CS 336 Lecture 2– 2/9/98

Announcements

- Exercise 1 is online and due Wednesday.

The Physical Layer

1. As I explained last time, the physical layer of the OSI model is concerned with the physical details of the mechamisms used to transport digital data between a pair of machines.

2. Transmission methods can first be divided into two categories:

   guided – which includes systems in which the signals send from one machine to another are guided along some path through a wire or optical fiber, and

   unguided – which includes systems using radio waves, microwaves, infrared transmission or any other form of electromagnetic radiaton propagating through open space.

   We will devote most of our attention to guided transmission systems.

3. To guide the propagation of an electrical signal one typically uses a pair of conductors and signals by varying the voltage difference between the two conductors (Bell's original phone system apparently used just one conductor and depended on the ground for a "ground", but...).

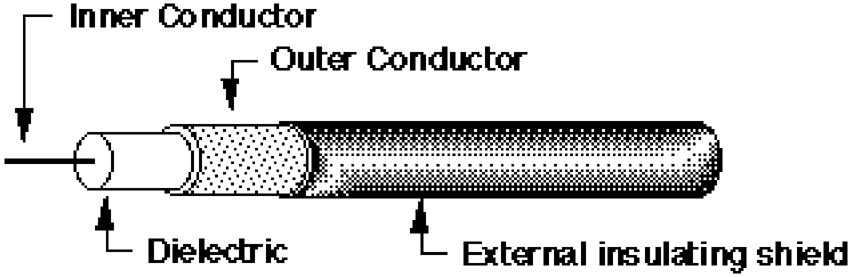
   The most common packaging of such conductors used in current networks are:

   Twisted Pair which should look a lot like telephone wire to you (if you have ever messed around with the phone wiring in your house).

   Basically, as its name suggests, "twisted pair" is just two independently insulated conductors twisted toghether. Typically, it is packaged with several pairs (2,3, or 4) encased together within a plastic casing.

   Coaxial cable which should look a lot like cable TV wire to vou.

   Here the two conductors are arranged so that one (the inner conductor) is completely surrounded by the other (with a layer of insulation in between the two and another layer of insulation surrounding the whole package). While the inner conductor is typically a solid wire, the outer conductor in a coaxial cable is frequently a wire mesh (providing more flexibility).

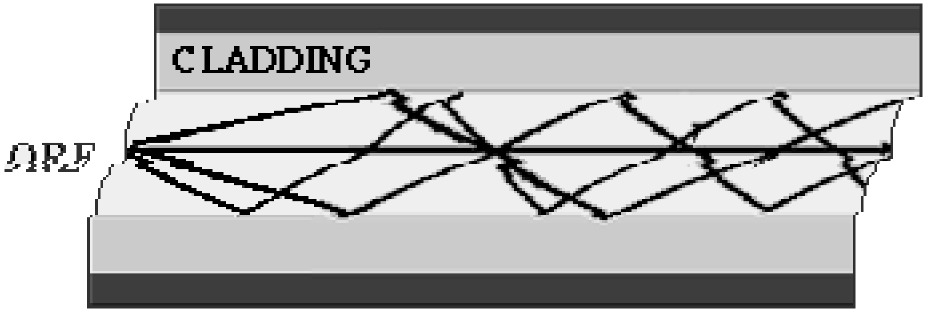
   If you recall at least as much of the physics of electricty and magnetism as I do (which is not much), you should know that electric current flowing through a conductor produces a magnetic field and that exposing a conductor to a varying magnetic field produces current in the conductor.

   As a result, exposing wires to magnetic fields can produce current that would interfere with date signals transmitted through those wires. Worse yet, wires carrying signals are generating magnetic fields. So, network wires can interfere with each other.

   The particular physical construction of each of the types of cabes used in data networks (i.e. the twisting or nesting of one conductor within another) is designed to minimize the degree to such interference (although I won't pretend to remember enough physics to explain precisely why).

4. An alternative to electrical signaling is to use light waves guided by optical fiber.

   FIber is structured somewhat like coaxial cable. A transparent "inner core" is surrounded by another transparent layer called the cladding. The cladding is in turn surrounded by a protective plastic cover.

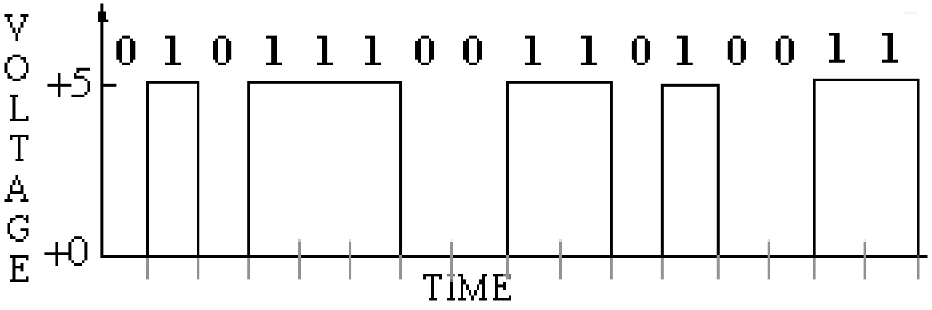
   

   The difference in the indices refraction of the core and cladding is designed so that a significant portion of a beam of light projected into one end of the fiber will be reflected at the boundary between the core and cladding. As a result, light can travel from one end of the fiber to the other.

Baseband Signalling

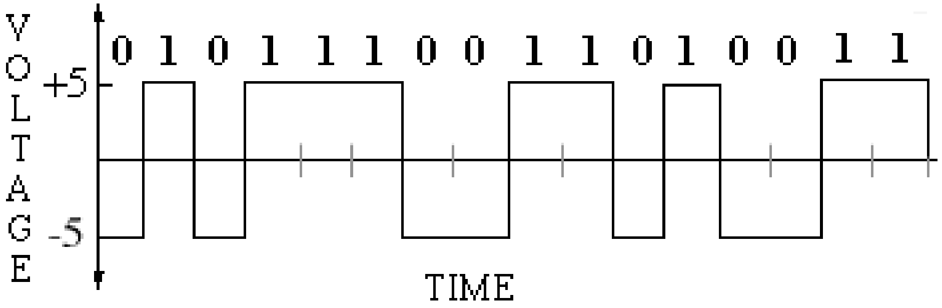
1. The simplest way to send digital information through wires is to encode everything in binary and use the same system for encoding bits that is used within the digital logic components of a computer. That is, simple choose one voltage to represent 0 and another to represent 1.

2. If d(t) is a function whose value at potin t is the value of the binary digit we wish to represent on a wire at time t (i.e. d(t)'s value is always either 0 or 1), then the value of the voltage used as a signal to represent the bit inside a typical digital logic circuit is V x d(t) for some voltage V.



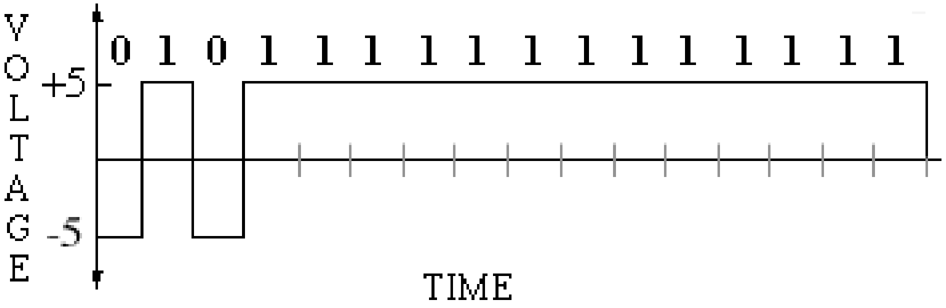
3. On a network transmission line, it is more common to use two voltages of equal magnitude but opposite polarity to represent 0 and 1. This reduces the direct current component of the signal. As a result, in such a transmission system

   s(t) = 2 x V x (d(t) - 1/2)



   This scheme is knows as Non-Return to Zero (NRZ) signalling.

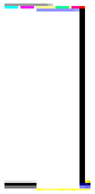
4. When sending a long sequence of zeroes or ones, the voltage used in NRZ transmission remains fixed for a long period of time.



   This causes two problems:

   - The signal will again have a direct current component (although I must admit that I have too little background to really explain why this is bad).
   - The receiver and sender will have to have precisely synchronized and highly accurate clocks since the signal itself will provide no information to enable the receiver to detect any drift in its clock.

5. Several codes are used that avoid these problems by making a voltage transition at some point in the process of sending each bit. For in "manchester encoding", the direction of the voltage change in the middle of the time interval associated with the transmission of a bit is used to encode the value of the bit.



- At the sending end of the fiber, an electrical signal produced by the computer is used to control a light emitting diode or laser producing a beam of light whose intensity varies to reflect the bits being transmitted.
- At the receiving end, a photo detector converts the light back into an electrical signal.

Multiplexing

1. Although process-to-process communication is the realm of the transport layer rather than of the physical layer, one implication of process-to-process communication is important to understanding important aspects of the physical layer — the need for multiplexing.

   - In a situation where process A on machine 1 wants to communicate with process B on machine 2 at the same time that process X on machine 1 wants to communicate with process Y on machine 2 we basically have two choices:
     (a) Drag multiple cables between the two machines.
     Unless the machines are very close together this can get expensive quickly.
     (b) Find some way that the two pairs of communicating processes (or more!) can share a single physical link.

     In case you can't guess, we need to discuss how to make the second approach possible.

2. One approach to sharing is taking turns.

   - Since the phrase "taking turns" isnt quite impressive enough, this approach is know as time division multiplexing (TDM) in the world of data communications.
   - The idea is that as long as the total number of bits all the processes wish to send per unit time is less than the capacity of the connection, the sending computer can take turns sending data for different processes.
   - Getting this to work is a software issue and belongs to the upper layers (transport).
   - Notice, however, that it only works because it is so easy to chop digital data up and then glue it back together later.

3. The other approach is to somehow send two signals on a wire or fiber simultaneously in such a way that the reciever can distinguish one incoming signal from the other.

   - To understand how this is possible, imagine two pairs of humans trying to signal through a single fiber at the same time.
   - Suppose that at one end of the fiber we give the two humans different flashlights (red and blue) and then tell them to send signals in binary by turning on their flashlights to send a one and turning them off to send a zero.
   - The person receiving from the individual with the blue flashlight would recognize a zero when the fiber was dark or red and recognize a one when the fiber was blue or purple. Similarly, the individual whose friend had the red flashlight would identify darkness or blueness as a zero and redness and purpleness as a one.
   - This process can be automated by using prisms to combine beams of different colors at the sending end and to direct them to separate photo detectors at the receiving end.

   - This technique is known as *frequency division multiplexing.*
   - As we will see, it is also possible in electical communication systems.