SCALING SUNGARD HIGHER EDUCATION BANNER SOFTWARE ON DELL HARDWARE

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For institutions of higher education, a scalable IT infrastructure can be critical. To demonstrate the scalability and performance of SunGard Higher Education's Banner® software on Dell™ hardware, Dell collaborated with the State University of New York to build and test a proof-of-concept architecture designed to handle up to 175,000 students with sub-second response times.

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In November 2007, SunGard Higher Education announced that Dell was a partner in its new Unified Digital Campus (UDC) Test Center, and that Dell servers and storage would make up the hardware reference platform for SunGard Higher Education's Banner UDC solutions using Microsoft® Windows® and Linux® operating systems. Banner UDC, an enterprise resource planning solution for higher education that integrates with Oracle® databases, is in use at over 900 institutions worldwide and is designed to work seamlessly with other SunGard Higher Education, third-party, and organization-developed applications to meet the basic information processing needs of higher-education institutions. The partnership between SunGard Higher Education and Dell in the UDC Test Center is intended to facilitate interoperability and performance testing of SunGard Higher Education software and Dell hardware as well as the development of tested and validated reference architectures for Banner software on Dell hardware, helping simplify adoption of Banner at institutions of higher education.

To demonstrate the scalability and performance of Banner software on Dell servers and storage, the Dell Reference Architecture team partnered with the State University of New York (SUNY) Information Technology Exchange Center (ITEC) to perform a proof-of-concept (POC) test in the Dell Austin lab in late 2007 and early 2008. ITEC, a central IT resource for the 64 separate institutions of higher education and research that make up SUNY, manages servers and hosts applications at multiple university campuses. ITEC currently supports Banner for 24 campuses, and manages more than 140 Oracle databases and more than 50 Oracle application servers that provide a variety of applications in addition to Banner.

The Dell-SUNY POC tests extend previous testing performed by Dell and SunGard Higher Education for Texas Tech University.[1] Whereas this previous testing resulted in an architecture designed to meet the needs of the 28,000 students at Texas Tech by running Banner software on Dell hardware, the Dell-SUNY testing was designed to demonstrate that Banner running on Dell PowerEdge™ servers and Dell/EMC storage could scale to handle more than six times that load to help meet the needs of ITEC.

Through the use of VMware® virtualization software to help manage the application servers, Oracle Real Application Clusters (RAC) with Oracle Enterprise Manager Grid Control to manage the large databases, an F5® Networks BIG-IP® load balancer to send the requests to the application servers, and Spotlight from Quest Software to help manage the Oracle RAC databases, the Dell-SUNY POC architecture successfully

[1] For more information, see "Unity and Freedom in One Seamless Solution," by Dell Inc., January 2007, DELL.COM/Content/Topics/Global.aspx/CaseStudies/fy2008_q3_id706?c=us&cs=RC956904&l=en&s=hied.

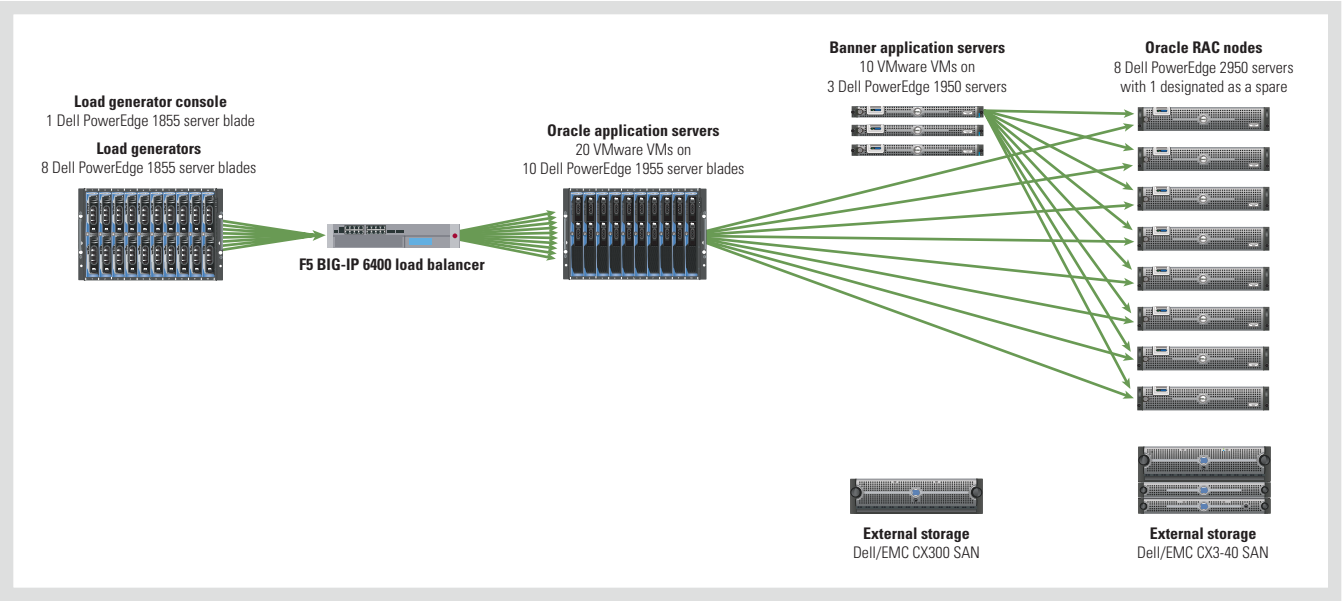

Figure 1. *Hardware configuration in the test environment*

handled a workload representing 175,000 students while providing sub-second response times. In the largest configuration tested, more than 11,000 students simultaneously registered for courses and performed other tasks, with nearly 70,000 courses selected in one hour—37 times the actual number seen at a SUNY school of 11,000 students during a peak one-hour enrollment period.

TEST ENVIRONMENT

Banner UDC from SunGard Higher Education is a tightly integrated suite of higher-education applications that runs on a single database. The Banner components provide universities with tools to manage students, financial aid, finances, human resources, enrollment, and other constituents such as alumni, partners, and the community. Additional elements like the Luminis® and Banner XtenderSolutions components provide portal and document imaging and management features.[2]

To model the large Banner configuration required by ITEC, the test team built the configuration in the Dell Reference Architecture lab along with a sufficient number of load generator servers to model the workload generated by 175,000 students. Figures 1 and 2 detail the hardware configuration used in the Dell-SUNY POC test environment:

- **Load generators:** During the Texas Tech POC tests, SunGard Higher Education and Dell captured the input keystrokes and Web clicks for many of the key Banner user actions using the HP LoadRunner tool. This data was then sanitized to remove real names and other data and used as the workload for the Dell-SUNY POC tests, with 1 Dell PowerEdge 1855 server blade functioning as the load generator console and 8 PowerEdge 1855 server blades functioning as load generators.
- **F5 BIG-IP load balancer:** The F5 BIG-IP 6400 load balancer steered the

	Servers	Processors	Memory	Platform
Load generator console	1 Dell PowerEdge 1855 server blade	Two single-core Intel® Xeon® processors at 2.8 GHz	4 GB	Microsoft Windows Server® 2003 OS (32-bit)
Load generators	8 Dell PowerEdge 1855 server blades	Two single-core Intel Xeon processors at 3.6 GHz	2 GB	Microsoft Windows Server 2003 (32-bit)
Hosts for virtualized Oracle application servers	10 Dell PowerEdge 1955 server blades	Two dual-core Intel Xeon processors at 3.0 GHz	8 GB	VMware ESX 3.02
Hosts for virtualized Banner application servers	3 Dell PowerEdge 1950 servers	Two dual-core Intel Xeon processors at 3.0 GHz	8 GB	VMware ESX 3.02
Oracle RAC nodes	8 Dell PowerEdge 2950 servers	Two quad-core Intel Xeon processors at 2.6 GHz	32 GB	Red Hat Enterprise Linux 4 Update 5 (64-bit)

Figure 2. *Servers used for each role in the test environment*

[2] For more information, visit www.sungardhe.com/products/product.aspx?id=832.

> **"To demonstrate the scalability and performance of Banner software on Dell servers and storage, the Dell Reference Architecture team partnered with SUNY ITEC to perform a POC test in the Dell Austin lab."**

simulated user requests to the application servers in a balanced way.

- **Oracle and Banner application servers:** The key Self-Service Banner (SSB) and Internet Native Banner (INB) components ran on the Oracle Application Server platform. Other Banner functions such as batch processing and compiling ran on the Banner application servers. To help maximize server utilization and flexibility, the test team installed VMware ESX virtualization software on 10 PowerEdge 1955 server blades and 3 PowerEdge 1950 rack servers to create a virtual machine (VM) farm. The test team created 20 VMs running the 32-bit Red Hat® Enterprise Linux 4 Update 5 OS on the 10 PowerEdge 1955 server blades to function as Oracle application servers, and 10 VMs running the 32-bit Red Hat Enterprise Linux 4 Update 5 OS on the 3 PowerEdge 1950 servers to function as Banner application servers.
- **Oracle RAC nodes:** The Banner components stored their data in an 8-node Oracle RAC database running as an Oracle grid. Each node was a PowerEdge 2950 server running the 64-bit Red Hat Enterprise Linux 4 Update 5 OS. The database was managed by Oracle Enterprise Manager and the Spotlight tool from Quest Software.
- **External storage:** The application server VMs were stored on a Dell/EMC CX300 storage area network (SAN) with ten 73 GB disks. The Oracle RAC database was stored on a Dell/EMC CX3-40 SAN with three DAE4P disk pods of fifteen 146 GB disks each.

The Oracle RAC database was a key component in the test environment. Unlike in the traditional database model, where each database resides on its own set of servers and storage, in the Oracle grid computing model multiple databases share a single infrastructure of servers and storage and provide database services to applications. This model allows an Oracle grid to provide dynamic resource sharing and allocation as well as continuous high availability for the databases in the grid.

The Oracle grid computing model was well suited for the multiple-campus Dell-SUNY infrastructure. In this infrastructure, 10 application databases were consolidated in an eight-node Oracle RAC 10*g* Release 2 (R2) cluster to provide database services for the corresponding 10 Banner applications, each of which was designed to serve one campus.

In addition to Oracle RAC and database services, Oracle Database 10*g* includes features to implement the grid computing model, including Oracle Automatic Storage Management (ASM), Oracle Enterprise Manager Grid Control, and load balancing. The grid configuration used in the Dell-SUNY POC tests included the following hardware:

- Eight Dell PowerEdge 2950 database servers
- Two private interconnect network switches connecting the database servers, forming a fully redundant interconnect heartbeat between the database nodes
- Fibre Channel storage connections with dual host bus adapters in each database server as well as dual Fibre Channel switches connecting the servers to the SAN, providing full redundancy for high availability and I/O workload balance
- A Dell/EMC CX3-40 SAN with 37 spindles, providing shared storage and I/O bandwidth for the 10 databases

Each Oracle RAC node ran the 64-bit Red Hat Enterprise Linux 4 Update 5 OS, Oracle Clusterware 10*g* R2, Oracle RAC 10*g* R2, and an Oracle ASM instance. Based on these software stacks, the test team created 10 database instances on the Oracle RAC cluster: 5 large databases designed to handle a load equivalent to that of the Texas Tech tests (28,000 students) and

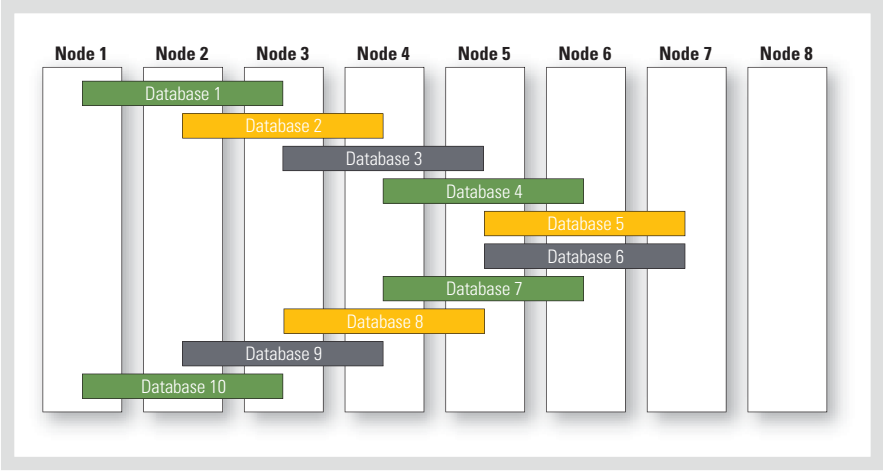

Figure 3. *Database instances on the Oracle RAC nodes in the test environment*

Function	Users (large database)	Users (small database)
Performing a traditional course registration	320	80
Performing a shopping-cart course registration	320	80
Viewing course lists	200	50
Adding or dropping courses	160	40
Viewing grades	800	200
Total	1,800	450

Figure 4. *Number of simulated users performing different functions in each database during the tests*

Databases used	Total simulated student enrollment	Simultaneous simulated users
1 large and 1 small	35,000	2,250
3 large and 3 small	105,000	6,750
5 large and 5 small	175,000	11,250

Figure 5. *Simulated student enrollments and simultaneous users during the tests*

5 small databases one-fourth that size (7,000 students).

To distribute the workloads across the cluster nodes, the test team initially configured each of the 10 databases instances to run on three of the eight Oracle RAC nodes, as illustrated in Figure 3. An instance could be added or dropped from a node by defining which database services ran on which nodes. Node 8 was reserved for future expansion.

TEST METHODOLOGY AND RESULTS

The Dell-SUNY POC tests focused on five of the most common Banner UDC student requests: performing a traditional course registration (one course at a time), performing a shopping-cart course registration (multiple courses at a time), viewing course lists, adding or dropping courses, and viewing grades. To model a typical student workload, the test team configured the load generators to simulate a particular number of users performing the various functions for each database size (see Figure 4). To demonstrate the infrastructure's scalability from the previous Texas Tech POC tests, the test team combined the large databases (representing 28,000 students) and small databases (representing 7,000 students) to model different university sizes (see Figure 5).

Using LoadRunner, the test team ran the workloads simulating the five Banner student functions shown in Figure 4 against the three database configurations shown in Figure 5. Each run lasted 90 minutes, including 10 minutes of ramp-up time. The test team measured three key metrics: response time, processor utilization on the database servers, and total registrations in a given time.

To help model actual behavior, the load generators inserted pauses of several seconds between the actions of the simulated users to represent think time. The response time to an action was defined as the time from when the simulated user submitted a request to the Banner Web page to the time that the Banner software sent a response back to the simulated user session. Figure 6 shows the average response times for each step during traditional course registrations for each of the three workloads, which were all well below 1 second—significantly lower than the requirements specified originally for the Texas Tech tests of 5 seconds for logging in and registering for classes and 2 seconds for the other steps.

Figure 7 shows the average total response time and processor utilization on the database servers during traditional course registration for each of the three

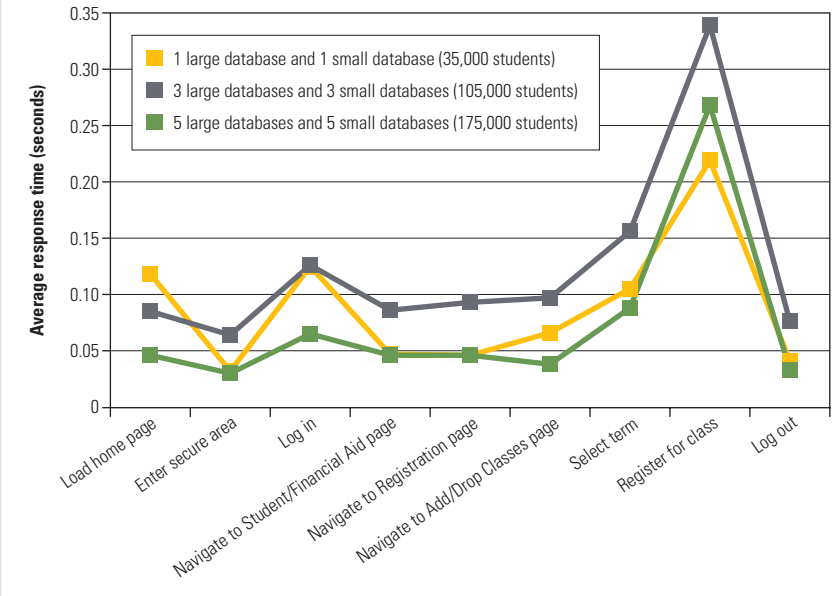

Figure 6. *Average response times for each step during traditional course registration*

Databases used	Number of database servers	Average total response time	Average processor utilization on the database servers
1 large and 1 small	3	0.7 seconds	25%
3 large and 3 small	5	1.1 seconds	31%
5 large and 5 small	6	0.8 seconds	30%

Figure 7. *Average total response time and processor utilization for each workload during traditional course registration*

	Dell-SUNY POC tests	Buffalo State enrollment period
Maximum number of course registrations in a single 15-minute period	20,267	1,172
Maximum number of course registrations in a single one-hour period	67,807	1,820

Figure 8. *Maximum number of course registrations in the largest test configuration compared with the Buffalo State enrollment period*

workloads. The total time an average simulated user waited for the system to respond was about 1 second for the entire set of registration actions. The average processor utilization on the database servers ranged between 25 percent and 31 percent, which left plenty of room for workload spikes.

One way to evaluate the throughput of the largest configuration tested—5 large databases and 5 small databases, for a total of 175,000 students—in real-world terms is to compare the maximum number of course registrations for a single 15-minute period and for a one-hour period with actual data measured during the November 14, 2007, enrollment period at Buffalo State, a SUNY member school with 11,000 students. As Figure 8 shows, the total number of registrations achieved by the Dell-SUNY POC configuration at its peak was about 17 times higher than the peak 15-minute period and 37 times higher than the peak one-hour period during the Buffalo State enrollment.

SCALABLE ARCHITECTURE FOR HIGHER EDUCATION

The results of the Dell-SUNY POC tests demonstrated that SunGard Higher Education Banner UDC software running on Dell PowerEdge servers and Dell/EMC storage along with an Oracle RAC database could scale to handle the needs of multiple large campuses. The test configuration handled a user load representing 175,000 students, with 11,250 simultaneously registering for courses and performing other typical tasks, while providing sub-second response times and supporting nearly 70,000 course selections in one hour—37 times the actual number seen at a SUNY school of 11,000 students. These results indicate the considerable scalability provided by the Banner software and Dell servers and storage that formed the basis of the Dell-SUNY architecture used in the test environment.

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