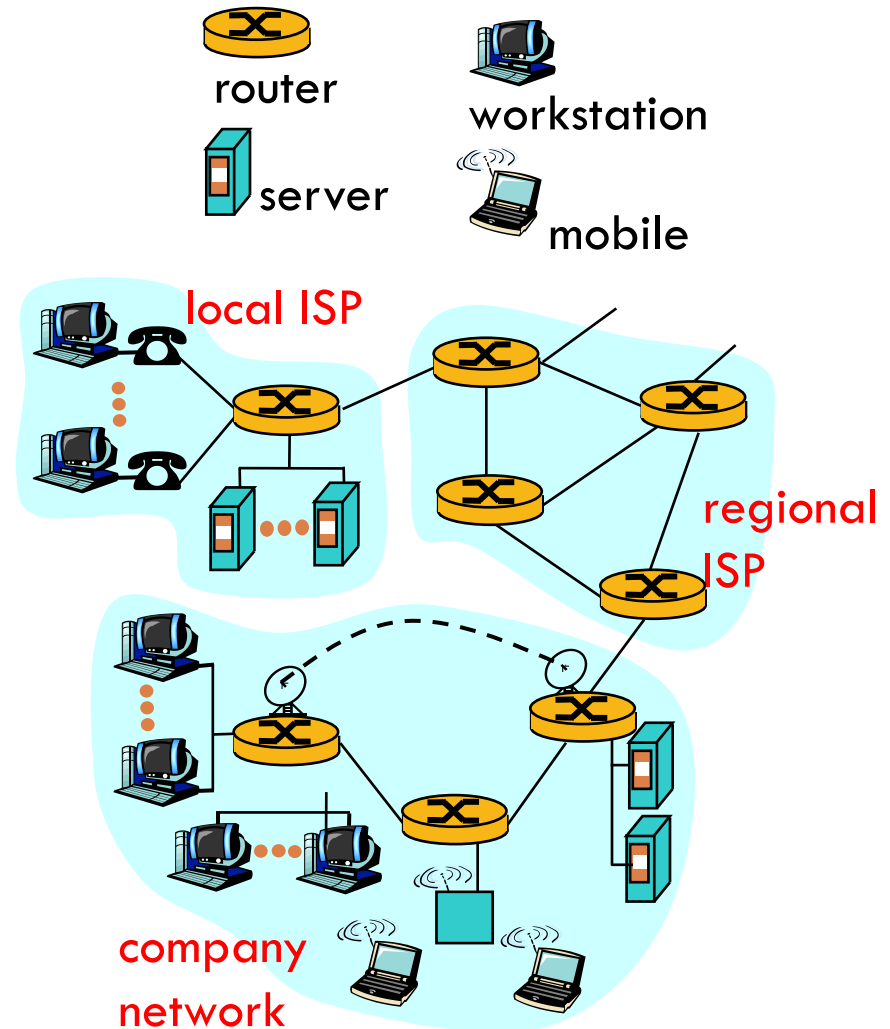


LECTURE 2

Networking Primer

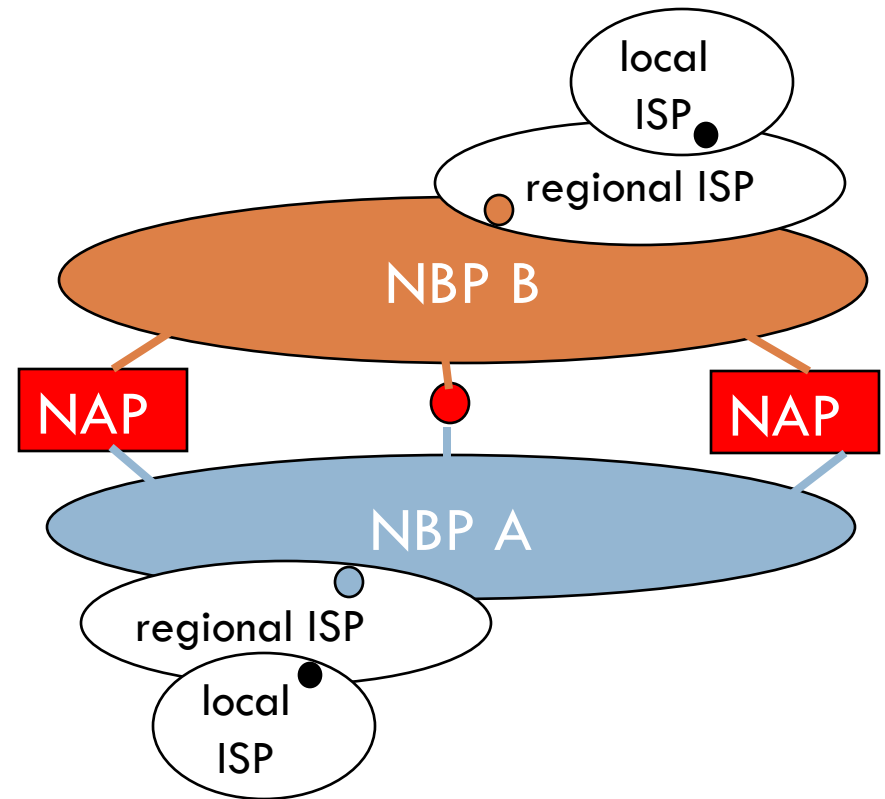
Visualizing the Internet

- millions of connected computing devices: *hosts, end-systems*
 - ▣ pc's workstations, servers
 - ▣ Tablets, smartphones, toastersrunning *network apps*
- *communication links*
 - ▣ fiber, copper, radio, satellite
- *routers*: forward packets (chunks) of data thru network



Internet structure: network of networks

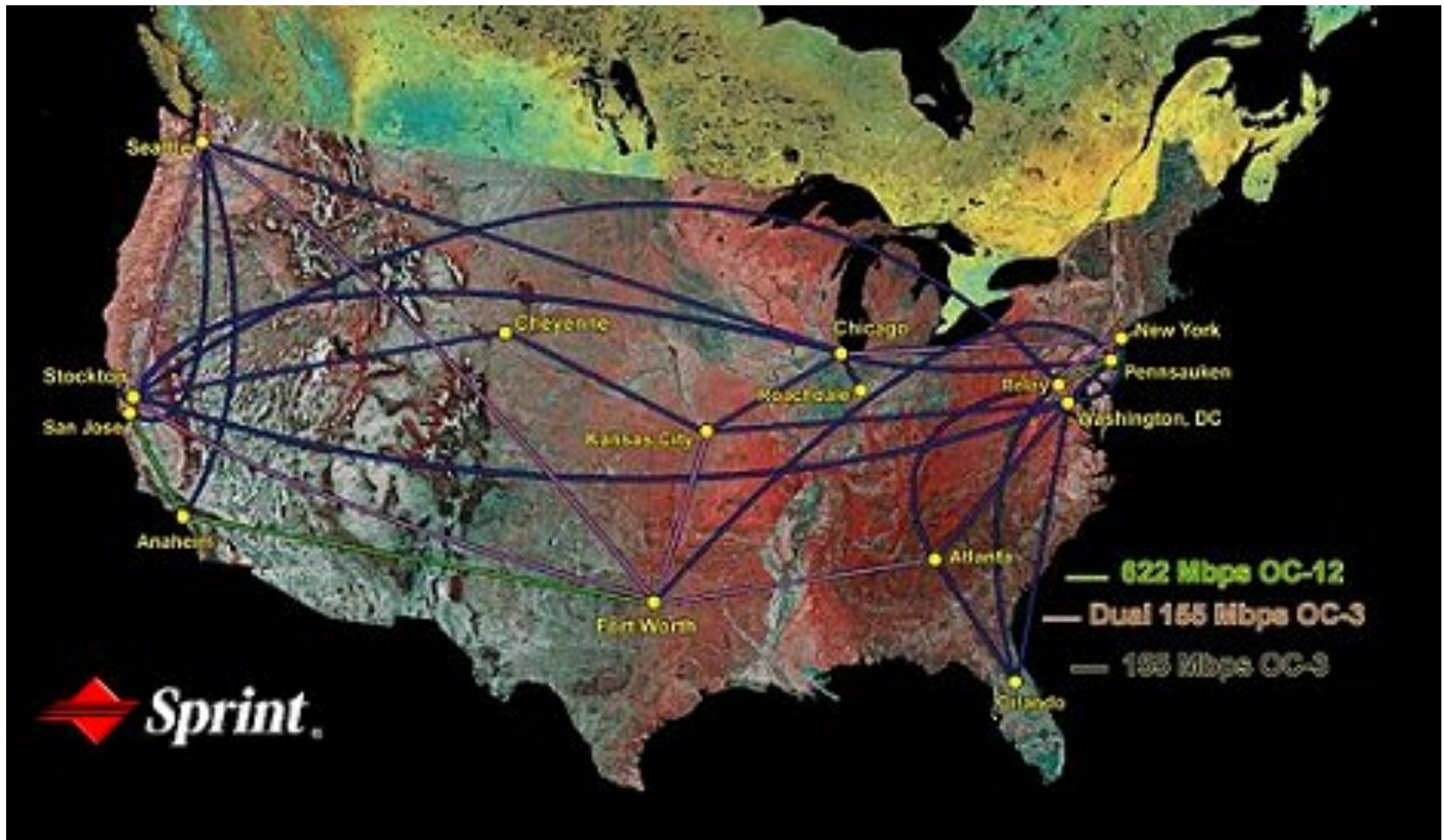
- roughly hierarchical
- **national/international backbone providers (NBPs)**
 - e.g. BBN/GTE, Sprint, AT&T, IBM, UUNet
 - interconnect (peer) with each other privately, or at public Network Access Point (NAPs)
- **regional ISPs**
 - connect into NBPs
- **local ISP, company**
 - connect into regional ISPs



National Backbone Provider

4

e.g. Sprint US backbone network



Links between computers

5

- Point to point link -- a direct cable or wire that is dedicated for use between the computers.



- Multiple access link -- shared between many nodes -- example a bus, wireless medium etc.

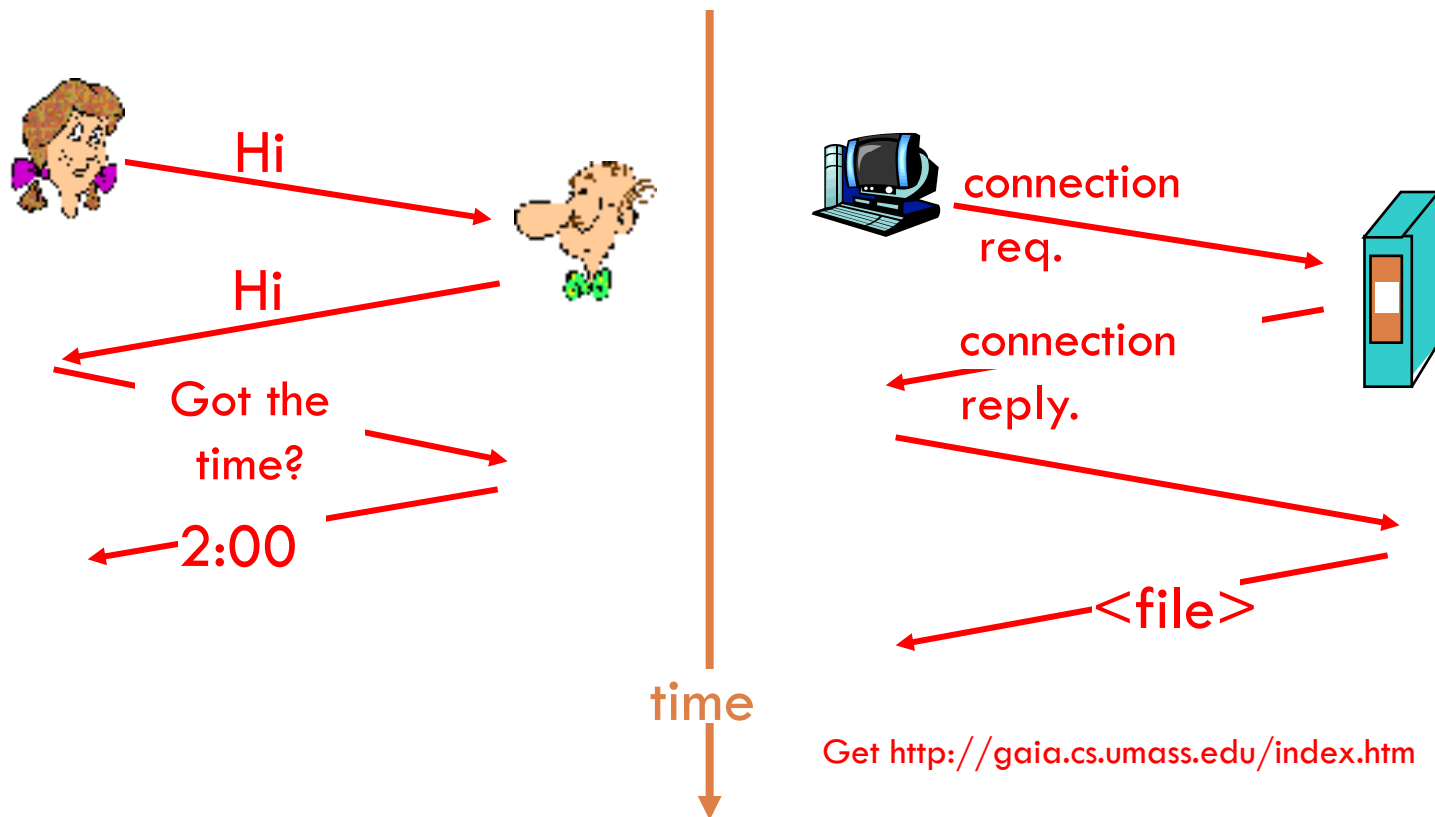
Why structure ?

6

- Direct connectivity does not scale -- all computers cannot be directly connected to each other.
- Need organization
 - ▣ End hosts -- clients and servers -- usually house information
 - ▣ Routers and switches -- nodes that are primarily used for relaying information -- sending information where it needs to go.

What's a protocol?

- The definition of a behavior --set of rules
- Here: the format of a communication exchange:
- Sequence of actions, format of information, predefined interpretation

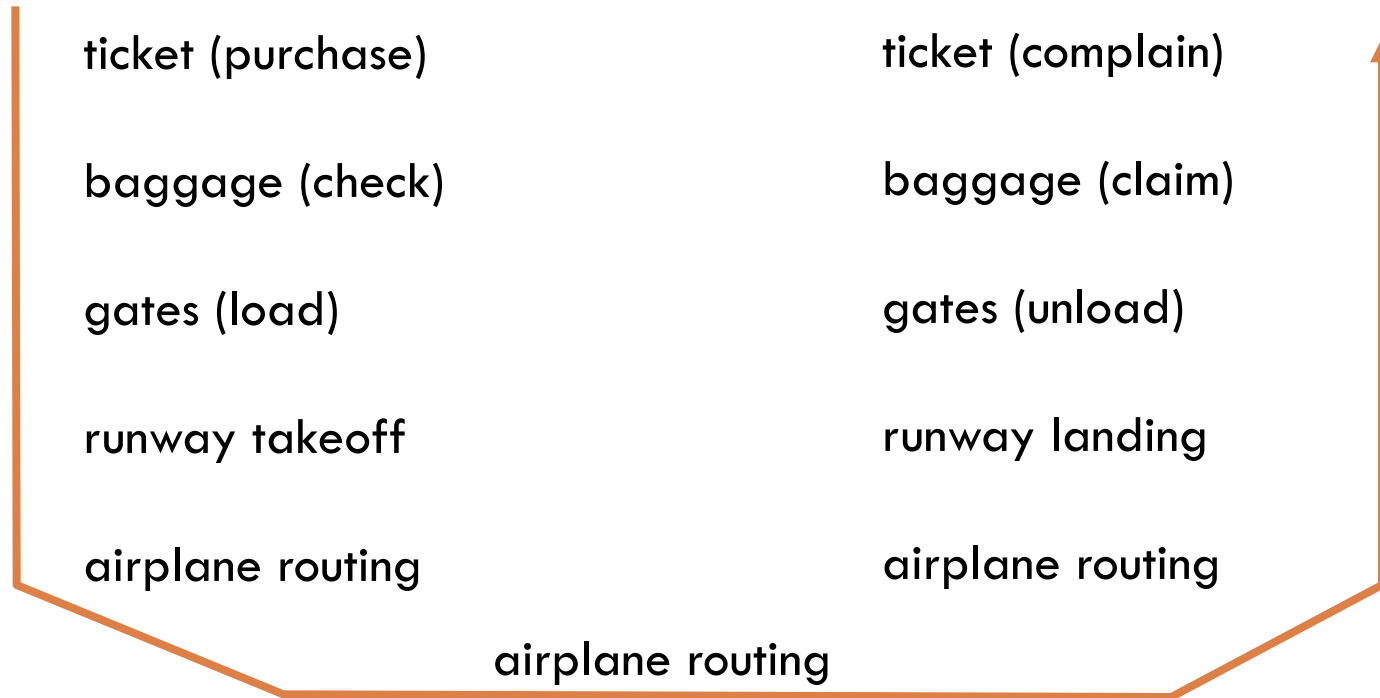


Packets

- Packets are similar to postal letters -basic units of information
 - ▣ From, to, content
 - ▣ Postman handles all packets similarly
 - ▣ Addressing is hierarchical.
- The protocol that defines how packets are to be “routed” is the Internet Protocol or IP.
 - ▣ Hierarchical addresses like in the postal world.

Organization of air travel

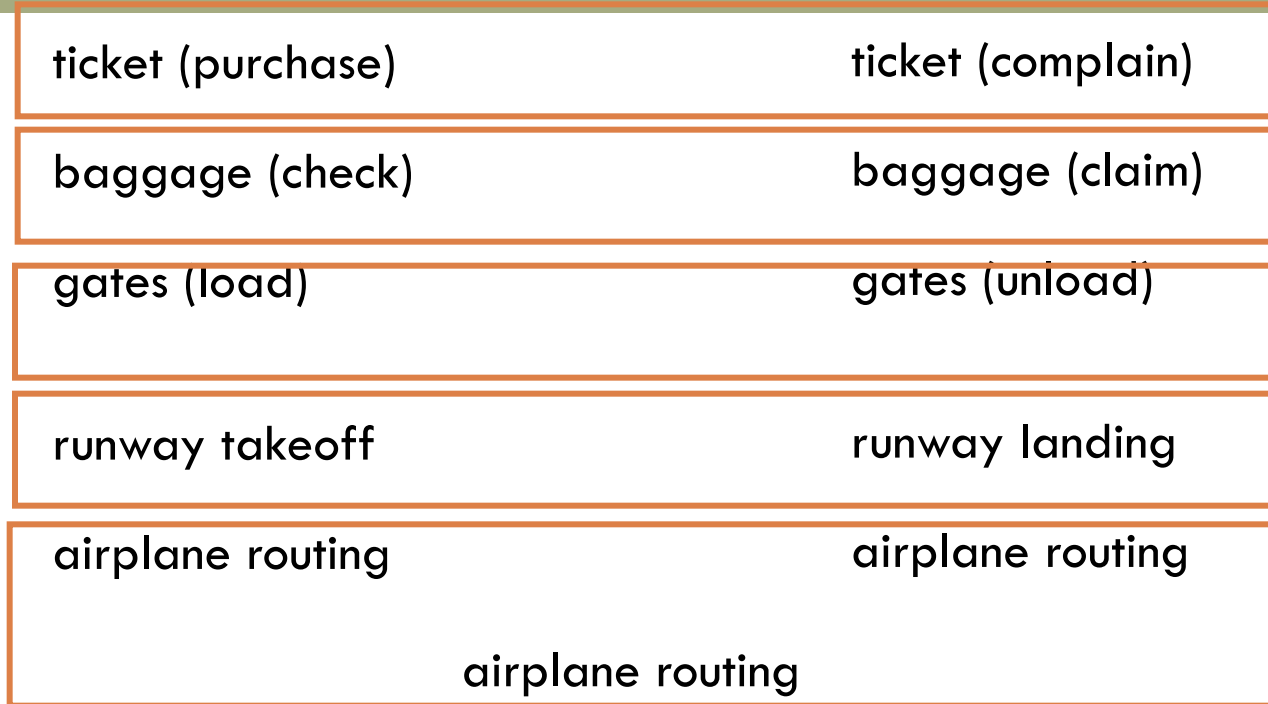
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- a series of steps

Organization of air travel: a different view

10

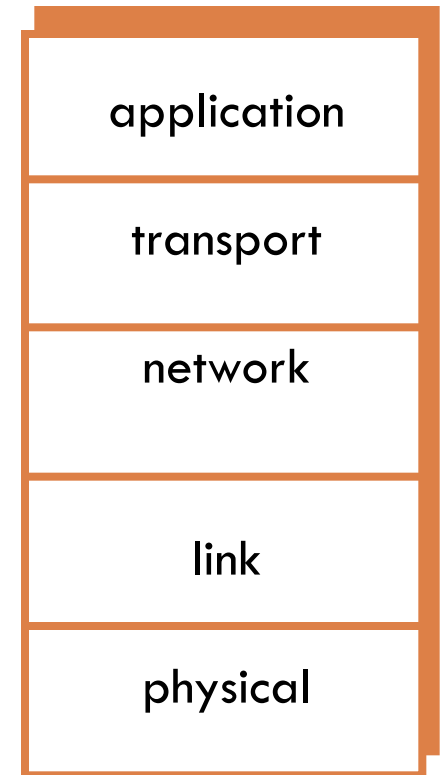


Layers: each layer implements a service

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

Internet protocol stack

- **application:** supporting network applications
 - ▣ ftp, smtp, http
- **transport:** host-host data transfer
 - ▣ tcp, udp
- **network:** routing of datagrams from source to destination
 - ▣ ip, routing protocols
- **link:** data transfer between neighboring network elements
 - ▣ ppp, ethernet, wireless link
- **physical:** bits “on the wire or wireless” -- representation, signal modulation.



Why layering?

12

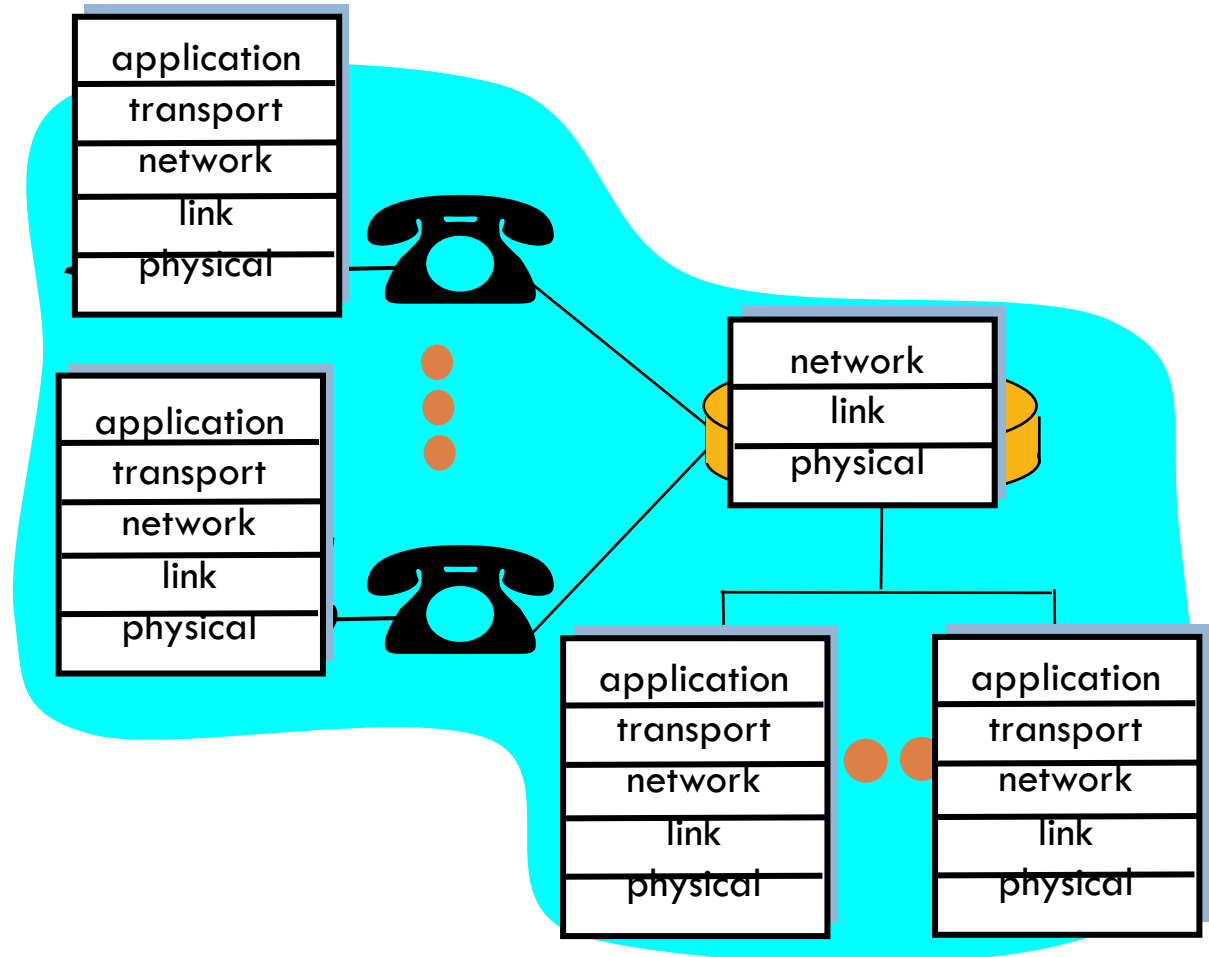
Dealing with complex systems:

- 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
- Isolating “functions” and interactions components
 - ▣ layered **reference model** for discussion

Layering: logical communication

Each layer:

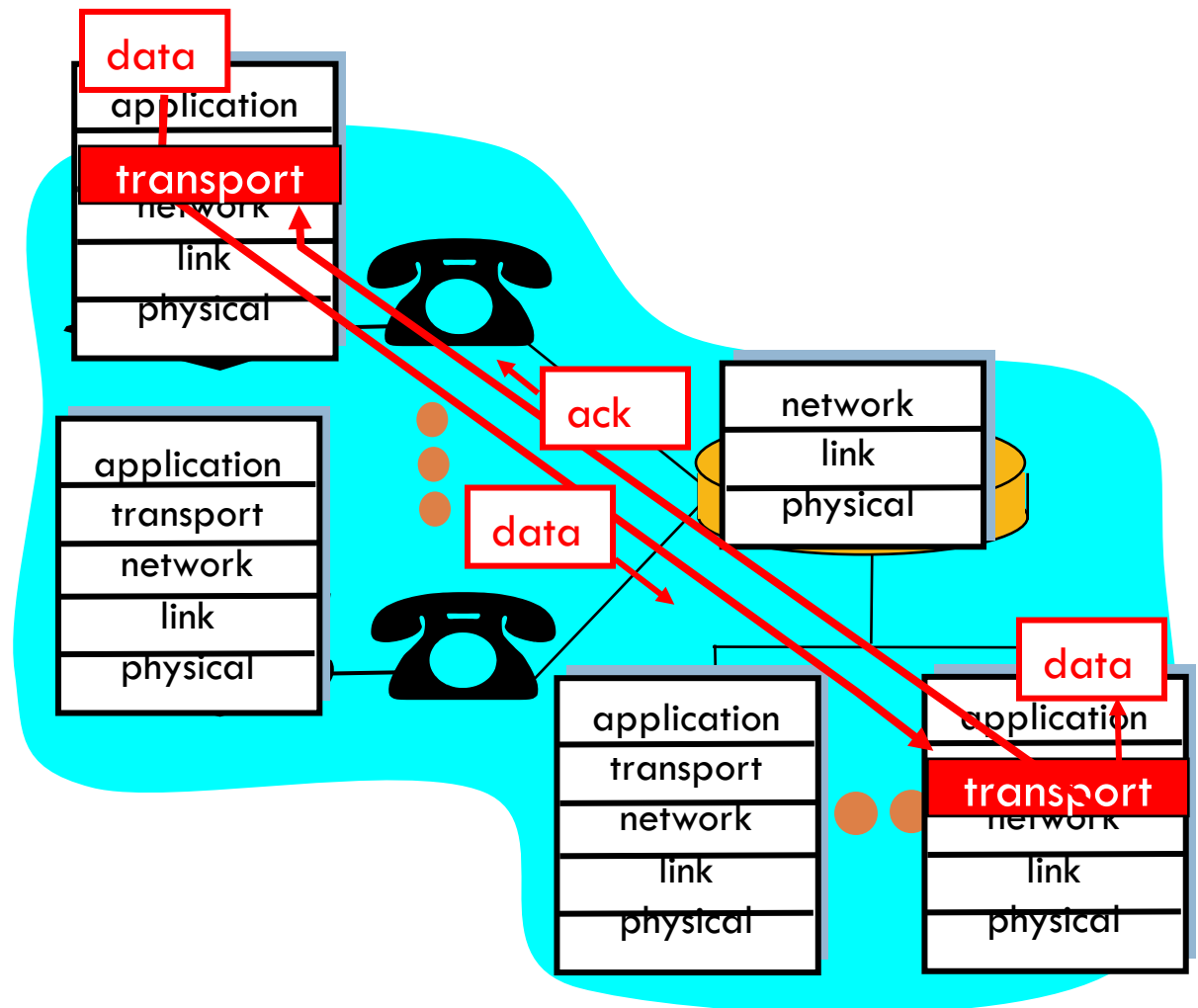
- distributed
- “entities”
implement layer
functions at each
node
- entities perform
actions, exchange
messages with
peers



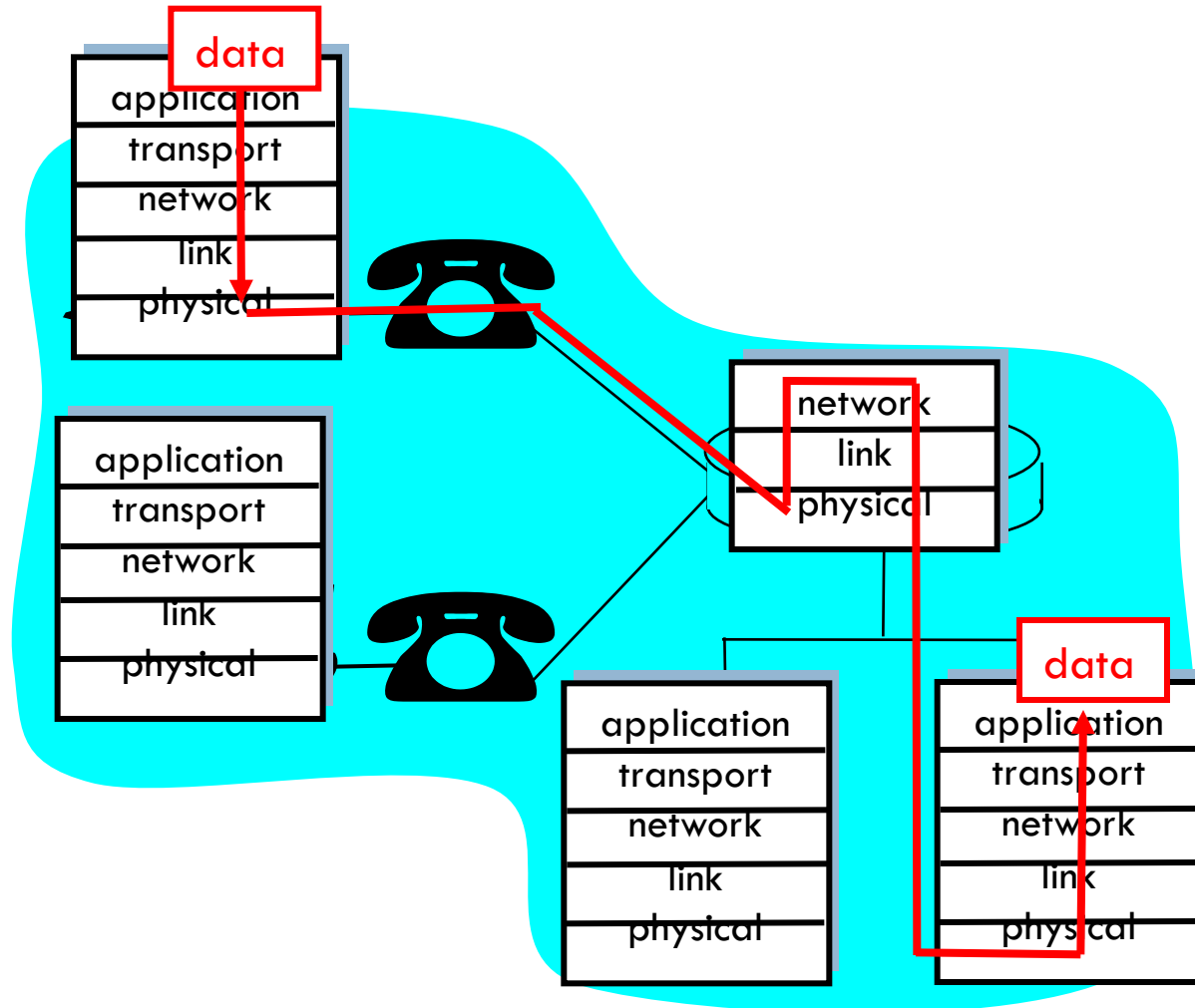
Layering: *logical* communication

E.g.: transport

- take data from app
- add addressing, reliability check info to form “datagram”
- send datagram to peer
- wait for peer to ack receipt
- analogy: post office

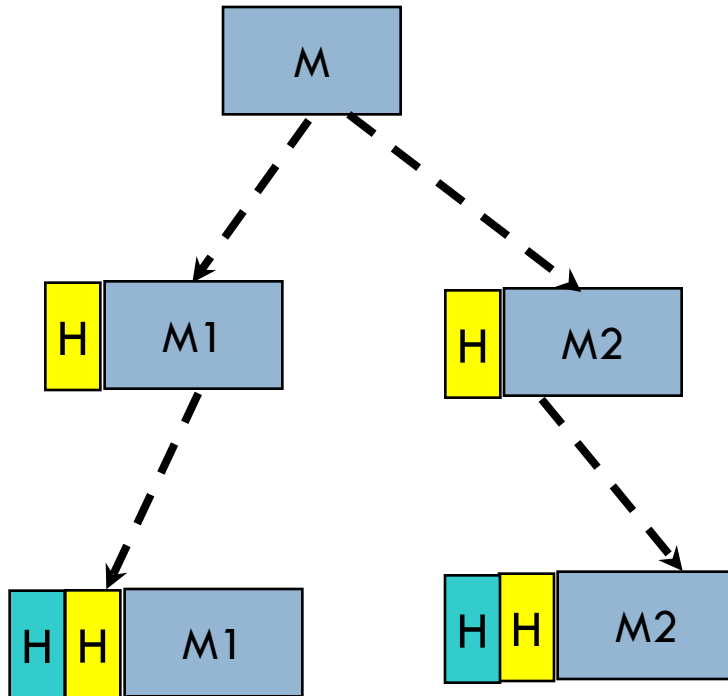


Layering: physical communication



Message flow through stack

16



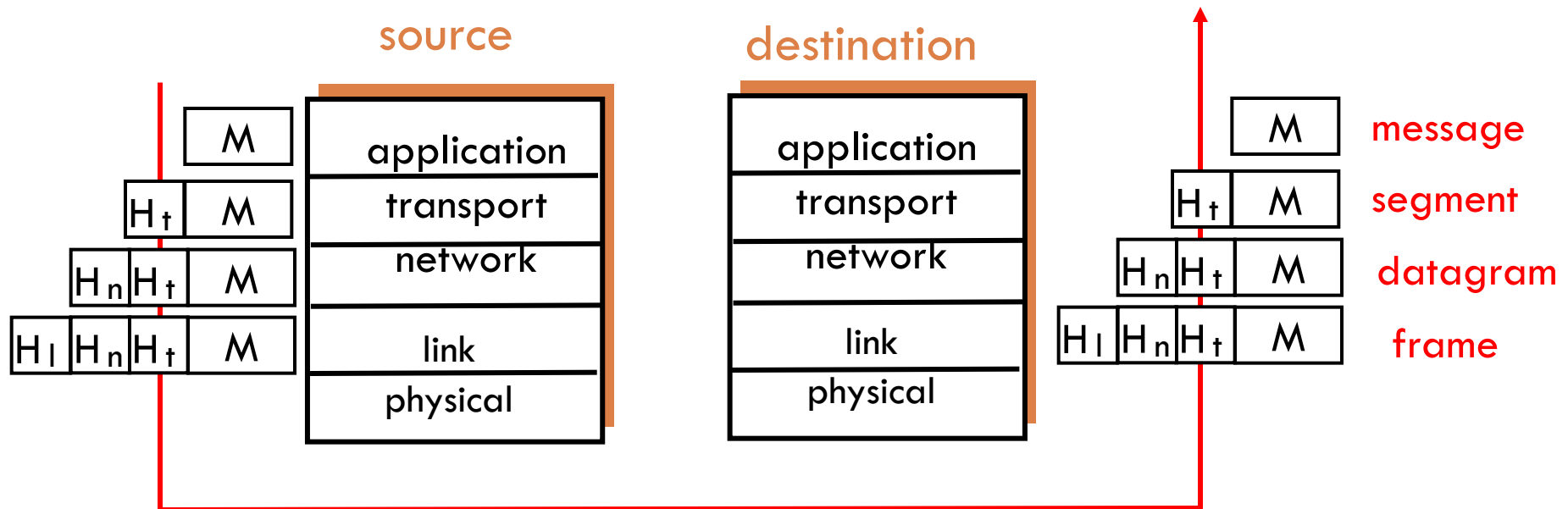
- At each layer, headers added.
- A protocol defines maximum packet size -- might require higher layer packet to be fragmented.

Protocol layering and data

17

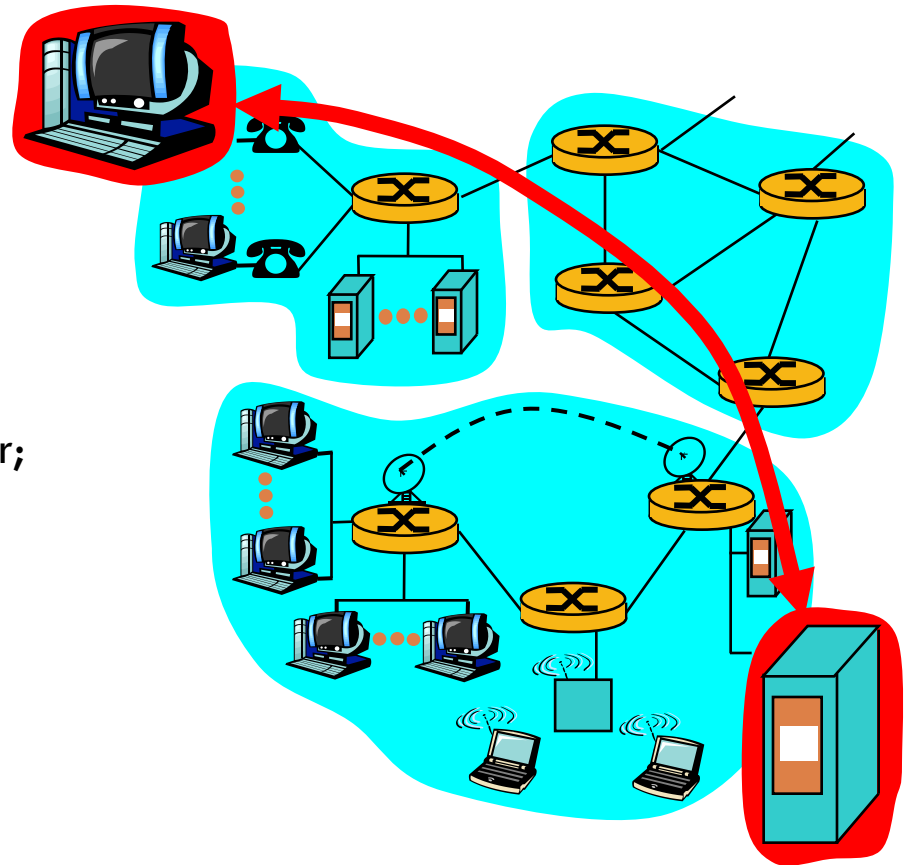
Each layer takes data from above

- adds header information to create new data unit
- passes new data unit to layer below



The network edge:

- **end systems (hosts):**
 - run application programs
 - e.g., WWW, email
 - at “edge of network”
- **client/server model**
 - client host requests, receives service from server
 - e.g., WWW client (browser)/ server; email client/server
- **peer-peer model:**
 - host interaction symmetric
 - e.g.: Gnutella, KaZaA



IP Address

- Dotted decimal notation – IPv4
 - ▣ 169.235.29.12
- Consists of a network part (prefix) and a host part.
 - ▣ The network part leads to the proper network
 - ▣ The host part helps identify the host within the network
- 169.235.29.12/24 – indicates that the prefix consists of the first 24 bits.
 - ▣ Note – routing uses the longest prefix match

Network edge: connection-oriented service

Goal: data transfer between end sys.

- *handshaking*: setup (prepare for) data transfer ahead of time
 - Hello, hello back human protocol
 - *set up “state”* in two communicating hosts
- TCP - Transmission Control Protocol
 - Internet’s connection-oriented service

TCP service [RFC 793]

- *reliable, in-order* byte-stream data transfer
 - loss: acknowledgements and retransmissions
- *flow control*:
 - sender won’t overwhelm receiver
- *congestion control*:
 - senders “slow down sending rate” when network congested

Network edge: connectionless service

Goal: data transfer between end systems

- ▣ same as before!
- ▣ **UDP** - User Datagram Protocol [RFC 768]: Internet's connectionless service
 - ▣ unreliable data transfer
 - ▣ no flow control
 - ▣ no congestion control