BLG 337E- Principles of Computer Communications

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18/09/2018

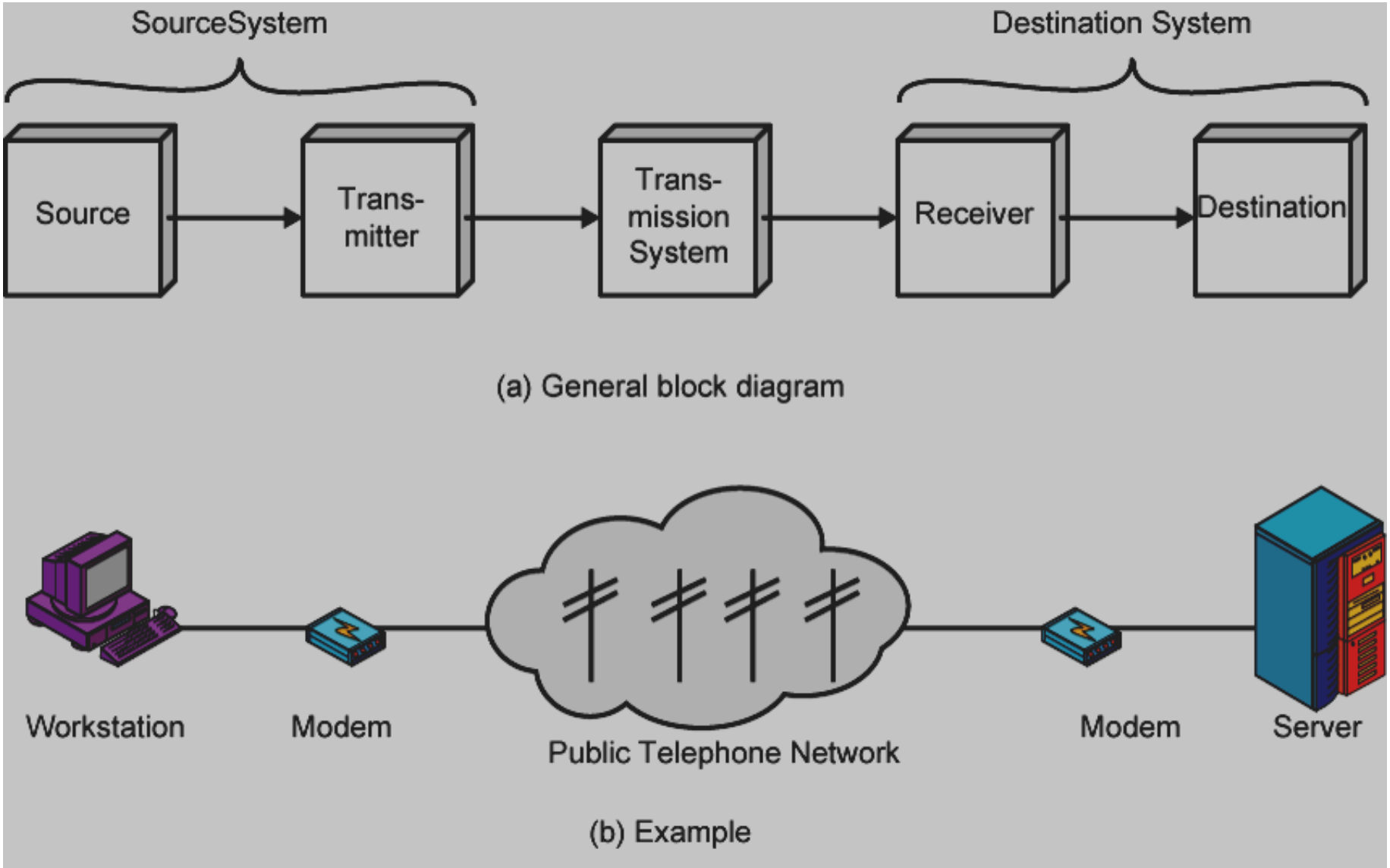
-Introduction-

References:

-*Data and Computer Communications*, William Stallings, Pearson-Prentice Hall, 9th Edition, 2010.

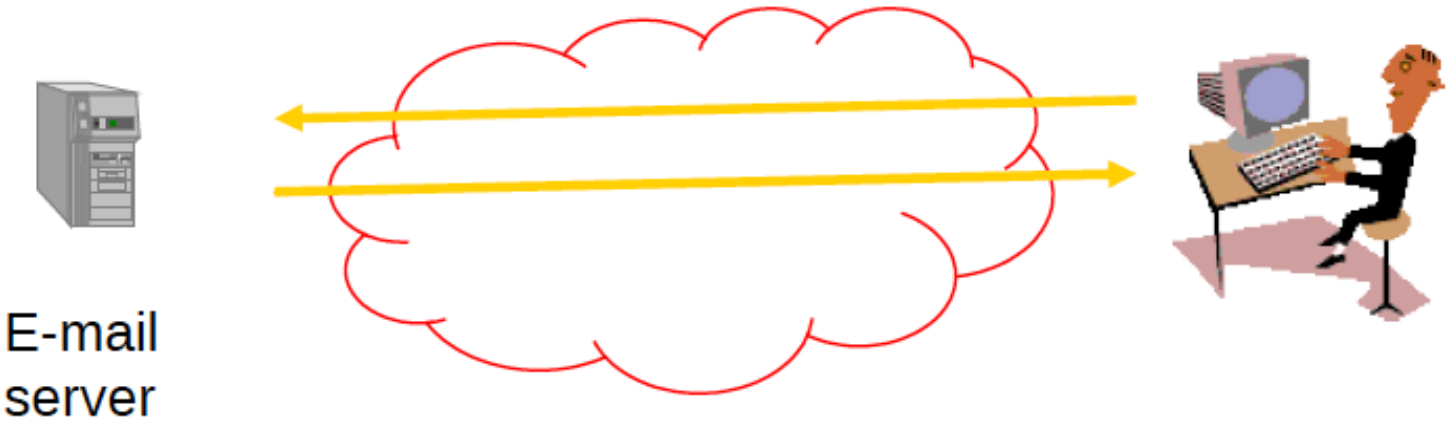
-*Computer Networking, A Top-Down Approach Featuring the Internet*, James F.Kurose, Keith W.Ross, Pearson-Addison Wesley, 6th Edition, 2012.

Communications Model



A communication service enables the exchange of information between users at different locations.

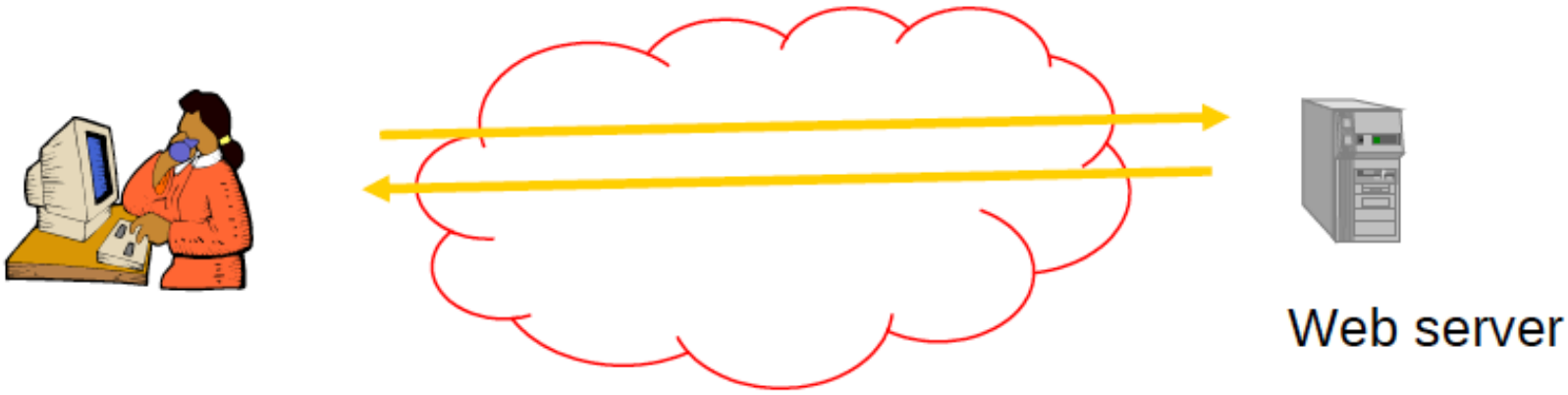
E-mail



Exchange of text messages via servers

A communication service enables the exchange of information between users at different locations.

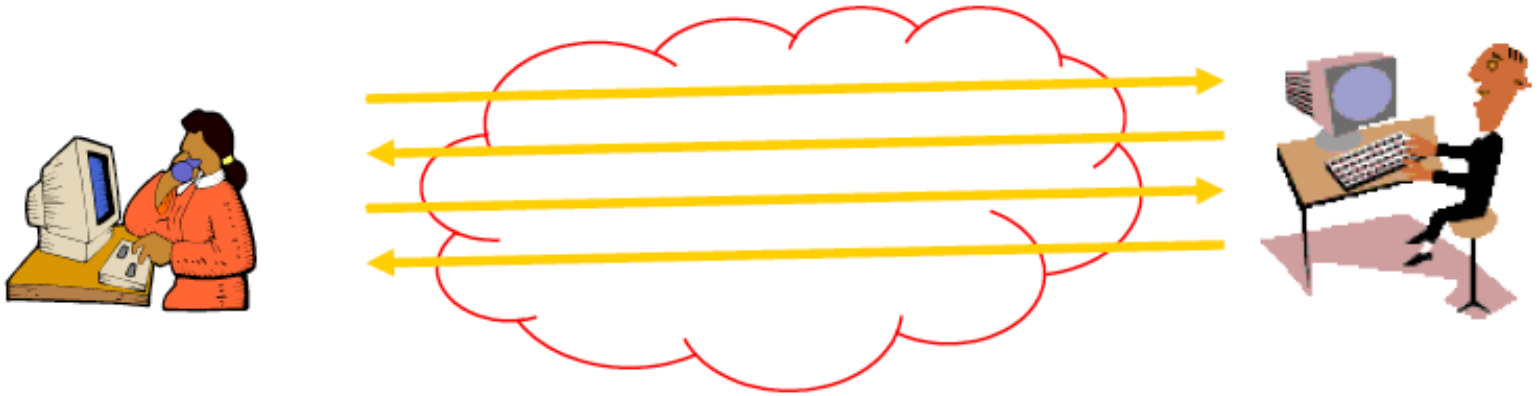
Web Browsing



Retrieval of information from web servers

A communication service enables the exchange of information between users at different locations.

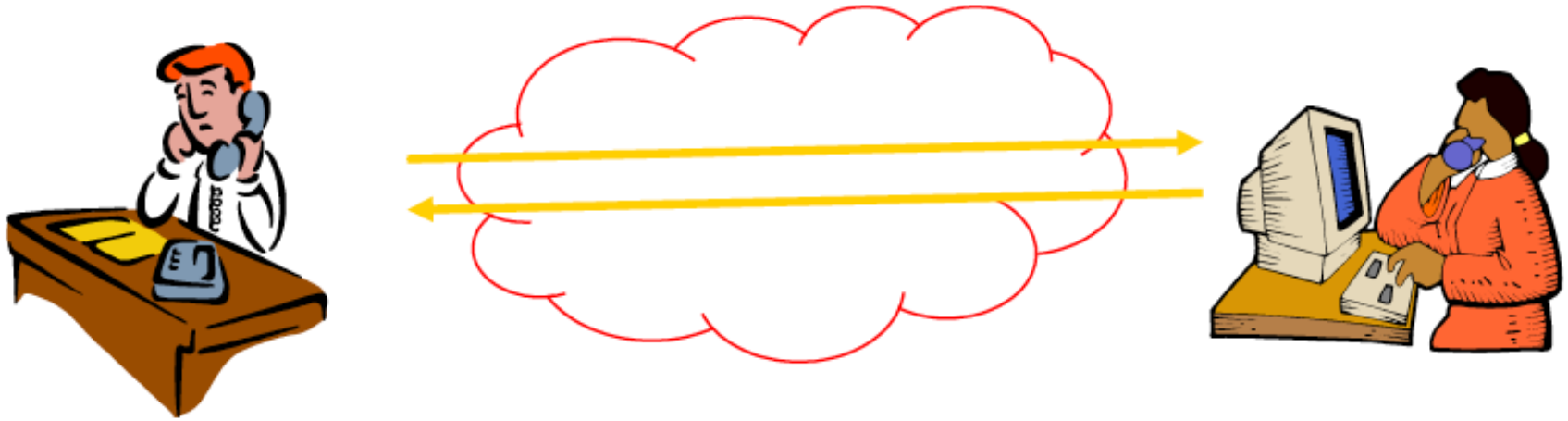
Instant Messaging



Direct exchange of text messages

A communication service enables the exchange of information between users at different locations.

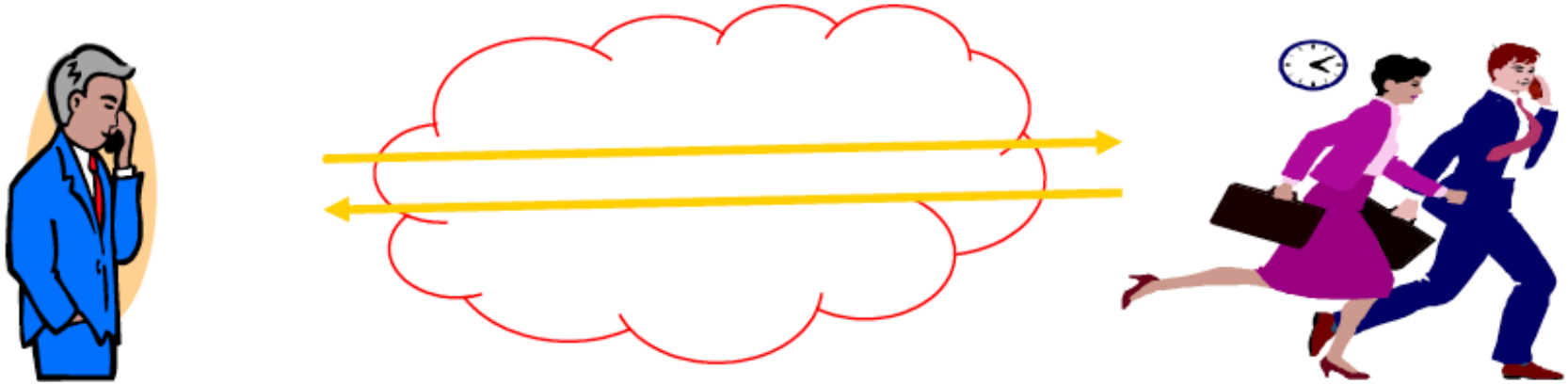
Telephone



Real-time bidirectional voice exchange

A communication service enables the exchange of information between users at different locations.

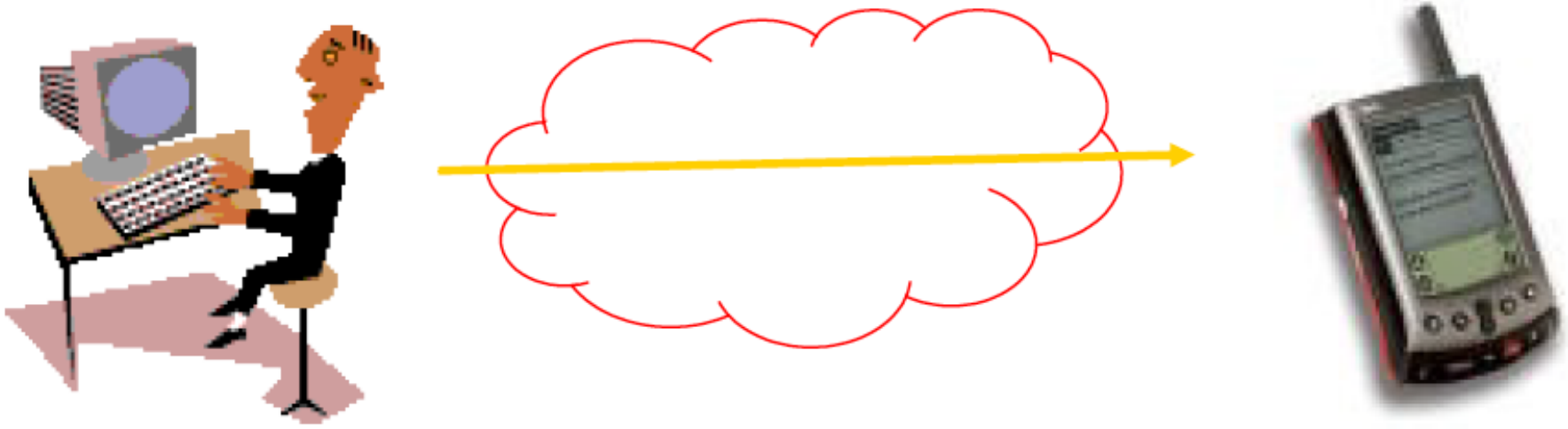
Cell phone



Real-time voice exchange with mobile users

A communication service enables the exchange of information between users at different locations.

Short Message Service



Fast delivery of short text messages

Why Networking??

- Point to point communication NOT usually practical
  - Devices are too far apart
  - Large set of devices would need impractical number of connections

  (have you heard of N^2 *problem* ???)
- Solution is a *communications network*

Communication Network

- (A set of) equipment (hardware & software) and facilities that provide the basic communication services (among computing entities)
- Virtually invisible to the user; usually represented by a cloud

- Equipment
  - Routers, servers, switches, multiplexers, hubs, modems, WLAN cards, cellular phones etc…
- Facilities
  - Copper wires, coaxial cables, optical fiber, air etc…

Communication Network Architecture

- *Network architecture:* the plan that specifies how the network is built and operated
  - Architecture is driven by the network services
  - Overall communication process is complex
  - *Network architecture partitions overall communication process into separate functional areas called layers (will be seen later in detail)*

History of Communication Network..

History of Communication Network..
What is the FIRST message ever sent on the internet??

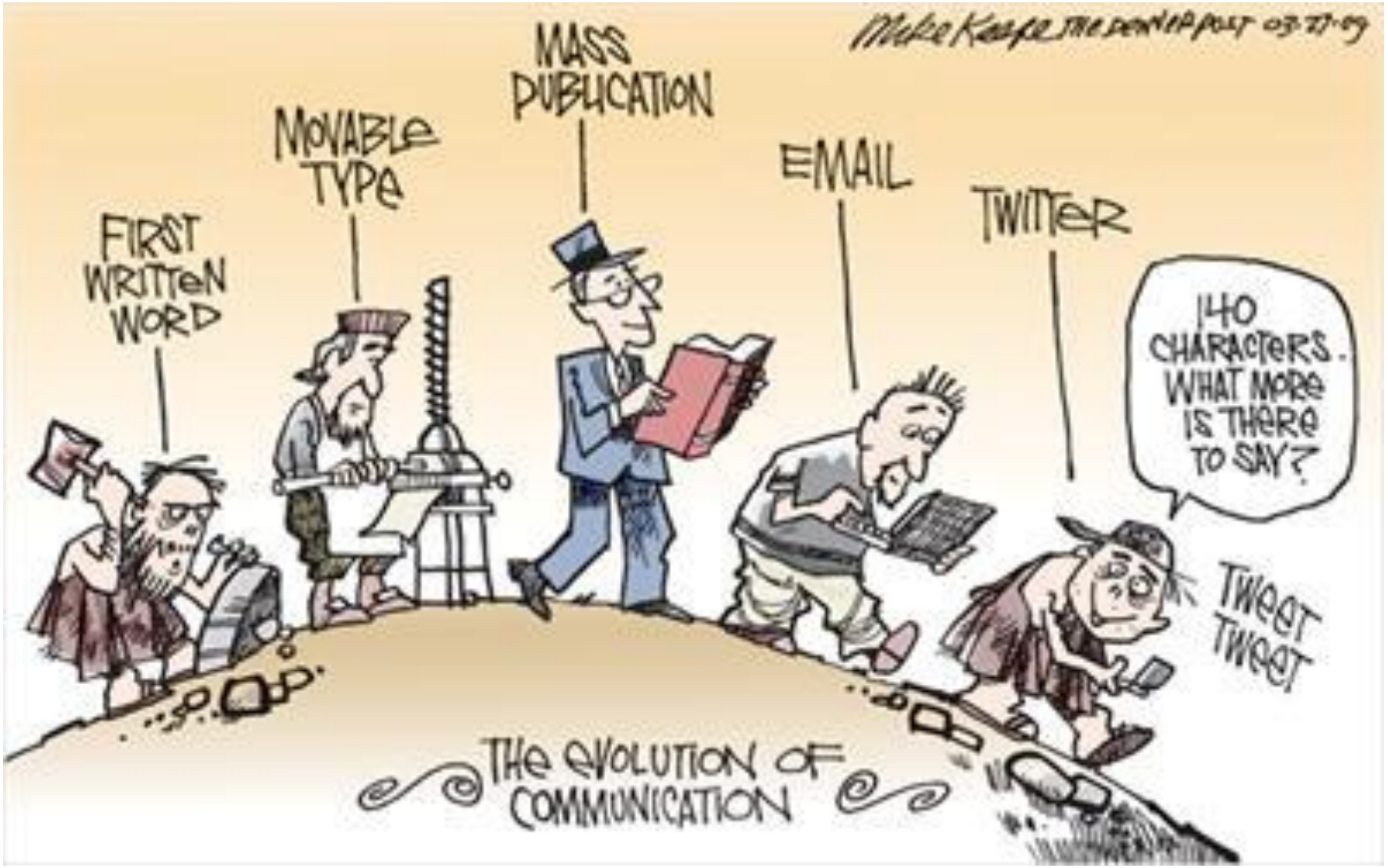
- Was it “What hath God Wrought” (Morse 1844)?
- Or “Watson, come here. I want you.” (Bell 1876)?
- Or “This is a Giant Step for Mankind” (Armstrong 1969)?

It was simply a LOGIN from the UCLA computer to the SRI computer.

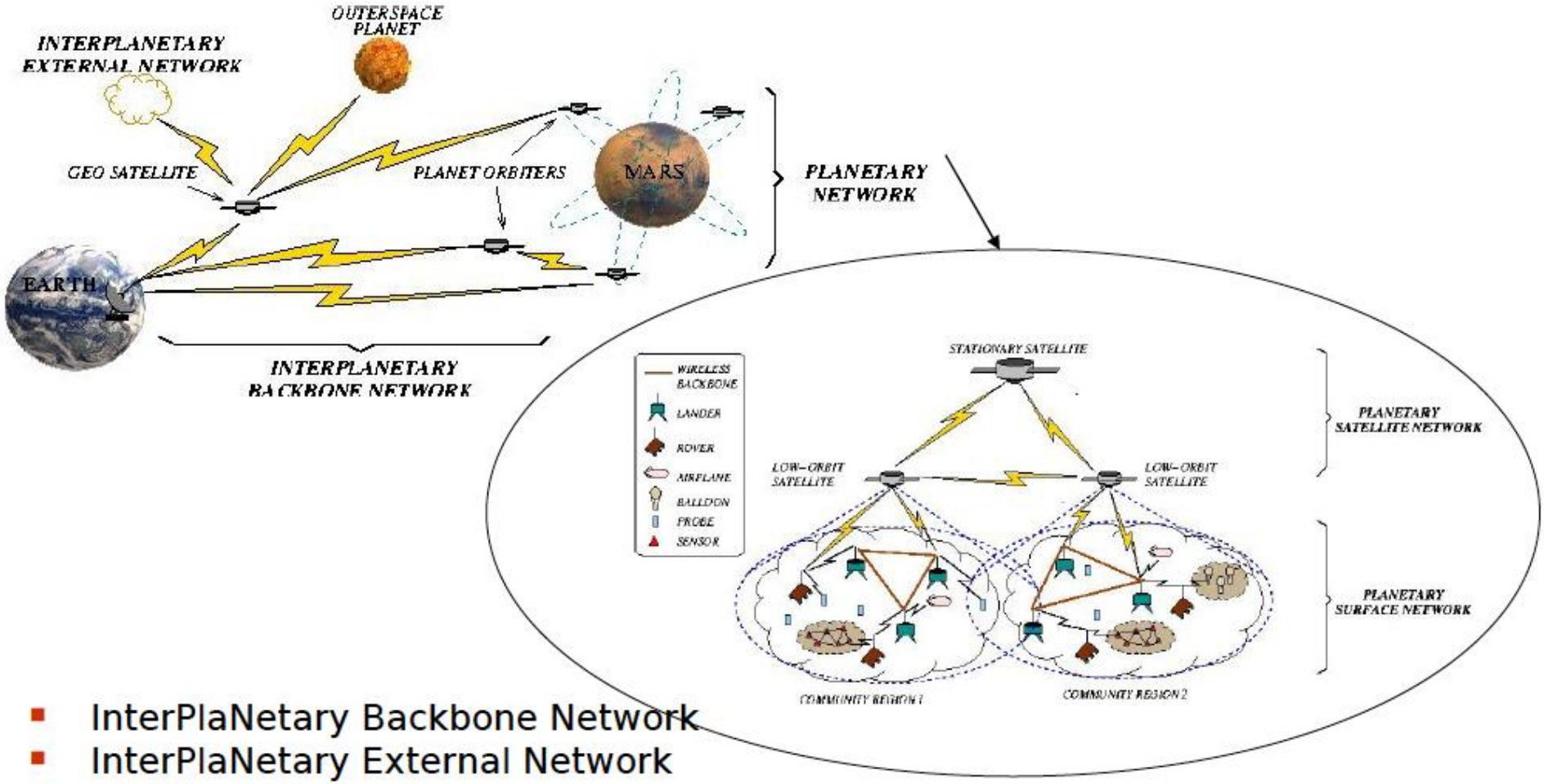
- We sent an “L” - did you get the “L”? YEP!
- We sent an “O” - did you get the “O”? YEP!
- We sent a “G” - did you get the “G”?

(by Leonard Kleinrock)

History of Communication Network..



And Now..



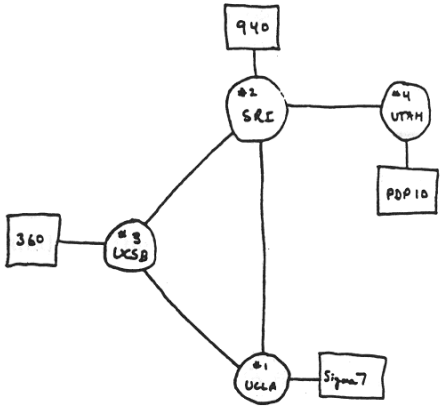
- InterPlaNetary Backbone Network
- InterPlaNetary External Network
- PlaNetary Network
  - PlaNetary Satellite Network
  - PlaNetary Surface Network

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 ARPA NETWORK

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
- late70'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
- 1982: smtp e-mail protocol defined
- 1983: DNS defined for name-to-IP-address translation
- 1985: ftp protocol defined
- 1988: TCP congestion control

- new national networks: Csnet, BITnet, NSFnet, Minitel
- 100,000 hosts connected to confederation of networks

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:

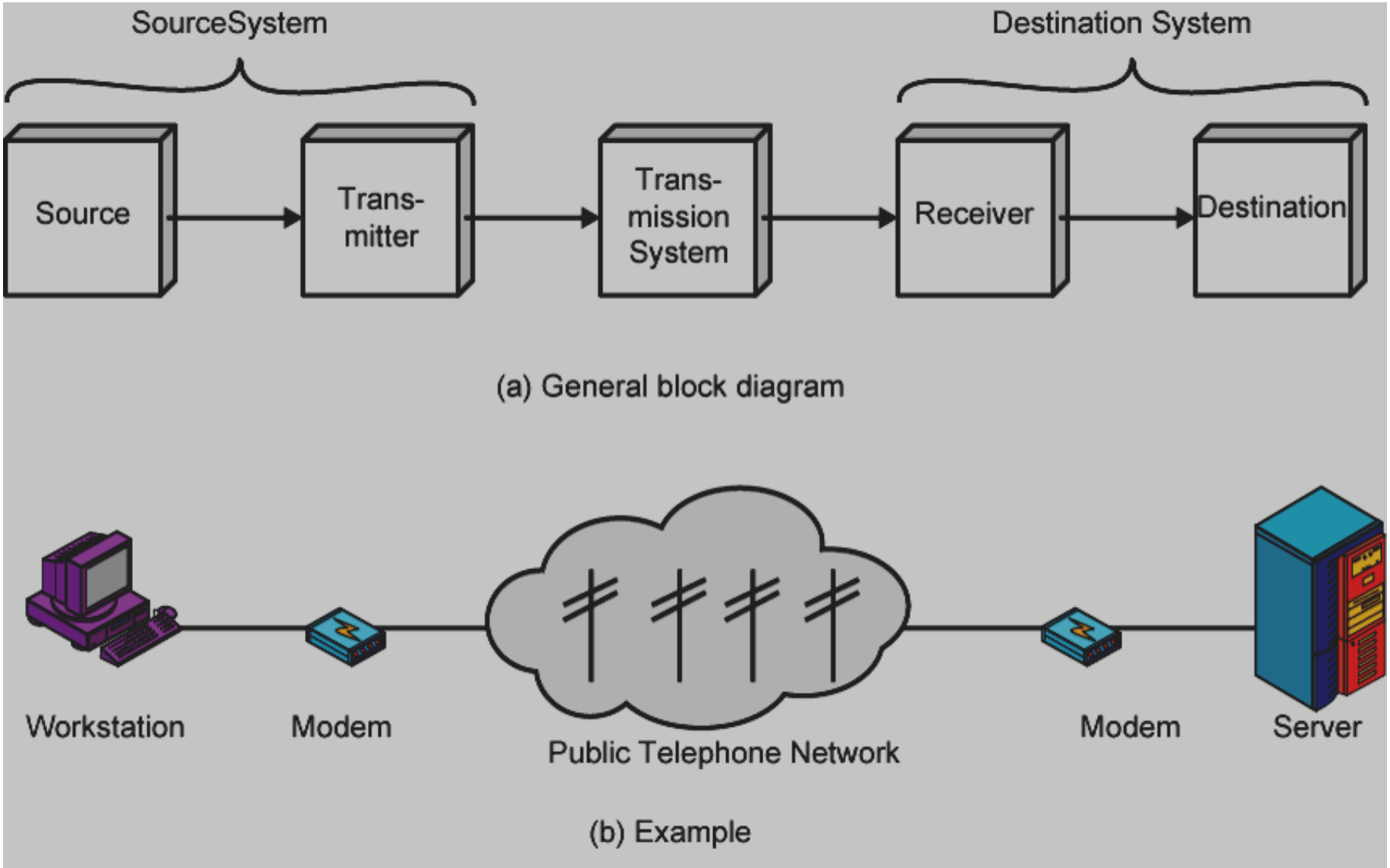
- more killer apps: instant messaging, P2P file sharing
- network security to forefront
- est. 50 million host, 100 million+ users
- backbone links running at Gbps

Internet history

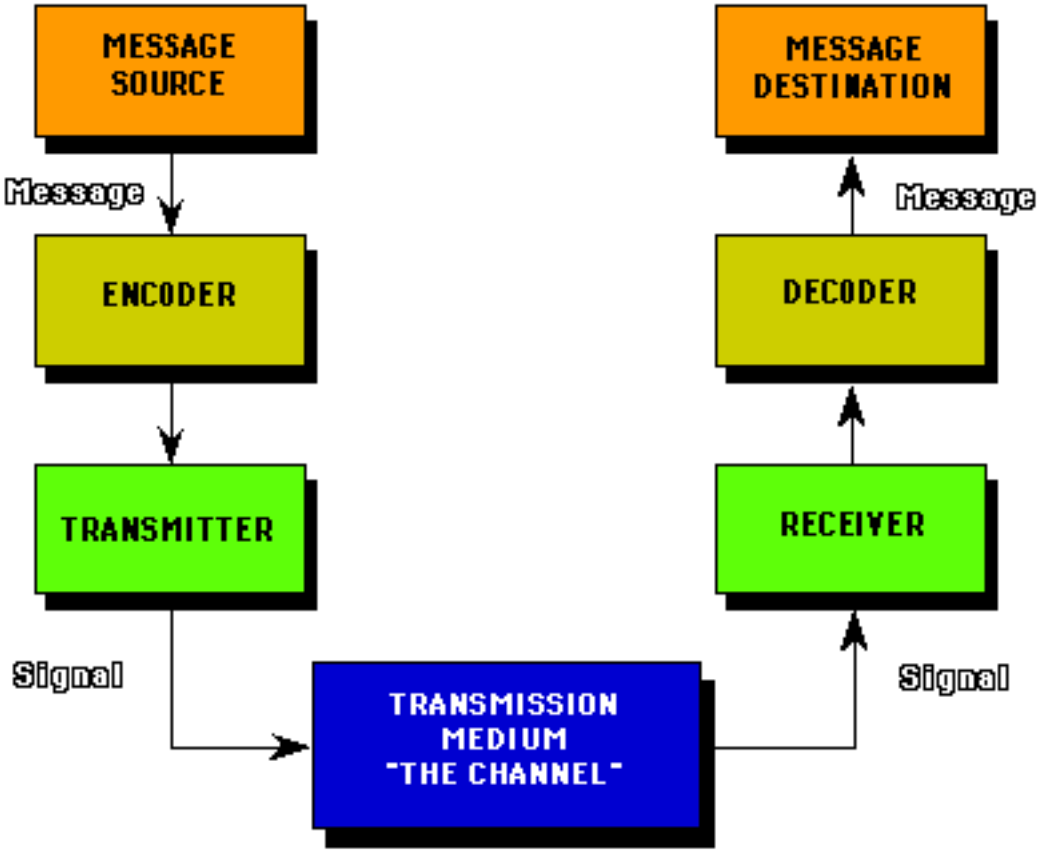
2005-present

- ~750 million hosts
  - Smartphones and tablets
- Aggressive deployment of broadband access
- Increasing ubiquity of high-speed wireless access
- Emergence of online social networks:
  - Facebook: soon one billion users
- Service providers (Google, Microsoft) create their own networks
  - Bypass Internet, providing "instantaneous" access to search, emai, etc.
- E-commerce, universities, enterprises running their services in "cloud" (eg, Amazon EC2)

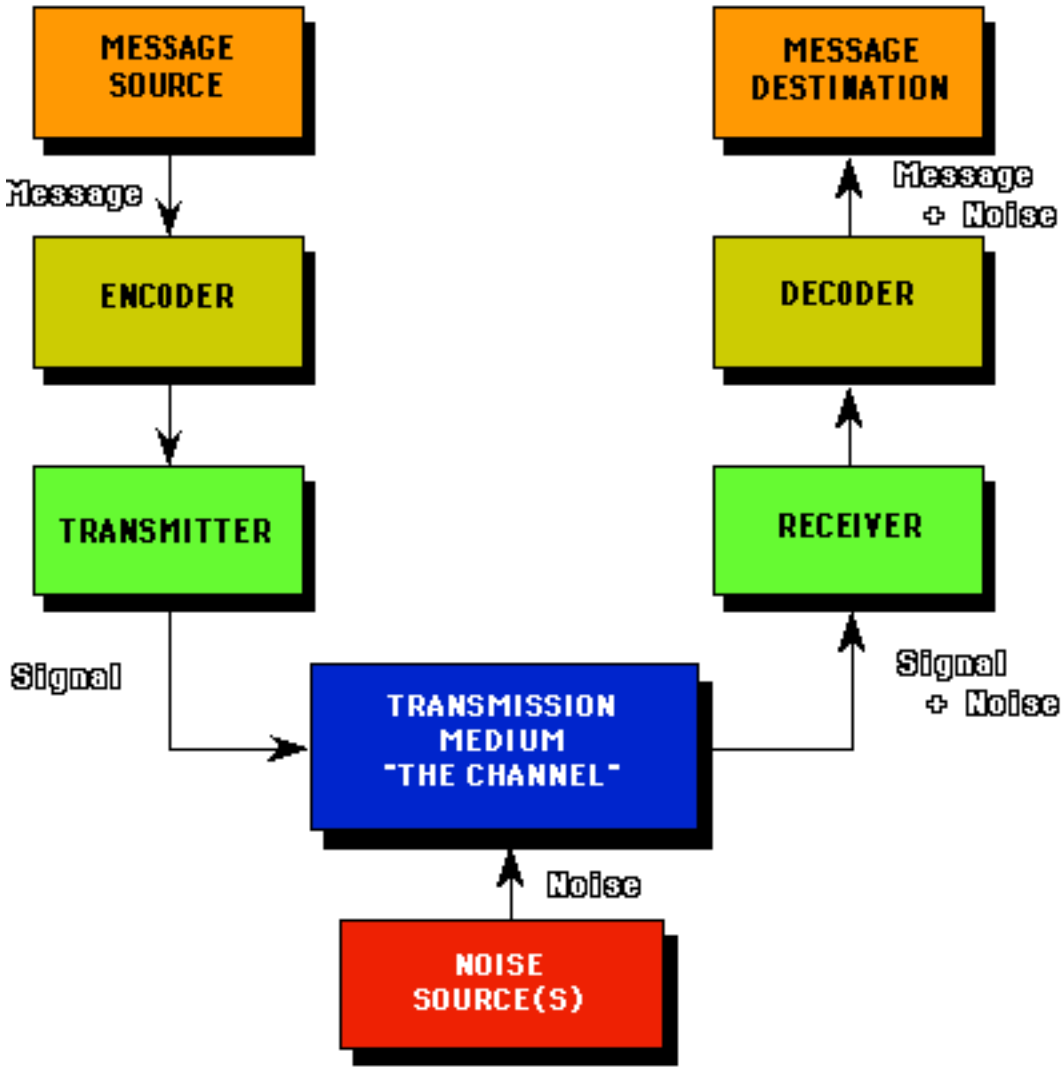
Communications Model



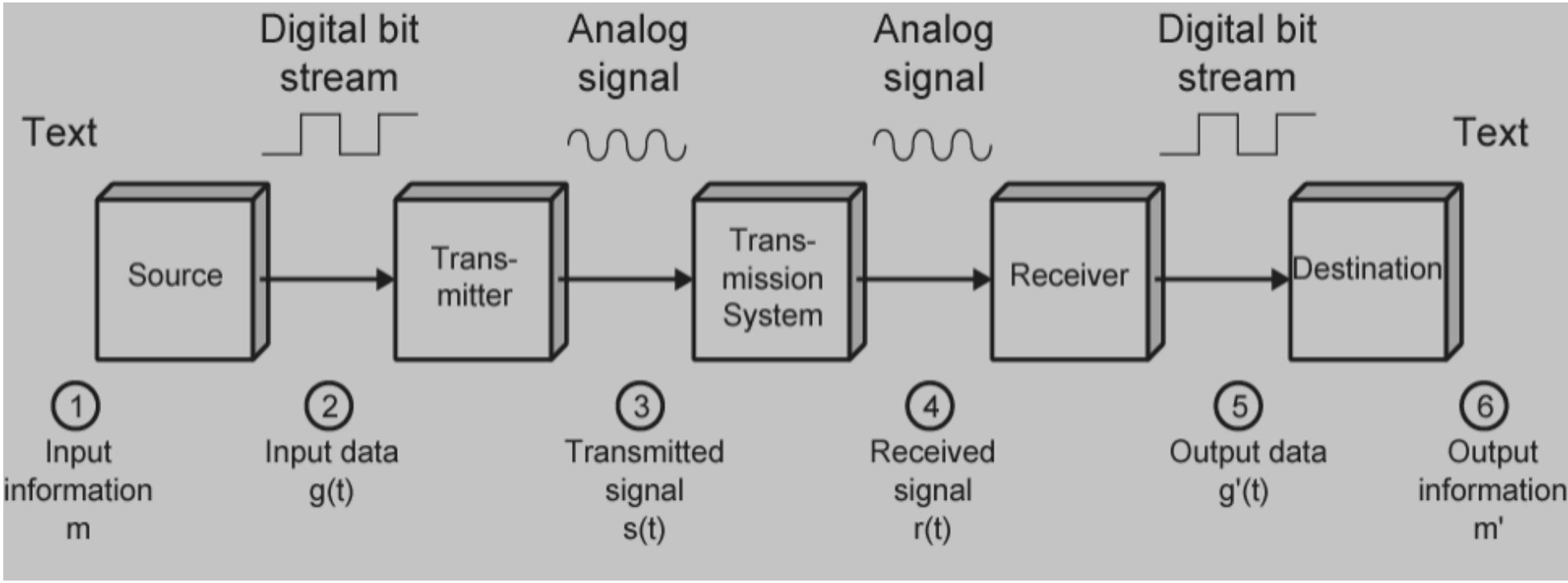
Shannon Communication Model



Shannon Communication Model



Data Communications Model



What's a protocol?

human protocols:

- "what's the time?"
- "I have a question"
- introductions

… specific msgs sent

… specific actions taken when msgs received, or other events

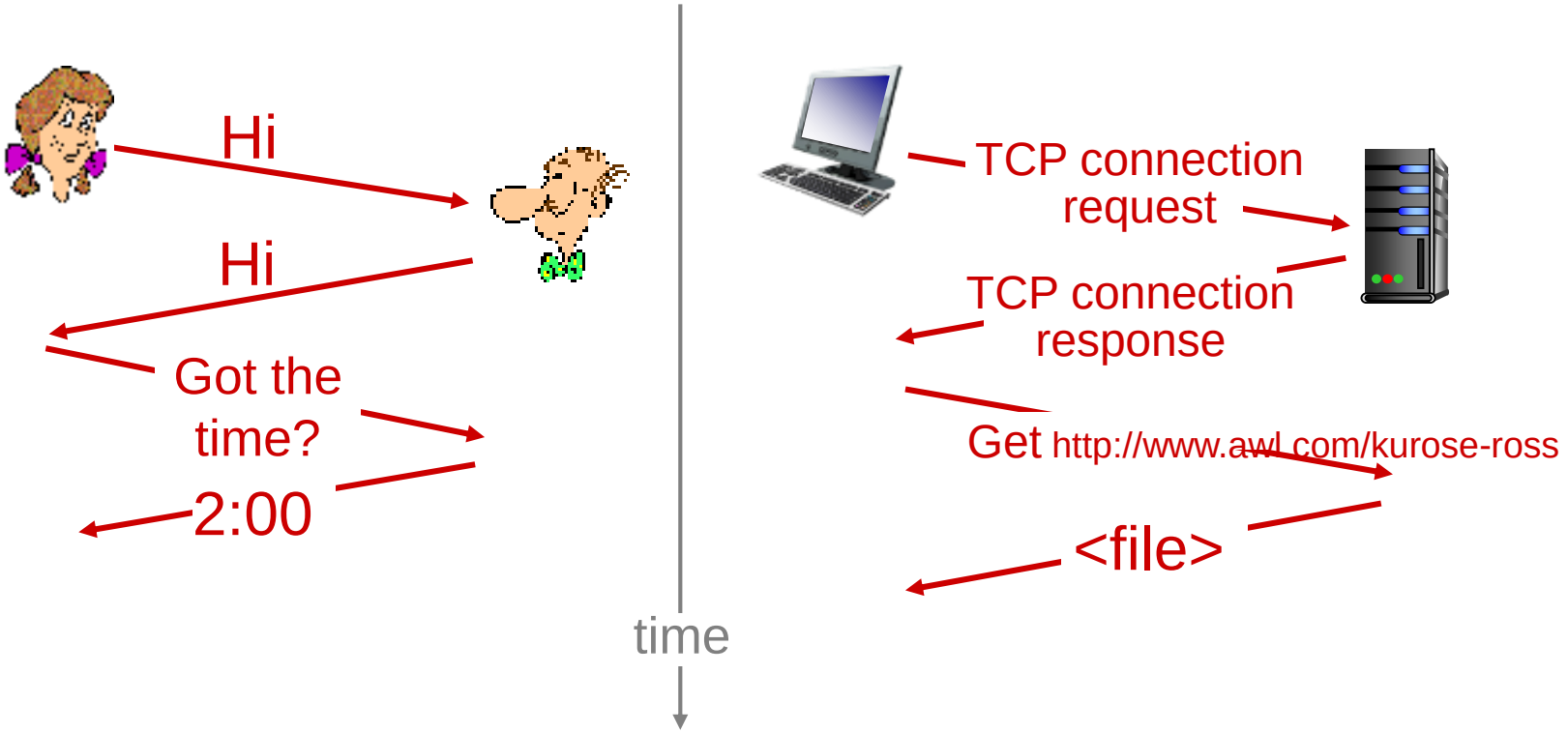
network protocols:

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

protocols define format, order of msgs sent and received among network entities, and actions taken on msg transmission, receipt

What's a protocol?

a human protocol and a computer network protocol:



Q: other human protocols?

Protocol "layers"

Networks are complex, with many "pieces":

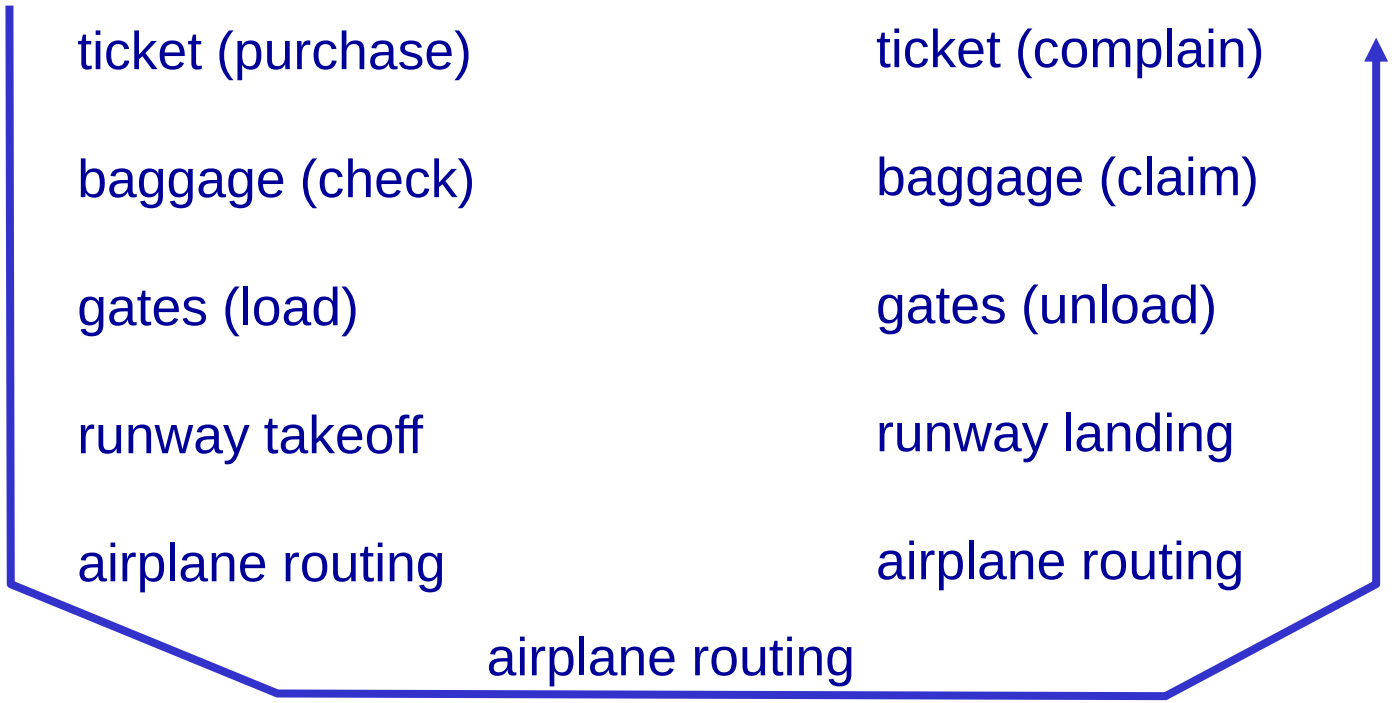
- hosts
- routers
- links of various media
- applications
- protocols
- hardware, software

Question:

is there any hope of *organizing* structure of network?

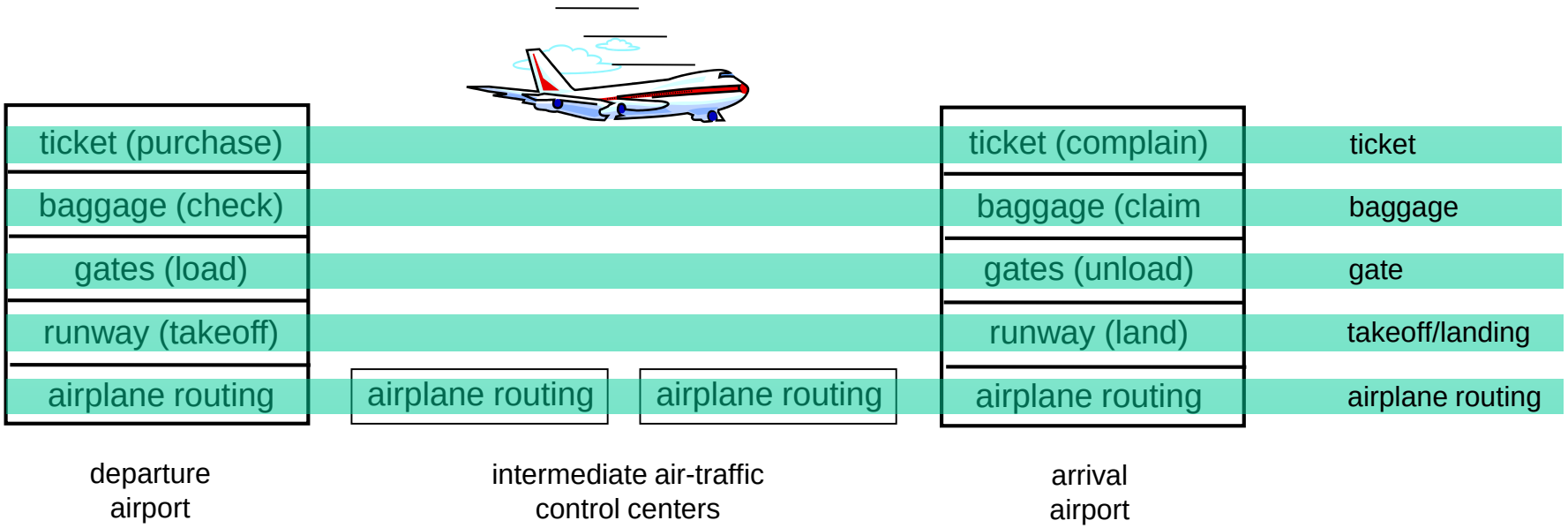
…. or at least our discussion of networks?

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

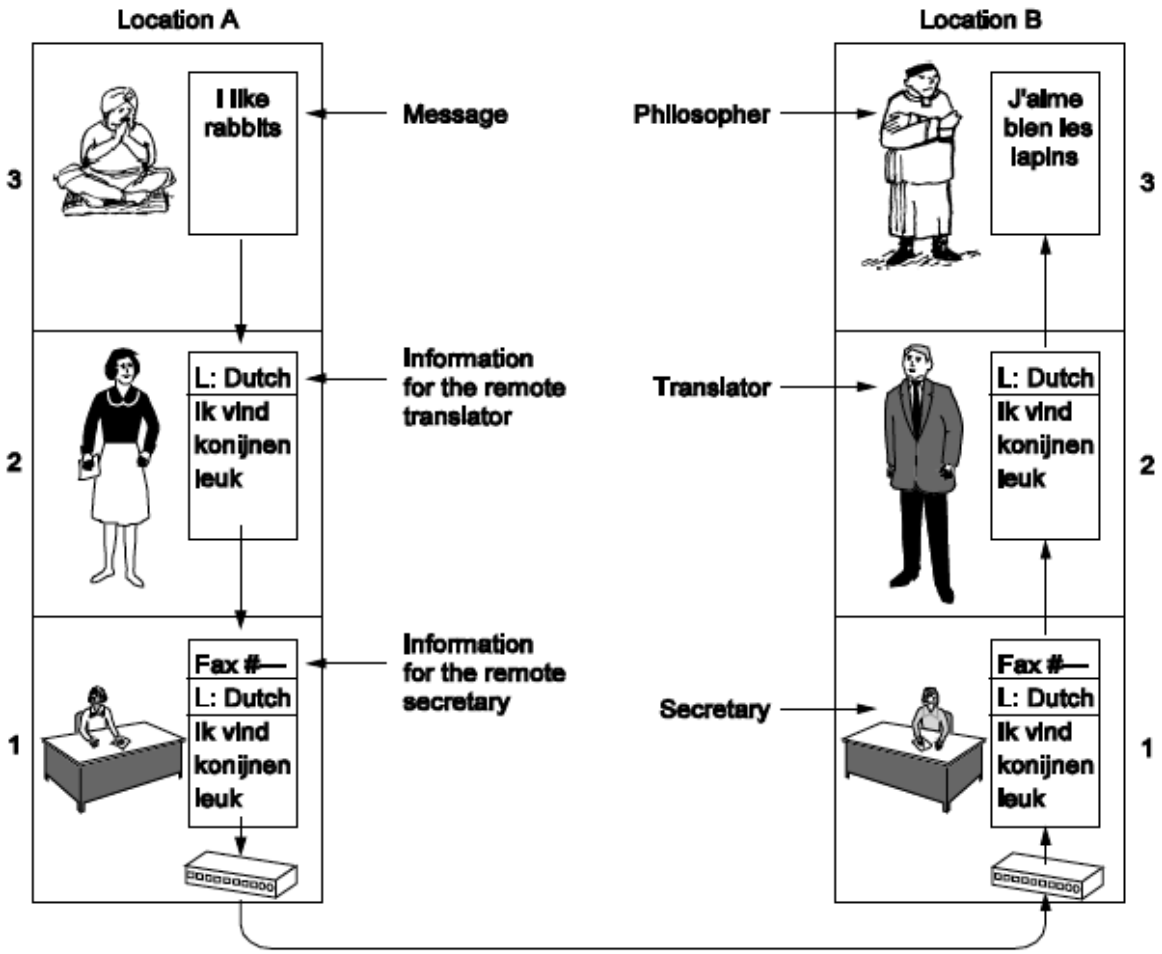
Why layering?

dealing with complex systems:

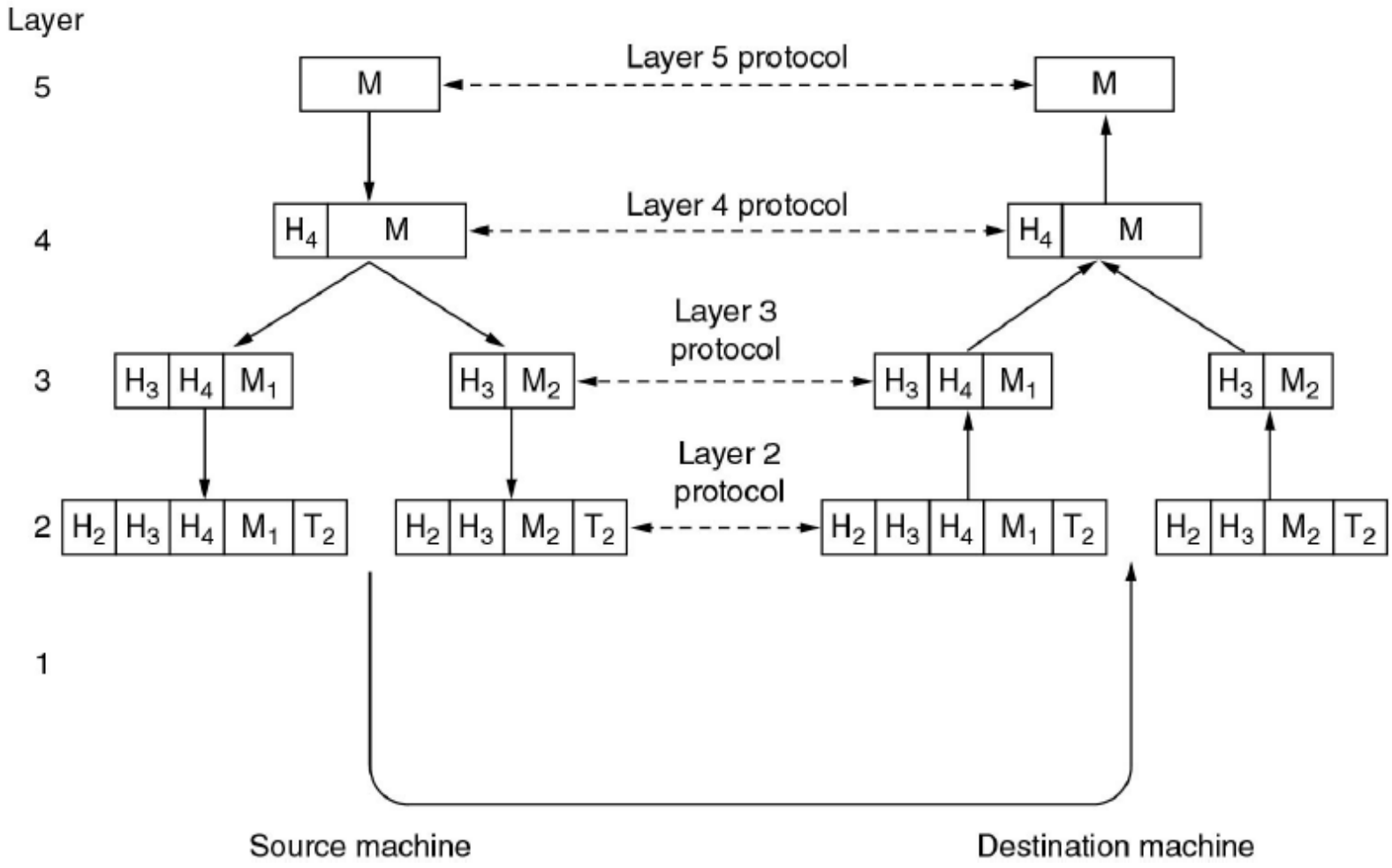
- explicit structure allows identification, relationship of complex system's pieces
  - layered *reference model* for discussion
- modularization eases maintenance, updating of system
  - change of implementation of layer's service transparent to rest of system
  - e.g., change in gate procedure doesn't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

Protocol Hierarchy..

- The philosopher-translator-secretary architecture.

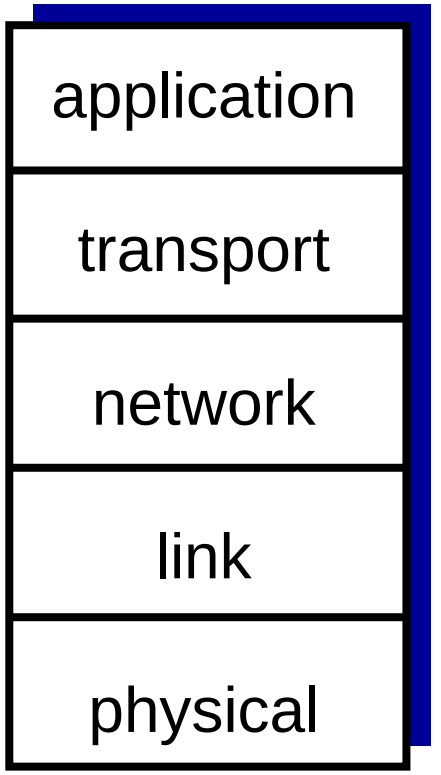


- Example information flow supporting virtual communication in layer 5.



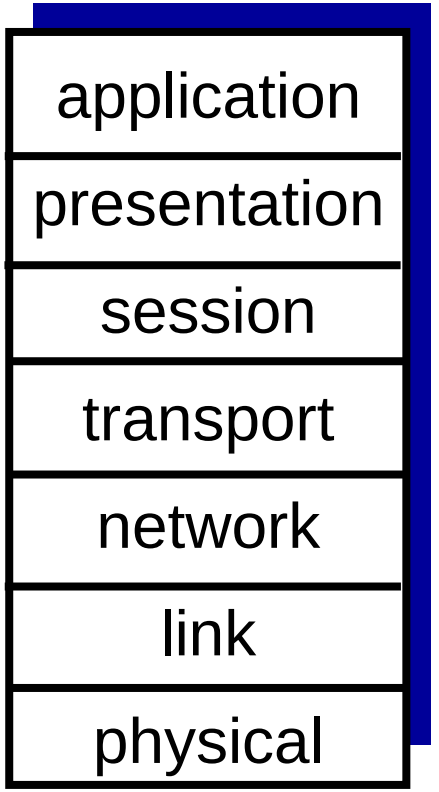
Internet protocol stack

- *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"

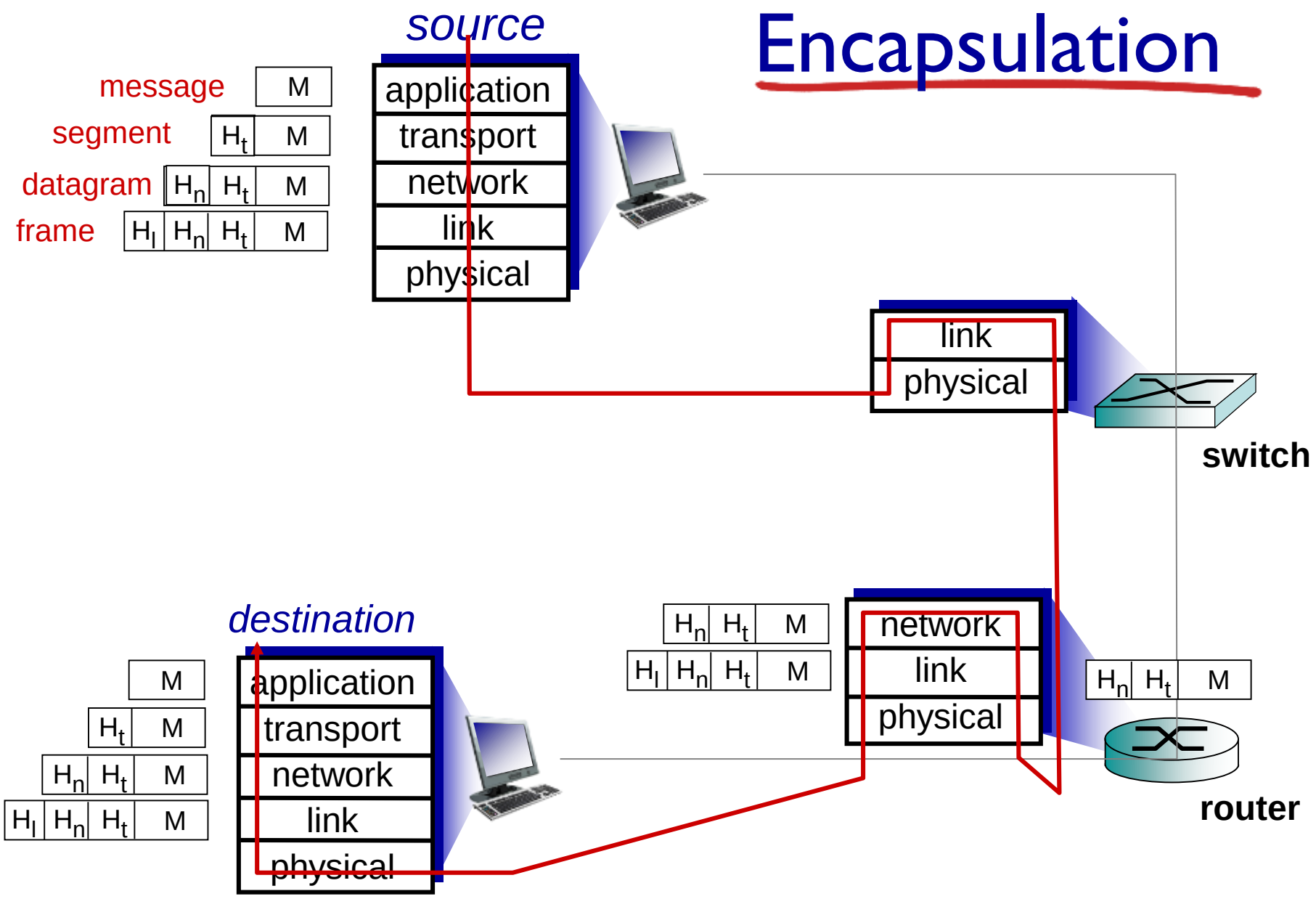


ISO/OSI reference model

- *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?

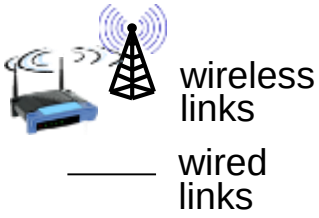


Encapsulation

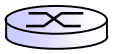


What's the Internet: "nuts and bolts" view

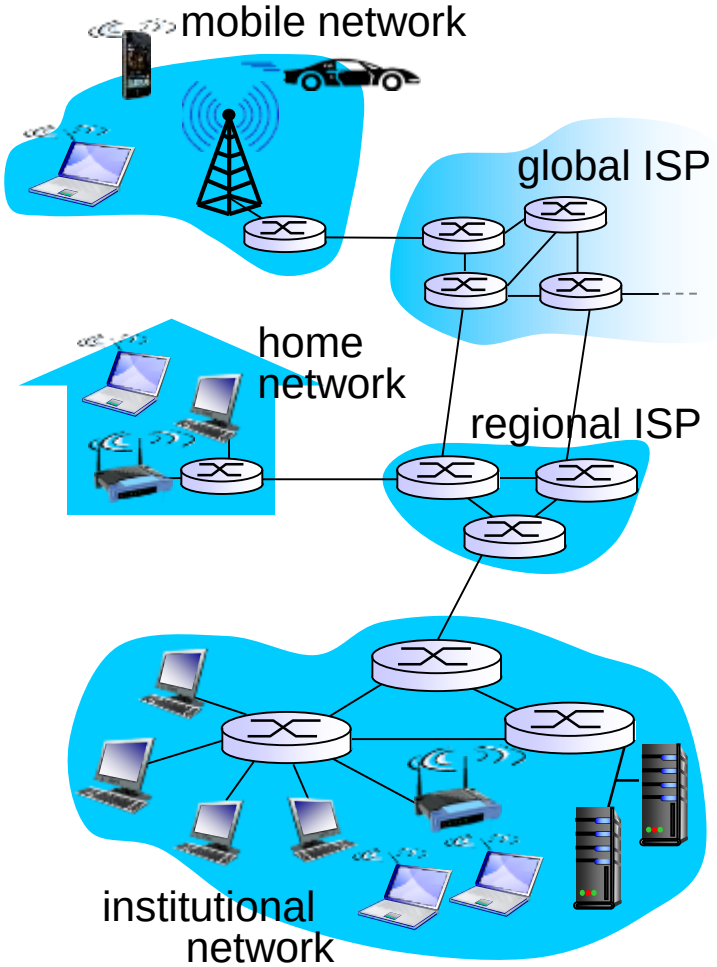
- millions of connected computing devices:
  - *hosts* = *end systems*
  - running *network apps*



- *communication links*
  - fiber, copper, radio, satellite
  - transmission rate: *bandwidth*



- *Packet switches:* forward packets (chunks of data)
  - *routers* and *switches*



"Fun" internet appliances

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

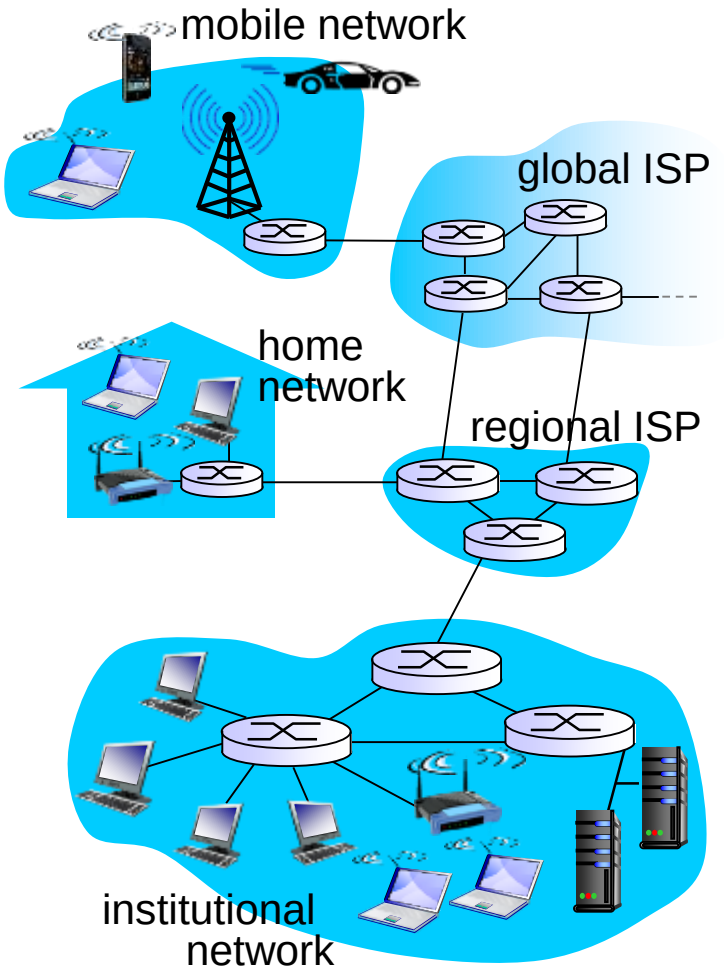
Web-enabled toaster +
weather forecaster

Tweet-a-watt:
monitor energy use

Internet
refrigerator

Slingbox: watch,
control cable TV remotely

Internet phones

A closer look at network structure:

- *network edge:*
  - hosts: clients and servers
  - servers often in data centers
- *access networks, physical media:* wired, wireless communication links
- *network core:*
  - interconnected routers
  - network of networks