

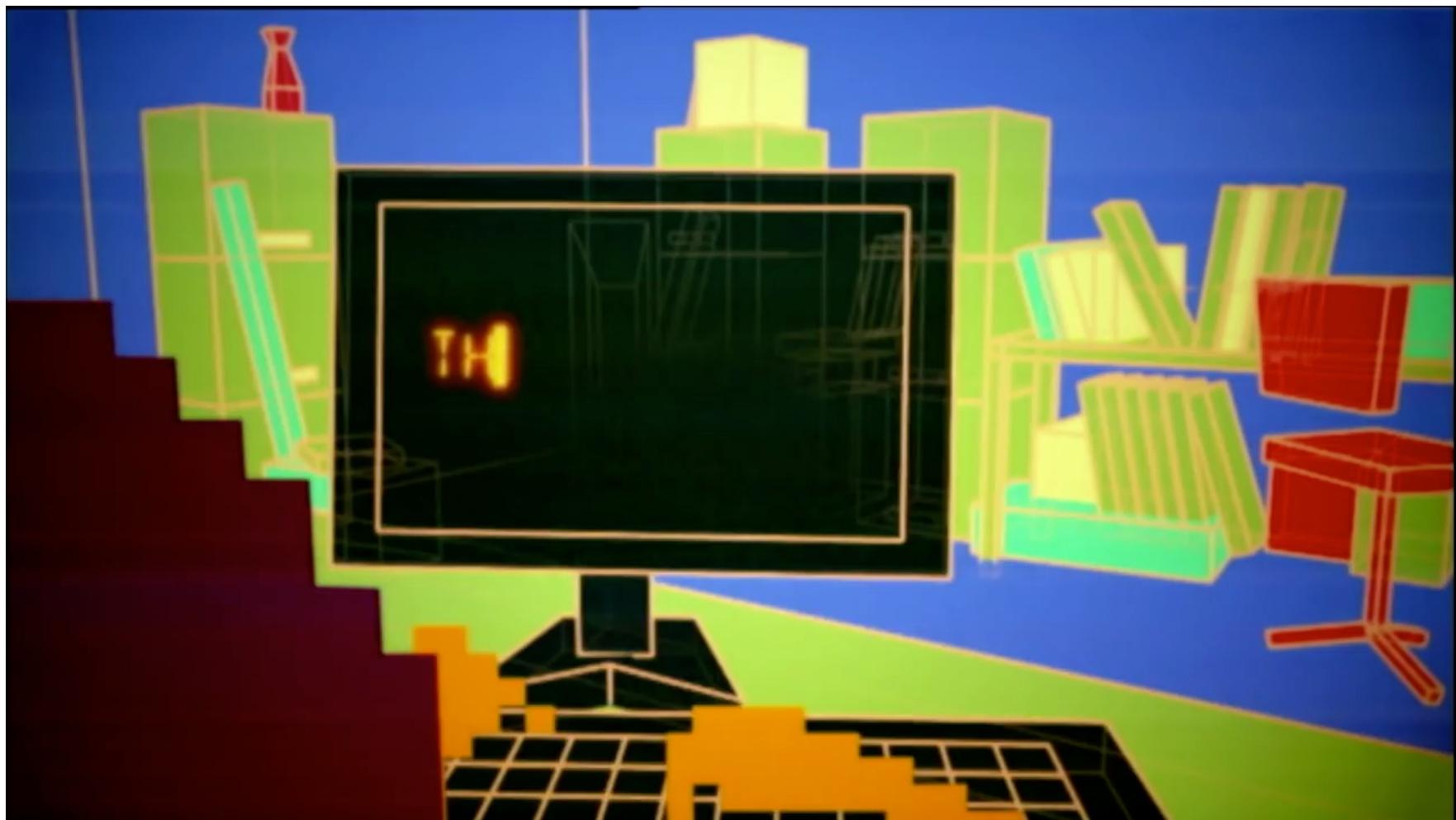
# **Networks & Communications**

MS216  
Semester 1  
Session 2021-22

# Who: Course Staff

- ❖ Your Instructor: Jamal Abdul Nasir
  - Lecturer at BIS, School of Business & Economics
  - Teaching this course 4<sup>th</sup> time at Undergraduate level
  - Research Area: Data Mining, Distributed Computing, and Machine Learning
  - Office Hours: TBD
  - Office#375
  - Email: [jamal.nasir@nuigalway.ie](mailto:jamal.nasir@nuigalway.ie)

# **What *is* the Internet?**



<https://www.youtube.com/watch?v=iDbyYGrswtg>

# The Internet has and is transforming everything

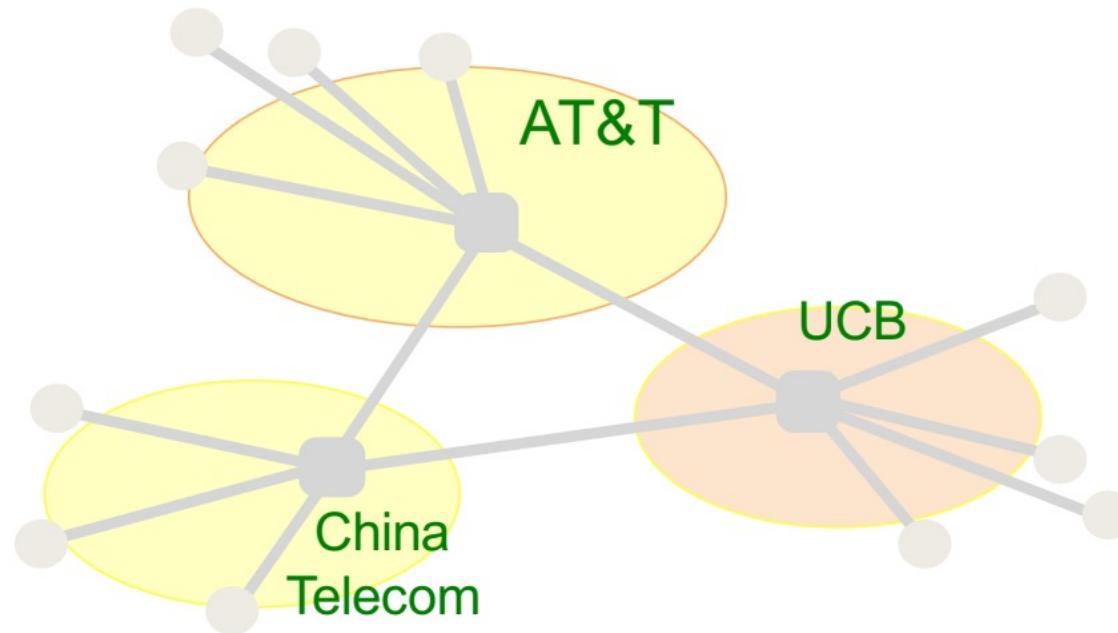
- ❖ The way we do business ...
- retail, advertising, cloud computing
- ❖ The way we have relationships
- Facebook, twitter, WhatsApp
- ❖ • The way we learn
- Wikipedia, search engines, MooCs
- ❖ • The way we govern
- E-voting, censorship, cyber-warfare
- ❖ • The way we cure disease
- digital health, remote surgery

# Network versus “The Internet”

- ❖ There are many kinds of network technologies (switches and links, Ethernet, optical, WIFI access points, DSL modems, Infiniband switches, ...)
- ❖ The Internet is not a new/particular kind of network technology
- ❖ Instead, the Internet ties different networks together  
The Internet

# A federated system

**Interoperability is the Internet's most important goal!**



The Internet interconnects over 40,000 independently operated networks

# A federated system

- ❖ Fundamental challenge: how do you interconnect competing entities?
- ❖ Leads to a constant tussle between business and technical factors
- Real-world incentives determine topology, path selection, diagnostics, and more
  - ❖ And complicates innovation
  - Upgrading “the Internet” is not an option

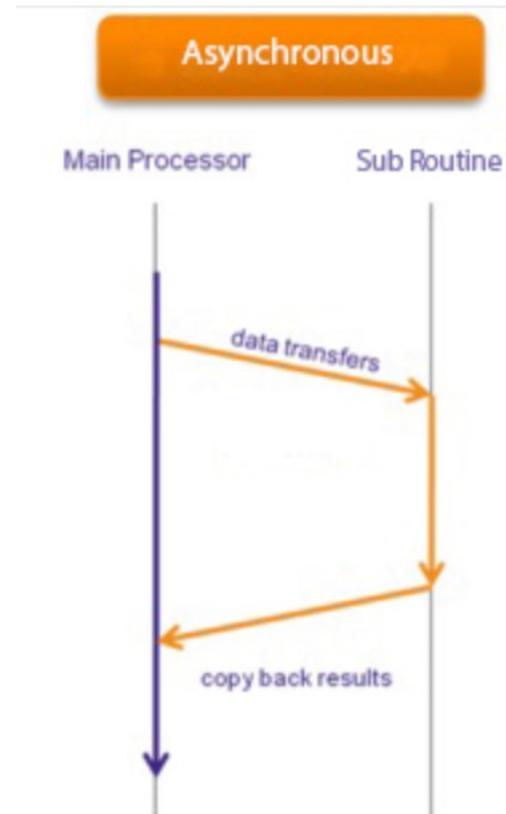
# Internet scale

- ❖ 3.8 Billion users (51% of world population)
- ❖ 1.24 Trillion unique URLs (web pages)
- ❖ Every second, we generate ~ 6000 tweets, 40,000 Google queries, 2M emails

# Enormous diversity and dynamic range

- **Technology**: optical, wireless, satellite, copper,...
- **Communication latency**: microseconds to seconds ( $10^6$ )
- **Bandwidth**: 1Kbits/second to 1 Terabit/second ( $10^8$ )
- **Packet loss**: 0 – 90%
- **Endpoint devices**: sensors, cell phones, datacenters,...
- **Applications**: skype, live video, gaming, remote medicine,...
- **Users**: the governing, governed, operators, selfish, malicious, naïve, savvy,...

# Asynchronous Operation



# Prone to Failure

- ❖ Many components along a path
  - software, switches, links, network interface cards, wireless access points, modem,...
- ❖ Consider: 50 components, that work correctly 99% of time à 39.5% chance communication fail

# Constant Evolution

## 1970s:

- 56,000 bits/second links
- < 100 computers in the US
- Copying files is the “killer” app

## Today

- $10^{12}$  bits/second links
- 8B+ devices, all over the globe
- 2.45B people use facebook

# Recap: The Internet is ...

- ❖ A federated system ...
- ❖ of enormous scale ...
- ❖ with tremendous dynamic range and diversity ...
- ❖ that is asynchronous in operation ...
- ❖ failure prone ...
- ❖ and constantly evolving

# What (I hope) MS 216 will teach you

- ❖ How the Internet works
- ❖ Why it works the way it does
- ❖ How to reason through a complex (networking) design problem

# Communication

- ❖ Website: Blackboard
- ❖ Calendar, schedule, policies, labs, links, assignments, etc.
  - Grade book and assignment submissions via BB
- ❖ Discussion:
  - Ask and answer questions
  - *ALL* questions on course material should go here
  - Can email to make individual appointments

# Course Components and Grading

- ❖ **Individual Homeworks** (15% total)
- ❖ **Group Project** (30%)
- ❖ **Final Exam** (55%)
  - Comprehensive

# Submission Policy

- ❖ Late penalties: 1 day = 10%; 2 day late = 20%; 3 day late = 30%
- ❖ You may only submit ONCE with 50% deduction if you are more than three days late.

# How to Get an A

- ❖ Attend every class
- ❖ Complete your assignments on time
- ❖ Reach out to us if you ever feel stuck or overwhelmed
- ❖ **Persistence is important:** a lot of things will seem new and confusing at first, but you can figure them out – stick with it and don't give up!
  - You learn best from your mistakes

# How to Get an F

- ❖ Attend class after few weeks
- ❖ Copy your assignments from others
- ❖ Never try to understand concepts

# Attendance

- ❖ I dislike mandatory attendance... but in the past we noticed...
  - People who did not attend, failed in the course
  - People who did not attend were less happy with the course

Settings  
Take Attendance  
[Attendance Record](#)

TAKE ATTENDANCE  
2122-MS216 Networks & Communications

FULL LIST **1/1** ONE BY ONE  ACCESSIBILITY  CHECK-IN

Session Title Week-1

Start Check In >

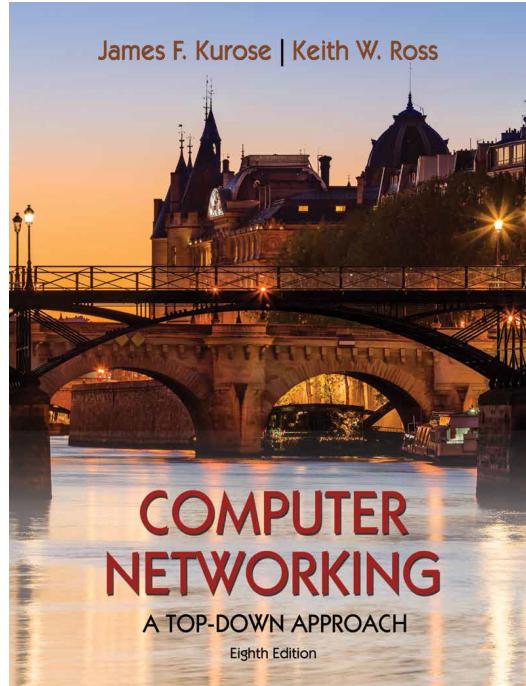
Starting student check in will allow students to check in on their own devices through a web browser, but will prevent you from manually taking attendance.  
- A PIN will be generated on the next screen that students will need to enter.

# Course Outline

Weeks	Readings
<b>Week 1: Introduction to Networking</b>	Chapter-1
<b>Week 2,3,4: Internet Communication Model: Application Layer Services</b> <ul style="list-style-type: none"><li>• WWW and Web Servers, HTTP</li><li>• E-mail Components</li><li>• Video Streaming: Netflix</li><li>• P2P systems</li><li>• DNS</li></ul>	Chapter-2
<b>Week 5: Transport Layer Services</b> <ul style="list-style-type: none"><li>• TCP/UDP</li><li>• Congestion Control</li></ul>	Chapter-3
<b>Week 6: IP addresses and Routing</b> <ul style="list-style-type: none"><li>• What's inside a router?</li><li>• The Internet Protocol</li><li>• IPv4 addressing</li><li>• IPv6 addressing</li></ul>	Chapter-4
<b>Week 7: The Internet Control Message Protocol</b>	Chapter-5
<b>Week 8: The Link Layer and LANs</b>	Chapter-6
<b>Week 8: Network Security</b>	Chapter-8
<b>Week 9: Network Security Techniques</b>	Chapter-8
<b>Week 10: Firewalls</b>	Chapter-7, 10
<b>Week 11: Wireless Networking</b>	Chapter-7
<b>Week 12: Virtualization and Cloud Computing</b>	Class notes

# Text Book

Class textbook:  
*Computer Networking: A Top-Down Approach (8<sup>th</sup> ed.)*  
J.F. Kurose, K.W. Ross  
Pearson, 2020



# The Internet: a “nuts and bolts” view



Billions of connected computing *devices*:

- *hosts* = *end systems*
- running *network apps* at Internet's "edge"



*Packet switches*: forward packets (chunks of data)

- *routers, switches*



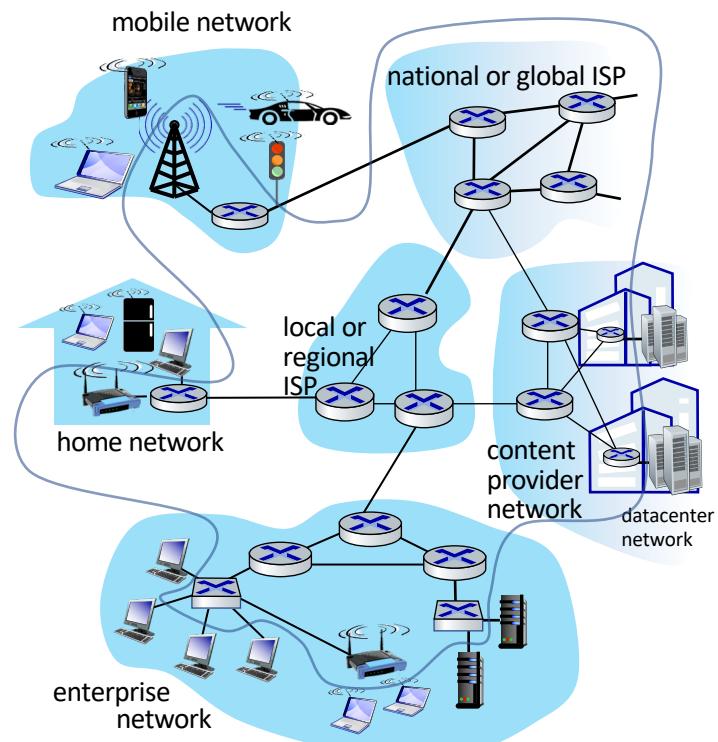
*Communication links*

- fiber, copper, radio, satellite
- transmission rate: *bandwidth*



*Networks*

- collection of devices, routers, links: managed by an organization



# “Fun” Internet-connected devices



Amazon Echo



Internet refrigerator



Security Camera



Internet phones



IP picture frame



Slingbox: remote control cable TV



Pacemaker & Monitor



Web-enabled toaster + weather forecaster



sensorized, bed mattress



Gaming devices



Tweet-a-watt:  
monitor energy use



bikes



cars



scooters



AR devices

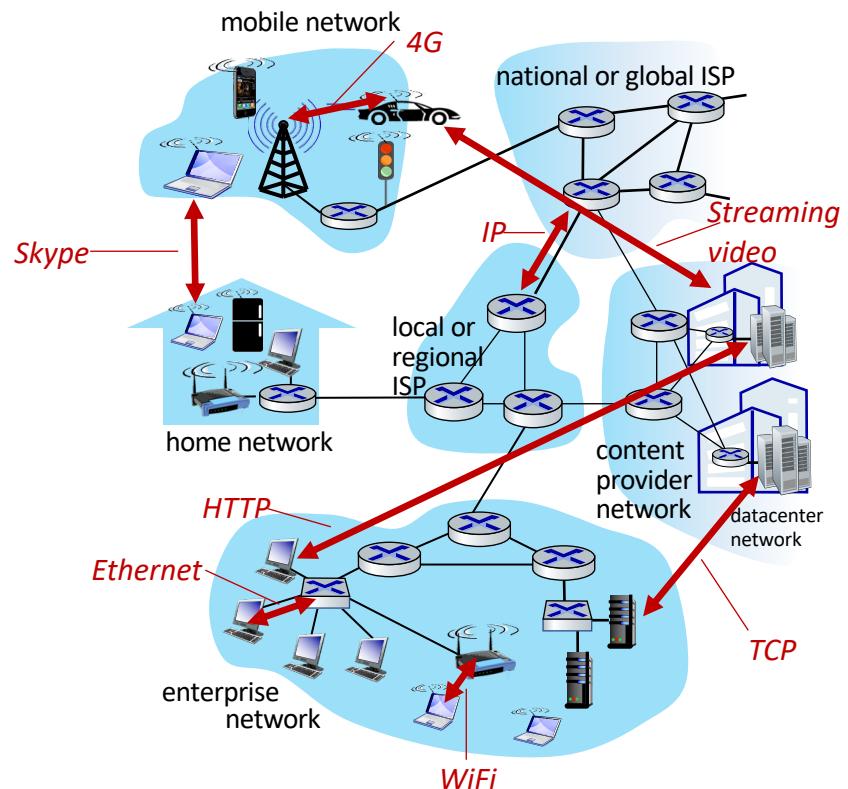


Fitbit

*Others?*

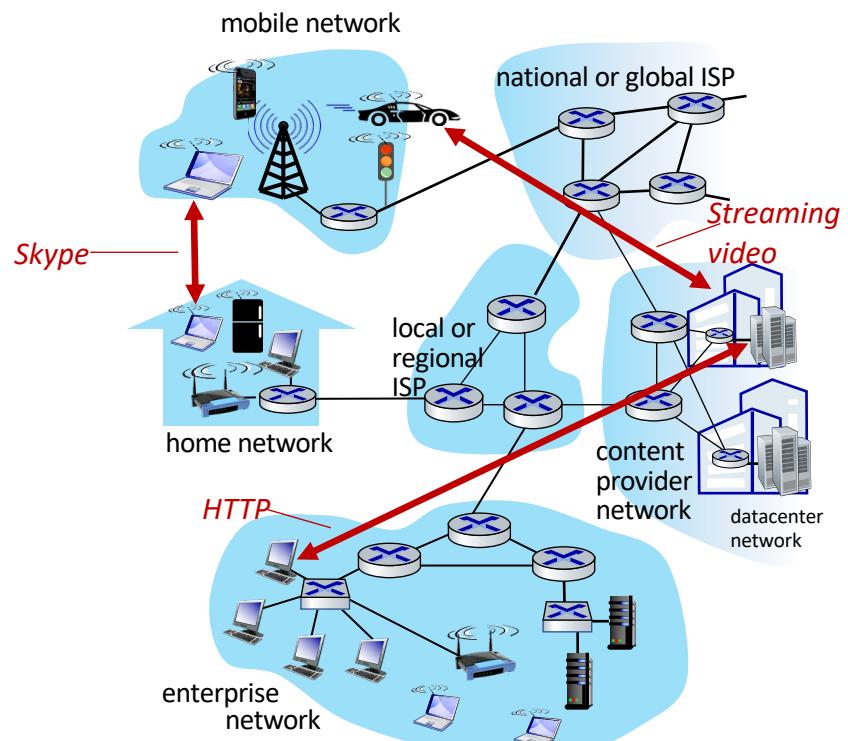
# The Internet: a “nuts and bolts” view

- *Internet: “network of networks”*
  - Interconnected ISPs
- *protocols are everywhere*
  - control sending, receiving of messages
  - e.g., HTTP (Web), streaming video, Skype, TCP, IP, WiFi, 4G, Ethernet
- *Internet standards*
  - RFC: Request for Comments
  - IETF: Internet Engineering Task Force



# The Internet: a “services” view

- *Infrastructure* that provides services to applications:
  - Web, streaming video, multimedia teleconferencing, email, games, e-commerce, social media, interconnected appliances, ...
- provides *programming interface* to distributed applications:
  - “hooks” allowing sending/receiving apps to “connect” to, use Internet transport service
  - provides service options, analogous to postal service



# What's a protocol?

## *Human protocols:*

- “what’s the time?”
- “I have a question”
- introductions

Rules for:

- ... specific messages sent
- ... specific actions taken  
when message received,  
or other events

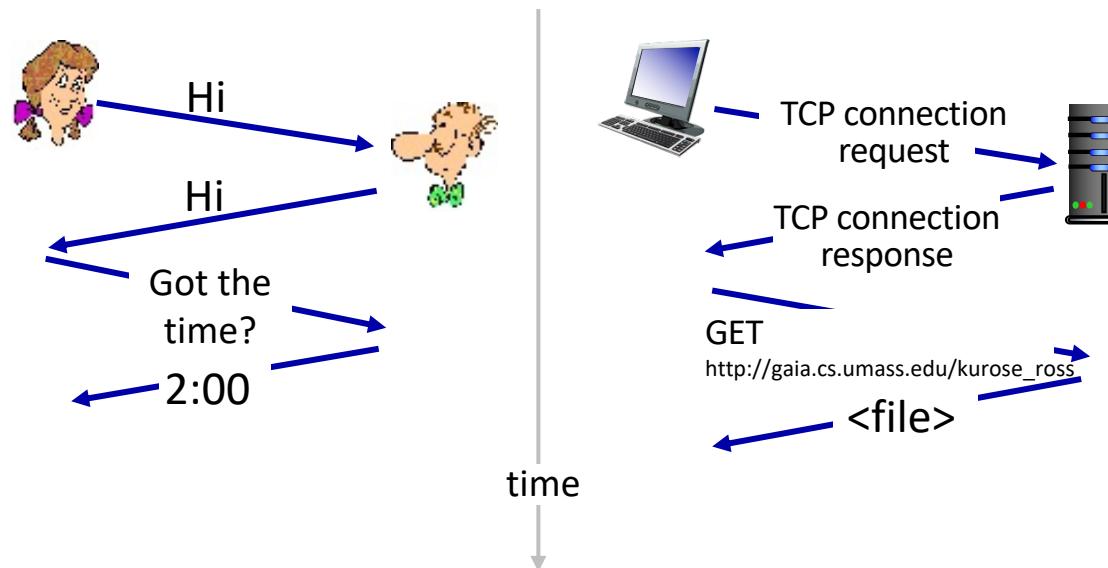
## *Network protocols:*

- computers (devices) rather than humans
- all communication activity in Internet governed by protocols

*Protocols define the **format, order** of messages sent and received among network entities, and **actions taken** on message transmission, receipt*

# What's a protocol?

A human protocol and a computer network protocol:

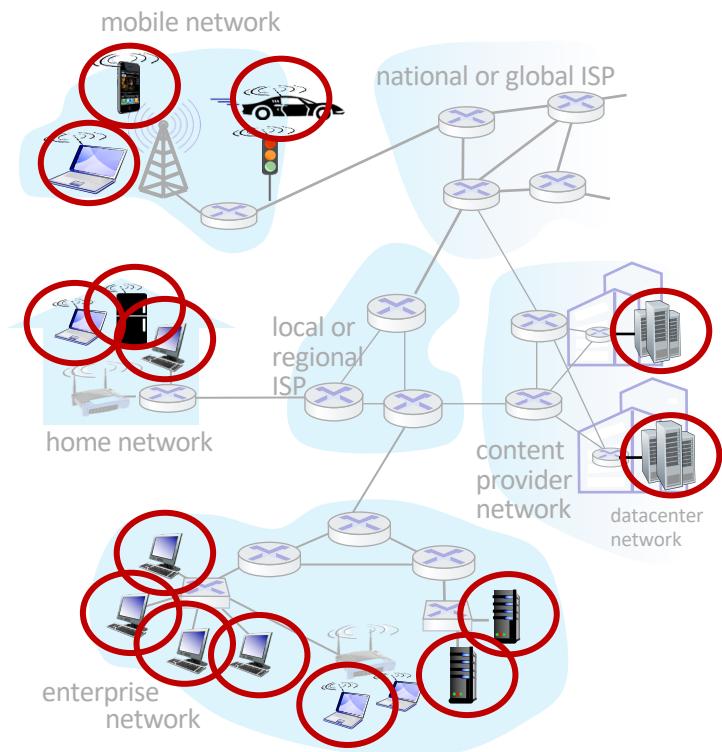


*Q:* other human protocols?

# A closer look at Internet structure

## Network edge:

- hosts: clients and servers
- servers often in data centers



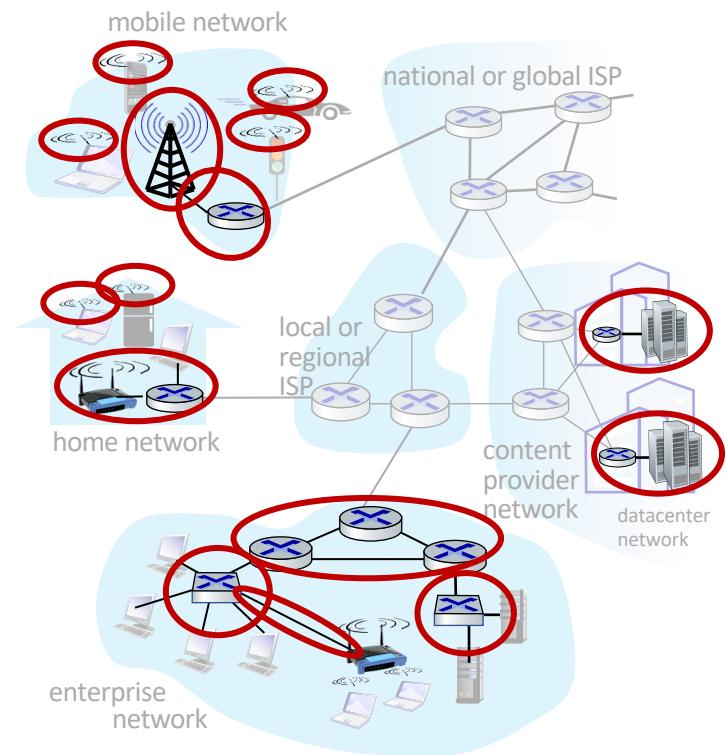
# A closer look at Internet structure

## Network edge:

- hosts: clients and servers
- servers often in data centers

## Access networks, physical media:

- wired, wireless communication links



# A closer look at Internet structure

## Network edge:

- hosts: clients and servers
- servers often in data centers

## Access networks, physical media:

- wired, wireless communication links

## Network core:

- interconnected routers
- network of networks

