Networking: Physical & Link Layer

Summer 2013
Cornell University
Today

- Which are the services that the Link layer offers?
- Link layer
- Implementation
- Media Access Control
- Addressing
- Ethernet
- Switch
Protocol Stack

Message
Segment
Datagram
Frame
LAN

- Local Area Network:
  - Small geographical area (office, house).
  - Small number of nodes (computers, network devices).
  - **Links** to connect nodes.
- How are messages transferred between nodes of the same LAN?
  - It is responsibility of the Link Layer.
Link Layer

- Mission: Transfer a frame through a link.
- Examples: Ethernet, LAN 802.11 (WiFi).
- Frame: Transfer unit
- Services
  - Encapsulation (datagram + header → frame)
  - Addressing
  - Media Access Control
  - Error Detection / Correction
  - Not all link protocols offer all the services.
Implementation

- A Network Interface Card (NIC) is attached to nodes.
  - One node may have multiple NICs.
- A chip in NIC is responsible to implement most of the Link services.
- The controller of a NIC, takes the datagram (Network Layer) from the memory of the node.
- Then, the datagram is encapsulated into a frame in the NIC.
- Finally, the frame is converted into a signal and released into the link.
- Generally, the Link layer is implemented by both the software and the hardware.
Media Access Control

• How can we connect the nodes with each other?
  • Point-to-point link
    - The link is shared only between 2 nodes.
    - The frame goes from the source to the destination.
    - Disadvantages?
  • Broadcast link
    - One link shared between all the nodes.
    - The frame goes from the source to all the nodes.
    - Only the destination will read it.
    - Disadvantages?
    - The Link Layer is responsible to share the media access between the nodes.
Media Access Control

• Broadcast Link:
  • Which resource are the nodes going to share?
    - Bandwidth (bits per second – bps).
      • Rate with which data is transmitted in the link.
  • So, nodes compete for bandwidth.
    - Like processes compete for CPU → multiplexing
  • How will the Link layer control the competition?
    - Channel Partition
      • Time slices
    - Random access
      • CSMA/CD
    - Taking-turns access
Addressing

- After having defined the Media Access Control, how will the nodes be identified?
  - Each NIC has a static 6-byte identification.
    - Ex. 1A-23-F9-CD-06-95
  - The Link layer uses this identification to distinguish nodes, and its name is:
    - MAC address
  - In a broadcast link, the destination checks the MAC address to decide if it should keep the frame or not.
Ethernet

- Link Layer Protocol
- Invented in 70's.
- Through the time, different LAN architectures were supported:
  - **Bus**
    - One common broadcast cable.
    - Need for Media Access Control.
  - **Star with hub**
    - The nodes are connected to the hub.
    - The hub, simply, was reproducing the received signal from a link to the rest of the links.
    - Need for Media Access Control.
  - **Star with switch**
    - The nodes are connected to the switch.
    - The switch controls the flow of frames.
      - It sends the frame to its destination without conflicting with other frames.
Ethernet

- Frame structure:
  - Header
    - MAC destination, source (6 byte each)
    - Preamble (8 bytes)
    - CRC (4 bytes)
  - Data
    - 46 to 1500 bytes
    - Encapsulated datagram
Ethernet

- Multiple Access Control:
  - Bus, Star with hub
  - CSMA/CD
    - **Carrier sensing**
      - The sender waits until the channel is unoccupied.
    - **Collision detection**
      - If two nodes sent frames simultaneously, they detect the collision and stop transmitting.
      - They will try again after a specific time period.
        - Exponential backoff.
Ethernet

- **Switch:**
  - It forwards the frame only to the destination.
    - Using the switch table. It is an array of (MAC Address, port).
    - If it does not know where the destination is, yet, it forwards the frame to all direction.
  - It buffers the frames to avoid collisions.
    - When 2 frames head for the same destination.
  - It filters and discards frames, based on predefined rules.
Ethernet

Computer A

Application

Transport

Network

Link

Physical

Computer B

Application

Transport

Network

Link

Switch

Link

Physical

Physical

Physical
Ethernet

What happens when 1A-23-F9-CD-06-95 sends a frame to 1B-23-F0-CD-06-11?
Today

- Which are the services that the Link layer offers?
- Link layer
- Implementation
- Media Access Control
- Addressing
- Ethernet
- Switch