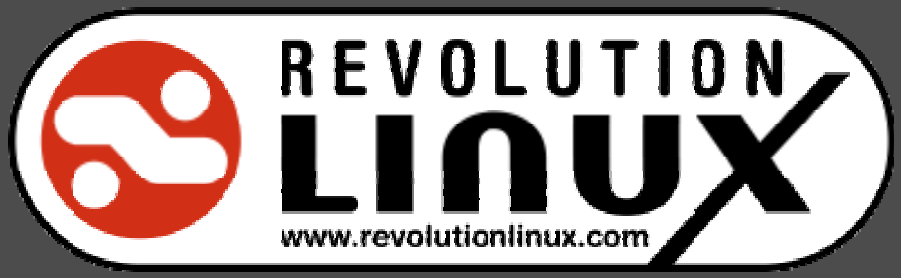
Virtualization of Linux based computers: the Linux-VServer project



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Objectives:

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1) ***Present the available programs that can provide a virtualization of Linux computers with different technologies.***

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2) Focus on Linux-VServers: a very lightweight and effective technology for the regular Linux user not intersted in Kernel hacking.

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- Overview of the available technology

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- Classification of the problems: usage criteria

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- Conclusion

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- ***Virtualization is now more and more acessible for regular users given the extreme processing power of the current computers***
- ***The availability of COTS multi-processor 64 bit architecture accelerates the needs for a mature virtualization technique, as it's more and more difficult for a common application to use 100% of the available resources***
- ***Virtualization also affect scientific computing and could become, in the near future, the corner stone of the so called «grid computing» as it solves elegantly most of the problems (security, resources consumption) of the current Grid technology***

Overview of the available technology

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- VMware

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- QEMU

VMware

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« Vmware workstation is a powerfull virtual machine software for the desktop. VMware workstation runs multiple operating systems, including Microsoft Windows, Linux and Novell NetWare, simultaneously on a single PC in fully networked, portable virtual machines »

http://www.vmware.com/products/

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- Resource consumption is static (RAM, Disck, etc) and very important (up to 50% of the available computing power!)

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- It's needed to recompile the kernel on the guest OS
- Very slow at the time of this writing

Bochs

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« Bochs is a highly portable open source IA-32(x86) PC emulator written in C++, that runs on most popular platforms. It includes emulation of the Intel x86 CPU, common I/O devices and a custom BIOS. Currently, Bochs can be compiled to emulate a 386, 486, Pentium, Pentium Pro or AMD64 CPU including optional MMX, SSE, SSE2 and 3DNow instructions »

http://bochs.sourceforge.net/ (Feb/2005)

Bochs

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- There is no locking mechanism for the disks.

The Linux-VServers

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« Linux-VServer allows you to create virtual private servers and security contexts which operate like a normal Linux server, but allow many independent servers to be run simultaneously in one box at full speed»

http://www.linux-vserver.org (Feb/2005)

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- Because only one kernel access the hardware and interrupts, it uses the advanced management mechanism already present in the Linux Kernel

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- Network access, device access and many more capabilities can be given or taken in order to have a more secure virtual server.

User-Mode Linux (UML)

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- very slow performance because only one program can run in privileged mode: the host Kernel that support the hosted ones
- the performance penalty is very important and a complete boot process is necessary

Xen

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« Xen is a virtual machine monitor for x86 that supports execution of multiple guest operating systems with unprecedented levels of performance and resource isolation»

http://www.cl.cam.ac.uk/Research/SRG/netos/xen/
(Feb/2005)

Xen

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- the virtual servers interact with Xen hardware (including CPU) needs a specific kernel but applications can run unchanged.
- a lightweight technology, but demands complete systems to be «booted» inside the Xen domains (virtual servers) so resource consumption (RAM, CPU, processes, etc) is much more important than the Linux-VServer project.

QEMU

QEMU

« QEMU is a generic and open source processor emulator which achieves a good emulation speed by using dynamic translation»

http://fabrice.bellard.free.fr/qemu/ **(Feb/2005)**

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- a young and still very experimental project

Classification of problems: usage criteria

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We present in the following several needs for computer virtualization and will use those criteria to compare the selected technology

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- Multi OS virtualization systems include VMware and Xen.

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- UML has been designed for Kernel Hacking and development

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- VMware supports perfectly the simulation of the installation process for the supported Linux distributions

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- VMware needs a lot of resources, as does UML, then Xen and finally Linux-VServers.

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- Some users need to dynamically change the resources used by a virtual computer. Some virtualization programs allow the user to live change the resources available for the virtual server while others can not do this.
- UML, Xen and Linux-VServers can dynamically alocate resources an ensure QoS criteria between the virtual servers and the host system.

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- UML and Linux-VServers support several architectures.

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- UML and Linux-VServer are production ready
- Xen is more experimental

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- While all virtualization techniques increases security by allowing system administrators to cleanly separate services on different virtual servers, some of them offers additional protections with rules/roles and additional security models that can make a virtual server more robust than a real one.

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- We did not consider this as a vulnerability because we consider that if a security problem occurs in the kernel in a primitive method used by a Linux-VServer (chroot, chcontext, chbind, etc) then every Linux server (vserver or not) has this problem and has to be upgraded.

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- The other technologies do not provide additional security.

Comparative study of the existing technology

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- ***The Bochs and plex86 projects will not be compared with the others as they are not yet fully functional***

Comparative study of the existing technology

Name	Multi OS	Kernel Development	Intall Process	Resources	Dynamical Resources	Sercurity	Maturity	Architecture
Vmware	Yes	No	Yes	2 Gb	No	No	Good	x86
Linux-VServer	No	No	No	256 Mb	Yes	Yes	Excelent	x86, IA64, x86_64
UML	No	Yes	No	1 Gb	No	No	Good	x86, IA64, x86_64
Xen	Yes	Exp.	Yes	1 Gb	No	No	Young	x86
QEMU	Exp.	No	Exp.	1 Gb	No	No	Young	x86

Comparative study of the existing technology

- ***Based on the needs from the user, one should be able to easily choose the best suited virtualization technique***

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  - Disaster recovery

Hosting

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- Additional security is provided by the POSIX capabilities

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- Unification is a mechanism at the package level that allows Linux-VServers to share programs and library

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- Perform stress tests or unitary testing on one application.
- Is easy to move a Linux-VServer on different hardware to compare performance.
- Because the regular device drivers are used, the virtualization layer impact on performance measurement is expected to be nebligible.

- Build environment or development environment

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- Development starting from a clean virtual server:
  - Greatly increases bug reproducibility and process of development
  - When a bug is found, the vserver where the bug can be triggered can be easily copied and «given » to the developer in charge.

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- As a consequence, and while this is certainly not the best practices, developers often need to develop on or «near» the production systems.
- With one of the virtualization techniques it is very easy to duplicate the production environment in the laboratory: just copy your production virtual computer on a development system.

Security usage

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[1] Keep It Simple and Stupid

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- This principle is rarely used on the field because this will lead to a very big increase of the physical computers number.
- In turn, because modern computers have a huge computing power, those computers will be under-used

High availability

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- While Xen is presently one of the first to manage load balancing between lives computers, one can easily set up a high availability system with any virtualization technique.
- A cold swap server that is synced either periodically (cron is your friend) of live, either at the application level (replication for MySQL, PostGreSQL, LDAP, etc) or with a low level tool like DR-DB/

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- One can even use this procedure on a single hardware system: this will provide what we called «software high availability» and protect the user from software bugs.

Disaster recovery

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- This meands that heterogeneous hardware can easily be used, without additional risk, to provide disaster recovery capacities.

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- The community is very active and supportive

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- chroot: disk isolation
- chcontext: process isolation
- chbind: network isolation
- capabilities: additional security

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- If the chrooted service is hacked, only the files writable inside the chroot can be compromised.

chroot: disk isolation

Briefly:

the root of all the commands run in a Linux-VServer is not the same as the host system root. This provides file system isolation.

chcontext: process isolation

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- This is a specific vserver system call that creates a new security context.
- This provide what we call «process isolation».
- The usual or «hosted» security context is the context "0", which has the same privileges of the root user (UID 0): can see and kill other tasks in the other contexts.

chcontext: process isolation

- If we except the context number 1 which is used to «view» other contexts but can not affect them, then the context isolation is complete: processes from one context can not see neither interact with processes from another context.

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- If we except the context number 1 which is used to «view» other contexts but can not affect them, then the context isolation is complete: processes from one context can not see neither interact with processes from another context.
- This provide the ability to run similar contexts on the same computer without any interaction possible at the application level.

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- Processes run from one chbind send packets with one IP address while processes run from another chbind send packets with another IP adress.
- This uses the virtual device infrastructure that allow a computer with a single NIC to have numerous IP address.

chbind: network isolation

Briefly:

each packet send from a Linux-VServer has its origin sent to a well defined IP address. This provides network isolation.

capabilities: additional security

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- A root account in a default Linux-VServer has much less privileges than a root account on a regular Linux server
- For instance, IP addresses cannot be changed (no ifconfig!), nodes can not be created (no mknod), hardware time can not be set, etc.

capabilities: additional security

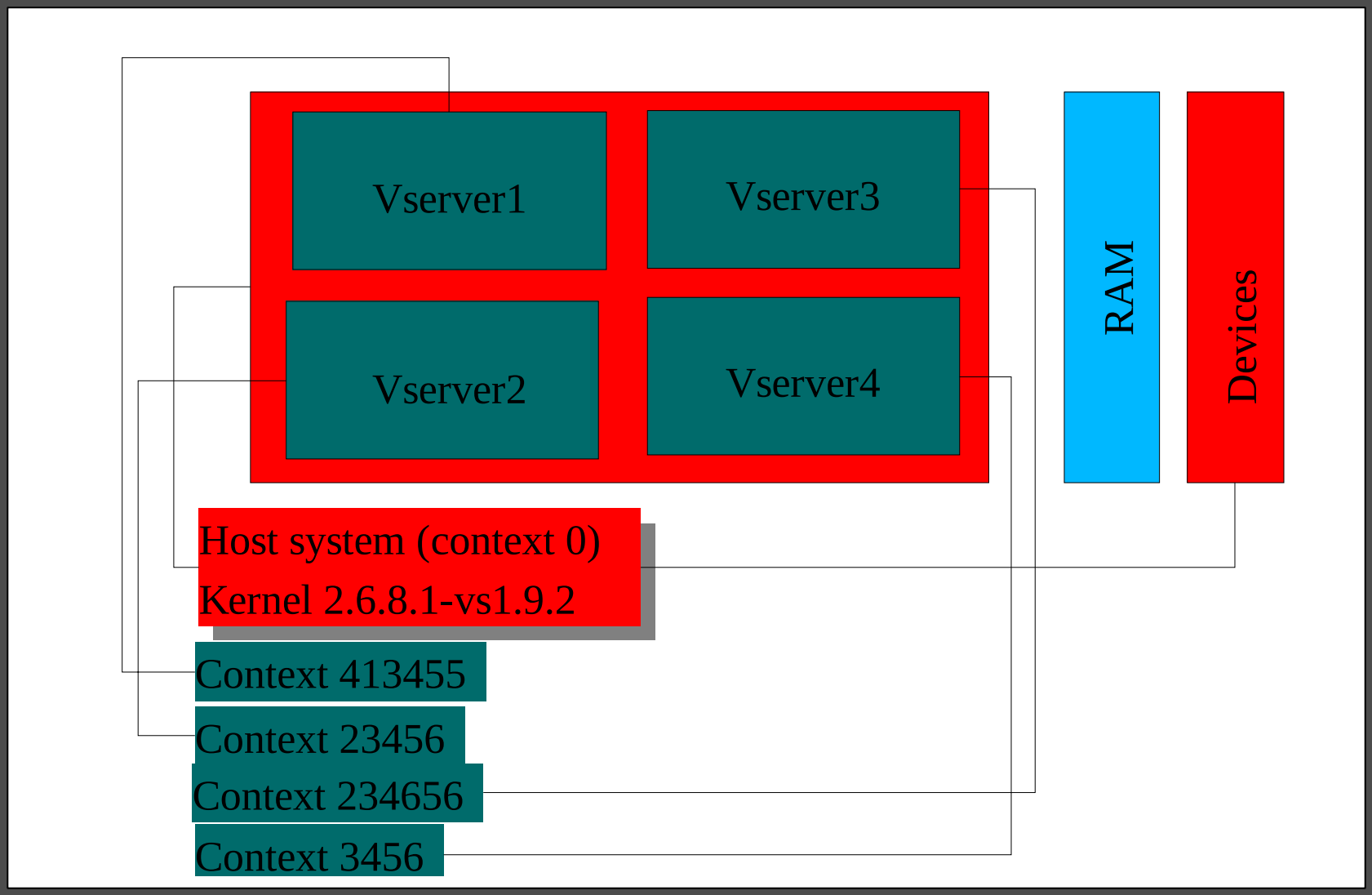
- This is specially intersting because fits very nicely with the Linux-VServer model where only the host server can set up certain properties of the vserver (IP address, time, network interface, etc) and the Linux-VServers can not alter those settings (for obvious security reasons).

capabilities: additional security

Briefly:

each Linux-VServer has a set of capabilities (none by default) in order to be able to work. Strictly speaking, this means that a root on a Linux-VServer has much less «privileges» than a root account on a regular Linux server. This provides «root»-isolation.

How it works?



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- Context 1 : can only watch the other contexts (special)
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- Devices : it's the host server (context 0) that decides who have acess to what
- Exemple : network, mount points, /proc, etc.

Conclusion

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- ***Because of its maturity (several production systems with more than 20 Linux-VServers in production for years) and because this is the more lightweight virtualization technique, we believe that Linux-VServer is the best tool for virtualizing Linux servers on a Linux operating system host.***

Conclusion

- ***There are some cases where other techniques are necessary, mainly running another OS and kernel development, but beside this two cases, the Linux-VServer is really the best virtualization technique available.***

Conclusion

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- ***The use of a single kernel for all the Linux-VServers hosted on one system provides the project several key advantages when compared to other virtualization techniques:***

- Lightweight: only services are started on the hosted Linux-VServer, not all the processes resulting from a complete boot process.

Conclusion

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- ***Uses the latest Linux kernel development easily:*** ***for instance, with the O(1) scheduler, all the processes are well prioritized.***

- Native usage of device drivers: with the Linux-VServer project, one can use the latest kernel drivers without any performance penalty introduced by the virtualization layer.

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