Computer Networks

Amir Mahdi Sadeghzadeh, Ph.D.

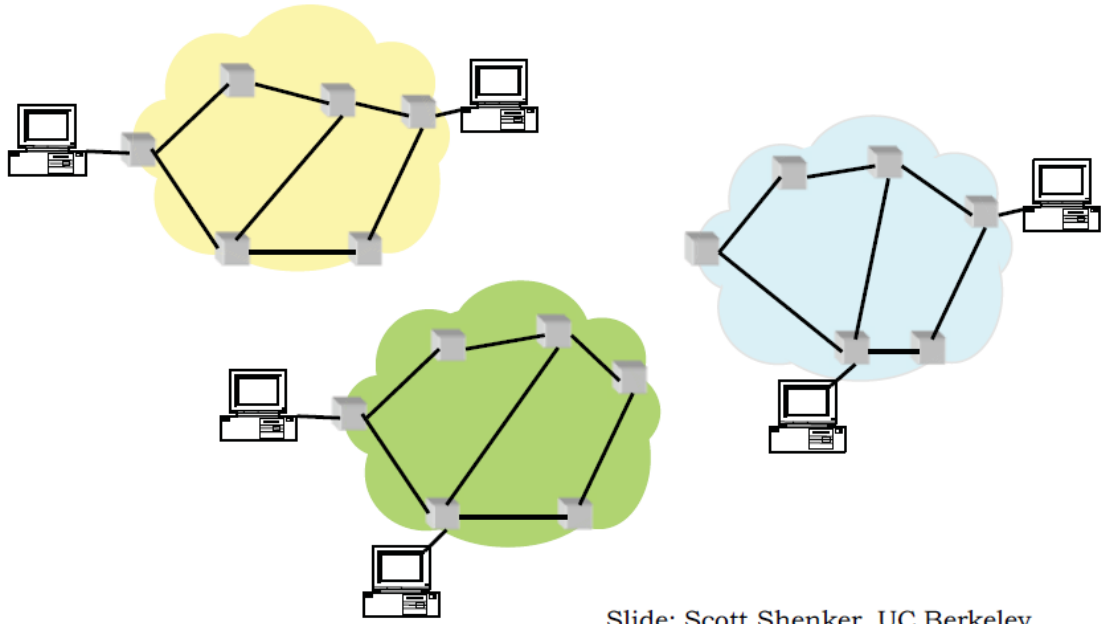
Course information

- Course Number: 40443-1
  - Time: Sat-Mon 13:30-15
  - Rooms: CE-102 & https://vc.sharif.edu/ch/amsadeghzadeh
- Instructor
  - Amir Mahdi Sadeghzadeh (amsadeghzadeh@gmail.com)
    - Office: CE-704
    - Lab: CE-502
    - Office hours: by appointment and through email
- Course Website: https://quera.org/course/add_to_course/course/20780/ (CN-032)
  - Syllabus, Lecture slides, Discussions, Assignments, etc

The Initial Internetting Concepts

The Problem

- Many different packet-switching networks
- Only nodes on the same network could communicate



Slide: Scott Shenker, UC Berkeley

Open Architecture Networking

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  - In an open-architecture network, the individual networks may be separately designed and developed and each may have its own unique interface
  - But rather could be selected freely by a provider and made to interwork with the other networks through a meta-level "Internetworking Architecture"

Bob Kahn

NCP Problems

- NCP did not have the ability to address networks (and machines) further downstream than a destination IMP on the ARPANET and thus some change to NCP would also be required.

- NCP relied on ARPANET to provide end-to-end reliability.
  - If any packets were lost, the protocol (and presumably any applications it supported) would come to a grinding halt.
    - Since the ARPANET was to be the only network in existence and it would be so reliable that no error control would be required on the part of the hosts.

TCP/IP

- Kahn decided to develop a new version of the Network Control Protocol (NCP) which could meet the needs of an open-architecture network environment.
- This protocol would eventually be called the Transmission Control Protocol/Internet Protocol (TCP/IP).

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    - These would later be called gateways and routers.
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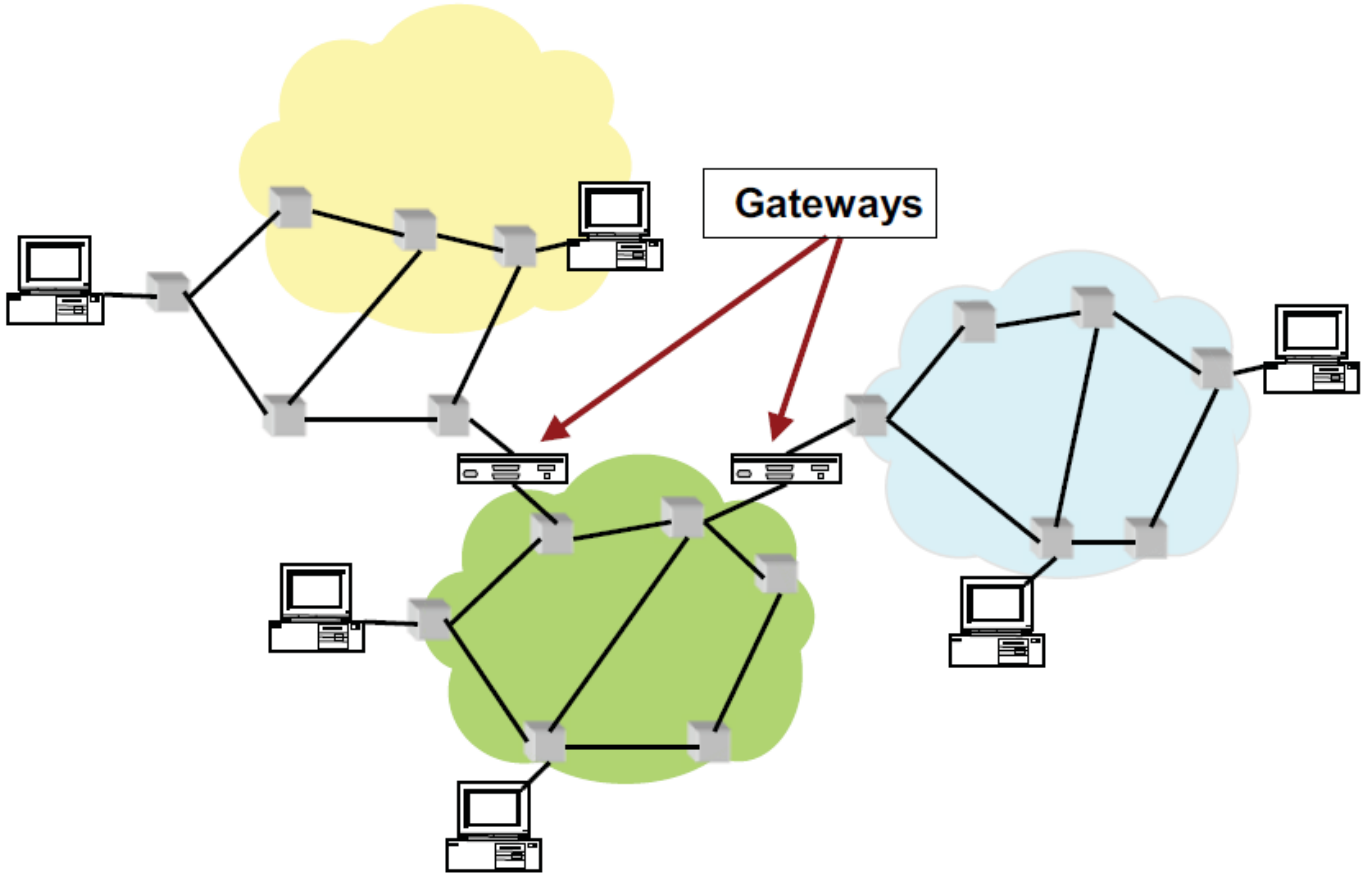
  - There would be no global control at the operations level.

Solution for internetworking



Kahn and Cerf

- In the spring of 1973, after starting the internetting effort, Kahn asked Vint Cerf (then at Stanford) to work with him on the detailed design of the protocol.

- They teamed up to spell out the details of what became TCP/IP.

A Protocol for Packet Network Interconnection

A Protocol for Packet Network Intercommunication

VINTON G. CERF AND ROBERT E. KAHN,
MEMBER, IEEE

Abstract — A protocol that supports the sharing of resources that exist in different packet switching networks is presented. The protocol provides for variation in individual network packet sizes, transmission failures, sequencing, flow control, end-to-end error checking, and the creation and destruction of logical process-to-process connections. Some implementation issues are considered, and problems such as internetwork routing, accounting, and timeouts are exposed.

of one or more *packet switches*, and a collection of communication media that interconnect the packet switches. Within each HOST, we assume that there exist *processes* which must communicate with processes in their own or other HOSTS. Any current definition of a process will be adequate for our

V. G. Cerf and R. E. Kahn, "A protocol for packet network interconnection", IEEE Trans. Comm. Tech., vol. COM-22, V 5, pp. 627-641, May 1974.

A Protocol for Packet Network Interconnection

PROCESS LEVEL COMMUNICATION

We suppose that processes wish to communicate in full duplex with their correspondents using unbounded but finite length messages. A single character might constitute the text of a message from a process to a terminal or vice versa. An entire page of characters might constitute the text of a message from a file to a process. A data stream (e.g. a continuously generated bit string) can be represented as a sequence of finite length messages.

Within a HOST we assume that existence of a transmission control program (TCP) which handles the transmission and acceptance of messages on behalf of the processes it serves. The TCP is in turn served by one or more packet switches connected to the HOST in which the TCP resides. Processes that want to communicate present messages to the TCP for transmission, and TCP's deliver incoming messages to the appropriate destination processes.

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  - The simple IP which provided only for addressing and forwarding of individual packets
  - The separate TCP, which was concerned with service features such as flow control and recovery from lost packets.
  - For those applications that did not want the services of TCP, an alternative called the User Datagram Protocol (UDP) was added in order to provide direct access to the basic service of IP.

The Role of Documentation

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  - The effect of the RFCs was to create a positive feedback loop, with ideas or proposals presented in one RFC triggering another RFC with additional ideas, and so on.
  - When some **consensus** (or a least a consistent set of ideas) had come together a specification document would be prepared.
    - Such a specification would then be used as the base for implementations by the various research teams.

Request for Comments (or RFC)

- Over time, the RFCs have become more focused on protocol standards (the "official" specifications)

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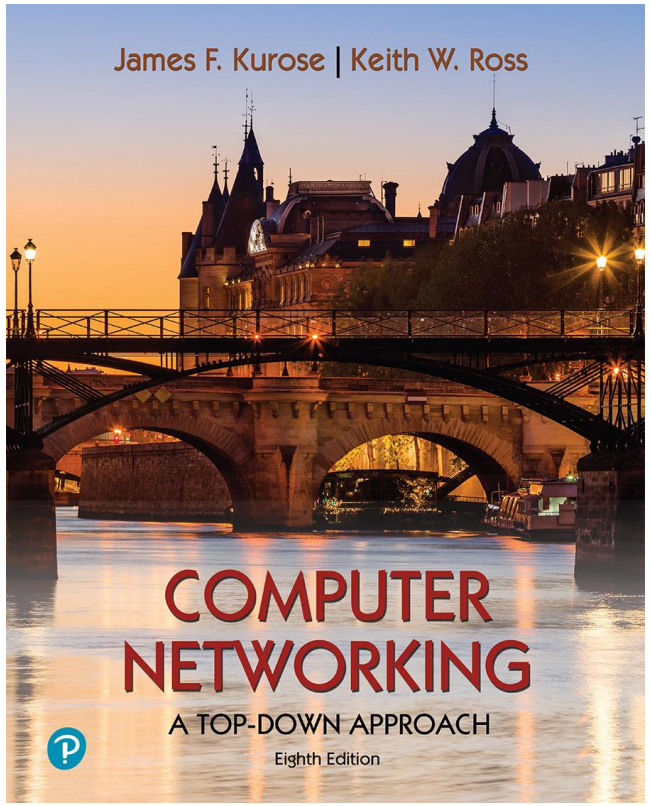
- The IETF publishes its technical documentation as RFCs, an acronym for their historical title *Requests for Comments*.
    - They describe the Internet's technical foundations, such as addressing, routing, and transport technologies.

Chapter 1
Introduction



Computer Networking: A Top-Down Approach
8th edition
Jim Kurose, Keith Ross
Pearson, 2020

Chapter 1: introduction

Chapter goal:

- Get "feel," "big picture," introduction to terminology
  - more depth, detail *later* in course

Overview/roadmap:

- What *is* the Internet? What *is* a protocol?
- Network edge: hosts, access network, physical media
- Network core: packet/circuit switching, internet structure
- Performance: loss, delay, throughput
- Protocol layers, service models
- Security
- History

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)

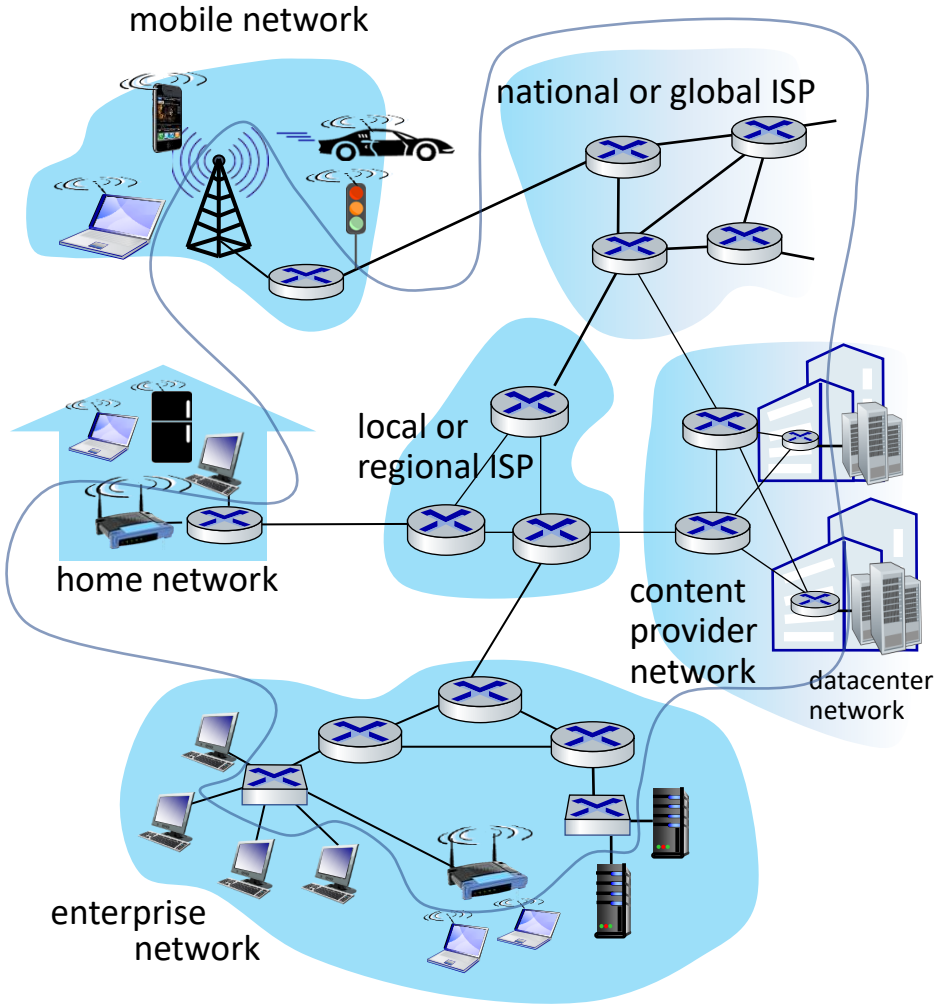
- *routers, switches*

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

IP picture frame

Pacemaker & Monitor

Tweet-a-watt: monitor energy use

bikes

cars

Security Camera

Slingbox: remote control cable TV

Web-enabled toaster + weather forecaster

AR devices

Fitbit

scooters

Internet phones

Gaming devices

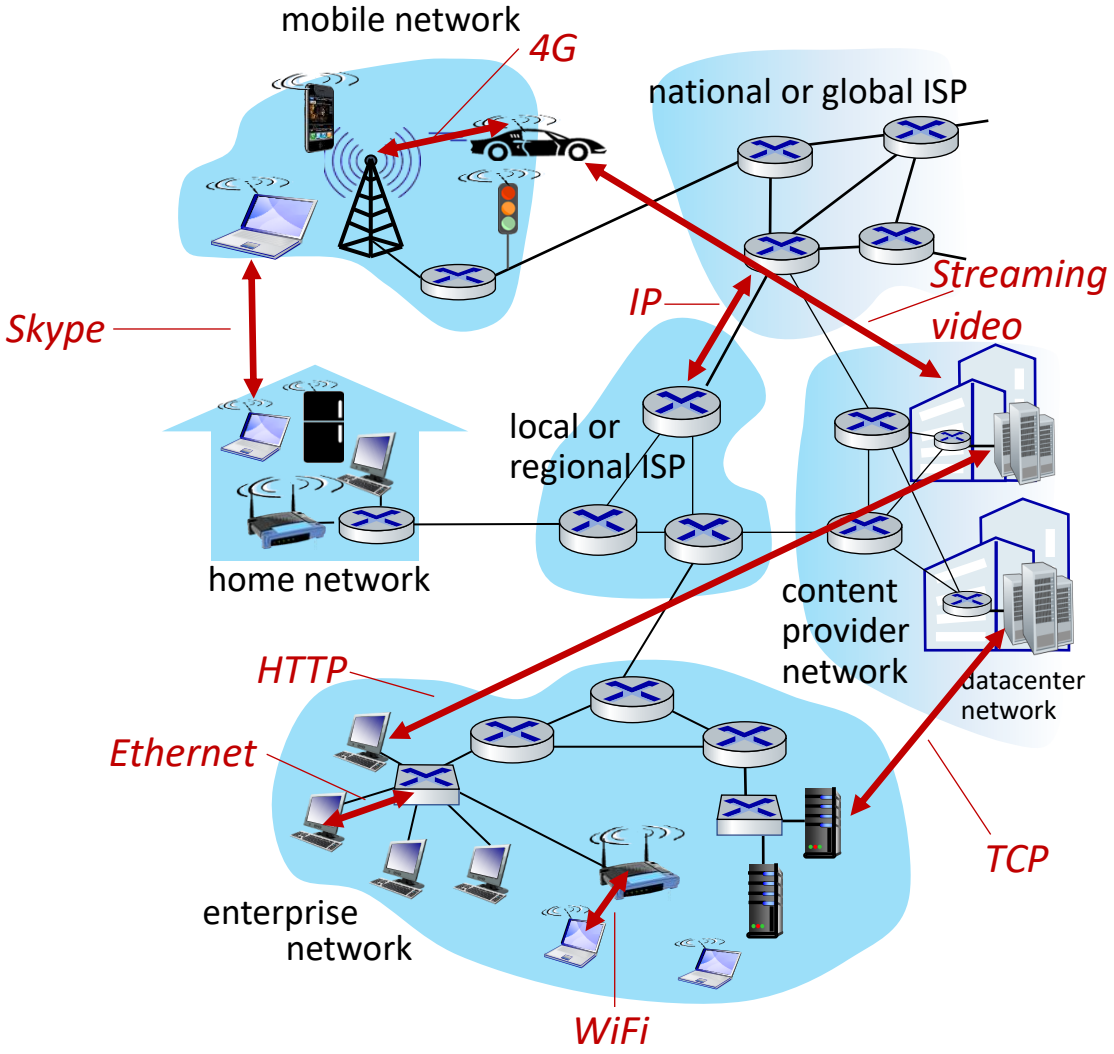
sensorized, bed mattress

diapers

Others?

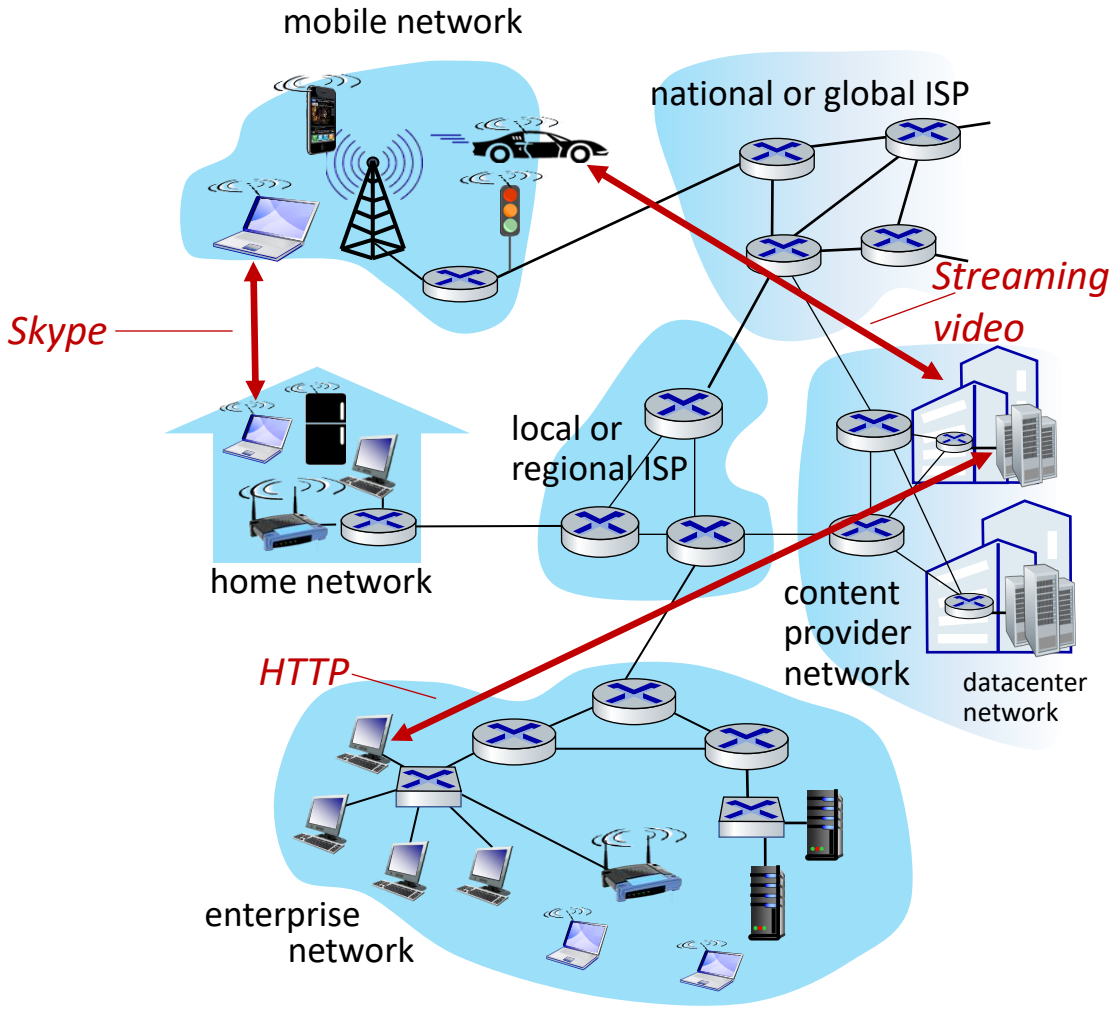
The Internet: a "nuts and bolts" view

- *Internet:* "network of networks"
  - Interconnected ISPs
- *protocols* are *everywhere*
  - control sending, receiving of messages
  - e.g., HTTP (Web), streaming video, Skype, TCP, IP, WiFi, 4/5G, 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, inter-connected 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

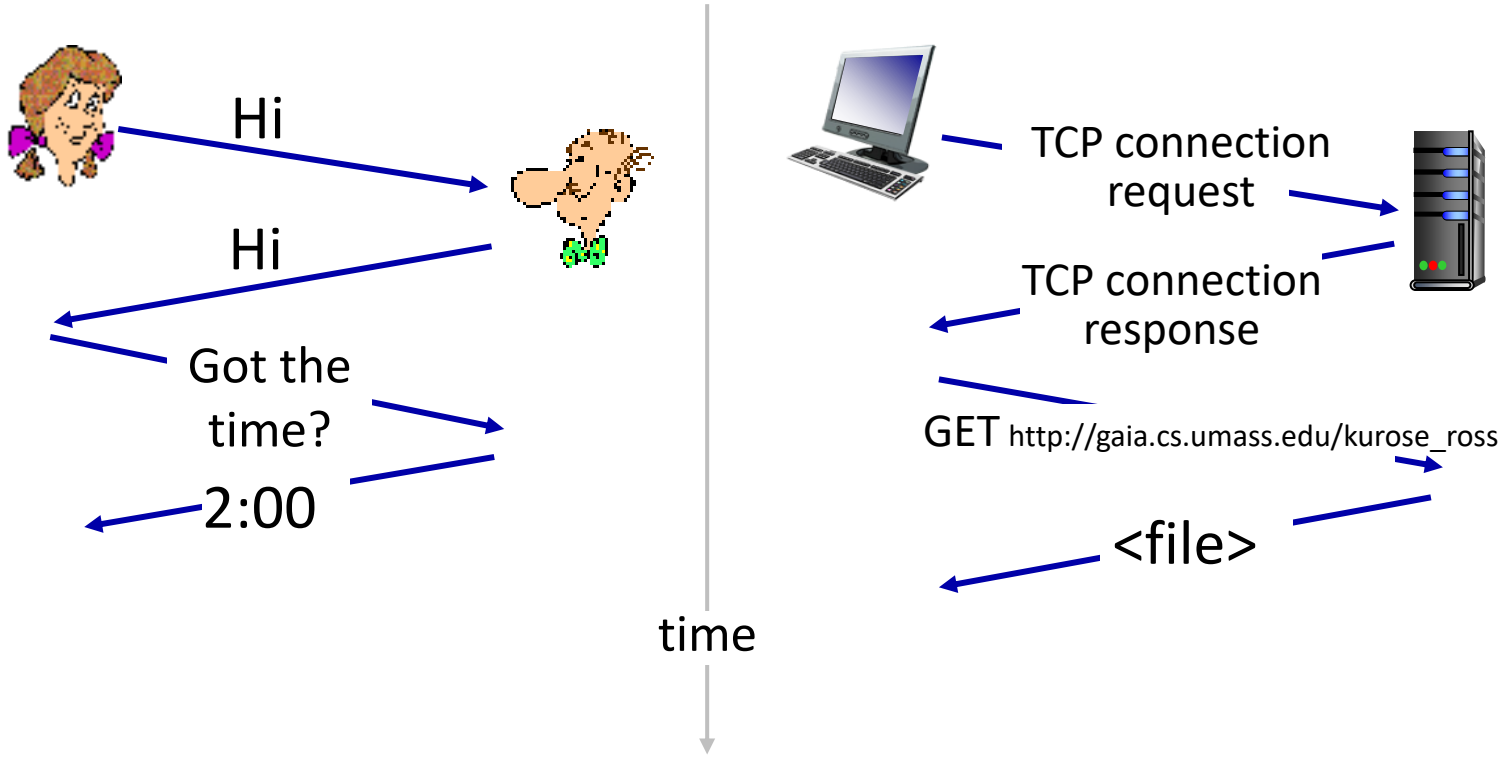
Network protocols:

- 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?