Department of Computer Science
Core Graduate Comprehensive Exam
Spring 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 or 13. 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,

   $T(n) = 2T(n/2) + n \;\; for \;\; n > 1$

   (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.

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

   We want an efficient algorithm to sort n elements G[1..n], where each element G[i] is of either 0 or 1. The sorting must be done IN-PLACE, using only O(1) amount of additional space.

   (a) Write a procedure (pseudocode) for SORT(G,n).

   (b) What is the time complexity of this algorithm?

   (c) Illustrate how the sorting is done on the following array of key values. Show the result after each data movement.
   0 1 0 1 0 0 1 0 0 0 1 1 0 1 1

Group 2

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

   (a) Explain Hill Climbing (with and without back tracking) in detail with examples and compare it with the A* algorithm.

   (b) A database of a county banks loan department is represented as positive and negative instances in the following table:

Individual	BAL	RATING	APP	INC	OK
1	1	0	0	1	0
2	0	0	1	0	0
3	1	1	0	1	1
4	0	1	1	1	1
5	0	1	1	0	0
6	1	1	1	0	1
7	1	1	1	1	1
8	1	0	1	0	0
9	1	1	0	0	0

Derive a set of rules which cover all and only the positive instances.

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 $\{P_0, P_1, P_2\}$ be the remaining execution time of $\{T_0, T_1, T_2\}$ respectively and let $\{P_3, P_4, P_5\}$ be the current wait time of $\{T_0, T1, T_2\}$ respectively, where:

   $P_0 = 1,$

   $P_1 = 4,$

   $P_2 = 2,$

   $P_3 = 1,$

   $P_4 = 2,$

   $P_5 = 3,$

   1) Clearly describe the state of the system in 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 university real world problem including information for Class, Course, Instructor, Student, and Classroom. 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: The Course is the course in government inventory such as CS 5332; while the Class is in the class scheduling such as CS 5332 Fall 2016 Sec 1 and CRN#. You must use crow feet notation. Do not choose this problem unless you master crow feet notation.)

8. **CS 5332 Data Base Theory and Design**
   {*from Dr. Ngu*}

   Consider the following relational schema describing a part of a university database:

   Department(dno:integer, dname:string)
   Instructor(staffNo:integer, name:string, dno:integer)
   Course(cid:string, name:string)
   Class(cid:string, meetAt:string, room: string, staffNo:integer)
   Enrolled(studentid:integer, cid:string)
   Student(studentid:integer, name:string, major: string)

   Assume the followings:

   - the fields that are underlined are the primary keys of the relations
   - there is a referential integrity constraint between Department and Instructor via 'dno'
   - there is a referential integrity constraint between 'staffNo' in relation Instructor and 'staffNo' in relation Class
   - there is a referential integrity constraint between 'cid' in relation Course and 'cid' in relation Class
   - there are also referential integrity constraints between 'cid' in relation Course and relation Enrolled as well as between 'studentid' in relation Student and Enrolled.
   - Some example values of meetAt are "Monday 12:30 pm", "Thursday 6:30 pm".
   - Some example values of cid are "CS4332", "CS3343".

   Implement solutions to the following:

   (a) Which students are enrolled in 'CS4332' course, display both studentid and student name.

   (b) How many students are enrolled in the course 'CS5332'?

   (c) Which students have classes on Monday? Display names of students.

   (d) How many students are enrolled in the courses that Dr. Hongchi Shi teaches?

   (e) Show a list of all students (name and student-id) and the number of courses each student is enrolled in. A correct answer will involve using outerjoin since some students might not be enrolling in any course in a particular year.

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. Zare* }

    (a) True or false only. No need to make any argument or explain why.

        i. The complement of a decidable language is decidable regular.
        ii. A decidable language can be recognized by a push–down automaton.
        iii. Boolean sustainability problem (SAT) is not in NP.
        iv. There is a regular language that is in NP but not in P.
        v. The language $A = \{0^n 1^{2n+m} 0 | m > 2, n < 3\}$ is regular.

(b) Determine the regular languages in the following list. For those language that you think are regular, provide a proof for your claim. For the rest, you do NOT need to do anything. The alphabet is $\Sigma = \{0,1\}$.

i. $L_1 = \{0^{m-1}1^{n+1} | n > m.\}$
ii. $L_2 = \{ww | w$ starts with 000 and contains 001 or 11 .$\}$
iii. $L_3 = \{0^n10^m101^k | n$ is odd and $k < 2.\}$
iv. $L_4 = \{wv | w$ starts with 000 and contains 001 or 11.$\}$

11. **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 ε ∈ 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 ε ∈ L(M).
(c) Let M be a NDFSM. If ε ∈ 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 ε ∈ 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.

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

Given the following grammar:

A $\rightarrow$ **a** E | **b** A A

B $\rightarrow$ **b** E | **a** B B

E $\rightarrow$ **a** B | **b** A | ε

(a) Give a left-most derivation and draw the parse tree for **a b b a a b a**.

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

(c) Design appropriate attribute(s) and write an attribute grammar to count the number of **a**'s and the number of **b**'s in the input sentence. For example, the number of **a**'s and the number of **b**'s the sentence in a) are 4 and 3, respectively.

(d) Decorate the parse tree for the sentence in a) with your attribute(s) defined in c) to show how the number of **a**'s and the number of **b**'s are counted.

13. **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.