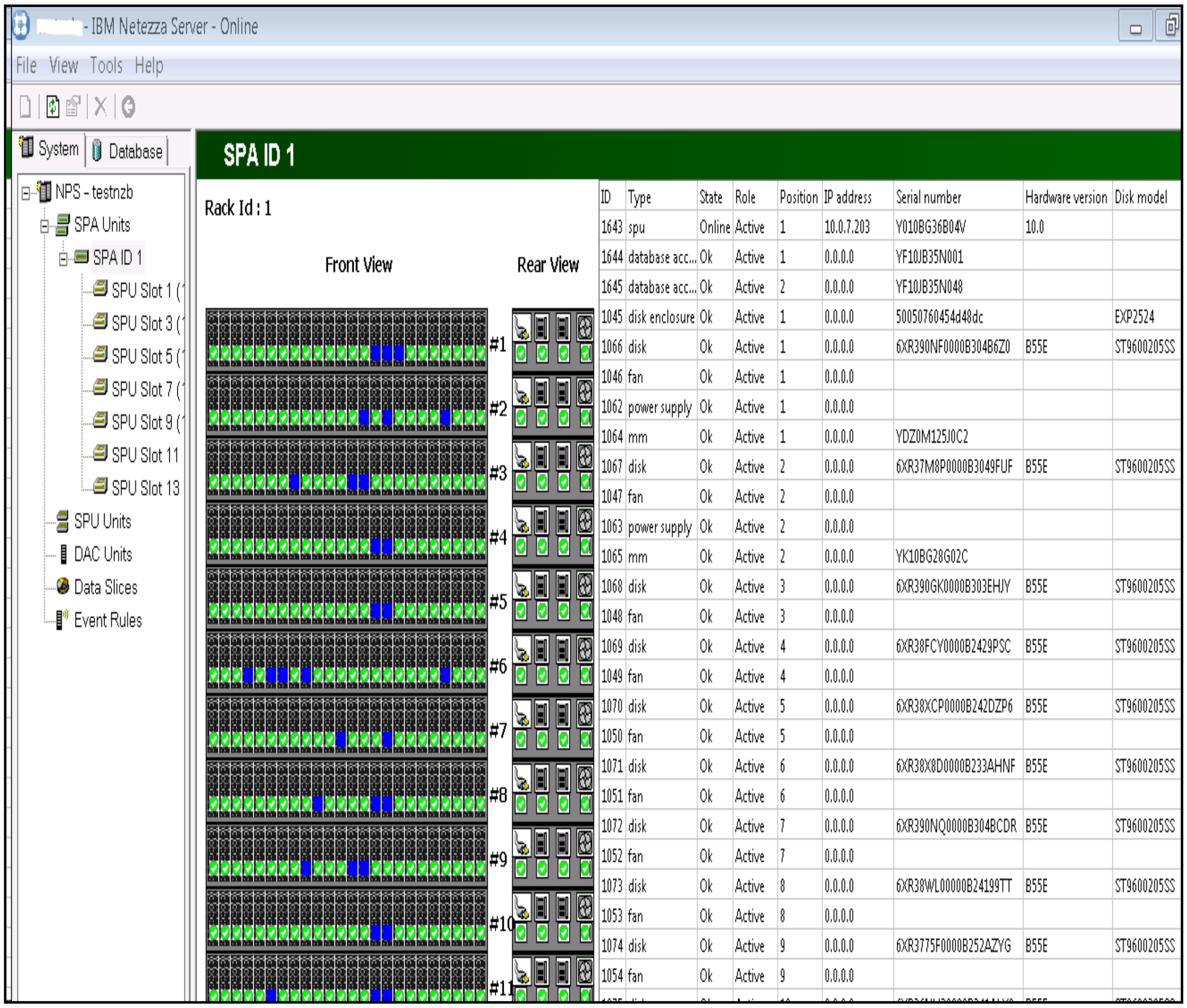
The hardware section on the NzAdmin interface displays the server's hardware components including number of racks, memory modules, SPU count and failure hardware components if any.



Tip: Click on a SPA for more information.

```
Database Status              Color Key
System state:   Online       OK
Authentication: LOCAL        Needs Attention
SPAs:             1          Critical
SPUs
  Total:          7
  Online:         7
  Active:         7
Spare Disks:     34
System Disk Status
  Total disk space: 45.703 TB
  Used:  34.195 TB  (74.82%)
  Free:  11.508 TB  (25.18%)
Active Data Slices that exceed 90 percent disk space usage: 0
Storage Utilization
Minimum   73.47%
Average   74.70%
Maximum   86.16%
```

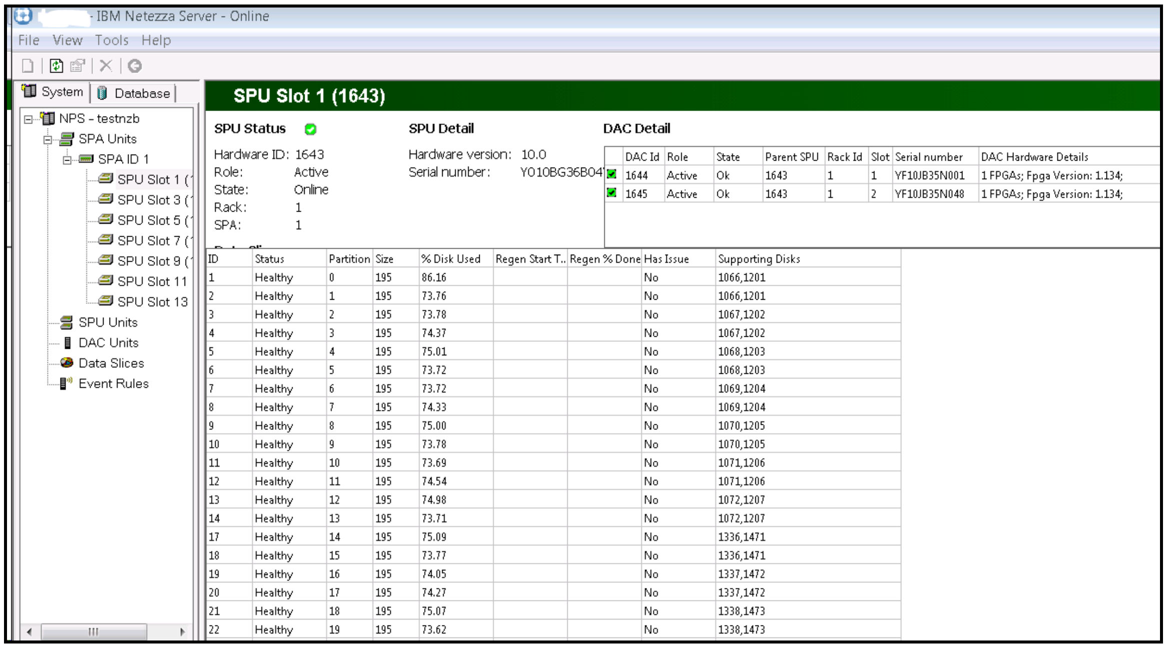
Figure 11. NzAdmin–Netezza Hardware Specifications



ID	Type	State	Role	Position	IP address	Serial number	Hardware version	Disk model
1643	spu	Online	Active	1	10.0.7.203	Y010BG36B04V	10.0	
1644	database acc...	Ok	Active	1	0.0.0.0	YF10JB35N001		
1645	database acc...	Ok	Active	2	0.0.0.0	YF10JB35N048		
1045	disk enclosure	Ok	Active	1	0.0.0.0	50050760454d48dc		EXP2524
1066	disk	Ok	Active	1	0.0.0.0	6XR390NF0000B304B6Z0	B55E	ST9600205SS
1046	fan	Ok	Active	1	0.0.0.0			
1062	power supply	Ok	Active	1	0.0.0.0			
1064	mm	Ok	Active	1	0.0.0.0	YDZ0M125J0C2		
1067	disk	Ok	Active	2	0.0.0.0	6XR37M8P0000B3049FUF	B55E	ST9600205SS
1047	fan	Ok	Active	2	0.0.0.0			
1063	power supply	Ok	Active	2	0.0.0.0			
1065	mm	Ok	Active	2	0.0.0.0	YK10BG28G02C		
1068	disk	Ok	Active	3	0.0.0.0	6XR390GK0000B303EHJY	B55E	ST9600205SS
1048	fan	Ok	Active	3	0.0.0.0			
1069	disk	Ok	Active	4	0.0.0.0	6XR38FCY0000B2429PSC	B55E	ST9600205SS
1049	fan	Ok	Active	4	0.0.0.0			
1070	disk	Ok	Active	5	0.0.0.0	6XR38XCP0000B242DZP6	B55E	ST9600205SS
1050	fan	Ok	Active	5	0.0.0.0			
1071	disk	Ok	Active	6	0.0.0.0	6XR38X8D0000B233AHNF	B55E	ST9600205SS
1051	fan	Ok	Active	6	0.0.0.0			
1072	disk	Ok	Active	7	0.0.0.0	6XR390NQ0000B304BCDR	B55E	ST9600205SS
1052	fan	Ok	Active	7	0.0.0.0			
1073	disk	Ok	Active	8	0.0.0.0	6XR38WL00000B24199TT	B55E	ST9600205SS
1053	fan	Ok	Active	8	0.0.0.0			
1074	disk	Ok	Active	9	0.0.0.0	6XR3775F0000B252AZYG	B55E	ST9600205SS
1054	fan	Ok	Active	9	0.0.0.0			

Figure 12. NzAdmin – Netezza SPU Specifications

On the SPU hardware information screen, there are various options a user can click on to get detailed specifications. This includes DAC ID, Status of the SPU, parent SPU, rack ID, slot number, serial number of the SPU, and other hardware details which includes number of FPGA engines including its version. Disks associated with respect to each SPU are displayed on clicking each SPU slot.



SPU Slot 1 (1643)

SPU Status ✓

Hardware ID: 1643
Role: Active
State: Online
Rack: 1
SPA: 1

SPU Detail

Hardware version: 10.0
Serial number: Y010BG36B04

DAC Detail

	DAC Id	Role	State	Parent SPU	Rack Id	Slot	Serial number	DAC Hardware Details
✓	1644	Active	Ok	1643	1	1	YF10JB35N001	1 FPGAs; Fpga Version: 1.134;
✓	1645	Active	Ok	1643	1	2	YF10JB35N048	1 FPGAs; Fpga Version: 1.134;

ID	Status	Partition	Size	% Disk Used	Regen Start T..	Regen % Done	Has Issue	Supporting Disks
1	Healthy	0	195	86.16			No	1066,1201
2	Healthy	1	195	73.76			No	1066,1201
3	Healthy	2	195	73.78			No	1067,1202
4	Healthy	3	195	74.37			No	1067,1202
5	Healthy	4	195	75.01			No	1068,1203
6	Healthy	5	195	73.72			No	1068,1203
7	Healthy	6	195	73.72			No	1069,1204
8	Healthy	7	195	74.33			No	1069,1204
9	Healthy	8	195	75.00			No	1070,1205
10	Healthy	9	195	73.78			No	1070,1205
11	Healthy	10	195	73.69			No	1071,1206
12	Healthy	11	195	74.54			No	1071,1206
13	Healthy	12	195	74.98			No	1072,1207
14	Healthy	13	195	73.71			No	1072,1207
17	Healthy	14	195	75.09			No	1336,1471
18	Healthy	15	195	73.77			No	1336,1471
19	Healthy	16	195	74.05			No	1337,1472
20	Healthy	17	195	74.27			No	1337,1472
21	Healthy	18	195	75.07			No	1338,1473
22	Healthy	19	195	73.62			No	1338,1473

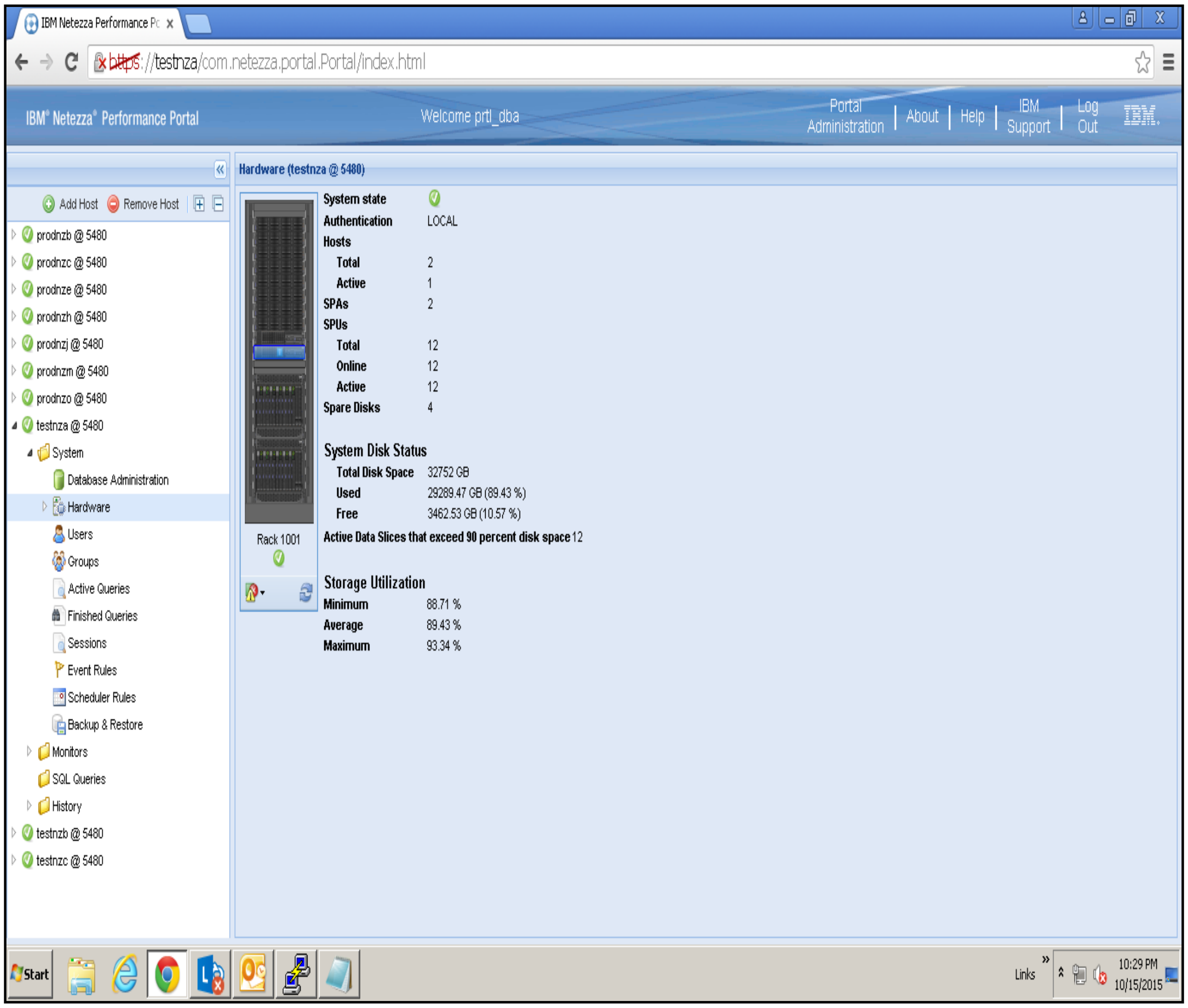
Figure 13. NzAdmin–Netezza SPU Details

Netezza Web Portal

Netezza web portal is a web based GUI interface to administer and manage the netezza machine. Database objects and various other technical aspects can be monitored. Web portal runs through the IP address of a netezza machine.

Following actions can be performed on a netezza web portal.

- Monitor database objects, active queries and active sessions.
- Run SQL queries.
- DML operations can be performed.
- Validate events and configuration rules.
- Diagnosis and troubleshoot workload management.
- Capacity Planning.
- Flexible ability to create custom performance charts based on the needs of business.



Hardware (testnza @ 5480)

System state	✓
Authentication	LOCAL
Hosts	
Total	2
Active	1
SPAs	2
SPUs	
Total	12
Online	12
Active	12
Spare Disks	4

System Disk Status

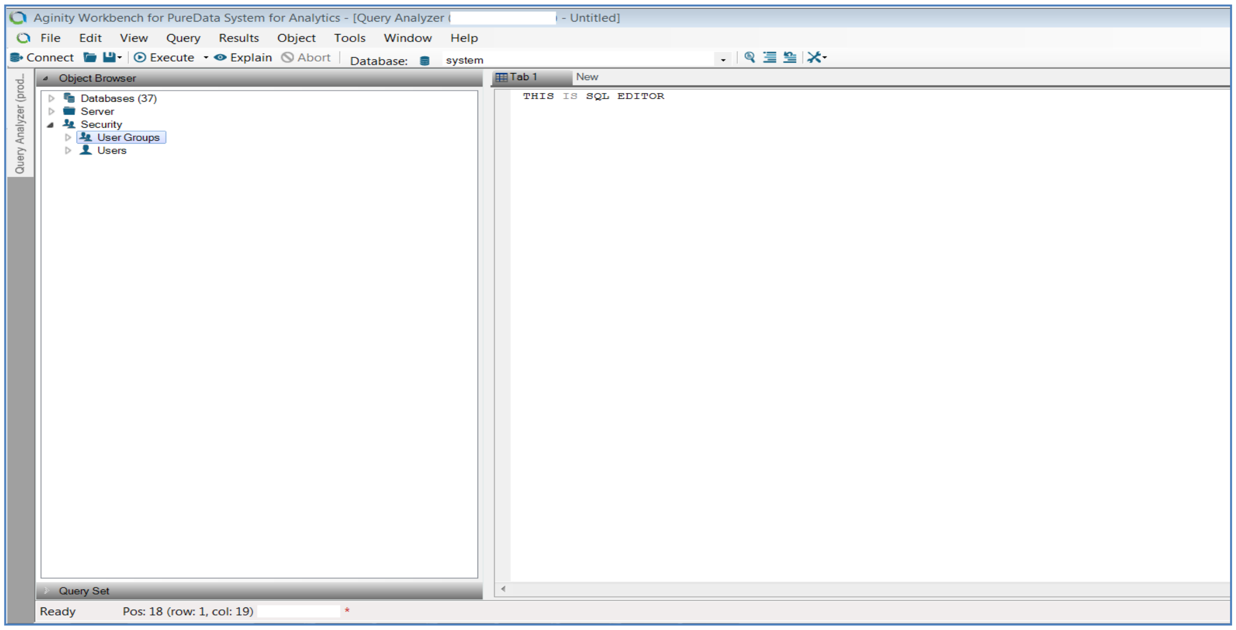
Total Disk Space	32752 GB
Used	29289.47 GB (89.43 %)
Free	3462.53 GB (10.57 %)
Active Data Slices that exceed 90 percent disk space	12

Storage Utilization

Minimum	88.71 %
Average	89.43 %
Maximum	93.34 %

Figure 14. Netezza Web Interface

Aginity Workbench


Aginity Workbench for PureData System for Analytics - [Query Analyzer (- Untitled]
File Edit View Query Results Object Tools Window Help
Connect Execute Explain Abort Database: system
Object Browser
Databases (37)
Server
Security
User Groups
Users
Query Analyzer (prod...
Tab 1 New
Query Set
Ready Pos: 18 (row: 1, col: 19)

```
THIS IS SQL EDITOR
```

Figure 15. Aginity Workbench

Netezza's developer tool Aginity Workbench was developed by Aginity. This tool works a GUI interface along with a SQL interface to run SQL queries. Other features includes comparing database object definitions, migrate database objects over databases and servers, load data from flat files or by using netezza's data loading feature – NzLoad.

Technology

The entire tests were carried out on a Netezza TwinFin model. Following are the attributes of a Netezza twinFin model.

- Host Name: testnzaa

  Testnza is hostname of the netezza machine on which the research and validations are carried out. Each netezza machine has two hosts, primary host A and secondary host B. The tests were carried out on the primary host hence the naming convention testnzaA. Secondary host is up only when the primary host is failed over. There is no downtime required while the hosts switch to and fro primary and secondary. The end user will notice no difference regardless of which host is up and running.

- Model Number: IBM PureData System for Analytics N1001-010

  This is the model number for a netezza machine. N100X series represents the twinfin family of machines. N200X represents the next series of netezza machine, striper model. N300X represents the mako server which is by far the most advanced and latest netezza model in the market. The number system followed by the model number represents the number of racks pertained on a server.

Table 3

Netezza Machine Models

Netezza Model	Number of Racks
N1001-002	
N1001-005	½ rack
N1001-010	Full rack
N1001-015	1 and ½ rack2
N1001-020	2 racks
N1001-030	3 racks
N1001-040	4 racks
N1001-060	6 racks
N1001-080	8 racks
N1001-100	10 racks
N2001-005	½ rack
N2001-010	Full rack
N2001-020	2 racks
N2001-040	4 racks

- Software Revision: 7.0.4.6p3, 7.2.0.5p1,7.2.0.5p2 and 7.2.0.6

  IBM releases a number of upgrades and patches over the time based on the criticality of the bug and enhancements. The release notes for each NPS version is covered in the appendices section.
- Snippet Processing Array: 2

  Describes the number of snippet processing arrays on a netezza machine. Each SPA consists of several SPUs. Multiple SPA's contribute towards the overall functionality and performance of a netezza system. Losing a SPA can decrease the performance of system and may crash the NPS server.
- Snippet Processing Unit: 14

  Each SPU contributes towards the performance of a system. Losing a SPU can decrease the throughput and performance of a machine. testnzA has 14 SPUs altogether caged and split among two SPAs. Each SPU has a FPGA turbo engine, memory module, a CPU and network cables. Losing a SPU here can decrease the performance of a system by 7.14%.
- Number of DataSlices: 92

  TestnzA has altogether 92 data slices shared among 14 SPUs. If a data slice is corrupted the mirror information resides on a different data slice on another SPU. Data loaded on a netezza machine is distributed equally among each data slice to avoid skew.

- Total Storage: 45.608TB

  This represents the total size of testnzA server in compressed format where in the entire displayed size is user usable. Additional racks can be added to the machine to expand the data storage.

- Power/rack (Max. Watts/rack): 7,635

  This denotes the maximum power, in terms of watts, which is generated out of each rack on a netezza machine. Adding additional racks increases the overall power consumption of a netezza machine.

- FDT Version: FDT 4.1.0.0, 4.1.1.0, 4.1.2.0

  FDT stands for Firmware Diagnostics and Tools. Contains firmware updates about each hardware component on a netezza machine. The tests were carried out across three different FDT versions due to new releases scheduled by the product owner.

- Red Hat Version: Red Hat Enterprise Linux Server release – 5.9, 5.10 (Tikanga)

  Netezza machine runs on Linux platform – Red Hat. Over the time, new versions were released to match up with the same level FDT and NPS versions.

- HPF Version: 5.3.4.5, 5.3.5.0

  HPF stands for Host Platform. This piece updates the software version of a netezza machine including kernel version, firmware updates, host versions etc. HPF upgrade involves error-checking, backups and logging.

- Supported APIs: SQL, OLE DB, ODBC 3.5, JDBC V 3.0 Type 4

  Denotes the supported application programming interfaces on a netezza machine.

- In-Database Analytics: nzAnalytics, R Analytics, Scientific Analytics
- Programming Languages: Java, Python, R, FORTRAN and C/C++

  Netezza supports a few programming languages on its Linux platform which includes Java, C, C++, R language and FORTRAN. These languages are written and executed in binary or hexa format and needs to be converted into a readable text format to have users view it.
- Parallel Analytic Engines: nzMatrix, nzEngine for R, nzEngine for Hadoop

  Netezza is compatible to run with other appliances to support additional functionality and richness in a data warehouse environment.

Chapter IV

DATA PRESENTATION AND ANALYSIS

Introduction

In this chapter, a brief introduction is illustrated on how the performance of a query can be calculated and tweaked to achieve leverage in performance. Each workload management feature will be illustrated in this chapter. Runtime of a query depends upon various factors from leveraging the hardware components such as CPU, I/O bandwidth, disk size to toggling the software pieces of a machine such as system resource management and configuring system registry parameters. Since this paper is limited to only the components of a workload management and how the runtime of a query can be excelled; the paper describes on how the components of netezza's workload management can be added, tweaked and combined to achieve best performance.

Data Presentation and Analysis

The following sections describe and illustrate the impact of each workload feature on a Netezza database system. Each component of a workload feature consists of a few to several system configuration parameters pertained to it. Tweaking these parameters can result in a large variance in terms of query runtime and query performance. This section covers the attributes of a resource group on database system along with their performance measure using the "nzsqa schedqueues" inbuilt script. Performance graphs are illustrated depicting the consumption of memory resources by resource groups over a period of time. With the introduction of a new workload feature "Scheduler Rules" in the recently released version 7.2.0.5, the gatekeeper feature has been disabled. Custom rules along with the impact are illustrated in the scheduler rules section.

Each of the below workload features illustrates different scenarios which impacts the performance of a database system.

Guaranteed Resource Allocation

Resource groups created on a database server are allocated with a certain amount of system resources for a query to execute with. A resource group is configured to run with a minimum and maximum percentile of system resources at any given time on a system. The maximum percentage a resource group can be assigned is 100%. Netezza by default comes with a default resource group "Public". By default all the users are added to the Public group. Multiple resource groups can created based on the role of the application users or groups. To begin with, following commands are run to create and assign resources to a resource group.

```
SYSTEM (ADMIN) => CREATE GROUP DEVELOPER WITH RESOURCE MINIMUM 50 RESOURCE
MAXIMUM 100;
```

To change the resource minimum of a group to 30% from 50%

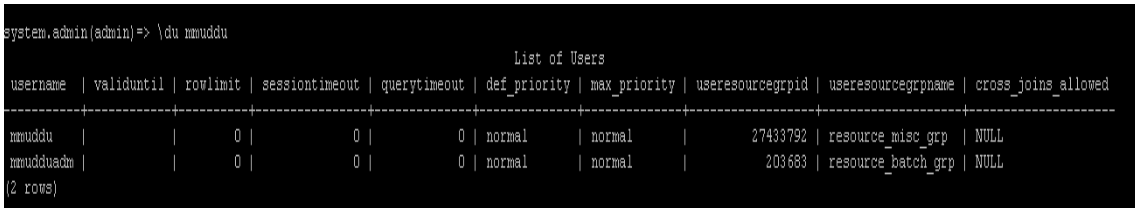
```
SYSTEM (ADMIN) => ALTER GROUP DEVELOPER WITH RESOURCE MINIMUM 30%;
```

Add user 'mmuddu' to the group DEVELOPERS

```
SYSTEM (ADMIN) => ALTER GROUP DEVELOPERS ADD USER MMUDDU;
```

Following example illustrates the system resources the user 'mmuddu' is running with when there is no active query running on a system.

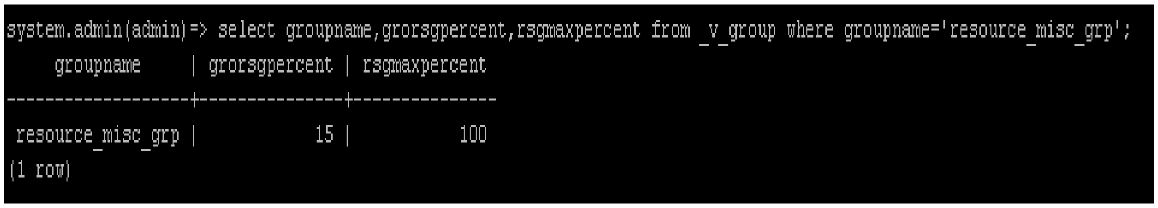
User mmuddu belongs to resource group 'resource_misc_grp'. In addition, another user 'mmudduadm' with higher resource percentages is assigned to 'resource_batch_grp'.



```
system.admin(admin)=> \du mmuddu
                                                             List of Users
 username  | validuntil | rowlimit | sessiontimeout | querytimeout | def_priority | max_priority | useresourcegrpid | useresourcegrpname | cross_joins_allowed
-----------+------------+----------+----------------+--------------+--------------+--------------+------------------+--------------------+---------------------
 mmuddu    |            |        0 |              0 |            0 | normal       | normal       |         27433792 | resource_misc_grp  | NULL
 mmudduadm |            |        0 |              0 |            0 | normal       | normal       |           203683 | resource_batch_grp | NULL
(2 rows)
```

Figure 16. User and User Group Information

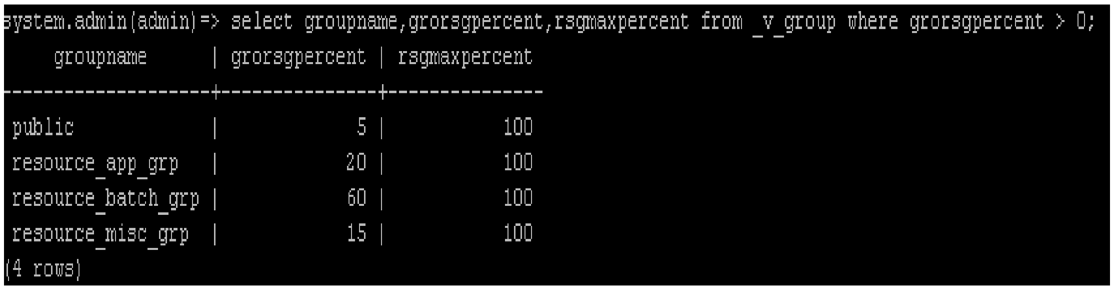
For example, resource_misc_grp is running with a resource minimum of 15% and maximum of 100%.



```
system.admin(admin)=> select groupname,grorsgpercent,rsgmaxpercent from _v_group where groupname='resource_misc_grp';
     groupname     | grorsgpercent | rsgmaxpercent
-------------------+---------------+---------------
 resource_misc_grp |            15 |           100
(1 row)
```

Figure 17. “resource_misc_grp” Group Information

Similar to the above resource group, there are other groups defined along with their share of resource percentages.

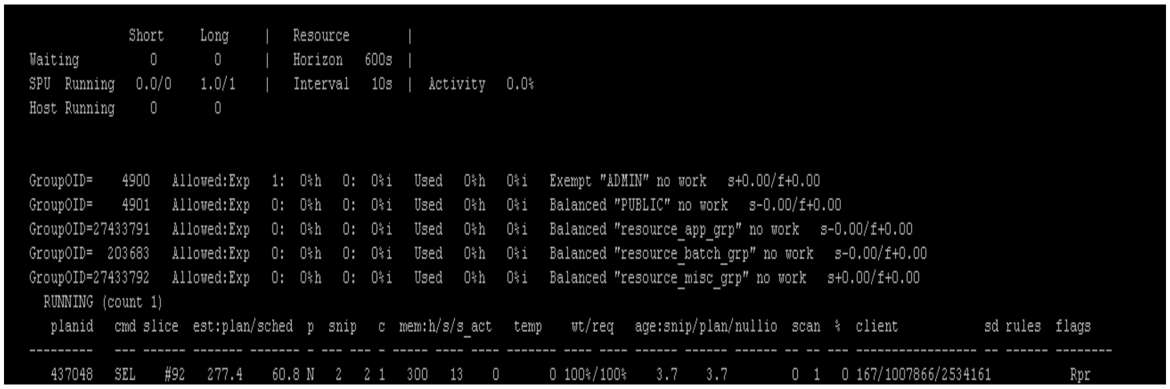


```
system.admin(admin)=> select groupname,grorsgpercent,rsgmaxpercent from _v_group where grorsgpercent > 0;
     groupname      | grorsgpercent | rsgmaxpercent
--------------------+---------------+---------------
 public             |             5 |           100
 resource_app_grp   |            20 |           100
 resource_batch_grp |            60 |           100
 resource_misc_grp  |            15 |           100
(4 rows)
```

Figure 18. Resource Groups

User ‘mmuddu’ runs a sample query to display all the records in a table. The system resources a query are running with can be captured on another terminal connected to the same server. Netezza’s inbuilt tool “`nzsqa schedqueues`” is run to calculate the system resource a query is running with at any given moment.[1]

`SQL: select * from table_name;`



```
             Short     Long     |   Resource       |
Waiting        0        0       |   Horizon   600s |
SPU  Running   0.0/0    1.0/1   |   Interval   10s |  Activity   0.0%
Host Running    0        0


GroupOID=    4900   Allowed:Exp   1:  0%h   0:  0%i   Used   0%h   0%i   Exempt "ADMIN" no work   s+0.00/f+0.00
GroupOID=    4901   Allowed:Exp   0:  0%h   0:  0%i   Used   0%h   0%i   Balanced "PUBLIC" no work   s-0.00/f+0.00
GroupOID=27433791   Allowed:Exp   0:  0%h   0:  0%i   Used   0%h   0%i   Balanced "resource_app_grp" no work   s-0.00/f+0.00
GroupOID=  203683   Allowed:Exp   0:  0%h   0:  0%i   Used   0%h   0%i   Balanced "resource_batch_grp" no work   s-0.00/f+0.00
GroupOID=27433792   Allowed:Exp   0:  0%h   0:  0%i   Used   0%h   0%i   Balanced "resource_misc_grp" no work   s+0.00/f+0.00
  RUNNING (count 1)
   planid   cmd slice  est:plan/sched  p  snip   c  mem:h/s/s_act   temp    wt/req   age:snip/plan/nullio  scan  %  client           sd rules  flags
---------   --- ------ ------- ------- - --- --- - ----- ---- ---- ------- ---- ---- ------ ------ ------ -- -- --- ---------------- -- ------ --------
   437048   SEL    #92   277.4    60.8 N   2   2 1   300   13    0       0 100%/100%    3.7    3.7        0  1   0 167/1007866/2534161          Rpr
```

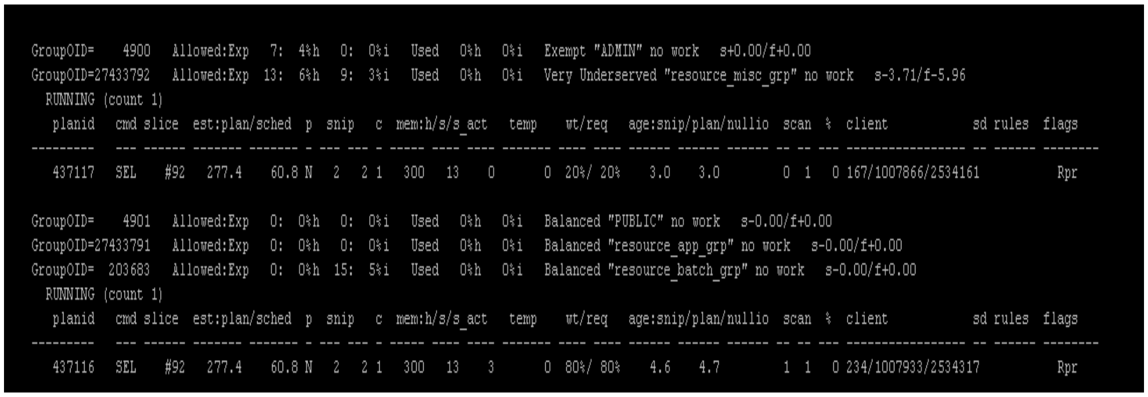
Figure 19. “nzsqa schedqueues” Output

In the above picture, one can see the amount of resources the query is running with when you have no other active sessions running. The “*wt/req*” percentage displayed is the amount of system resources the query is utilizing.

Say, there are two queries running concurrently against the system. User ‘mmuddu’ runs a sample query to extract all the data from table1 and another user ‘mmudduadm’ with higher resource percentage runs a similar query to extract data from table2[2]. In order to calculate the system resources utilized by the two users, a simple inbuilt tool can be run - *`‘nzsqa schedqueues’`*.

[1] This test is carried out a Netezza TwinFin server running on 7 active SPU’s with a disk storage capacity of 45.703 TB. The entire testing piece was carried out on a quiet system with no other active queries.

[2]Both the users run the same query on two different tables. Table2 is a copy of Table1 having same data. The users run a query to retrieve the count of records in each table.



```
GroupOID=    4900   Allowed:Exp   7:  4%h   0:  0%i   Used   0%h   0%i   Exempt "ADMIN" no work   s+0.00/f+0.00
GroupOID=27433792   Allowed:Exp  13:  6%h   9:  3%i   Used   0%h   0%i   Very Underserved "resource_misc_grp" no work   s-3.71/f-5.96
  RUNNING (count 1)
   planid   cmd slice  est:plan/sched  p  snip   c  mem:h/s/s_act   temp    wt/req   age:snip/plan/nullio  scan  %  client           sd rules  flags
---------   --- ------ ------- ------- - --- --- - ----- ---- ---- ------- ---- ---- ------ ------ ------ -- -- --- ---------------- -- ------ --------
   437117   SEL    #92   277.4    60.8 N   2   2 1   300   13    0       0  20%/ 20%    3.0    3.0        0  1   0 167/1007866/2534161          Rpr

GroupOID=    4901   Allowed:Exp   0:  0%h   0:  0%i   Used   0%h   0%i   Balanced "PUBLIC" no work   s-0.00/f+0.00
GroupOID=27433791   Allowed:Exp   0:  0%h   0:  0%i   Used   0%h   0%i   Balanced "resource_app_grp" no work   s-0.00/f+0.00
GroupOID=  203683   Allowed:Exp   0:  0%h  15:  5%i   Used   0%h   0%i   Balanced "resource_batch_grp" no work   s-0.00/f+0.00
  RUNNING (count 1)
   planid   cmd slice  est:plan/sched  p  snip   c  mem:h/s/s_act   temp    wt/req   age:snip/plan/nullio  scan  %  client           sd rules  flags
---------   --- ------ ------- ------- - --- --- - ----- ---- ---- ------- ---- ---- ------ ------ ------ -- -- --- ---------------- -- ------ --------
   437116   SEL    #92   277.4    60.8 N   2   2 1   300   13    3       0  80%/ 80%    4.6    4.7        1  1   0 234/1007933/2534317          Rpr
```

Figure 20. “nzsqa schedqueues” GRA Output

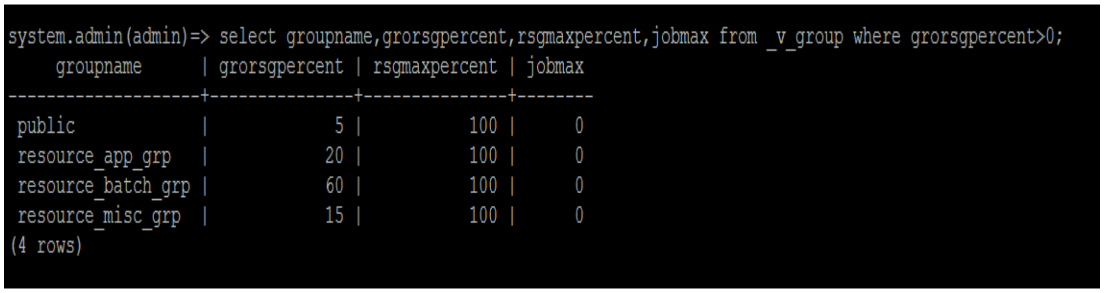
Apart from assigning min and max resource percentages to a resource group; a database administrator can place several controls over the Resource Sharing Groups (RSG) such as

- *Job Maximum*–Total number of concurrent queries a RSG can run. Typically not more than 48 should be set.
- *Querytimeout*–Defines max runtime of a query before it gets terminated.
- *Sessiontimeout*–The idle time before a user session drops.
- *Rowsetlimit*–The number of rows to be returned on executing a query.
- *Defpriority* and *Maxpriority*–Four levels of priority given to a user in a RSG - critical, high, normal, low.

If Group A has n number of equal priority queries running then each query will get 1/n of 40% of the resources to be shared among the n queries equally. Now, say at a given time Group C and Group D have queries running concurrently, the GRA scheduler re-computes the allocation of resources on the fly in such a way that Group C gets 20/30(~67%) and Group D gets 10/30(~33%) of the system resources. If only the Group D has queries running, then it would get 100% of the available system resources.[3]

As described earlier, the JOB MAXIMUM attribute defines the number of concurrent queries a group can run at any given time. Additional queries running concurrently beyond the defined JOB MAXMIMUM are queued up until the active queries have finished running. One can define the JOB MAXIMUM attribute with the values -1, 0 and 1 to 48.

- ➢ A value of -1 state that the JOB MAXIMUM value is calculated based on the GRA and the group's resource minimum in order to decide the number of concurrent queries a particular group can run. If a group has RESOURCE MINIMUM defined as 30% and the JOB MAXIMUM would be 30% multiplied by 48 (max no of concurrent queries) which is approximately 14.
- ➢ A value of 0 states that the group has no restrictions on the number of maximum jobs runs concurrently.
- ➢ A value of 1 to 48 sets the count of the number of job maximum value.

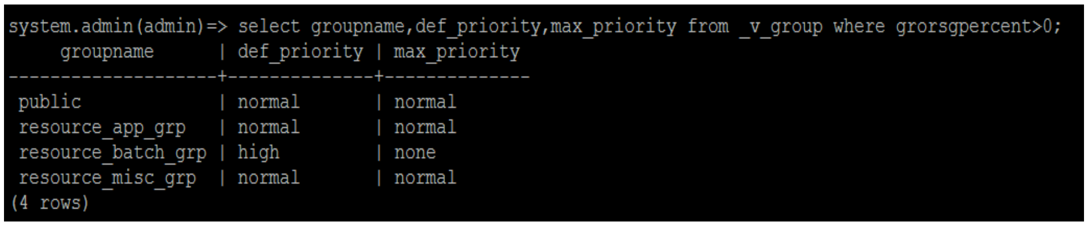


```
system.admin(admin)=> select groupname,grorsgpercent,rsgmaxpercent,jobmax from _v_group where grorsgpercent>0;
     groupname      | grorsgpercent | rsgmaxpercent | jobmax
--------------------+---------------+---------------+--------
 public             |             5 |           100 |      0
 resource_app_grp   |            20 |           100 |      0
 resource_batch_grp |            60 |           100 |      0
 resource_misc_grp  |            15 |           100 |      0
(4 rows)
```

Figure 21. Job Max Information

[3] This has been tested on the Netezza model twinfin with four different resource groups running different queries concurrently. Only the users in group A are assigned with equal priorities.

Query priority and GRA can defined on a Resource Sharing Group wherein the queries are run with priorities ranging from low to critical. Assigning high priority to one query and low priority to another query in a RSG does not mean that the high priority query runs before the low priority one. In order to balance the allocation of resources for each job, Netezza has an in built registry setting to define the weights for each priority query. It is *`host.snPriorityWeights`*. The values of this registry setting are predefined internally by Netezza wherein 1 – Low, 2 – Normal, 4–High and 8–Critical.



```
system.admin(admin)=> select groupname,def_priority,max_priority from _v_group where grorsgpercent>0;
     groupname      | def_priority | max_priority
--------------------+--------------+-------------
 public             | normal       | normal
 resource_app_grp   | normal       | normal
 resource_batch_grp | high         | none
 resource_misc_grp  | normal       | normal
(4 rows)
```

Figure 22. User Group Priorities

To illustrate a scenario on how GRA and query priority works together, consider a Resource Sharing group ‘DEVELOPERS’ having RESOURCE MINIMUM as 50% and assume two jobs are being scheduled to run by this group. One is critical priority and the other is low priority. The ratio is 8:1, which means the resource allocated to the group DEVELOPERS is shared by the two queries in the ratio of 8:1.

Critical job gets 8/(8+1) share of the resources, which is approximately 89% of the resources allocated to the DEVELOPERS group 50% allocation which is about 44.5% of the resources and the Low priority job gets 1/(1+8) share of the resources, which is approximately

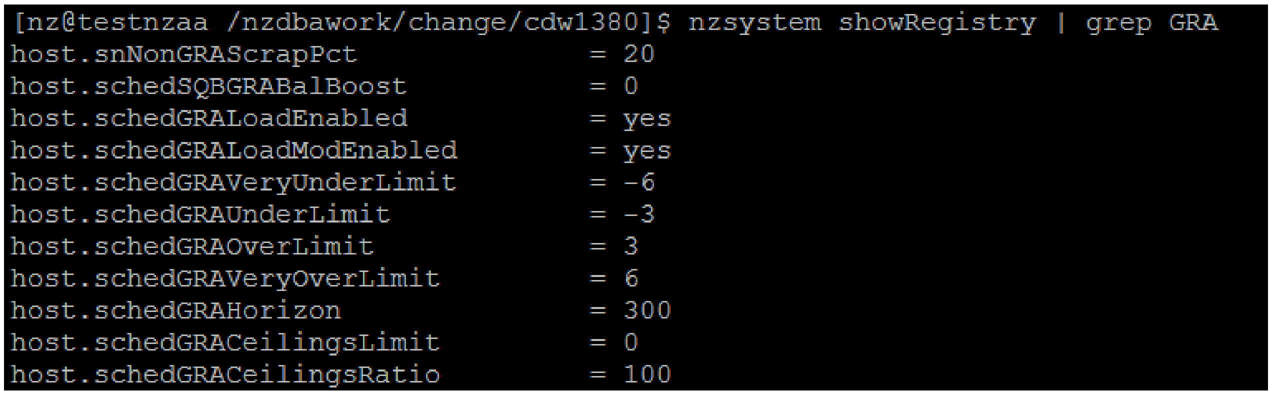
11% of the resources allocated to the DEVELOPERS group 50% allocation which is about 5.5% of the resources.[4]

Table 4

GRA Compliance Settings

host.schedGRAHorizon	Time range for which GRA scheduler calculates the compliance of RSG
host.schedGRAVeryUnderLimit	Percentage under which the GRA is said to be much underserved.
host.schedGRAUnderLimit	Percentage under which the GRA is said to be underserved.
host.schedGRAOverLimit	Percentage over which the GRA is said to be over served.
host.schedGRAVeryOverLimit	Percentage over which the GRA is said to be very over served.

Each parameter displayed in the table above illustrates various functionality of a GRA workload management. Threshold parameter can be set up which provides notification if a resource group is very underserved, underserved, overserved or very overserved.



```
[nz@testnzaa /nzdbawork/change/cdw1380]$ nzsystem showRegistry | grep GRA
host.snNonGRAScrapPct                = 20
host.schedSQBGRABalBoost             = 0
host.schedGRALoadEnabled             = yes
host.schedGRALoadModEnabled          = yes
host.schedGRAVeryUnderLimit          = -6
host.schedGRAUnderLimit              = -3
host.schedGRAOverLimit               = 3
host.schedGRAVeryOverLimit           = 6
host.schedGRAHorizon                 = 300
host.schedGRACeilingsLimit           = 0
host.schedGRACeilingsRatio           = 100
```

Figure 23. GRA System Registry Configurations

There are three ways to monitor GRA Utilization

[4] Two resource groups were created on a Netezza twinfin model. Group A has critical priority assigned to it and Group B has low priority to it. The priorities were assigned to the resource group unlike to each individual users in the resource group. Also, both the resource groups were allocated same number of resources.

- There are Netezza system tables and views which display the information about the ongoing resource allocation among the groups.
    - System views which tracks the GRA :
        - `_v_sched_gra_ext and _v_sched_sn_ext`

          Displays the GRA historical information about the allocation among various resource groups.
        - `_v_sched_gra_ext_latest, _v_sched_sn_ext_latest`

          Displays the GRA allocation among various resource groups in the past ten minutes.
        - `_v_plan_resource`

          Supports the WLM by troubleshooting issues. Keeps track of 2000 records of query plan activity.
        - `_v_system_util`

          This system view displays information about the system resources utilization.
- Also, NzPortal which is a Netezza performance portal can be used to display information about the resource allocation.
- NzADMIN interface also displays the information about the resource allocation.

Resource Allocation Performance summary can be seen on NzADMIN interface which displays various stats about the resource allocation among groups. To view the Resource Allocation Performance, on the NzADMIN interface click on Tools -> Workload Management -> Performance -> Summary.

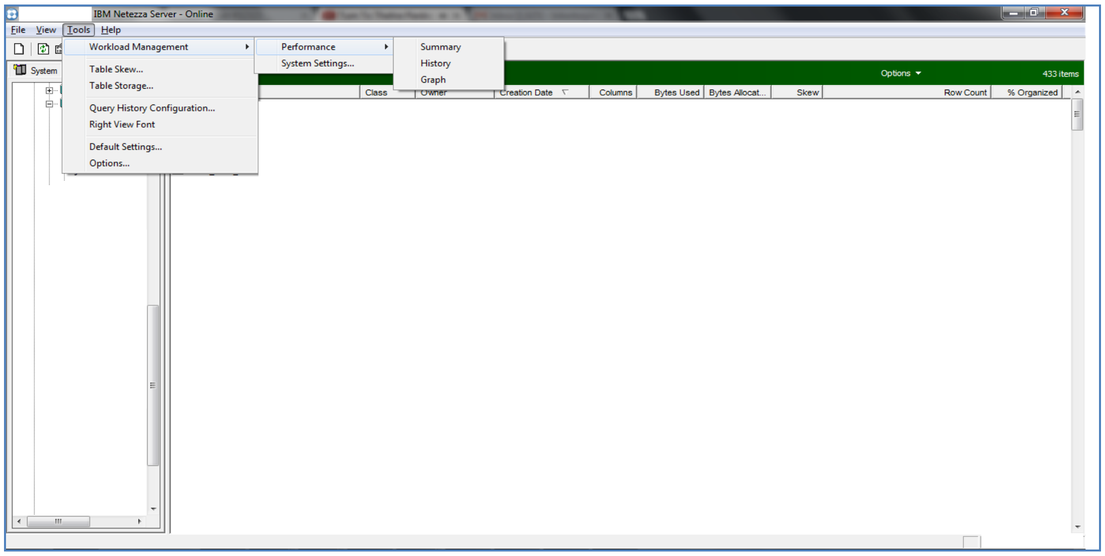
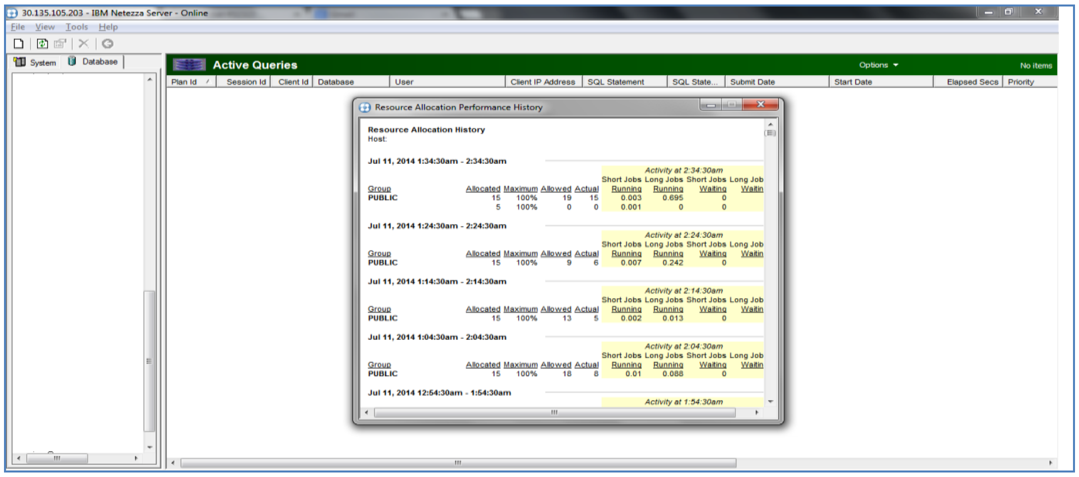


Figure 24. NzAdmin Resource Allocation Performance

Resource Performance history displays the information about the last one hour track of utilization of system resources. To view the Resource Performance History, on the NzADMIN interface click on Tools -> Workload Management -> Performance -> History.

Resource Performance Graph compares and displays the allocation of resources among different groups on a day to day basis. Up to 14 different groups can be compared and analyzed.



```
Resource Allocation History
Host:

Jul 11, 2014 1:34:30am - 2:34:30am
                                                        Activity at 2:34:30am
                                                Short Jobs Long Jobs Short Jobs Long Job
Group          Allocated Maximum Allowed Actual  Running   Running   Waiting   Waitin
PUBLIC                15    100%      19     15    0.003     0.695         0
                       5    100%       0      0    0.001         0         0

Jul 11, 2014 1:24:30am - 2:24:30am
                                                        Activity at 2:24:30am
                                                Short Jobs Long Jobs Short Jobs Long Job
Group          Allocated Maximum Allowed Actual  Running   Running   Waiting   Waitin
PUBLIC                15    100%       9      6    0.007     0.242         0

Jul 11, 2014 1:14:30am - 2:14:30am
                                                        Activity at 2:14:30am
                                                Short Jobs Long Jobs Short Jobs Long Job
Group          Allocated Maximum Allowed Actual  Running   Running   Waiting   Waitin
PUBLIC                15    100%      13      5    0.002     0.013         0

Jul 11, 2014 1:04:30am - 2:04:30am
                                                        Activity at 2:04:30am
                                                Short Jobs Long Jobs Short Jobs Long Job
Group          Allocated Maximum Allowed Actual  Running   Running   Waiting   Waitin
PUBLIC                15    100%      18      8     0.01     0.088         0

Jul 11, 2014 12:54:30am - 1:54:30am
                                                        Activity at 1:54:30am
```

Figure 25. Resource Allocation Performance History

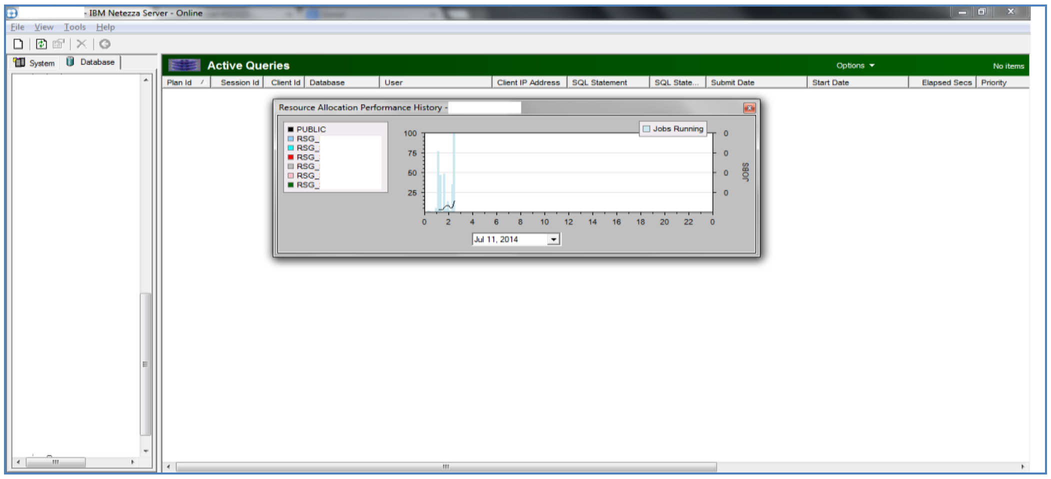

IBM Netezza Server - Online
File View Tools Help
System Database
Active Queries
Options
No items
Plan Id Session Id Client Id Database User Client IP Address SQL Statement SQL State... Submit Date Start Date Elapsed Secs Priority
Resource Allocation Performance History
PUBLIC
RSG_
Jobs Running
JOBS
Jul 11, 2014

Figure 26. Resource Performance Graph

Gate Keeper

As the name states this feature in the workload management is designed to manage jobs/queries based on their priority. User groups are usually assigned with a priority based on their role in an environment. Queries run of different priorities are submitted to the gatekeeper which is responsible to sort out the queries based on their priorities. High priority queries are run at first place while the other priority queries are queued up unless there are system resources available for them to jump in.

Gatekeeper is disabled by default. It can always be enabled by toggling the system registry setting *'host.gkEnabled'* to yes in the *postgresql.conf* configuration file[5]. There are up to four levels of priority a user or a user group can be assigned with ranging from low (normal, high) to critical. One can set the number of maximum queries a resource group can run at any given instance. Gatekeeper queues up any additional queries when it has reached its max limit defined for each prioritized resource group. If a resource group with job priority set to critical

[5] postgresql.conf configuration file can be found under /nz/data/config/ directory. Any changes made to this file will need a database server restart to have the changes in effect.

has been assigned 40 as *‘jobmaximum’*, the maximum number of queries it can run is 40 at any given time. Additional queries lined up from the same resource group will have to wait in queue until a system resource is available for it to sneak in.

Two registry settings needs to be configured in order to make the gatekeeper settings affective.

-*host.gkMaxPerQueue*

This registry setting controls the maximum number of queries that can run concurrently out of a queue.

-*host.gkQueueThreshold*

This registry setting is used to define the different estimated run times of a queue. *host.gkQueueThreshold* setting is used to set the number of queues as well as the run time of the queries. In the following example, three query runtime queues are created separated by a comma. First queue is for the queries with the run time of less than a second. Second queue is for the queries with the run time between 1-10 seconds and then the last queue is for the queries having run time 10-60 seconds. The maximum number of gate keepers that can be set is four.

```
host.gkQueueThreshold=1, 10, 60
```

Now that the queues have been set up along with the query run times, next step is to set up the number of concurrent queries that can run through each of the queues and this can be done with the registry *host.gkMaxPerQueue.*

```
host.gkMaxPerQueue=10, 5, 3
```

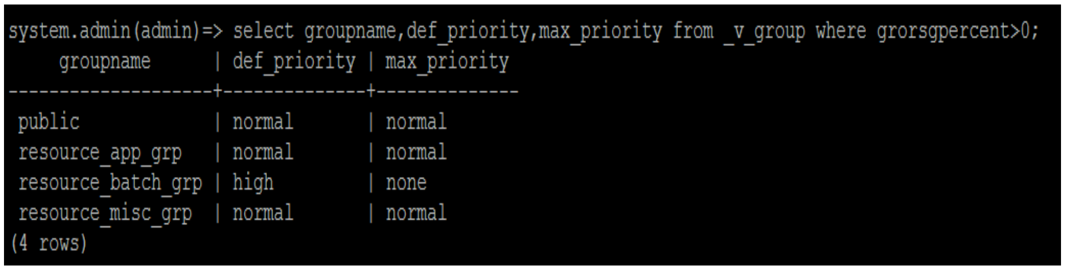
The numbers of concurrent queries are 10 for the queries having run time of less than a second, 5 for the queries having run time of 1-10 seconds, and 3 for the queries having run time of more than 60 seconds. More number of shorter queries is being sent to the SPU for processing compared to the longer queries. The numbers of queries are being sent to SPU for processing is controlled by the *host.gkMaxPerQueue* registry.

Priority Query Execution

A resource group or a user can be assigned to a priority level ranging from Low to Critical. There is a need to assign priority based on the role of a user or user group in a data warehouse environment. Jobs with higher priority are assigned with more system resources compared to other priority level jobs. High priority jobs are allowed to run before the lower priority jobs when you have multiple jobs on a system with different priority levels. It is always recommended to enable the Gatekeeper along with the priority query execution workload management feature.

Netezza SQL command to set system‘s default and maximum priority.

- `SET SYSTEM DEFAULT [DEFPRIORITY | MAXPRIORITY ] TO [ CRITICAL | HIGH | NORMAL | LOW | NONE ]`



```
system.admin(admin)=> select groupname,def_priority,max_priority from _v_group where grorsgpercent>0;
    groupname      | def_priority | max_priority
-------------------+--------------+-------------
 public            | normal       | normal
 resource_app_grp  | normal       | normal
 resource_batch_grp | high         | none
 resource_misc_grp | normal       | normal
(4 rows)
```

Figure 27. Resource Group Priorities[6]

[6] Priorities are set on resource groups unlike to each individual user. Users in each resource group acquire the attributes of a resource group they belong to.

Following are the Netezza SQL commands to assign a user and a group with a priority level

```
-ALTER USER MMUDDU WITH DEFPRIORITY HIGH MAXPRIORITY CRITICAL;
-ALTER GROUP GROUP_NAME WITH DEFPRIORITY NORMAL MAXPRIORITY HIGH;
```

Apart from assigning priorities to a user or a group, Netezza also supports in assigning priorities to the user sessions. A user may have multiple high priority jobs to run throughout a single session. Using the 'ALTER SESSION', admin can grant the priority level to the session. Also, 'nzsession priority' can be used to assign the priority levels to a user session. The 'nzsession' command displays the current user sessions on a Netezza system along with the idle sessions. As mentioned earlier, the priority of a session can be altered using the 'nzsession priority'.

```
nzsession priority –CRITICAL –id SESSION_ID;
```
[7]

```
SYSTEM(ADMIN) => ALTER SESSION SESSION_ID SET PRIORITY TO CRITICAL;
```

Short Query Bias

Netezza categorizes the queries into two types – Short and Long. Short queries typically run very fast and Netezza defines a short query as the one with the run time less than two seconds. Long queries on the other side takes many seconds, minutes or hours to run depending upon factors ranging from the amount of data being pulled by the business intelligence team to complex queries having many joins and conditions. With SQB enabled, users running short queries are not impacted by the complex queries run by other users.

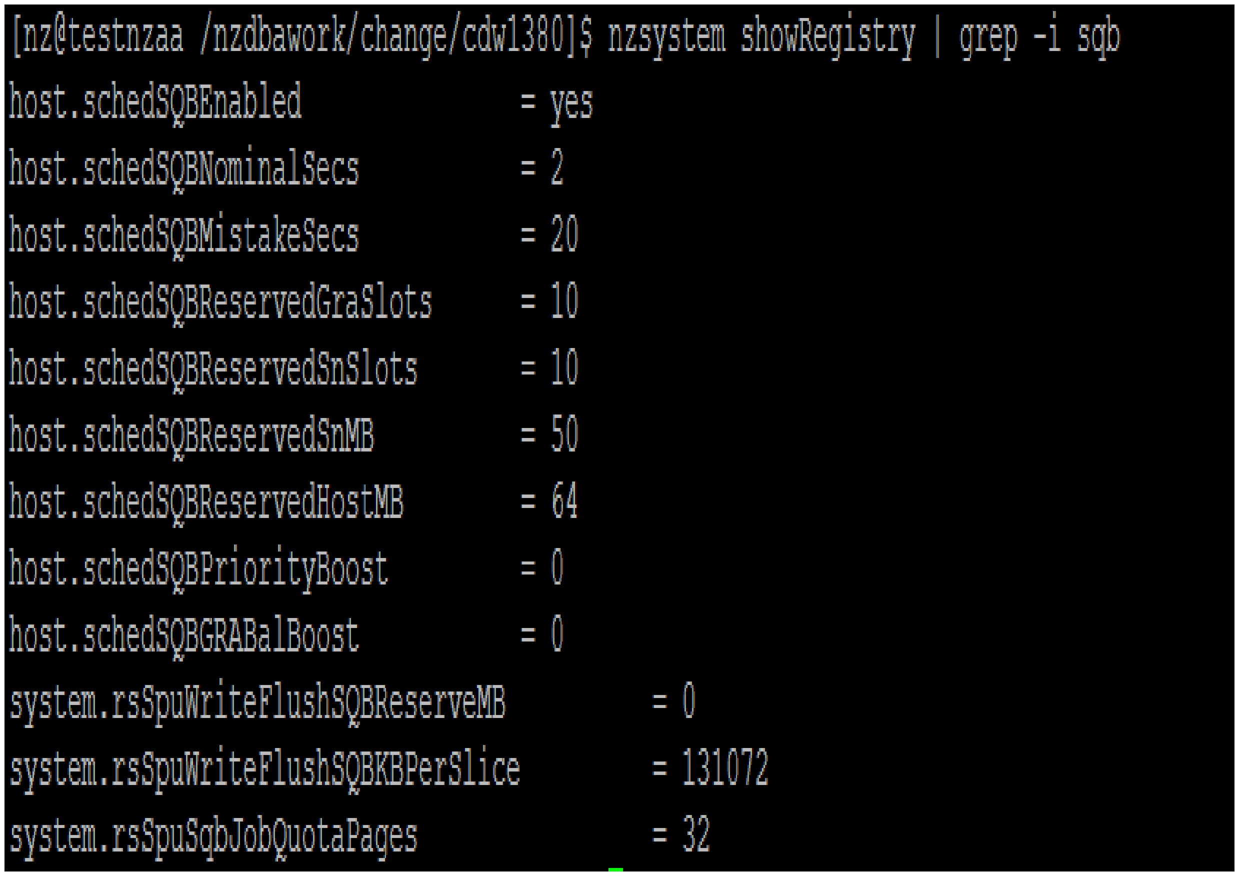
[7] *nzsession* is an inbuilt netezza tool which displays the active and idle sessions on a netezza server. For more usage run *"nzsession -?"*

Netezza favors the shorter queries over the longer queries, with the SQB enabled on the system. SQB is enabled by default on the Netezza system. With SQB enabled, Netezza reserves memory and system resources so that the shorter queries are run with no hindrance from the longer queries. This effect can make a large impact on performance. A short query typically includes a query which does either a quick look-up to retrieve data or dimensional data lookups. The run time duration of a short query can be changed but this change will require a system pause and resume operation. Long queries include multiple join operations across large tables which takes large amount of time for the system to process it.

Netezza is smart enough to differentiate the run of different queries. And this is because of Netezza' s internal feature 'prep' snippet which analyzes the run time of a query much before it is run on the system. Not only are the prep snippets but there are other factors the Netezza system relies on to distinguish run time of queries–Just-In-Time stats[8] and zone maps[9]. The queries usually go through the GRA and Snippet scheduler by forming queues. When the queues are occupied with no more queries being accepted by the scheduler, the scheduler then releases the additional allocated memory for the shorter queries, which is nothing but a separate queue for the shorter queries. Each of the schedulers, GRA and Snippet, reserves slots for the shorter queries.

[8] Netezza system automatically runs statistics on tables when a user queries against it. This is useful since it helps the optimizer function more efficiently thereby reducing the query run time.

[9] Zone maps are internal tables built virtually over the base tables. Netezza eliminates the need of having a query run over a large table by cutting it short to run over the zone maps. A zone map table is built on the table columns the query is running against more often.



```
[nz@testnzaa /nzdbawork/change/cdw1380]$ nzsystem showRegistry | grep -i sqb
host.schedSQBEnabled              = yes
host.schedSQBNominalSecs          = 2
host.schedSQBMistakeSecs          = 20
host.schedSQBReservedGraSlots     = 10
host.schedSQBReservedSnSlots      = 10
host.schedSQBReservedSnMB         = 50
host.schedSQBReservedHostMB       = 64
host.schedSQBPriorityBoost        = 0
host.schedSQBGRABalBoost          = 0
system.rsSpuWriteFlushSQBReserveMB         = 0
system.rsSpuWriteFlushSQBKBPerSlice        = 131072
system.rsSpuSqbJobQuotaPages               = 32
```

Figure 28. Short Query Bias System Registry Configuration

Table 5

Short Query Bias System Configuration Parameters

host.schedSQBEnabled	Enables SQB. Set to 1/true to enable.
host.schedSQBNominalSecs	Defines the “short” query definition duration. Default value 2.
host.schedSQBReservedGraSlots	Defines the number of GRA slots that are reserved for short queries. Default value is 10.
host.schedSQBReservedSnSlots	Defines the number of snippet scheduler slots that are reserved for short queries.
host.schedSQBReservedSnMb	Memory reserved on SPU for short query execution.
host.schedSQBReservedHostMb	Memory reserved on host for short query execution.

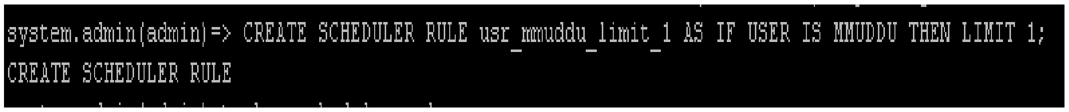
As described earlier, changes made to alter the estimated run time of a query requires system pause using the *nzsystem pause* command. After the registry changes are completed, resume the system using the command *nzsystem resume.*

Scheduler Rules

IBM has released a new workload management feature since its new NPS version release; v7.1[10]. A database administrator can write and set up custom rules which are executed by the netezza server. Based on the resources allocated through the guaranteed resource allocation, priorities set through the priority query execution and short query bias system's settings defined on a server, the scheduler executes a job. Scheduler rules take the priority over all the other WLM features defined on a server.

Syntax:

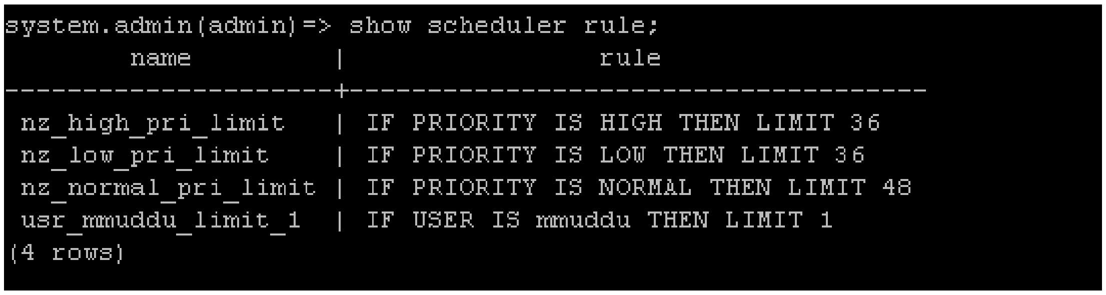
- Create scheduler rule



```
system.admin(admin)=> CREATE SCHEDULER RULE usr_mmuddu_limit_1 AS IF USER IS MMUDDU THEN LIMIT 1;
CREATE SCHEDULER RULE
```

Figure 29. Create Scheduler Rule

- Show defined scheduler rules

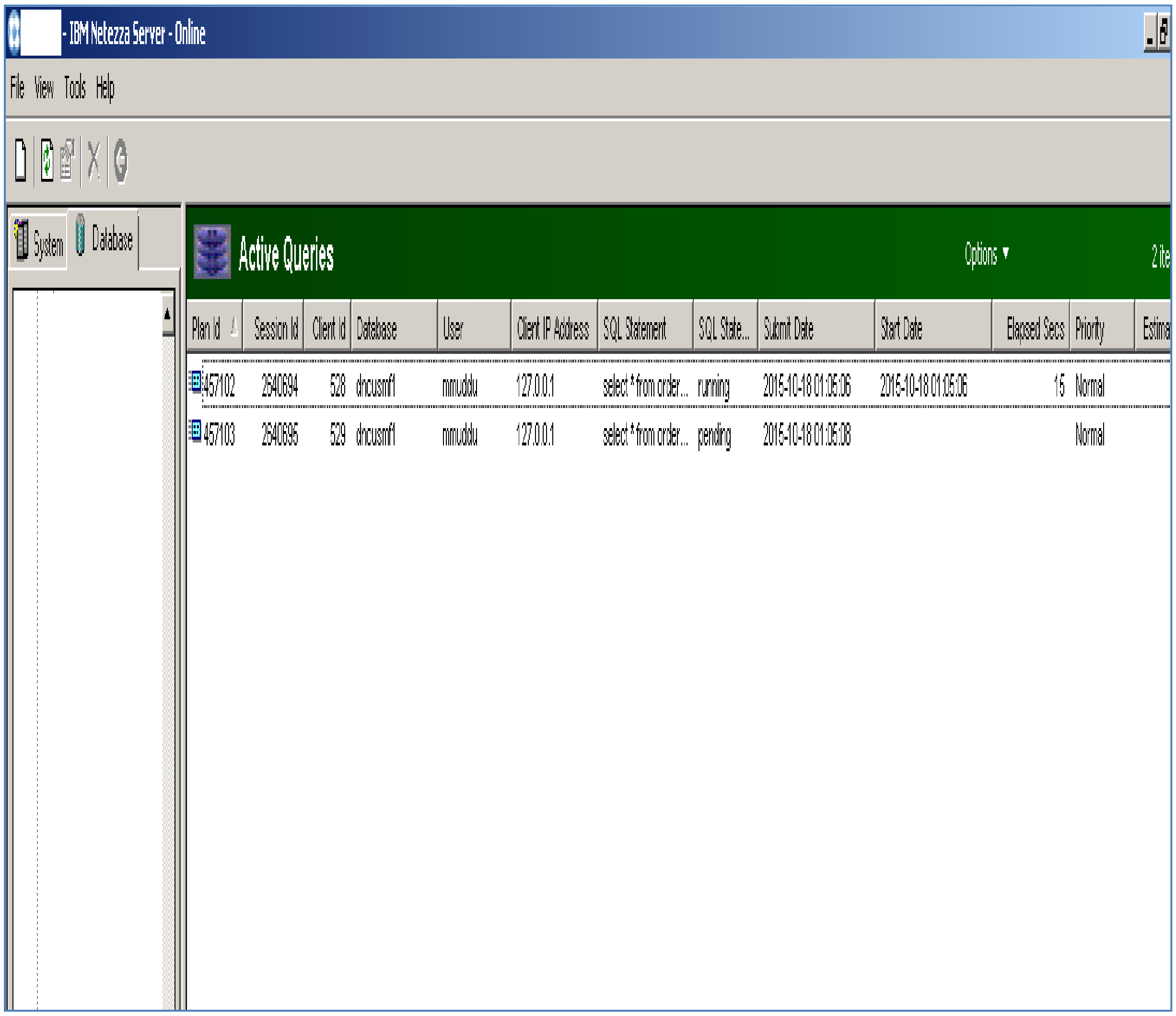


```
system.admin(admin)=> show scheduler rule;
        name         |                 rule
---------------------+-----------------------------------
 nz_high_pri_limit   | IF PRIORITY IS HIGH THEN LIMIT 36
 nz_low_pri_limit    | IF PRIORITY IS LOW THEN LIMIT 36
 nz_normal_pri_limit | IF PRIORITY IS NORMAL THEN LIMIT 48
 usr_mmuddu_limit_1  | IF USER IS mmuddu THEN LIMIT 1
(4 rows)
```

Figure 30. Current Scheduler Rules

[10] IBM released nps7.1 through the package 7.1.0.1-P1-IM-Netezza-NPS-fp78666 on May 15, 2014.

In the above example, a rule is defined to limit the number of concurrent queries the user 'mmuddu' can run on a system. Any other job run in concurrency will be queued up in pending state until the active job completes running.[11]



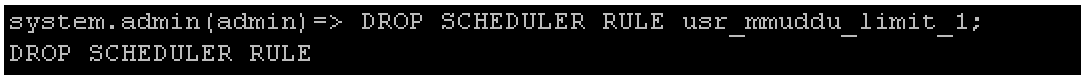
Plan Id	Session Id	Client Id	Database	User	Client IP Address	SQL Statement	SQL State...	Submit Date	Start Date	Elapsed Secs	Priority	Estima
457102	2640694	528	dncusmf1	mmuddu	127.0.0.1	select * from order...	running	2015-10-18 01:05:06	2015-10-18 01:05:06	15	Normal	
457103	2640695	529	dncusmf1	mmuddu	127.0.0.1	select * from order...	pending	2015-10-18 01:05:08			Normal	

Figure 31. Query Pending State

Similarly, a scheduler rule can be modified to change its actions or conditions or both the action and condition. Using the alter command a scheduler name as well as a tag attached to it

[11] The scheduler rules has been tested on a newer NPS version, 7.1.0.1.

can be renamed. Lastly, a scheduler rule can be dropped by running the drop scheduler command.



```
system.admin(admin)=> DROP SCHEDULER RULE usr_mmuddu_limit_1;
DROP SCHEDULER RULE
```

Figure 32. Drop Scheduler Rule

Scheduler Rule Syntax:

- One action
- Zero or more conditions to a defined action.
- To which users the action is applicable to.

Every job that is submitted to the system undergoes through the scheduler. Jobs which satisfy the scheduler rules undergoes through the defined action, else the job executes without any changes.

Scheduler rule are of two types:

Limitation: This rule limits the number of jobs that can run in parallel. For example the following rule limits the number jobs to 3 that can run concurrently with the group resource_misc_grp.

IF GROUP IS resource_misc_grp THEN LIMIT 3;

Any new jobs submitted are queued up until any one of the running job executes.

Modifying: This rule alters the job condition or in simple terms it alters the attributes of a job submitted to the scheduler. For example, the following rule changes the priority of a job submitted for the user group resource_misc_grp.

```
IF GROUP IS resource_misc_grp THEN SET PRIORITY TO HIGH;
```

Chapter V

IMPLICATIONS, CONCLUSION, AND RECOMMENDATIONS

Introduction

A fine mixture and combination of various workload management features needs to be tweaked and configured to achieve the best possible performance in a data warehouse environment. Based on the frequency of jobs that are run by the application teams a database administrator needs to configure the workload management on a server. This section provides the solutions to the study questions that were imposed in the earlier sections of the paper. A brief explanation is provided about the recommendations an external user can concur through this paper.

Implications

By configuring the workload management a database administrator can enforce the way a query runs on a server. Workload management rules are imposed based on the frequency of jobs run by the application teams. To conclude this section, each of the study questions imposed earlier in this paper will answered and justified.

1. ***How can the workload management feature enhance the Netezza system to handle concurrent queries of various complexities without much hassle?***

Jobs run by the various application teams are in large volume. Netezza is capable of handling up to 48 concurrent queries submitted to a system at any given instant. Not all the queries can run with the same complexity level, granularity and importance. One of the most recommended practices is to place priorities and allocate system resources to the jobs based on the database groups identified. With no priorities and resources configured, for example, a user running a query against a terabyte sized table can hamper the daily load jobs which run on a scheduled basis. Assigning system resources can help certain application teams as well as the batch jobs to utilize most of the available system resources to run the jobs faster. Moreover, having priorities placed in addition will provide an extra edge of boost in performance by having the higher priority jobs run before the lower ones.

2. ***The tools and bash scripts required to configure the workload management and how the predefined system configurations can be tweaked on the lines of workload management to achieve improvised performance?***

Workload management can be observed using the NzAdmin GUI interface. Three different ways you can visualize the resource management on a server.

The following figure illustrates the resource allocation summary of the four resource groups defined on a server. The graph in the figure depicts the system resources with which the jobs are running. X-axis denotes the time in 2hrs window and Y-axis denoted the number of jobs that have run during that specific time frame.[12]

[12] Resource allocation summary is one of the tools that exist on the netezza NzAdmin GUI interface. Concurrent queries were run between 2am - 8.15am EDT. The graph displays the percentage of system resources the queries ran with between 2:00- 8.15 am EDT.

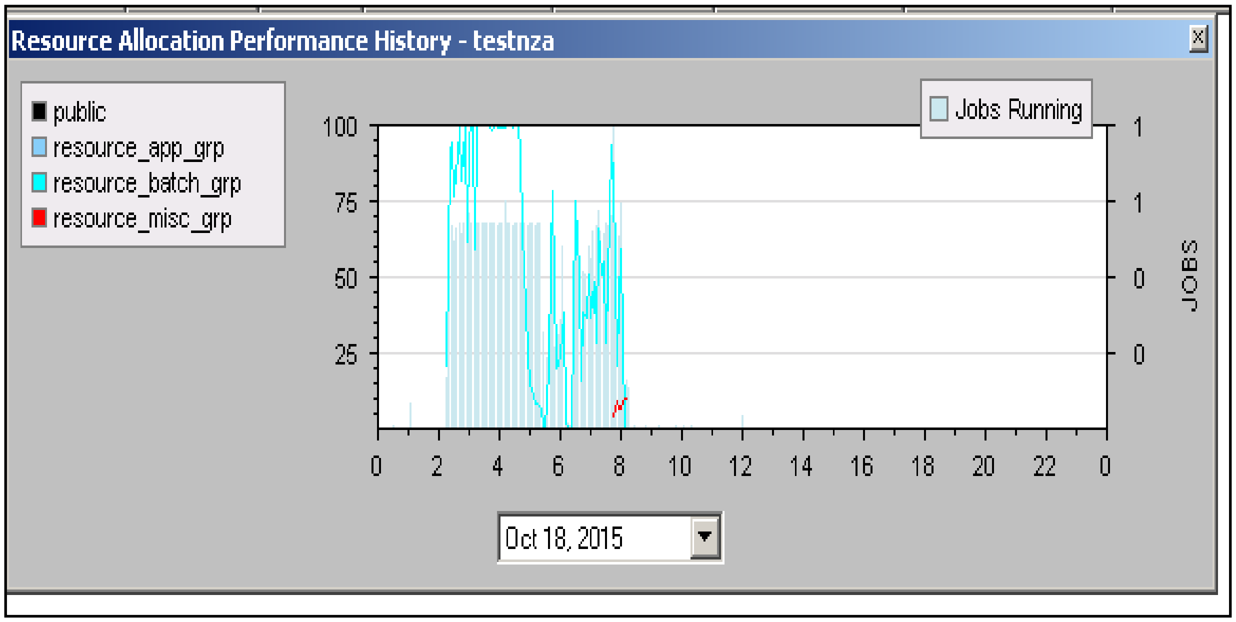
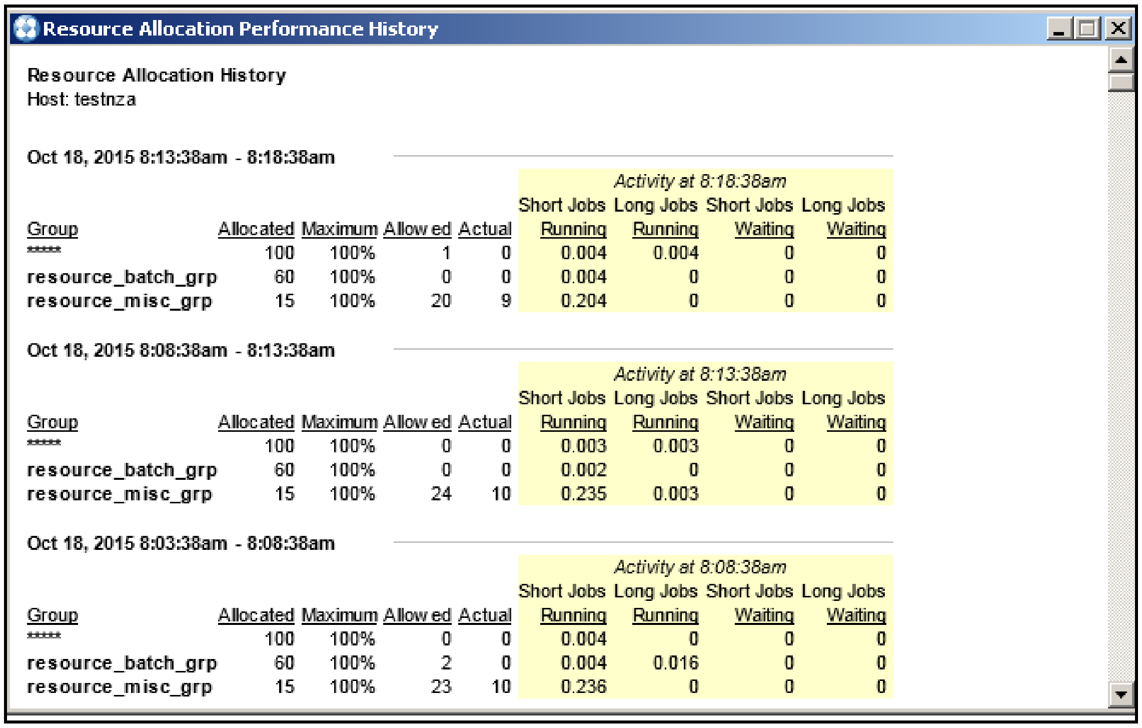


Figure 33. GRA Performance Summary



Resource Allocation History
Host: testnza

Oct 18, 2015 8:13:38am - 8:18:38am

					Activity at 8:18:38am			
					Short Jobs	Long Jobs	Short Jobs	Long Jobs
Group	Allocated	Maximum	Allow ed	Actual	Running	Running	Waiting	Waiting
*****	100	100%	1	0	0.004	0.004	0	0
resource_batch_grp	60	100%	0	0	0.004	0	0	0
resource_misc_grp	15	100%	20	9	0.204	0	0	0

Oct 18, 2015 8:08:38am - 8:13:38am

					Activity at 8:13:38am			
					Short Jobs	Long Jobs	Short Jobs	Long Jobs
Group	Allocated	Maximum	Allow ed	Actual	Running	Running	Waiting	Waiting
*****	100	100%	0	0	0.003	0.003	0	0
resource_batch_grp	60	100%	0	0	0.002	0	0	0
resource_misc_grp	15	100%	24	10	0.235	0.003	0	0

Oct 18, 2015 8:03:38am - 8:08:38am

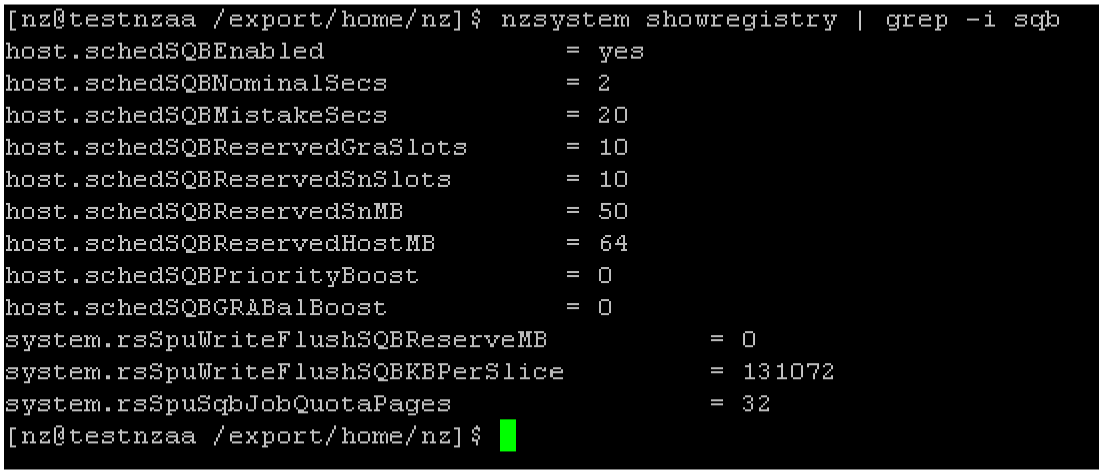
					Activity at 8:08:38am			
					Short Jobs	Long Jobs	Short Jobs	Long Jobs
Group	Allocated	Maximum	Allow ed	Actual	Running	Running	Waiting	Waiting
*****	100	100%	0	0	0.004	0	0	0
resource_batch_grp	60	100%	2	0	0.004	0.016	0	0
resource_misc_grp	15	100%	23	10	0.236	0	0	0

Figure 34. GRA Performance History

In order to check the history of the resource allocation, there is an option under the tools menu in the NzAdmin tool. The output of which can be seen in the Figure 26.

Workload management can be enabled, configured, and disabled through the system settings. Bash scripts can be designed to code the workload management. Other way around following are the various system parameters once can tweak under each workload management features.

Short Query Bias:



```
[nz@testnzaa /export/home/nz]$ nzsystem showregistry | grep -i sqb
host.schedSQBEnabled                 = yes
host.schedSQBNominalSecs             = 2
host.schedSQBMistakeSecs             = 20
host.schedSQBReservedGraSlots        = 10
host.schedSQBReservedSnSlots         = 10
host.schedSQBReservedSnMB            = 50
host.schedSQBReservedHostMB          = 64
host.schedSQBPriorityBoost           = 0
host.schedSQBGRABalBoost             = 0
system.rsSpuWriteFlushSQBReserveMB            = 0
system.rsSpuWriteFlushSQBKBPerSlice           = 131072
system.rsSpuSqbJobQuotaPages                  = 32
[nz@testnzaa /export/home/nz]$
```

Figure 35. Short Query Bias System Configuration Registry

There are two ways one can configure the workload management, temporary and permanent.

Temporary:

a. Pause the system – *nzsystem pause*

b. nzsystem set -arg setting=value

c. Resume the system – nzsystem resume

Permanent:

Parameter needs to be added, modified or removed in the configuration file in order to have the changes taking effect. The parameters can be found in the system.cfg configuration file. System needs to be restarted unlike pause to have the settings take place.

3. ***On what basis the workload management features needs to be assigned and allocated to? How the workload management is configured based upon the role of a database user or a database group?***

Workload management needs to be configured based on the role of application teams and batch jobs. It is always tricky for a database environment to have an ideal and static workload management setting since it needs to be tweaked often on a certain basis. With the dynamic change in data and application roles, the configurations are required to be tuned on a regular basis. User 'admin' carry the highest priority with majority of system resources allocated to it. And, there are user groups and applications teams which run the load jobs followed by the other user groups.

Conclusion

Although Netezza server runs on AMPP architecture, workload management needs to be configured in order to make the server run efficient and faster thereby providing rapid results. Various factors contribute to a performance of a server, including user data, database changes, and workload changes on an application level. A database server must be tweaked on a regular basis to achieve higher levels of performance. A smart mixture of guaranteed resource allocation (GRA), priority execution (PQE), gatekeeper (GK) configuration, and short query bias (SQB) is required to run the data warehouse system faster and easier. Improper system configurations can lead to a disaster. Performance of a database server is directly proportional to the performance of the system resources. The better the allocation of resources the better the server performs. Workload management parameters and system configuration needs to be assigned based on the role of users and user groups in a data warehouse environment. It is the responsibility of a Data modeler and database administrator to design the environment and identify the jobs and applications which require the higher priority edge over the other jobs. With no workload management configured jobs that are submitted to the system are going to run with the same allocation of resources. With resource allocation configured jobs assigned with higher allocation are going to run faster.

Future Work

The research in this paper can possibly be extended to a point where the entire process can be automated with minimal activity for a database administrator. Future scope relies on the number of additional configurations that are released by the product owner and the way it shapes a data warehouse environment. With a wide variety of workload management features and system configuration parameters there is a wide variance in configuring a data warehouse environment. Netezza currently comes with five predefined workload features along with more than a hundred system configuration parameters linked to each WLM feature. There is always a tremendous potential in solving numerous performance problems based on the data a company deals with along with the configurations of a workload management and system configurations.

Automating the workload management reduces the overhead work and high cost of ownership of maintaining a database administrator. With the newly released feature, Scheduling Rules, workload management can be automated greatly. Prior to this release, cron job was an option to automate the workload management. With scheduler rules, micro management of system resources has become possible. Using scheduling rules one can limit or enforce the number of concurrent queries, allocate system resources, and assign priorities, all this apart from custom rules that can be created.

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Appendix

Following are the netezza release notes which describes the improvements in the technical functionality, bug fixes and also the new features that are introduced in each of the released version,

NPS7.0.4.6p3

87682 - Fixes an issue where an NPS backup operation did not capture changes made by CREATE TABLE AS transactions that were running at the time of the previous backup increment.

87771 - Updates the Netezza Platform Software (NPS) and clients to use OpenSSL 0.9.8zb. This OpenSSL update includes a number of fixes and updates for reported vulnerabilities including CVE-2014-3505, CVE-2014-3506, CVE-2014-3507, CVE-2014-3508, and CVE-2014-3510. Refer to http://www.openssl.org/news/vulnerabilities.html for more information about the OpenSSL vulnerabilities and fixes.

89132 - Corrects an optimization rule to check whether joins between dimension tables and fact tables have hash joinable restrictions so that the optimizer can take advantage of pre-broadcast tables for join performance improvements.

NPS7.2.0.5p1

100729 -Fixes an issue where the nzhw command failed with an authentication error when using a database user account that has a cached password.

22907 (40482) - Improves the performance of queries that process large IN-LISTs due to a problem where runtimes could increase when the system appends values to the end of the list. This change speeds up the append process for the lists to reduce the query runtime.

71488 - Restores internal view lookup behavior to ensure that NPS uses the object name for lookups if the initial lookup of the object by internal object ID yields no results.

77183 - Fixes an issue where the runaway query event did not attach the query plan files to the event email in NPS release 7.0 and later.

86335 - Fixes an issue where NPS hosts showed false alerts that the hosts had exceeded the average power usage threshold. This nzhealthcheck monitoring has been disabled because it is not intended for the hosts in NPS appliances.

86472 - Fixes an issue where the query internal code generation calculated an invalid record size resulting in a SPU reset.

86638 - Fixes an issue where, after a restored database is renamed, backed up, and restored again, the restore fails to create views that reference other views because the view definitions reference the old database name. If users in your environment often rename databases between backup operations, consider running new full backups for those databases after you upgrade to a version of NPS that contains this fix.

87396 - Fixes an issue where internal routines that process expressions in the query planning did not record all the column information used in an expression, leading to a database restart.

88350 - Fixes an issue where privileges granted on system objects were failing.

88561 - Fixes an issue where a query that has a restrict operation that involves a join expression with a boolean equality operator could sometimes result in a database restart.

92148 - Fixes an internal query plan optimization that improves the performance of queries against the system catalog that join on multiple attributes.

92159 - Adds a notice message that can alert users when their queries return a subset of results because of a configured rowset limit for the user or the user's group. If a query returns a subset of results, the system writes the message "NOTICE: Rowset limit of <limit> applied" to the pg.log file. For ODBC/JDBC users, the SQLGetDiagRec()/ getwarning functions can show the notice when it occurs.

93333 - Adds a new command SHOW TEMP TABLE that lists all the temp tables that exist at the time the command runs, and size of the tables on the SPUs. The database user must have the System privilege to execute this command.

93514 - Fixes an issue where the ScanNode object in the plan file did not show the correct schema name for an object.

94002 - Fixes an issue where query performance for queries on the _v_odbc_columns* or _v_jdbc_columns* views took longer to complete.

94316 - Adds changes to help reduce query runtimes and memory consumption for queries that have nested selects and function calls in the projection list, such as select func(select(func(x))).

94656 - Fixes an issue where the nzload command failed with a "reference zone 1" error when the first column of the record to be loaded is defined as nullable and contains a null value.

94813 - Updates the internal nzdumpschema Support tool to collect more parameters like enable_simple_jit_avoidance to troubleshoot queries.

94886 - Fixes an issue where loads to a versioned table failed with errors such as 'ERROR: Column reference "rowid" not supported for views.' for special user table attributes referenced in the load.

95076 - Fixes an issue where the nzrestore command fails with an error "Cross Database Access not supported for this type of command."

95119/90082 - Adds a series of improvements to the CASE WHEN support to resolve issues such as pg_atoi errors that stemmed from internal temporary variable initialization problems.

95212 - Fixes an issue for IBM Netezza Replication Services environments where the subordinate nodes might not have received updated metadata files.

95217 - Fixes an issue where a join to a pre-broadcast table created a negative startup cost and biased the cost to ignore other more optimal join paths. If you had set the enable_2phase_cost_adj variable to false as a workaround for this issue, you should change the variable value back to true after you upgrade to NPS 7.0.4.9.

95251 - Fixed a rare timing issue where a system that had hundreds of concurrent sessions encountered a lock that prevented Netezza commands from running on the system.

95315 - Fixes an issue where the NzAdmin interface could hang when trying to access a locked database.

95695 - Fixes an issue where a query failed with the error "ERROR: parsenodes_mutator: Unexpected node type 103."

95830 - Fixes an issue where a false warning appeared for a backup and restore connector argument that did not apply for the backup connector specified in the command.

96038 - Adds support for Netezza backup and restore operations with a 64-bit Tivoli Storage Manager 7.1.x client.

96060 - Fixes an out-of-memory issue triggered when the single-slice throughput enhancement evaluates OR restrictions against a table's distribution key.

96182 - Fixes an issue where the optimizer ignored an additional filtering join to a pre-broadcast table even though the just-in-time (JIT) scan had identified that the pre-broadcast join was beneficial.

96338 - Fixes an issue where new database users created on an NPS system that is configured for LDAP authentication could not log in due to an expired password. The problem was due to an internal time representation change for password ranges.

96362 - Adds support for a Netezza file system backup connector option, FSYNC_DEST_BYTES, that throttles the host writes to an external file system by flushing the modified buffers after a specified number of bytes and waiting for the device to finish. This option helps to reduce cases where NPS host could restart and failover while writing data to a slow external file system. You can use the FSYNC_DEST_BYTES option to set a maximum write size before flushing the buffers, for example:

```
nzbackup -dir /home/user/backups -u user -pw password -db db1-v -connectorArgs
FSYNC_DEST_BYTES=65536
```

Note that the option will increase the overall time of the backup process, so you should not use this option unless file system backups are causing your NPS host to restart.

96545 - Fixes an issue where a database restore with the -nodata option created a view that had a different definition than the original view in the backup.

96614 - Fixes an issue where a query that called an EXISTS condition in a subselect could encounter a planner loop that caused NPS to restart.

96703 - Fixes an issue where the lastupdate column of _v_restore_history did not show the completion time of the restore operation.

96705 - In Netezza Replication Services environments, fixes an issue with parsing distribution keys in a by-value replication process that could cause a subordinate to suspend.

96792 - Fixes an issue where the nztmpwatch script was not cleaning up old dbos and sysmgr log files. The script was selecting files based on last access time, not last modified time, so older files were lingering beyond the cleanup date.

96948 - Adds support to verify that extent IDs never exceed the defined limit for their data type. Data slices which have invalid, large extent IDs could encounter problems that prevent zone maps from being created for those data slices.

97259 - In a Netezza Replication Services environment, adds the replHeartbeatLatency variable to control how long the system waits for a heartbeat before considering it a missed hearbeat, and the replHeartbeatMaxMissedInterval variable to specify how many consecutive heartbeats can be missed before the system triggers a missed heartbeat event. These settings help to tune the event notifications for the replication environment.

97330 - Fixes an issue where a GENERATE STATISTICS command failed with the error "Table size too big for caching."

97350 - Fixes a stored procedure issue where two processes attempt to drop the same transient table.

97472 - Adds a session variable enable_pullup_notexists_sublink that allows a user to disable ANSI standard behavior for correlated subqueries used in NOT IN/NOT EXISTS anti-join evaluation. Netezza behavior prior to 46364 (made in 7.0.2.11-P1 and later) did not follow ANSI standard behavior in terms of evaluating correlated subquery predicates that solely referenced the "outer" result set. The default for this session variable is true to use the ANSI standard behavior. To restore the original, non-ANSI, Netezza behavior, set the enable_pullup_notexists_sublink session variable to false.

97508 - Fixes an issue where a multi-stream restore from Tivoli Storage Manager backup tape drives could be blocked from completing.

97550 - Fixes an issue where in NzAdmin, displaying the object privileges for a database did not display any results. The NzAdmin interface now prompts the user for a database and a schema to display the privileges.

98178 - Fixes an issue where an external table contains an incorrect value INF for numerics and for cases where float and double data types are empty.

98188 - Fixes an issue where NPS upgrades that include a catalog upgrade (such as between major releases like 7.0.4.x to 7.1.0.x), the custom settings for system settings such as QUERYTIMEOUT, SESSIONTIMEOUT, ROWSETLIMIT, MAXPRIORITY or DEFPRIORITY were reset back to their default values.

98226 - Fixes an issue that caused an NPS restart while the system was reassembling a stored procedure definition and validating its UTF-8 correctness. This validation occurs when procedure definitions are stored in segments.

98427 - Fixes an issue where table statistics are not reset after a TRUNCATE table command. In 7.2.0.5 and later, NPS automatically resets table statistics after a TRUNCATE command. You can set the value to false to maintain the current 7.2.0.4 behavior to retain the table statistics and rowcount of the table before the TRUNCATE, which increase over time as new rows are inserted to the table. For more information, see http://www-01.ibm.com/support/docview.wss?uid=swg21959596.

98491 - Fixes an issue where the SPU kernel scheduler process checked the wrong task for a possible restart operation. This problem typically occurred on SPUs that were running many concurrent processes.

98691 - Fixes an issue where several system tables returned a "did not find any relation" error when used with the nzsql \d (describe) option.

98763 - Fixes an issue where the command to create a materialized view incorrectly returned the error "CTAS not permitted because of conflicting backup transaction."

98916 - Fixes system catalog performance for queries that directly or indirectly reference the system _v_obj_relation, _v_obj_relation_xdb, and _v_object_data views.

99210 - In Netezza Replication Services environments, fixes an issue where a delete by value command failed with an ambiguous column error because a user table column name matched an internal replication column alias. The change updates the internal alias names with a CSN suffix.

99310 - Fixes an issue in the internal casting of string literals used in SET operations which could result in invalid string literal values that cause the query to fail and restart the NPS software

99520 - Fixes an issue where TRUNCATE operations on tables did not clean up some internal resources, resulting in out-of-memory conditions on SPUs.

99533 - Improves call home behavior to ensure that user-initiated events do not cause a PMR to be opened unless they are specifically test events.

99741 - Changes the default setting to disable the snippet results cache feature on upgrades to 7.1.0.6 because it was optimized for specific types of workloads. For more information, see http://www-01.ibm.com/support/docview.wss?uid=swg21960526.

99742 - Changes the default setting to disable the single slice optimization feature on upgrades to 7.2.0.5 because the feature was optimized for specific types of workloads. For more information, see http://www-01.ibm.com/support/docview.wss?uid=swg21960527.

99790 - Fixes an issue where the IBM Netezza Software Support tools were not upgraded along with the NPS upgrade in a 7.2 patch release.

NPS7.2.0.5p2

95530 - Fixes an issue where all queries fail with the error "storage transaction table is full" and the user must stop and restart the system.

96684 - Fixes a code generation issue that added multiple nodes for a user-defined function, resulting in SPU resets.

98709 - Fixes an issue where the change for 85397 prevented the planner from leveraging the right outer join optimization for queries that join with fact tables. This change adds a variable enable_setop_dispersion_adj to disable the 85397 join dispersion improvement changes in cases where the right outer join optimization is more beneficial.

100813 - Improves the performance of bridge queries that compare a 32-bit integer data type to an OID data type.

100977 - Improves the performance of queries against system catalog views that were using a less efficient index to access the ACL system table.

101046 - Fixes an issue in multi-stream restore operations where a database backup that had user-defined functions required a long time to load the UDX objects.

101572 - Fixes an issue where a routine that reserves space in a metadata log for data slices was failing and preventing NPS from starting.

NPS7.2.0.6

92154 - Fixes an issue where a backup operation could fail if a vacuum operation ran concurrently with the backup. The system now aborts a vacuum operation when there is a backup already running on the system.

94159 - Adds support for Windows 8 in the NPS clients and drivers.

94868 - For NEC InfoFrame DWH Appliance models ZA25 and ZA50, fixes an issue where the nznetw command displays an incorrect status for the switch ports.

95530 - Fixes an issue where all queries fail with the error "storage transaction table is full" and the user must stop and restart the system.

96246 - Improves workload scheduling to check system resource utilization and, when lower utilization is detected, to schedule more queries to run to increase concurrency and utilization.

96999 - Improves support for the includeHeader feature of CREATE EXTERNAL TABLE to include alias names in the column names.

97067 - Fixes an issue that can help to reduce the time needed to generate a plan for a query.

97621 - Fixes an issue that prevented scheduler rules from supporting the serialization of INSERT INTO <table> VALUES... commands.

97334 - For IBM Netezza replication services environments, improves transaction management and queueing algorithms to improve the throughput of queries that are running on subordinate nodes.

97335 - For Netezza replication service environments, improves an internal troubleshooting tool to show which plan is in progress when a replapply is waiting to finish.

98232 - For an IBM PureData System for Analytics N3001-001 appliance, fixes an issue where a SPU could not be activated on the second host after the second host had restarted.

98454 - Fixes an issue where a blade memory check routine failed and caused DBOS to restart. The memory check failure occurred after a previous system pause/resume operation after which queries were automatically restarted.

98519 - Fixes an object lookup issue that caused an nzrestore to restart the NPS software when a user-defined function referenced in a view could not be resolved by the restore logic.

98687 - Fixes a rare timing issue that occurred when an internal routine that tracks SPU resource usage referenced a plan that was aborted, causing a database restart.

98696 - Fixes an issue where an UPDATE operation to an altered table that references rows by row ID failed with the error " List error in nth()."

98747 - Fixes an issue where an optimization that transforms qualifying OR lists into a subplan expression did not correctly handle certain cases where the OR list was enclosed in a NOT operator.

98814 - Fixes an issue where the data skew value shown in the _v_table_only_storage_stat view did not show the correct skew percentage.

98922 - Fixes an issue where a query that compares nchar or nvarchar data using operators such as < , <= , > , >=, BETWEEN, or LIKE could result in poor estimates and less efficient join processing.

98946 - Fixes an issue where a windowing aggregate query failed with a "pqFlush() -- connection not open" error.

99049 - Fixes an issue where the word AUTHORIZATION changed to become a reserved keyword. It should be a non-reserved keyword available for table or column names.

99055 - Fixes an issue where an nzrestore -incrementlist command unlocked a database.

99291 - Fixes an issue where the nzload command fails on a Windows client with "Error: NULL delimiter is not allowed for DateStyle : MONDY."

99775 - Fixes an issue where an upgrade to a patch release did not update some system views to apply changes that provide a performance improvement for queries that use those views.

99865 - Fixes an issue where a query that calls LAST_VALUE and uses a window aggregate was incorrectly converted to a FIRST_VALUE call for optimization, resulting in a "Partition rowcount limit exceeded" error.

100152 - Improves the latency based scheduler to apply the algorithms to High priority queries in addition to Normal priority queries.

100163 - Fixes an nzloader issue where the loader failed because of an unterminated record, but the failure message referred to an erroneous line feed character that is actually not present.

100263 - Fixes an issue where a query that uses a range between typecast values failed with the error "convert_timevalue_to_scalar: unsupported type 23" because unsupported data types were not handled correctly by internal casting routines.

100658 - Improves the ODBC and JDBC system views to improve performance. This change corrects an issue where the system views for version "2" (those named _V_JDBC_FUNCTION2, for example) were returning cross-database results; the views now return results for only the database where the query is running.

100866 - Fixes an issue where the NPS Linux ODBC driver manager did not set the client information fields for query connections, causing client information to be unavailable in the query history database.

100980 - Fixes an issue where a table is considered for pre-broadcasting but at the stage of consideration not all information is present to identify all columns that need projection. In such cases the table will not be considered as a pre-broadcast candidate.

101309 - Fixes an issue where a cross-database query run from a user database and which referenced a fully qualified SYSTEM view name used a view defined in the user database.

101348 - Fixes a timing issue in the SPU Linux kernel that could cause the SPU to lock up and require a SPU restart.

101535 - Fixes an issue in a SQL UPDATE command where the updated relation has an alias and the alias is used to reference a column in the target list.

101980 - Fixes an issue where queries on the system catalog run by a non-admin user account were not completing as quickly as for the admin user.