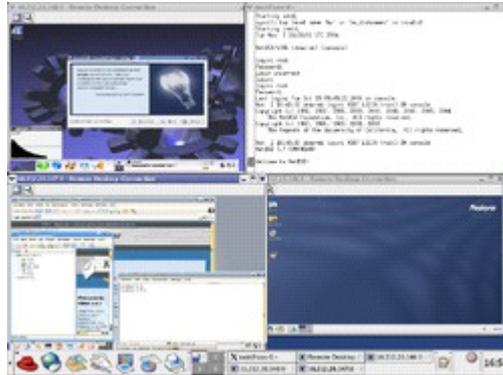


Citrix Systems Xen



Xen running [NetBSD](#) and three [Linux](#) distributions

<u>Original author(s)</u>	Keir Fraser, Steven Hand, Ian Pratt , University of Cambridge Computer Laboratory
<u>Developer(s)</u>	The Xen Project XenSource, Inc.
Initial release	2003
<u>Stable release</u>	4.1.2 ^[1] / October 21, 2011; 8 months ago
<u>Operating system</u>	Linux , BSD , OpenSolaris as management host; many OSs including Microsoft Windows as guests
<u>Type</u>	Virtual machine monitor
<u>License</u>	GNU GPL v2
Website	www.xen.org

Xen

- **Xen** /'zɛn/ is a **Hypervisor** providing services that allow multiple computer operating systems to execute on the same computer hardware concurrently.
- The University of **Cambridge Computer Laboratory** developed the first versions of Xen.
- The **Xen community develops and maintains Xen as free software**, licensed under the GNU General Public License (GPLv2).
- Xen is currently available for the IA-32, x86-64 and ARM computer architectures.

Xen-Architecture

- Xen is a native, or bare-metal hypervisor. It runs in a more privileged CPU state than any other software on the machine.
- **Responsibilities** of the hypervisor include **memory management and CPU scheduling of all virtual machines ("domains")**, and for launching the **most privileged domain ("dom0")** - the only virtual machine which by default has direct access to hardware. From the dom0 the hypervisor can be managed and unprivileged domains ("domU") can be launched.
- **The dom0 domain** is typically a **modified version of Linux, NetBSD or Solaris**. User domains may either be **unmodified open-source or proprietary operating systems**, such as Microsoft Windows (if the host processor supports x86 virtualization, e.g., Intel VT-x and AMD-V), or **modified, *para-virtualized* operating system with special drivers that support enhanced Xen features**.
- On x86 Xen with a Linux dom0 runs on Pentium II or newer processors. **Xen boots from a bootloader such as GNU GRUB**, and then usually loads a paravirtualized host operating system into the host domain (dom0).

Xen- History

- Xen originated as a research project at the University of Cambridge, led by Ian Pratt, senior lecturer at Cambridge and founder of XenSource, Inc. **The first public release of Xen was made in 2003.**
- Xen has been supported originally by XenSource Inc., and since the acquisition of **XenSource by Citrix in October 2007 by Citrix**. This organisation supports the development of the free software project and **also sells enterprise versions of the software.**
- On 22 October 2007, Citrix Systems completed its acquisition of XenSource, and the Xen project moved to **<http://www.xen.org/>**. This move had started some time previously, and made public the existence of the Xen Project Advisory Board (Xen AB), which had members from Citrix, IBM, Intel, Hewlett-Packard, Novell, Red Hat, Sun Microsystems and Oracle.
- The **Xen Advisory Board** advises the Xen project leader and is responsible for the Xen trademark, which Citrix has freely licensed to all vendors and projects that implement the Xen hypervisor.
- Confusingly, Citrix has also used the Xen brand itself for some proprietary products unrelated to Xen, including at least "XenApp" and "XenDesktop".
- The Xen project itself is self-governing.

Xen-Release history for Xen (upstream project)

Version	Release date	Notes
1.0	2003-10-02 ^{[8][9]}	
2.0	2004-11-05 ^[10]	<ul style="list-style-type: none">• Supports the Intel VT technology for hvm guests.• Support the Intel IA64 architecture.
		The releases up to 3.0.4 also added:
3.0	2005-12-05 ^{[11][12]}	<ul style="list-style-type: none">• Support for the AMD SVM virtualization extensions.^[13]• Support for the PowerPC architecture.^[14]• Graphical framebuffer support for paravirtualised guests.^[15]
3.1	2007-05-18 ^[16]	Live migration for HVM guests, XenAPI
3.2	2008-01-17 ^[17]	PCI passthrough and ACPI S3 standby mode for the host system.
3.3	2008-08-24 ^[18]	Improvements for the PCI passthrough and the power management.
3.4	2009-05-18 ^[19]	Contains a first version of the "Xen Client Initiative", shortly XCI.
4.0	2010-04-07 ^[20]	Makes it possible to use a dom0 Linux kernel, which has been implemented by using PVOps. A Linux kernel of version 2.6.31 has been modified for this purpose, because the official Linux kernel actually doesn't support the usage as dom0 kernel (date July 2010). ^[21]
4.1	2011-03-25 ^[22]	Some of the improvements: Support for more than 255 processors, better stability. Linux kernel v2.6.37 and onward support usage as dom0 kernel (^[23]).

Xen in Linux distributions and Linux upstream

- As of 2009, most Linux distributions had included Xen packages to interact with the Xen hypervisor and start additional domains, **but because Xen was not accepted into the mainline Linux kernel and installation required several kernel patches**, some distros such as Red Hat Enterprise Linux 6 and Ubuntu 8.10 **dropped out-of-the-box support for dom0** in subsequent releases.
- With the inclusion of the most significant parts of **Xen in the Linux 2.6.37 mainline kernel in early 2011**, several distributions are again considering dom0 support.
- **Version 3.0** of the Linux kernel supports dom0 and domU in the mainline kernel.

History of Citrix Xen-based products

- After the acquisition Citrix renamed Xensource's products under the Citrix brand:
 - ❖ **XenExpress** became "XenServer Express Edition" and "XenServer OEM Edition" (embedded hypervisor)
 - ❖ **XenServer** became "XenServer Standard Edition"
 - ❖ **XenEnterprise** became "XenServer Enterprise Edition"
- Subsequently the product lines have been renamed **XenServer (Free)**, **Essentials for XenServer Enterprise**, and **Essentials for XenServer Platinum**.
- On 21 October 2009, Citrix further announced their non-commercial XenServer would be fully open-source and made freely available to the public under the name **Xen Cloud Platform (XCP)**. Simon Crosby, CTO of Virtualization and Management division at Citrix, stated: "XenServer is 100% free, and also shortly fully open sourced. There is no revenue from it at all."
- The "**Free Edition**" comes free of charge but **requires activation**. This activation must be renewed annually
- The product lines were renamed in Spring 2010:
 - ❖ **XenServer [Free edition]**
 - ❖ **XenServer Advanced Edition**
 - ❖ **XenServer Enterprise Edition**
 - ❖ **XenServer Platinum Edition**

Xen - Uses

- **Internet hosting service companies use hypervisors** to provide virtual private servers. Amazon EC2, Fujitsu Global Cloud Platform, Linode, and Rackspace Cloud use Xen as the VM hypervisor
- Virtual machine monitors (also known as hypervisors) also often **operate on mainframes and large servers running IBM, HP**, and other systems. Server virtualization can provide benefits such as:
 - ❖ consolidation leading to increased utilization
 - ❖ rapid provisioning
 - ❖ dynamic fault tolerance against software failures (through rapid bootstrapping or rebooting)
 - ❖ hardware fault tolerance (through migration of a virtual machine to different hardware)
 - ❖ the ability to securely separate virtual operating systems
 - ❖ the ability to support legacy software as well as new OS instances on the same computer

Xen - Uses

- Xen's support for virtual machine live migration from one host to another allows workload balancing and the avoidance of downtime.
- Virtualization also has benefits when working on development (including the development of operating systems): running the new system as a guest avoids the need to reboot the physical computer whenever a bug occurs. Sandboxed guest systems can also help in computer-security research, allowing study of the effects of some virus or worm without the possibility of compromising the host system.
- Finally, hardware appliance vendors may decide to ship their appliance running several guest systems, so as to be able to execute various pieces of software that require different operating systems.

Citrix Systems Xen - Technology

- **Types of virtualization**
- Xen supports two different approaches to running the guest operating system.
 - ❖ **Paravirtualization - modified guests**
 - ❖ **Hardware-assisted virtualization, allowing for unmodified guests**
- The choice of approach is up to the Xen hosting system administrator.

Xen - Paravirtualization - modified guests

- Xen pioneered a form of virtualization known as **paravirtualization**, in which guests run a modified operating system. The guests are modified to use a **special hypercall ABI**, instead of certain architectural features.
- Through **paravirtualization**, Xen can achieve **high performance** even on its host architecture (x86) which has a reputation for non-cooperation with traditional virtualization techniques.
- Xen can run **paravirtualized guests** ("PV guests" in Xen terminology) even on CPUs without any explicit support for virtualization.
- Paravirtualisation avoids the need to **emulate a full set of hardware and firmware services**, which makes a PV system simpler to manage and reduces the attack surface exposed to potentially-malicious guests.
- On 32-bit x86, the **Xen host kernel code runs in Ring 0**, while the hosted domains run in **Ring 1 (kernel) and Ring 3 (applications)**.

Xen-Hardware-assisted virtualization, allowing for unmodified guests

- Many modern CPUs now have explicit support for virtualization. These processor features make it possible to support unmodified guests, including proprietary operating systems (such as Microsoft Windows). This is known as **hardware-assisted virtualization (HVM)**.
- **HVM extensions provide additional execution modes**, with an explicit distinction between the most-privileged modes used by the hypervisor with access to the real hardware (called "root mode" in x86) and the less-privileged modes used by guest kernels and applications with "hardware" accesses under complete control of the hypervisor (in x86, known as "non-root mode"; both root and non-root mode have Rings 0-3).
- Both Intel and AMD have contributed modifications to Xen to support their respective **Intel VT-x and AMD-V architecture extensions**. Support for ARMv 7A virtualization extensions is under development.

Xen-Hardware-assisted virtualization, allowing for unmodified guests

- **HVM extensions also often offer new instructions** to support direct calls by a paravirtualized guest/driver into the hypervisor, typically used for I/O or other operations needing high performance. **These allow HVM guests with suitable minor modifications to gain many of the performance benefits** of paravirtualised I/O.
- In current versions of Xen (up to 4.2) only **fully-virtualised HVM guests can make use of hardware support for multiple independent levels of memory protection and paging**. As a result, for some workloads, HVM guests with PV drivers (also known as PV-on-HVM) **provide better performance than pure PV guests**.
- **Xen HVM has device emulation based on the QEMU project to provide I/O virtualization to the virtual machines. The system emulates hardware via a patched QEMU "device manager" (qemu-dm) daemon** running as a backend in dom0. This means that the **virtualized machines see an emulated version of a fairly basic PC**. In a performance-critical environment, PV-on-HVM disk and network drivers are used during normal guest operation, so that the emulated PC hardware is mostly used for booting.

Xen - Virtual machine migration

- Administrators can "live migrate" Xen virtual machines between physical hosts across a LAN without loss of availability.
- During this procedure, the LAN iteratively copies the memory of the virtual machine to the destination without stopping its execution.
- The process requires a stoppage of around 60–300 ms to perform final synchronization before the virtual machine begins executing at its final destination, providing an illusion of seamless migration. Similar technology can serve to suspend running virtual machines to disk, "freezing" their running state for resumption at a later date.

Citrix Systems Xen - Scalability

- Xen **can scale to**
 - ❖ >255 physical CPUs ,
 - ❖ 128 VCPUs per PV guest,
 - ❖ 1TB of RAM per host, and
 - ❖ up to 1TB of RAM per HVM guest
 - ❖ or
 - ❖ 512 GB of RAM per PV guest.

Xen - Hosts

- Xen can be shipped in a dedicated virtualization platform, such as Citrix XenServer Enterprise Edition (formerly XenSource's XenEnterprise).
- Alternatively, Xen is distributed as an optional configuration of many standard operating systems. Xen available for and distributed with:
 - ❖ openSUSE 10.x to 12.x
 - ❖ Novell's SUSE Linux Enterprise Server (since version 10)
 - ❖ Sun Microsystems' Solaris
 - ❖ Debian GNU/Linux (since version 4.0 "etch") and many of its derivatives including Ubuntu (12.04 "Precise Pangolin" and later releases; also 8.04 Hardy Heron, but no dom0-capable kernel in 8.10 Intrepid Ibex until 12.04)
 - ❖ Gentoo and Arch Linux both have packages available to support Xen
 - ❖ OpenSolaris-based distributions can function as dom0 and domU from Nevada build 75 onwards
 - ❖ NetBSD 3.x. includes host support for Xen 2, with host support for Xen 3.0 available from NetBSD 4.0

Citrix Systems Xen - Guests

- **Unix-like systems as guests**
- **Guest systems can run fully virtualized** (which requires hardware support) **or paravirtualized** (which requires a modified guest operating system).
- Most operating systems which can run on PC can run as a Xen HVM guest.
- Additionally the following systems have patches allowing them to operate as **paravirtualized Xen guests**:
 - ❖ Linux, paravirtualization integrated in 2.6.23, patches for other versions exist
 - ❖ Minix
 - ❖ Plan 9 from Bell Labs
 - ❖ NetBSD (NetBSD 2.0 has support for Xen 1.2, NetBSD 3.0 has support for Xen 2.0, NetBSD 3.1 supports Xen 3.0, NetBSD 5.0 features Xen 3.3)
 - ❖ FreeBSD (Limited, experimental support for Xen 3 in 8-CURRENT)
 - ❖ OpenSolaris (See The Xen Community On OpenSolaris)
 - ❖ NetWare (at Brainshare 2005, Novell showed a port that can run as a Xen guest)
 - ❖ GNU/Hurd/Mach (gnumach-1-branch-Xen-branch)
 - ❖ OZONE (has support for Xen v1.2)

Xen-Microsoft Windows systems as guests

- Xen version 3.0 introduced the capability to run **Microsoft Windows as a guest operating system unmodified** if the host machine's processor supports hardware virtualization provided by Intel VT-x (formerly codenamed Vanderpool) or AMD-V (formerly codenamed Pacifica).
- During the development of Xen 1.x, Microsoft Research, along with the University of Cambridge Operating System group, developed a port of **Windows XP to Xen** — made possible by Microsoft's Academic Licensing Program. The terms of this license do not allow the publication of this port, although documentation of the experience appears in the original Xen SOSP paper
- James Harper and the Xen open-source community have started developing **GPL'd Paravirtualisation drivers for Windows**. These provide front-end drivers for the Xen block and network devices, and allow much higher disk and network performance for Windows systems running in HVM mode. Without these drivers all disk and network traffic has to be processed through QEMU-DM

Xen - Other guests

- The **Haskell lightweight virtual machine (HalVM)**
 - allows running Haskell programs
 - directly under the Xen hypervisor
 - with no intervening operating system.
-
- It implements its own file system and network stack written in Haskell, above a thin C interface layer connecting the Haskell runtime system to Xen.

Xen Management Consoles

- **Third-party developers have built a number of tools** (known as Xen Management Consoles) to facilitate the common tasks of administering a Xen host, such as configuring, starting, monitoring and stopping of Xen guests. Examples include:
 - ❖ Servarica WHMCS XenServer Module SWXSM
 - ❖ SolusVM
 - ❖ Xen Tools
 - ❖ Ganeti
 - ❖ the Perl-based MLN
 - ❖ the web-based HyperVM and FluidVM
 - ❖ the web-based Cloudmin
 - ❖ the GUI applications Convirture (formerly XenMan) which does not currently support Xen 4 and Red Hat's Virtual Machine Manager, virt-manager
 - ❖ the OpenNebula cloud management toolkit
 - ❖ OpenXenManager - An open source clone of Citrix's XenCenter.
 - ❖ XVP - Web-based VM manager for XenServer and Xen Cloud Platform
 - ❖ On OpenSUSE YaST and virt-man offer graphical VM management.
- Novell's PlateSpin Orchestrate also manages Xen virtual machines for Xen shipping in SUSE Linux Enterprise Server

Xen- Commercial versions

■ Commercial versions of Xen

- ◆ Citrix XenServer
- ◆ Oracle VM
- ◆ Sun xVM
- ◆ Virtual Iron
- ◆ Thinsy Corporation

- The Xen hypervisor is covered by the GNU General Public Licence, so all of these versions contain a **core of Free Software with source code**. However, **many of them contain proprietary additions**.

xen.org- Xen.org Open Source Projects and Solutions

- **Xen.org Open Source Projects and Solutions**
- The Xen.org hosts a variety of open source solutions for the virtualization industry.
- From servers to client devices, Xen.org ensures that the open source community continues to be a leader in the virtualization revolution.
- Xen projects are normally is licensed under the GNU General Public License (GPL2)

- **Project Governance**
- Projects hosted on Xen.org follow the governance model as laid out in the Governance section. The project governance model is new and not all projects are fully implementing the model at this stage

Projects, Products and Services for the Xen



xen.org - Xen Related Projects and Products

■ Xen Related Projects and Products

- Xen is a popular virtualization platform.
- As one would expect, many projects that depend on Xen, build applications for Xen, etc. exist.
- These projects are not hosted on Xen.org.
 - ❖ Project that have a dependency on the Xen Hypervisor
 - ❖ Products that have a dependency on the Xen Hypervisor
 - ❖ Project that have a dependency on the Xen Cloud Platform
 - ❖ Products that have a dependency on the Xen Cloud Platform
 - ❖ Further services and projects in the community ...

xen.org - Mature Projects and Solutions

■ Xen Hypervisor project

- The Xen hypervisor is a unique open source technology, developed collaboratively by the Xen community and engineers at over 50 of the most innovative data center solution vendors, including AMD, Cisco, Dell, Fujitsu, HP, IBM, Intel, Mellanox, Network Appliance, Novell, Red Hat, Samsung, SGI, Sun, Unisys, Veritas, Voltaire, and Citrix.
- The Xen Hypervisor project develops the Xen Hypervisor including basic command line tools, Dom0 drivers, etc.
- The project only delivers source code release. It does not deliver a binary version of the hypervisor.
- But, binary versions of Xen are distributed by major Linux and BSD distributions:
 - ◆ Dom0/Control Domain Kernels with Xen support
 - ◆ Distributions with Guest Support

xen.org - Mature Projects and Solutions

■ Xen Cloud Platform

- The Xen Cloud Platform (XCP) is an open source enterprise-ready server virtualization and cloud computing platform, delivering the Xen Hypervisor with support for a range of guest operating systems including Windows® and Linux® network and storage support, management tools in a single, tested installable image.

xen.org - Xen Hypervisor Project

- The Xen hypervisor is also **exceptionally lean-- less than 150,000 lines of code**.
- That translates to extremely **low overhead** and near-native performance for guests.
- **Xen re-uses existing device drivers (both closed and open source) from Linux, making device management easy**. Moreover Xen is robust to device driver failure and protects both guests and the hypervisor from faulty or malicious drivers.

- Release Information
 - ◆ **Xen 4.1.x**: Xen 4.1.x Datasheet
 - ◆ **Xen 4.0.x**: Xen 4.0.x Datasheet

- **Xen LiveCD**
- Try Xen Hypervisor 3.2 without installing any code on your machine with the Xen LiveCD

xen.org - Xen Cloud Platform Project

- **Open source software to build private and public clouds**
- **The Xen Cloud Platform (XCP) is an open source enterprise-ready server virtualization and cloud computing platform**, delivering the Xen Hypervisor with support for a range of guest operating systems including Windows® and Linux® network and storage support, management tools in a single, tested installable image, which is also called XCP appliance.
- **XCP addresses the needs of cloud providers**, hosting services and data centers by combining the isolation and multi-tenancy capabilities of the Xen hypervisor with enhanced security, storage and network virtualization technologies to offer a rich set of virtual infrastructure cloud services. The platform also address user requirements for **security, availability, performance and isolation across both private and public clouds.**
- XCP consolidates server workloads, enables savings in power, cooling, and management costs and thus contributing to environmentally sustainable computing, an increased ability to adapt to ever-changing IT environments, an optimized use of existing hardware, and an improved level of IT reliability.

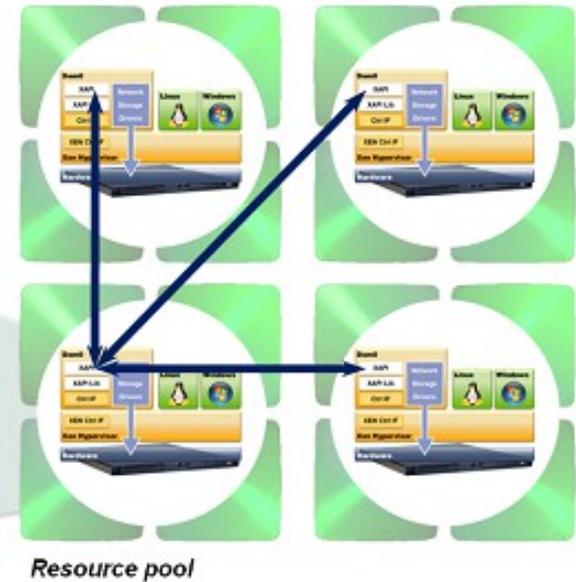
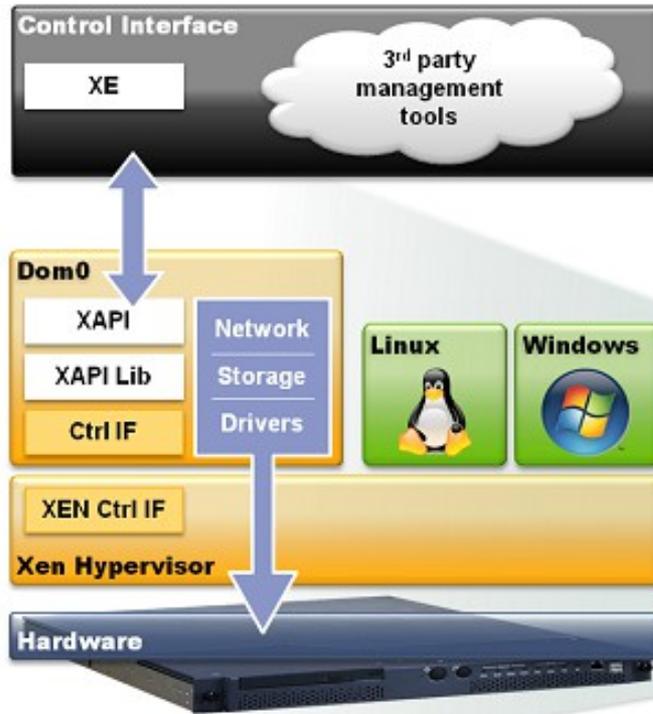
xen.org - XCP Packages in Linux

- XCP traditionally comes as an ISO that is installed on a bare metal server.
- However XCP, packages are available in Debian and Ubuntu.
- For more information see:
 - ❖ XCP toolstack on a Debian-based distribution
 - ❖ XCP in Debian Wheezy
 - ❖ XCP in Ubuntu Server LTS 12.04
 - ❖ Project Zeus: XCP on Fedora and CentOS

xen.org - License

- XCP was originally derived from Citrix XenServer
- Today, the XCP code is licensed under the GNU General Public License (GPL2) and is available at no charge in both source and binary format.
- XCP is, and always will be, open sourced, uniting the industry and the Xen ecosystem to speed the adoption of virtualization and cloud technologies and actively works with open source and open standards to help solve challenges in cloud mobility.

xen.org - XCP in detail



xen.org - XCP in detail

- **XAPI or XenAPI** is a management stack implemented in OCaml that configures and controls Xen-enabled hosts and resource pools and co-ordinates resources within the pool. XAPI exposes the XenAPI interface.
- **XAPI Lib**: is a set of libraries and utilities implemented in OCaml.
- **Control Interfaces**: XCP contains the XE command line tool to control Xen virtual machines and resource pools. A wide range of graphical user interfaces that work with XCP have been created by open source projects and commercial vendors.
- **Xen Hypervisor**: XCP contains the Xen Hypervisor.
- **Dom0 privileged domain including support for network, storage and drivers**: XCP contains the Dom0 Linux kernel including drivers, rich virtual networking capabilities via Open vSwitch and support for cloud storage infrastructures.
- **Guest Operating Systems**: the XCP binary distribution is delivered with a wide range of Linux and Windows guests. Check out the release notes for a complete list.

xen.org - Projects under Development

■ Xen ARM Project

- In recent months, Xen.org has seen an increased interest in Xen for the **ARM architecture** to augment the continuing work of Samsung on the Xen ARM Project. The project, led by Samsung, is responsible for the direct port of the Xen hypervisor to the ARM processor. To help channel increased interest in Xen for the ARM architecture, Xen.org is working with Samsung and others on an initiative within the Xen ARM Project to extend the scope of the project. We want to ensure that Xen ARM can support future ARM based clients and servers, that ARM support is merged into mainline Xen by 2012 and build a sustainable and diverse community around the project.

■ Xen Client Initiative

- This is a Xen Hypervisor based project **developing Xen based open source code for laptops and other client devices.**

■ Archived and Completed Projects

- A number of Xen.org projects have been completed or archived. Please follow the links to get more information.
 - ◆ **Project HXEN**
 - ◆ **Project Satori**

xen.org - Incubation Projects

- This list includes projects which we have not yet migrated to the Governance introduced in June 2011.
- **The Xen ARM Project**
- In recent months, Xen.org has seen an increased interest in Xen for the ARM architecture to augment the continuing work of Samsung on the **Xen ARM Project**. The project, led by Samsung, is responsible for the direct port of the Xen hypervisor to the ARM processor.
- To help channel increased interest in Xen for the ARM architecture, Xen.org is working with **Samsung** and others on an initiative within the **Xen ARM Project** to extend the scope of the project. We want to ensure that Xen ARM can support future ARM based clients and servers, that ARM support is merged into mainline Xen by 2012 and build a sustainable and diverse community around the project.
- **XCI - Xen Hypervisor for Client Devices**
- **XCI** is an embedded client hypervisor based on the Xen hypervisor using smaller libraries; giving a smaller memory and disk footprint than the standard Xen hypervisor. This product is intended for laptops or other mobile devices using standard Intel or AMD architecture. The project is an **incubation project**.

xen.org -Xen ARM Project

- In recent months, Xen.org has seen an increased interest in Xen for the ARM architecture. To help channel the interest in Xen for the ARM architecture, Xen.org is working with Samsung and others to augment the continuing work of Samsung on the **Xen ARM Project**. The main goal of this work is to ensure that Xen ARM can support future ARM based clients and servers, to merge ARM support into mainline Xen by 2012 and to incubate a diverse and sustainable community around ARM support for Xen. ARM is supportive of the initiative.
- The **Xen ARM Project**, led by Samsung, is responsible for the direct port of the Xen hypervisor to the ARM processor. So far the focus of the project has been to use Xen Paravirtualization (PV) for a range of processors (ARM v5 - v7). The project is also working on problems such as solving real-time guarantees in a virtualized environment and multi-processor support. The project is led by Sang-bum Suh from Samsung and can be monitored on the Xen ARM Wiki or the project mailing list.
- A number of discussions with interested parties have started to see how ARM support can be added into mainstream Xen. A set of preliminary goals has been discussed, which will likely evolve as more momentum builds:
 - ◆ Provide a focalpoint for building a sustainable community for Xen ARM .
 - ◆ Investigate how support for full ARM virtualization to Xen (using ARMv7 virtualization extensions for the Cortex A15) can be added to mainline Xen and establish a plan.
 - ◆ Establish a plan for merging the functionality delivered in the Xen ARM project into mainstream Xen.
 - ◆ Investigate how functionality such as multi-core support, real-time extensions and other functionality that is important to embedded developers can be merged into mainstream Xen.
 - ◆ Deliver on the plan: in other words add Xen ARM support to mainline Xen.

xen.org - Archived and Completed Projects

■ HXEN - Hosted Xen

- Hosted Xen (HXEN) runs the Xen core hypervisor as a Type-2 VMM on top of a regular operating system instead of the usual Type-1 methodology that the Xen hypervisor is designed for. HXEN is capable of running on top of any operating system but is currently being developed for Windows and Mac OSX. The project has been **archived**. If you are interested in restarting the HXE project or starting a new project to port HXEN to another operating system, please contact your Community Manager.

■ Project Satori

- Project Satori is the result of a collaborative agreement between **XenSource and Microsoft**, and was carried forward after XenSource was acquired by Citrix Systems. The base Satori components are released by Microsoft as the Linux Integration Components for **Hyper-V, and provide support for paravirtualized XenLinux guests running on Hyper-V**. The Linux Integration Components can be downloaded here.
- The Project Satori home page on Xen.org is here and includes licensing information and code downloads. The project has **completed** and has thus been **archived**.

xen.org - Downloads - Latest Product Releases from Xen.org

■ Xen Hypervisor Download

- Xen 4.1.2 is available [here](#). Xen 3.4.4 is available [here](#).

■ Xen Cloud Platform Download

- XCP 1.5 Beta is available [here](#). XCP 1.1 is available [here](#)."

■ XCI Download

- The current XCI product in development is available [here](#).

■ HXEN Download

- The latest HXEN [Source Code](#) and HXEN [Binary Code](#) are available.

■ Project Satori

- The latest release of Project Satori is available [here](#).

■ **Desktop Virtualization**

- Reduce desktop management costs and enable users to work securely and productively from any device, anywhere.
- XenDesktop
 - XenApp
 - AppDNA
 - XenClient
 - Citrix Receiver
 - VDI-in-a-Box
 - GoToMyPC

■ **Networking**

- Accelerate and secure network performance across the LAN, WAN, Internet and the cloud.
- NetScaler App Delivery Controller
 - NetScaler Access Gateway
 - NetScaler Branch Repeater
 - NetScaler App Firewall
 - NetScaler CloudConnector

xen.org

■ **Datacenter and Cloud**

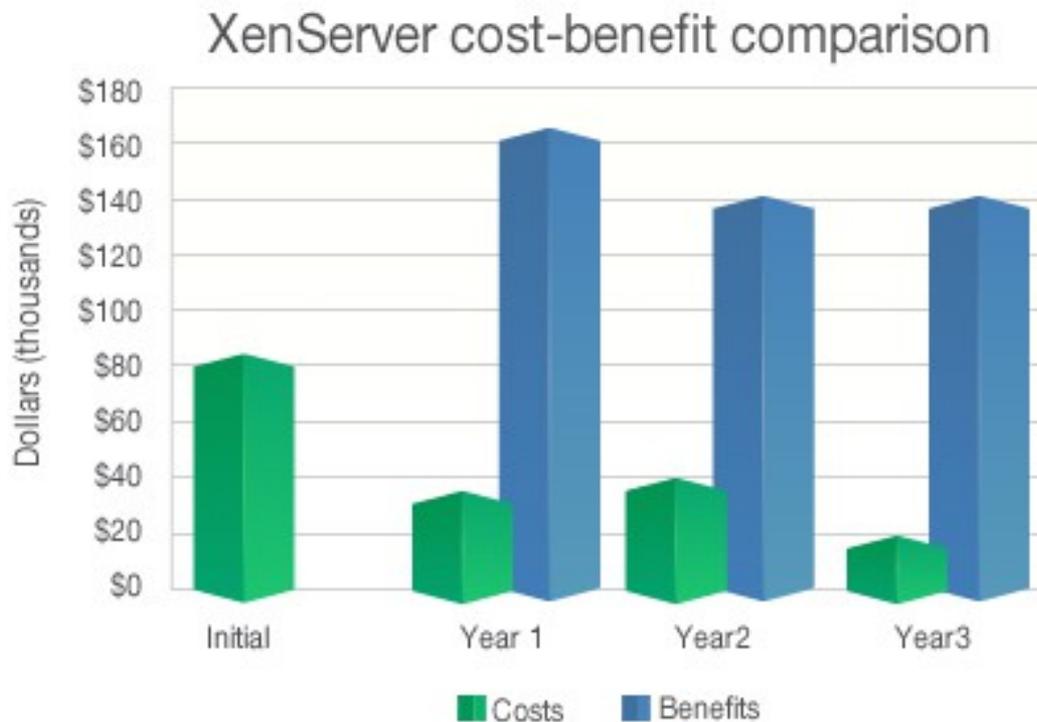
- Virtualize your datacenter, build your own cloud and seamlessly connect to public cloud services.
- XenServer
CloudPlatform
CloudGateway
CloudBridge
CloudPortal

■ **Collaboration and Support**

- **Web-based services for everything** from online meetings to remote support and file storage.
- GoToMeeting
GoToWebinar
GoToTraining
GoToAssist
HiDef Corporate
Podio
ShareFile

- **Automation, adaptability, reliability and the cloud**
- As a true virtual computing solution, XenServer helps you achieve **cloud-like** economics through datacenter automation, increased administrative efficiency, high reliability and business continuity, and the ability to leverage the cloud as an extension of your infrastructure.
- **Streamline datacenter operations through automation**
- By consolidating server workloads, **XenServer** reduces power, cooling and management costs and helps you make optimized use of existing hardware—but shrinking your overall number of servers is only one of the benefits of XenServer. Administrators can also automate key IT processes to improve application service delivery, saving both time and money. Improved IT reliability and the ability to adapt to ever-changing IT environments help you deliver optimal support to the business.
- XenServer features for automating datacenter processes

xen.org-Calculate server virtualization ROI



- ROI: 136%, Payback period: 0.64 months
- Source: The Total Economic Impact™ of Citrix XenServer Enterprise Edition: A commissioned study conducted by Forrester Consulting on behalf of Citrix, February 2010

- Solutions for Business and IT
 - **Business Continuity**
 - Improve IT infrastructure reliability
 - **Cloud Computing**
 - **Modernize and automate the datacenter**
 - Desktop Virtualization
 - Streamline desktop management
 - Server Consolidation
 - Reduce datacenter footprint

- **Adapt to increasing IT demands for administrative efficiency**
- Virtualization gives you the flexibility to adapt your datacenter to meet constantly evolving IT requirements. For example, XenServer optimizes the location of server workloads to improve performance and utilization while increasing server readiness within resource pools. This ensures that application requirements and expected performance levels are always met and helps you deliver new applications into production more quickly.
- **Using XenServer to efficiently manage your datacenter operations**
- **Reduce unplanned downtime**
- Natural disasters and other business disruptions can cripple any organization—but downtime and data loss are not acceptable in today's business environment. To keep the business moving and protect the bottom line, companies must protect their IT and data investments and keep the infrastructure running so users always have access to the IT resources their work depends on. With server virtualization, servers are separated from underlying hardware and delivered as virtual machines (VM), making the protection of VMs and associated data easier than in a physical infrastructure. This makes server virtualization a key strategy to protect IT infrastructure against natural disasters and business disruptions, helping organizations reduce downtime due to disasters and increase worker productivity.

- Using XenServer to **create your business continuity plan**
- Leverage the cloud
- Now more than ever, enterprises are moving to cloud computing to lower capital costs and deliver more responsive and timely IT services to the business. With the growth of both public and private clouds, IT is rapidly expanding beyond traditional datacenter boundaries and exposing new concepts such as platform as a service (PaaS) or infrastructure as a service (IaaS) to users via an enterprise network.
- Inherent in the promise of cloud computing is an IT infrastructure that is extremely flexible and can be quickly customized to the meet needs of the business, rather than having the business bend to the needs of IT.

What is Xen Hypervisor?

What is Xen Hypervisor?

- What is Xen Hypervisor?
- The Xen hypervisor is a layer of software running directly on computer hardware replacing the operating system thereby allowing the computer hardware to run multiple guest operating systems concurrently.
- Support for x86, x86-64, Itanium, Power PC, and ARM processors allow the Xen hypervisor to run on a wide variety of computing devices and currently supports Linux, NetBSD, FreeBSD, Solaris, Windows, and other common operating systems as guests running on the hypervisor.
- The Xen.org community develops and maintains the Xen hypervisor as a free solution licensed under the GNU General Public License

What is Xen Hypervisor?



Hardware

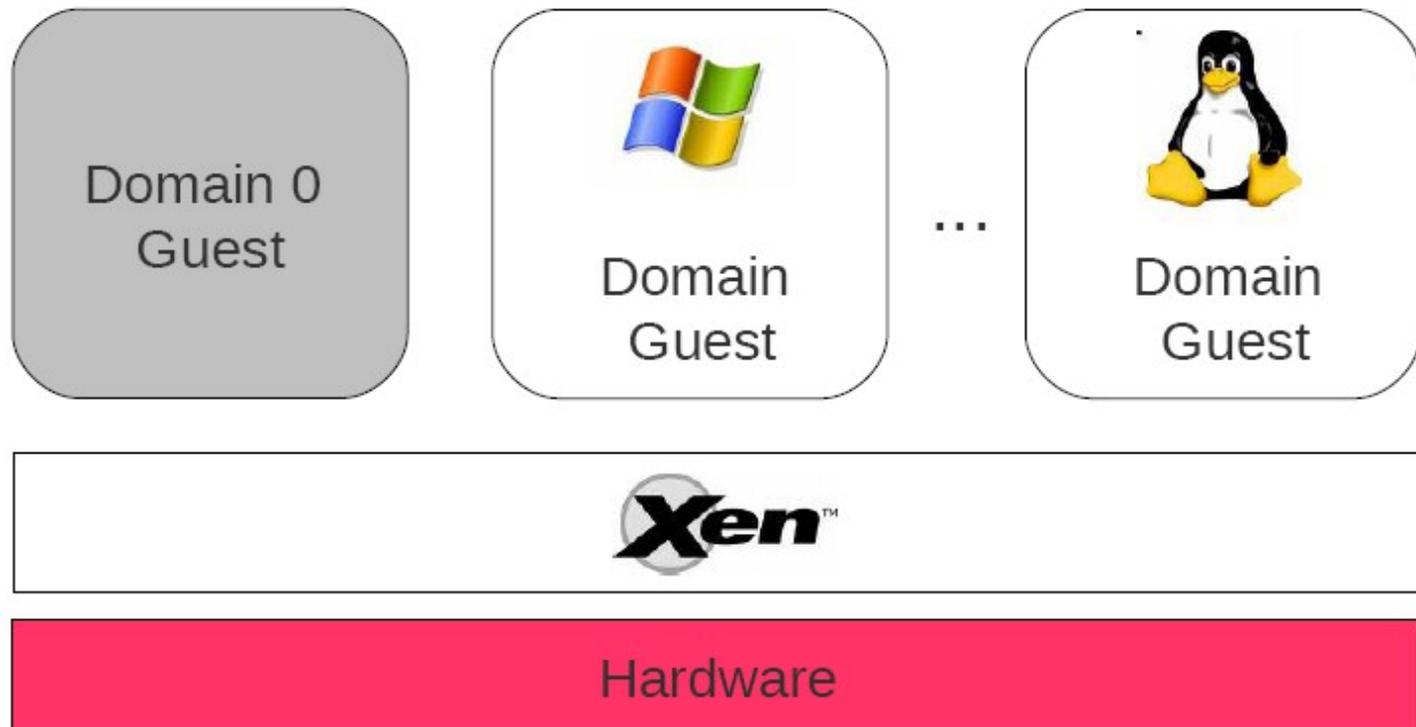
Standard Computer
Hardware + OS



Hardware

Virt. Computer
Hardware + Xen

What is Xen Hypervisor?



What is Xen Hypervisor?

- A computer running the Xen hypervisor **contains three components**:
 - ❖ **Xen Hypervisor**
 - ❖ **Domain 0, the Privileged Domain (Dom0)** – Privileged guest running on the hypervisor with direct hardware access and guest management responsibilities
 - ❖ **Multiple DomainU, Unprivileged Domain Guests (DomU)** – Unprivileged guests running on the hypervisor; they have no direct access to hardware (e.g. memory, disk, etc.)

What is Xen Hypervisor?

- The **Xen hypervisor runs directly on the hardware and becomes the interface for all hardware requests such as CPU, I/O, and disk for the guest operating systems**. By separating the guests from the hardware, the Xen hypervisor is able to run multiple operating systems securely and independently.
- The **Domain 0 Guest referred to as Dom0** is launched by the Xen hypervisor during initial system start-up and can run any operating system except Windows. The Dom0 has unique privileges to access the Xen hypervisor that is not allocated to any other Domain Guests. These privileges allow it to manage all aspects of Domain Guests such as starting, stopping, I/O requests, etc. A system administrator can log into Dom0 and manage the entire computer system.
- The **Domain Guests referred to as DomUs** are launched and controlled by the Dom0 and independently operate on the system. These guests are either run with a special modified operating system referred to as **paravirtualization** or unmodified operating systems leveraging special virtualization hardware (Intel VT and AMD-V) referred to as **hardware virtual machine (HVM)**. Note – Microsoft Windows requires a HVM Guest environment

What is Xen Hypervisor?

■ Paravirtualization

- A term used to describe a virtualization technique that allows the operating system to be aware that it is running on a hypervisor instead of base hardware. The **operating system must be modified to accommodate the unique situation of running on a hypervisor instead** of basic hardware.

■ Hardware Virtual Machine (HVM)

- A term used to describe an operating system that is running in a **virtualized environment unchanged and unaware** that it is not running directly on the hardware.
- **Special hardware is required to allow this, thus the term HVM**

What is Xen Hypervisor?

- **For more information on Xen Hypervisors:**
- Xen at Wikipedia - <http://en.wikipedia.org/wiki/Xen>
- Xen Overview (In Process) - <http://wiki.xensource.com/xenwiki/XenOverview>
- Virtualization at Wikipedia - <http://en.wikipedia.org/wiki/Virtualization>
- Xen Dom0 Kernels - <http://wiki.xensource.com/xenwiki/XenDom0Kernels>
- Xen FAQ - <http://wiki.xensource.com/xenwiki/XenFaq>
- Xen Case Studies - http://wiki.xensource.com/xenwiki/Xen_Case_Studies

- **Xen Books** = <http://wiki.xensource.com/xenwiki/Books?highlight=%28books%29>
 - ◆ ◦ For Developers
 - ✓ ▪ The Definitive Guide to the Xen Hypervisor
 - ◆ ◦ For Users
 - ✓ ▪ The Book of Xen
 - ✓ ▪ Running Xen: A Hands-on Guide to the Art of Virtualization

How Does Xen Work?

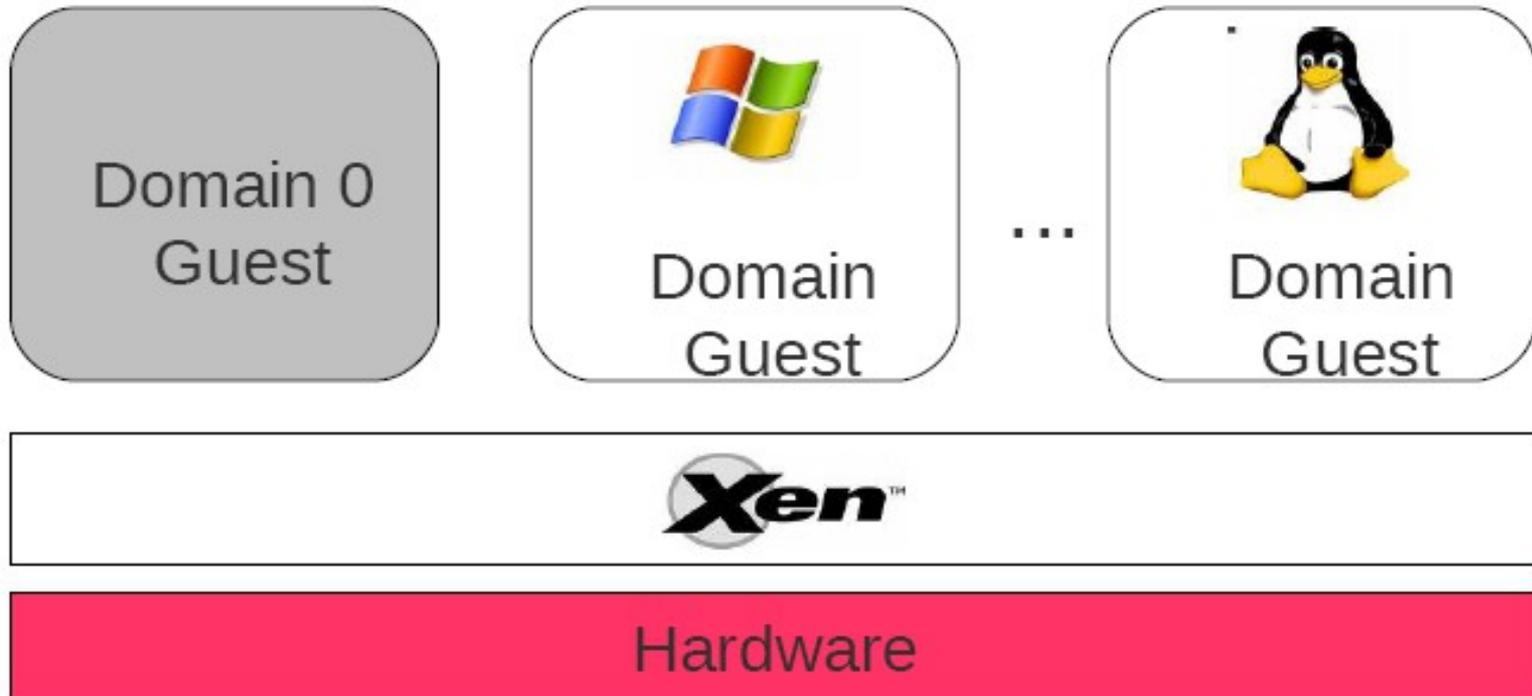
How Does Xen Work?

■ Xen Environment Components

- A Xen virtual environment consist of several items that work together to deliver the virtualization environment a customer is looking to deploy:

- ◆ Xen Hypervisor
- ◆ Domain 0 Guest
 - ✓ Domain Management and Control (Xen DM&C)
- ◆ Domain U Guest (Dom U)
 - ✓ PV Guest
 - ✓ HVM Guest

- The diagram below shows the basic organization of these components.



How Does Xen Work?

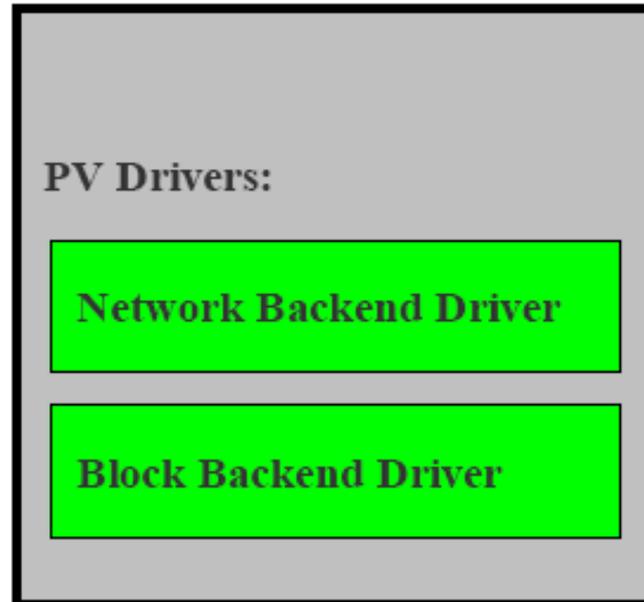
- ***Xen Hypervisor***
- The Xen hypervisor is the basic abstraction layer of software that sits directly on the hardware below any operating systems. **It is responsible for CPU scheduling and memory partitioning** of the various virtual machines running on the hardware device.
- The hypervisor not only abstracts the hardware for the virtual machines but also controls the execution of virtual machines as they share the common processing environment.
- It **has no knowledge of networking, external storage devices**, video, or any other common I/O functions found on a computing system.

How Does Xen Work?

- **Domain 0**
- **Domain 0, a modified Linux kernel**, is a unique virtual machine running on the Xen hypervisor that has special rights to access physical I/O resources as well as interact with the other virtual machines (Domain U: PV and HVM Guests) running on the system. **All Xen virtualization environments require Domain 0 to be running before** any other virtual machines can be started.
- **Two drivers** are included in Domain 0 to support network and local disk requests from Domain U PV and HVM Guests (see below);
 - ◆ **the Network Backend Driver**
 - ◆ **and**
 - ◆ **the Block Backend Driver**
- The Network Backend Driver communicates directly with the local networking hardware to process all virtual machines requests coming from the Domain U guests.
- The Block Backend Driver communicates with the local storage disk to read and write data from the drive based upon Domain U requests.

How Does Xen Work?

■ *Domain 0*

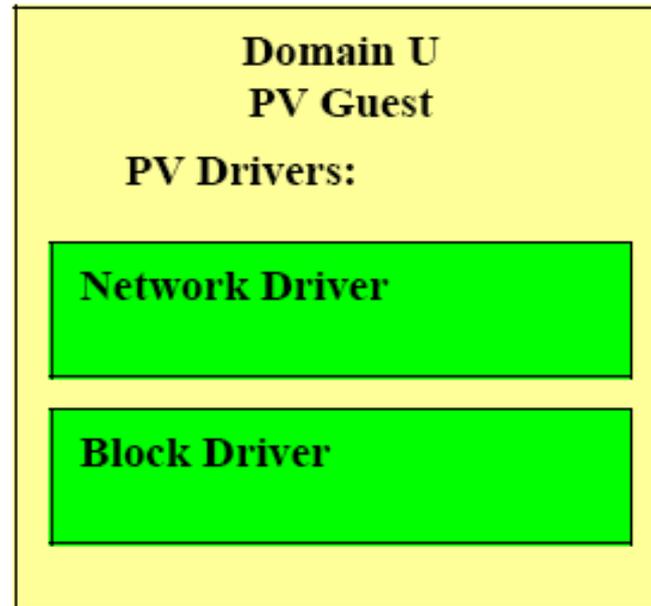


How Does Xen Work?

- **Domain U**
- DomainU guests have **no direct access to physical hardware** on the machine as a Domain0 Guest does and is often referred to as unprivileged.
 - ❖ All paravirtualized virtual machines running on a Xen hypervisor are referred to as **Domain U PV Guests** and are modified Linux operating systems, Solaris, FreeBSD, and other UNIX operating systems.
 - ❖ All fully virtualized machines running on a Xen hypervisor are referred to as **Domain U HVM Guests** and run standard Windows or any other unchanged operating system.
- The **Domain U PV Guest** virtual machine is aware that it does not have direct access to the hardware and recognizes that other virtual machines are running on the same machine.
- The **Domain U HVM Guest** virtual machine is not aware that it is sharing processing time on the hardware and **that other virtual machines are present**.
- A **Domain U PV Guest contains two drivers** for network and disk access, **PV Network Driver** and **PV Block Driver**.

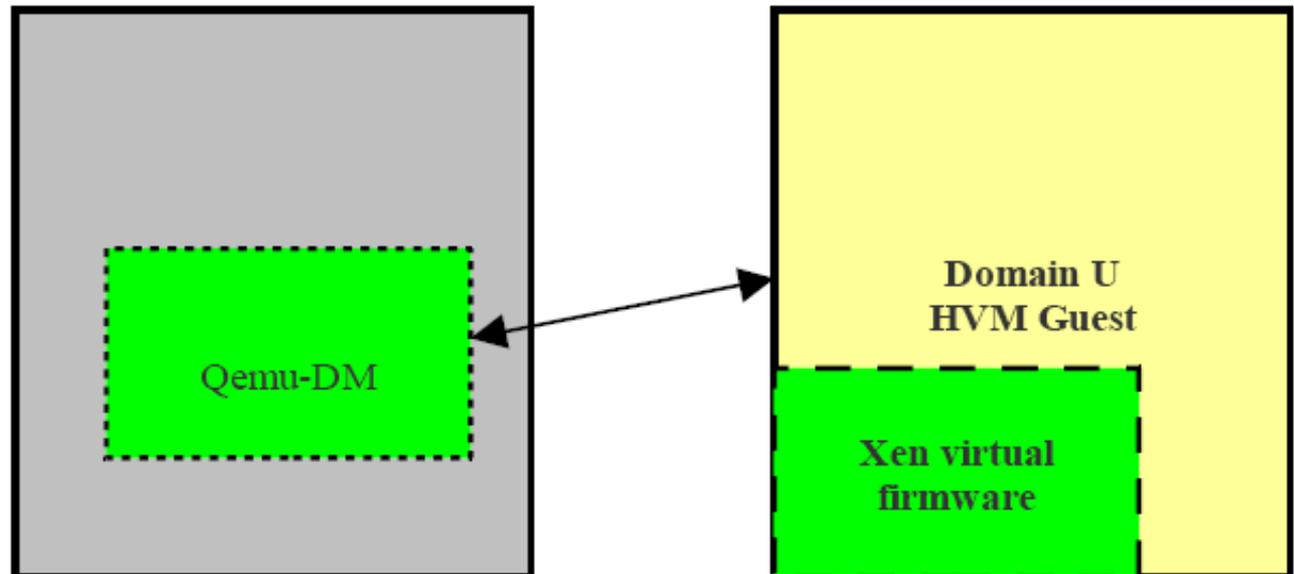
How Does Xen Work?

■ *Domain U*



How Does Xen Work?

- A **Domain U HVM Guest does not have the PV drivers** located within the virtual machine; instead a special daemon is started for each HVM Guest in Domain 0, **Qemudm**. **Qemu-dm supports the Domain U HVM Guest for networking and disk access requests.**
- The Domain U HVM Guest must initialize as it would on a typical machine so software is added to the Domain U HVM Guest, **Xen virtual firmware, to simulate the BIOS an operating system** would expect on startup. More information on the Xen virtual firmware is presented later in this document.

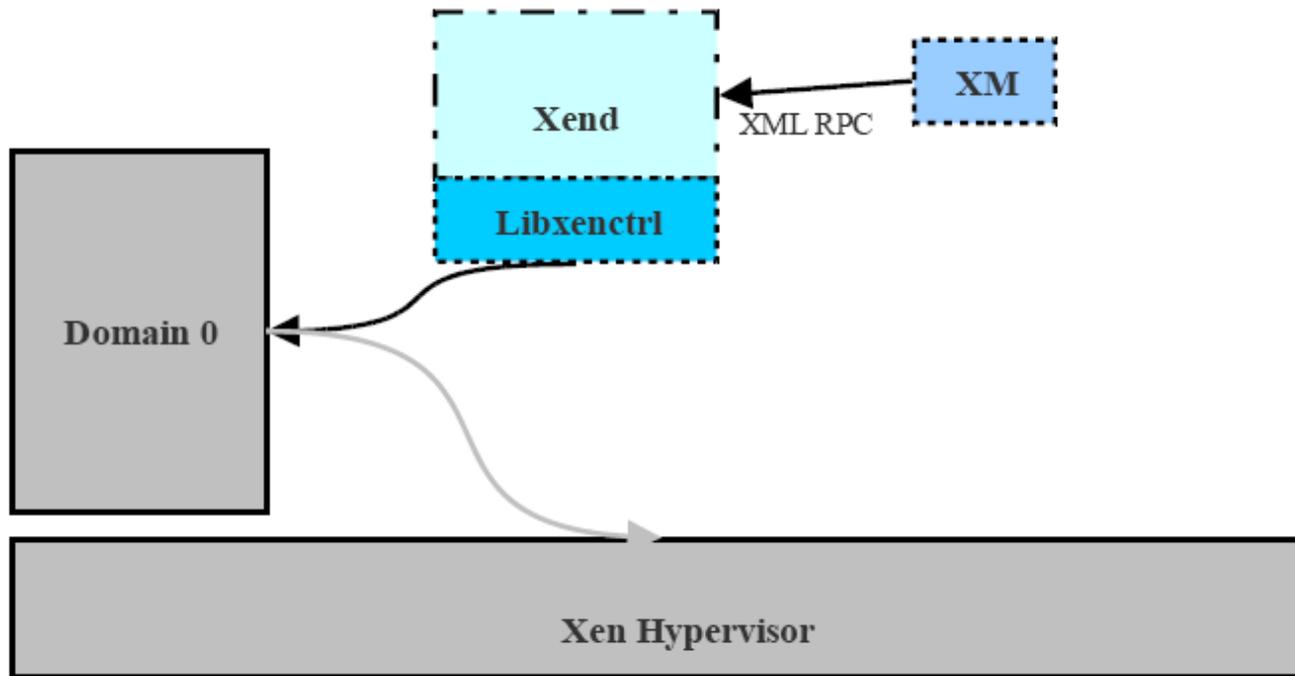


How Does Xen Work?

- ***Domain Management and Control***
- A series of Linux daemons are classified as Domain Management and Control by the open source community.
- These services support the overall management and control of the virtualization environment and exist within the Domain 0 virtual machine.
- The diagrams below show the daemons outside the Domain 0 diagram for a clearer understanding of the architecture.

How Does Xen Work?

- **Xend**
- The **Xend daemon** is a **python application that is considered the system manager for the Xen environment**. It leverages the libxenctrl library to make requests of the Xen hypervisor. All requests processed by the Xend are delivered to it via an XML RPC interface by the **Xm tool**



How Does Xen Work?

■ Xm

- The command line tool that takes user input and passes to Xend via XML RPC.

■ Xenstored

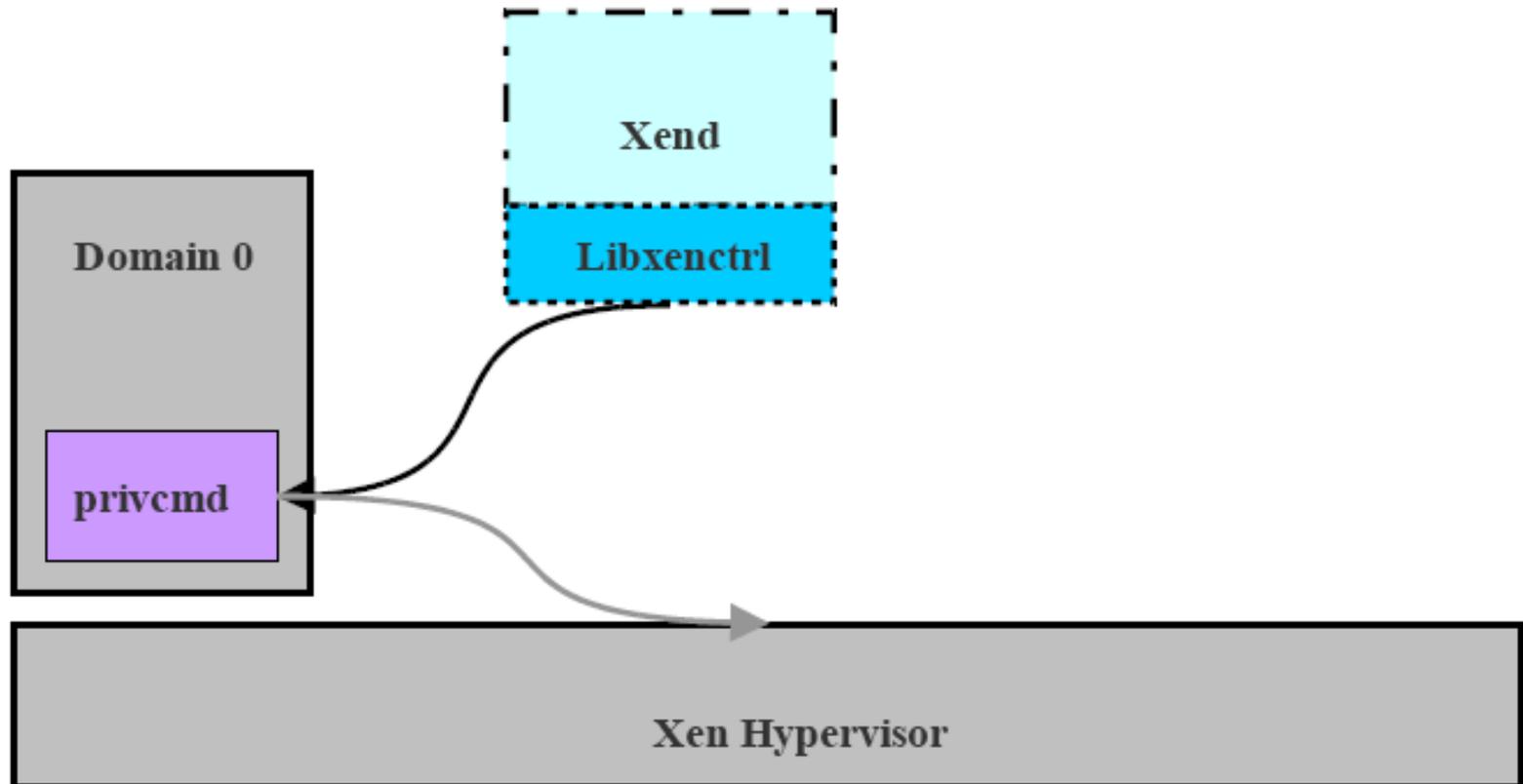
- The **Xenstored daemon maintains a registry of information** including memory and event channel links between Domain 0 and all other Domain U Guests. The Domain 0 virtual machine leverages this registry to setup device channels with other virtual machines on the system. (See Domain 0 to Domain U Communication for more details).

■ Libxenctrl

- Libxenctrl is a C library that **provides Xend the ability to talk with the Xen hypervisor via Domain 0**. A special driver within Domain 0, privcmd delivers the request to the hypervisor.

How Does Xen Work?

- **Libxenctrl**
- **Libxenctrl** is a C library that provides Xend the ability to talk with the Xen hypervisor via Domain 0. A special driver within Domain 0, **privcmd** delivers the request to the hypervisor.



How Does Xen Work?

- **Qemu-dm**
- **Every HVM Guest running on a Xen environment requires its own Qemu daemon.** This tool handles all networking and disk requests from the Domain U HVM Guest to allow for a fully virtualized machine in the Xen environment. Qemu must exist outside the Xen hypervisor due to its need for access to networking and I/O and is therefore found in Domain 0
- A **new tool, Stub-dm**, is in development for future versions of Xen that will remove the need for a Qemu running for every Domain U HVM Guest and will instead provide a set of services available to every Domain U HVM Guest. This feature is not available in Xen 3.2 but is currently part of the xen-unstable tree and will be released as part of **Xen 3.3**
- **Xen Virtual Firmware**
- The Xen Virtual Firmware is a virtual BIOS that is inserted into every Domain U HVM Guest to ensure that the operating system receives all the standard start-up instructions it expects during normal boot-up providing a standard PC-compatible software environment

How Does Xen Work?

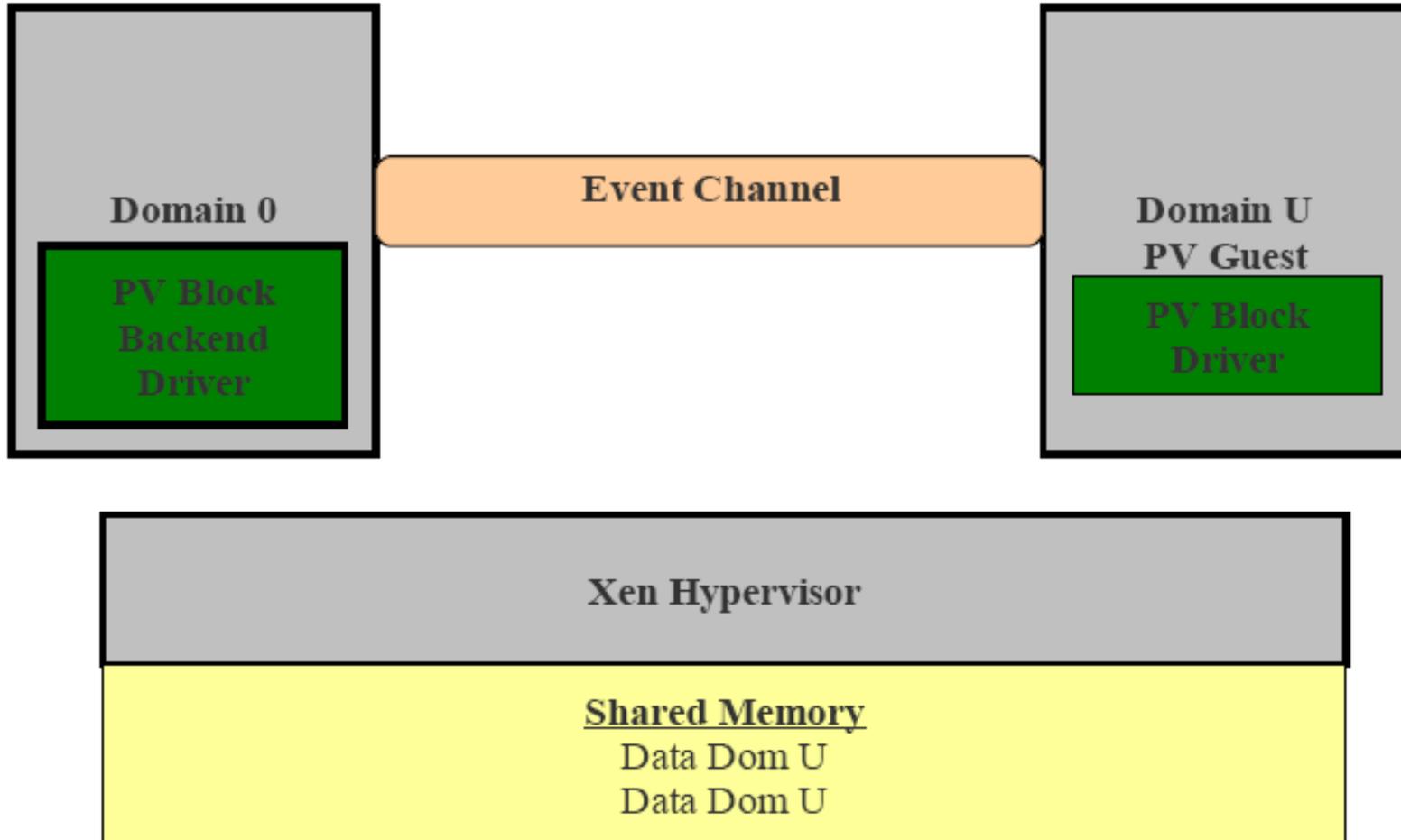
■ Xen Operation

- This section demonstrates how a paravirtualized Domain U is able to communicate with external networks or storage via the Xen hypervisor and Domain 0
- **Domain 0 to Domain U Communication**
- As stated earlier, the **Xen hypervisor is not written to support network or disk requests** thus a Domain U PV Guest must communicate via the Xen hypervisor with the Domain 0 to accomplish a network or disk request. The example presented below shows a Domain U PV Guest writing data to the local hard disk.
- The **Domain U PV Guest PV block driver receives a request to write to the local disk and writes the data via the Xen hypervisor to the appropriate local memory which is shared with Domain 0**. An event channel exists between Domain 0 and the Domain U PV Guest that allows them to communicate via asynchronous inter-domain interrupts in the Xen hypervisor. Domain 0 will receive an interrupt from the Xen hypervisor causing the PV Block Backend Driver to access the local system memory reading the appropriate blocks from the Domain U PV Guest shared memory. The data from shared memory is then written to the local hard disk at a specific location.

How Does Xen Work?

- The event channel is shown below as a **direct link between Domain 0 and Domain U PV Guest which is a simplified view of the way the system works.**
- In fact, the event channel runs through the Xen hypervisor with specific interrupts registered in Xenstored allowing both the Domain 0 and Domain U PV Guest to quickly share information across local memory.
- The figure below shows the previously described situation:

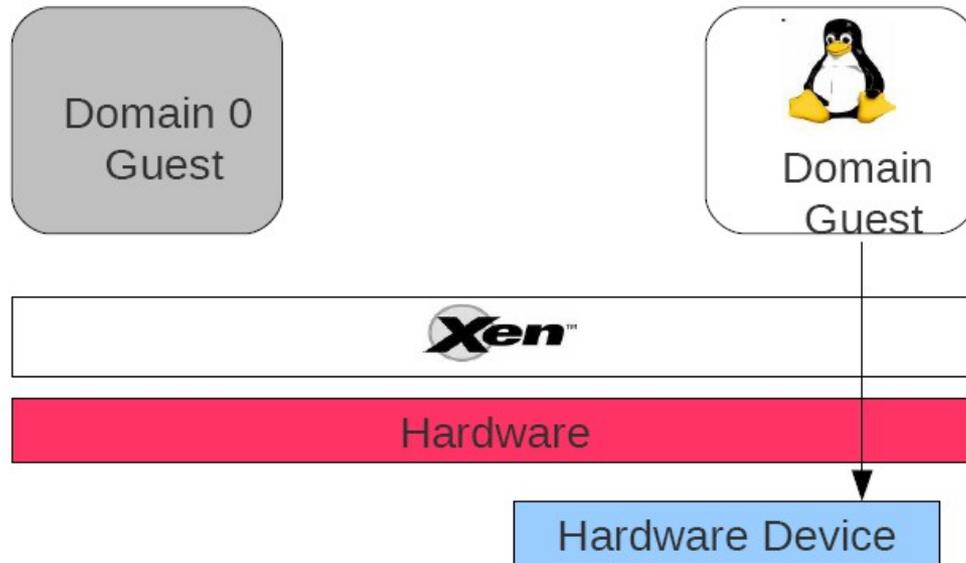
How Does Xen Work?



How Does Xen Work?

■ Xen PCI Passthru

- A new feature in Xen designed to improve overall performance and reduce the load on the Dom 0 Guest is PCI Passthru **which allows the Domain U Guest to have direct access to local hardware without using the Domain 0 for hardware access.** The diagram below shows how this feature works:



- The Domain U Guest is given rights to talk directly to a specific hardware device instead of the previous method of using Frontend and Backend drivers.

Why xen?

Why Xen?

■ Xen Compared to Other Hypervisors

■ The following points compare Xen to VMware ESXi, Hyper-V, and KVM.

- ◆ Xen has “thin hypervisor” model
 - ✓ No device drivers and keeps domains/guests isolated
 - ✓ 2 MB executable
 - ✓ Relies on service domains for functionality

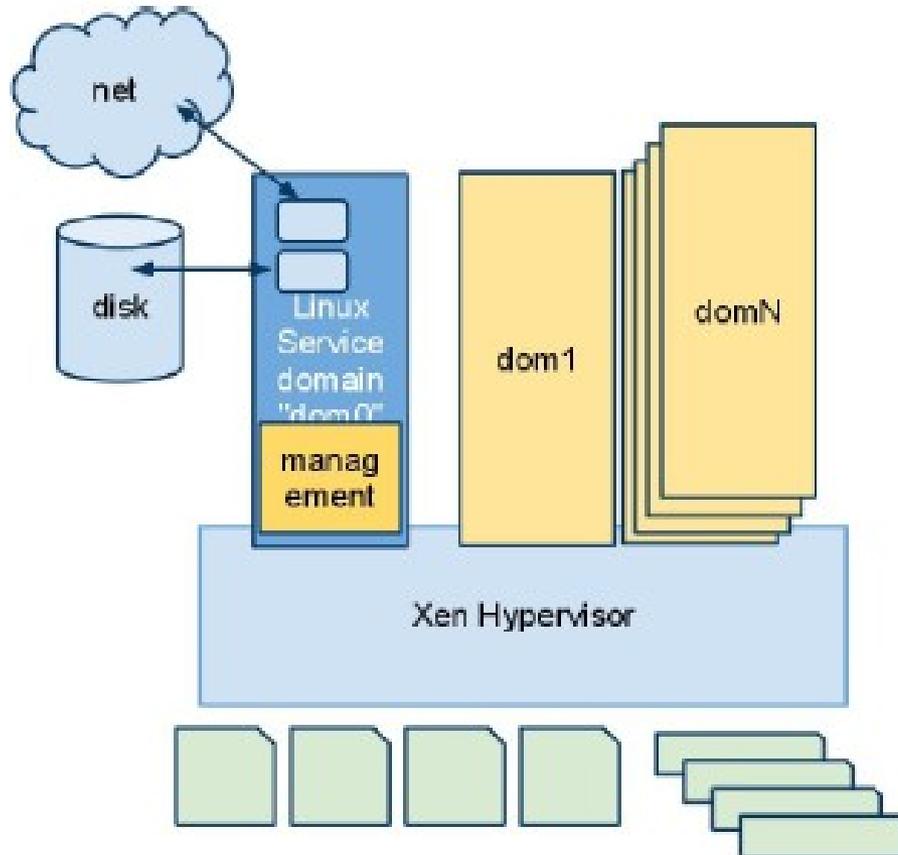
- ◆ VMware ESXi – similar to Xen
 - ✓ Contains device drivers and base of management stack
 - ✓ Hardware support depends on VMware created drivers

- ◆ Hyper-V – modeled on Xen hypervisor

- ◆ KVM – unlike Xen model
 - ✓ Linux kernel as hypervisor

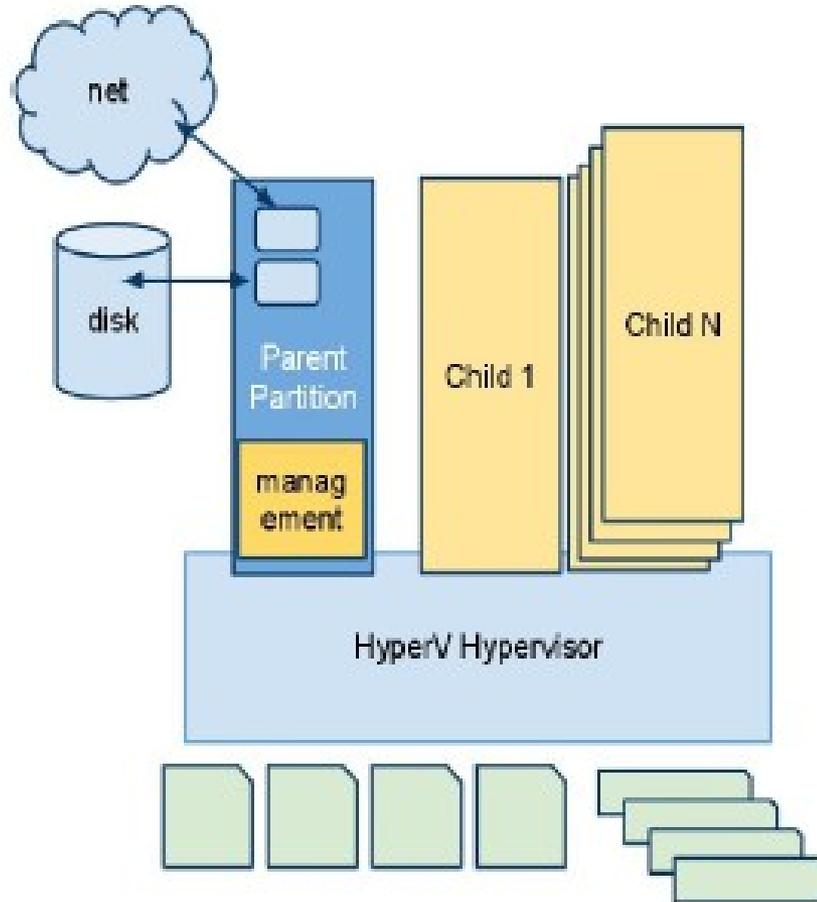
Why xen?

- *Hypervisor Architecture Diagrams*
- **Xen Architecture**
- Linux Service domain “Domain0” can be Solaris, BSD, etc.



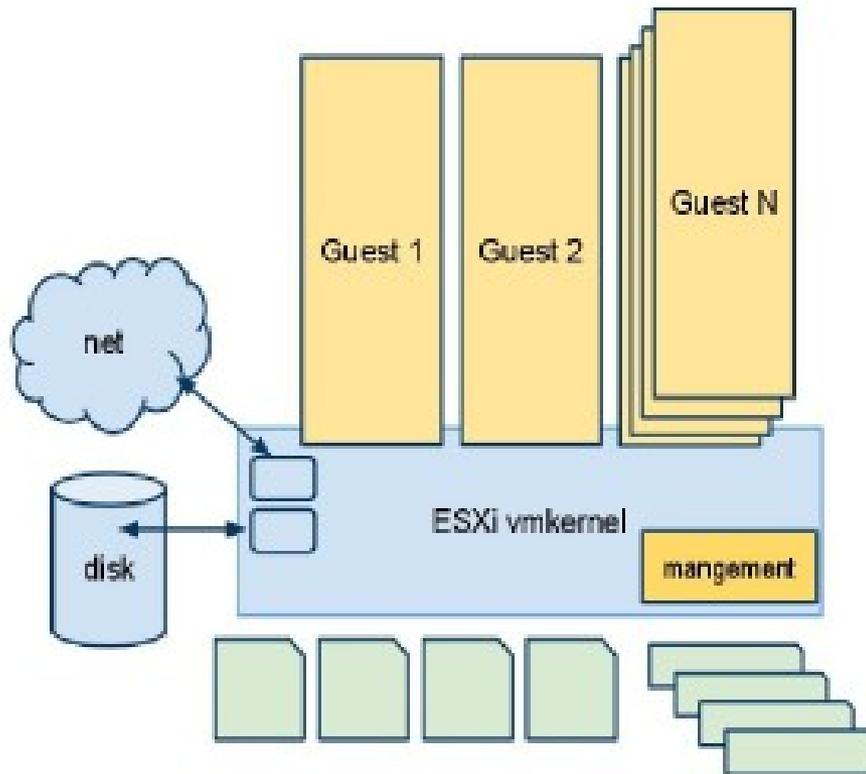
Why xen?

■ Hyper-V Architecture



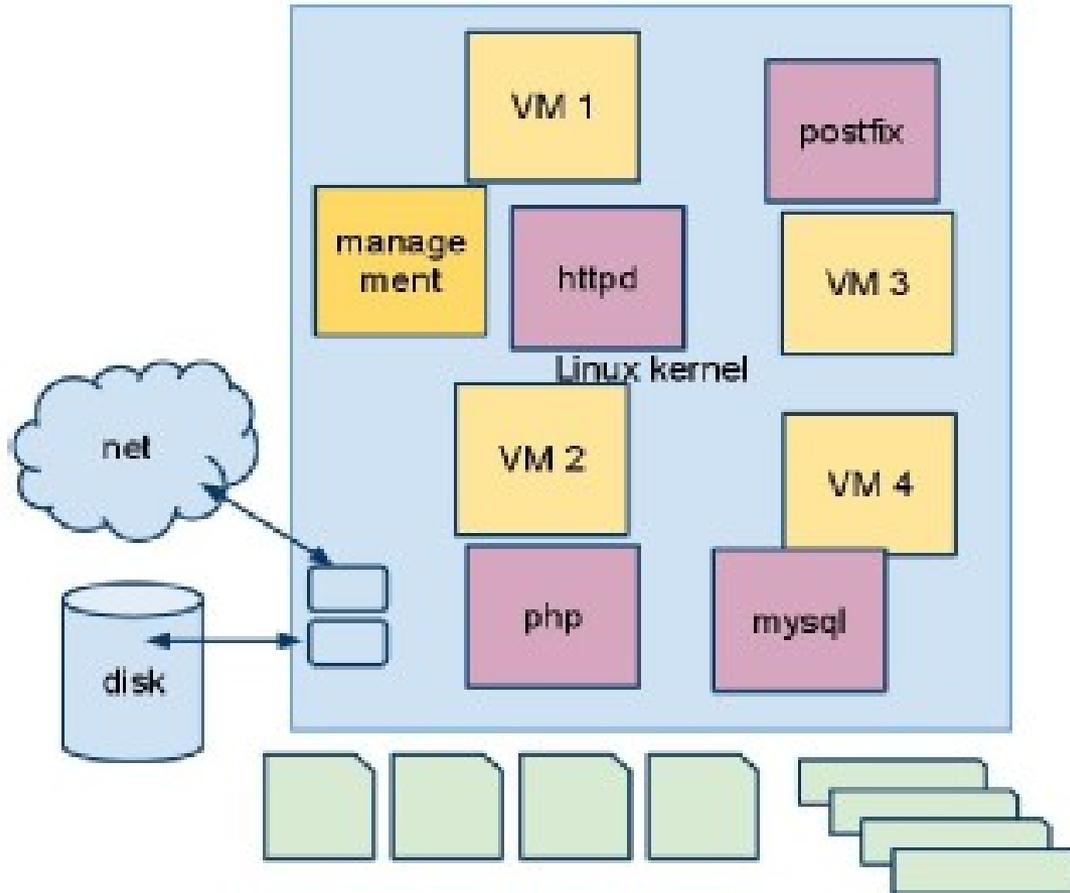
Why xen?

■ VMware ESXI Architecture



Why xen?

■ KVM Architecture



Why xen?

- ***Xen Comparison Highlights***
- Xen separates the hypervisor execution from management OS, management stack, device drivers, and guests (components)
- Components are interchangeable – choose the best OS to support your needs
- Strong isolation between all components – assisted with modern hardware and domains can restart without taking out full system
- Scalability

Why xen?

■ Operating System Neutrality

- A critical benefit of the Xen Hypervisor is its neutrality to the various operating systems. Due to its independence, Xen is capable of allowing any operating system (Linux, Solaris, BSD, etc) to be the Domain0 thereby ensuring the widest possible use case for customers. For example, many hardware manufacturers leverage NetBSD as their OS of choice for Domain0 and are able to deploy Xen in the manner of their choosing.
- This separation of hypervisor from the Domain0 operating system also ensures that Xen is not burdened with any operating system overhead that is unrelated to processing a series of guests on a given machine. In fact, more are beginning to break up the Domain0 from a single guest into a series of mini-OS guests each with a specific purpose and responsibility which drives better performance and security in a virtualization environment.
- As for DomainU, guests, the Xen community has led the way in paravirtualization technology which is now part of mainstream Linux and available to everyone creating a Linux distribution.
- The Xen community also provides industry leading paravirtualization drivers for Windows guests as well to ensure that the broader enterprise computing industry is able to deploy their OS of choice as a guest on Xen

Why xen?

■ Security and Reliability Built-In

■ A critical aspect of building a hypervisor is ensuring that the solution is secure, especially when the solution is deployed in enterprise and cloud computing environments. Xen ensures a high level of security via a variety of methods/features:

- ◆ • **Guest Isolation** – every DomainU guest is isolated from other DomainU guests with no way to access each other's memory or networking connections
- ◆ • **Privileged Access** – only the Domain0 or single purpose control guests are given the ability to communicate with the hardware via the hypervisor
- ◆ • **Small Code Base** – the Xen hypervisor contains a “tiny” code footprint which limits the areas for attack
- ◆ • **Operating System Separation** – by separating the hypervisor from an operating system, the Xen hypervisor cannot be used to attack an operating system; e.g. Xen cannot attack the host operating system as there is no host operating system to attack

■ The Xen.org community also works closely with the The Invisible Things Lab who focus exclusively on cutting edge security needs for computing infrastructures. Working together, the Xen hypervisor is attacked by leading security experts who work directly with Xen.org to close the loop on any security hole found. In fact, The Invisible Things Lab has developed a complete, secure open source operating system, Qubes OS, leveraging the Xen hypervisor as their virtualization foundation

Why xen?

■ Performance

- It is difficult to credibly present hypervisor performance statistics as there are multiple benchmarks available which are not universal in the methodologies and metrics. Instead, I will highlight some of the ways that the Xen hypervisor is fundamentally lowering processing time, memory usage, and networking efficiency.
- Paravirtualization (enlightenment), created by the founders of the Xen hypervisor allows the guest operating system to co-operate with the hypervisor to improve overall performance for I/O, CPU, and memory virtualization. By being aware that the operating system is running in a virtualized platform, the modified operating system is able to assist the hypervisor in a variety of tasks. All Linux distributions currently support paravirtualization out of the box and Windows paravirtualization drivers are available in the Xen.org community.

Why xen?

- **Performance**

- **Pass-through technology allows a guest domain to speak directly with a specific piece of hardware directly without having to send communication to and from the Domain0.** Allowing a guest domain direct access to hardware significantly improves time to response for a guest, lowers processing time by eliminating the Domain0 middleman, and reduces load on the Domain0 queue. Of course, security is maintained as the guest is restricted in what hardware it can access thereby preventing guest interaction.
- As stated previously, having the hypervisor separate from the operating system also ensures maximum performance. Any operating system will have a series of tasks that must be scheduled and processed during normal operation. The majority of these tasks are not related to processing the virtualized guests and thus can potential impact overall performance.
- The Xen hypervisor is able to process the virtualized guests without any operating system overhead and can even be tuned specifically to maximum guest processing based on user demands and requirements for a given guest. The scheduler within Xen is also customized for a virtualized environment thereby ensuring that a Xen infrastructure is capable of meeting the highest user expectations

Why xen?

- **Cutting Edge Features**

- As an **open source community with many leading technology vendors participating** (e.g. AMD & Intel), Xen.org is able to ensure that the Xen hypervisor supports both paravirtualized (or enlightened) guests and fully virtualized guests, so Xen users can take advantage of both the latest in software and hardware virtualization technology. By working closely with hardware manufacturers including networking equipment vendors, the Xen hypervisor becomes the testing ground for new hardware ensuring that Xen is always a cutting edge solution.

- The **Xen hypervisor** also benefits from a variety of university research which is developed and tested before integrating into the final Xen hypervisor solution. A recent example of this close relationship is Project Remus from the University of British Columbia. Remus provides transparent, comprehensive high availability to ordinary virtual machines running on the Xen virtual machine monitor. It does this by maintaining a completely up-to-date copy of a running VM on a backup server, which automatically activates if the primary server fails

Why xen?

■ The Cloud

- The **Xen hypervisor is the most used virtualization platform in the cloud computing space**. With leading vendors such as Amazon, Cloud.com, GoGrid, and Rackspace all using Xen, the community is able to ensure that their scalability and performance needs are met. In fact, the largest virtualization deployments in the world are primarily running the Xen hypervisor in a cloud computing environment. To better support these cloud providers, the Xen.org community created a new project in 2009, Xen Cloud Platform.
- **Xen Cloud Platform** offers ISVs and service providers a **complete cloud infrastructure platform with a powerful management stack** based on open, standards-based APIs, support for multi-tenancy, SLA guarantees and detailed metrics for consumption based charging. More details in the Xen in the Cloud document.
- To follow XCP, join the Xen.org xen-api mailing list

Why xen?

■ Proven Technology

- The Xen hypervisor has been available for enterprise deployment since 2004 and is the first **open source hypervisor to successfully be deployed by industry leading Linux vendors**, software corporations, and global customers taking advantage of the virtualization revolution.
- The Xen hypervisor is currently available in solutions from Avaya, Cisco, Citrix, Fujitsu, Lenovo, Novell, Oracle, Samsung, VALinux, and others. Cloud providers including Amazon, Cloud.com, GoGrid, and Rackspace are amongst the many cloud solutions using Xen as their virtualization foundation.
- For sample case studies on the Xen hypervisor go [here](#), [here](#), and [here](#). These case studies from **Citrix, Oracle, and the Xen.org** community demonstrate the global, secure, and scalable capabilities of the Xen hypervisor

Why xen?

- **Community**
- The open source Xen hypervisor is built by a fully-engaged, global developer community consisting of corporate developers, university researchers, independent developers, and virtualization technologists.
- With over **250 patches (on average) submitted to the community monthly**, the Xen hypervisor continues to lead the industry in hardware support and new features. Supported by the Xen Advisory Board (Citrix, Fujitsu, HP, IBM, Intel, Novell, Oracle, and VA Linux Systems Japan) and a large customer base, the Xen hypervisor has a solid future in being a leader in hypervisor technology.
- Become a part of the Xen.org community...
 - ❖ Developers? Join the xen-devel mailing list
 - ❖ Users? Join the xen-users mailing list
 - ❖ General Interest?
 - ✓ Follow the Xen.org community blog
 - ✓ Follow the Xen.org community on twitter

Why xen?