Ph.D. Comprehensive Examination

Computer Science Department
University of Miami

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Student Name: Student Number:

Problem number	Points (10 max)
1	
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Total:	

1. **Data organization; Algorithms and complexity**

   Each item x in a set S has a unique key $key[x]$. We need to implement the following operations.

   (a) Search (S, key)
   (b) Insert (S, x)
   (c) Successor (S, x)
   (d) Predecessor (S, x)

   Give the 4 running times as an O() for the following implementations:

   (a) Ordered (sorted) array,
   (b) Ordered doubly linked list,
   (c) Min-Heap, and
   (d) Hash table

2. **Program control and structure; Programming language and notations**

   Suppose that procedure *swap* is declared as follows:

```
procedure swap( x, y: integer);
    procedure f(): integer;
        var z: integer;
        begin // f
            z = x; x = y; return z;
        end // f
    begin // swap
        y = f();
    end // swap
```

   Describe the effect of the procedure call *swap*(i, A[i]) under each of the following parameter passing methods:

   (a) Call-by-value

   (b) Call-by-reference

   (c) Call-by-value-result

3. **Software engineering**

   From the software engineering point of view, any software development process can be divided into several sub-disciplines:

   (a) Requirement Analysis

   (b) Functional Specification

   (c) Architectural Design

   (d) Implementation

   (e) Testing and Evaluation

   (f) Maintenance

   Choose three sub-disciplines or tasks within these sub-disciplines that involve a mathematical approach, and illustrative them with examples.

4. **Systems**

(a) _____ linked libraries can support shared library code, allowing one copy of a library routine to be used by several different processes.

absolute relative static dynamic none of these is correct

(b) When it is not known at compile time where a process will reside in memory, _____ code must be generated.

logical physical absolute relocatable

(c) A UNIX process calls *fork()* to create a child process as shown: *pid = fork()*;

i. What value will be assigned to pid in the parent process by the call to *fork()*?

the parents process id the childs process id zero none of these

ii. What value will be assigned to pid in the child process by the call to *fork()*?

the parents process id the childs process id zero none of these

(d) The Banker's algorithm is used for deadlock _____.

denial prevention avoidance recovery

(e) Belady's anomaly can affect the performance of the _____ page replacement algorithm.

FIFO LRU optimal SJF

(f) _____ access files are made of fixed length records that allow programs to read and write records in no particular order.

sequential direct logical none of these is correct

(g) When an I/O request is being handled for a users process, which term refers to the policy of returning control to the user process before the I/O is completed?

synchronous I/O asynchronous I/O delayed I/O none of these

(h) Which multithreading model requires that a new kernel thread be created for each new user thread?

many-to-one one-to-one many-to-many none of these is correct

(i) A process that does not affect, and is not affected by, another process is referred to as:

static independent cooperating dynamic unbounded

5. **Software, Programming Techniques**

   Given that

   $B(x)$ means "x is a bear"
   $F(x)$ means "x is a fish", and
   $E(x, y)$ means "x eats y",

   what is the best English translation of
   $\forall x[F(x) \rightarrow \forall y(E(y, x) \rightarrow B(y))]$?

   (a) All fish eat bears.
   (b) Every fish is eaten by some bear.
   (c) Bears only eat fish.
   (d) Every bear eats fish.
   (e) Only bears eat fish.

6. **Networking and Communications**

   (a) Draw a diagram showing layers of the Internet Protocol Stack and briefly discuss role of each layer.

   (b) Describe functions of each layer when a file is transferred from a source to destination using (*file transfer protocol* (FTP).

7. **Algorithms and complexity**

   Describe an algorithm that takes two input lists of integers $A = a_1, ..., a_n$ and $B = b_1, ..., b_m$ and delivers the list of all the elements that belong to A but not to B. A and B do not contain redundant elements, however, the elements of A and B might have a large range.

   The algorithm should run in $O(n \log m + m \log m)$ time.

8. **Automata and language theory**

Consider the following grammar:

$G \longrightarrow S\ \$\$$
$S \longrightarrow A\ M$
$M \longrightarrow S \mid \epsilon$
$A \longrightarrow a\ E \mid b\ A\ A$
$E \longrightarrow a\ B \mid b\ A \mid \epsilon$
$B \longrightarrow b\ E \mid a\ B\ B$

(a) Describe the language that the grammar generates in English.

(b) Show a parse tree for the string `a b a a`.

(c) Is the grammar LL(1)? If so, show the parse table; if not, identify a prediction conflict.

9. **Discrete Structures**

   Recall that the Hamiltonian Cycle Problem is the problem of deciding, on input graph G, whether G has a cycle that visits all the nodes exactly once. Show that this problem is polynomial time decidable if the input is restricted to the graphs with the property that each node has at most two neighbors (i.e., at most two adjacent nodes).

10. **Other Topics**

    Give a detailed explanation of any one approach to machine learning. Give a substantial example that illustrates the technical operation of the approach, and demonstrates interesting knowledge learned.