Operating Systems

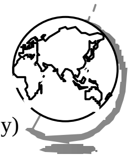
File Systems (in a Day)
Ch 10 - 11

Outline

- ✦ Files ¬
- ✦ Directories
- ✦ Disk space management
- ✦ Misc

File Systems

- ✦ Abstraction to disk (convenience)
  - – “The only thing friendly about a disk is that it has persistent storage.”
  - – Devices may be different: tape, IDE/SCSI, NFS
- ✦ Users
  - – don’t care about detail
  - – care about interface
- ✦ OS
  - – cares about implementation (efficiency)



File System Concepts

- ✦ *Files* - store the data
- ✦ *Directories* - organize files
- ✦ *Partitions* - separate collections of directories (also called “volumes”)
  - – all directory information kept in partition
  - – `mount` file system to access
- ✦ *Protection* - allow/restrict access for files, directories, partitions

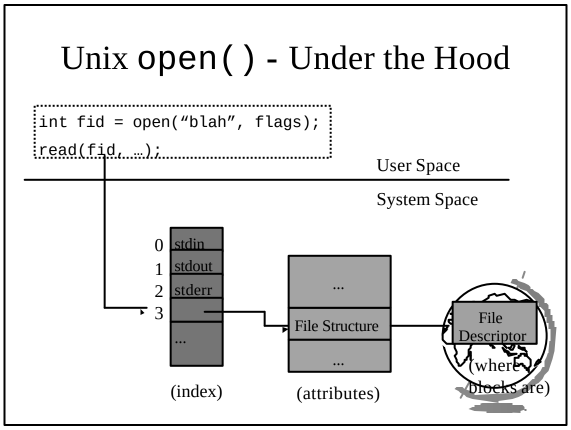
Files: The User’s Point of View

- ✦ Naming: how do I refer to it?
  - – blah, BLAH, Blah
  - – file.c, file.com
- ✦ API: how do I access it?
  - – `open()`
  - – `read()`
  - – `write()`

Example: Unix `open()`

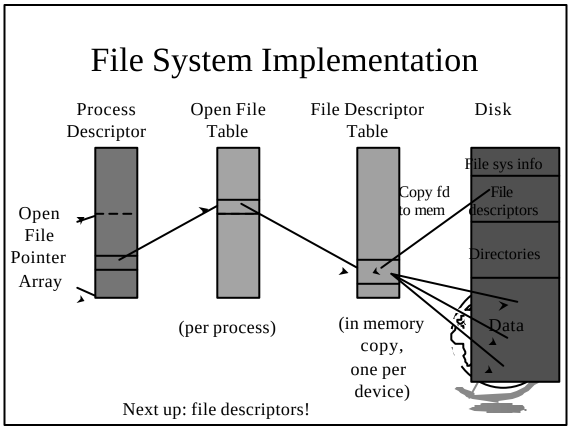
```
int open(char *path, int flags [, int mode])
```

- ✦ `path` is name of file
- ✦ `flags` is bitmap to set switch
  - – O_RDONLY, O_WRONLY…
  - – O_CREATE then use `mode` for perms
- ✦ success, returns index



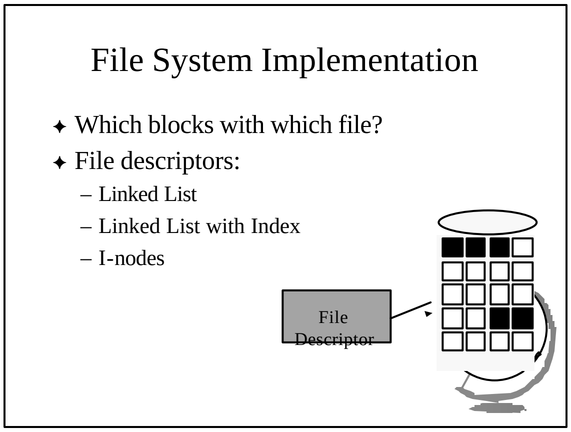
Unix `open()` - Under the Hood

```
int fid = open("blah", flags);
read(fid, …);
```



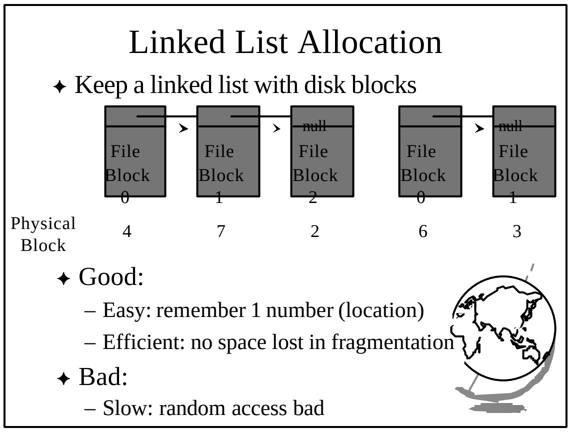
File System Implementation

Next up: file descriptors!



File System Implementation

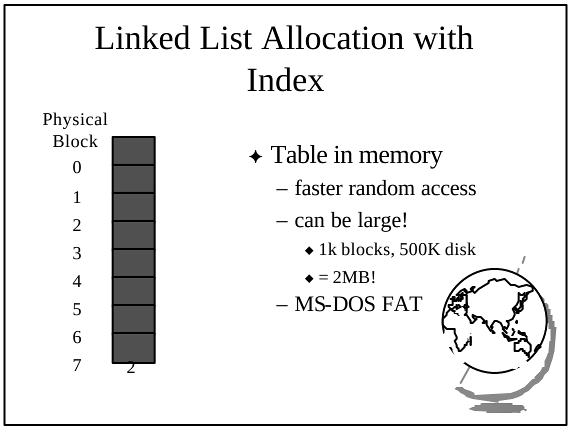
- ✦ Which blocks with which file?
- ✦ File descriptors:
  - – Linked List
  - – Linked List with Index
  - – I-nodes



Linked List Allocation

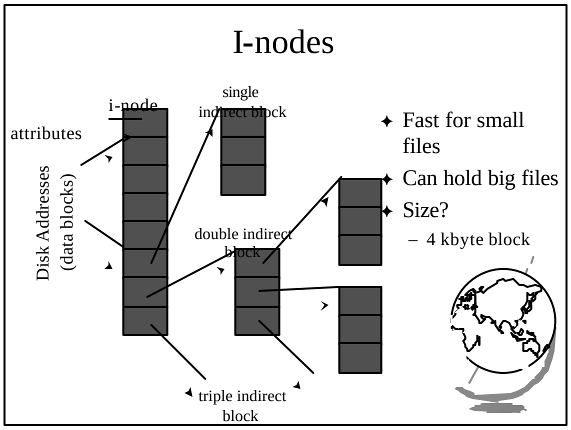
- ✦ Keep a linked list with disk blocks

- ✦ Good:
  - – Easy: remember 1 number (location)
  - – Efficient: no space lost in fragmentation
- ✦ Bad:
  - – Slow: random access bad



Linked List Allocation with Index

- ✦ Table in memory
  - – faster random access
  - – can be large!
    - ◆ 1k blocks, 500K disk
    - ◆ = 2MB!
  - – MS-DOS FAT



I-nodes

- ✦ Fast for small files
- ✦ Can hold big files
- ✦ Size?
  - – 4 kbyte block

Outline

- ✦ Files ✓
- ✦ Directories ¬
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Directories

- ✦ Just like files, only have special bit set so you cannot modify them
- ✦ Data in directory Maps File name to File descriptor
- ✦ Tree structure directory the most flexible
  - – aliases allow files to appear at more than one location

Directories

- ✦ Before reading file, must be opened
- ✦ Directory entry provides information to get blocks
  - – disk location (block, address)
  - – i-node number
- ✦ Map `ascii` name to the *file descriptor*

Hierarchical Directory (Unix)

- ✦ Tree
- ✦ Entry:
  - – name
  - – inode number
- ✦ example:

`/usr/bob/mbox`

inode	name

Hierarchical Directory (Win/FAT)

- ✦ Tree
- ✦ Entry:
  - – name
  - – type (extension)
  - – time
  - - date
  - - block number (w/FAT)

name	type	attrib	time	date	block	size

Outline

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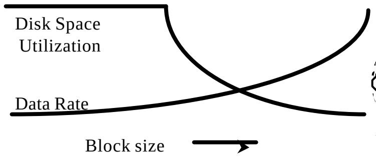
Disk Space Management

- *n* bytes
  - – contiguous
  - – blocks
- Similarities with memory management
  - – contiguous is like segmentation
    - but moving on disk very slow!
    - so use blocks
  - – blocks are like paging
    - how to choose block size?

Choosing Block Size

- Large blocks
  - – wasted space (internal fragmentation)
- Small blocks
  - – more seek time since more blocks



Keeping Track of Free Blocks

- Two methods
  - – linked list of disk blocks
    - one per block or many per block
  - – bitmap of disk blocks

(note, these are stored on the disk)

- Linked List of Free Blocks (many per block)
  - – 1K block, 16 bit disk block number
    - = 511 free blocks/block
    - 200 MB disk needs 400 blocks = 400k
- Bit Map
    - 200 MB disk needs 20 Mbits
    - 30 blocks = 30 K
    - 1 bit vs. 16 bits

Tradeoffs

- Only if the disk is nearly full does linked list scheme require fewer blocks
- If enough RAM, bitmap method preferred
- If only 1 “block” of RAM, and disk is full, bitmap method may be inefficient since have to load multiple blocks
  - – linked list can take first in line

File System Performance

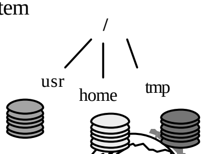
- Disk access 100,000x slower than memory
  - – reduce number of disk accesses needed!
- Block/buffer cache
  - – cache to memory
- Full cache? FIFO, LRU, 2nd chance …
  - – exact LRU can be done
- LRU inappropriate sometimes
  - – crash w/i-node can lead to inconsistent state
  - – some rarely referenced (double indirect block)

Outline

- Files ✓
- Directories ✓
- Disk space management ✓
- Misc ¬
  - – partitions (`fdisk, mount`)
  - – maintenance
  - – quotas
  - – Linux
  - – WinNT

Partitions

- `mount`, `unmount`
  - load “super-block”
  - pick “access point” in file-system
- Super-block
  - file system type
  - block Size
  - free blocks
  - free inodes



Partitions: `fdisk`

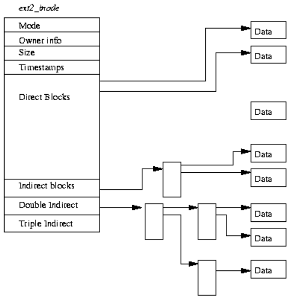
- Partition is large group of sectors allocated for a specific purpose
  - IDE disks limited to 4 physical partitions
  - logical partition inside physical partition
- Specify number of sectors to use
- Specify type
  - magic number recognized by OS

File System Maintenance

- Format:
  - create file system structure: super block, inodes
  - `format` (Win), `mke2fs` (Linux)
- “Bad blocks”
  - most disks have some
  - `scandisk` (Win) or `badblocks` (Linux)
  - add to “bad-blocks” list (file system can ignore)
- Defragment
  - arrange blocks efficiently
- Scanning (when system crashes)
  - lost+found, correcting file descriptors...

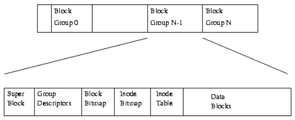
Linux Filesystem: ext2fs

- “Extended (from minix) file system vers 2”
- Uses inodes
  - *mode* for file, directory, symbolic link ...



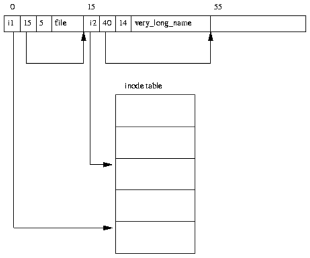
Linux filesystem: blocks

- Default is 1 Kb blocks
  - small!
- For higher performance
  - performs I/O in chunks (reduce requests)
  - clusters adjacent requests (block *groups*)
- Group has:
  - bit-map of free blocks and inodes
  - copy of super block



Linux Filesystem: directories

- Special file with names and inodes


0
15
55
i1
15
5
file
i2
40
14
very_long_name
inode table