Know your competition

A review of qemu and KVM for System z

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SHARE is an independent volunteer-run information technology association that provides education, professional networking and industry influence.

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Agenda

- What is qemu and KVM
- High-level architecture
- Creation, interaction with, and management of virtual machines
  - Live demo?
- Terminology
- Questions

What is qemu and KVM

- qemu (quick emulator) is a processor (CPU) and other hardware emulator.
- KVM stands for “Kernel-based Virtual Machine,” meaning the infrastructure for creating virtual machines is included in the Linux kernel itself.
- KVM is a
  - Virtualization technology
  - Kernel module + userspace program + tools
  - Linux package

KVM/qemu status in SLES

- KVM/qemu is a Technology Preview with SLES11 SP3 and SLES12
  - Tech Previews are not supported, and are not intended for production use
- KVM/qemu will (likely) remain a Technology Preview with SLES11 SP4 when it ships.

qemu

- Community project founded in 2003
- Provides (mostly PC) hardware emulation (device model) and ability to add accelerations (eg: KVM)
  - Host CPU, memory, storage, and networking resources
- Project forked (qemu-kvm) by Qumranet to add KVM support. Qemu project later added KVM support but not as complete. Projects have now mostly converged back together.
- qemu-kvm fork is mainly used for KVM acceleration
- Communicates with KVM via /dev/kvm

KVM

- Open source project (GPL v2) with many contributors
- Originally developed by Qumranet
  - Qumranet was bought by Red Hat in 2008.
- First release in early 2007, coinciding with the introduction of x86 hardware-assisted virtualization
- First included in 2.6.20 Linux kernel release
- Included in SUSE Linux Enterprise Server 11 for Intel/AMD since March, 2009

- KVM is based on hardware assisted virtualization, but also uses paravirtualization and trap and emulate as needed.
- Implemented as kernel modules
  - kvm.ko: provides virtualization infrastructure
  - kvm_amd.ko and kvm_intel.ko: hardware platform specific modules (no equivalent on s390x)
- Regular Linux kernel becomes virtual machine monitor (VMM, hypervisor), which can use any kernel infrastructure without modifications
- KVM virtual machines created by KVM accelerated qemu (qemu-kvm) run as regular user-space processes

KVM virtualization

- Uses AMD-V, Intel VT-x, and System z SIE hardware virtualization
- Implements Full Virtualization
  - Guests run unmodified
  - Para-virtual drivers available, device pass through possible
    - For System z, the para-virtual drivers are mandatory and device pass through is not possible.
- Leverages Linux to provide a 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

- Guest life-cycle controls
  - Start,stop,reboot, pause/resume, suspend/restore
  - Live migration (Intel/AMD only at this time)
  - Snapshots, delta storage images
- CPU, memory and disk over-commit
- Direct kernel boot option

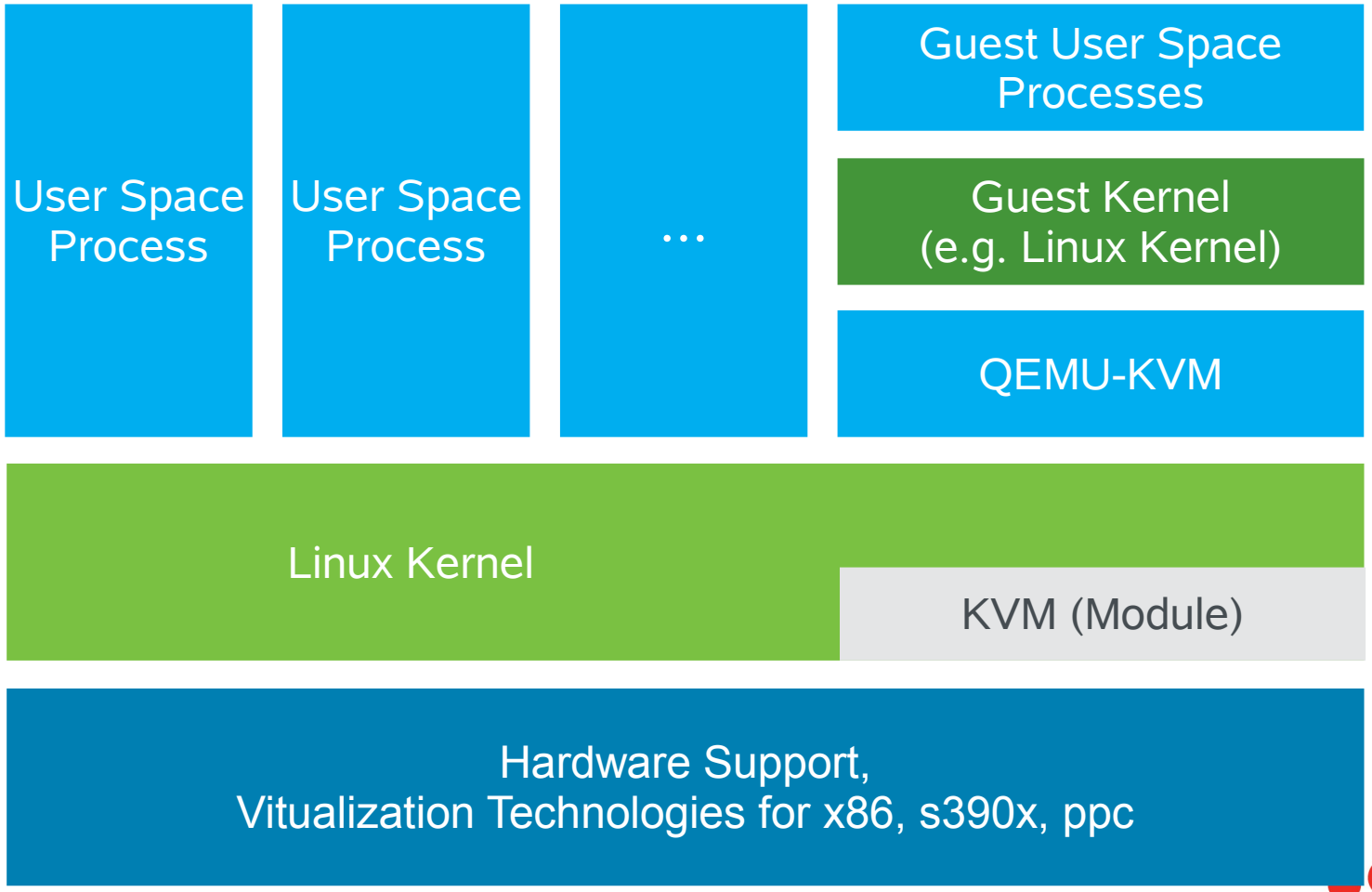
KVM features

- Transparent Huge Page (THP) optimized
- Kernel Samepage Merging (KSM) supported (Intel/AMD only)
- Non-root user support
- User-mode networking stack (DNS, DHCP, TFTP, BOOTP, SMB)
- Macvtap device networking (required on s390x)
- Guest details provided on the qemu-kvm command line
- Nested virtualization (“second level”) (Intel/AMD only)
- 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				+

High-level architecture



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

KVM limits supported by SUSE

- Host RAM and CPU limits are the same with or without KVM modules loaded
- Maximum guest RAM size: 4 TB
- Maximum number of guests: total vCPUs in all guests ≤ 8 times total CPU cores in host
  - Maximum virtual CPUs per guest: <= 160 (soft limit)
- Maximum NICs per guest: 8
- Maximum block devices per guest:
  20 para-virtual (virtio-blk), 4 emulated

Using KVM

- For distributed systems, we recommend using libvirt and libvirt tools to access KVM
  - Includes: vm-install, virt-install, virt-manager, virt-viewer, virsh commands
  - Adds additional security, configurability, compatibility, etc.
  - I'm not sure what we're going to recommend for System z
  - Plenty of command line tools to work with.
- Using qemu-kvm command-line also supported – documentation identifies supported parameters
- qemu-img image management tool provided

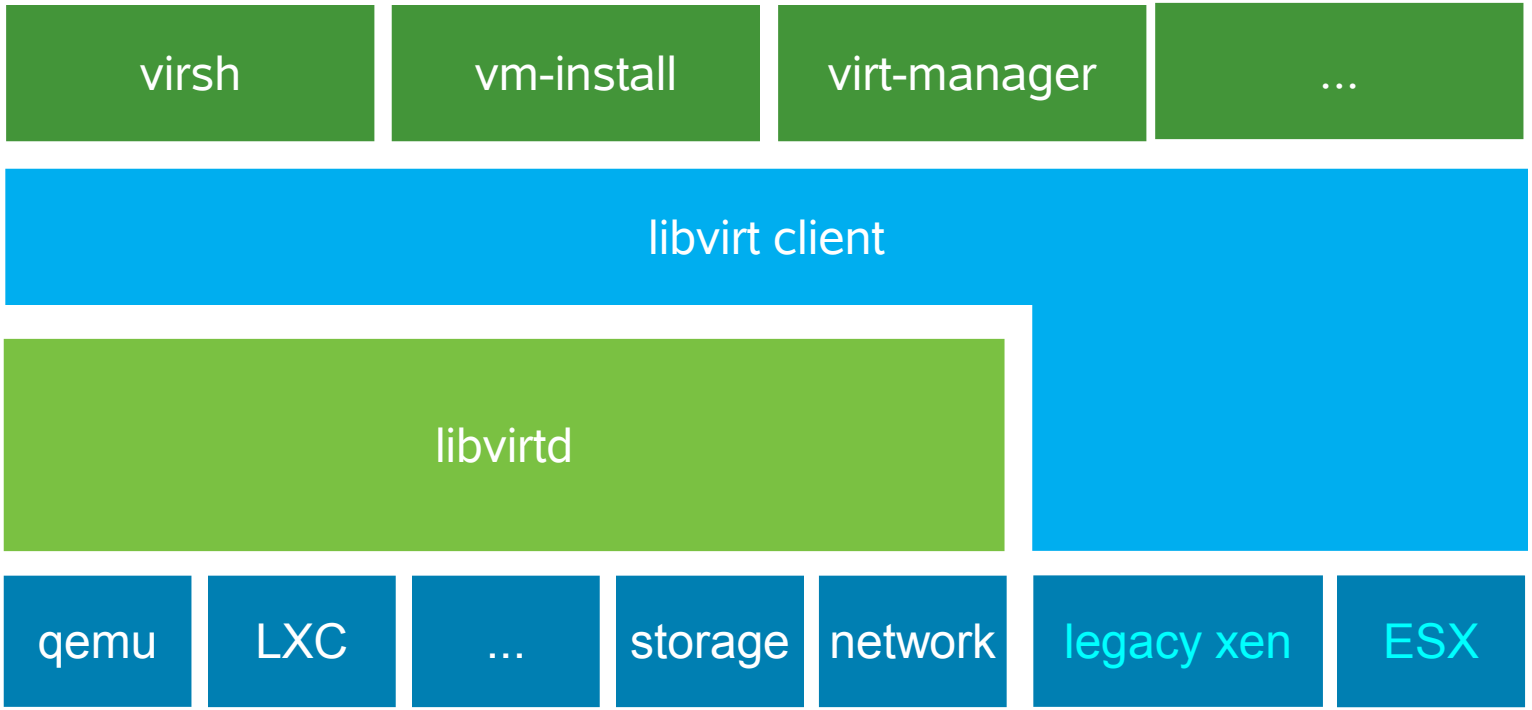
How's this for instantiaing a guest?

```
/usr/bin/qemu-kvm -name sles11 -M s390-ccw-virtio
-enable-kvm
-m 512 -smp 1,sockets=1,cores=1,threads=1
-nographic
-rtc base=utc
-drive file=/var/lib/kvm/images/sles11/disk0.raw,
if=none,id=drive-virtio-disk0,format=raw
-device virtio-blk-ccw,scsi=off,devno=fe.0.0000,
drive=drive-virtio-disk0,id=virtio-
disk0,bootindex=1
-netdev tap,fd=19,id=hostnet0
-device virtio-net-ccw,netdev=hostnet0,id=net0,
mac=ea:02:91:19:cf:ff,devno=fe.0.0001
19<>/dev/tap?
```

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
  - Command line application exposing libvirt API
- vm-install
  - GUI based (if DISPLAY is set, CLI if not)
    - Prompts for the parameters needed
  - Create virtual hardware configuration
  - Install an OS in a virtual machine
- virt-install
  - CLI only/mostly
    - Expects lots of parameters to be specified
  - Create virtual hardware configuration
  - Install an OS in a virtual machine

libvirt tools

- virt-manager
  - Graphical tool for administering virtual machines
- virt-viewer
  - Graphical console client for virtual machines (currently not working on s390x)
- libvirt-cim
  - libvirt-based implementation of DMTF Virtualization Management standards

Domain definition file (don't try to read the eye chart)

```
<domain type='kvm'>
  <name>sles11</name>
  <uuid>0b596405-e956-1412-f098-d4c0d00bc727
  </uuid>
  <memory>524288</memory>
  <currentMemory>524288</currentMemory>
  <vcpu>2</vcpu>
  <os>
    <type arch='s390x' machine='s390-ccw-virtio'>hvm
    </type>
    <boot dev='hd'/>
  </os>
  <features/>
  <clock offset='utc' />
  <on_poweroff>destroy</on_poweroff>
  <on_reboot>restart</on_reboot>
  <on_crash>destroy</on_crash>
  <devices>
    <emulator>/usr/bin/qemu-kvm</emulator>
    <disk type='file' device='disk'>
      <driver name='qemu' type='raw' cache='default'/>
      <source file='/var/lib/kvm/images/sles11/disk0.raw'/>
      <target dev='vda' bus='virtio'/>
    </disk>
    <interface type='direct'>
      <mac address='52:54:00:06:4a:e9'/>
      <source dev='eth0' mode='bridge'/>
      <model type='virtio'/>
    </interface>
    <console type='pty'>
      <source path='/dev/pts/1'/>
      <target type='sclp' port='0'/>
    </console>
  </devices>
</domain>
```

Domain definition file – part 1 of 6

```
<domain type='kvm'>
  <name>sles11</name>
  <uuid>0b596405-e956-1412-f098-d4c0d00bc727
  </uuid>
  <memory>524288</memory>
  <currentMemory>524288</currentMemory>
  <vcpu>2</vcpu>
```

Domain definition file – part 2 of 6

```
<os>
  <type arch='s390x' machine='s390-ccw-virtio'>hvm
  </type>
  <boot dev='hd'/>
</os>
```

Domain definition file – part 3 of 6

```
<features/>
<clock offset='utc' />
<on_poweroff>destroy</on_poweroff>
<on_reboot>restart</on_reboot>
<on_crash>destroy</on_crash>
```

Domain definition file – part 4 of 6

```
<devices>
  <emulator>/usr/bin/qemu-kvm</emulator>
  <disk type='file' device='disk'>
    <driver name='qemu' type='raw' cache='default'/>
    <source file='/var/lib/kvm/images/sles11/disk0.raw'/>
    <target dev='vda' bus='virtio'/>
  </disk>
```

Domain definition file – part 5 of 6

```
<interface type='direct'>
  <mac address='52:54:00:06:4a:e9'/>
  <source dev='eth0' mode='bridge'/>
  <model type='virtio'/>
</interface>
```

Domain definition file – part 6 of 6

```
    <console type='pty'>
      <source path='/dev/pts/1'/>
      <target type='sclp' port='0'/>
    </console>
  </devices>
</domain>
```

What's that buy me?

- All that XML allows you to do this:
  virsh start sles11 --console
  or
  virsh start sles11
  and then later
  virsh console sles11
- “virsh help” or “man virsh” will reveal a huge amount of subcommands and options to manipulate the host or a guest.
  - Note that a lot of changes won't take effect until the guest is restarted.

Places of interest

- /etc/kvm/vm
- /etc/libvirt/qemu
- /etc/libvirt/
- /var/lib/kvm/images
- /var/lib/libvirt/images and qemu
- /var/log/libvirt/
- /var/run/libvirt/
- ~/.virt-manager/virt-manager.log

Things to consider

- Install your KVM Host system in an LPAR.
  - SIE won't be available to a z/VM guest
- If you're going to start with a “small” LPAR (in terms of real storage), don't start too many guests at one time.
- You can use multiple OSAs, but then you'll need to manually make sure the guests are spread across them.
- Guests will be able to communicate with each other via TCP/IP but not with the Host.

- If you don't use the “Install Hypervisor and Tools” module in YaST, you'll have to manually add “switch_amode” to your kernel parameters before you reboot.
  - This is ***no longer*** true for KVM on SLES12
- If you issue the qemu-kvm command directly, you'll need to issue this command for every virtual NIC used by a guest:
  `ip link add link eth0 name macvtap0 type macvtap mode bridge`
  - And then make sure to use the MAC address it is assigned
- Hard to keep track of things if you don't use virsh or virt-manager.

Live demo

- Please pray to the demo gods. Thank you.

Terminology

- Domain – guest virtual machine
- Image – file, partition, etc., used as the block device backing a virtual disk for a guest.
- VM – virtual machine, *not* z/VM.
- Host, Node – Linux instance hosting the Linux guests.
- Virtual Machine Manager - virt-manager

Questions?

- Is there a way to check whether KVM is using hardware virtualization (SIE instruction)?
  - Your qemu process should have kvm file descriptors open in /proc/<pid>/fd/ and you should see a debug area in /sys/kernel/debug/s390dbf/kvm-<pid>/

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