UNIVERSITY OF CAPE TOWN

Department of Electrical Engineering

EEE3093S (Communication and Network Engineering) 2022

Date: 26 September 2022

Tutorial 6

Due Date (on VULA): 3 October 2022

1. Suppose nodes A, B, and C each attach to the same broadcast LAN (through their adapters). If A sends thousands of IP datagrams to B with each encapsulating frame addressed to the MAC address of B, will C's adapter process these frames? If so, will C's adapter pass the IP datagrams in these frames to the network layer C? How would your answers change if A sends frames with the MAC broadcast address? [3 marks]

   C's adapter will process the frames,
   but the adapter will not pass the datagrams up the protocol stack.
   If the LAN broadcast address is used, then C's adapter will both process the frames and pass the datagrams up the protocol stack.

2. Why is an ARP query sent within a broadcast frame? Why is an ARP response sent within a frame with a specific destination MAC address? [2 marks]

   In order for a sender to send an IP datagram the sender must know both the IP address and the MAC address. In order to get the unknown MAC address the sender will send an ARP query as a broadcast message across the LAN. Each node will receive this message and determine that it is a broadcast message. That node/adapter will then send the message up to its own ARP module. Each ARP module checks to see if that IP address matches its IP address. If it does, it will send the ARP response back to the sender with the MAC address inside a frame of the packet.

3. Consider Figure T7.1. Now we replace the router between subnets 1 and 2 with a switch S1, and label the router between subnets 2 and 3 as R1.

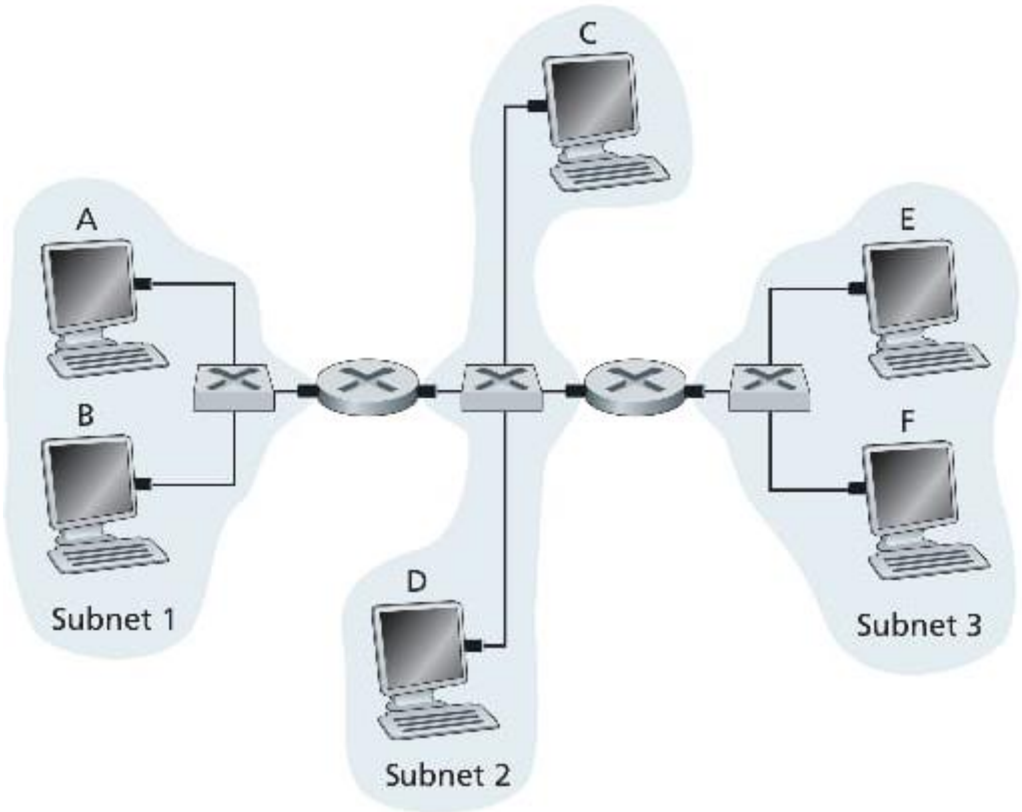

Figure T7.1: Three subnets, interconnected by routers

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a. Consider sending an IP datagram from Host E to Host F. Will Host E ask router R1 to help forward the datagram? Why? In the Ethernet frame containing the IP datagram, what are the source and destination IP and MAC addresses? [2.5 marks]

The IP datagram which Host E sends to Host F can be directly sent to Host F as both hosts are situated on the same subnet, this means that the IP datagram is not sent to the router.
In the Ethernet frame, the following information is contained:

Source IP: Host E's IP	Source MAC: Host E's MAC
Destination IP: Host F's IP.	Destination MAC: Host F's MAC

b. Suppose E would like to send an IP datagram to B, and assume that E's ARP cache does not contain B's MAC address. Will E perform an ARP query to find B's MAC address? Why? In the Ethernet frame (containing the IP datagram destined to B) that is delivered to router R1, what are the source and destination IP and MAC addresses? [1.5 marks]

No, E does not perform an ARP query as they are on the same (LAN) network which means that the IP address of host B can be directly accessed and will receive the MAC address when a return datagram is received.
Host E send IP datagram to B

Ethernet frame source and destination IP & MAC

Source IP: Host E's IP	Source MAC: Host E's MAC
Destination IP: Host B's IP.	Destination MAC: Router R1 first Hop (interface connecting to Subnet 3.)

c. Suppose Host A would like to send an IP datagram to Host B, and neither A's ARP cache contains B's MAC address nor does B's ARP cache contain A's MAC address. Further suppose that the switch S1's forwarding table contains entries for Host B and router R1 only. Thus, A will broadcast an ARP request message. What actions will switch S1 perform once it receives the ARP request message? Will router R1 also receive this ARP request message? If so, will R1 forward the message to Subnet 3? Once Host B receives this ARP request message, it will send back to Host A an ARP response message. But will it send an ARP query message to ask for A's MAC address? Why? What will switch S1 do once it receives an ARP response message from Host B? [3 marks]

What actions will switch S1 perform once it receives the ARP request message?

Switch S1 functions on the data link layer which only uses MAC addresses to forward data. Since S1's forwarding table only contains entries for Host B and R1, it will broadcast the Ethernet frame as the received frame is also a broadcast frame.

Will router R1 also receive this ARP request message? If so, will R1 forward the message to Subnet 3?

Host A mac address can now be added to S1's forwarding table as it knows which subnet it is located on. Router R1 will receive the ARP but will not broadcast the ARP to subnet 3.

Once Host B receives this ARP request message, it will send back to Host A an ARP response message. But will it send an ARP query message to ask for A's MAC address? Why?

Host B will not send back an ARP query message to Host A as it already has the MAC address of Host A in the received broadcast message.

What will switch S1 do once it receives an ARP response message from Host B?

The ARP response can be used to add Host B MAC entry into its forwarding table and it will not need to forward the frame.

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4. As a mobile node gets farther and farther away from a base station, what are two actions that a base station could take to ensure that the loss probability of a transmitted frame does not increase? [3 marks]

   The two possible ways are, 1) increasing the transmission power, and 2) reducing the transmission rate.

5. Why are acknowledgments used in 802.11 but not in wired Ethernet? [2 marks]

   - In a wireless LAN, when a station sends a frame, the frame may not reach the destination station for a variety of reasons. The main reason is due to high bit error rates of wireless channels. To deal with this problem, the 802.11 MAC protocol uses acknowledgments scheme.
   - In wired Ethernet, bit error rate is very negligible and transmission in wired Ethernet is very reliable. Therefore, acknowledgements are not required in wired Ethernet.

6. Suppose there are two ISPs providing WiFi access in a particular café, with each ISP operating its own AP and having its own IP address block.
   a. Further suppose that by accident, each ISP has configured its AP to operate over channel 11. Will the 802.11 protocol completely break down in this situation? Discuss what happens when two stations, each associated with a different ISP, attempt to transmit at the same time. [3 marks]
   b. Now suppose that one AP operates over channel 1 and the other over channel 11. How do your answers change? [1 mark]

   a) No, 802.11 will not completely break down since the MAC and SSID of every AP is different. A wireless station arriving to the café will associate with one of the SSIDs (that is, one of the APs). After association, there is a virtual link between the new station and the AP. Label the APs AP1 and AP2. Suppose the new station associates with AP1. When the new station sends a frame, it will be addressed to AP1. Although AP2 will also receive the frame, it will not process the frame because the frame is not addressed to it. Thus, the two ISPs can work in parallel over the same channel. However, the two ISPs will be sharing the same wireless bandwidth. If wireless stations in different ISPs transmit at the same time, there will be a collision. For 802.11b, the maximum aggregate transmission rate for the two ISPs is 11 Mbps.

   b) Now if two wireless stations in different ISPs (and hence different channels) transmit at the same time, there will not be a collision. Thus, the maximum aggregate transmission rate for the two ISPs is 22 Mbps for 802.11b.

7. You want to transmit the word "HOW" using an 8-ary system
   a. Encode the word "HOW" into a sequence of bits, using 7-bit ASCII coding, followed by an eighth bit for error detection, per character. The eighth bit is chosen so that the number of ones in the 8 hits is an even number. How many total bits are there in the message? [3 marks]

   Encode: HOW--> H 1001000,
   O 1001111,
   W 1010111,

	Parity	7-bit ASCII code						
H	0	1	0	0	1	0	0	0
O	1	1	0	0	1	1	1	1
W	1	1	0	1	0	1	1	1
Parity bit	0	1	0	1	0	0	0	0

Total: 24 bits.

b. Partition the bit stream into k = 3 bit segments. Represent each of the 3-bit segments as an octal number (symbol). How many octal symbols are there in the message? [3 marks]

K = $\log_2 M$ =>(M-ary)
K = $\log_2 8$ = 3 bits -> 8-ary
Bit: 010 010 001 100 111 111 010 111
Octal: 2 2 1 4 7 7 2 7

24/3=8 octal symbols.

c. If the system were designed with 256-ary modulation, how many symbols would be used to represent the word "HOW'? [2 marks]

256-ary k = $\log_2 256$ = 8 bits/symbol
Bit: 01001000 11001111 11010111
256-ary: 72 207 215

256-ary, 24/8=3 symbols

8. We want to transmit 800 characters/s, where each character is represented by its 7-bit ASCII codeword, followed by an eighth bit for error detection, per character, as in Problem 7. A multilevel PAM waveform with M-16 levels is used.
   a. What is the effective transmitted bit rate? [3 marks]
   b. What is the symbol rate? [2 marks]

(a) Total number of bits in one character = 7 + 1 = 8 bits.
So, the number of bits transmitted per second
= Effective transmitted bit rate
= 800 × 8 bps
= 6400 bits per second.

(b) m =16 and m = 2^n = 16 = 2^4
Hence n = 4
Thus number of bits per symbol = 4
So, symbol rate = $\frac{6400\text{bits/s}}{4\text{bits/symbol}}$ = 1600 symbols/second

9. An analog signal is sampled at its Nyquist rate $1/T_s$, and quantized using L quantization levels. The derived digital signal is then transmitted on some channel.
   a. Show that the time duration, T, of one bit of the transmitted binary encoded signal must satisfy. $T \leq T_s/(\log_2 L)$. [3 marks]
   b. When is the equality sign valid? [1 mark]

a. l quantization levels requires a minimum of $\log_2 L$ bits.
$l > \log_2 L$
It is necessary to transmit at least $\log_2 L$ bits in T_s seconds.
$T \leq T_s / l = T_s / \log_2 L$
Therefore, the time period, T, for one bit is $T \leq T_s / \log_2 L$

b. The equality sign is valid if L is a power of 2.