Foundations of Information Systems

Makeup Final Exam

April 13, 2023

1. Determine whether the following statements are true or false. If true, state the name of the respective Boolean algebra axiom or elementary theorem (a proof is not required). If false, state a counterexample.

   (a) $a \wedge (b \wedge c) = (a \wedge b) \wedge c$

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

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

   (d) $a \vee (b \wedge c) = (a \vee b) \wedge (a \vee c)$

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

   (2+2+2+2+2)

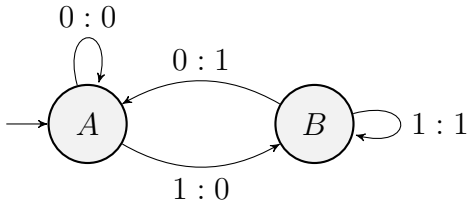
2. (a) Convert the decimal number 7.1875 to binary.

   (b) Using an 8-bit allocation, first convert each of the following integers to the two's complement binary representation, perform the operation, then convert the result back to decimal:

   $$(-23) + 19$$

   (5+5)

3. Consider the following finite state transducer:



   (a) Describe the function that is performed by this transducer.

   (b) The transducer can be used as a "multiply-by-two" machine. How do you need to organize input and output of the transducer so that it performs this function correctly?

   (5+5)

4. (a) State the four necessary conditions for deadlock.

   (b) Describe the difference between deadlock and starvation.

(5+5)

5. On a filesystem that allows soft links and hard links, you create `file_1`, soft-link `file_2` to `file_1`, and hard-link `file_3` to `file_2`. Then you delete `file_1`. Is there a way to still access the data? Explain. (5)

6. RAID-10, also called RAID 1+0, is a RAID arrangement in which four (in the simplest case) disks are grouped in pairs. Each pair is operated as a RAID-1 ("mirroring") pair, the two pairs are then grouped together in a RAID-0 ("striping") configuration. Describe the characteristics of a RAID-10 configuration consisting of four identical disks, in the following categories:

   (a) storage capacity (relative to the capacity of a single disk),

   (b) protection against disk failure,

   (c) read and write performance (compare with bare RAID-0 and bare RAID-1).

(3+3+4)

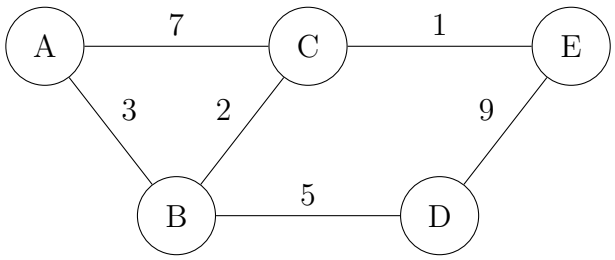
7. The following questions refer to the $(8, 4)$-Hamming code with parity, using the bit ordering convention adopted in class.

   (a) Detect double-bit errors and correct single-bit errors in the following Hamming $(8, 4)$-encoded bit streams: 00000111 and 10010101.

   (b) Encode the message 1011 as an $(8, 4)$-Hamming code.

(5+5)

8. Consider the following router network, where the numbers on each edge indicate the cost of the link.



   (a) Use distance-vector routing to compute the routing tables: Fill, for each router, a table of the form

Router A		
Dest.	**Next Hop**	**Cost**
A		
B		
C		
D		
E		

Router B		
Dest.	**Next Hop**	**Cost**
A		
B		
C		
D		
E		

Router C		
Dest.	**Next Hop**	**Cost**
A		
B		
C		
D		
E		

Router D		
Dest.	**Next Hop**	**Cost**
A		
B		
C		
D		
E		

Router E		
Dest.	**Next Hop**	**Cost**
A		
B		
C		
D		
E		

which you should update in steps until it no longer changes.

(b) Now the link C–E goes down. How many update steps does it take until the distance-vector algorithm has converged to the new solution?

(10+5)