Introduction to OS-Level Virtualization on Linux

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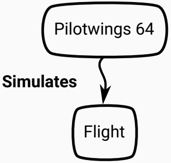
May 25th, 2020

What are Simulation, Emulation, Virtualization?



Pilotwings 64

Simulates

Flight

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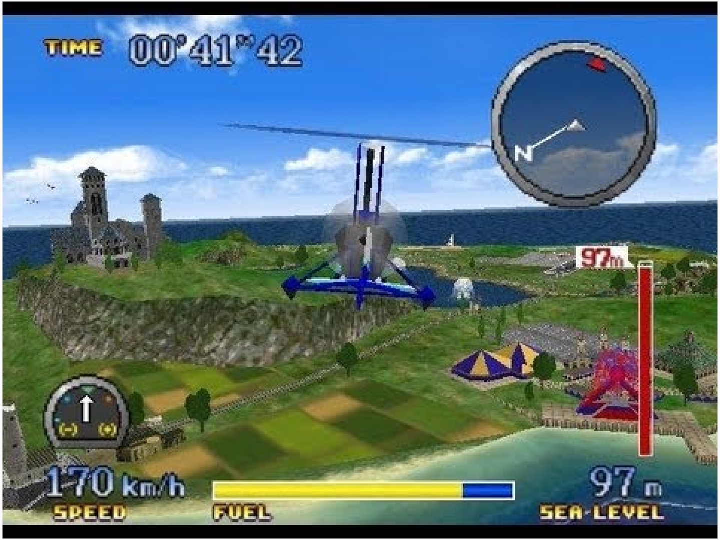

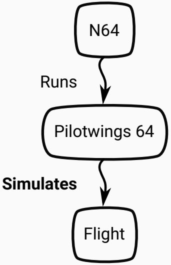

N64

Runs

Pilotwings 64

Simulates

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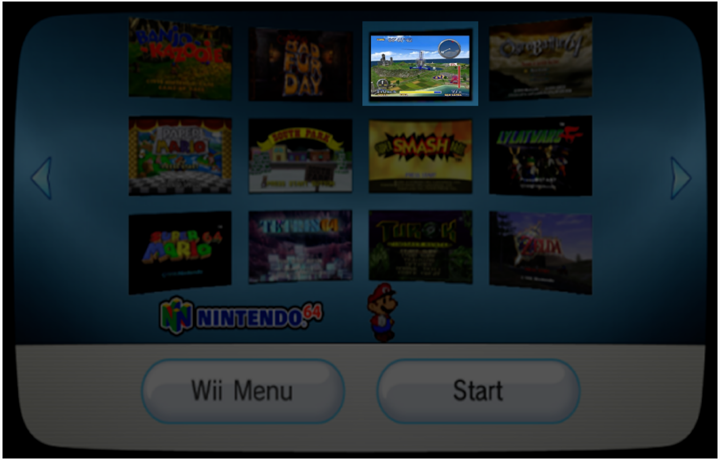

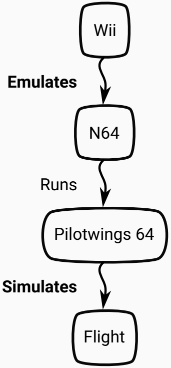

Wii

Emulates

N64

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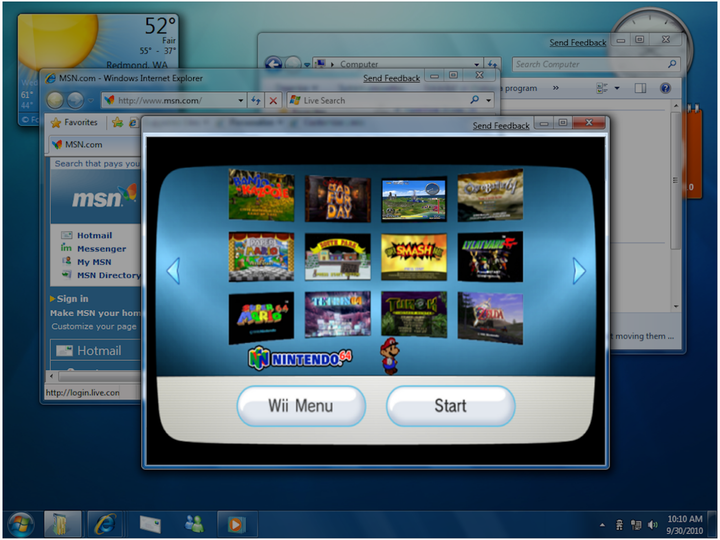

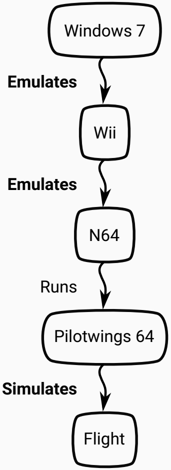
Windows 7

Emulates

Wii

Emulates

N64

Runs

Pilotwings 64

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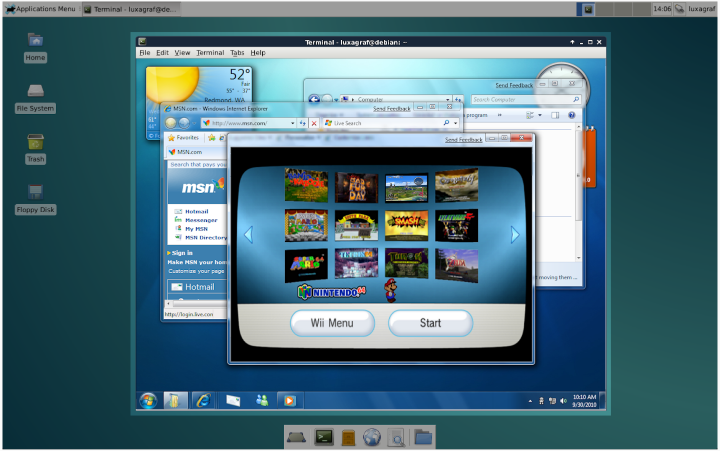

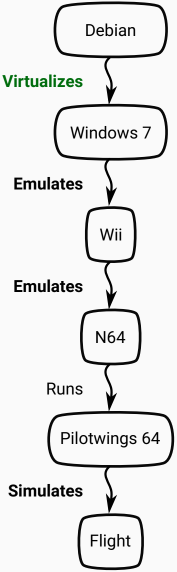

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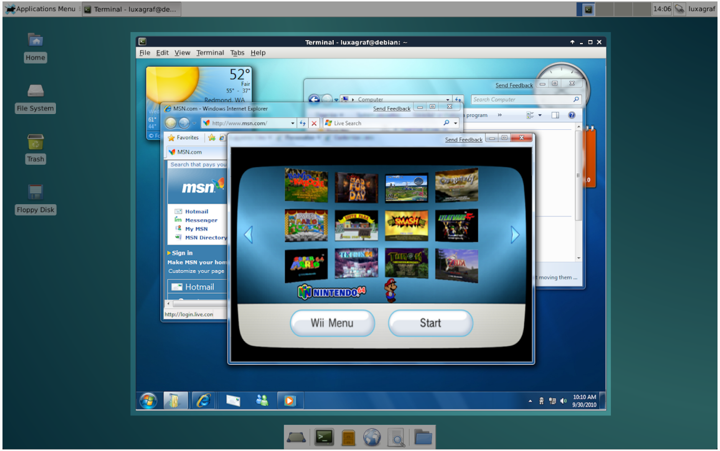
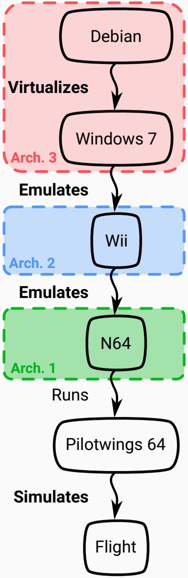




Debian

Virtualizes

Windows 7

Arch. 3

Emulates

Wii

Arch. 2

Emulates

N64

Arch. 1

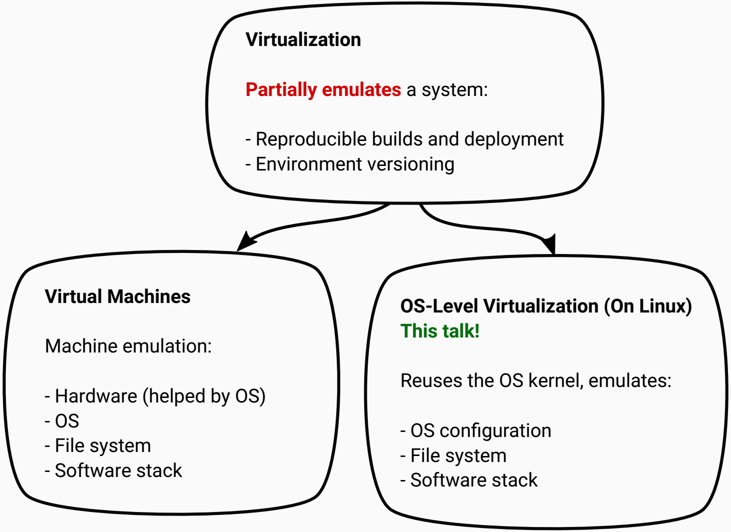
Runs

Pilotwings 64

Simulates

Flight

OS-Level Virtualization



Virtualization

Partially emulates a system:

- Reproducible builds and deployment
- Environment versioning

Virtual Machines

Machine emulation:

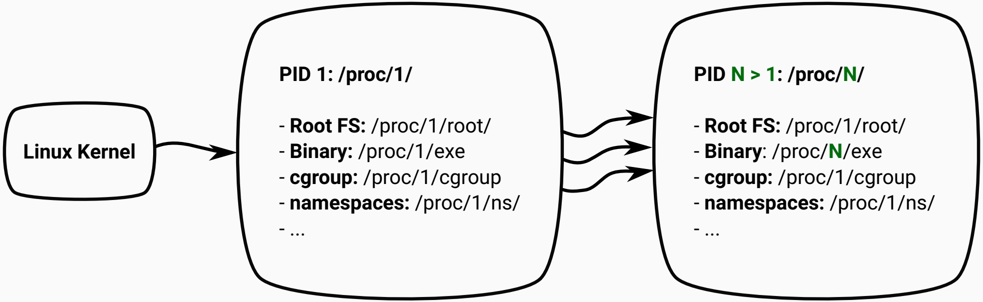
- Hardware (helped by OS)
- OS
- File system
- Software stack

OS-Level Virtualization (On Linux)
This talk!

Reuses the OS kernel, emulates:

- OS configuration
- File system
- Software stack

OS-Level Virtualization on Linux



Linux Kernel

PID 1: /proc/1/

- **Root FS:** /proc/1/root/
- **Binary:** /proc/1/exe
- **cgroup:** /proc/1/cgroup
- **namespaces:** /proc/1/ns/
- ...

PID N > 1: /proc/N/

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- **Binary**: /proc/**N**/exe
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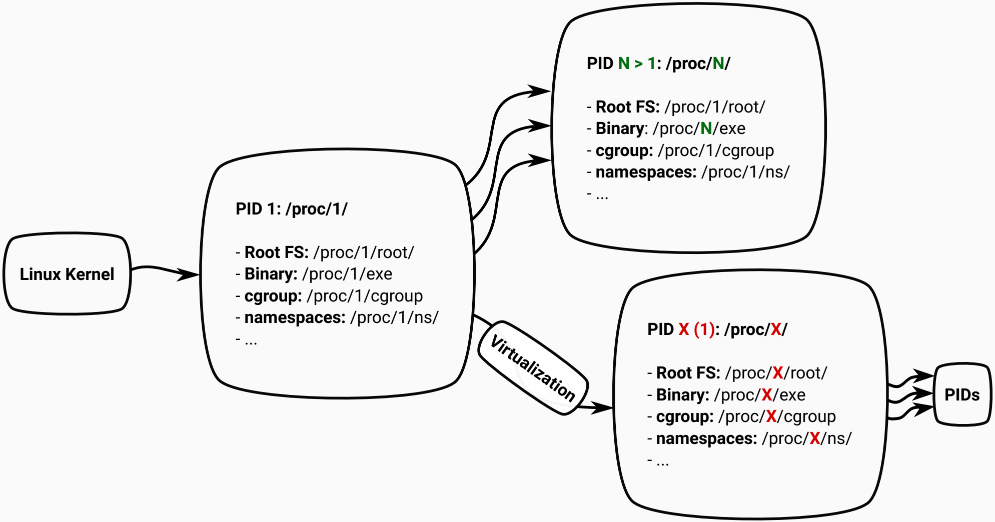
OS-Level Virtualization on Linux



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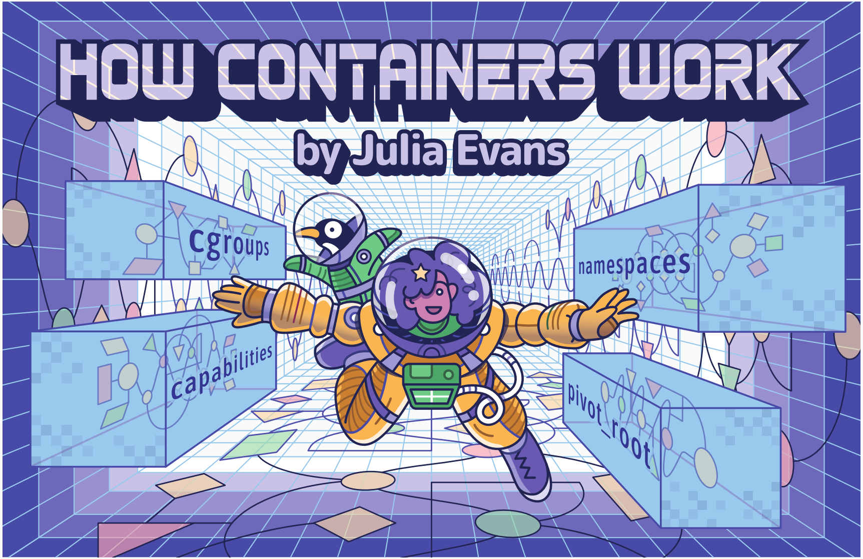
- ...

PIDs

How Containers Work Zine



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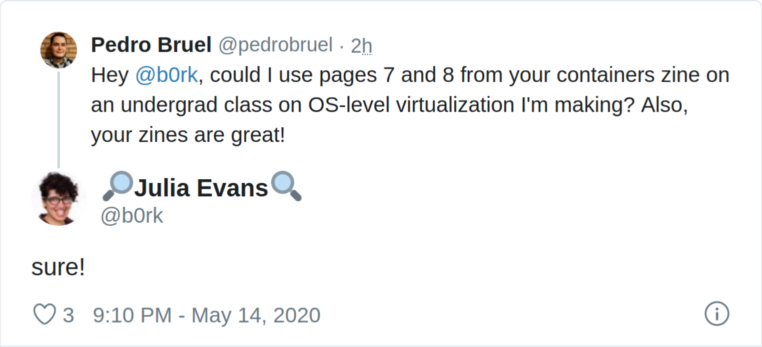


Pedro Bruel @pedrobruel · 2h

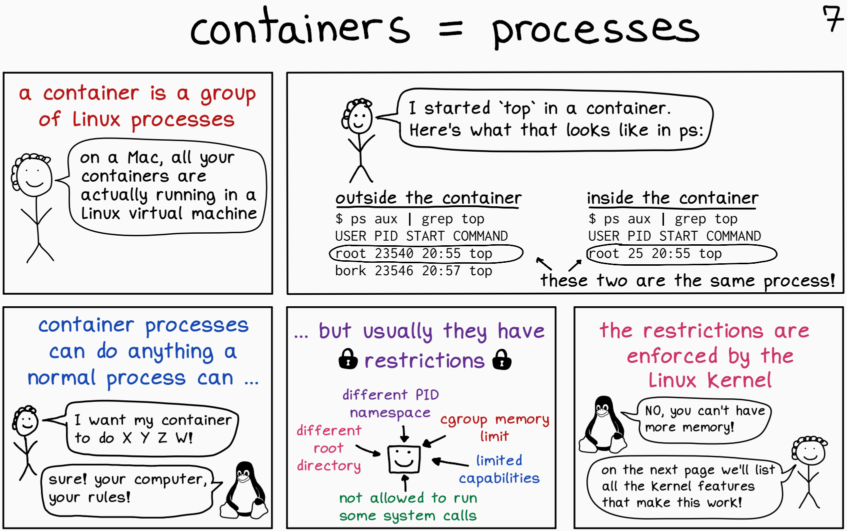
Hey @b0rk, could I use pages 7 and 8 from your containers zine on an undergrad class on OS-level virtualization I'm making? Also, your zines are great!

🔎**Julia Evans**🔍
@b0rk

sure!

♡ 3 9:10 PM - May 14, 2020

Containers on Linux are Just Processes



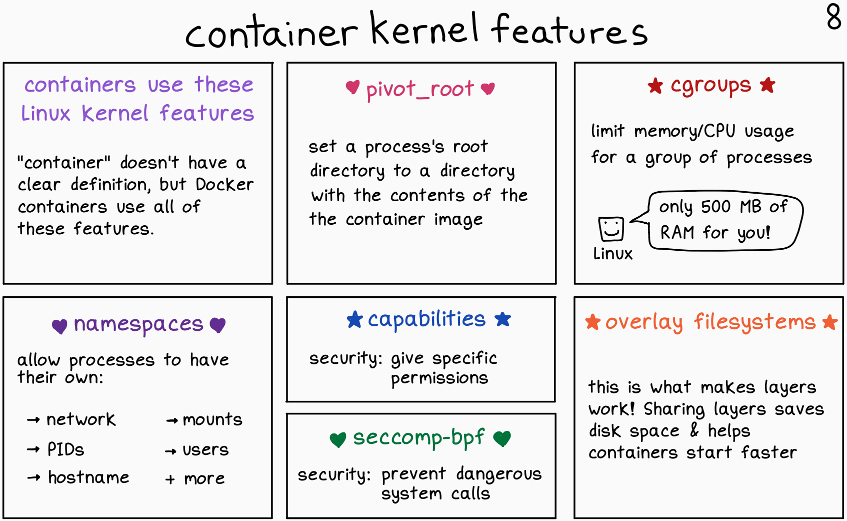
containers = processes
7
a container is a group of Linux processes
on a Mac, all your containers are actually running in a Linux virtual machine
I started `top` in a container. Here's what that looks like in ps:
outside the container
inside the container

```
$ ps aux | grep top
USER PID START COMMAND
root 23540 20:55 top
bork 23546 20:57 top
```

```
$ ps aux | grep top
USER PID START COMMAND
root 25 20:55 top
```

these two are the same process!
container processes can do anything a normal process can ...
I want my container to do X Y Z W!
sure! your computer, your rules!
... but usually they have 🔒 restrictions 🔒
different PID namespace
cgroup memory limit
different root directory
limited capabilities
not allowed to run some system calls
the restrictions are enforced by the Linux kernel
NO, you can't have more memory!
on the next page we'll list all the kernel features that make this work!

Containers on Linux use Some Kernel Features



container kernel features

8

containers use these Linux kernel features

"container" doesn't have a clear definition, but Docker containers use all of these features.

♥ pivot_root ♥

set a process's root directory to a directory with the contents of the the container image

★ cgroups ★

limit memory/CPU usage for a group of processes

Linux: only 500 MB of RAM for you!

♥ namespaces ♥

allow processes to have their own:

→ network
→ PIDs
→ hostname
→ mounts
→ users
+ more

★ capabilities ★

security: give specific permissions

♥ seccomp-bpf ♥

security: prevent dangerous system calls

★ overlay filesystems ★

this is what makes layers work! Sharing layers saves disk space & helps containers start faster

Containers from Scratch: Obtaing an ”Image”

```bash
#!/usr/bin/bash

IMG_DIR="alpine_img"
IMG_REPO="https://us.images.linuxcontainers.org/images"
IMG_URL="$IMG_REPO/alpine/3.11/amd64/default/20200521_13:00/rootfs.tar.xz"
[ ! -d $IMG_DIR ] && \
    mkdir -p $IMG_DIR && \
    curl $IMG_URL | tar xJ -C $IMG_DIR
cd $IMG_DIR
```

Containers from Scratch: Creating cgroups and Setting Limits

```
CGROUP_ID="MAC0475-145"
sudo cgcreate -g "cpu,cpuacct,memory:$CGROUP_ID"
sudo cgset -r cpu.shares=512 "$CGROUP_ID" # 1024 is 100% CPU
sudo cgset -r memory.limit_in_bytes=10000000000 "$CGROUP_ID"
```

Containers from Scratch: Launching the Alpine Container

```
HOSTNAME="alpine-container"
sudo cgexec -g "cpu,cpuacct,memory:$CGROUP_ID" \
     unshare -fmuipn --mount-proc \
     chroot "$PWD/" \
     /bin/sh -c "PATH=/bin && mount -t proc proc /proc && hostname $HOSTNAME && sh"

# Cleanup:
sudo cgdelete "cpu,cpuacct:/$CGROUP_ID"
```