CS 425: Computer Networks **Jan-Apr 2020**

Lecture 12: Computer Networks – February 11, 2020

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Introduction

In the last lecture we discussed:

- Carrier Sensing Multiple Access (CSMA)
- Wireless Multiple Access

In this lecture we will look at 802.11 protocol along with another randomized media access protocol - CSMA/CA, contention free media access protocols, and finally we will discuss switching.

12.1 802.11 Protocol

- This is the most popular protocol for wireless communication.
- 802.11 networks can be used in two modes.
  - The most popular mode is to connect clients, such as laptops and smart phones, to another network, such as a company intranet or the Internet. This mode is shown in Fig.12.1 (a). In **infrastructure mode**, each client is associated with an AP (Access Point) that is in turn connected to the other network. The client sends and receives its packets via the AP.
  - The other mode, shown in Fig.12.1 (b), is the **Ad-Hoc mode** . This mode is a collection of computers that are associated so that they can directly send frames to each other. There is no access point and ad-hoc networks are also not very popular.
- Multiple accesses are handled differently, unlike CSMA/CD, MACA.

12.1.1 802.11 Physical Layer

- It uses bandwidth of 20-40 MHz, channels on ISM (Industrial, Scientific, Medical) band. For more details, please refer [2].
- The 802.11 b/g/n and 802.11 a/n protocols operate on the 2.4 GHz and 5 GHz frequency bands, respectively.
- The frequency at which it operates is a little higher than mobile telephone frequency.
- OFDM (Orthogonal Frequency Division Multiplexing)
  - The data transfer rates ranges from 6 to 54 Mbps.
  - In 802.11 n protocol, instead of one antenna, multiple antennas are used. (MIMO - Multiple Input, Multiple Output).

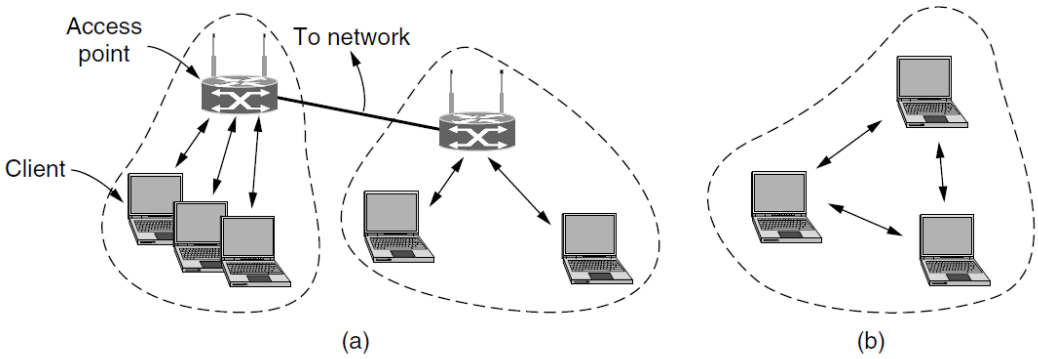

Figure 12.1: 802.11 architecture (a) Infrastructure mode (b) Ad-Hoc mode.

12.1.2 802.11 Link Layer

- 802.11 tries to avoid collisions with a protocol called CSMA/CA (CSMA with Collision Avoidance).
- Usually RTS/CTS are not used in 802.11 . Wireless communication usually uses small frame size, so we don't want to add overhead of RTS/CTS.

12.1.2.1 CSMA/CA

- Carrier-sense multiple access with collision avoidance (CSMA/CA) is a network multiple access method in which carrier sensing is used, but nodes attempt to avoid collisions by beginning transmission only after the channel is sensed to be idle.
- After the channel becomes idle, nodes wait for a random backoff time. This technique works as it can be shown that the probability of two nodes drawing the same value from a continuous distribution is 0.
- While one of the nodes is transmitting packets,other nodes hold off their exponential backoff time until the nodes finish transmission and then complete their remaining backoff time.
- Unlike CSMA/CD (Ethernet), frames are ACKed, and re transmission is done via ARQ.
- This protocol uses three addresses (T_X, R_X, AP). Frames thus have to mention the AP that the T_X uses in order to access the R_X. Here T_X denotes the Transmission point and R_X the Destination point.
- There is no significant delay and error detection is done via CRC-32.
- This protocol is more efficient than RTS/CTS in practice because they add overhead.
- It has some other features like battery, encryption, etc.

12.1.2.2 Example

- An example timeline is shown in figure 12.2. Station A is the first to send a frame. While A is sending, stations B and C become ready to send. They see that the channel is busy and wait for it to become idle.

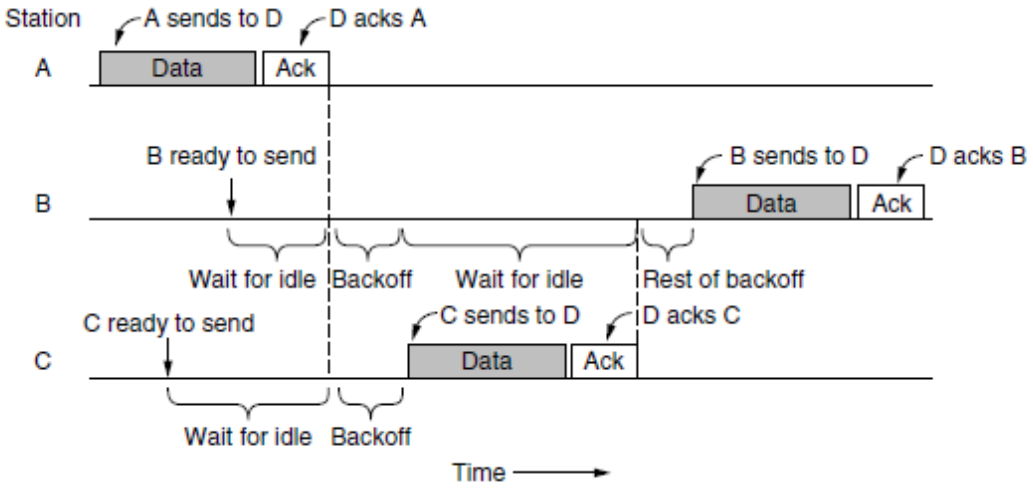

Figure 12.2: Sending a frame with CSMA/CA.

- Shortly after A receives an acknowledgement, the channel goes idle. However, rather than sending a frame right away and colliding, B and C both perform a back-off.
- C picks a short back-off, and thus sends first. B pauses its countdown while it senses that C is using the channel, and resumes after C has received an acknowledgement. B soon completes its back-off and sends its frame.

So far we have been discussing about Randomized multiple access protocols, Now let us take a look at contention free MA protocols. These protocols are effective, when the load is high.

Question: Why contention free? Why Randomized MA protocols are not enough?

Answer: CSMA is good under low load, as it provides immediate access. In the case of high load, there are high chances of collision, which can lead to reduced throughput.

12.1.3 Turn-Taking multiple access

- This protocol defines an order over the hosts.
- A small message called a token is passed from one station to the next in the same predefined order. The token represents permission to send.
- If a station has a frame queued for transmission when it receives the token, it can send that frame before it passes the token to the next station. If it has no queued frame, it simply passes the token.
- This protocol is similar to TDM, but here the host can donate its position to another host.
- An example of this is Token Ring.

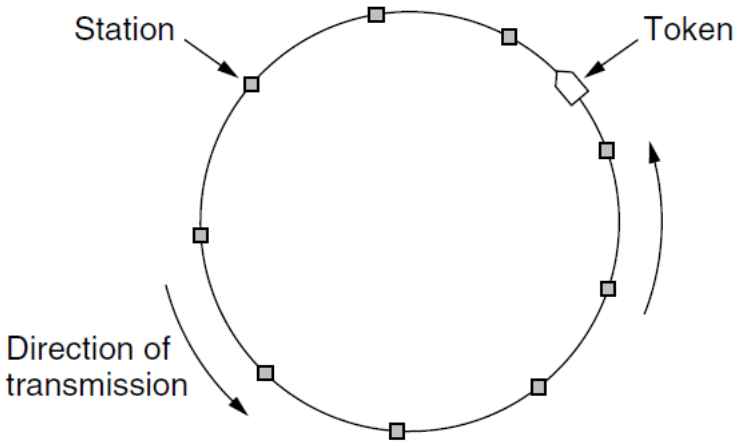

Figure 12.3: Token Ring

12.1.4 Token Ring

- In a token ring protocol, the topology of the network is used to define the order in which stations send. The stations are connected one to the next in a single ring.
- Passing the token to the next station then simply consists of receiving the token in from one direction and transmitting it out in the other direction, as seen in Fig. 12.3.
- Frames are also transmitted in the direction of the token. This way they will circulate around the ring and reach whichever station is the destination.

12.1.4.1 Advantages

- It has a fixed overhead but there are no collisions.
  - It provides more efficiency under high load.
- It provides a predictable service.
  - Guaranteed Quality of Service: Randomised Access gives only statistical guarantee.

12.1.4.2 Disadvantages

- It has more complexity than it's other alternatives.
  - We need to settle the ordering, and as devices can get added/deleted the complexity further increases.
  - What if token gets corrupted?
    All devices can then agree on token being lost and mint a new token.
- It results in a high overhead under low load.

12.2 Switching

12.2.1 LAN Switches(Wired LAN)

This section deals with mechanics of switching in **wired LANs** and not wireless LAN's.We can architect **LAN** networks a little differently from MANs/WANs as here we have control over how devices connect and communicate with each other.

Multiple Access is primarily for wireless networks.

- Wired devices can have exclusive transmissions.
- CSMA/CD was associated with old or classic Ethernet. Nowadays, the modern Ethernet is the switched Ethernet.

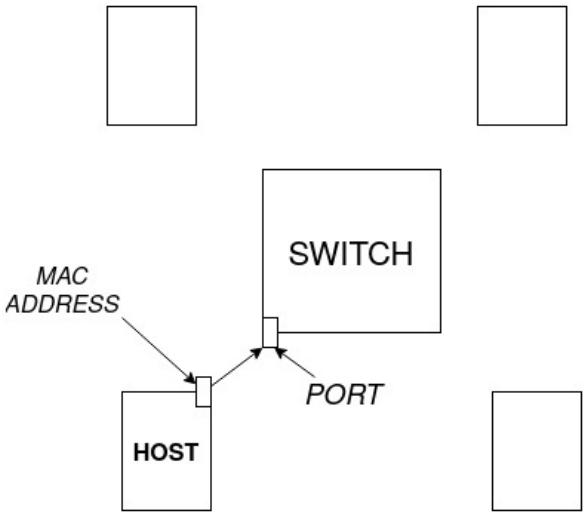

Figure 12.4: Interaction between Switch and Port

Some important points to note regarding Switch are

- A switch would have to constantly update its mappings between the port address and MAC addresses as a user might connect a new device to a particular port.
- Initially Hub was preferred over switch due to its cost efficiency.

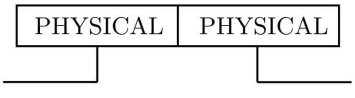

Figure 12.5: Repeaters/hubs

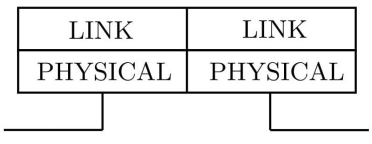

Figure 12.6: Switch/Bridge

12.2.1.1 Inside view of HUB

A **Hub** is similar to the **classic Ethernet representation**. It's a Physical layer device.
In a Hub a message is **broadcasted** to everyone.

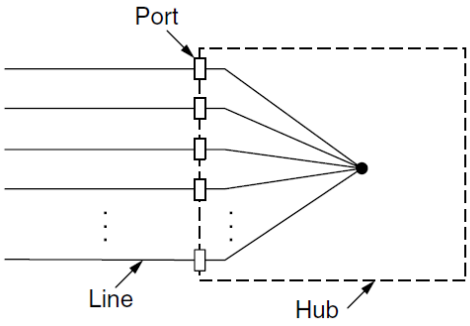

Figure 12.7: Schematic diagram of Hub

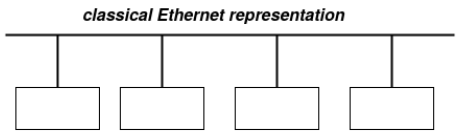

Figure 12.8: Classical Ethernet Representation

12.2.1.2 Inside view of SWITCH

- Switch is a Link layer device which means that it can read frames and link layer source/destination addresses and hence optimize the frame delivery process.
- The above property also allows it to detect/correct errors but that it is usually not done in practice.
- Switches are full duplex i.e the message transfer can take place in both directions.

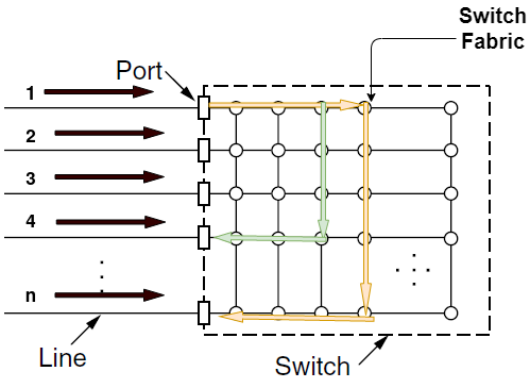

Figure 12.9: Schematic Diagram of Switch

Question: Can switches eliminate the need of multiple access?

Answer: **Yes**, this is because a switches are effectively handling all the traffic between them and hence a switch can act as a multiplexing device by storing and transmitting data thereby eliminating the need of multiple access .

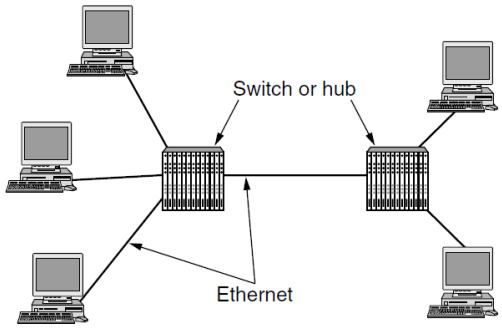

Figure 12.10: Schematic Diagram of Switch

12.2.2 Challenges

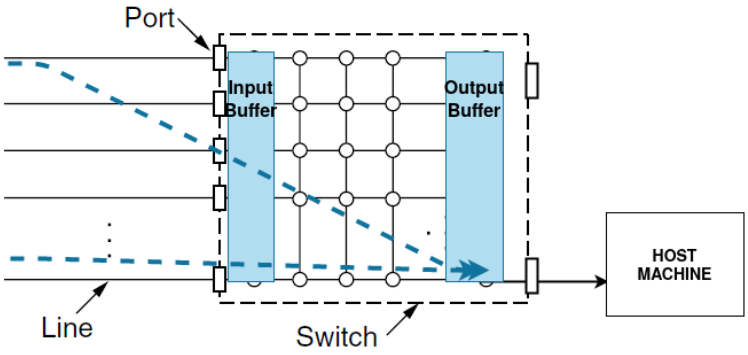

Figure 12.11: Schematic Diagram of Switch

Consider the case when multiple devices are trying to send data to one port at the same time. To handle this, it temporarily stores the data .
If too much data is transmitted to a specific port, then data loss will happen due to limited capacity of RAM.
We need some techniques that can balance the flow (TCP).

12.2.3 Advantages of Switching

- No multiple access is required when using switching.
- Switch provides more reliable communication primarily because
  - Physical damage done is easy to repair.
  - It also helps in Error Detection and Correction.
- The performance provided by switching is scalable i.e it can easily extend to multiple users without significantly affecting performance.
  - It allows us to use the entire bandwidth for each and every user.
    For example, with multiple access say,we can get at max 10 Mbps, but using switch we can use 10 Mbps for every user.

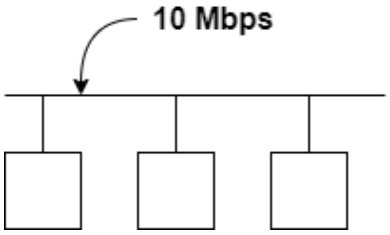

Figure 12.12: Schematic diagram of Hub

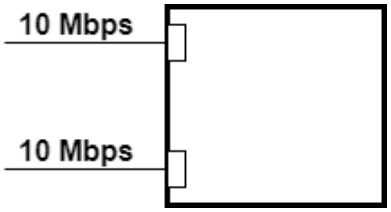

Figure 12.13: Classical Ethernet Representation

References

[1] *AS Tanenbaum DJ Wetherall*, Computer Networks, 5th Ed., Prentince-Hall, 2010.

[2] WikiPage for 802.11 protocols