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Sample Question Paper for
Ph.D. (Computer Science & Engineering)
SPSAT'18

INSTRUCTIONS

The test is 60 minutes long and consists of 40 multiple choice questions (MCQ) adding up to 40 marks.

1. Which of the following case does not exist in complexity theory
   (a) Best case (b) Worst case (c) Average case (d) Null case

2. The indirect change of the values of a variable in one module by another module is called
   (a) Internal change (b) Inter-module change
   (c) Side effect (d) Side-module update

3. Which one of the following is true at any valid state in shift-reduce parsing?
   (a) Viable prefixes appear only at the bottom of the stack and not inside
   (b) Viable prefixes appear only at the top of the stack and not inside
   (c) The stack contains only a set of viable prefixes
   (d) The stack never contains viable prefixes

4. For computers based on three-address instruction formats, each address field can be used to specify which of the following:
   S1: Memory operand   S2: Processor register
   S3: Implied accumulators register
   (a) Either S1 or S2 (b) Either S2 or S3 (c) Only S2 and S3 (d) All of S1, S2 and S3

5. Which one of the following is the recurrence equation for the worst case time complexity of the Quicksort algorithm for sorting n ($\geq$ 2) numbers? In the recurrence equations given in the options below, c is a constant.
   (a) $T(n) = 2T(n/2) + cn$ (b) $T(n) = T(n-1) + T(1) + cn$
   (c) $T(n) = 2T(n-2) + cn$ (d) $T(n) = T(n/2) + cn$

6. Suppose two hosts use a TCP connection to transfer a large file. Which of the following statements is/are FALSE with respect to the TCP connection?
   I. If the sequence number of a segment is m, then the sequence number of the subsequent segment is always m+1.

II. If the estimated round trip time at any given point of time is t sec, the value of the retransmission timeout is always set to greater than or equal to t sec.

III. The size of the advertised window never changes during the course of the TCP connection.

IV. The number of unacknowledged bytes at the sender is always less than or equal to the advertised window

    (a) III only   (b) I & III only   (c) I & IV only   (d) II & IV only

7. Which data structure allows deleting data elements from front and inserting at rear?

    (a) Stacks   (b) Queues   (c) Linked list   (d) Binary search tree

8. The following two functions P1 and P2 that share a variable B with an initial value of 2 execute concurrently. P1( ) { C = B − 1; B = 2 * C; } and P2( ) {D = 2 * B; B = D − 1;} The number of distinct values that B can possibly take after the execution is

    (a) 0   (b) 1   (c) 2   (d) 3

9. You have an array of n elements. Suppose you implement quick sort by always choosing the central element of the array as the pivot. Then the tightest upper bound for the worst case performance is

    (a) O(n2)   (b) O(log n)   (c) O(n)   (d) O(n log n)

10. Which one of the following fields of an IP header is NOT modified by a typical IP router?

    (a) Checksum   (b) Source address   (c) Time to Live (TTL)   (d) Length

11. Select operation in SQL is equivalent to

    (a) Selection operation in relational algebra

    (b) Selection operation in relational algebra, except that SELECT in SQL retains duplicates

    (c) Projection operation in relational algebra

    (d) Projection operation in relational algebra, except that SELECT in SQL retains duplicates

12. The length of the shortest string NOT in the language (over $\Sigma = \{a,b\}$) of the regular expression a*b* (ba)* a* is

    (a) 0   (b) 1   (c) 2   (d) 3

13. A file is organized so that the ordering of data records is the same as or closes to the ordering of data entries in some index. Then that index is called

    (a) Dense   (b) Sparse   (c) Clustered   (d) Unclustered

14. What are the worst-case complexities of insertion and deletion of a key in a binary search tree?

    (a) $\theta(logn)$ for both insertion and deletionn   (b) $\theta(n)$ for both insertion and deletion

    (c) $\theta(n)$ for insertion and $\theta(logn)$ for deletion   (d) $\theta(logn)$ for insertion and $\theta(n)$ for deletion

15. Which of the following statements are CORRECT?

(I) Static allocation of all data areas by a compiler makes it impossible to implement recursion.

(II) Automatic garbage collection is essential to implement recursion.

(III) Dynamic allocation of activation records is essential to implement recursion.

(IV) Both heap and stack are essential to implement recursion.

(a) I & II only   (b) II & III only   (c) III & IV only   (d) I & III only

16. One of the purposes of using intermediate code in compilers is to

(a) Make parsing and semantic analysis simpler

(b) Improve error recovery and error reporting

(c) Increase the chances of reusing the machine-independent code optimizer in other compliers

(d) Improve the register allocation

17. Suppose that everyone in a group of N people wants to communicate secretly with the (N–1) others using symmetric key cryptographic system. The communication between any two persons should not be decodable by the others in the group. The number of keys required in the system as a whole to satisfy the confidentiality requirement is

(a) 2N   (b) N(N – 1)   (c) N(N – 1)/2   (d) (N – 1)2

18. In the context of modular software design, which one of the following combinations is desirable?

(a) High cohesion and high coupling   (b) High cohesion and low coupling

(c) Low cohesion and high coupling   (d) Low cohesion and low coupling

19. Consider a non-pipelined processor with a clock rate of 2.5 gigahertz and average cycles per instruction of four. The same processor is upgraded to a pipelined processor with five stages; but due to the internal pipeline delay, the clock speed is reduced to 2 gigahertz. Assume that there are no stalls in the pipeline. The speed up achieved in this pipelined processor is

(a) 2.5   (b) 3.2   (c) 2.8   (d) 3

20. A prime attribute of a relation scheme R is an attribute that appears

(a) In all candidate keys of R   (b) In some candidate key of R

(c) In a foreign keys of R   (d) Only in the primary key of R

21. An algorithm performs $(logN)1/2$ find operations, N insert operations, $(logN)1/2$ delete operations and $(logN)1/2$ decrease-key operations on a set of data items with keys drawn from a linearly ordered set. For a delete operation, a pointer is provided to the record that must be deleted. For the decrease-key operation, a pointer is provided to the record that has its key decreased. Which one of the following data structures is the most suited for the algorithm to use, if the goal is to achieve the best total asymptotic complexity considering all the operations?

(a) Unsorted array   (b) Min-heap

(c) Sorted array   (d) Sorted doubly linked list

22. Let an represent the number of bit strings of length n containing two consecutive 1s. What is the recurrence relation for an?

(a) an–2 + an–1 + 2n–2

(b) an–2 + 2an–1 + 2n–2

(c) 2an–2 + an–1 + 2n–2

(d) 2an–2 + 2an–1 + 2n–2

23. A bit-stuffing based framing protocol uses an 8-bit delimiter pattern of 01111110. If the output bit-string after stuffing is 01111100101, then the input bit-string is

(a) 0111110100   (b) 0111110101   (c) 0111111101   (d) 0111111111

24. Let G be a connected planar graph with 10 vertices. If the number of edges on each face is three, then the number of edges in G is

(a) 20   (b) 28   (c) 10   (d) 24

25. Suppose that the stop-and-wait protocol is used on a link with a bit rate of 64 kilobits per second and 20 milliseconds propagation delay. Assume that the transmission time for the acknowledgment and the processing time at nodes are negligible. Then the minimum frame size in bytes to achieve a link utilization of at least 50% is

(a) 200   (b) 280   (c) 320   (d) 240

26. Consider a main memory with five page frames and the following sequence of page references: 3, 8, 2, 3, 9, 1, 6, 3, 8, 9, 3, 6, 2, 1, 3; which one of the following is true with respect to page replacement policies First-In-First-Out (FIFO) and Least Recently Used (LRU)?

(a) Both incur the same number of page faults

(b) FIFO incurs 2 more page faults than LRU

(c) LRU incurs 2 more page faults than FIFO

(d) FIFO incurs 1 more page faults than LRU

27. Consider the operations: f (X,Y,Z) = X′YZ + XY′+Y′Z′ & g (X,Y,Z) = X′YZ + X′YZ′ + XY; which one of the following is correct?

(a) Both {f} & {g} are functionally complete

(b) Only {f} is functionally complete

(c) Only {g} is functionally complete

(d) Neither {f} nor {g} is functionally complete

28. Consider the transactions T1, T2, and T3 and the schedules S1 and S2 given below.

T1: r1(X); r1(z); w1(X); w1(z)

T2: r2(X); r2(z); w2(z)

T3: r3(X); r3(X); w3(Y)

S1: r1(X); r3(Y); r3(X); r2(Y); r2(Z); w3(Y); w2(Z); r1(Z); w1(X); w1(Z)

S2: r1(X); r3(Y); r2(Y); r3(X); r1(Z); r2(Z); w3(Y); w1(X); w2(Z); w1(Z)

Which one of the following statements about the schedules is TRUE?

(a) Only S1 is conflict-serializable (b) Only S2 is conflict-serializable

(c) Both S1 & S2 are conflict-serializable (d) Neither S1 nor S2 is conflict-serializable

29. A system contains three programs and each requires three tape units for its operation. The minimum number of tape units which the system must have such that deadlocks never arise will be

(a) 3 (b) 7 (c) 9 (d) 6

30. Consider the basic block given below:

a = b + c; c = a + d; d = b + c; e = d − b; a = e + b

The minimum number of nodes and edges present in the DAG representation of the above

basic block respectively are

(a) 6 and 6 (b) 8 and 10 (c) 9 and 12 (d) 4 and 4

31. Which one of the following problems is undecidable?

(a) Deciding if a given context-free grammar is ambiguous

(b) Deciding if a given string is generated by a given context-free grammar

(c) Deciding if the language generated by a given context-free grammar is empty

(d) Deciding if the language generated by a given context-free grammar is finite

32. Let S be a sample space and two mutually exclusive events A and B be such that $A \grave{E} B = S$. If P(.) denotes the probability of the event, the maximum value of $P(A)P(B)$ is

(a) 0.25 (b) 0.5 (c) 0.75 (d) 1

33. The memory access time is 1 nanosecond for a read operation with a hit in cache, 5 nanoseconds for a read operation with a miss in cache, 2 nanoseconds for a write operation with a hit in cache and 10 nanoseconds for a write operation with a miss in cache. Execution of a sequence of instructions involves 100 instruction fetch operations, 60 memory operand read operations and 40 memory operand write operations. The cache hit-ratio is 0.9. The average memory access time (in nanoseconds) in executing the sequence of instructions is

(a) 1.68 (b) 0.98 (c) 0.75 (d) 1.54

34. An instruction pipeline has five stages, namely, instruction fetch (IF), instruction decode and register fetch (ID/RF), instruction execution (EX), memory access (MEM), and register write back (WB) with stage latencies 1 ns, 2.2 ns, 2 ns, 1 ns, and 0.75 ns, respectively (ns stands for nanoseconds). To gain in terms of frequency, the designers have decided to split the ID/RF stage into three stages (ID, RF1, RF2) each of latency 2.2/3 ns. Also, the EX stage is split into two stages (EX1, EX2) each of latency 1 ns. The new design has a total of eight pipeline stages. A program has 20% branch instructions which execute in the EX stage and produce the next instruction pointer at the end of the EX stage in the old design and at the end of the EX2 stage in the new design. The IF stage stalls after fetching a branch instruction until the next instruction pointer is computed. All

instructions other than the branch instruction have an average CPI of one in both the designs. The execution times of this program on the old and the new design are P and Q nanoseconds, respectively. The value of P/Q is

(a) 1.54   (b) 0.98   (c) 0.75   (d) 1.68

35. Consider the set of all functions $f : \{0,1,...,2014\} \rightarrow \{0,1...,2014\}$ such that $f(f(i)) = i$, for all $0 \leq i \leq 2014$. Consider the following statements.

P: For each such function it must be the case that for every i, f(i) = i,

Q: For each such function it must be the case that for some i, f(i) = i,

R: Each such function must be onto.

Which one of the following is CORRECT?

(a) P, Q & R are true   (b) Only Q & R are true

(c) Only P & Q are true   (d) Only R is true

36. If G is a forest with n vertices and k connected components, how many edges does G have?

(a) [n / k]   (b) [n * k]   (c) n − k   (d) n − k + 1

37. Consider an undirected random graph of eight vertices. The probability that there is an edge between a pair of vertices is ½. What is the expected number of unordered cycles of length three?

(a) ½   (b) 1   (c) 7   (d) 8

38. What is the time complexity of Bellman-Ford single-source shortest path algorithm on a complete graph of n vertices?

(a) (n2)   (b) (n2logn)   (c) (n3)   (d) (n3logn)

39. The transport layer protocols used for real time multimedia, file transfer, DNS and email, respectively are

(a) TCP, UDP, UDP & TCP   (b) UDP, TCP, TCP & UDP

(c) UDP, TCP, UDP & TCP   (d) TCP, UDP, TCP & UDP

40. What is the maximum number of reduce moves that can be taken by a bottom-up parser for a grammar with no epsilon- and unit-production □i.e., of type A □□□□and A □□a□□to parse a string with n tokens?

(a) n/2   (b) n-1   (c) 2n-1   (d) 2n