IT2004 – Introduction to Data communication & Networking

DNS – Domain Name Service

What is Domain Name ?

- Familiar, easy to remember names for computers on the Internet (such as sliate.net).
- alphanumeric names for IP addresses(e.g., www.google.com, ietf.org)
- Correspond to a series of numbers (called Internet Protocol numbers, IP addresses) that serve as routing addresses on the Internet.
- Domain names are used generally as a convenient way of locating information and reaching others on the Internet.

What is DNS?

- Domain Name Service/Domain Name System
- Is an Internet-wide distributed database that translates between domain names and IP addresses
- Defines a hierarchical namespace where each level of the namespace is separated by a "."
- Provides resolution of names to IP addresses and resolution of IP addresses to names

What does it mean to "register" a Domain Name

- The Internet domain name system (DNS) consists of a directory, organized hierarchically, of all the domain names and their corresponding computers registered to particular companies and persons using the Internet.
- When you register a domain name, it will be associated with the computer on the Internet you designate during the period the registration is in effect.

What is a DNS Server?

- Computer running DNS service
- Can be:
  - Microsoft® Windows® .NET Server 2003
  - Windows 2000
  - Microsoft Windows® NT 4
  - UNIX
  - Linux
  - NetWare
  - Etc.
- Capabilities vary by operating system and/or DNS server software version

What is DNS Resolution?

- DNS Resolution is the procedure used to resolve a IP address from a domain name.
- This is very similar to how we get the phone number of a person we want to contact.
- It is all based on hierarchy.

DNS Resolution analogy

Looking up a phone number

- Get the phone book of the right city
- People are listed by last name
- Then narrow it down to a first name.

It is the phone number that allows you to communicate over the phone, not the person's name.

DNS Foundation

- All computers communicate by addressing each other using IP addresses.
- So every time you try to connect to a website, or send an e-mail, DNS resolution is occurring.
- Just like phone numbers, multiple domain names can resolve to the same IP address. (just like multiple people can have the same phone number).

Before there was DNS ….

…. there was the HOSTS.TXT file

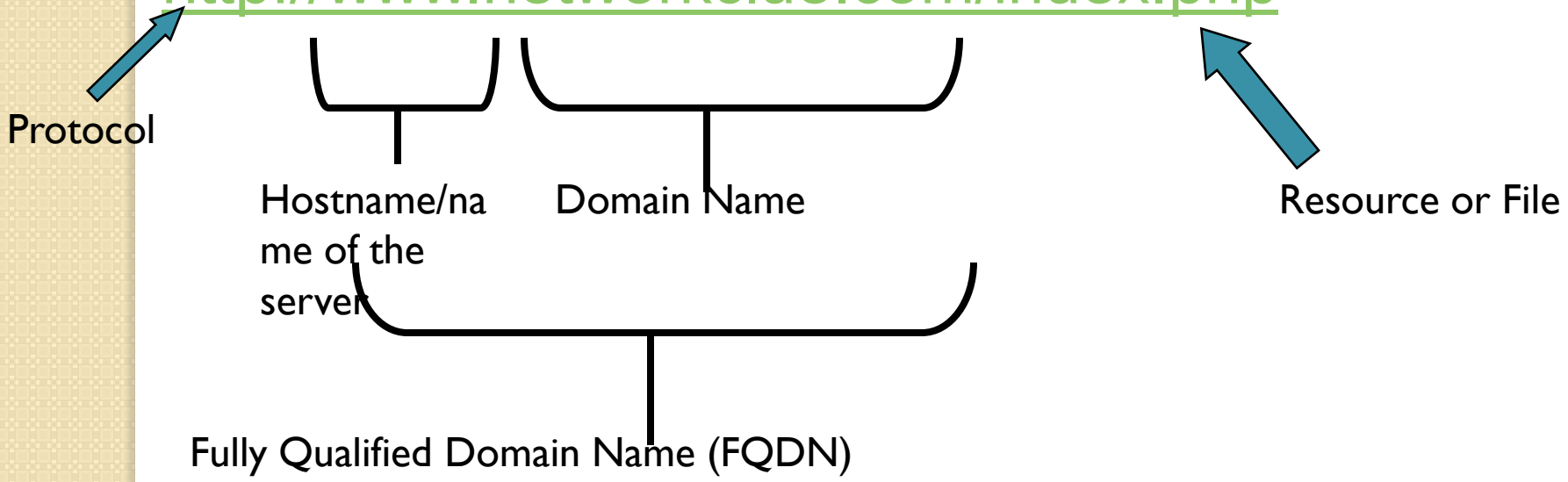
- Before DNS (until 1985), the name-to-IP address was done by downloading a single file (hosts.txt) from a central server with FTP.
  - Names in hosts.txt are not structured.
  - The hosts.txt file still works on most operating systems. It can be used to define local names.

Domain Names vs. URLs

A domain name is contained in a URL. See the examples below.

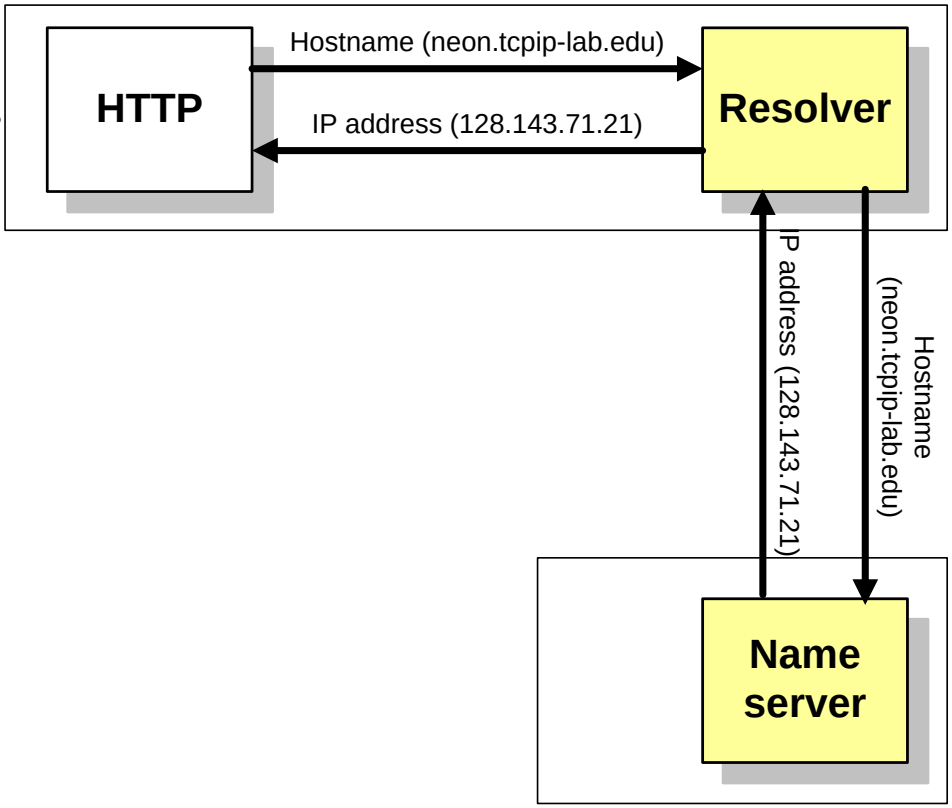
ftp://ftp.company.com/downloads.report.doc

http://www.networkclue.com/index.php



Resolver and name server

1. An application program on a host accesses the domain system through a DNS client, called the **resolver**
2. Resolver contacts DNS server, called name server
3. DNS server returns IP address to resolver which passes the IP address to application



- Reverse lookups are also possible, i.e., find the hostname given an IP address

Resolver

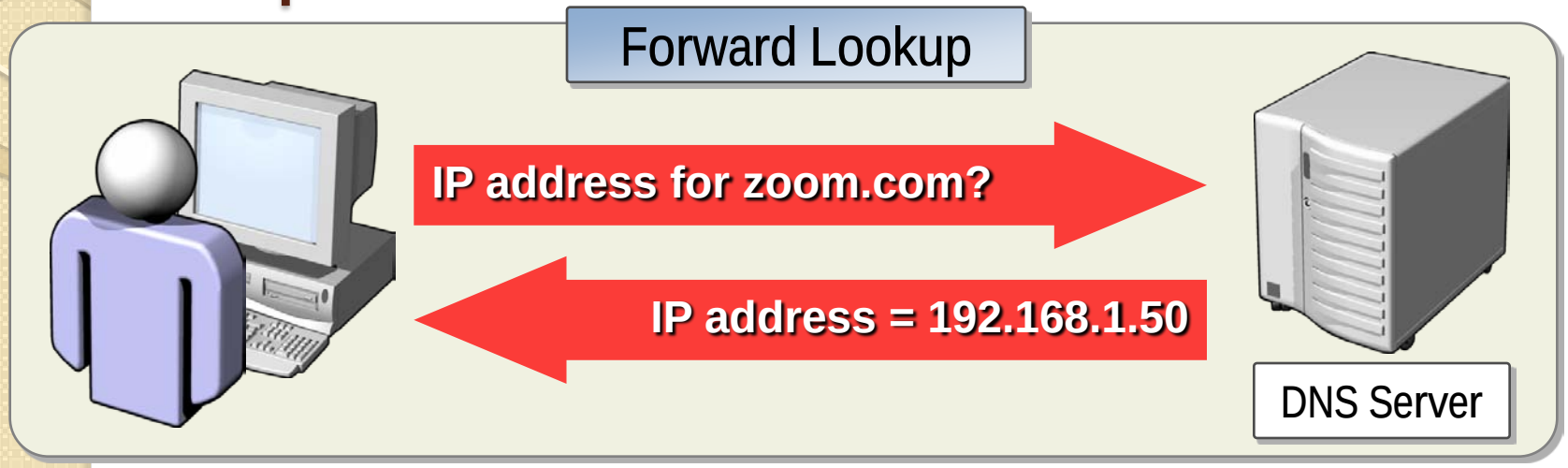
- Computer that requests DNS resolution
- Issues queries that ask for specific types of mappings of computers and IP addresses (*records*)
- Query types determine behavior of DNS server receiving query
- Lookup types determine whether a name-to-IP mapping or an IP-to-name mapping is sought

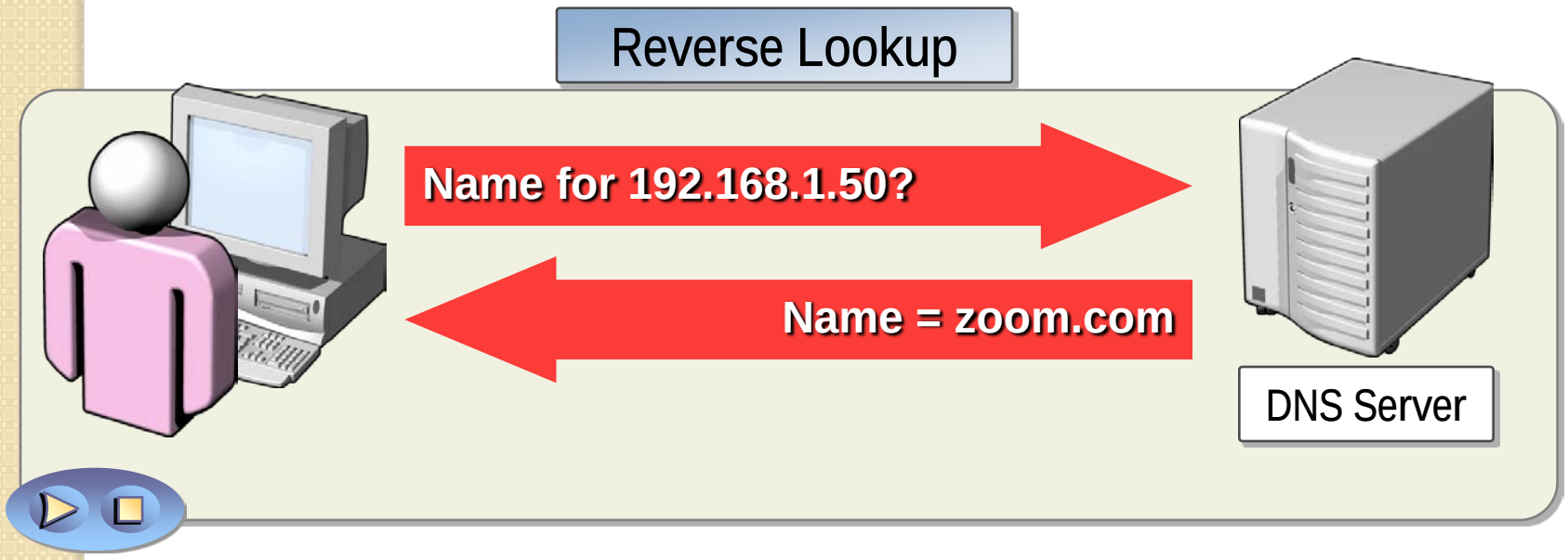
Query and Lookup Types

Query Types	
Iterative query	**The DNS server returns an answer to the query or a pointer to other DNS servers**
Recursive query	**The DNS server returns a complete answer to the query, not a pointer to another DNS server**

Lookup Types	
Forward lookup	**Requests name-to-address resolution**
Reverse lookup	**Requests address-to-name resolution**

DNS Zone Types: Forward and Reverse Lookup



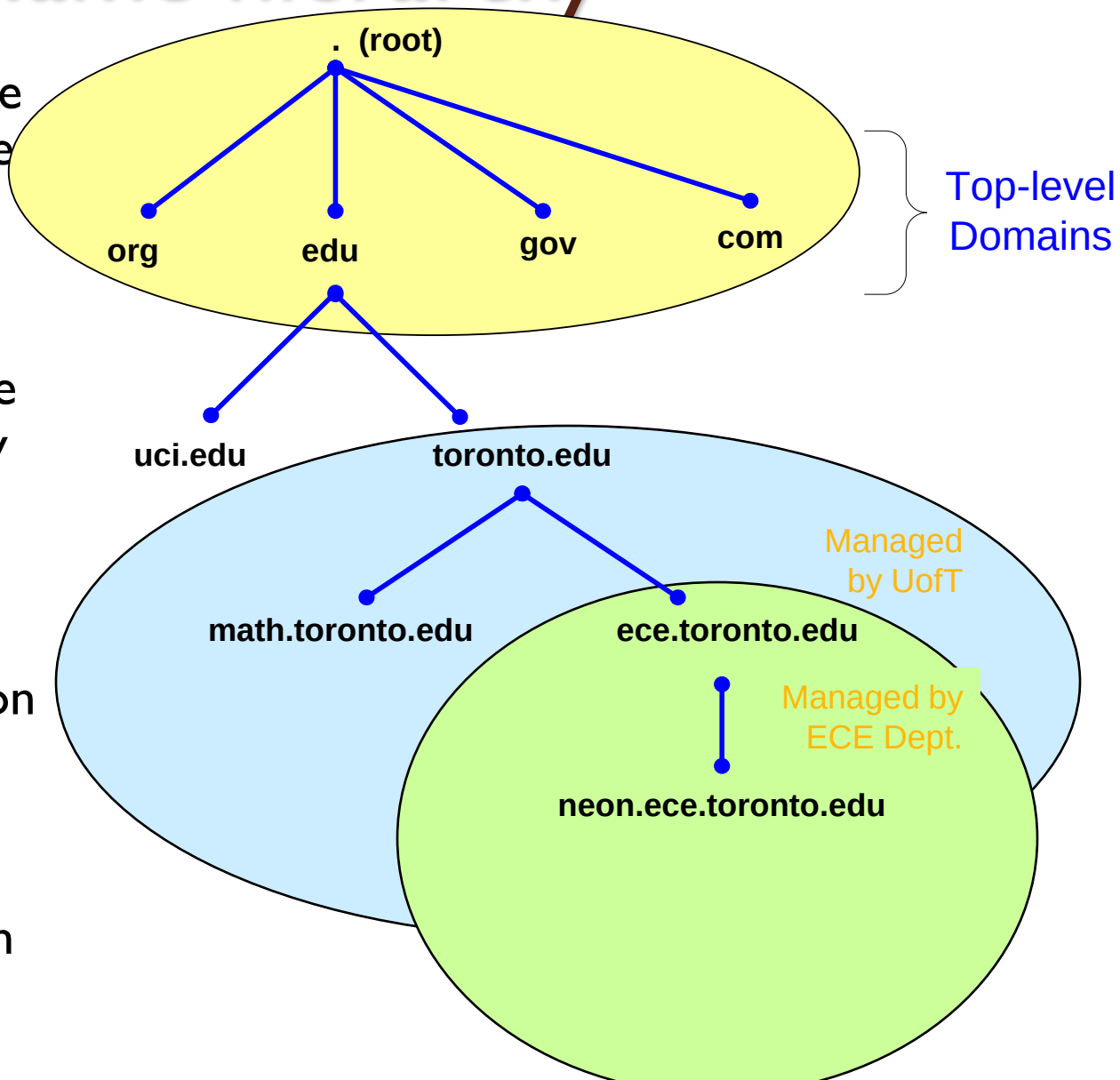


Design principle of DNS

- The naming system on which DNS is based is a hierarchical and logical tree structure called the *domain namespace*.
- An organization obtains authority for parts of the name space, and can add additional layers of the hierarchy
- Names of hosts can be assigned without regard of location on a link layer network, IP network or autonomous system
- In practice, allocation of the domain names generally follows the allocation of IP address, e.g.,
  - All hosts with network prefix 128.143/16 have domain name suffix virginia.edu
  - All hosts on network 128.143.136/24 are in the Computer Science Department of the University of Virginia

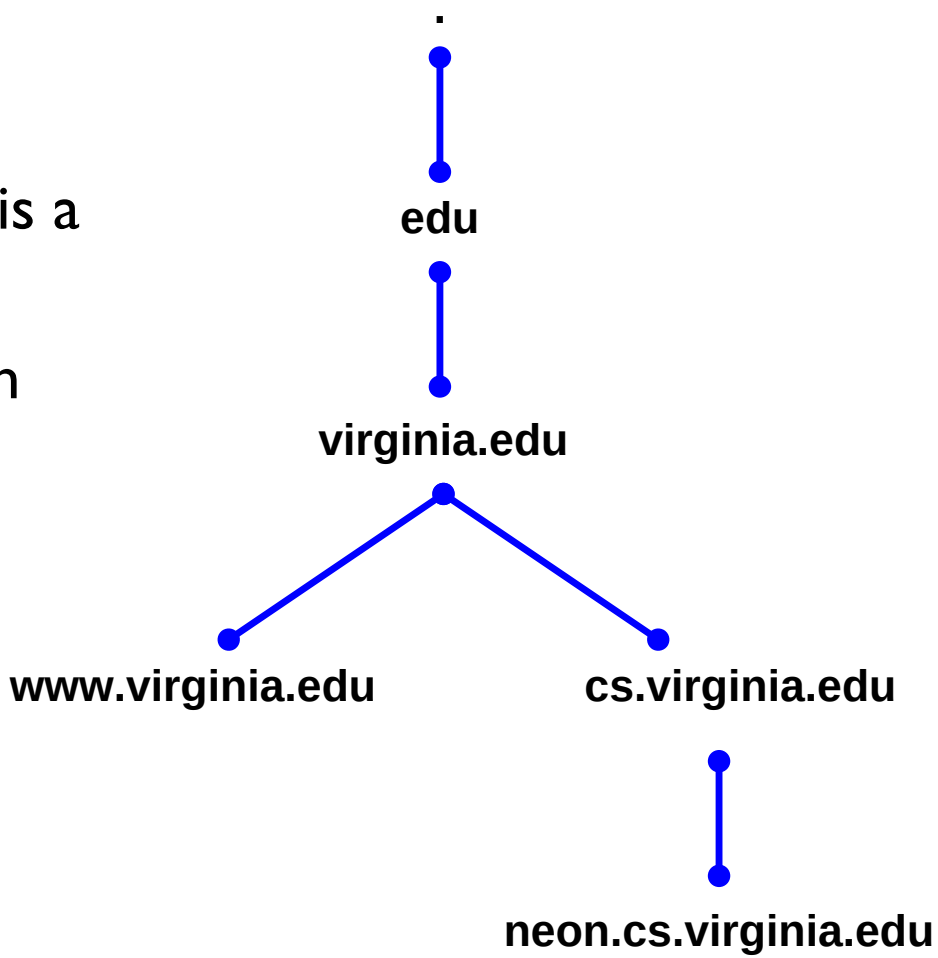
DNS Name hierarchy

- DNS hierarchy can be represented by a tree
- Root and top-level domains are administered by an Internet central name registration authority (ICANN)
- Below top-level domain, administration of name space is delegated to organizations
- Each organization can delegate further



Domain name system

- Each node in the DNS tree represents a DNS name
- Each branch below a node is a DNS domain.
  - DNS domain can contain hosts or other domains (subdomains)
- Example:
  DNS domains are
  ., edu, virginia.edu, cs.virginia.edu



Domain names

- Hosts and DNS domains are named based on their position in the domain tree
- Every node in the DNS domain tree can be identified by a unique Fully Qualified Domain Name (FQDN). The FQDN gives the position in the DNS tree.

cs.virginia.edu or cs.virginia.edu.

- A FQDN consists of labels (“cs”,“virginia”,”edu”) separated by a period (“.”)
- There can be a period (“.”) at the end.
- Each label can be up to 63 characters long
- FQDN contains characters, numerals, and dash character (“-”)
- FQDNs are not case-sensitive

Top-level domains

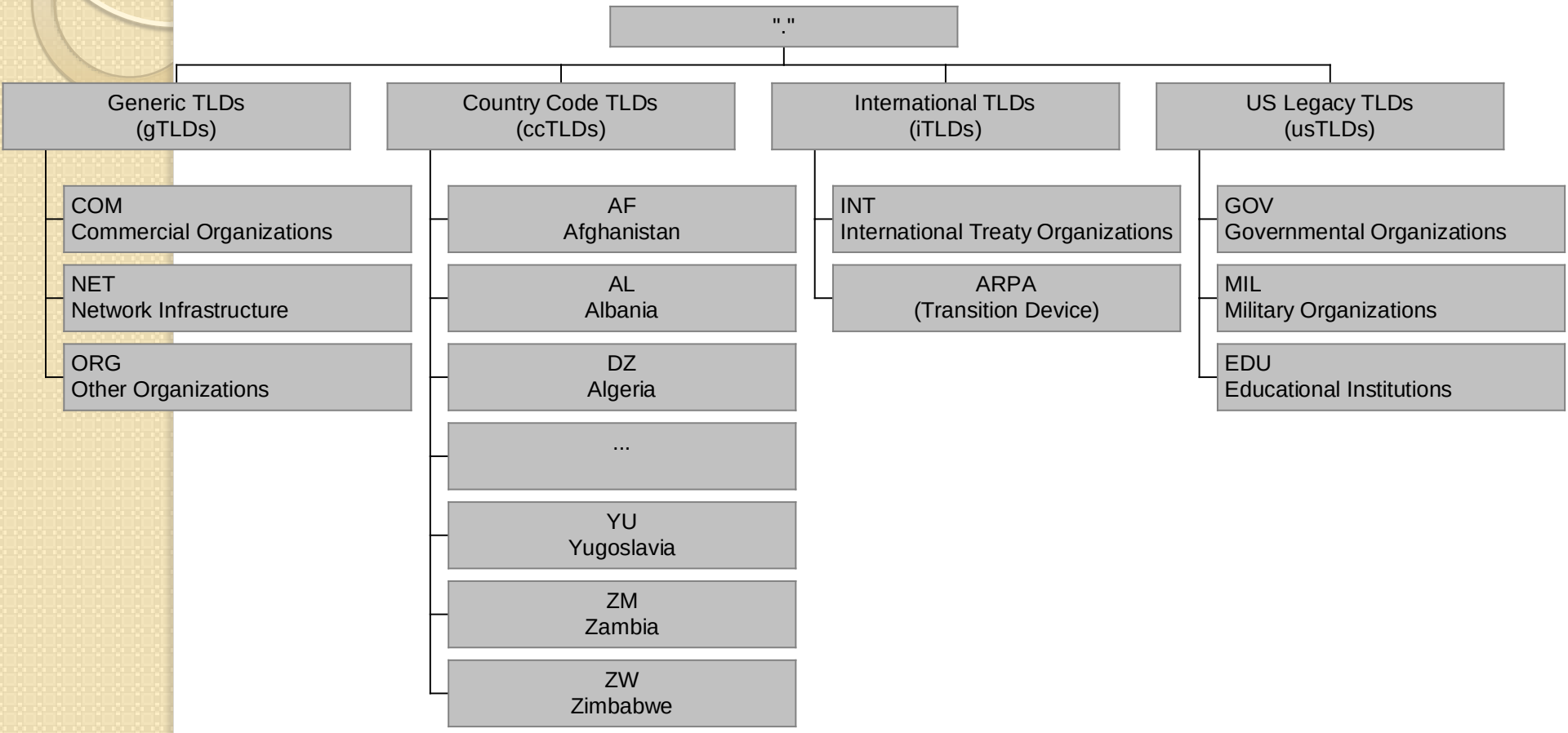
- Three types of top-level domains:
  - Organizational: 3-character code indicates the function of the organization
    - Used primarily within the US
    - Examples: gov, mil, edu, org, com, net
  - Geographical: 2-character country or region code
    - Examples: us, va, jp, de,lk,uk
  - Reverse domains: A special domain (in-addr.arpa) used for IP address-to-name mapping

There are more than 200 top-level domains.

Organizational top-level domains

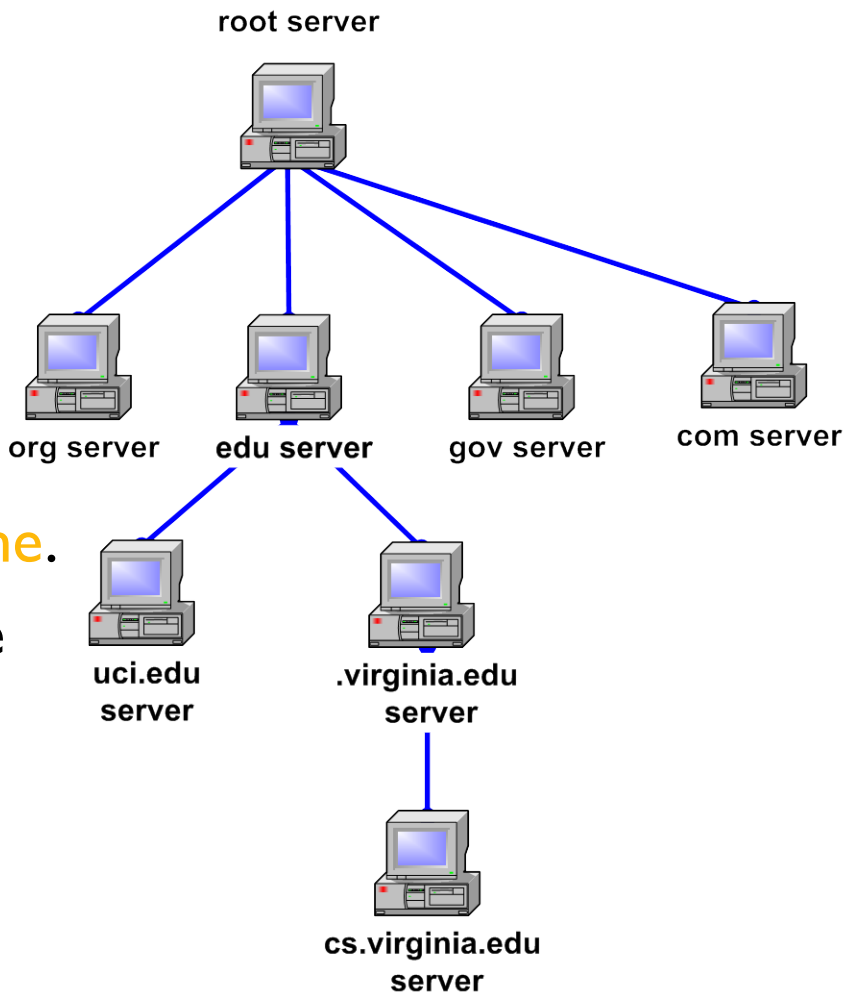
com	Commercial organizations
edu	Educational institutions
gov	Government institutions
int	International organizations
mil	U.S. military institutions
net	Networking organizations
org	Non-profit organizations

The Current TLDs



Hierarchy of name servers

- The resolution of the hierarchical name space is done by a hierarchy of name servers
- Each server is responsible (authoritative) for a contiguous portion of the DNS namespace, called a zone.
- Zone is a part of the subtree
- DNS server answers queries about hosts in its zone



Authority and delegation

- Authority for the root domain is with the Internet Corporation for Assigned Numbers and Names (ICANN)
- ICANN delegates to accredited registrars (for gTLDs) and countries for country code top level domains (ccTLDs)
- Authority can be delegated further

- Chain of delegation can be obtained by reading domain name from right to left.
- Unit of delegation is a “zone”.

DNS domain and zones

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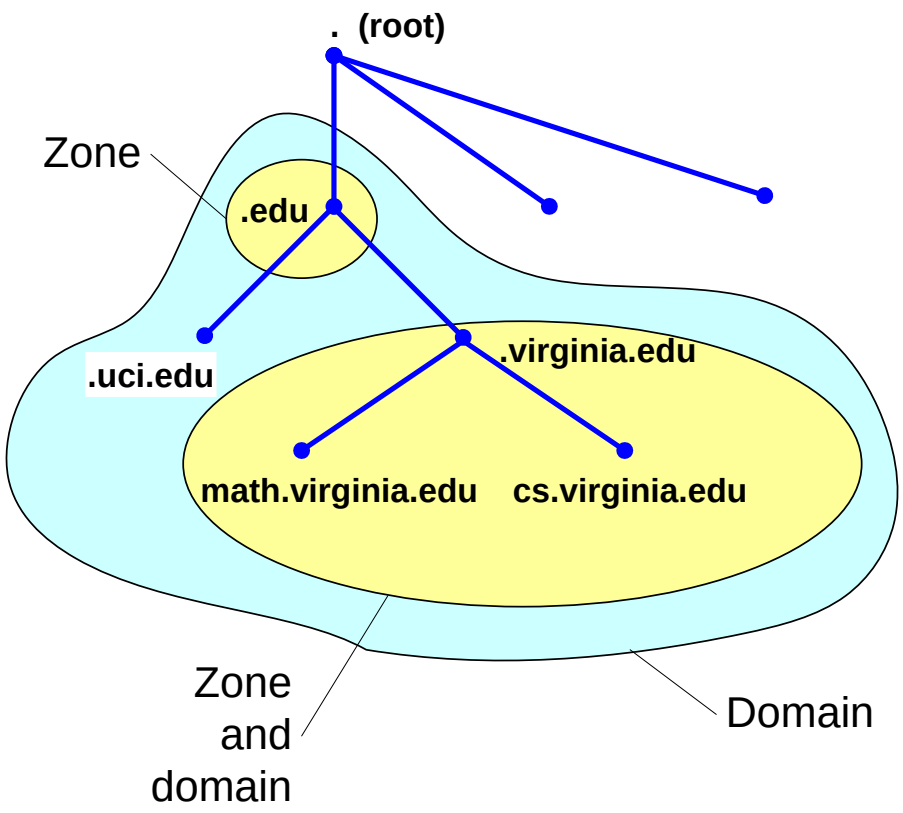
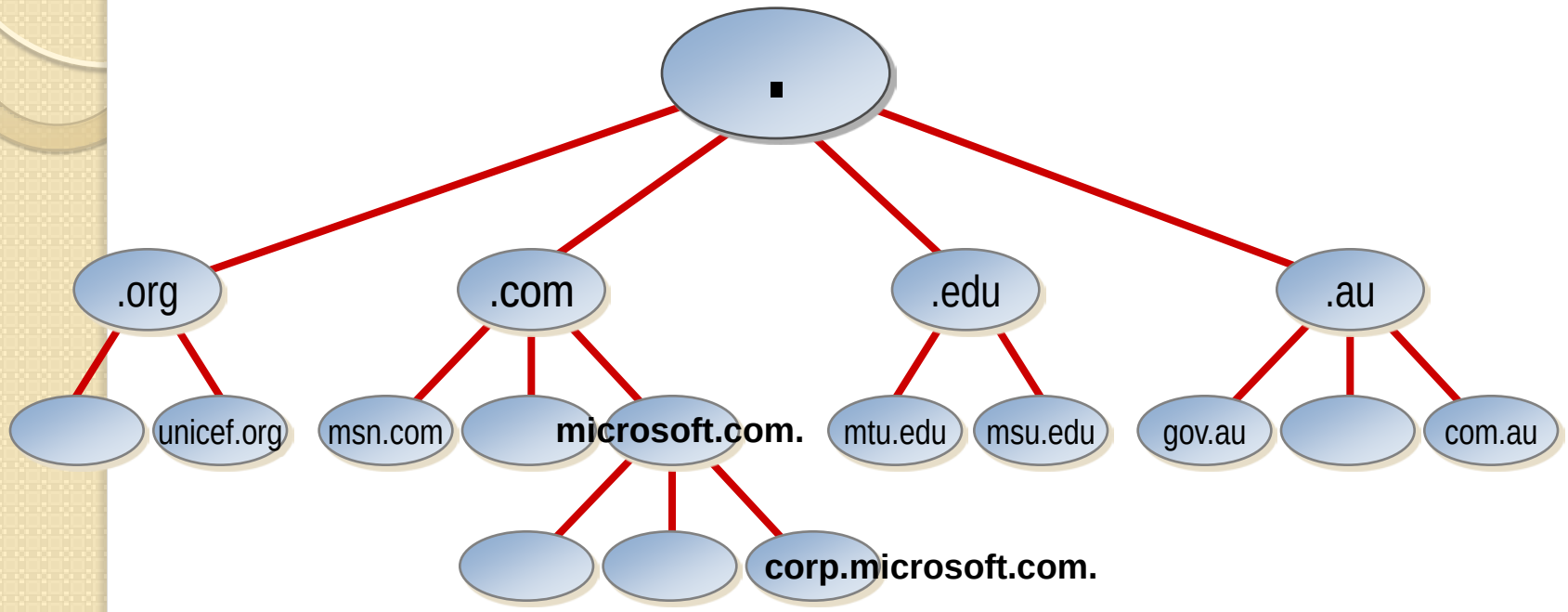
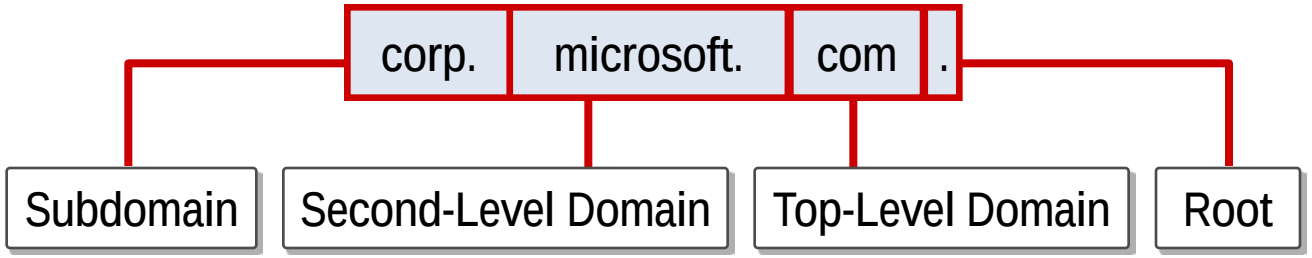
- Each zone is anchored at a specific domain node, but zones are not domains.
- *A DNS domain* is a branch of the namespace
- A zone is a portion of the DNS namespace generally stored in a file (It could consists of multiple nodes)
- A server can divide part of its zone and delegate it to other servers



DNS Namespace





Primary and secondary name servers

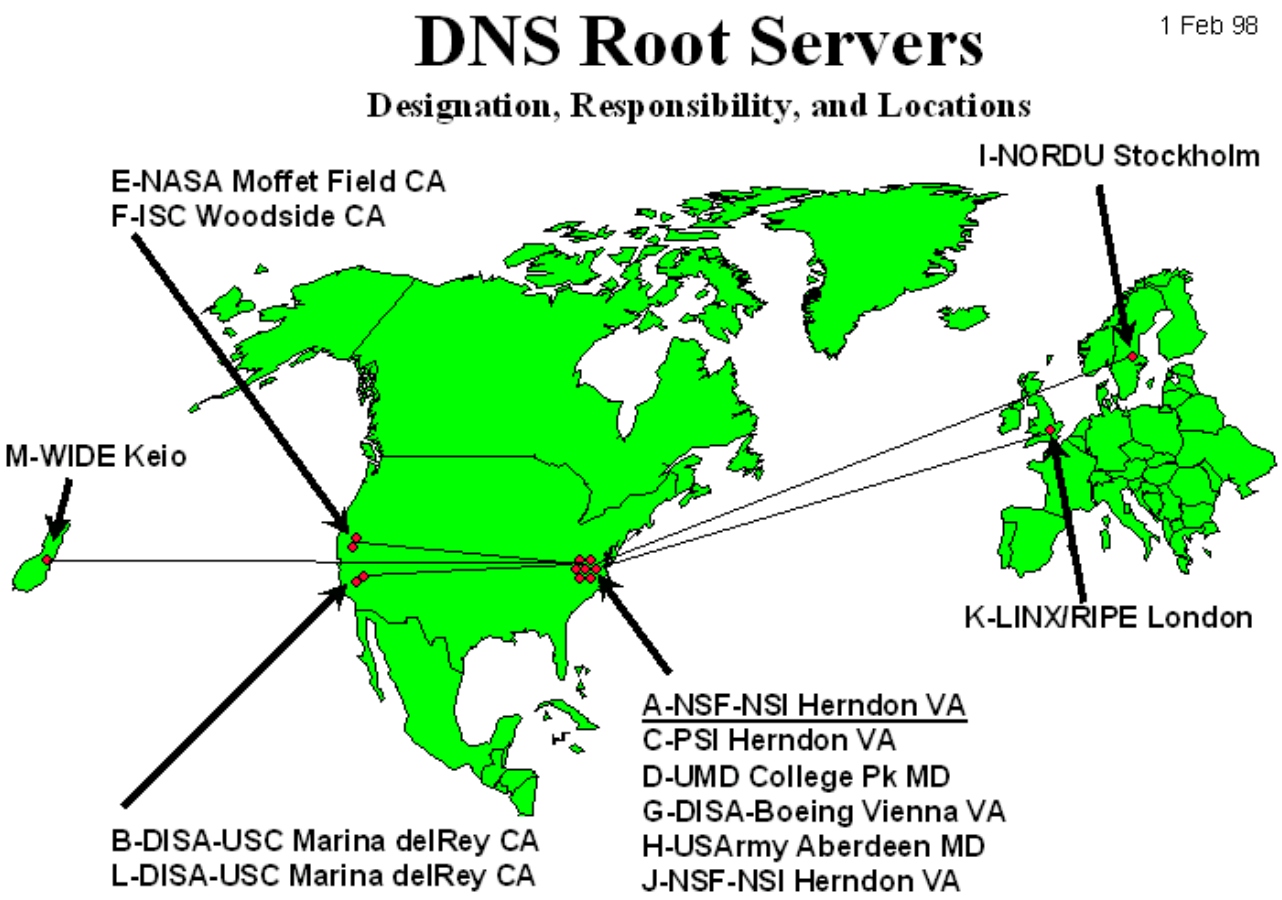
- For each zone, there must be a primary name server and a secondary name server
  - The primary server (master server) maintains a zone file which has information about the zone. Updates are made to the primary server
  - The secondary server copies data stored at the primary server.

Adding a host:

- When a new host is added ("gold.cs.virginia.edu") to a zone, the administrator adds the IP information on the host (IP address and name) to a configuration file on the primary server

Root name servers

- The root name servers know how to find the authoritative name servers for all top-level zones.
- There are only 13 root name servers
- Root servers are critical for the proper functioning of name resolution



The Root Nameservers

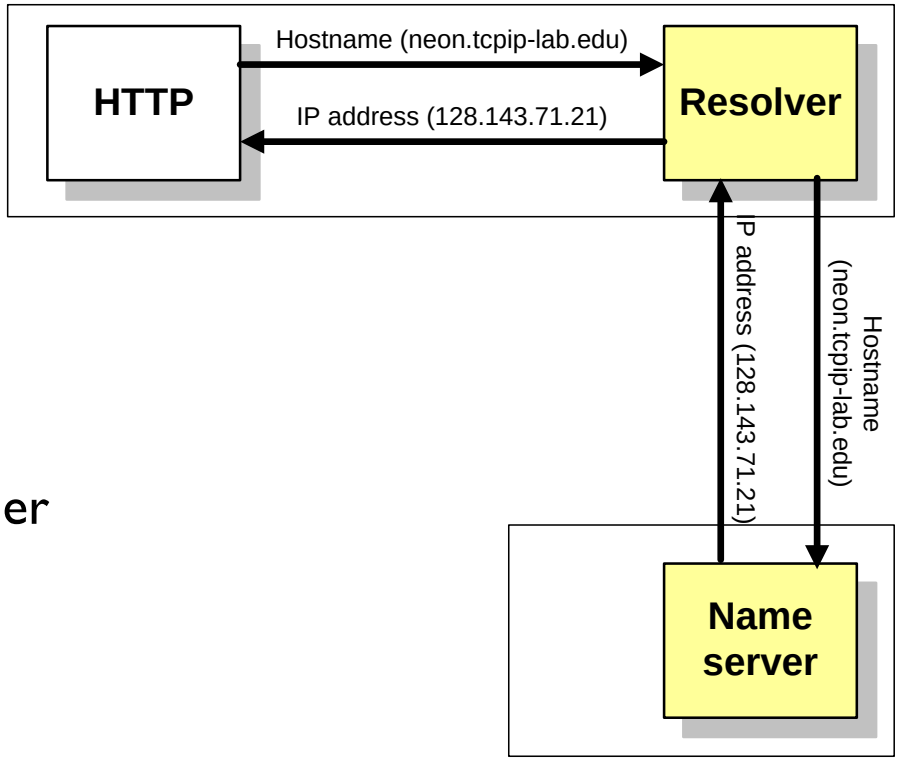
- Modification of the root zone file is pointless unless that zone file is published
- The root zone file is published on 13 servers, "A" through "M", around the Internet
- Root name server operations currently provided by volunteer efforts by a very diverse set of organizations

Root Name Server Operators

Nameserver	Operated by:	IP Address
A	Verisign (US East Coast)	198.41.0.4
B	University of S. California –Information Sciences Institute (US West Coast)	128.9.0.107
C	PSI (US East Coast)	192.33.4.12
D	University of Maryland (US East Coast)	128.8.10.90
E	NASA (Ames) (US West Coast)	192.203.23
F	Internet Software Consortium (US West Coast)	192.5.5.241
G	U. S. Dept. of Defense (ARL) (US East Coast)	192.112.36.4
H	U. S. Dept. of Defense (DISA) (US East Coast)	128.63.2.53
I	KTH (SE)	192.36.148.17
J	Verisign (US East Coast)	198.41.0.10
K	RIPE-NCC (UK)	193.0.14.129
L	ICANN (US West Coast)	198.32.64
M	WIDE (JP)	202.12.27.33

Domain name resolution

1. User program issues a request for the IP address of a hostname
2. Local resolver formulates a DNS query to the name server of the host
3. Name server checks if it is authorized to answer the query.
   a) If yes, it responds.
   b) Otherwise, it will query other name servers, starting at the root tree
4. When the name server has the answer it sends it to the resolver.



Recursive and Iterative Queries

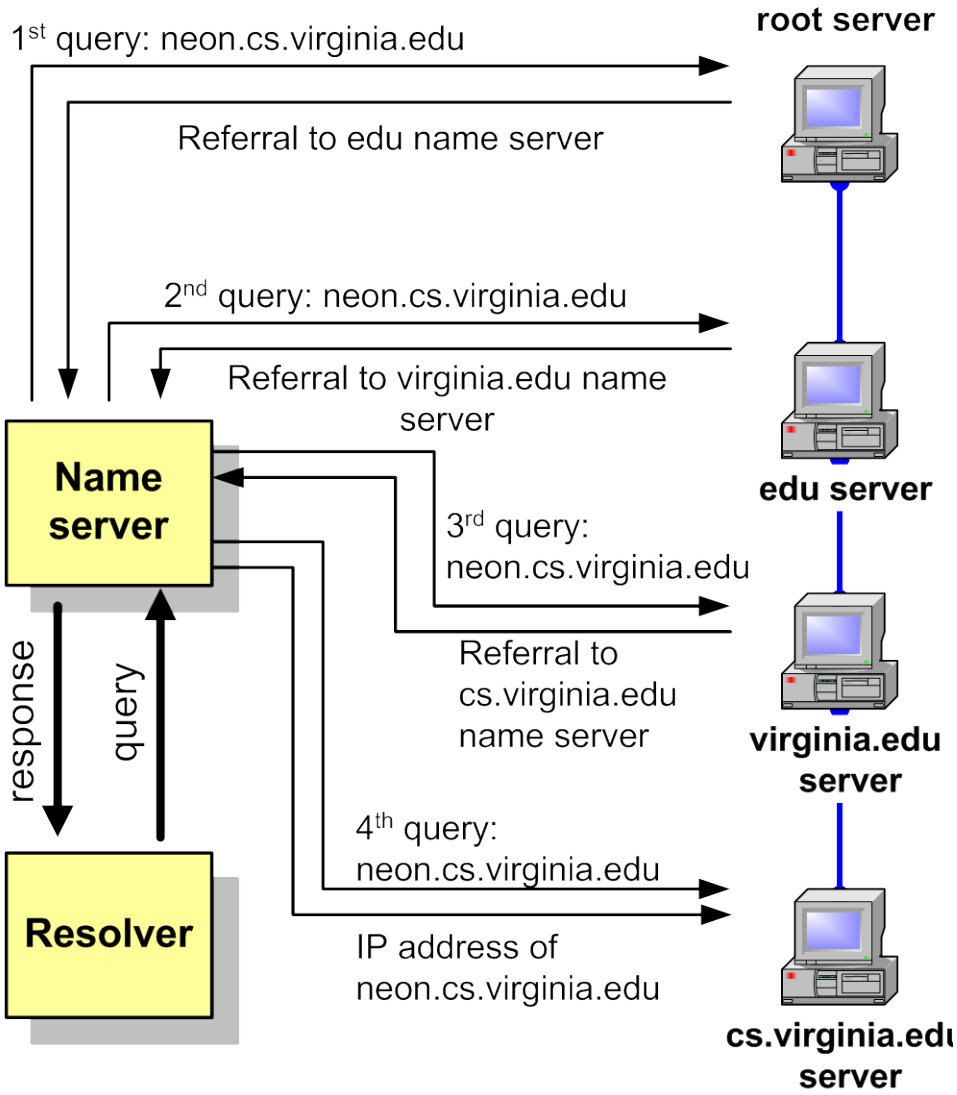
- There are two types of queries:
  - Recursive queries
  - Iterative (non-recursive) queries
- The type of query is determined by a bit in the DNS query
- Recursive query: When the name server of a host cannot resolve a query, the server issues a query to resolve the query
- Iterative queries: When the name server of a host cannot resolve a query, it sends a referral to another server to the resolver

Recursive Queries

- A query made from a client to a DNS server in which the server assumes the full workload
- DNS server returns either a complete answer or negative
- Issued by:
  - Client computers
  - DNS servers configured to use forwarder(s)

Recursive Queries

- In a recursive query, the resolver expects the response from the name server
- If the server cannot supply the answer, it will send the query to the "closest known" authoritative name server (here: In the worst case, the closest known server is the root server)
- The root sever sends a referral to the "edu" server. Querying this server yields a referral to the server of "virginia.edu"
- … and so on

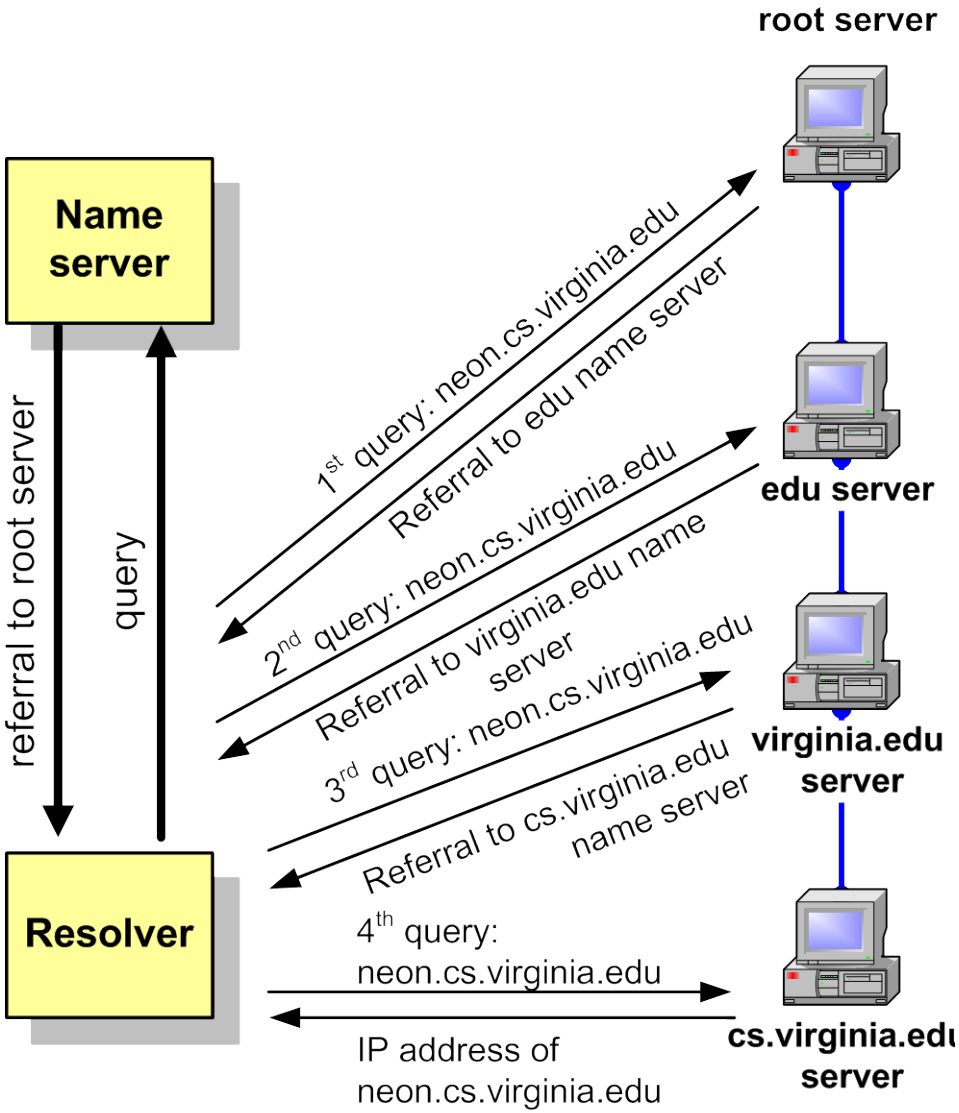


Iterative Queries

- Receiving server may return an answer, a negative response, or a referral to other DNS server(s)
- Typically issued by DNS servers not configured to use forwarders for resolution of queries
- "Walk" the DNS tree
- "Give me an answer or refer me to somebody else who can help me obtain resolution."

Iterative Queries

- In an iterative query, the name server sends a closest known authoritative name server a referral to the root server.
- This involves more work for the resolver



Caching

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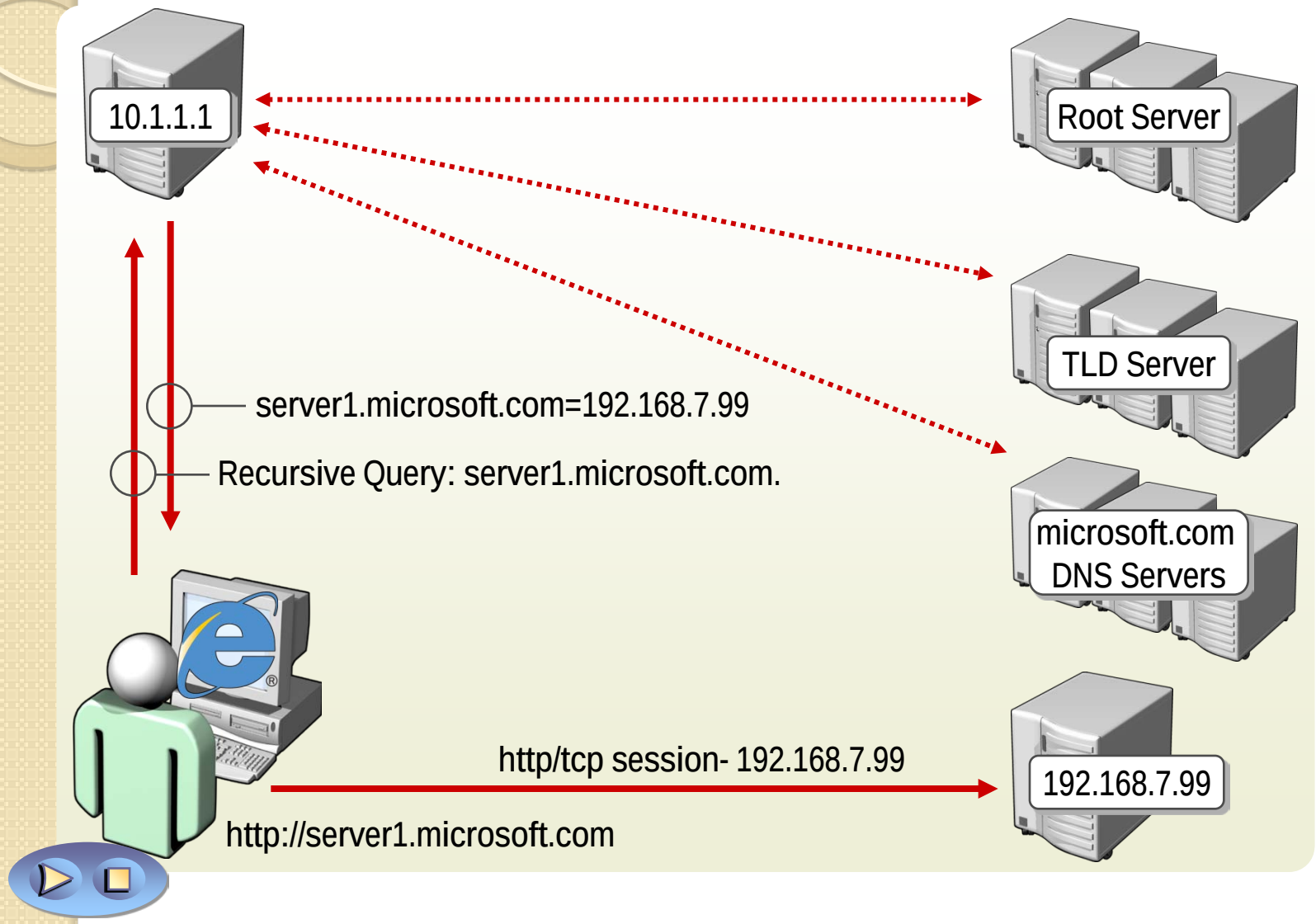
- To reduce DNS traffic, name servers caches information on domain name/IP address mappings
- When an entry for a query is in the cache, the server does not contact other servers
- Note: If an entry is sent from a cache, the reply from the server is marked as "unauthoritative"

How DNS Works



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