NATIONAL UNIVERSITY OF SINGAPORE
SCHOOL OF COMPUTING
SEMESTER 2 (2017/2018) MID-TERM EXAMINATION FOR

CS3223: DATABASE SYSTEMS IMPLEMENTATION

March 2018 Time Allowed: 60 minutes

NAME: MATRIC NUMBER:

This paper contains 9 questions. You should answer ALL questions. The total marks for this paper is 20 marks.

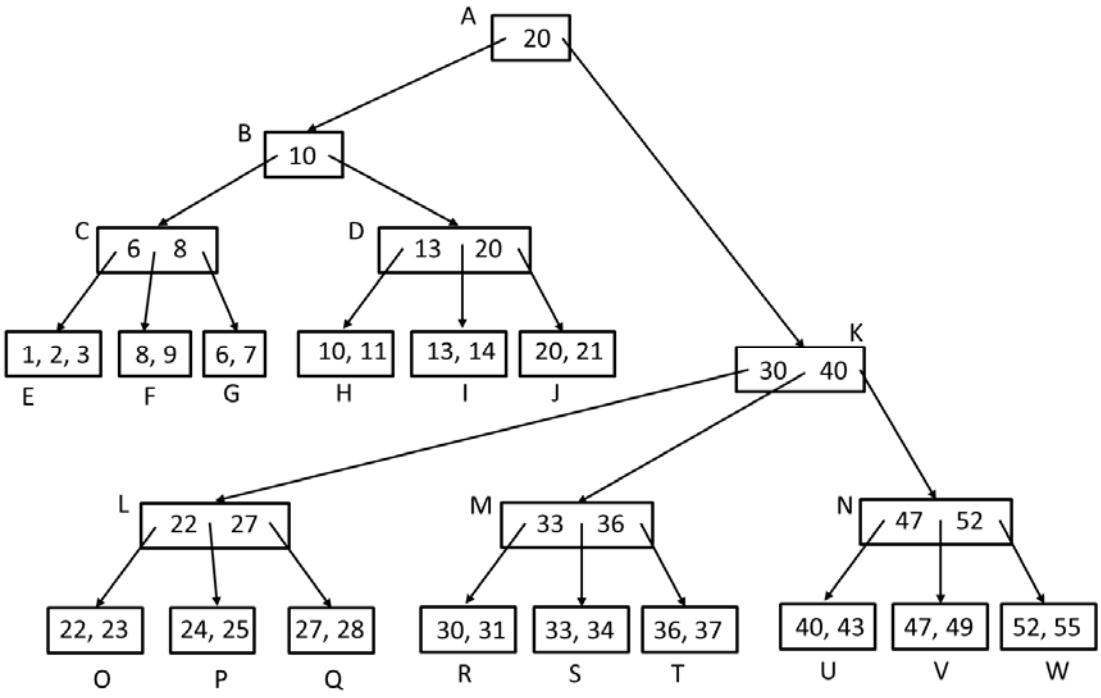
1. (2 marks) Consider a table with 50 attributes – 20 of these are mandatory (i.e., information must always be captured) while the other 30 are optional. Moreover, the values for all attributes are a fixed size of 10 bytes. Based on historical data, on average, k% of these optional fields will be captured. Now, consider the following two possible record storage formats:
   (a) Fixed-length record format that reserves space for every attribute.
   (b) Variable-length record format where all captured fields are tagged. Each tag is 1 byte. The tag contains information that indicates an attribute is present. Note that variable-length record format has no concept of mandatory or optional fields; all fields are deemed optional.

   For what range of k values is the fixed format option superior?

2. (2 marks) To modify a block on disk, we must read it into main memory, perform the modification, and write it back. Assume that the modification in main memory takes less time than it does for the disk to rotate one block, and that the disk controller postpones other requests for disk access until the block is ready to be written back to the disk. Consider a disk with the following characteristics:
   (a) Tracks hold 2000 sectors of 1024 bytes each
   (b) 10% of each track is used for gaps
   (c) The disk rotates at 6000 rpm
   (d) Average seek time is 10ms
   (e) A block consists of 8 sectors

   What is the time to modify a block (assume the initial read is random)?

3. (4 marks) Consider the following B^+-tree structure. Find any/all violations of the B^+-tree properties. For each bad node, indicate the node (labeled by alphabets A, B, C … W), and give a brief explanation of each error. Assume the order of the tree is 2, i.e., there are at most 4 key-value pairs and 5 pointers. Complete your answer in the table below (Note that it does not mean that there are as many violations as the number of rows in the able; you can leave some of the rows empty if you have identified fewer).



Node ID	What's wrong with the node?

4. (2 marks) In the basic linear hashing that we have discussed in the lecture, we split the buckets in a round-robin fashion one at a time. In fact, the bucket that is split need not be the bucket that overflows (assuming we use overflow as a splitting criterion). Now, consider the following variant: if the overflowed bucket is before the "next" pointer, then we follow the basic algorithm (there is no need to split as the bucket has already been split); however, if the overflowed bucket is at or after the "next" pointer, we split all buckets from the bucket pointed to by the "next" pointer to the overflowed bucket, and move the "next" pointer to the bucket after the overflowed bucket. What are the pros and cons of this variant in comparison to the basic scheme.

5. (2 marks) Suppose you are required to create a linear hash index for a table. You decide to initialize k empty primary buckets (the capacity of the k buckets is larger than the number of records). Then you insert the tuples into the buckets accordingly (as we cover in the lecture). You want to minimize the number of split buckets to keep the hash table as small as possible. Which of the following three insertion orders is expected to perform best: (a) Insert the records belonging to the first bucket first, then insert records belonging to the second bucket next, and so on; (b) Insert one record at a time in a round-robin fashion, i.e., one record to bucket one, one record to bucket two and so on; after one round, insert another record to bucket one, and so on. In this way, the buckets are hopefully balanced; (c) Insert the records belonging to the last bucket first, then records belonging to the second last bucket, then third last bucket and so on? Justify your answer.

6. (2 marks) Consider the following sequence of numbers:

   20, 41, 39, 7, 49, 12, 10, 23, 89, 48, 76, 55, 50, 77, 33, 28, 11, 46, 40, 29

   Suppose each page has only 1 record. Let the number of buffer pages be 4 (we can ignore output buffers). Suppose we use replacement selection to generate sorted runs. List the sorted runs below.

7. (2 marks) Consider a relation R using B buffer pages. Describe the various ways in which the B pages can be allocated in the merging phase for sorting.

8. (2 marks) Consider the join of two tables R and S. Let |R| (|S|) denote the size of R (S) in terms of number of pages. Let B be the buffer size available to perform the join. Suppose the join result is immediately returned to the user (i.e., there is no need to buffer the output) . For the following two join methods (using the basic methods that we learn in our lecture), what is the best/earliest possible time (in terms of I/O cost) that the first output tuple can be returned?

   (a) Nested Loops Join

   (b) Hash-Join. You can assume data are uniformly distributed, and memory is sufficient (i.e., $B > \sqrt{|R|}$ or $B > \sqrt{|S|}$). In other words, the scheme we learned in the lecture works.

9. (2 marks) Suppose we want to compute R $JOIN_{R.a=S.b}$ S. Let |R| = 100 pages, ||R|| = 1000 tuples. Let |S| = 100 pages, ||S|| = 5000 tuples. Suppose there is an unclustered B^+-tree index on S.b. As covered in the lecture, the index is in format 2, i.e., it stores (key, pointer)-pairs. Moreover, let the height of the B^+-tree be 3 (root node is at level 1, and leaf nodes are at level 3). Consider the nested-index join algorithm. Suppose 5% of R has one and only one matching S record while the rest do not have a match. Let every access (be it index or data pages) incurs an I/O, what is the I/O cost to perform the join using the index?

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