- [x] 1. Last time
- [x] 2. Cooperative multithreading (⇒ user-level threading)
- [x] 3. Preemptive multithreading
- [ ] 4. Disks
- [ ] 5. File systems

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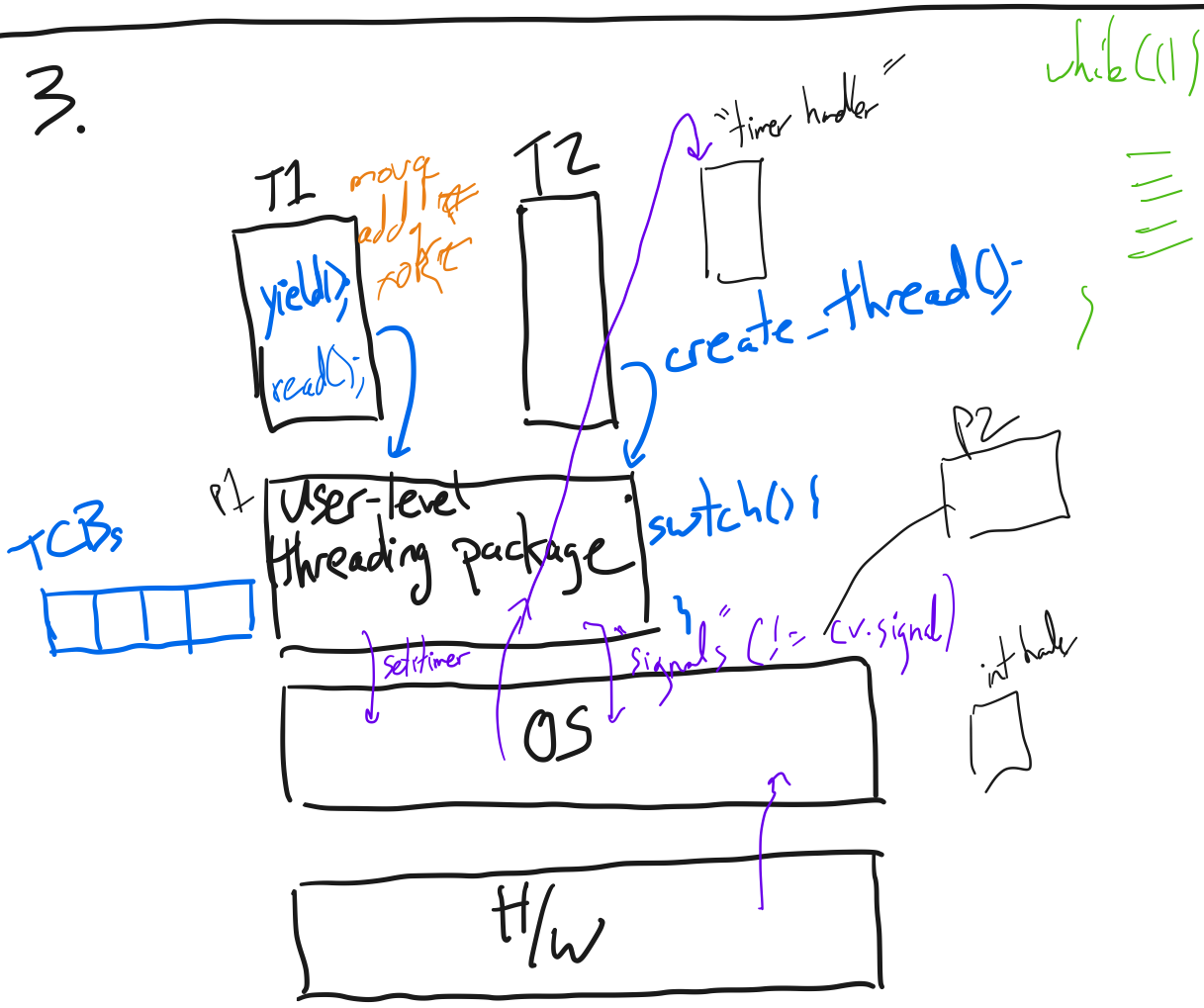
2. and 3.



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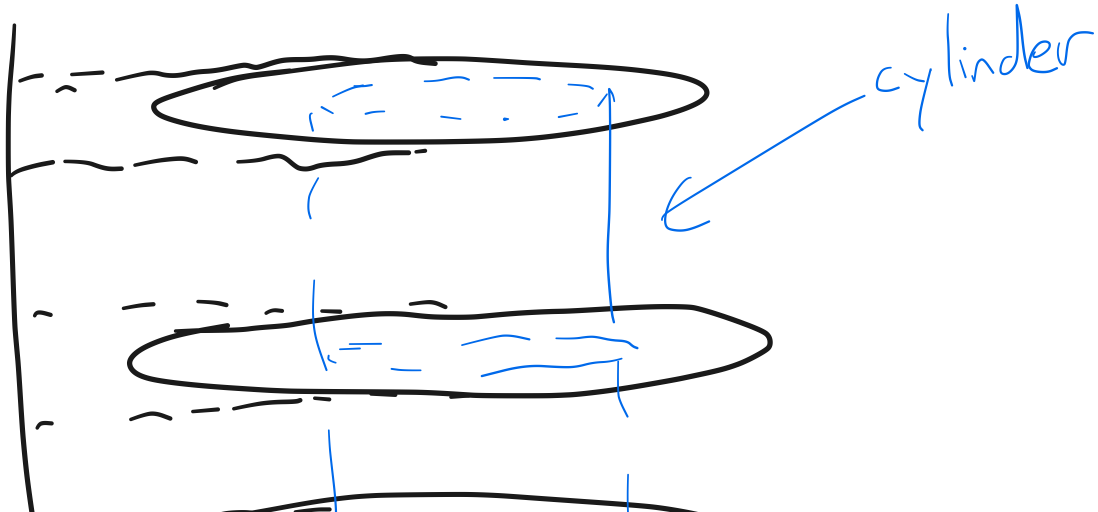
4. Disks

- [x] A. What is a disk?

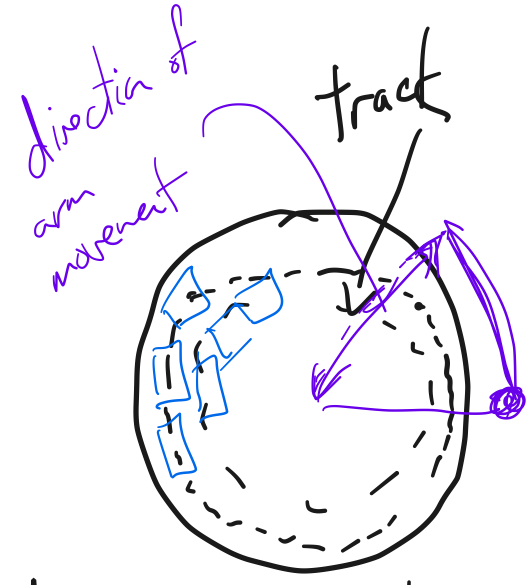
- [x] B. Geometry
- [x] C. Performance
- [x] D. Common numbers
- [x] E. Interface to disks
- [ ] F. Performance II
- [ ] G. Disk scheduling (performance III)
- [ ] H. Technology + systems trends

- stack of magnetic platters
- rotate together on central spindle
  3600 - 15,000 RPM (=60 - 250 rot/sec)



Arms move together

Arms contain disk heads; heads read & write to platters



Geometry

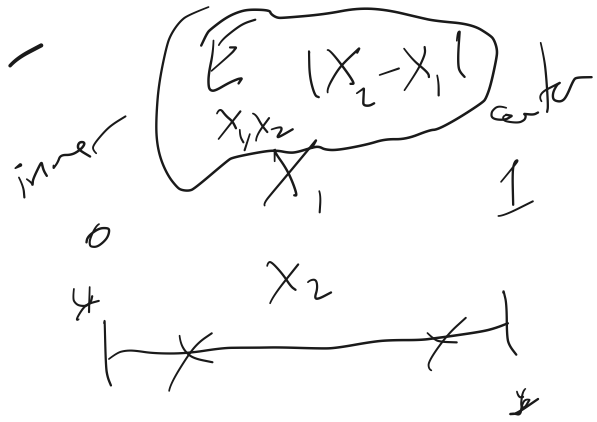
- track: circle on a platter
- sector: chunk of a track
- cylinder: all tracks of fixed radius on all platters
- generally only one head active at a time
- disk positioning system: moves head to a track and keeps it there

- seek: 4 phases: speedup, coast, slowdown, settle

Performance

Components of transfer time:

- rotational delay
- seek delay
- transfer time



"Avg seek time"
= time to seek 1/3 of the disk, but manufacturers might report:
1/3 of "time to seek the whole disk"

Common #s

Capacity: TBs common (10^{12} bytes vs. 2^{40} bytes)

Platters: 8

Number of cylinders: tens of thousands or more

Sectors per track: ~1000

RPM: 10,000

Transfer rate: 50-150 MB/s

MTBF: ≈1 million hours

B b
byte bit

How driver interfaces to disk

Sectors

Interface to disk is a linear array of sectors

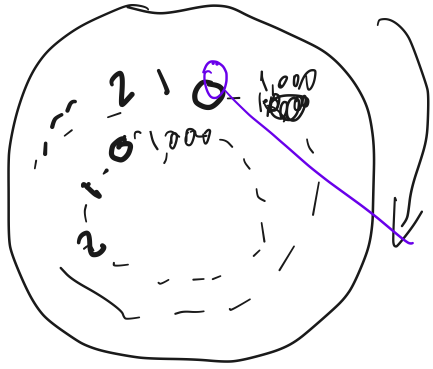
Sector: 512 bytes, moving to 4KB written atomically

Disk does some cool things under the hood (invisibly to OS)

Zoning

Skewing

Sparing

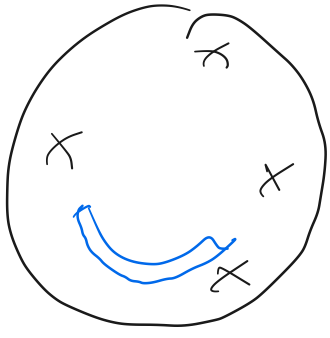


Disk performance example

Spindle speed: 12,000 RPM

Avg seek time: 12ms

Transfer rate: 128 MB/s



Sector: 512 bytes

(a) What is throughput if doing 500 sector reads, spread randomly over the disk + serviced in FIFO order?

(b) Same question, but now the reads are sequential.

(a) tput = data/time

data = 512 × 500

time = rot. delay + seek delay + transfer rate

per Carol: $\frac{1}{2}$[rot. delay: $\frac{1 \text{ minute}}{12{,}000 \text{ R}} \times \frac{60 \text{ s}}{1 \text{ min}} = \frac{1}{200} \text{ s} = 5 \text{ ms}$]

2.5 ms

seek delay: 12 ms

transfer time: $\frac{\text{s}}{128 \text{ MB}} \cdot 512 \text{ B} = \frac{2^9}{2^{27}} \text{ s} = 2^{-18} \text{ s} = \frac{1}{2^{18}} \text{ s}$

$\approx \frac{1}{256{,}000}$ s

$= 4 \mu s$

tput: $\frac{512 \times 500}{500(2.5 \text{ ms} + 12 \text{ ms} + 4 \mu s)} = \frac{512}{14.5 \text{ ms}} = \frac{35{,}310}{1 \text{ s}}$

≈ 30 KB/s terrible

Sequential: $\frac{\text{data}}{\text{time}}$

$\frac{512 \cdot 500}{2.5 \text{ ms} + 12 \text{ ms} + \frac{\text{s}}{128 \text{ MB}} \times 512 \times 500} = \frac{}{14.5 \text{ ms} + \frac{2^{18} \to 2^2}{2^{27}}}$

$\approx \frac{2^9 \cdot 2^2 = 2^{18}}{14.5 \text{ ms} + 2^{-9} \text{ s}} = \frac{2^{18} \text{ B}}{14.5 \text{ ms} + 2 \text{ ms}} = \frac{2^{18} \text{ B}}{16.5 \text{ ms}}$

Scheduling
See text

Technology + systems trends

$2^{-9}s \approx 2ms$

$2(2^{-10})$

$\approx 15MB/s$