Systems Breadth Exam: Fall 2002

Department of Computer Science, University of Kentucky

You must answer all the questions in the Core Material section. You must also answer all the questions in two of the other sections.

Answer every section on a different piece of paper (or pieces of paper). **Put your exam id on every piece of paper you submit.** Do **not** put your name on any piece of paper. Your exam id is

1 Core material

1. In a particular computer architecture for paging, 16-bit addresses are considered to have 8 bits for page number and 8 bits for offset.

   (a) Are the page-number bits the high-order or the low-order bits?

   (b) What is the reason that the page-number bits must be the ones you suggest in part (a)?

2. What three things does the hardware (not the operating system) do when an interrupt occurs?

3. Write a program with two processes that use semaphores as their synchronization technique. This program should always deadlock when it is run. Other than deadlocking, the program does not have to have any obvious purpose. Use any programming-language notation you like (it can look like C, for instance) so long as it is clear.

4. I am building a special-purpose computer for a scientific application. I need to represent integers, but I guarantee they will always be in the range from 0 to 3,235,121.

   (a) How many bits long must my integer representation be? (You may not use a calculator for this question!)

   (b) How many bits would you recommend I use for my integers?

   (c) Explain your reason for the answer you gave to (b).

2 Compilers

1. Consider the following CFG G:

   $S \rightarrow (S) B \mid n B \mid i B$
   $B \rightarrow A S B \mid \epsilon$
   $A \rightarrow + \mid - \mid * \mid /$

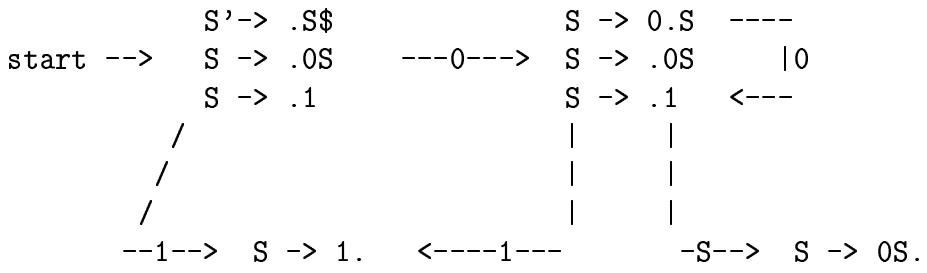
   Answer the following questions:

   (a) Provide two example of strings belonging to L(G).

   (b) Describe the language generated by G.

   (c) Define at least four properties of CFG and state which of them are satisfied by G. Justify one of your answers.

2. The parsing automaton shown below has been constructed for a certain context-free grammar G. Actually, one or more states and transitions are omitted from this automaton.



   (a) What is the name of the parsing technique used to construct this automaton?

   (b) What is the grammar G?

   (c) Add the missing states and transitions.

   (d) Construct the parse table based on the automaton. Describe the rules that you are using in constructing the parse table.

   (e) Show the parsing process when the table constructed in step (d) is applied to string `0001`.

3 Databases

1. Consider the following database schema used by a computer manufacturer:

```
Hardware (Platform, Vendor, Model)
Software (Product, Name, Version, Usage, Cost, Vendor)
Employee (SS_Num, Name, Vendor)
Installed (Platform, Product, Date, SS_Num)
```

   The following questions ask that you formulate the following into any commercial query language (e.g., SQL, QBE or Quel). It is acceptable to formulate several simple expressions to produce the requested result.

   (a) List every hardware platform (Hardware.Platform) that is manufactured by Dell (that is, `Hardware.Vendor = "Dell"`) or by Compaq that runs either C++ (that is, `Software.Name = "C++"`) or Java.

   (b) Microsoft has just decided to change the product name of "Office 2000" and "Office XP" to "Business Pro". Henceforth, the name "Office 2000" and the name "Office XP" will always appear as "Business Pro". All references to "Office 2000" and "Office XP" are to be changed. Give the query (or queries) necessary to make this change.

   (c) List every computer (Platform) that has never had installed on it any software product sold by Microsoft (`Software.Vendor = "Microsoft"`).

   (d) Find all employees who have installed every game in the database (`Usage="Game"`).

2. A database management system is trying to concurrently execute transactions T_1, T_2, T_3, and T_4. Consider the following execution schedule:

	T_1	T_2	T_3	T_4
1	R(A)			
2		R(A)		
3			R(B)	
4				W(B)
5				R(A)
6			R(A)	
7		W(B)		
8	R(B)			
9		W(A)		
10			W(B)	
11	W(A)			
12				
13	commit			
14		commit		
15			commit	
16				commit

(a) Indicate all conflicts that occur in this schedule. For each conflict, indicate its type, actions and transactions affected.

(b) Indicate all blind writes in the schedule.

(c) Is this schedule serializable? Why or why not?

(d) Using 2-Phase Locking with wait-die, show how this schedule will be executed. Actions come in the order they are shown in the schedule, except that actions in transactions waiting for locks are skipped. Aborted transactions are restarted immediately.

4 Distributed Operating Systems

1. Replication is a technique used in distributed file systems to improve file availability. The quorum-based protocol can guarantee that a read can get the most up-to-date copy without requiring that write operations be executed on all copies.

   (a) Describe the operation of the quorum-based protocol.

   (b) Explain how the quorum-based protocol achieves the guarantee mentioned above.

2. Consider the following simple method to enforce mutual exclusion: All sites are arranged in a logical ring fashion and a unique token circulates around the ring hopping from a site to another site. We say "a CS (critical section) request arrives" when a site needs to enter its CS. When a CS request arrives, its site waits for the token, grabs the token, executes the CS, and then dispatches the token to the next site on the ring. If a site does not need the token on its arrival, it immediately dispatches the token to the next site (in zero time).

   Assume there are N sites, the message/token delay is T, the CS execution time is E, and the load is very low.

   (a) After a CS request arrives, what is the average waiting time before its site gets the token?

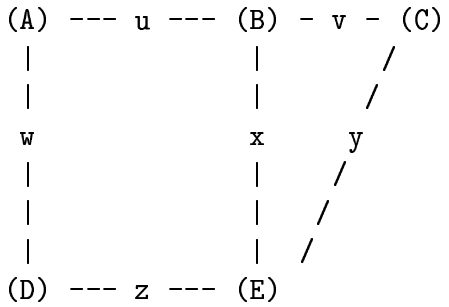
   (b) If a CS request arrives in the entire system every R time units, what is average number of messages exchanged per CS execution?

3. Baboons cross the Victoria Falls by going hand-over-hand along a rope strung across the Falls. Several baboons can cross at the same time provided they are going in the same direction. Baboons going in opposite directions should not be on the rope concurrently, so a baboon trying to cross must insure that no baboon is currently crossing in the opposite direction. To insure freedom from starvation, after a baboon has started waiting to cross the Falls, no more than 10 new baboons are allowed to start from the opposite end to cross the Falls.

   Write a monitor solution to solve the problem. (Since the solution is symmetric for both sides, just give it for one side.)

5 Networks

1. Consider the following network topology:



   (a) Assume that link u "breaks" or "fails".

      i. Will a Distance Vector Routing Protocol correctly adjust each machine's routing table to route around the failure?

      ii. Will a Link State Routing Protocol correctly adjust each machine's routing table to route around the failure?

   (b) Now assume that link z also "breaks" or "fails" (that is, both u and z fail).

      i. Will a Distance Vector Routing Protocol correctly adjust each machine's routing table to route around the failure?

      ii. Will a Link State Routing Protocol correctly adjust each machine's routing table to route around the failure?

   Explain your answers (with examples when necessary).

2. Consider an HTTP connection between a client and a server, where the path through the network includes a satellite channel. The one-way propagation delay is the same in both directions: 0.25 seconds. The server is transmitting a one-million-byte (1,000,000 bytes) hypertext object to the client. Assume each segment (packet) transmitted by the server TCP contains 1000 bytes of user data, the client's TCP receive buffer is infinite, and Van Jacobson congestion control is in use. Write down any other assumptions you need to make.

   (a) If the bandwidth available to the connection is 8×10^9 (8,000,000,000) bits/second, and the sender begins transmission at time t and no losses

occur during transmission, at what time will the last byte of the file be delivered to the client program? (You may want to draw a timing diagram.)

(b) Answer the same question as in (a), only this time assume the bandwidth available to the connection is 160,000 bits/second, the routers along the path have buffering equal to the bandwidth-delay product, and any packets transmitted in excess of that amount are dropped. (A diagram is strongly recommended.)