1   The OSI Model

The **OSI (Open Systems Interconnection) model** is a way of stratifying the different layers of a network. The goal is to isolate each layer so that engineers can specialize in the specific implementation of a single one without having to worry about the entire stack. The layers are as follows from top to bottom:

1. Application. Ex protocol: HTTP.

2. Presentation. Ex protocol: TLS.

3. Session. Ex protocol: RPC.

4. Transport. Ex protocol: TCP/UDP.

5. Network. Ex protocol: IP.

6. Data Link. Ex protocol: MAC.

7. Physical. Ex protocol: encoding bits.

While many network classes prefer to go top-down, this class will take a bottom-up approach.

2   Basic Network Architecture

Suppose you want to send information between two people without any pre-existing infrastructure. This could be compared to a "cup phone"that you may have constructed as a child.

Much like sound in a cup phone, information from one person needs to be modulated and transmitted through the wire to the other person. This is done with a **Network Interface Card (NIC)**. The card is responsible for converting binary information into voltages on the wire. Once the signal is on the wire, it gets transmitted to the other person, who also has a NIC to demodulate back into readable binary.

If there are multiple computers on the network, transmitting to all of them from multiple sources simultaneously would cause interference. Instead, a **Switch** is used to determine where to route the signal. Switches can be further connected to **Routers** to route the signal to even more other computers. If we combine enough switches and routers, we can make a very large network.
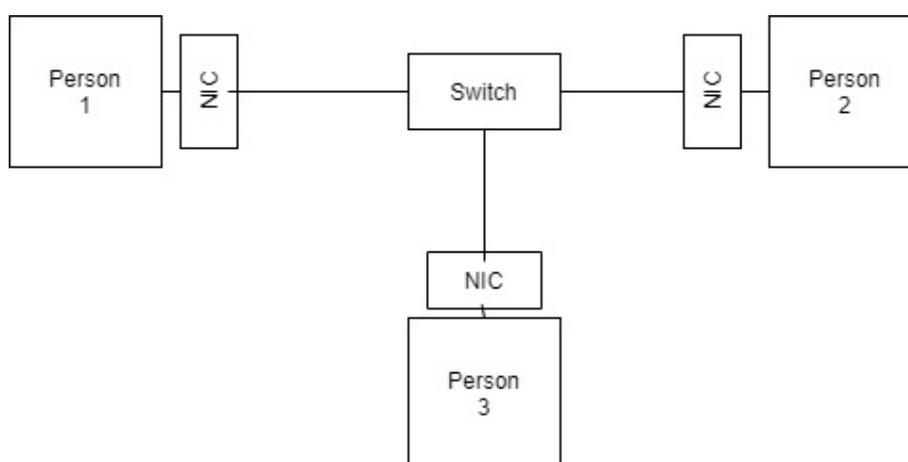

Figure 1: An example network

3 Inside a Packet

What kind of information actually gets transmitted through this network? First a few terms:

- The **Symbol Length** is how long we toggle a signal on and off for.

- The **Baud Rate** is how many symbols per second the machine is transmitting. If the symbol has multiple bits in it, then the **bit rate** is simply the number of bits times the reciprocal of the symbol length.

- **ASCII (the American Standard Code for Information Interchange)** is a way of encoding standard characters like the alphabet into binary.

When we send information along the wire, we can't just fire off data without warning. The information needs to be transmitted in a certain way, called a **Packet**. The packet arranges data in a standard way so that it can be easily interpreted on the receiving end. First the packet needs to transmit the destination of the data (for example, a phone number in a telephone network). Then the packet can transmit the data.
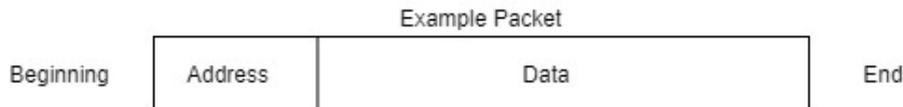

Figure 2: An example packet

Note: Packets need to be a fixed size or have a fixed length, so that the receiver knows when to start and stop reading them.

Quiz Question: If the symbol length is 0.125 seconds, what is the bit rate?
Answer: 8 bits/second

4 Frequency Shift Key

While we have talked about simply toggling a voltage on and off, we can actually encode more data by having different frequencies correspond to different binary values. For example, if we have 8 frequencies, we could have the first correspond to 000, the second to 001, etc. up to 111. This technique is called **Frequency Shift Key**. With just two frequencies the technique is called **Binary Frequency Shift Key**

Quiz Question: If the symbol length is 0.125 sec and you have 8 frequencies, what is the baud rate?
Answer: 24 bits/second, because 8 frequencies encode 3 bits per symbol, and there are 8 symbols per second.

This method is much more efficient than simply toggling a voltage on and off.

5 Types of Modulation

As a refresher, the formula for a wave is:

$$y(t) = A sin(2\pi f t + \phi)$$

Where A is the amplitude, f is the frequency, t is time, and ϕ is the phase. By modulating these values, we get several types of modulation:

- Change A: Amplitude Modulation (AM)

- Change f: Frequency Modulation (FM)

- Change ϕ: Binary Phase Shift Key

- Change A and ϕ: Quadrature Amplitude Modulation (used in WiFi)

Note that you can change more than one, you are not restricted to manipulating just one of the three values.