

16 – Networking, OS, and virtualization

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Firewalls

- In a perfect world, we wouldn't need a firewall.
- Lives in the network, or in the kernel
- inspects traffic *before* it reaches its destination
- Two primary uses: filter legitimate services, block unwanted ones

Firewalls: the good uses

- Legit: *Filters* certain ports to prevent regions of the internet from accessing them
 - Cornell firewall drops all traffic destined to on-campus servers originating from off-campus IPs
 - **wash** firewall does the same
 - mail relay firewall would only allow known senders to connect
- prevents server from being overloaded by random external grievers
- prevents aggressive server scans from the darkweb
 - which, by the way, exists. ask me later.

Firewalls: the lazy uses.

- Block insecure / old apps
- cover up for weird/bad OS/system design
 - Example: print server on a mac at port 631
 - Example: just a lot of windows
- Block **all** uninvited remote connections
 - if your laptop isn't a server, shouldn't have exposed ports
 - if it does have exposed ports, some application is doing a bad.
- Fundamentally lazy: right answer is to secure the applications, not hide them.
- lots of legacy apps (that we're stuck with) can't be fixed, so also fundamentally necessary

Operating systems, and what they
do.

Processors

- The CPU; the chip at the center of your computer
- it actually runs your code
- wired via a *bus* to everything else in your computer
- Has multiple *cores* or *hyperthreads*
 - to allow code to execute simultaneously

Processors have protection modes

- Pieces of code get associated with a protection mode
 - there's an instruction that literally says “when you run this code, drop these privileges”
- Protection modes let you drop lots of privileges
 - device access
 - physical memory access
 - ability to change protection modes
- Operating system always runs first and keeps all its privileges
- Operating system's job is to run processes for its users

What is a process, really?

- A sequence of processor instructions
- runs from start to finish
- only thing running on CPU core
- what can a process do?
 - access its own memory
 - run arbitrary computation CPU commands
 - fire *interrupts*

What is an interrupt?

- An “unexpected event”
- A request for something else to take over
- Like a signal (in C/unix), or Exception (in java/python/etc)
- Can register *interrupt handlers*, pieces of code that run interrupts
- The operating system registers itself as an *interrupt handler*
- A *syscall* is an interrupt handled by the OS
 - is how you read files, use network, etc.
 - OS registered the handler, so can have all privileges
 - most basic C functions / linux commands just fancy syscall wrappers!

A potential process flow

- start a process
 - drop privileges
 - jump to process code
- do some computation
- read a file
 - fire an interrupt
 - interrupt handler (in OS) gets file
 - file placed in process memory
 - jump back to process code
- use file contents
- do more computation
- exit with result
 - fire an interrupt
 - interrupt handler (in OS) gets result
 - OS clears process memory

Where VMs fit into this

- Using devices (from the OS) also interrupt-based!
- special instruction that sends message along system *bus*
- When host OS launches a VM
 - drops *some* privileges
 - registers *itself* (host OS) for device interrupts
 - launches guest OS
- when guest process wants to use a resource
 - interrupt back to guest OS
 - guest OS interrupts for device
 - Host OS gets interrupt
 - Host OS interrupts for device, or
 - Host OS takes over for a bit

Containers, and how they work

chrooting

change root directory

```
chroot <dir> <command>
```

- Must execute as root
- hides filesystem below <dir>
- **dir** looks like new /

- Why do this?
 - all **PATHs** relative to new root
 - system programs and libraries used from new root
 - can use programs that need incompatible libraries
 - can avoid upgrading system when using a program
- demo

- What's still the same in the chroot?
 - kernel
 - process space
 - RAM
 - devices
- Halfway to a container; can have a **chroot** of debian on ChromeOS
- No isolation between **chrooted** processes and “real” ones

containers

- Special OS feature called LXC containers
- hides processes from each other
- can limit device access within a single container
 - how? checks PID after interrupt, denies request from container process
- 90% of a docker container is chroot + LXC
- Other 10%? Secretly a VM.
 - but only when needed
 - this is why “fancy” Windows 10 is required
- Docker build scripts and bundles are also nice

References

- [1] Stephen McDowell, Bruno Abrahao, Hussam Abu-Libdeh, Nicolas Savva, David Slater, and others over the years. “Previous Cornell CS 2043 Course Slides”.