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Administrivia

- (None.)

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What Is An Operating System? (Review)

- Definition by example:
 - Recent: Windows, Linux, UNIX, iOS, OS X (Mac), ...
 - Older: MULTICS, VMS, MVS, VM/370, ...
 - (Also special-purpose O/S's for special-purpose hardware — e.g., video-conferencing system.)
- Definition(s) from operating systems textbooks:
 - Something that provides “virtual machine” for application programs and users (“top down”).
 - Something that manages computer’s resources (“bottom up”).
- Another view — key part of bridging gap between what hardware can do (not much, but very fast) and what users want.

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What The Hardware Can Do

- CPU: fetch machine instruction from memory, execute; repeat.
- Disk: read data from / write data to location on disk.
- And so forth — very primitive.

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What The Software Must Do

- Programs students usually write in CS1, CS2:
 - Define and manipulate data structures.
 - Do arithmetic/logical calculations.
 - Read stdin / write stdout.
 - Call GUI/graphics library routines.
- The magic cloud (operating system):
 - Read from keyboard, write to screen.
 - Manage what's on screen — windows, taskbar, etc.
 - Run multiple applications “at the same time”.
 - Manage disk contents — files, directories/folders.
 - Share the machine with other users.

Why Review History?

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- To understand roots/development of current operating systems.
- As a way of getting many perspectives on “what do we want an O/S to do, and how do we make it do that?”
- Because history is intrinsically interesting? Try to imagine what using some of those early machines might have been like.
- (To allow the instructor to relive the days of his/her youth?)

The Early Days (1940s)

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- Programming done by making physical connections on a plugboard (!).
- Better than no computer at all, but tedious and inefficient!
- Example: the ENIAC (picture via “links” page).

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The Early Days (1940s – 1950s)

- Key improvements: stored-program concept, punch cards.
- Programming done by encoding machine language into cards.
- Program included code to start up computer, read rest of program into memory, do all input and output, etc. (no operating system).
- One program at a time, machine operated by programmer.
- Better, but still tedious and inefficient!

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The Early Days (1950s)

- Key improvements: assemblers and compilers, libraries of commonly-used code, specialists to run machine (operators).
- Programming done in assembly language (or early high-level language), punched into cards.
- Separate steps to translate to machine language, execute.
- One program at a time, but machine operated by specialist.
- Less tedious, less inefficient.
- Still cumbersome for programmers, CPU idle between steps.

Batch Systems (1950s)

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- Key improvement: “batch” idea — automate transitions between steps (translate program, execute, translate next program, etc.).
- How to make this work? separate input by “control cards”, write primitive operating system to interpret them, manage transitions.
- Less inefficient, but I/O devices slow, so CPU idle a lot — still one program at a time.
- Still cumbersome for programmers — punch program into cards, give to operator, wait for output.

Control Cards — Example

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```
//jobname JOB acctno,name, ....
//stepname EXEC PGM=compiler_name,PARM=(options)
//STEPLIB DD DSNAME=path_for_compiler
//SYSUT1 DD UNIT=SYSDA,SPACE=(subparms)
//SYSPRINT DD SYSOUT=A
//SYSLIN DD DSNAME=object_code,UNIT=SYSDA,
// DISP=(MOD,PASS),SPACE=(subparms)
//SYSIN DD *
source code
/*
//stepname EXEC PGM=load-and-go
....
.... input data for program ....
```

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Multiprogramming Systems (1960s – ?)

- Key improvement: “multiprogramming” — more than one program in memory, so when one has to wait another can run.
- How to make this work? requires much more complex operating system — must share memory and I/O devices among programs, switch between them, etc.
- Efficient use of hardware.
- Still cumbersome for programmers — no real changes here.
- Example: IBM mainframe (1964) and peripherals (pictures on “links” page).

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Timesharing Systems (1960s – ?)

- Key improvements: “interactive” users (using text terminals), utility programs to support them (shells, text editors, etc.).
- How to make this work? like multiprogramming, but now programs sharing memory are interactive users wanting fast response.
- Efficient use of hardware.
- Much less cumbersome for program development!
- Example: IBM terminal (picture on “links” page).

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Personal Computers (1980s – ?)

- Similar evolution of operating systems — initially very simple, gradually becoming more complex/capable.
- Features from mainframes adopted as hardware permitted.
- A key difference — emphasis on user convenience rather than efficient use of hardware.

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Evolution of Operating Systems, Recap

- Increasing hardware capability.
- Increasing O/S functionality and complexity — from simple program loader to complex multitasking system.
- Parallels between evolution of mainframe O/S and PC O/S. (Similar evolution may be happening with O/S for “smart phones”?)

Minute Essay

- What's the most primitive and/or cumbersome system you've personally used? (I mean system-as-a-whole here, not specific tools — a PC without a GUI, say, or a mainframe of some sort.)

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