CS 134:
Operating Systems
Disk Deja-vu

2013-05-17

CS34


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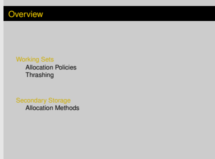
Operating Systems
Disk Deja-vu

Overview

- Working Sets
  - Allocation Policies
  - Thrashing
- Secondary Storage
  - Allocation Methods

└Overview



Overview

Working Sets
Allocation Policies
Thrashing

Secondary Storage
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Enough Frames?

How do you know if you have enough frames to work with. . . ?

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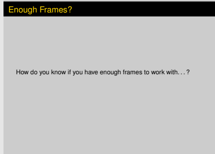
└Working Sets
  └Enough Frames?



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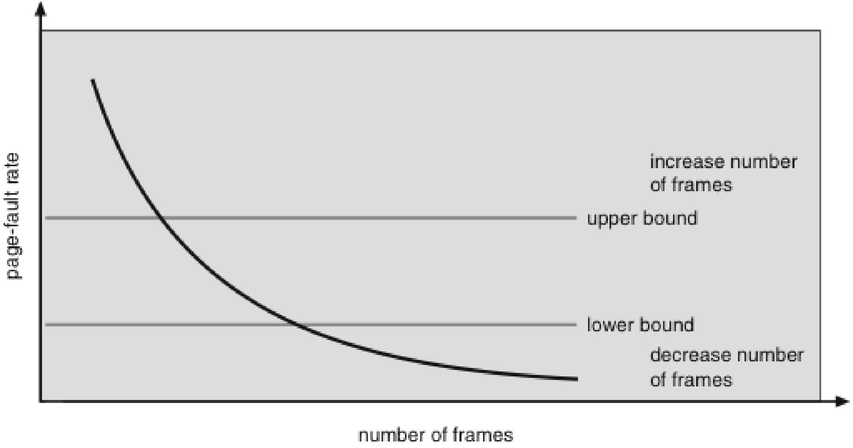
Working Sets

With fewer pages, page fault rate rises.

- If a process “almost always” page faults, it needs more frames
- If a process “almost never” page faults, it has spare frames



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└Working Sets
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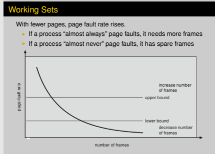
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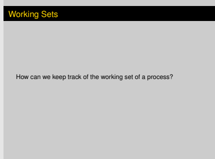
Working Sets

How can we keep track of the working set of a process?



Working Sets

How can we keep track of the working set of a process?

Formal definition is “pages referenced in last *k* accesses.” Close approximation is “pages referenced in last *n* ms.” Note that this is pretty close to what the CLOCK algorithm does, except that other processes can interfere. Which leads to…

Local vs. Global

Whose pages do we take?

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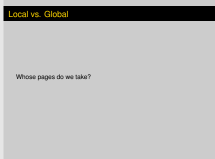
- Working Sets
  - Allocation Policies
    - Local vs. Global



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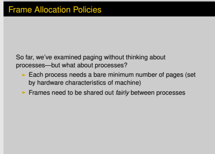
Frame Allocation Policies

So far, we've examined paging without thinking about processes—but what about processes?

- Each process needs a bare minimum number of pages (set by hardware characteristics of machine)
- Frames need to be shared out *fairly* between processes



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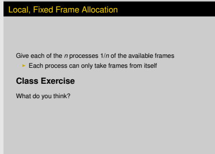
Give each of the n processes $1/n$ of the available frames

- Each process can only take frames from itself

Class Exercise

What do you think?



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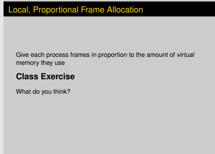


Local, Proportional Frame Allocation

Give each process frames in proportion to the amount of *virtual* memory they use

Class Exercise

What do you think?

- Some processes use a lot of VM, but don’t access it often
- Some processes use a little VM, but access it often
- Not fair

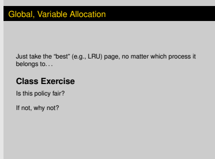
Global, Variable Allocation

Just take the “best” (e.g., LRU) page, no matter which process it belongs to. . .

Class Exercise

Is this policy fair?

If not, why not?



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- Use *working set* measurements to adjust frame allocation from time to time.
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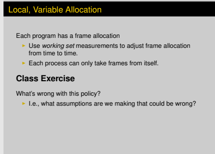
What's wrong with this policy?

- I.e., what assumptions are we making that could be wrong?



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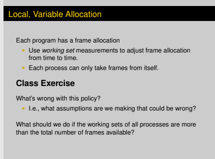

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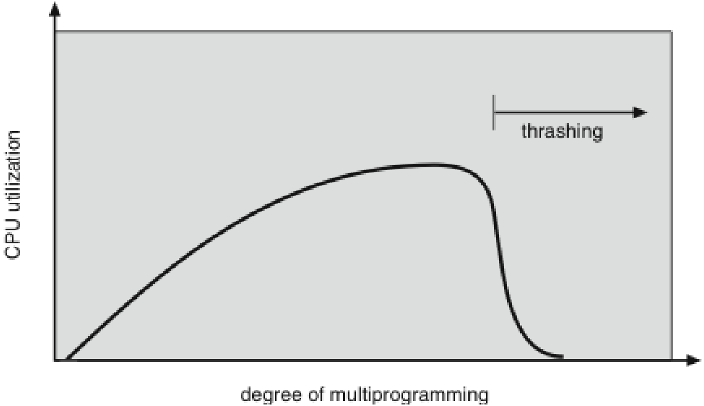
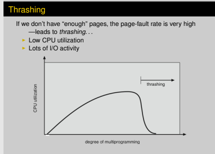
If we don’t have “enough” pages, the page-fault rate is very high —leads to *thrashing*. . .

- Low CPU utilization
- Lots of I/O activity

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- Can detect and swap out until can give bigger working set
- If can't give big enough, might want to kill. . .

Under global replacement policy, whole machine can be brought to its knees!

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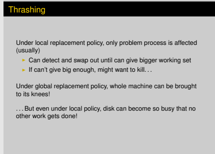

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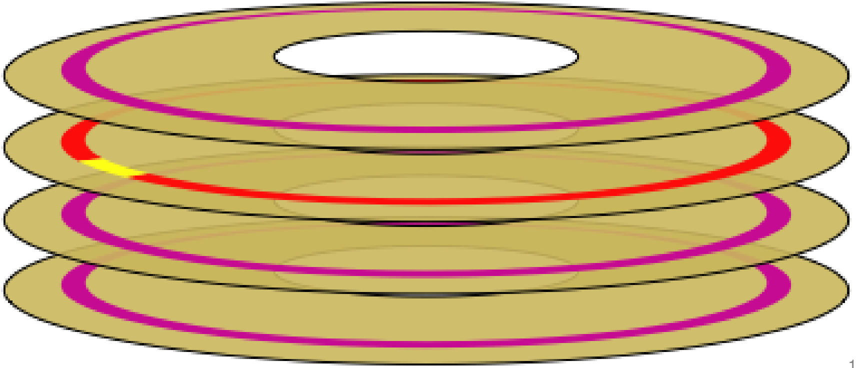
Secondary Storage

I.e., Storing stuff on disk, SSD, or network—why?

Class Exercise

What properties does disk have that differentiate it from RAM?

What properties are similar?



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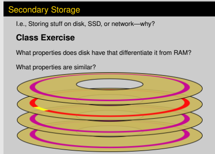

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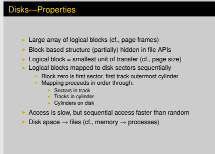
Disks—Properties

- Large array of logical blocks (cf., page frames)
- Block-based structure (partially) hidden in file APIs
- Logical block = smallest unit of transfer (cf., page size)
- Logical blocks mapped to disk sectors sequentially
  - Block zero is first sector, first track outermost cylinder
  - Mapping proceeds in order through:
    - Sectors in track
    - Tracks in cylinder
    - Cylinders on disk
- Access is slow, but sequential access faster than random
- Disk space → files (cf., memory → processes)



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Like giving all memory to one process

- Entire disk used for one “file”
- File is seen as big stream of bytes
- Usually fixed size, writes overwrite old data
- To read data at position *p*,
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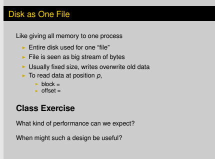
What kind of performance can we expect?

When might such a design be useful?



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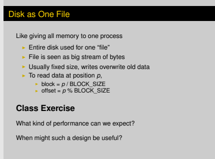

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Pretty much the same…

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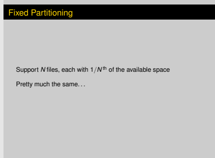

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More than one file per disk; all space per file is contiguous

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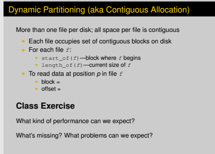

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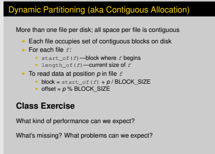

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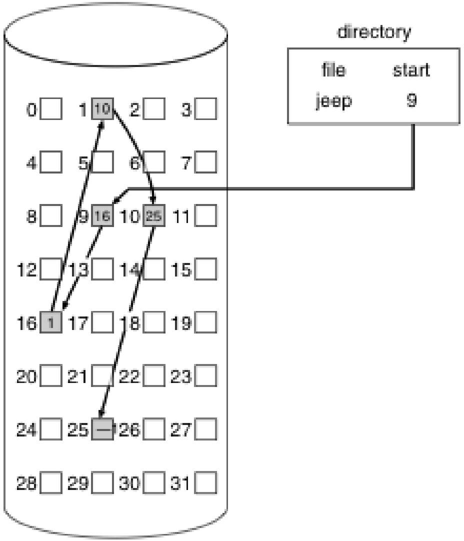

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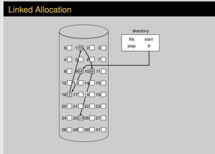

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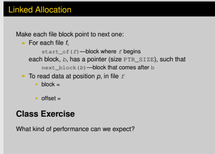

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  - block = `find_block(start_of(f),`
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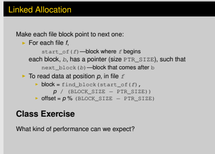

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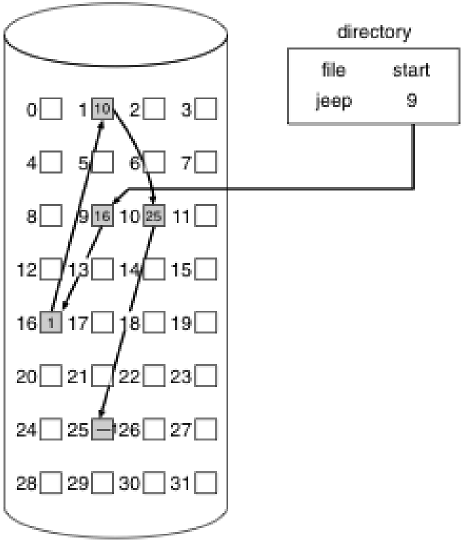

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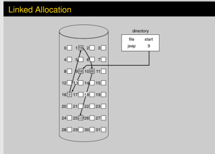

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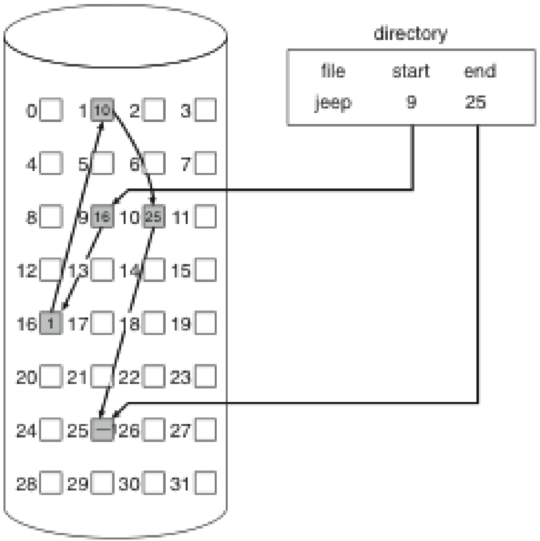

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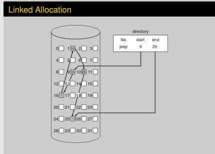

Adding an end pointer makes appends much cheaper.

File Allocation Table

Make each block in an array (`fat`) point to the next one block in file

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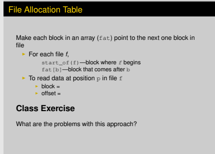

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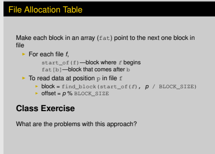

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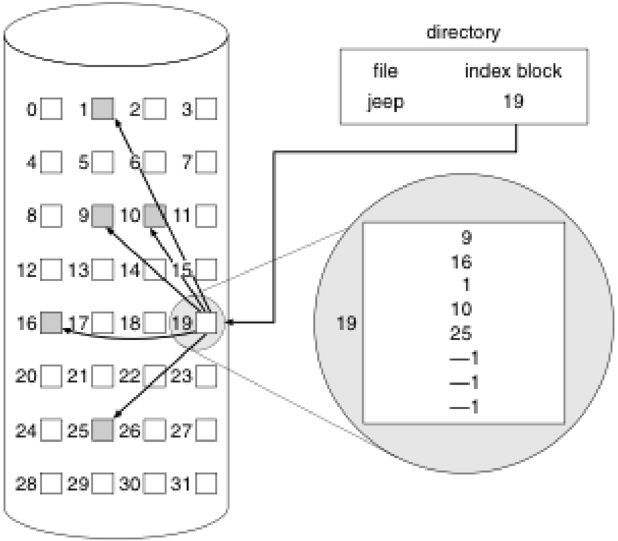

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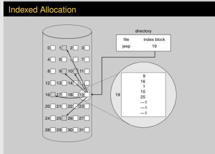
  └Allocation Methods
    └Indexed Allocation



Indexed Allocation

Bring all pointers together in an index block (cf., page table)

- For each file *f*,

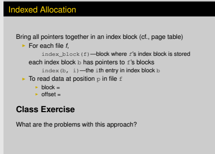
  `index_block(f)`—block where `f`'s index block is stored

  each index block `b` has pointers to `f`'s blocks

  `index(b, i)`—the `i`th entry in index block `b`
- To read data at position `p` in file `f`
  - block =
  - offset =

Class Exercise

What are the problems with this approach?



Random and sequential access are okay; you have dynamic access without external fragmentation. But the index block is overhead, and limits on the size of the index block also limit the sizes of files.

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  - offset = *p* % `BLOCK_SIZE`

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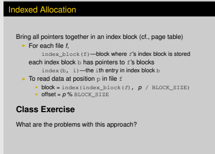

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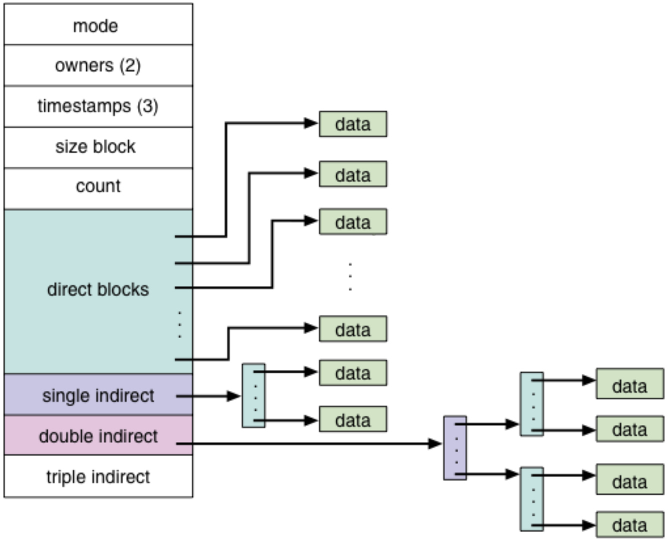
Combined Indexing



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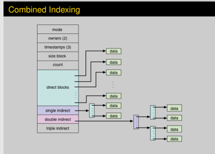
CS34
└Secondary Storage
  └Allocation Methods
    └Combined Indexing



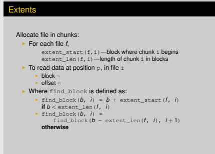
This has long been the standard in Unix-like systems. But it's not the only way!

Extents

Allocate file in chunks:

- For each file *f*,

  `extent_start(f,i)`—block where chunk `i` begins
  `extent_len(f,i)`—length of chunk `i` in blocks
- To read data at position `p`, in file `f`
  - block =
  - offset =
- Where `find_block` is defined as:
  - `find_block(`b`, `i`) = `b` + extent_start(`f`, `i`)` **if** $b <$ `extent_len(`f`, `i`)`
  - `find_block(`b`, `i`) =`
    `find_block(`b` - extent_len(`f`, `i`), `$i+1$`)`
    otherwise



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  - block = $\texttt{find\_block}(p\ /\ \texttt{BLOCK\_SIZE},\ 0)$
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  - $\texttt{find\_block}(b,\ i) = b + \texttt{extent\_start}(f,\ i)$ **if** $b < \texttt{extent\_len}(f,\ i)$
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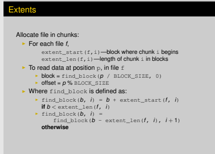
CS34
└ Secondary Storage
  └ Allocation Methods
    └ Extents



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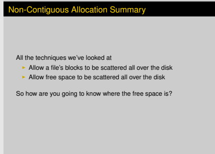
Non-Contiguous Allocation Summary

All the techniques we've looked at

- Allow a file's blocks to be scattered all over the disk
- Allow free space to be scattered all over the disk

So how are you going to know where the free space is?



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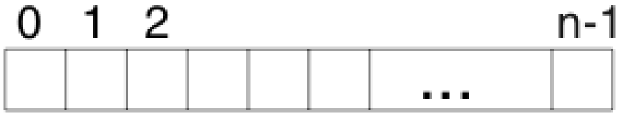
Desirable properties:

- Try to locate the file (or large pieces of the file) in the same region of the disk
  - Requires enough free space to be able to pick a region of the disk that has chunks of space free
- Minimize head movement

Free-Space Management—Bit Vector

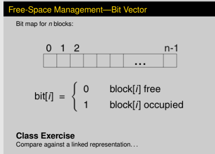
Bit map for *n* blocks:



$$\text{bit}[i] = \begin{cases} 0 & \text{block}[i] \text{ free} \\ 1 & \text{block}[i] \text{ occupied} \end{cases}$$

Class Exercise

Compare against a linked representation…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