

NPS

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Domain Name
System

Name Space

Resolution

DNS Messages

Dynamic Domain
Name System

Simple Mail
Transfer
Protocol

Application Layer: DNS,SMTP



Dr. G. Omprakash

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Aim of the session

To familiarize students with the basic concept of Application Layer Protocol: Domain Name System and SMTP

Learning Outcomes

At the end of this session, you should be able to:

- Describe the three domains of the domain name space
- Two main categories of DNS messages
- Describe SMTP, POP3



Overview

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1 Domain Name System

- Name Space
- Resolution
- DNS Messages
- Dynamic Domain Name System

2 Simple Mail Transfer Protocol



Application Layer

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- The application layer provides services to the user.
- The layers below the application layer are there to provide transport services
- Protocols are required to allow applications to function
- **Domain Name System:** Maps Internet names to IP addresses
 - nslookup klh.edu.in
 - nslookup google.com
- **SMTP:** Simple Mail Transfer Protocol
- **SNMP:** Simple Network Management Protocol



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Domain Name System



Domain Name System

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- TCP/IP protocols use the IP address, which uniquely identifies the connection of a host to the Internet
- People prefer to use names instead of numeric addresses
- Internet needs to have a directory system that can map a name to an address
- This is analogous to the telephone network.
- A central directory system cannot hold all the mapping.
 - If the central computer fails, the whole communication network will collapse.
- **Better solution:** Distribute the information among many computers in the world.
- Host that needs mapping can contact the closest computer holding the needed information.



Steps to map the host name to an IP address

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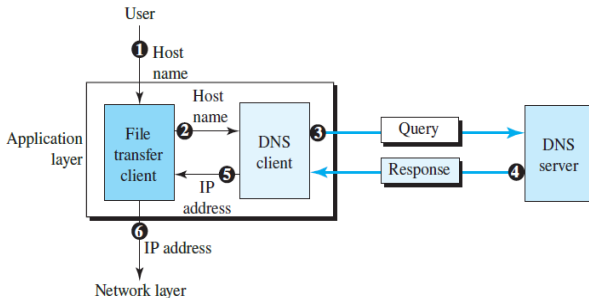
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A user wants to access file from server running on a remote host (source.com). IP address of the server is required to make the connection.



To know about the DNS servers connected to your PC: Type "ipconfig /all" in the command prompt



DNS servers in your Laptop

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In the Command Prompt type: `ipconfig /all`

```
DNS Servers . . . . . : 2406:b400:8:1::2
                        2406:b400:50:7::2
                        49.205.171.194
                        49.207.34.210

NetBIOS over Tcpip. . . . . : Enabled

Ethernet adapter Bluetooth Network Connection:

    Media State . . . . . : Media disconnected
    Connection-specific DNS Suffix . :
    Description . . . . . : Bluetooth Device (Personal Area Network)
    Physical Address. . . . . : 58-1C-F8-30-7A-E0
    DHCP Enabled. . . . . : Yes
    Autoconfiguration Enabled . . . . : Yes

C:\Users\ompg6>nslookup 49.205.171.194
DNS request timed out.
    timeout was 2 seconds.
Server: UnKnown
Address: 2406:b400:8:1::2

Name:      hyddns.actcorp.in
Address:   49.205.171.194

C:\Users\ompg6>nslookup 49.207.34.210
Server: UnKnown
Address: 2406:b400:8:1::2

Name:      broadband.actcorp.in
Address:   49.207.34.210
```

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Steps to map the host name to an IP address



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A user wants to access file from server running on a remote host (source.com). IP address of the server is required to make the connection.

- User passes the host name to the file transfer client
- File transfer client passes the host name to the DNS client
- DNS client sends a message to a DNS server with a query
 - Each computer, after being booted, knows the address of one DNS server ("ipconfig /all")
- The DNS server responds with the IP address of the desired file transfer server
- The DNS client passes the IP address to the file transfer server.
- The file transfer client now uses the received IP address to access the file transfer server



Name Space

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- Postal system: Name management is done by requiring letters to specify (implicitly or explicitly)
 - Country, state or province, city, street address, and name of the addressee.
 - DNS works the same way
- For the Internet, the top of the naming hierarchy is managed by an organization called **ICANN (Internet Corporation for Assigned Names and Numbers)**.



Name Space: Flat Name space

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- The names must be unique because the addresses are unique
- Name space is organized in two ways
- **Flat name space**
 - A name in this space is a sequence of characters without structure
 - Names may or may not have a common section
 - It must be centrally controlled to avoid ambiguity and duplication
 - It cannot be used in a large system such as the Internet
- Eg: network hostnames in small intranet setups
 - myserver, server42, companymail, hrserver



Hierarchical name space

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- **Hierarchical name space**

- Each name is made up of several parts
 - First part: Defines the nature of the organization
 - Second part: Defines the name of an organization
 - Third part can define departments in the organization
 - The authority to assign and control the name spaces can be decentralized
- <https://www.kluniversity.in/>
 - <https://www.kluniversity.in/ece/default.aspx>
 - <https://www.kluniversity.in/ece/faclist.aspx>
 - <https://www.kluniversity.in/bt/default.aspx>



Domain Name Space

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Domain name space was designed to have a hierarchical name space.

- Names are defined in an inverted-tree structure with the root at the top
- Tree can have only 128 levels: level 0 (root) to level 127

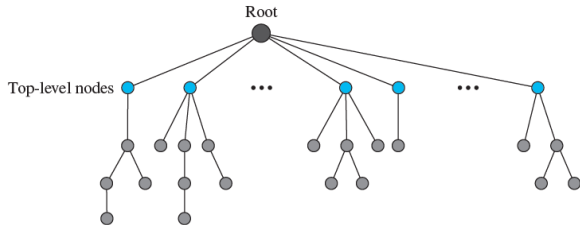


Figure: Domain name space



Domain Name Space

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- **Label:** Each node in the tree has a label
 - String with a maximum of 63 characters
 - Children of a node have different labels (to guarantee uniqueness)
- **Domain Name:** A full domain name is a sequence of labels separated by dots (.).

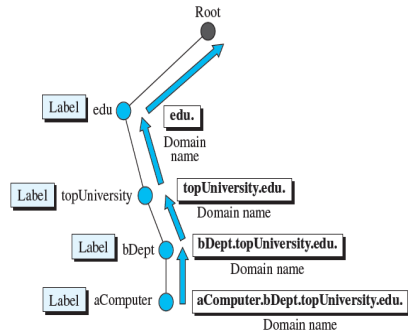


Figure: Domain name space



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A **domain** is a subtree of the domain name space

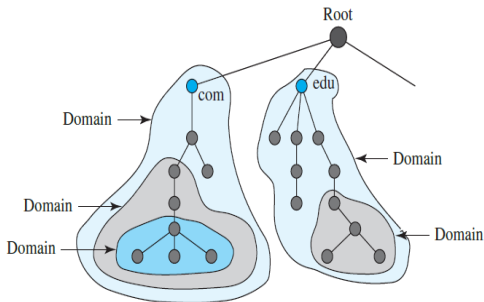


Figure: Domains

Name of the domain: Name of the node at the top of the subtree



FQDN vs PQDN

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- **Fully Qualified Domain Name (FQDN)**
- An FQDN is a complete domain name that specifies the exact location of a host within the DNS hierarchy.
- Ends with a trailing dot (.)
 - Eg: mail.google.com.
 - Eg: ftp.microsoft.com.
- **Partially Qualified Domain Name (PQDN)**
- It does not fully specify the hostname's absolute position in the DNS hierarchy
 - It depends on the context or local DNS settings to resolve.
- Eg: **mail** (could refer to **mail.google.com** or **mail.company.local**)



Hierarchy of Name Servers

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- **Problem:** Storing information contained in the domain name space in one server is inefficient and unreliable
- **Solution:** Distribute the information among many computers called DNS servers
- Each server can be responsible (authoritative) for either a large or small domain

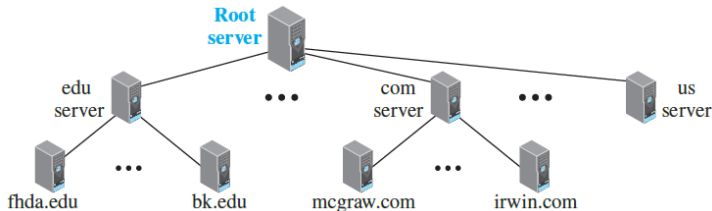


Figure: Domains



Generic Domains

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- Generic Domain refers to a category of Top-Level Domains (TLDs) in the Domain Name System
 - They are not country-specific

<i>Label</i>	<i>Description</i>	<i>Label</i>	<i>Description</i>
aero	Airlines and aerospace	int	International organizations
biz	Businesses or firms	mil	Military groups
com	Commercial organizations	museum	Museums
coop	Cooperative organizations	name	Personal names (individuals)
edu	Educational institutions	net	Network support centers
gov	Government institutions	org	Nonprofit organizations
info	Information service providers	pro	Professional organizations

Figure: Generic Domains



Country Domains

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- Country domains section uses two-character country abbreviations
 - in \Rightarrow India; us \Rightarrow United States
- "uci.ca.us." translated to University of California, Irvine in the state of California in the United States.
- "iitk.ac.in" translated to IIT Kanpur, Academic Institution in India

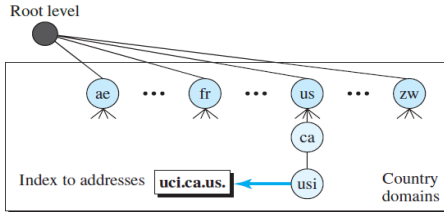


Figure: Country Domain



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- Mapping a name to an address is called name-address resolution.
- For mapping: Host calls a DNS client (called **resolver**)
- Resolver accesses the closest DNS server with a mapping request.
- A resolution can be
 - Recursive
 - Iterative



Recursive Resolution

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- DNS resolver (client) asks a DNS server to resolve a domain name fully and return the final IP address.
- DNS server **takes responsibility** for querying other DNS servers if needed.

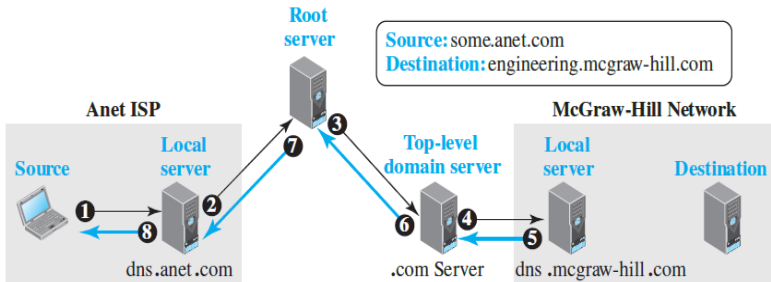


Figure: Recursive Resolution



Recursive Resolution

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Steps:

- 1 The resolver (client) sends a recursive query to a local DNS server
- 2 If the local DNS server doesn't have the IP, it performs recursive queries to other DNS servers on behalf of the client.
- 3 The DNS server collects the final answer (IP address) and returns it to the client.

Example: User enters: `ww.iitk.ac.in`

The local DNS server queries `root` \Rightarrow `.in` \Rightarrow `.ac.in` \Rightarrow `iitk.ac.in` servers recursively

- Client sends one query, gets the final answer.
- DNS server does all the work, increasing its load.



Iterative Resolution

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- The DNS resolver queries a DNS server, but instead of fetching the final answer, the server refers the resolver to another DNS server.
- The resolver must contact multiple DNS servers itself until it gets the IP.

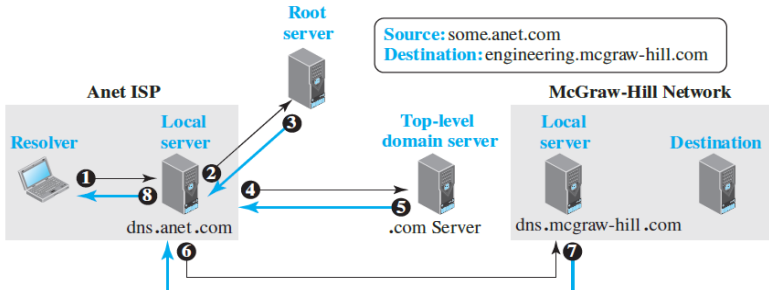


Figure: Iterative Resolution



Iterative Resolution

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- 1 Resolver (client) queries a local DNS server.
- 2 If the local DNS server doesn't have the IP, it responds with a referral
- 3 The resolver independently queries the referred DNS servers step by step until it reaches the final IP address.

Example: User enters `www.iitk.ac.in` in a browser

Resolver queries the local DNS server \Rightarrow Root DNS server
 \Rightarrow `.in` server \Rightarrow `.ac.in` server \Rightarrow `iitk.ac.in` server.

- Client makes multiple queries, collecting responses step by step.
- DNS servers have lower load (only provide referrals).



DNS Messages

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To retrieve information about hosts, DNS uses two types of messages (both same format)

- Query
- Response

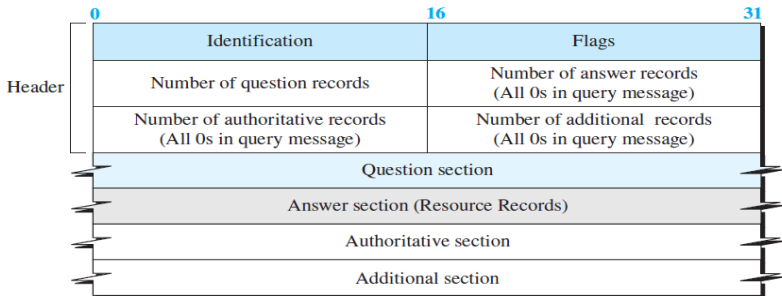


Figure: Iterative Resolution



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- **Identification field** is used by the client to match the response with the query.
- **Flag field** defines whether the message is a query or response.
 - Also includes status of error
- **Question section** is included in the query and repeated in the response message
- The **answer section** consists of one or more resource records.
 - It is present only in response messages
- The **authoritative section** gives information (domain name) about one or more authoritative servers for the query.



Dynamic Domain Name System (DDNS)

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Need for DDNS:

- No one predicted that there would be so many address changes
- Every change (adding a new host, removing a host, changing an IP address) must be updated in the DNS master file

DDNS is devised to update the DNS master file dynamically

- If binding between a name and an address is determined \implies Update
- Update: DHCP \implies primary DNS server \implies Zone \implies Notify secondary servers



Review Questions

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- What is an advantage of a hierarchical name space over a flat name space for a system the size of the Internet?
- What are the three domains of the domain name space?
- What is an FQDN?
- What is an PQDN?



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SMTP Architecture

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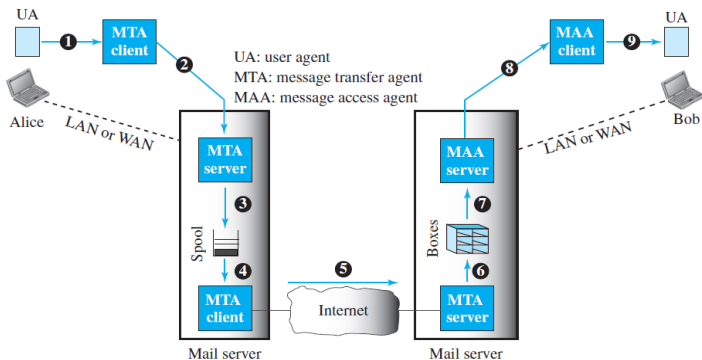
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Common Scenario

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- Alice wants to send an e-mail to Bob
- Alice and Bob are connected via a LAN/WAN to two mail servers.
- Admin has created one mailbox for each user
 - Mailbox is part of a server hard drive
- Alice and Bob use three different agents: **User Agent (UA)**, **Message Transfer Agent (MTA)**, **Message Access Agent (MAA)**.
- Alice runs UA program to prepare the message and send it to her mail server.
- Admin created a queue (spool) to store messages waiting to be sent.
- Message needs to be sent through the Internet using MTA



Common Scenario

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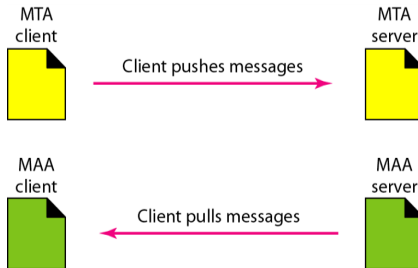
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- Two MTAs (Client/Server) needs to run all the time because it does not know when a client will ask for a connection.
- MTA client is triggered when there is a message in the queue
- Bob uses an MAA client to retrieve the message from an MAA server running on the second server





Three Agents: User Agent

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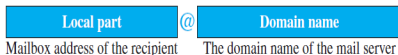
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- The first component of an electronic mail system is the **user agent (UA)**.
- It provides service to the user to **send** and **receive** a message
- Two types of user agents: command-driven and GUI-based
- A mail handling system must use an addressing system





E-mail Format

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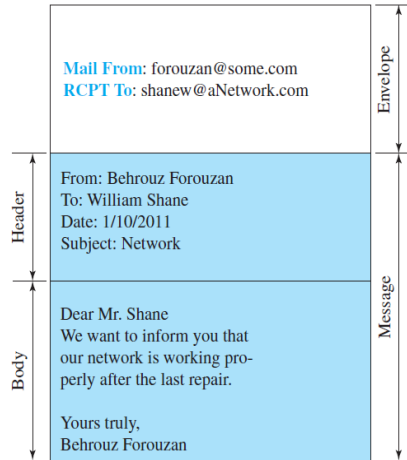
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Electronic mail



Three Agents- Message Transfer Agent: SMTP

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- SMTP is a *push* protocol: it pushes the message from the client to the server
- SMTP is used two times
 - Between the sender and the sender's mail server
 - Between the two mail servers
- POP or IMAP is used between the mail server and the receiver

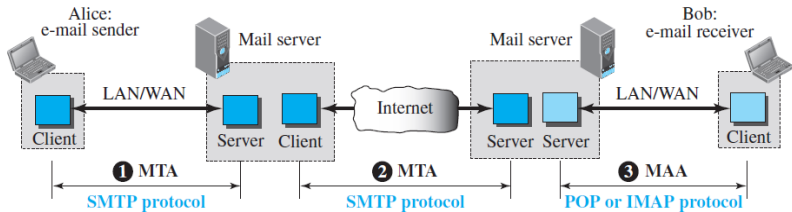


Figure: Protocols used in e-mail



Message Access Agent: POP

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- The third stage needs a *pull* protocol
- Two message access protocols are available:
 - Post Office Protocol, version 3 (POP3)
 - Internet Mail Access Protocol, version 4 (IMAP4)
- POP3: Post Office Protocol, version 3 (POP3) is simple but limited in functionality.
 - Install client POP3 software \implies recipient computer
 - Install server POP3 software \implies mail server
- User invokes POP3 client
 - Creates TCP connection to POP3 server
 - User authenticates by login & password
 - User client sends commands to retrieve messages



Message Access Agent: IMAP

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POP3 is deficient in several ways. It doesn't allow user to

- Organize mail
- create folders
- Partially check the contents

IMAP4 provides the following extra functions

- A user can check the e-mail header prior to downloading
- A user can search the contents of the e-mail
- A user can partially download e-mail
- A user can create, delete, or rename mailboxes on the mail server
- A user can create a hierarchy of mailboxes in a folder



Video Lectures

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- SMTP:
<https://www.youtube.com/watch?v=PJo5y0tu7o8>
- POP3, IMAP:
<https://www.youtube.com/watch?v=SBaARws0hy4>
- <https://www.youtube.com/watch?v=gLNOVbcyWbI>



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Acknowledge various sources for the images.
Thankyou