Linux Kernel Management

Michael Tsai
2019/05/06

GNU
General Public License (GPL)

- Find online about GPL & BSD licenses. What are their major differences?

- Since version 0.12, Linux kernel is released under GPL. How has the use of GPL helped the development of Linux?

- (20 minutes)

Recommend reading

- http://keithcu.com/wordpress/?page_id=599

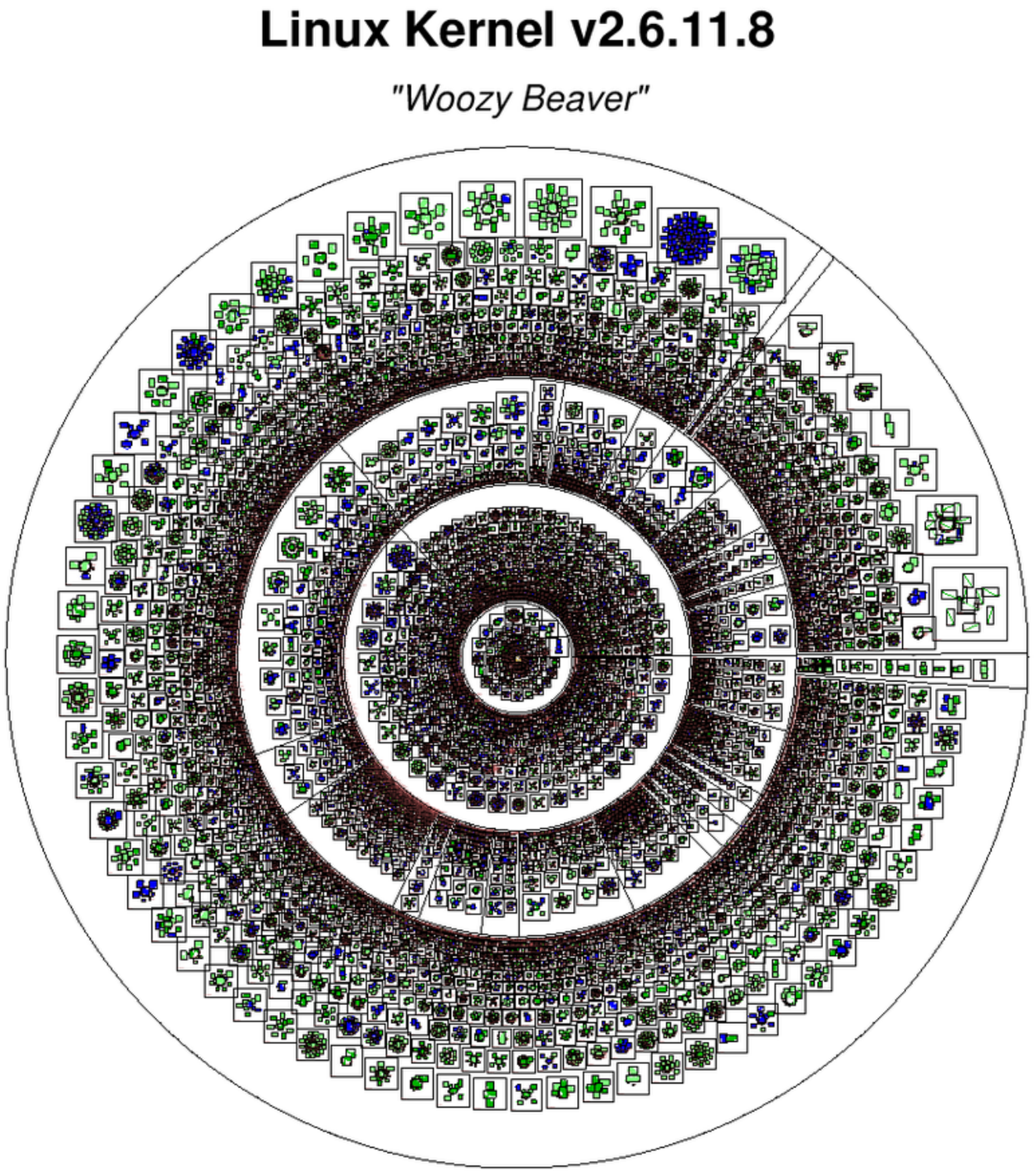
- (Linux “chapter”, “After the Software Wars,” Keith Curtis, 2010)

- http://keithcu.com/SoftwareWars.pdf

What does Kernel do?

- Kernel creates these concepts from the low-level hardware features:
  - Processes (time-sharing, proceeded address space)
  - Signals and semaphores
  - Virtual memory (swapping, paging, mapping)
  - The filesystem (files, directories, namespace)
  - General input/output (specialty hardware, keyboard, mouse, USB, etc.)
  - Interprocess communication (pipes and network connections)

Linux kernel in a diagram



- 50% device driver
  - “Read the first 64 bytes of of /etc/passwd” —> “fetch block 3,348 from device 3”
- 25% CPU specific code
- Two inner layers are generic
- Mostly written in C + some assembly language to interface with hardware or chip specific functions

http://keithcu.com/wordpress/?page_id=599

Advantages of Open Source Kernel

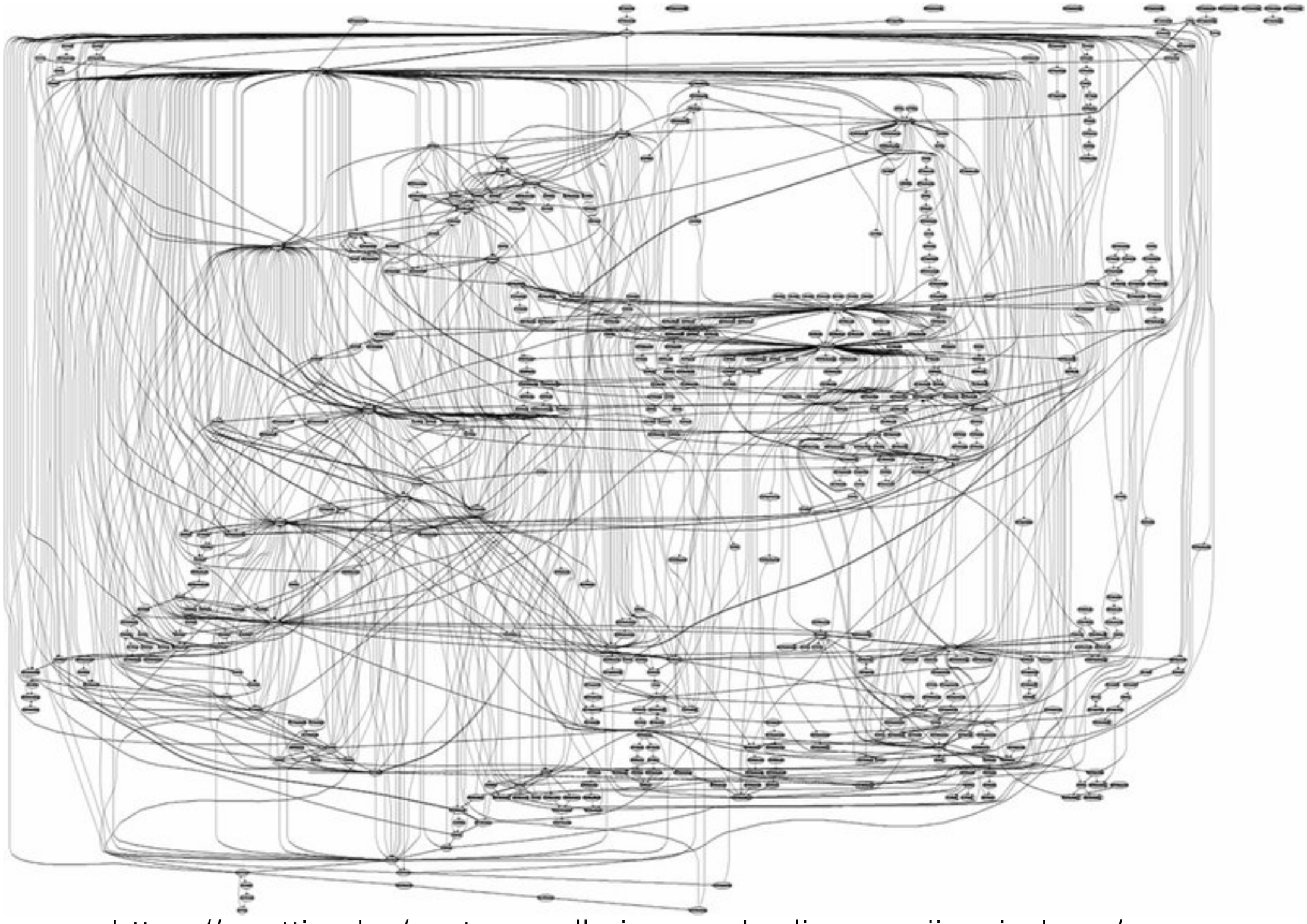
- Refactoring (smoothing, refining, simplifying, polishing) is done continuously in Linux

- Code is not freely available & in one place —> hard to evolve

  - Comparison: Microsoft's proprietary kernel
    The need to keep the old version alive for old code/ hardware

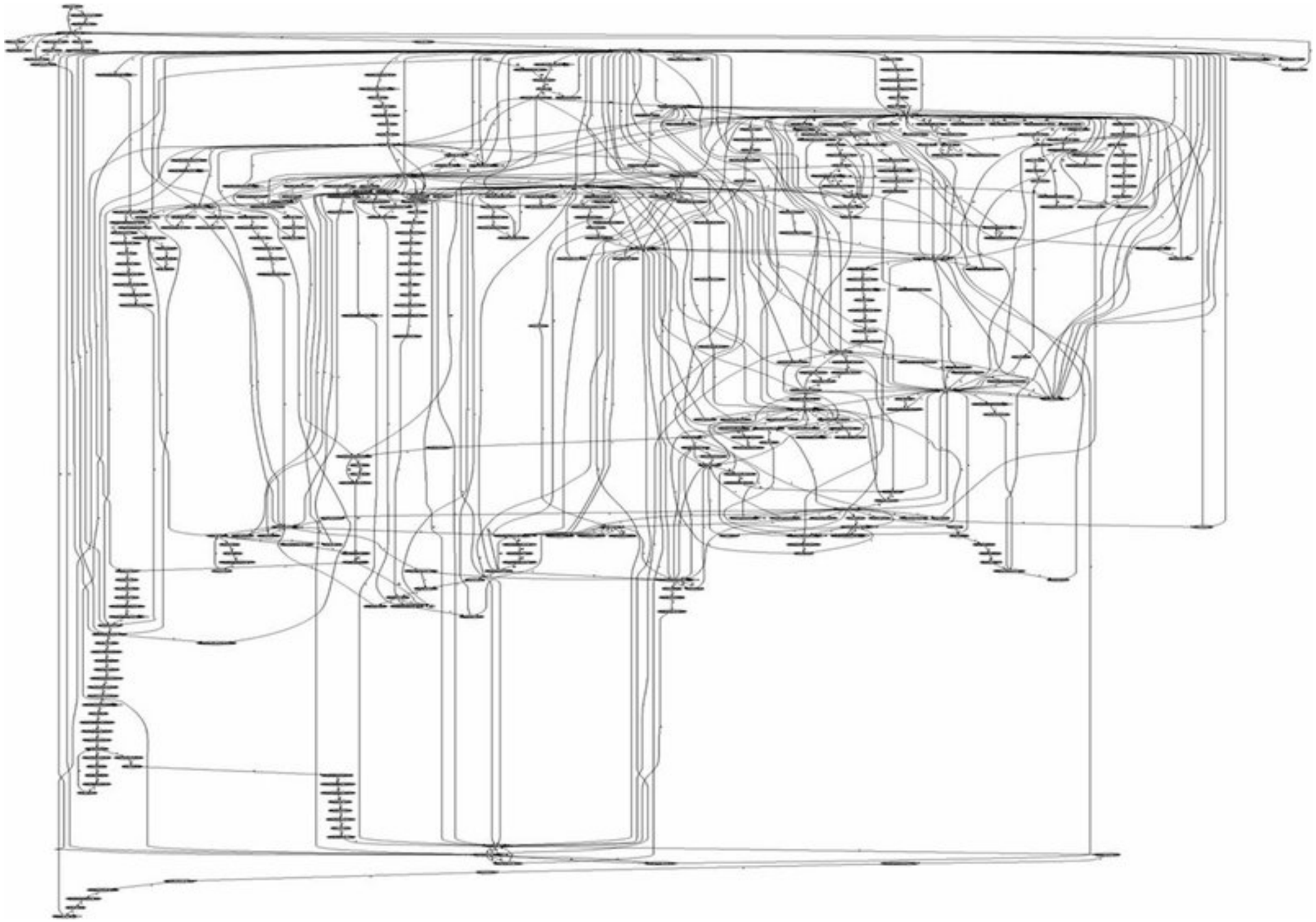
- Stanford research: Linux kernel has **0.17 bugs per 1,000 lines of code**, **150 times less** than average commercial code containing 20-30 bugs per 1,000 lines.

  Ref: http://keithcu.com/wordpress/?page_id=599



https://ma.ttias.be/system-calls-in-apache-linux-vs-iis-windows/

System call graph in Microsoft's proprietary web server, **IIS**.



System call graph to return a picture in the free web server **Apache**.

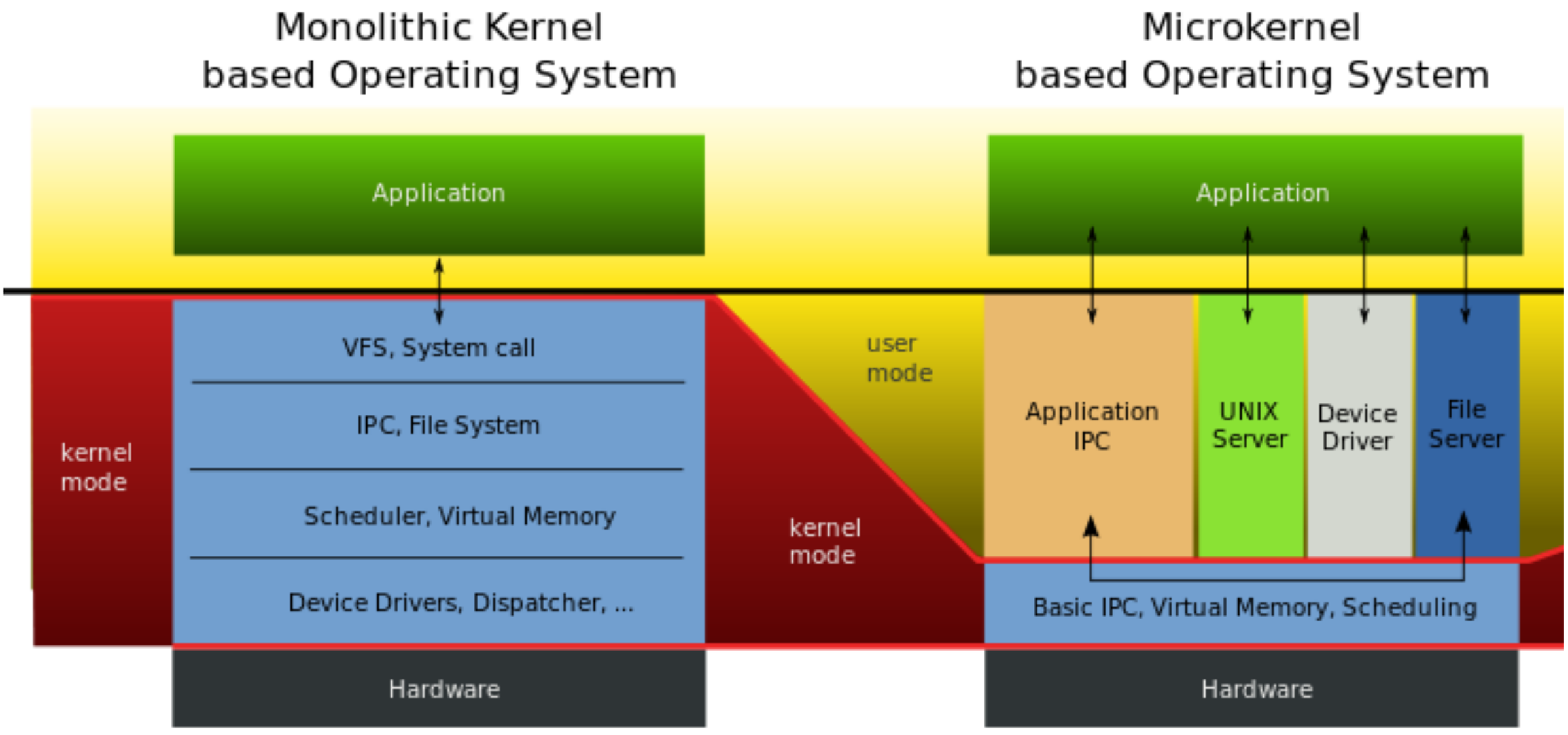
In-class: learn “screen”

- Allow you to have multiple “tabs” in terminal window
- Ctrl-a c to create a new “tab”
- Ctrl-a <number> to switch to that window
- Ctrl-a d to detach
- Re-attach using “screen -r”
- Use the workstation in the department to practice!

Kernel Adaptation

- Linux is a monolithic kernel at heart
    - Monolithic kernel: the entire OS runs in **kernel space** - a section of memory reserved for privileged operating system functions (device drivers, IPC, virtual memory, scheduling all run in the same address space)
        - Microkernel: many of the “services” run in user mode as regular processes
- Modern monolithic kernels support on-demand loading of modules
    - No need to re-build the entire kernel & **reboot**
        - Example: filesystem and device drivers
- Modern OS’es (e.g., Windows, Mac OS X) use hybrid kernel

https://en.wikiversity.org/wiki/Operating_Systems/Kernel_Models#Monolithic_Kernel
https://en.wikipedia.org/wiki/Tanenbaum–Torvalds_debate



http://en.wikipedia.org/wiki/Image:OS-structure.svg

Drivers and Device Files

- Device driver: manages the interaction between the system and the hardware
- User space access: from /dev. Kernel maps operations “on these files” to calls to the driver code.
- Major and minor device numbers - (use ‘ls -l /dev’ to see them) map device file references to drivers
- Block device - read or write one block (multiples of 512) at a time
- Character device - read or write one byte at a time
- Some of the device driver’s functions

```
attach close dump ioctl open probe
prize read receive reset select stop
strategy timeout transmit write
```

“Phantom devices”

- /dev/zero & /dev/null:
  data written here is discarded.
  read from /dev/zero always returns 0.
  read from /dev/null always returns EOF.

- /dev/random and /dev/urandom:
  read from /dev/random will return random bytes.
  (interface to kernel’s random number generator)

Custom kernels v.s. loadable modules

- When installed, a system comes with a generic kernel
- Linux's udev system can manage real-time device changes
- Do we need custom-built kernels?
  - Pros: Opportunity for performance gain
  - Cons: Patch & system upgrade could be difficult
- For stability reasons:
  using the stock kernel is recommended.

Kernel module related commands / files

- Files:
  /vmlinuz: the actual kernel binary file
  /lib/modules: kernel modules (separated by version)

- lsmod: list all kernel modules that have been loaded
- depmod: generate kernel module dependency file (modules.dep)
- modinfo: list information about a particular kernel module
- modprobe: load a kernel module (and its dependency)
- insmod, rmmod: manually load and unload kernel module

Initial ramdisk

- You might have seen this: initrd.tbz
- This is initial RAM disk (a disk in the memory)
- This is loaded before the root file system is mounted.
- Reason: some essential kernel modules might be needed for initial boot operation (storage, filesystem), but they are in /lib/modules
- Solution: load initrd, where these modules are stored.

Kernel Configuration

1. Modify tunable kernel configuration parameters

   - Parameters can be adjusted via hooks in /proc (procfs)

   - /proc/sys contains various special files for users to view and set kernel options

   - Try it:
     cat /proc/sys/fs/file-max
     (maximum number of files the system can open at once)
     sudo sh -c “echo <an integer> > /proc/sys/fs/file-max”

   - Note that the changes are not carried across reboots

When to upgrade the kernel?

- Resist the temptation to keep up with the latest version

- Weigh between needs & risks

- Good rule of thumb:
  Upgrade or apply patches only when expected productivity gains is larger than the effort to install.