Foundations of Information Systems

Final Exam

February 12, 2025

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

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

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

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

   (5+5+5)

2. Consider a 7-bit floating-point representation where a floating point number has 1 sign bit followed by 3 exponent bits, and 3 bits for the significant. According to the IEEE standard, subnormal numbers have the exponent 000; the bias for a 3-bit exponent is $2^{3-1} - 1 = 3$. Answer the following questions:

   (a) Which number is represented by the bit pattern $1\,100\,111$?

   (b) Write out the bit pattern for the representation of 5.5.

   (c) What is the smallest positive number of the form $\varepsilon = 2^i$ in this floating point representation such that $1 \oplus \varepsilon > 1$?

   (5+5+5)

3. Construct a finite state transducer that reads an input string which consists of letter characters, as well as ␣ (space) to separate words. It outputs a string containing only the first letters of each word. Assume the sentence is terminated by a single . (period).

   Example: Input

   ```
   Smart people enjoy language lessons.
   ```

   should produce output

   ```
   Spell
   ```

   (10)

4. A web service accepts file upload via ZIP archives, converts the uploaded files to PDF, and a provides a preview of the converted files. Within a short period of time, the service is compromised by hackers. What could have possibly gone wrong, given that ZIP archives can contain symbolic links? (5)
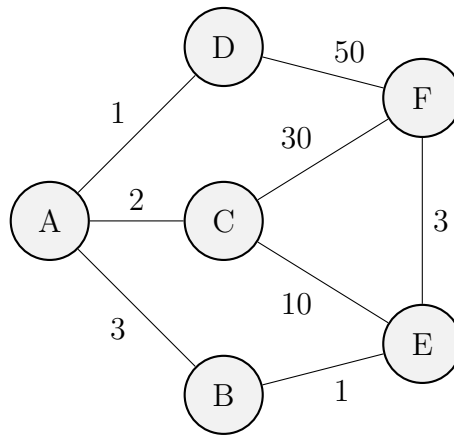
5. (a) Encode the data word 1000 using the Hamming-(8,4) code.

   (b) You receive the following Hamming-(8,4)-encoded message:

   $$11100111$$

   Extract the message, if possible, correcting single-bit errors as appropriate. The bit-order convention is the one used in class. Show all steps in your work.

   (5+5)

6. Consider the following router network:

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

   (b) State the information that is contained in the link state packet that router C sends to its neighbors, with the actual data corresponding to the network shown.

   (10+5)

7. You are given the following library database schema:

```
Borrower(BorrowerID, Name)
Book(BookID, Title)
Checkout(BorrowerID, BookID, DueDate)
```

   (a) Underline the primary keys and dashed-underline all foreign keys.

   (b) Write a query, using relational algebra or SQL, to list the titles of all over-due books ("DueDate < TODAY") together with the name of the person who borrowed the book.

   (5+5)