



COMPUTER NETWORKS

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Application Layer

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Unit – 2 Application Layer

2.1 Principles of Network Applications

2.2 Web, HTTP and HTTPS

2.3 The Domain Name System

2.4 P2P Applications

2.5 Socket Programming with TCP & UDP

2.6 Other Application Layer Protocols

Unit – 2 Application Layer

2.1 Principles of Network Applications

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2.4 P2P Applications

2.5 Socket Programming with TCP & UDP

2.6 Other Application Layer Protocols

Our goals:

- Conceptual *and* implementation aspects of application-layer protocols
 - transport-layer service models
 - client-server paradigm
 - peer-to-peer paradigm
- Learn about protocols by examining popular application-layer protocols
 - HTTP
 - SMTP, IMAP
 - DNS
- Programming network applications
 - socket API

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Some Network Apps

- social networking
- Web
- text messaging
- e-mail
- multi-user network games
- streaming stored video (YouTube, Hulu, Netflix)
- P2P file sharing
- voice over IP
- real-time video conferencing (e.g., Skype, Hangouts)
- Internet search
- remote login
- ...



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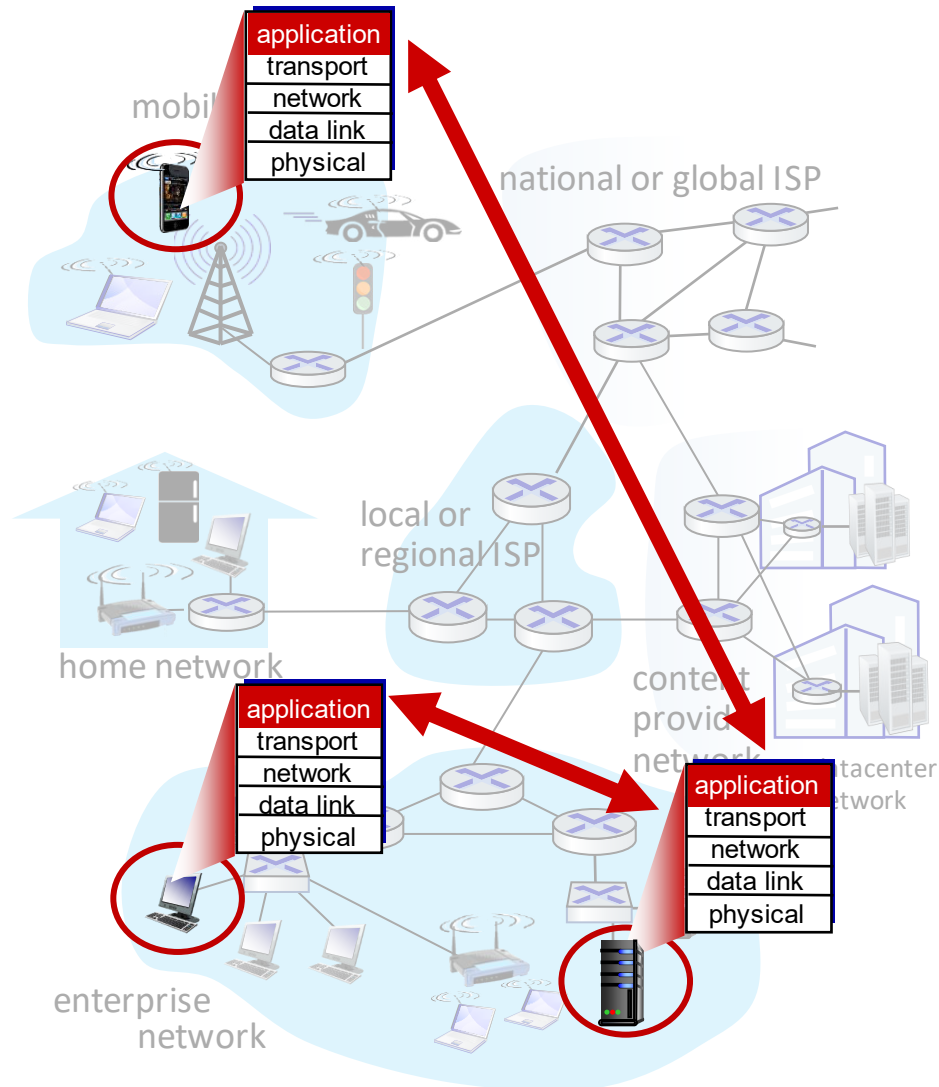
Creating a Network App

write programs that:

- run on (different) end systems
- communicate over network
- e.g., web server software communicates with browser software

no need to write software for network-core devices

- network-core devices do not run user applications
- applications on end systems allows for rapid app development, propagation



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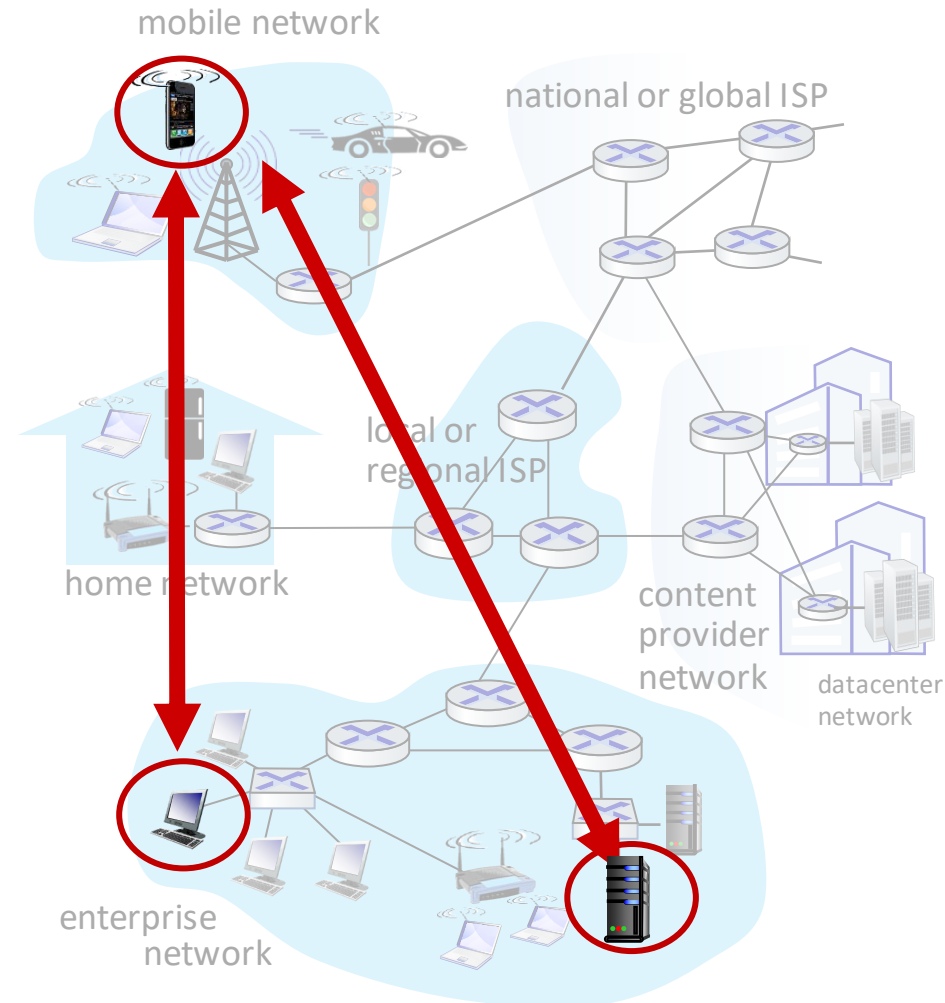
Client-Server Paradigm

server:

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

clients:

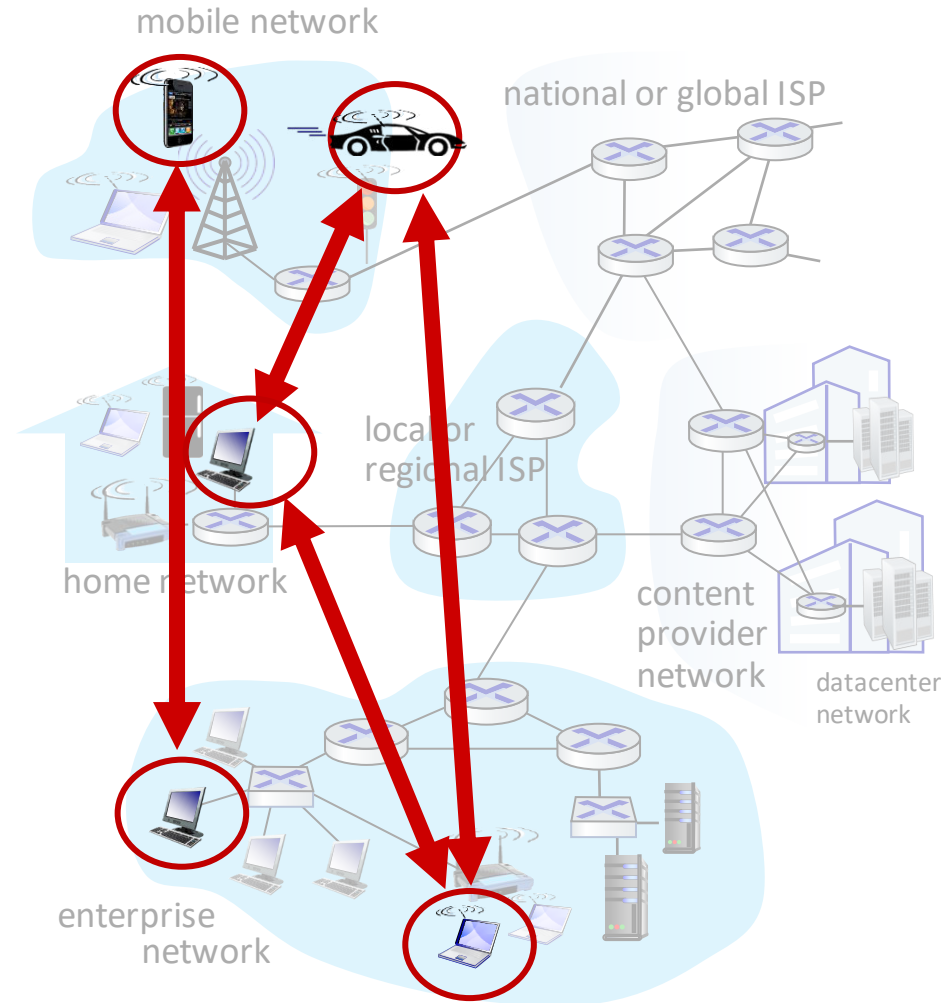
- contact, communicate with server
- may be intermittently connected
- may have dynamic IP addresses
- do *not* communicate directly with each other
- examples: HTTP, IMAP, FTP



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Peer-to-Peer Architecture

- *no* always-on server
- arbitrary end systems directly communicate
- peers request service from other peers, provide service in return to other peers
 - *self scalability* – new peers bring new service capacity, as well as new service demands
- peers are intermittently connected and change IP addresses
 - complex management
- example: P2P file sharing



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Processes Communicating

process: program running within a host

- within same host, two processes communicate using **inter-process communication** (defined by OS)
- processes in different hosts communicate by exchanging **messages**

clients, servers

client process: process that initiates communication

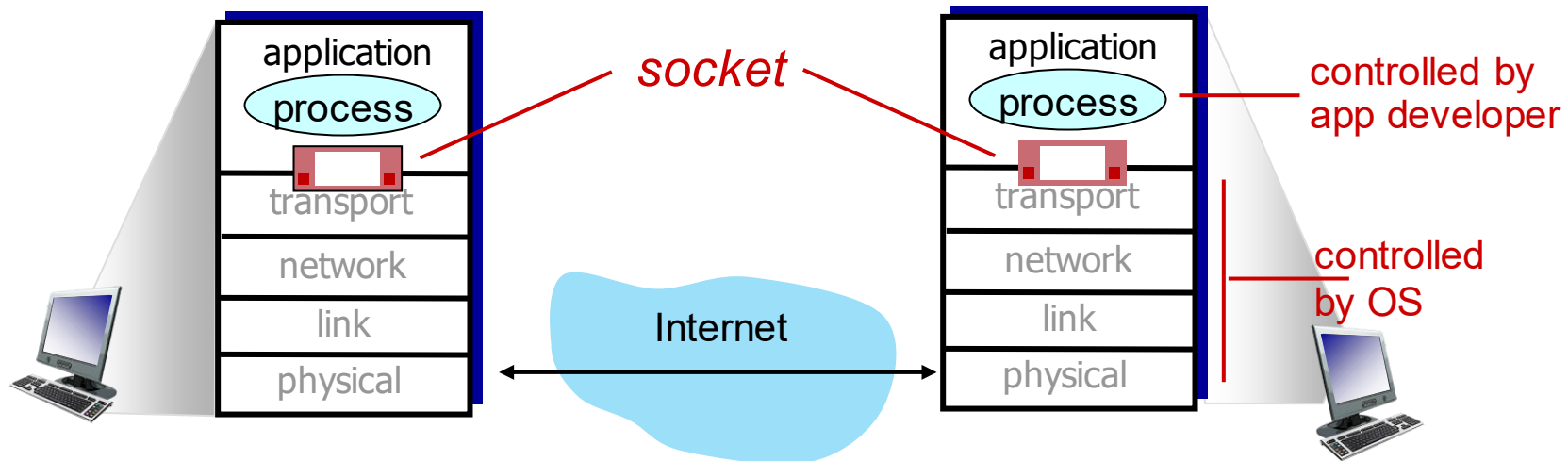
server process: process that waits to be contacted

- note: applications with P2P architectures have client processes & server processes

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Sockets

- process sends/receives messages to/from its **socket**
- socket analogous to door
 - sending process shoves message out door
 - sending process relies on transport infrastructure on other side of door to deliver message to socket at receiving process
 - two sockets involved: one on each side



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Addressing Processes



- to receive messages, process must have *identifier*
- host device has unique 32-bit IP address
- Q: does IP address of host on which process runs suffice for identifying the process?
 - A: no, *many* processes can be running on same host
- *identifier* includes both **IP address** and **port numbers** associated with process on host.
- example port numbers:
 - HTTP server: 80
 - mail server: 25
- to send HTTP message to gaia.cs.umass.edu web server:
 - **IP address**: 128.119.245.12
 - **port number**: 80
- more shortly...

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An Application-layer Protocol defines:

- **types of messages exchanged**,
 - e.g., request, response
- **message syntax**:
 - what fields in messages & how fields are delineated
- **message semantics**
 - meaning of information in fields
- **rules** for when and how processes send & respond to messages

open protocols:

- defined in RFCs, everyone has access to protocol definition
- allows for interoperability
- e.g., HTTP, SMTP

proprietary protocols:

- e.g., Skype

data integrity

- some apps (e.g., file transfer, web transactions) require 100% reliable data transfer
- other apps (e.g., audio) can tolerate some loss

timing

- some apps (e.g., Internet telephony, interactive games) require low delay to be “effective”

throughput

- some apps (e.g., multimedia) require minimum amount of throughput to be “effective”
- other apps (“elastic apps”) make use of whatever throughput they get

security

- encryption, data integrity, ...

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Transport service requirements: common apps



application	data loss	throughput	time sensitive?
file transfer/download	no loss	elastic	no
e-mail	no loss	elastic	no
Web documents	no loss	elastic	no
real-time audio/video	loss-tolerant	audio: 5Kbps-1Mbps video:10Kbps-5Mbps	yes, 10's msec
streaming audio/video	loss-tolerant	same as above	yes, few secs
interactive games	loss-tolerant	Kbps+	yes, 10's msec
text messaging	no loss	elastic	yes and no

TCP service:

- *reliable transport* between sending and receiving process
- *flow control*: sender won't overwhelm receiver
- *congestion control*: throttle sender when network overloaded
- *does not provide*: timing, minimum throughput guarantee, security
- *connection-oriented*: setup required between client and server processes

UDP service:

- *unreliable data transfer* between sending and receiving process
- *does not provide*: reliability, flow control, congestion control, timing, throughput guarantee, security, or connection setup.

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Internet Transport Protocol Services



application	application layer protocol	transport protocol
file transfer/download	FTP [RFC 959]	TCP
e-mail	SMTP [RFC 5321]	TCP
Web documents	HTTP 1.1 [RFC 7320]	TCP
Internet telephony	SIP [RFC 3261], RTP [RFC 3550], or proprietary (Skype)	TCP or UDP
streaming audio/video	DASH	TCP
interactive games	WOW, FPS (proprietary)	UDP or TCP



THANK YOU

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