

NPS

Dr. G.  
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Domain Name  
System

Name Space

Resolution

DNS Messages

Dynamic Domain  
Name System

Simple Mail  
Transfer  
Protocol

## Application Layer: DNS,SMTP



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## Aim of the session

To familiarize students with the basic concept of Application Layer Protocol: Domain Name System ans 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 kh.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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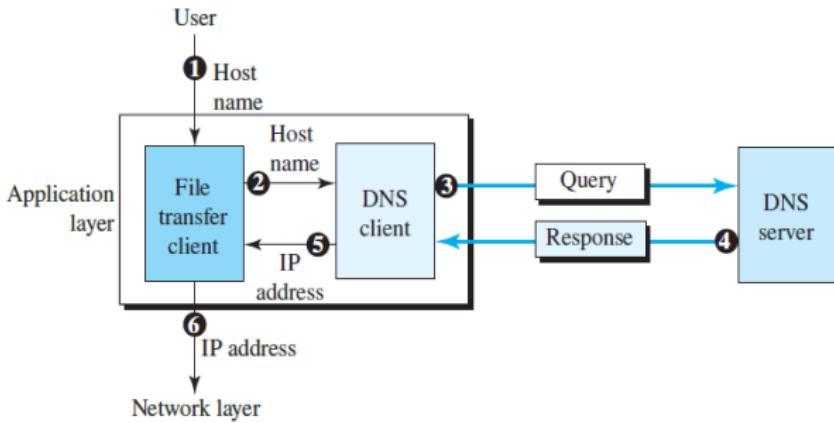
Resolution

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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
```



# 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>



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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

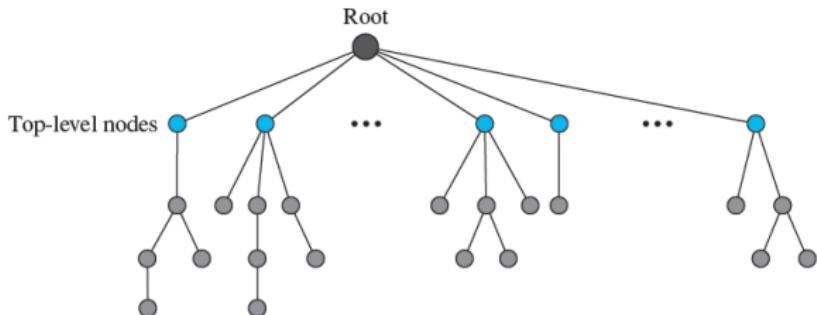


Figure: Domain name space



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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 (.).

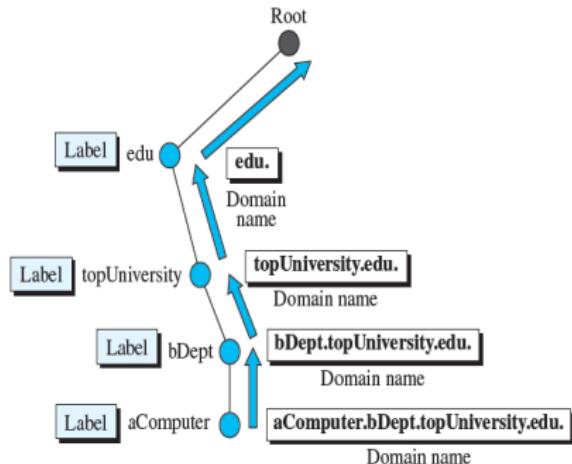


Figure: Domain name space



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

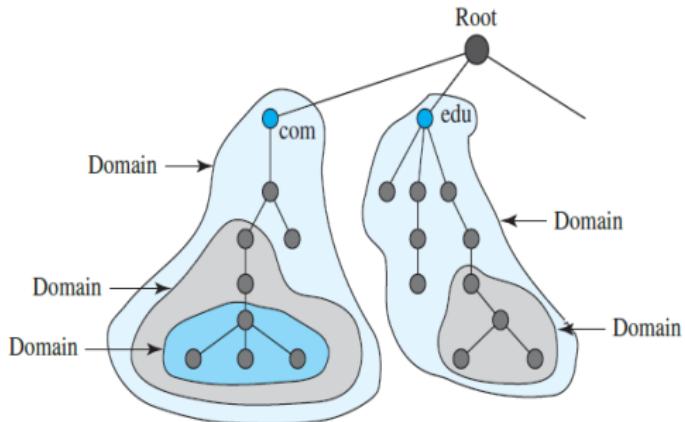


Figure: Domains

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

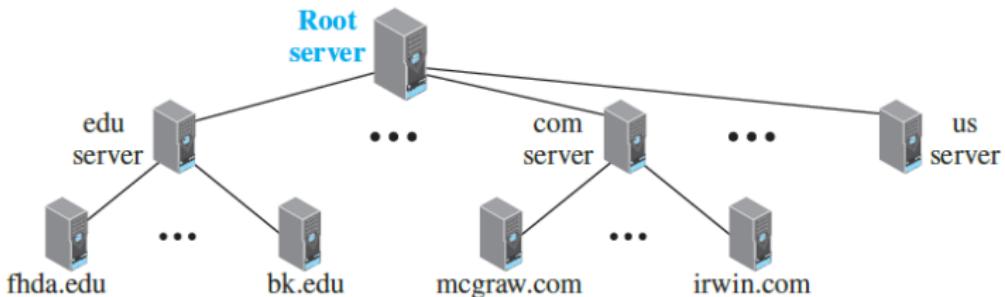


Figure: Domains



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

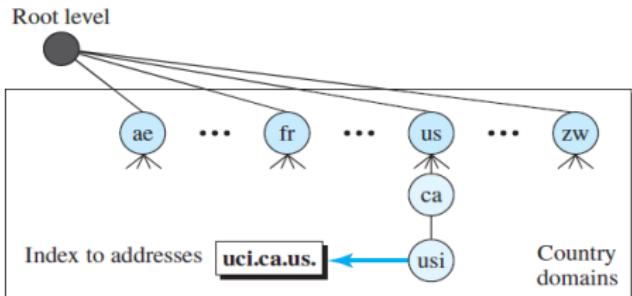


Figure: Country Domain



# Resolution

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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.

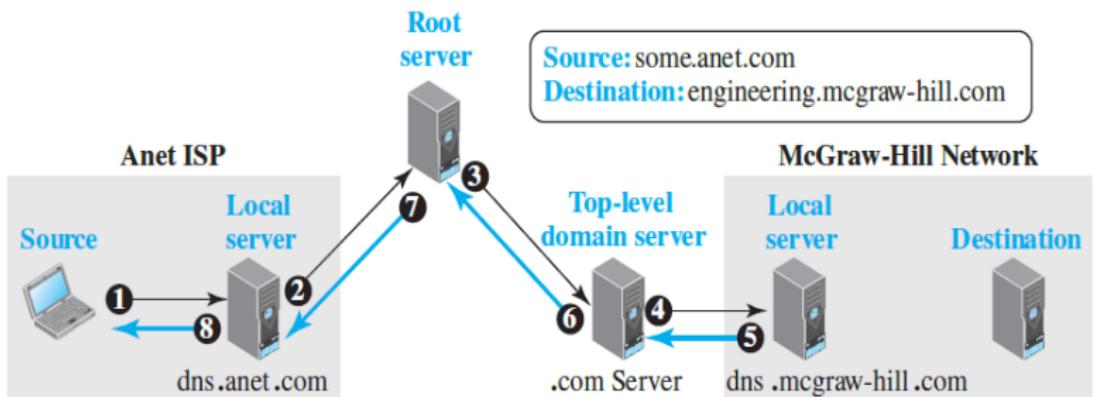


Figure: Recursive Resolution



# 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.

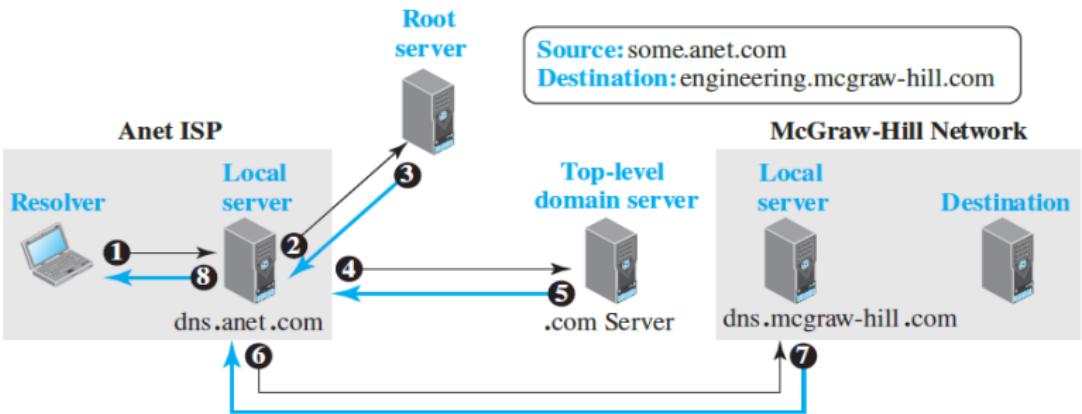


Figure: Iterative Resolution



# 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  $\implies$  Root DNS server  $\implies$  .in server  $\implies$  .ac.in server  $\implies$  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

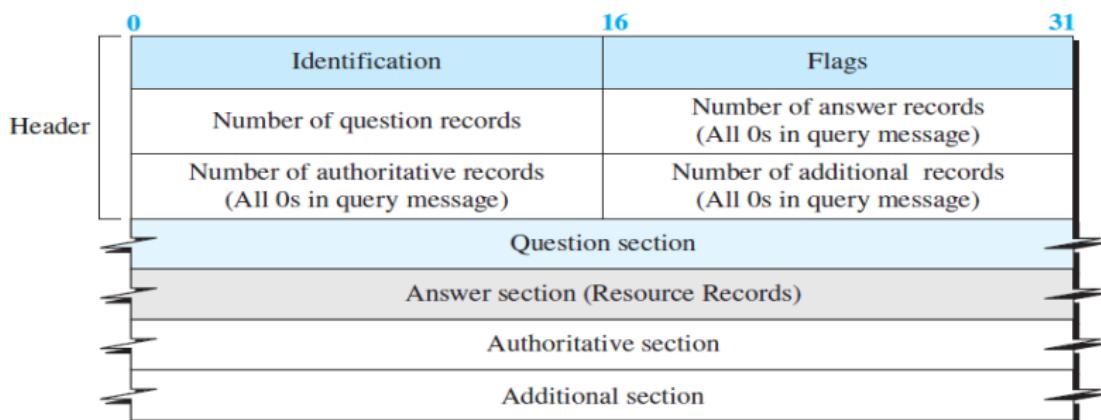


Figure: Iterative Resolution



# DNS Messages

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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  
    ⇒ Update
- Update: DHCP ⇒ primary DNS server ⇒ Zone ⇒  
    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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## Simple Mail Transfer Protocol

# Simple Mail Transfer Protocol



# SMTP Architecture

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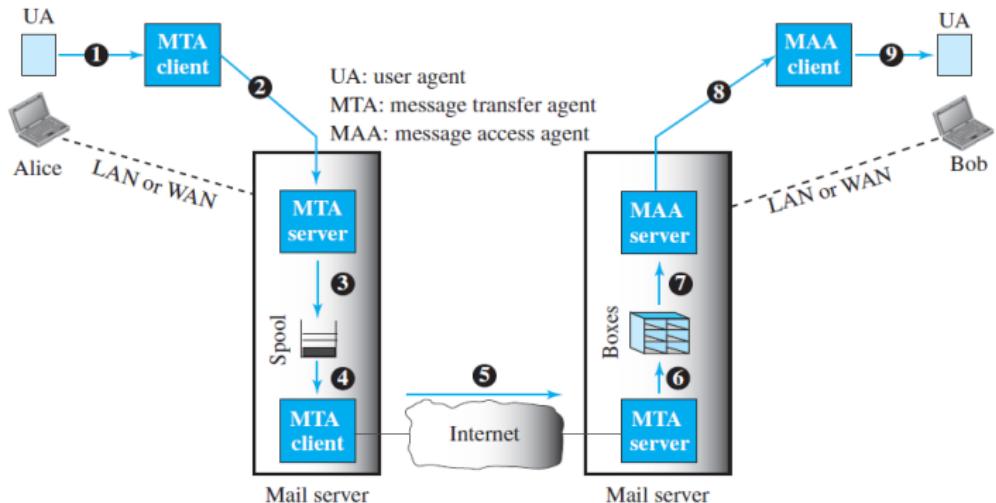
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# Common Scenario

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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



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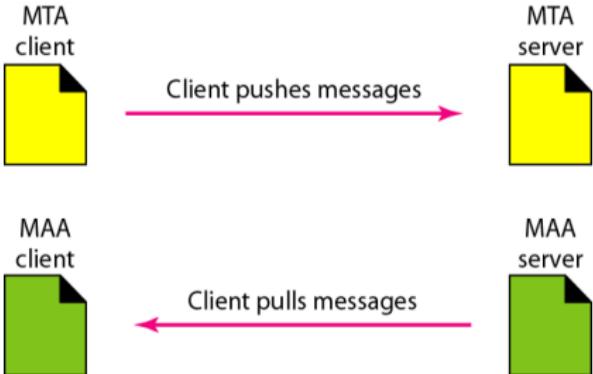
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- Two MTAs (Client/Server) needs to run all the time because it does not know when a client will ask for a connection.
- MTA client is triggered when there is a message in the queue
- Bob uses an MAA client to retrieve the message from an MAA server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





# Three Agents: User Agent

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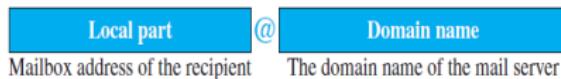
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- The first component of an electronic mail system is the **user agent (UA)**.
- It provides service to the user to **send** and **receive** a message
- Two types of user agents: command-driven and GUI-based
- A mail handling system must use an addressing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





# E-mail Format

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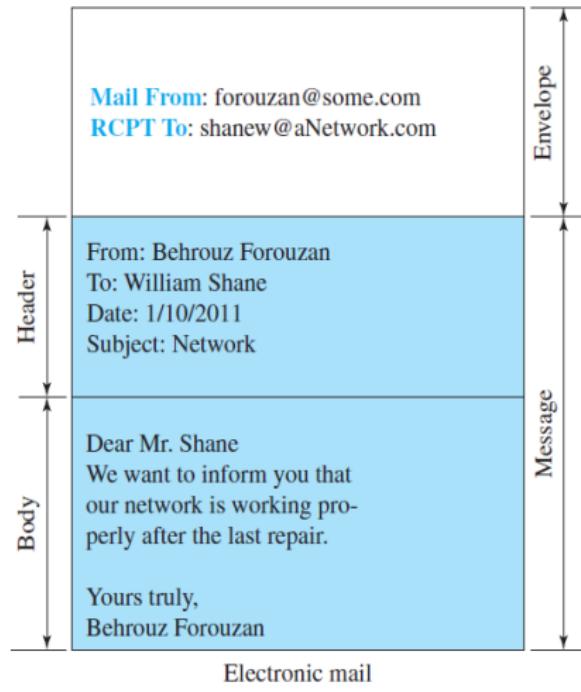
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# Three Agents- Message Transfer Agent: SMTP

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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

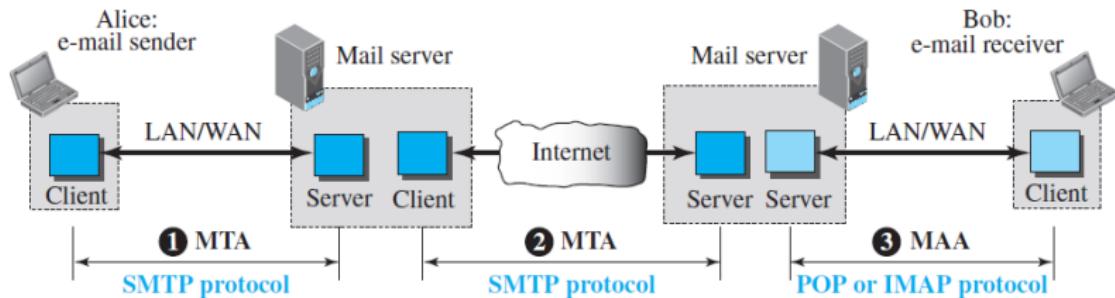


Figure: Protocols used in e-mail



# 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