DNS (Domain Name System)

- Since each computer connected to Internet has IP address.
- So when Internet was developed then we need this address of computer to access any information present on it.
- But human brain can remember names rather than numbers.
- So each computer was given a unique name and user uses this name to access information.
- But internally this name must be mapped to IP address and for this mapping in early days of Internet hosts.txt file was used which was having only two columns that is names and IP addresses.
- We can imagine that this process is similar to phonebook of mobile.
- This file was stored on every host connected to Internet and it was periodically updated from master host file which was stored at specific computer.
- Today however it is impossible to have one single host file to relate every address with name and vice versa because of two reasons:
- Size of file will be very large.
- It is impossible to update changes in this file as this change must be broadcast to each and every host.
- Better solution is to divide this huge amount of information into smaller parts and store each part on different computer.
- Same parts are stored on multiple computers to provide fault tolerance.
- Host that need mapping can contact closest computer holding that information.
- This method is known as DNS (Domain Name System).
- It uses distributed database approach.
- It is an application layer protocol and uses UDP as transport layer protocol and port number is 53.

NAMESPACE

- We must assign a unique name to each IP address so that mapping become possible.
- Set of all these unique names which are assigned to IP address are called namespace.

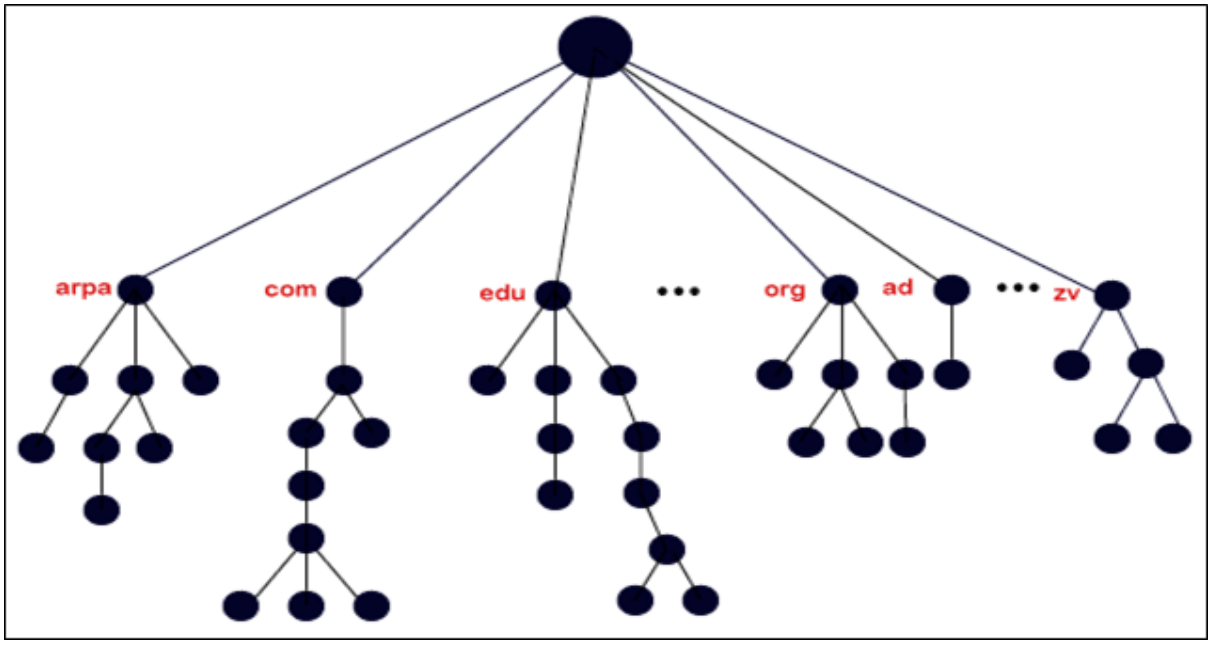
1. **Flat namespace**
   - As the name suggests there was no link between names and this was used in hosts.txt file.
   - But it is very difficult to manage in today Internet as we need a central authority which will manage all these names and guarantee there uniqueness.

2. **Hierarchal Namespace**
   - Each name is made of several parts.
   - The first part can define nature of organisation, second can define the name of organisation and third can define departments in organisation and so on.
   - So here Central authority will be responsible for assigning only nature and name of organisation and this organisation itself can assign names to its departments and computer inside department.
   - So Central authority only assign part of name and not entire name for example nature is commercial organisation (.com) and name is Cisco.
   - Now Cisco will give name to department like "sales" and give name to computer in sales department as "abc" Domain name of "abc" computer will be abc.sales.cisco.com.
   - Also note that other organisations will also have "sales" department and can have computer name "abc" but as a whole domain name will be unique for example abc.sales.cisco.com and abc.sales.tcs.com.
   - This hierarchical namespace is used in DNS.

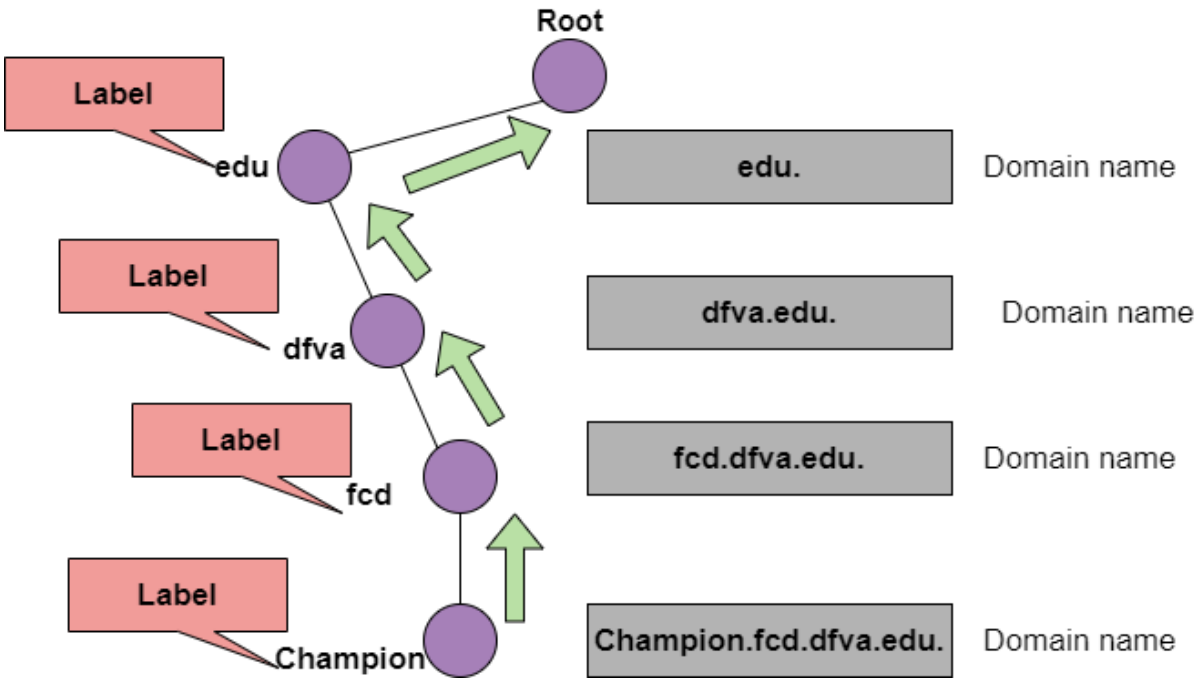
DOMAIN NAME

To have hierarchical namespace in DNS domain name space was designed.

In this design the names are defined in inverted tree structure with the root on the top.



- The tree can have 128 level (0 to 127) each node in a tree has a label which is a string of up to 63 characters.
- The root label is Null or empty string.
- DNS requires that children of a node have different labels which guarantee uniqueness of domain names.
- A domain name is sequence of labels separated by dots. Domain names are always read from the node up to the root and maximum size can be 255 characters and these are case insensitive.



Domain names are of two types:

Domain name which ends with null string i.e., dot (.) is called fully qualified domain name for e.g.

1. Fully Qualified Domain Name (FQDN)

Domain name which ends with null string i.e., dot (.) is called fully qualified domain name for e.g. "abc.sales.cisco.com."

2. Partially Qualified Domain Name (PQDN)

Domain name which does not end with null string is called partially qualified domain name. It is used when a host A which wants to know IP address of another host B are connected to same network.

DNS IN INTERNET

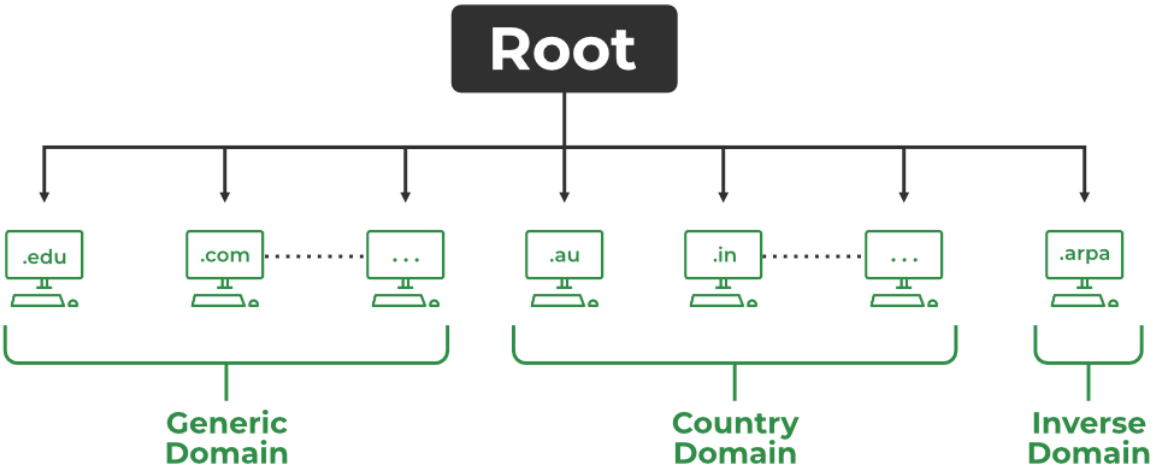
In the Internet, the domain name space (tree) is divided into three different sections:

1. Generic domains

2. Country domains

3. Inverse domain

NOTE: Here arpa, org, com, in... all these are called as top-level domains.



Generic domains

The generic domains define registered hosts according to their generic behaviour. Each node in the tree defines a domain, which is an index to the domain name space database. The first level in the generic domains section allows 14 possible labels. These labels describe the organization types as listed in Table below.

Label	Description
aero	Airlines and aerospace companies
biz	Businesses or firms (similar to "com")
com	Commercial organizations
coop	Cooperative business organizations
edu	Educational institutions
gov	Information service providers
int	International organizations
mil	Military groups
museum	Museums and other nonprofit organizations
name	Personal names (individuals)
net	Network support centres
org	Nonprofit organizations
pro	Professional individual organizations

Country Domains

- The country domains section uses two-character country abbreviations (e.g., in for India, us for United States). Second labels can be organizational, or they can be more specific, national designations.
- The United States, for example, uses state abbreviations as a subdivision of us (e.g., ca.us for California state in USA).
- Yet another example can be the address www.amazon.in can be translated to organization amazon in India.

Inverse Domain

The inverse domain is used to map an address to a name.

This may happen, for example, when a server has received a request from a client to do a task. Although the server has a file that contains a list of authorized clients, only the IP address of the client (extracted from the received IP packet) is listed. The server asks its resolver to send a query to the DNS server to map an address to a name to determine if the client is on the authorized list.

This type of query is called an inverse or pointer (PTR) query. To handle a pointer query, we have only one top level (first level) domain known as arpa.

It was the first domain in DNS. Originally it was called Advance Research Project Agency but now it is called **Address and Routing Parameter Area.**

At second level 2 domains are used for inverse mapping i.e. in-addr (for inverse address). and ip6. in-addr is used for IPV4 and ip6 is used for IPV6.

DISTRIBUTION OF NAMESPACE

- It means that how this huge amount of information is distributed over servers.
- Part of tree Stored at server is called its zone and it is always contiguous part of tree.
- We have not stored this entire information at one place to avoid single point of failure and responding request from all over the world places heavy load on system.

Types of Servers

1. Non-Authoritative
2. Authoritative

Non Authoritative

- It has no DNS database i.e. it has no entry for IP address and name for any organisation.
- It is also known as cache only servers because to service any query they uses their cache or ask other servers the same query or refer the DNS client to some other server.
- Example is root server and it is type of server who's zone is entire DNS tree. Actually it does not store any information about domain but it stores the IP address of different servers whose zone is top level domain. There are several root servers in the Internet and all stores same redundant information.

Authoritative

It has DNS database and it is of 2 types

Primary

- It stores file for a zone for which it is responsible.
- It is responsible for generating maintaining and updating this zone file.

Secondary

- It transfers the complete information about zone from any other server (primary or secondary) and store the file on its disk.

- It neither creates nor update the zone file.

- If updation is required then it can be done only by primary server and it sent the updated file to all secondary servers.
- Also note that we can have only one primary server for zone and many secondary servers for the same zone.

WORKING OF DNS

- When we type URL in address bar of web browser like www.google.com it is partially qualified domain name (as it does not end with a dot).
- It passes this address to program called resolver (DNS client) and it first convert it into FQDN that is www.google.com.
- Now it will first check in DNS cache that is temporary memory or buffer for the mapping. If entry is present then corresponding IP address is given to web browser. Entry is present if recently web browser has opened that page. This entry is timed out after some time.
- If entry is absent then this resolver will send this query to local DNS server (address of the server is present in TCP/IP settings)
- Now this server will first check in its cache if mapping is present then it sends corresponding address to resolver and it sends to web browser.
- But if entry is not present then it will send query to root server.
- Root server has IP address of all top-level domain servers only so it does not have IP address of www.google.com So it will send IP address of server whose domain is .com that is it partially solve the query.
- Now local DNS will send query to .com server and it will send IP address of DNS server of Google organization because.com server don't store IP addresses of hosts of Google organisation.
- Now again local DNS server send query to this Google DNS server which has IP address of www, mail, plus etc hosts of Google and it will send IP address of www.google.com now it is fully solved.
- Now query is resolved and local DNS server send reply to resolver and this resolver replies to web browser.

DNS QUERY

We have 3 types of DNS queries

1. Reverse lookup query

It is used for reverse process i.e., IP to domain name.

2. Recursive query

- When client do this then server has to give definitive answer that is if name exists then IP address otherwise error message must be given.
- DNS server can't refer client to any other DNS server.
- Generally recursive recursive queries are sent by end devices to local DNS server.

3. Iterative query

- DNS client allows the DNS server to return best answer it may be definitive or not.
- So now DNS server can send IP of another DNS server also and client will request the same query to it.
- For example as seen in working of DNS all 3 queries from local DNS server are iterative queries.
- This process is also called walking the tree.

DNS ANSWER TYPES

There are 4 types of answers given by DNS server to DNS clients.

1. **Negative**
   - It is the error message given by server if name does not exist.

2. Authoritative

- If server give definitive answer after searching from its own database.
- For eg, as seen in DNS working, google server reply to our local DNS server.

3. Non authoritative

- Reply to query is given by not searching its own database.
- For e.g., as seen in DNS working, local DNS server reply to resolver.

4. Referral

- Answer with give IP of other DNS servers.

REGISTRARS

How are new domains added to DNS? This is done through a registrar, a commercial organization accredited by ICANN. A registrar first verifies that the requested domain name is unique and then enters it into the DNS database. A fee is charged.

Today, there are many registrars; their names and addresses can be found at

http://www.intenic.net

To register, the organization needs to give the name of its server and the IP address of the server. For example, a new commercial organization named abc with a server named ws and IP address 200.200.200.5 needs to give the following information to one of the registrars.

Domain name: WS.wonderful.com

IP address: 200.200.200.5

DYNAMIC DOMAIN NAME SYSTEM (DDNS)

- When the DNS was designed, no one predicted that there would be so many address changes.
- In DNS, when there is a change, such as adding a new host, removing a host, or changing an IP address, the change must be made to the DNS master file.
- These types of changes involve a lot of manual updating.
- The size of today's Internet does not allow for this kind of manual operation.
- The DNS master file must be updated dynamically.
- The Dynamic Domain Name System (DDNS) therefore was devised to respond to this need.