Lecture 03: Application Layer Intro

CS 356 Computer Networks

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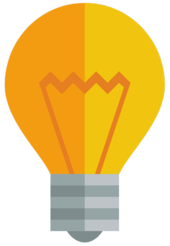
Internet Reference Model



Example Protocols	Layer	Responsible for
FTP, HTTP, SMTP	Application	application specific needs
TCP, UDP	Transport	process to process data transfer
IP	Network	host to host data transfer across different network
Ethernet, WiFi	Link	data transfer between physically adjacent nodes
802.3 PHY	Physical	bit-by-bit or symbol-by-symbol delivery

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Outline

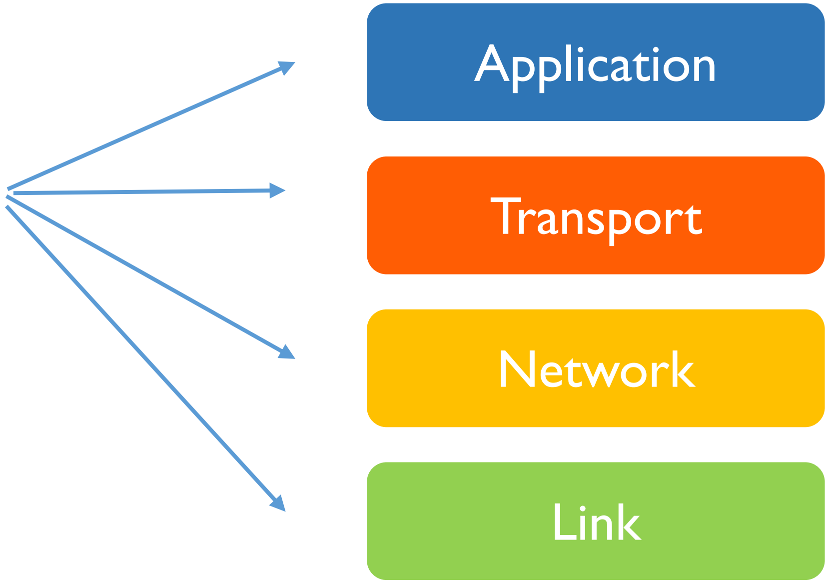
1. Design point of view: End-to-end argument
2. Architecture point of view: Server/client vs peer-to-peer
3. Maintenance point of view: Stateless protocol vs Stateful protocol
4. OS point of view: Network application as a process

Imagine yourself
as one of the system designers of the Internet

Liba Svobodova (left)
David D. Clark(mid)
Jerome H. Saltzer (right)
David P. Reed (below)

According to end-to-end argument: Not at the Core But at the Edges!

Where to place functionality?



Saltzer, Reed, Clark advocated for dumb network and intelligent endpoints

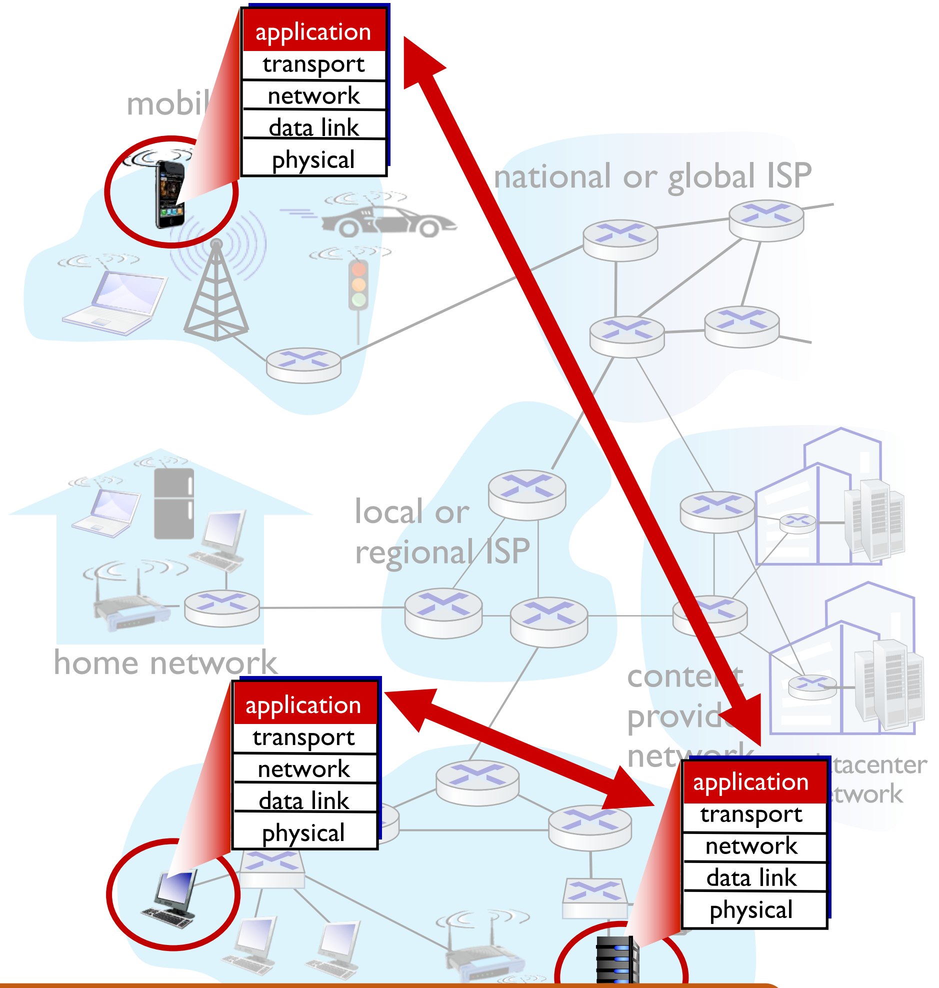
- “The application knows best.”
- “Functionality should be implemented at a lower layer if and only if it can be correctly and completely implemented there”
  - Avoid at lower level if redundant with higher level
  - Performance optimizations are not a violation

Reliable File Transfer: What can go wrong when sending a file over a network?

- Disk can introduce bit errors
- Host I/O buses can introduce bit errors
- Packets can get garbled, dropped, mis-ordered at any hop
- Checking correctness at each step/hop is redundant
- Solution: integrity check on file by application

Applications only run on the endpoints!

- Network core devices do NOT run user applications
  - No code to write for these ☺
- When developing an app, we only need to consider the two ends
  - server/client or peers



This allowed rapid app development and propagation

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Client-server model

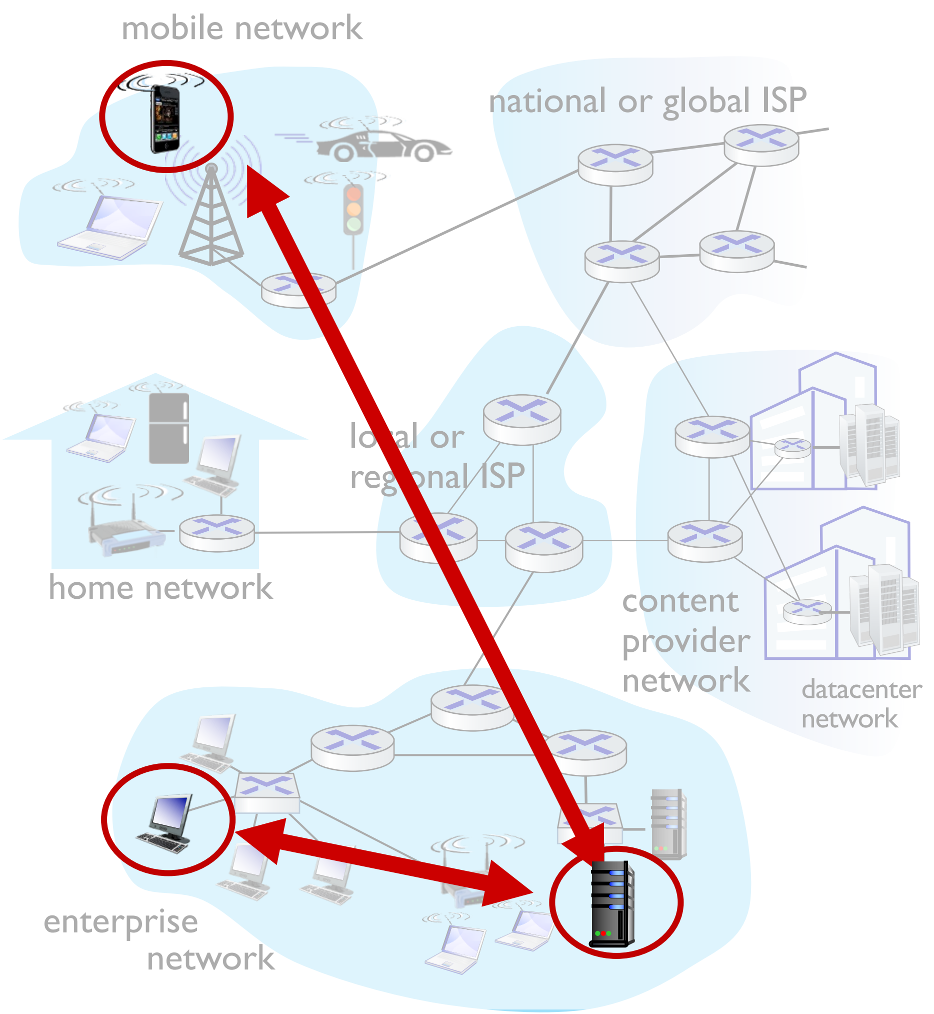
server:

- always-on host
- permanent IP address
- often in data centers, for scaling

clients:

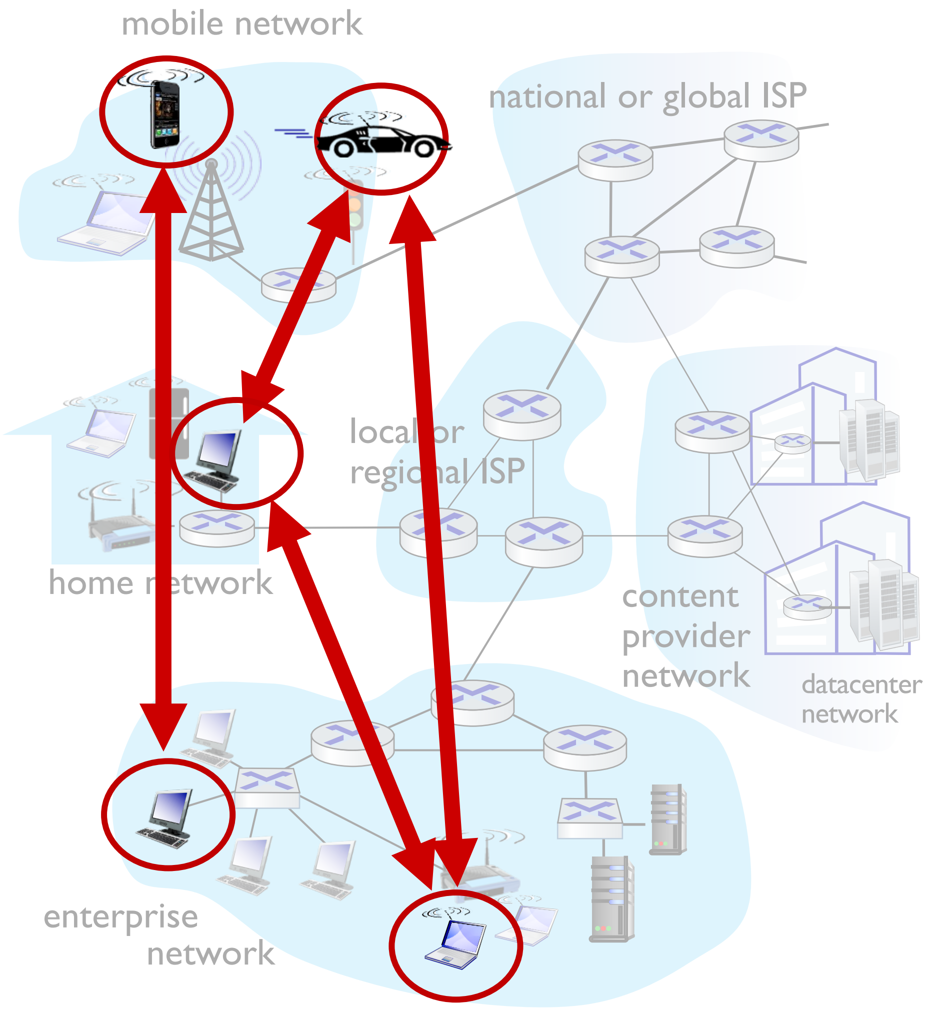
- contact, communicate with server
- may be intermittently connected
- may have dynamic IP addresses
- do not communicate directly with each other

- examples: HTTP, IMAP, FTP



Peer-to-peer model

- no always-on server
- arbitrary end systems directly communicate
- Self scalability - new peers bring new service capacity, as well as new service demands
- peers are intermittently connected and change IP addresses
- example: Gnutella, BitTorrent



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A stateless protocol does not store any “state”

- No session information is retained by the server or the client (or peers)
- Does not track “state” of each other
- Each request/response pair is independent of each other
- No need to do recovery from a partially-completed transaction
- Ex) HTTP, IP, UDP

Is POP a stateless protocol or stateful?

A stateful protocol does store and maintain "states"

- Typically, the server keeps track of session info for each client (Or peers keep track of session info of others)
- The request has to be understood within a context based on previous history
- When one crash, need to handle the recovery from partially completed session

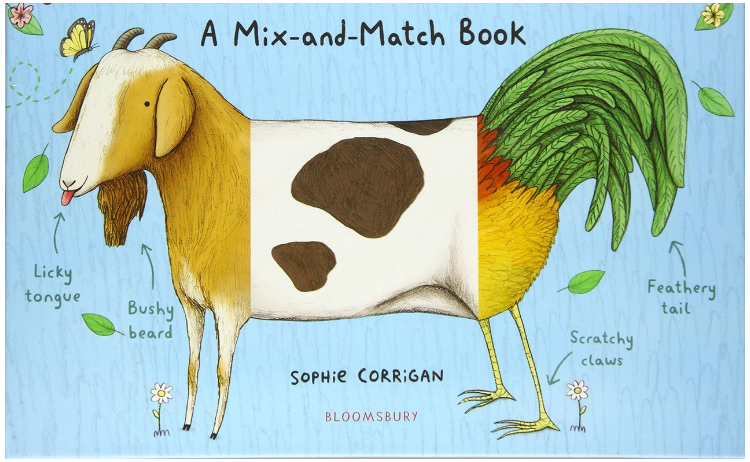
Is P0P a stateless protocol or stateful?

Can stateless protocol be used on top of stateful one?

- Vice-versa?

Yes! Mix-n-match is possible!

- HTTP – stateless
- TCP – stateful
- IP – stateless
- 802.11 – stateful



Encapsulation of layering enables it!

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Net applications are two processes communicating over network by exchanging messages

Process? A program running within a host

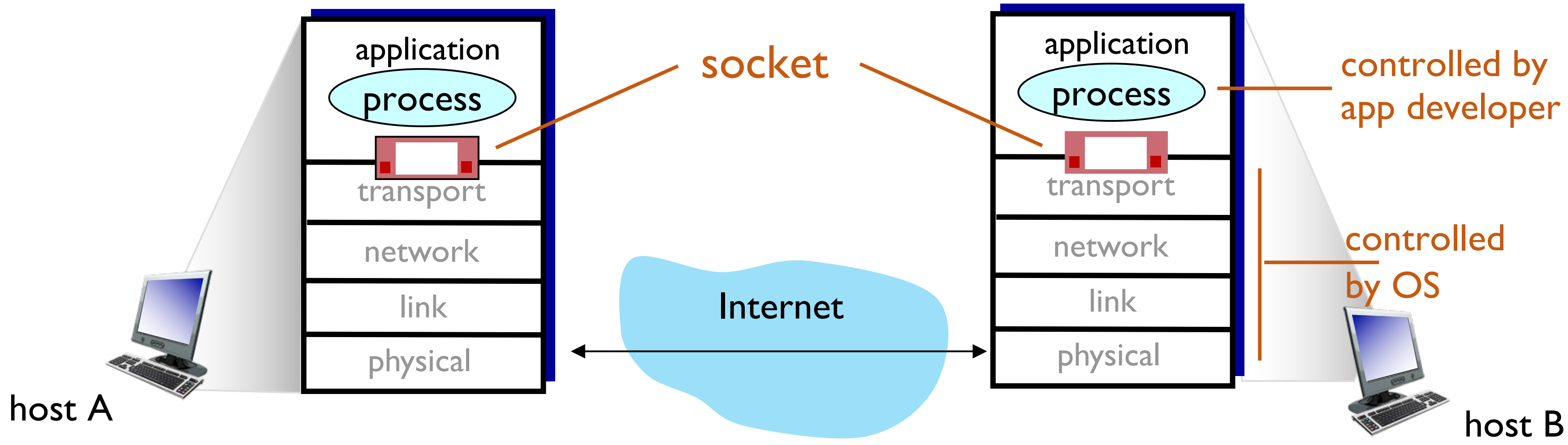
- processes within the same hosts communicate using inter-process communication (defined by OS)
- processes in different hosts communicate by exchanging messages across network

client process: process that initiates communication

server process: process that waits to be contacted

What is a Socket?

- process sends/receives messages to/from its socket
- socket analogous to a "door"
  - sending process shoves message out the door
  - sending process relies on transport layer to deliver message to socket at receiving process
  - two sockets involved: one on each end



Since many processes run on the same host thus the identifier must include IP and port number

- Socket is an endpoint of the communication
  - Door to the process
- Socket needs to be identified
  - UDP: identified by pair <IP: Port>
  - TCP: identified by 4 tuples <src IP: src Port, dst IP: src Port>
- example port numbers:
  - HTTP server: 80
  - mail server: 25
- to send HTTP message to www.cs.utexas.edu web server:
  - IP address: 128.83.120.48
  - port number: 80

In summary, network application vs socket vs port

- Network app is a process that runs on an end-host
- End-host is identified by a IP address
  - Must be unique within the Internet (ignoring NAT for now)
- Network app sends/recvs messages to/from transport layer via socket
  - Sockets are the two endpoints of transport layer
- Sockets are identified by a port number
  - Must be unique within the host
- One application may have multiple sockets
  - Multiple doors: why?

Acknowledgements

Slides are adopted from Kurose’ Computer Networking Slides