CS 348: Computer Networks

- PHY; 30th July 2012

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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.

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

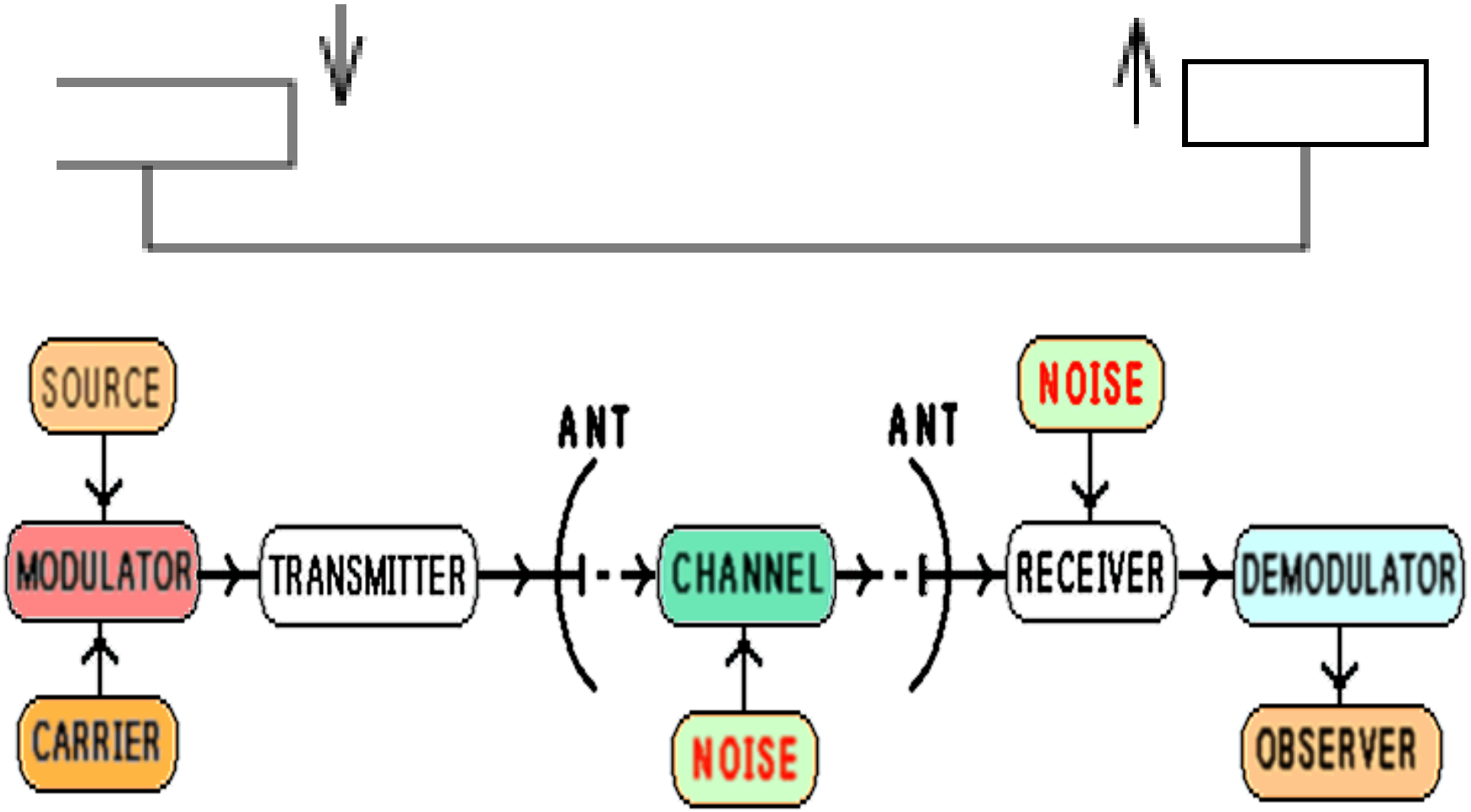
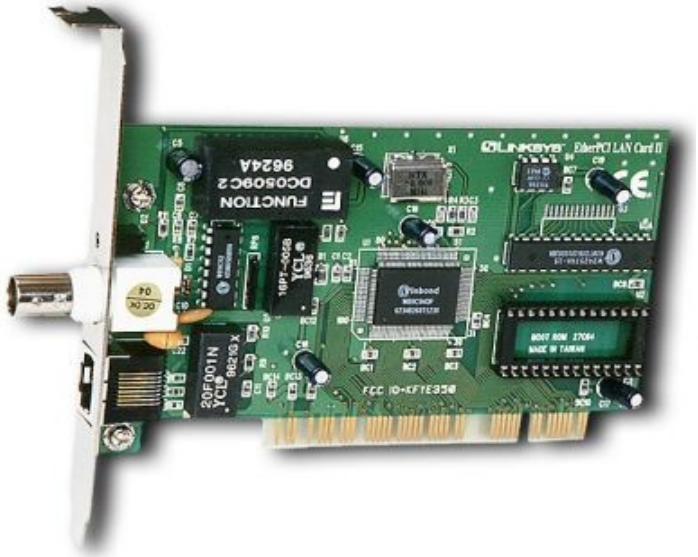


Figure source: http://www.williamson-labs.com/480_com.htm

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.

Some factors in PHY design

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.

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

Example: Linux PHY interface

PHY Interface definitions

- int phy_read(struct phy_device *phydev, u16 regnum);
- int phy_write(struct phy_device *phydev, u16 regnum, u16 val);
- Other functions such as print_status, enable_interrupt, ...

- Ethernet drivers in /usr/src/linux/net/inet/eth.c
  - http://www.kernel.org/pub/linux/kernel/v1.0
  - http://www.google.co.in/codesearch

Example PHY protocols

- Telephone Modems V.92, SONET/SDH, DSL, ISDN.
- Ethernet: 10BASE-T, 1000BASE-T.
- WiFi: 802.11 a/b/g
- GSM Um radio interface physical layer.
- Bluetooth Physical Layer.
- USB, RS-232.
- Firewire
- ....
- Quick reference: http://en.wikipedia.org/wiki/Category:Physical_layer_protocols

PHY configurable parameters

- Preset configurations are sufficient in most cases.

- GUI and text-based tools/utilities available to user:
    - ethtool, Mii-tool
- Common actions:
    - ifup eth0: Turn on the Ethernet
    - Ifdown eth0: Turn off the Ethernet
    - /etc/init.d/network [status | stop | start]
- Config parameters are stored in files typically in:
    - /etc/network/interfaces
    - /etc/sysconfig/network-scripts/ifcfg-eth0 /etc/network/
  - Actual file names may vary across Linux flavours/versions

More on Modulation schemes

- Fast Ethernet 100BASE-T and Gigabit Ethernet 1000BASE-T utilize Pulse Amplitude Modulation (PAM-5).
  - See Ethernet Working Group, IEEE 802.3

    http://www.ieee802.org/3/

- WiFi 802.11b uses Direct Sequence Spread Spectrum (DSSS) and 802.11g uses Orthogonal Frequency Division Multiplexing (OFDM)
  - See Wireless LAN Working Group, IEEE 802.11

    http://www.ieee802.org/11/

More on PHY design

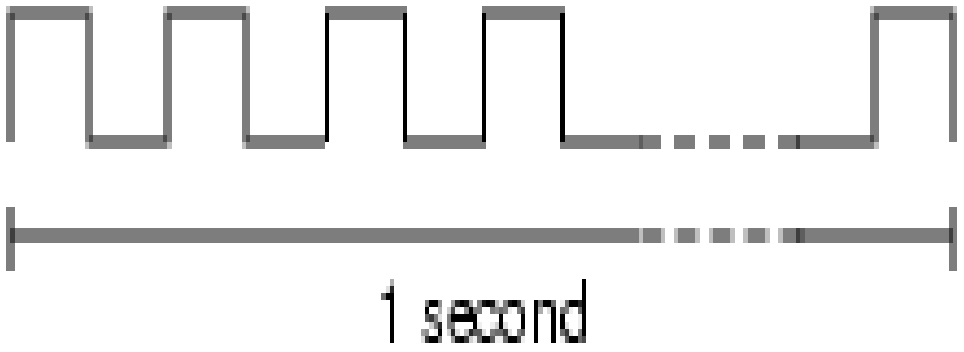
- Is beyond the scope of this course!

- Topics in PHY lead to research areas such as:
  - Design of Transmitters, Antennas and Receivers.
  - Modulation techniques.
  - Coding, error correction.
  - … and many more.

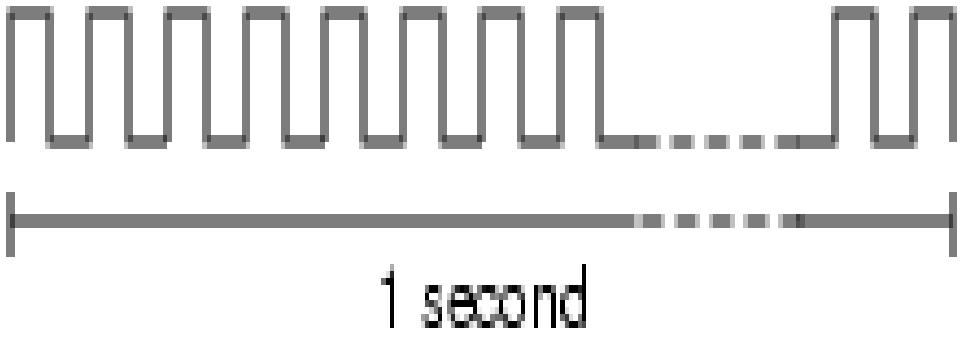
Key ideas in PHY: Bandwidth

- 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

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

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