CS 4410
Operating Systems

Networking: Introduction

Summer 2016

Cornell University

Today

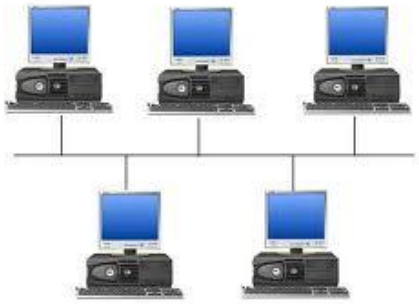
- The role of OS in computer networking.
- To appreciate this role we give a summary of the networking principles.

Communication

- It is in our nature to communicate:
  - Our voice needs a means to be transmitted.
  - We, usually, use a protocol to make the communication effective.
    - We group the information into chunks.
    - We should speak the same language.
    - We don not speak if somebody else is speaking.

Communication

- People save data, information in computers.
- It was a logical consequence the realization of the communication between the computers.
- Example: Scientists who exchange data.
- Today: Internet, Email, VoIP, Web, Social network, ...
- But how do the computers exchange data?



Computer Network

- First, computers should be interconnected with each other, forming a network.
- Depending on the interconnection means, we have:
  - Wired networks
  - Wireless networks
- Depending on the size of the network, we have:
  - Local Area networks (LANs)
  - Wide Area networks (WANs)

Network Protocols

- Then, we should define how data will be sent between connected computers.
- Computers should “agree” on the way the digital information is transmitted through the network.
- Interconnected computers should use the same network protocols.

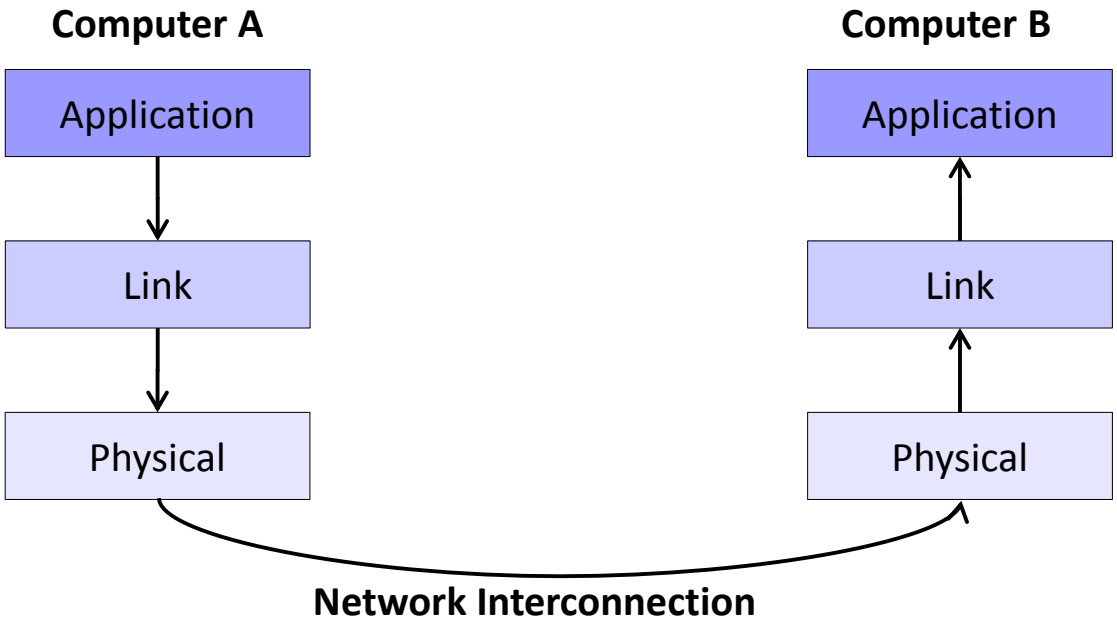
Protocol Stack: Case 1

- Suppose:
  - We have a reliable, small, wired computer network (LAN).
  - The interconnected computers run only one network application.
  - The network application is a simple email program, with which a user writes a text and sends it to another interconnected computer.
- Questions:
  - How is the data going to be transmitted?
    - Probably into packets.
  - How can we name the computer that should receive the email?
    - Each packet reaches every interconnected computer.
    - Only the receiver should read the packet.
    - We can assign static ids to computers.
  - How do we incorporate this information into the actual data (text)?
    - We add a header in-front of each packet (destination, packet id, size).

Protocol Stack: Case 1

- So:
  - We have the level of the application, in which the text is created.
  - We need a 2nd level, which takes the text and the destination, splits the text into packets and adds a header to each packet.
  - Finally, we need a 3rd layer that will take each packet (in bytes) and will convert it into an electromagnetic signal.
  - The electromagnetic signal is transmitted to the common interconnection means.
  - The receiver-computer (3rd layer) gets the signal and converts it into packet (sequence of bytes).
  - The 3rd layer passes the packet to the 2nd layer.
  - The 2nd layer reads the header and verifies that this computer is the receiver.
  - Then, it removes the header and saves the rest of the packet in a buffer.
  - When the data is received, the 2nd layer passes the buffer to the application layer.
  - The application layer reads the data and prints it as a text to the user.

Protocol Stack: Case 1



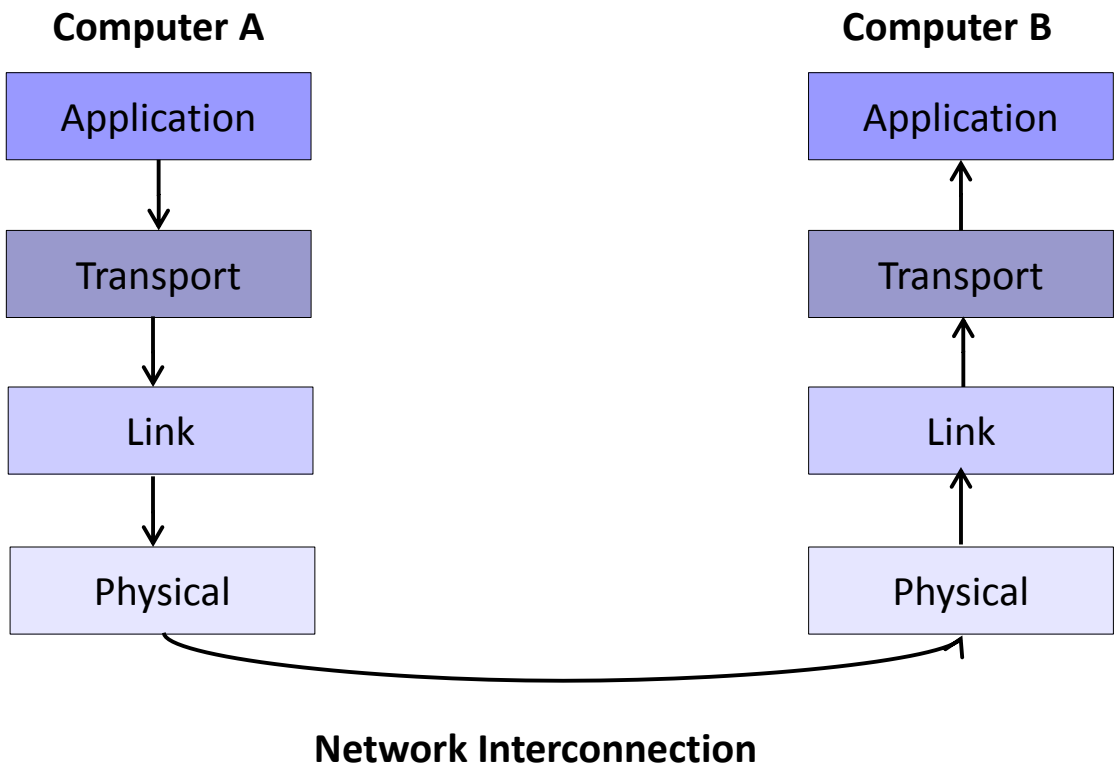
Protocol Stack: Case 2

- Suppose:
  - We have a ~~reliable~~, small, wired computer network (LAN).
  - ~~The interconnected computers run only one network application.~~
  - The network application is a simple email program, with which a user writes a text and sends it to another interconnected computer.
- Questions:
  - How will we distinguish the different network applications?
    - We should assign an identity number (port) to each application.
  - How are we going to deal with packet loss and reordering?
    - We can take an action and correct the mistake or we can afford it.

Protocol Stack: Case 2

- So:
  - Between the Application and the Link Layer, we add the Transport Layer.
  - The Transport Layer splits the text into packets, if need be, and at every packet adds a header.
  - The header has at least the port of the corresponding application (email) at the receiver.
  - If we want to retransmit lost packets or keep the correct order of received packets at the receiver, the Transport Layer of the sender writes the needed information in the header.
  - Then, the Transport Layer forward the packets to the Link Layer.
  - The remaining steps are the same as these of the Case 1.
  - The Transport Layer of the receiver keeps internal states to correct possible packet lost or reordering. It, also, reassembles the text and forwards it to the application.

Protocol Stack: Case 2



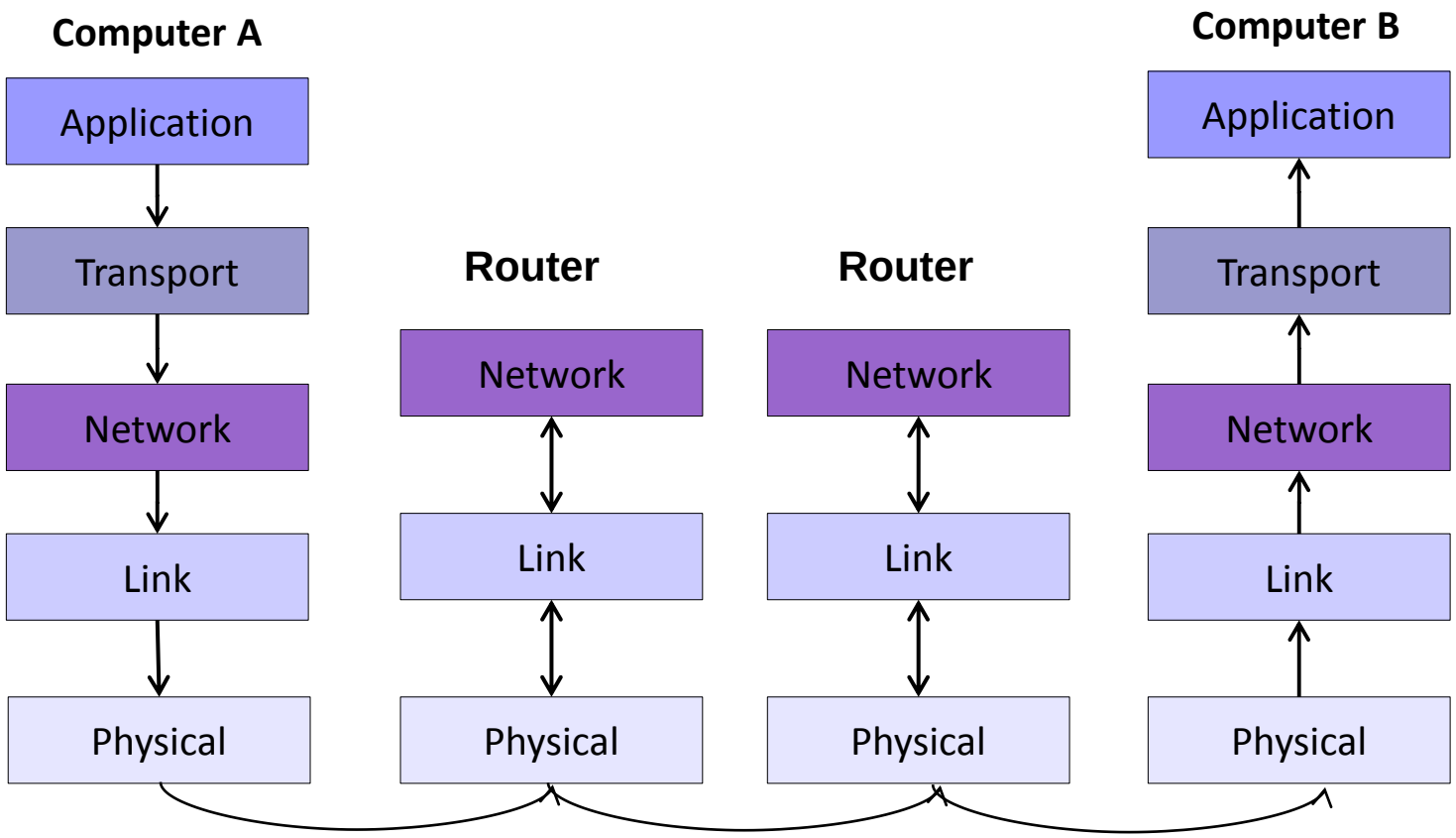
Protocol Stack: Case 3

- Suppose:
  - We have a ~~reliable, small~~, wide wired computer network (WAN).
  - ~~The interconnected computers run only one network application~~.
  - The network application is a simple email program, with which a user writes a text and sends it to another interconnected computer.
- Questions:
  - How will the computers be connected with each other?
    - One common interconnection means is not enough.
    - We should define subnetworks of computers.
    - The subnetworks will be connected with each other using specific devices (routers).
  - How can we identify the computer that should receive the email?
    - We should give to the computer a second name (address).
    - The name should help the process to find the destination.
    - It should be an indication about the subnetwork that contains the destination.
  - How can the message find the destination?
    - Every packet should ask the routers which direction it should take to reach the destination. (Routing)

Protocol Stack: Case 3

- So:
  - We add between the Transport and the Link Layer, the Network Layer.
  - The Network Layer takes the packet from the Transport Layer and adds a new header.
  - The header contains at least the address of the destination.
  - The Network Layer forwards the new packet to the Link Layer.
  - When the packet reaches the interconnection means of the subnetwork, a specific device will see that the packet's destination is in a different subnetwork and it will send it to the next router.
  - After packet being routed through the network, it reaches the subnetwork of the destination.
  - Using the id that exists in the header of the Link Layer, the packet reaches the destination.

Protocol Stack: Case 3



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Coming up…

- Next lecture: Physical and link layer
- HW4 is due today