



Oracle Database Virtualization with VMware vSphere at the Idaho Supreme Court

VMware Technical Case Study: State and Local Government

TECHNICAL WHITE PAPER

Table of Contents

- 1. Introduction 3
- 2. Business and Technical Challenge 3
 - 2.1 Business Challenge 3
 - 2.2 Technical Challenge..... 3
- 3. VMware Solution 4
 - 3.1 Solution Architecture Overview 4
 - 3.2 Solution Benefits 9
 - 3.3 VMware Features Used 10
 - 3.4 Performance Considerations..... 11
 - 3.5 Support and Licensing 12
- 4. Conclusion 12

1. Introduction

The Idaho Supreme Court (ISC) manages all the court operations in the state of Idaho from adjudicating traffic citations to hearing appeals. The ISC also provides public access to statewide court case information and services such as victim notification of prisoner releases and state agency reporting. Per statute, time-sensitive services such as these mandate that information must be available constantly and updated in nearly real time. The ISC is also in the process of streamlining operations, reducing personnel requirements, and shrinking timeframes for application rollouts and upgrades. VMware vSphere® is providing the foundation for many of these process improvements.

2. Business and Technical Challenge

The ISC is charged with managing all court data and supporting infrastructure in the state, reaching from Utah to Canada, with limited human and physical resources. This includes providing superior customer service to judges, court officers, constituents, state agencies, and the general public. Operating with limited funds and personnel, the ISC was faced with applying necessary application upgrades and requisite technology updates in a very limited timeframe.

2.1 Business Challenge

The ISC

- Is responsible for management of all courts in Idaho
 - District courts, each with a local Oracle database, are located in each of 44 counties
 - Appellate court operations, including a data warehouse providing state level reporting, public access to case information and victim notification
- Delivers all this functionality using a court case management system built on Oracle database technology
- Had received notice that the application vendor required an Oracle version upgrade

2.2 Technical Challenge

Business Requirements Surrounding the Oracle Database Upgrade

The Oracle database upgrade requirement by the court case management system vendor came at a time when several conditions made a traditional rollout on physical servers impractical. This prompted the ISC IT staff and personnel from Yucca Group, an IT consulting company and VMware partner, to explore an innovative approach based on virtualizing all Oracle databases to meet the needs of the court. Business requirements and constraints included:

- Staffing
 - There were staff limitations (two staff to roll out and administer the entire statewide installation)
 - The ISC IT staff needed to consolidate management to “a single pane of glass”
 - The administrative workload of IT staff needed to be reduced to allow more focus on strategic projects
- Technical
 - An Oracle upgrade was required in each of 44 branch offices statewide
 - An Oracle upgrade was required at the data warehouse
 - A server hardware upgrade was required at the data warehouse
 - Data warehouse performance needed to improve to support new functionality

- Organizational
 - Both branch office and data warehouse functionality (especially public access) were required to remain essentially uninterrupted during the upgrade
 - Court operations required a very compressed time frame (a few months at most)
 - Upgrade operations needed to be seamless to meet expected service levels
 - The ISC was requiring improved availability of branch offices and the data warehouse moving forward
- Financial
 - IT staff was evaluating options to extend the use of existing OS licenses and minimize new OS costs, while providing a new server hardware platform
 - There was no budget for additional Oracle licensing

3. VMware Solution

Considering all the business drivers listed above, careful study determined that every condition could be successfully met by skillful virtualization of all the Oracle databases statewide, including the data warehouse.

The solution that was settled on included the following points:

- Create an “All Purpose” (scalable) Oracle virtual appliance
- Design the virtual appliance to be completely scalable while maximizing performance and availability at the database and OS level (details are described in the Design and Build of the Oracle Virtual Appliance section below)
- Use vSphere 5.1 to optimize scalability and performance at the hypervisor level
- Rapidly deploy to multiple sites
 - Distribute Oracle virtual appliance on a hard drive
 - Requires minimal personnel resources

3.1 Solution Architecture Overview

Architecture Before Oracle Virtualization

This section contains an overview of the District Court branch office and data warehouse configuration and issues pertinent to the Oracle virtualization initiative:

- All branch office functionality was running on virtualized infrastructure except for the Oracle databases
- The client server application at each of 44 branch offices was running against a local 32 bit Oracle database on dedicated hardware
- Virtualization of Oracle would consolidate branch office servers (85 to 48)
- One central data warehouse was in use for state agency reporting, public access and victim notification was running on a dedicated physical server
- Daily Materialized View replication from branch offices was updating the data warehouse
- The entire state court system was being managed by existing two- person staff who needed to move from reactive to proactive management

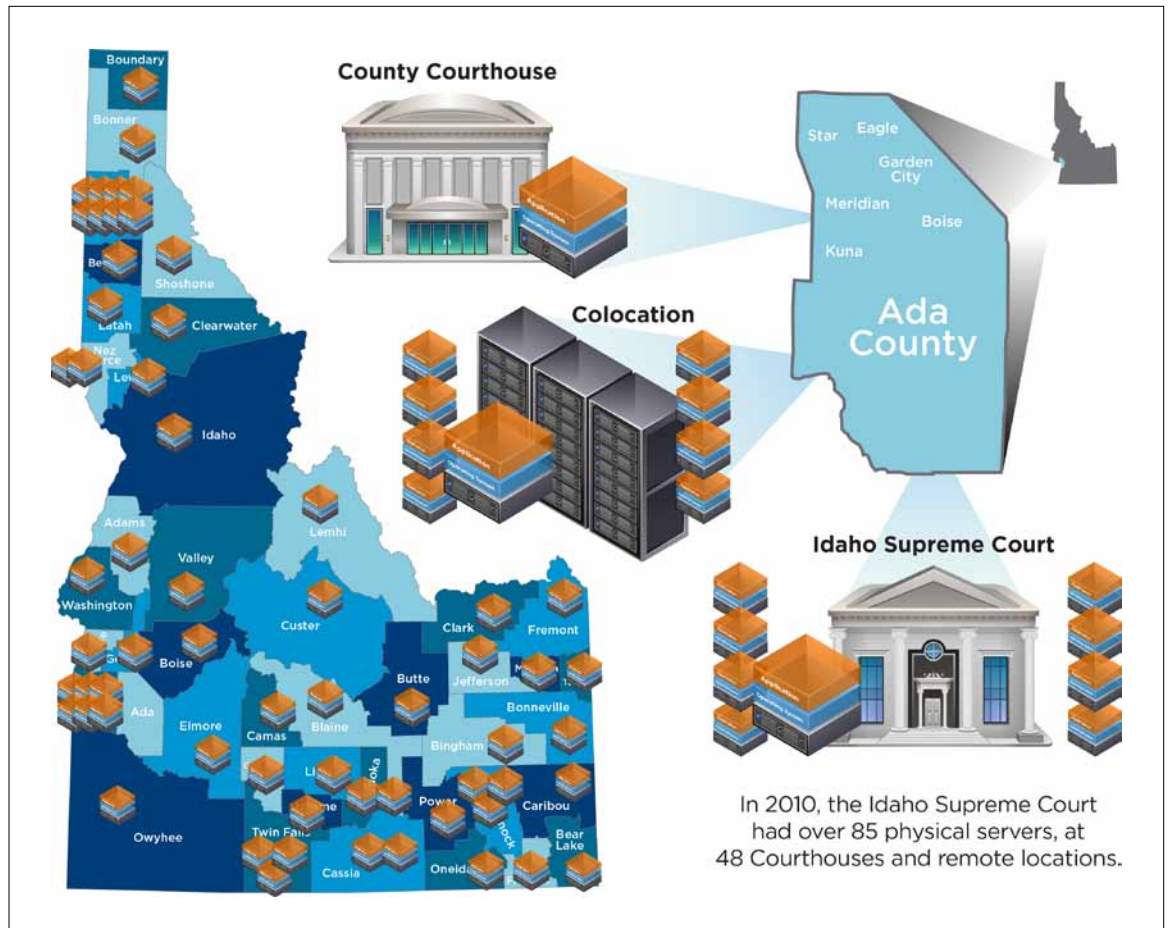


Figure 1. Pre-Oracle virtualization VMware architecture. All servers except Oracle database servers are virtualized.

Design and Build of the Oracle Virtual Appliance

Design Considerations for Performance and Scalability

- Oracle 11.2.0.2 (current at the time)
- vSphere 5.1 (64 vCPUs, hot add CPU, hot add memory, hot add disk)
- Use Linux to optimize performance and availability of Oracle
- Oracle database is developed on Linux – Linux implementation of Oracle is more mature
- Kernel
 - Oracle Enterprise Linux SMP Kernel supports hot add CPU capability
 - Install SMP Kernel by installing Linux with 2 virtual processors
 - Hot add CPU to scale as needed at each site
 - Oracle Unbreakable Enterprise Kernel to enhance performance
 - Hot patch kernel with Ksplice - reduces planned downtime
- Memory
 - Hot add memory (Oracle Doc ID 1510710.1) (VMware KB 1012764)
 - Use Linux huge pages for performance, scalability (Oracle Doc ID 361323.1)

- Storage
 - Hot add disk
 - Use Oracle Automatic Storage Management (ASM) - many small thick eager provisioned disks, in this case 25 GB LUNs (added one at a time as needed)
 - Use ASM disk groups for flash recovery area (FRA) and data (DATA) storage.
 - ASM is storage agnostic, can distribute storage across heterogeneous SANs
 - Uses raw disk space to increase performance
 - Can easily be configured to balance IO across spindles and HBAs for optimal performance
 - Use only disk space needed
 - Overall system availability enhanced by ability to live migrate storage

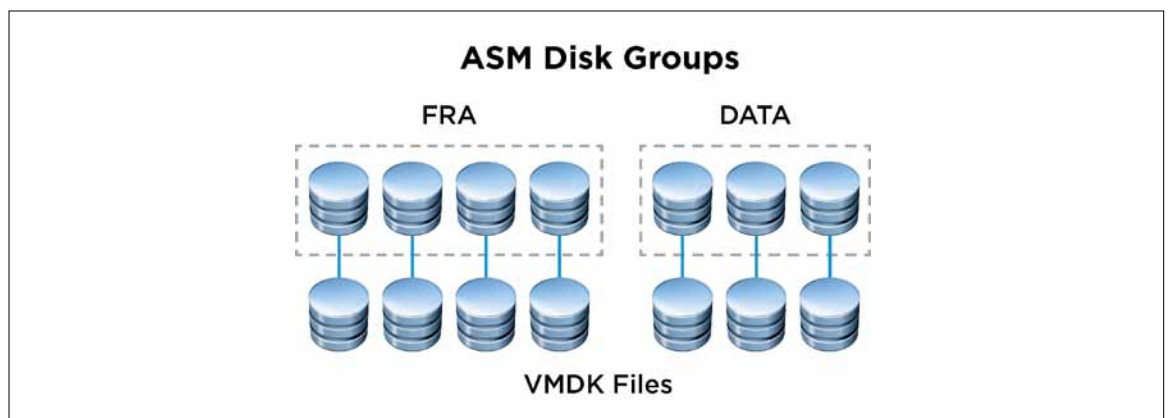


Figure 2. Sample ASM disk group configuration.

Deployment and Tuning

Physical Specs After Oracle Virtualization

Branch Office Specs

- Single Dell PowerEdge T710 server - ESXi 5.1
- 1 x 6 core 3.3 GHz processor Intel x5680
- 24 GB DDR3 with 1333Mhz FSB
- 16 x SAS 10k drives, using PERC H700 with RAID 50Every VM has dedicated cores on server
- 4 vCPUs per Oracle VM

Data Warehouse Specs

- Single dedicated server - ESXi 5.1 (dedicated to address Oracle licensing issues)
- 2 x 8 core 2.26 GHz processors (hyperthreaded) Dell R810 Intel x7560
- 256 GB RAM
- EMC VNX SAN
- 4 Gbps FC connection
- 8 vCPUs
- 20-30% CPU utilization consumed (6400 MHz total)
- 20 other VMs running on same machine (3000 MHz goes to all other machines)
- Consolidated from 8 to 1 physical server

Deployed Virtual Machine to Branch Offices

The objective of the project was rapid deployment to the branch offices. In the actual rollout the virtual appliance performed exactly as designed in speed of deployment, performance and scalability. A typical branch office implementation included the following:

- Shipped Oracle virtual appliance on a hard drive
- Copied virtual machine (VM) to data store and powered up
- Changed the IP address
- Imported Oracle application schema
- Updated Oracle TNS information (occasionally required)
- Tested database connectivity
- Tuned the database CPU, memory and disk IO in a few larger sites
- Exported DB using Oracle exp, then imported into new Oracle DB
- Completed each office in a few hours

Deployed Same Virtual Appliance to Data Warehouse

Because of the scalable design of the virtual appliance, the same appliance was deployed at the data warehouse. Due to the size of the warehouse, a more intensive tuning effort was required but only consisted of adding CPU, memory and storage. The data warehouse rollout process included the following:

- VM was ready to scale
- Installed newer generation hardware
- Installed ESXi 5.1
- Added 4 vCPUs to virtual appliance for a total of 8
- Tuned memory
 - Increased memory to 108 GB RAM
 - Expand shared_pool to a total of 8 GB (different app than at branch offices)
 - shared_pool_size=8053063680
 - .db_cache_size=99614720000
 - .job_queue_processes=1000
 - .large_pool_size=262144000
 - .open_cursors=10000
 - SQL> show sga

Total System Global Area	1.0850E+11 bytes
Fixed Size	2239272 bytes
Variable Size	8589935832 bytes
Database Buffers	9.9858E+10 bytes
Redo Buffers	50479104 bytes

SQL>
- Tuned disk IO
 - Provisioned several small (25 GB) thick eager zeroed disks to ASM storage groups to accommodate data, indexes and RMAN backups
 - Small disks allow thick eager provisioning for performance without wasting SAN
 - Added disks to ASM data and Flash Recovery Area disk groups
- Verified materialized view replication
- Iteratively tuned Oracle under load for performance of large reports

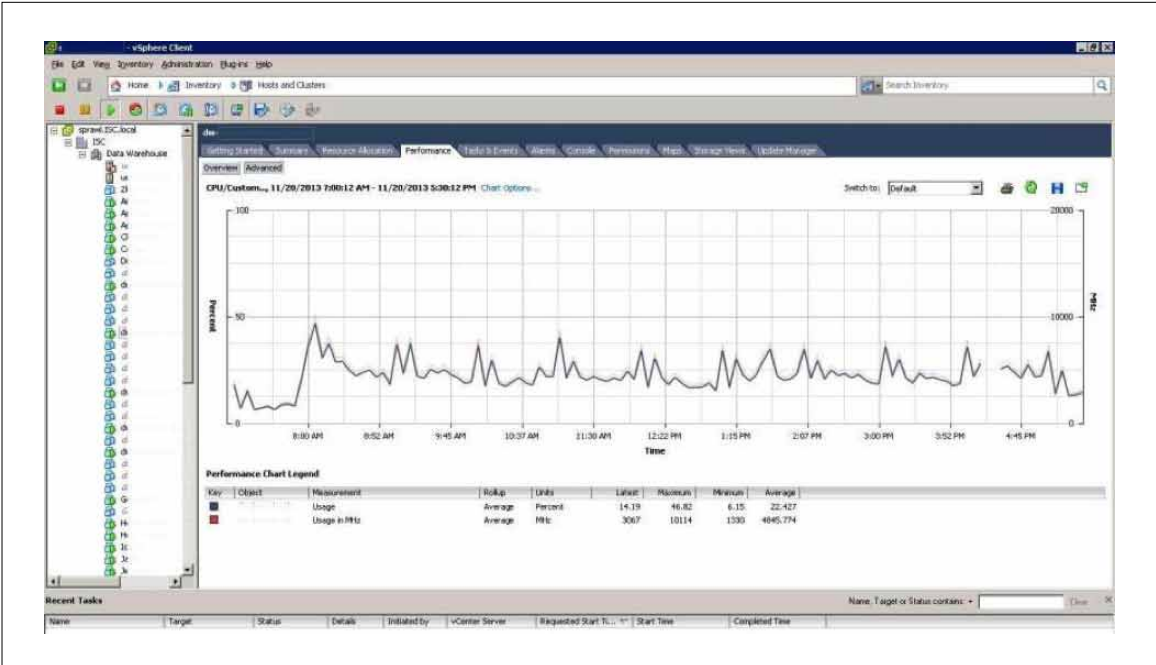


Figure 3. Data warehouse CPU usage on a typical day. Notice the spikes during hourly materialized view replication from the District Court branch offices (see section below).

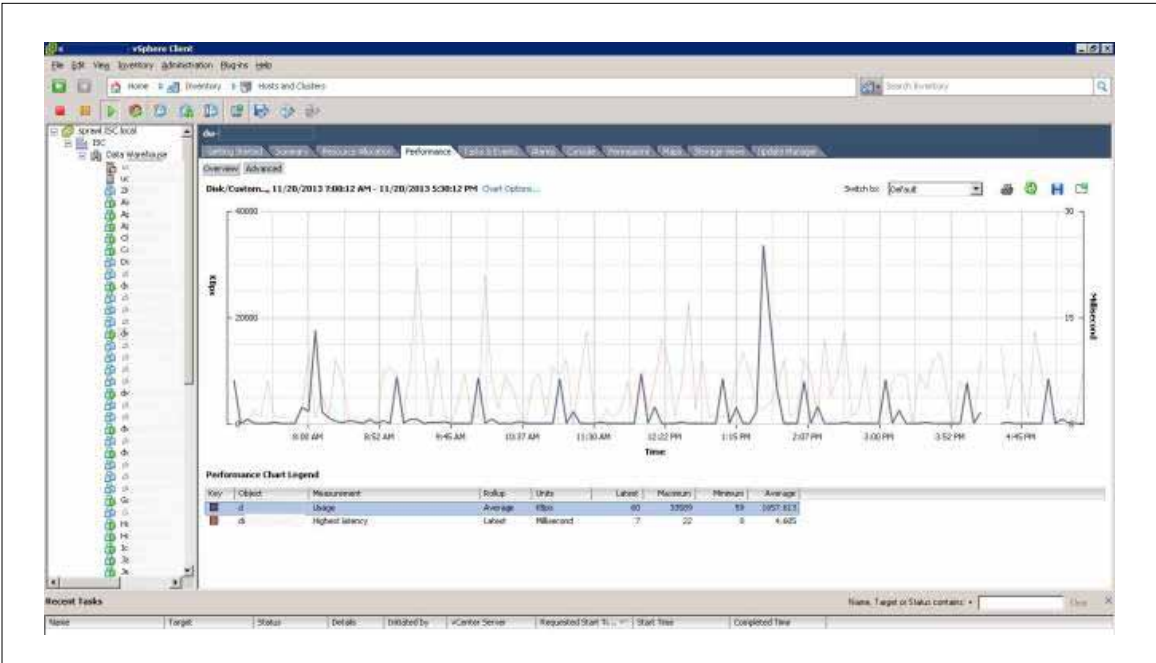


Figure 4. Data warehouse disk activity on a typical day. Notice the disk usage spikes associated with hourly materialized view replication from branch offices and a report (see section below). Disk usage is minimal due to a sufficiently large db_cache_buffers setting in Oracle.

Populated Data Warehouse - Materialized View Replication

Once the data warehouse was up and running, the next step was to populate the data warehouse with up to date data from each branch office. That process included the following:

- Established materialized view replication from each branch office
- Populated the warehouse with complete refresh
 - Took about a week to populate
- Set materialized view replication for once an hour from once daily as before (now possible due to performance increase)
 - Employed fast refresh materialized view replication jobs
 - Scheduled replication jobs

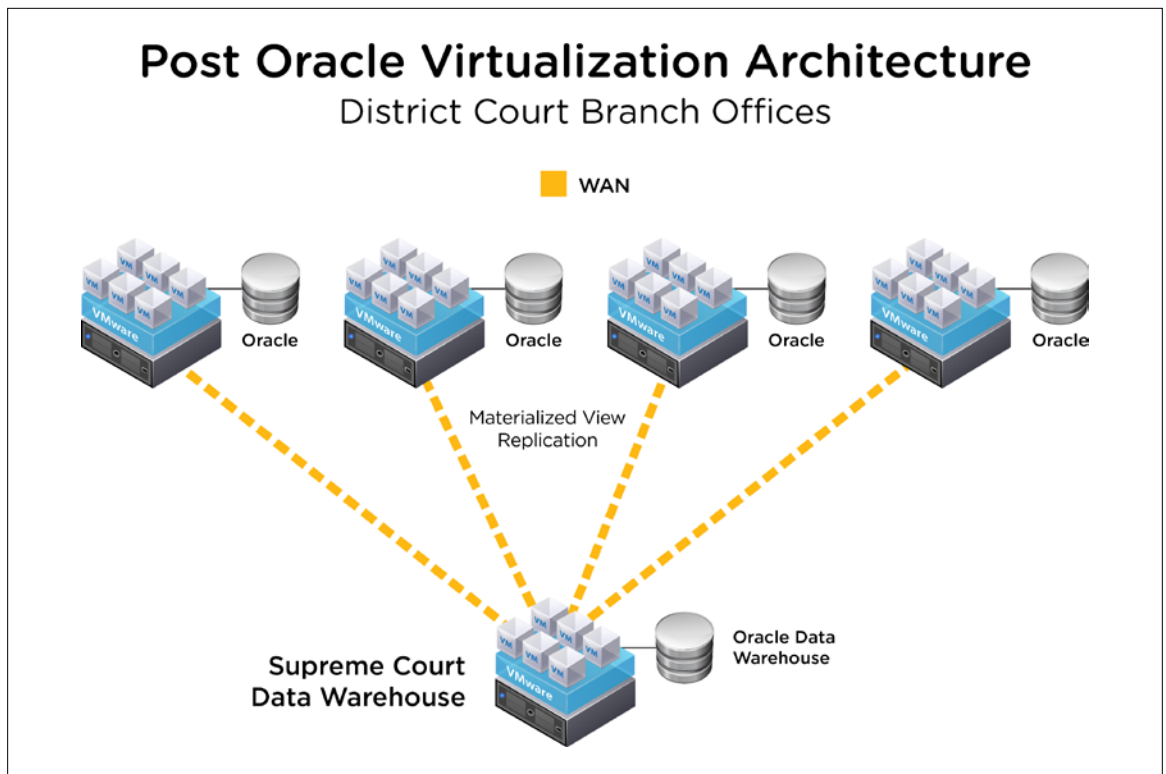


Figure 5. Architecture after Oracle virtualization

3.2 Solution Benefits

Project Results

All the stakeholders in the Oracle virtualization project had their requirements met, and in many cases, exceeded significantly. Following are results from specific areas.

Branch Office Results

- Oracle upgrades were completed in most sites in less than a day
- Statewide rollout was completed in five calendar months (down from over two years) and two man months (down from two years) while not detracting from the regular duties of the two IT staff. This represents a 92 percent reduction in rollout time.

Data Warehouse Results

- Exceeded five 9s (99.999 percent) availability over the last three years with the exception of one application related issue. This availability was achieved with a single instance Oracle database running on a vSphere HA cluster. The 10 day Oracle standby licensing rule allowed for live vSphere® vMotion® of the active database server for proactive maintenance, etc.
- Hourly fast refresh of materialized views were now workable due to increased performance of both branch offices and the data warehouse.

Project Cost Containment

- Due to monitoring of exact Oracle database server resource consumption, several other VMs were able to be hosted on the same physical host without impacting database performance
- Reduced vendor support requirements
- All vendor work was performed remotely (no travel costs incurred)
- Reduced staff travel expense
- Staff cost for project reduced by approximately 92 percent
- Expedited project schedule
- Reduced ongoing administrative expense

3.3 VMware Features Used

The features of vSphere 5 Enterprise Edition lent themselves nicely to virtualizing Oracle in this distributed environment. Management and availability features filled the ISC business requirements along with providing performance necessary for public access and statewide reporting.

This project began on vSphere 5.0, was upgraded to vSphere 5.1 and subsequently upgraded to vSphere 5.5, all of which provided flawless support and superior performance of virtualized Oracle.

VMware® vCenter Server™ and vCenter™ Operations Manager™ provide a “single pane of glass” to address the day to day management tasks of the Supreme Court IT staff. In particular, proactive notification of potential performance and availability issues on 44 servers distributed across an entire state allowed the two person IT staff to provide timely support for all users, no matter how remote.

The combination of vCenter Operations Manager and vSphere® Distributed Resource Scheduler™ (DRS) helps automate the task of providing sufficient resources for the Oracle data warehouse VM by live migrating other VMs to servers with less resource utilization.

At the data warehouse, vMotion and High Availability (HA) have allowed hardware maintenance and replacement, all while exceeding 99.999 percent (5 9s) availability of the Oracle data warehouse over the last three years.

Update Manager allowed the ISC IT staff to upgrade all the hosts and virtual hardware in the state without any travel or impact on end users' productivity.

Hot add CPU is in place to add more CPU resources to the data warehouse in the event that large reports require more resources than necessary for normal operation.

3.4 Performance Considerations

End User Impact

- Court services remained available to court patrons and public during the upgrade
- Upgrades were completed at many sites without any interruption to court operations
- End users saw a large improvement in performance due to upgraded host servers.
- Dramatically improved performance of state wide reporting. Some reports went from three hours to three minutes run time.

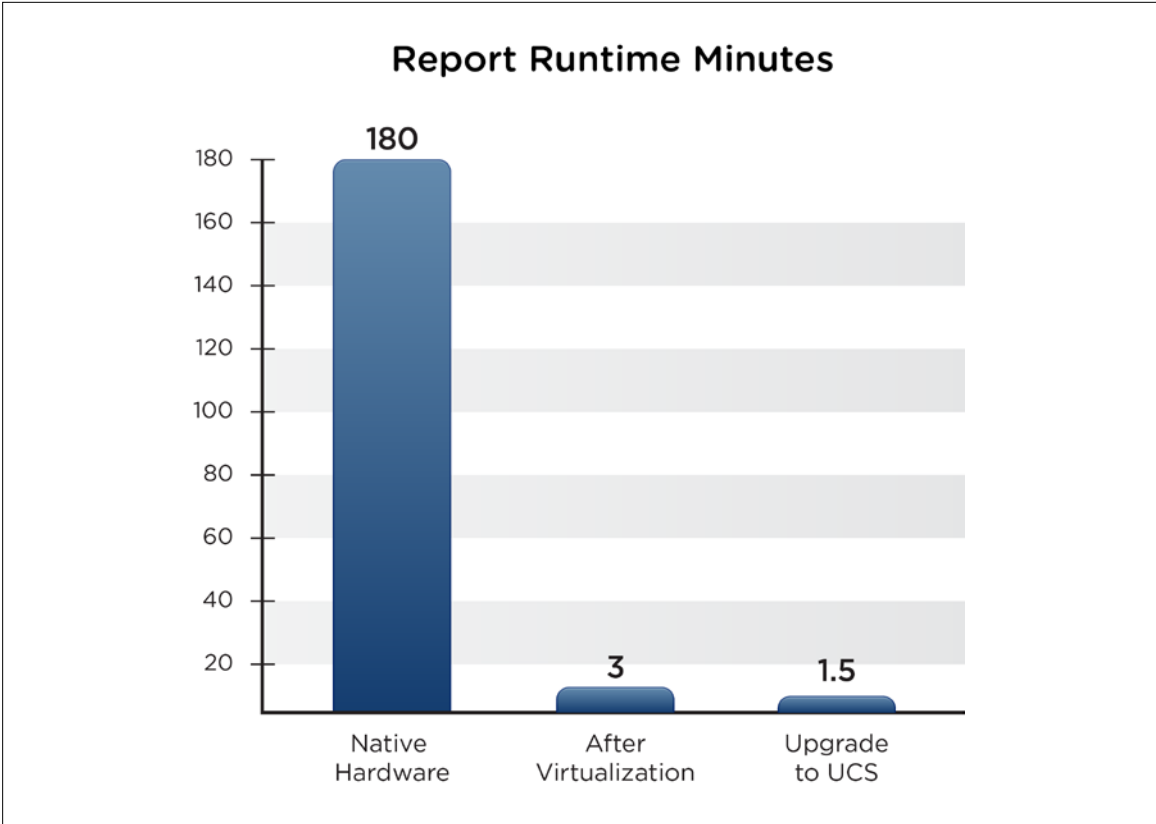


Figure 6. Reduction in runtime of selected reports after virtualization and again after a subsequent migration of vSphere infrastructure to Cisco UCS.

3.5 Support and Licensing

Due to the distributed nature of this installation, no Oracle license savings could be realized through license consolidation. However, because the existing licensing was all Oracle Standard Edition, dramatic performance gains were realized by replacing branch office servers as well as the data warehouse hardware with servers having more and faster cores per socket in addition to much more memory. Hardware and maintenance costs were also reduced by requiring fewer servers at each branch office.

Although the client opted not to pursue this option, the Oracle Standard Edition licenses could have been adjusted to Oracle Standard Edition One licenses due to the increase in computing power of the newer processors (requiring fewer processor sockets). This would have resulted in a 66 percent savings on per processor maintenance at the data warehouse and a 48 percent savings on the named user license maintenance at each branch office site.

A strong selling point for the ISC was that any issues relating to the interaction of Oracle and VMware could be addressed through a single support call to VMware. However, this service has never been necessary.

Oracle virtualized on vSphere in the data warehouse or at any of the branch office installations has not required any support from either Oracle or VMware to date.

4. Conclusion

All the business requirements of the ISC were met through the Oracle virtualization project. Performance and availability were improved while significant cost savings were realized in the process of rolling out the Oracle upgrade. Again, the methodology followed in this project was to apply best practices in tuning VMware software, Linux and Oracle optimally, each in their respective spheres. The success of the project resulted from the optimization of all three components.



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