Review for Internet Introduction
What’s the Internet: Two Views

**View 1: “Nuts and Bolts” View**
- billions of connected *hosts*
- *routers* and *switches*
- *protocols* control sending, receiving of messages
- “network of networks”

**View 2: Service View**
- *Infrastructure that provides services to applications:*
- Web, VoIP, email, games, e-commerce, social nets, …
Internet Components

- **Network Edge:**
  - hosts: clients and servers

- **Access networks**
  - **Home:** DSL & Cable
  - **Institutional:** Ethernet
  - **Wireless:** WiFi & 3G & 4G LTE

- **Physical Media**
  - **guided media:** copper, fiber, coax
  - **unguided media:** radio

- **Network Core:**
  - Interconnected Routers
  - Packet Switching: Shared Resources: Store and Forward
  - Circuit Switching: Shared Resources: Reserved Circuit
End systems connect to Internet via access ISPs
- residential, company and university ISPs
Access ISPs in turn must be interconnected.
Network Metrics 1: Delay

\[ d_{\text{nodal}} = d_{\text{proc}} + d_{\text{queue}} + d_{\text{trans}} + d_{\text{prop}} \]
Network Metrics 2: Packet loss

- Queue (aka buffer) has limited capacity
- Packet is dropped if arriving to full queue (aka lost)
Network Metrics 3: Throughput

- **throughput**: rate (bits/time unit) at which bits transferred between sender/receiver
  - *Real-time*: rate at a given time point
  - *Average*: rate over longer period of time
Internet protocol stack

- **application**: supporting network applications
  - FTP, SMTP, HTTP
- **transport**: process-process data transfer
  - TCP, UDP
- **network**: routing of datagrams from source to destination
  - IP, routing protocols
- **link**: data transfer between neighboring network devices
  - Ethernet, 802.11 (WiFi), PPP
- **physical**: bits “on the wire”
ISO/OSI reference model

- **Open Systems Interconnections**
  - *Presentation*: allow applications to interpret meaning of data, e.g., encryption, compression,
  - *Session*: synchronization, recovery of data exchange

- 5-layer Internet stack “missing” these 2 layers!
  - these services, *if needed*, must be implemented in application

Quiz 3-2
Network security

- field of network security:
  - how bad guys can attack computer networks
  - how we can defend networks against attacks
  - how to design architectures that are immune to attacks

- Malware can get in host from:
  - Virus & Worm

- Denial of Service (DoS): attackers make resources (server, bandwidth) unavailable to legitimate traffic by overwhelming resource with bogus traffic
Review for App Layer Protocols
App-Layer Protocols
App-layer protocol defines

- Types of messages exchanged:
  - e.g., request, response

- Message format:
  - Syntax: what fields in messages
  - Semantics: meaning of information in fields

- Rules for when and how processes send & respond to messages

Public-domain protocols:
- defined in RFCs
- DNS, HTTP, FTP, SMTP

Proprietary protocols:
- e.g., Skype, Hangout

- A network connection is a 4-tuple: $IP_S$, $Port_S$, $IP_D$, $Port_D$
  - To communicate, 2 hosts need to identify each other with IP address
  - More than one process on a host: Port #
Client-server architecture (CS)

Server:
• Always-on host
• Permanent IP address
• A net of servers for scaling

Clients:
• may not be always connected
• may have dynamic IP addresses
• communicate with server but do not communicate directly with each other

Quiz 5
App-layer protocols

- DNS: Domain Name Service  Quiz 6
- HTTP: HyperText Transfer Protocol  Quiz 7
- CDN: Content Distribution Networks  Quiz 8
- FTP: File Transfer Protocol  Quiz 9
- SMTP: Simple Mail Transfer Protocol  Quiz 10
DNS
Domain Name System (DNS)

- For any networked application, we need to know the IP address of a given host name.

- Problem:
  - On average, IP addresses have 12 digits.
  - We need an easier way to remember IP addresses.

- Solution:
  - Use names to refer to hosts.
  - Add a service (DNS) to map between host names and IP addresses.
  - We call this Address Resolution.
Simple DNS

Centralize DNS?
- Single Point of Failure
- traffic volume
- Distant centralized database
- maintenance  

doesn’t scale!

Quiz 6
Distributed, Tree-based DNS Database

RFC 1034
2 DNS Query Types

Iterated Query

Recursive Query
DNS: Caching, Updating, Bootstrapping

- Once (any) name server learns mapping, it *caches* mapping
- Cache entries timeout (disappear) after some time
- How does a host *contact* the name server if all it has is the name and no IP address?
  - IP address of at least 1 nameserver must be given in advance
HTTP
HTTP overview

- Web page consists of a base HTML-file which includes several referenced objects addressable by a URL

- Client/Server model
  - client: browser that requests, receives, “displays” Web objects
  - server: Web server sends objects in response to requests

- Request & Response Message
HTTP connections

Nonpersistent HTTP
- At most one object is sent over a single TCP connection.

Persistent HTTP
- Multiple objects can be sent over a single TCP connection between client and server.

Nonpersistent HTTP issues:
- requires 2 RTTs per object
  - TCP Connection and HTTP Request
- Browsers can open parallel TCP connections to fetch objects

Persistent HTTP
- server leaves TCP connection open after sending response
- subsequent HTTP messages sent over open connection

Quiz 8
Cookie : User-server State

HTTP is “stateless”
- server maintains no information about past client requests
- What state can bring:
  - Authorization, shopping carts, recommendations, user session state

Four components:
1) cookie header line of HTTP response message
2) cookie header line in HTTP request message
3) cookie file kept on user’s host, managed by user’s browser
4) back-end database at Web site
Web caches (proxy server)

- Reduce response time for client request.
- Reduce traffic on an institution’s access link.

- browser sends all HTTP requests to cache
  - Miss: cache requests object from origin server, then returns object to client
  - Hit: cache returns object

- guarantees cache content is up-to-date
- saves traffic and response time whenever possible
CDN
Content Distribution Networks (CDN)

- Reduce bandwidth Requirement & Traffic of content provider
- Reduce $$ of maintaining Servers
- Improve response time to user

Without CDN

Huge B/W requirements & Does not scale

With CDN

Clients

Origin Server

Using CDN

CDN servers

Origin server

Quiz 7
FTP
FTP: the file transfer protocol

- Transfer file to/from remote host
- client/server model
  - client: side that initiates transfer (either to/from remote)
  - server: remote host

- “out of band” control
  - Control connection port 21 & Data connection port 20
  - Active connection: data connection initiated form server
  - Passive connection: data connection initiated form client
- Key Drawback: Sends passwords in plain ASCII text
- Replaced with scp, sftp instead

Quiz 9
SMTP
Electronic Mail

Three Components:

1. User Agents

2. Mail Servers
   - mailbox contains incoming messages for user
   - message queue of outgoing (to be sent) mail messages

3. SMTP protocol
   - Used to send messages
   - Client: sending user agent or sending mail server
   - server: receiving mail server

Quiz 10

- Mail access protocol: retrieval from server
  - POP: Post Office Protocol
  - IMAP: Internet Mail Access Protocol
  - HTTP: Hotmail, Yahoo! Mail, etc.
Questions ?