Foundations of Information Systems

Makeup Final Exam

April 16, 2025

1. Simplify the following Boolean algebra expressions as much as possible.

   (a) $(a \vee 0) \wedge (a' \vee 1)$

   (b) $a \vee (a' \wedge b)$

   (c) $((a \vee b) \wedge (a' \vee c)) \wedge ((a' \wedge b') \vee (a \wedge c'))$

   (5+5+5)

2. Suppose you evaluate the expression

$$f(x) = \frac{1}{x-1} - \frac{1}{x+1}$$

   in floating point arithmetic for large values of x.

   (a) Is the absolute error large? Is the relative error large? Explain!

   (b) Can you reduce the floating point error when x is large by rewriting the expression? Explain!

   (5+5)

3. Consider the following tasks.

   (i) Take two arbitrary length integers as binary strings written right-to-left and output their sum, also as a binary string right-to-left.

   (ii) Take two arbitrary length integers as binary strings written left-to-right and output their sum, also as a binary string written left-to-right.

   (iii) Count the number of zeros in a binary string or arbitrary length.

   (iv) Read a binary string whose length is divisible by four and output the parity of every group of four bits.

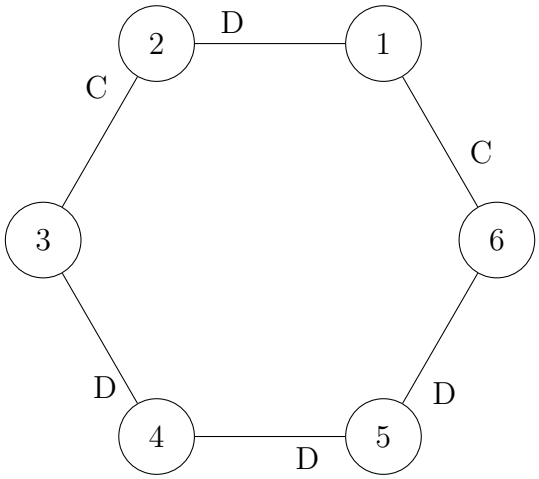
   Answer the following questions:

   (a) Which of the tasks above can be performed by a finite state transducer? Give a concise justification in each case.

   (b) Pick one of the tasks that can be performed by a finite state transducer and draw the transducer that solves the task.

(8+7)

4. Consider the dining philosopher's problem with six philosophers sitting around a table. They follow the Chandy–Misra protocol. A chopstick is either *dirty* ("D") or *clean* ("C"), and held by the philosopher closest to it in the following initial configuration:



Assume, for simplicity, that the philosophers "are running on the same CPU", i.e., no two actions (starting to eat, requesting a chopstick, honoring the request for a chopstick) can happen at the same time. You have no control on the ordering of events, except for the constraints imposed by the Chandy–Misra protocol.

   (a) All philosophers are currently hungry. Which philosopher is the first to eat? If there is ambiguity, state all possibilities.

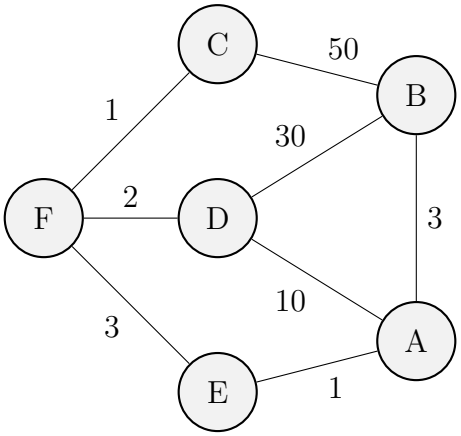
   (b) Argue that Philosopher 3 cannot starve, i.e., eventually gets to eat.

   (c) Give a high-level summary of the proof that the Chandy–Misra protocol always works, i.e., that the philosophers cannot deadlock, and that every philosopher who wants to eat will eventually get to eat.

(5+5+5)

5. How many data bits can you encode in a Hamming code of total length 20 if additional parity is used? (5)

6. Consider the following router network:



Use Dijkstra's algorithm to compute the shortest path from router A to every other router in the network. (10)

7. (a) Design a database schema for a (simplified) employee database. An *employee* has a name and is a member of exactly one *team*. A team has a *team leader* who is an employee and may have additional members that are also employees.

   (b) Write a query, using relational algebra or SQL, to find the name of the leader of the team where employee "Susie Miller" is a member.

   (5+5)