1. (a) Finding keys for the query condition age ≥ 35 and age ≤ 65

First, starting from the root node, that's the first I/O

Then, we'll go to the ~~right~~ left, find the last key 19

Then, go to the block starting with 19.

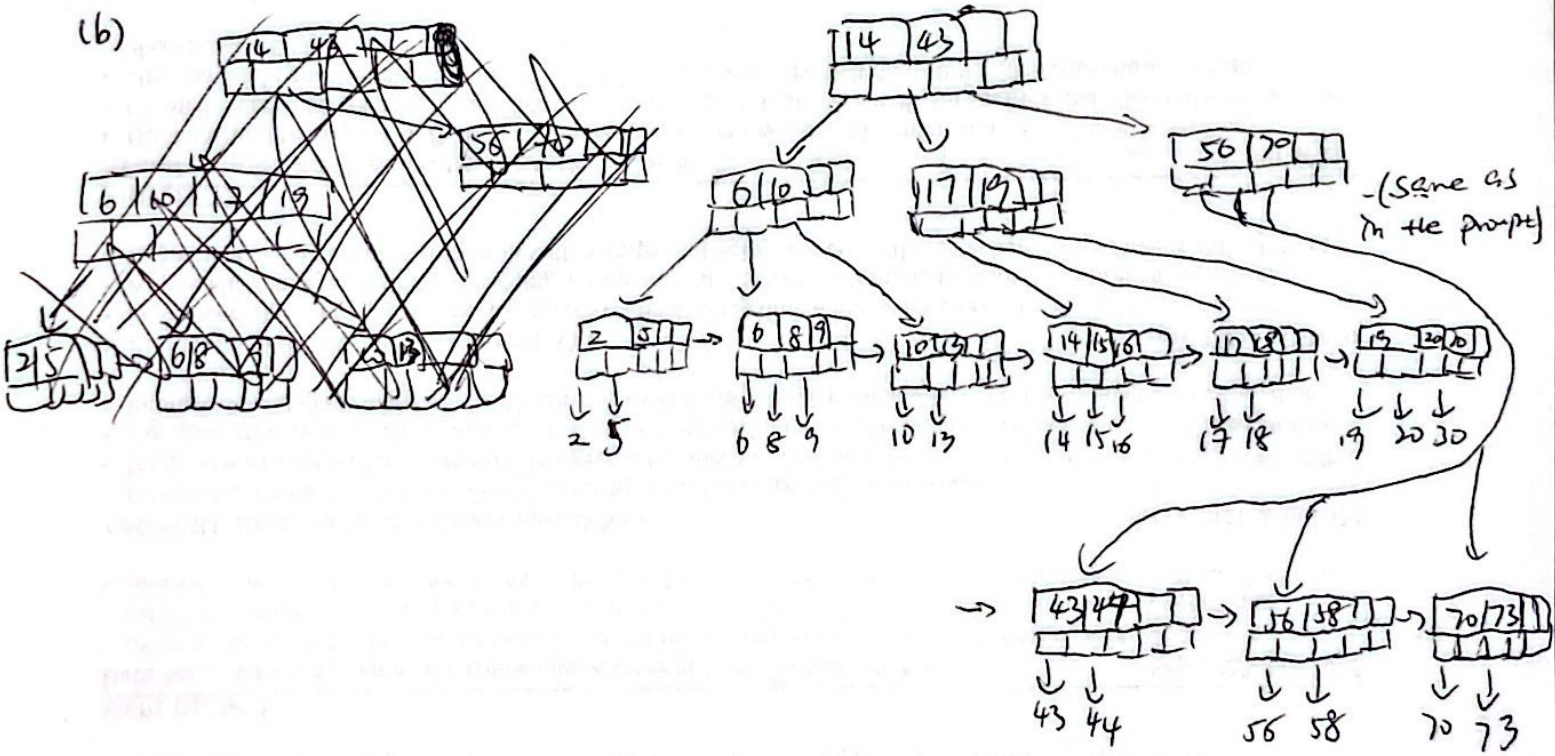
Then, move to the right block starting with 43

Then, move to the right block starting with 56

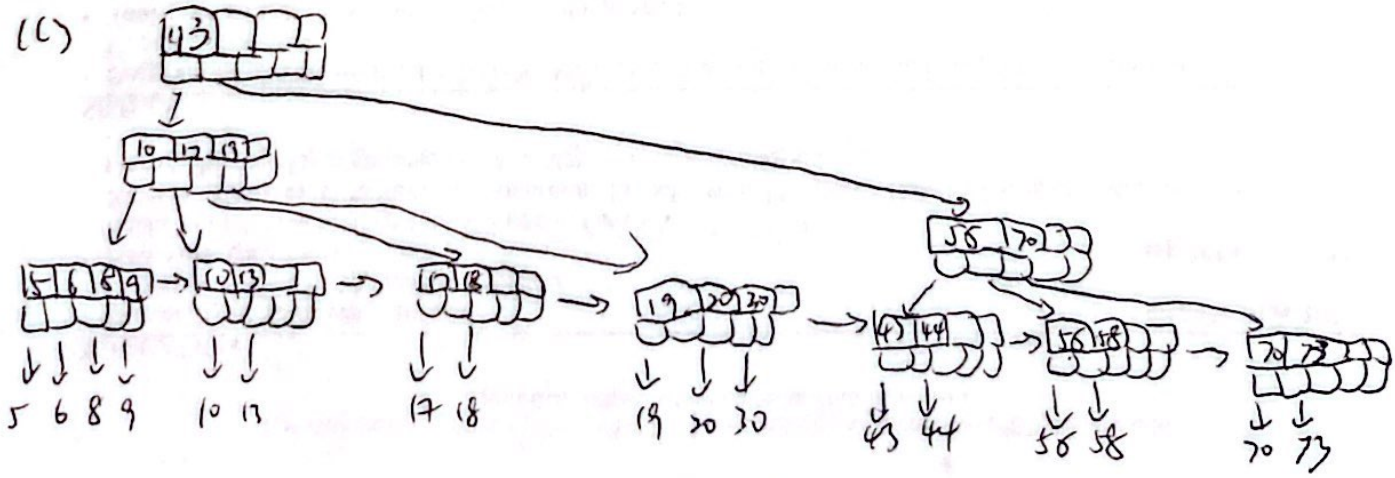
Then, move to the last block starting with 70

So in total, 6 I/O blocks are needed for the process.

(b)



(c)



2. (a) R(a,b), S(a,c). R: 5000 Blocks, S: 20,000 blocks. 102 pages M

for each M-2 blocks br of R do
  for each block bs of S do
    for each tuple r in the block br
      for each tuple s in bs do
        if r & s join then output (r,s)

# of block's I/O = $B(R)+B(R)\cdot B(S)/(M-2) = 5000 + \frac{5000 \times 20000}{100} = 1005000$

(b) for each M-2 block of bs of S do
  for each block of R in R do
    for each tuple s in bs do
      for each tuple r in br do
        if r & s join then output (r,s)

# of block's I/O = $B(S)+B(S)\cdot B(R)/(M-2) = 20000 + 20000 \times 5000/100$
$= 1020000$

(c) 100 sorting. 101: merging

pass 1: sort R => 50 runs, 100 Blocks/run 2B(R)
  sort S => 200 runs, 100 Blocks/run 2B(S)
  => 2 runs, 100 Blocks/run 2B(S)

But $B(R)+B(S) \geq M^2$

pass 2: merge: B(R)+B(S)

Total: 2B(R) + 2B(S) + 2B(S) + B(R) + B(S)
= 3B(R)+5B(S) = 115000 # of I/O Blocks

(d) pass 1: hash R into 100 Buckets, 50 block/Bucket (Ri)
  hash S into 100 Buckets, 200 block/Bucket (Si)

$\min(B(R)/(M-1), B(S)/(M-1)) <= M-2$

cost = 2B(R)+2B(S) = 50000

pass 2: join Ri with Si

B(R)+B(S) = 25000

total = 75000 # of I/O Blocks