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

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

1 MHz
(each bit 1 microsecond wide)

1 second

2 MHz
(each bit 0.5 microsecond wide)

1 second
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

- Search - modulation schemes animations