Department of Computer Science
Core Graduate Comprehensive Exam
Fall 2018

- **Answer the questions on the paper supplied.**
- **Answer question 1 or 2. Answer question 3 or 4. Answer question 5 or 6 or 7 or 8 or 9. Answer question 10 or 11 or 12. You should answer a total of four questions. Please Note: If you answer more than one question in one group, only the one with the LOWEST score will be counted.**
- **Start each question on a new page. Write on only one side of the paper.**
- **Write your SIX-DIGIT Texas State ID in the top right corner of each page of your answer. Do NOT put your name anywhere on the answers.**
- **Put the number of the question being answered in the top left corner of each answer page. Put the CORRECT question number to avoid missing your answer.**
- **If the answer to a question is written on more than one page, number the pages consecutively.**

Group 1

1. **CS 5329 Algorithm Design and Analysis**
   {*from Dr. Hwang*}

   For the recurrence formula from Merge Sort and Max-subrray,

$$T(n) = 2T(n/2) + n \text{ for } n > 1$$

   (a)**Derive** the total running time T(n) by **using** Recursion Tree method.

   (b) **Derive** the total running time T(n) by **using** Iteration method.

   (Answers alone will receive very minimum credit.)

2. **CS 5329 Algorithm Design and Analysis**
   {*from Dr. Metsis*}

   Dynamic Programming

   The longest common subsequence (LCS) of two sequences of characters can be computed using the following algorithm:

```
LCS-LENGTH(X, Y)
m ← length[X]
n ← length[Y]
for i ← 1 to m
      do c[i, 0] ← 0
for j ← 0 to n
      do c[0, j] ← 0
for i ← 1 to m
      do for j ← 1 to n
            do if x_i = y_j
                  then c[i, j] ← c[i − 1, j − 1] + 1
                       b[i, j] ← "↖"
                  else if c[i − 1, j] ≥ c[i, j − 1]
                          then c[i, j] ← c[i − 1, j]
                               b[i, j] ← "↑"
                          else c[i, j] ← c[i, j − 1]
                               b[i, j] ← "←"
return c and b
```

   a) Given the sequences A = a,e,a,a,g,s,s,t and B = b,a,e,b,s,a,g,t, find the longest common subsequence. Show the resulting tables c and b. Table c shows the length of the LCS, whereas table b shows the path to be followed to extract the LCS itself.

   b) What is the time and space complexity of the above algorithm? Can we make any further improvements to either of them?

Group 2

3. **CS 5346 Advanced Artificial Intelligence**
   {*from Dr. Ali*}

   (a) Consider the Wumpus environment E as a 4 X 4 grid of rooms (E2,3 represents 2nd row and 3rd column). Sensors have detected the following facts:

   B2,1; B1,2; B2,3; B3,2 Where Bi,j indicates Breeze in the i-th row and j-th column. Breeze is not detected in any other room.

   Write rules in propositional logic to determine the position of the Pit and change them into Conjunctive Normal Form.

   Using resolution rule, develop a proof tree to determine the location of the Pit.

   (b) Represent the following story in propositional logic and then transform it to the conjunctive Normal Form:

   "James, Stevens and Nelson hold the jobs of dentist, pilot, and marine (not necessarily in that order). James owes the dentist $39. The marine's spouse prohibits borrowing money. Stevens is not married."

   Using resolution rule develop a proof tree and determine which person has which job.

4. **CS 5391 Survey of Software Engineering**
   {*from Dr. Chen*}

   Explain the following software process models and point out their pros and cons:

   (a) Formal methods

   (b) Agile development model

Group 3

5. **CS 5306 Advanced Operating Systems**
   {*from Dr. Tamir*}

   Assume a single core system implementing an intra-core preemptive HRRN scheduling policy with a slice size of 1 second. Further assume that at time T there are 3 tasks $\{T_0, T_1, T_2\}$ in the Ready Queue of the core with no task in the execution slot of the core. Additionally, assume that the tasks are compute-bound with no I/O whatsoever. Let $\{P_0, P_2, P_2\}$ be the remaining execution time of $\{T_0, T_1, T_2\}$ respectively and let $\{P_3, P_4, P_5 4\}$ be the current wait time of $\{T_0, T_1, T_2\}$ respectively, where:

   $P_0 = 1,$

   $P_1 = 4,$

   $P_2 = 2,$

   $P_3 = 1,$

   $P_4 = 2,$

   $P_5 = 3,$

   Clearly describe the state of the system in each of the first 20 seconds following time T.

6. **CS 5306 Advanced Operating Systems**
   {*from Dr. Chen*}

   Design a distributed algorithm to synchronize physical clocks in a distributed system in a room.

7. **CS 5332 Data Base Theory and Design**
   {*from Dr. Hwang*}

   For the following real world universities problem including information

   for Class, Course, Instructor, Student, and Classroom.

   (a) Indicate all functional dependencies among all essential attributes including those you created.

   (b) Draw an E/R diagram by creating essential attributes for all information with pk's, fk's, and relationships.

You may need to add additional information as needed.

(Notes: Courses are in the university inventory, like CS 5332; while classes are the classes you are taking or were taken, like CS 5332 Spring 2018 Section 1.)

(You must use crow feet notation for this problem. If you can not master the notation, do not select this problem.)

8. **CS 5332 Data Base Theory and Design**
{ *from Dr. Ngu*} Consider the following employee database, where the primary keys are underlined.

   Employee(ename:string, street:string, city:string)
   Works(*employee:string, company:string*, salary:real)
   Company(cname:string, city:string)
   Manages(*employee:string, company:string*)

   Give a single SQL statement for each of the following queries:

   (a) *()* Find the names, street, and cities of residence of all employees who work for the "First Bank Corporation" and earn more than $40,000.

   (b) *()* Find the names of all employees in the database who live in the same cities as the companies for which they work.

   (c) *()* Give all managers of "First Bank Corporation" a 10 percent salary raise.

   (d) *()* Find the names of all employees in the database who earn more than every employee of the "Small Bank Corporation".

   (e) *()* Find the name of the company that has the most employees. Your solution should not involve an intermediate view.

9. **CS 5310 Network and Communication Systems**
{ *from Dr. Peng*}

   (a) Describe the steps and protocols used when you send an email message using a computer in CS lab to a friend of yours who uses an email server on a campus in California.

   (b) Describe briefly why network layer is not an end-to-end layer.

Group 4

10. **CS 5338 Formal Languages**
{ *from Dr. Gao*}

   For each of the following questions, circle all the correct statements or write "none" if none of them are correct.

   (a) The correct statements are:
   (a) A language can have infinite number of strings.
   (b) Each string in a language must be finite.
   (c) A string in a language must be non-empty.
   (d) A language must be non-empty.

   (b) The correct statements are:
   (a) A DFSM must halt.
   (b) A NDFSM must halt.
   (c) A NDFSM without ε-transitions must halt.

   (c) The correct statements are:
   (a) A DPDA must halt.
   (b) A NDPDA must halt.
   (c) A NDPDA without ε-transitions must halt.

(d) The correct statements are:
(a) Let M be a DFSM. If $\varepsilon \in L(M)$, then the start state of M must be an accepting state.
(b) Let M be a DFSM. If the start state of M is an accepting state, then $\varepsilon \in L(M)$.
(c) Let M be a NDFSM. If $\varepsilon \in L(M)$, then the start state of M must be an accepting state.
(d) Let M be a NDFSM. If the start state of M is an accepting state, then $\varepsilon \in L(M)$.

(e) The correct statements are:
(a) Regular languages are closed under union.
(b) Regular languages are closed under intersection.
(c) Regular languages are closed under complement.
(d) Regular languages are closed under set difference.

(f) The correct statements are:
(a) Context free languages are closed under union.
(b) Context free languages are closed under intersection.
(c) Context free languages are closed under complement.
(d) Context free languages are closed under set difference.

(g) The correct statements are:
(a) A DTM must halt.
(b) A DTM must halt in at most $|w|$ steps.
(c) A NDTM must halt.
(d) A NDTM must halt in at most $|w|$ steps.

(h) The correct statements are:
(a) In terms of computability, DFSM = NDFSM $<$ DPDA $<$ NDPDA $<$ DTM = NDTM.
(b) In terms of computability, DFSM = NDFSM $<$ DPDA = NDPDA $<$ DTM = NDTM.
(c) In terms of computability, DFSM $<$ NDFSM $<$ DPDA $<$ NDPDA $<$ DTM $<$ NDTM.

(i) The correct statements are:
(a) Decidable languages are closed under union.
(b) Decidable languages are closed under intersection.
(c) Decidable languages are closed under complement.
(d) Semi-decidable languages are closed under complement.

(j) The correct statements are:
(a) SAT is the first language proved to be NP-complete.
(b) 3-SAT is the first language proved to be NP-complete.
(c) Both SAT and 3-SAT are NP-hard.

11. **CS 5318 Design of Programming Languages**
{ *from Dr. Shi* }

(a) Discuss how an actual parameter is related to its corresponding formal parameter in the following four parameter-passing methods for procedure calls.

a. Pass by value

b. Pass by reference

c. Pass by name

(b) Given the output of the following program (written in C syntax) using the above three parameter-passing methods:

```
int i, j, a[5]; // a is a 5 element array with indices 0 - 4

void swap(int x, int y) {

int temp = x;

x = y;

y = temp;

}

int main() {

for (j=0; j<5; j++)

a[j] = j;

i = 1;

swap(i, a[i+1]);

printf("%d %d\n", i, a[2]);

return 0;

}
```

Assume that procedure arguments are evaluated from left to right. What numbers does the program print if both parameters in swap are passed by

a. value?

b. Reference?

c. Name?

Note that you can get partial credit if you show your hand evaluation of the code.

12. **CS 5351 Parallel Processing**
{ *from Dr. Burtscher*}

Assume a shared-memory parallel program that requires synchronization to avoid potential data races. Explain under which conditions a critical section, an atomic operation, or a lock can be used to eliminate the data races. Next, compare and contrast the three approaches in terms of performance, portability, and ease-of-use for the programmer.