



Some Examples

(for DATA REPRESENTATION)

NOTE: Examples are not lectured,
but it is highly recommended that you go through
them to check your understanding.



Example: Disk Organization – I

- ✓ Consider a (very old) disk with the following characteristics:
 - block size $B=512$ bytes
 - gap size $G=128$ bytes
 - 20 sectors per track
 - 400 tracks per surface
 - 15 double-sided platters
 - disk platters rotates at a speed of 2400 RPM
 - average seek time 30 ms
 - (all numbers are given as a factor of 2, i.e., $\text{KB} = 2^{10}$, $\text{MB} = 2^{20}$)

- ✓ What is the total capacity of a track
 - ⇒ **Total = $20 * (512+128) = 12800$ bytes = 12.5 KB**
- ✓ What is its useful capacity of a track (excluding interblock gaps)
 - ⇒ **Useful = $20 * 512 = 10240$ bytes = 10 KB**



Example: Disk Organization – II

✓ How many cylinders are there?

⇒ Number of cylinders = number of tracks = 400

✓ What is the total capacity of a cylinder?

⇒ Total = $15 * 2 * 20 * (512+128) = 384000 \text{ B} = \underline{375 \text{ KB}}$

✓ What is the useful capacity of a cylinder?

⇒ Useful = $15 * 2 * 20 * 512 = 307200 \text{ B} = \underline{300 \text{ KB}}$

✓ What is the total capacity of the disk?

⇒ Total = $15 * 2 * 400 * 20 * (512+128) = 153600000 \text{ B} = \underline{146.5 \text{ MB}}$

✓ What is the useful capacity of a disk?

⇒ Useful = $15 * 2 * 400 * 20 * 512 = \underline{117.18 \text{ MB}}$

✓ What is the average rotational delay rd ?

⇒ $rd = (\text{time for one disk revolution}) / 2 = 25 / 2 = \underline{12.5 \text{ ms}}$



Example: Disk Organization – III

✓ What is the total transfer rate (ttr)?

⇒ $ttr = (\text{total track size in bytes}) / (\text{time for one disk revolution})$
 $= 12800 \text{ B} / (60 / 2400) \text{ s} = 12800 \text{ B} / 25 \text{ ms} = \underline{500 \text{ KB/s}}$

✓ What is the efficient (formatted) transfer rate (etr)?

⇒ $etr = (\text{useful capacity of a track}) / (\text{time for one disk revolution})$
 $= 10240 \text{ B} / (60 / 2400) \text{ s} = 10240 \text{ B} / 25 \text{ ms} = \underline{400 \text{ KB/s}}$

✓ What is the sector transfer time (stt)?

⇒ $512 / (512 + 128) * 360 / 20 = 14.4 \text{ degrees per sector}$
 $stt = 14.4 / 360 * 25 \text{ ms} = \underline{1 \text{ ms}}$



Example: Disk Organization – IV

✓ What is the time to transfer 4 KB (sectors in same track)?

⇒ 7 gaps and 8 sectors must pass under disk head

14.4 degrees per sector

$128 / (512 + 128) * 360 / 20 = 3.6$ degrees per gap

$btt = ((8 * 14.4) + (7 * 3.6)) / 360 * (60 / 2400) s$

$= 140.4 / 360 * 25 ms = \underline{9.75 ms}$

⇒ an approximate value may be calculated using the efficient transfer time or *bulk transfer rate* (btr)

$btr = (B / (B + G)) * ttr = 0.8 * 500 = 400$ KB/s

time to transfer 4 KB $\approx 4096 / 400$ KB/s = 10 ms



Example: Disk Organization – V

- ✓ How much time does it take (on average) to locate and transfer a single sector given its address?

⇒ $\text{average time} = s + rd + stt = 30 + 12.5 + 1 = \underline{43.5 \text{ ms}}$

- ✓ Calculate the average time to transfer 20 random sectors

⇒ $\text{time} = 20 * (s + rd + stt) = 20 * 43.5 = \underline{870 \text{ ms}}$

- ✓ How much time is saved if the 20 sectors are stored contiguously (on same track)?

⇒ $20 \text{ sectors and } 19 \text{ gaps} = 356.6 \text{ degrees}$
 $\text{time} = 30 + 12.5 + (356.6/360 * 25) = 67.25 \text{ ms}$
 $\text{you save} = 870 - 67.25 = \underline{802.75 \text{ ms}} \quad (92.2 \%)$



Example: Disk Organization – VI

- ✓ Assume a process uses 100 ms to process the data in a 4 KB block. How much time is saved using double buffering compared to single buffering if we shall process 10 blocks?

⇒ single = 10 * (retrieval time + processing time)
 = 10 * (9.75 + 100) = 1097.5 ms

double = retrieval time + 10 * processing time
 = 9.75 + 10 * 100 = 1009.75 ms

savings = 1097.5 – 1009.75 = 87.75 ms (8 %)



Example: Disk Organization – VI

- ✓ Assume we want to read an MPEG movie in DVD quality (average 3.5 Mbps). How many disks do we need in parallel to achieve requested bandwidth assuming
 - (i) random placement
 - ⇒ $3.5 \text{ Mbit/s} \approx 458.8 \text{ KB/s}$
per-disk-transfer-rate = $512 \text{ byte} / (30+12.5+1) \text{ ms} \approx 11.5 \text{ KB/s}$
number of needed disks = $\text{ceiling}(458.8 / 11.5) = \underline{40 \text{ disks}}$
 - (i) random placement, but increasing block size to 4 KB
 - ⇒ per-disk-transfer-rate = $4096 \text{ byte} / (30+12.5+9.75) \text{ ms} \approx 214 \text{ KB/s}$
number of needed disks = $\text{ceiling}(458.8 / 214) = \underline{3 \text{ disks}}$

Example: Disk Organization – VI

- ✓ The disk we have used is OLD. What would the total transfer time (using bulk/efficient transfer time) be for a 4 KB blocks if use specifications from Seagate X15 to change
 - (i) only data density on the platter to 617 sectors per track (20)
 - ⇒ the new track can hold 315904 B data (10240 B)
 - etr = (useful capacity of a track) / (time for one disk revolution)
 - = (617 * 512) B / (60 / 2400) s = 12.05 MB/s (400 KB/s)
 - total = 30 + 12.5 + (4 / 12340) = 42.5003 ms (52.5 ms)
 - ✓ (ii) only seek time to 3.6 ms (30 ms)
 - ⇒ total = 3.6 + 12.5 + 10 = 26.1 ms (52.5 ms)
 - ✓ (iii) only rotational speed to 15.000 RPM (2400 RPM)
 - ⇒ etr = 10240 / (60 / 15000) = 10240 / 0.004 = 2.44 MB/s (400 KB/s)
 - total = 30 + 2 + (4 / 2500) = 32.502 ms (52.5 ms)
 - ✓ (iv) all the above
 - ⇒ etr = 315904 / 0.004 = 75.31 MB/s (400 KB/s)
 - total = 3.6 + 2 + (4 / 77125) = 5.60005 ms (52.5 ms)



Example: File Organization – I

- ✓ A file has $r=20000$ fixed-length STUDENT records. Each record has the following fields:
 - NAME (30 bytes),
 - SSN (9 bytes),
 - ADDRESS (40 bytes),
 - PHONE (9 bytes),
 - BIRTHDATE (8 bytes),
 - SEX (1 byte),
 - MAJORDEPTCODE (4 bytes),
 - MINORDEPTCODE (4 bytes),
 - CLASSCODE (4 bytes),
 - DEGREEPROGRAM (3 bytes)
- The file is stored on the disk used in the previous example.



Example: File Organization – II

- ✓ If the record header have 5 fields of 4 bytes for pointers to schema, record length, etc. Calculate the record size R in bytes
 - ⇒ $R = \text{record header} + \text{record fields}$
 $= (4+4+4+4+4) + (30+9+40+9+8+1+4+4+4+3)$
 $= \underline{132 \text{ B}}$
- ✓ Calculate the blocking factor bfr
 - ⇒ $\text{bfr} = \text{floor}(B / R) = \text{floor}(512 / 132) = \underline{3 \text{ records per block}}$
- ✓ Calculate the number of file blocks b needed assuming
 - (i) an unspanned organization.
 - ⇒ $b = \text{ceiling}(r / \text{bfr}) = \text{ceiling}(20000 / 3) = \underline{6667 \text{ blocks}}$
 - (ii) a spanned organization (assume $3 * 2 \text{ B}$ extra for record header)
 - ⇒ $b = 138 \text{ bytes per record} * 20000 \text{ records} / 512 \text{ B} = \underline{5391 \text{ blocks}}$



Example: File Organization – III

- ✓ If the 32-bit processor requires 4-byte alignment. What is the new record size?
 - ⇒ For each field: $\text{size} = \text{ceiling}(\text{old_size}/4) * 4$
 $R = \underline{144 \text{ B}}$
- ✓ If the block header have 3 fields of 4 bytes for ID, pointer to first record, and pointer to overflow. What is the new blocking factor?
 - ⇒ $\text{bfr} = \text{floor}((512 - 12) / 144) = \underline{3 \text{ records per block}}$
- ✓ What is the new number of file blocks b needed assuming
 - (i) an unspanned organization.
 - ⇒ $b = \text{ceiling}(r / \text{bfr}) = \text{ceiling}(20000 / 3) = \underline{6667 \text{ blocks}}$
 - (ii) a spanned organization (assume $3 * 2 \text{ B}$ extra for record header)
 - ⇒ $b = 156 \text{ bytes per record} * 20000 \text{ records} / 500 \text{ B} = \underline{6240 \text{ blocks}}$

Example: File Organization – IV

- ✓ What is the time to retrieve the whole file assuming random placement on disk for
 - (i) unspanned records?
 - ⇒ Average time to retrieve a block is 43.5 ms
 - Total time = $6667 * 43.5 \text{ ms} = \underline{290 \text{ s}}$
 - (i) spanned records?
 - ⇒ Total time = $6240 * 43.5 \text{ ms} = \underline{271 \text{ s}}$
- ✓ How much time is saved using larger block sizes (4096 B) when using unspanned records?
 - ⇒ $\text{bfr} = \text{floor}((4096 - 12) / 144) = 28 \text{ records per block}$
 - $\text{b} = \text{ceiling}(20000 / 28) = 715 \text{ blocks}$
 - time to transfer one block is = $30 + 12.5 + 9.75 = 52.25 \text{ ms}$
 - total time = $52.25 * 715 = 37 \text{ s}$
 - savings = $290 - 37 = \underline{253 \text{ s}} \quad (87 \%)$

Example: File Organization – V

- ✓ Assume we want to change the order of the fields of all records, i.e., update all fields. The update processing operation takes $1 \mu\text{s}$ (10^{-6}) per record. What is the time to update the database using contiguous placement and
 - (i) single buffering, 512 B blocks, unspanned records
 - ⇒ 3 records per block → 6667 blocks,
update operation: read, update, write, verify
total time = $6667 * (43.5 + (3 * 10^{-3}) + 43.5 + 25) = \underline{747 \text{ s}}$
 - (ii) single buffering, 4 KB blocks, unspanned records
 - ⇒ 28 records → 715 blocks
total time = $715 * (52.25 + (28 * 10^{-3}) + 52.25 + 25) = \underline{93 \text{ s}}$
- ⇒ NOTE: processing time consumes about 0.003 % and 0.022 % of the total time, respectively → disk I/O consumes VERY much time