Welcome to

***CS 3516**:*
Advanced Computer Networks

Prof. Yanhua Li

Time: 9:00am –9:50am M, T, R, and F

Location: AK219

Fall 2018 A-term

Lab assignment 1 Grading

Done

Quiz 1 and 2 Grading

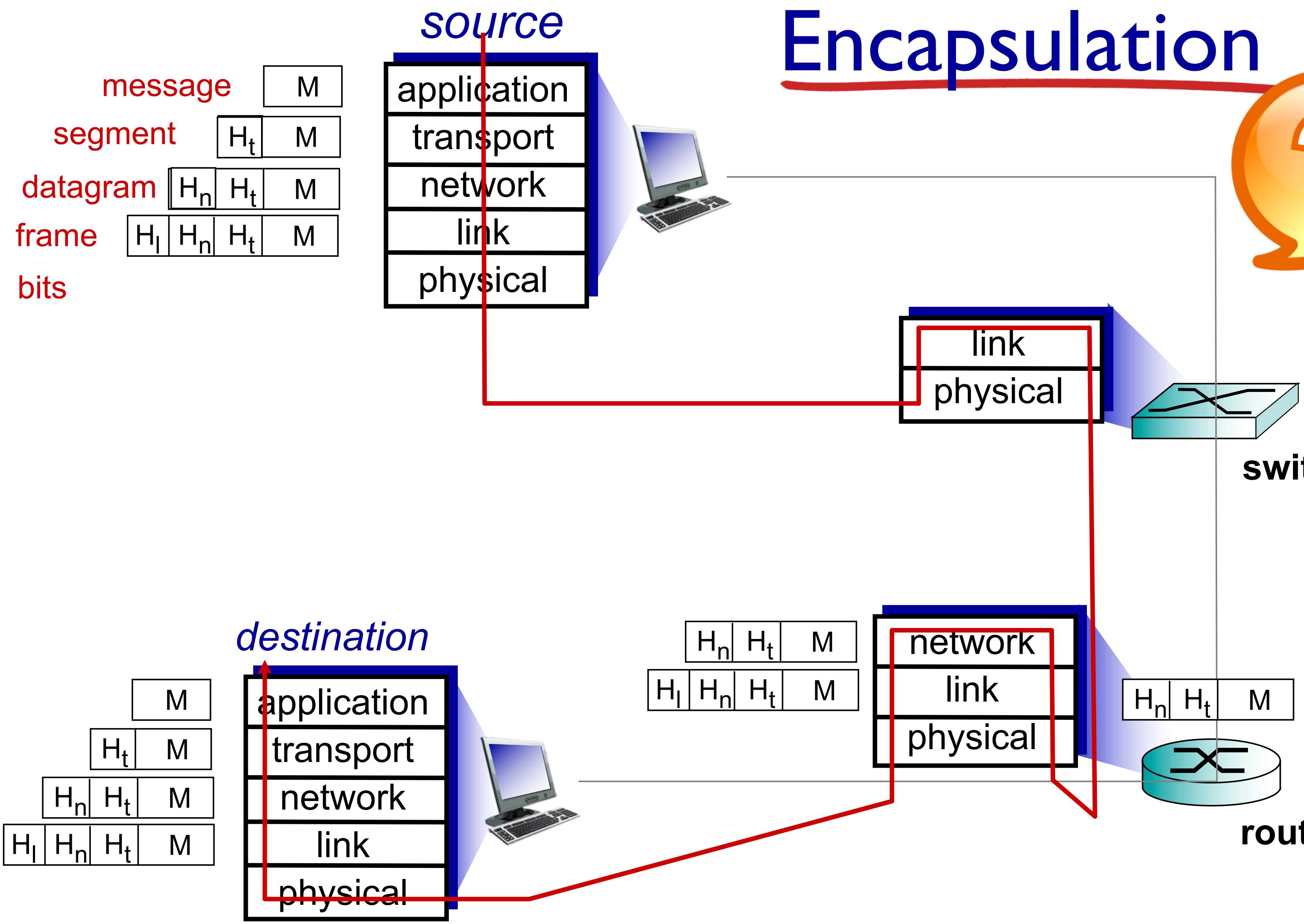
Quiz 1: Done

Quiz 2: by today

Quiz 3 this Friday

On HTTP protocol with a bonus question

Encapsulation



Course Progression

- Week 1-2: Overview
- Week 2-4: Application Layer Protocols
  - HTTP, DNS, P2P, SMTP
- Week 4-5: Transport Layer Protocols
  - UDP and TCP
- Week 6: IP, Routing Protocols
- Week 7: Link Layer Protocols
- Week 8: Wireless & Data Center Networking
- Slides for the lecture will be posted on the website

Online social networks

Voice call

Online search service

Online shopping

Video Streaming

Some network apps

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

Chapter 2: application layer

2.1 principles of network applications

- app architectures
- app requirements

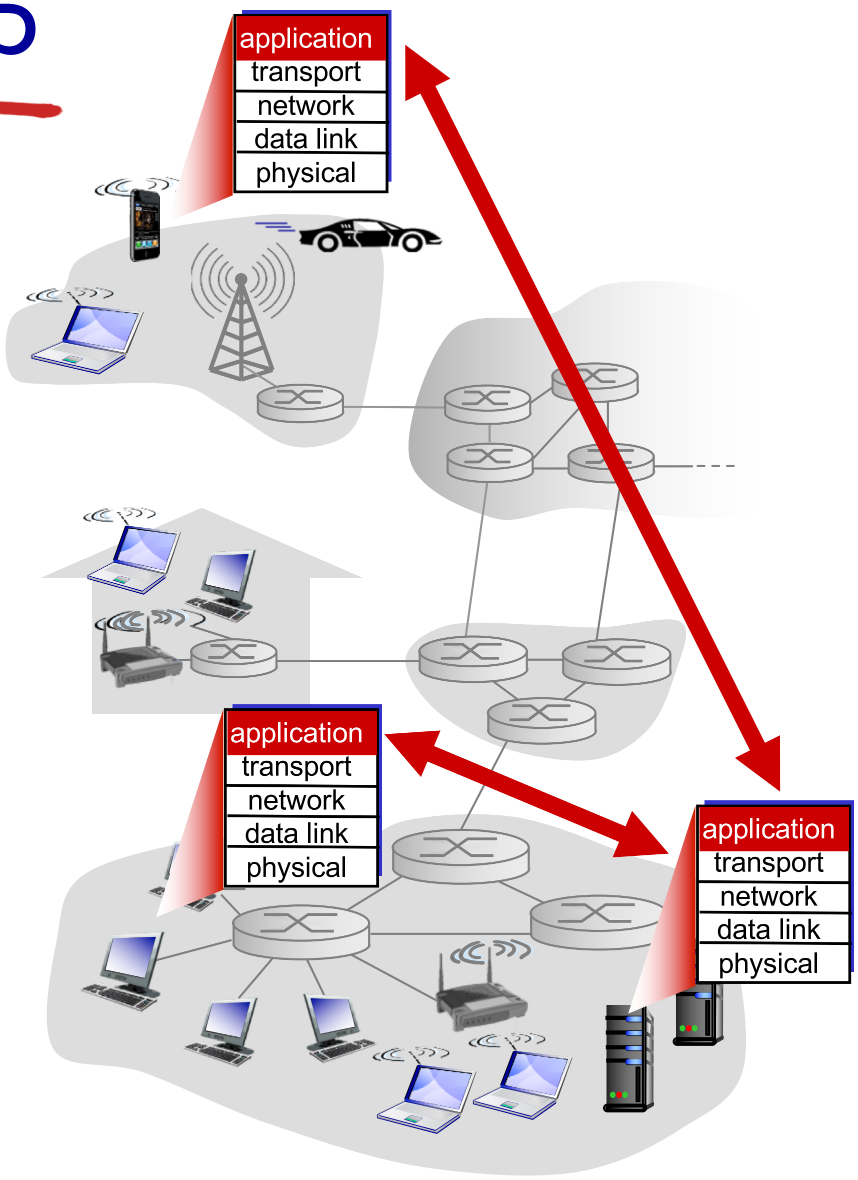
Creating a network app

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**

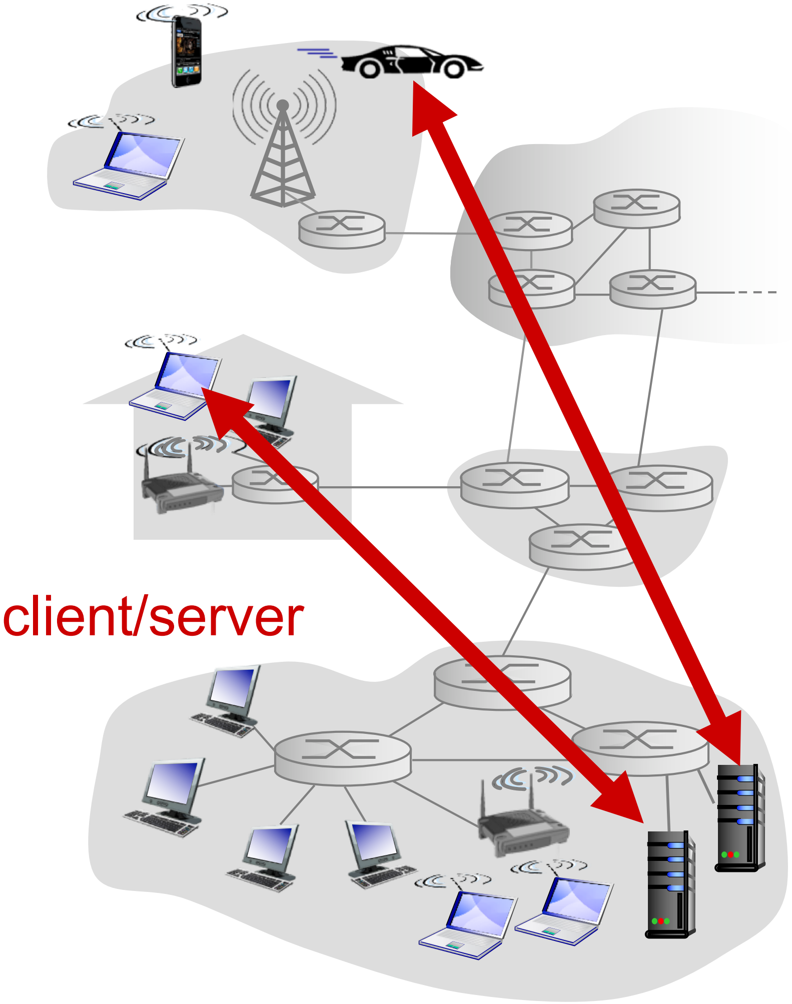


Application architectures

possible structure of applications:

- client-server
- peer-to-peer (P2P)

Client-server architecture



server:

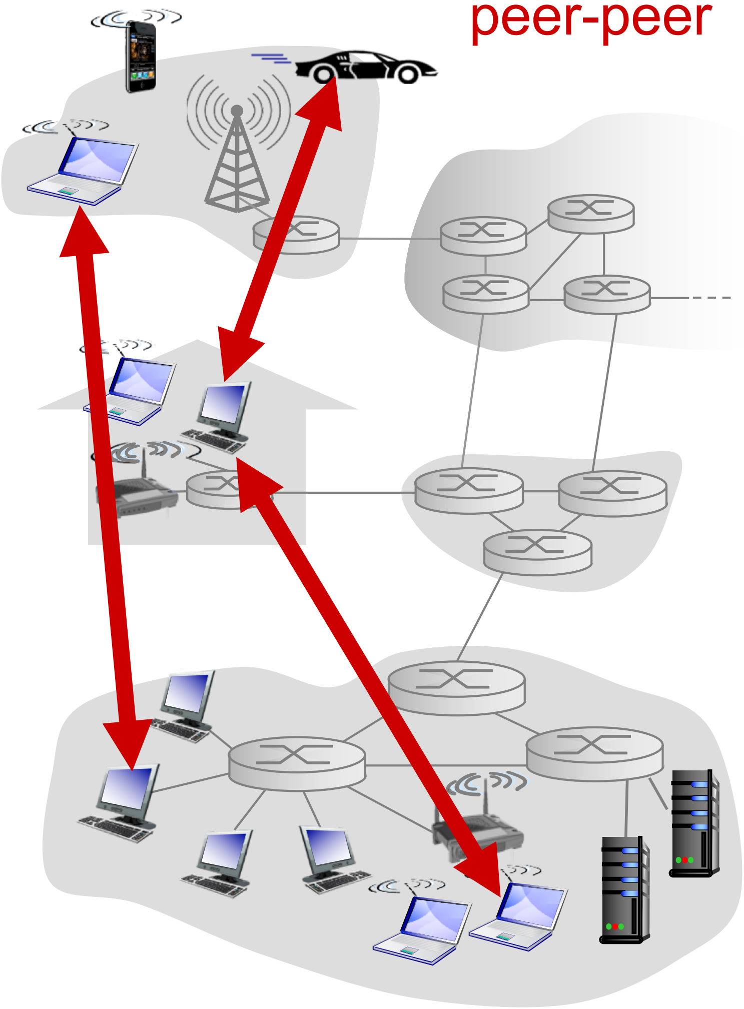
- always-on host
- permanent IP address
- data centers for scaling

clients:

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

P2P 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



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 via sockets

clients, servers

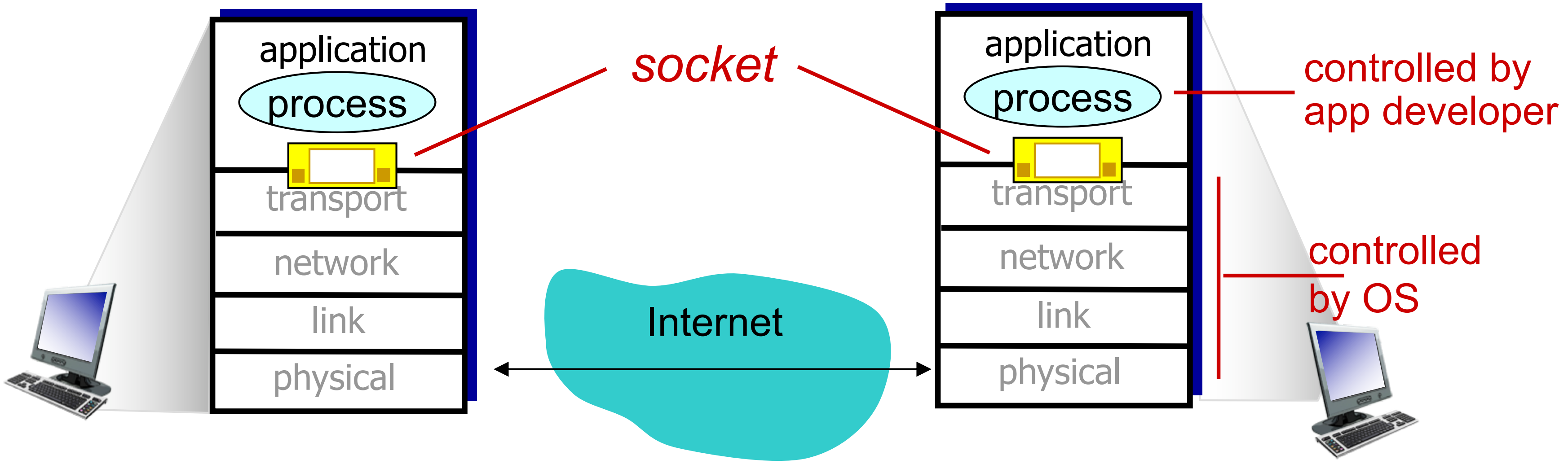
client process: process that initiates communication

server process: process that waits to be contacted

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

Sockets

- process sends/receives messages to/from its socket
- socket analogous to door / mail box
  - sending process shoves message out door / drop it to mail box
  - sending process relies on transport infrastructure on other side of door to deliver message to socket at receiving process



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…

Chapter 2: outline

2.1 principles of network applications

- app architectures
- app requirements

App-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
- allows for interoperability
- e.g., HTTP, SMTP

proprietary protocols:

- e.g., Skype

Transport service requirements: common apps

application	data loss	throughput	time sensitive
file transfer	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, 100's msec
stored audio/video	loss-tolerant	same as above	yes, a few secs
interactive games	loss-tolerant	a few kbps up	yes, 100's msec

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

UDP service:

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

Q: why bother? Why is there a UDP?

A: Lightweight protocol,

Circumventing congestion control & packet overhead

Internet apps: application, transport protocols

application	application layer protocol	underlying transport protocol
e-mail	SMTP [RFC 2821]	TCP
remote terminal access	Telnet [RFC 854]	TCP
Web	HTTP [RFC 2616]	TCP
file transfer	FTP [RFC 959]	TCP
streaming multimedia	HTTP (e.g., YouTube), RTP [RFC 1889]	TCP or UDP
Internet telephony	SIP, RTP, proprietary (e.g., Skype)	TCP or UDP

Questions?

What *transport service* does an app need?

data integrity/ accuracy

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

Timing/delay

- some apps (e.g., Internet telephony, interactive games) require low delay to be "effective"
- Emails may allow longer delay

throughput

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

security

- encryption, data integrity, …

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

- *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,

Q: why bother? Why is there a UDP?

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Circumventing congestion control & packet overhead