Virtual systems: (current practices and) future possibilities

Or: *Smoke and mirrors for doing less (effort) with less (time), and achieving more*

Virtual systems: current practices and future possibilities

- What are virtual systems?
- What is the current technology?
- What can we do with virtual systems?
- Demonstration: Akimbi Slingshot (now VMWare Lab Manager)
- What's the next step?

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- Versions of the presentation will be available at:
  http://www.cs.uwaterloo.ca/~trg/public/toc.php

What are virtual systems?

- The usual definition goes something like:
  - "A way to run some software on a computer that makes it look like there's more than one computer there."
  - A way to run multiple OS instances simultaneously on one physical computer (as opposed to multiple-boot computers which can only run one OS at a time)
  - Saves the expense of buying extra computers, saves power and heat, etc.
- But, that's not really doing justice to the concept!

What are virtual systems? 2

- Some history: first there was virtual memory:
  - When a computer uses its disk drives to fake real RAM. Very slow. www.math.okstate.edu/system/terms.html
  - Well sort of, but kind of misses the point
  - Virtual (or logical) memory is a concept that, [...] use a very large range of memory or storage addresses for stored data. [...] www.cheap-computers-guide.com/computer-related-glossary.html
- Right! It’s a concept, or abstraction

What are virtual systems? 3

- Then there were virtual machines:
  - A functional simulation of a computer and its associated devices. appl.nasa.gov/resources/lexicon/terms_v.html
  - Not bad; not sure about "simulation", though
  - An abstract specification for a computing device that can be implemented in different ways, in software or hardware. [...] software.allindiansite.com/java/uvjava.html
- Right. And there's that "abstraction" word again...

What are virtual systems? 4

- And generally, there is virtualization:
  - In computing, virtualization involves the process of presenting computing resources in ways that users and applications can easily get value out of them, rather than presenting them in a way dictated by their implementation, geographic location, or physical packaging. In other words, it provides a logical rather than physical view of data, computing power, storage capacity, and other resources. en.wikipedia.org/wiki/Virtualization

So really: what are virtual systems?

- My definition:
  - A virtual system is a software—hardware hybrid system that enables users to define idealized hardware and software platforms without regard to the actual underlying hardware and software
  - We can create an abstraction that (usually) simplifies the details of the hardware, and thus lets us build software for a truly standard platform
  - We become isolated from the vagaries of hardware manufacturer
- N.B. *virtual system* vs. *virtual machine*

What is the current technology?

- Historical note: virtualization isn't new:
  - IBM's first commercial products were in use in the late 1960s (IBM 360/67)
  - UW was an early adopter of IBM's VM products (1970s)
  - Used in administrative, research and teaching through the 1980s and into the early 1990s
- Types of virtualization technology:
  - Hardware
  - Software that is the real hardware's OS
  - Software that runs on (or beside) a traditional OS
  - Application virtualization

What is the current technology? 2

- Hardware virtualization:
  - For example: IBM zSeries mainframes
  - Successor to the 390 mainframes, which were successors to the 370 (e.g. UW's 370/158 and 43xx mainframes)
  - Implemented in hardware/firmware: partition a single hardware platform into many independent pieces, each of which is equivalent to the original, but independent (called LPARs – logical partitions)
  - Also available in IBM's pSeries (PowerPC)
  - Hardware typically has special support for virtualization (x86 in ~2005, IBM zSeries for 30+ years)
  - Typically less overhead cost than software solutions

What is the current technology? 3

- Software that is the real hardware's OS:
  - Install like an os
  - Principal job is to implement virtualization *hypervisor*
  - Provides little or no end-user interaction
- VMware's <u>ESX</u> product is an example
  - For Intel x86/AMD platforms
  - Installs on the "bare metal" and implements the virtualization hypervisor
  - Intended to run current server-class OSes unmodified
  - Intended for enterprise deployments; bells&whistles++

What is the current technology? 4

- Another example: IBM's z/VM and its ancestors (VM/ESA, VM/CMS)
  - Two components: the hypervisor and the guest OS
  - Hypervisor installs in an LPAR and creates a platform to run many virtual machines (called CP)
  - Virtual machine is equivalent to the underlying hardware
  - Can run any guest OS capable of running on the hardware, including a nested z/VM
  - Linux for zSeries hardware is widely used as a guest
  - Virtual machines can interact with CP via an API or interactive command interface

What is the current technology? 5

- Virtualization under an existing OS:
  - VMware GSX (now VMware Server) and derivatives
  - Microsoft Virtual PC 2004 and Virtual Server 2005
  - And many others (list growing daily)
- Virtualization software installs as an application under the host OS
  - Defines the hardware for the virtual machine
  - Standard video, sound, disk, RAM, networking etc are defined in terms of host OS resources
  - Guest operating systems must support the virtual hardware

What is the current technology? 6

- Xen is a variation of “virtualization under OS”:
  - Open-source project from Cambridge, now commercial
  - A set of kernel modifications for the host OS: “para-virtualization”
  - Blends the hypervisor into the modified kernel
  - Several Linux/Unix host OSes are supported
  - Guest OSes generally require modification
  - But: as of Xen v3.0, x86 hardware virtualization assist allows unmodified Windows guests

What is the current technology? 7

- Solaris containers/zones are another variation:
  - A modified kernel partitions the single OS system
  - Software version of LPARs
  - Similar techniques include “chroot jails”, FreeBSD jails
  - Essential idea is to isolate resources and make accidental interaction impossible

What is the current technology? 8

- Application virtualization:
  - Application programs that define and implement some kind of virtual environment
  - MS SoftGrid:
    - Wrap a “virtualization bubble” around an application and run the bubble
  - Java virtual machines
  - Microsoft’s .Net
  - DOSBox – runs DOS programs by complete emulation of a DOS-based computer
  - Could consider that Windows Remote Desktop or XDMCP are a kind of virtualization

What is the current technology? 9

- Key points to remember:
  - Virtualization represents an abstraction of hardware
  - The abstraction is derived from (sometimes independent of) the underlying real hardware
  - “Virtualization under an OS”, such as VMware Server, MS Virtual PC/Virtual Server and Xen, and “bare-metal virtualization” like VMWare ESX are the leading players
  - The host OS and the guest OS are independent
  - This independence is what makes virtualization so attractive from the perspective of IT management
  - Virtual systems might lower hardware costs, but OS costs are the same

What can we do with virtual systems?

- So what good is all this technology?
- Several “classic” uses:
  - Reduction of real hardware (consolidation)
  - Testing and development environments
  - Infrastructure management
  - Backup and recovery

What … with virtual systems? 2

- Reduction of real hardware (consolidation):
  - Run two, three or more virtual systems on one real platform
  - Reduce hardware costs
  - Reduce power (and UPS) requirement
  - Reduce cooling requirements
  - Reduce floor/rack space usage
  - Most servers are under-utilized and have excess capacity, especially newer multi-core, multi-cpu servers

What … with virtual systems? 3

- Testing and development environments:
  - Production systems are never used for testing or development ☺
  - Testing environments can be built and torn down as required
  - Multi-version and multi-platform environments can be hosted conveniently
  - Virtual networks (of virtual systems) can be created to simulate workloads, interactions
  - Current products support (to varying degrees) snapshots and storing of VM states for later re-activation

What … with virtual systems? 4

- Infrastructure management:
  - Providing service redundancy without hardware costs
  - Isolation of critical services for reliability or security
  - Guest OS images can be moved, cloned and deployed easily
  - Workloads can be moved easily between virtual system hosts as required

What … with virtual systems? 5

- Backup and recovery:
  - Even with the best backup and recovery strategies, a failed disk or external storage takes time to recover
  - Most current products store virtual disks as files within the host OS file system
  - The VM definitions themselves are also files
  - Recovering a system and bringing up a replacement is simply a matter of copying files and starting a new VM
  - Disaster recovery ≡ virtual machine migration

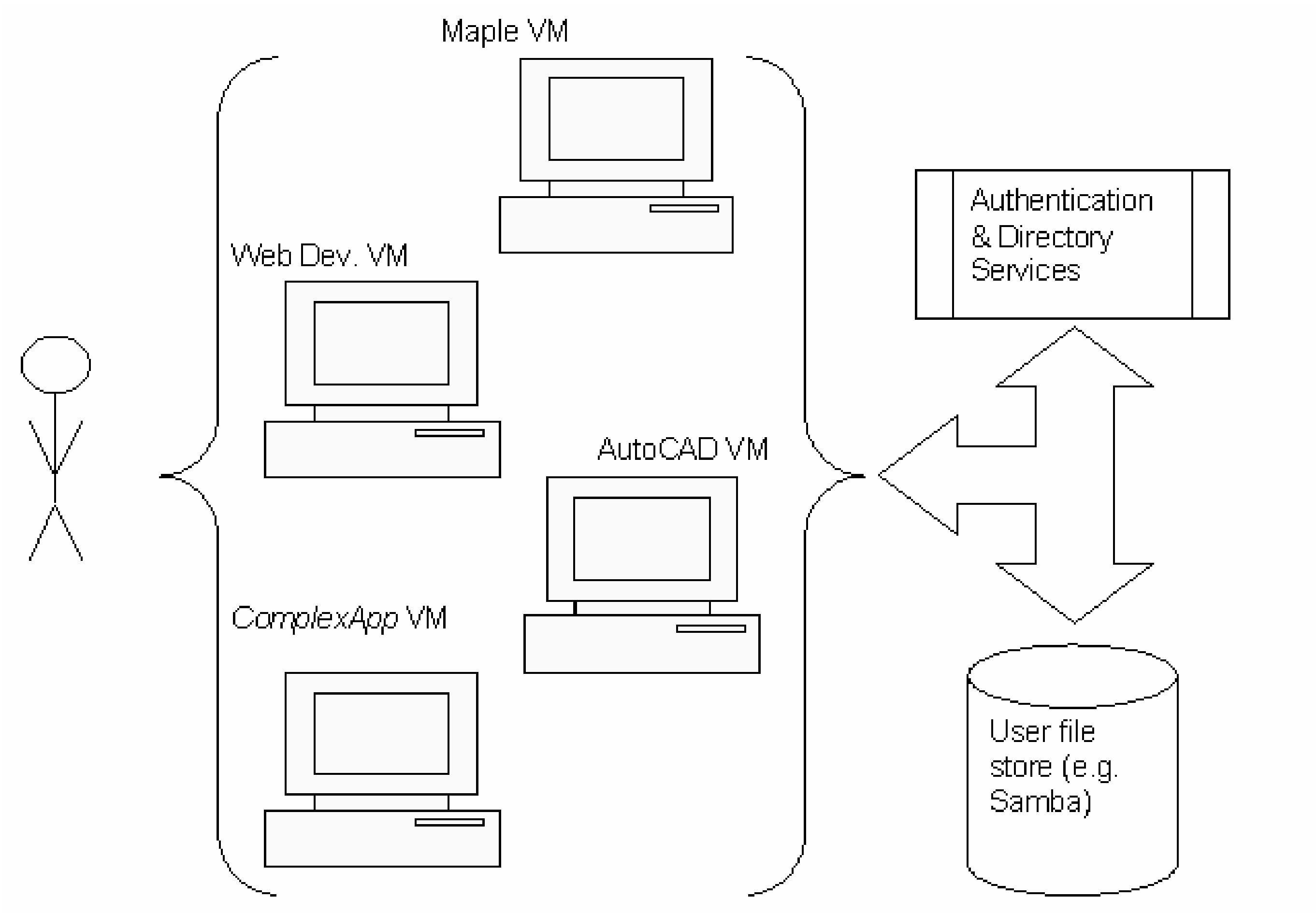
What … with virtual systems? 6

- Some less-common uses for virtual systems
- Software distributions:
  - For complex software, instead of receiving a set installation media, receive an image of a ready-to-run VM
  - For guest OSes and “big” applications
- Teaching labs & standard computing platforms
  - Install a completely stock host OS, then run a carefully-crafted guest OS
  - Users never interact with the host OS, only the guest
  - User files stored outside the virtual system (e.g. network-based)

What … with virtual systems? 7

- More less-common uses for virtual systems
- Platforms for special-purpose applications
  - Instead of installing software on the user's platform, give the user the complete platform with the application pre-installed
  - Create a different VM for each application
  - Users choose the VM that is appropriate to the task
  - User authentication and file storage is elsewhere

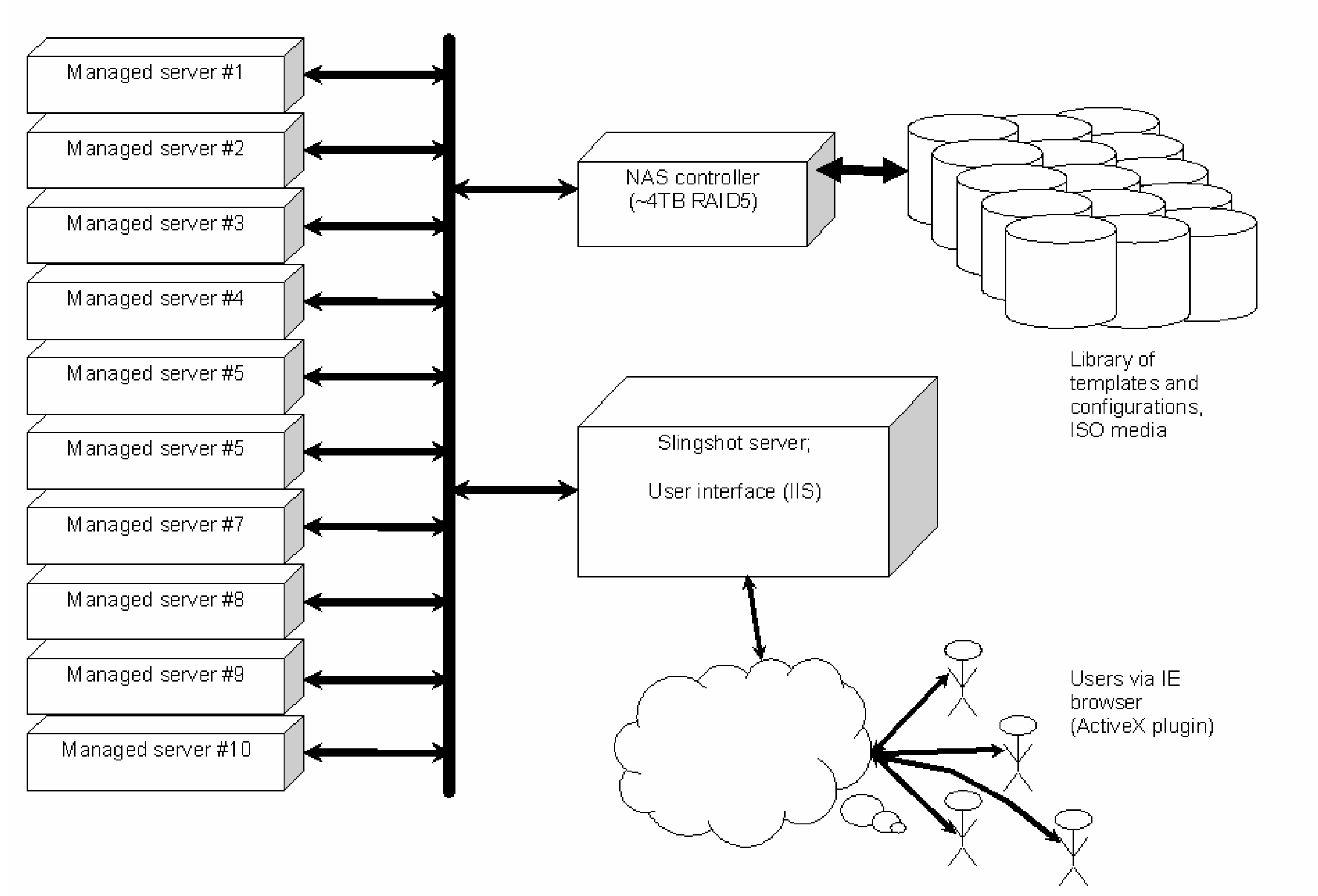
What … with virtual systems? 8



Demonstration

- Akimbi Slingshot (now VMware Lab Manager):
  - SCS Tetherless Computing Lab; for network simulation
  - Management system for controlling sets of virtual systems – presents a high-level abstraction called *configurations*
  - Exploits the programming API for VMware ESX (prior to VMware acquisition, also worked with Microsoft Virtual Server – demo will be of the Akimbi MS VS version)
  - Supports multiple users who can share virtual systems
  - Consists of a management server and a set of worker systems that host virtual machine (*managed servers*)

Demonstration



Demonstration

- Akimbi Slingshot management server:
  - Create virtual system templates and configurations and store them in a shareable library
  - Deploy configurations across managed systems completely transparently to the end user
  - Manager handles IP addressing, NATting, firewalling
  - Running configurations can be “snapshotted”, suspended, stored, restarted, shared
  - Users interact only with the management server, which brokers all interactions with the virtual guests
  - Currently requires IE (uses ActiveX controls to display VM consoles)

Demonstration

- Script:
  - Log into system
  - Create a VM template
  - Deploy to bare machine
  - Install an OS (start – won’t complete this)
  - Create a single-machine configuration and deploy
  - Add another VM to the configuration
  - Suspend configuration
  - Remote desktop
  - Log in as administrator to look at overall system

What's next: a vision for computing

- Disclaimer
- This is a personal opinion and extrapolation and in **no way whatsoever** represents anything even vaguely or remotely associated with CSCF, the DRCSCS or any official policies thereof
- This discussion is given from the perspective of requirements of Computer Science teaching and research, but I believe many of the ideas are applicable in other disciplines and environments

A vision for computing

- CS teaching facilities require packaging applications to fit into the available OS environment.
  - The environment varies, from single-user Macs to multi-user Solaris & Linux
- Instead of packaging applications for an OS and bringing students to the OS, package the OS around the application and bring it to the student
- Requires personal workstations conforming to a minimal standard – capable of running a VM

A vision for computing

- Examples:
  - First-year CS students need a Java environment that has a specific set of tools and underlying OS environment
  - Upper-year students requires specific tools on a course-by-course basis – some work better in Windows, or Linux, or Solaris or a customized OS kernel
  - Grad students use one OS environment for their own work, but have TA responsibilities for other environments
- The only standard required is the virtual system platform technology

A vision for computing

- So imagine:
  - Students have personal systems running any host OS they want as long as it can run the VM
  - Enrolling in a course automatically grants access to any required virtual system images defined for the course
  - OS images are acquired and used, and can be refreshed and replaced trivially
  - Personal data is not stored permanently in the VM images, so there is requirement for infrastructure to provide a globally-accessible file-store – off-campus access will be required

A vision for computing

- User advantages:
  - Use any platform for general computing – the need to conform to a mandated platform is mostly eliminated
  - No requirements to acquire, install, configure or maintain application packages
  - Ultimate portability – like taking the “lab computer” with you
  - Coursework is independent of personal work
  - Potential to increase diversity and exposure to different computing environments

A vision for computing

- Infrastructure advantages:
  - Software licencing costs reduced – user community size is constrained to enrolled students
  - Reduces or eliminates the need for general-purpose labs and multi-use systems
  - Focus on infrastructure: networking, file-stores, email and directory services
  - VM images can be created by faculty or staff, tested, tuned and adjusted independently – no more “version conflicts” or forced updates of packages to meet pre-requisites

Summary

- Virtualization is an old idea that presents new and interesting opportunities
- There are many virtualization products available of differing technologies
- Virtualized environments can reduce costs, improve reliability and resource management, simplify management
- A new way to use virtualization: visionary or hallucinogenic? ☺

The End