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Homework 2, due 23:59 03/24/2025

Problem 1:

- Block size $B = 512$ bytes
- Interblock gap $G = 128$ bytes
- Blocks per track $= 20$
- Disk pack: 15 double-sided disks
  $\rightarrow$ 30 surfaces
- Rotation speed: 2400 rpm
- Average seek time: 30 msec

a) Total and useful capacity of a track:

- 1 block slot is $512 + 128 = 640$ bytes

$\Rightarrow$ Total capacity per track:

$20 \text{ blocks} \times 640 \text{ bytes} = 12{,}800 \text{ bytes} \approx 12.8 \text{ Kbytes}$

$\Rightarrow$ Useful capacity (data only):

$20 \text{ blocks} \times 512 \text{ bytes} = 10{,}240 \text{ bytes} = 10.24 \text{ Kbytes}$

b) Number of cylinders = number of tracks

$\rightarrow$ There are 400 cylinders

c) Total capacity per cylinder:

$15 \times 2 \times 20 \times 640 = 384000$ bytes $= 384$ KB

15 x 2 x 20 x 640 = 384000 bytes = 384 KBytes

Useful capacity per cylinder:
15 x 2 x 20 x 512 = 307200 bytes = 307.2 KBytes

d) Capacity of disk pack:

- The disk pack contains 400 cylinders:

- Total capacity:
400 x 384 000 Bytes = 153,600,000 Bytes = 153.6 MB
- Useful capacity:
400 x 307200 Bytes = 122,880,000 Bytes = 122.88 MB

e) Transfer rate, Block Transfer Time, Rotational delay

- One revolution time: 2400 rpm
→ 60,000 msec / 2400 = 25 msec per revolution

- Useful transfer rate:
1 revolution: 12,800 bytes of data are read → Transfer rate = 12500 / 25

= 512 bytes/msec

- Block Transfer Time: 512 bytes / 512 bytes/msec
=> 1 msec to read 1 block

- Average rotational delay = 25/2 = 12.5 msec

f) Average time to locate & transfer a block:
30 + 12.5 + 1 = 43.5 msec

g) Time to transfer 20 random blocks:
=> 20 × 43.5 = 870 msec

- Time to transfer 20 consecutive blocks using double buffering: 30 + 12.5 + (20 × 1)
= 62.5 msec

Problem 2:

a) Fan-out = 30
Root level (L1) = 1 page
Second level (L2) = 30 pages = fan out

Tenth level = 30^9 pages

b) Number of levels and Space per level

Number of rows = 2 billions (2×10^9)

Number of level = $\log_f(N) = \log_{30}(2\text{ billion})$

$= 6.29$ (round up to 7)

$\Rightarrow$ 7 levels

- Number of leaf pages $= 2 \times 10^9 / 30 = 66.7$ million

Level	Approx Pages	Calculation
L1 (leaf)	66,667,000	2,000,000,000/30
L2	2,222,234	66,667,000 / 30
L3	74,075	2,222,234 / 30
L4	2,470	74,075 / 30
L5	83	2,470 / 30
L6	3	83 / 30
L7 (Root)	1	3/39

Level	**Approx Pages**	**Space (MB)**	Rounded
L1 (leaf)	66,667,000	66,667,000 x 4 / 1024 = 260,582.0	260,582.0 MB
L2	2,222,234	8,679.80	8,679.8 MB
L3	74,075	289.3	289.3 MB
L4	2,470	9.6	9.6 MB
L5	83	0.3	0.3 MB
L6	3	0.01	0.01 MB
L7 (Root)	1	0.004	0.01 MB

c) Worst case scenario I/O
(1 page/node x 7 levels) + 1 → equality search

$\Rightarrow$ (1x 7) + IO cost (Result)

PROBLEM 3 :

a) $IO = P(R) + T(R) \times P(S) + P(R,S)$
$= 20 + 1600 \times 200 + 100$
$= 320120$

b) $IO = P(S) + T(S) \times P(R) + P(R,S)$
$= 200 + 15000 \times 20 + 100$
$= 300300$

c) $IO(R,S) = P(R) + P(R) \times P(S)/B + P(R,S)$
$= 20 + 20 \times 200/32 + 100 = 245$

$IO(RS,T) = P(R,S) + P(R,S) \times P(T)/B + P(R,S,T)$
$= 100 + 100 \times 2000/32 + 500 = 6850$

IO(S,T) = P(S)+P(S)*P(T)/B+P(S,T) = 200+200*2000/32+1000 = 13600

IO(ST,R) = P(S,T) +P(S,T)*P(R)/B+P(S,T,R) = 1000+1000*20/32+500 = 2125

d) IO(R,S) = ~Sort(P(R)) + Sort(P(S)) + P(R) + P(S) = 40 + 800 + 20 + 200 = 1060

IO(RS,T) = ~Sort(P(R,S)) + Sort(P(T)) + P(R,S) + P(T) = 400 + 8000 + 100 + 2000 = 10500

e) IO(S,T) = ~Sort(P(S)) + Sort(P(T)) + P(S) + P(T) = 800 + 8000 + 200 + 2000 = 11000

IO(ST,R) = ~Sort(P(S,T)) + Sort(P(R)) + P(S,T) + P(R) = 4000 + 40 + 1000 + 20 = 5060

f) IO(R,S) = ~Sort(P(R)) + Sort(P(S)) + P(R) + P(S) = 40 + 800 + 20 + 200 = 1060

g) IO(R,S) = 2 * (P(R) + P(S)) + (P(R) + P(S)) = 2 * (20 + 200) + (20 + 200) = 660

IO(RS,T) = 2 * (P(R,S) + P(T)) + (P(R,S) + P(T)) = 2 * (100 + 2000) + (100 + 2000) = 6300

h) IO(S,T) = 2 * (P(S) + P(T)) + (P(S) + P(T)) = 2 * (200 + 2000) + (20 + 2000) = 6420

IO(ST,R) = 2 * (P(S,T) + P(R)) + (P(S,T) + P(R)) = 2 * (1000 + 20) + (1000 + 20) = 3060

PROBLEM 4:

a) Buckets in primary area

- Load factor = 0.7

- Total records = 112,000
- Records per bucket = 20

- Buckets needed = 112,000 / (20 × 0.7)
  = 8000 buckets

b) Number of bit for bucket addresses

- Buckets = 8000
- Bits required = $\log_2 (8000) \approx 13$ bits