Virtual Leverage: Server Consolidation in Open Source Environments

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What Is Virtualization?

Abstraction of Hardware Components

- Hides complexity of hardware infrastructure, simplifying its management
- Isolates software from underlying hardware to increase reliability and flexibility
- Abstracts services from hardware dependencies for better control and access
- Reduces administration through enhanced automation capabilities
Why Are Customers Using Virtualization?

Virtualization technology enables the consolidation of resources

✓ **Reduced hardware cost**
  - Higher physical resource utilization
  - Smaller footprint that requires less infrastructure support (power, cooling, space, etc)

✓ **Improved flexibility and responsiveness**
  - Resources can be adjusted dynamically
  - Enables *On Demand* and *Adaptive Enterprise* operating environments
Server Virtualization Trends

Consolidating Resources

Carve a Server into Many Virtual Machines

**Problem:** hardware is underutilized

**Solution:** partition server into virtual machines that run different applications concurrently

** Benefit:** more efficient use of hardware resources through workload consolidation

Unite Many Servers into a Virtual Machine

**Problem:** applications need large capacity

**Solution:** consolidate commodity computers into a virtual machine that than can be reconfigured as needed to run required applications

**Benefit:** flexibility to resize hardware resource to fit the demands
Unite Many Servers into a Virtual Machine

- Virtualization software manages resources of many servers
- Unites these resources to appear as one server to guest OS and applications
- Might require specific type of server and/or interconnection technology
- Egenera PAN Manager
Virtual Machine Approaches

Carve a Server into Many Virtual Machines

- Available on mainframes and high-end Unix servers for many years
- Applications run independently from each other in separate partitions
- Hardware resources are divvied up according to the needs of the applications running on the system
- Example: Solaris 10 Containers
Virtual Machine Approaches

Carve a Server into Many Virtual Machines

- Virtualization software manages resources between Host/Guest OS’s
- Application can suffer decreased performance due to added overhead
- Example: VMware Workstation, VMware GSX

- Hypervisor is host environment
- Enables better software performance by eliminated some of associated overhead
- If Hardware is available, the Hypervisor can be designed to take advantage of it
- Example: VMware ESX, Xen Open Source Hypervisor
Xen Open Source Virtualization Project

- Virtual machine monitor for x86-based systems
- Paravirtualization approach which requires OS’s be ported
  - Linux 2.4 and 2.6 and NETBSD run over Xen
- Applications run unmodified
  - Supports demanding applications like MySQL, Apache and PostgreSQL
- Released under the GNU General Public License

http://www.cl.cam.ac.uk/Research/SRG/netos/xen/
Xen Open Source Virtualization Project

- OS must be ported to run over Xen
  - More efficient than schemes that rely on trapping faulting instructions or emulating privileged operating system code
- OS’s running over Xen execute in x86 privilege ring 1
  - Prevents guest OS’s from using the normal privileged instructions to turn on/off interrupts, change page table bases etc.
  - Guest OS make a 'hypercall' down into Xen to ask operations to be performed
- Xen exports specially designed block device and network interface abstractions to guest OS’s
  - Results in excellent guest I/O performance
Relative performance on native Linux (L), Xen/Linux (X), VMware Workstation 3.2 (V), and User Mode Linux (U).

http://www.cl.cam.ac.uk/Research/SRG/netos/xen/performance.html
AMD64 Processors and Virtualization

AMD64 Processors with Direct Connect Architecture

Integrated Memory Controller
- Increases application performance by reducing memory latency

AMD64 Cores
- Enables both 32- and 64-bit computing
- Eliminates 4GB memory barrier of 32-bit only systems

HyperTransport™ Technology
- Provides up to 24.0 GB’s peak bandwidth per processor - reducing I/O bottlenecks
- Directly connects CPUs enabling scalability
AMD64 Dual-Core Overview

Dual-Core AMD Opteron™ and AMD Athlon™ 64 processors:

- AMD Opteron™ processor compatible with existing 940-pin sockets that support 90nm (95W/80A) with a BIOS update, streamlining upgrade paths while increasing performance and value
- AMD Athlon™ 64 processors compatible with existing 939-pin sockets with BIOS update
- Completely compatible with x86 and AMD64 applications while benefiting multi-threaded environments
- AMD64 technology designed from the ground up for multi-core
AMD64 Processors and Virtualization

**Traditional x86 Architecture**

**Direct Connect Architecture**

Direct Connect Architecture revolutionizes the system architecture by eliminating the bottlenecks of the front-side bus.
 AMD64 processors with Direct Connect Architecture are well suited to support virtualization technology

✓ Integrated Memory Controller
  • High-speed, low latency access to memory
  • Enables Host and Guest OS’s to run more efficiently

✓ HyperTransport™ Technology
  • Improved scalability and I/O capabilities
  • Supports more Guest OS sessions and/or users sessions

✓ AMD64 Core
  • Retains compatible with x86 software
  • Provides support for legacy OS’s and applications

✓ Multi-Core Technology
  • Single physical processor with multiple execution cores
  • Delivers high-bandwidth communication between virtual machines
Web Bench: 4P AMD Opteron™ Processors vs. 4P Xeon 4 VMs per machine (1 VM per CPU)

Test results

Request latency at 60 clients
- 65.6 ms = AMD Opteron™
- 88.6 ms = Xeon

http://www.veritest.com/clients/reports/amd/default.asp
Web Bench: 4P AMD Opteron™ Processors vs. 4P Xeon 8 VMs per machine (2 VM per CPU)

Test results

Requests Per Second vs. Number of Participating clients

- **AMD**
- **Intel 2100**
- **Intel 2700**

**Request latency at 64 clients**

- **74.5 ms = AMD Opteron™**
- **110.4 ms = Xeon**

28% difference

http://www.veritest.com/clients/reports/amd/default.asp
## AMD64 Processors and Virtualization

### Current Software Status

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Future Trends in Virtualization

- Native virtualization of x86 architecture requires “unnatural acts” to achieve – leading to increased performance overhead, lower security, and increased complexity.

- Moving functionality traditionally served by software-based hypervisor into the processor helps to solve these problems.

- “PACIFICA” is AMD’s technology to provide silicon enhanced virtualization.

- “PACIFICA” allows the software vendors to focus on the value-add, leaving the worry of proper emulation to the processor.

“Pacifica” virtualization technology allows AMD to continue to offer a competitive performance roadmap while meeting the system architecture demands of our customers.
“Pacifica” Overview & Highlights

• “Pacifica” is the code name for AMD silicon feature set which enhances the performance of native virtualization software.

• “Pacifica” enabled parts will launch in all AMD processors beginning in 2006.

• Completely compatible with x86 and AMD64 applications while benefiting virtualization environments, where Hypervisor is “Pacifica” aware.

• Virtualization and partitioned applications will experience the greatest performance advantage. Examples of these applications include:
  - Server consolidation
  - OS migration
  - Blade computing
  - Desktop Hypervisor-based security

• AMD64 processors with enhanced virtualization is a continuing example of how AMD is extending it’s Direct Connect Architecture and multi-core technology leadership.
“Pacifica” Silicon Enhanced Virtualization

Guest OS

Guest instructions run native speed to CPU

VMCB struct

VMRUN

Hypervisor

AMD Processor

AMD64 Core

Intercept PRIV instruction or register access?

“Pacifica”

Tagged TLB

Memory Controller

Allow memory access?

Memory Access

System Memory

I/O Space

External Interrupts

Intercept Interrupt?

EXCEPTION

Device Exclusion Vector

External Interrupts

Allow memory access?

AMD Processor
Summary
Virtual Machine Benefits

Reduces software development and testing cycles

- Shortening the time needed to provision, install, build, test and restore a new machine
- Development teams can share development environments and pre-packaged operating system and application testing configurations
Virtual Machine Benefits

- Partitions and isolates a server into secure and transportable virtual machines
- Errors that interfere with operation running in one virtual machine have no effect on other virtual machines on the same system
- Obsolete hardware can be upgraded without software losing compatibility

Can use more reliable, highly scalable servers to minimize system failures
Summary
Virtual Machine Benefits

Allows for more efficient utilization of resources through server consolidation

- Consolidate multiple applications onto newer server regardless of operating environment
- Consolidate multiple servers to support demanding application
- Helps to reduces costs associated with space, power, installation, integration, and administration

“If mature virtualization technologies could be applied to x86 servers today, a conservative rough estimate is that overall IT spending in support of x86 servers would decline by 20% to 30%.”

Gartner, Predicts 2004: Server Virtualization Evolves Rapidly
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