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Thanks and enjoy! JFK/KWR
Chapter 2: outline

2.1 principles of network applications
  ▪ app architectures
  ▪ app requirements
2.2 Web and HTTP
2.3 FTP
2.4 electronic mail
  ▪ SMTP, POP3, IMAP
2.5 DNS

2.6 P2P applications
2.7 socket programming with UDP and TCP
**DNS: domain name system**

**people:** many identifiers:
- SSN, name, passport #

**Internet hosts, routers:**
- IP address (32 bit) - used for addressing datagrams
- “name”, e.g., www.yahoo.com - used by humans

**Q:** how to map between IP address and name, and vice versa?

**Domain Name System:**
- **distributed database** implemented in hierarchy of many **name servers**
- **application-layer protocol:** hosts, name servers communicate to resolve names (address/name translation)
  - note: core Internet function, implemented as application-layer protocol
  - complexity at network’s “edge”
DNS: services, structure

**DNS services**
- hostname to IP address translation
- host aliasing
  - canonical, alias names
- mail server aliasing
- load distribution
  - replicated Web servers: many IP addresses correspond to one name

**why not centralize DNS?**
- single point of failure
- traffic volume
- distant centralized database
- maintenance

A: *doesn’t scale!*
client wants IP for www.amazon.com; 1st approx:

- client queries root server to find com DNS server
- client queries .com DNS server to get amazon.com DNS server
- client queries amazon.com DNS server to get IP address for www.amazon.com
DNS: root name servers

- contacted by local name server that can not resolve name
- root name server:
  - contacts authoritative name server if name mapping not known
  - gets mapping
  - returns mapping to local name server

13 root name "servers" worldwide

- a. Verisign, Los Angeles CA (5 other sites)
- b. USC-ISI Marina del Rey, CA
- c. Cogent, Herndon, VA (5 other sites)
- d. U Maryland College Park, MD
- e. NASA Mt View, CA
- f. Internet Software C. Palo Alto, CA (and 48 other sites)
- g. US DoD Columbus, OH (5 other sites)
- h. ARL Aberdeen, MD
- i. Netnod, Stockholm (37 other sites)
- j. Verisign, Dulles VA (69 other sites)
- k. RIPE London (17 other sites)
- l. ICANN Los Angeles, CA (41 other sites)
- m. WIDE Tokyo (5 other sites)
TLD, authoritative servers

**top-level domain (TLD) servers:**
- responsible for com, org, net, edu, aero, jobs, museums, and all top-level country domains, e.g.: uk, fr, ca, jp
- Network Solutions maintains servers for .com TLD
- Educause for .edu TLD

**authoritative DNS servers:**
- organization’s own DNS server(s), providing authoritative hostname to IP mappings for organization’s named hosts
- can be maintained by organization or service provider
Local DNS name server

- does not strictly belong to hierarchy
- each ISP (residential ISP, company, university) has one
  - also called “default name server”
- when host makes DNS query, query is sent to its local DNS server
  - has local cache of recent name-to-address translation pairs (but may be out of date!)
  - acts as proxy, forwards query into hierarchy
DNS name resolution example

- host at cis.poly.edu wants IP address for gaia.cs.umass.edu

**iterated query:**

- contacted server replies with name of server to contact
- “I don’t know this name, but ask this server”
DNS name resolution example

recursive query:

- puts burden of name resolution on contacted name server
- heavy load at upper levels of hierarchy?
DNS: caching, updating records

- once (any) name server learns mapping, it **caches** mapping
  - cache entries timeout (disappear) after some time (TTL)
  - TLD servers typically cached in local name servers
    - thus root name servers not often visited
- cached entries may be **out-of-date** (best effort name-to-address translation!)
  - if name host changes IP address, may not be known Internet-wide until all TTLs expire
- update/notify mechanisms proposed IETF standard
  - RFC 2136
**DNS records**

**DNS:** distributed db storing resource records (RR)

RR format: \((\text{name}, \text{value}, \text{type}, \text{ttl})\)

**type=A**
- **name** is hostname
- **value** is IP address

**type=NS**
- **name** is domain (e.g., foo.com)
- **value** is hostname of authoritative name server for this domain

**type=CNAME**
- **name** is alias name for some “canonical” (the real) name
- **value** is canonical name

**type=MX**
- **value** is name of mailserver associated with **name**
**DNS protocol, messages**

- *query* and *reply* messages, both with same *message format*

**msg header**
- **identification**: 16 bit # for query, reply to query uses same #
- **flags**: 
  - query or reply
  - recursion desired
  - recursion available
  - reply is authoritative

<table>
<thead>
<tr>
<th>Identification</th>
<th>Flags</th>
</tr>
</thead>
<tbody>
<tr>
<td># questions</td>
<td># answer RRs</td>
</tr>
<tr>
<td># authority RRs</td>
<td># additional RRs</td>
</tr>
</tbody>
</table>

- questions (variable # of questions)
- answers (variable # of RRs)
- authority (variable # of RRs)
- additional info (variable # of RRs)
### DNS protocol, messages

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- **Identification**: 2 bytes
- **Flags**: 2 bytes
- **Questions**: (variable # of questions)
- **Answers**: (variable # of RRs)
- **Authority**: (variable # of RRs)
- **Additional Info**: (variable # of RRs)

- **Name, type fields for a query**
- **RRs in response to query**
- **Records for authoritative servers**
- **Additional “helpful” info that may be used**
Inserting records into DNS

- example: new startup “Network Utopia”
- register name networkuptopia.com at DNS registrar (e.g., Network Solutions)
  - provide names, IP addresses of authoritative name server (primary and secondary)
  - registrar inserts two RRs into .com TLD server:
    (networkutopia.com, dns1.networkutopia.com, NS)
    (dns1.networkutopia.com, 212.212.212.1, A)
- create authoritative server type A record for www.networkuptopia.com; type MX record for networkutopia.com
Attacking DNS

DDoS attacks
- Bombard root servers with traffic
  - Not successful to date
  - Traffic Filtering
  - Local DNS servers cache IPs of TLD servers, allowing root server bypass
- Bombard TLD servers
  - Potentially more dangerous

Redirect attacks
- Man-in-middle
  - Intercept queries
- DNS poisoning
  - Send bogus relies to DNS server, which caches

Exploit DNS for DDoS
- Send queries with spoofed source address: target IP
- Requires amplification
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Pure P2P architecture

- no always-on server
- arbitrary end systems directly communicate
- peers are intermittently connected and change IP addresses

Examples:
- file distribution (BitTorrent)
- Streaming (KanKan)
- VoIP (Skype)
Chapter 2: summary

our study of network apps now complete!

- application architectures
  - client-server
  - P2P
- application service requirements:
  - reliability, bandwidth, delay
- Internet transport service model
  - connection-oriented, reliable: TCP
  - unreliable, datagrams: UDP
- specific protocols:
  - HTTP
  - FTP
  - SMTP, POP, IMAP
  - DNS
  - P2P: BitTorrent, DHT
- socket programming: TCP, UDP sockets
Chapter 2: summary

most importantly: learned about protocols!

- typical request/reply message exchange:
  - client requests info or service
  - server responds with data, status code
- message formats:
  - headers: fields giving info about data
  - data: info being communicated

important themes:
- control vs. data msgs
  - in-band, out-of-band
- centralized vs. decentralized
- stateless vs. stateful
- reliable vs. unreliable msg transfer
- “complexity at network edge”