Virtualization with SUSE® Linux Enterprise Server:

Capabilities, Best Practices, and Guidelines

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Agenda

- Introduction to Xen and KVM
- Xen and KVM in SUSE Linux Enterprise Server 11 SP2
- Using Virtualization: Tooling
- Best Practices and Guidelines
- Questions

Introduction to Xen and KVM

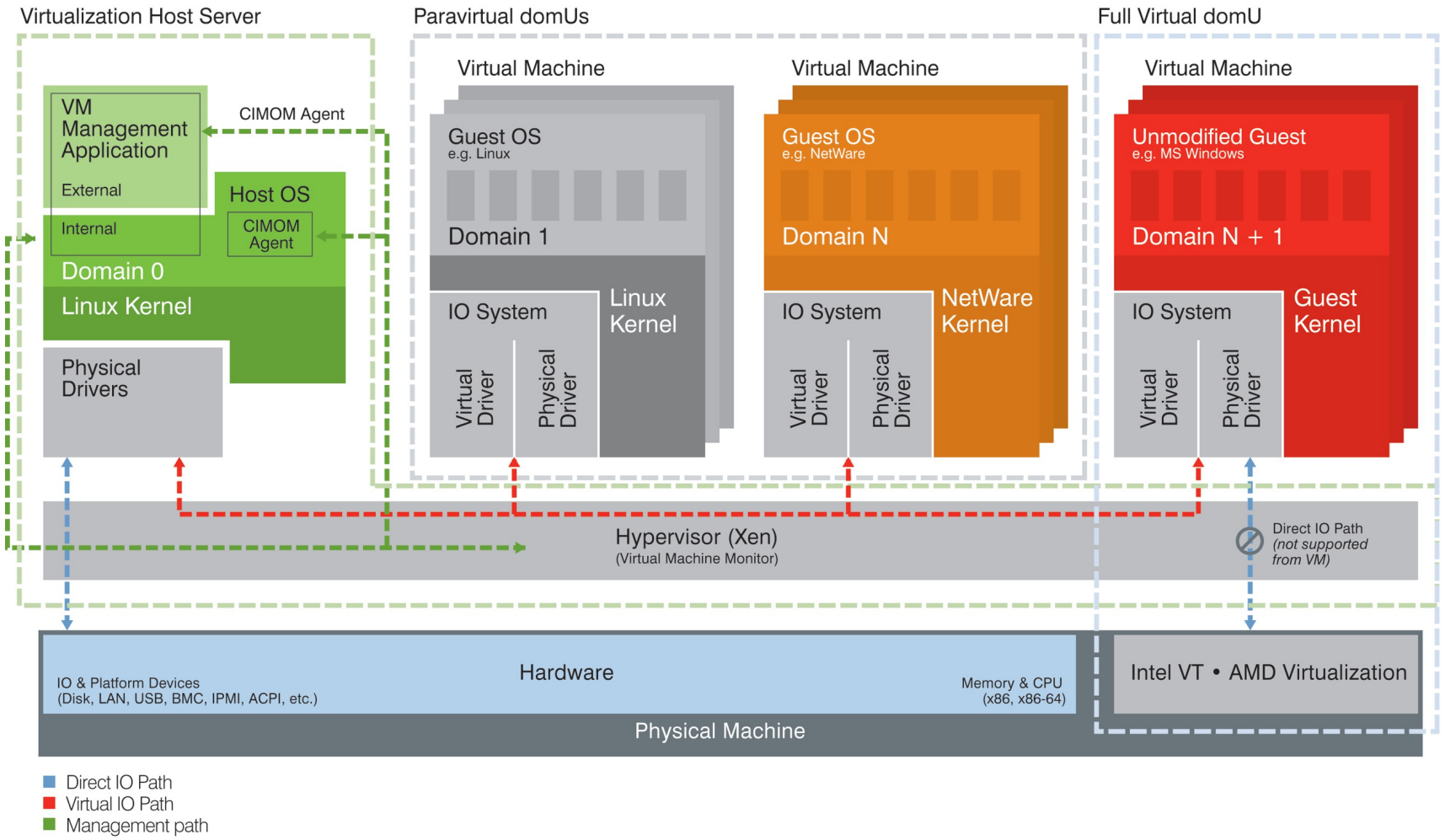
What is Xen?

- Open source virtualization technology specializing in paravirtualization
  - paravirtualization consists of running guest OS's which have been modified to perform well with Xen
  - stable, proven, and highly performant
- Also supports running unmodified guests by using hardware-assisted virtualization (AMD-V & Intel VT)
- A SUSE® Linux Enterprise Server 11 Supported Virtualization Solution

Xen History

- First released in 2003, now at version 4.2
  - Currently an active, healthy open source project
  - Development community has many contributors, including SUSE®
  - Partly merged with Mainline Linux kernel and QEMU projects
  - SUSE uses additional Linux kernel patches to achieve better performance and more features
- Included in SUSE Linux Enterprise Server 10 and 11

Xen Architecture



What is KVM?

- A virtualization technology?
- A kernel module?
- A Linux package?
- A kernel module + userspace program + tools?
- A SUSE® Linux Enterprise Server 11 Supported Virtualization Solution

All the above!

- KVM stands for “Kernel-based Virtual Machine,” meaning the infrastructure for creating virtual machines is included with the Linux kernel

KVM History

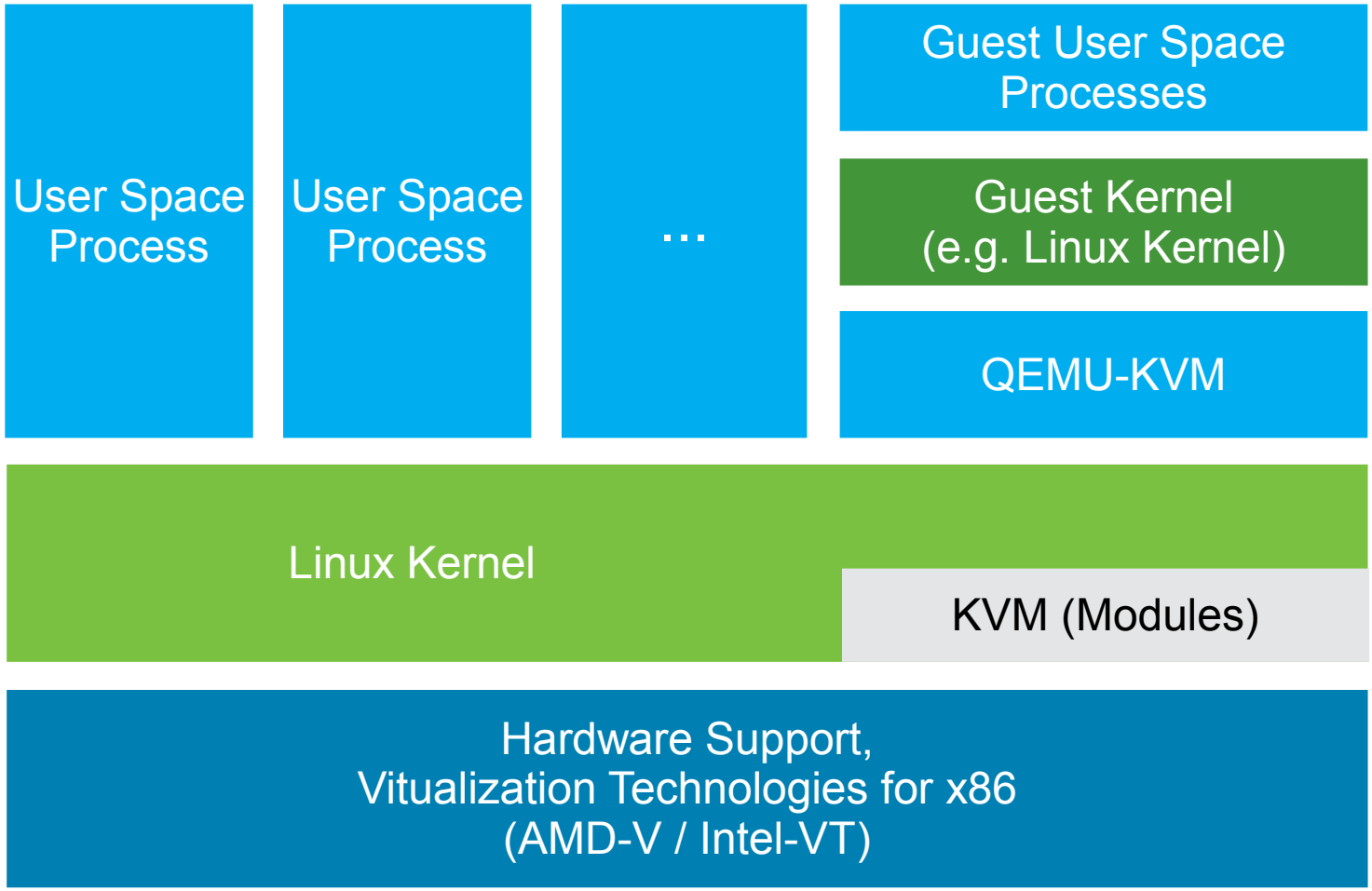
- Development began in 2006, first released 2007
  - Currently an active, healthy open source project
  - Development community has many contributors, including SUSE®
  - Merged with Linux kernel and QEMU projects
- Included in SUSE Linux Enterprise Server 11
  - Tech Preview in GA
  - Supported since SP1

KVM Virtualization

- Uses AMD-V and Intel VT-x Hardware Virtualization
  - Found in commodity hardware as well as high-end servers
- Implements Full Virtualization
  - Guests run unmodified
  - Para-virtual drivers available, device pass through possible
- Leverages Linux to provide a superb virtualization platform
  - Virtualization hardware control: generic and vendor KVM kernel modules (kvm.ko, kvm_amd.ko, kvm_intel.ko)
  - The Linux kernel acts as a hypervisor
  - A KVM accelerated QEMU userspace process runs the guest, which is just another userspace process to Linux

KVM Architecture

Adds “Guest Mode” to Traditional Kernel and User Modes



Source: “Virtualization with KVM” training, B1 Systems GmbH

Supported Hardware

- CPU: AMD-V and Intel VT-x, 64 bit mode
- VT-d / IOMMU
- SR-IOV
- And all the additional virtualization features added as each new processor version come out: EPT, NPT, VPID, ASID, Restricted Guest, PCID/INVPCID, ...

QEMU

- QEMU project + KVM acceleration => qemu-kvm userspace program
- Emulates a PC style hardware platform, accommodates para-virtual devices (Virtio, clock), accelerators (KVM, vhost-net), and pass-through capabilities (virtFS, PCI and usb device assignment)
- Provisions host cpu, memory, storage, and networking resources to the guest securely and efficiently

KVM Virtual Machine Base Features

- “Modern PC style” machine architecture
- SMP and NUMA architecture
- Various cpu types and features selectable
- ISA, PCI, USB buses (including PCI hotplug)
- IDE, AHCI, SCSI and floppy storage interfaces and devices
- Common network adapters, sound cards
- Standard display, keyboard, mouse
- System BIOS, PXE BIOS's. Boot control
- Paravirtual devices: blk, net, clock, memory balloon

KVM Virtualization Features

- Supports latest hardware virtualization technologies
- Guest life-cycle controls
  - Start,stop,reboot, pause/resume, suspend/restore
  - Live migration
  - Snapshots, delta storage images
- Co-exists with other virtualization technologies
- PCI and USB host device pass through (incl. SR-IOV)
- VirtFS: filesystem “pass through”
- CPU, memory and disk over-commit
- Direct kernel boot option
- Emulated (TCG) CPU execution mode available

KVM Virtualization Features (continued)

- Transparent Huge Page (THP) optimized
- Kernel Samepage Merging (KSM) supported
- Non-root user support
- User-mode networking stack (DNS, DHCP, TFTP, BOOTP, SMB)
- Tap device, bridged, and vhost-net networking
- Guest details provided on the qemu-kvm command line
- Nested virtualization
- Guest Agent
- Built-in GDB server for guest debugging
- Various storage formats: raw, qcow2, qed, vmdk

KVM

Selected Storage Image Formats and Features

Name	Compression	Snapshot	Encryption	Deltas
raw				
qcow2	+	+	+	+
vmdk				+

Xen Support

Xen Guests Supported by SUSE® (I)

Paravirtualized OS Support

- SUSE Linux Enterprise Server 11 SP2
- SUSE Linux Enterprise Server 10 SP4
- Novell Open Enterprise Server 2 SP3
- Novell Open Enterprise Server 11 SP1
- Novell NetWare 6.5 SP8
- Red Hat Enterprise Linux 4 (limited support)
- Red Hat Enterprise Linux 5 (limited support)
- Red Hat Enterprise Linux 6 (limited support)

Xen Guests Supported by SUSE® (II)

Fully Virtualized OS Support - Linux

- SUSE Linux Enterprise Server 11 SP2
- SUSE Linux Enterprise Server 10 SP4
- Novell Open Enterprise Server 2 SP3
- Novell Open Enterprise Server 11 SP1
- Red Hat Enterprise Linux 4 (limited support)
- Red Hat Enterprise Linux 5 (limited support)
- Red Hat Enterprise Linux 6 (limited support)

Xen Guests Supported by SUSE® (III)

Fully Virtualized OS Support – Microsoft Windows

(PV drivers available through VMDP 2.0)

- Microsoft Windows Server 2012
- Microsoft Windows Server 2008 SP2+ / R2+
- Microsoft Windows Server 2003 SP2
- Microsoft Windows 8 (limited support)
- Microsoft Windows 7 SP1+ (limited support)
- Microsoft Windows Vista SP2+ (limited support)
- Microsoft Windows XP SP2+ (limited support)

Xen Limits Supported by SUSE®

- Host CPUs: 256 (64 for dom0)
- Host RAM: 2TB (500 GB for dom0)
- Guest RAM size: 512 GB
- Virtual CPUs per guest: 64
- NICs per guest: 8
- Block devices per guest: 4 IDE (emulated), 100 PV

KVM Support

KVM – Supported Guest Systems

Linux

Windows

Solaris, OpenSolaris

BSD Unix

KVM Guests Supported by SUSE® (I)

Linux – both 32 and 64 bit

- SUSE Linux Enterprise Server 11 SP2 on (fully supported)
- SUSE Linux Enterprise Server 11 SP1 on (fully supported)
- SUSE Linux Enterprise Server 10 SP4 (fully supported)
- SUSE Linux Enterprise Desktop 11 SP2 on (tech. preview)
- Red Hat Enterprise Linux 4 (limited support)
- Red Hat Enterprise Linux 5 (limited support)
- Red Hat Enterprise Linux 6 (limited support)

KVM Guests Supported by SUSE® (II)

Microsoft Windows – both 32 and 64 bit

(fully supported from SUSE Linux Enterprise Server 11 SP2 on)

- Microsoft Windows 2003 SP2+ plus PV drivers
- Microsoft Windows 2008 SP2+ or R2+ plus PV drivers
- Microsoft Windows 2012 plus PV drivers
- Microsoft Windows XP SP3+ plus PV drivers (limited support)
- Microsoft Windows Vista SP2+ plus PV drivers (limited support)
- Microsoft Windows 7 SP1+ plus PV drivers (limited support)
- Microsoft Windows 8 plus PV drivers (limited support)

KVM Limits Supported by SUSE®

- Host RAM and CPU limits are the same with or without KVM modules loaded
- Guest RAM size: 512 GB
- Virtual CPUs per guest: 64
- NICs per guest: 8
- Block devices per guest: 4 emulated, 20 para-virtual (virtio-blk)
- Maximum number of guests: total vCPUs in all guests ≤ 8 times total CPU cores in host

Xen and KVM: A Comparison

Xen

- VMM implementation of its own; hypervisor
- Kernel (dom0) used as I/O dispatcher and management domain
- Maintained and supported as a patch to mainline kernel by SUSE®
- Supports fully virtualized and paravirtualized Vms
- Uses older qemu for device model

KVM

- Kernel module
- Uses kernel as VMM
- In upstream kernel
- Supports fully virtualized VMs only
- Uses current qemu for device model

SUSE® Linux Enterprise Server 11 SP2

- SUSE Linux Enterprise Server 11 SP2 ships with both Xen and KVM virtualization solutions
- Xen and KVM considered to be on par, differentiated mainly by their different approaches to virtualization
- Toolset shipped in SUSE Linux Enterprise Server 11 SP2 supports both Xen and KVM
- Versions: Linux kernel 3.0, qemu-kvm 0.15.1, Xen 4.1

Using Xen and KVM: Tooling

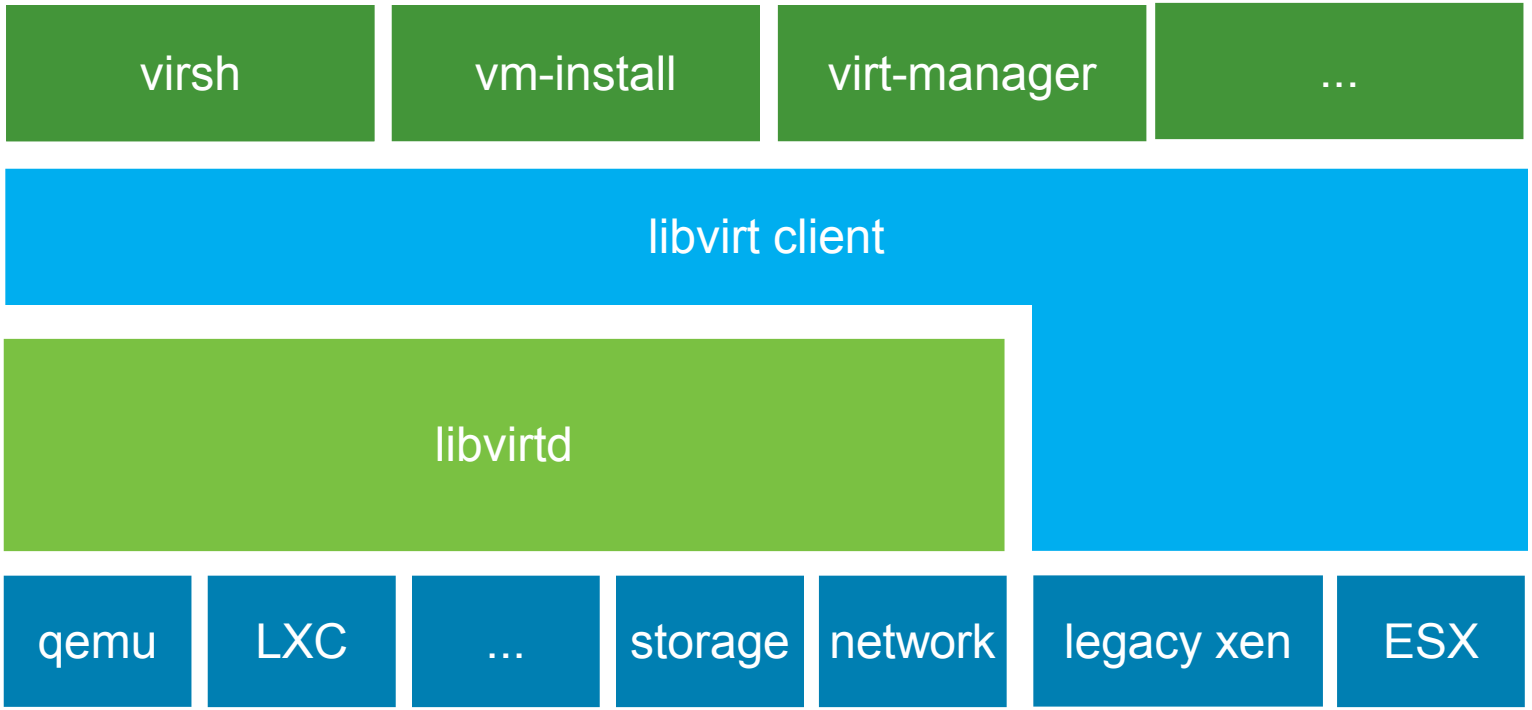
Using Xen and KVM

- We recommend using libvirt and libvirt tools to access Xen and KVM
  - Includes: vm-install, virt-manager, virt-viewer, virsh commands
  - Adds additional security, configurability, compatibility, etc.
- Using qemu-kvm command-line also supported – documentation identifies supported parameters
- Using xm commands supported with Xen 4.1 – new libxenlight (xl) commands are unsupported
- Qemu-img image management tool provided
- The SUSE® Virtual Machine Driver Pack (VMDP) provides Xen and KVM drivers for Windows guests

libvirt

- Virtualization library for managing one host
  - Domains, networks, storage, host devices, ...
- Share application stack between hypervisors
  - Xen, qemu/kvm, LXC, VMware, VirtualBox, ...
- Long-term API/ABI stability and compatibility
- Integration with other SUSE® Linux Enterprise components
  - AppArmor, SELinux, CGroups, Linux Audit Framework, PolicyKit, ...
- libvirt.org

libvirt Architecture



libvirt – Host Management

- Storage Pools
  - Dedicated device, partition, directory, LVM, iSCSI, NFS
- Storage Volumes
  - raw, qcow2, vmdk
- Network Interfaces
  - Bonds, bridges, ethernet devices, VLANs
- Virtual Networks
  - NAT with DHCP
  - Routed
  - Isolated

libvirt – Domain Management

- Domains defined in XML
- Lifecycle management
  - Define, start, stop, pause, resume, save, restore, migrate
- Configuration management
  - Change virtual hardware, e.g. memory, cpu
  - Add, remove, modify devices
- Tuning
  - CPU, memory, blkio, NUMA

libvirt Tools

- virsh
  - In-tree command line application exposing libvirt API
- vm-install
  - Create virtual hardware configuration
  - Install an OS in a virtual machine
- virt-viewer
  - Graphical console client for virtual machines
- virt-manager
  - Graphical tool for administering virtual machines
- vhostmd
  - Metrics communication channel between host and virtual machines
- libvirt-cim
  - libvirt-based implementation of DMTF Virtualization Management standards

Guidelines and Best Practices

Guidelines and Best Practices: General Guidance

- We'll just touch on a few things here. There is so much more that could be said.
- Best Practice is “Practice makes Perfect” - the best approach is to experiment to find optimal solution.
  - Virtualization increases complexity on many levels. Validate your assumptions. Re-evaluate decisions as things evolve.
- Identify Goals: What trumps? Security, Flexibility, ROI, Consolidation, Maintainability, Performance, and more?
- Best options come from using latest host and guest releases (latest is most virtualization friendly)
- Minimize services run on the host

Guidelines and Best Practices: General Guidance (continued)

- "Virtualize and forget" attitude is just asking for trouble
  - Your workload will behave differently when virtualized
  - Use this opportunity to control more closely the memory and cpu needs of each workload
- Take advantage of the dynamic, decoupled nature of virtualization
  - Migration, pausing, specialized disk storage formats, snapshots, optimized VM to VM interaction, memory bindings
  - Easily stage new configurations, releases, patches
  - Additional networking and storage options permit better customization and performance

XEN Guidelines and Best Practices

- Restrict Dom0 memory with dom0_mem=
- Disable ballooning in Dom0
- Pin guests to a single NUMA node where possible
- Ensure Dom0 isn't starved
  - Adjust credit scheduler weight
  - Dedicate cpu(s)
- Timekeeping
  - ntp for Dom0 and FV guests
  - independent_wallclock=0 for PV guests

KVM Guidelines and Best Practices

"Walk this way"- no brainer choices (Well, mostly - there are exceptions to every rule!)

- Avoid over commitment (storage, cpu, memory)
- Use Para-virtual devices (virtio) over emulated ones
- Avoid swapping – swap within guests instead of host
- Use vhost-net (on by default)
- Bind guest to single numa node if possible
- Use kvmclock in guest
- Libvirt's cgroup tunables

KVM Guidelines and Best Practices

"Choose you must"

- Use libvirt or qemu-kvm command-line
- Keep Guest Migratable?
  - Migration inhibitors: device passthrough, incompatible target cpu, non-cache coherent shared or non-shared storage, certain storage formats and cache modes, virtfs, -mem-path option

KVM Guidelines and Best Practices

"Beware the Jabberwock" Use caution, don't be silly!

- Using qemu-kvm command-line directly
- Using cache=unsafe
- Guest vcpu count > host cpu count
- NFS as shared storage
- Sparse file-backed storage
- Using unsupported features or configurations
  - Nested virtualization, hotplug devices, tcg cpu emulation, sound hw, certain vcpu types and emulated devices, host running 32 bit kernel

KVM Guidelines and Best Practices

"Odds and Ends"

- Memory: THP, KSM, Ballooning, Explicit Hugepages
  - How to implement a memory policy
- vcpu pinning – generally improves performance
- cache=none is generally best
- Host i/o scheduler: deadline is generally best
- Run qemu-kvm as non-root for better security
- Keep guest memory and vcpus at minimum needed
- Reserve resources for the host
- PCI NIC passthrough for higher network performance

Thank You!

Questions?


SUSE®
We adapt. You succeed.