

INTERNET PROTOCOLS AND CLIENT-SERVER PROGRAMMING

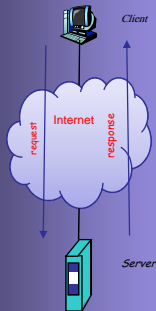
SWE344

Fall Semester 2008-2009 (081)

Module 4.2: IP Addressing and DNS

Dr. El-Sayed El-Alfy

Computer Science Department
King Fahd University of Petroleum and Minerals
alfy@kfupm.edu.sa



Objectives

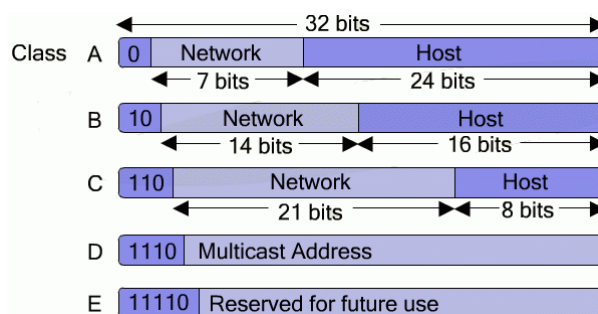
- ⊕ Learn how IP addresses are used to identify network nodes
- ⊕ Learn how DNS is used to map domain-names to IP addresses
- ⊕ Learn how to find IP address of a node using C#

IP Addresses

- ✦ Every node (host or router) on the Internet is identified using a unique IP address
 - IP address is 32 bits in length (IPv4)
 - IP address is 128 bits in length (IPv6)
 - Although 32 bits currently provides adequate coverage, this is unlikely to be true in the future.
- ✦ IP address is normally written in dotted decimal format (each 8 bits are separated by a dot).

11000100 00000001 01000001 10001111 = 196.1.65.143
- ✦ To ensure that no two machines are mistakenly using the same IP, the allocation of IP addresses is done by the International Network Information Center (Internic).

Classes of IP Addresses



- ✦ IP addresses are presently separated into five different classes (although only four classes are actually used).
- ✦ IP addresses mostly consist of two different parts:
 - a network-identifier identifies the network to which the IP belongs
 - a host-identifier identifies the particular host within that network

Classes of IP Addresses ...

✚ The class ranges are as follows:

- Class A provides support for 126 networks, each with up to 16 million hosts (IP range: 1.0.0.0 to 127.255.255.255).
- Class B provides support for 16,382 networks, each with up to 64k hosts (IP range: 128.0.0.0 to 191.255.255.255).
- Class C provides support for 2 million networks, each with up to 254 hosts (IP range: 192.0.0.0 to 223.255.255.255).
- Class D IP addresses are used for multicasting, i.e. sending IP packets to multiple hosts (IP range: 224.0.0.0 to 239.255.255.255).
- Class E IP addresses are reserved for future use (IP range: 240.0.0.0 to 247.255.255.255).

Special Addresses

✚ A number of special IP addresses are defined:

- 0.0.0.0 refers to the current host.
- 255.255.255.255 denotes a broadcast to all machines on the local network.
- A network number of 0 enables hosts to refer to their own network without knowing the exact network number.
- A host address consisting of all 1's denotes a broadcast upon a distant network as specified by the network number.
- An IP address starting with 127.xxx.yyy.zzz is considered as a loopback address (this is primarily for debugging network applications).

This host

00000000 ... 00000000

Broadcast Local Network

11111111 ... 11111111

A Host on this Network

000 ... 000 Host

Broadcast Distant Network

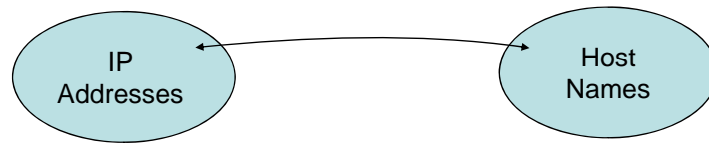
Network 1111 ... 1111

Loopback Address

127 Anything

Domain Name Services (DNS)

- ✚ DNS provides a means of mapping between a numeric IP address (which is hard to remember) and an ASCII string (which is easier to remember).
 - For example, would you rather try to remember `www.google.com` or `216.239.39.100`?



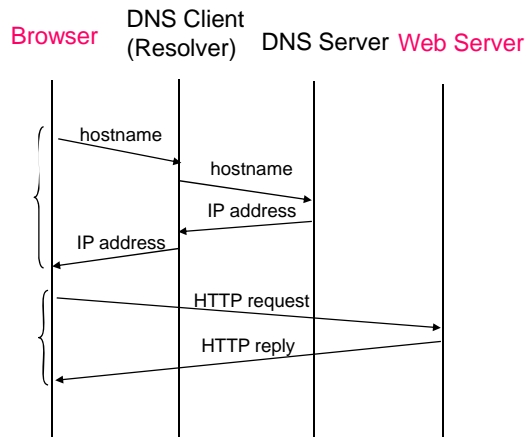
DNS ...

- ✚ DNS can provide additional services such as
 - Hostname aliasing
 - Have more than one hostname mapped to the same IP address; useful in cases where the canonical hostname is complicated and not mnemonic especially for email address
 - Load distribution
 - A set of IP addresses is associated with one hostname; the DNS server can distribute the load among replicated servers such as replicated web servers
 - As a simple approach to uniformly distribute the load, the DNS server rotates the list of IP addresses each time it receives a query for that hostname

High-Level Illustration of How DNS Works

✦ An application (e.g. a browser) that wishes to resolve a DNS name onto an IP address,

- sends the hostname to a resolver (DNS Client)
- the DNS client sends a query containing the hostname to the local DNS server which then looks up the name and returns the IP address to the resolver, which in turn passes it on to the application.
- the application can then use the IP address to establish a TCP connection or send UDP packets, etc.



Name Space

Flat name space

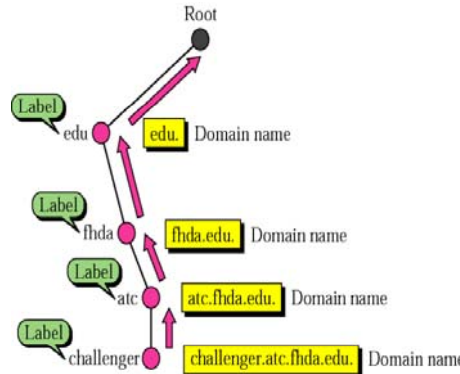
- ✦ The name is a sequence of characters without any structure
- ✦ Names have no meaningful common sections
- ✦ A *central* authority is required to assign name to an address
- ✦ Disadvantages
 - Needs to be centrally controlled to avoid duplication
 - Cannot be used in large systems such as the Internet

Hierarchical name space

- ✦ Each name is made of several parts, for example, (from the left)
 - The first part can define the nature of the organization (educational, commercial, ...)
 - The second part can define the organization name
 - The third part can define the department name, and so on
- ✦ Advantages
 - The authority to assign and control the name can be decentralized
 - Different sections can be common but still the names are distinguishable
 - An organization does not need to worry that the prefix chosen for a host is taken by another organization

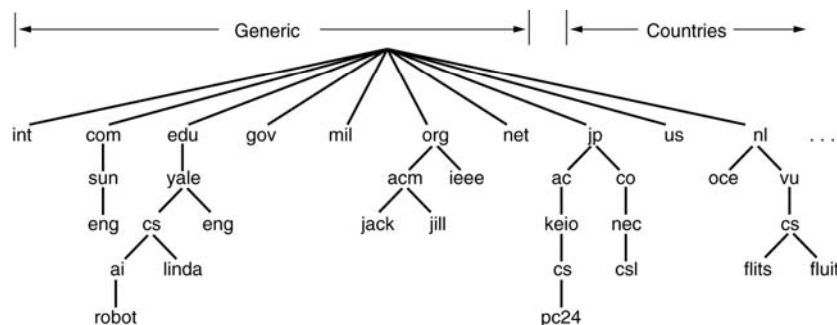
Domain Name Space in the Internet

- ✦ Uses hierarchical name space; names are defined as an inverted tree with the root at the top
- ✦ The tree can have up to 128 levels (level 0 is the root)
- ✦ Each node has a string *label* with a max. of 63 characters (the root label is empty string)
- ✦ Names are case insensitive
- ✦ Children of a node have different labels (to guarantee uniqueness of the domain names)
- ✦ Each node in the tree has a *domain name* (sequence of node labels from the node to the root separated by dots)
 - Fully Qualified Domain Name (FQDN)
 - Partially Qualified Domain Name (PQDN)



The Domain Name Space in the Internet ...

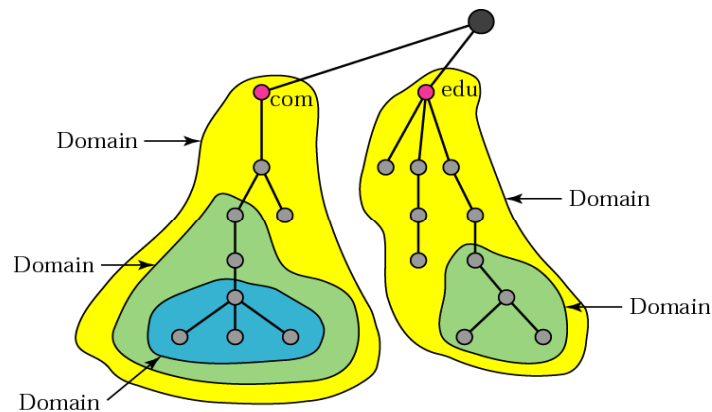
A portion of the Internet domain name space



com	commercial	mil	US armed forces
gov	US government	net	Network providers
edu	Educational institutions	org	Non-profit organizations
int	International organizations		

Domains

- ✦ A domain is a subtree of the domain name space; the name of the domain is the domain name of root node of the subtree
- ✦ A domain may be divided into smaller domains (also called subdomains)

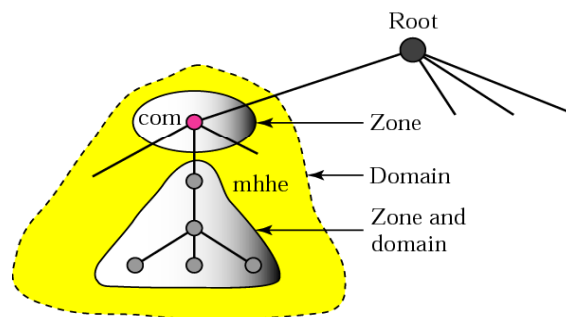


Name Servers

- ✦ **Centralized approach:** Using a single DNS server containing all mappings with two columns: one for the name and one for the address
 - Very simple and centralized design
 - Disadvantages
 - A single point of failure
 - Huge traffic volume: to handle all DNS queries
 - Distant server: leads to significant delay
 - Maintenance difficulty: Huge database file and also to be updated frequently
 - Not applicable for today's Internet (because of scalability problem)
- ✦ **Distributed hierarchical approach:** distributes the huge amount of information among a large number of servers organized in a hierarchical fashion and distributed worldwide
 - Overcomes the problems of centralized approach
 - DNS name space is divided up into a number of non-overlapping regions called zones.
 - Each zone contains part of the entire DNS namespace tree, along with a number of domain name servers which manage the zone.
 - Normally a zone will have one primary name server, which is responsible for maintaining details of all the hosts within the zone.
 - In addition to the primary server, a number of secondary servers which mirror the information contained on the primary server are used.

Zones and Domains

- ✦ Zone: what a server is responsible for
- ✦ If the server is responsible for a domain and does not divide the domain into smaller domains, then the domain and the zone refer to the same thing

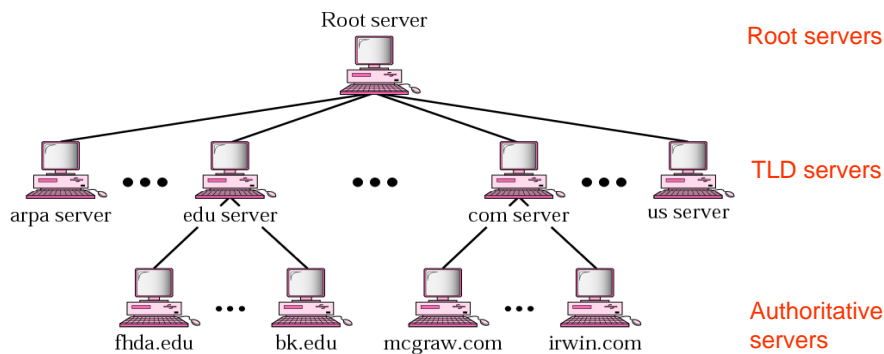


KFUPM: Dr. El-Alfy © 2005 Rev. 2008

15

The Internet Name Servers

- ✦ The Internet is divided into several top-level domains (TLD), with each domain covering a number of related hosts.
- ✦ Each domain is then further subdivided (in a tree like structure) until individual hosts are reached, e.g.



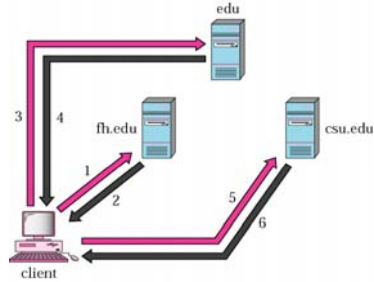
KFUPM: Dr. El-Alfy © 2005 Rev. 2008

16

Name-Address Resolution

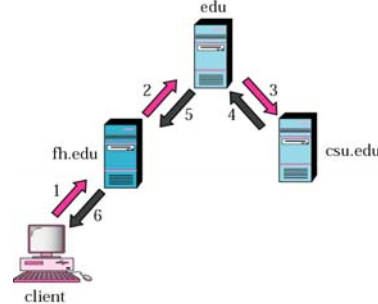
- ✚ What is name-address resolution?
 - Mapping names to addresses (mostly)
 - Mapping addresses to names
- ✚ Resolution Approaches

Iterative Resolution



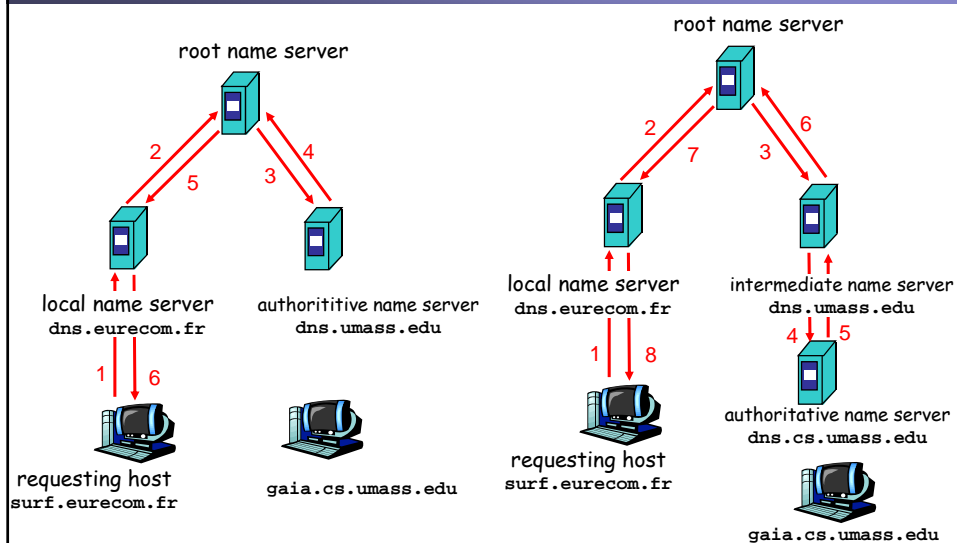
Contacted server says "I do not know" but ask another server and replies with that server IP address

Recursive Resolution



Puts burden of name resolution on contacted name server; it replies with the required IP address

Name-Address Resolution ...



Root server knows the authoritative server

Root server does not know the authoritative server but knows an intermediate server

Finding IP Address

- ✦ When sending data across the network, you often need to determine the IP network information for the system running your program.
- ✦ The Windows OS family offers many ways to determine IP configuration information, both manually and from within a program. We look at few of these methods:
 - Using ipconfig
 - Using nslookup
 - Using DNS class in C#

Using ipconfig

- ✦ ipconfig is a command line programs that comes with the OS. It can be used to display IP network information for each active network interface on the current system. It has many options, but the most commonly used are:

```
C:\Documents and Settings\ics>ipconfig /all

Windows IP Configuration

Host Name . . . . . : ics-bmghandi
Primary Dns Suffix . . . . . : 
Node Type . . . . . : Hybrid
IP Routing Enabled. . . . . : No
WINS Proxy Enabled. . . . . : No
DNS Suffix Search List. . . . . : pc.ccse.kfupm.edu.sa
                                   ccse.kfupm.edu.sa
                                   kfupm.edu.sa

Ethernet adapter Local Area Connection:

   Connection-specific DNS Suffix  : pc.ccse.kfupm.edu.sa
   Description . . . . . : Intel(R) PRO/100 VE Network Connection
   Physical Address. . . . . : 00-08-02-BC-4A-30
   Dhcp Enabled. . . . . : Yes
   Autoconfiguration Enabled . . . . : Yes
   IP Address. . . . . : 196.1.65.143
   Subnet Mask . . . . . : 255.255.255.0
   Default Gateway . . . . . : 196.1.65.253
                                   196.1.65.254
   DHCP Server . . . . . : 196.1.65.21
   DNS Servers . . . . . : 196.1.65.21
                                   172.16.0.1
                                   196.1.64.3
   Primary WINS Server . . . . . : 196.1.65.21
   Secondary WINS Server . . . . . : 172.16.0.1
   Lease Obtained. . . . . : Sunday, October 05, 2003 8:39:57 PM
   Lease Expires . . . . . : Monday, October 06, 2003 1:39:57 AM
```

Z: \>ipconfig

Displays basic IP network information about the host on which it is run

Z: \>ipconfig /all

Displays detailed IP network information about the host on which it is run

Using nslookup

- ✦ nslookup is a command line programs that also comes with the OS. It can be used to query the local DNS server about any host on the internet.

- ✦ Example:

```
C:\Documents and Settings\ics>nslookup www.microsoft.com
Server: ccse-tungsten.pc.ccse.kfupm.edu.sa
Address: 196.1.65.21

Non-authoritative answer:
Name: a562.cd.akamai.net
Addresses: 81.52.248.159, 81.52.248.161, 81.52.248.166, 81.52.248.142
          81.52.248.145, 81.52.248.151, 81.52.248.152, 81.52.248.153, 81.52.248.
158
Aliases: www.microsoft.com, www.microsoft.com.edgesuite.net
```

- ✦ Notes:

- The first two lines displays info about the local DNS sever reporting the query result.
- *Non-authoritative* indicates that this information is obtained from the cache of the local DNS server.
- Name indicates the actual name of the machine – thus, www.microsoft.com is just an alias as we can see from the last line.
- All IPs associated with the machine are returned.

Using DNS Class in C#

- ✦ C# provides the DNS class in the **System.Net** namespace, which provides static methods that can be used to query the local DNS server to resolve IPs and domain names.

- ✦ Some of the methods of the DNS class are:

```
//returns the name of the current host.
static string GetHostName()
//return an instance of IPHostEntry class
static IPHostEntry GetHostByName(string hostname)
static IPHostEntry GetHostByAddress(string address)
static IPHostEntry GetHostByAddress(IPAddress address)
static IPHostEntry Resolve(string hostName)
```

Using DNS Class in C# ...

- ✦ IPHostEntry class has three properties which are used to retrieve the information about the host

AddressList	Returns an array of IPAddress objects, one for each IP Address of the machine.
Aliases	Returns An array of string objects, one for each alias.
HostName	Returns a string object representing the name of the host.

Example

```
1. using System;
2. using System.Net;

3. class DNSIPInfo
4. {
5.     public static void Main()
6.     {
7.         string hostName = Dns.GetHostName();
8.         Console.WriteLine("Local hostname: {0}", hostName);

9.         IPHostEntry myself = Dns.GetHostByName(hostName);
10.        foreach (IPAddress address in myself.AddressList)
11.        {
12.            Console.WriteLine("IP Address: {0}", address.ToString());
13.        }
14.    }
15. }
```

Resources

- ✦ MSDN Library
 - <http://msdn.microsoft.com/en-us/default.aspx>
- ✦ Books
 - Richard Blum, C# Network Programming. Sybex 2002.
 - [Data Communications and Networking](#), 4/e. Behrouz A Forouzan, McGraw-Hill Higher Education
 - Computer Networking: A Top Down Approach Featuring the Internet, 4/e, J. Kurose & Keith Ross, Addison Wesley, 2008
- ✦ Lecture notes of previous offerings of SWE344 and ICS343
- ✦ Some other web sites and books; check the course website at
 - <http://faculty.kfupm.edu.sa/ics/alfy/files/teaching/swe344/index.htm>