

# Xen

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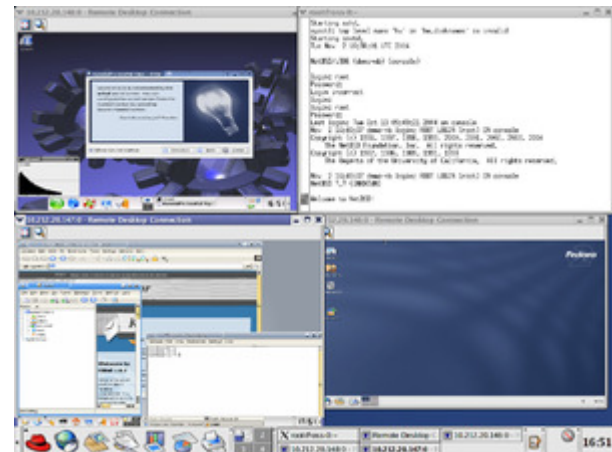
**Xen** /ˈzɛn/ is a hypervisor using a microkernel design, providing services that allow multiple computer operating systems to execute on the same computer hardware concurrently.

The University of Cambridge Computer Laboratory developed the first versions of Xen. The Xen community develops and maintains Xen as free and open-source software, subject to the requirements of the GNU General Public License (GPL), version 2. Xen is currently available for the IA-32, x86-64 and ARM instruction sets.

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## Xen



Xen running NetBSD and three Linux distributions

<b>Original author(s)</b>	Keir Fraser, Steven Hand, Ian Pratt, University of Cambridge Computer Laboratory
<b>Developer(s)</b>	Xen Project
<b>Initial release</b>	2003
<b>Stable release</b>	4.5 <sup>[1]</sup> / January 15, 2015
<b>Type</b>	Hypervisor
<b>License</b>	GNU GPL version 2
<b>Website</b>	<span>www.xenproject.org</span> ( <span>http://www.xenproject.org/</span> )

- 11 External links

## Software architecture

Xen 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.<sup>[2]</sup>

The dom0 domain is typically a version of Linux, or BSD. User domains may either be traditional operating systems, such as Microsoft Windows under which privileged instructions are provided by hardware virtualization instructions (if the host processor supports x86 virtualization, e.g., Intel VT-x and AMD-V),<sup>[3]</sup> or *para-virtualized* operating system whereby the operating system is aware that it is running inside a virtual machine, and so makes hypercalls directly, rather than issuing privileged instructions.

Xen boots from a bootloader such as GNU GRUB, and then usually loads a paravirtualized host operating system into the host domain (dom0).

## History

Xen originated as a research project at the University of Cambridge, led by Ian Pratt, senior lecturer at Cambridge who co-founded XenSource, Inc. with Simon Crosby also of Cambridge University. 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. 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,<sup>[4]</sup> and the Xen project moved to the xen.org domain. 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,<sup>[5]</sup> which Citrix has freely licensed to all vendors and projects that implement the Xen hypervisor.<sup>[6]</sup>

Citrix has also used the Xen brand itself for some proprietary products unrelated to Xen, including at least "XenApp" and "XenDesktop".

On 15 April 2013, it was announced that the Xen Project was moved under the auspices of the Linux Foundation as a Collaborative Project.<sup>[7]</sup> The Linux Foundation launched a new trademark for "Xen Project" to differentiate the project from any commercial use of the older "Xen" trademark. A new community website was launched at xenproject.org<sup>[8]</sup> as part of the transfer. Project members at the time of the announcement included: Amazon, AMD, Bromium, CA Technologies, Calxeda, Cisco, Citrix, Google, Intel, Oracle,

Samsung, and Verizon.<sup>[9]</sup> The Xen project itself is self-governing.<sup>[10]</sup>

## **Release history for Xen (upstream project)**

Version	Release date	Notes
1.0	October 2, 2003 <sup>[11][12]</sup>	
2.0	November 5, 2004 <sup>[13]</sup>	
3.0	December 5, 2005 <sup>[14][15]</sup>	<ul style="list-style-type: none"> <li>■ Supports the Intel VT technology for HVM guests.</li> <li>■ Support for the Intel IA-64 architecture.</li> </ul> <p>The releases up to 3.0.4 also added:</p> <ul style="list-style-type: none"> <li>■ Support for the AMD SVM virtualization extensions.<sup>[16]</sup></li> <li>■ Support for the PowerPC architecture.<sup>[17]</sup></li> <li>■ Graphical framebuffer support for paravirtualised guests.<sup>[18]</sup></li> </ul>
3.1	May 18, 2007 <sup>[19]</sup>	Live migration for HVM guests, XenAPI
3.2	January 17, 2008 <sup>[20]</sup>	PCI passthrough and ACPI S3 standby mode for the host system.
3.3	August 24, 2008 <sup>[21]</sup>	Improvements for the PCI passthrough and the power management.
3.4	May 18, 2009 <sup>[22]</sup>	Contains a first version of the "Xen Client Initiative", shortly XCI.
4.0	April 7, 2010 <sup>[23]</sup>	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 does not support the usage as dom0 kernel (date July 2010). <sup>[24]</sup>
4.1	March 25, 2011 <sup>[25]</sup>	Some of the improvements: Support for more than 255 processors, better stability. Linux kernel v2.6.37 and onward support usage as dom0 kernel. <sup>[26]</sup>
4.2	September 8, 2012 <sup>[1]</sup>	XL became the default toolstack. Support for up to 4095 host processors and up to 512 guest processors.
4.3	July 9, 2013 <sup>[27]</sup>	Experimental ARM support. NUMA-aware scheduling. Support for Open vSwitch.
4.4	March 10, 2014 <sup>[28]</sup>	Solid libvirt support for libxl, new scalable event channel interface, hypervisor ABI for ARM declared stable, Nested Virtualization on Intel hardware. <sup>[29][30]</sup>
4.5	January 17, 2015 <sup>[31]</sup>	With 43 major new features, 4.5 includes the most updates in the project's history. <sup>[31]</sup>

## Xen in Linux distributions and Linux upstream

Since version 3.0 of the Linux kernel, Xen support for dom0 and domU exists in the mainline kernel.<sup>[32]</sup>

## Uses

Internet hosting service companies use hypervisors to provide virtual private servers. Amazon EC2, IBM SoftLayer,<sup>[33]</sup> Liquid Web, Fujitsu Global Cloud Platform,<sup>[34]</sup> Linode, OrionVM<sup>[35]</sup> and Rackspace Cloud use Xen as the primary VM hypervisor for their product offerings.<sup>[36]</sup>

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'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.

## Technology

### Types of virtualization

Xen supports five different approaches to running the guest operating system: HVM (hardware virtual machine), HVM with PV drivers, PVHVM (HVM with PVHVM drivers), PVH (PV in an HVM container) and PV (paravirtualization).<sup>[37]</sup>

#### Paravirtualization - modified guests

Xen supports 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.<sup>[38][39]</sup>

Xen can run paravirtualized guests ("PV guests" in Xen terminology) even on CPUs without any explicit support for virtualization.

Paravirtualization 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).

### **Hardware-assisted virtualization, allowing for unmodified guests**

CPUs that support virtualization make it possible to support unmodified guests, including proprietary operating systems (such as Microsoft Windows). This is known as hardware-assisted virtualization, however in Xen this is known as hardware virtual machine (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.<sup>[40]</sup> Support for ARM v7A and v8A virtualization extensions came with Xen 4.3.<sup>[41]</sup>

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, or PVH) 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.

### **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.

## Target processors

The Xen hypervisor has been ported to a number of processor families.

- Intel: IA-32, IA-64 (before version 4.2<sup>[42]</sup>), x86-64
- PowerPC: previously supported under the XenPPC project, no longer active after Xen 3.2<sup>[43]</sup>
- ARM: previously supported under the XenARM project for older versions of ARM without virtualization extensions, such as the Cortex-A9. Currently supported since Xen 4.3 for newer versions of the ARM with virtualization extensions, such as the Cortex-A15.
- MIPS: XLP832 experimental port<sup>[44]</sup>

## Scalability

Xen can scale to 4095 physical CPUs, 256 VCPUs per HVM guest, 512 VCPUs per PV guest, 16 TB of RAM per host, and up to 1 TB of RAM per HVM guest or 512 GB of RAM per PV guest.<sup>[45]</sup>

## 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 is available for and distributed with:

- Alpine Linux offers a minimal Dom0 system (Busybox, UCLibc) that can be run from removable media, like USB sticks.
- Qubes OS for desktop usage
- openSUSE 10.x to 12.x;<sup>[46]</sup> only 64-bit hosts are supported since 12.1
- SUSE Linux Enterprise Server (since version 10)
- Sun Microsystems' Solaris
- Debian GNU/Linux (since version 4.0 "etch") and many of its derivatives
- 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<sup>[47][48]</sup>
- Gentoo and Arch Linux both have packages available to support Xen.<sup>[49]</sup>
- 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.<sup>[50]</sup>
- Mageia (since version 4)

# 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<sup>[51]</sup>
- OpenSolaris (See The Xen Community On OpenSolaris (<http://opensolaris.org/os/community/xen/>))
- NetWare (at Brainshare 2005 (<http://www.novell.com/brainshare/>), 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)

## 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.<sup>[52]</sup>

James Harper and the Xen open-source community have started developing GPL'd Paravirtualisation (<http://wiki.xenproject.org/wiki/XenWindowsGplPv>) 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.<sup>[53]</sup>

## 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:



- the web-based HyperVM
- Web-based ConVirt (<http://www.convirture.com>)
- the OpenNebula cloud management toolkit
- On openSUSE YaST and virt-man offer graphical VM management
- Web-based Xen Orchestra (<https://xen-orchestra.com/>)

Novell's PlateSpin Orchestrate also manages Xen virtual machines for Xen shipping in SUSE Linux Enterprise Server.

## Commercial versions

- Citrix XenServer
- Oracle VM
- Sun xVM (discontinued by Oracle)
- Virtual Iron (discontinued by Oracle)
- Thinsy Corporation
- Huawei FusionSphere<sup>[54][55]</sup>

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.

## See also

- CloudStack
- Kernel-based Virtual Machine (KVM)
- OpenStack
- tboot, a TXT-based integrity system for the Linux kernel and Xen hypervisor
- Virtual disk image

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51. "FreeBSD/Xen - FreeBSD Wiki" (<http://wiki.freebsd.org/FreeBSD/Xen>). Wiki.freebsd.org. 2012-06-25. Retrieved 2012-10-18.
52. "Xen and the Art of Virtualization" (<http://www.cl.cam.ac.uk/research/srg/netos/papers/2003-xensosp.pdf>) (PDF) (PDF). University of Cambridge SOSP'03 paper. Retrieved 2012-10-18.

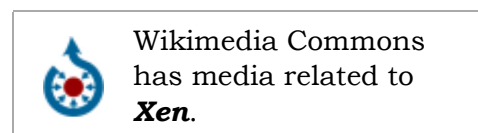
53. The information on the XenSource wiki seems to be outdated, but newer information is here: "Open Source Windows Paravirtualization Drivers for Xen (GPLPV)" ([http://jolokianetworks.com/70Knowledge/Virtualization/Open\\_Source\\_Windows\\_Paravirtualization\\_Drivers\\_for\\_Xen](http://jolokianetworks.com/70Knowledge/Virtualization/Open_Source_Windows_Paravirtualization_Drivers_for_Xen)). Jolokia Networks. Retrieved 2012-10-18.
54. Huawei FusionSphere: Optimize Business with Data Center Virtualization ([http://enterprise.huawei.com/ilink/cnenterprise/download/HW\\_193449](http://enterprise.huawei.com/ilink/cnenterprise/download/HW_193449))
55. Huawei to virtual world: Give us your desktops and no-one gets hurt ([http://www.theregister.co.uk/2014/07/25/huawei\\_virtualisation\\_strategy/](http://www.theregister.co.uk/2014/07/25/huawei_virtualisation_strategy/))

## Further reading

- Paul Venezia (April 13, 2011) Virtualization shoot-out: Citrix, Microsoft, Red Hat, and VMware. The leading server virtualization contenders tackle InfoWorld's ultimate virtualization challenge (<http://www.infoworld.com/d/virtualization/virtualization-shoot-out-citrix-microsoft-red-hat-and-vmware-666>), *InfoWorld*

## External links

- Official website (<http://www.xenproject.org/>)
- Archived xen.org page (<http://www-archive.xenproject.org>)
- Official Citrix product site (<http://www.citrix.com/xenserver/>)
- Step-by-step installation instructions for Xen, with a DomU capable of running Windows XP SP3 and ReactOS (<http://www.lumbercartel.ca/library/xen/>)
- University of Cambridge research page for Xen (<http://www.cl.cam.ac.uk/Research/SRG/netos/xen/>)
- University of Cambridge, Technical Report Number 553, January 2003 (<http://www.cl.cam.ac.uk/TechReports/UCAM-CL-TR-553.pdf>). Early report outlining the architecture of Xen.
- Xen Guide by Tapas Mishra ([http://wiki.xenproject.org/wiki/Xen\\_on\\_4\\_app\\_servers](http://wiki.xenproject.org/wiki/Xen_on_4_app_servers))
- UnifiedSessionsManager - An Unofficial Xen configuration file creator (<http://www.unifiedsessionsmanager.org/doc/en/html/man1/ctys-createConfVM.html>)
- Trusted Boot: Verifying the Xen Launch ([http://www-archive.xenproject.org/files/xensummit\\_fall07/23\\_JosephCihula.pdf](http://www-archive.xenproject.org/files/xensummit_fall07/23_JosephCihula.pdf))
- XAPI: Open source software to build private and public clouds (<http://www.xenproject.org/developers/teams/xapi.html>)



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Categories: 2003 software | Cross-platform free software | Free virtualization software | Linux Foundation | University of Cambridge Computer Laboratory | Virtualization-related software for Linux

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