

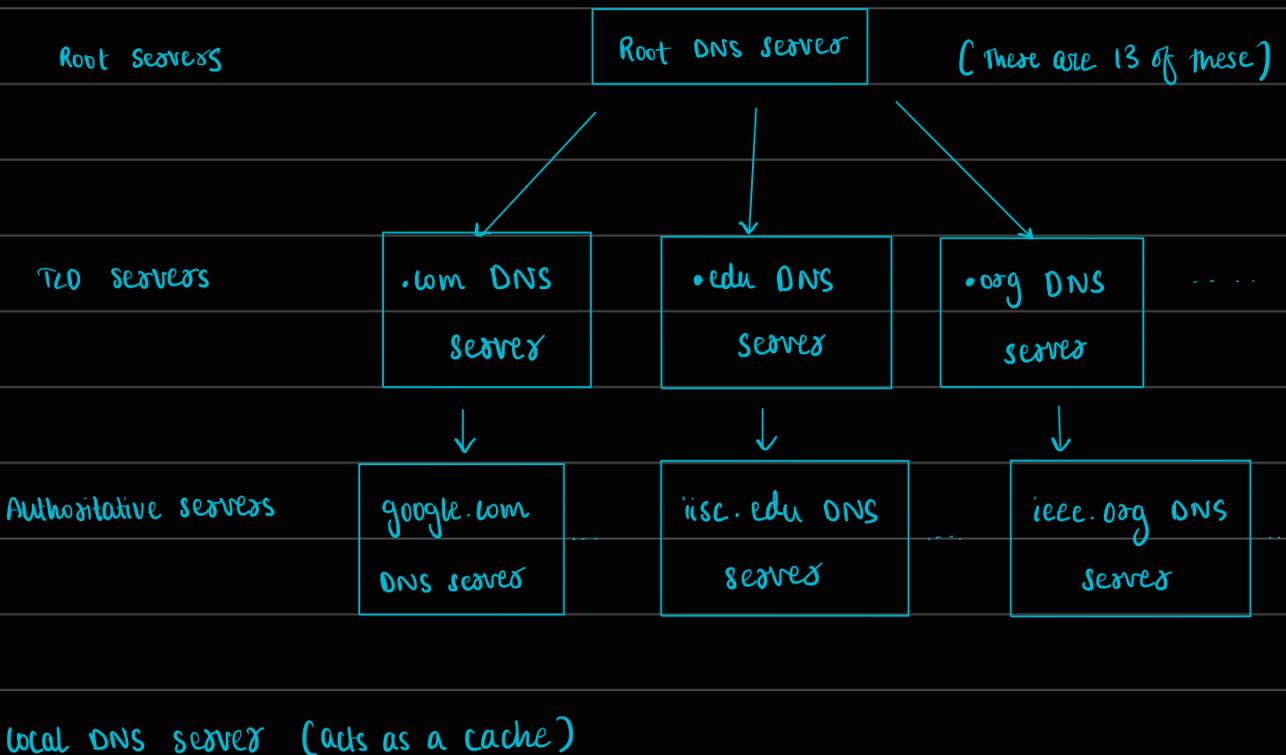
Application Layer Protocols

- DNS (Domain Name System) :

- Most commonly used domain are :

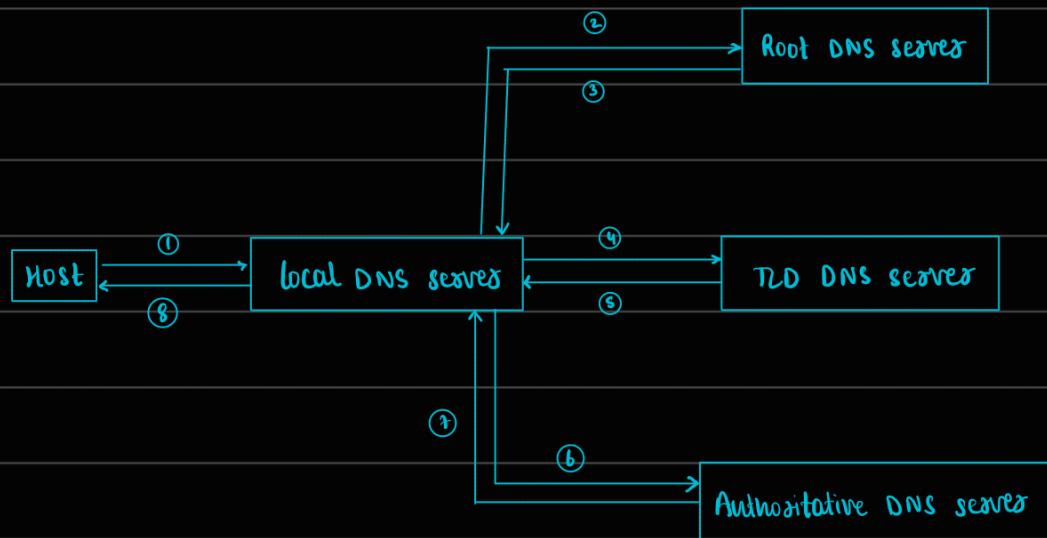
- 1 com : used by commercial organizations
- 2 edu : used by educational institution
- 3 org : used by non-profit organizations
- 4 mil : used by military organizations
- 5 net : used by open public or any commercial organizations
- 6 gov : used by government organizations

- All the websites are stored in a distributed database (sort of). This is how the websites are organized : (TLD → top level domain)



- 2 types of DNS queries :

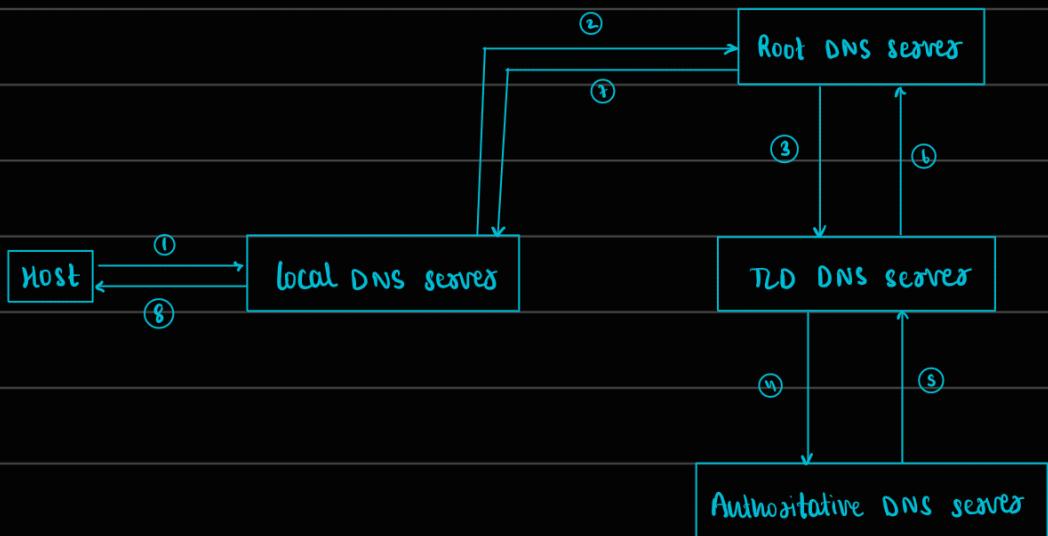
- Iterative Queries :



What happens :

- ① Sends the URL to local DNS server for the 1st time (say the URL is : "www.iisc.edu")
local DNS server DOES NOT have the IP address of that website
- ② local DNS server makes a query TO THE ROOT DNS SERVER
- ③ Root DNS server DOES NOT have info. regarding "www.iisc.edu" but it does have info. about .edu servers Root DNS server returns the IP address (and other data) of various .edu servers
- ④ Now, local DNS server queries one of these .edu servers. These servers also DON'T HAVE any info. abt. the given website but it does have the IP address (and other data) about "iisc" authoritative DNS servers
- ⑤ TLD server returns that info. to the local DNS server
- ⑥ local DNS server queries the "iisc" authoritative DNS server. Now this has the IP address (and other info.) of the required website
- ⑦ and ⑧ Authoritative DNS server returns the IP address (and other info.) to the local DNS server which then CACHES it and returns it to the host

Q2. Recursive Queries :



What happens :

- ① Sends the URL to local DNS server for the 1st time (say the URL is : "www.iisc.edu")
local DNS server Does NOT have the IP address of that website
- ② local DNS server makes a query to the ROOT DNS SERVER
- ③ Root DNS server Does NOT have info regarding "www.iisc.edu" but it does have info about .edu servers. Root DNS server ASKS the IP address (and other data) to the TLD servers.
- ④ TLD server does NOT have the required info. So, it queries the authoritative servers
- ⑤ Authoritative server Has the info. So it RETURNS the data back to the TLD DNS server
- ⑥ TLD server then RETURNS the data back to Root DNS server
- ⑦ Root DNS server then RETURNS the data back to local DNS server
- ⑧ local DNS server then CACHES it and returns it to the host

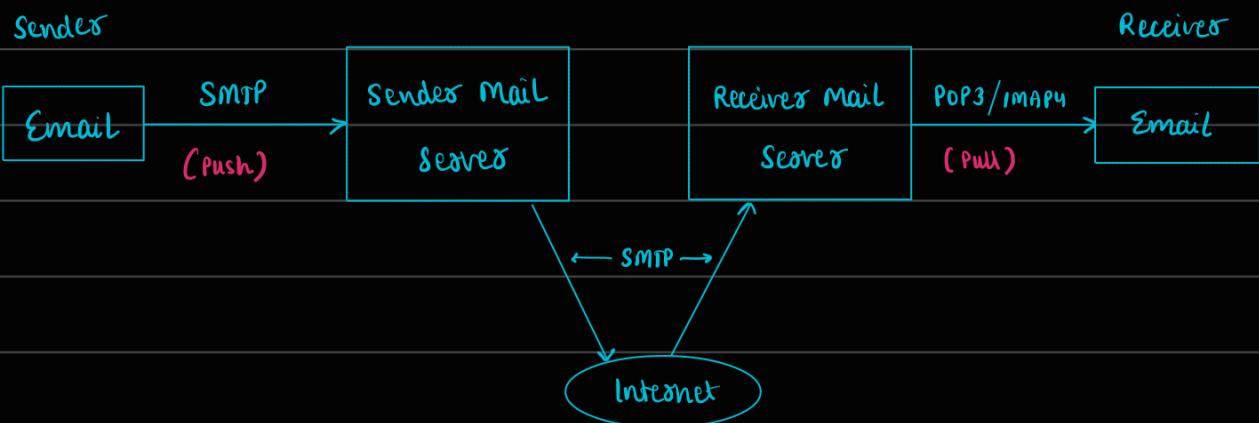
NOTE : • All of the communications mentioned here are of type : one seq. - one reply. So, by default DNS uses UDP at the transport layer. But, DNS can use TCP

- DNS query size ≤ 512 Bytes \Rightarrow UDP } either way, port used by
- DNS query size > 512 Bytes \Rightarrow TCP DNS = 53

- Email :

- SMTP (Simple Mail Transfer Protocol) is used to transfer the mail from sender's mail server to receiver's mail server
- SMTP is used TWICE while sending an email :
 - b/w sender and sender's mail server
 - b/w receiver and receiver's mail server
- Another protocol is needed b/w the receiver mail server and receiver. The most common protocols are :
 - POP3 (Post Office Protocol 3) : • uses port 110 for insecure connection (without encryption) and 995 for secure connection
 - IMAP4 (Internet message Access Protocol 4) : • uses port 143 for insecure conn. and port 993 for secure conn.

NOTE : Secure conn. means using SSL/TLS



- SMTP :
 - Objective of this is to transfer mail efficiently and reliably
 - Uses port no. 25
 - There are 2 Components :
 - User Agent (UA) : prepares the msg., create the envelope and put the

message in the envelope

- Mail Transfer Agent (MTA) : transfers mail across the internet i.e. actual mail transfer is done by MTA
- To send a mail, the sender must have the Client MTA and to receive a mail, it should have a Server MTA
- As SMTP is a text based protocol. With the help of POP, we can only send text messages. SMTP can handle messages containing ONLY 7 BIT ASCII TEXT
- SMTP CAN NOT transfer the following:
 - 1 Multi-media data like image, video, etc
 - 2 Binary or executable files
 - 3 Can not transfer text data for languages other than English
- To send the above mentioned types, we use a supplementary protocol called MIME (multipurpose Internet mail extension).
- MIME is a set of software functions that transforms non-ASCII data to ASCII data or vice versa (nothing much thh. Base64 encode/decode + some headers like Content-Type, etc). MIME is used to convert text data to non-text data and vice versa
- SMTP is a stateless connection. It does not maintain any info. about the user. If an email is asked to send twice then server resends it without saying that email has already been sent
- SMTP is a connection-oriented protocol. It uses persistent TCP connections, so it can send multiple emails at once. SMTP is used for Push (upload)
- SMTP is an in-band protocol

NOTE :

- In-band communication involves using the same network or channels for both data and management traffic
- Out-of-band communication involves using a separate, dedicated network or channel for management traffic, isolated from primary operational data

- POP3 :
 - ₁ It is a message access protocol. uses port 110
 - ₂ Is connection-oriented. Uses persistent TCP connections
 - ₃ Is a STATEFUL protocol and is an in-band protocol
 - ₄ POP3 does not allow users to partially check the content of the mail before downloading. It also does not allow the user to organize mail on the mail server

- IMAP4 :
 - ₁ Is similar to POP3 but it has many features. It is more complex and powerful
 - ₂ IMAP4 provides the following extra functions. Users can :
 - ₁ Check email header prior to downloading
 - ₂ Search the content of the email for a specific string of characters prior to downloading
 - ₃ Partially download the email
 - ₄ Can create, delete or rename the mail box on the mail server
 - ₅ Can create a hierarchy of mailboxes in a folder for email storage

POP3

- ₁ Mails can only be accessed from a single device
- ₂ Download the email from server to a single computer and the copy at the server is DELETED
- ₃ User can not organize the mails in mail box of the mail server
- ₄ It is UNI-DIRECTIONAL i.e. all the changes made on a device DOES NOT affect the content present on the server
- ₅ It does NOT allow user to SYNC emails

IMAP4

- ₁ Mails can be accessed from multiple devices
- ₂ The email messages are stored on the mail server itself
- ₃ Users can organize mails in the mail server
- ₄ It is BI-DIRECTIONAL i.e. all the changes made on a device DOES affect the content present on the server
- ₅ It allows users to SYNC emails

- File Transport Protocol (FTP) :

- Uses TCP/IP to transfer files b/w computers. Is a connection-oriented protocol
- Is a STATEFUL protocol. Is an out of band protocol.
- It has 2 types of connections:
 - Control connection :
(port no. 21)
 - Remains connected during the entire interactive FTP session
 - uses persistent TCP connections
 - Data connection :
(port no. 20)
 - Is opened and closed for each file transfer activity
 - uses non-persistent TCP conn. (Each req/resp pair uses a separate TCP conn.)
- When user starts an FTP session, the control conn. opens. While the control conn. is open, the data conn. can be opened or closed multiple times if several files are transferred
- FTP can transfer file across the data conn. using one of the following interpretations of the structure of the data :
 - file structure
 - Record structure
 - Page structure

- HTTP (Hypertext Transfer Protocol) :

- Is a client-server protocol using port no. 80 on TCP
- Is a stateless, in-band and a connection-less protocol
- There are 2 types of HTTP protocol:
 - Non-persistent (HTTP 1.0) :
 - One TCP conn. is made for each req/resp.
 - So, for N resources, N conn. are made. For eg. if a webpage requests some text and S images, there will be a total of $N + S$ TCP connns.
 - But note that if a req. is made for a file containing links of N-DIFFERENT images all located on the same server (or a similar "container" setup),

There will be $(N+1)$ TCP connns. : 1 for the file

itself and N for the imgs. in it.

- 2 Persistent (HTTP 1.1):
 - The server leaves the conn. open for more req. after sending a response
 - The server closes the conn. at client's request or when a timeout has been reached

- Important Table:

Protocol	Port No.	Tl protocol used	stateless ?	connection - oriented ?
DNS	53	UDP	stateless	Conn. less
HTTP	80	TCP	stateless	Conn. less *
SMTP	25	TCP	stateful	Conn. oriented
POP	103	TCP	stateful	Conn. oriented
IMAP	143	TCP	stateful	Conn. oriented
FTP	20, 21	TCP	stateful	Conn. oriented
SNMP	161, 162	UDP	stateless	Conn. less
TFTP	69	UDP	stateless	Conn. less
Telnet	23	TCP	stateful	Conn. oriented
DHCP	67, 68	UDP	stateless	Conn. less
SSH	22	TCP	stateful	Conn. oriented

- SNMP : Simple Network Management protocol
- TFTP : Trivial file Transfer Protocol
- DHCP : • Dynamic Host Configuration Protocol
 - Port 67 → DHCP server ; Port 68 : DHCP client to transmit data.
- Telnet is used for remote access. Is replaced by SSH since telnet uses plaintext