Internet Technology

01r. Lecture 1 Review: Key Terms

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Basic principles & terminology

- The basic principles of data communication were established *long before* computer networking
- Let's review some key terms we covered in the last lecture

Key terms (1)

- Broadcast
  - Send a message that will be received by everyone on the network
- Unicast
  - Send a message to one specific recipient
- Synchronization
  - Coordinate the delivery of messages.
  - E.g., agree to start, stop, or coordinate who transmits
- Relay
  - Repeater: regenerate the message to extend the network farther

Key terms (2)

- Control data vs. message data
  - Control data relates to the messaging protocol
    - synchronization, acknowledgements, flow control, priority, etc.
  - Message data is the actual data that you want to convey to the receiver
- Acknowledgement (also known as positive acknowledgement)
  - A control message sent from the receiver to the sender to indicate that a message has been received successfully
- Negative Acknowledgement
  - A form of *error notification*
  - A control message sent from the receiver or some network element to the sender to indicate that a message has *NOT* been delivered successfully

Key terms (3)

- Congestion
  - The inability of a network element to receive or transmit messages at the desired rate, leading to a buildup or possibly a loss of messages and a deterioration in the quality of service
- Flow control
  - Modifying the rate at which messages are sent to avoid congestion
  - This may includes control messages, such as "slow down"

Key terms (4)

- Message encoding
  - The techniques used to represent a message.
  - Before computers, this referred to, for example, the number of torches to display or positions of a semaphore for a specific message.
  - With digital techniques, this refers to the binary symbols used to represent the message and how those binary symbols are transmitted.
- Best-effort message delivery
  - An attempt to deliver messages reliably. If a message does not make it to the destination, try again: re-transmit

ARPANET

- ARPANET was a precursor to the Internet
- Inter-network – a network of networks
  - The devices on the ARPANET (and, later, the Internet) do not have to use the same (or compatible) networking hardware.
  - Routers interconnect the various networks together, creating a larger logical network
- Early key components of the ARPANET
  - IMP – Interface Message Processor. This evolved to the router.
    - This provided the hardware to route messages to their destination.
  - NCP – Network Control Protocol. This evolved to TCP/IP.
    - This provided the software for addressing, sending, and receiving messages.

Key design principles

Design principles of ARPANET, which became the design principles of the Internet

1. The Internet is a network of networks
   - No modification is needed to any underlying physical network to support the Internet
   - Different organizations may use different networking hardware
2. Assume unreliable networks
   - The network (collection of networks that a message takes) does not guarantee that a message will arrive at its destination or that messages will arrive in the order they were sent.
   - Software will be responsible for retransmitting lost or corrupt messages and for sequencing the messages in proper order.
3. Routers connect the networks that make up the Internet
   - Routers do not have to store information about past packets they've seen
4. There is no central control of the network

The network

- Two parts: the core & edge
- The edge
  - the devices (computers, TVs, phones) that connect to the network
  - These devices are called nodes, hosts, or end points
- The core
  - The network itself: the wires & radio waves that carry the messages and the routers that relay them toward their destination.

Local area network (LAN)

- The network within a small area (e.g., home, office)
- Compatible networking hardware
  - E.g., all ethernet (Wi-Fi bridges to ethernet and is compatible)
  - No routers needed to send messages from one node to another
- All nodes are peers: anyone can send a message to anyone else
- Generally high speed links with low latency

Local Area Network terms

- A NIC (Network Interface Component) connects a network to a device.
- Media: the communication links of the network
  - Unshielded Twisted Pair (e.g., ethernet), radio (e.g., Wi-Fi), coaxial cable (e.g., cable TV internet service), optical fiber (e.g., FiOS)
- Hubs & switches
  - Central point on a LAN for cables from the various nodes on the LAN
    - Consists of multiple ports. Port = connector for one cable.
  - Hub
    - Takes incoming data from one port and sends it to all other ports
  - Switch
    - Takes incoming data from one port and sends it only to the port where it needs to go. Better than a hub because it does not create extra network traffic for node. [Hubs are practically obsolete now; switches are pretty cheap]
- Routers
  - Used to move messages between local area networks

Local Area Network terms

- Modem
  - Stands for Modulator-Demodulator
  - Converts data between different analog formats (e.g., phone lines, cable TV, fiber optic cable)
- Access link
  - The interface between a LAN and the Internet
  - Common access links
    - DSL: digital subscriber line
      - DSL modem: places data packets on frequencies in the 4 kHz – 1 MHz range of a phone line
    - Cable TV
      - DOCSIS cable modem: places data packets on one or more 6 MHz wide channels. Each of these channels is the space that a single HDTV channel occupies and gives 38 Mbps of downstream service
    - Fiber to the Home (FTTH)
      - Verizon FiOS

Internet Service Providers

- Internet access is provided by a company called an Internet Service Provider (ISP)
  - There are thousands of ISPs
- ISPs are (roughly) organized into three tiers
  - Tier 1: top-level ISPs
    - Peer with each other
    - Peering = forward & receive traffic with another ISP at no cost
    - Keep a global routing table. For any destination address, a Tier 1 ISP will know which Tier 1 ISP can route the message
  - Tier 2: second level - regional
    - May peer with some networks – across regions or with competitors within a region
    - Purchases connectivity to the rest of the Internet from Tier 1 & other Tier 2 ISPs
  - Tier 3: third level – focus on retail and consumers
    - Purchases internet service from Tier 1 & Tier 2 ISPs

Packet Routing

- A packet going from a source node to a destination will typically pass through many networks (routers), both within an ISP and between ISPs

Sharing a network

- Lots of nodes & applications need to share a network
- Two options:
  1. Allow everyone to talk at the same time
     - …but use different frequency bands
     - FDM: Frequency Division Multiplexing
  2. Take turns
     - Two ways of doing this:
       1. Give each communication line a fixed time slot (e.g., you can transmit for 15 milliseconds every second)
          - TDM: Time Division Multiplexing
       2. Let anyone transmit on variable-size time slots (more time for bigger packets)
          - Packet switching

Circuit switching

- Requires connection setup
  - Connection setup figures out the path from source to destination
    - Each router in the path allocates memory buffers and time to ensure that it can handle the data traffic
  - Once the connection has been acknowledged, data transmission can occur
- Circuit switching offers
  - Guaranteed, fixed, bandwidth
  - Constant latency
- BUT … it does not use resources efficiently
  - The time slot is there whether you use it or not

Packet switching

- A data stream is broken into chunks called packets
- Each packet contains a destination address
- Routers do need to store state of past packets
  - They figure out a route when they get the packet
- Packet switching can lead to:
  - Variable latency
  - Congestion and possible packet loss
- BUT … it allows far more efficient use of the network
  - And network capacity is not limited by the number of nodes or applications that need to send data
- The Internet is built around packet switching

The end