

# Computer Networks

## CS3001

### (Section BDS-7A)

## Lecture 06

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# Chapter 2

## Application Layer

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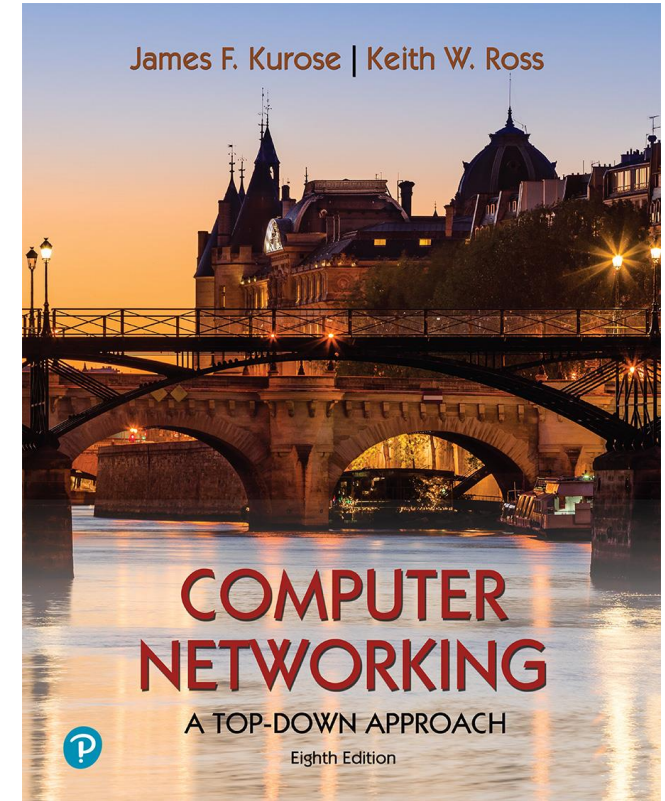
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*Computer Networking: A  
Top-Down Approach*

8<sup>th</sup> edition  
Jim Kurose, Keith Ross  
Pearson, 2020

# Topics Excluded Tentatively (Chapter 2)

- Peer-to-Peer Applications, Video Streaming, CDN, DASH
- GDPR
- Socket Programming: Creating Network Applications

# Application layer: overview

- Principles of network applications
- Web and HTTP
- E-mail, SMTP, IMAP
- The Domain Name System DNS
- P2P applications
- video streaming and content distribution networks
- socket programming with UDP and TCP



# Application layer: overview

## 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 and infrastructure
  - HTTP
  - SMTP, IMAP
  - DNS
  - video streaming systems, CDNs
- programming network applications
  - socket API

# 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 (e.g., Skype)
  - real-time video conferencing (e.g., Zoom)
  - Internet search
  - remote login
  - ...
- Q: *your* favorites?

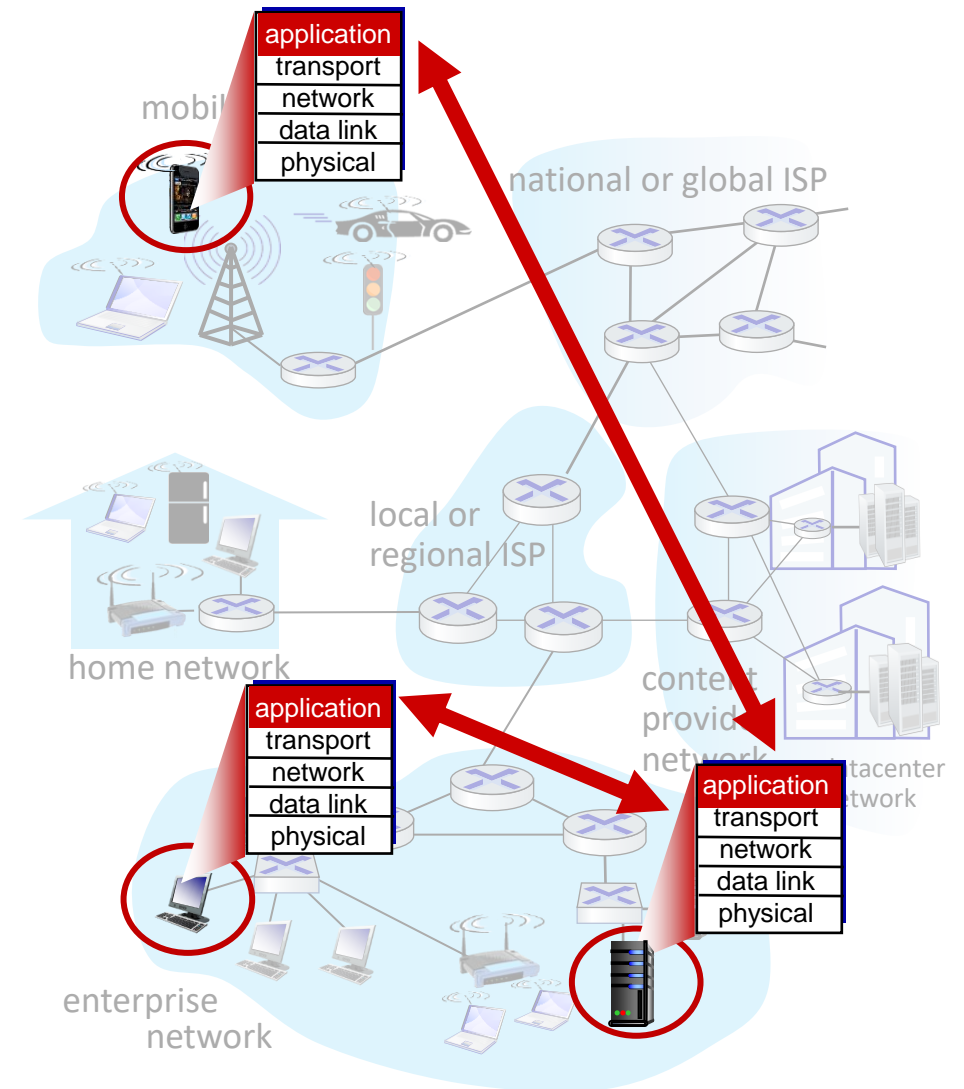
# Creating a network app

## 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



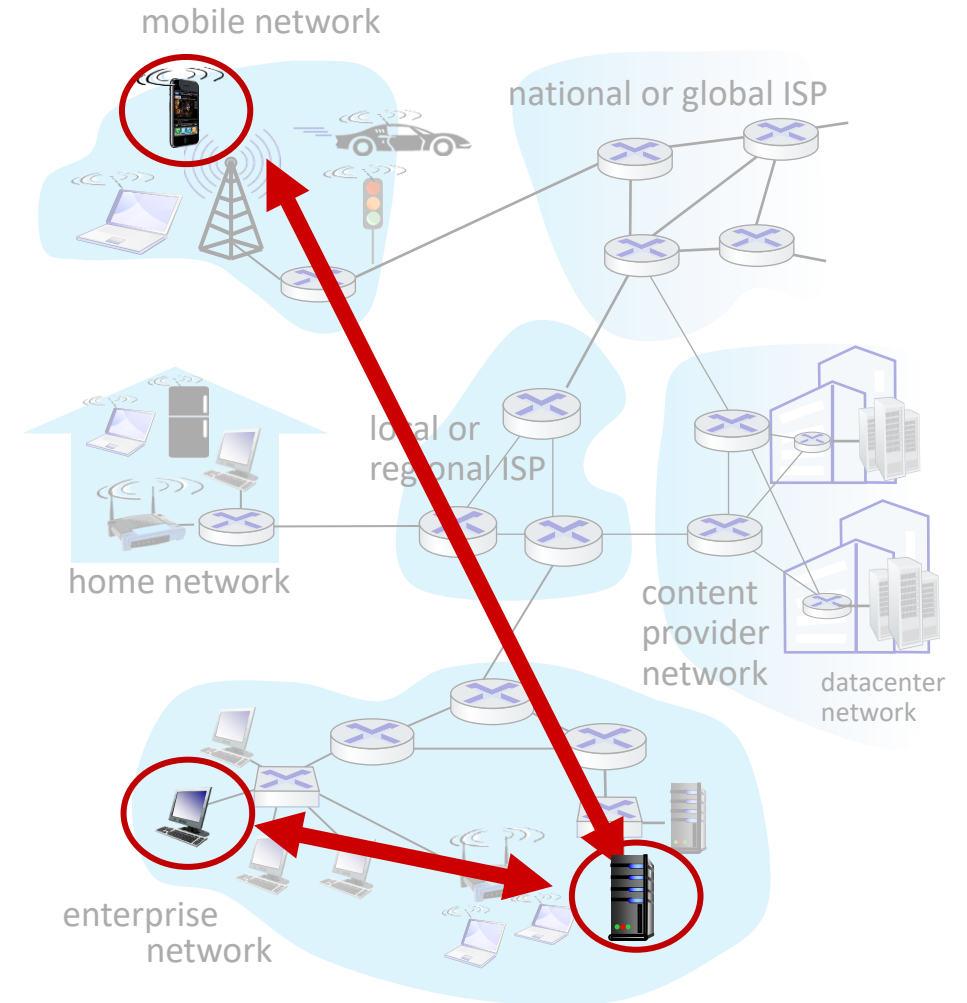
# Client-server paradigm

## server:

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

## clients:

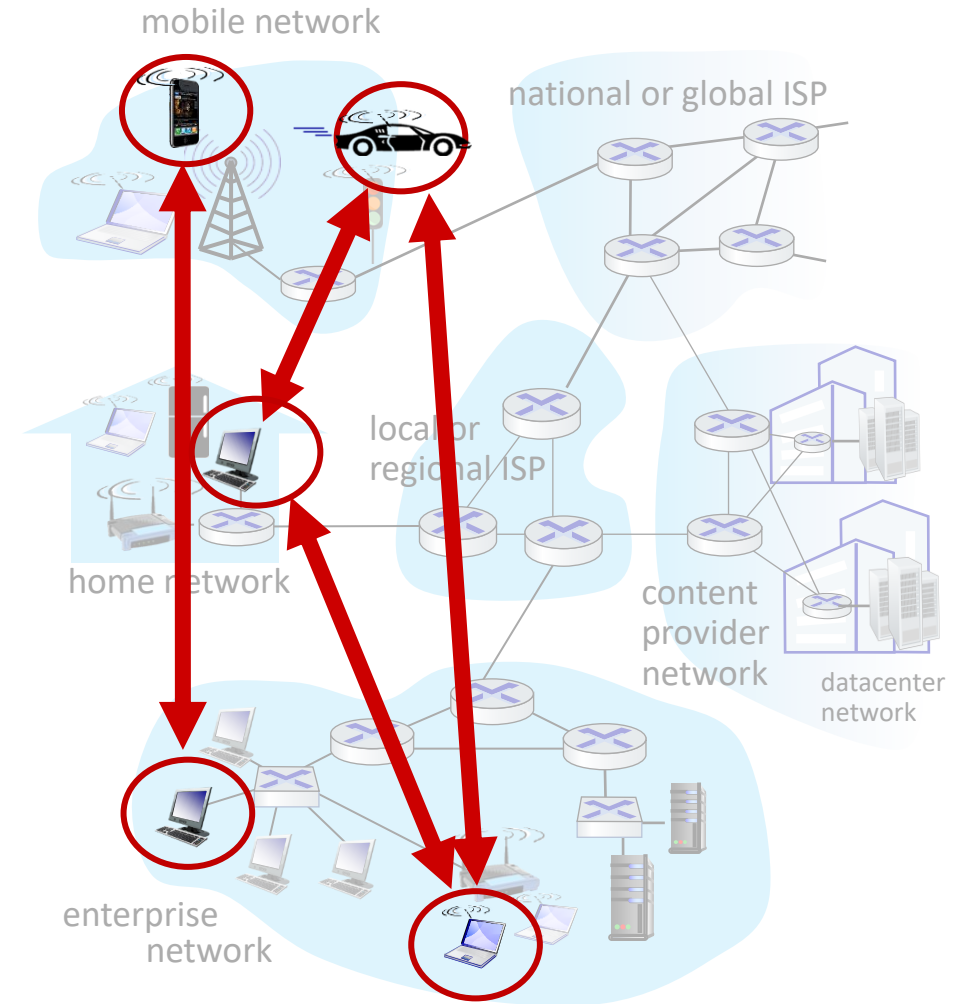
- contact, communicate with server
- may be intermittently connected
- may have dynamic IP addresses
- do *not* communicate directly with each other
- examples: HTTP, IMAP, FTP





# Peer-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 [BitTorrent]



# 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

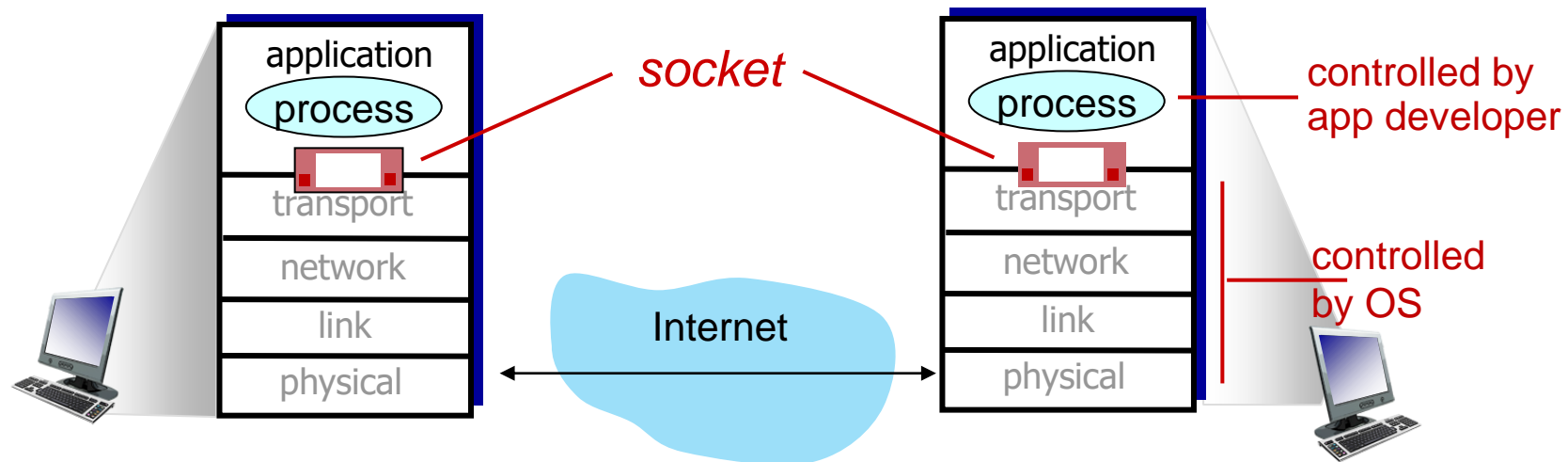
*client process*: process that initiates communication

*server process*: process that waits to be contacted

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

# 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



# 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...

# 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, Zoom

# What transport service does an app need?

## 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, ...

# Transport service requirements: common apps

<b>application</b>	<b>data loss</b>	<b>throughput</b>	<b>time sensitive?</b>
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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

# Internet transport protocols services

## *TCP service:*

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

## *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.

Q: why bother? *Why* is there a UDP?



# Internet applications, and transport protocols

<b>application</b>	<b>application layer protocol</b>	<b>transport protocol</b>
file transfer/download	FTP [RFC 959]	TCP
e-mail	SMTP [RFC 5321]	TCP
Web documents	HTTP [RFC 7230, 9110]	TCP
Internet telephony	SIP [RFC 3261], RTP [RFC 3550], or proprietary	TCP or UDP
streaming audio/video	HTTP [RFC 7230], DASH	TCP
interactive games	WOW, FPS (proprietary)	UDP or TCP