Computer Networks
CS3611

Introduction-Part 1

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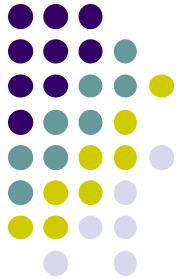
The slides are adapted from those provided by Prof. Shizhen Zhao.

Chapter 1: Introduction



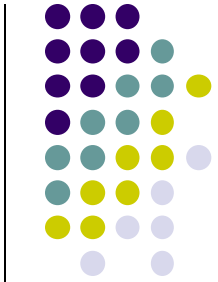
Our goal:

- get "feel" and terminology
- paint a broad picture
- see the forest through the trees
- approach:
  - use Internet as example

Topics:

- What's Computer Network?
- Protocol layers, service models
- What's the Internet?
- Network edge
- Access net and physical media
- Network core
- Internet structure and ISPs
- Delay, loss, and throughput in packet-switched networks
- History of Internet

Chapter 1: roadmap



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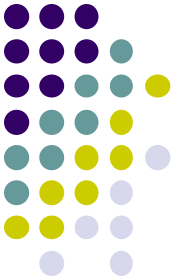
What is Computer Network



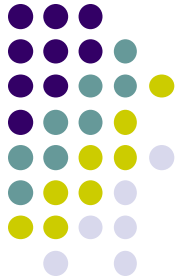
- Collection of autonomous computers interconnected by a single technology

  -- From Computer Network by Tanenbaum

- A collection of computers and devices interconnected by communications channels that facilitate communications among users and allows users to share resources.

  -- From wikipedia

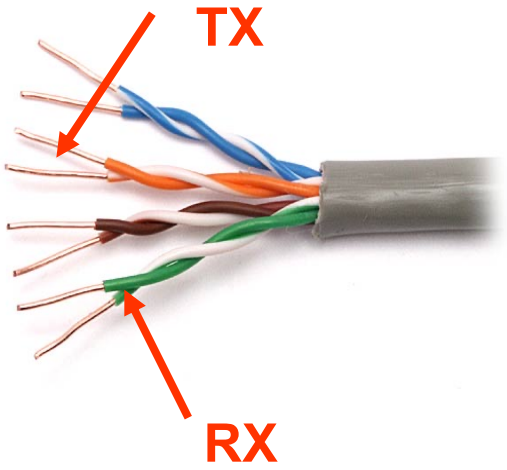
Classification of network by physical media

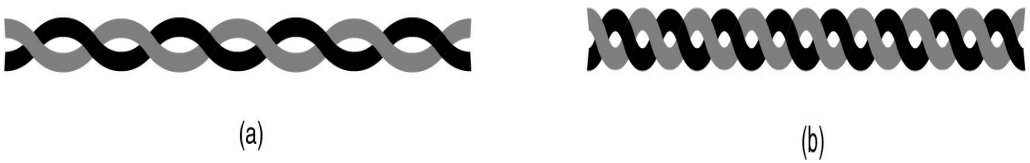


- bit propagates between transmitter/receiver pairs in the form of electromagnetic waves or optical pulse across physical media.
- physical media: what lies between transmitter & receiver
  - guided media: signals propagate in solid media: twisted pair, fiber optics, coaxial cable
  - unguided media: signals propagate freely, e.g., atmosphere, outer space

Guided Media: Twisted Pair

- Two insulated copper wires, twisted like a DNA string (reduces electrical interference). Often twisted pairs go by the bundle.
- Due to their adequate performance and low cost, twisted pairs are widely used.
- UTP (Unshielded Twisted Pair)
  - CAT3 8 cores, 16MHz bandwidth, 10Mbps
  - CAT5 8 cores, 100MHz bandwidth, 100Mbps

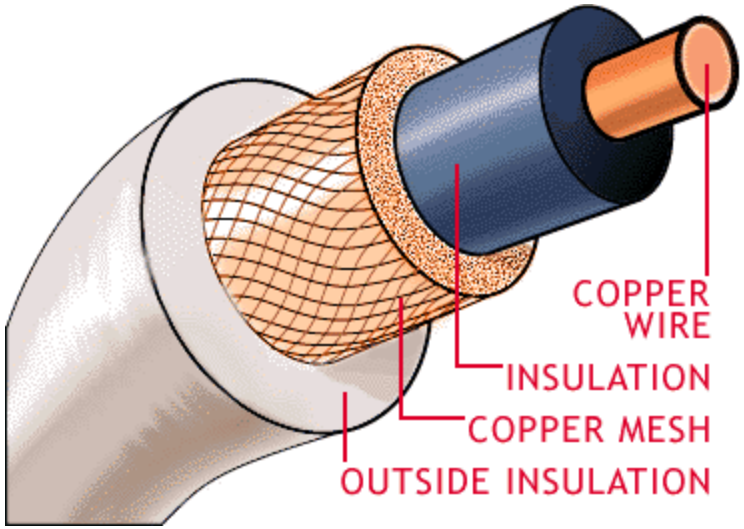




(a) Category 3 UTP (b) Category 5 UTP.

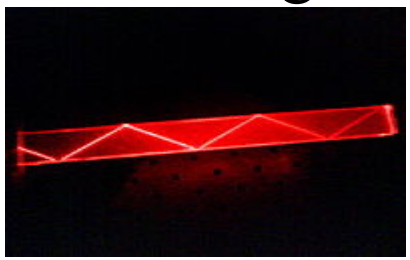
Guided Media: coaxial cable

- The construction and shielding of the coaxial cable give it a good combination of high bandwidth and excellent noise immunity. 1GHz
- Coax is better than twisted pair when you need more bandwidth, but is now rapidly being replaced with fiber.
- baseband:
  - single channel on cable
  - legacy Ethernet
- broadband:
  - multiple channels on cable
  - HFC

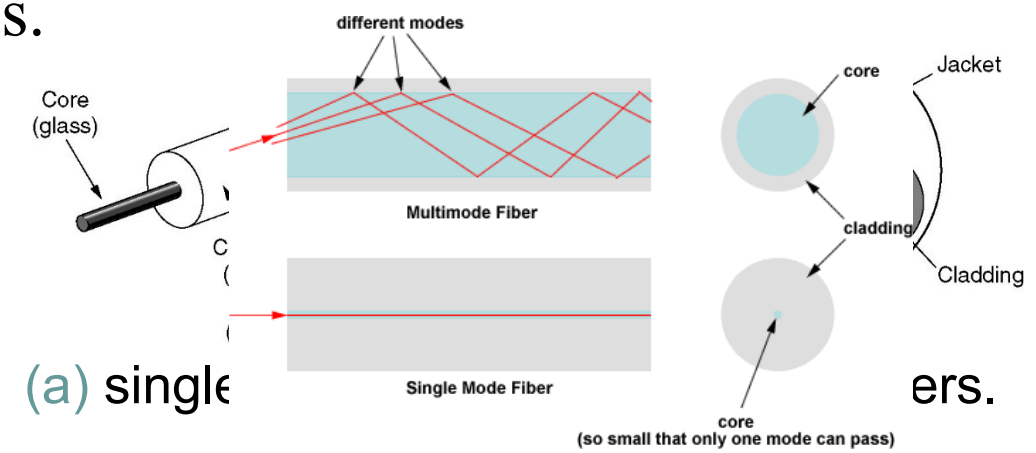


Guided Media: Fiber Optics

- glass fiber carrying light pulses, each pulse is a bit, which is surrounded by a glass cladding with a lower index of refraction than the core, to keep all the light in the core.
- ultra wide bandwidth: 10's THz, 10's-100's Gps
- low error rate: immune to electromagnetic noise
- ultra low attenuation : repeaters spaced far apart, can be used for long distances.

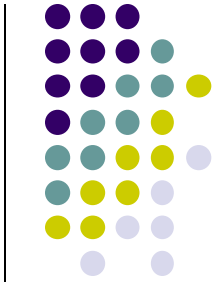


Total internal reflection



(a) single ers.

Unguided media: radio

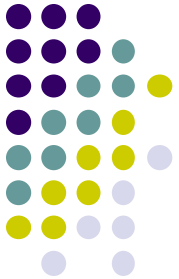


- signal carried in electromagnetic spectrum
- no physical "wire"
- propagation environment effects:
  - reflection
  - obstruction by objects
  - interference

Radio link types:

- terrestrial microwave
  - e.g. up to 45 Mbps channels
- LAN (e.g., Wifi)
  - 11Mbps, 54 Mbps
- wide-area (e.g., cellular)
  - 4G cellular: ~ 100 Mbps
- satellite
  - Kbps to 45Mbps channel (or multiple smaller channels)
  - 270 msec end-end delay
  - geosynchronous versus low altitude

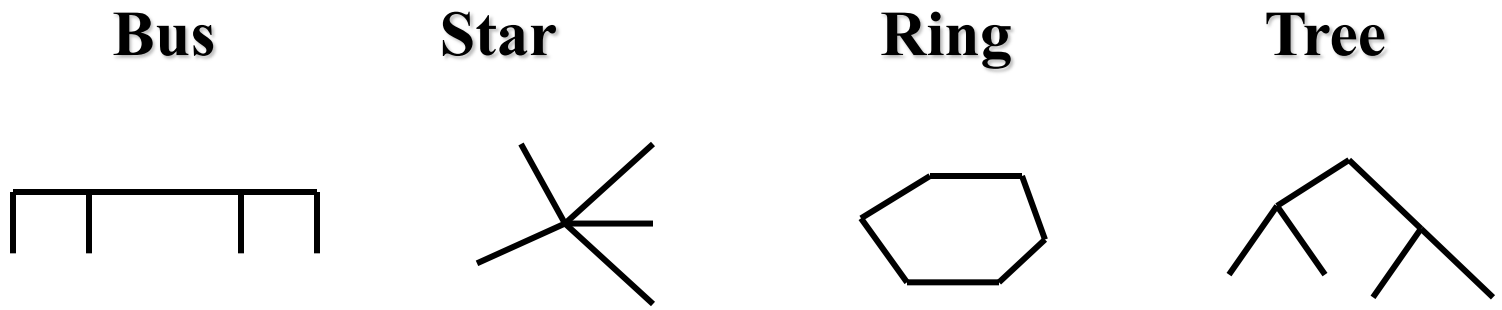
Classification of network by physical media



- Wired network:
  - Twisted-pair copper wire
  - Coaxial cable
  - Optical fiber
- Wireless network:
  - Wi-Fi
  - Cellular System
  - Satellite

Classification of network by Topology

- **Network topology** is the coordination by which devices in the network are arranged in their logical relations to one another, independent of physical arrangement.

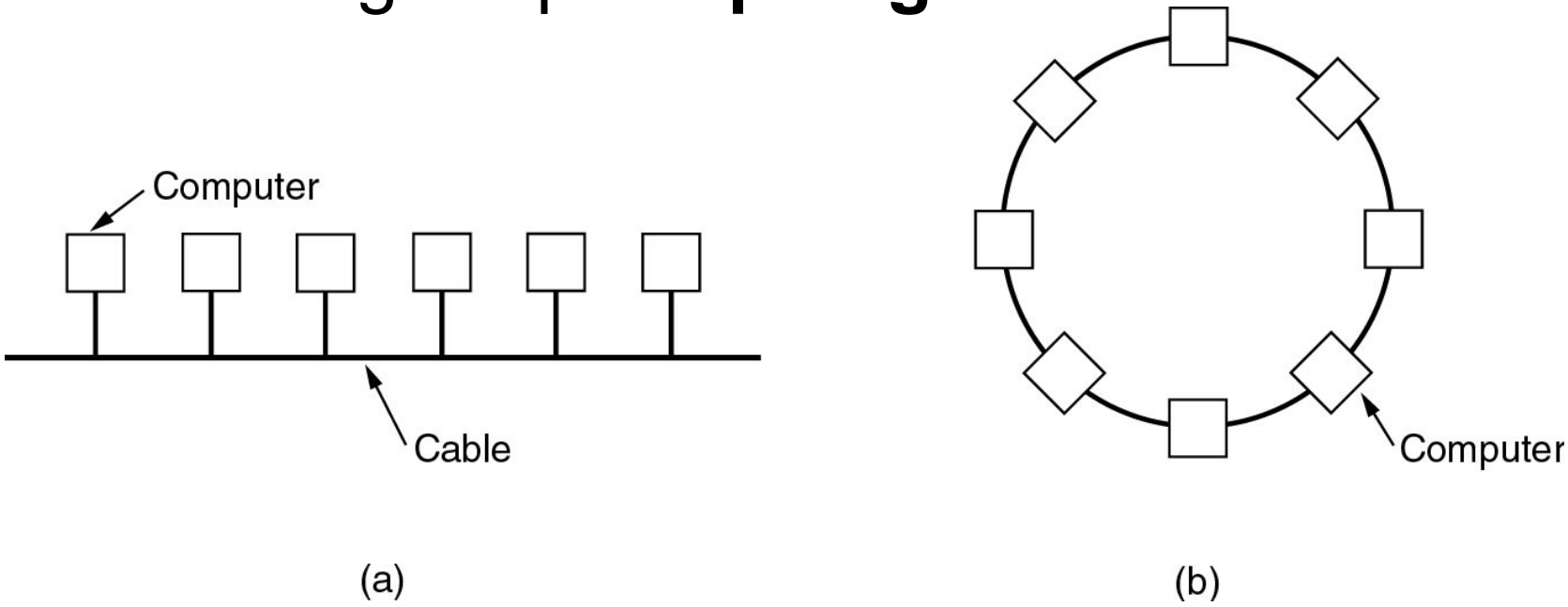


Classification of network by scale

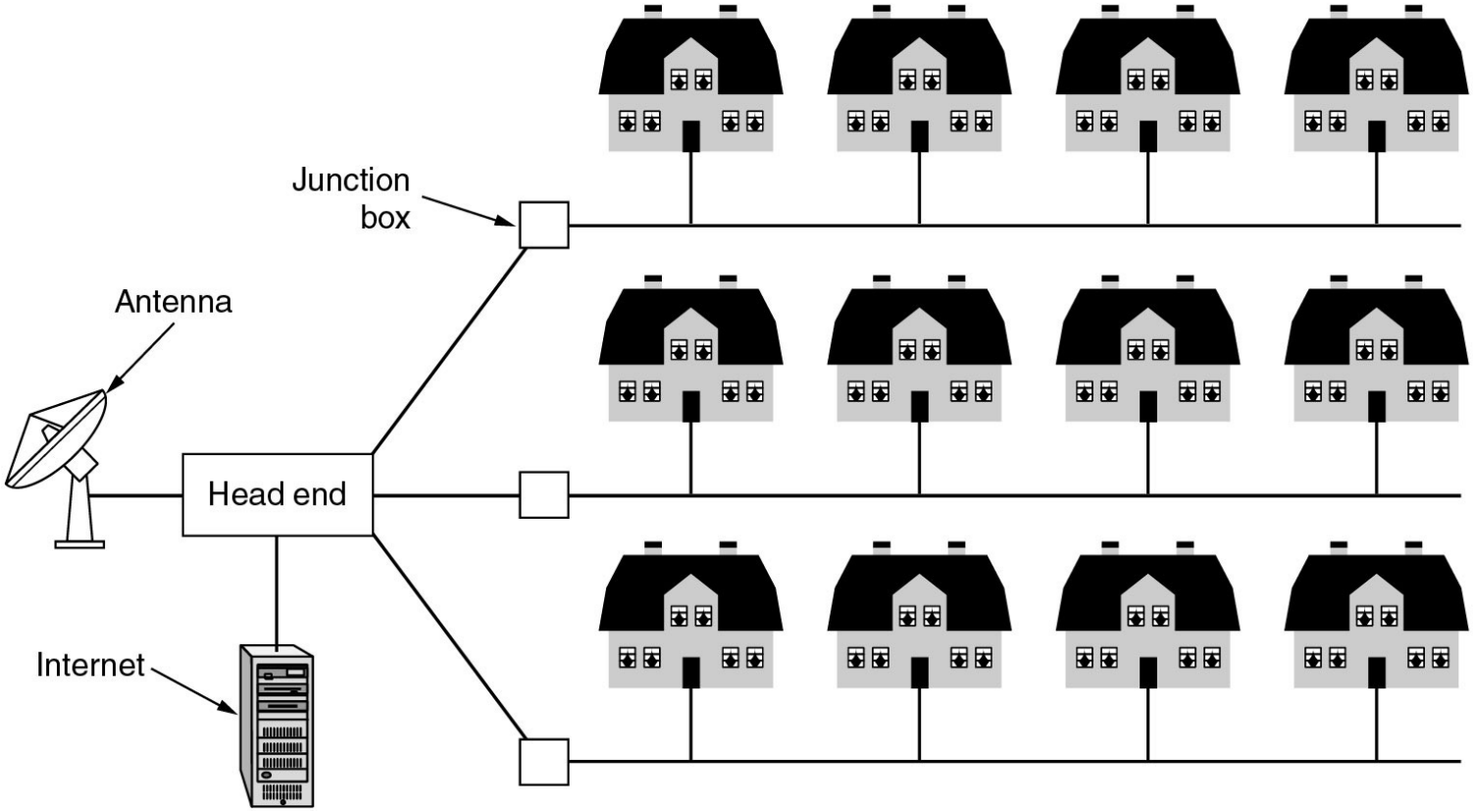
Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network (PAN)
10 m	Room	Local area network (LAN)
100 m	Building	
1 km	Campus	
10 km	City	Metropolitan area network (MAN)
100 km	Country	Wide area network (WAN)
1000 km	Continent	
10,000 km	Planet	The Internet

Local Area Networks

- Apart from scale, LANs distinguish themselves from other networks by (generally) using **broadcast** technology,
- and having simple **topologies**:



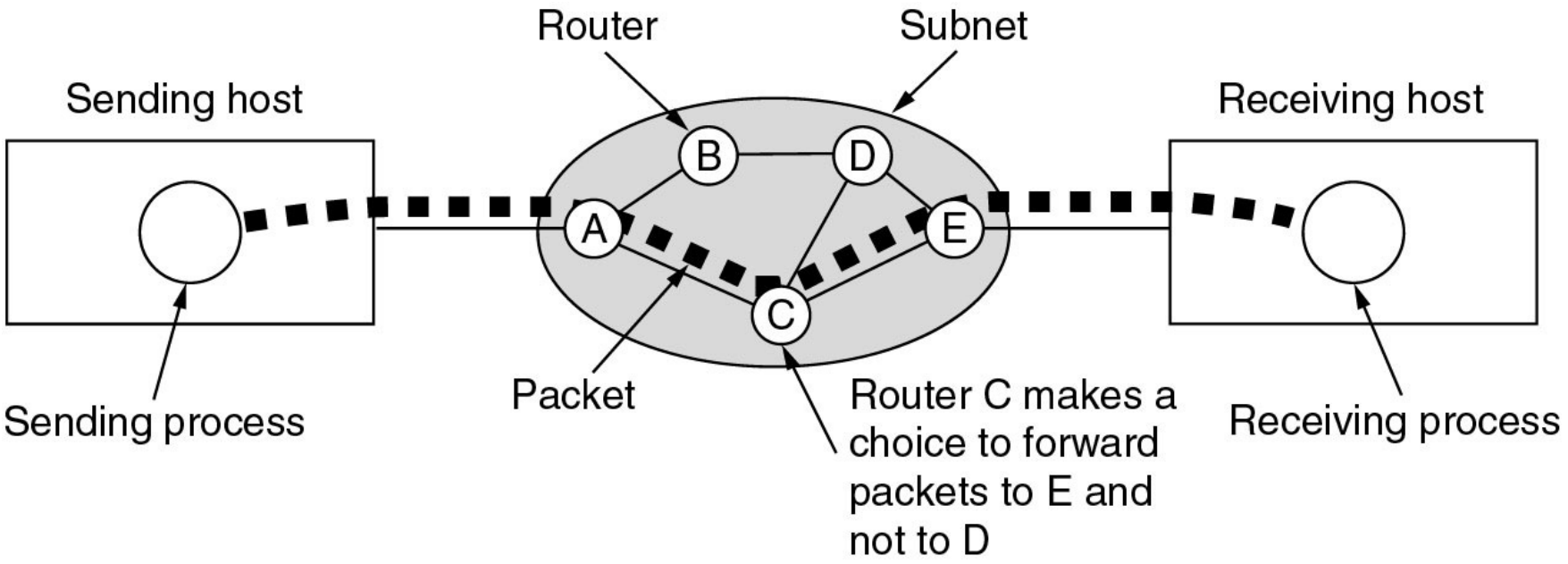
Metropolitan Area Networks



A metropolitan area network based on cable TV.

Wide Area Networks

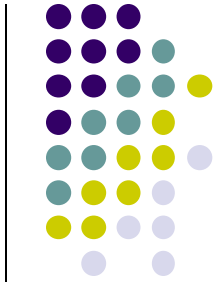
- A stream of packets from sender to receiver.



Communication Subnet

Network Core / backbone

Chapter 1: roadmap



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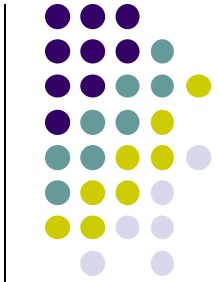
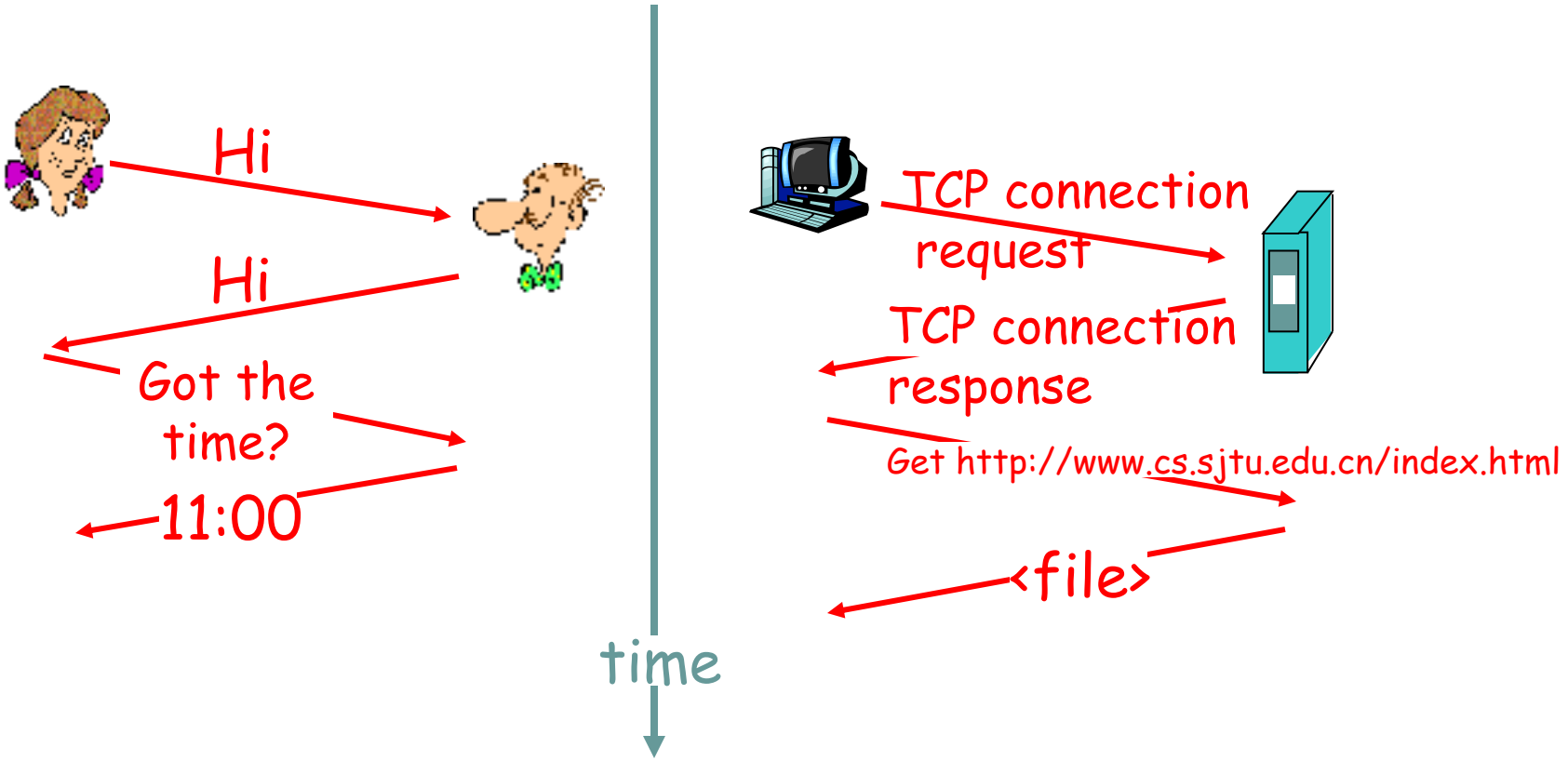
The Need for Protocols



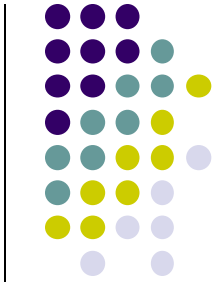
- Basic communication hardware consists of mechanisms that can transfer bits from one point to another. (cumbersome and inconvenient)
- Application programs that use a network don't interact directly with network hardware. Instead, they interact with protocol software that follows the rules of a given protocol.
- A protocol defines the format and the order of messages exchanged between two or more communicating entities, as well as the actions taken on the transmission and/or receipt of a message or other event.

What's a protocol?

a human protocol and a computer network protocol:



Protocols are complex



Networks are complex!

- many “pieces”:
  - hosts
  - routers
  - links of various media
  - applications
  - protocols
  - hardware, software

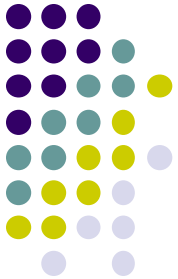
Communication are complex!

- many “tasks”:
  - data encoding,
  - transportation,
  - addressing,
  - error control,
  - flow control,
  - congestion control,
  - Media Access Control

Why Protocol Layering

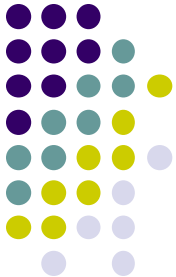
- most network software are organized as a stack of layers or levels, each one built upon the one below it.
  - To reduce design complexity, divide the communication problem into subpieces and to design a separate protocol for each subpiece, making each protocol easier to design, analyze and implement.
  - Independence. Each layer could be designed, maintained and updated independently, as long as keep in mind the services the lower layer provides for it and the services it should provide for the upper layer.
  - Flexibility. Allow subsets of protocols be used as needed and allow any one of the protocols be replaced or updated.

Concepts of Layering

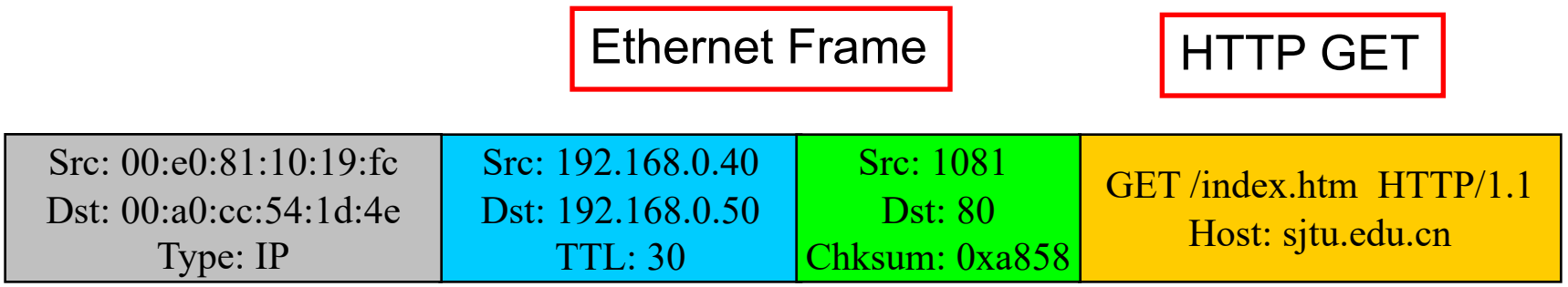


- **Protocol:** two parties at different sites, but at the same level (peers), always agree on how they will exchange information.
- In order for one party to send and receive information, it can only make use of the **communication services** offered by the layer directly underneath it.
- Services offered by a layer are always fully specified in terms of an **interface** that makes those services accessible.

How Layered Software Works

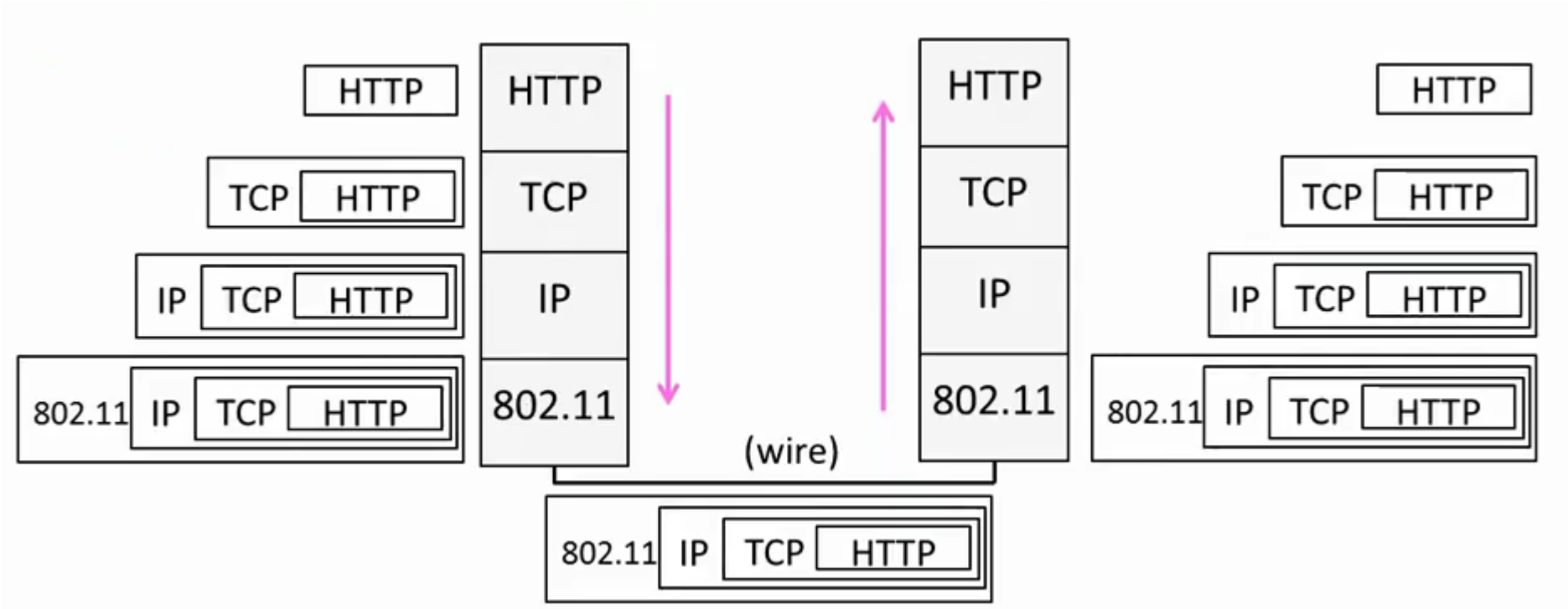


- Encapsulation: multiple, nested Headers
  - Protocol software in a given layer on the sending computer adds information (header) to the outgoing data, and software in the same layer on the receiving computer uses the header to process incoming data.
  - Outgoing data passes down through each layer, with headers added, and incoming data passes up through each layer, with headers verified and removed.

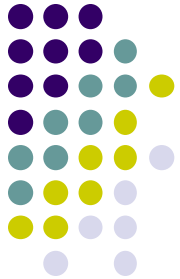


How Layered Software Works

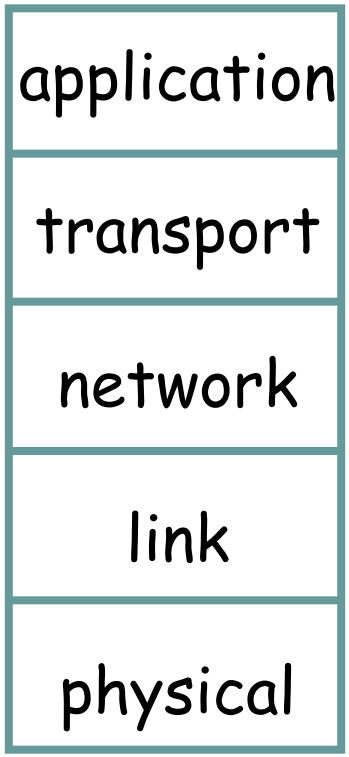
Encapsulation



Hybrid Model Used in this Course



- application: programs using network services (http, ftp, smtp)
- transport: end-end data transfer (tcp, udp)
- network: send packets over multiple networks (ip, routing algorithms)
- link: data transfer between neighboring network nodes (Ethernet, WiFi, ppp, MAC)
- physical: send bits as signals “on the wire” (media, modulation,encoding)



Unit Name

Message

Segment

Datagram /Packet

Frame

bit

Protocol Walkthrough