Physical Layer

Layer 1

Introduction

- The lowest layer of the OSI Reference Model is layer 1, the *physical layer*;
- Commonly abbreviated “PHY”.
- The physical layer is special compared to the other layers of the model, because it is the only one where data is physically moved across the network interface.
- All of the other layers perform useful functions to create messages to be sent, but they must all be transmitted down the protocol stack to the physical layer, where they are actually sent out over the network.

Role of the PHY

- The name “physical layer” can be a bit problematic. Because of that name, and because of what I just said about the physical layer actually transmitting data, many people who study networking get the impression that the physical layer is only about actual network hardware. Some people may say the physical layer is “the network interface cards and cables”. This is not actually the case, however. The physical layer defines a number of network functions, not just hardware cables and cards.

- A related notion is that “all network hardware belongs to the physical layer”. Again, this isn't strictly accurate. All hardware must have ***some*** relation to the physical layer in order to send data over the network, but hardware devices generally implement multiple layers of the OSI model, including the physical layer but also others. For example, an Ethernet network interface card performs functions at both the physical layer and the data link layer.

PHY Functionalities

Definition of Hardware Specifications: The details of operation of cables, connectors, wireless radio transceivers, network interface cards and other hardware devices are generally a function of the physical layer (although also partially the data link layer).

Encoding and Signaling: The physical layer is responsible for various encoding and signaling functions that transform the data from bits that reside within a computer or other device into signals that can be sent over the network.

Data Transmission and Reception: After encoding the data appropriately, the physical layer actually transmits the data, and of course, receives it. Note that this applies equally to wired and wireless networks, even if there is no tangible cable in a wireless network!

Topology and Physical Network Design: The physical layer is also considered the domain of many hardware-related network design issues, such as LAN and WAN

FYI…

Physical layer technologies are ones that are at the very lowest level and deal with the actual ones and zeroes that are sent over the network.

For example, when considering network interconnection devices, the simplest ones operate at the physical layer: repeaters, conventional hubs and transceivers. These devices have absolutely no knowledge of the contents of a message. They just take input bits and send them as output.

Devices like switches and routers operate at higher layers and look at the data they receive as being more than voltage or light pulses that represent one or zero.

Issues to consider at the PHY

- The PHY layer provides an electrical, mechanical and procedural interface to the transmission medium

- Parameters specified are:
  - Which frequency to broadcast on
  - What modulation scheme to use
  - What error correction/detection mechanism to use

Transmission Medium

- The transmission medium maybe
  - Guided, Wireless or Satellite

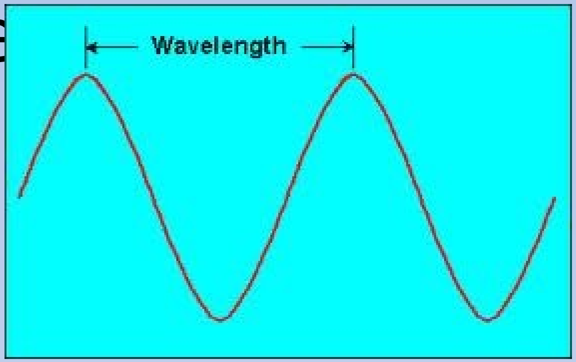
Medium	Frequency Range	Typical Attenuation	Typical Delay	Repeater Spacing
Twisted Pairs	0-3.5 KHz	0.2db/km @ 1KHz	50µs/km	2km
Multipair cables	0-1 MHz	0.7db/km @ 1KHz	5µs/km	2km
Coaxial Cables	0-500 MHz	7 db/km @ 10 MHz	4µs/km	1 to 9 km
Optical Fibre	186-370 MHz	0.2 – 0.5 db/km	5µs/km	40 km

Electromagnetic Waves - Properties

- When electrons move, they create EM waves that can propagate through space
- These waves of energy – known as electromagnetic radiation – can be created in various different ways
- Some are created by the sun, others are man made (TV/radio signals, Microwave, Remotes)
- All these waves taken together form the electromagnetic spectrum

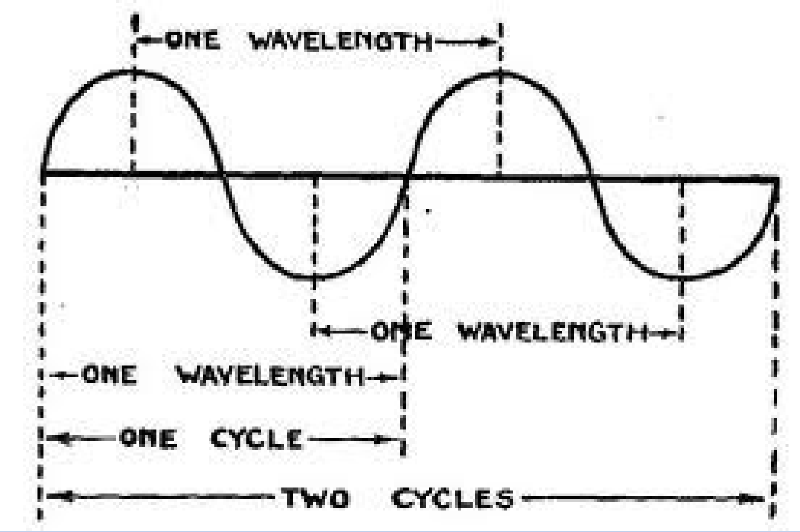
Wave Properties

- Wavelength
  - Length between two consecutive peaks of an energy wave. They can be as long as 10^6 meters at the bottom of the spectrum or as short as 10^{-15} m at the top of the spectrum
  - It is denote



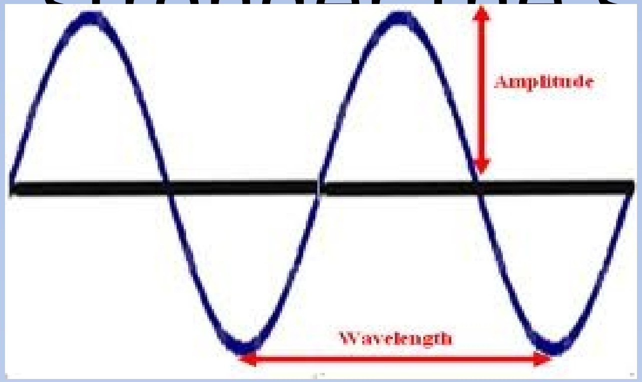
Frequency

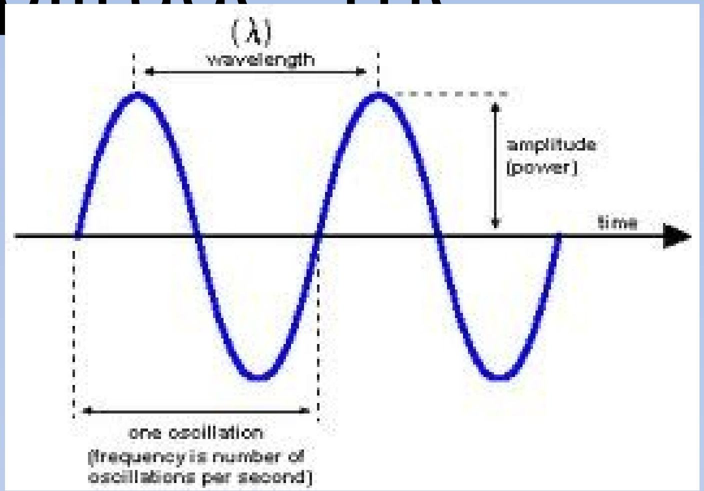
- Frequency refers to the number of times or cycles/sec that wave cycles occur
- The number of cycles per second are measured in Hertz (Hz)
- KHz (10^3 cycles/sec), MHz (10^6 cycles/sec)
- The longer the wavelength, the lower the frequency



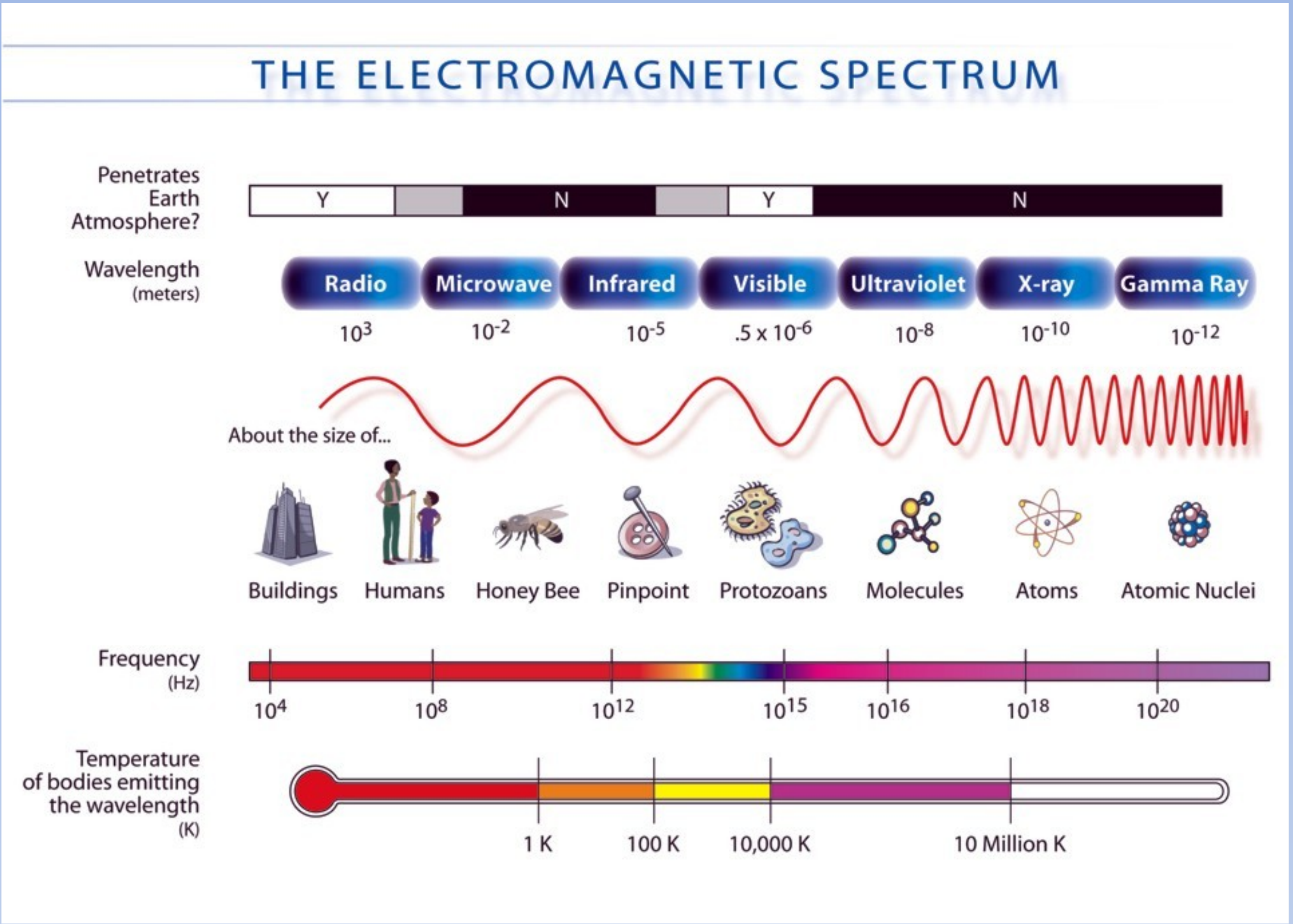
Amplitude

- Measurement of height of a wave
- Also measurement of strength of transmission
- The higher the amplitude, the stronger the signal





The Electromagnetic Spectrum



Radio is the generic name given to EM Waves that can be used for communicatio

Bandwidth

- Vague term – different meanings in different applications
- Networks: Digital BW often refers to data measured in bits per second (bps)
- Analog communication: difference between the upper and lower cutoff frequencies of a filter, a channel or a signal spectrum. Typically measured in Hz

Channel Capacity

- Every medium/channel has a finite transmission capacity
- Nyquist – MDR for a finite BW noiseless channel = 2H lg V bps
- Shannon – MDR of a noisy channel with SNR is MDR = Hlg (1+S/N) bps
- SNR measured in decibel (dB) = SNR = 100 = 20dB (10log(S/N))

Channel Capacity Examples

- 3 KHz channel, binary signal cannot transmit at a rate higher than 6 Kbps in a noiseless channel

- 3 KHz channel, SNR = 30dB (S/N = 1000)
  - MDR = 30Kbps

MODULATION

- Modulation is the process of encoding source data onto a carrier signal
- The source data can either be in analog or digital form
- The carrier wave is always an analog wave

Forms of Modulation

Digital Data -> Digital Signal	**Digital Data -> Analog Signal**
Simplest form of encoding of digital data is to assign one voltage level to binary one and another to binary zero	Modem converts digital data to analog signal so that it can be carried over telephone lines Basic techniques are: Amplitude Shift Keying (ASK) Frequency Shift Keying (FSK) Phase Shift Keying (PSK)
Analog Data -> Digital Signal	Analog Data -> Analog Signal
Pulse Code Modulation (PCM) is used which involves sampling the analog data periodically and quantizing the samples	Analog data are modulated by a carrier frequency to produce an analog signal in a different frequency band which can be utilized on an analog transmission system. Techniques are: AM, FM

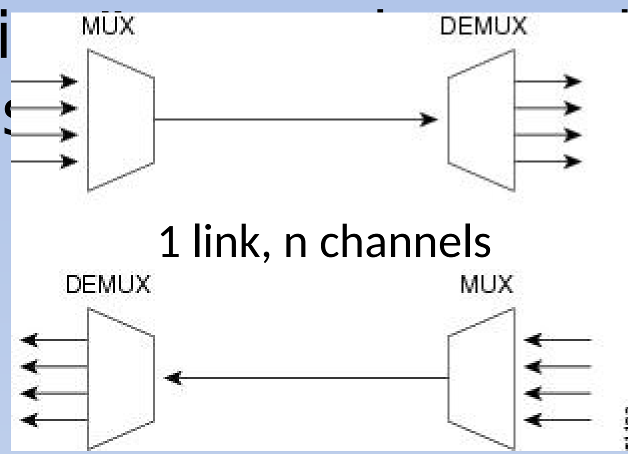
Nyquist Sampling Theorem

- If a signal f(t) is sampled at regular intervals of time at a rate higher than twice the highest frequency of the signal, then the sample contains all the information required to reconstruct the original signal f(t)

- The number of samples/sec is measured in “Baud”

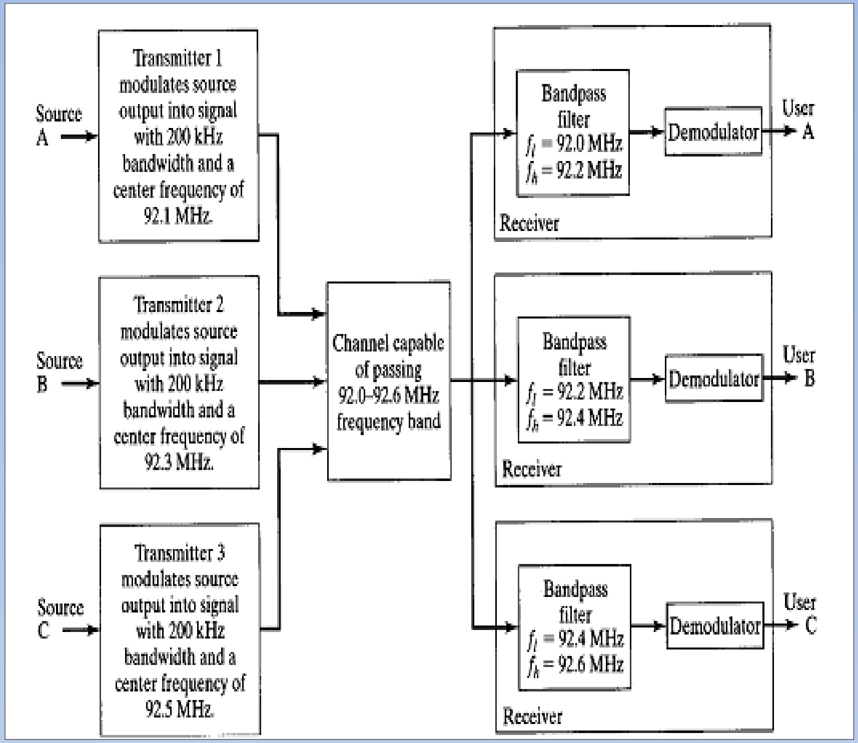
Multiplexing

- Process where multiple analog or digital data streams are combined into one signal
- Aim is to share an expensive resource
- Divides the capacity of a communication channel into several logical channels, one for each message signal or data stream
- “De-multiplexi … extracts original signals



Kinds of Multiplexing

Frequency Division Multiplexing (FDM)



Time Division Multiplexing (TDM)