Lecture (3)

5.3 Multiple Access Links and Protocols

There are two types of network links:

1- point-to-point links and

2- Broadcast links.

A **point-to-point link** consists of a single sender at one end of the link and a single receiver at the other end of the link. Many link-layer protocols have been designed for point-to-point links; the point-to-point protocol (PPP) and high-level data link control (HDLC) protocol are examples of such protocols.

The second type of link, a **broadcast link**, can have multiple sending and multiple receiving nodes all connected to the same, single, shared broadcast channel.

The term *broadcast* is used here because when any one node transmits a frame, the channel broadcasts the frame and each of the other nodes receives a copy. **Ethernet and wireless LANs** are examples of broadcast link-layer protocols.

How to coordinate the access of multiple sending and receiving nodes to a shared broadcast channel?

This is known as the **multiple access problem.**

Computer networks have protocols, called **multiple access protocols,** by which nodes regulate their transmission into the shared broadcast channel.

Figure 5.8, shows that multiple access protocols are needed in a wide variety of network settings, including both wired and wireless access networks, and satellite networks.

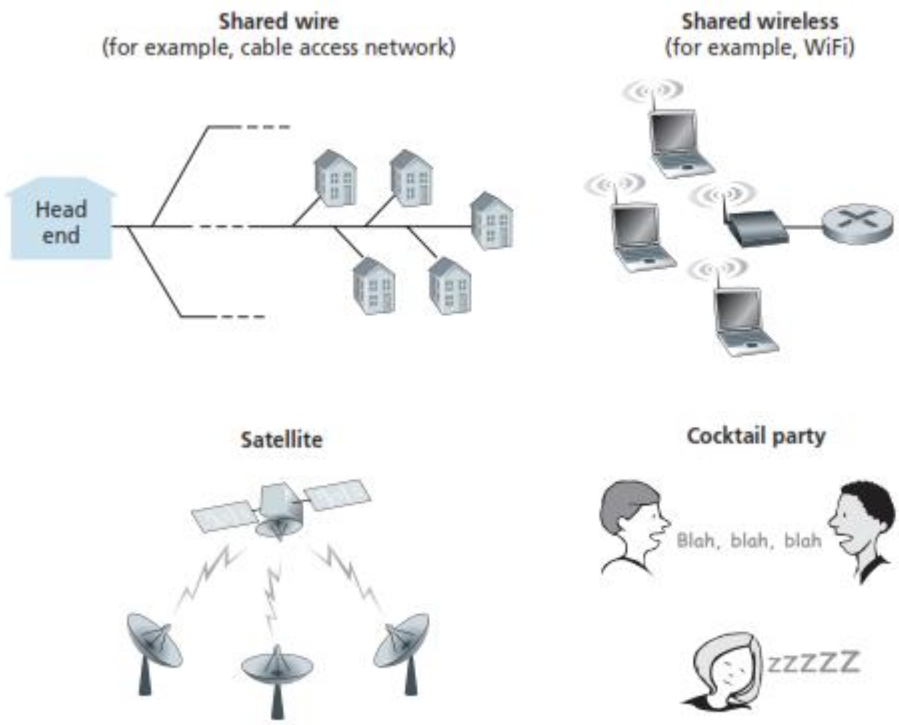

Figure 5.8 ♦ Various multiple access channels

What is Collision?

Because all nodes are capable of transmitting frames, more than two nodes can transmit frames at the same time. When this happens, all of the nodes receive multiple frames at the same time; that is, the transmitted frames **collide** at all of the receivers. Typically, when there is a collision, none of the receiving nodes can make any sense of any of the frames that were transmitted; in a sense, the signals of the colliding frames are tangled together.

What is the Result of Collision?

1/All the frames involved in the collision are lost, and

2/ the broadcast channel is wasted during the collision interval.

Clearly, if many nodes want to transmit frames frequently, many transmissions will result in collisions, and much of the bandwidth of the broadcast channel will be wasted.

Multiple Access Protocol

In order to ensure that the broadcast channel performs useful work when multiple nodes are active, it is **necessary to somehow coordinate the transmissions of the active nodes.** This *coordination job is the responsibility of the multiple access protocol (MAPs)..*

What are the Categories of MAPs?

Over the years, dozens of multiple access protocols have been implemented in a variety of link-layer technologies. Nevertheless, any multiple access protocol as belonging to one of three categories: **channel partitioning protocols, random access protocols,** and **taking-turns protocols**.

Characteristics of a multiple access protocol

Ideally, a multiple access protocol for a broadcast channel of rate *R* bits per second should have the following desirable characteristics:

1. When only one node has data to send, that node has a throughput of *R* bps.
2. When *M* nodes have data to send, each of these nodes has a throughput of *R*/*M* bps. This need not necessarily imply that each of the *M* nodes always has an instantaneous rate of *R*/*M*, but rather that each node should have an average transmission rate of *R*/*M* over some suitably defined interval of time.
3. The protocol is decentralized; that is, there is no master node that represents a single point of failure for the network.
4. The protocol is simple, so that it is inexpensive to implement.

5.3.1 Channel Partitioning Protocols

Time-division multiplexing (TDM) and frequency-division multiplexing (FDM) are two techniques that can be used to partition a broadcast channel's bandwidth among all nodes sharing that channel.

1. TDM

Suppose the channel supports *N* nodes and that the transmission rate of the channel is *R* bps. **TDM divides time into time frames** and further divides each time frame into *N* **time slots**. Each time slot is then assigned to one of the *N* nodes. Whenever a node has a packet to send, it transmits the packet's bits during its assigned time slot in the revolving TDM frame. Typically, slot sizes are chosen so that a single packet can be transmitted during a slot time. Figure 5.9 shows a simple four-node TDM example.

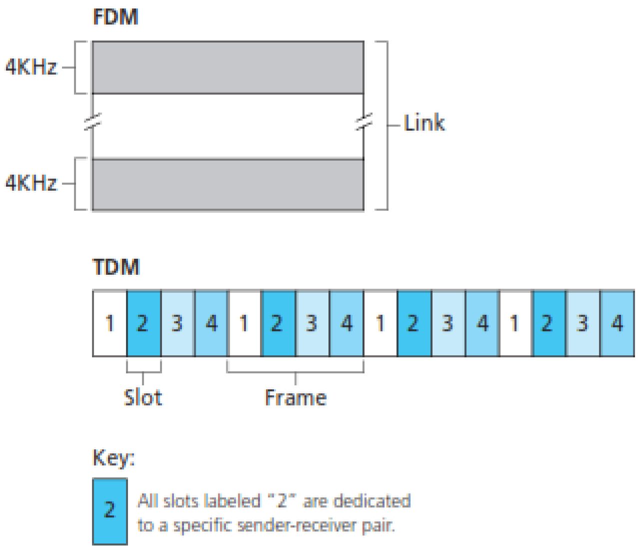

Figure 5.9 ♦ A four-node TDM and FDM example

Analog Example to TDM

If you have a class of 5 students, and all want to talk at the time, then their talks will collide. If you the organizer (The TDM), then you can allow each one to talk a minute, one after another, and the repeat the round until each one finish his talk.

Thus, TDM is appealing because it eliminates collisions and is perfectly fair: Each node gets a dedicated transmission rate of *R*/*N* bps during each frame time.

However, it has two major drawbacks.

First, a node is limited to an average rate of *R*/*N* bps even when it is the only node with packets to send.

A second drawback is that a node must always wait for its turn in the transmission sequence again, even when it is the only node with a frame to send.

2. FDM

While TDM shares the broadcast channel in time, FDM divides the *R* bps channel into different frequencies (each with a bandwidth of *R*/*N*) and assigns each frequency to one of the *N* nodes. FDM thus creates *N* smaller channels of *R*/*N* bps out of the single, larger *R* bps channel.

FDM shares both the advantages and drawbacks of TDM.

It avoids collisions and divides the bandwidth fairly among the *N* nodes. However, FDM also shares a principal disadvantage with TDM, that is, a node is limited to a bandwidth of *R*/*N*, even when it is the only node with packets to send.

Therefore A third channel partitioning protocol is **code division multiple access (CDMA)** is developed. While TDM and FDM assign time slots and frequencies, respectively, to the nodes, CDMA assigns a different *code* to each node. Each node then uses its unique code to encode the data bits it sends. We will study CDMA later in the next lecture.