Class Notes - The Data Link Layer II

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1 General Class Info

In person office hours will be held in this room (Thorton Hall E303) from 3:00 pm to 3:30 pm est.

2 Demo

We demoed an example of how information can be transmitted at different frequencies and played back.

- As long as they are on different frequencies, it is possible to have multiple played at the same time.
- Other than the law, there is nothing preventing you from playing 2 transmissions on the same frequency. This will interfere with the other transmissions, leading to nearby radios picking up your transmission instead.
- The stronger the transmitters used, the larger range they have.

3 Previous Class Review

3.1 Cyclic Redundancy Checks (CRC)

Cyclic Redundancy Check: A method of error detection that ensures data sent is accurate. A calculation is performed on the sent packet and the same is performed on the receiving end, with any discrepancies in number signalling that an error has occurred.

We have some data D and want to add onto this data R. To do this without creating corrupted data, we need to shift D over r bits before xoring this with the data R.

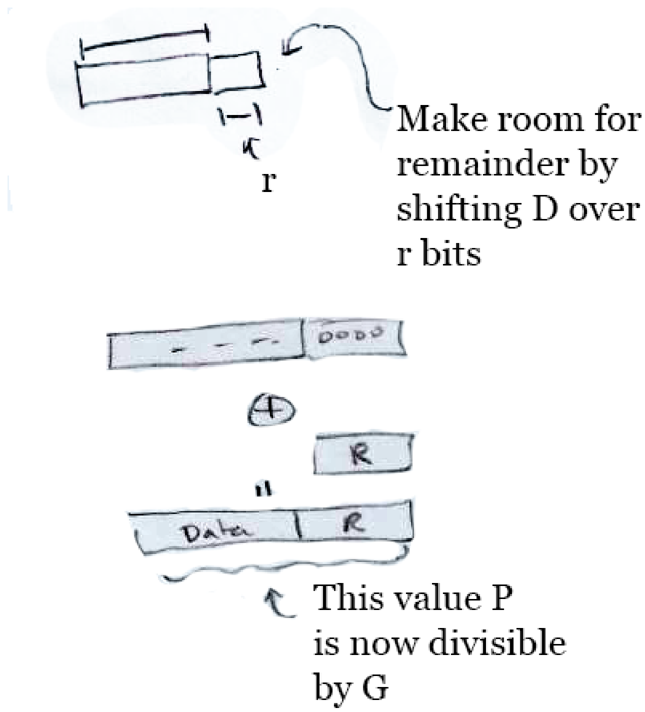

Figure 1: Visual Demonstration of CRC Shifting and Verification

We have some standard value G, that when the data transmitted D is divided by it, its remainder R is equal to 0

- **G:** The Cyclic Redundancy Code, A standard value known by all NIC cards using the same standard. It has a length of r+1. For instance, if r=5 bits, then G is 6 bits.
- **D** The data to be transferred.
- **R:** The remainder calculated when D/G or $D * 2^r/G$, if no error occurred it will be equal to 0
- **P:** The overall packet, containing both D and R

$$R[P/G] = 0$$
$$\frac{D * 2^r}{G} = R$$
$$D * 2^r \oplus R$$

If the remainder of (P/G) is equal to 0, the packet is accepted. If not, it is rejected.

4 Multiple Access Protocols

Access Point: Transmits data wireless over set frequencies
Multiple Access Protocol: A set of protocols that allow for a number of nodes or users to access a shared network channel. What do we want from a Multiple Access Protocol?

1. Distributed
2. No out of band communication
3. Same medium of distribution

Ideal Multiple Access Protocol Features.

- Transmission rate of R bps from one node
- M other nodes receiving transmission at R/M bps
- Fully Decentralized
  - No shared time
  - No shared clocks
  - No communication
- **Simple** to use/understand

4.1 MACs, Managing our MAC

Media Access Control (MAC): A protocol located on the Data Link layer that controls the hardware responsible for making the connections on the Physical layer. It is responsible for controlling the flow of data.
There are a number of ways we can manage our MAC protocol.

1. **Channel Partitioning**
   - Divide into slots for each node. This can be by time, frequency, or code
   - **Time Division Multiple Access (TDMA)**
     - **Pros**
       (a) Easy
     - **Cons**
       (a) Requires global time
       (b) Need to assign slots to each node
       (c) Can't burst
       (d) May have idle slots
   - **Frequency Division Multiple Access (FDMA)**
     The demo we used at the start of class, is an example of this.**Pros**
     - (a) Can have many Channels running in
       (b) No Synchronized clocked needed
       (c) Can burst
       (d) Easy
       (e) No idle time due to people waiting
     - **Cons**
       (a) Each individual node only uses small subsection of the Full Rate R.
       (b) Need to assign slots to each node, or nodes can interfere with each other.
       (c) Unused frequencies may be nearby
   - **Code Division Multiple Access (CDMA)**
     Mostly used in phones.**Cons**
     - (a) Need to assign slots to each node
2. **Random Access** Whenever a node wants to transmit, they are allowed to. They have to determine themselves if the probability of collision is low enough to risk sending.
   - **Pros**
     (a) Full Rate R can be used by individual
     (b) Don't need to assign nodes
   - **Cons**
     (a) Must detect and address collisions
     (b) Synchronized clocks across all nodes

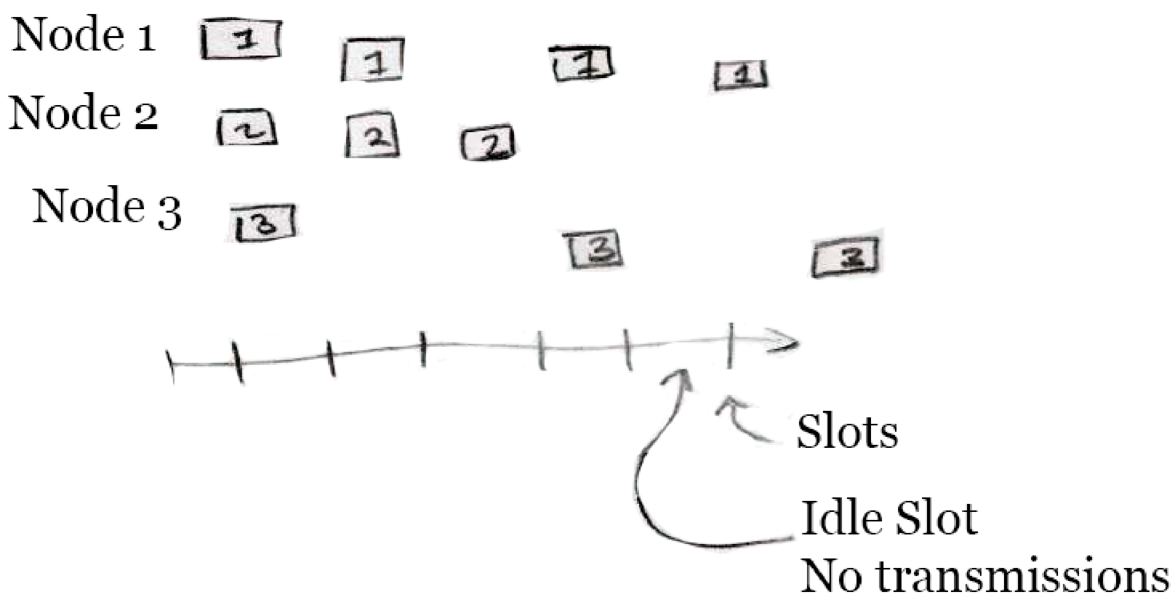

Figure 2: Demonstration of 3 node CSMA

- **Examples:**
  - **Aloha (Slotted Aloha)**
    Slotted Aloha has 3 nodes, each of which can send a frame at any time. If Any collisions are detected, the data is transmitted with P. The probability of success in a slot is equal to $P * (1 - P)^{N-1}$
  - **Carrier-Sense Multiple-Access (CSMA)**
    (a) Transmits when it senses that channel is idle
    (b) Waits when it senses that channel is busy.
    (c) Collisions still possible if multiple nodes try to transmit at same time. This is due to both sensing that the channel is idle and sending their transmission before the other one arrives.
  - **Carrier-Sense Multiple-Access with Collision Detection (CSMA/CD)** This is what makes up the Ethernet.
    (a) Same Base Principles as CSMA
    (b) If NIC detects another transmission, then send jam signal
    (c) if collusion, wait a random amount of time, which has an exponential probability of ending as time goes on.

3. **Taking Turns** This is very similar to Channel Partitioning, except if someone does not use their spot, then the next person can go early. It can be thought of like waiting in a line, if someone leaves, then they lose their spot.

   - **Pros**
     (a) Don't waste idle time
   - **Cons**
     (a) Need to assign slots to each node
     (b) Nodes need to be ready to send packets at all times