COMP/ELEC 429/556
Introduction to Computer Networks

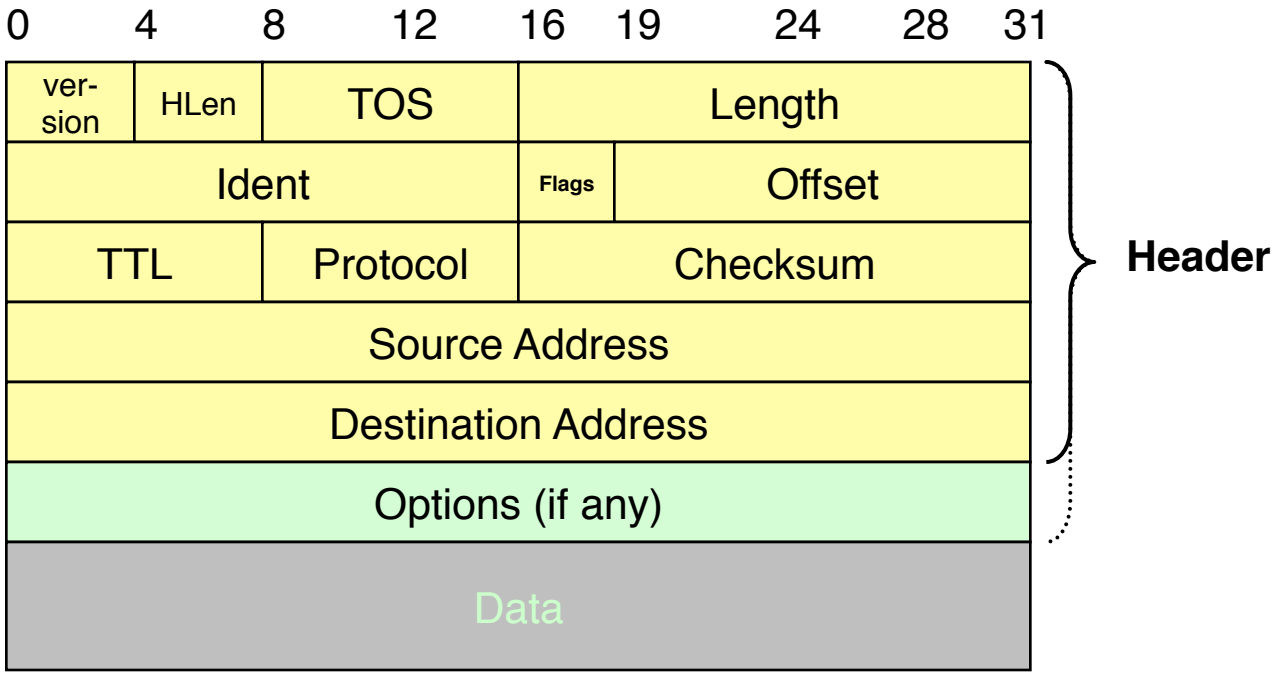
Domain Name System

Some slides used with permissions from Edward W. Knightly, T. S. Eugene Ng, Ion Stoica, Hui Zhang

Data Packet

- Fundamental unit for communications in Internet

IPv4 Packet Format



An IP address

2150268945

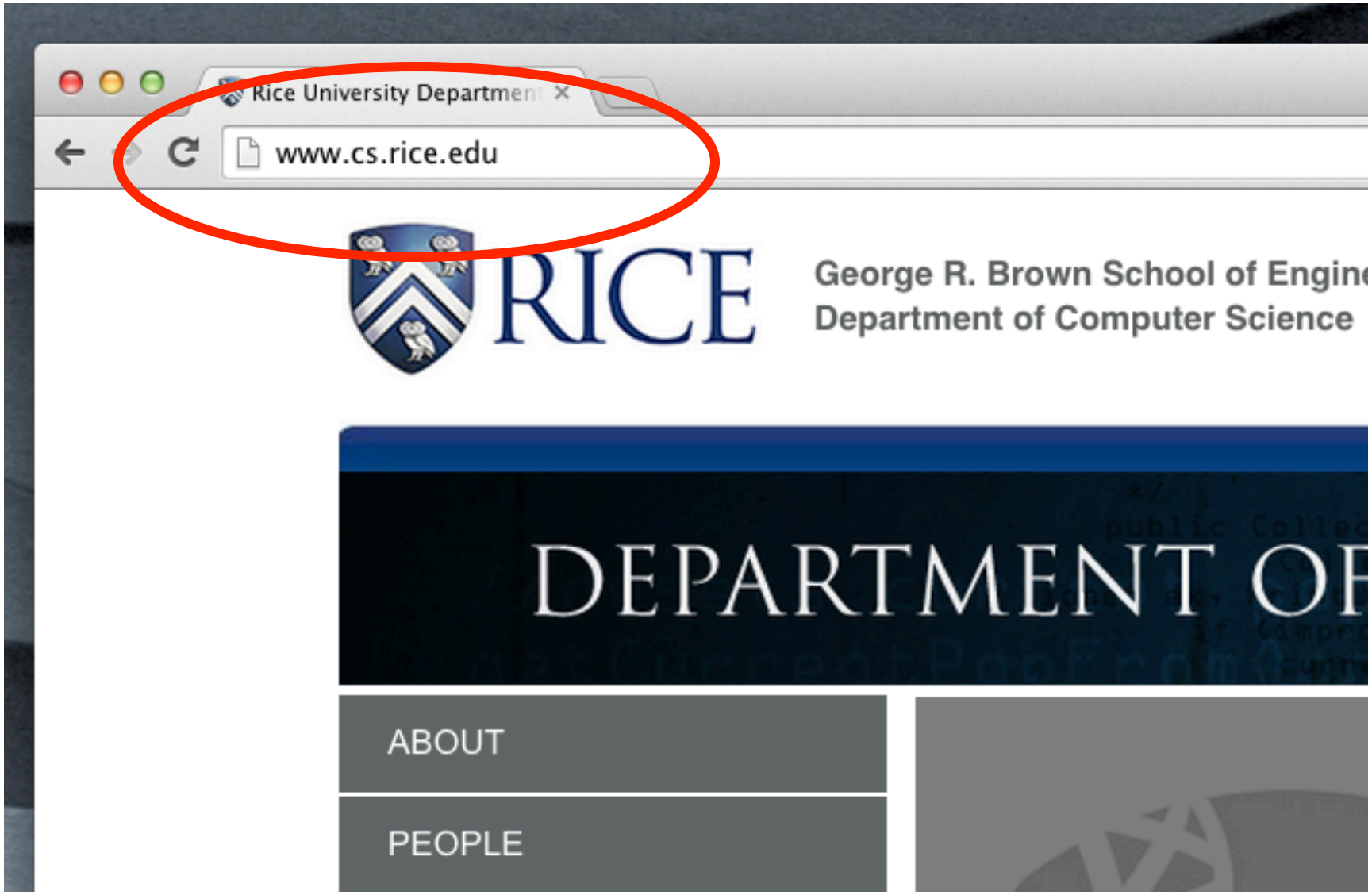
An IP address

128.42.128.17

10000000 00101010 10000000 00010001

A Domain Name

www.cs.rice.edu


Rice University Department
www.cs.rice.edu
RICE
George R. Brown School of Engine
Department of Computer Science
DEPARTMENT OF
ABOUT
PEOPLE

Motivation

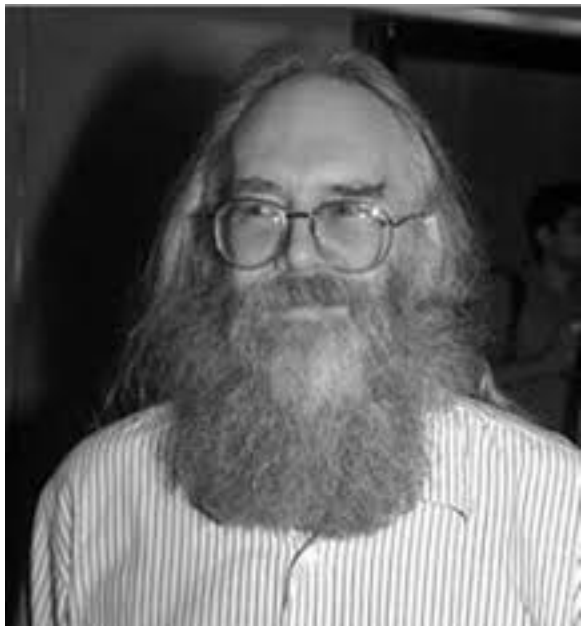
- Fact: A fundamental feature of the Internet is that every network interface is identified by a numerical IP address
- An application needs to know the IP address of the communication peer
- There is no magic, some out-of-band mechanism is needed
  - Word of mouth
  - Read it in magazine advertisements
  - Etc.
- But IP addresses are bad for humans to remember and tell each other, need names that makes sense to humans

Internet Names & Addresses

- Names: *e.g. www.rice.edu*
  - human-usable labels for machines
  - why this funny looking style with all these dots?
- Addresses: *e.g. 128.42.204.11*
  - 32-bit number, written this way for convenience
  - machine-usable labels for machines
  - more efficient to process than names
- How do you lookup from one to another?
- Let's try nslookup!

Remainder of this set of slides are for your reference only. They will not be needed for assignments.

Domain Name System is a case study of the importance of scalability



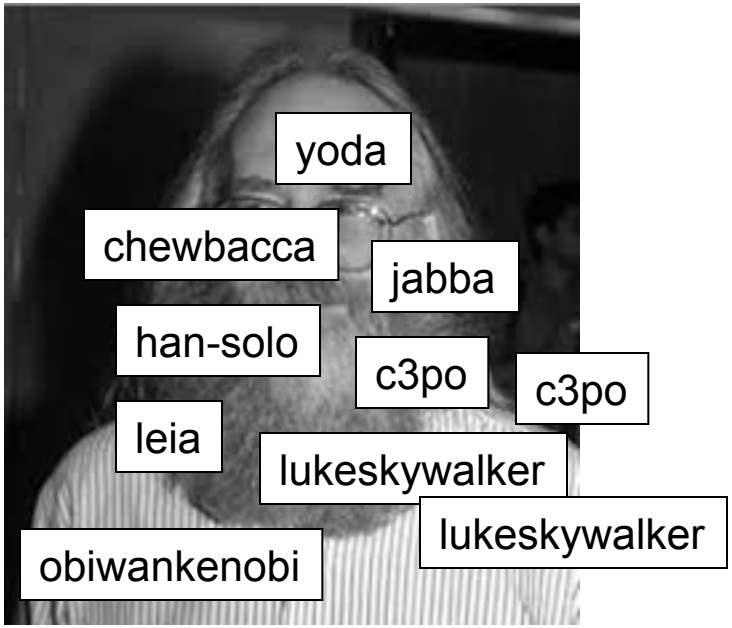
- Who's this guy?

Jon Postel

From Wikipedia, the free encyclopedia

Jonathan Bruce Postel (/pəˈstɛl/; August 6, 1943 – October 16, 1998) was an American computer scientist who made many significant contributions to the development of the Internet, particularly with respect to standards. He is known principally for

Domain names used to be arbitrary and stored in one shared file hosts.txt



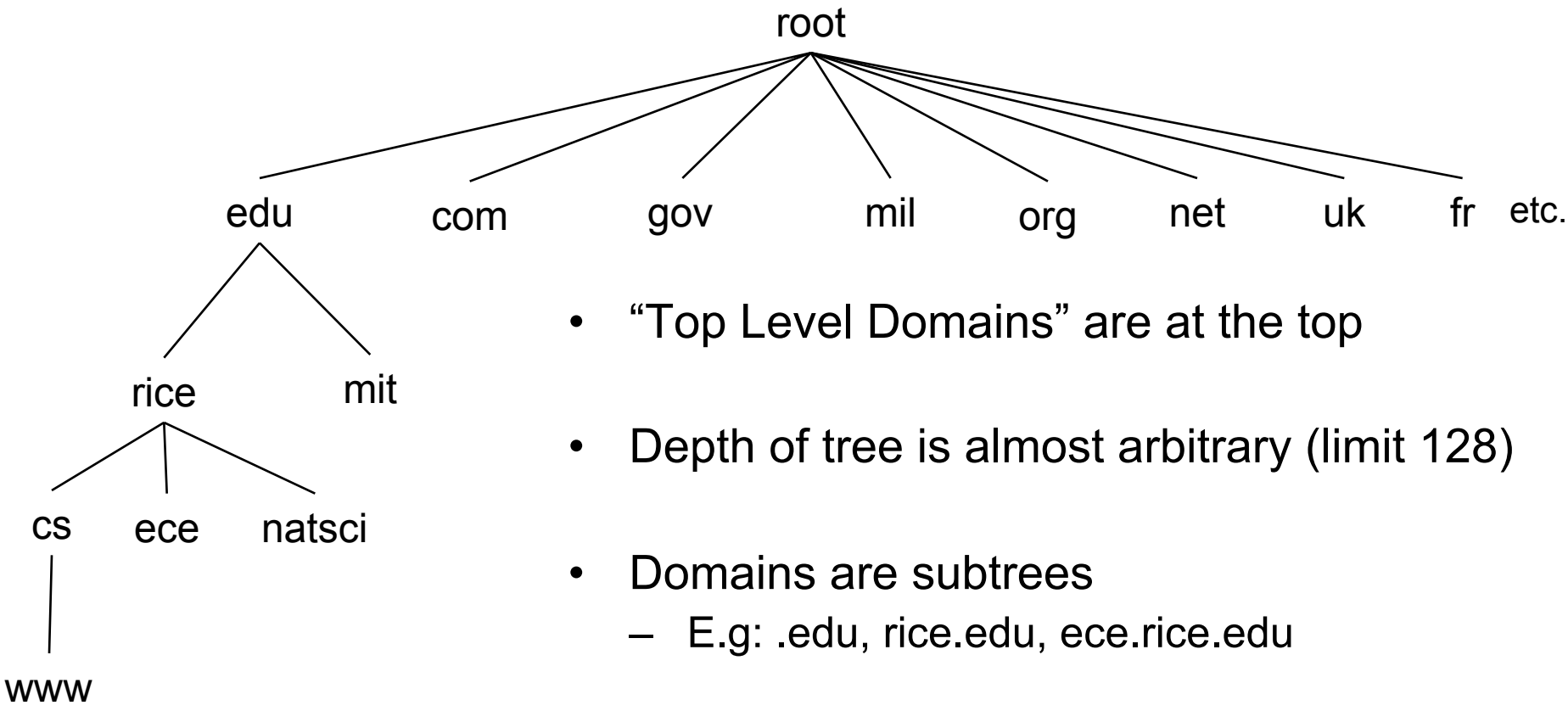
History

- Initially all host-addess mappings were in a file called hosts.txt (in /etc/hosts)
  - Changes were submitted to SRI by email
  - New versions of hosts.txt ftp'd periodically from SRI
  - An administrator could pick names at their discretion
  - Any name is allowed: eugenesdesktopatrice
- As the Internet grew this system broke down because:
  - SRI couldn't handled the load
  - Hard to enforce uniqueness of names
  - Many hosts had inaccurate copies of hosts.txt
- How to build a lookup system that scales!!!
  - billions of names and addresses to insert/delete/modify
  - billions of lookups per second
- Strategy: Divide and Conquer!
  - Now do you see why domain names look like www.rice.edu instead of lukeskywalker?

Basic DNS Features

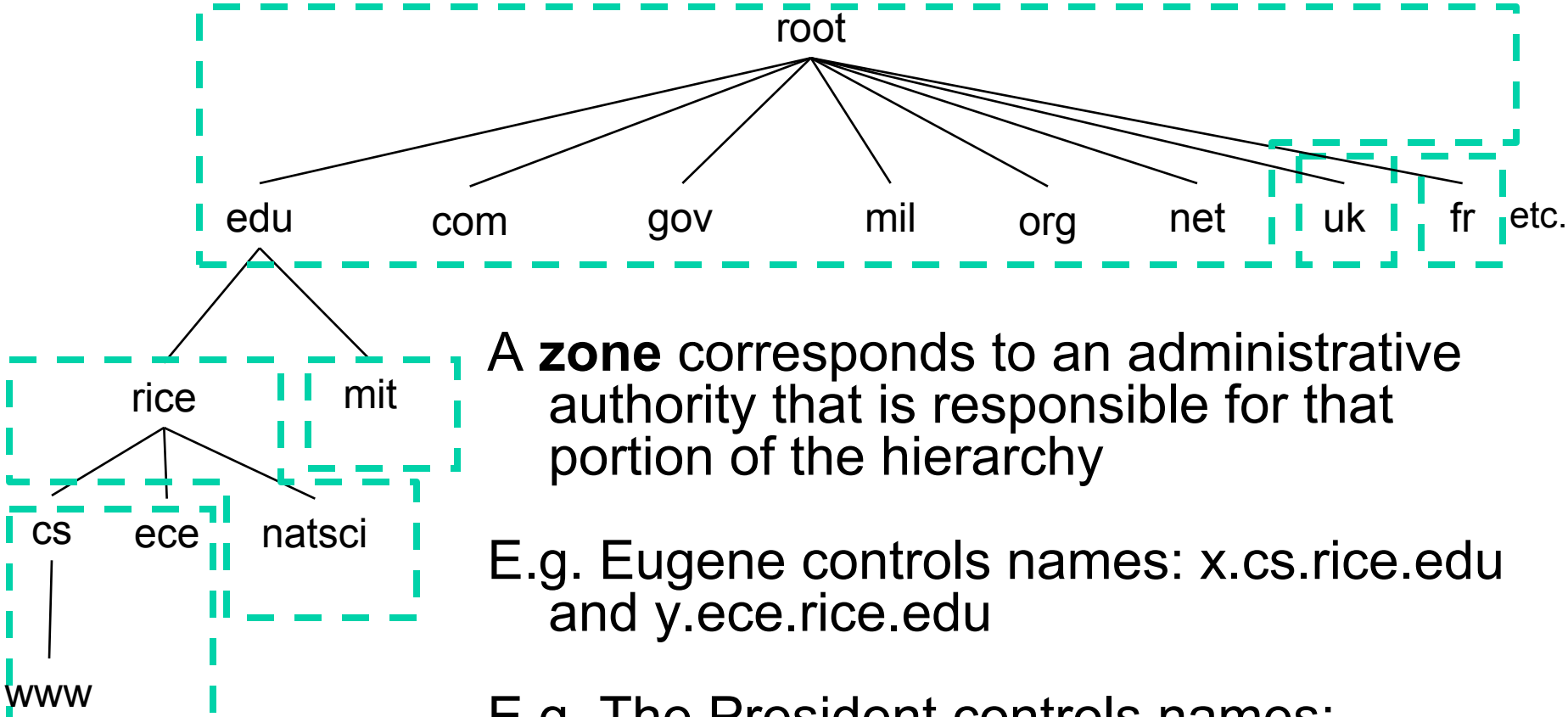
- Hierarchical namespace
  - as opposed to original flat namespace
- Distributed storage architecture
  - as opposed to centralized storage (plus replication)

Naming Hierarchy



- "Top Level Domains" are at the top
- Depth of tree is almost arbitrary (limit 128)
- Domains are subtrees
  - E.g: .edu, rice.edu, ece.rice.edu
- Name collisions avoided
  - E.g. rice.edu and rice.com can coexist, but uniqueness is job of domain

Host names are administered hierarchically



A **zone** corresponds to an administrative authority that is responsible for that portion of the hierarchy

E.g. Eugene controls names: x.cs.rice.edu and y.ece.rice.edu

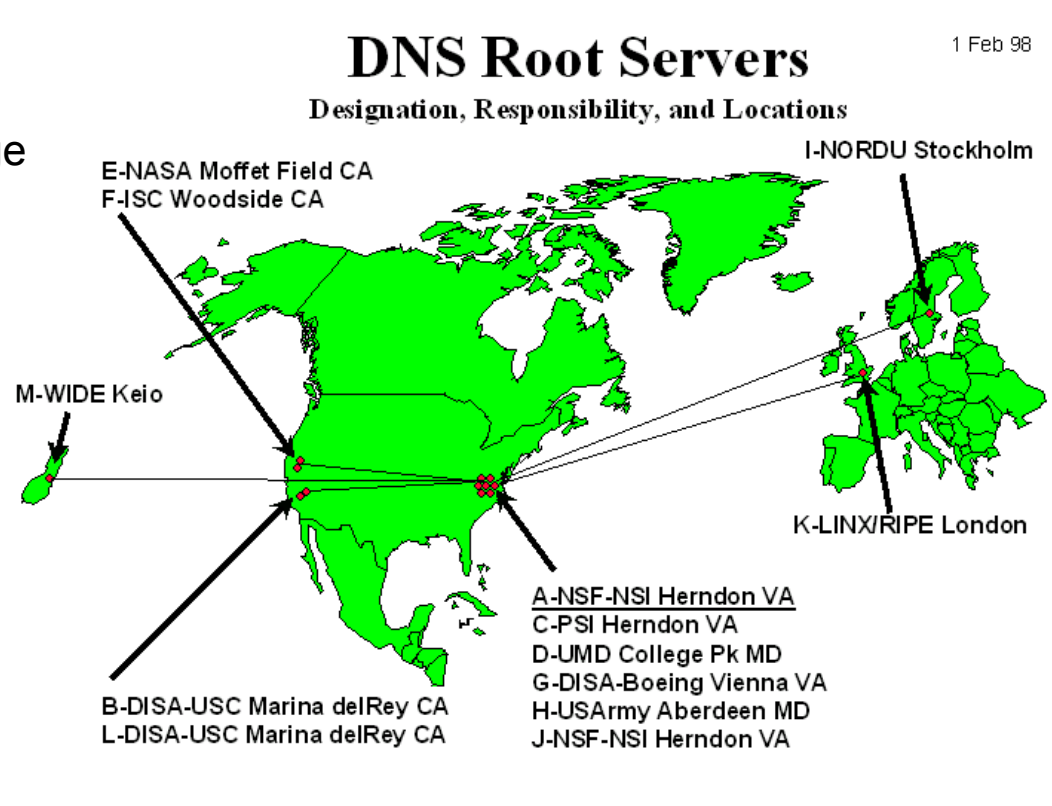
E.g. The President controls names: x.rice.edu and y.natsci.rice.edu

DNS Server Hierarchy

- Each server has authority over a portion of the hierarchy called zone
- Each server contains all the records for the hosts or domains in its zone
  - That zone can be empty; why will be revealed later
  - a server might be replicated for robustness
  - “Root server” knows about all top-level domains

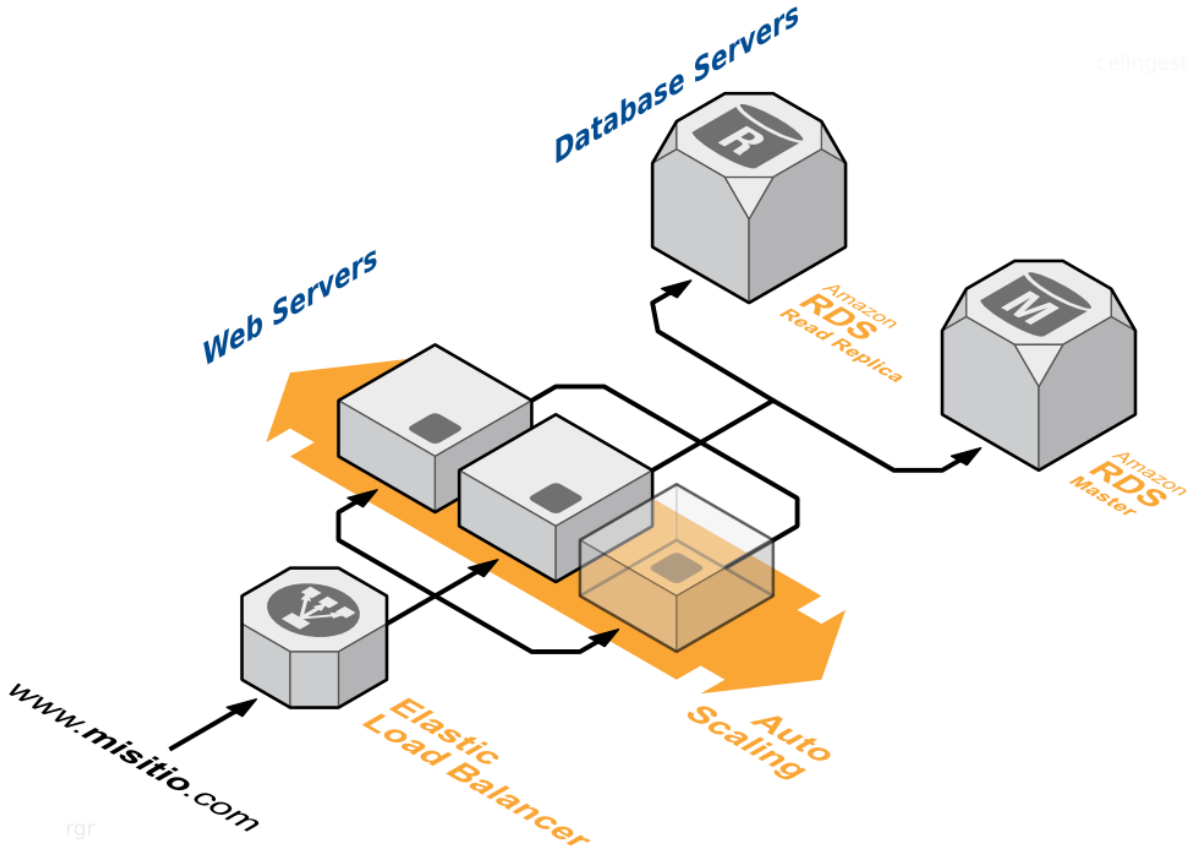
DNS: Root Servers

- About a dozen root server IP addresses
  - Each address can refer to a large cluster of replicated servers to achieve sufficient performance
- Contacted by other servers that cannot resolve name



Load Balancers Are Very Common

- e.g. Amazon AWS



Basic Domain Name Resolution

- Every host knows a local DNS server
  - Through DHCP, for example
  - Sends all queries to a local DNS server
- Every local DNS server knows the ROOT servers
  - When no locally cached information exists about the query, talk to a root server, and go down the name hierarchy from the root
  - If we lookup www.rice.edu, and we have a cached entry for the rice.edu name server, then we can go directly to the rice.edu name server and bypass the root server

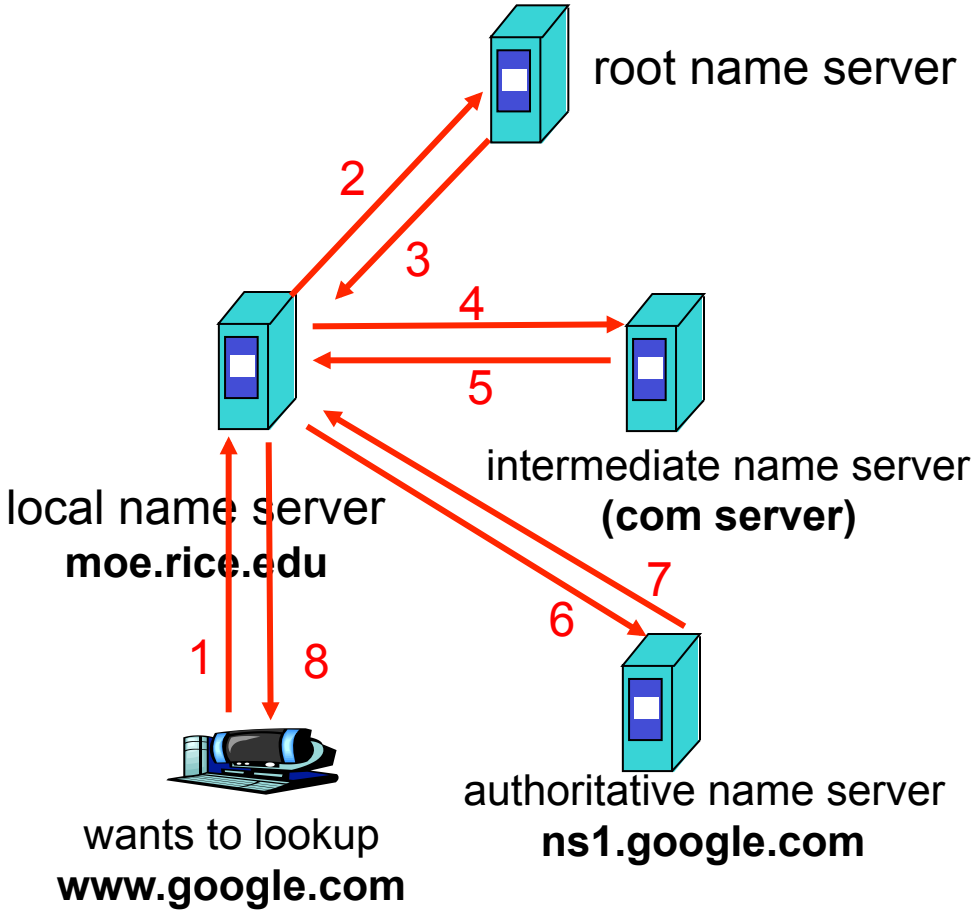
Example of Iterated DNS Query

Root name server:

- May not know authoritative name server
- May know intermediate name server: who to contact to find authoritative name server

Iterated query:

- Contacted server replies with name/address of another server
- "I don't know this name, but ask this server"

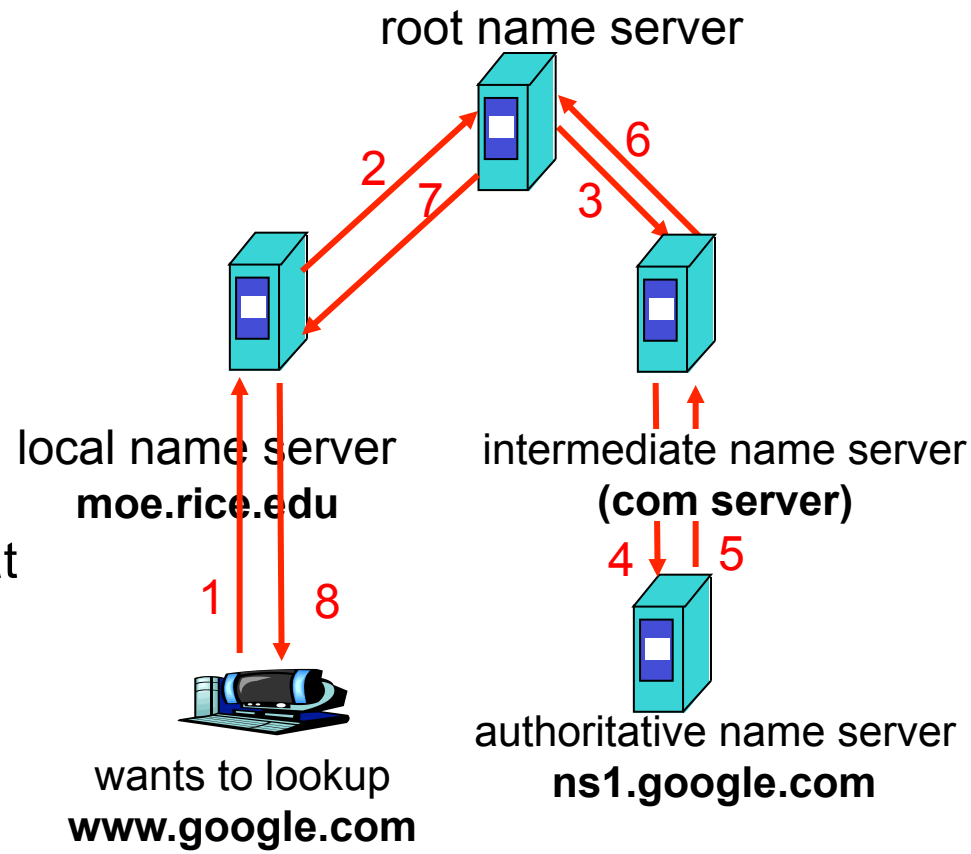


Example of Recursive DNS Query

Which scales better?
Iterative or Recursive?

Recursive query:

- Puts burden of name resolution on contacted name server
- Extra "state" maintained at the intermediate servers
- More "state" is more complexity and hurts scalability
- Support is uncommon



DNS Resource Records

- DNS Query:
  - Two fields: (name, type)
- Resource record is the response to a query
  - Four fields: (name, value, type, TTL)
  - TTL (time to live) is the duration the response can be cached
  - There can be multiple valid responses to a query
- Type = A:
  - name = hostname
  - value = IP address

Other Common Record Types

- Type = NS:
  - name = domain
  - value = name of dns server for domain
- Type = CNAME:
  - name = hostname
  - value = canonical name
- Type = MX:
  - name = domain in email address
  - value = canonical name of mail server and priority

Discussions

- DNS caching
  - Each record has a TTL
  - Crucial to scalability
  - Improve performance by saving results of previous lookups
  - E.g. results of address records and name server records (e.g. if rice.edu name server is cached, then can bypass root server the second time looking for a rice.edu host)
- DNS “hacks”
  - Return records based on requesting IP address
  - Round-robin over a list of IP addresses mapped to the same name for load balancing
  - Return address of least loaded machine
  - Basis for many web content distribution networks such as Akamai and Limelight

Discussions

- DNS has been a large source of security problems throughout the history of the Internet

Examples:

- DNS servers can be leveraged to amplify a denial of service attack
- DNS cache poisoning can allow attackers to direct traffic to malicious machines
- Original DNS server software had lots of buffer overflow bugs that could be exploited by an attacker to take over the DNS server