OS-level virtualization (Containers)

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- Isolation

 - Limiting who can see a process/application
- Two extremes
 - Traditional Process
 - System Virtual Machines

Isolation

Limiting what/who a process/application can see.

Traditional Processes

Process	Proces

- Each process gets its own
 - Virtual memory
 - One or more virtual CPUs (threads)
 - Access to OS services via system calls
- All co-located processes can see/share a lot (in an OS-controlled manner)
 - File system, storage, network, and I/O devices
 - Other processes (for Inter-process communication)



System Virtual Machines

Processes

Guest OS

Нуμ

- Co-related processes grouped into VMs
- Each VM has its own \bullet
 - Guest OS
 - Guest physical memory ("virtualized" view of memory seen by guest OS)
 - One or more virtual CPUs
 - Virtual I/O devices: virtual disk, virtual network
- Ideally: Co-located VMs don't see/share ANYTHING

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	Guest OS	
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What level to isolate?

- Processes share too much
 - Great performance but not isolated enough
- System VMs are too heavy
- Operating-system-level virtualization
 - Multiple isolated user-spaces
 - Share one kernel.
 - Native performance

Great Isolation but too heavy due to separate guest OS per VM



Traditional VMs





Process, VM, Container

Traditional Processes

Process	Process	Process
	Container	

Host OS

Containers



- Containers
 - group traditional processes together and
 - restrict what resources they can see/access.
- In Linux, containers consist of
 - Namespaces
 - Control Groups (cgroups)

Chroot

- An early precursor to modern namespaces
- given path
- \$ chroot NEWROOT

OR

- \$ chroot(path)
- "This call changes an ingredient in the pathname resolution" process and does nothing else." — man chroot
- Not secure. Lots of ways to escape chroot jail.

Change root directory for the calling process and its children to a

FreeBSD Jails

- Jails protects rest of the system from the jailed process
 - Not the other way around!
- Virtualized resources
 - file system,
 - the set of users, including own root account.
 - networking subsystem
- Again: Jail escapes were possible!

• Builds upon chroot to compartmentalize files and other resources

Linux Namespaces

- from "\$ man namespaces"
- PID Namespace
 - Limit the set of processes that can be see each other.
- IPC namespace
 - Limit the set of processes which are allowed to communicate with each other
- Filesystem namespace
 - Limit which part of filesystem is seen by a process group
- Network namespace
 - Unique IP address host name, domain name, etc for a group of processes
- User Namespace
 - User and Group IDs

"A **namespace** wraps a global system resource in an abstraction that makes it appear to the processes within the namespace that they have their own isolated instance of the global resource."

Cgroups (Control Groups)

- Beancounter
 - performs resource accounting for groups of processes
- of memory, network bandwidth, CPU etc.

Allows administrator to set soft/hard limits on usage

Typically used alongside with Linux namespaces

Single System Image

- Extend the notion of namespaces to multiple physical machines
- Multiple machines look like one (or more) namespace(s)
 - PID namespace
 - IPC Namespace
 - Filesystem namespace
- Process migration
 - changing its namespace.
- Examples: MOSIX, OpenSSI, Kerrighed

Allows moving processes from one machine to another without