CS 352 Sockets, App Layer, DNS

Lecture 3

http://www.cs.rutgers.edu/~sn624/352-F22

Srinivas Narayana



Review of concepts

- Switching: Circuit, Message, Packet
- Layering: Modularity

Application: useful user-level functions

Transport: provide guarantees to apps

Network: best-effort global pkt delivery

Link: best-effort local pkt delivery

Kernel space

User space

Protocol: Message format and actions

.......

Protocols can be public domain (RFCs) or proprietary.

Today's lecture

- Understand how to measure the Internet
- Learn how application software accesses the Internet
- Dive into our first app-layer protocol

Measuring Networks (including the Internet)

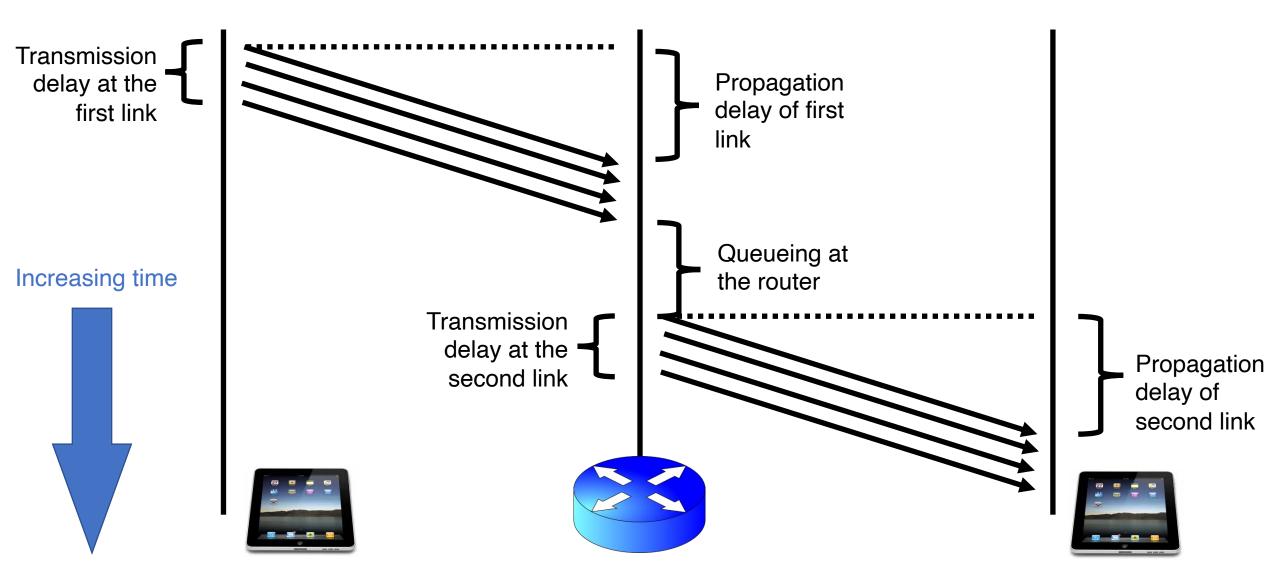
Some definitions

- Packet size: length of a packet (bits or bytes), incl. header and data
- Bandwidth: For a single link, amount of data it can transmit per unit time (bits/second or Bytes/second or packets/second)
- Propagation delay: Time needed to move one bit across (second)
 - Imposed by the communication medium; depends on the link "length"
- Transmission delay: Time from first bit@sender to last bit@sender
 - Determined by link bandwidth and packet size
- Queueing delay: Time that a packet waits for transmission
 - Determined by contention for the link
- Total packet delay: time from first bit@sender to last bit@receiver
 - propagation delay + queueing delay + transmission delay for a single packet

An analogy: Conveyor belt

- Propagation delay = time for first box to travel the length of the belt
- Bandwidth = the number of boxes put on the belt per minute ("rate")
- Suppose we have N boxes in one shipment
- Shipment transmission time = N / rate
 - The next box is put on the belt (1/rate) minutes after the last
- Total transfer time = transmission time + propagation delay

Visualizing the components of delay



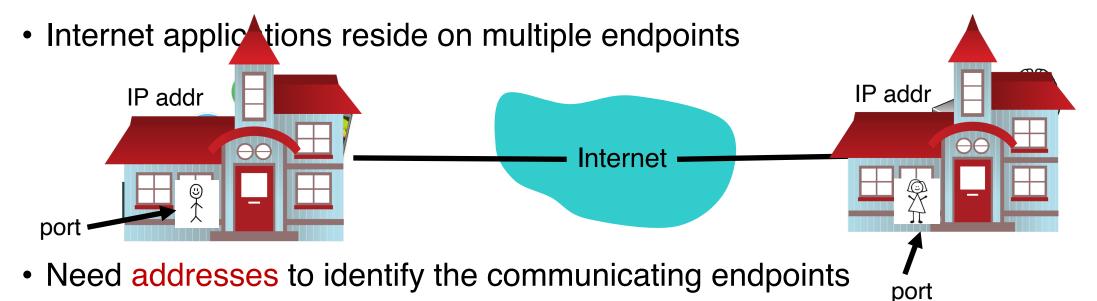
Bandwidth and delay demo

• Throughput (related to bandwidth)

- iperf -s # at the destination
- iperf -c <destination> # at the source,
- e.g., iperf -c localhost
- (total) delay
 - ping <destination>
 - e.g., ping google.com
- (Don't just watch; you can try it!)

Application Layer

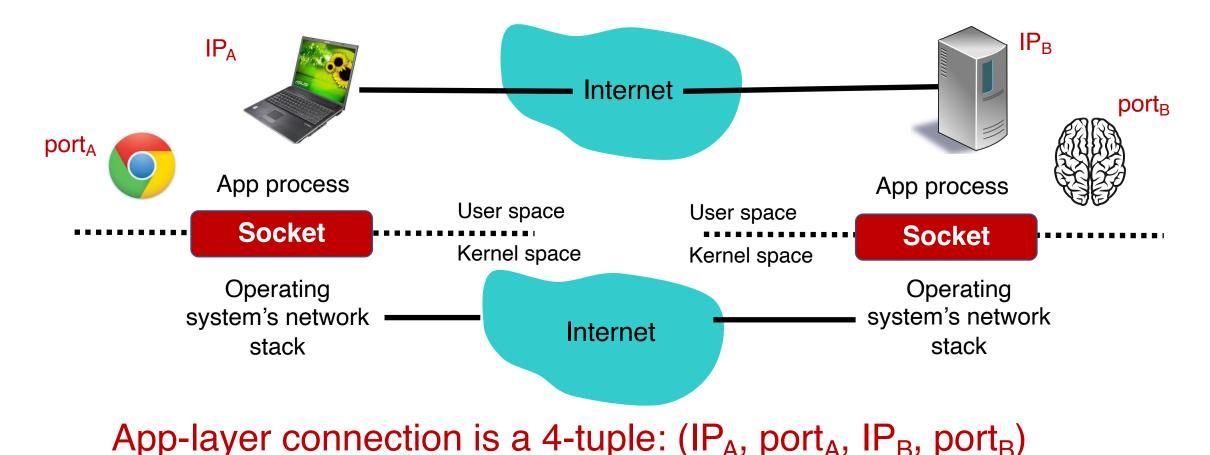
App-layer communication



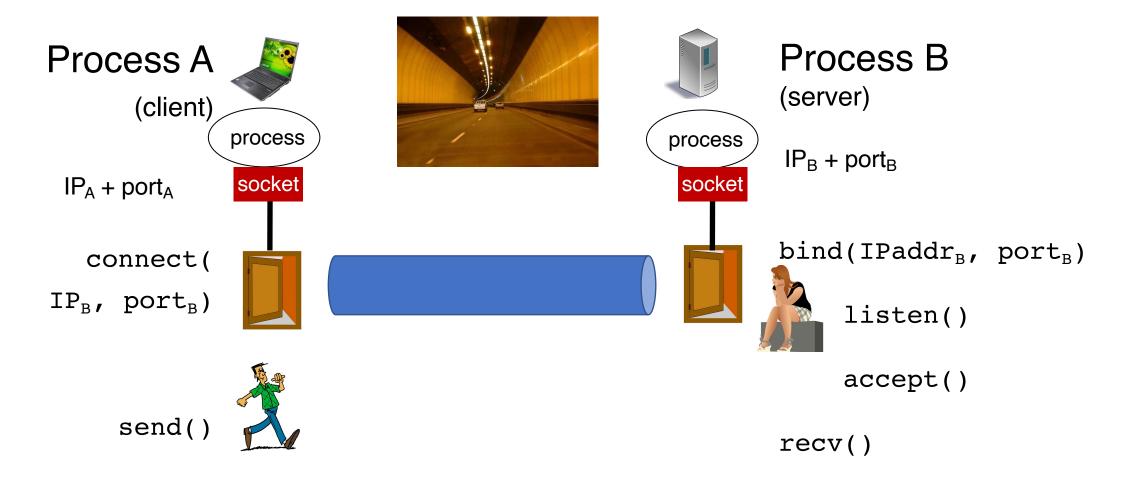
- E.g., Telephone network: xxx-yyy-zzzz
- Internet: Internet Protocol (IP) addresses
 - IPv4 (32 bits) 128.6.24.78
 - IPv6 (128 bits) 2001:4000:A000:C000:6000:B001:412A:8000
- Which app on each endpoint? Port number

How are addresses used?

• Socket: abstraction (API) of the Internet for applications



Socket system calls

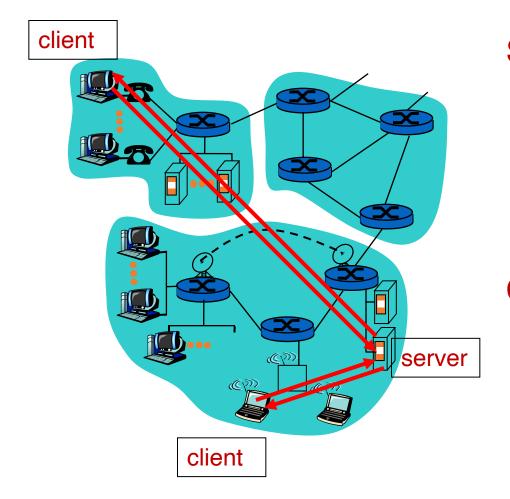


Seeing app-layer connections

- netstat
- SS

Common Architectures of Applications

Client-server architecture



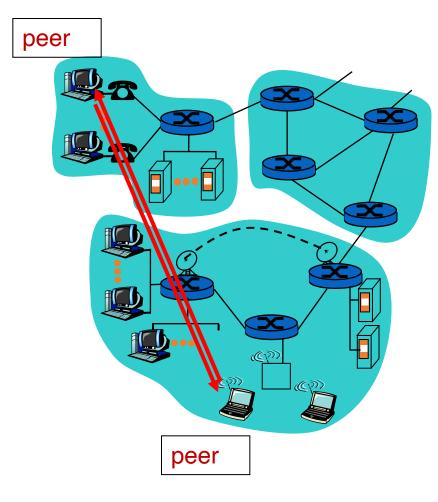
Server:

- Always-on endpoint
- Provides a "service" to the world
- Typically, a permanent IP address
- Compute clusters to scale to many users

Clients:

- A "customer" of the server
- May be intermittently connected
- May have dynamic IP addresses
- Typically, do not communicate directly with other clients
- The web and most mobile apps use a client-server architecture 15

Peer-to-peer (P2P) architecture



• Peers:

- Intermittently connected hosts
- Directly talking to each other

Little to no reliance on always-up servers

- Examples: BitTorrent
- Today, many applications use a hybrid model
 - Example: (webRTC) Google meet, FB messenger, ...

Going forward: A few app-layer protocols

- Domain Name System
- The web
- Mail
- Streaming video

Domain Name System

You have my name. Can you lookup my address?

Domain Name System (DNS)

• Problem statement:

- Average brain can easily remember 7 digits for a few names
- On average, IP addresses have 12 digits
- We need an easier way to remember IP addresses
- Solution:
 - Use alphanumeric names to refer to hosts.
 - Called host names or domain names (e.g.: cs.rutgers.edu)
 - We need a directory (address book)
 - A service to map alphanumeric host names to binary IP addresses
 - We call this process Address Resolution

Types of Directories

- Directories map a *name* to an *address*
- Simplistic designs
 - Central directory
 - Ask everyone (e.g., flooding)
 - Tell everyone (e.g., push to a file like /etc/hosts)

Scalable distributed designs

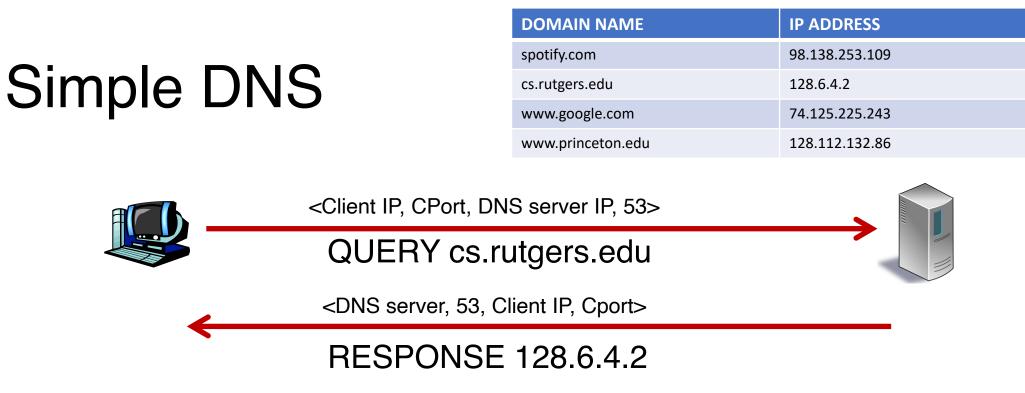
- Hierarchical namespace (e.g., Domain Name System (DNS))
- Flat name space (e.g., Distributed Hash Table)



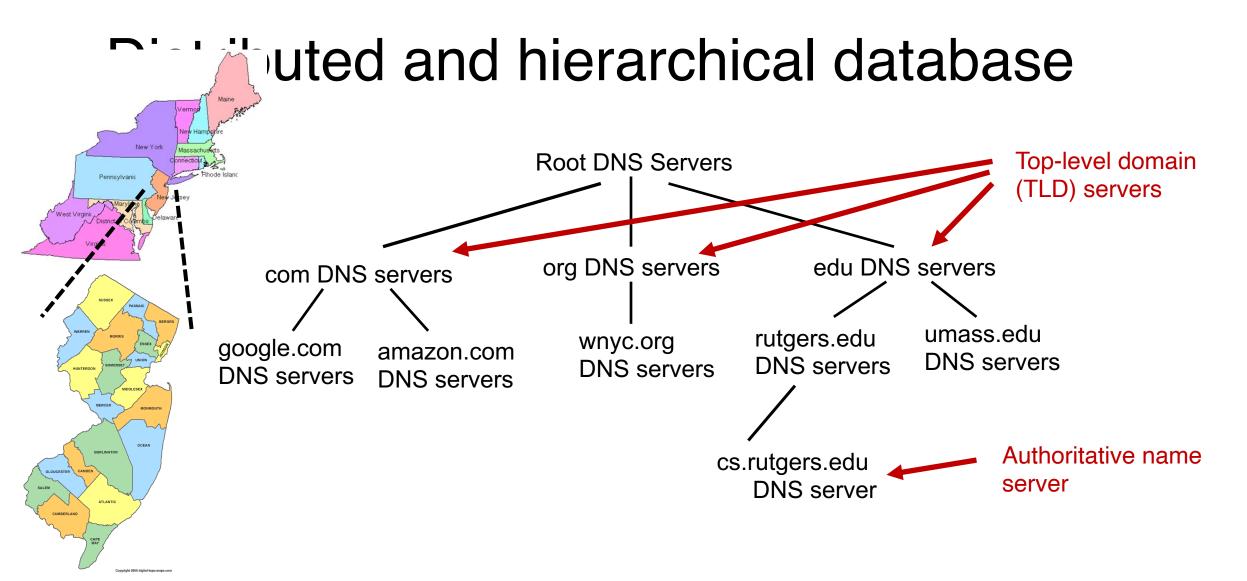
Simple DNS

- What if every endpoint has a local directory?
- /etc/hosts.txt
 - How things worked in the early days of the Internet!
- What if endpoints changed addresses? How do you keep this up to date?

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- Key idea: Implement a server that looks up a table.
- Will this scale?
 - Every new (changed) host needs to be entered in this table
 - Performance: can the server serve billions of Internet users
 - Failure: what if the server or the database crashes?
 - How to secure this server?



RFC 1034: Distribution through hierarchy enables scaling

DNS Protocol

- Client-server application
- Client connects to (known) port 53 on server
- Assume DNS server IP known
- Two types of messages
 - Queries
 - Responses
- Type of Query (OPCODE)
 - Standard query (0x0)
 - e.g., Request IP address for a given domain name
 - Updates (0x5)
 - Provide a binding of IP address to domain name
- Each type has a common message format that follows the header