

Supporting Mission Critical eLearning Services

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Introduction

Since 2000, eLearning has taken off in a dramatic fashion in the Nanyang Technological University (NTU) in Singapore. It has reached saturation levels in the adoption rates by the professors and students. It has now become a mission critical service that requires 24 hours by 7 days availability. This article presents in four sections an overview of NTU's eLearning infrastructural support models and management and operational structure. The processes the University adopted in facilitating the best practices for eLearning support, proactive systems monitoring and performance tuning are also described.

Background to NTU's eLearning Experience

In May 1999, NTU was among the last institutions in Singapore to implement eLearning using a centralized approach. It crested edveNTure as the University's initiative. Within a short span of 4 years, the number of on-line courses in NTU has witnessed a dramatic growth from zero in May 2000 to an accumulative 8,945 courses in May 2004 (active courses is about 2000 course-sites per semester); this accounts for over 90% of NTU undergraduate course curriculum, and 75% of post-graduate courses. The weekly web page views – a strong indicator of usage and impact - have surged to typically 1.5 million (2.1 million peak) page-view hits. This establishes edveNTure as an on-line service that is heavily used and depended on by the campus community in NTU.

Today, edveNTure can be regarded as a **real-time mission critical service** of the University. NTU has a large student population of 22,818 (15,764 undergraduates, 7,054 postgraduates) and over 1,300 professors. Students depend on this eLearning service for courseware content material, forum discussion, self online assessment, etc. Professors use it as a means to communicate and keep in touch with their students. They also lean heavily on it as a (productivity) tool for online assessment, progress tracking, etc.

For its achievements, it has been accorded the following recognitions:

1. CIO100 Honoree 2004
2. Intelligent20 2003
3. Centre of Excellence in eLearning (SUN Microsystems), 2003
4. MOA with Blackboard Inc - International Certified Education Centre, 2003

Section 1

Support Models for eLearning Infrastructure

In a typical campus environment like NTU, the stakeholders responsible for supporting the eLearning infrastructure include the Computer Centre (CC) and the Educational Services Centre (ES). Though there is no single solution that best fits all campus organization structures and culture, it is feasible for any institution to consider adopting one of the following models.

Model A	<ul style="list-style-type: none">• CC is responsible for all domains - networking, server hosting, operating system administration and eLearning application.
Model B	<ul style="list-style-type: none">• CC is responsible for IT related domains networking, server hosting and operating system administration, except the eLearning application.• ES focuses only on eLearning application administration
Model C	<ul style="list-style-type: none">• CC is responsible for networking, server hosting and operating system administration.• With the servers hosted at CC Data Centre, ES co-shares the responsibility of operating system administration with its focus remaining on eLearning application administration.
Model D	<ul style="list-style-type: none">• CC is responsible only for the networking support.• ES is responsible for all IT related domains except networking. This includes server hosting, operating system administration and eLearning application administration

Earlier in May 1999, NTUs' Centre for IT Services (CITS) initiated an eLearning pilot run using an eLearning platform called TopClass. After 12 months of usage, only 22 courses went on-line. The reasons behind the limited success in this trial, based on user feedback, were essentially due to the user-unfriendliness of the graphical user interface, proprietary database format and pricey business model (US\$7.50 per user per year). During this 1 year of trial run, Model A was adopted with CITS providing services in all IT related domains.

Following this trial, it was decided to explore what was available for on-line courseware delivery and management platform on a campus wide basis. A eLearning team was formed in early 2000, led by the Director of the Centre for Educational Development (CED) with an IT Manager and a Courseware Specialist. During the transition from TopClass to the new platform, Model B was adopted with CED focusing on eLearning application administration, and CITS providing support for networking, server hosting and operating system administration.

When the University embarked on this new eLearning project, CED undertook a process of due diligence to select a suitable platform and system with careful use and selection of professor-friendly tools. NTU made the decision to move from the platform used in the pilot, and adopted Blackboard as its courseware and learning management platform (www.blackboard.com). With its large user base and community it was assumed that this courseware management system would evolve, receive community feedback, and provide new tools and better features that would continuously enhance the learning experience for students.

When edveNTUre was soft launched in May 2000, the support model C was used with CED co-sharing the responsibility of the operating system administration with CITS, with the former focusing on the eLearning application administration. Owing to the shortage of professional IT staff, the Centre for IT Services (CITS)

allocated 2 Systems Analysts (on a part-time basis) to help administer the operating system and tape backup of the SUN Enterprise E10000 server hosted at CITS. The IT Manager from CED was responsible for administering the eLearning application services and the server operating system. The two CITS Systems Analysts assisting CED had other additional responsibilities, and consequently, could only provide partial attention on the system administration of the CED eLearning servers.

In April 2002, it was proposed to move the eLearning servers from CITS to CED and form a core team of dedicated eLearning IT staff to take care of eLearning services. Approval was given in June 2002; this new setup is congruent with Model D. In January 2003, CED set up a full-fledged data centre (with proper power/air-conditioning, fire/security measure) called eLearning Operations Centre (EOC); all eLearning servers hosted at CITS were successfully moved to CED EOC in January 2003. With the commissioning of CED EOC, the two CITS Systems Analysts relinquished their support duties with CED. CED has been providing full self-support for all eLearning server administration and network operations with the small number of CED EOC team members. At present, the eLearning Operations Centre (EOC) team has a total of two professional IT staff and six technical staff; they provide campus wide support for edveNTure eLearning services (23,000 students and 1,300 professors) and the lecture theatre PCs. The edveNTure eLearning services included supporting the back-end eLearning servers, front end phone/email/walk-in support, networking, systems security, tape backup, daily systems maintenance and anti-virus preventive measures.

Figure 2 below shows a photograph of the EOC, while Figure 3 captures the overall eLearning infrastructure.



Figure 2: eLearning Operations Centre

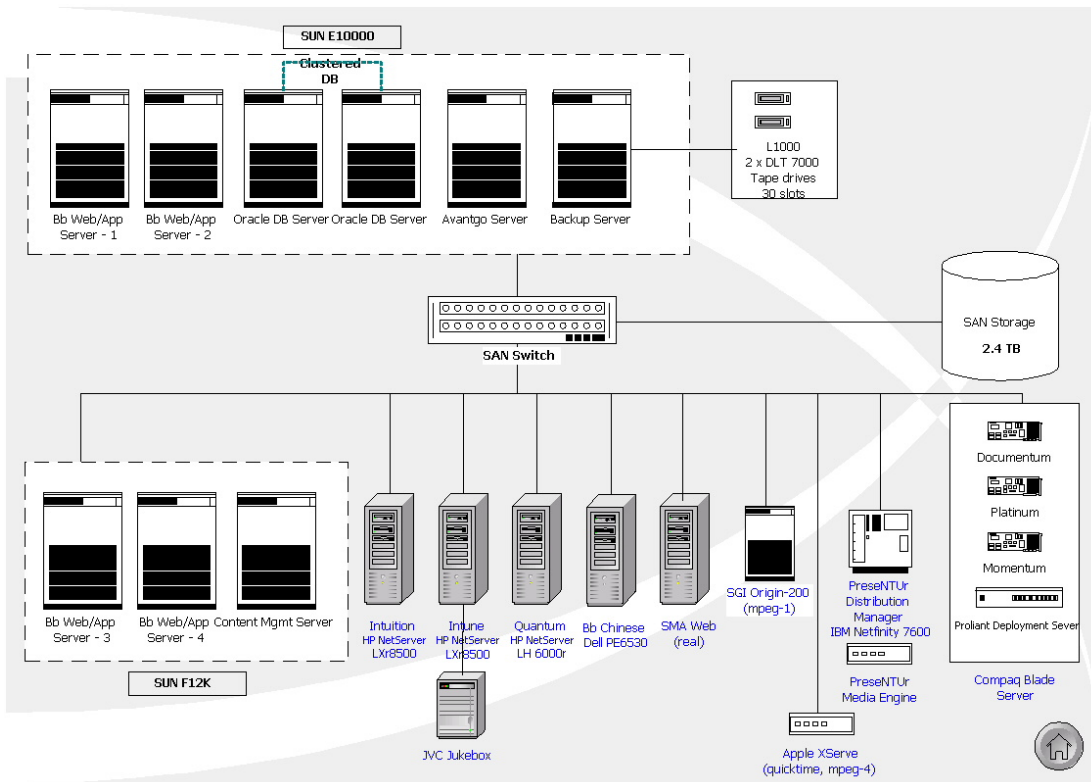


Figure 3: NTU's eLearning Infrastructure

Section 2

Organizational Support Structure for eLearning

At a higher administrative level, the eLearning initiative is fully supported and guided by an executive committee called IT-SEED (IT Steering Executive on Electronic Education). It provides directives and vision for new educational initiatives in NTU. The IT-SEED committee members comprise of senior appointment holders and stake-holders, and have the capability to expedite influential action plans efficiently at a campus level. These senior executives also lead an eLearning support team at the departmental or school level.

As a facilitator of eLearning services, CED has created a central support team with 4 instructional designers and 8 trained systems administrators to provide instructional and technical support for any phone, walk-in and on-line inquiry. CED has also established (and the team has been adhering to) a standard of a working day's response for any problem reported to the central support team.

At the schools' operational level, a school-based eLearning support model was established to provide effective first line proximity help. Members of the school support team are trained departmental technicians who provide first-line assistance with a familiar face to academic and administrative staff. Problems beyond their first line supportive role are escalated to CED.

Figure 4 shows NTU's organizational support for eLearning.

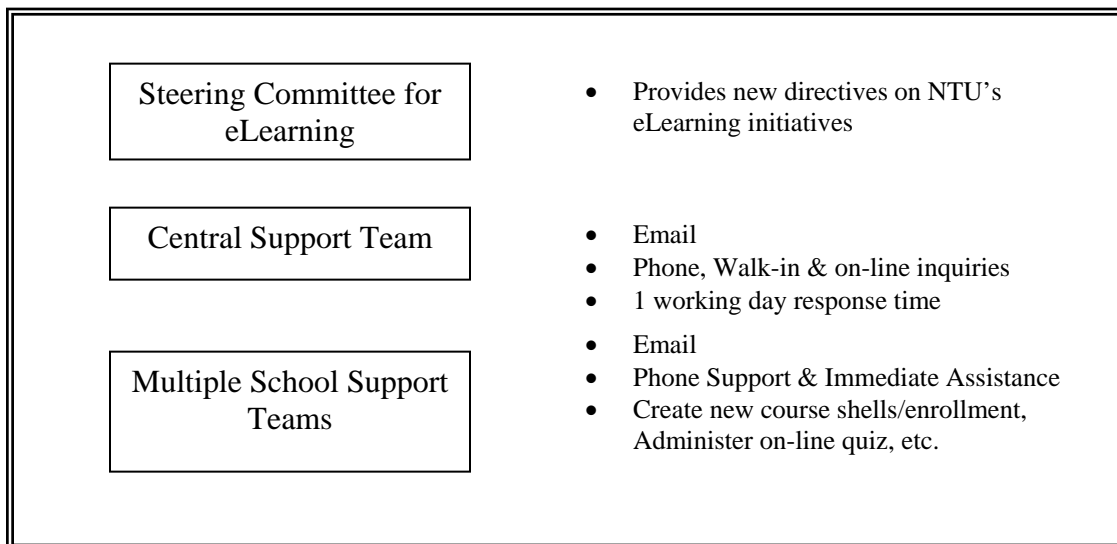


Figure 4: Support Structure for eLearning

An online line help-desk application from Parature (<http://www.parature.com>) ensures efficiencies (quick response and resolution) and effectiveness (tracking of help requests and technical assistance, case management and closure). This server is hosted externally and the application has been integrated seamlessly within edveNTUre Learning Management System with "My HelpDesk" icons available on the main portal window and individual course sites. A screenshot of this helpdesk ticketing system (as seen by NTU professors and students) is shown in Figure 5. With this system, we are able to track all tickets submitted to central and school-based support teams. We are able to ascertain how many tickets are currently pending further investigation and have been resolved by the support teams. NTU had configured alert emails to be sent to the central support team when there are more than 20 tickets in the new tickets queue. A screen shot of the backend utility used by the support team members is shown in Figure 6.



Figure 5: edventure Helpdesk Ticketing System (front end)

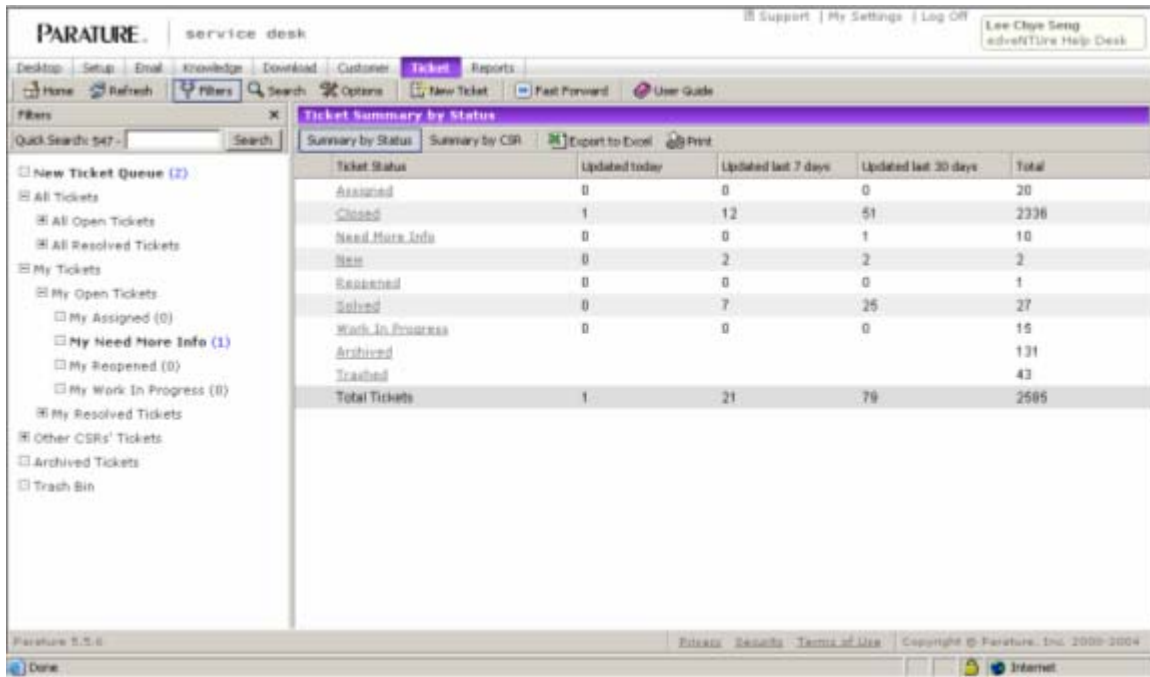


Figure 6: edventure Helpdesk Ticketing System (back end)

Section 3

Proactive Systems Performance Monitoring

Supporting a large population of 24,000 users is a daunting task for any IT department. With only a lean IT staff strength of eight, CED believes in adopting the right technology to do the right things right the very first time. As such, the Centre strives to automate the manual operational mundane tasks using the available technologies in the IT industry. The guiding principle here is that customer's experience comes first and eLearning services must be highly available.

To monitor the health status of the core eLearning servers and network, CED uses Mercury Interactive's SiteScope to track the performance of the hardware resources (e.g. CPU, Memory usage, etc) and the application software (e.g. the number of Apache web processes). SMS alerts are configured to inform key administrators of any server crash. Illustrations of Site Scope monitoring are in Figure 7 and Figure 8.

Other than this internal health status monitoring within the eLearning Servers Farm, CED also engages SUN Remote Monitoring Services to help track the status of all SUN servers hosted within the eLearning Operations Centre on a 24x7 basis. If any SUN server were to malfunction (e.g. hardware component failure), the remote monitoring service team will alert CED IT team via email and phone. If required, SUN would proactively dispatch engineers to our Data Centre.

CED hosts a total of 35 Windows Servers (Dell, HP, IBM, Compaq Blade and NEC Blade), 20 SUN domains/servers (1 SUN Fire F15K, 1 E10K and 5 V880), 2 Red Hat Linux Servers, 1 SGI server and 2 Apple XServe Servers in EOC. Besides these servers, CED is also responsible for the technical support of 110 PCs located at the Lecture Theaters, Audio Video Control Rooms, Smart Classroom, CED Instruction Room and Nanyang Executive Centre. In such a multi-vendors server environment, and with this huge number of PCs to administer, it is a challenging task when there is a need to perform security and operating system patches on the servers and the PCs. CED has acquired Patch Link software management tool to help perform effective patch management. It deploys patches and install them when the servers and PCs are not in used (e.g. 4am in the morning). A screen capture of Patch Link deployment is shown in Figure 9. A project plan is in progress to implement a software application called SystemSkan that tracks all PC activities (e.g. what application did a particular user start at a certain date/time stamped, document opened, etc). This would be useful if there is a need to perform audit trail related to suspicious PC activities, e.g. the hard disk was reformatted on a certain date and there is need to find out who was the last user. It is possible to retrieve past information as all activities are tracked and captured in a remote database. SystemSkan also provides the means for a helpdesk staff to take control of a remote PC to troubleshoot a problem instead of going down to the site.

In terms of servers and network security, 2 units of load-balanced Fortigate Intrusion Prevention Systems have been set up, in addition to the existing security firewalls at the Internet gateway. This provides intrusion prevention, content filtering and anti-virus scanning. CED also adopted managed security monitoring services from a local service provider that detects and proactively prevents potential wide area and zero-day security attacks to the eLearning Servers round the clock.



Figure 7: SiteScope monitors – eLearning Servers and Network

The screenshot shows the 'Monitors in the "edveNTUre Server" Group' interface. It features a table with columns for Status, Name, More, Edit, Refresh, Updated, and Del. The table lists several monitors including CPU Utilization, Memory, Disk Space, Service (http and sh), SNMP, and NT Performance Counter. Below the table, there are instructions on how to get more information on a monitor and links to add new monitors, sets, or subgroups, edit group properties, and manage monitors and groups.

Status	Name	More	Edit	Refresh	Updated	Del
99% avg, cpu1 13%, cpu2 10%, cpu3 14%, cpu4 6%, cpu5 3%, cpu6 24%, cpu7 5%, cpu8 4%	CPU Utilization on 155.69.240.138		Edit	Refresh	6:36 PM 3/24/02	X
26% used, 5500MB free, 0.01 pages/sec	Memory on 155.69.240.138		Edit	Refresh	6:35 PM 3/24/02	X
76% full, 21136MB free, 87120MB total	Disk Space /dev/bsdd/learnapp/app on 155.69.240.138		Edit	Refresh	6:35 PM 3/24/02	X
67% full, 2177MB free, 6531MB total	Disk Space /dev/bsdd/disk/d1 on 155.69.240.138		Edit	Refresh	6:36 PM 3/24/02	X
running, 46 processes, 2073.25MB memory	Service http (Web service) on 155.69.240.138	Tools	Edit	Refresh	6:36 PM 3/24/02	X
running, 7 processes, 7.07MB memory	Service sh on 155.69.240.138	Tools	Edit	Refresh	6:35 PM 3/24/02	X
372265225	SNMP: edventure.system.sysUpTime	Tools	Edit	Refresh	6:35 PM 3/24/02	X
26% used, 5498MB free, 0.01 pages/sec	Memory on 155.69.240.138		Edit	Refresh	6:35 PM 3/24/02	X
Pages/sec = 0.00/sec, Page Faults/sec = 24.27/sec, Page Reads/sec = 0.00/sec	NT Performance Counter: Memory.pmc		Edit	Refresh	6:35 PM 3/24/02	X

Get more information on a monitor by clicking on the name of the monitor.

[Add](#) a new Monitor to this Group
[Add](#) a new Monitor Set to this Group
[Add](#) a new Subgroup

[Edit](#) Group Properties
[Manage Monitors and Groups](#), including moving, duplicating, deleting, disabling or enabling
[Disable](#) all the monitors or temporarily disable alerts for monitors in this group

Figure 8: Details of eLearning Servers Parameters

Computers @ PatchLink Update Server - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Refresh Home Search Favorites Media

Links Customize Links Free Hotmail Windows Windows Media AOL for Broadband Leave Chart CTO Stafflink

Computers PATCHLINK

Home | Reports | Inventory | Packages | **Computers** | Groups | Users | Options | Help | Server Time: 5/10/2004 6:09:45 PM (GMT+08:00)

Computers Filter By: Enabled

Enabled Computers Total Computers: 38

Computer Name	Status	Platform	OS Info	Version	Group List
\\ACULEARN	Offline	Microsoft Windows XP Professional	WinXP-Service Pack 1	5.0.1.60	LT PC, WinXP
\\ACULEARN-CED	Offline	Detection results not found	WinXP-Service Pack 1	5.0.1.60	LT PC, WinXP
\\ACULEARN-LT22	Offline	Detection results not found	WinXP-Service Pack 1	5.0.1.60	LT PC, WinXP
\\ACULEARN-LT25	Offline	Microsoft Windows XP Professional	WinXP-Service Pack 1	5.0.1.60	LT PC, WinXP
\\ACULEARN-SCI	Offline	Detection results not found	WinXP-Service Pack 1	5.0.1.60	LT PC, WinXP
\\ACULEARN-SME	Offline	Detection results not found	WinXP-Service Pack 1	5.0.1.60	LT PC, WinXP
\\CED02TR4	Sleeping	Microsoft Windows XP Professional	WinXP-Service Pack 1	5.0.0.6	Training Room PC, WinXP
\\CEDTR1	Sleeping	Microsoft Windows XP Professional	WinXP-Service Pack 1	5.0.0.6	Training Room PC, WinXP
\\CEDTR2	Sleeping	Microsoft Windows XP Professional	WinXP-Service Pack 1	5.0.0.6	Training Room PC, WinXP
\\CEDTR5	Sleeping	Microsoft Windows XP Professional	WinXP-Service Pack 1	5.0.0.6	Training Room PC, WinXP
\\LT20	Offline	Detection results not found	WinXP-Service Pack 1	5.0.1.60	LT PC, WinXP
\\LT2A	Offline	Microsoft Windows XP Professional	WinXP-Service Pack 1	5.0.1.60	LT PC, WinXP
\\LTSREC	Offline	Microsoft Windows XP Professional	WinXP-Service Pack 1	5.0.1.60	WinXP
\\MLT	Offline	Microsoft Windows XP Professional	WinXP-Service Pack 1	5.0.1.60	LT PC, WinXP
\\NEC_AUD	Offline	Microsoft Windows XP Professional	WinXP-Service Pack 1	5.0.1.60	NEC PC, WinXP
\\NEC_LR1	Offline	Microsoft Windows XP Professional	WinXP-Service Pack 1	5.0.1.60	NEC PC, WinXP

Previous 100 Display 100 rows per page Next 100

cslee Install View Disable Export Scan Now

Local intranet

Figure 9: Patch Link Management in operation

Part 4

Best Practices for Blackboard 5.5 Backend Administrations

This section outlines the best practices for Blackboard 5.5 backend administrations. It includes the procedure required to automate service restart after an outage, log file management, polling mechanism to ensure service availability and some practical tips on performance tuning. This section on performance tuning is applicable only to Blackboard 5.5 platform using Solaris 8 operating system and Oracle 8.1.6i database.

1. Automated Service Restart

A procedure has been in place to restart the service should an unexpected outage like power failure occurs. Other than the industry practice of having an Uninterrupted Power Supply (UPS) unit to shut down the servers gracefully, we have added the capability to re-start automatically when the power resumes. This is useful for situations as power outages might occur in the wee hours when nobody is around in the office (e.g. 3am) to execute the manual service restart procedure.

In such a scenario, the Blackboard 5.5 application and web services as well as the Oracle 8.1.6i database services must be able to start up automatically while the servers are being booted up. Scripts have been written to bounce or start up services for Apache, WebLogic and the Oracle Database instance.

2. Log Files

Log files for web access and system errors are useful resources when there is a need to perform investigation on systems malfunctioning or forensic analysis on illegitimate web access to course site repository (like on-line grade book).

The size of log file especially the web access log file can be huge, especially in an active eLearning environment like ours. In NTU, the daily access log file can be as large as 300MB during the peak period (usually, the first 3 weeks of the semester). Owing to this, log files must be properly managed for the Blackboard service to run responsively.

Ideally, the log files must be compressed and archived into a date/time stamped folder daily. The file compression will help save disk space and prevent unnecessary wastage of storage. In addition to the log files archival process, a set of new log files should be created daily at 12.00am. If this new set of log files creation is not done, all user access information will be logged and appended to the same set of log files that gets accumulated over time; this results in extremely huge file size. This may lead to slow server response time as every new log entry will require the servers to append it to the end of a growing humongous file.

3. Polling Mechanism

For Blackboard sites that have multiple load balanced server configuration and are always heavily used, it might be useful to write scripts to poll the availability of the WebLogic service at regular intervals of, say 5 or 10 min. If the service becomes unavailable, the script will automatically restart it when it detects a malfunction during the polling process. The script can also be written to alert the systems administrators via email for the occurrence of a service restart. This mechanism will help provide fast service turn around time for the users with minimal human intervention.

4. Tips on Blackboard 5.5 Performance Tuning

The systems architecture depicting the essential components for Blackboard 5.5 is shown in Figure 10 below. The areas that require performance tuning include the Apache web server, the BEA Web Logic portal server and the Oracle 8.1.6i database server.

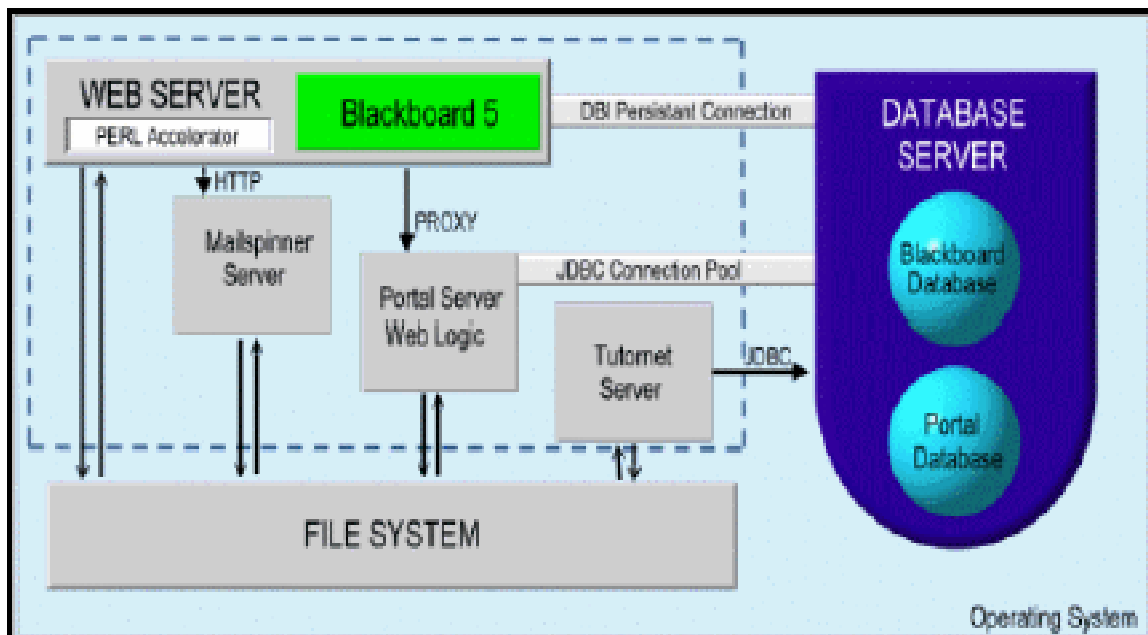


Figure 10: Blackboard 5.5 Systems Architecture

It should be noted that the following tips are the experience of the NTU team while administering Blackboard 5.5 servers. The configurations are tabulated here for the purpose of sharing experience. For the optimal performance tuning for your institution's Blackboard 5.5 servers, you may adopt the tips given here but you are advised to verify the server configuration settings with Blackboard Professional Services team.

In NTU, the Blackboard platform is configured using 3 x Blackboard 5.5 Application Servers (4 x CPU/8GB RAM) and 1 x clustered Oracle 8.1.6i database (6 x CPU/8GB RAM, active-passive failover). This set up is load balanced using 2 x F5 BIG-IP 5000 web load balancers (active-passive failover).

This platform configuration has been able to sustain high utilization rate of 2.1 million weekly page views (or 300,000 daily page views) generated by the academic community.

4.1 Apache Server

Technical details related to the tuning of the Apache web server can be found at

<http://perl.apache.org/docs/1.0/guide/performance.html>.

The apache configuration file is found in this directory:

`/usr/local/blackboard/httpd/conf/httpd.conf`

There are some parameters to tune the Apache server. They are discussed below. It would be useful to have a technical person to perform the tuning of the servers. Some of the values are set using trial and error for our environment (that is, nature of transaction, typical transaction length, transaction loads, etc)

- 4.1.1 Max Clients:** this is the maximum number of child processes that the server will spawn. It can be translated to the number of simultaneous users that the server can support or the number of concurrent sessions at that particular instance in time.

The formula used to calculate this parameter is:

$$\text{MaxClients} = \text{Available Memory}/40\text{MB}$$

Thus, if you have 8GB RAM on your server, you may set the MaxClients setting to (8GB/40MB =) 200.

This is a theoretical calculation. Based on our experience, we set the parameter to 200 initially based on the above calculation but had lowered it to 175 during peak load when the servers were found to running low on memory resources for 8GB RAM.

When this MaxClient limit is reached (that is, the number of simultaneous sessions approach the set value of 200) and the server is unable to process any further new web request owing to limited resources, error message like “*Internal Server Error*” will appear on the client browser window of the user.

This is recorded in the web error log and the directory is located at

`/usr/local/blackboard/httpd/logs/erro_log`

A typical entry looks like this:

[Sun Jan 24 12:05:32 2001] [error] server reached MaxClients setting, consider raising the MaxClients setting.

- 4.1.2 Start Servers:** this refers to the number of child processes initially created to service the users. The default number is 10; NTU set it to 16. The number should not be too low as time and system resource are required to create a child process.
- 4.1.3 MaxRequestsPerChild:** this is the maximum number of requests that a child process can handle before it dies off and restarts. The default is 300; NTU set it to 400.
- 4.1.4 MinSpareServers:** this is minimum number of children awaiting requests. The default number is 5; NTU set it to 8.
- 4.1.5 MaxSpareServers:** this is the maximum number of children awaiting requests. The default number is 10; NTU set it to 32.

4.2 BEA Web Logic Portal Server

- 4.2.1 File Descriptor:** when the server experiences an error with the web logic portal server, and messages like “Portal Server not available” appears, there is a need to increase a server parameter called File Descriptor.

A File Descriptor is used whenever the application opens a file or communicates across a network.

This parameter can be found in this directory

`/usr/local/blackboard/apps/weblogic/weblogicctl ulimit -n 1024`

NTU sets it to 1024 for stable performance.

- 4.2.2 **Web Logic Threads:** When user complaints of “slowness logging onto Bb server” start streaming to your helpdesk, there is a need to review the number of web logic threads assigned. This thread is used whenever there is a connection made to Director Server (LDAP) for user authentication.

The web logic properties file is located at

```
/usr/local/blackboard/apps/weblogic/weblogic.properties.  
Weblogic.system.executeThreadCount 200
```

The recommended number is 15; NTU sets it to 200 for optimal performance

4.3 Oracle 8.1.6i Database Server

The cluster Oracle 8.1.6i database is powered by a high-end 6 CPU and 8GB RAM configuration.

The Database parameters are tabled below for information sharing:

```
db_block_buffers = 512000  
shared_pool_size = 268435456  
sort_area_size = 4194304  
log_buffer = 4194304
```

Conclusion

To get started with eLearning is easy but to get it going smoothly requires established processes to support good customer services and strong support right from the top management to trainers and frontline operational staff. There is also a need to stay close to technology partners so that support is always rendered promptly when the call for help is activated. From the technological view- point, there should be sound processes in place that provides proactive information alerts of any malfunctioned system that require immediate attention from the systems administrators.