CSCI 3411: Operating Systems

Acknowledgements: Some slide material derived from Silberschatz, et al.

Administrative Fun

- See course webpage (up tomorrow)!
- http://www.seas.gwu.edu/~gparmer/courses/f13_3411
- Forget the URL:
    - google “gabe parmer” or “gparmer”...first link
    - Go to the “courses” tab
    - Click: Fall '13 3411

Administrative Fun II

- Format of Class
  - Lecture
    - Concepts
    - Written HW/tests
  - Lab: Jiguo Song (jiguos@gwu.edu) – there is lab this week!
    - Implementation: C, Linux
    - Programming assignments & final project
- Book(s)
- Grading – hw, exams, **participation**
- Piazza (search for csci3411) – homework: signup now!
  - Good app
- Academic Honesty

Undergraduate Education

Why are you here???

- In college?
- In CS?
- In OS?

This Semester: Perspective

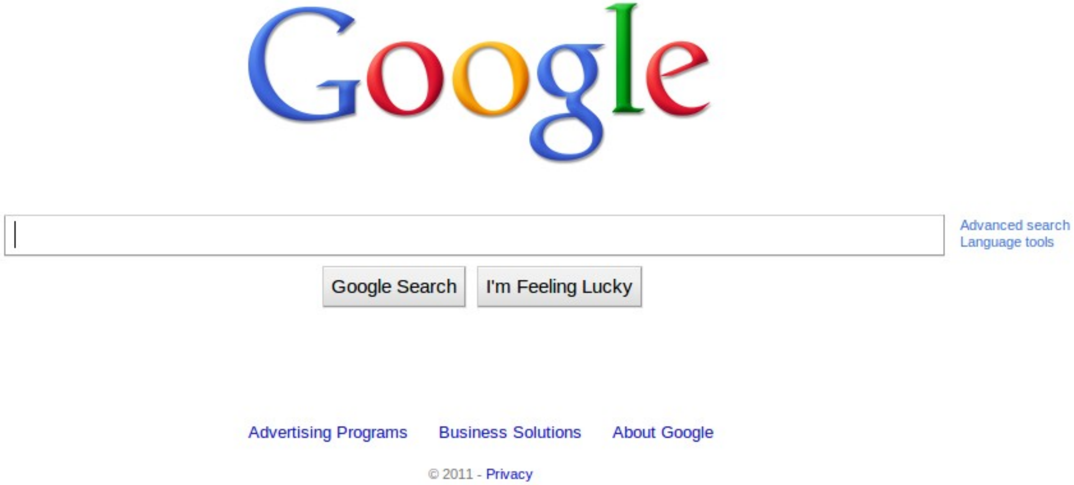
- You have at least 2 years under your belt.
- Undergraduate – a unique, *limited* opportunity
  - Learning for learning's sake
  - Constant intellectual progress

- Decision time
  - Are you here to get a degree and a job?
  - Are you here to improve as a human being?

This Semester: Perspective

- Question: If you kept on doing what you're doing, ***would you be happy with your undergraduate education***?
- This semester
  - challenging
  - opportunity
- *You can do more with your next two years*
  - **Take responsibility for your education**

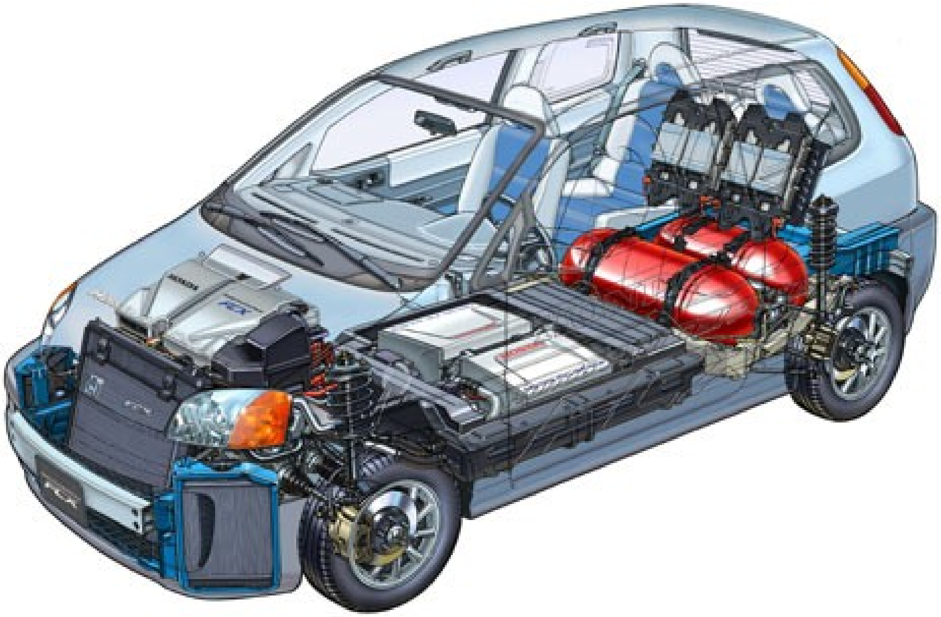
“High-level”



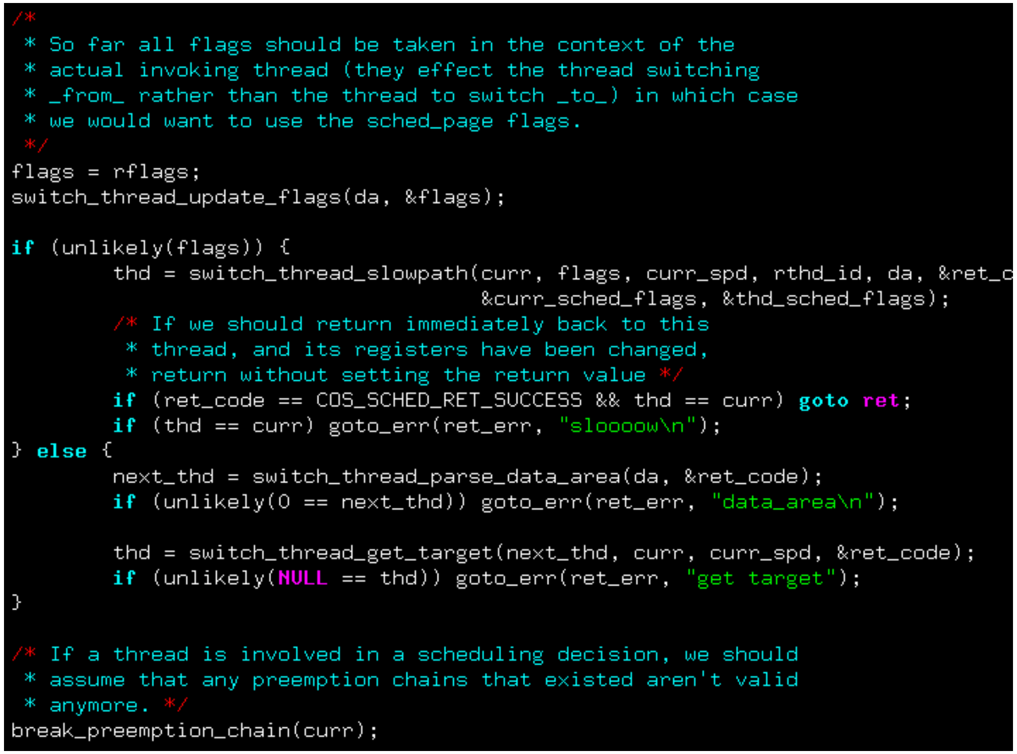
Cars

Computers

...details...



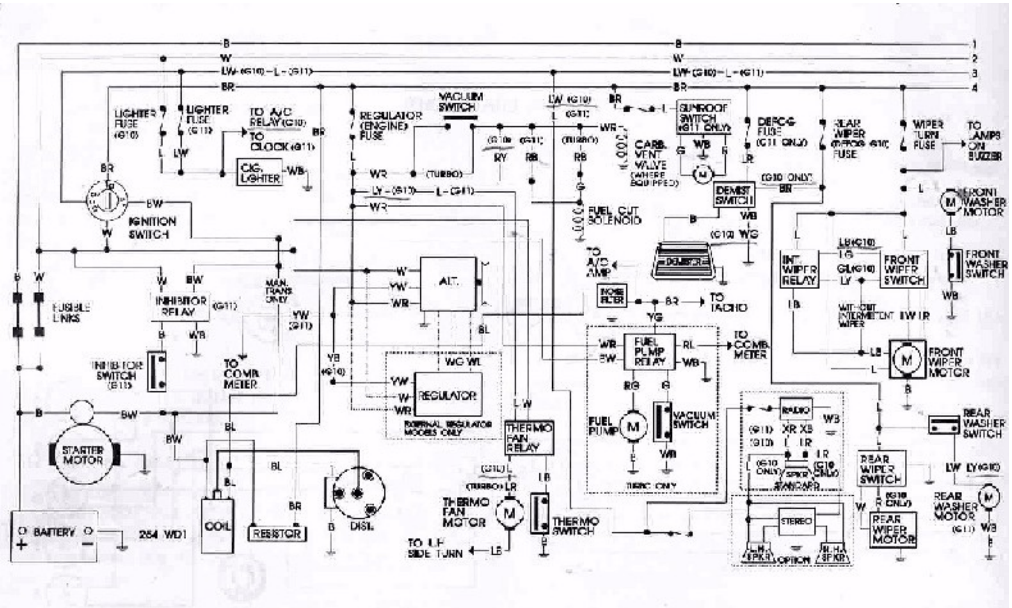
Cars



```
/*
 * So far all flags should be taken in the context of the
 * actual invoking thread (they effect the thread switching
 * _from_ rather than the thread to switch _to_) in which case
 * we would want to use the sched_page flags.
 */
flags = rflags;
switch_thread_update_flags(da, &flags);

if (unlikely(flags)) {
        thd = switch_thread_slowpath(curr, flags, curr_spd, rthd_id, da, &ret_c
                                     &curr_sched_flags, &thd_sched_flags);
        /* If we should return immediately back to this
         * thread, and its registers have been changed,
         * return without setting the return value */
        if (ret_code == COS_SCHED_RET_SUCCESS && thd == curr) goto ret;
        if (thd == curr) goto_err(ret_err, "slooooow\n");
} else {
        next_thd = switch_thread_parse_data_area(da, &ret_code);
        if (unlikely(0 == next_thd)) goto_err(ret_err, "data_area\n");

        thd = switch_thread_get_target(next_thd, curr, curr_spd, &ret_code);
        if (unlikely(NULL == thd)) goto_err(ret_err, "get target");
}

/* If a thread is involved in a scheduling decision, we should
 * assume that any preemption chains that existed aren't valid
 * anymore. */
break_preemption_chain(curr);
```

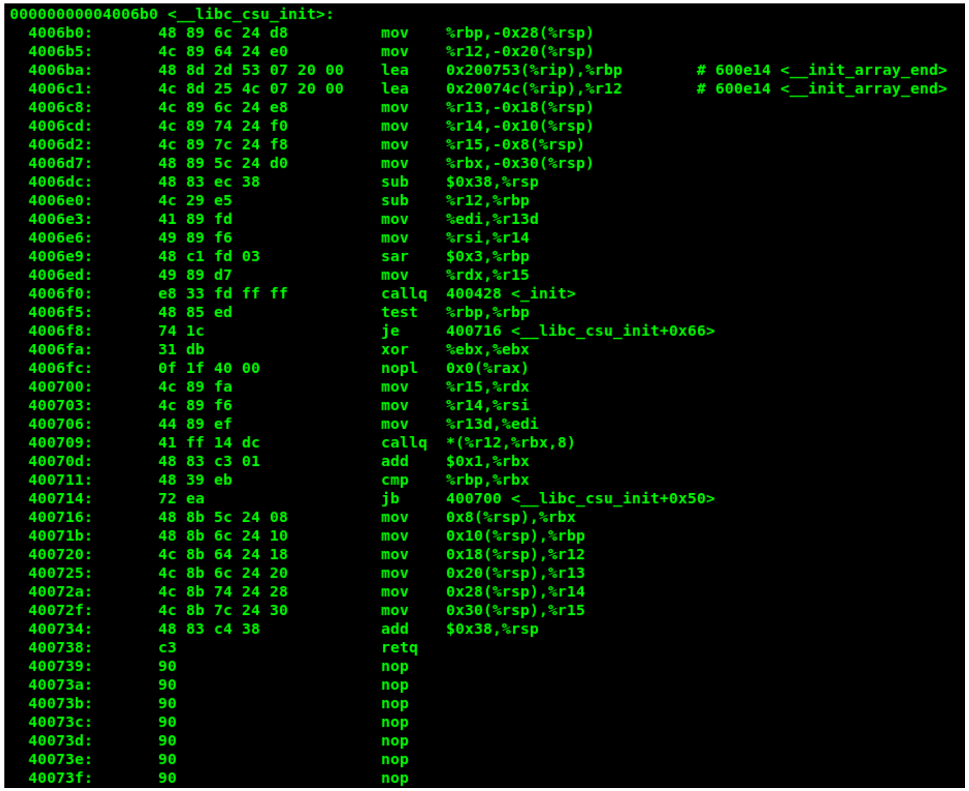
Computers

..."low-level"



Wiring diagram for the power supply, starting, charging, engine, front and rear wiper, cigarette lighter, sunroof (G11), sound system and rear demister systems. G10, G11 and G11 Turbo models.

Cars



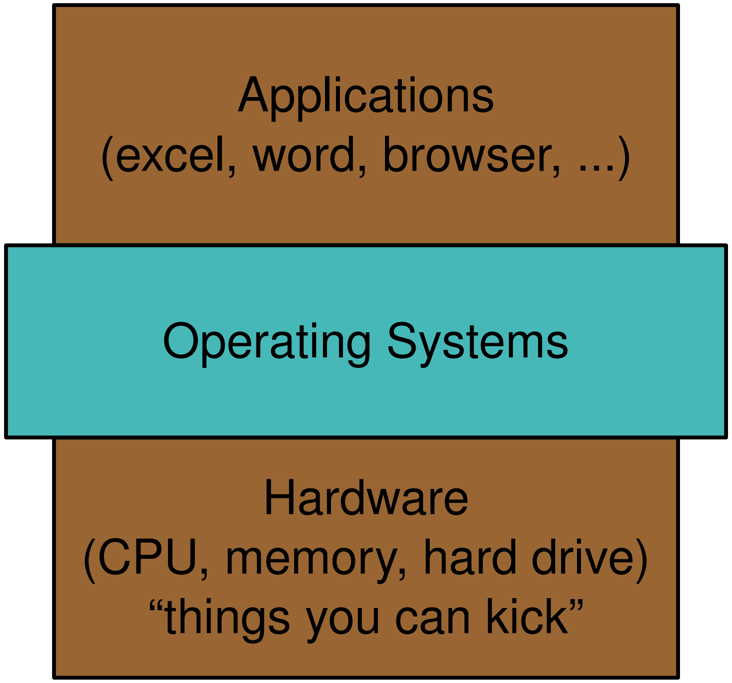
```
0000000000004006b0 <__libc_csu_init>:
  4006b0:       48 89 6c 24 d8          mov    %rbp,-0x28(%rsp)
  4006b5:       4c 89 64 24 e0          mov    %r12,-0x20(%rsp)
  4006ba:       48 8d 2d 53 07 20 00    lea    0x200753(%rip),%rbp        # 600e14 <__init_array_end>
  4006c1:       4c 8d 25 4c 07 20 00    lea    0x20074c(%rip),%r12        # 600e14 <__init_array_end>
  4006c8:       4c 89 6c 24 e8          mov    %r13,-0x18(%rsp)
  4006cd:       4c 89 74 24 f0          mov    %r14,-0x10(%rsp)
  4006d2:       4c 89 7c 24 f8          mov    %r15,-0x8(%rsp)
  4006d7:       48 89 5c 24 d0          mov    %rbx,-0x30(%rsp)
  4006dc:       48 83 ec 38             sub    $0x38,%rsp
  4006e0:       4c 29 e5                sub    %r12,%rbp
  4006e3:       41 89 fd                mov    %edi,%r13d
  4006e6:       49 89 f6                mov    %rsi,%r14
  4006e9:       48 c1 fd 03             sar    $0x3,%rbp
  4006ed:       49 89 d7                mov    %rdx,%r15
  4006f0:       e8 33 fd ff ff          callq  400428 <_init>
  4006f5:       48 85 ed                test   %rbp,%rbp
  4006f8:       74 1c                   je     400716 <__libc_csu_init+0x66>
  4006fa:       31 db                   xor    %ebx,%ebx
  4006fc:       0f 1f 40 00             nopl   0x0(%rax)
  400700:       4c 89 fa                mov    %r15,%rdx
  400703:       4c 89 f6                mov    %r14,%rsi
  400706:       44 89 ef                mov    %r13d,%edi
  400709:       41 ff 14 dc             callq  *(%r12,%rbx,8)
  40070d:       48 83 c3 01             add    $0x1,%rbx
  400711:       48 39 eb                cmp    %rbp,%rbx
  400714:       72 ea                   jb     400700 <__libc_csu_init+0x50>
  400716:       48 8b 5c 24 08          mov    0x8(%rsp),%rbx
  40071b:       48 8b 6c 24 10          mov    0x10(%rsp),%rbp
  400720:       4c 8b 64 24 18          mov    0x18(%rsp),%r12
  400725:       4c 8b 6c 24 20          mov    0x20(%rsp),%r13
  40072a:       4c 8b 74 24 28          mov    0x28(%rsp),%r14
  40072f:       4c 8b 7c 24 30          mov    0x30(%rsp),%r15
  400734:       48 83 c4 38             add    $0x38,%rsp
  400738:       c3                      retq
  400739:       90                      nop
  40073a:       90                      nop
  40073b:       90                      nop
  40073c:       90                      nop
  40073d:       90                      nop
  40073e:       90                      nop
  40073f:       90                      nop
```

Computers

What is an Operating System!?

?

What is an OS: Where is it?

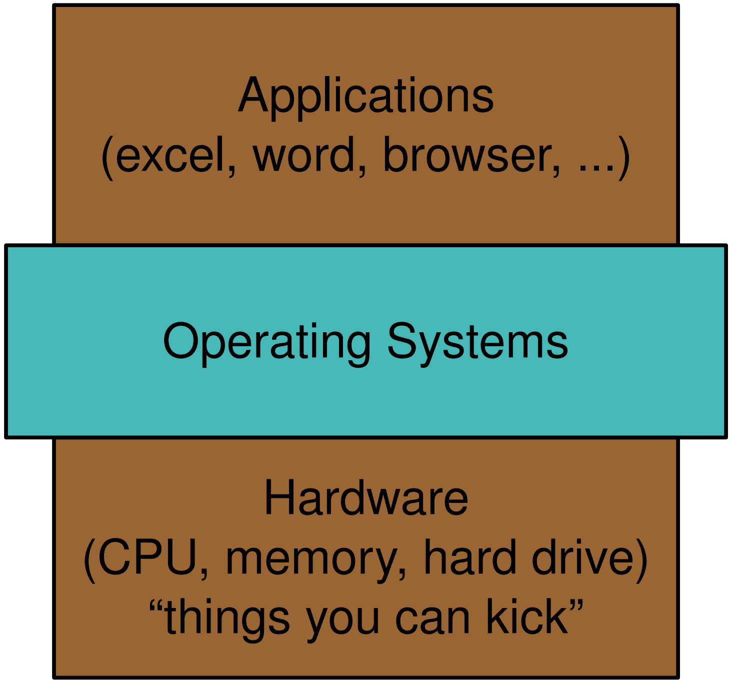


Applications
(excel, word, browser, ...)

Operating Systems

Hardware
(CPU, memory, hard drive)
“things you can kick”

What is an OS: Where is it?



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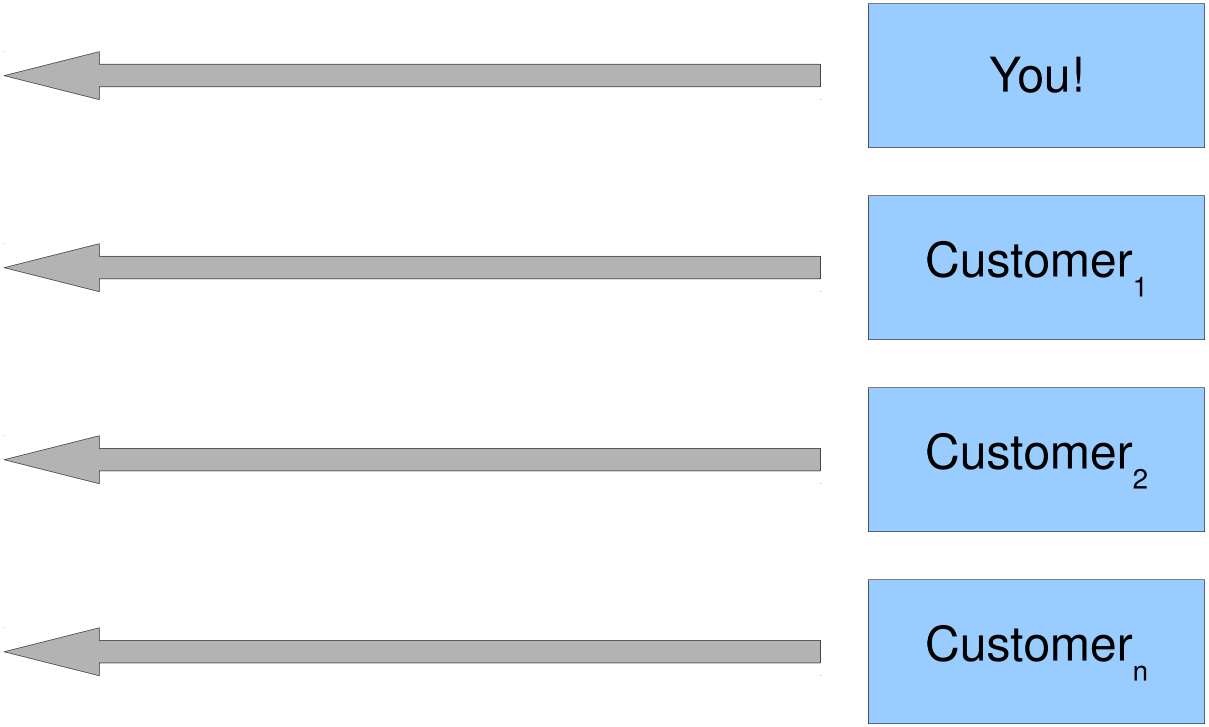
COURTESY: KFC

What is an OS: Analogy



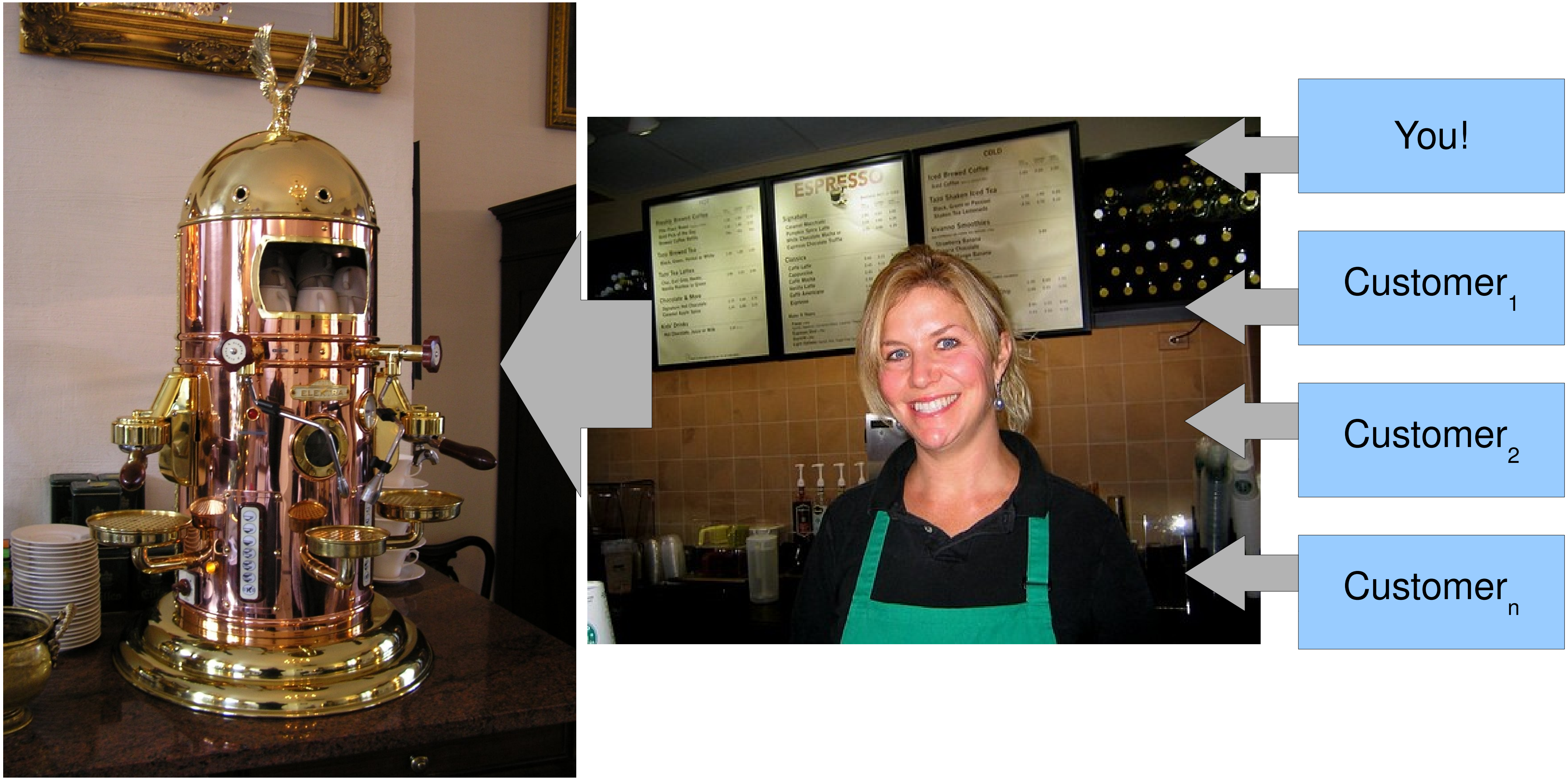
You!

Customer$_1$

Customer$_2$

Customer$_n$

What is an OS: Analogy



You!

Customer$_1$

Customer$_2$

Customer$_n$

What is an OS: Analogy

Hardware

Operating System

Applications

You!

Customer$_1$

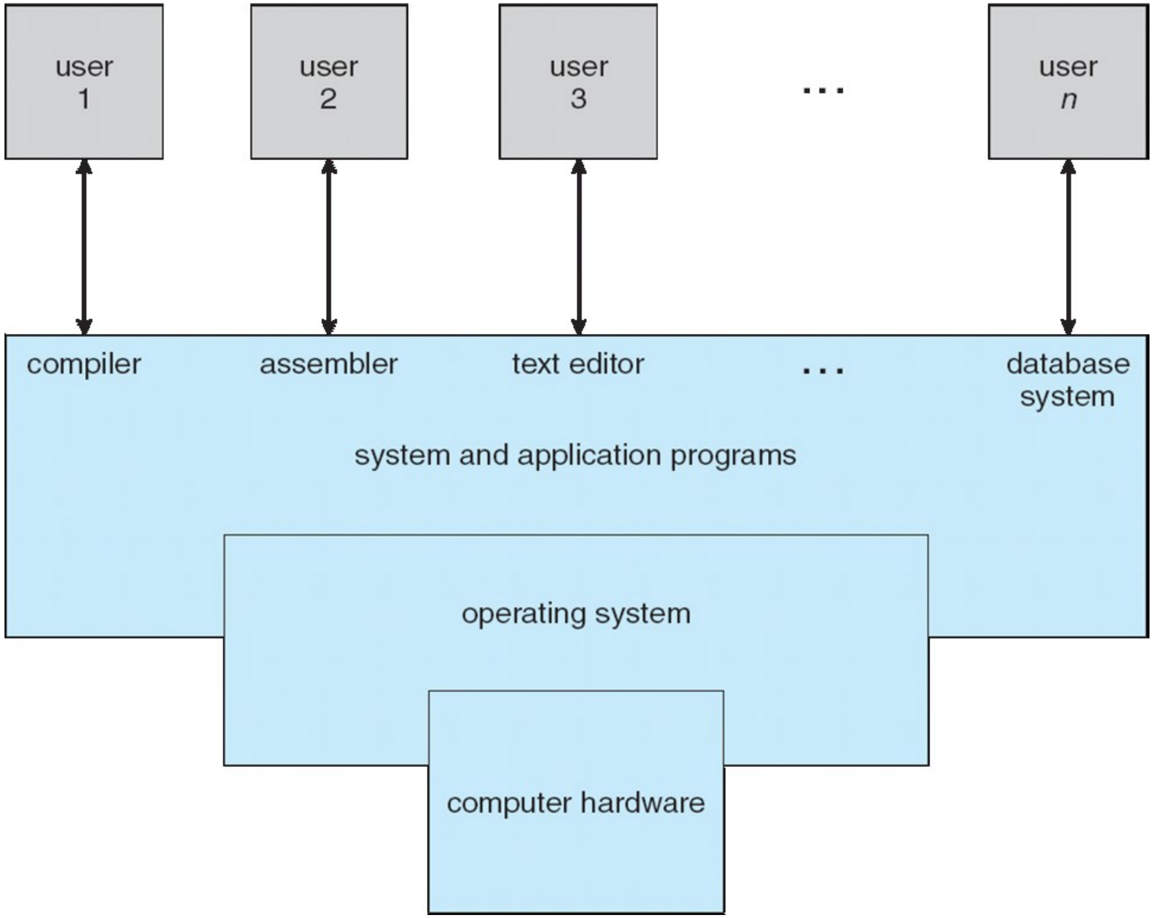
Customer$_2$

Customer$_n$

Operating System as Abstraction

- *"The effective exploitation of his powers of abstraction must be regarded as one of the most vital activities of a competent programmer."* - Edsger W. Dijkstra
- Abstractions for resources (memory, CPU, disk)
- Environment for application execution
  - Self-centered processes
- Aside: Edsger Dijkstra - Discipline in Thought

OS as Abstraction: System Layers

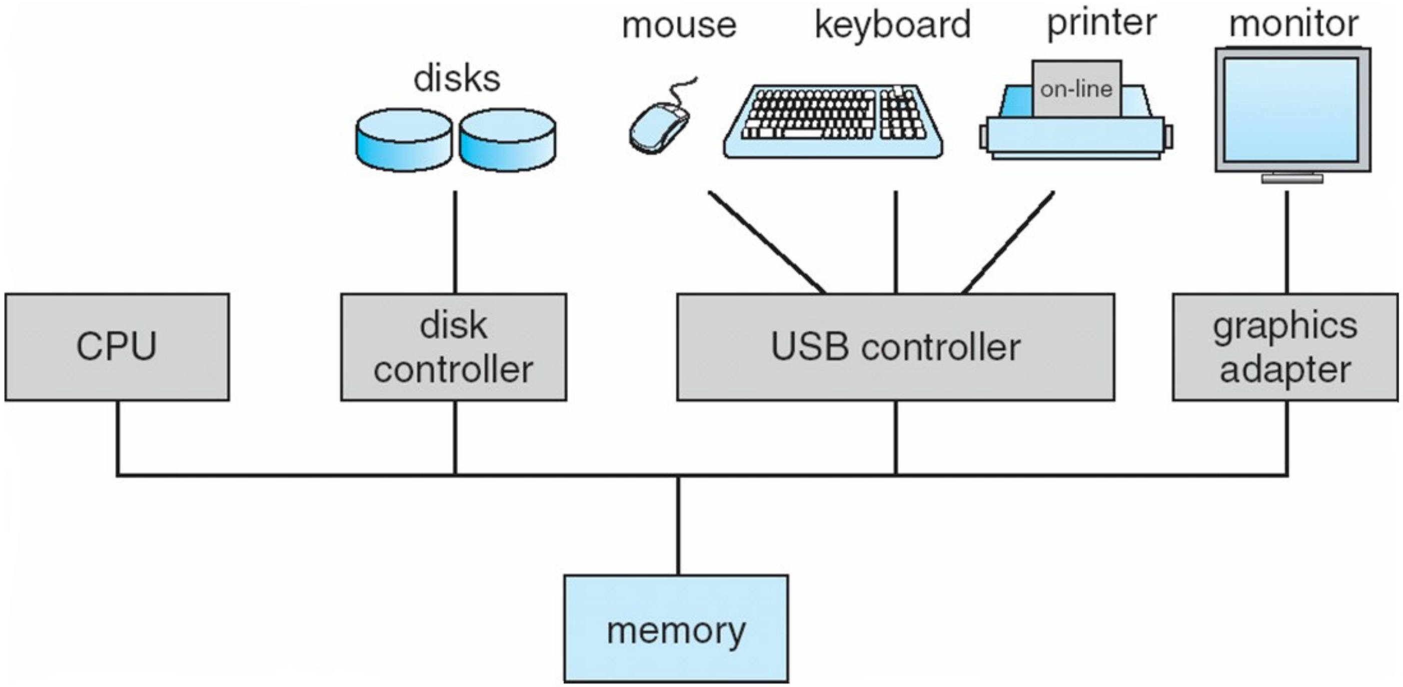


AN x64 PROCESSOR IS SCREAMING ALONG AT BILLIONS OF CYCLES PER SECOND TO RUN THE XNU KERNEL, WHICH IS FRANTICALLY WORKING THROUGH ALL THE POSIX-SPECIFIED ABSTRACTION TO CREATE THE DARWIN SYSTEM UNDERLYING OS X, WHICH IN TURN IS STRAINING ITSELF TO RUN FIREFOX AND ITS GECKO RENDERER, WHICH CREATES A FLASH OBJECT WHICH RENDERS DOZENS OF VIDEO FRAMES EVERY SECOND
BECAUSE I WANTED TO SEE A CAT JUMP INTO A BOX AND FALL OVER.
I AM A GOD.

Source: xkcd.com

Computers as Distributed Systems

“Hardware: The parts of a computer system that can be kicked.”
- Jeff Pesis



OS as Hardware Manager

- Control a diverse set of hardware
  - Processors
  - Memory
  - Disks
  - Networking cards
  - Video cards
- Coordinates these hardware resources amongst user programs
- OS as a *resource manager/multiplexer*

History, or How did we get were we are now?

- Bare metal
  - Life cycle:
    - Boot up
    - Run a single application
    - Output result
    - Power down

- *OS support for these systems???*

History: Batch Systems

- Goal: Maximize amount work done for multiple users
- Applications run one after the other
  - One application at a time!
- Application uses all computer resources
- *OS support for batch systems???*

History: Batch Multiprogramming

- Multiple applications in memory
- When one waits for I/O, another executes
    - Better utilization of CPU

- *OS support for these systems???*

History: Timesharing Systems

- Interactive use of computers
  - Responsiveness matters
  - Expect system to respond to keyboard input immediately
- Several users/applications can share computer
  - Share CPU, Disk, Memory...
- *OS support???*

Batch vs. Timesharing: Fight!

- Which is more efficient? Which gets more work done?

Batch vs. Timesharing: Fight!

- Which is more efficient? Which gets more work done?
  - Computer work: instructions processed per second
  - Human work: perform operations user requires

History: PCs, Servers, Mobile

- Iterations on timesharing systems
- PCs
  - Less emphasis initially on protection (argh!)
- Servers
  - Throughput oriented
- Mobile
  - Power consumption

iPhone vs. Android

- Original iPhone vs. Android
- Which paradigm does each fall into?

iPhone vs. Android

- Which paradigm does each fall into?

- Iphone: single user application running at any point in time
  - Back to the 70s
- Android: multiple applications concurrently execute
  - What happens when memory runs out?

Fundamental OS Concepts

- Abstraction
- Resource management (CPU, RAM, devices)
- Concurrency
- Parallelism
- Protection/Security
- Performance
  - Kernel doesn't **do** useful work, enables it

Course Objectives

- Explore core ideas in Operating Systems in two ways:
  1) understanding the concepts behind resource management, abstraction, and hardware interface
  2) practical coding experience with a real OS to understand the subtleties and challenges of systems

Why should you care about OSes!?

- Fundamentally: Understand what's going on under the hood
  - *"In theory, there is no difference between theory and practice.   But, in practice, there is."* - Jan L. A. van de Snepscheut/Yogi Berra
- The world runs on systems
  - Microsoft, VMWare, Google (Operating systems, virtual machines)
  - Google, Yahoo, Facebook, Twitter (distributed systems)
  - Boeing, NASA, BMW (embedded/distributed systems)
  - Financial firms (have to spend stimulus money on something!)
  - AppNexus (GWU staffed NYC startup focusing on systems)
- The world is concurrent!
- Industry feedback