CSE/EE 461 – Lecture 14

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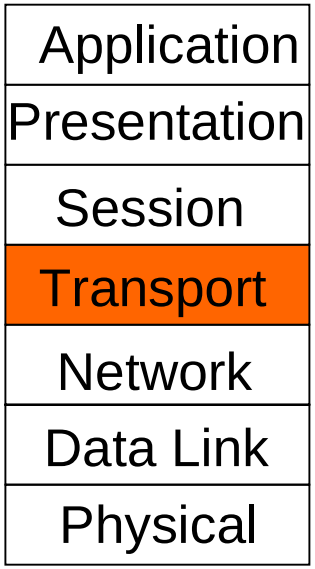
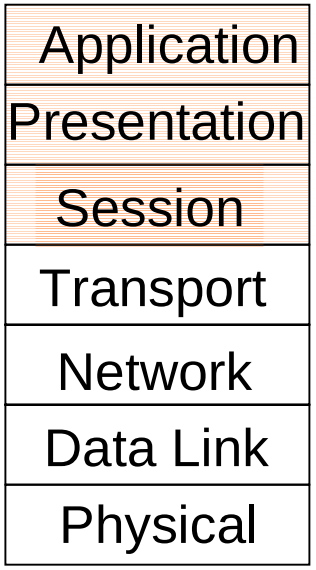
Last Time

- Wrap up on the Transport Layer
- Focus
  - How does TCP share bandwidth?
- Topics
  - Slow-start and congestion avoidance
  - Fast retransmission and recovery

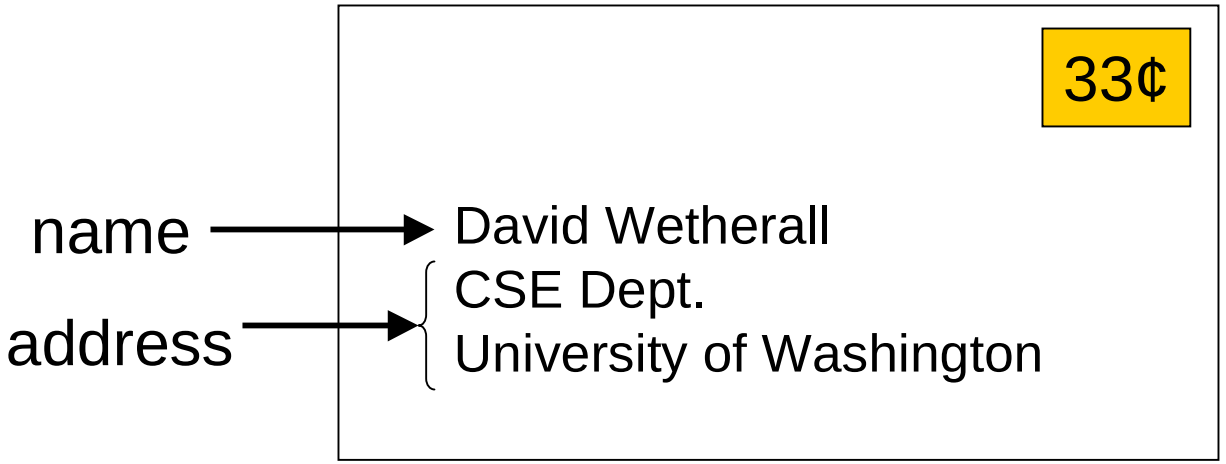


This Time

- Naming
- Focus
  - How do we name hosts etc.?
- Topics
  - Domain Name System (DNS)
  - Email/URLs



Names and Addresses



- Names are identifiers for objects/services (typ. high level)
- Addresses are locators for objects/services (typ. lower level)
- Process of mapping name to (lower level) address is resolution
- BUT: Addresses are really lower-level names; many levels used

Naming in Systems

- Ubiquitous
  - Files in filesystem, processes in OS, pages on the web, ...
- Decouple identifier for object/service from location
  - Hostnames provide a level of indirection for IP addresses
- Naming greatly impacts system capabilities and performance
  - Ethernet addresses are a unique flat 48 bits
    - unique → management; flat → any address anywhere
  - IP addresses are hierarchical 32/128 bits
    - hierarchy → smaller routing tables but constrained locations

Case Study: Internet Hostnames

- Hostnames are human-readable identifiers for end-systems based on an administrative hierarchy
  - galah.cs.washington.edu is my desktop machine
- IP addresses are a fixed-length binary encoding for end-systems based on their position in the network
  - 128.95.2.106 is galah's IP address

- Original name resolution: HOSTS.TXT
- Current name resolution: Domain Name System
- Future name resolution: ?

Original Hostname System

- When the Internet was really young ...
- Flat namespace
  - Simple (host, address) pairs
- Centralized management
  - Updates via a single master file called HOSTS.TXT
  - Manually coordinated by the Network Information Center (NIC)
- Resolution process
  - Look up hostname in the HOSTS.TXT file

Scaling Problems

- Coordination
  - Between all users to avoid conflicts
- Inconsistencies
  - Between update and distribution of new version
- Reliability
  - Single point of failure
- Performance
  - Competition for centralized resources

Domain Name System (DNS)

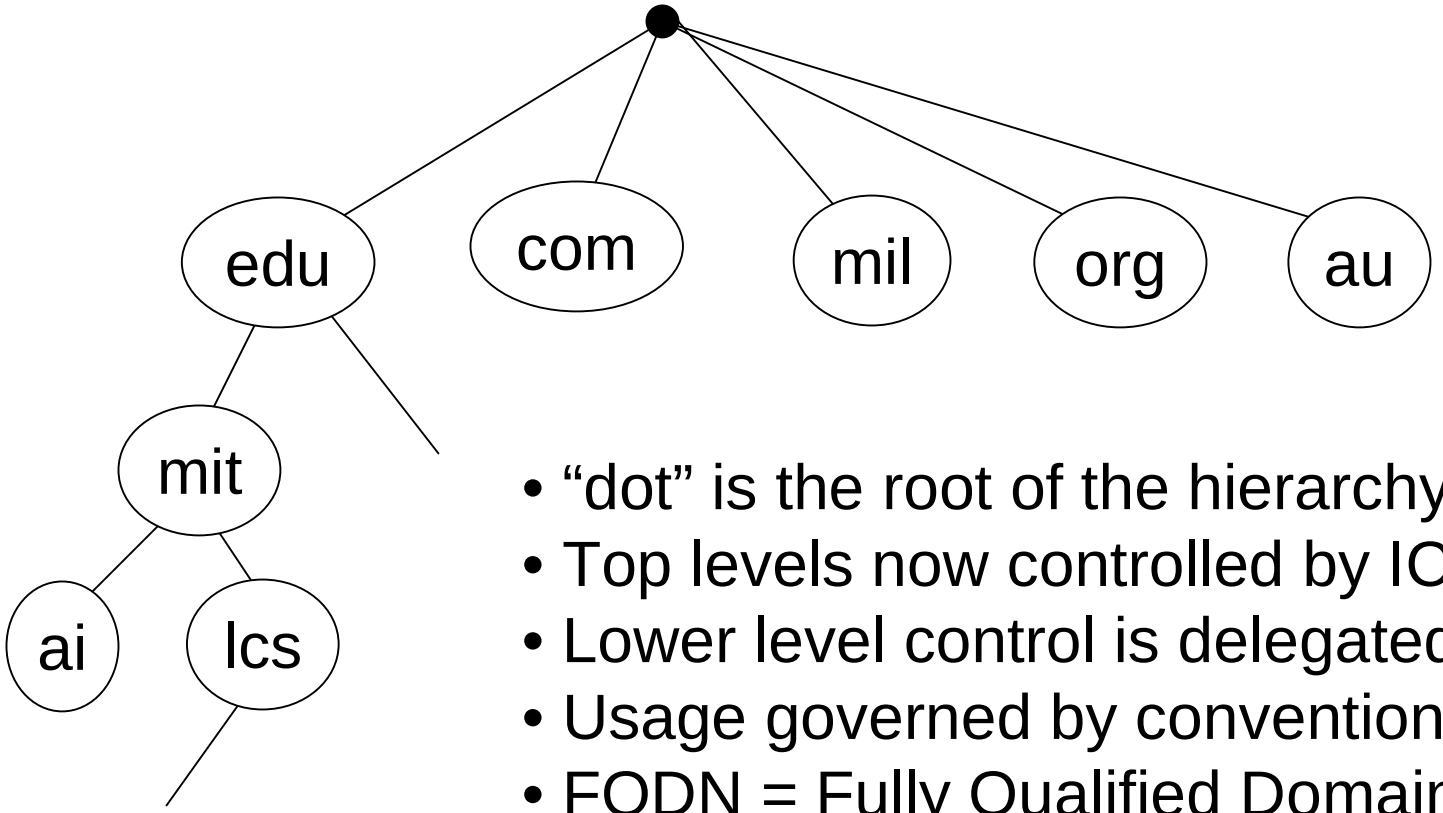
- Mockapetris and Dunlap mid 80s; Keshav 10, esp. 10.8

- Namespace is hierarchical
  - Allows much better scaling of data structures
  - e.g., galah.cs.washington.edu

- Namespace is distributed
  - Decentralized administration and access
  - e.g., galah managed by CSE

- Resolution is by query/response
  - With replicated servers for redundancy
  - With heavy use of caching for performance

DNS Hierarchy



- “dot” is the root of the hierarchy
- Top levels now controlled by ICANN
- Lower level control is delegated
- Usage governed by conventions
- FQDN = Fully Qualified Domain Name

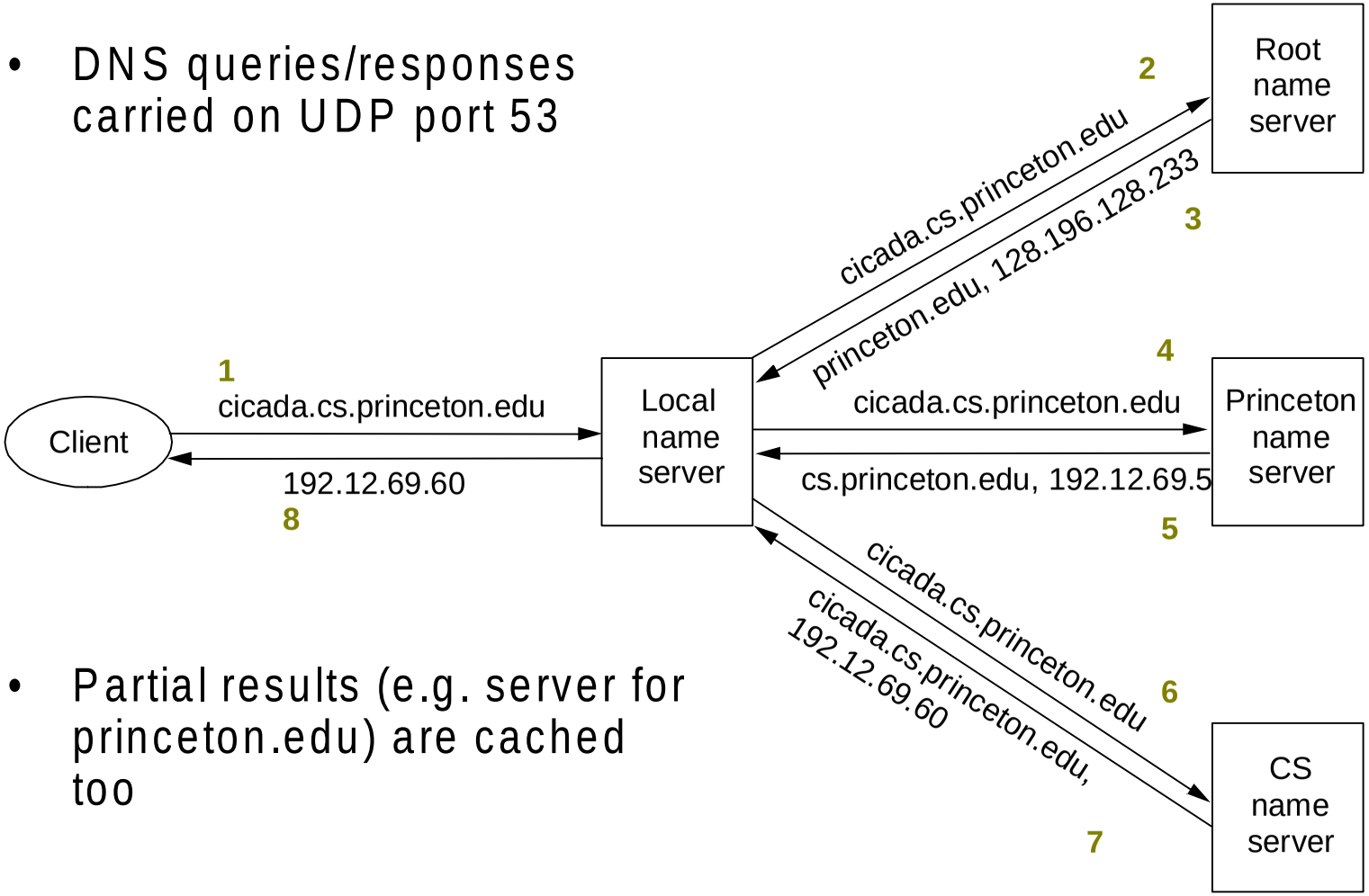
DNS Components

- Data managed by zones that contain resource records
  - Zone is a complete description of a portion of the namespace
  - e.g., all hosts and addresses for machines in washington.edu with pointers to subdomains like cs.washington.edu
  -
- One or more nameservers manage each zone
  - Zone transfers performed between nameservers for consistency
  - Multiple nameservers provide redundancy

- Client resolvers query nameservers for specified records
  - Multiple messages may be exchanged per DNS lookup to navigate the name hierarchy (coming soon)

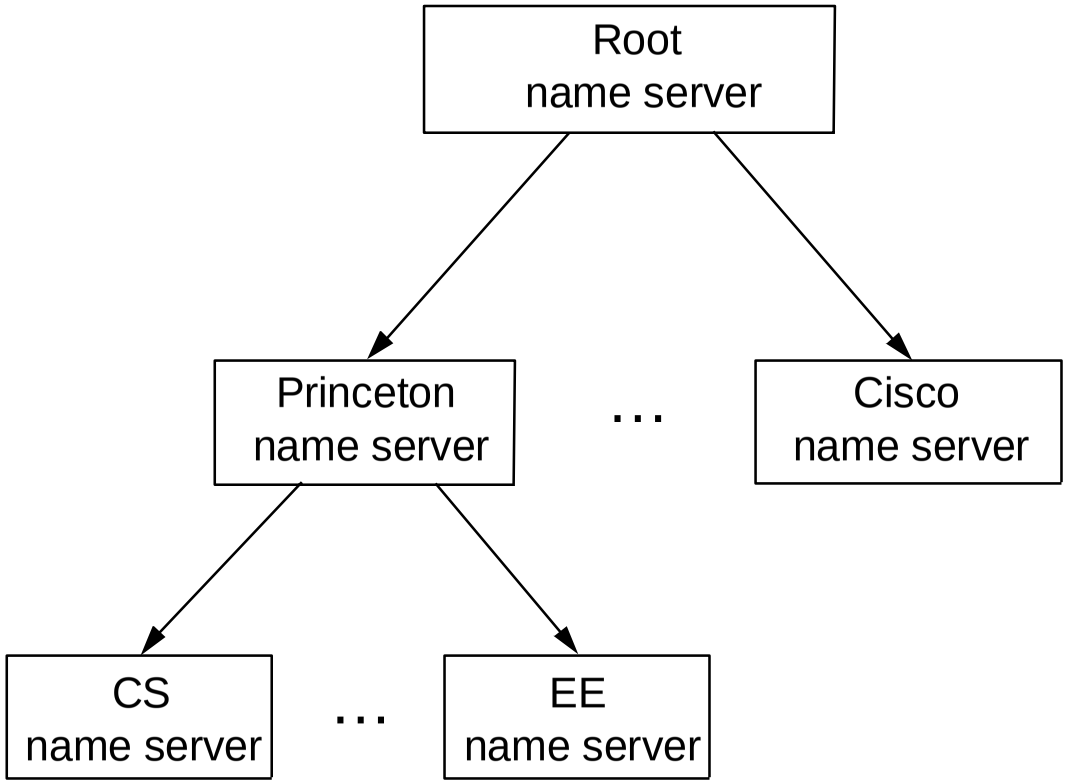
DNS Lookups

- DNS queries/responses carried on UDP port 53



- Partial results (e.g. server for princeton.edu) are cached too

Hierarchy of Nameservers



Caching

- Servers and clients cache results of DNS lookups
  - Cache partial results too (e.g., server for princeton.edu)
  - Greatly improves system performance; lookups the rare case
- Cache using time-to-live (TTL) value from provider
  - higher TTL means less traffic, lower TTL means less stale info
- Negative caching is used too!
  - errors can cause repeated queries for non-existent data

DNS Bootstrapping

- Need to know IP addresses of root servers before we can make any queries

- Addresses for 13 root servers ([a-m].root-servers.net) handled via initial configuration (named.ca file)

Finally, Reverse Queries

- How do we find out what hostname corresponds to an IP address?
  - Used as a weak authentication check by many web servers
- Idea: Reuse existing DNS machinery
  - Called the IN-ADDR.ARPA domain
  - Reverse IP address and query in that domain
  - e.g., 106.2.95.128.IN-ADDR.ARPA

Building on the DNS

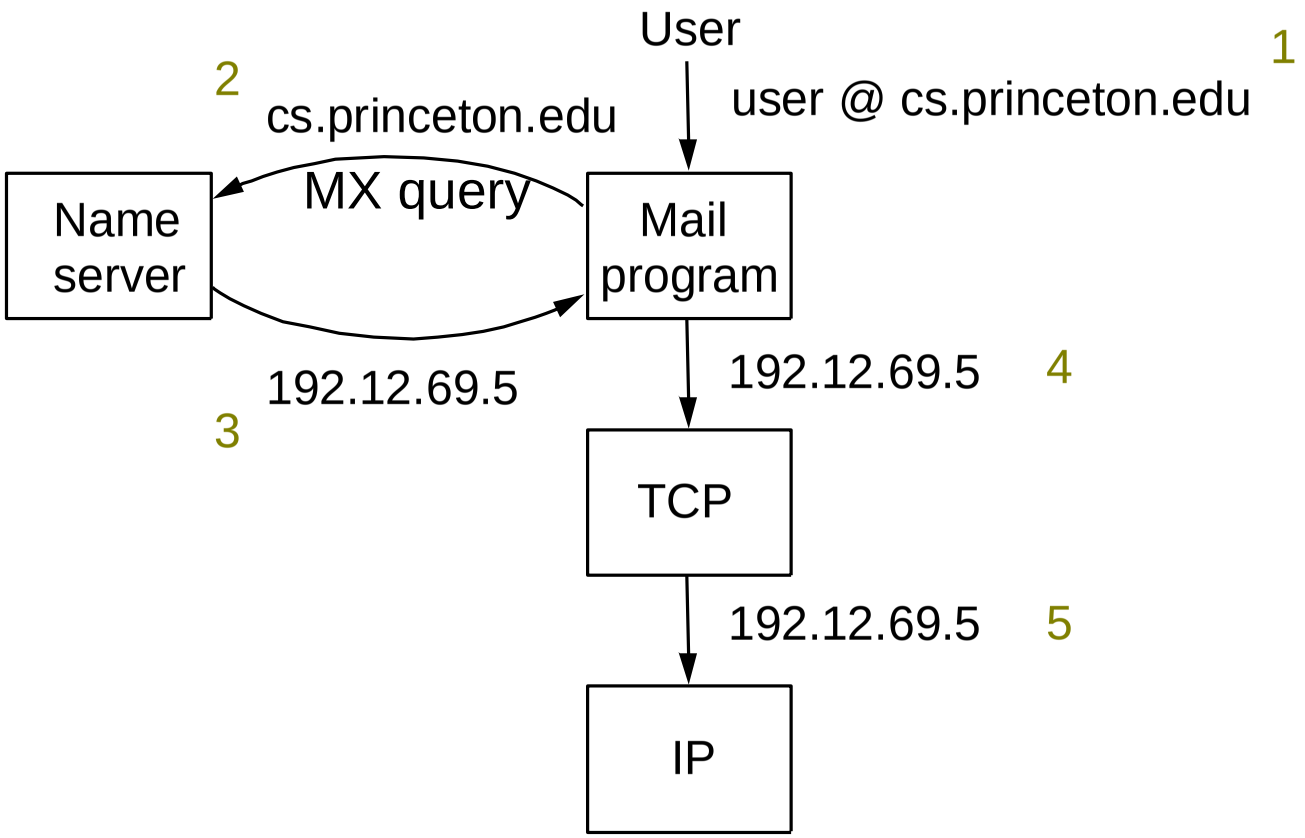
- Other naming designs leverage the DNS
- Email:
  - djw@cs.washington.edu is djw in the domain cs.washington.edu
- Uniform Resource Locators (URLs) name for Web pages
  - e.g., www.cs.washington.edu/homes/djw
  - Use domain name to identify a Web server
  - Use "/" separated string to name path to page (like files)

Email

- Mail messages delivered between mailboxes with SMTP (Simple Mail Transport Protocol) over TCP port 25
  - SMTP defines mail/address formats, and handoff procedures
  - Other protocols (POP3, IMAP) used to check your mailbox

- Question:
  - How do we find the mailbox for djw@cs.washington.edu?
- Answer:
  - Might contact host cs.washington.edu ... not done
  - Instead, look up MX (Mailer Exchange) DNS record for domain
  - Saves users from knowing internal details

Email Names and Addresses



Web/URLs

- Pages retrieved from Web server by client (browser) using HTTP (HyperText Transfer Protocol) running on TCP port 80 (typically)
  - HTTP defines format of requests/responses
  - Each page a separate connection (until persistent HTTP)
  - Try telnet <webserver> 80 and then "GET /index.html"

- Question:
  - How do we find the server www.mit.edu?
- Answer:
  - Ah ha! What about looking up a "WX" record in the DNS ... No
  - Instead, use hostname as Web server directly

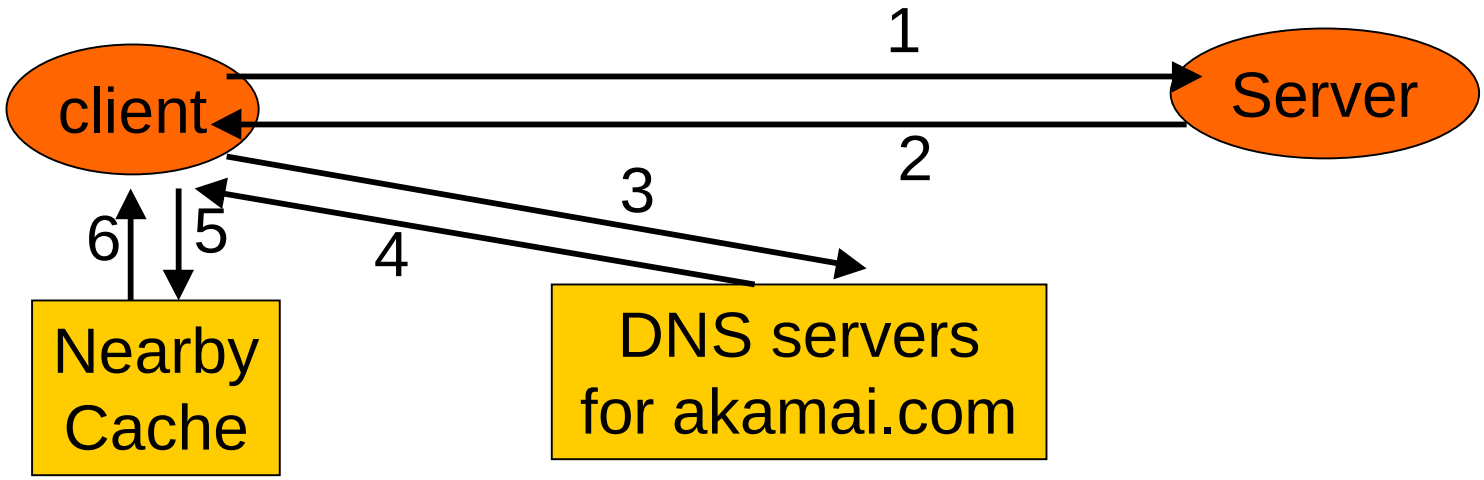
Future Evolution of the DNS

- Design constrains us in two major ways that are increasingly less appropriate

- Static host to IP mapping
  - What about mobility (Mobile IP) and dynamic address assignment (DHCP)
- Location-insensitive queries
  - What if I don't care what server a Web page comes from, as long as it's the right page?
  - e.g., a yahoo page might be replicated

Akamai

- Use the DNS to effect selection of a nearby Web cache



- Leverage separation of static/dynamic content
- Beware DNS caching

Key Concepts

- The design of names, addresses and resolution has a significant impact on system capabilities
- Hierarchy, decentralization and caching allow the DNS to scale
  - These are general techniques