LinuX Containers

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- Concepts
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  - Virtualization
- LinuX Containers
- Usage
  - Schematics
  - Demo
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- Relevance
  - Spread
  - Use Cases
- QA

IT trends

- More resources
  - Better hardware at lower costs
  - Higher standards for software quality
- More users
  - Contact with technology at an earlier age
  - Shared access to the same device
- Data consolidation
  - Data warehousing
  - Service unification
  - Differentiated access
- Increased flexibility
  - Versatile configuration
  - Focus on usability

OS Recap

- Resources
  - CPU
  - Memory
  - Peripherals
- Structures
  - The scheduler
  - The pager
  - Filesystems
- The kernel
  - Handles hardware
  - Exposes capabilities
  - Manages resources

Figure: The Memory Pager

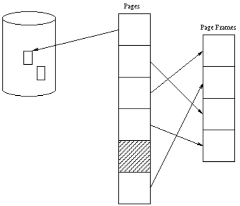
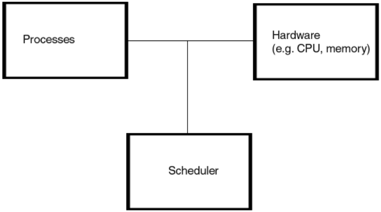


Figure: The Scheduler



Virtualization

- Key aspects:
  - Simulation (of HW / SW)
  - Virtual machines
  - Autonomous computing
  - Utility computing
- Advantages:
  - Better resource usage
  - Lower running costs
  - Improved security
- Concerns:
  - Management
  - Isolation
  - Performance
  - Applicability

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OS-level Virtualization

- One host
- Multiple running OS instances
- Rootfs, system libs, binaries

OS instance = a process hierarchy
OS level virtualization = **partitioning** the process tree
Advantage: **close to 0% performance overhead**
Flaw: **shared kernel**

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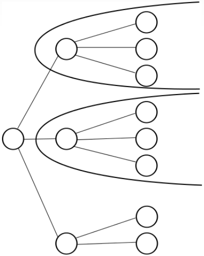
LinuX Containers

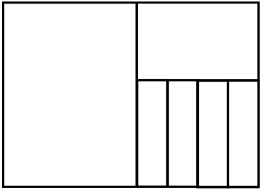
- a.k.a. LXC:
  - Mature technology implementation
  - Mainline kernel support
  - Application vs. System
  - Active development
- Components:
  - *Kernel features*
  - *Userspace tools*
  - *Configuration files*
  - *Template files*

Kernel Support

- Namespaces:
  - Abstract resources
  - Processes see the resource as their own
  - Isolation between namespaces



- Control Groups
  - Resource management among processes
  - Hierarchical support
  - Interaction with resource responsible structures:
    - Scheduler
    - Pager



Sample Process Hierarchy

```
init(1)-+-dnsmasq(2162)
        |-klogd(2175)
        |-lxc-start(2964)---init(2966)----+-init(2972)
        |                                 |-sh(2971)
        |                                 `-syslogd(2969)
        |
        |
        |-lxc-start(2974)---init(2976)----+-init(2982)
        |                                 |-sh(2981)
        |                                 `-syslogd(2979)
        |
        |
        |-netserver(2167)
        |-sh(2179)
        |-syslogd(2173)
        `-udevd(962)-+-udevd(1189)
                     `-udevd(1190)
```

Process IDs

```
init(1)-+-dnsmasq(2162)
        |-klogd(2175)
        |-lxc-start(2964)---init(2966)(1)-+-init(2972)(7)
        |                                 |-sh(2971)(6)
        |                                 `-syslogd(2969)(4)
        |
        |
        |-lxc-start(2974)---init(2976)(1)-+-init(2982)(7)
        |                                 |-sh(2981)(6)
        |                                 `-syslogd(2979)(4)
        |
        |
        |-netserver(2167)
        |-sh(2179)
        |-syslogd(2173)
        `-udevd(962)-+-udevd(1189)
                     `-udevd(1190)
```

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Namespace Segregation

```
init(1)-+-dnsmasq(2162)
        |-klogd(2175)
        |-lxc-start(2964)--- init(2966)(1)-+-init(2972)(7)
        |                                  |-sh(2971)(6)
        |                                  `-syslogd(2969)(4)
        |                    PID Namespace 1
        |
        |-lxc-start(2974)--- init(2976)(1)-+-init(2982)(7)
        |                                  |-sh(2981)(6)
        |                                  `-syslogd(2979)(4)
        |                    PID Namespace 2
        |
        |-netserver(2167)
        |-sh(2179)
        |-syslogd(2173)
        `-udevd(962)-+-udevd(1189)
                     `-udevd(1190)
```

Filesystem Segregation

"chroot on steroids"

```
init(1)-+-dnsmasq(2162)
        |-klogd(2175)         root: /var/lib/lxc/foo1/rootfs/
        |-lxc-start(2964)--- init(2966)(1)-+-init(2972)(7)
        |                                  |-sh(2971)(6)
        |                                  `-syslogd(2969)(4)
        |                    PID Namespace 1
        |                    root: /var/lib/lxc/foo1/rootfs/
        |-lxc-start(2974)--- init(2976)(1)-+-init(2982)(7)
        |                                  |-sh(2981)(6)
        |                                  `-syslogd(2979)(4)
        |                    PID Namespace 2
        |
        |-netserver(2167)
        |-sh(2179)
        |-syslogd(2173)
        `-udevd(962)-+-udevd(1189)
                     `-udevd(1190)
```

CPU Partitioning

```
init(1)-+-dnsmasq(2162)
        |-klogd(2175)         root: /var/lib/lxc/foo1/rootfs/
  ,-----|-lxc-start(2964)--- init(2966)(1)-+-init(2972)(7)
  |     |       25%                        |-sh(2971)(6)
  |     |                                  `-syslogd(2969)(4)
  |     |                    PID Namespace 1
  |     |                    root: /var/lib/lxc/foo1/rootfs/
1 core  |-lxc-start(2974)--- init(2976)(1)-+-init(2982)(7)
  |     |       75%                        |-sh(2981)(6)
  |     |                                  `-syslogd(2979)(4)
  |     |                    PID Namespace 2
  `-----|-----------------------------------------------
        |-netserver(2167)
        |-sh(2179)
        |-syslogd(2173)
        `-udevd(962)-+-udevd(1189)
                     `-udevd(1190)
```

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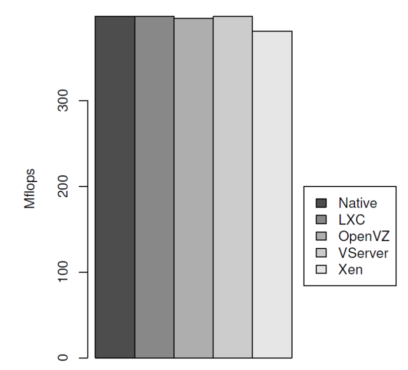
Demo

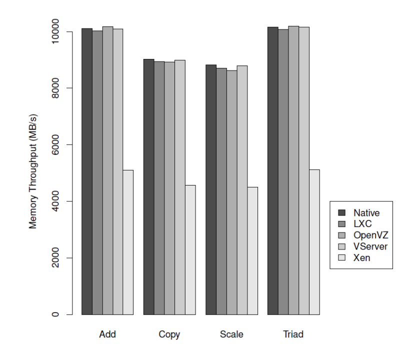
1. Start 2 containers
2. Check PIDs
3. Assign them a single core on the host
4. Balance CPU usage 25% - 75%

System Performance

CPU performance
Linpack

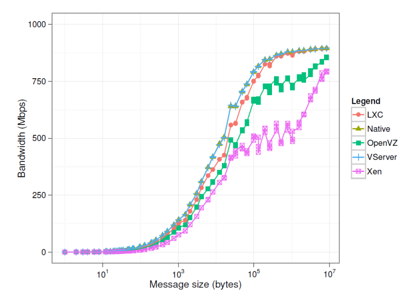


Mem throughput
Stream

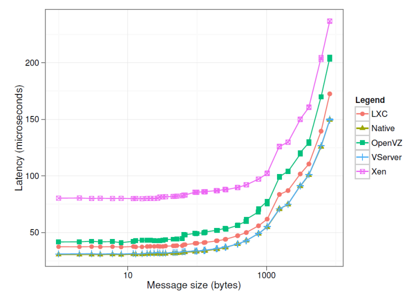


Networking Performance

Bandwidth
NetPIPE



Latency
NetPIPE



Isolation

PERFORMANCE ISOLATION FOR LU APPLICATION. THE RESULTS REPRESENT HOW MUCH THE APPLICATION PERFORMANCE IS IMPACTED BY DIFFERENT STRESS TESTS IN ANOTHER VM/CONTAINER. DNR MEANS THAT APPLICATION WAS NOT ABLE TO RUN.

	LXC	OpenVZ	VServer	Xen
CPU Stress	0	0	0	0
Memory	88.2%	89.3%	20.6%	0.9%
Disk Stress	9%	39%	48.8%	0
Fork Bomb	DNR	0	0	0
Network Receiver	2.2%	4.5%	13.6%	0.9%
Network Sender	10.3%	35.4%	8.2%	0.3%

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Popularity

- Running on:
  - Major distros: Fedora, Debian, Ubuntu, ...
  - Android
  - Virtually any system with Linux >= 2.6.26
- Integrated with high(er) level tools:
  - `docker.io` - The Linux Container Runtime
  - `libvirt.org` - The Virtualization API
  - `criu.org` - Checkpoint-Restart in Userspace
- Maintained by both kernel and userspace developers

Use Cases

- General:
  - Server replication
  - Application sandboxing
  - Legacy software support
  - Live migration
  - GPL insulation
- Embedded (networking, smartphones):
  - Separate traffic from different departments
  - Separate QoS policies
  - Run RTOS and HLOS at the same time

Freescale USDPAA in Containers

- DPAA - DataPath Acceleration Architecture
  - HW architecture providing advanced networking capabilities
  - Present in dedicated networking equipment
  - Traffic shaping, package accelerators, cryptography engine
- USDPAA - User Space DPAA
  - Userspace drivers based on the kernel UIO framework
  - Increased flexibility in application development
  - Reduced risk of bugging the kernel
  - Better error handling and system protection
  - Performance overhead
- Multiple USDPAA instances in containers
  - Improved isolation
  - Additional protection layer
  - Finer resource tuning

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References

- `lxc.sourceforge.net`
- Yang Yu: OS-level Virtualization and Its Applications
- Miguel G. Xavier: Performance Evaluation of Container-based Virtualization for High Performance Computing Environments

Thank you!

Questions?