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OPTIMIZED SOLUTIONS

An Oracle Technical White Paper
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# Oracle Optimized Solution for PeopleSoft Human Capital Management Consolidation

## using M-Series servers, Flash and Enterprise Storage

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# Introduction

Whether deploying a new application service or modernizing existing business critical services, selecting and implementing a hardware architecture that will perform optimally and meet service level agreements is a complex process. With almost endless combinations of hardware components and new technologies, planning to meet today's needs, as well as future capacity requirements can be a daunting task.

This paper describes extensive testing of two modules in Oracle PeopleSoft Enterprise Human Capital Management (HCM) to demonstrate how Oracle's servers, disk storage and advanced flash based storage technology can be used to accelerate database transactions and enable unprecedented application performance.

Server consolidation is another deployment strategy that can help reduce the cost and complexity of architectures and control datacenter sprawl. Using electrically isolated server Domains and powerful virtualization tools integrated into Oracle's hardware server platforms this paper describes how Oracle can simplify the application architecture and increase hardware utilization levels.

The two modules referenced above are Oracle's PeopleSoft Enterprise Human Resources and PeopleSoft Enterprise Payroll of North America (NA). Although PeopleSoft modules can be implemented separately as independent applications, most organizations require multiple modules to address their HCM needs. This paper also describes how this can be done by clearly documenting the deployment and testing methodology used to verify both the scalability and speed achieved using Oracle's server and storage systems. For further reference, a sizing guide is also included in the document to help identify hardware options for different size environments.

The systems selected for this implementation are highly scalable in order to provide enough compute power for even the largest enterprises. The storage architecture leverages the latest in FlashFire technology for speed, and reliable enterprise class storage for capacity.

## A Brief Overview

Today's datacenters have large investments in Storage Area Network (SAN) based storage that offer exceptional storage capacity and performance. The challenge with spindle-based storage becomes apparent when the applications accessing them require high rates of throughput or large numbers of Input/Output (I/O) operations, which saturate the mechanical capabilities to the point where the spindles simply can't keep up. Historically, the solution has been to add more spindles – in the order of hundreds or thousands – that are minimally used for capacity but rather aggregated to provide higher I/O operations.

The traditional solution described above has long been used to address the problem, but the increasing cost pressures of administering these massive disk farms, floor space and increasing energy consumption and heat generation makes it increasingly difficult to justify the cost/performance trade-off.

The Sun Storage Flash Arrays offer a cost effective alternative to short-stroked hard drives for accelerating databases and I/O intensive applications. The technology can offer significant benefits when compared to hard drives as shown by the table below.

| METRIC | HARD DRIVE | ORACLE'S FLASHFIRE TECHNOLOGY |
|---|---|---|
| Input/Output operations per second (IOPS) | 200-500 per hard drive | 100k per F20 Flash Storage PCIe Card<br>Up to 1.6M (in a fully loaded F5100 Flash Array) |
| Devices needed to achieve 100k IOPS | 2,000 hard drives | One Sun Flash Accelerator F20 PCIe card |
| Devices needed to achieve 1.6M IOPS | 32,000 hard drives | One Sun Storage F5100 Flash Array |
| Latency (ms) | 2 | .378 |
| Power required for 1.6M IOps (kWh) | 68 (4000 disks / 18 racks) | < 0.4 (one array / one rack unit) |

The two PeopleSoft HCM modules selected for this architecture were the Payroll for North America and Human Resources. The reason for choosing the payroll module is that it represents a workload that is batch in nature requiring many transactions to occur sequentially in the database. Conversely, the HR module offers an online/transactional workload that will drive random transactions to the database.

By having both workloads implemented the test will represent a workload much closer to a real world scenario. In reality, an enterprise will host both modules in an environment that accesses the same database on a single infrastructure for reduced management and increased workload consolidation.

# Components

The key to choosing the right hardware elements resides in understanding the appropriate balance of performance, availability, cost and expected future capacity requirements. In order to better replicate a real enterprise class scenario, the deployment environment was implemented using systems that have integrated redundancy and reliability mechanisms. Below are the components selected for this scenario with the above criteria in mind.

## Software

### Oracle Solaris 10 10/09 operating system

Oracle Solaris is the ideal operating system for enterprises that need to solve challenging business and technical requirements, such as lowering costs, simplifying system administration, and maintaining high service levels. Its innovative, built-in features deliver industry leading performance and numerous advanced features including:

- Virtualization – Optimize resource utilization to deliver predictable service levels with Solaris Containers
- Networking – Near wire-speed throughput with the open, programmable Solaris networking stack
- Advanced Security – Integrated security, including Solaris Trusted Extensions, provides the isolation and control required by governments, financial institutions and HR environments without sacrificing hardware and application compatibility.
- High Availability –Predictive Self Healing, which enables Oracle hardware and services to maximize availability in the face of software and hardware faults and facilitates a simpler and more effective end-to-end experience for system administrators

### Oracle Database 11g Release 1

Oracle's database is the market-leader and the preferred database for hundreds of thousands of enterprises as well as application developers and database administrators worldwide. Over the years, enterprises have come to rely on the Oracle database to provide unparalleled performance and reliability.

Designed for data center environments that are rapidly evolving and changing to keep up with the demands of the business, Oracle Database 11g provides efficient, reliable and secure data management for mission-critical transactional applications, query-intensive data warehouses, and mixed workloads. With new self-managing capabilities, Oracle also eliminates time-consuming, error-prone administrative tasks, so database administrators can focus on strategic business objectives instead of performance and availability fire drills.

### Oracle PeopleSoft Enterprise (PeopleTools) 8.49

PeopleSoft Enterprise PeopleTools provides a comprehensive development toolset that supports the development and runtime of PeopleSoft Enterprise Human Capital Management applications. By leveraging metadata and other efficiencies within the toolset, application developers build and customize the PeopleSoft applications quickly and easily. Also, through the use of the delivered and robust middleware options and the PeopleSoft Integration Broker, PeopleSoft Enterprise PeopleTools supports the Service Oriented Architecture (SOA) that is becoming a development standard.

### Oracle PeopleSoft Enterprise Human Resources 9.0

PeopleSoft Enterprise Human Resources (HR) delivers comprehensive HR capabilities, from workforce management to compensation and talent management. Extensive business process automation and rich self-service capabilities are included to improve productivity while reducing operational costs.

At its foundation, PeopleSoft Human Resources offers an enterprise-wide human resources database to support myriad business processes, maintain historical records and job related data, report progress on critical HR functions, and facilitate better decision making.

### Oracle PeopleSoft Payroll for North America 9.0

Oracle's PeopleSoft Enterprise Payroll for North America ensures that your payroll is accurate, on time, and efficient payroll processing. PeopleSoft Payroll for North America is part of Oracle's PeopleSoft Enterprise Human Capital Management family of applications. Full database integration with other PeopleSoft products such as Time and Labor, Compensation, Recruiting, Project Costing, and General Ledger facilitates accurate, timely management and reporting of payroll expenses.

### Oracle WebLogic Server 9.2 MP3

Oracle WebLogic Server Enterprise Edition is the application server of choice for applications and services requiring enterprise-grade production used in demanding customer environments the world over. Comprehensive management capabilities enable administration of sophisticated systems via a well-designed graphical console and/or automation. Proven clustering technology, cross-domain management, and comprehensive diagnostic tools are standard with Enterprise Edition and the WebLogic Suite is well integrated with the rest of Oracle's portfolio for superior interoperability and support across the technology stack.

### Oracle Tuxedo 9.1

Oracle Tuxedo is the industry's #1 platform for distributed transaction processing. It provides mainframe-class scale and performance on open, distributed systems for software written in C, C++, and COBOL, and is the premier platform for "rehosting" mainframe applications on mainstream hardware. Oracle Tuxedo provides cost-effective reliability, extreme scalability up to

hundreds of thousands of transactions per second, and investment preservation by extending the life of existing IT assets as part of modern architectures such as SOA. Oracle Tuxedo is Oracle Fusion Middleware's strategic transaction processing product.

## Hardware

### SPARC Enterprise M8000 Server

Designed for large organizations and demanding applications that require 24/7 mission-critical, the high-end SPARC Enterprise M8000 server from Oracle delivers superior performance, unmatched reliability, availability and serviceability (RAS), and extensive expansion and virtualization capabilities. It can be customized with mix-and-match configurations using the latest high-performance SPARC64 VII quad-core and SPARC64 VI dual-core processors using the Oracle Solaris operating system. The SPARC Enterprise M8000 server is optimized for enterprise-class applications such as Enterprise Resource Planning (ERP), Customer Resource Management (CRM), Business Intelligence and Data Warehousing (BIDW), large databases, technical computing, and large-scale data warehousing and OLTP applications and databases.

### SPARC T3-1 Server

Oracle's SPARC T3-1 server is the platform of choice for Web infrastructure, Middleware workloads, and Application development. Delivering the world's first 16-core processor with unsurpassed throughput, the SPARC T3-1 server boasts speed, security, and unmatched availability to data in a sleek, compact design. Oracle's SPARC T3-1 server is a fully integrated system capable of running many virtual servers, helping drive up utilization, lower IT costs and keep server sprawl to a minimum.

### Sun SPARC Enterprise T5220 Server

Oracle's Sun SPARC Enterprise T5220 server offers security, speed, and scale for web infrastructure. It provides integrated on-chip 10 GbE networking, cryptographic acceleration and very efficient, low-power consumption in one rack unit (1RU). It is the first 64-thread, general-purpose server powered by the UltraSPARC T2 "system on a chip" processor. The processor packs up to eight cores and up to 64 simultaneous threads onto a single piece of silicon, together with the key functions of an entire system on a single chip—computing, networking, security, and I/O delivered in a compact 1RU form factor. The Sun SPARC Enterprise T5220 server offers the industry's only built-in and no-cost virtualization technologies with a choice of Oracle Solaris Containers and Oracle Virtual Machine for SPARC servers. By enabling up to 64 isolated domains per server, one can deploy more than 2,500 operating environments per rack for unparalleled server virtualization and consolidation.

### Sun Storage 6780 Array

Oracle's Sun Storage 6780 Array is an enterprise-class modular storage system that combines superior performance and price/performance with enterprise-class availability and scalability to

support business-critical enterprise applications and best-in-class investment protection. The systems include a rich set of data management features and data services at no extra cost, and with its relentless data density, performance, and seventh-generation architecture, Oracle's Sun Storage 6780 Array provides the highest reliability and availability in its class.

### Sun Flash Accelerator F20 PCIe card

Based on Oracle FlashFire technology, the Sun Flash Accelerator F20 PCIe card delivers the I/O performance of over 300 disk drives to minimize storage I/O bottlenecks such as storage latencies and help your servers and applications run faster and more efficiently. It speeds up applications, improves response times to maximize productivity while reducing space utilization and increasing power efficiency.

Each Sun Flash Accelerator F20 PCIe card offers 100k IOPS performance and 96GB of Flash storage on a single low-profile PCIe card. The integrated HBA provides hybrid storage management and saves on costs and space. Since no special software or drivers are required it is easy to implement.

### Sun Storage F5100 Flash Array

Oracle's Sun Storage F5100 Flash Array offers a new approach to solving the storage performance issues that slow down modern enterprise applications. With well over 1 million I/O operations per second (IOPS) in just one rack unit (1U) of space and using only 300 Watts of power at peak load, the system can help minimize storage bottlenecks, decrease latencies, and improve response times while conserving datacenter resources. Its power and space requirements are as much as 100 times lower than traditional disk drive solutions, dramatically improving transactional scalability while also reducing operating costs.

# Benefits

### A tested environment offers predictable results

This solution includes a guide to identify the hardware resources needed to run different size workloads. The guide provides a starting point for sizing a solution with mixed server and storage environments. When implementing a new environment, these starting points should shorten the overall deployment time and help predict the performance levels.

### RAS capabilities in M-series servers

RAS features come standard in the SPARC Enterprise M8000 server—features like automatic recovery with instruction retry, up to 1 TB of system memory error-correcting code (ECC) protection with extended ECC support, guaranteed data-path integrity, total SRAM and register protection, and configurable memory mirroring. Major system components are redundant and hot-swappable, providing the superior reliability and availability required by a 24x7 compute infrastructure.

### Choice of options for consolidation: Dynamic Domains and Oracle Solaris Containers

The SPARC Enterprise M8000 server is one in a family of systems Oracle hast o offer for consolidation. It supports up to 16 Dynamic Domains, enabling massive server consolidation and data center virtualization. Each physical domain can also be further optimized through the use of Oracle Solaris Containers, enabling each SPARC Enterprise M8000 server to support thousands of soft partitions.

Dynamic domains technology offers flexibility in resource allocation. This flexibility allows the system to accommodate workload changes depending on the various events that occur throughout the month or the year.

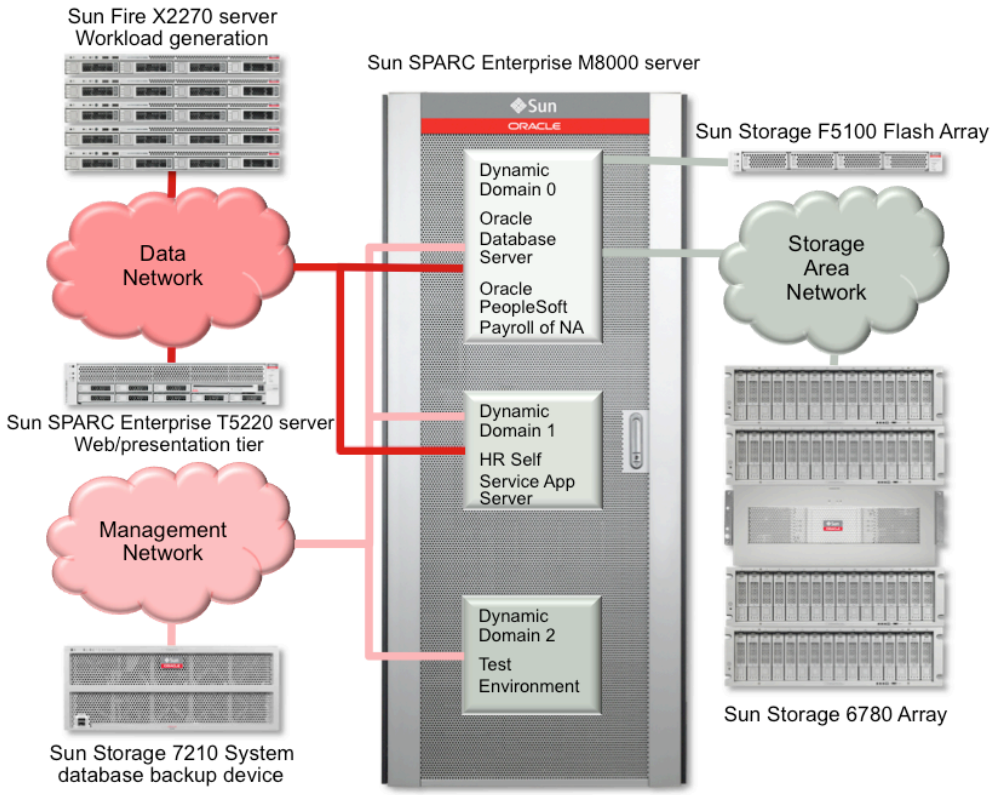
### Better Performance and Throughput by using Oracle's new Sun FlashFire technology

Based on Oracle's Sun FlashFire technology, the Sun Flash Accelerator F20 PCIe Card and the Sun Storage F5100 flash array devices allow customers to turbo charge applications instantly, improve response times, and reduce I/O latency. Databases and storage grids are two of the key applications of the Sun FlashFire technology.

When a system is configured with the Oracle FlashFire technology, it can accelerate applications and improve response times therefore offering improved productivity, space utilization and power efficiency. The use of it reduces storage latencies and minimizes I/O bottlenecks. The unit is high performance and offers highly reliable FlashFire technology that is easy to use with no need for special software or drivers required. Oracle's Sun FlashFire devices support multiple operating systems and integrate with Oracle Solaris Zettabyte File System (ZFS).

## Architecture

The diagram below represents a logical view of how the different dynamic domains in the Sun SPARC Enterprise M8000 server is partitioned in order to allocate resources to the different applications.




From the above diagram, the Sun SPARC Enterprise M8000 server performs most of the load running multiple infrastructure and application components. Domain 0 as outlined above is destined to run the Oracle Database 11g that will provide services to both the Oracle PeopleSoft Payroll of North America application that also resides on Domain 0 and to PeopleSoft Human Resources module for which the application server will run on Domain 1. For the HR system, a Sun SPARC Enterprise T5220 server runs the front end web server for on-line access.

For primary storage, Oracle's Sun Storage 6780 was used in combination with four storage trays that provide high performance bulk storage. The Sun Storage 6780 offers large volumes of storage. In addition to the drive arrays, the Sun Storage F5100 Flash Array storage device is also used to compare and contrast the performance of various storage mediums running the same

workload. Each of these devices has characteristics that in some ways overlap. This exercise will help identify how an application would benefit from having both types of storage in a mixed or hybrid environment.

A secondary storage tier is also implemented as a data repository and shared storage for backups. In this case an Oracle's Sun Storage 7210 device was used to leverage its vast 48-disk capacity and ease of use.

In order to generate sufficient load to simulate thousands of users accessing the Oracle PeopleSoft HR application simultaneously, a number of Oracle's Sun Fire X2270 servers were used to run the performance and load testing tool, LoadRunner.

## Workload Description

In order for scalability to be studied and understood, an adequate workload needs to be applied such that the systems under test (SUT) can be stressed and show the optimum utilization of the architecture under peak loads.

For this particular test, two workloads were chosen:

- PeopleSoft Payroll for North America batch workload
- PeopleSoft HR Self Service Online workload

The payroll workload requires very intensive compute and throughput (I/O) capabilities in order to perform the heavy batch jobs being executed, where as the HR workload offers on-line style workload with heavy throughput characteristics.

The North American Payroll batch workload measures five Payroll application business process runtimes for one database model representing a large organization. For this workload, different size tests were run up to 240,000 employee environments.

The five Payroll processes used are as follows:

- Paysheet Creation: Generates payroll data worksheets for employees, consisting of standard payroll information for each employee for the given pay cycle. The Paysheet process can be run separately from the other two tasks, usually before the end of the pay period.
- Payroll Calculation: Looks at Paysheets and calculates checks for those employees. Payroll Calculation can be run any number of times throughout the pay period. The first run will do most of the processing, while each successive run updates only the calculated totals of changed items. This iterative design minimizes the time required to calculate a payroll, as well as the processing resources required. In this workload, Payroll Calculation was run only once, as though at the end of a pay period.
- Payroll Confirmation: Takes the information generated by Payroll Calculation and updates the employees' balances with the calculated amounts. The system assigns check numbers at this

time and creates direct deposit records. Confirm can only be run once, and therefore, must be run at the end of the pay period.

- Print Advice Forms: This process takes the information generated by Payroll Calculation and Confirmation and produces an Advice for each employee to report Earnings, Taxes, Deductions, net pay and bank accounts where Net Pay were sent.
- Create Direct Deposit File: This process takes the information generated by Payroll Calculation and Confirmation and produces an electronic transmittal file used to transfer payroll funds directly into an employee's bank account.

The HR Self Service workload consists of measured client response times for 4,000 concurrent users. The thirteen PeopleSoft Enterprise HR business processes tested in this workload are as follows:

- EMPLOYEE SELF-SERVICE
  - eProfile
    - Update Home Address: Update address in Personal Data section.
    - Update Home Phone: Update phone number in Personal Data section.
  - eBenefits
    - View Benefits Summary: View overall benefits enrollment data.
    - Benefits Change Life: View benefits and alter the beneficiaries' allocations in the Basic Life Plan.
  - ePay
    - View Paycheck: View current paycheck information.
    - Update Direct Deposit Info: Add a direct deposit directive.
- MANAGER SELF-SERVICE
  - eDevelopment
    - View Employee Info: View job and personal information.
  - eProfile
    - Initiate Termination: Initiate a termination by recording an effective date and reason for termination.
    - Initiate Promotion: Initiate a promotion by entering a new job title and salary.
  - eCompensation
    - Initiate Employee Salary Change: Process a salary change for a single employee.
- HR ADMINISTRATION
  - Add a Person: Add a person and their biographical details.
  - Hire a Person: Enter the specified job data and work location, followed by the payroll and compensation details.
  - Add a Job: Add job details to an existing employee.

# Test Environment

The test environment was implemented as described previously in the Architecture section. In this section the in depth component configuration is described.

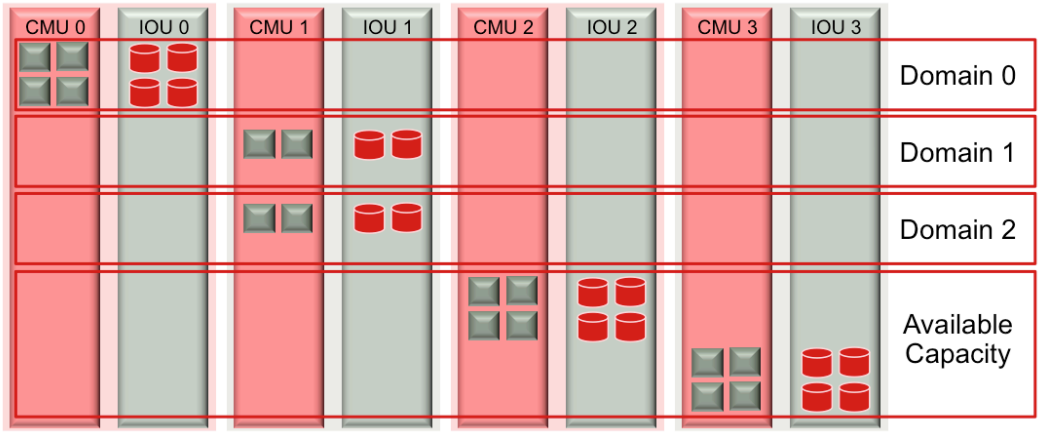
## Oracle's SPARC Enterprise M8000 server configuration

The system was initialized and partitioned into three independent dynamic domains. The first domain was responsible for hosting the Oracle Database as well as the PeopleSoft Payroll for North America so this domain was assigned four CPUs along with all of the memory in the first CPU/Memory module (also known as CMU) – CMU0. Each CPU is directly associated with one I/O module (IOU) and therefore one IOU – IOU0 – will be dedicated to Domain 0.

In order to accomplish the configuration outlined above, CMU0 must be used as a Uni-XSB configuration meaning that all four CPU's and all the memory in a CMU board are working together.

Two more Dynamic Domains were created by configuring CMU1 and IOU1 as a Quad-XSB, which means that the resources of the two boards were broken into four independent units and they become available for new domains. In this case, Domain 1 and Domain 2 were created using two CPU's, half the memory and half of the I/O resources in each board. The rest of the resources that are not allocated become available capacity for future expansion of the existing domains or for new domains that will run other applications.

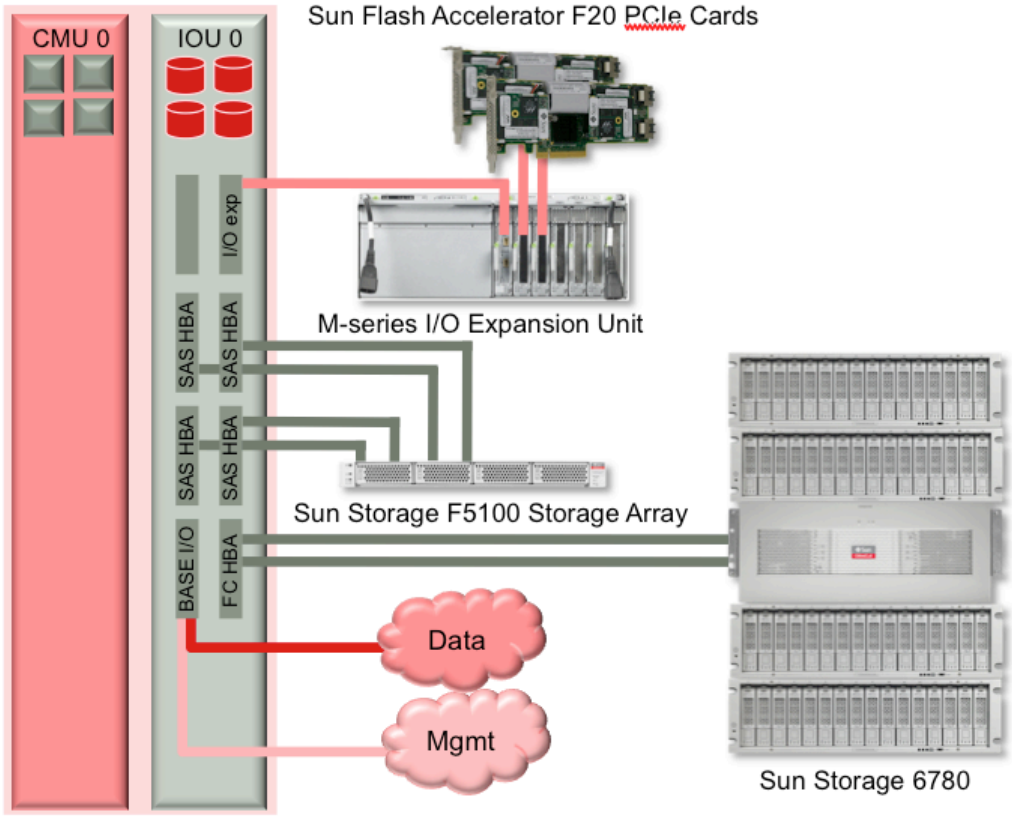
The final CPU and memory configuration is illustrated in the diagram below:




The I/O configuration consists of connecting each of the domains to the necessary devices for the applications running on those domains. Since Domain 0 will be accessing the database and all of the storage – both hard drive based and flash – then it will require SAS connectivity for the flash devices as well as Fiber Channel for the hard drives. The one exception is the Oracle FlashFire F20 card that will require to be attached directly to a PCIe slot. These cards were

inserted into an I/O expansion boat, which is attached to a PCIe slot on the IOU board assigned to Domain 0.

To attach the domain to the Sun Storage F5100 flash array, SAS HBA's were used and to attach the domain to the Sun Storage 6780 device, a Fiber Channel card was used. Network connectivity was leveraged from the Base I/O cards that include the network interfaces in addition to the HBA for the local/boot drives.




In order to achieve this configuration, the system administrator must access the remote management interface known as XSCF and assign resources to the domains as described above with a few commands. These commands are detailed in Appendix A.

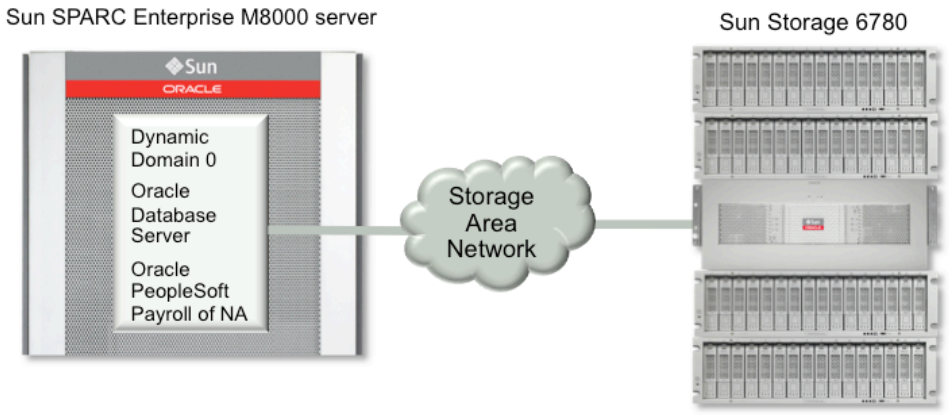
## Oracle's Sun Storage 6780 configuration

The Sun Storage 6780 storage system consists of a head node with two redundant controllers and no hard drives in the head node. The storage capacity is added using a number of storage trays using optical cables. In this scenario the Sun Storage 6780 was attached to four CSM200 trays with 16 hard drives each. One of the trays was completely loaded with SATA hard drives while the other three had Fiber Channel drives for a total of 16 SATA hard drives and 48 Fiber Channel drives.

# Test Results

## Test Case 1: Payroll batch with the database on the Sun Storage 6780 Array

The purpose of this test is to measure the performance of PeopleSoft Payroll for North America using traditional enterprise disks that are tuned for the workload at hand. Running this test will provide a baseline to which we can compare the follow-on test results provided by Test Cases #2 and #3.



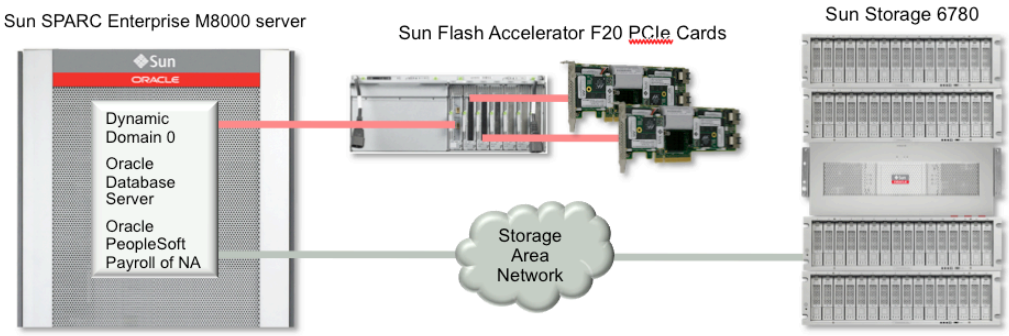

Using the above configuration for the deployment and running the predetermined workload in this environment the following results were accomplished:

| PAYROLL BATCH PROCESS USING THE SUN STORAGE 6780 ARRAY | 60K EMPLOYEES | | 120K EMPLOYEES | | 240K EMPLOYEES | |
|---|---|---|---|---|---|---|
| | ELAPSED TIME [MINUTES] | USER + SYS CPU UTIL % | ELAPSED TIME [MINUTES] | USER + SYS CPU UTIL % | ELAPSED TIME [MINUTES] | USER + SYS CPU UTIL % |
| PAYSHEET CREATION | 2.00 | 12 | 2.75 | 13.8 | 5.25 | 23.6 |
| PAYROLL CALCULATION | 6.27 | 22.1 | 12.30 | 28.9 | 26.53 | 27.6 |
| PAYROLL CONFIRMATION | 12.15 | 14.5 | 20.52 | 17.8 | 43.70 | 16.5 |
| PRINT ADVICE FORMS | 2.48 | 25 | 4.47 | 21.8 | 9.47 | 19.6 |
| DIRECT DEPOSIT | 1.25 | 4 | 4.45 | 4 | 4.50 | 4.4 |
| TOTAL TIME | 24.15 | | 44.79 | | 89.45 | |

These test results provide us with a baseline to which we can compare the results obtained with the architectures tested once flash technologies are introduced.

## Test Case 2: Payroll batch with the database on a hybrid storage environment

The purpose of this test is to measure the performance of PeopleSoft Payroll of North America using a combination of traditional enterprise disks and the Sun Flash Accelerator F20 PCIe card to form a hybrid environment.




Most customers already own Enterprise class storage like the Sun Storage 6000 series shown above. The key is that to achieve low latency, high throughput or high I/O operations (IOPS) large amounts of spindles or hard drives are needed to supply that throughput. In these situations, using flash in a hybrid implementation, where some of the data – particularly hot objects as outlined below – is stored on the flash device and the rest remains on the SAN attached storage is recommended. This offers the best high storage capacity and high IOPS/throughput in a smaller footprint with fewer spindles and consuming less power.

In this particular test, a few of the tables used by Oracle PeopleSoft were moved to the Sun Flash F20 PCIe card in order to enhance I/O performance and demonstrate the improvement that can be achieved by making simple changes to the storage architecture using a low cost flash device. The following tables and their indices were moved to flash storage for this test:

PS_PAY_EARNINGS, PS_JOB, PS_EARNINGS_BAL, PS_DEDUCTION_BAL, PS_TAX_BALANCE, PS_PAY_SPCL_EARNS

| PAYROLL BATCH PROCESS USING THE SUN FLASH ACCELERATOR AND SUN STORAGE 6780 | 60K EMPLOYEES | | 120K EMPLOYEES | | 240K EMPLOYEES | |
|---|---|---|---|---|---|---|
| | ELAPSED TIME [MINUTES] | USER + SYS CPU UTIL % | ELAPSED TIME [MINUTES] | USER + SYS CPU UTIL % | ELAPSED TIME [MINUTES] | USER + SYS CPU UTIL % |
| PAYSHEET CREATION | 1.75 | 14 | 2.50 | 20.7 | 4.25 | 22.4 |
| PAYROLL CALCULATION | 5.02 | 33.2 | 10.02 | 33.2 | 19.03 | 38.6 |
| PAYROLL CONFIRMATION | 9.68 | 17.1 | 16.70 | 20.8 | 37.80 | 17.9 |
| PRINT ADVICE FORMS | 1.73 | 25.3 | 3.22 | 32.5 | 6.73 | 36 |
| DIRECT DEPOSIT | 1.25 | 4.5 | 3.25 | 5.5 | 3.50 | 5 |
| TOTAL TIME | 19.43 | | 35.69 | | 71.31 | |

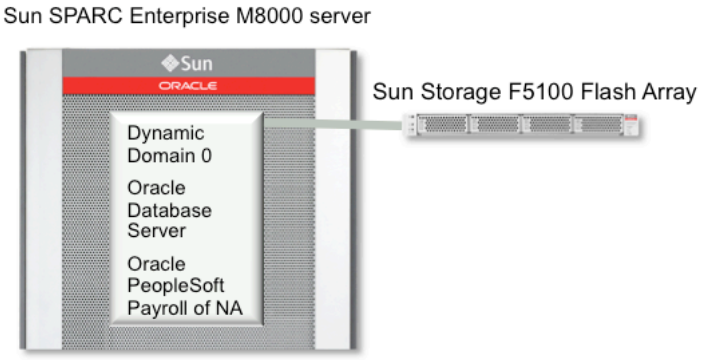
As seen from the above results, the improvement over using raw disk storage is significant considering that the inclusion of the Sun Flash Accelerator F20 PCIe card is really a minor architectural modification. The time improvement varies between 19% and 21% less time to complete the test than using traditional disk alone as shown in test case #1.

The database performance can further be improved if the following tables and their indices are also stored on the Sun Flash F20 PCIe card:

PS_PAY_TAX, PS_PAY_DEDUCTION, PS_PAY_CHECK and PS_PAY_LINE

### Test Case 3: Payroll batch with the database on the Sun Storage F5100 Flash Array

Given only flash storage is being used, this test is expected to render the highest performance. For this test the entire database is moved to the Sun Storage F5100 Flash Array except for the redo logs which were still hosted on the Sun Storage 6780:



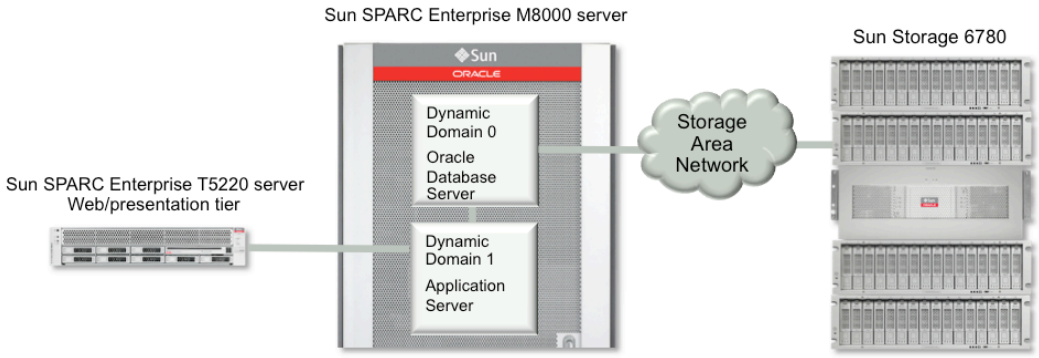

Using the architecture shown above, a noticeable improvement can be measured when the workload is run exclusively using flash storage technology:

| PAYROLL BATCH PROCESS USING THE SUN STORAGE F5100 FLASH ARRAY | 60K EMPLOYEES | | 120K EMPLOYEES | | 240K EMPLOYEES | |
|---|---|---|---|---|---|---|
| | ELAPSED TIME [MINUTES] | USER + SYS CPU UTIL % | ELAPSED TIME [MINUTES] | USER + SYS CPU UTIL % | ELAPSED TIME [MINUTES] | USER + SYS CPU UTIL % |
| PAYSHEET CREATION | 1.00 | 19.5 | 1.75 | 27 | 3.00 | 37.5 |
| PAYROLL CALCULATION | 4.25 | 34.8 | 8.50 | 42.2 | 17.27 | 44 |
| PAYROLL CONFIRMATION | 5.20 | 31.5 | 9.27 | 40.1 | 17.78 | 40.3 |
| PRINT ADVICE FORMS | 1.48 | 26 | 2.73 | 42.7 | 5.73 | 38.3 |
| DIRECT DEPOSIT | 0.75 | 5.5 | 3.75 | 5 | 3.75 | 5 |
| TOTAL TIME | 12.68 | | 26.00 | | 47.53 | |

These results show elapsed time reductions between 41% and 47% for payroll calculations as compared to test case #1 which uses traditional hard drive storage, demonstrating the advantage of using flash storage devices.

## Test Case 4: HR Self Service online workload with up to 4,000 concurrent users

The online services portion of the testing access database tables in a very different way than the payroll process. Users access the services and update information in a somewhat random way, so it is hard to predict which tables to include in the Flash storage devices. Still, since the SAN based storage devices are also high performance and high bandwidth, the users benefit from fast service times and responsiveness.




The above configuration represents the architectural components that were used for this particular test. For this test three tiers are implemented using the Sun SPARC Enterprise T5220 server for the front end to accept all the web requests. For larger configurations a SPARC T3-1 server should be used for greater scalability. The web server then communicates with the application server deployed in Dynamic Domain 1, which then communicates to the Database Server deployed in Dynamic Domain 0.

| HR SELF SERVICE ONLINE TRANSACTIONS | AVERAGE TRANSACTION RESPONSE TIME [SEC] | | |
|---|---|---|---|
| | 1K USERS | 2K USERS | 4K USERS |
| SEARCH | 0.83 | 0.87 | 1.03 |
| SAVE | 0.48 | 0.48 | 0.48 |
| ESTIMATED TRANSACTIONS PER MIUNUTE | 200 | 400 | 800 |

The next table documents the CPU and memory utilization for each of the Web, Application and Database tiers for reference in the sizing exercise.

| HR SELF SERVICE ONLINE TRANSACTIONS | 1K USERS | | 2K USERS | | 4K USERS | |
|---|---|---|---|---|---|---|
| | CPU % | MEMORY FOOTPRINT [GB] | CPU % | MEMORY FOOTPRINT [GB] | CPU % | MEMORY FOOTPRINT [GB] |
| WEB | 2.56 | 7.63 | 4.53 | 10.35 | 8.59 | 13.38 |
| APPLICATION | 5.56 | 6.11 | 11.10 | 6.19 | 31.40 | 6.38 |
| DATABASE | 1.61 | 13.35 | 3.56 | 13.35 | 9.82 | 13.64 |

These results show that the architecture used renders good results without any negative impact from the changes made to improve the Payroll batch workload test results.

## Sizing Guidelines

LEGAL DISCLAIMER - Expected performance characteristics are based on laboratory test implementations and are provided as is without warranty of any kind. The entire risk of the use of information provided herein remains with the recipient and in no event shall Oracle be liable for any direct, consequential, incidental, special, punitive or other damages including without limitation, damages for loss of business profits, business interruption or loss of business information.

For sizing guidelines, we provide hardware configurations for the workloads previously described as a starting point for Small, Medium, Large and Extra Large deployments based on the testing explained above. For accurate sizing information, contacting your local Oracle representative is encouraged and recommended.

The configurations outlined below refer to the CPUs used to run the tests described in this document, so it is recommended to use the latest and fastest CPUs available at the time of implementation.

### Small Configuration – up to 1,000 concurrent users and up to 60,000 payroll employees.

For this particular configuration, the following hardware components are recommended.

| | COMPONENT | CONFIGURATION |
|---|---|---|
| Storage | Sun Storage 6180 | 1 to 3 expansion trays |
| Servers | Database server: Sun SPARC Enterprise M4000 | 2 x CPU's and 16GB of RAM |
| | Application: server Sun SPARC Enterprise M3000 | 1 x CPU and 8GB of RAM |
| | Web server: Sun SPARC Enterprise T5220 or SPARC T3-1 | 1 x CPU and 8GB of RAM |
| Flash Storage | Sun Flash Accelerator F20 PCIe card | 1 in the Sun SPARC Enterprise M4000 server |

The storage portion of this configuration is described as a single Sun Storage 6180 which can have up to 16 hard drives and can be further be expanded to an additional 1-3 trays with 16 drives each for a capacity of 128 TB of raw storage capacity, which should be more than sufficient storage for the application discussed in this paper. Since it's a SAN array, it can also be used for multiple applications when it's carved into LUNs and sharing them over the network.

The server portion of this configuration suggests an Oracle Sun SPARC Enterprise M4000 server to use as a database in a configuration with two CPU's and 16GB of RAM offering plenty of expansion capabilities or the opportunity to run other applications in the available headroom. If other CPU's are added, an additional dynamic domain can be configured which can be used for the application server as an alternative to the suggested Oracle Sun SPARC Enterprise M3000

server with a single CPU and 8GB of RAM for the application tier. On the front end or presentation layer (web tier), the Sun SPARC Enterprise T5220 server is suggested because of its high throughput capabilities on web-based applications, small footprint and low power consumption.

For database acceleration, the Sun Flash Accelerator F20 PCIe card is recommended as a configuration option for the Sun SPARC Enterprise M4000 to accelerate the processes associated with the payroll application. This is an entry level flash device and that is configured internally on the Sun SPARC Enterprise M4000 server.

### Medium Configuration – up to 2,000 concurrent users and up to 120,000 payroll employees.

The next step in growth from the previous recommendation is really on the compute area of the architecture. The storage recommendations remain consistent but an additional option is suggested for environments that can leverage an even more consolidated storage environment.

| | NOTES | COMPONENT | CONFIGURATION |
|---|---|---|---|
| Storage | | Sun Storage 6180 | 1 to 3 expansion trays |
| | Alternate for greater storage capacity | Sun Storage 6580 | 4 to 16 expansion trays |
| Servers | | Database server: Sun SPARC Enterprise M4000 | 2 – 4 x CPU's and 16GB of RAM |
| | | Application server Sun SPARC Enterprise M4000 | 2 x CPU and 16GB of RAM |
| | Alternate configuration for a consolidated approach using dynamic domains | Database server: Sun SPARC Enterprise M5000 Domain 0 | 2 – 4 x CPU's and 16GB of RAM |
| | | Application server: Sun SPARC Enterprise M5000 Domain 1 | 2 CPU's and 16GB of RAM with spare compute capacity |
| | | Web server: Sun SPARC Enterprise T5220 or SPARC T3-1 | 1 x CPU and 16GB of RAM |
| Flash Storage | Lower cost solution | Sun Flash Accelerator F20 PCIe Cards | 2 in Sun SPARC Enterprise server used for database |
| | Alternate for future expansion option | Sun Storage F5100 Flash Array | 20 Flash Modules |

The Sun Storage 6580 offers a significant increase in storage capacity and features that can be used for larger, consolidated environment. The database and application servers can either be split into two M4000 systems with capacity for growth or they can be consolidated into a single M5000 that runs both database and application server environments in two dynamic domains. On the front end or presentation layer (web tier), the Sun SPARC Enterprise T5220 server is suggested because of its high throughput capabilities on web-based applications, small footprint and low power consumption.

For database acceleration, the Sun Flash Accelerator F20 PCIe card is recommended as a configuration option for the Sun SPARC Enterprise M4000 to accelerate the database processes associated with the payroll application. It is an entry-level flash device and that is configured internally on the Sun SPARC Enterprise M4000 or M5000 server.

### Large Configuration – up to 4,000 concurrent users and up to 240,000 payroll employees.

The following recommendation represents the natural progression of the trend we see from the previous sizing exercises. In this case, the larger Sun Storage 6780 head node is chosen not only for its large capacity and reliability features but also for the throughput capabilities this platform offers. Again, 8-28 expansion trays can be configured for capacity considering that this device can be used for multiple applications sharing the controllers and therefore consolidating the datacenter storage footprint.

| | COMPONENT | CONFIGURATION |
|---|---|---|
| Storage | Sun Storage 6780 | 8 to 28 expansion trays |
| Servers | Database server: Sun SPARC Enterprise M5000 | 4 x CPU's and 32 GB of RAM |
| | Application server: Sun SPARC Enterprise M4000 | 2 x CPU's and 32 GB of RAM |
| | Web server: Sun SPARC Enterprise T5220 or SPARC T3-1 | 1 x CPU and 32 GB of RAM |
| Flash Storage | Sun Storage F5100 Flash Array | 40 Flash Modules |

For the database and process scheduler (batch server), it is recommended that Oracle's SPARC Enterprise M5000 server be configured with 4 CPU's and 32GB of RAM, which can be expanded if necessary. Due to the I/O requirements of the solution, the database server and payroll application of the solution take advantage of the additional I/O that the Sun SPARC Enterprise M5000 has to offer.

For the application server, an M4000 server can be configured with two CPU's and 32GB of RAM and to complement the front end presentation layer the Sun SPARC Enterprise T5220 with a single CPU and 32GB of RAM can provide the throughput necessary for PeopleSoft HR Online Self Service.

For database acceleration, the Sun Storage F5100 flash array is recommended as a configuration option for the SPARC Enterprise M5000 to accelerate the database processes associated with the payroll application. This option offers advanced acceleration as a high performance flash device attached through four SAS HBA's for increased throughput.

## Extra Large Configuration – up to 8,000 concurrent users and up to 500,000 payroll employees.

For the largest enterprises, the corresponding configuration is listed below:

| | NOTE | COMPONENT | CONFIGURATION |
|---|---|---|---|
| Storage | | Sun Storage 6780 | 8 to 28 expansion trays |
| Servers | | Database Sun SPARC Enterprise M5000 | 8 x CPU's and 48GB |
| | | App server Sun SPARC Enterprise M5000 | 8 x CPU's and 48GB |
| | Alternate configuration for a consolidated approach using dynamic domains | Database Sun SPARC Enterprise M8000 Domain 0 | 6 x CPU's and 48 GB |
| | | App server Sun SPARC Enterprise M8000 Domain 1 | 6 x CPU's and 48 GB |
| | | Web Server Oracle SPARC T3-1 | 1 x CPU and 48 GB |
| Flash Storage | Lower Cost Solution | Sun Flash Accelerator F20 PCIe card | 4 in database server |
| | Alternate for future expansion option | Sun Storage F5100 Flash Array | 40 FMODs |

The storage environment is chosen by the fact that extra large environments will be able to leverage an Sun Storage 6780 extensively for multiple applications including PeopleSoft Enterprise. It will provide capacity for future growth and offers a full feature set to address enterprise's needs.

For the database servers, two options are featured giving the option of using SPARC Enterprise M5000 servers to host the database and the application tiers as well as provide database services to the PeopleSoft HR module. The second option is to use a SPARC Enterprise M8000 system, like the one described in this document that can be partitioned to allocate resources to the database in a dynamic domain. The rest of the resources can be used for other purposes, such as the application server in the PeopleSoft HR module.

The application server can also be deployed using a second M5000 server with 6 CPU's and 48GB of RAM or as mentioned above in an M8000 using a separate dynamic domain. To complement the front end presentation layer (web tier), a Sun SPARC Enterprise T5240 with two CPUs and 48GB of RAM can provide the throughput necessary for PeopleSoft Online Self Service.

For database acceleration, the Sun Storage F5100 flash array is recommended as a configuration option for the M5000 to accelerate the database processes associated with the payroll application. This option offers advanced acceleration as a high performance flash device attached through four SAS HBA's for increased throughput.

# High Availability

Most companies that have PeopleSoft Human Capital Management need continuous access to the online self-service applications. This requires that the architecture be designed with a failover or disaster recovery plan in mind. A simpler failover architecture that allows the services to quickly migrate to equivalent systems in the same datacenter or a more robust failover architecture that allows the services to be operational even in the face of total loss of the infrastructure such as a natural disaster or severe communications breakdown. These two scenarios are explained in more detail below.

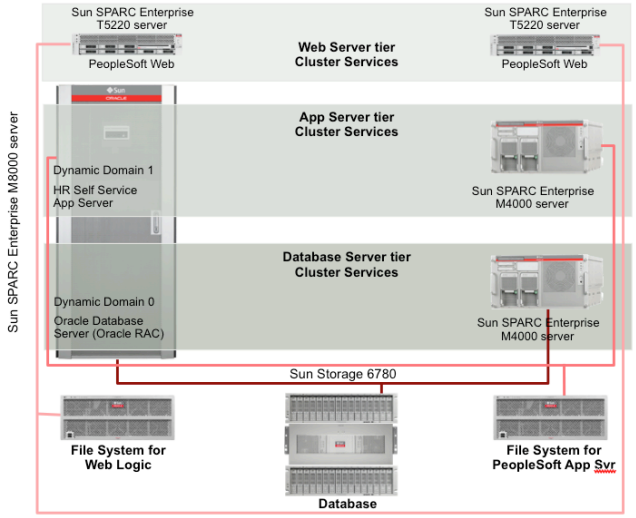
Oracle Solaris Cluster has an agent developed for PeopleSoft HCM online self-service applications that simplifies the deployment of an environment ready for failover or disaster recovery. In the following paragraphs, this architecture is broken down into different aspects of an implementation including the use of hardware, software and best practices.

## Local clustering

Businesses or applications that need to minimize recovery times and recovery point objectives (RPO's) need more proactive strategies, including highly available clusters. A cluster is a collection of tightly-coupled computing nodes that provide a single view of application services, including databases, Web, and file services. A cluster implemented with Oracle Solaris Cluster offers several benefits, including restart, failover, and scalable services; capacity for modular growth; flexibility for changing requirements, and a low entry price compared to fault-tolerant systems. In addition, it simplifies management of planned downtime of individual servers within a cluster, and creates a foundation for disaster recovery capabilities.

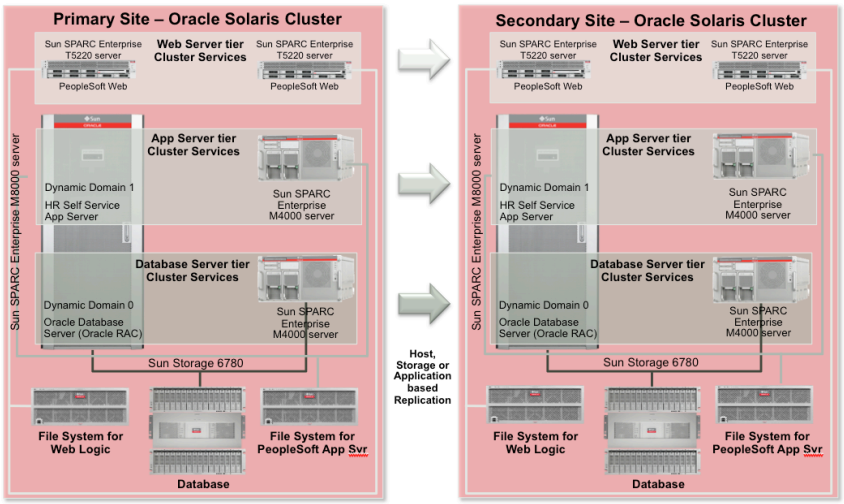
A local cluster involves two or more physical machines (nodes) that may share common disk storage and logical IP addresses. When an error is detected in one of the nodes, the cluster software will switch the clustered services over to the secondary machine. Oracle Solaris Cluster offers high availability for today's complex solution stacks, with failover protection from the application layer through to the storage layer.

The diagram below represents one way to build a local cluster using asymmetrical hardware configurations. This cluster could also be built using identical systems by configuring two SPARC Enterprise M8000 servers, but this example shows the flexibility that the clustering technology has to offer.




## Campus and Metropolitan Clustering and Long Distance Failover

The next level of availability is to extend a cluster to another room or across a campus. When planning a disaster recovery infrastructure, it's important to note that local clustering can provide a solid level of continuous service availability in the event of application, operating system, or hardware failure in a single datacenter, but it does not provide site-level disaster tolerance against disasters. Campus clustering enables components, such as nodes and shared storage, to be located up to 400 kilometers apart. In the event of a localized disaster such as a flood, fire, or building power outage, the surviving nodes can support the service for a failed node. This solution offers some site-level tolerance, but the short distance limits survivability of the cluster and its services for larger disasters like earthquakes or power grid outages. Oracle Solaris Cluster Geographic Edition extends Oracle Solaris Cluster, offering the control and flexibility required when working with long distances.



## Oracle Solaris Cluster for PeopleSoft Enterprise PeopleTools

HA for PeopleSoft Enterprise provides fault monitoring and automatic failover for the PeopleSoft Enterprise application to eliminate single points of failure in a PeopleSoft Enterprise system. Any PeopleSoft Enterprise application runs on the PeopleSoft Enterprise PeopleTools three-tier architecture. Oracle Solaris Cluster orchestrates the startup, shutdown, and failover of the PeopleSoft Enterprise PeopleTools components. The following table lists the data services that protect PeopleSoft Enterprise PeopleTools components in an Oracle Solaris Cluster configuration.

The following table provides a description of the protection elements for PeopleSoft Enterprise PeopleTools components:

| PEOPLESOFT ENTERPRISE PEOPLETOOLS COMPONENT | PROTECTED BY |
|---|---|
| Database server | Depends on the data service for the database that you are using, for example:<br>For the Oracle database, the data service is explained in the Oracle Solaris Cluster Data Service for Oracle Guide.<br>For the Oracle RAC database, the data service is explained in the Oracle Solaris Cluster Data Service for Oracle Real Application Clusters Guide. |
| Application server | The data service is HA for PeopleSoft Application Server.<br>The resource type is `ORCL.PeopleSoft_app_server`. |
| Web server | The data service is explained in the Oracle Solaris Cluster Data Service for WebLogic Server Guide. |

## Conclusion

Testing shows that introducing flash technologies to an existing architecture or building one from scratch with the use of these high performance components can increase performance to new levels with simple changes to the configuration. In the data shown above, even a small amount of flash storage may increase performance by ~20%, and using larger capacity of flash storage technology up to ~47% of performance improvements can be seen relative to traditional disk storage.

This exercise also showed that fewer spindles can be used to store the entire database and fully utilize each hard drive to increase storage density in these high performance SAN attached devices. The PeopleSoft HR module helped verify this by confirming that service response times remained good when using this traditional storage device.

The SPARC Enterprise M8000 server helped consolidate the entire environment into a single managed server leveraging the Dynamic Domains technology, which offers the complete separation of different applications or modules. The managed environment can further be enhanced in the datacenter by using the other management tools from Oracle including Oracle Ops Center and Oracle Enterprise Manager for a complete and integrated managed environment.

Overall, these results lead us to the conclusion that Oracle's integrated stack of end to end products may offer great benefits to the customer given its highly competitive products and highly integrated environments.

# Best Practices

Optimizing the performance of the workload is key to drive the solution to obtain the best possible results. In order to do this, specific tunings were tested in the process of this proof of concept. The result of this tuning exercise is documented in the next paragraphs.

The best practices described here were extracted from an earlier paper for which the full text can be found at the following URL:
https://www.sun.com/offers/details/peoplesoft_enterprise_payroll.xml

Even though the section titles explicitly mention "Payroll" or "HR", these tuning recommendations are applicable to the majority of batch and online PeopleSoft workloads with little or no changes.

### Tuning configurations for PeopleSoft Payroll for North America

It is a recommend practice to set up concurrent execution for batch jobs. The following two steps are essential in setting up the concurrent execution:

- 1. Set up requires a number of PSAESRV processes on the process scheduler server. Set the value of Max Instances to the desired number in the [PSAESRV] section in the `psprcs.cfg` configuration file.
- 2. Log in to PIA and set the same value for the Max API Aware field in the Process Scheduler —> Servers —> PSUNX —> Server Definition Web interface. The Max API Aware value should be larger than or equal to the total of Max Concurrent value set for all of the process types including Application Engine.
- 3. Split the workload into multiple batch jobs

Another recommended practice is to monitor the database performance for suboptimal queries and to improve the performance of these queries using various database techniques. It is usually not a recommended practice to edit the queries that are initiated by the application. However, some situations may demand editing the queries to achieve a performance improvement.

Oracle might not support rewriting the SQLs. Restrict SQL editing to adding hints. Consult Oracle support before editing SQLs on your own.

### Dynamic Statistics Gathering for Temporary Tables

PeopleSoft's Process Scheduler uses temporary tables in some of the batch processes. These temporary tables may have few or no rows in the beginning of a batch process. Rows of data will be added and removed as the batch process executes, and in the end, these tables are left with few or zero rows. If the statistics on a temporary table which is emptied, repopulated and used

during a batch process do not accurately represent the content of the table, the database optimizer may choose an execution plan that is not optimal. Hence keeping the statistics current for this kind of temporary tables is challenging. To minimize the impact, the `%UpdateStats` construct in Process Scheduler configuration can be used as a workaround.

Setting `DbFlags` bitfield to a value of 0 (zero) in the Process Scheduler configuration file turns on the `%UpdateStats` construct. When turned on, the PeopleSoft Application Engine replaces this meta-SQL construct with a platform-dependent SQL statement that updates the system catalog tables used by the database optimizer in choosing optimal query plans. Having the update statistics enabled at runtime incurs some overhead. However enabling `%UpdateStats` on smaller tables may have negligible negative impact on database performance. If the overhead of the update statistics outweighs the performance gains, they can be turned off by setting `DbFlags` bitfield to a value of 1 in the Process Scheduler configuration file.

### Processor Binding on Solaris

On the database server and process scheduler node(s), it is recommended to bind active Oracle database and sqr processes to different CPUs for improved performance and CPU utilization.

Processor binding instructs the Oracle Solaris operating system that a process or a thread in the application should run on the same processor throughout the execution of it. When a process or LWP is bound to a processor, it will be executed only by that processor except when the process or LWP requires a resource that is provided only by another processor. The binding is not exclusive, that is, the processor is free to execute other processes and LWPs as well. Bindings are inherited, so new LWPs and processes created by a bound LWP or process will have the same binding.

Processor binding, when used along with static scheduling, benefits applications that exhibit a certain data reuse pattern where data accessed by a thread in a parallel or worksharing region will be in the local cache from a previous invocation of a parallel or worksharing region.

If *n* virtual processors are available, then *n* processes or threads can be scheduled to run at the same time. Depending on the system, a virtual processor may be a processor, a core, etc. For example, each SPARC64 VII physical processor has four cores and each core can run two simultaneous processing threads. From the Oracle Solaris point of view, each of those processing threads is a virtual processor onto which a thread can be scheduled to run. Hence there are eight virtual processors onto which threads can be scheduled to run. On the Oracle Solaris operating system, the number of virtual processors can be determined by using the `psrinfo(1M)` command.

When the operating system binds threads to processors, they are in effect bound to specific virtual processors, not physical processors.

The following script binds the top eight CPU consuming processes to eight virtual processors. The system must have at least eight virtual processors for these bindings to succeed. On systems

with less than eight virtual processors, some of the process bindings in the example may fail. The `pbind` command requires superuser privileges.

```
#!/bin/bash
prstat -n 25 1 1 | grep -v PID | head -8 | awk '{ print $1 }' > /tmp/topproc.txt
let count=0;
for i in `cat /tmp/topproc.txt`
do
        echo pbind -b $count $i
        pbind -b $count $i
        let count=$count+1;
done
echo "bound processes:"
pbind
```

The following script removes the bindings of all processes that are bound to specific processors by executing the previous script.

```
#!/bin/bash
for i in `cat /tmp/topproc.txt`
do
echo "pbind -u $i .."
pbind -u $i
done
echo "bound processes:"
pbind
```

### Tuning configurations for Oracle's Solaris operating system

Enable 256M large pages for process heap and ISM. By default, the latest update of Solaris 10 uses a maximum of 4M pages even when 256M pages are a good fit. Hence appropriate `/etc/system` parameters must be set for enabling 256M large pages.

Set the following `/etc/system` parameters and reboot the system:

- 256M pages for the process heap — `set max_uheap_lpsize=0x10000000`
- 256M pages for ISM — `set mmu_ism_pagesize=0x10000000`

If system time is high and if `lockstat` reports *page_trylock_contig_pages* as one of the most frequent callers, disable coalescing of smaller pages into large page by setting the following tunable in `/etc/system` file. Reboot the system to enact the change:

- Disable coalescing of small pages – `set pg_contig_disable=1`

In addition, set the following parameters in `/etc/system` :

- `set hires_tick=1`

### Tuning configurations for SPARC processors

Ensure that the firmware on the target hardware is up-to-date. Check the Oracle System Firmware Release Hub at http://www.oracle.com/technetwork/systems/patches/firmware/firmware-140779.html for the latest firmware.

Some PeopleSoft workloads exhibited improvement in CPU utilization when the hardware prefetch was disabled on the Sun SPARC Enterprise M3000 server but this improvement was not noticeable on the Sun SPARC Enterprise M4000 and larger servers.

Depending on the situation, disabling the hardware prefetch might or might not enhance performance. Sun recommends careful testing before deploying the application sever with prefetch disabled.

### Tuning configurations for the Oracle Database

There are a few recommended practices when running PeopleSoft Payroll for North America workloads.

#### Data Partitioning

It is a good idea to partition hot tables that are very large in volume of data, i.e., with millions of records. Partitioning is a data volume management technique that addresses the key problem of supporting very large tables and indexes by allowing tables and indexes to be decomposed into smaller and more manageable pieces called partitions. Once partitions are defined, SQL statements can access and manipulate the data in smaller partitions rather than the entire table or index.

#### Optimizer Statistics

By default, Oracle 10g and 11g uses the Cost Based Optimizer. When using the Cost Based Optimizer, table and index statistics play a vital role in query performance. Maintaining these statistics is critical to optimal database and query performance.

It is a recommended best practice to gather statistics periodically for objects where the statistics become stale over time because of changing data volumes or changes in column value. New statistics should be gathered after a schema object's data or structure are modified in ways that make the previous statistics inaccurate.

For example, after loading a significant number of rows into a table, collect new statistics on the number of rows. After updating data in a table, new statistics on the average row length are needed.

PeopleSoft recommends gathering the statistics for the whole schema and for each individual table by using the following commands:

```
DBMS_STATS.GATHER_SCHEMA_STATS (ownname => [table_owner], ESTIMATE_PERCENT =>
DBMS_STATS.AUTO_SAMPLE_SIZE, method_opt => 'FOR ALL INDEXED COLUMNS SIZE AUTO');

DBMS_STATS.GATHER_TABLE_STATS (ownname => [table_owner], tabname => [table_name],
ESTIMATE_PERCENT => DBMS_STATS.AUTO_SAMPLE_SIZE, method_opt=> 'FOR ALL INDEXED
COLUMNS SIZE AUTO', CASCADE => TRUE);
```

#### Database Indexes

Exercise caution when creating new indexes. Restrain from the temptation of adding new indexes to resolve performance issues, which may or may not be due to a missing index. If a new index resolves a critical performance problem, monitor the overall performance of the database, not just the targeted query; and ensure that there are no side effects of the new index.

If DML statements that modify data such as `INSERT`, `UPDATE`, or `DELETE` are being executed large number of times on a table, make sure that the addition of a new index on the same table does not negatively affect the performance of those DML operations. Usually this is not a problem if the SQLs being executed are simply retrieving but not adding or modifying the existing data. In all other cases, there is some index maintenance overhead. For example, if there are 10 indexes created on a table "`TEST`", adding a new row of data to the table "`TEST`" may require updating all 10 indexes by the database management system behind the scenes.

Occasionally instrument the indexes on heavily operated tables and monitor the index usage for the periods during which a burst of database activity occur.

To instrument any index for the purpose of usage monitoring, run:

```
ALTER INDEX <INDEX_NAME> MONITORING USAGE;
```

Once instrumented, query the `V$OBJECT_USAGE` view intermittently to check whether the instrumented index is being used in executing any SQL queries.

```
SELECT USED, START_MONITORING
  FROM V$OBJECT_USAGE
  WHERE INDEX_NAME LIKE '%<INDEX_NAME>%'
  /
```

Consider dropping indexes that are not in use to execute any SQL query. Doing so may reduce the index maintenance overhead, which results in improved performance.

To stop monitoring the index usage, alter the index with the keywords `NOMONITORING USAGE`.

```
ALTER INDEX <INDEX_NAME> NOMONITORING USAGE;
```

#### Database Initialization Parameters

Check Oracle Support document ID 747587.1 PeopleSoft Enterprise PeopleTools Certifications for the recommended Oracle database initialization parameters for the PeopleTools version and the Oracle RDBMS version running in the environment.

It is recommended to configure the following database initialization parameters for all PeopleSoft application modules:

```
optimizer_dynamic_sampling=0
_gby_hash_aggregation_enabled=false
_unnest_subquery=false
```

### Tuning Configurations for PeopleSoft Human Resource Management System

Below are the parameters recommended for the different components of the Oracle PeopleSoft HR environment.

#### Parameter tunings needed for PeopleSoft HR's application and web servers

Within the Application Server configuration files, the following parameters should be modified in the `psappsrv.cfg` file:

Key JOLT listener settings should be changed to:

```
Min Handlers=XX
Max Handlers=XY
Max Clients per Handler=10
```

The minimum number of handlers should be at least the expected concurrency divided by 10. For example, if 100 users is the expected concurrency, set `min Handlers` to a value of 100/10 = 10.

The default value for `Max Clients per Handler` is 40, but the recommendation is to set it to a lower value such as 10.

Key PSAPPSERV UBBGEN settings are listed below:

```
Min Instances=YX
Max Instances=YY
```

The general recommended value for both minimum and maximum instances is one PSAPPSERV process per 100 concurrent users. For example, if the expected concurrency is 500 users, set Min Instances = Max Instances = 5.

Monitor the PSAPPSRV queue size using the psadmin command line utility, and increase or decrease the number of PSAPPSRV instances as needed.

PSAPPSERV recycle settings should be changed as shown below to minimize disruptions.

```
Recycle Count=0
```

### Oracle WebLogic Server Tunables

In general, it is recommended to configure one web server domain to handle 400 to 500 concurrent users. For example, if the expected concurrency is 1200 users, configure at least three identical web domains.

For the Java Virtual Machine (JVM) the following shell variables should be set in the `setEnv.sh` file for optimal configuration:

```
JAVA_OPTIONS_SOLARIS="-server -Xms512m -Xmx512m -XX:MaxPermSize=128m -
Dtoplink.xml.platform=oracle.toplink.platform.xml.jaxp.JAXPPlatform -XX:
+DisableExplicitGC -Xnoclassgc –Xrs -Xss128k -Xverify:none
-XX:+UseConcMarkSweepGC"
```

To monitor the GC activity, add the following JVM options to the above parameters:

```
-verbose:gc –XX:+PrintGCDetails –Xloggc:/tmp/gc.$$.log
```

In the Oracle WebLogic Server configuration file `config.xml`, the following changes are recommended:

```
<ExecuteQueue Name="default" ThreadCount="150"/>
<WebAppComponent Name="PORTAL" ServletReloadCheckSecs="-1" Targets="PIA"
URI="PORTAL"/>
```

By default, `ThreadCount` is set to a value of 50.

```
ServletReloadCheckSecs="-1"
```

Disables checking whether a servlet has been modified.

If multiple application servers are to be used for scalability or reliability purposes, the `<web_domain>/applications/peoplesoft/PORTAL/WEB-INF/psftdocs/ps/configuration.properties` file should be edited for web server load balancing.

In the following example, the web server tries to load balance among "server1", "server2", …, "servern" in a round-robin fashion:

```
psserver=<server1>:<jslport>,<server2>:<jslport>,..,<servern>:<jslport>
```

The following parameters are recommended for the configuration of the application and web servers in the `/etc/system` file:

For application servers configure 32M large pages for the heap on M-series servers:

```
set max_uheap_lpsize=0x2000000
```

For web servers configure 256M pages:

```
set max_uheap_lpsize=0x10000000
```

Also for both the application server and the web servers, the file descriptor settings should be modified in the .profile file as follows

Application server:

```
ulimit –SH –n 512
```

Web Server:

```
ulimit –SH –n 1024
```

If you are using the Oracle WebLogic web server, then set the same shell limit for open files in `$WL_HOME/common/bin/commEnv.sh` as well. The "`ulimit -n`" statement is in the `resetFd(){}` sub-function in `commEnv.sh`.

Inter Process Communications (IPC) settings

It is recommended that Oracle Solaris operating system projects be used for various workload types. Projects are mainly used for controlling resources used by processes. In this case they will simplify setting certain parameters like the shared memory and message queues for specific processes as outlined below.

The default value for maximum number of message queues (128) is sometimes insufficient to handle a application server instance configured to handle a large number of users. When all message queues are filled, the follow error message will occur as the application server processes are booting:

```
Booting server processes ...
exec PSSAMSRV -A -- -C psappsrv.cfg -D CS90SPV -S PSSAMSRV :
        Failed.
113954.ben15!PSSAMSRV.29746.1.0: LIBTUX_CAT:681: ERROR: Failure to create message
queue
113954.ben15!PSSAMSRV.29746.1.0: LIBTUX_CAT:248: ERROR: System init function
failed, Uunixerr = :
msgget: No space left on device
113954.ben15!tmboot.29708.1.-2: CMDTUX_CAT:825: ERROR: Process PSSAMSRV at ben15
failed with /T
tperrno (TPEOS - operating system error)
```

In such situations, Oracle recommends setting the project resource control `project.max-msg-ids` to any value larger than the default of 128.

The following example demonstrates the steps to increase the `max-msg-ids` to a value of 256:

- Get the project ID.

```
% id -p
uid=222227(psft) gid=2294(dba) projid=3(default)
```

- Increase the maximum value for the message queue identifiers to 256 using the prctl utility.

```
# prctl -n project.max-msg-ids -r -v 256 -i project 3
```

• Verify the new maximum value for the message queue identifiers

```
# prctl -n project.max-msg-ids -i project 3
project: 3: default
NAME    PRIVILEGE       VALUE   FLAG    ACTION  RECIPIENT
project.max-msg-ids
        privileged      256     -       deny    -
        system          16.8M   max     deny    -
```

By default, the maximum shared memory segment size is set to 25% of installed physical memory. If it is needed to configure a large SGA for the database, the resource control `project.maxshm-memory` should be increased so Oracle can succeed in starting up the database. Oracle will output the following error during startup should `project.max-shm-memory` be too small:

```
ORA-27102: out of memory
```

### Flash array configurations

#### Preparing the Sun Storage F5100 Flash Array

The first step in preparing the Sun Storage F5100 Flash Array is to make sure the array has the latest firmware and that the server has the correct version of the Solaris 10 OS.

1. The OS on the host system should be Solaris 10 Update 5 or higher. Also, make sure the following OS patches are installed:

• `ses/sgen` patch 138881-01 or equivalent for the hardware

• `mpt` patch 141737-05 or equivalent for the hardware

• To enable multithreading in this version of mpt, edit `/kernel/drv/mpt.conf` and append the following line: `mpt_doneq_thread_n_prop=8;`

2. Review the product notes to make sure the right patches for the OS and host CPU are installed.

http://docs.sfbay.sun.com/app/docs/prod/stor.f5100~f5100flash-array_INT#hic

3. Install the CAM 6.5 or later software on the host from the following link:

http://www.sun.com/download/index.jsp?tab=4

4. Review the CAM release notes and install the required CAM firmware patches:

http://dlc.sun.com/pdf/821-0126-10/821-0126-10.pdf

5. Once CAM software is installed, register the array. When registering the array, update the firmware by following the instructions provided.

6. Update Sun StorageTek PCIe SAS Host Bus Adapter Enterprise-class SAS HBA card firmware. The firmware is available from the LSI Web site:

http://www.lsi.com/support/sun

#### Configuring the Sun Storage F5100 Flash Array Volumes

Creating File Systems on the Sun Storage F5100 Flash Array using Solaris Volume Manager (SVM)

The steps involved in creating soft partitions and filesystems on a F5100 array are shown below with examples. The examples shown below create two soft partitions, two UFS filesystems and finally mount those filesystems on two mount points.

Step #1. Create the SVM state database

```
# format
..
     4. c2t150d0 <ATA-MARVELLSD88SA02-MP1F cyl 23435 alt 2 hd 16 sec 128>
          /pci@1,700000/LSILogic,sas@0/sd@96,0
       5. c2t151d0 <ATA-MARVELLSD88SA02-MP1F cyl 23435 alt 2 hd 16 sec 128>
          /pci@1,700000/LSILogic,sas@0/sd@97,0
       6. c2t152d0 <ATA-MARVELLSD88SA02-MP1F cyl 23435 alt 2 hd 16 sec 128>
          /pci@1,700000/LSILogic,sas@0/sd@98,0
...
...
Specify disk (enter its number): 4
selecting c2t150d0
[disk formatted]
Disk not labeled.  Label it now? yes

format> disk 5
selecting c2t151d0
[disk formatted]
Disk not labeled.  Label it now? yes

..
..
..

# metadb
metadb: m8000-d0: there are no existing databases

# fstyp /dev/dsk/c2t150d0s2
Unknown_fstyp (no matches)
```

```
# metadb -a -f c2t150d0s2
# metadb
flags first blk block count
     a        u      16 8192 /dev/dsk/c2t150d0s2

# fstyp /dev/dsk/c2t150d0s2
Unknown_fstyp (no matches)
```

In this example, `c2t150d0` is one of the flash modules in the F5100 array. The `metadb` command requires a slice with no filesystem created on it. Hence `c2t150d0s2` was used to create the metadatabase. Note that metadatabase can be created on any disk slice including internal disks, traditional disk drives and flash modules.

Step #2. Configure metadevices

```
# metainit d100 1 8  c2t156d0s6   c3t130d0s6      c3t136d0s6      c6t55d0s6
c6t59d0s6       c7t130d0s6      c7t134d0s6      -i 128k
d100: Concat/Stripe is setup
# metainit d200 1 8  c2t151d0s6   c2t157d0s6      c3t131d0s6      c3t137d0s6
c6t56d0s6       c6t60d0s6       c7t131d0s6      c7t135d0s6      -i 128k
d200: Concat/Stripe is setup
..
..
```

NOTE: Since `c2t150d0s2` and `c2t150d0s6` are pointing to the same device and since `c2t150d0s2` holds the metadevice state DB, it is not possible to use `c2t150d0s6` in creating a soft partition. Attempting to create one using `c2t150d0s6` may fail with error message similar to the following:

```
metainit: m8000-d0: c2t150d0s6: overlaps with device in metadevice state database
```

Step #3. Create UFS file systems

Using the script described below (called `create_fs_lf.sh`) the file systems can be quickly created:

```
for i in 1 2 3 4 5 6
do
newfs -T -m 0 /dev/md/rdsk/d${i}00
done

# ./create_fs_lf.sh
newfs -T -m 0 /dev/md/rdsk/d100
newfs: construct a new file system /dev/md/rdsk/d100: (y/n)? y
/dev/md/rdsk/d100: 142411776 sectors in 69537 cylinders of 16 tracks, 128 sectors
69537.0MB in 324 cyl groups (215 c/g, 215.00MB/g, 256 i/g)
```

```
super-block backups (for fsck -F ufs -o b=#) at:
32, 440480, 880928, 1321376, 1761824, 2202272, 2642720, 3083168, 3523616,
3964064,
Initializing cylinder groups:
......
super-block backups for last 10 cylinder groups at:
138261792, 138702240, 139142688, 139583136, 140023584, 140464032, 140902432,
141342880, 141783328, 142223776
newfs -T -m 0 /dev/md/rdsk/d200
newfs: construct a new file system /dev/md/rdsk/d200: (y/n)? y
/dev/md/rdsk/d200: 189882368 sectors in 92716 cylinders of 16 tracks, 128 sectors
92716.0MB in 432 cyl groups (215 c/g, 215.00MB/g, 256 i/g)
super-block backups (for fsck -F ufs -o b=#) at:
32, 440480, 880928, 1321376, 1761824, 2202272, 2642720, 3083168, 3523616,
3964064,
Initializing cylinder groups:
........
super-block backups for last 10 cylinder groups at:
185815840, 186256288, 186696736, 187137184, 187577632, 188018080, 188458528,
188898976, 189339424, 189779872
#
```

Step #4. Mount the file systems

```
# mkdir /DATAVOL1
# mkdir /DATAVOL2
# mount /dev/md/dsk/d100 /DATAVOL1
# mount /dev/md/dsk/d200 /DATAVOL2
# df -h | egrep "DATAVOL|Filesystem"
Filesystem size used avail capacity Mounted on
/dev/md/dsk/d100 68G 64M 68G 1% /DATAVOL1
/dev/md/dsk/d200 91G 64M 90G 1% /DATAVOL2
#
```

#### Tuning the Sun Storage F5100 Flash Array

When setting up partitions using the format command, start all partitions on 4k aligned boundaries. That is, the partitions should start on cylinders that are a multiple of 8: 0, 8, 16, etc. In addition to aligning the partition on 4 boundaries, verify that the I/O pattern of the workload is predominantly also 4k aligned. Start up the workload and run this Dynamic Tracing (DTrace) script to verify this:

```
#!/usr/sbin/dtrace -qs
# align.d : script to check for 4k alignment on fmods.
BEGIN {
  start = timestamp;
```

```
}
int issued, misaligned, nonmult, tot_issued, tot_misaligned,tot_nonmult,
tot_elapsed;
struct buf *bp;
struct sd_xbuf *xp;
tick-5sec
{
        /*   exit(0); */
        elapsed = timestamp - start;
        printf("%d.%09d seconds elapsed\n\n",elapsed/1000000000,
        elapsed%1000000000);
        printf("%8d IOs issued\n%8d IOs misaligned\n", issued,misaligned);
        printf("%8d IOs non-multiple of 4KB\n", nonmult);
        printf ("%8d Percent non-4k IOs\n\n", (nonmult * 100 / issued) );
        tot_elapsed += elapsed;
        tot_issued += issued;
        tot_misaligned += misaligned;
        tot_nonmult += nonmult;
        start = timestamp;
        issued = 0;
        misaligned=0;
        nonmult=0;
}
fbt:sd:sd_core_iostart:entry
{
        issued++;
        bp = (struct buf *) arg2;
        xp = (struct sd_xbuf *)((bp)->b_private);
        misaligned += (xp->xb_blkno % 8) ? 1 : 0;
        nonmult += (bp->b_bcount % 4096) ? 1 : 0;
        @a[bp->b_bcount] = count();
}
END {
        elapsed = timestamp - start;
        tot_elapsed += elapsed;
        tot_issued += issued;
        tot_misaligned += misaligned;
        tot_nonmult += nonmult;
        printf("%d.%09d seconds elapsed\n\n", tot_elapsed/1000000000,
        tot_elapsed%1000000000);
        printf("%8d IOs issued\n%8d IOs misaligned\n", tot_issued,
        tot_misaligned);
        printf("%8d IOs non-multiple of 4KB\n", tot_nonmult);
```

```
        printf ("%8d Percent non-4k IOs\n", (tot_nonmult * 100 / tot_issued) );
        printf("\n IO size Count\n");
        printa(@a);
}
```

Here is sample output that prints out results every 5 seconds, and also reports the percentage of non-4k I/Os.

```
# ./align.d
4.945950845 seconds elapsed
        1 IOs issued
        1 IOs misaligned
        0 IOs non-multiple of 4KB
        0 Percent non-4k IOs
4.999997672 seconds elapsed
        4 IOs issued
        4 IOs misaligned
        0 IOs non-multiple of 4KB
        0 Percent non-4k IOs
.
.
.
10.687317268 seconds elapsed
        5 IOs issued
        5 IOs misaligned
        0 IOs non-multiple of 4KB
        0 Percent non-4k IOs
IO size Count
        8192 1
        4096 4
```

For these tests the PeopleSoft Payroll database was configured on UFS and the Oracle init.ora parameter `filesystemio_options` was set to "`setall`".

This causes Oracle to bypass the Solaris OS file page cache when accessing data files on UFS file systems. This eliminates double-buffering and improves the performance of UFS.

An alternate way of eliminating double-buffering is to use the UFS filesystem mount option "`forcedirectio`" when mounting the filesystem on a mount point as shown here:

```
# mount -o forcedirectio /dev/md/dsk/d100 /DATAVOL1
```

A best practice for using UFS on the Sun Storage F5100 Flash Array is to mount file systems with the 'nologging' option. This eliminates a source of non-4K aligned writes.

For Oracle, writes to Redo Log files are not 4K boundary aligned, so it is a best practice to allocate Oracle Redo Log files on a storage device other than the Sun Storage F5100 Flash Array. The Sun Storage J4200 array is a good choice. Redo Logs should be allocated on a storage array

with cache for best performance. All other database objects (tables, indexes, undo, and temp) write on a 4K boundary and are prime candidates for allocation on the Sun Storage F5100 Flash Array. Check Appendix A "Identifying Ideal Oracle Database Objects for Flash Storage and Accelerators" for more details.

For the PeopleSoft Payroll test, a half-capacity (40 FMod) Sun Storage F5100 Flash Array was used. The FMods were configured into four 10 FMod domains, each assigned to a unique host port. These were presented to the SPARC Enterprise M8000 server as 40 devices.

#### Tuning the Solaris OS

In the `/etc/system` file, make the following changes:

- Settings for the Sun Storage F5100 Flash Array — `set sd:sd_max_throttle=24`
- Settings for the Sun Storage F5100 Flash Array — `set sd:sd_min_throttle=2`

# Appendix

## A. Identifying Ideal Oracle Database Objects for Flash Storage and Accelerators

Oracle's Sun Storage F5100 Flash Array and Oracle's Sun Flash Accelerator F20 PCIe Card help accelerate I/O bound applications such as databases. The following are some of the guidelines to identify Oracle database objects that can be placed in flash storage to improve access speed of these objects. Exercise discretion, evaluate and experiment before implementing these recommendations as they are.

- Heavily used database tables and indexes are ideal for flash storage.
  - Workloads with no I/O bottlenecks may not show significant performance gains.
  - Workloads with severe I/O bottlenecks can fully realize the benefits of flash devices.
  - The `Top 5 Timed Foreground Events` section in any Automated Workload Repository (AWR) report collected by the target database system is useful in finding whether disk I/O is a bottleneck. A large number of Waits and a large amount of time spent waiting for some blocked resource under `User I/O` Wait Class is an indication of I/O contention in the system.
- Identify the I/O intensive tables and indexes in a database with the help of Oracle Enterprise Manager Database Control using the web-based tool for managing Oracle database(s)
  - The "Performance" page in the OEM Database Control panel helps quickly identify and analyze performance problems.
  - Historical and real-time database activity can be viewed in the "performance" tab. It also provides information about the top resource consuming database objects.
- An alternate way to identify the I/O intensive objects in a database is to analyze the AWR reports that are generated over a period of time especially when the database is busy
  - Scan through the `SQL ordered by…` tables in each AWR report
  - Look for the top `INSERT & UPDATE` statements with more elapsed and DB times. The database tables that are updated frequently & repeatedly, along with the indexes created on such tables are good candidates for the flash devices
  - `SQL ordered by Reads` is useful in identifying the database tables with large number of physical reads. The database table(s) from which large amounts of data is read/fetched from physical disk(s) are also good candidates for the flash devices. To identify I/O intensive indexes, look through the explain plans of the top SQLs that are sorted by `Physical Reads`
- Examine the `File IO Stats` section in any AWR report that was collected on the target database system
  - Consider moving the database files with heavy reads, writes and relatively high average buffer wait time to flash volumes

- Examine `Segments by Physical Reads`, `Segments by Physical Writes` and `Segments by Buffer Busy Waits` sections in AWR report
  - The database tables and indexes with large number of physical reads, physical writes and buffer busy waits may benefit from the flash acceleration
- Oracle flash storage may not be ideal for storing database *redo* logs
  - Sun Flash Modules (FMOD) in the Sun Storage F5100 array and the Sun Flash F20 PCIe Accelerator Card are optimized for 4k sector size. A redo log write that is not aligned with the beginning of the 4k physical sector results in a significant performance degradation.
  - In general, Oracle redo log files default to a block size that is equal to the physical sector size of the disk, which is typically 512 bytes. This means that writing redo logs to flash devices will not use the optimized block size for this hardware.
  - The majority of recent Oracle Database server platforms detect the 4k sector size on Sun Flash devices. If this is the case, the Oracle Database server automatically creates redo log files with a 4k block size on file systems created on Sun flash devices. However with a block size of 4k for the redo logs, there will be significant increase in redo wastage that may offset expected performance gains

### F5100 Flash Storage and F20 PCIe Flash Accelerator Card as Oracle Database Smart Flash Cache

In addition to the I/O intensive database objects, customers running Oracle 11*g* Release 2 or later versions have the flexibility of using flash devices to turn on the "Database Smart Flash Cache" feature to reduce physical disk I/O. The Database Smart Flash Cache is a transparent extension of the database buffer cache using flash storage technology. The flash storage acts as a Level 2 cache to the (Level 1) SGA. Database Smart Flash Cache can significantly improve the performance of Oracle databases by reducing the amount of disk I/O at a much lower cost than adding an equivalent amount of RAM.

F20 Flash Accelerator offers an additional benefit - since it is a PCIe card, the I/O operations bypass disk controller overhead.

The database flash cache can be configured and enabled by setting the right values in the following Oracle database parameters.

```
db_flash_cache_file

db_flash_cache_size
```

Check Oracle Database Administrator's Guide 11g Release 2 (11.2): Configuring Database Smart Flash Cache documentation for the step-by-step instructions to configure Database Smart Flash Cache on flash devices.

## B. Domain Configuration

Three domains were created in the SPARC M8000 Enterprise server. One of the domains was used to run the Oracle Database 11g and the other domains were used for the application servers and testing environment of the Oracle Database 10g. The domain configurations are shown below as well as the commands used to configure them. Two CPU/Memory boards (known as CMU's) were used with their respective I/O unites (known as IOU's). After accessing the M-Series server management controller known as XSCF using SSH, here are the commands needed to create the domains.

Domain 0:

```
XSCF>setupfru –x 1 sb 0
XSCF>setdcl –d 0 –a 0=0
XSCF>addboard –f –c assign –d 0 0
```

Domain 1:

```
XSCF>setupfru –x 4 sb 1
XSCF>setdcl –d 1 –a 0=01-0
XSCF>setdcl –d 1 –a 1=01-1
XSCF>addboard –f –c assign –d 1 01-0 01-1
```

Domain 2:

```
XSCF>setdcl –d 2 –a 0=01-2
XSCF>setdcl –d 2 –a 1=01-3
XSCF>addboard –f –c assign –d 2 01-2 01-3
```

Power on the Domains:

```
XSCF>poweron –d 0
XSCF>poweron –d 1
XSCF>poweron –d 2
```

Verify that the configurations are correct and that they are running:

```
XSCF> showdcl –a
DID   LSB   XSB   Status
00                Running
      00    00-0
---------------------------
01                Running
      00    01-0
      01    01-1
---------------------------
02                Running
      00    01-2
      01    01-3
XSCF> showdevices -d 0

CPU:
----
DID XSB  id  state    speed  ecache
00  00-0 0   on-line   2520       6
00  00-0 1   on-line   2520       6
00  00-0 2   on-line   2520       6
00  00-0 3   on-line   2520       6
00  00-0 4   on-line   2520       6
00  00-0 5   on-line   2520       6
00  00-0 6   on-line   2520       6
```

```
00  00-0 7   on-line   2520       6
00  00-0 8   on-line   2520       6
00  00-0 9   on-line   2520       6
00  00-0 10  on-line   2520       6
00  00-0 11  on-line   2520       6
00  00-0 12  on-line   2520       6
00  00-0 13  on-line   2520       6
00  00-0 14  on-line   2520       6
00  00-0 15  on-line   2520       6
00  00-0 16  on-line   2520       6
00  00-0 17  on-line   2520       6
00  00-0 18  on-line   2520       6
00  00-0 19  on-line   2520       6
00  00-0 20  on-line   2520       6
00  00-0 21  on-line   2520       6
00  00-0 22  on-line   2520       6
00  00-0 23  on-line   2520       6
00  00-0 24  on-line   2520       6
00  00-0 25  on-line   2520       6
00  00-0 26  on-line   2520       6
00  00-0 27  on-line   2520       6
00  00-0 28  on-line   2520       6
00  00-0 29  on-line   2520       6
00  00-0 30  on-line   2520       6
00  00-0 31  on-line   2520       6

Memory:
-------
           board   perm    base                domain  target deleted remaining
DID XSB    mem MB  mem MB  address             mem MB  XSB    mem MB  mem MB
00  00-0    65536    5345  0x000003c000000000   65536

IO Devices:
----------
DID XSB       device  resource               usage
00  00-0      sd2     /dev/dsk/c0t0d0s0      mounted filesystem "/"
00  00-0      sd2     /dev/dsk/c0t0d0s1      swap area
00  00-0      sd2     /dev/dsk/c0t0d0s1      dump device (swap)
00  00-0      sd44    /dev/dsk/c2t36d0s2     contains metadb(s)
00  00-0      sd45    /dev/dsk/c2t37d0s6     component of stripe
"/dev/md/dsk/d200"
00  00-0      sd51    /dev/dsk/c2t43d0s6     component of stripe
"/dev/md/dsk/d200"
00  00-0      sd46    /dev/dsk/c2t38d0s6     component of stripe
"/dev/md/dsk/d300"
00  00-0      sd52    /dev/dsk/c2t44d0s6     component of stripe
"/dev/md/dsk/d300"
00  00-0      sd49    /dev/dsk/c2t41d0s6     component of stripe
"/dev/md/dsk/d600"
00  00-0      sd47    /dev/dsk/c2t39d0s6     component of stripe
"/dev/md/dsk/d400"
00  00-0      sd53    /dev/dsk/c2t45d0s6     component of stripe
"/dev/md/dsk/d400"
00  00-0      sd48    /dev/dsk/c2t40d0s6     component of stripe
"/dev/md/dsk/d500"
00  00-0      sd50    /dev/dsk/c2t42d0s6     component of stripe
"/dev/md/dsk/d100"
00  00-0      sd27    /dev/dsk/c3t131d0s6    component of stripe
"/dev/md/dsk/d200"
00  00-0      sd33    /dev/dsk/c3t137d0s6    component of stripe
"/dev/md/dsk/d200"
00  00-0      sd28    /dev/dsk/c3t132d0s6    component of stripe
"/dev/md/dsk/d300"
00  00-0      sd25    /dev/dsk/c3t129d0s6    component of stripe
"/dev/md/dsk/d600"
```

```
00  00-0      sd31    /dev/dsk/c3t135d0s6     component of stripe
"/dev/md/dsk/d600"
00  00-0      sd29    /dev/dsk/c3t133d0s6     component of stripe
"/dev/md/dsk/d400"
00  00-0      sd24    /dev/dsk/c3t128d0s6     component of stripe
"/dev/md/dsk/d500"
00  00-0      sd30    /dev/dsk/c3t134d0s6     component of stripe
"/dev/md/dsk/d500"
00  00-0      sd26    /dev/dsk/c3t130d0s6     component of stripe
"/dev/md/dsk/d100"
00  00-0      sd32    /dev/dsk/c3t136d0s6     component of stripe
"/dev/md/dsk/d100"
00  00-0      fp0     /devices/pci@3,700000/SUNW,qlc@0/fp@0,0SCSI Multipathing
PHCI (offline)
00  00-0      fp0     /dev/dsk/c8t600A0B8000475D900000C1974B91030Ad0s6mounted
filesystem "/PSFTvol4"
00  00-0      fp0     /dev/dsk/c8t600A0B80004777500000A2494B91024Ad0s6mounted
filesystem "/PSFTvol3"
00  00-0      fp0     /dev/dsk/c8t600A0B8000475D900000C1964B9101FBd0s6mounted
filesystem "/PSFTvol2"
00  00-0      fp0     /dev/dsk/c8t600A0B80004777500000A2484B910140d0s6mounted
filesystem "/PSFTvol1"
00  00-0      fp0     /dev/dsk/c8t600A0B8000475D900000C1954B910119d0s6mounted
filesystem "/PSFTData"
00  00-0      fp0     /dev/dsk/c8t600A0B80004777500000A2464B91002Ed0s6mounted
filesystem "/PSFTRedo"
00  00-0      fp0     /dev/dsk/c8t600A0B80004777500000A24B4B910E16d0s6mounted
filesystem "/dbfile2"
00  00-0      fp0     /dev/dsk/c8t600A0B8000475D900000C1984B93B815d0s6mounted
filesystem "/dbfile1"
00  00-0      fp1     /devices/pci@3,700000/SUNW,qlc@0,1/fp@0,0SCSI Multipathing
PHCI (offline)
00  00-0      sd3     /dev/dsk/c1t1d0s3       mounted filesystem "/export"
00  00-0      bge2    SUNW_network/bge2       bge2 hosts IP addresses: 10.60.21.31
00  00-0      bge3    SUNW_network/bge3       bge3 hosts IP addresses:
192.168.21.31
00  00-0      sd19    /dev/dsk/c6t56d0s6      component of stripe
"/dev/md/dsk/d200"
00  00-0      sd23    /dev/dsk/c6t60d0s6      component of stripe
"/dev/md/dsk/d200"
00  00-0      sd14    /dev/dsk/c6t51d0s6      component of stripe
"/dev/md/dsk/d300"
00  00-0      sd20    /dev/dsk/c6t57d0s6      component of stripe
"/dev/md/dsk/d300"
00  00-0      sd17    /dev/dsk/c6t54d0s6      component of stripe
"/dev/md/dsk/d600"
00  00-0      sd21    /dev/dsk/c6t58d0s6      component of stripe
"/dev/md/dsk/d600"
00  00-0      sd15    /dev/dsk/c6t52d0s6      component of stripe
"/dev/md/dsk/d400"
00  00-0      sd16    /dev/dsk/c6t53d0s6      component of stripe
"/dev/md/dsk/d500"
00  00-0      sd18    /dev/dsk/c6t55d0s6      component of stripe
"/dev/md/dsk/d100"
00  00-0      sd22    /dev/dsk/c6t59d0s6      component of stripe
"/dev/md/dsk/d100"
00  00-0      sd7     /dev/dsk/c7t131d0s6     component of stripe
"/dev/md/dsk/d200"
00  00-0      sd11    /dev/dsk/c7t135d0s6     component of stripe
"/dev/md/dsk/d200"
00  00-0      sd4     /dev/dsk/c7t128d0s6     component of stripe
"/dev/md/dsk/d300"
00  00-0      sd8     /dev/dsk/c7t132d0s6     component of stripe
"/dev/md/dsk/d300"
```

```
00  00-0      sd12    /dev/dsk/c7t136d0s6     component of stripe
"/dev/md/dsk/d300"
00  00-0      sd5     /dev/dsk/c7t129d0s6     component of stripe
"/dev/md/dsk/d600"
00  00-0      sd9     /dev/dsk/c7t133d0s6     component of stripe
"/dev/md/dsk/d600"
00  00-0      sd13    /dev/dsk/c7t137d0s6     component of stripe
"/dev/md/dsk/d600"
00  00-0      sd6     /dev/dsk/c7t130d0s6     component of stripe
"/dev/md/dsk/d100"
00  00-0      sd10    /dev/dsk/c7t134d0s6     component of stripe
"/dev/md/dsk/d100"
XSCF> showdevices -d 1

CPU:
----
DID XSB  id  state    speed  ecache
01  01-0 0   on-line   2520       6
01  01-0 1   on-line   2520       6
01  01-0 2   on-line   2520       6
01  01-0 3   on-line   2520       6
01  01-0 4   on-line   2520       6
01  01-0 5   on-line   2520       6
01  01-0 6   on-line   2520       6
01  01-0 7   on-line   2520       6
01  01-1 40  on-line   2520       6
01  01-1 41  on-line   2520       6
01  01-1 42  on-line   2520       6
01  01-1 43  on-line   2520       6
01  01-1 44  on-line   2520       6
01  01-1 45  on-line   2520       6
01  01-1 46  on-line   2520       6
01  01-1 47  on-line   2520       6

Memory:
-------
          board   perm    base                domain  target deleted remaining
DID XSB   mem MB  mem MB  address             mem MB  XSB    mem MB  mem MB
01  01-0   16384    1625  0x000003c000000000   32768
01  01-1   16384       0  0x0000038000000000   32768

IO Devices:
-----------
DID XSB       device  resource                usage
01  01-0      sd1     /dev/dsk/c0t0d0s0       mounted filesystem "/"
01  01-0      sd1     /dev/dsk/c0t0d0s1       swap area
01  01-0      sd1     /dev/dsk/c0t0d0s1       dump device (swap)
01  01-0      sd0     /dev/dsk/c0t1d0s3       mounted filesystem
"/zones/AppServer2"
01  01-0      sd0     /zones/AppServer2/dev   mounted filesystem
"/zones/AppServer2/root/dev"
01  01-0      bge0    SUNW_network/bge0       bge0 hosts IP addresses: 10.60.21.32
01  01-0      bge1    SUNW_network/bge1       bge1 hosts IP addresses:
192.168.21.32
01  01-0      nxge0   SUNW_network/nxge0      nxge0 plumbed but down
XSCF> showdevices -d 2

CPU:
----
DID XSB  id  state    speed  ecache
02  01-2 16  on-line   2520       6
02  01-2 17  on-line   2520       6
02  01-2 18  on-line   2520       6
02  01-2 19  on-line   2520       6
02  01-2 20  on-line   2520       6
```

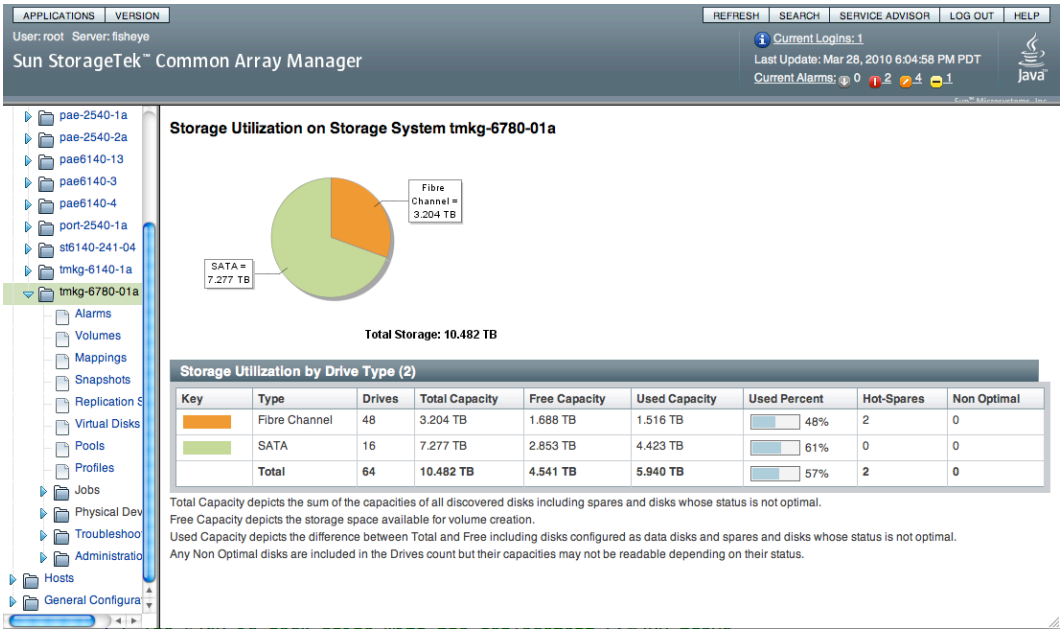
```
02  01-2 21  on-line   2520       6
02  01-2 22  on-line   2520       6
02  01-2 23  on-line   2520       6
02  01-3 56  on-line   2520       6
02  01-3 57  on-line   2520       6
02  01-3 58  on-line   2520       6
02  01-3 59  on-line   2520       6
02  01-3 60  on-line   2520       6
02  01-3 61  on-line   2520       6
02  01-3 62  on-line   2520       6
02  01-3 63  on-line   2520       6

Memory:
-------
          board   perm    base                domain  target deleted remaining
DID XSB   mem MB  mem MB  address             mem MB  XSB    mem MB  mem MB
02  01-2   16384    2806  0x000003c000000000   32768
02  01-3   16384       0  0x0000038000000000   32768

IO Devices:
-----------
DID XSB       device  resource                usage
02  01-2      sd1     /dev/dsk/c0t0d0s0       mounted filesystem "/"
02  01-2      sd1     /dev/dsk/c0t0d0s1       swap area
02  01-2      sd1     /dev/dsk/c0t0d0s1       dump device (swap)
02  01-2      sd0     /dev/dsk/c0t1d0s6       mounted filesystem "/export"
02  01-2      bge0    SUNW_network/bge0       bge0 hosts IP addresses: 10.60.21.33
02  01-2      bge1    SUNW_network/bge1       bge1 hosts IP addresses:
192.168.21.33
02  01-3      fp0     /devices/pci@17,700000/SUNW,qlc@0/fp@0,0SCSI Multipathing
PHCI (online)
02  01-3      fp0     /dev/dsk/c3t600A0B8000475D900000C1994B96B481d0s6mounted
filesystem "/PSFTRedo"
02  01-3      fp0     /dev/dsk/c3t600A0B80004777500000A24E4B96B3EEd0s6mounted
filesystem "/PSFTData"
02  01-3      fp1     /devices/pci@17,700000/SUNW,qlc@0,1/fp@0,0SCSI Multipathing
PHCI (standby)
XSCF>
```

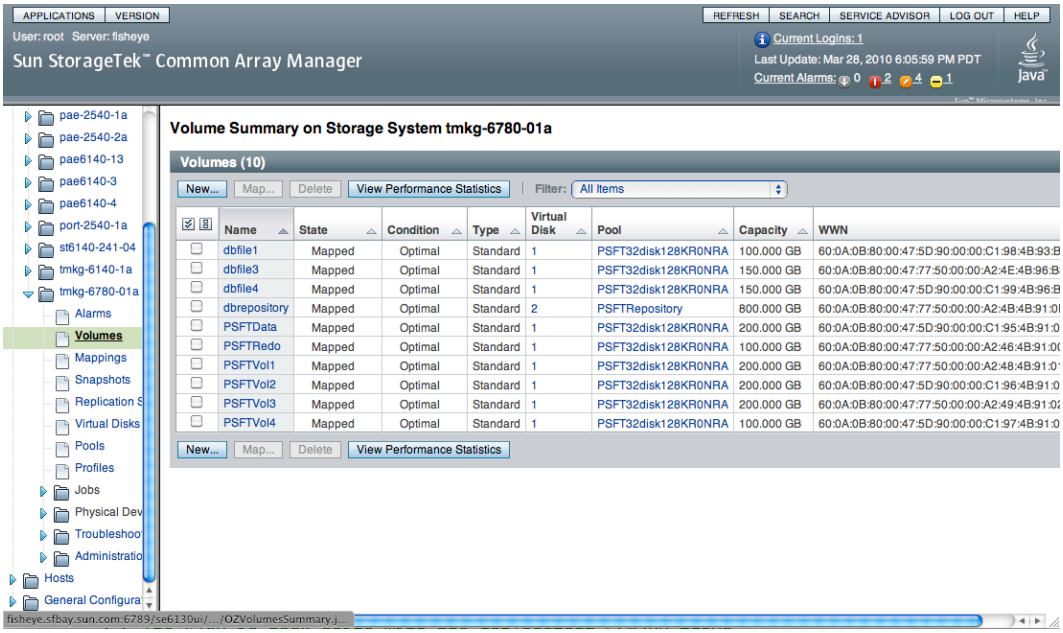
## C. Sun Storage 6780 Array Configuration

The Sun Storage 6780 that was used for these tests had a total of four CSM200 expansion arrays. One of them was filled with SATA hard drives and the rest were filled with Fiber Channel drives. A disk pool was created using 32 Fiber Channel drives and from that pool nine volumes were created for the various servers in the configuration as shown in the following screen captures. Fiber Channel drives were used for the tests in order to use the best performing devices.




The above screen capture represents the total available storage for both Fiber Channel and SATA technologies. It is the high level overview of the array that is presented by the Browser User Interface for the Sun Storage 6780 is accessed. The software used to manage the array is called the StorageTek Common Array Manager also known as CAM.

The next screen shows all the volumes that were created on the array and the storage distribution across them and the worldwide numbers.



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