Virtualization Technologies and Blackboard: The Future of Blackboard® Software on Multi-Core Technologies

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Agenda

- Session Length: 50 minutes
- Focus will be on enterprise level technologies.
- Virtualization – What and Why?
- Main Approaches
- Virtualization Technologies
  - Xen
  - VMware
  - Solaris Containers
  - Logical Domains
  - Microsoft Virtualization Server
- Xen vs. VMware performance comparison
- Hardware vendor architecture improvements
- Alternatives to virtualization
- Resources
What is Virtualization?

• Abstraction Layer
• Hypervisor – firmware layer structure which can expose or hide various resources
• Decouples Hardware and O/S
• One Physical Machine
• Multiple Virtual Machines
• Heterogeneous Operating Systems
What is Virtualization?

- Each Virtual Machine is assigned specific hardware resources.
- O/S must access resources via the hypervisor.
Virtual vs. Direct I/O

- Both Direct and Virtual access to I/O possible
- Virtual LAN provides direct network access between virtual servers (no need to access external network).
Why Virtualize?

• Manageability
  – Virtualized servers can be individually rebooted
  – Servers can be consolidated

• Flexibility
  – Physical resources can be dynamically reallocated as load dictates
  – Applications can run simultaneously on different operating systems

• Efficiency
  – Overall CPU utilization maximized with virtualization vs. multiple, smaller machines
  – Reduced hardware, power, cooling and floor space requirements
  – Reduced management overhead
  – Some technologies allow users to overcommit of resources
Why Virtualize?

• Reduced licensing costs
  – Vendors currently license based on sockets or cores.
  – This will change if vendors begin to license based on virtual machines.

• Security Improvements
  – Applications can be separated
  – Virtual servers can communicate on a virtual LAN

• Dedicated Resources
  – Resources can be dedicated to a specific application
  – An application can be sheltered from “resource hogs”

• Multi-Core Technology
  – Chip architecture improvements across various vendors
Two Main Approaches

• Full Virtualization

• Para-virtualization
Full Virtualization

- Total abstraction of underlying physical system
- Complete virtual system for guest O/S
- No modification of guest O/S required
- Streamlined migration among physical systems
- Performance penalty due to management overhead
- VM monitor must provide image of entire system
  - Virtual BIOS, memory space, devices
- VM monitor must create and maintain data structures for virtual components
  - Must be updated for every access
- Microsoft Virtual Server
- VMware
Para-Virtualization

- Allows more efficient use of system resources through resource sharing
- Requires guest O/S modifications
- Guest O/S is aware it is executing on a VM
- Allows for near-native performance and efficient scaling
- Lower flexibility in O/S releases
- Possible security issues to be resolved
  - Guest O/S cache data
  - Unauthenticated connections
  - Risk of impacting the lower hardware level and other VMs
- Performance generally better with para-virtualization
- RHEL5 native support
- Xen
Virtualization Technologies

- Xen
- VMware
- Solaris Containers
- Logical Domains
- Microsoft Virtualization Server
Xen

- Installs on bare metal x86 hardware
- Leverages Intel Virtualization Technology
- Enterprise support via RHEL5
- High Speed I/O for enhanced disk and network performance
- Quick and easy installation and deployment
- Physical-to-Virtual conversion tools
- Multi-server management console
- Real time and trended performance reporting
- Very high performance in Blackboard benchmarks
Xen

• XenSource Management Console
Xen Reporting Tools

- Individual VM and total CPU usage at a glance
VMware Infrastructure

- Complete virtualization suite
- ESX Server
- VMFS – cluster file system
- Virtual SMP – multi-processor support
- Virtual Center – centralized management
- High Availability
- DRS – Dynamic resource allocation and balancing
- VMotion – live migration of virtual machines
- Consolidated Backup
VMware ESX Server

- Component of VMware Infrastructure 3
- Installs on “bare metal” machine
- Intelligent process scheduling and load balancing across available CPUs
- Built-in high availability and security features
- Supports Intel, AMD, and Sun hardware
VMware VMotion

• VMotion allows the instantaneous movement of an entire running virtual machine from one physical server to another.
• Provides a reliable mechanism for failover
• Complete virtualization of servers, storage, and networking
• Entire state of virtual machine is encapsulated by a set of files on shared storage
VMware VMotion

- VMotion example: each drop in hits/second is the result of VMotion failover
- Hits/second never reach zero – requests are still being serviced.
- Error free in every case
VMware Server

- Free Download
- Installs and runs as an application on top of a host Windows or Linux operating system.
- Runs on any standard x86 hardware
- Encapsulates a virtual machine environment as a set of files, which are easy to back-up, move and copy
- Supports 64-bit guest operating systems, including Windows, Linux, and Solaris
- Wizard-driven virtual machine creation
- Virtual machine monitoring and management with an intuitive, user friendly remote console
- Good way to explore virtualization technology
- NOT a worthwhile solution for production servers due to performance overhead
Solaris Containers

- Also known as Solaris Zones
- Multiple virtualized environments
- All reside within one Solaris kernel structure
- Low memory footprint
- Highly flexible resource management
Logical Domains

- Free Download
- Virtual switch created based on one physical device
- CPU allocated and deallocated dynamically
- Memory allocation currently requires a system reboot
- Disk slices assigned to each LDom
- Pool of unallocated resources available for future use
Microsoft Virtual Server

- Focused on Windows Server virtualization
- Linux support available
- Virtual Server 2005 R2 SP1 Enterprise Edition – free download
- Can be installed on systems with up to 32 CPUs
- x64 support
- Active Directory integration
- Automated Deployment Services
- Virtual Server Migration Toolkit
Xen vs. VMware ESX

- Performance comparison of 2x2 ESX, 2x2 Xen and 1x1 bare metal configurations
- VMware is working to improve performance issues.
Virtualization Architecture

• Sun Architecture Changes
• Multithreaded Execution Model
• Intel Virtualization Technology
Sun Architecture Improvements

• Legacy SPARC Execution Mode
  – sun4u Architecture
Sun Architecture Improvements

- New SPARC Execution Mode (sun4v)
Sun Architecture Improvements

- New SPARC Execution Mode (sun4v)
Multithreaded Execution Model

- Compute time is staggered among execution threads to minimize memory latency impacts.
- Threads within a core work in concert, so it is advisable to maintain core/thread affinity.
Intel Virtualization Technology

- Set of hardware enhancements to Intel platforms to improve virtualization
- Processor and I/O enhancements to improve performance and robustness
- Provides improved failover and consolidation
- Hardware-based Direct Memory Access Remapping
Alternatives to Virtualization

• Clustering
  – The Blackboard Academic Suite™
    • One physical server only
  – The Blackboard Learning system – Vista Enterprise License™
    • One physical server
    • Multiple physical servers

• Load Balancing
  – Academic Suite only
    • Multiple physical servers only
Vista Clustering (single server)

- All HTTP traffic is routed through an external hardware load balancer.
- Cluster nodes are configured on a single large server.
Vista Clustering (multiple servers)

- All HTTP traffic is routed through an external hardware load balancer.
- Cluster nodes are installed on separate commodity servers.
- Easy to scale laterally
- High space, power, cooling, and administration overhead
Academic Suite Clustering

- Supported on a single physical server only
- All HTTP requests are routed through a single instance of Apache Web Server.
- Eventually, the web server can become the performance bottleneck.
Academic Suite Load Balancing

- Simple configuration
- No clustering overhead
- Each Tomcat Server instance is serviced by its own web server.
Academic Suite on Virtual Servers

- Load balanced across multiple virtual servers on one physical machine
- Each JVM is isolated – no one process can crash the entire machine.
- Extremely flexible architecture
Resources

• http://www.xensource.com/products/
• http://www.vmware.com/products/vi/esx/
• http://www.intel.com/technology/virtualization/
• http://www.microsoft.com/windowsserversystem/virtualserver/
• Logical Domains Product Download
• Beginners Guide to Logical Domains
• Logical Domains Administration Guide
  – Included with LDom software distribution