Lecture 10: File systems

File systems, databases, cloud storage

- file: a sequence of bytes stored on a computer
  - content is arbitrary (just bytes); any structure is imposed by the creator of the file, not by the operating system
- file system: software that provides hierarchical storage and organization of files, usually on a single computer (or nearby)
  - a significant part of the operating system

- database: an integrated collection of logically related records
  - data is organized and structured for efficient systematic access
  - may be distributed across lots of machines & geographically dispersed
- database system: software that provides efficient access to information in a database
  - not usually part of the operating system

- cloud storage: the same thing, but on someone else's computer(s)

File systems: managing stored information

- logical structure: users and programs see a hierarchy of folders (or directories) and files
  - a folder contains references to folder and files
  - "root" folder ultimately leads to all others
  - a file is just a sequence of bytes
    contents determined and interpreted by programs, not the operating system
  - a folder is a special file that contains names of other folders & files
    plus other information like size, time of change, etc.
    contents are completely controlled by the operating system
- physical structure: disk drives operate in tracks, sectors, etc.
  - other storage devices have other physical properties
- the operating system converts between these two views
  - does whatever is necessary to maintain the file/folder illusion
  - hides physical details so that programs don't depend on them
  - presents a uniform interface to disparate physical media
- the "file system" is the part of the operating system that does this conversion

How the file system converts logical to physical

- disk is physically organized into sectors, or blocks of bytes
  - each sector is a fixed number of bytes, like 512 or 1024 or …)
  - reading and writing always happens in sector-sized blocks
- each file occupies an integral number of blocks
  - files never share a block
  - some space is wasted: a 1-byte file wastes all but 1 byte of the block

- if a file is bigger than one block, it occupies several blocks
  - the blocks are not necessarily adjacent on the disk
- need a way to keep track of the blocks that make up the file

- this is usually done by a separate "file allocation table" that lists the blocks that make up each file
  - this table is stored on disk too so it persists when machine is turned off
  - lots of ways to implement this

Converting logical to physical, continued

- every block is part of some file, or reserved by operating system, or unused

- "file allocation table" keeps track of blocks
  - by chaining/linking them together
    first block of a file points to second, second points to third, etc.
    last block doesn't point to a successor (because it doesn't have one)
  - or (much more common) by some kind of table or array
    that keeps track of related blocks

- also keeps track of unused blocks
  - disk starts out with most blocks unused ("free")
    some are reserved for file allocation table, etc.
  - as a file grows, blocks are removed from the unused list and attached to the list for the file:
    to grow a file, remove a block from the list of unused blocks
    and add it to the blocks for the file

Converting logical to physical: directories

- a directory / folder is a file
  - stored in the same file system
  - uses the same mechanisms
- but it contains information about other files and directories

- the directory entry for a file tells where to find the blocks

  IT DOES NOT CONTAIN THE DATA ITSELF

- the directory entry also contains other info about the file
  - name (e.g., midterm.doc)
  - size in bytes, date/time of changes, access permissions
  - whether it's an ordinary file or a directory

- the file system maintains the info in a directory
  - very important to keep directory info consistent
  - application programs can change it only indirectly / implicitly

Old-style directories

3565 Cawley, Robert Ralston, 1893-1973
.244

Unpathed waters; studies in the influence of the voyagers on Elizabethan literature.. Princeton, Princeton university press, 1940.
[illegible] 285 p. 23 cm.

30103 Downer, Alan Seymour, 1912-1970
.308

The art of the play; an anthology of nine plays.. New York, Holt [c1955]
451 p. illus. 24 cm.

NjP 40x

898304

HM219 **Niebuhr, Reinhold**, 1892-1971
.N55

Does civilization need religion? A study in the social resources and limitations of religion in modern life, by Reinhold Niebuhr. New York, The Macmillan company, 1929.

What happens when you say "Open"?

- search for file in sequence of directories as given by the components of its name
  - report and error if any component can't be found
- read blocks of file as needed
  - using the location information in the file allocation table to find the blocks
  - store some of them in RAM

What happens when you say "Save"?

- make sure there's enough space (enough unused blocks)
  - don't want to run out while copying from RAM to disk
- create a temporary file with no bytes in it
- copy the bytes from RAM and/or existing file to temporary file:

```
while (there are still bytes to be copied) {
    get a free block from the unused list
    copy bytes to it until it's full or there are no more bytes to copy
    link it in to the temporary file
}
```

- update the directory entry to point to the new file
- move the previous blocks (of old version) to the unused list
  - or to recycle bin / trash

What happens when you remove a file?

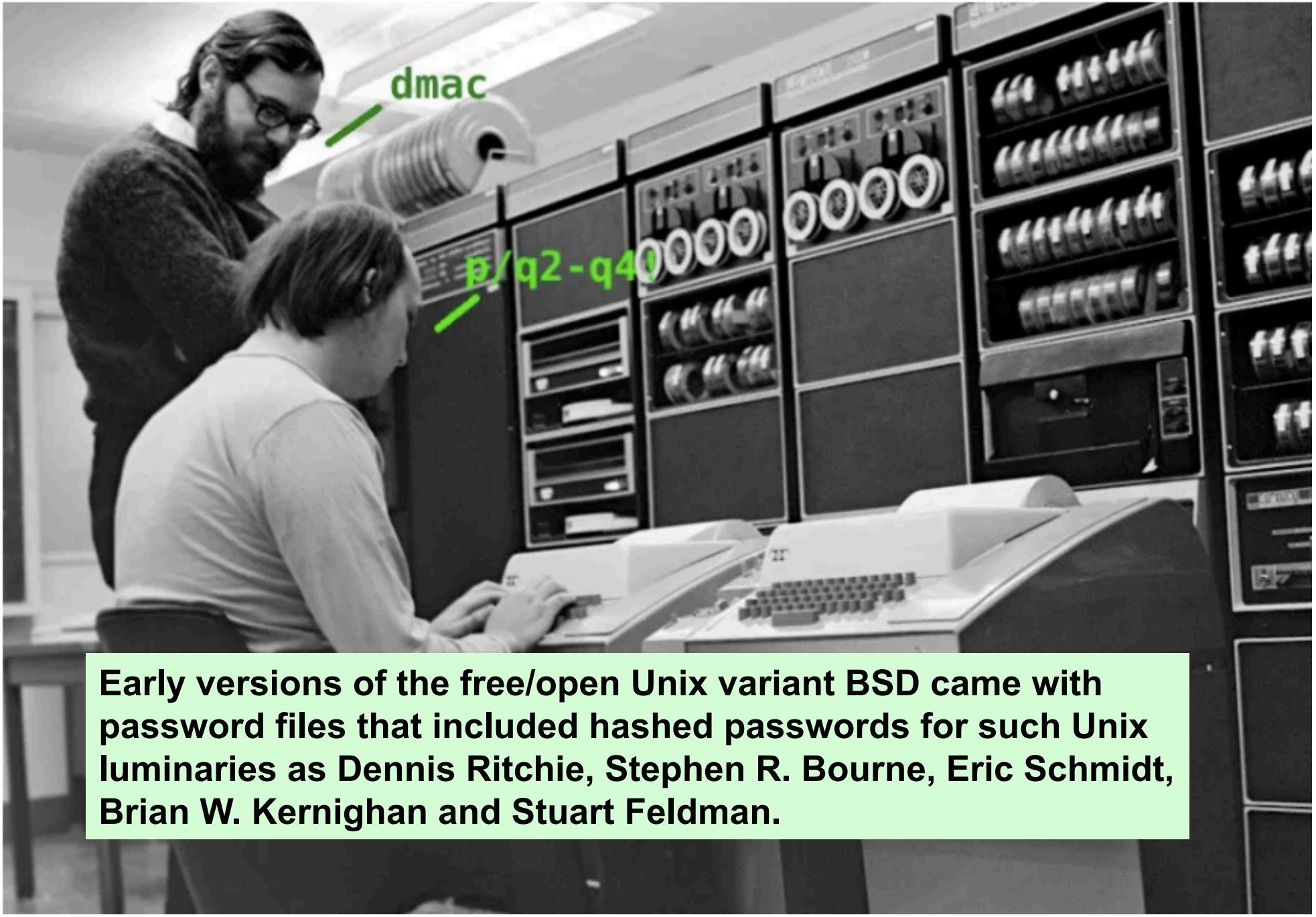
- move the blocks of the file to the unused list
- set the directory entry so it doesn't refer to any block
  - set it to zero, maybe

- recycle bin / trash
  - recycle bin or trash is just another directory
  - removing a file just puts the name, location info, etc., in that directory instead

- "emptying the trash" moves blocks into unused list
  - removes entry from Recycle / Trash directory

- why "removing" a file isn't enough
  - usually only changes a directory entry
  - often recoverable by simple guesses about directory entry contents
  - file contents are often still there even if directory entry is cleared

Computer historians crack passwords of Unix's early pioneers



Early versions of the free/open Unix variant BSD came with password files that included hashed passwords for such Unix luminaries as Dennis Ritchie, Stephen R. Bourne, Eric Schmidt, Brian W. Kernighan and Stuart Feldman.

Network file systems

- the file system doesn't have to be local
  - the data could be on some other computer

- need software for accessing remote files across networks
  - user programs access files and folders as if they are on the local machine
  - operating system converts these into requests to ship information to/from another machine across a network
- there has to be a program on the other end to respond to requests
  - "mapping a network drive" or "mounting your H: drive" sets up the connections

- subsequent reads and writes go through the network instead of the local disk

Cloud storage

- the file system doesn't have to be local
  - the data could be on some other computer

- need software for accessing remote files across networks
  - user programs access files and folders as if they are on the local machine
  - operating system converts these into requests to ship information to/from another machine across a network
- there has to be a program on the other end to respond to requests
  - connecting to Google Drive or Dropbox or iCloud or ... sets up the connections

- subsequent reads and writes go through the network instead of the local disk

Cloud computing

- put data on computers that are somewhere else
  - not on your laptop
  - access it via the Internet

- do (most of) the actual computing on computers that are somewhere else
  - not on your laptop
  - but owned by someone else
  - use the Internet to connect to the programs and the data

- Amazon Web Services, Google Cloud Platform, Microsoft Azure, ...
  - can rent processors, operating systems, data storage, ...
  - scales easily, easier to administer,
- relies on virtual machines
  - gives users the appearance of having their own hardware and systems

Browser as operating system

- a browser provides many of the services that an operating system does
  - can use "the cloud" for storage and computation
  - programs mostly run in cloud; browser is an interface
  - email, social networks, games, Google docs (and similar), ...
- how about a *computer* that only runs a browser?
  - Chromebook: runs Chrome OS (Linux-based operating system)
  - applications and data are in the cloud, not on computer itself
  - very little local storage and local apps

Samsung XE303C12 11.6" Chromebook, Samsung Exynos 5250 Dual Core, 16GB Solid State Drive, 2GB DDR3L, 2x2 802.11n, USB 3.0, HDMI, ChromeOS - (Scratch & Dent)

$99.99

This product has not been reviewed yet.

Condition Refurbished - Scratch & Dent

Screen Size 11.6"

Quantity 1 Limit 10 per customer

Shipping **Standard** - Estimated delivery Oct 17 - Oct 23
Free Standard shipping for Prime members