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COMP 4320: Assignment 6

**Problem 1:**

Imagine you are a network engineer responsible for optimizing network efficiency and reliability by leveraging Software-Defined Networking (SDN) principles and error detection mechanisms at the link layer. Using your understanding of SDN architecture, OpenFlow, link-layer services, and error detection techniques, answer the following questions:

**1.1 Explain the key characteristics of SDN, including control/data plane separation and flow-based forwarding. Describe the role of the SDN controller and how it interacts with switches using OpenFlow messages (e.g., controller-to-switch, switch-to-controller, and symmetric messages).**

SDN divides the control plane, which makes the decisions on where certain traffic will be sent, from the data plane, which is what forwards the traffic for real. This separation makes sure there is centralized control, network programmability, and flexibility. Flow-based forwarding is where the SDNs will take advantage of flows in substitute of destination-based forwarding. A flow is explained by headers of a packet like IP address and port. There are three different OpenFlow message types controller-to-switch, switch-to-controller, and symmetric messages. Controller-to-switch controls the switches to do certain actions such as add or modify flow entries. Switch-to-controller transports packet-in messages when they cannot locate a similar matching flow. Symmetric messages are in use for messages like hello or echo.

**1.2 Describe the role of the link layer in ensuring reliable data transmission across a single communication link. Compare different error detection methods (e.g., Parity Checking, Internet Checksum, and Cyclic Redundancy Check (CRC)), explaining their strengths and weaknesses.  Given a scenario where a wireless network suffers from frequent packet errors, propose an optimal error detection and correction mechanism to minimize retransmissions.**

The link layer makes sure that transmission will happen over a single hop through techniques such as framing, error detection, and occasionally correction. The three error detection methods are parity checking, internet checksum, and cyclic redundancy check. Parity checking involves adding on a parity bit. This can be either even or odd. The strength of this method is that it is very straightforward and speedy. The weakness of this method is that it will only flag odd number of the bit errors. Internet checksum is able to represent a word in a message and calculates the 1’s complement. The strength of this method is that it is simple to put into place. The weakness of this method is that it is possible to miss miniature errors in high-speed networks. Cyclic redundancy check is able to implement polynomial division. The strength of this method is that it is very accurate and is able to view burst errors. The weakness of this method is much more intense on the computational side. My recommendation for a noisy wireless network would be to take advantage of CRC and Forward Error Correction (FEC). FEC, such as Hamming codes or Reed-Solomon, make it in a way that the receiver is able to fix any errors without having to deal with retransmission. This is important because it can work well whenever there is a large amount of packet loss.

**1.3 Explain how SDN can improve network resilience by dynamically responding to link failures or congestion using flow rule modifications. Discuss how SDN can interact with link-layer reliability mechanisms, such as dynamically adjusting error control strategies based on network conditions. Given a scenario where a link experiences high bit errors and congestion, propose an SDN-based approach to mitigate the issue while maintaining performance.**

SDN is able to level up network resilience by checking the network and ensuring that the flow rules are updating. Whenever a link fails or it gets overly congested the controller can move traffic dynamically, it can either throttle flows or move up others, and it can make sure secondary paths are downloaded. The SDN and link-layer interaction includes the controller that views the bit error rate and link congestion. It also is able to change error control strategies dynamically. The solution to the scenario that includes a link that has high errors and congestions contains many steps. It can take advantage of link monitoring tools that are located at the controller. It can also change the direction of high priority flows which create paths that are more stable. It is able to take advantage of better error detection and correction on any links that have issues. They can also take advantage of flow shaping or QoS rules to limit congestion.

**Problem 2:**

Imagine you are a network engineer; you are responsible for designing an efficient local area network (LAN) infrastructure that ensures efficient medium access control, proper addressing, and optimized packet forwarding. Using your understanding of multiple access protocols, MAC addressing, ARP, and Ethernet switching, answer the following questions:

**2.1 Compare the three categories of multiple access protocols: channel partitioning, random access, and taking turns protocols. Explain how Slotted ALOHA, CSMA, and CSMA/CD manage medium access and resolve collisions. Given a scenario where a wireless network is experiencing high collisions, propose the best medium access protocol to minimize contention and justify your choice.**

Channel partitioning, including TDMA and FDMA, is able to cut up the channel into fixed slots. Random access, including ALOHA and CSMA, is able to transmit whenever ready but collisions are able to occur. Taking turns, including token ring, is when nodes take different turns when they are able to use the channel. Slotted ALOHA has the ability to cut up time into slots, nodes are able to transmit at slot boundaries, and it is relatively start forward but there is a large chance of collisions. CSMA has the ability to hear before beginning the transmission and it lowers the idle time and collision chances. CSMA/CD has the ability to see any collisions throughout the transmission and it cuts down on wasted transmission time. In order to solve the scenario, taking use of CSMA/CA is important for wireless. It helps to stop any collisions by holding off until acknowledgments are received and taking use of RTS/CTS.

**2.2 Explain the role of MAC addresses in LAN communication and how they differ from IP addresses in terms of hierarchy and scope. Describe the ARP (Address Resolution Protocol) process and how it allows devices to resolve IP addresses to MAC addresses. Given a scenario where a host needs to send a packet to another host in a different subnet, describe the steps taken at both IP and MAC layers for successful delivery.**

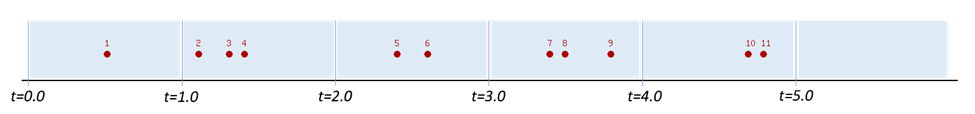
MAC addresses include its own hardware ID. It also uses flat addressing and LAN. IP address is logical and hierarchical. It is on a global scope. The ARP process includes the hosts double check ARP cache. Next step is if it is not known it will send out an ARP request. Then the destination will talk back with MAC. Finally, the host will be able to change and update the cache. The IP layer will send out the packet to the default gateway. The MAC layer includes attaining the MAC of the gateway with ARP and the frame is sent to gateway and then sent to the destination subnet.

**2.3 Explain how Ethernet switches use MAC address learning to make forwarding decisions and eliminate network collisions. Compare the benefits of switching over traditional hub-based LANs in terms of performance and efficiency. Given a scenario where a network has multiple interconnected Ethernet switches, explain how self-learning and frame filtering ensure efficient forwarding without loops.**

MAC learning includes different switches that can construct a MAC address table by looking through source addresses. It also is able to move frames to the right port. Switching is a full-duplex, it also avoids any collisions, and has a smarter forwarding. Hubs are able to speak to all of the ports, it is half-duplex, and collisions occur often. The scenario which includes multiple switches interconnected. Self-learning can be when switches can learn which MAC is located on each port. Frame filtering is able to stop any flooding that is unnecessary. Loop prevention is able to put into action spanning tree protocol which prevents loops from occurring.

**Problem 3:**

Consider the figure below, which shows the arrival of 11 messages for transmission at different multiple access wireless nodes at times   
t = <0.5, 1.1, 1.3, 1.4, 2.4, 2.6, 3.4, 3.5, 3.8, 4.7, 4.8> and each transmission requires exactly one time unit.



**A)**

**1. Suppose all nodes are implementing the Slotted Aloha protocol. For each message, indicate the time at which each transmission begins. Separate each value with a comma and no spaces.**

1,2,2,2,3,3,4,4,4,5,5

**2. Which messages transmit successfully? Write your answer as a comma separated list with no spaces using the messages' numbers**

Slot 1: Msg 1 -> successful

Slot 2: Msg 2, 3, 4 -> collision

Slot 3: Msg 5,6 -> collision

Slot 4: Msg 7, 8, 9 -> collision

Slot 5: Msg 10, 11 -> collision

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**B)**

**1. Suppose all nodes are implementing Carrier Sense Multiple Access (CSMA), with collision detection (CSMA/CD). Suppose that the time from when a message transmission begins until it is beginning to be received at other nodes is 0.4 time units, and assume that a node can stop transmission instantaneously when a message collision is detected. (Thus if a node begins transmitting a message at t=2.0 and transmits that message until t=3.0, then any node performing carrier sensing in the interval [2.4, 3.4] will sense the channel busy.) For each message, indicate the time at which each message transmission begins, or indicate that message transmission does not begin due to a channel that is sensed busy when that message arrives. Separate each value with a comma and no spaces, and if the channel is sensed busy, substitute it with 's'**

Msg 1 (0.5): idle -> transmit at 0.5

Msg 2 (1.1): idle -> transmit at 1.1

Msg 3 (1.3): detects Msg 2 (started at 1.1) at 1.5 -> transmit at 1.3 -> collision

Msg 4 (1.4): same -> starts at 1.4 -> collision

Msg 5 (2.4): idle -> transmit at 2.4

Msg 6 (2.6): before 2.8 -> channel is busy -> wait -> s

Msg 7 (3.4): idle -> transmit at 3.4

Msg 8 (3.5): before 3.8 -> channel is busy -> wait -> s

Msg 9 (3.8): idle -> transmit at 3.8

Msg 10 (4.7): idle -> transmit at 4.7

Msg 11 (4.8): before 5.1 -> detects Msg 10 -> s

0.5,1.1,1.3,1.4,2.4,s,3.4,s,3.8,4.7,s

**2. Which messages transmitted successfully? Write your answer as a comma separated list with no spaces using the messages' numbers**

1,2,5,7,9,10

**3. At what time did each message stop transmitting due to a collision. Write your answer as a comma separated list with no spaces using the messages' numbers in order, and if a message didn't stop, write 'x' for that message**

Msg 1:x

Msg 2:x

Msg 3: 1.3

Msg 4: 1.4

Msg 5: x

Msg 6: x

Msg 7: x

Msg 8: x

Msg 9: x

Msg 10: x

Msg 11: x

x,x,1.3,1.4,x,x,x,x,x,x,x

**YouTube Videos:**

Problem 1: <https://youtu.be/LHvM4EssK3c>

Problem 2: <https://youtu.be/p_cphTtj4GQ>

Problem 3: <https://youtu.be/--BEAKRCR_4>