CS 716: Introduction to communication networks

- 6th class; 10th Aug 2011

Instructor: Sridhar Iyer
IIT Bombay

Activity: Think-Pair-Share

Consider two people who want to communicate by talking.

- Think – Individually (about the following questions):
  - What is required to make the communication happen?
  - What factors influence the success of communication?
- Write down as many points as you can for each of the above questions.

- Pair - Discuss with your neighbour.
  - Copy answers from your neighbour's list that you have missed out!
  - Convince your neighbour that each of your points is a valid answer.

- Share - Discuss with entire class.

Some points from last year

- Both should have same language, vocabulary.
- Compatible speeds. One should not talk too fast.
- Clarity of speech.
- Surroundings should not be noisy.
- It should not be just one-person talking all the time!
- ...

Key points in communication

- What is required to make the communication happen?
  - Should speak the same language.
    - => Agreement on interpretation; Syntax, Semantics.
  - Should be able to hear each other 'clearly'.
    - => Range, Pitch of voice.
  - Should speak 'coherently'.
    - => Talk at 'normal' speed; No mumbling; Meaningful sentences.
- What factors influence choice of language?
  - Fluency => Encoding and decoding.
- What factors influence being able to hear?
  - Distance, Noise => Modulation.

Today's class discussion

- Having seen the concepts of layering, interfaces and protocols, we will get into the Physical layer (PHY).
  - Why should there be a separate PHY layer?
  - What should be the concerns of the PHY layer?
  - What services should PHY layer provide?
- Let us quickly put some answers on the board!

Physical layer (PHY)

PHY functions

- Physical Layer consists of the basic hardware for transmission and reception between any two nodes in a network.
  - Complex layer - due to plethora of technologies.
  - May be point-to-point or multi-point connectivity.
  - Implementation of this layer is termed as PHY.

- PHY defines
  - Means of transmitting bits rather than logical data packets over a physical link.
  - Bit stream is grouped into code words or symbols, then converted to a physical signal that is transmitted.
  - Link parameters to be negotiated with the peer layer on the other side.

PHY end-to-end communication

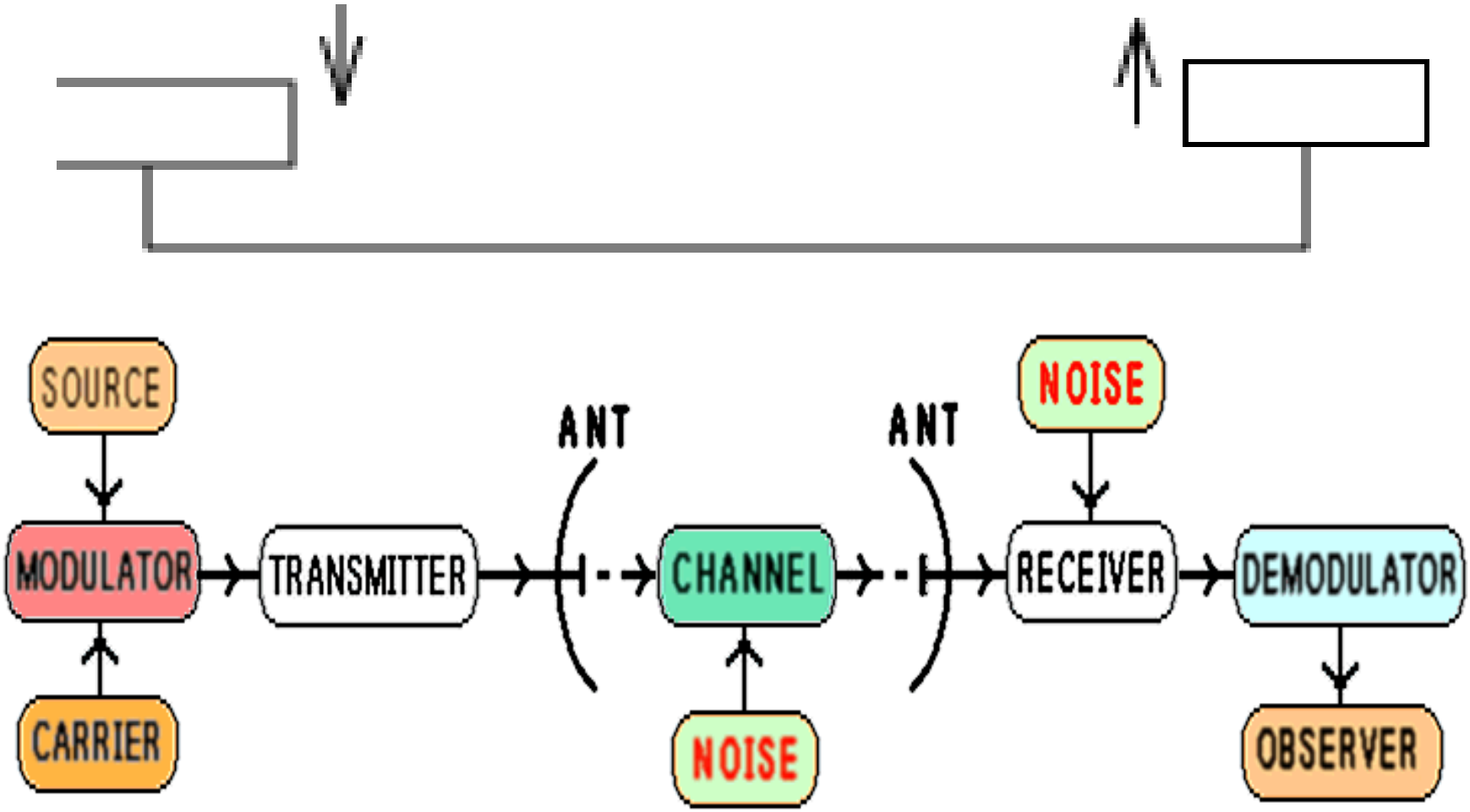


Figure source: http://www.williamson-labs.com/480_com.htm

Hardware: Network Cards/Adapters

Ethernet card

Wireless LAN

Other types of PHY Hardware:
Modems, Repeaters, Hub, Media converters, Cables, etc.

PHY interface

- PHY provides
  - A mechanical, electrical and procedural interface to the transmission medium. It defines the:
    - Shapes and properties of the electrical connectors.
    - Frequencies and modulation scheme to use.
    - Other low level parameters...signal levels, impedances...
  - A set of registers to device drivers to
    - Determine and configure settings.
    - Send and receive data.
  - Carrier sense and other indicators to upper layer.
- PHY translates logical communications requests from the upper layer (Link Layer) into hardware-specific Tx/Rx operations.

Activity: Think-Pair-Share

Questions:

- What factors need to be considered for PHY design?
- How does each factor influence the PHY design?

Example:

Factors	How they affect
Distance	Repeaters, Modulation schemes, Antennas, Transmit power
Medium	wired/wireless; interference, noise

- Think – Individually
  - Add as many entries as you can to the above table.
- Pair - Discuss with your neighbour.
  - Copy answers from your neighbour's list that you have missed out!
- Share - Discuss with entire class.

Some points from last year

Factors	**How they affect**
Distance	Repeaters, Modulation schemes, Antennas, Transmitter power
Medium	wired/wireless; interference, noise
Cost	Spectrum licensing
Link capacity	Decides data rate which is determined by application needs
Security	Wireless (encryption)
Topology	Point-to-point v/s Broadcast
Redundancy	More than one link; error correction
Amount of data	Decides choice of link (data rate).
Mobility	Wireless; Power control (CDMA example)

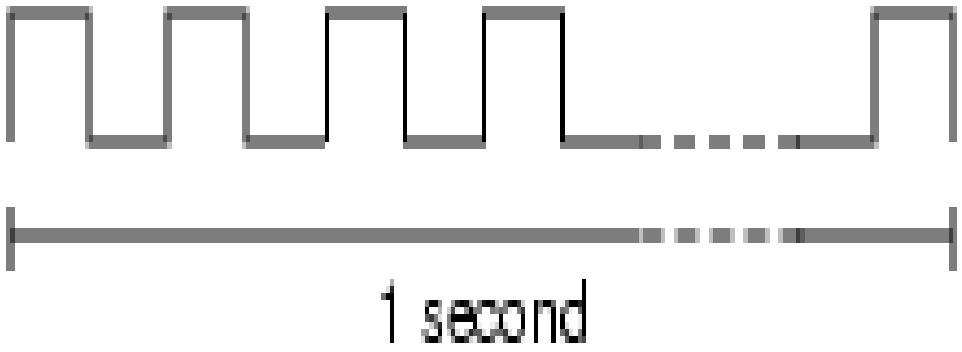
Key factors influencing PHY design

- Distance of receiver from transmitter
  - Shout if listener is far away => Transmit power at sender.
- Noise in the Medium
  - High pitch if windy; low if fog => Modulation schemes;
  - Signal-to-Noise ratio.
- Capture mechanism at receiver
  - Receiver only cares about whether it can hear properly, not about sender's transmit power or noisy medium.
  - => Received Signal Strength; Capture Threshold.

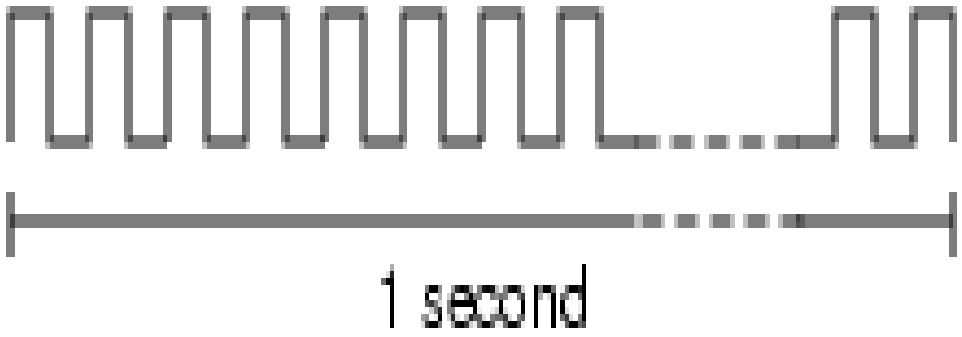
Key ideas in PHY: Bandwidth

- Amount of data that can be transmitted per unit time
  - expressed in cycles per second, or Hertz (Hz) for analog devices
  - expressed in bits per second (bps) for digital devices
- Units - KB = 2^10 bytes; Mbps = 10^6 bps
- Notion of Link Bandwidth v/s End-to-End

Bandwidth v/s bit width



1Mbps
(each bit 1 microseconds wide)



2 Mbps
(each bit 0.5 microseconds wide)

Key ideas in PHY: Latency (delay)

Time taken to send a message from point A to point B

- Latency = Propagation + Transmit + Queue

- Propagation = Distance / SpeedOfLight
- Transmit = Size / Bandwidth
- Queue = Waiting for transmit

- Notion of End-to-End delay

Activity: Think-Pair-Share

Consider the email application that you designed in the last class. Focus on the part between the sending mail server and the receiving mail server.

- List all the various delays in this communication.
  - Sender side: Sending mail server (Application) sends the email to the Transport layer, which in turn does some processing and sends it to the Network layer, which then sends it to Link layer and down to PHY.
  - Receiver side: PHY receives, sends it up the layers, each doing some processing, till the mail reaches the receiving mail server (Application).
- Assume that there is a direct link between the servers (no need to consider intermediate routers or multi-hop network).

Do this activity in a **Think-Pair-Share** mode.

Class discussion (draw figure)

Major sender side delays:

1. Application-to-Transport: Data construction + Header attachment + Queue (delay till transport layer starts processing).
2. Transport-to-Network: Segmentation (create packets), Processing for retransmission (setup buffers, timers), Attach header, Queue (delay till network layer starts).
3. Network-to-Link: Packetization, Processing for routing (Addressing, Route lookup), Queue (for link layer).
4. Link-to-PHY: Queue (medium access) + Transmit.
5. At PHY: Propagation delay

Class discussion (contd.)

Major receiver side delays:

1. PHY-to-Link: Frame construction (bits to packet); Transmit up to link layer.
2. Link-to-Network: Demultiplexing; Error check.
3. Network-to-Transport: Demultiplexing; Error check.
4. Transport-to-Application: Processing for sending ACK; Reassembly.
5. Application: Manipulation of data (Ex: web server processing requests or browser rendering responses).

Latency

- Queue is not relevant for direct links.
- Bandwidth not relevant if Size = 1 bit.

- Process-to-process latency includes software overhead
- Software overhead can dominate when Distance is small

- Terminology
  - RTT: round-trip time

PHY: Wireless v/s Wired networks

- Regulations of frequencies
  - Limited availability, coordination is required
  - Useful frequencies are almost all occupied
- Bandwidth
  - Low transmission rates; few Kbits/s to some Mbit/s.
- Delays and losses
  - Higher delays: several hundred milliseconds
  - Higher loss rates: susceptible to interference
- Always shared medium
  - Lower security, simpler active attacking
  - radio interface accessible for everyone

Animations

- Some sites that provide Java applets (animations) on modulation techniques are:
- www.educypedia.be/electronics/
- http://www.comapps.com/tonyt/Applets/Applets.html
- http://tams-www.informatik.uni-hamburg.de/applets/hades/webdemos/toc.html
- Search - modulation schemes animations

At the end of this topic

You should be able to do:

- Determine factors that influence communication in a given scenario.
- Describe the functions and services of the PHY layer in a network.
- Compare PHY aspects of wired and wireless networks.
- Define bandwidth and latency.
- Compute the time taken to transmit a given file over a link.
-

Reflection

- What did I learn in today's class?
- Take-home questions:
  - What all should be specified in the protocol between peers at the PHY layer?
  - What services should PHY provide to the upper layer?
  - When should we create a new layer?
  - When can we merge two adjacent layers?