(Kernel) Isolation – PV, HVM, OS-V technologies in Linux

Introduction and description of the isolation differences between HM, PV and OS-level virt. technologies.
Paravirtualization
Paravirtualization (a.k.a. PV - Xen)

- Not kernel module, uses a hypervisor (domain 0)
- Guest OS has to be aware of the fact it is being paravirtualized (Kernel 3.0+).
- Hypervisor provides ABI to communicate and Guest OS calls it
Paravirtualization (a.k.a. PV)

• “No” Performance losses (direct access to resources)
• Faster boot - Can boot kernel directly (no bootloader)
• Guests uses own kernel
• Isolation on the underlying OS – processes could be secured by Apparmor/Selinux
Hardware-assisted virtualization
Hardware-assisted virtualization (a.k.a. HVM)

For example: KVM or Xen

- **Using „hypervisor“** - guests are completely isolated
  
  binary translation to trap and virtualize non-virtualized instructions => emulation

- Has own bootloader
- Has own kernel
- **Not** modified OS.
Hardware-assisted virtualization (a.k.a. HVM)

- All resources are handled in-directly through emulation.
- Nowadays **PVHVM** can be used if OS supports it (Kernel 2.6.32+)
- Needs CPU flags (Intel `vmx` | AMD `svm`)
Operating-system-level virtualization
Operating-system-level virt. (a.k.a. containers)

When we talk about containers we can think about a book in a shelf. There are multiple chapters in the book. Every chapter has a different "story" but they belong to the same piece of book.
Operating-system-level virt. (a.k.a. containers)

- Sometimes called as "jail on steroids".
- Containers provide an additional layer of the security by isolating resources on a OS level.
- Can be used together with apparmor/SELinux to enhance security.
Operating-system-level virt. (a.k.a. containers)

- Solves issues with shared libraries (multiple versions) and helps with keeping OS clean
- Easily destroyed
- Sharing the kernel with the host
Differences between virtual machines & containers
Differences between virt. machines & containers

- VMs are "heavier" to setup/start - in general
- OS boot takes up to minutes (PV/HVM difference)
- HW isolation on a hypervisor level (HVM/PV/PVHVM)
- Qemu process represents virtual machine, storage backend involved
Differences between virt. machines & containers

- Lightweight (MiB-"hundreds of MiB")
- Can be application oriented
- Isolation on an OS level - process tree
Containers
technologies
Containers technologies

- chroot *1982
- OpenVZ *2005
- lxc(lxd) *2008
- docker *2013
- systemd-nspawn *2013
Containers technologies

**chroot**  *1982*

- partial file system isolation
- nested virtualization
Containers technologies

**OpenVZ** *2005*

- file system isolation
- disk quotas (ZFS)
- IO limiting
- memory limits
- cpu quotas
- network isolation
- partial nested virtualization
- live migration
- root isolation
Containers technologies

**lxc(lxd)** *2008*

- file system isolation
- partial disk quotas (lvm/btrfs)
- partial IO limiting (btrfs)
- memory limits
- cpu quotas
- network isolation
- partial nested virtualization
- root isolation
Containers technologies

**docker** *2013*

- file system isolation
- IO limiting (since 1.10)
- memory limits
- cpu quotas
- network isolation
- partial nested virtualization
- root isolation (since 1.10)
Containers technologies

**systemd-nspawn  *2013**

- file system isolation
- disk quotas
- partial IO limiting (systemd+Cgroups)
- memory limits (systemd+Cgroups)
- cpu quotas (systemd+Cgroups)
- network isolation
- nested virtualization
- root isolation
What are they using to isolate resources?
What are they using to isolate resources?

- PID namespace - Process identifiers and capabilities
- UTS namespace - Host and domain name
- MNT namespace - File system access and structure
What are they using to isolate resources?

- IPC namespace - Process communication over shared memory
- NET namespace - Network access and structure
- USR namespace - User names and identifiers
What are they using to isolate resources?

- Cgroups

Resource protection (cpu usage, memory usage, io)
When to choose containers and when VMs
When to choose containers

- testing a new application (from source - from the internet)
- fast deployments - "iso" template for the application (or for whole cycle)
When to choose vms

- wider isolation (running in the process, access to resources is filtered/emulated HVM or through api/drivers PV)
- "sendboxes" for customers
Questions?

Sources:
https://en.wikipedia.org/wiki/Hardware-assisted_virtualization
Thank you

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