

# **Introduction to Computer Networks**

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Slides adapted from *Computer Networking: A Top Down Approach*

# Chapter 1: introduction

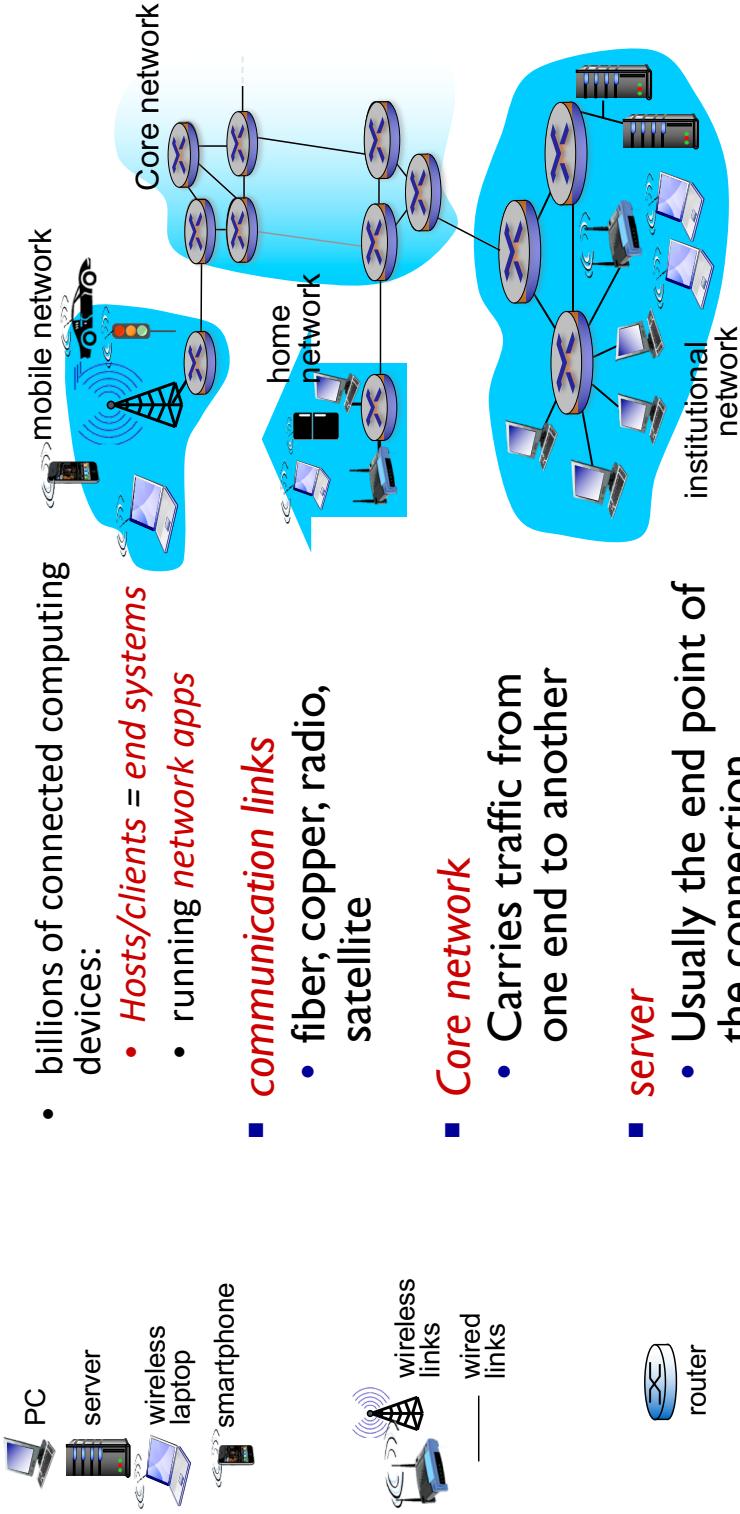
## **Terminology:**

- What is the Internet?
- Internet history.
- What is a protocol?
- Network terms: network edge; network core; hosts; media/medium; network-interface card; server/web server; client/web client.

## **Core concepts:**

- Layering
- Abstraction
- 7-layer OSI stack

## What's the Internet: "nuts and bolts" view



# “Fun” Internet-connected devices



IP picture frame  
<http://www.ceiva.com/>



Web-enabled toaster +  
weather forecaster



Internet  
refrigerator



Slingbox: watch,  
control cable TV remotely



sensorized,  
bed  
mattress



Internet phones

Tweet-a-watt:  
monitor energy use



# What's the Internet: “nuts and bolts” view

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- *Internet: “network of networks”*

- Interconnected Internet server providers (or core network) connecting edge nodes (servers and clients)
- Access network is used to connect the subscriber (client/server) to the server provider (the core)

- *protocols* tells you what a message means

- e.g., TCP, IP, HTTP, Skype, 802.11

- *Internet standards*

- RFC: Request for comments
- IETF: Internet Engineering Task Force

# What's a protocol?

## *human protocols:*

- “what’s the time?”
  - “I have a question”
  - introductions
- ... specific messages sent
- ... specific actions taken when messages received, or other events

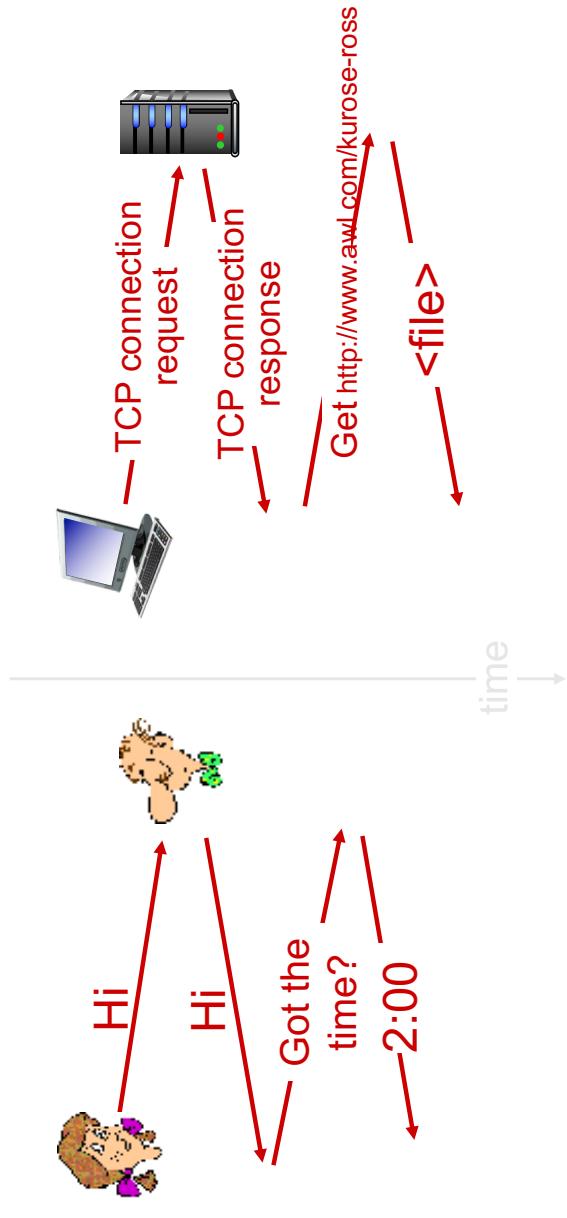
## *network protocols:*

- machines rather than humans
- all communication activity in Internet governed by protocols

**protocols define format, order of messages sent and received among network entities, and actions taken on message transmission, receipt**

# What's a protocol?

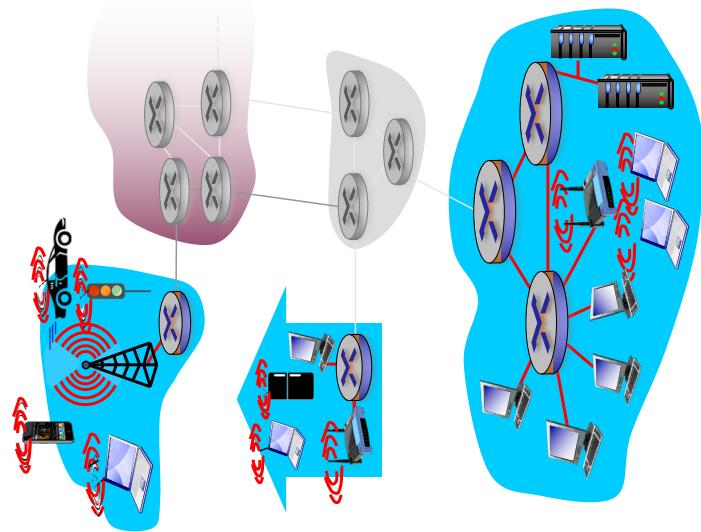
a human protocol and a computer network protocol:



## Access networks and physical media

*Q: How to connect end systems to edge router?*

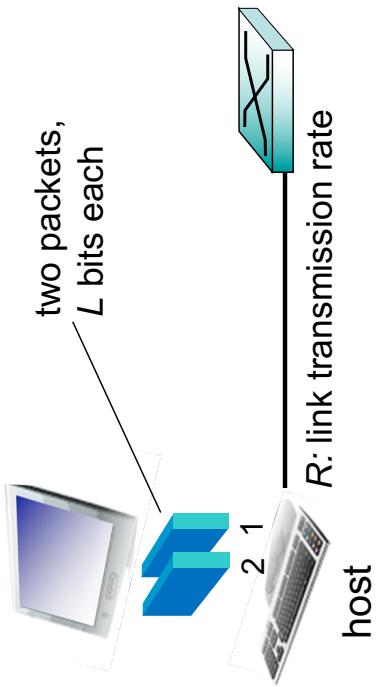
- residential access nets
- institutional access networks (school, company)
- mobile access networks



# Host: sends packets of data

host sending function:

- takes application message
- breaks into smaller chunks,  
known as **packets**, of length  **$L$**   
bits
- transmits packet into access  
network at **transmission rate**  
 **$R$**
- Packets can get lost or  
delayed



# Protocol “layers”

*Networks are complex,  
with many “pieces”:*

- hosts
  - routers
  - links of various media
  - applications
  - protocols
  - hardware,  
software
- is there any hope of organizing structure of network?  
.... or at least our discussion of networks?

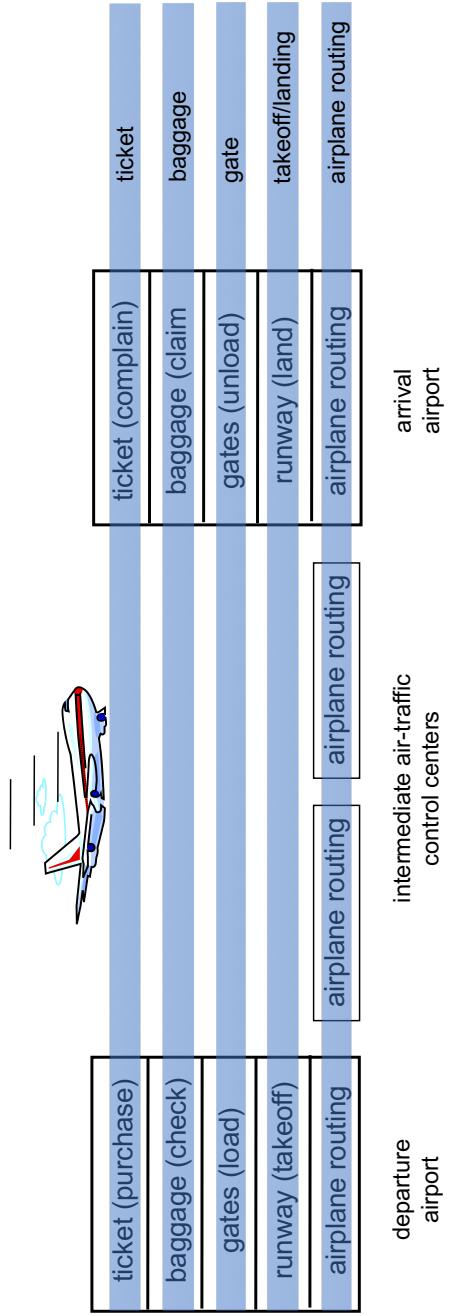
*Question:*

## Organization of air travel



- a series of steps

# Layering of airline functionality



***layers:*** each layer implements a service

- via its own internal-layer actions
- relying on services provided by layer below

# Why ~~layering~~?

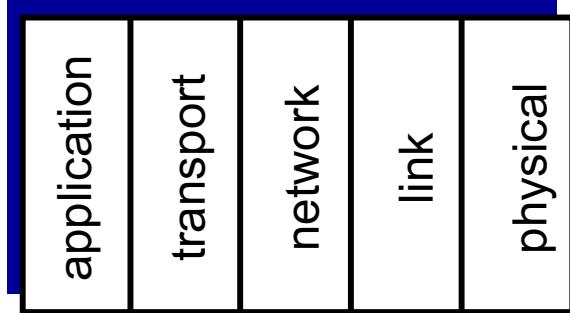
dealing with complex systems:

- explicit structure allows identification, relationship of complex system's pieces
  - layered *reference mode* for discussion
- modularization eases maintenance, updating of system
  - change of implementation of layer's service transparent to rest of system
  - e.g., change in gate procedure doesn't affect rest of system

## Internet protocol stack

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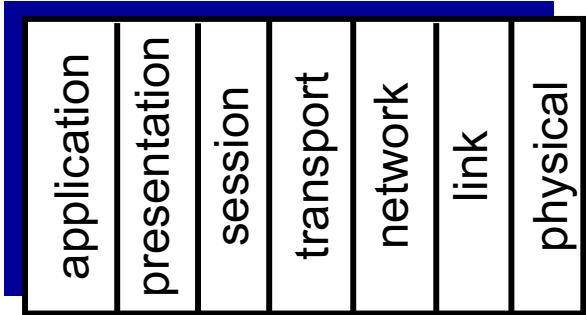
- **application:** supporting network applications
  - FTP, SMTP, HTTP
- **transport:** process-process data transfer
  - TCP, UDP
- **network:** routing of datagrams from source to destination
  - IP, routing protocols
- **link:** data transfer between neighboring network elements
  - Ethernet, 802.111 (WiFi), PPP
- **physical:** bits “on the wire”

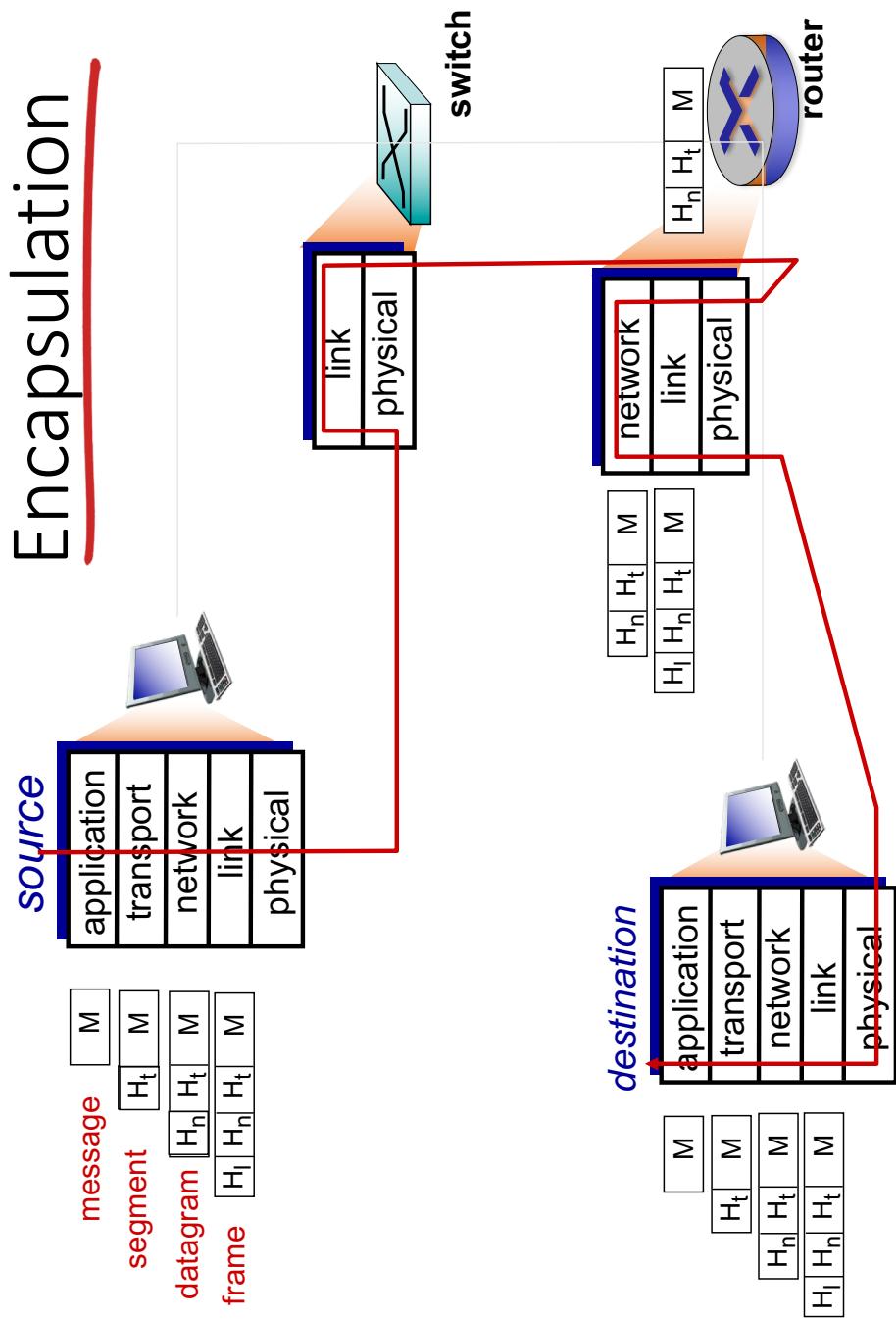


# ISO/OSI reference model

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- ***presentation:*** allow applications to interpret meaning of data, e.g., encryption, compression, machine-specific conventions
- ***session:*** synchronization, checkpointing, recovery of data exchange
  - Internet stack “missing” these layers!
    - these services, *if needed*, must be implemented in application
    - needed?





# ~~Chapter 1: roadmap~~

**1.1 what is the Internet?**

**1.2 network edge**

• end systems, access networks, links

**1.3 network core**

• packet switching, circuit switching, network structure

**1.4 delay, loss, throughput in networks**

**1.5 protocol layers, service models**

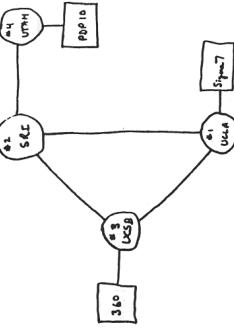
**1.6 networks under attack: security**

**1.7 history**

## Internet history

### *1961-1972: Early packet-switching principles*

- 1961: Kleinrock - queueing theory shows effectiveness of packet-switching
- 1964: Baran - packet-switching in military nets
- 1967: ARPAnet conceived by Advanced Research Projects Agency
- 1969: first ARPAnet node operational
- 1972:
  - ARPANET public demo
  - NCP (Network Control Protocol) first host-host protocol
  - first e-mail program
  - ARPANET has 15 nodes



THE ARPANET

# Internet history

## *1972-1980: Internetworking, new and proprietary nets*

- 1970: ALOHAnet satellite network in Hawaii
- 1974: Cerf and Kahn - architecture for interconnecting networks
- 1976: Ethernet at Xerox PARC
- late 70' s: proprietary architectures: DECnet, SNA, XNA
- late 70' s: switching fixed length packets (ATM precursor)
- 1979: ARPAnet has 200 nodes

### Cerf and Kahn's internetworking principles:

- minimalism, autonomy - no internal changes required to interconnect networks
  - best effort service model
  - stateless routers
  - decentralized control
- define today's Internet architecture

# Internet history

## *1980-1990: new protocols, a proliferation of networks*

- 1983: deployment of TCP/IP
  - new national networks: CSnet, BITnet, NSFnet, Minitel
- 1982: smtp e-mail protocol defined
  - 100,000 hosts connected to confederation of networks
- 1983: DNS defined for name-to-IP-address translation
- 1985: ftp protocol defined
- 1988: TCP congestion control

# Internet history

## *1990, 2000's: commercialization, the Web, new apps*

- **early 1990's:** ARPAnet decommissioned
- **1991:** NSF lifts restrictions on commercial use of NSFnet (decommissioned, 1995)
- **early 1990s:** Web
  - hypertext [Bush 1945, Nelson 1960's]
  - HTML, HTTP: Berners-Lee
  - 1994: Mosaic, later Netscape
- **late 1990's:** commercialization of the Web
- **late 1990's – 2000's:**
  - more killer apps: instant messaging, P2P file sharing
  - network security to forefront
  - est. 50 million host, 100 million+ users
  - backbone links running at Gbps

# Internet history

## **2005-present**

- ~5B devices attached to Internet (2016)
  - smartphones and tablets
- aggressive deployment of broadband access
- increasing ubiquity of high-speed wireless access
- emergence of online social networks:
  - Facebook: ~ one billion users
- service providers (Google, Microsoft) create their own networks
  - bypass Internet, providing “instantaneous” access to search, video content, email, etc.
- e-commerce, universities, enterprises running their services in “cloud” (e.g., Amazon EC2)