

CIS MASTERS COMPREHENSIVE EXAM – SPRING 2017

ANSWER EACH PART OF THE EXAM IN A SEPARATE TEST BOOKLET.

IF YOU DO NOT, YOU MAY LOSE PARTIAL CREDIT.

You must answer **3 PARTS** of the exam.

Be sure to indicate on the outside of each test booklet which part is being answered. On some exams, you must answer each question; on some exams there is a choice. Within each particular question, there may be further choices as well.

ONCE AGAIN BE SURE TO ANSWER EACH PART IN A SEPARATE BOOK.
BE SURE TO PUT YOUR NAME ON EACH BOOKLET.

PART 1 { } Analysis of Algorithms (MA STUDENTS MUST TAKE THIS EXAM)

PART 2 { } Architecture

PART 3 { } Artificial Intelligence

PART 4 { } ~~Compilers~~ *Programming languages*

PART 5 { } Database

PART 6 { } Management Information Systems (MS STUDENTS MUST TAKE THIS EXAM)

PART 7 { } Operating Systems

PART 8 { } Telecommunications and Networking

PART 9 { } Theoretical CS

DO NOT LEAVE THE ROOM WITH ANY PORTION OF THE EXAMINATION.
IF PART OF THE EXAM IS MISSING, YOU WILL FAIL THE EXAM.

DO NOT CALL THE CIS DEPARTMENT FOR YOUR GRADE. IT WILL BE E-MAILED TO YOU.

GOOD LUCK!!!

Analysis of Algorithms - Spring 2017

Do any (4) out of the following (5) problems

1. Find the sum of the following n terms. Note that the last term is n and not $2n$.

$$\left(\sum_{i=1}^{i=n-1} 2i \right) + n = 2 + 4 + 6 + \cdots + (2n-4) + (2n-2) + n.$$

Hint: You may use the identity $1 + 2 + \cdots + n = n(n+1)/2$.

2. Let $f(n) = 1000n$ and $g(n) = n^2/1000$. For each one of the following 4 parts, find a function $h(n)$ that satisfies the conditions of this part or explain why such a function does not exist.

(a) $h = O(f)$ and $h = O(g)$.

(b) $h = O(f)$ and $h = \Omega(g)$.

(c) $h = \Omega(f)$ and $h = O(g)$.

(d) $h = \Omega(f)$ and $h = \Omega(g)$.

3. Bob selects an integer x in the range $[1..n]$ for $n = 2^k$ and $k > 1$. Alice is trying to find x using the binary search procedure. After exactly k questions of the type: "is x less than i ?" for some $1 < i \leq n$, she announces that Bob has selected y . Unfortunately, $x \neq y$ because Bob lied in one of his answers while giving the correct answers to all the other $k - 1$ questions.

Justify your answers to the following three questions.

(a) If the first answer was a lie, what are the possible values for y ?

(b) If the first answer was a lie, how many more questions does Alice need to find x assuming Bob will not lie again?

(c) If the last answer was a lie, how many more questions does Alice need to find x assuming Bob will not lie again?

4. Two simple (no self loops and no parallel edges) undirected graphs G and H are **isomorphic** if there exists a 1-1 function f from the vertices of G to the vertices of H such that an edge (u, v) exists in G **if and only if** the edge $(f(u), f(v))$ exists in H .

For each one of the following 4 parts say if G and H (i) are always isomorphic, (ii) could never be isomorphic, (iii) sometimes isomorphic. Justify your answers.

(a) Both graphs have the same number of edges. However, G has n vertices while H has $n + 1$ vertices for $n \geq 1$.

(b) Both graphs have $n \geq 2$ vertices and exactly one edge.

(c) Both graphs have $n \geq 2$ vertices and exactly two edges.

(d) All the vertices have exactly one neighbor.

(e) All the vertices have exactly two neighbors.

5. Problem A is an NP-Complete problem and problem B can be solved with a polynomial time algorithm. Alice and Bob do not know these facts. Instead, Alice is trying to find a polynomial time reduction from problem A to problem B while Bob is trying to find a polynomial time reduction from problem B to problem A . Who has a fair chance to succeed and who will probably fail? Justify your answers.

**Computer Architecture Comprehensive Exam
Spring 2017**

Answer 3 of the 4 questions.

Show all your work. State any assumptions you make.

Explain your answers.

The questions are weighted equally

(33 points each plus 1 point for submitting the exam)

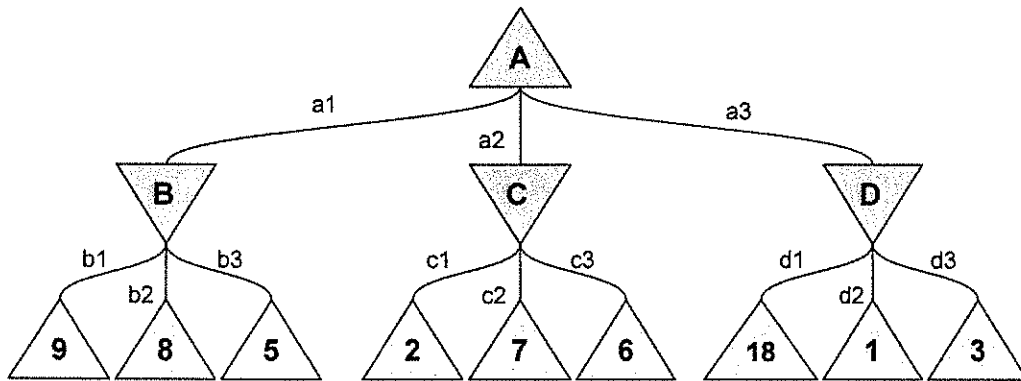
Within a question, sub-questions are weighted equally.

1. Assume the following floating point representation using a 14-bit format. There are 5 bits for the exponent with a bias of
 - a. 16, a normalized significand of 8 bits, and a single sign bit for the number.
 - b. Show the representation of the number 100.0.
 - c. Show the representation of the number 0.25.
2. Suppose a computer using direct mapped cache has 2^{20} words of main memory and a cache of 32 blocks, where each cache block contains 16 words.
 - a. How many blocks of main memory are there?
 - b. What is the format of a memory address as seen by the cache, that is, what are the sizes of the tag, block, and word fields?
 - c. To which cache block will the memory reference $0DB63_{16}$ map?
 - d. In many computers the cache block size is in the range of 32 to 128 bytes. What would be the main advantages and disadvantages of making the size of the cache blocks larger or smaller within this range?
3. Explain what a **branch hazard** is in a pipelined processor. Describe the problem a **conditional branch** can cause to the pipeline. Describe at least two ways of improving this situation.

Artificial Intelligence Comprehensive Exam – Spring 2017

Please answer THREE of the following five questions

1 Adversarial search



The above figure shows a two-ply game tree. The \triangle nodes are MAX nodes, in which it is MAX's turn to move, and the ∇ are MIN nodes. The terminal nodes show the utility values for MAX.

1. Label the interior nodes (A, B, C and D) with their minimax values.
2. Which nodes do not need to be evaluated?
3. What is MAX's best move at the root?

2 First order predicate logic

Use resolution to determine if the following argument in the First Order Predicate Logic is valid. Use the predicates provided.

1. All artificial intelligence students read Turing's work
2. All people who read Turing's work enjoy computer science
3. Either Jim or Mary is an artificial intelligence student
4. Jim is not an artificial intelligence student

-
5. Therefore, Mary enjoys computer science

Predicates:

- S: artificial intelligence student
- T: read Turing's work
- C: enjoy computer science

3 Probability

You are given two coins that are indistinguishable from one another. One coin is biased so that heads has a probability of $\frac{9}{10}$ and the other coin is unbiased (heads has a probability of $\frac{1}{2}$).

1. You choose one of the coins uniformly at random and flip it once. What is the probability that it will come up heads? Show your work.
2. It does come up heads. What is the probability that you have selected the biased coin? Show your work.
3. You flip the same coin again, without knowing for sure which one it is. What is the probability that it comes up heads again? Show your work.

4 Local search

In the following word game, you are given a set of letters and your objective is to form them into words. Suppose your final score is equal to the length of the longest word. Assume you have access to a dictionary \mathcal{D} that contains all legal words.

For example, if you had the letters

o	s	l	c	w	t	i	i	o	e	a	n	i	t
---	---	---	---	---	---	---	---	---	---	---	---	---	---

The optimal solution would be

s	o	l	i	c	i	t	a	t	i	o	n		w	e
---	---	---	---	---	---	---	---	---	---	---	---	--	---	---

A less good solution would be

c	o	i	l		c	i	t	a	t	i	o	n		w	e
---	---	---	---	--	---	---	---	---	---	---	---	---	--	---	---

1. Give a local search formulation for this problem.
 - a. States:
 - b. Actions:
 - c. Evaluation function:
2. What is one way that a greedy hill climbing strategy might get stuck?
3. What is one technique for preventing this?

5 Genetic algorithms

1. Explain clearly how a Genetic Algorithm (GA) works. Your discussion should include a definition for the following genetic operators:
 - a. Selection
 - b. Crossover
 - c. Mutation
2. How can a GA be used to solve an instance of the Traveling Salesperson Problem (TSP)? Begin by clearly defining the TSP and explaining how your solution formulation is initialized.

Comprehensive Exam on Compilers (Spring 2017)

Question 1

Consider the following language over the alphabet $\Sigma = \{a, b\}$: $L = \{w \mid w \text{ does not contain the substring } ab\}$. What is \bar{L} , the complement of L ? Design a *DFA* for \bar{L} , and then use it to give a *DFA* for L .

Question 2

Consider the following grammar, where G is the start symbol and terminals are double quoted.

```
G → DG
DG → DG ";" CG | CG
CG → CG "," NG | NG
NG → "not" NG | GF
GF → "x" | "(" G ")"
```

1. Build a parse tree for the following goal.

x ; (x , not not x)

2. Describe the associability (left-associative or right-associative) of the operators: ";", ",", "not", and "not".
3. Eliminate left-recursion from the grammar.

Question 3

Consider the following grammar.

```
S → F
S → "(" S "+" F ")"
F → "a"
```

1. Describe the language specified by the grammar.
2. Construct a top-down parsing table for the grammar.
3. Write a recursive descent parser for the grammar.

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Answer all three parts.

Part I (42 pts) You must answer all of the following questions

1. Given: The following tables:

You have a customer table called CUST containing:

- CustID (primary key)
- CustName (the name of the customer)
- CustPhone (the phone number of the customer)
- CustCreditLimit (the amount of money that customer could owe)

You have a product table called PRODUCT containing:

- ProdID (primary)
- ProdName (name of the product)
- ProdDesc (a long description of the product which may be over 10 lines)
- ListPrice

You have a payment table called PAYMENT containing:

- PayID (each payment has a unique number – primary key)
- PayDate
- CustID (should match CUSTID in the CUST table)
- PayAmt (amount of money paid is US dollars)

You have a purchase table called PURCHASE containing:

- PurchaseID (each purchase has only one item and has a unique purchase number - primary key)
- PurchaseDate
- CustID (should match the CUST table)
- ProdID (should match the PRODUCT table)
- ProductPrice (can include pennies)
- Quantity (must be a positive integer between 1 and 99)

For each part, give one or more SQL commands which will:

- a. Create the PURCHASE table (include the primary key, foreign key, and quantity constraints)
- b. Insert a row into PURCHASE showing that CustID 23 bought 3 units of Product 987 on 1/14/2015 for \$10 each.
- c. List all the records in PRODUCT whose ListPrice is more than AVERAGE list price.
- d. List all the records in PURCHASE where the ProductPrice is less than the ListPrice in PRODUCT.
- e. Somehow the CUST table has become corrupt. There are multiple customers having the same CustID. List all the records in CUST which have this problem. Just list the CustID, CustName for all the duplicated CustIDs.
- f. How much does customer ABC owe? Just subtract the amount paid from the amount owed.
- g. Update the CustCreditLimit in the CUST table as follows (be careful): If the credit limit is under 20,000 – double it - otherwise add 5,000.
- h. List the name of the customer who has paid the most money.
- i. List the name of the product which has never been purchased.
- j. Create a view on the PURCHASE table limiting the view to all products whose price is over 3000.

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Part II (40 pts) You must answer all of the following questions

(a) 25 pts Assume you are setting up a database for a prison library.

Each convict has a unique number (stenciled on all clothing). For each convict, we need to know the convict's name and date of birth. Some convicts are in jail for multiple crimes. Some convicts are in jail for only one crime. For each crime, we need to know the name of the crime and how many years they are sentenced for that crime.

Example: Al Capone #123 dob: Jan 12, 1888 was convicted of Murder 25 years - Arson 20 years – Robbery 10 yrs.

The library has many books. Each book in the library has a unique number. So each copy of "War and Peace" has a different unique number. Each book has only one genre (comedy, drama, history, business). For example: The book "Bomb Making 101" has a genre of CAREER-ADVANCEMENT. For each book, we want to maintain that book's condition (GOOD, BAD, RIPPED).

You also need to have a record of all library transactions. For example, convict 123 borrowed book 987 on 1/1/2015 and returned it on 2/2/2015. If the return date is null, that means the convict still has the book.

Design the 3NF tables necessary for this problem: Clearly indicate the field(s) and the primary key(s).

(b) 15 pts Using your design, write SQL queries to:

- 1- You found cocaine in Book # 456. List the name(s) of the convicts who borrowed this book.
- 2- There was a jail break. You found a uniform with the number 654 on it. What is the name of that convict.
3. List the names of all convicts convicted of ARSON.
4. List the names of all convicts who read a book in the COMEDY genre.

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Part III (18 pts) Answer three (2) of the following three (3) questions

Question 1.

- a. Look at the tables from part (1). You wanted to delete product 123 from the PRODUCT table. What effect will this have on any other tables and/or the purchasing history of each customer.
- b. You just executed a transaction which updated two records. Unfortunately, you now want to undo the effects of the transaction. What does the DBMS have to do in order to undo the effects of this transaction? (Hint: there are several cases to consider.) Be careful.

Question 2.

Given the following tables:

T1:	A	B	T2:	B	C
	5	16		15	33
	6	17		15	44
	7	18		15	77
	8	19		18	88
				19	99

- List the records in the
- Natural join
 - Left outer join of T1 and T2
 - Right outer join of T1 and T2
 - Full outer join of T1 and T2
 - Cartesian Product of T1 and T2

Question 3.

Given a distributed database system for a bank which has 3 datacenters located in NY, LA, and TEXAS. Each record contains an account number (unique) and a dollar amount.

Part 1. Assume: The data is fragmented with 33.33% of the data in each location with no overlapping data.

- (a) You wanted to know the account number of the account which has the most money. How would the DBMS determine this?
- (b) You wanted to change account 123's balance to 500 million. How would the DBMS accomplish this?

Part 2: Assume: The data is fully replicated at each location.

- (a) You wanted to know the account number of the account which has the most money. How would the DBMS determine this?
- (b) You wanted to change account 123's balance to 500 million. How would the DBMS accomplish this?

MIS Comprehensive Exam – Spring 2017 – Page 1

Complete Sections A, B, and C

Section A – Case Study - Sunburst Hotels (case attached) – Answer Both Questions in this Part – 15 points each for a total of 30 points

1. (15 points) (a) Describe the problems that caused Sunburst to decide to use an outside ASP. (b) What other reasons might they have had for making that decision? Explain why you agree or disagree with this decision.
2. (15 points) What management, organizational, and technical issues did Warczak have to consider in making each of these two decisions? (i) installing an ERP and (ii) outsourcing the ERP to an ASP.

Section B - Answer Both Questions in this Part – 15 points each for a total of 30 points

1. (15 points) Given the following tasks, activity times and precedence (predecessors): Remember to show your work.
 - (a) Compute the ES (early start), EF (early finish), LS (late start), and LF (late finish) times for each task
 - (b) What is (are) the critical path(s)?
 - (c) Draw the network graph

↓	Activity time	Prec 1	Prec 2
A	6		
B	3		
C	9		
D	2	a	b
E	10	b	c
F	8	d	
G	7	e	f

MIS Comprehensive Exam – Spring 2017 – Page 2

Section B (continued)

2. (15 points) How many widgets would a company have to sell to break even under the following conditions? Remember to show your work.
 - (a) Initial investment was \$60,000
 - (b) Widgets sold for \$25
 - (c) Materials to produce a widget cost \$10
 - (d) Direct labor costs are \$2.50 per widget
 - (e) Total indirect costs and overhead per widget is 10% of the selling price

Section C - Answer Four of Six Questions in this Part – 10 points each for a total of 40 points

1. (10 points) Draw a Use-Case Dependency Diagram that would represent the following:
 - (a) The ability to drive depends on having a license.
 - (b) The ability to have a license depends on passing a road test.
 - (c) The ability to have a license depends on the ability to have a permit.
 - (d) The ability to park a car depends on having a parking permit.
2. (10 points) In the systems development process:
 - (a) Which version of a system does Brooks think is most likely to be the best – the first, second or third? Why?
 - (b) What does an "Aristocracy that Needs No Apology" refer to?

MIS Comprehensive Exam – Spring 2017 – Page 3

Section C (continued)

3. (10 points) (a) Contrast the critical success factors (CSFs) and SWOT (Strengths, Weaknesses, Opportunities, and Threats) approaches for assessing opportunities in a strategic IS planning process. (b) Under what circumstances would each of these approaches be more useful than the other?
4. (10 points) (a) What are the three general approaches to obtaining an expert system? (b) Give one advantage and one disadvantage for each approach.
5. (10 points) (a) Match the Leadership Style with its Attitude

Leadership Style	Attitude
Coercive	a. Come with me!
Authoritative	b. What do you think?
Affiliative	c. People come first!
Democratic	d. Try this!
Pacesetting	e. Do as I say
Coaching	f. Do as I do, now!

- (b) Give one advantage and one disadvantage for each leadership style.
6. (10 points) There are four strategies (cutover, parallel, phasing, and pilot) for transitioning from an old system to a new one.
- Briefly describe each strategy
 - Give a case example for each strategy explaining why it would be the preferred approach in that case

CASE STUDY

Sunburst Hotels International Moves to an Application Service Provider

When Sunburst Hotels International Inc. was spun off in late 1997, the company had no IT infrastructure, and CIO Charles Warczak had to create it. Sunburst earned about \$114 million in 1997 by owning and operating 87 hotels in 27 states, including some Comfort Inns and EconoLodges. He knew his company could not perform all the many complex functions required without the support of application packages. Choice Hotels International Corp., Sunburst's former parent company, was using an enterprise resource planning (ERP) system from PeopleSoft, and Warczak wanted to use the same system. The major problems he faced involved costs. Warczak calculated that to acquire and install the ERP package he wanted, the company would have had to spend \$1.5 million on capital expenses (mainly computer hardware and software) up front, a hefty cost for the small, newly independent company. And that was only the beginning of his projected costs. In this case study we examine his problem and the method he selected to solve it.

Installing a new ERP system can be very expensive, particularly for a start-up or a new spin-off which may also lack information systems staff with the technical expertise for such projects. In Sunburst's case, Warczak met with both IS and finance personnel at Choice to determine Sunburst's needs and costs. They ultimately concluded that Sunburst needed to spend well over \$1 million up front on hardware and software, including both computers and networking. In addition Sunburst would need to purchase a \$500,000 Oracle database to support the PeopleSoft ERP system. And these were only some of the costs.

Complex computer systems require highly skilled staffs to run and maintain them, and Warczak estimated that the cost of such a staff for his small corporation would be about \$500,000. However, the immediate problem was even tougher: locating and hiring such a staff in the first place. Skilled technicians are in short supply and finding and hiring them was a challenge. Warczak would need staff skilled in PeopleSoft software, and the competition for experienced ERP technicians was fierce everywhere but particularly so in the greater Washington, DC, area. Sunburst headquarters are in Silver

Springs, Maryland, a Washington suburb. Networking experts were also difficult to locate and hire. However, hiring such a skilled staff would not be the end of the problem: Warczak would also face the challenge of keeping employees who are in such high demand. "We'd have a real tough time holding on to people who are experts in, say, the accounts payable module," said Warczak. And, thinking about long-range costs, he added, "There's a lot of cost with high turnover."

Being bottom-line oriented, Warczak believed that "Everything at the corporate office including IT is an overhead [expense]." However, the company had another major concern. ERP software is extremely complex, and its successful implementation can be a long and arduous process. Based on implementations at other corporations, Sunburst anticipated a minimum implementation period of six to eight months. However, Sunburst could look to an example of a challenging implementation program close to home. Choice faced the same problem a year earlier (prior to the Sunburst spin-off) when it installed PeopleSoft. Although they were ultimately pleased with the software, the implementation "was a disaster," according to Warczak. "There were lots of cost overruns." He added that once the implementation was completed, "functionality was terrible" because of technical problems, and there was a long learning curve for creating an infrastructure.

With all this information and experience, the decision was not difficult. Warczak opted to outsource his ERP system. However, he did not want to give the computer system and all the vital ongoing tasks the hotel used on a daily basis to outsiders, so he chose a route that had only recently become available, an application service provider (ASP). ASPs are different because they own and operate the computer hardware and software and rent usage on the computer application to customers. The customer, in this case Sunburst, pays the ASP and uses the system as if it owned it, but the ASP actually operates and maintains both the software and hardware.

Companies have been renting software in this way since 1997, and software renters include PeopleSoft, J.D. Edwards

& Co., Great Plains Software Inc., and Oracle Corp. Sunburst selected a less-known ASP, USInternetworking Inc. (USI) of Annapolis, Maryland, and signed a five-year contract that began on April 1, 1999. Let us consider some of the benefits Sunburst realized by going this route.

The fundamental change, out of which every other benefit flows, is that Sunburst did not have to purchase and own computers (except for PCs or network computers). The company also did not have to buy the PeopleSoft and Oracle software. In addition, the costs of building and maintaining a network were eliminated because Sunburst accesses its ERP via the Web. The only Sunburst costs, in addition to the monthly rental, are for PCs, Web browsers, and telephone lines to connect to the Web. Thus, most of Sunburst's infrastructure start-up costs were eliminated. The company did have the normal personnel costs associated with converting from the old system to the new one and learning the new system. Although Sunburst has not released the amount of its monthly fee, USI says its charges range from \$50,000 to \$200,000, depending on the number of PeopleSoft modules the customer uses. Some ASPs charge not by the module but by the number of users, typically charging \$3 to \$500 per user per month. This approach enables small companies to pay less; their costs grow only as their companies grow.

Staff costs were all but eliminated by going to an ASP because PeopleSoft software is owned and supported by USI. However, customers of ASPs usually assign one or more persons as full-time supervisors of the system to ensure that it is running properly and that the staff of the renting company is using it properly. This same person (or group) usually is assigned as liaison to the ASP. By using an ASP, Sunburst also eliminated the other staffing problem. The company did not have to face the fierce competition for skilled technicians—that was USI's problem and it already had its staff in place.

Even the implementation was much quicker than it would otherwise have been. The software was already working, ready for the Sunburst staff to access it. Sunburst's PeopleSoft ERP system was up and running in only 3 months and went live in April 1999.

Case Study - MIS Comprehensive Exam - Spring 2017 -2

Using an ASP has another benefit for many organizations. Companies are able to move slowly into using an ASP's software, trying out one function of the software package at a time. In that way they can find out whether the particular package is right for them without major upfront costs (a benefit Sunburst did not need because they earned the package when they were part of Choice, and they knew it was a good fit).

Using an ASP does present risks. Some companies are concerned because this type of service is so new. Companies that are risk averse may want to wait a year or two until ASPs have a longer track record. Security is a risk in the minds of many, particularly when a company has to access its sensitive data via the Internet. Dick Lefebvre, the vice president of information technology at auto parts producer Simpson Industries Inc. in Plymouth, Michigan, had precisely that concern. He wanted to use J.D. Edwards' ERP system through IBM Global Services, a company also in the ASP business. To solve the problem, he decided not to use the Web, but instead to connect to IBM Global Services through a private line. Leasing a

private line is expensive, however, and his communication costs were perhaps 10 times the cost of using the Web. Lefebvre was willing to pay the price in order to be certain that competitors could not capture vital information about the parts that his company produces. However, other companies feel very secure using the Internet. Typically they use multiple firewalls and encryption to protect their data.

One other fear common to all companies that outsource is that they will be locked into the outside vendor, placing them at the vendor's mercy. Only time will tell if this becomes the case, but using an ASP is an alternative, and risk may be reduced more than with traditional outsourcing. The main difference is that the software the company is using (PeopleSoft in the case of Sunburst) usually does not belong exclusively to the ASP (USI in this example). Sunburst is able to leave USI and take their business to another ASP that is running PeopleSoft's ERP. And ultimately, if the company (Sunburst) cannot make it work with any ASP, it can travel the original road, purchasing the software and hardware itself, bringing the whole operation inhouse.

CIS Master Comprehensive Exam, Operating Systems Spring 2017

Answer four (4) of the following five (5) questions.

Each question is worth 25 points

1. a) (15 pts) Give a pseudocode solution for the **bounded buffer Producer/Consumer** problem. Show the code for the **Producer** and the **Consumer**. Clearly indicate any **mutex** and/or **condition variables** that you use.
You may assume a fixed (circular) buffer capacity of $N=10$ items.
b) (10 pts) Does your solution work for **multiple Producers and Consumers**? Why or why not?
2. a) (5 pts) Explain how a **demand paging system** works with **virtual memory**. Describe what is stored in the **page table** and how a **virtual address** gets translated into an **actual memory address**.
b) (5 pts) If the number of **page frames** is very large this can create a problem. Explain what a **TLB** is and how it helps with this problem.
c) (5 pts) What causes a **page fault**? What does the **operating system** do in this case?
d) What is meant by **locality of reference** and how does that affect a **page replacement policy**?
d) (10 pts) Briefly explain how each of the following page replacement algorithms work:
I) **FIFO**
II) **Second Chance**
3. a) (5 pts) How does a multicore computer with shared memory differ from a distributed or a clustered system with respect to the OS? Make specific reference to the **OS kernel**.
b) (5 pts) Briefly explain the difference between **processes and threads**.
c) (5 pts) Threads on a single core system are often handled in **user mode**. Explain at least one weakness of this approach on a single processor system.
d) (5 pts) Explain why user mode thread handling is not acceptable on a **multicore computer**.
e) (5 pts) Explain how threads can be handled more effectively on a **multicore computer**.
4. a) (5 pts) Implement a **mutex lock** using **TestAndSet using busy waiting**, i.e. write pseudocode to implement each of the functions **lock(m)** and **unlock(m)** on a boolean variable **m** (the **mutex lock**).
b) (5 pts) Why is **TestAndSet** necessary?
c) (5 pts) Does your solution have a bounded waiting time for the lock? Why or why not?
d) (5 pts) How can a **semaphore** (with operations **Signal** and **Wait** or **P** and **V**) be implemented to guarantee fairness?
e) (5 pts) When is a **spin-lock** (or **busy waiting**) acceptable?
5. Consider the **Dining Philosopher's** problem with **4 philosophers**. The philosophers are each holding a shared chopstick and the system is in deadlock.
a) (5 pts) Draw a resource allocation graph representing the deadlock. Explain the nodes and arcs in the graph. Alternatively explain clearly the deadlock situation.
b) (5 pts) Explain how this deadlock can be broken.
c) (5 pts) Explain **two OS policies** that prevent this kind of this deadlock and include an explanation of how each method works in this case.
d) (5 pts) Describe a situation in a computer system that is similar to the **Dining Philosophers' problem**.
e) (5 pts) In the real world, most operating systems ignore the problem of deadlock. Why?

Comprehensive Examination in Telecommunications Spring 2017

Answer any five (5) of the following six (6) questions.

1. (a) Suppose the data are stored on 128 Gig SD cards (assume exact 128,000,000,000 bytes) that weigh 2 grams each. Suppose that an airliner carries 10^4 kg of these SD at a speed of 1000 km/h over a distance of 5000 km. What is the data transmission rate in bits per second of this system? What is the latency?
 - (b) Consider a baseband bus with a number of equally spaced stations with a data rate of 20 Mbps and a bus length of 2 km. What is the mean time to send a frame of 1000 bits to another station, measured from beginning of transmission to the end of reception? Assume propagation speed of 200 m/ μ s (meters per microsecond).
 - (c) Consider the use of 1000 bit frames on a 1 Mbps satellite channel with a 250 ms delay. What is the maximum link utilization for:
 - i. Stop-and-wait flow control?
 - ii. Continuous flow control with a window size of 7?
 - iii. Continuous flow control with a window size of 127?
 - iv. Continuous flow control with a window size of 255?
2. (a) You are sending an email to `user@brooklyn.cuny.edu`. Answer the following:
 - i. When looking up `brooklyn.cuny.edu`, what is the difference between recursive and iterative queries?
 - ii. What are MX records, and how do they differ from A records.
 - iii. What is the *minimum* number of network round trips to send a small email message using SMTP? (include DNS lookup) Explain.
 - (b) IP packet with a payload of 4480 octets is to be transmitted through an Ethernet with a maximum payload of 1500 octets. Show the Total Length, More Flag, and Fragment Offset values in each of the resulting fragments. Use 20 octets for IP header.
 - (c) What are RAW sockets, and why is there a need for them?
3. (a) We are transmitting data at a rate of 1000 bits per second. During transmission, the noise introduces errors so that, on average, 2% of bits are received incorrectly (i.e.: a 0 as 1, or 1 as 0). What is the maximum error free capacity of this channel?
 - (b) Given a channel with an intended capacity of 4 Mbps, the bandwidth of the channel is 3 MHz. Assuming white thermal noise, what signal to noise ratio is required to achieve this capacity?
 - (c) The spectrum of a channel is between 3 MHz and 7 MHz, and SNR_{dB} is 30 dB.
 - i. What is the maximum error free capacity of this channel?
 - ii. Assuming we can reach that capacity, how many signaling levels are required?
 - (d) A signal travels from point A to point B. At point A, the signal power is 100 W. At point B, the power is 90 W. What is the attenuation in dB?

4.
 - (a) Explain primary differences between Unipolar, Polar, Bipolar encoding.
 - (b) Explain primary differences between NRZ and RZ. What are the benefits/trade-offs?
 - (c) One positive side effect of bipolar encoding is that a bipolar violation (two consecutive + pulses or two consecutive - pulses separated by any number of zeros) indicates to the receiver that an error has occurred in transmission. Unfortunately, upon the receipt of such a violation, the receiver does not know which bit is in error (only that an error has occurred). For the received bipolar sequence: + - 0 + -0 - + which has one bipolar violation, construct two scenarios (each of which involves a different transmitted bit stream with one transmitted bit being converted via an error) that will produce this same received bit pattern.
5. For pure-ALOHA, slotted-ALOHA, CSMA/CD and CSMA/CA protocols, answer the following:
 - (a) When should the station access the medium?
 - (b) What should be done if the medium is busy?
 - (c) How should the station determine the success or failure of the transmission?
 - (d) What should the station do if there's an access conflict?
6. Consider a packet-switching network of N nodes. For each of the below topologies give the average number of hops between stations:
 - (a) Star: one central node, all other nodes attach to the central node.
 - (b) Loop: each node connects to two other nodes to form a closed loop.
 - (c) Fully connected: each node is connected to all other nodes.

Theoretical Computer Science
Spring 2017

Do any four (4) of the following six (6) Questions.

Part I: Formal Language Theory

Question I. (25 points.) Give a context-free grammar for the language $\{a^m b^n \mid m \neq n\}$.

Question II. (25 points.) Formally describe a pushdown automaton for the language $\{w \in \{a,b\}^* \mid w \text{ has exactly twice as many "a"s as "b"s}\}$,

Part II: Computability Theory

Question III. (25 points.) Prove that the Halting predicate (the function that tells if a Turing machine and an input halts) is Turing-Recognizable (r.e.). You do not have to show that it is not Turing-Decidable (Recursive).

Question IV. (25 points.) Give a high-level description of a Turing machine that recognizes the language $\{a^m b^n c^p \mid m \leq n \text{ and } n = p\}$.

Part III: Complexity Theory

Question V. (25 points.) Give exact definitions of **P**, **NP**, and **NP-Complete**.

Question VI. (25 points.) Answer one of the following:

- a) Give a plausible reason to believe that **P=NP**.
- b) Give a plausible reason to believe that **P \neq NP**.

Comprehensive Exam Spring 2018
(Programming Languages and Compilers)

Question 1

Consider the languages defined by the context-free grammars.

(a) $S \rightarrow x S \mid y S \mid x y$

(b) $S \rightarrow x \mid y \mid + S S \mid - S S$

where S is a non-terminal, and x , y , $+$, and $-$ are terminals.

1.1 What language is generated by each of the grammars?

1.2 Is the language defined by grammar (a) regular? If so, write a regular expression for the language.

1.3 Sketch a top-down parser for the language defined by grammar (b).

Question 2

Define the following functions in Python, Java, or C++.

2.1 `suffix(lst, suf)`: This function returns true if *suf* is a suffix, i.e., a sublist at the end, of list *lst*; otherwise, it returns false. Examples:

- `suffix([1,2,3], [])` returns true.
- `suffix([1,2,3], [2,3])` returns true.
- `suffix([1,2,3], [1,2,3])` returns true.
- `suffix([1,2,3], [1,2])` returns false.

2.2 `subsets(s)`: This function takes a set *s* represented as a list, and returns a list of all the subsets of *s*. For example: the function call `subsets([1,2,3])` returns

`[[], [1], [2], [3], [1,2], [1,3], [2,3], [1,2,3]]`

The order of the subsets in the list is not important.

Question 3

The following gives a partial implementation of a class named `MyList` in C++ and Java. A `MyList` object is a singly-linked list, where the first node is referenced by the variable `head`, and the last node is referenced by the variable `tail`.

```
// Java
class ListNode<E> {
    public ListNode(E data, ListNode<E> next){
        this.data = data;
        this.next = next;
    }
    public E data;
    public ListNode<E> next;
}
class MyList<E> {
    ...
    private ListNode<E> head, tail;
}

// C++
template <typename E>
class ListNode {
public:
    E data;
    ListNode<E> *next;
    ListNode(E& item, ListNode<E> *ptr = NULL): data(item), next(ptr) {}
};

template <typename E>
class MyList {
    // ...
private:
    ListNode<E> *head, *tail;
};
```

Do the questions in C++ or Java.

- 3.1 Implement a method, named `add(elm)`, in `MyList` class, which inserts `elm` at the end of this list.
- 3.2 Write a class, named `OrderedList`, that extends `MyList`, and overrides the method `add(elm)`. Elements in an `OrderedList` object are sorted in non-decreasing order. The method `add(elm)` inserts `elm` into this list such that the list remains ordered after insertion.