CALIFORNIA STATE UNIVERSITY
LONG BEACH
College of Engineering

CECS 303: Networks and Network Security

IP Addressing and DNS

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Week 3 – 2nd Lecture
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Objectives

- Discuss addressing schemes for TCP/IP in IPv4 and IPv6
- Discuss assignment of IP addresses via DHCP
- Identify the well-known ports for key TCP/IP services
- Describe the purpose and implementation of DNS (Domain Name System)

IPv4 Addressing

- Networks recognize two addresses
  - Logical (Network layer)
  - Physical (MAC / hardware) addresses
- IP Protocol handles logical addressing
- Specific Parameters
  - Unique 32-bit number
    - Divided into four octets (sets of eight bits) separated by periods
    - Example: 192.168.1.1
  - Network class determined from first octet

Common IPv4 Classes

Network class	Beginning octet	Number of networks	Maximum addressable hosts per network
A	1–126	126	16,777,214
B	128–191	> 16,000	65,534
C	192–223	> 2,000,000	254

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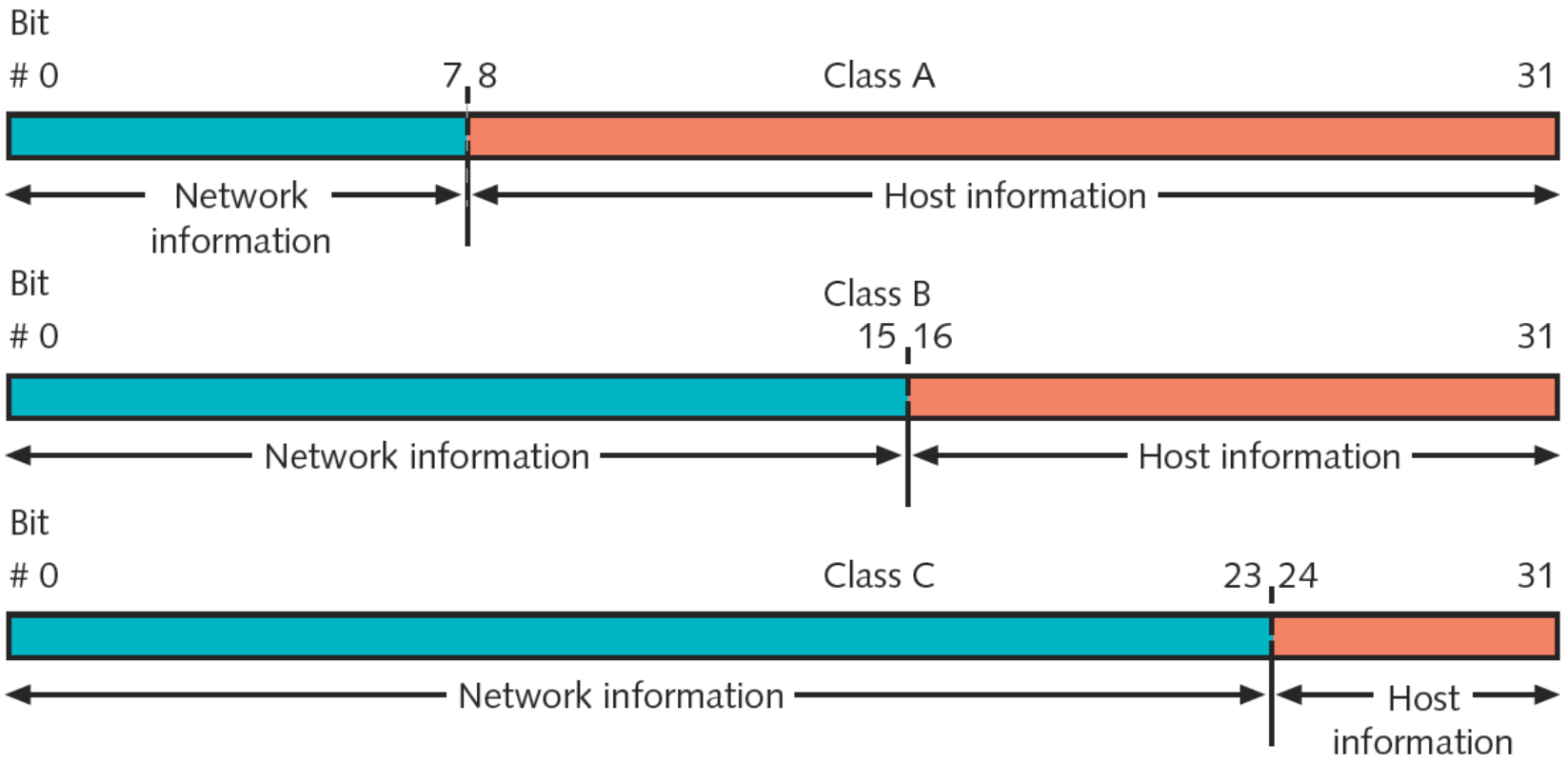
IPv4 Addressing (cont'd)

- Class D, Class E rarely used (never assign)
  - Class D: value between 224 and 239
    - Multicasting
  - Class E: value between 240 and 254
    - Experimental use
- Eight bits have 256 combinations
  - Networks use 1 through 254
  - 0: reserved as placeholder
  - 255: reserved for broadcast transmission

IPv4 Addressing (cont'd)

- Class A devices
  - Share same first octet (bits 0-7)
    - Network ID
  - Host: second through fourth octets (bits 8-31)
- Class B devices
  - Share same first two octet (bits 0-15)
  - Host: second through fourth octets (bits 16-31)
- Class C devices
  - Share same first three octet (bits 0-23)
  - Host: second through fourth octets (bits 24-31)

IPv4 Classes



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IPv4 Addressing (cont'd)

- Loopback address
  - First octet equals 127 (127.0.0.1)
- Loopback test
  - Attempting to connect to own machine
  - Useful for troubleshooting
- Windows
  - 'ipconfig' command
- Unix / Linux
  - 'ifconfig' command

Binary and Dotted Decimal Notation

- Dotted decimal notation
  - Common way of expressing IP addresses
  - Decimal number between 0 and 255 represents each octet
  - Period (dot) separates each decimal
- Dotted decimal address has binary equivalent
  - Convert each octet
  - Remove decimal points

10.10.200.11
00000010 00000010 11001000 00001011

Subnet Mask

- 32-bit number identifying a device's subnet
- Combines with device IP address
- Informs network about logical subdivision of IPs
- Four octets (32 bits)
  - Expressed in binary or dotted decimal notation
- Assigned same way as IP addresses
  - Manually or automatically (via DHCP)

Subnet Mask (cont'd)

Network class		Default subnet mask
A	1–126	255.0.0.0
B	128–191	255.255.0.0
C	192–223	255.255.255.0

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IPv6 Addressing

- Composed of 128 bits
- Eight 16-bit fields
- Typically represented in hexadecimal numbers
  - Separated by a colon
  - Example: 2001:0db8:85a3:0000:0000:8a2e:0370:7334
- Abbreviations for multiple fields with zero values
  - 00FF can be abbreviated FF
  - 0000 can be abbreviated 0
- Modern devices and operating systems can use both IPv4 and IPv6

Assigning IP Addresses

- Government-sponsored organizations
  - Distribute IP addresses
  - IANA, ICANN, RIRs (Regional Internet Registries)
    - ARIN (American Registry for Internet Numbers) responsible for serving the United States (and Antarctica, Canada, and various islands)
- Companies and individuals obtain IP addresses from ISPs (typically)
- Every network node must have a unique IP address
  - Otherwise network errors occur
  - Only one can exist in a router or switch's ARP table

Assigning IP Addresses (cont'd)

- Static IP address
  - Manually assigned
  - To change -> modify client workstation TCP/IP properties
  - Human error causes duplicates
- Dynamic IP address
  - Assigned automatically
  - Most common method
    - Dynamic Host Configuration Protocol (DHCP)

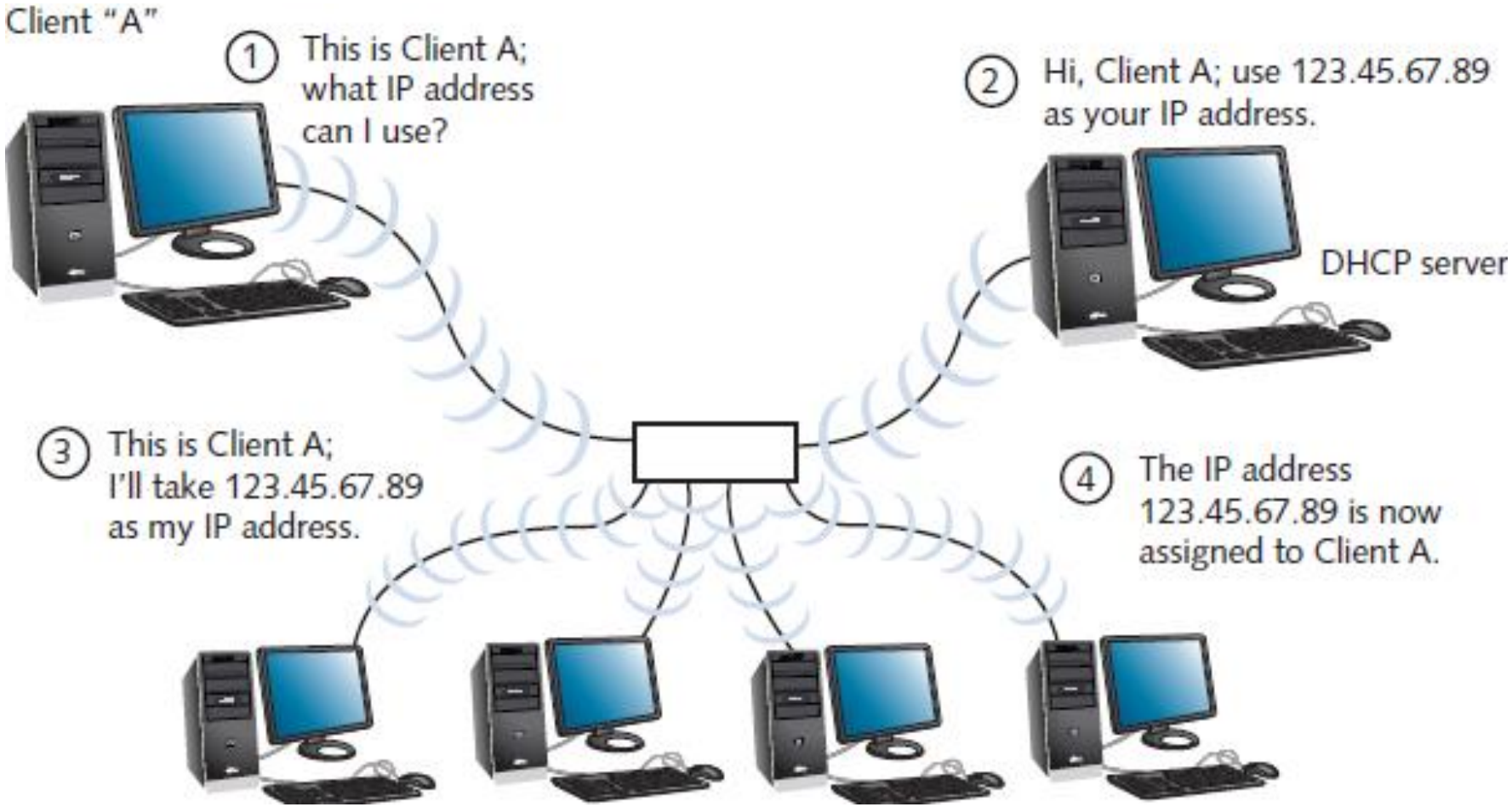
DHCP

- Automatically assigns device a unique IP address
- Application layer protocol
  - Uses lower layers, but functions as a service
  - Still some debate over whether it is an application or network layer protocol
- Reasons for implementing
  - Reduce time and planning for IP address management
  - Reduce potential for error in assigning IP addresses
  - Enable users to move workstations and printers
  - Make IP addressing transparent for mobile users

DHCP (cont'd)

- DHCP leasing process
  - Device borrows (leases) an IP address while attached to network
- Lease time
  - Determined when client obtains IP address at log on
  - User may force lease termination
- DHCP service configuration
  - Specify leased address range
  - Configure lease duration
  - Many additional options are configurable
- Several steps to negotiate client's first lease
  - DHCPDISCOVER
  - DHCPOFFER
  - DHCPREQUEST
  - DHCPACK

DHCP Leasing Process



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DHCP (cont'd)

- Terminating a DHCP Lease
  - Expire based on period established in server configuration
  - Manually terminated at any time
    - Client's TCP/IP configuration
    - Server's DHCP configuration
- Circumstances requiring lease termination
  - DHCP server fails and replaced
- DHCP services run on several server types
  - Installation and configurations vary

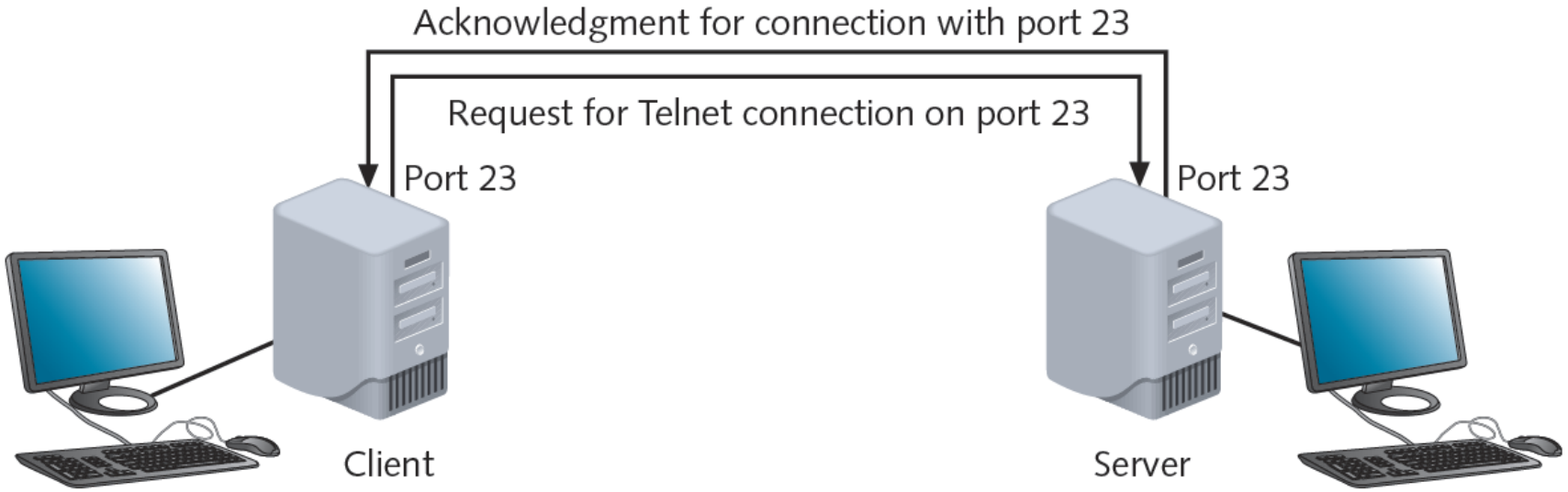
Private and Link-Local Addresses

- Private addresses
  - Allow hosts in organization to communicate across internal network
  - Cannot be routed on public network
- Specific IPv4 address ranges reserved for private addresses
  - Class A: 10.0.0.0 to 10.255.255.255
  - Class B: 172.16.0.0 to 172.31.255.255
  - Class C: 192.168.0.0 to 192.168.255.255
- Link-local address
  - Provisional address
  - Capable of data transfer only on local network segment

Sockets and Ports

- Processes assigned unique port numbers
- Process's socket
  - Port number plus host machine's IP address
- Port numbers
  - Simplify TCP/IP communications
  - Ensures data transmitted correctly
- Example
  - Telnet port number: 23
  - IPv4 host address: 192.168.1.28
  - Socket address: 192.168.1.28:23

Telnet Service Connection



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Sockets and Ports (cont'd)

- Port number range: 0 to 65535
- Three types
  - Well known ports
    - Range: 0 to 1023
    - Operating system or administrator use
  - Registered ports
    - Range: 1024 to 49151
    - Assigned by IANA
    - Network users, processes with no special privileges
  - Dynamic and/or private ports
    - Range: 49152 to 65535
    - No restrictions; typically used by customized services or temporary purposes

Common Port Numbers

Port number	Process name	Protocol used	Description
20	FTP-DATA	TCP	File transfer—data
21	FTP	TCP	File transfer—control
22	SSH	TCP	Secure Shell
23	TELNET	TCP	Telnet
25	SMTP	TCP	Simple Mail Transfer Protocol
53	DNS	TCP and UDP	Domain Name System
67 (client to server) and 68 (server to client)	DHCPv4	UDP	Dynamic Host Configuration Protocol version 4
69	TFTP	UDP	Trivial File Transfer Protocol
80	HTTP	TCP and UDP	Hypertext Transfer Protocol
110	POP3	TCP	Post Office Protocol 3
123	NTP	TCP	Network Time Protocol
143	IMAP	TCP	Internet Message Access Protocol
443	HTTPS	TCP	Secure implementation of HTTP
546 (client to server) and 547 (server to client)	DHCPv6	UDP	Dynamic Host Configuration Protocol version 6
3389	RDP	TCP	Remote Desktop Protocol

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Host Names and DNS

- IP addressing
  - Long, complicated numbers
  - Good for computers
- Easier for people to use words
  - Internet authorities established internet node naming system
- Host
  - Networked device
- Host name
  - Name describing device

Domain Names

- Domain
  - Group of computers belonging to the same organization
- Domain name
  - Identifies domain (e.g. abc.com)
  - Associated with company, university, government organization
  - Can be local/private or public
- Fully qualified domain name (FQDN)
  - Local host name + domain name
  - e.g. host1.abc.com

Domain Names (cont'd)

- Label (character string)
  - Separated by dots
  - Represents level in domain naming hierarchy
- Example: www.google.com
  - Top-level domain (TLD): com
  - Second-level domain: google
  - Third-level domain (aka. sub-domain): www
- May contain multiple third-level domains
- ICANN established domain naming conventions

Domain Names (cont'd)

- ICANN has approved 255 country codes
- Host and domain names restrictions
  - Any alphanumeric combination up to 253 characters
  - Include hyphens, underscores, periods in name
  - No other special characters

Host Files

- ARPAnet used hosts.txt file
  - Associated host names with IP addresses
  - Host matched by one line
    - Identifies host's name and IP address
    - Alias provides nickname
- UNIX-/Linux computer
  - Host file called hosts
  - Located in the /etc directory
- Windows computer
  - Host file called hosts
  - Located in Windows\system32\drivers\etc folder

Sample Hosts File


```
# Copyright (c) 1993-2009 Microsoft Corp.
#
# This is a sample HOSTS file used by Microsoft TCP/IP for Windows.
#
# This file contains the mappings of IP addresses to host names. Each
# entry should be kept on an individual line. The IP address should
# be placed in the first column followed by the corresponding host name.
# The IP address and the host name should be separated by at least one
# space.
#
# Additionally, comments (such as these) may be inserted on individual
# lines or following the machine name denoted by a '#' symbol.
#
# For example:
#
#      102.54.94.97     rhino.acme.com          # source server
#       38.25.63.10     x.acme.com              # x client host
192.168.1.34           www.abc.com

# localhost name resolution is handled within DNS itself.
#       127.0.0.1       localhost
#       ::1             localhost
```

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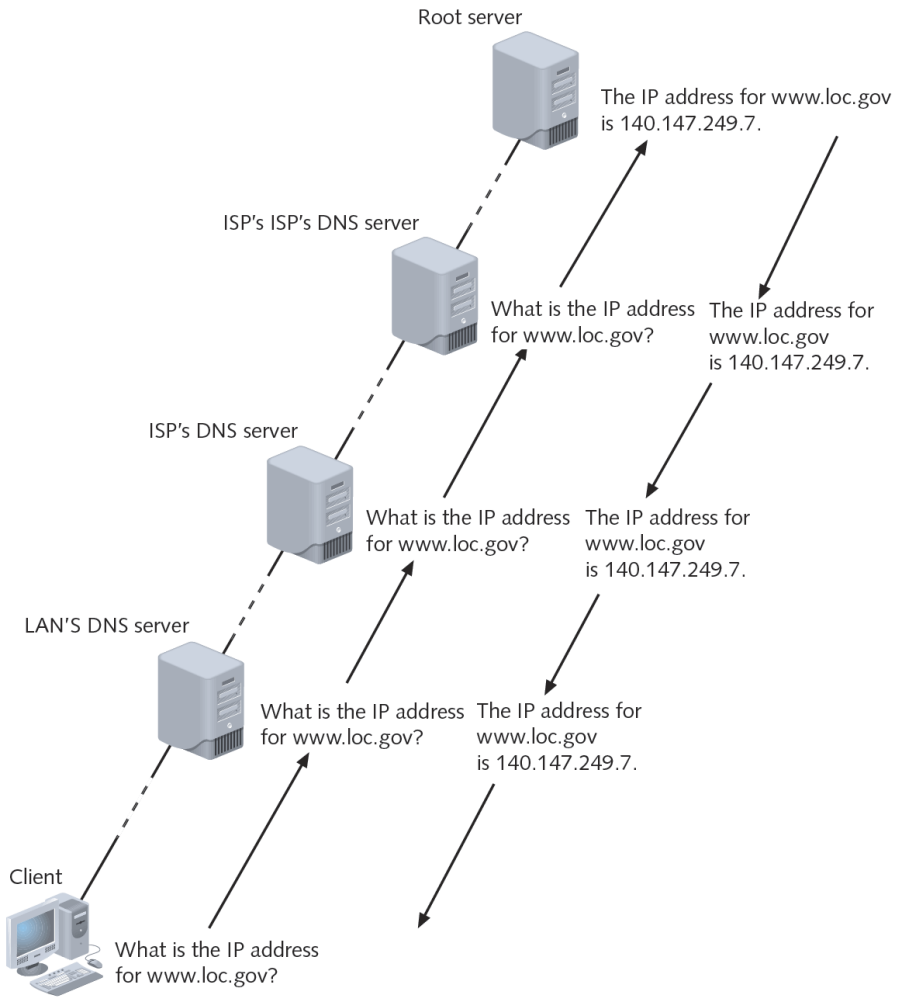
DNS

- DNS = Domain Name Service
- Hierarchical
- Associate domain names with IP addresses
- DNS refers to:
  - Application layer service accomplishing association
  - Organized system of computers, databases making association possible
- DNS redundancy
  - Many computers across globe related in hierarchical manner
  - Root servers
    - 13 computers (ultimate authorities)

DNS (cont'd)

- Three components
  - Resolvers
    - Any hosts on Internet needing to look up domain name information
  - Name servers (DNS servers)
    - Databases of associated names and IP addresses
    - Provide information to resolvers on request
  - Namespace
    - Abstract database of Internet IP addresses and associated names
    - Describes how name servers of the world share DNS information

Domain Name Resolution



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DNS (cont'd)

- Resource record
  - Describes one piece of DNS database information
  - Many different types
    - Dependent on function

Type	Name	Description
A	Address record	A host's IPv4 address
AAAA	Address record	A host's IPv6 address
CNAME	Canonical name record	Another name for the host
MX	Mail exchange record	Identifies a mail server
PTR	Pointer record	Points to a canonical name

Configuring DNS

- Large organizations
  - Often maintain multiple name servers
    - Primary and secondary designations
  - Ensures internet availability of translation
- DHCP service assigns clients appropriate addresses
- Manual configuration is also possible
  - Static often used for publically available DNS
  - Private networks often rely on a combination of manual (static) and automatic configurations

DDNS

- DDNS (Dynamic DNS)
- Often used for website hosting by small businesses or private individuals
  - Manually changing DNS records unmanageable with dynamic external IP addresses
- Process
  - Service provider runs program on user's computer
    - Notifies service provider when IP address changes
  - Service provider's server launches routine to automatically update DNS record
    - Effective throughout Internet in minutes
- Larger organizations buy statically assigned IP address blocks

Summary

- IPv4 addresses: unique 32-bit numbers
- IPv6 addresses: unique 128-bit numbers - composed of eight 16-bit fields
- DHCP assigns addresses automatically
- DNS tracks domain names and their respective IP addresses