

CS 4410
Operating Systems

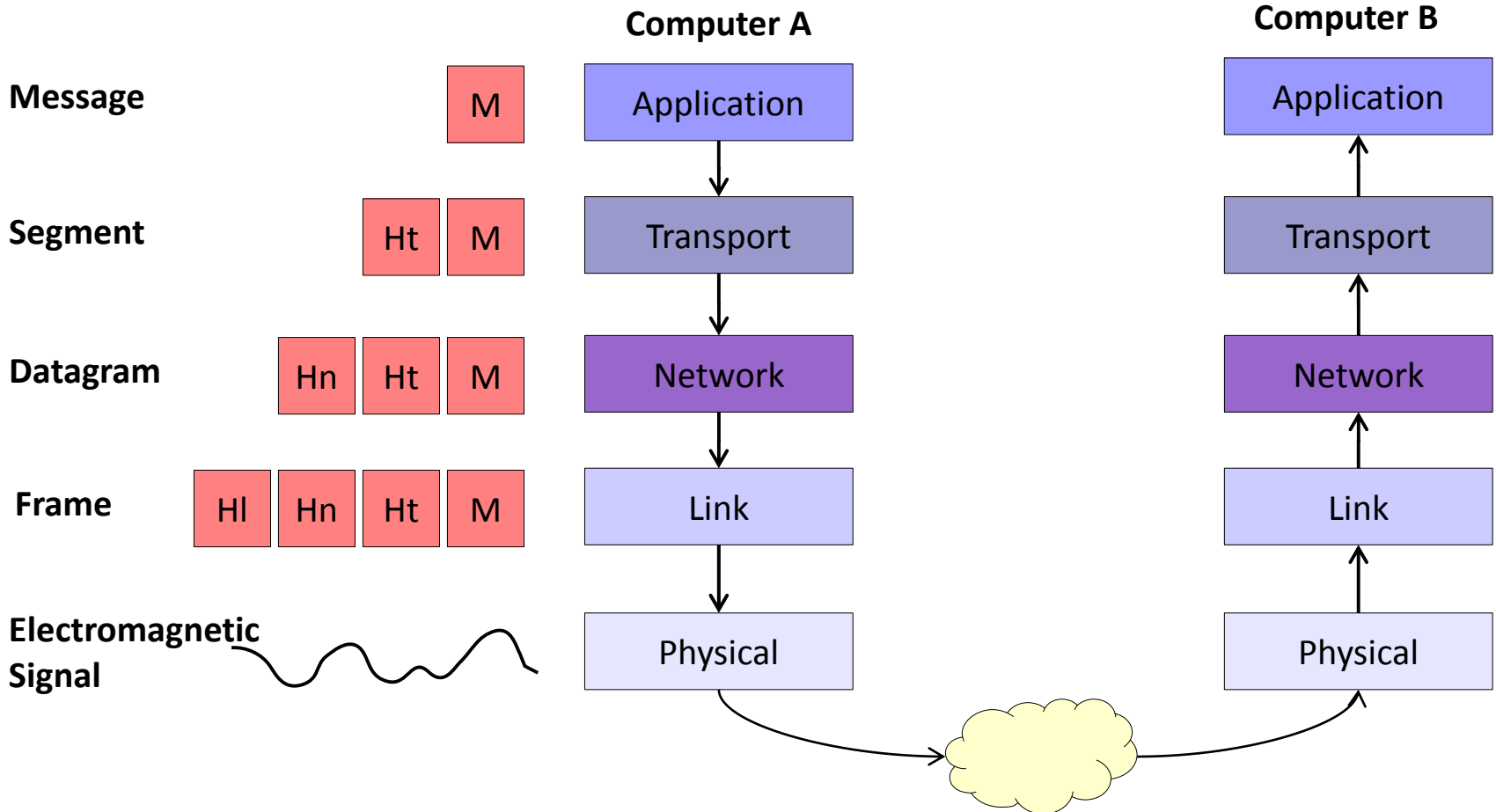
Networking:
Physical & Link Layer

Summer 2016
Cornell University

Today

- Communication between devices in the same LAN.

Protocol Stack

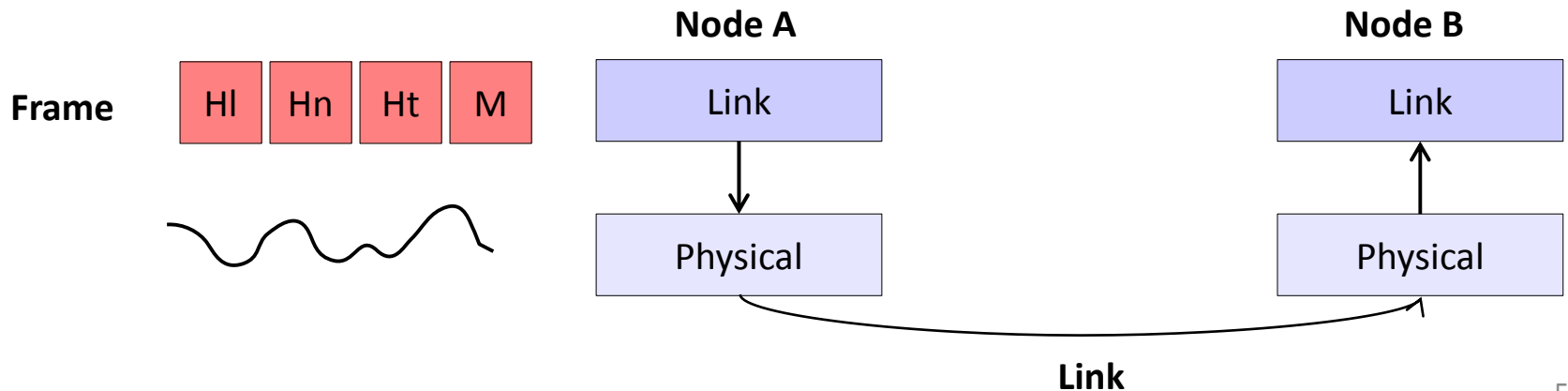


LAN

- 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).
- Services
 - Encapsulation (datagram + header (Hl) → frame)
 - Addressing
 - Media Access Control
 - Error Detection / Correction
 - Not all link protocols offer all the services.



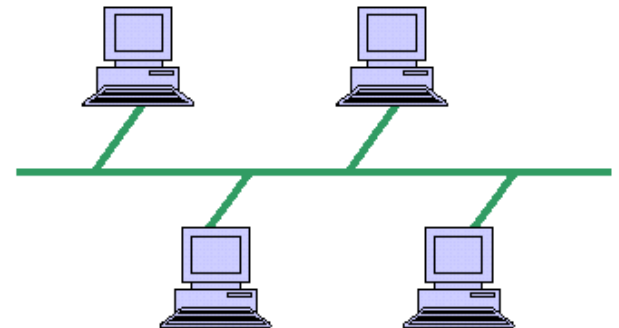
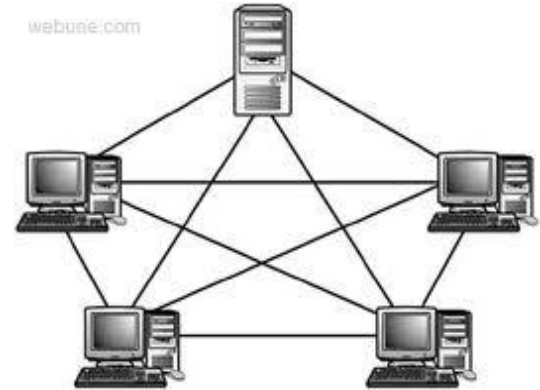
Implementation



- A Network Interface Card (**NIC**) is attached to nodes (e.g., computers).
 - A NIC is a hardware device specialized for computer networking.
 - 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 main 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 should read it.
 - Disadvantages?
 - The Link Layer is responsible to share the media access between the nodes.



Media Access Control

- Broadcast Link:
 - Which resource will be shared among nodes?
 - 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-division, frequency-division)
 - Random access
 - Taking-turns access

Addressing

- How are nodes 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.

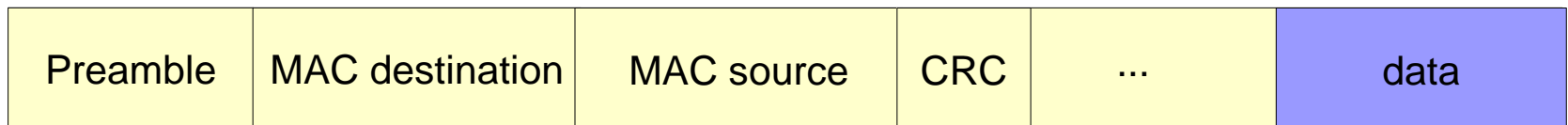
Ethernet



- 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

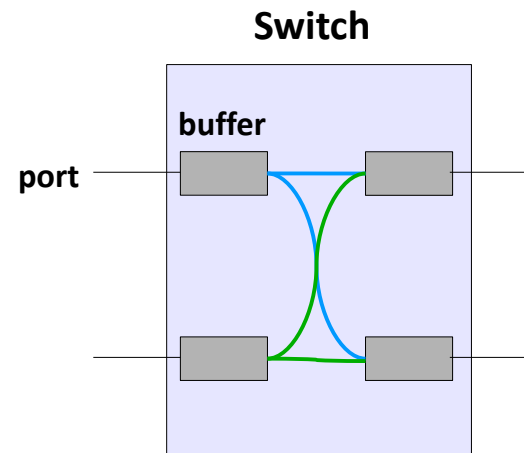


Ethernet

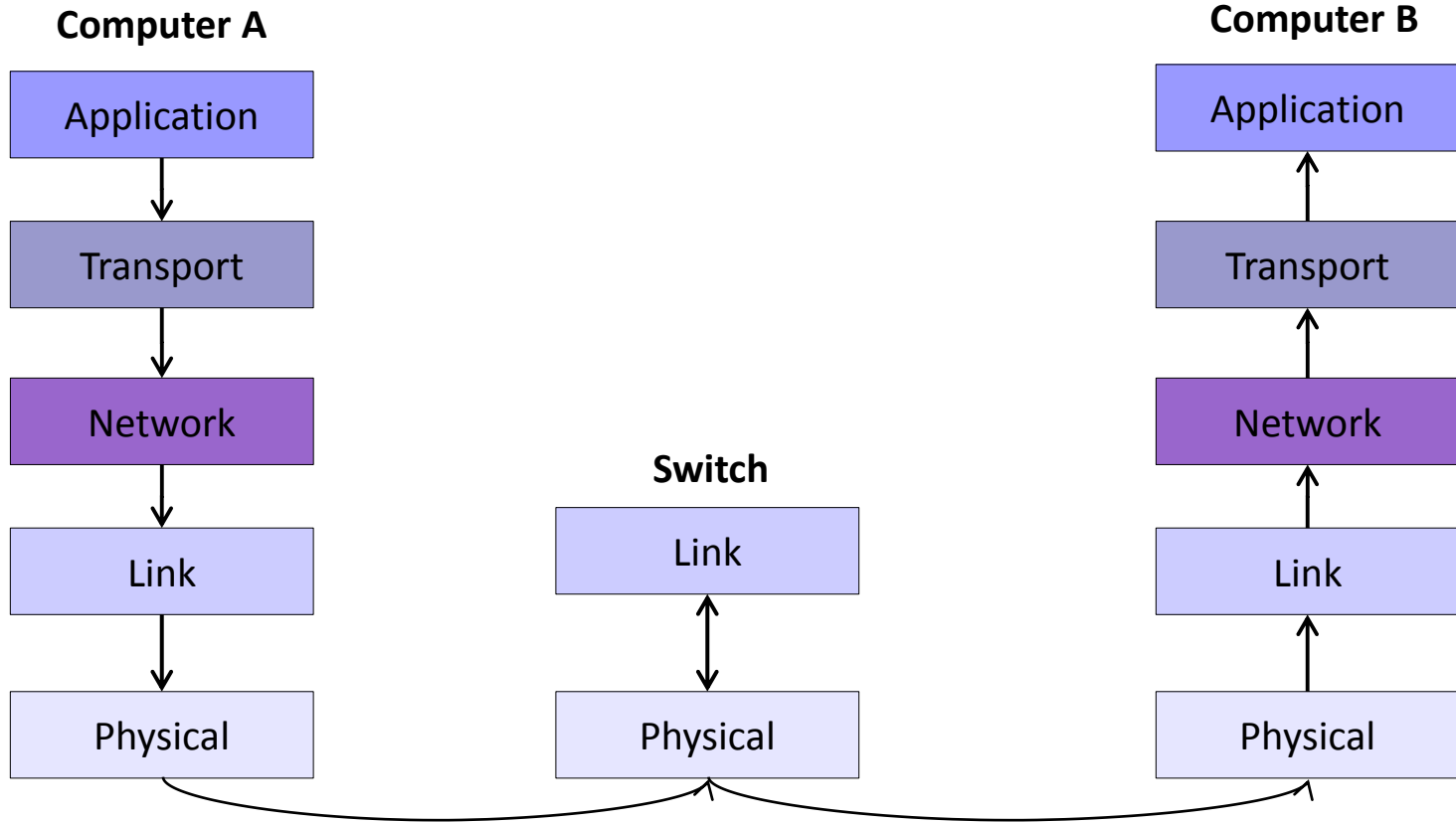
- Multiple Access Control:
 - Bus, Star with hub
 - CSMA/CD
 - **Carrier sensing**
 - The sender waits until the channel is unoccupied.
 - **Collision detection**
 - If two nodes sent frames simultaneously, they detect the collision and stop transmitting.
 - They will try again after a specific time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

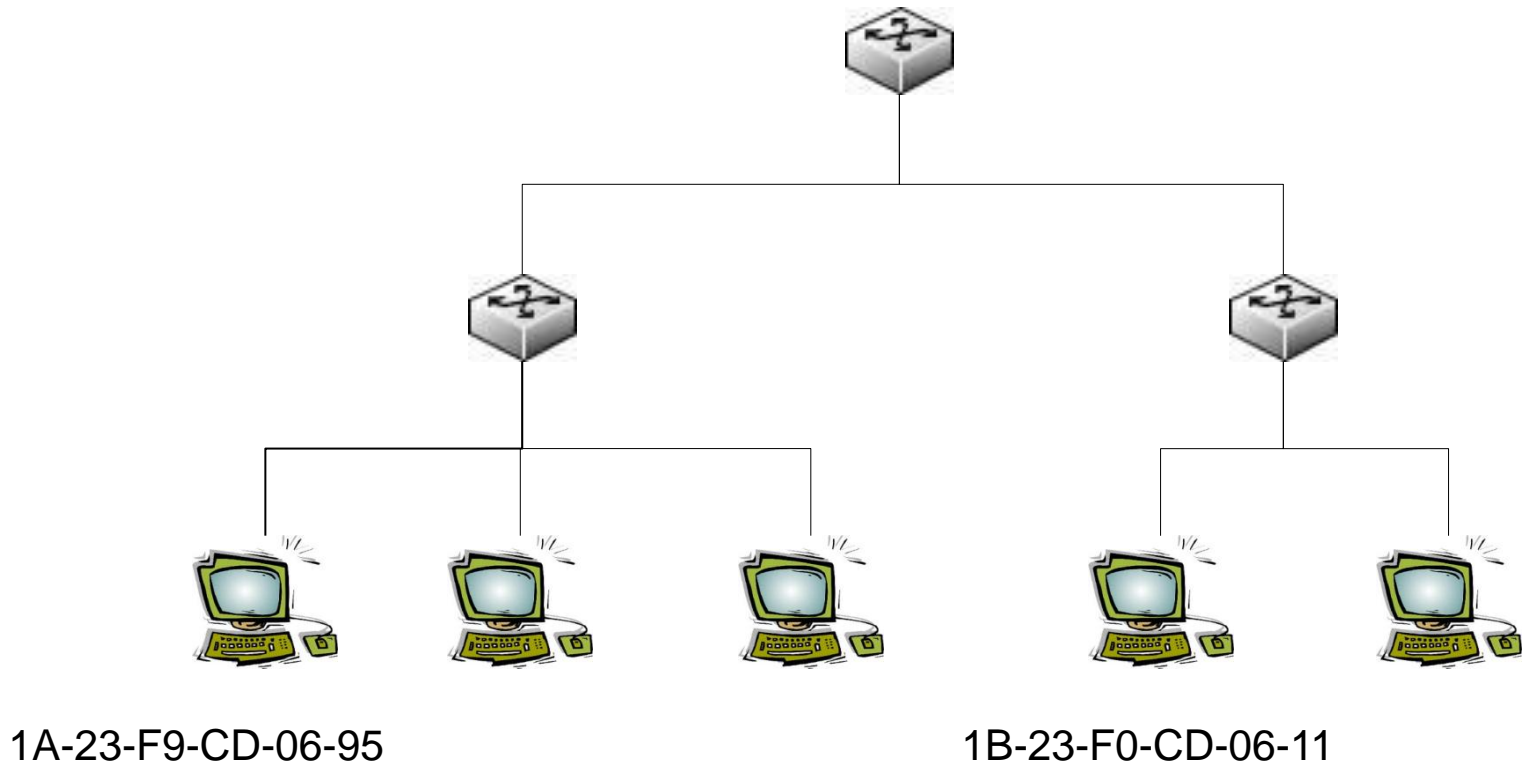


Ethernet



Ethernet

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



Today

- Communication between devices in the same LAN.

Coming up...

- Next lecture: Networking Layer
- Exam3
 - Tomorrow, last 20 mins
 - Last exam!
- Solutions for hw4: today at 6.00pm
- Solutions for exam2: tomorrow