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CS 118 – DIS 1A

Homework 7

1. List link layer functions. For each of the function, list categories (if applicable) and protocol/algorithm examples.

```
Data Framing: HDLC, PPP, COBS
Physical Addressing: ARP
Flow control: TDMA, FDMA
Error detection: CRC
Sequence control: MAC, ALOHA, CSMA/CD, CSMA/CA
Link management: switches/routers
```

2. Consider two data sequences that are received from the network layer by the link layer processor.

- 0x00 0x01 0x02 0xFF 0xFE 0xFD 0x00 0x00 0xFD 0xFD 0xFE
  = 00000000 00000001 00000010 11111111 11111110 11111101 00000000 00000000 11111101 11111101 11111110
- 0x02 0x00 0x01 0x02 0xFD 0x00
  = 00000010 00000000 00000001 00000010 11111101 00000000

Create frame-encoded output (i.e., each input sequence should be encoded as a separate frame) using

a. HDLC byte stuffing
- 00000000 00000001 00000010 111110111 1101111100 111110101 00000000 00000000 111110101 111110101 111110110
- 00000010 00000000 00000001 00000010 111110101 00000000

b. PPP byte stuffing
- 01111110 00000000 00000001 00000010 11111111 1111111-*01111101 01011110*-1 00000000 0000000-*01111101 01011110*-1 11111101 11111110 01111110
- 00000010 00000000 00000001 0000001-*01111101 01011110*-1 00000000

c. COBS
- 0x00 0x01 0x06 0x01 0x02 0xFF 0xFE 0xFD 0x01 0x01 0x04 0xFD 0xFD 0xFE 0x00
- 0x00 0x02 0x02 0x04 0x01 0x02 0xFD 0x01 0x00

3. Suppose nodes A and B are on the same 10 Mbps broadcast channel that uses CSMA/CD (10Base2 Ethernet), and the propagation delay between the two nodes is 20μs. Suppose A and B send Ethernet frames at the same time, the frames collide. Assuming no other nodes are active, what is the probability that four subsequent retransmissions of the frames will collide?

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Time	Event
0	A and B begin transmission
20µs	A and B detect collision
20µs + (10Mbps/48 bits) = 20µs + 4.8µs = 24.8 µs	A and B finish transmitting jam signal
24.8µs + 20µs = 44.8µs	B's last bit arrives at A; A detects idle channel
44.8µs + (10Mbps/96 bits) = 44.8µs + 9.6µs = 54.5µs	A starts transmitting (1)
24.8µs + (10Mbps/512 bits) = 24.8µs + 51.2µs = 76µs	B returns to step 2 B must sense idle channel for 9.6µs before it transmits (t = 76µs + 9.6µs = 85.6µs)
54.5µs + 20µs = 74.5µs	A's transmission reaches B; B detects idle channel
74.5µs + 9.6µs = 84.1µs	B starts transmitting (2)
84.1µs + 20µs = 104.1µs	B's transmission reaches A; A detects idle channel
104.1µs + 9.6µs = 113.7µs	A starts transmitting (3)
113.7µs + 20µs = 133.7µs	A's transmission reaches B; B detects idle channel
133.7 µs + 9.6µs = 143.3µs	B starts transmitting (4)
143.3µs + 20µs = 163.3µs	B's transmission reaches A

There is no probability that that four subsequent retransmission frames will collide, assuming that B chooses K=1 and A chooses K=0 after transmitting the jam signal.

4. Remember that in order to communicate over link layer, one need to have destination MAC address.

a. How a node can figure out which MAC address to use, given the incoming IP packet. Give a simple example.

Example:

My computer requests a page called cs118.com. This will generate an IP packet and TCP packet:

IP Packet source: 192.168.1.x (my private LAN IP)
IP Packet destination: 12.34.567.89 (cs118.com)
TCP Packet source: 192.168.1.x (my private LAN IP)
TCP Packet source port: 11111 (identifies my computer)
TCP Packet destination: 12.34.567.89 (cs118.com)
TCP Packet destination port: 80

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The IP packet reaches the node by setting the destination MAC address in the Ethernet frame to the MAC address of the node. The node will then set the IP/TCP packet source address to my public IP:

```
IP Packet source: 98.76.543.210 (my public IP)
IP Packet destination: 12.34.567.89 (cs118.com)
TCP Packet source: 98.76.543.210 (my public IP)
TCP Packet source port: 22222 (identifies node)
TCP Packet destination: 12.34.567.89 (cs118.com)
TCP Packet destination port: 80
```

The IP packet is then passed onto the next node until it reaches the destination. The website cs118.com will then generate a response and send it to the node via my public IP:

```
IP Packet source: 12.34.567.89 (cs118.com)
IP Packet destination: 98.76.543.210 (my public IP)
TCP Packet source: 12.34.567.89 (cs118.com)
TCP Packet source port: 80
TCP Packet destination: 98.76.543.210 (my public IP)
TCP Packet destination port: 22222 (identifies node)
```

Since the node remembers that port 22222 is assigned to my computer's port 11111, it will use the MAC address associated with that port:

```
TCP Packet source: 12.34.567.89 (cs118.com)
TCP Packet source port: 80
TCP Packet destination: 192.168.1.x (my IP)
TCP Packet destination port: 11111 (identifies my computer)
```

If this is over a wireless network, the node will broadcast an ARP packet to all devices in the network asking who has the matching IP address, and the device will reply to the node with its MAC address.

b. Is IP-MAC address mapping unique? Explain your answer.

It is not unique in the sense that a particular IP address (say 192.168.1.2) can only be to a single MAC address. For example, IP address 192.168.1.2 can be mapped to MAC address 00-11-22-33-44 for a period of time. When DHCP renews lease, IP address 192.168.1.2 can be mapped to another MAC address 55-66-77-88.

However, an IP address cannot be mapped to multiple MAC addresses. So it is unique in that way.

5. Consider the following network topology with specified MAC addresses for network interfaces and the con- figured IP addresses:

a. Assign minimum network mask for each of the sub networks.

If you want Node A and Node C to be in two different subnets:

```
Network mask for Node A, Node B, and Switch: 255.255.255.248
Network mask for Router and Node C: 255.255.255.252
```

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```
If you want Node A and Node C to be in the same subnet:
  Network mask: 255.255.0.0
```

b. You may notice that router has the same mac address assigned to different interfaces. Is it a fatal error? Explain your answer.

This is a fatal error. While it is possible to have multiple IP addresses assigned to a single MAC address, this can only be done on a single machine (like a server). Assigning the same MAC address to two different interfaces will cause incorrect packet forwarding.

c. Assuming that the routing tables are properly configured and the network just started (i.e., all caches are empty), enumerate steps needed for node B to send IP packet to 192.168.0.2 and receive a response back.

1. Node B looks in its ARP table, there is no match for 192.168.0.2
2. Node B broadcasts ARP request to all hosts in the subnet
3. Node A responds to ARP request
4. Node B receives response from Node A and adds Node A MAC address to ARP table
5. Node B constructs IP packet with the destination MAC address set to Node A
6. Node B sends the IP packet through Ethernet
7. Switch receives the IP packet and sends the packet to Node A
8. Node A receives IP packet from Node B
9. Node A looks in its ARP table, there is no match for 192.168.0.3
10. Node A broadcasts ARP request to all hosts in the subnet
11. Node B responds to ARP request
12. Node A receives response from Node B and adds Node B MAC address to ARP table
13. Node A constructs IP packet with the destination MAC address set to Node B
14. Node A sends the IP packet through Ethernet
15. Switch receives the IP packet and sends the packet to Node B

d. Considering success of the previous operation, enumerate steps for node B to send a packet to 192.168.1.253 and receive a reply.

If Node B and Node C are in the same subnet, the answer is the same as for part c.

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If Node B and Node C are in different subnets, the steps are as follows:

1. Node B calculates all of the possible addresses in its subnet and realizes that Node C is in a different subnet
2. Node B broadcasts ARP request for the router's MAC address
3. Router responds to Node B's ARP request
4. Node B constructs IP packet with the destination MAC address set to the router and the destination IP address set to Node C
5. Node B sends the packet through Ethernet
6. Router receives packet and notices destination IP is not for router, does a lookup in its local routing table
7. Router sets the destination MAC address to Node C's MAC address and sends packet through Ethernet
8. Node C receives IP packet from Node B
9. Repeat steps 1-8 but switch Node B and Node C