CS5223
Distributed Systems

Lecture 4: Naming

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Today's Roadmap

- Chapter 6 of textbook
  - P2P and DHT is a important topic and will be covered in a separate lecture
- Basic concepts in naming
- Simple naming mechanisms
- Domain name service

Motivation for Naming

- Example: We want to visit www.nus.edu.sg
  - The web server is located in some room that we don't know
  - There may be multiple web servers
  - ISP's may want to serve the content from their own machines – Akamai
  - www.nus.edu.sg –> ip address –> some physical machine (with specific MAC address)
- Example: Distributed file system
  - We know the file name (and full path), need to find out where the file is (i.e., on which machine, which disk sector, etc)
  - The file may migrate from one machine to another without changing its name

Basic Concepts in Naming

- General definition for naming:
  - We have a “name” and we want to find/locate the “entity”
  - Definitions in the textbook is unnecessarily convoluted, and sometimes circular – please ignore those
  - A lot of things can be called “naming” – just a definition issue – no need to draw a black-and-white boundary
- Name space: The set of all possible names in the given context
- Naming system: The system that enables you to find the “entity”
  - Name resolution
  - The naming system can be either non-distributed or distributed
  - Same tradeoff as before…

Different Kinds of Names

- Every name is a bit string
  - Some are human-friendly
- Hierarchical versus flat
- Alias
  - Multiple names for the same entity
  - Similar as symbolic links

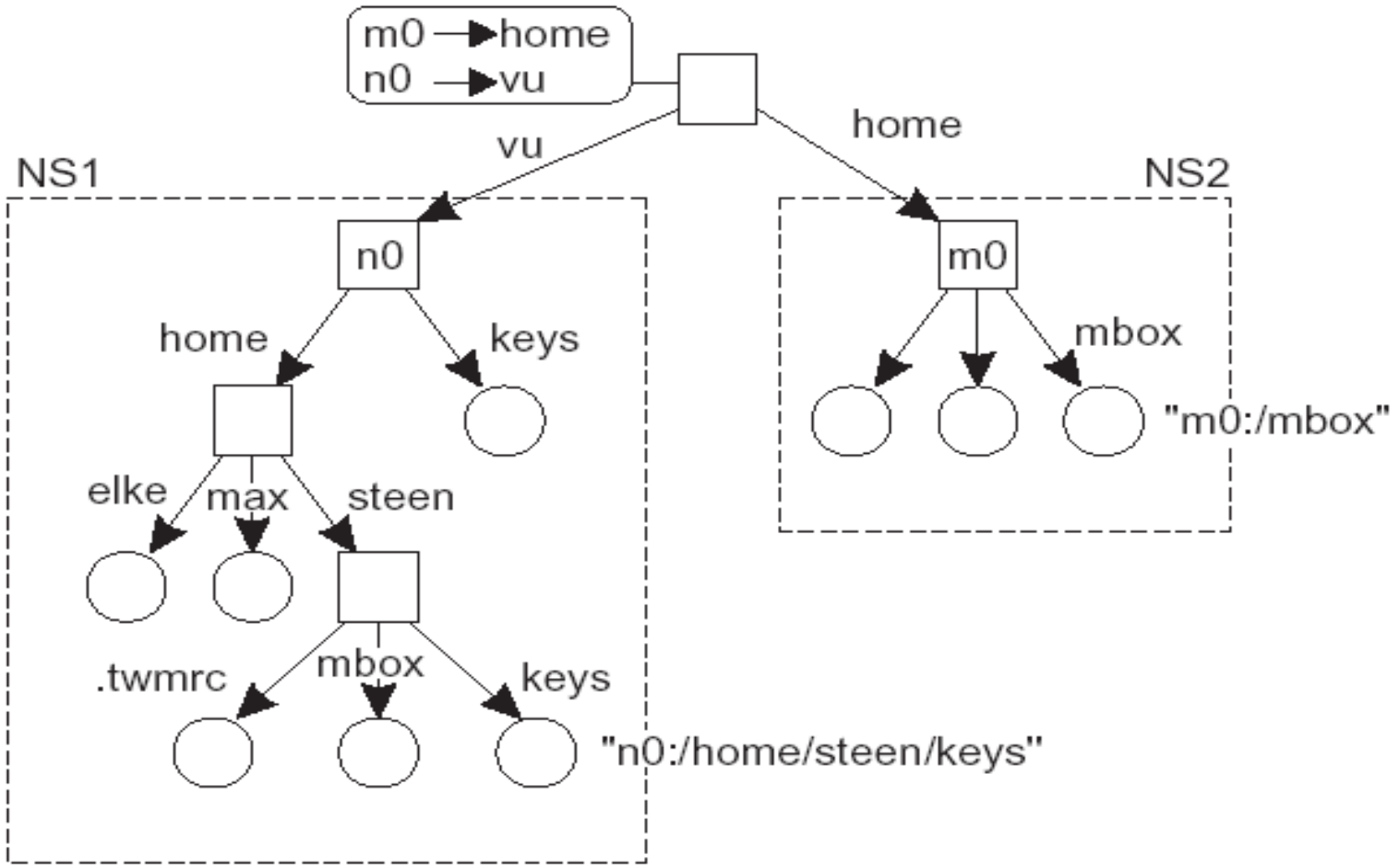
Merging Name Spaces

- We have two different name spaces
  - Now we want to define a unified name space
  - Name space merging
  - Generalizes to multiple name spaces…how?
- Example: Merging two network file systems
- Example: Two users want to give each other access to files in their home directories
- Main issue to take care of: There can be name collisions

Solution 1: New Root Node

- Merge by adding a new root node and make existing root nodes its children
- In principle, you always have to start in the new root
  - But you can avoid this by including the identifier of node from where resolution should start
  - Example, ~/XXX
- Problem: existing names need to be changed

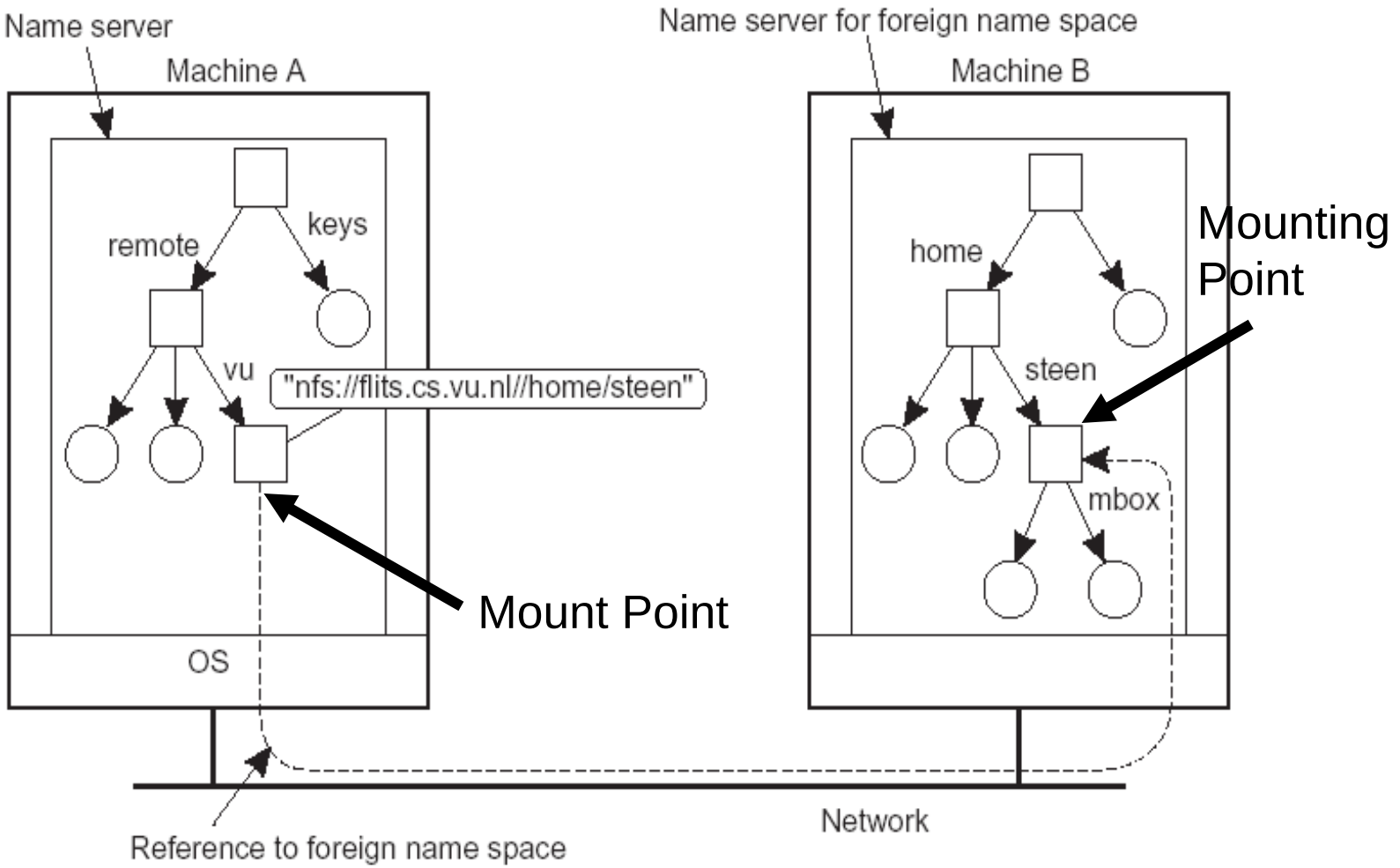
Example: New Root Node



Solution 2: Mounting

- Introduce nodes that contain the name of a node in a “foreign” name space
- Mount point: (Directory) node in naming graph that refers to other naming graph
- Mounting point: (Directory) node in other naming graph that is referred to

Example of Mounting



Simple Naming: Broadcast

- The “naming system” may or may not be a stand-alone software module
- Broadcast to resolve a name
  - Used in early day of computing
  - Simple is good!
- Drawback: performance
  - Alleviated but not fully addressed by using multicast

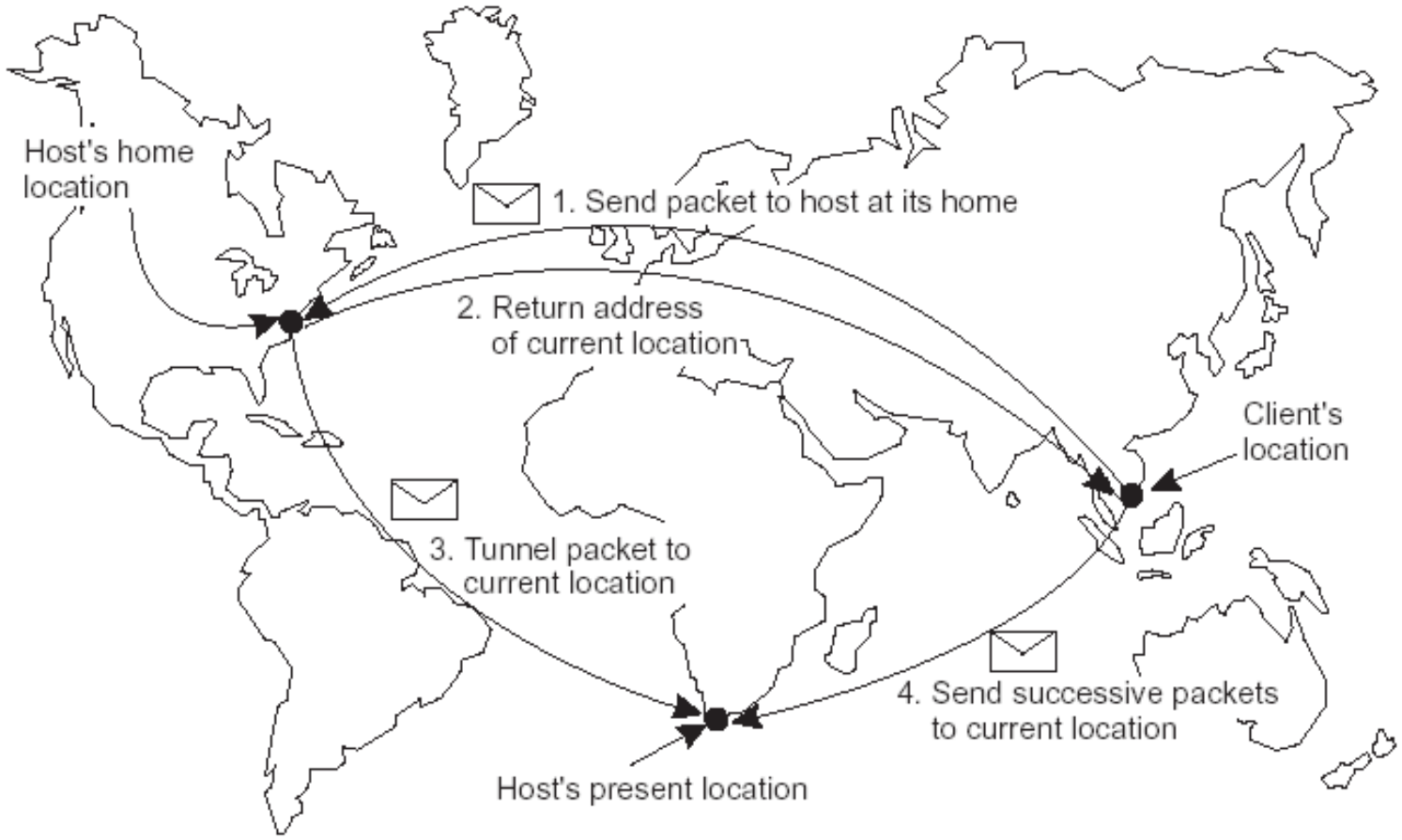
Simple Naming: Forwarding Pointers

- Forwarding pointers: Same idea as mail forwarding
- The machine A with ip_addr1 was initially the web server for www.nus.edu.sg
  - We want to use another B machine now with ip_addr2 as the server
- A will forward the HTTP requests to B
- Or A can inform the client of B's address
- Drawback:
  - A needs to stay there forever
  - The forwarding chain can become long

Simple Naming: Home-Based Approach

- Each entity has a “home”
  - The entity will register its IP address (which may change) with its home
- To find the entity, we contact the home first
- Only minor difference from forwarding pointers
  - Maximum one-hop forwarding
- Drawback:
  - The home needs to be there forever (i.e., have a fixed IP address)

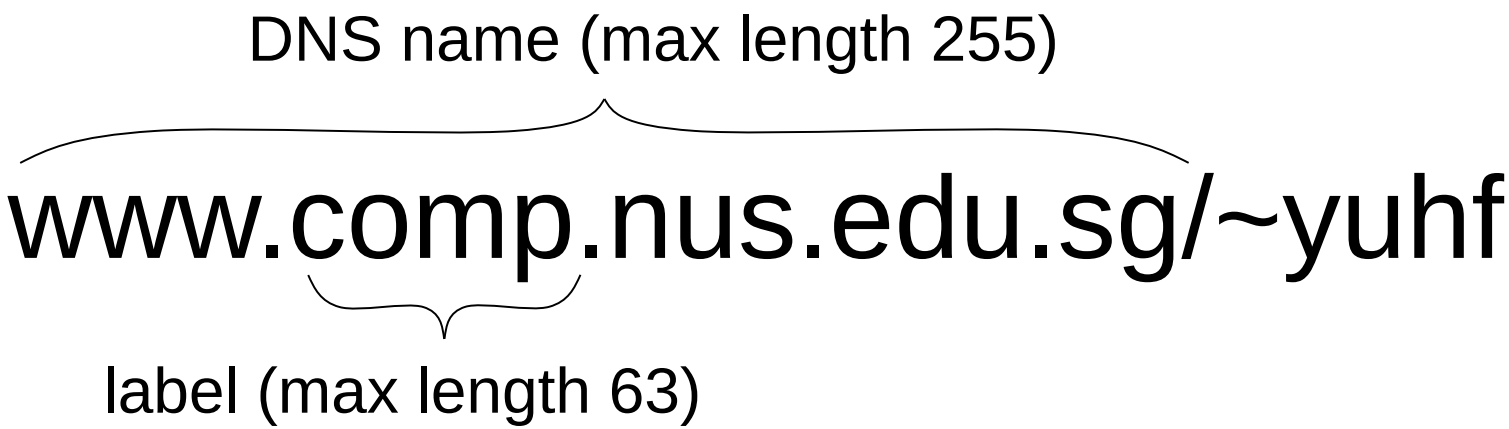
Example: Home-Based Approach



Domain Name System: DNS

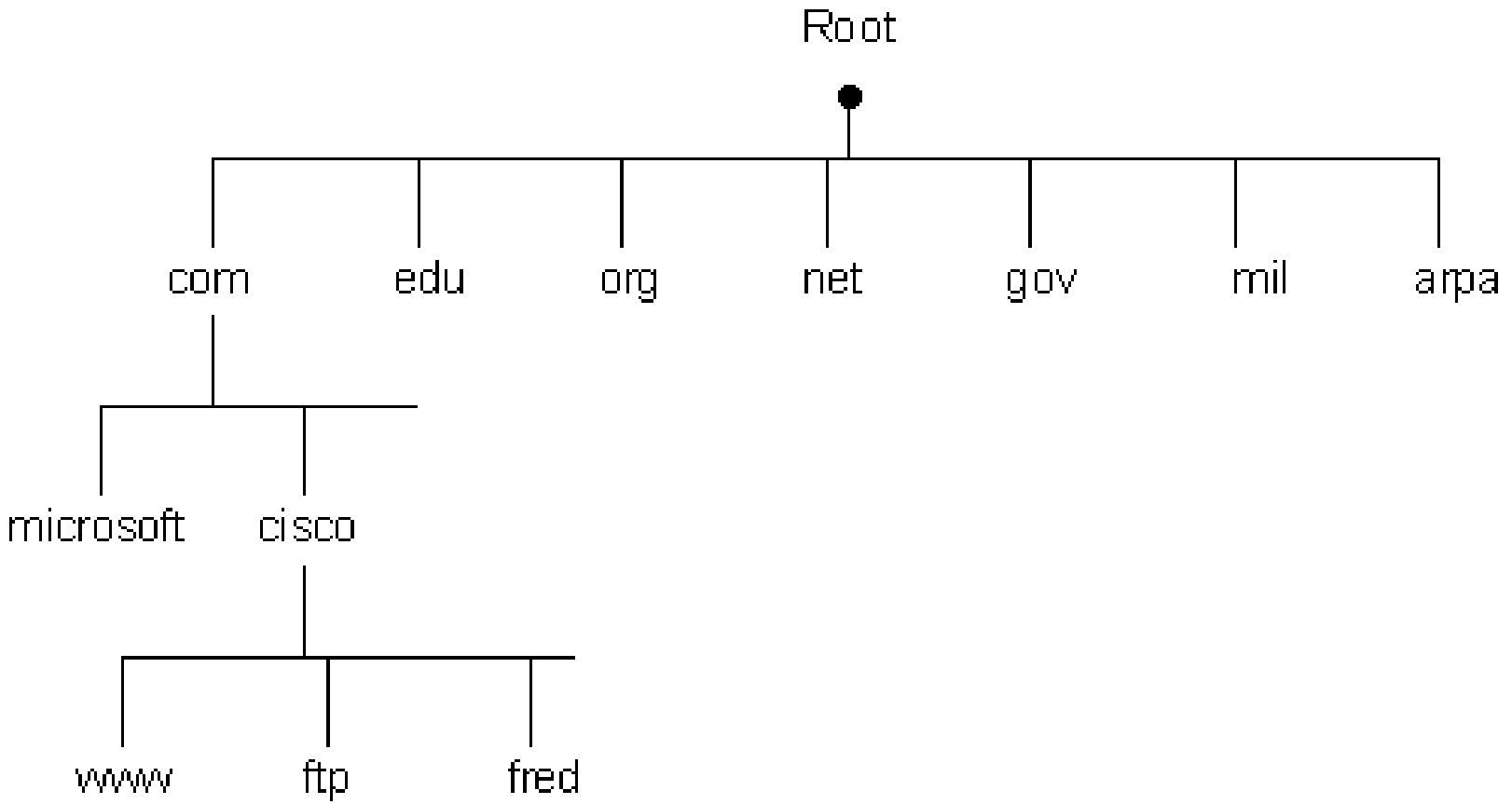
- For looking-up IP addresses
  - Example: what ip address www.nus.edu.sg corresponds to
- DNS dates back to over 30 years ago
  - Replaces the original Internet naming scheme that keep everything in a master file (lack of scalability and freedom for each domain to assign internal names)
- Overall, DNS has been a very successful distributed system
  - Many of the early design decisions turn out to be critical later
  - Additional reading (non-compulsory): “Signposts in cyberspace: The Domain Name System and Internet Navigation” by R. Levien, National Academic Research Council, 2005
- We will study it as a case study…

DNS Name Space



- Top-level domains
  - com, edu, net, org, etc.
  - sg, cn, fr, etc.
- The machine corresponding to XXX.XXX.sg may or may not be in Singapore

The DNS Tree



(from http://www.rhyshaden.com/dns.htm)

Relative Names in DNS

- Not supported in DNS specification
- However:
  - Your local software may automatically append the omitted part
  - Example, you can type ssh suna on any SoC unix machine, and you will connect to suna.comp.nus.edu.sg
  - If suna.comp.nus.edu.sg does not exist, ssh will try to connect to “suna” (which does not exist either)
  - Sometimes the local software may try appending different suffixes

Domains in DNS

- A domain is a name space for which there is a single overall administrative authority to assignment the DNS names
  - Example, the collection of all XXX.nus.edu.sg is a domain
- A domain's name is the common suffix of all the DNS names in the collection
  - Example, nus.edu.sg is the domain's name
  - By definition, a domain's name is also a DNS name
- Potential confusion
  - A DNS name is sometime called domain name, which is different from domain's name defined above
  - We will only use DNS name and domain's name to avoid confusion

Resolving DNS Names: The Perspectives of a Client

- Web browser
  - Make query to DNS server (how to find the DNS server?) to resolve www.nus.edu.sg into an IP address
  - Send HTTP request to that IP address at port 80
- ftp, telnet, ssh, smtp(email) are all similar
- Reverse resolution:
  - Translate an IP address into a DNS name
  - Only for IP addresses within the local domain

Resolving a DNS Request

- The client needs to know the “local DNS server”
  - The IP address of this server is given to you by your ISP
  - Bootstrapping
- Client sends DNS query to local DNS server S
  - Containing the DNS name e.g., www.nus.edu.sg
- S checks whether it has either authoritative RR or cached RR for
  - www.nus.edu.sg
  - nus.edu.sg
  - edu.sg
  - sg

Root DNS servers

- If no, S will send quest to the root DNS server
  - How does S know where to find the root DNS server?
- Root servers with well-known IP addresses
- https://www.iana.org/domains/root/servers

Resolving a DNS Request

- The root DNS server sends back to S the IP address of the DNS server responsible for the domain “sg”
- S contact that DNS server
  - And then recursively the DNS server for “edu.sg”, “nus.edu.sg”, …
- After a DNS name is resolved, the RR will be cached

Critical Design Decisions in DNS

- Delegation of responsibility
  - Allow individual domains to assignment their own DNS names
  - Hierarchical naming strcuture
- Caching and replication
  - Controls the overhead of DNS lookups
  - Controls the load on the root DNS servers

Vulnerability of DNS

- The root servers – “single points” of failure
  - Target of DoS attacks
  - Already happened
- Alternatives:
  - Completely decentralized distributed naming system for the Internet
  - Already possible technically, but backward-compatibility issues need to be addressed

History Readings (Non-compulsory)

- DNS root servers under attack
  - http://en.wikipedia.org/wiki/DNS_Backbone_DDoS_Attacks

The Fundamental Need for Bootstrapping in Naming

- To resolve a name, you need to know at least one bootstrapping point
  - Broadcast: Bootstrapping point not needed (or every machine is a bootstrapping point?)
  - Forwarding pointers: The first machine you contact
  - Home-base approach: The home
  - DNS: Your local DNS server and the root DNS servers
- Called “closure mechanism” on the textbook
- Bootstrapping mechanism significantly influences the “goodness” of a naming system

Today's Summary

- Basic concepts in naming
- Simple naming mechanisms
- Domain name service