

Ph.D. Comprehensive Examination

Computer Science Department
University of Miami

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Student Name:

Student Number:

Problem number	Points (10 max)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
total	

1. I.A Data organization; III.A 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. I.B Program control and structure; I.C 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. I.D 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. I.E Systems

Compare and contrast (i) hierarchical, (ii) network, (iii) the relational, and (iv) object-oriented data models.

5. II Computer Organization

- (a) Draw an architecture of a quad-core processor and discuss the role of each module in your diagram.
- (b) Find a binary representation of the decimal number 0.1.

6. II.D 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. III.A Algorithms and complexity

In light of recent events, the State Department and the CIA decide to get together and compare the list of issued visas with the list of suspected terrorists. There are $m = 10,000,000$ visas and $n = 100,000$ suspected terrorists. Each entry has a country name and passport number, which is unique for that country. Comparing every pair would take time $O(mn)$ or 1,000,000,000,000.

You are hired as a consultant to do it faster. Explain how to do it in $O(m + n)$ expected time.

8. Automata and language theory

For two languages A and B , we define $\text{mix}(A, B)$ to be the set of all words $x = u_1v_1 \cdots u_kv_k$ such that $u_1 \cdots u_k \in A$ and $v_1 \cdots v_k \in B$. Is the class of context-free languages closed under the mix operation; that is, is it the case that for all context-free languages A and B , $\text{mix}(A, B)$ is context free? Justify your answer.

9. III.C 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. **IV 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.