<u>Problem Set 5 Solutions</u>
(7.5, 7.11, 7.16, 7.17, 7.20, 7.21)
COMS W1004

<u>7.5:</u> Assume that we need to transmit a 1,440 x 900 uncompressed color image (using 16bits per pixel) over a computer network in less than 0.01 second.What is the minimal necessary line speed to meet this goal?

<u>Solution:</u>
Total number of pixels = 1440x900
16 bits per pixel
Total number of bits = 1440x900x16=20,736,000

Speed = total number of bits / time taken
Speed = 20,736,000 bits / 0.01sec
Speed = **2.0736x10^9 bits/sec (2.0736 Gbps)**
So based on the table from the book, the correct specification would be **10-gigabit Ethernet** line.

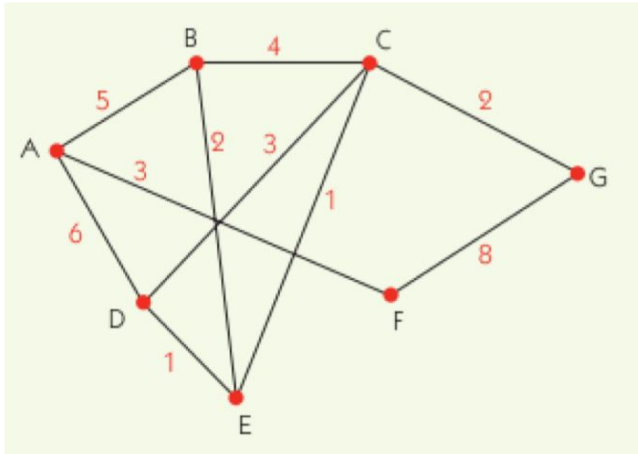
<u>7.11:</u>

a) Assume there is a wide area network with N Nodes, where N >= 2. What is the smallest number of point-to-point communication links such that every node in the network is able to talk to every other node? (Note: A network in which some notes are unable to exchange messages with other nodes because there is no path between them is called disconnected.)
b) If you are worried about having a disconnected network, what type of interconnection structure should you use when configuring your network?

<u>Solution:</u>

a) The smallest number of links you can have, and still be able to talk to every node is **N-1**. For the four node example of ABCD, A connects to B, B connects to C, C connects to D.
b) You should use a **completely connected network** (complete graph). This connects every node to every other node, using N(N-1)/2 links.

<u>7.16:</u> Given the following diagram, where the numbers represent the time delays across a link:



a) How many simple paths (those that do not repeat a node) are there from node A to G?
b) What is the *shortest path* from node A to node G? What is the overall delay?
c) If node E fails, does that change the shortest path? If so, what is the new shortest path?

Solution: (work below)

a) There are **7** simple paths from A to G. They are: **ABCG, ABECG, AFG, ADCG, ADEBCG, ADECG, ABEDCG**
b) The shortest path is **ADECG or ABECG,** both with delay 10

c) If node E fails, then the shortest path does change, since both the shortest paths (calculated above in b) contain node E. There are now three possible shortest paths, each with delay 11: **AFG, ABCG, ADCG**

b.

N:							
A	0	X	X	X	X	X	X
B	∞						
C	∞						
D	∞						
E	∞						
F	∞						

G	∞						

S = {A, }

N:							
A	0	X	X	X	X	X	X
B^A	∞	5					
C	∞	∞					
D^A	∞	6					
E	∞	∞					
F^A	∞	3	X	X	X	X	X
G	∞	∞					

S = {A, F}

N:							
A	0	X	X	X	X	X	X
B^A	∞	5	5	X	X	X	X
C	∞	∞	∞				
D^A	∞	6	6				
E	∞	∞	∞				
F^A	∞	3	X	X	X	X	X
G^F	∞	∞	11				

S = {A,F,B }

N:							
A	0	X	X	X	X	X	X

B^A	∞	5	5	X	X	X	X
C^B	∞	∞	∞	9			
D^A	∞	6	6	6	X	X	X
E^B	∞	∞	∞	7			
F^A	∞	3	X	X	X	X	X
G^F	∞	∞	11	11			

S = {A,F,B,D }

N:							
A	0	X	X	X	X	X	X
B^A	∞	5	5	X	X	X	X
C^B	∞	∞	∞	9	9		
D^A	∞	6	6	6	X	X	X
E^B	∞	∞	∞	7	7	X	X
F^A	∞	3	X	X	X	X	X
G^F	∞	∞	11	11	11		

S = {A,F,B,D,E }

N:							
A	0	X	X	X	X	X	X
B^A	∞	5	5	X	X	X	X
$C^{E\ B}$	∞	∞	∞	9	9	8	X
D^A	∞	6	6	6	X	X	X
E^B	∞	∞	∞	7	7	X	X

F^A	∞	3	X	X	X	X	X
G^F	∞	∞	11	11	11	11	

S = {A,F,B,D,E,C}

N:							
A	0	X	X	X	X	X	X
B^A	∞	5	5	X	X	X	X
$C^{E\ B}$	∞	∞	∞	9	9	8	X
D^A	∞	6	6	6	X	X	X
E^B	∞	∞	∞	7	7	X	X
F^A	∞	3	X	X	X	X	X
$G^{C\ F}$	∞	∞	11	11	11	11	10

S = {A,F,B,D,E,C,G}

G was last updated by C, C was last updated by E, E was last updated by B, B was last updated by A. So the path is:

A – B – E – C – G, with a delay of 10.

c.

If node E failed, then we'd have the following:

N:						
A	0	X	X	X	X	X
B						
C						
D						
F						
G						

S={A,}

N:						
A	0	X	X	X	X	X
B^A	∞	5				
C	∞	∞				
D^A	∞	6				
F^A	∞	3	X	X	X	X
G	∞	∞				

S={A,F}

N:						
A	0	X	X	X	X	X
B^A	∞	5	5	X	X	X
C	∞	∞	∞			
D^A	∞	6	6			
F^A	∞	3	X	X	X	X
G^F	∞	∞	11			

S={A,F,B}

N:						
A	0	X	X	X	X	X
B^A	∞	5	5	X	X	X
C^B	∞	∞	∞	9		
D^A	∞	6	6	6	X	X
F^A	∞	3	X	X	X	X

G^F	∞	∞	11	11		

S={A,F,B,D}

N:						
A	0	X	X	X	X	X
B^A	∞	5	5	X	X	X
C^B	∞	∞	∞	9	9	X
D^A	∞	6	6	6	X	X
F^A	∞	3	X	X	X	X
G^F	∞	∞	11	11	11	

S={A,F,B,D,C}

N:						
A	0	X	X	X	X	X
B^A	∞	5	5	X	X	X
C^B	∞	∞	∞	9	9	X
D^A	∞	6	6	6	X	X
F^A	∞	3	X	X	X	X
$G^{C\ F}$	∞	∞	11	11	11	11

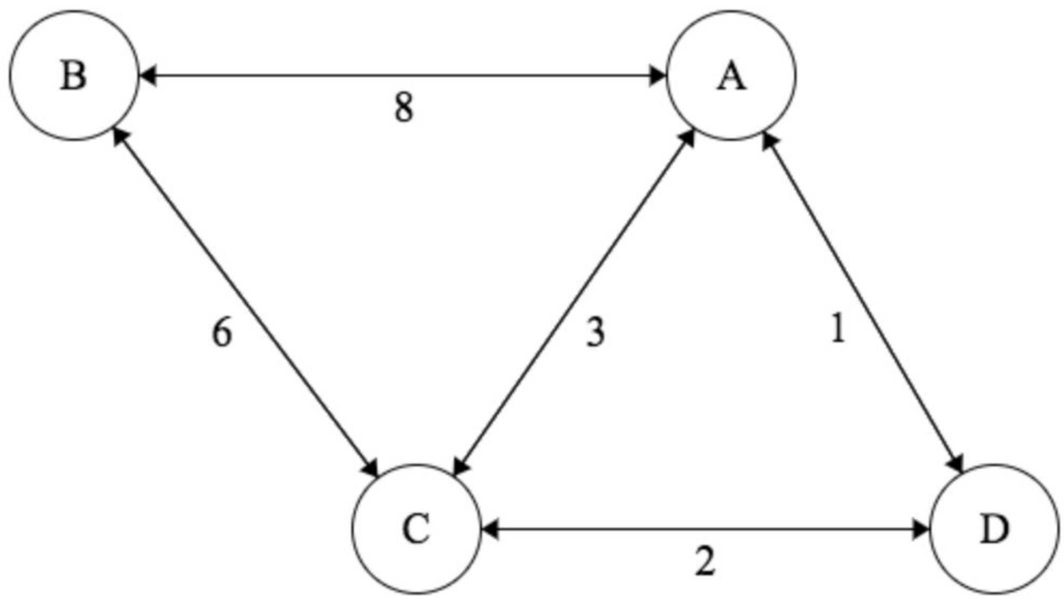
S={A,F,B,D,C,G}

G was last updated by C, C was last updated by B, B was last updated by A. So one possible path is:

A – B – C – G , with a delay of 11.

7.17:

Solution: No, it is **NOT** guaranteed. Counter example below. If you start at A, then you will never reach your goal B because you will get stuck in an infinite cycle of ADCADCADCADC…..



7.20: What are the advantages of breaking up a single logical message into a number of fixed-sized packets and then sending each one of those packets independently through the network?

Solution:

There are several advantages to sending messages in small, fixed-size packets:

- If delivery is interrupted, only the interrupted packets would have to be resent. This is a huge advantage over sending large messages all at once, in which case the whole message would have to be resent.
    - Additionally, resending packets may not be necessary. In the case of video calls, or VoIP, receiving all of the packets is not required.
- The message can be transmitted in any order, leaving the receiver to unscramble the order of the packets. In the case of sending the entire message in one go, the sender would have to ensure the bits were transmitted and received in the correct order, and this process would be more prone to error, thus requiring more intensive error-checking.

7.21: Look at the home page of the Internet Society (http://internetsociety.org) and read about one of the designers of the original ARPANET -- Larry Roberts, Leonard Kleinrock, Vinton Cerf, Robert Kahn, John Postel, or others. Learn about the early days of networking and the contributions that these individuals made to the ultimate development of the Internet. The home page of the Internet Society has links to many other places that provide a wealth of fascinating information about networks in general and the Internet and the web in particular.

Solution: (general points)