
Application Layer

CS5700 Fall 2019

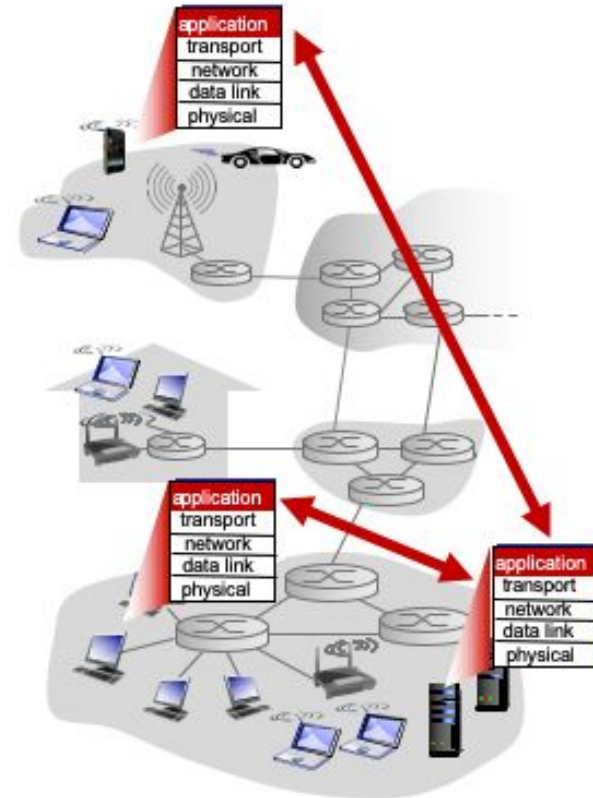
Agenda

- Principles of network applications
- DNS
- Web and HTTP
- SMTP
- CDN

Principles of network applications

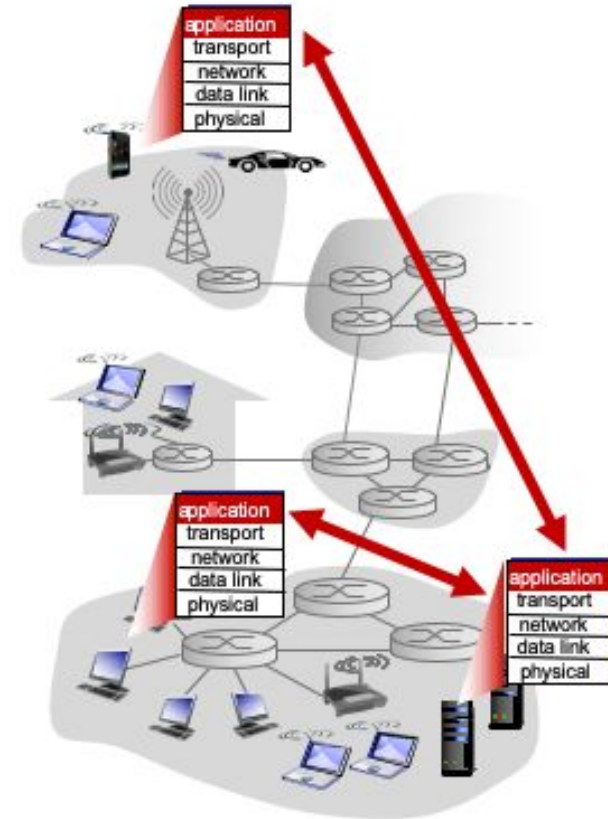
Principle - intelligence at the edge

- Internet does not provide services. It only provides communication.
- Application programs provide all services.



Principle - intelligence at the edge

- Write application programs that
 - Run on hosts
 - Communicate over network
- No need to change network core
 - Network core devices do not run user applications



Principle - intelligence at the edge

- Web
- Email
- Network games
- Streaming videos (Youtube, Netflix, Hulu, etc.)
- Realtime video conferencing
- Social networking
- ...
- All require no change at the network core

Why is it a good principle?



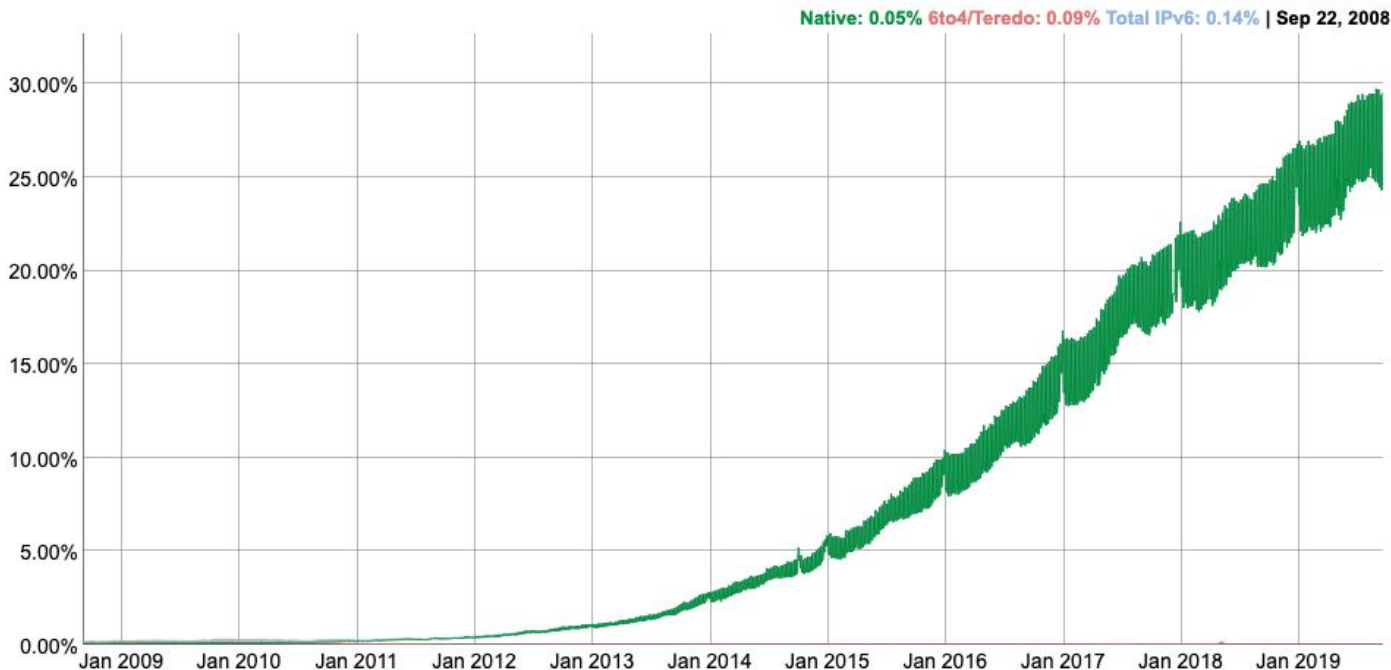
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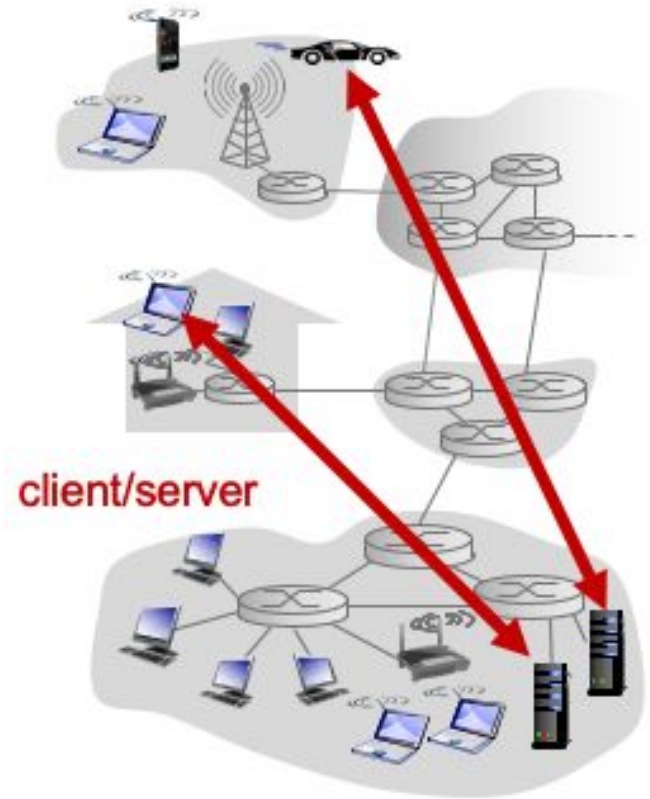
IPv6 Adoption

We are continuously measuring the availability of IPv6 connectivity among Google users. The graph shows the percentage of users that access Google over IPv6.



Client-server architecture

- Server
 - Always-on host
 - Permanent IP address
 - Data center for scaling
- Client
 - Communicate with server
 - May have dynamic IP address
 - Do not communicate directly with each other



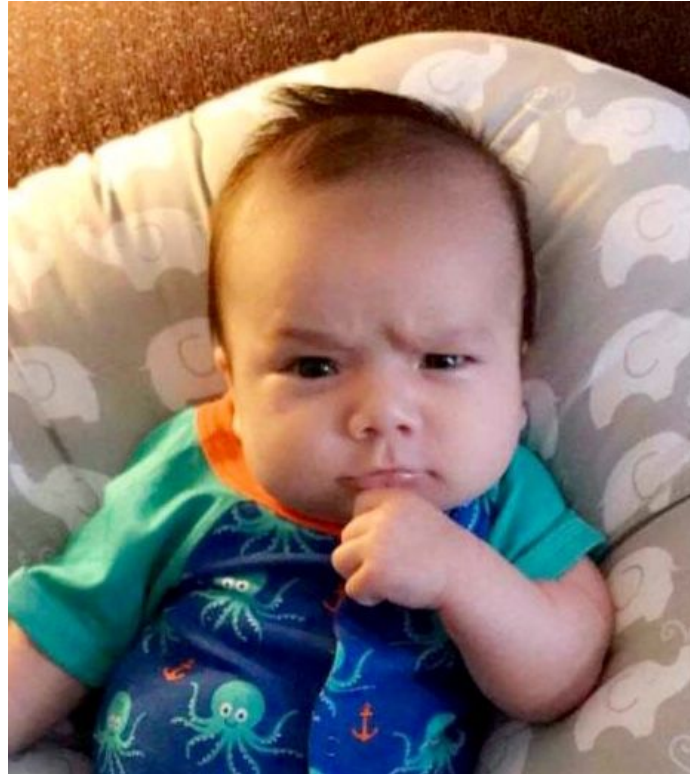
Transport layer service model - TCP

- Reliable data transfer
 - No loss, in-order
- Flow control: sender won't overwhelm receiver
- Congestion control: throttle sender when network is overloaded
- Connection oriented: setup required between client and server

Transport layer service model - UDP

- Unreliable data transfer
 - Loss, out-of-order, duplicate
- That's it!

Any service you'd like transport layer to have?



Other important services

- Timing (aka bounded latency)
 - E.g. Internet telephony, interactive games
- Throughput
 - E.g. multimedia
- Security
 - Encryption, data integrity, etc.
- ...
- None of the above is provided in transport layer! :(

DNS

DNS - domain name system

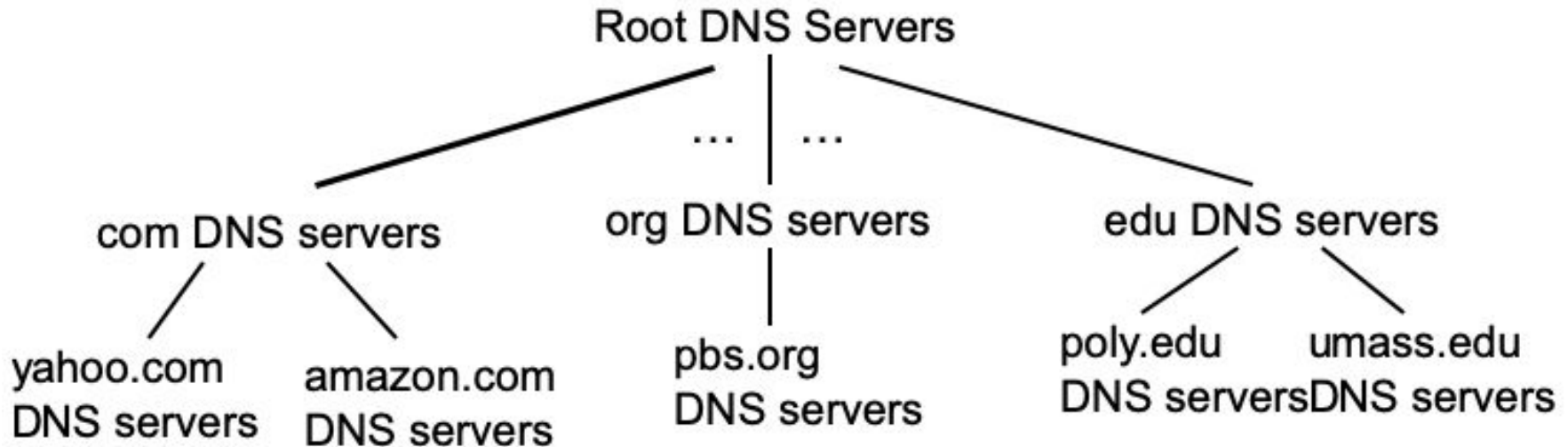
- Important piece of Internet infrastructure
- Runs at the application layer
- Translate human-readable names into IP addresses
- Distributed database
 - Centralized DNS doesn't scale!

DNS

- Names are hierarchical
- Each name divided into segments by period char
 - Read as “dot”
- Most significant segment is on the right
- Rightmost segment known as a top-level domain (TLD)
- E.g. neu.edu

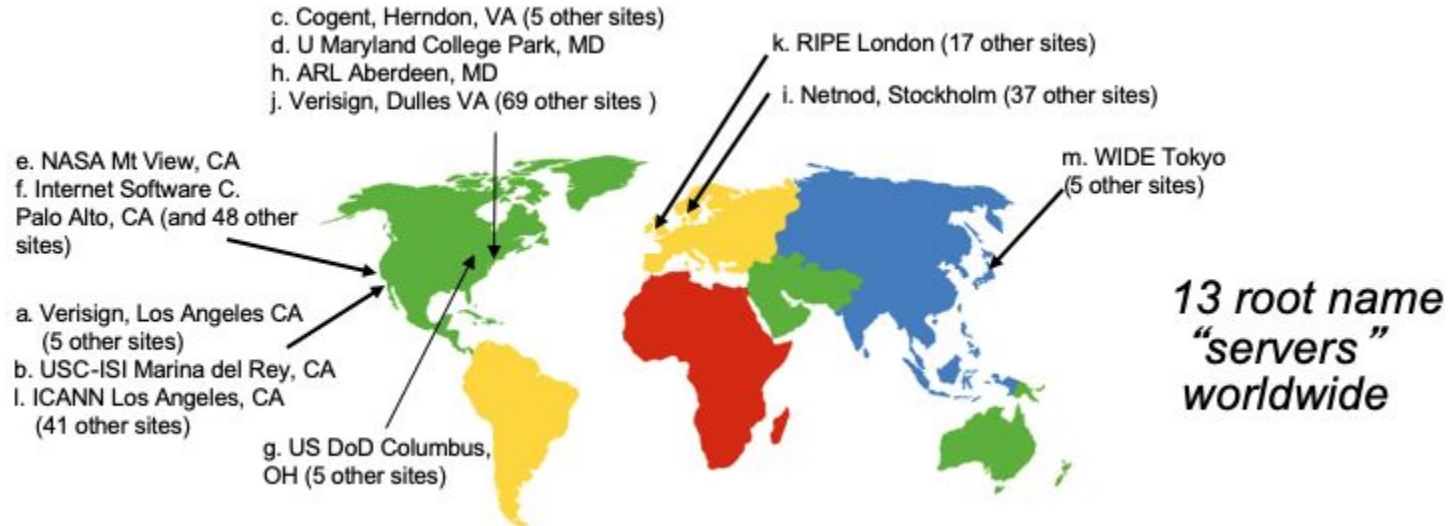
DNS - hierarchical database

- How do you get IP address for `www.neu.edu`?



DNS - root name servers

- 13 logical root name servers. ([a-m].root-servers.net)
- Provide which TLD name server to ask next



DNS - TLD name servers

- Responsible for com, org, net, edu, ..., and all top-level country domains
- Provide which authoritative name server to ask next

DNS - authoritative name servers

- Organization's own name servers
- Provide authoritative hostname to IP mappings for organization's named hosts

Summary so far...

- How many DNS queries you need?
 - 1 for root name server
 - 1 for TLD name server
 - 1 for authoritative name server
- Is there any issue?

Too slow!!

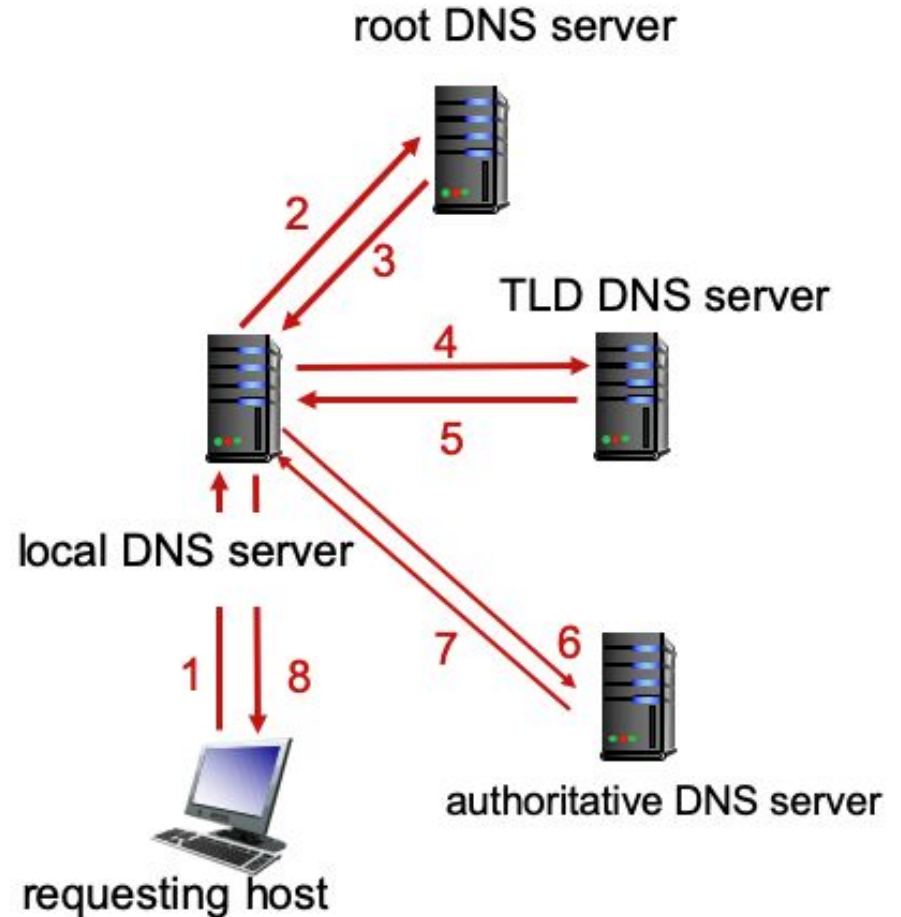


DNS - local name server

- Does not belong to hierarchy
- Each ISP (residential ISP, company, university) has one
- When host makes DNS query, query is sent to its local name server
 - Acts as proxy, forwards query into hierarchy
 - Has local cache of recent name-to-address map

Put all together

- Can you see this is more efficient?



DNS - caching

- Cache entries timeout after TTL
 - What is reasonable TTL? Who decide?
- TLD name servers typically cached in local name servers
 - Thus root name servers not often visited
- Cached entries may be out-of-date

DNS records

DNS: distributed db storing resource records (RR)

RR format: (name, value, type, 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

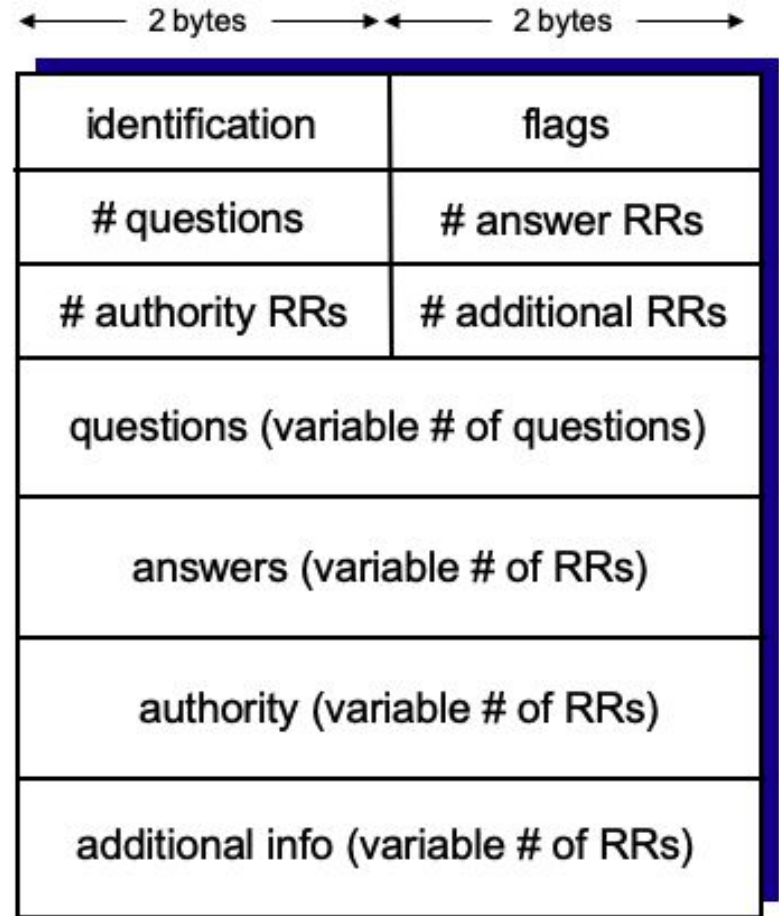
- **name** is alias name for some “canonical” (the real) name
- **www.ibm.com** is really **servereast.backup2.ibm.com**
- **value** is canonical name

type=MX

- **value** is name of mailserver associated with **name**

DNS - message format

- Both query and reply messages have the same format
- Flags:
 - Query or reply
 - Recursion desired
 - Recursion available
 - Reply is authoritative



DNS

- Is DNS using TCP or UDP as transport layer protocol?



Demo wireshark



Inserting records into DNS

- New startup “Network Utopia”
- Register name networkutopia.com at DNS registrar
 - Provide names, IP addresses of authoritative name server (primary and secondary)
 - Registrar inserts two RRs into .com TLD name server (networkutopia.com, dns1.networkutopia.com, NS) (dns1.networkutopia.com, 10.1.1.1, A)
- Create type A record for www.networkutopia.com in authoritative name server.