# DATA COMMUNICATIONS AND NETWORKING

## Domain Name System

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BIT 2ndYear, 2ndSemester

# Outline

- Domain Name Space
- DNS in the Internet
- Resolution
- Summary

# Domain Name System

- There are several applications in the application layer of the Internet model that follow the client/server paradigm. The client/server programs can be divided into two categories:
- Those that can be directly used by the user, such as e-mail, and those that support other application programs. The Domain Name System (DNS) is a supporting program that is used by other programs such as e-mail.
- Figure 1. shows an example of how a DNS client/server program can support an e-mail program to find the IP address of an e-mail recipient. A user of an e-mail program may know the e-mail address of the recipient; however, the IP protocol needs the IP address. The DNS client program sends a request to a DNS server to map the e-mail address to the corresponding IP address.

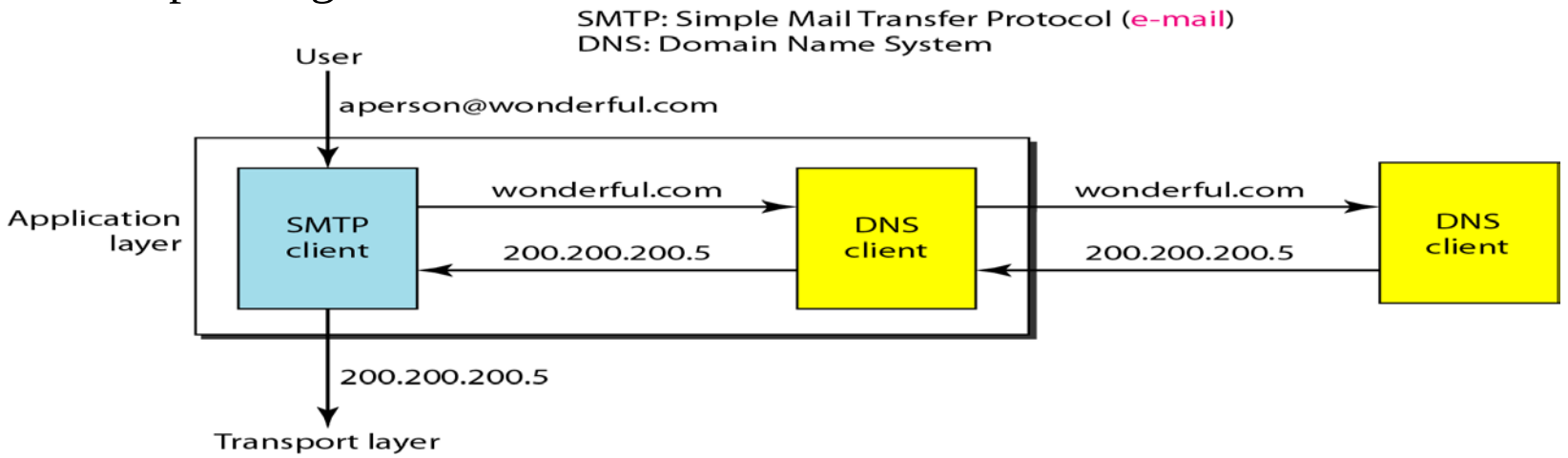


Figure 1. Example of using the DNS service



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# NAME SPACE

- To be unambiguous, the names assigned to machines must be carefully selected from a name space with complete control over the binding between the names and IP addresses.
- That is mean the names must be unique because the addresses are unique. A name space that maps each address to a unique name can be organized in two ways: flat or hierarchical.
- Flat name space
- A name is assigned to an address. A name in this space is a sequence of characters without structure.
- The main disadvantage of a flat name space is that it cannot be used in a large system such as the Internet because it must be centrally controlled to avoid ambiguity and duplication.
- Hierarchical name space
- A central authority can assign the part of the name that defines the nature of the organization and the name of the organization. The responsibility of the rest of the name can be given to the organization itself. The organization can add suffixes (or prefixes) to the name to define its host or resources. The management of the organization need not worry that the prefix chosen for a host is taken by another organization because, even if part of an address is the same, the whole address is different.



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# DOMAIN NAME SPACE

- To have a hierarchical name space, a domain name space was designed. In this design the names are defined in an inverted-tree structure with root at the top. Tree can have only 128 levels: level 0 (root) to level 127.

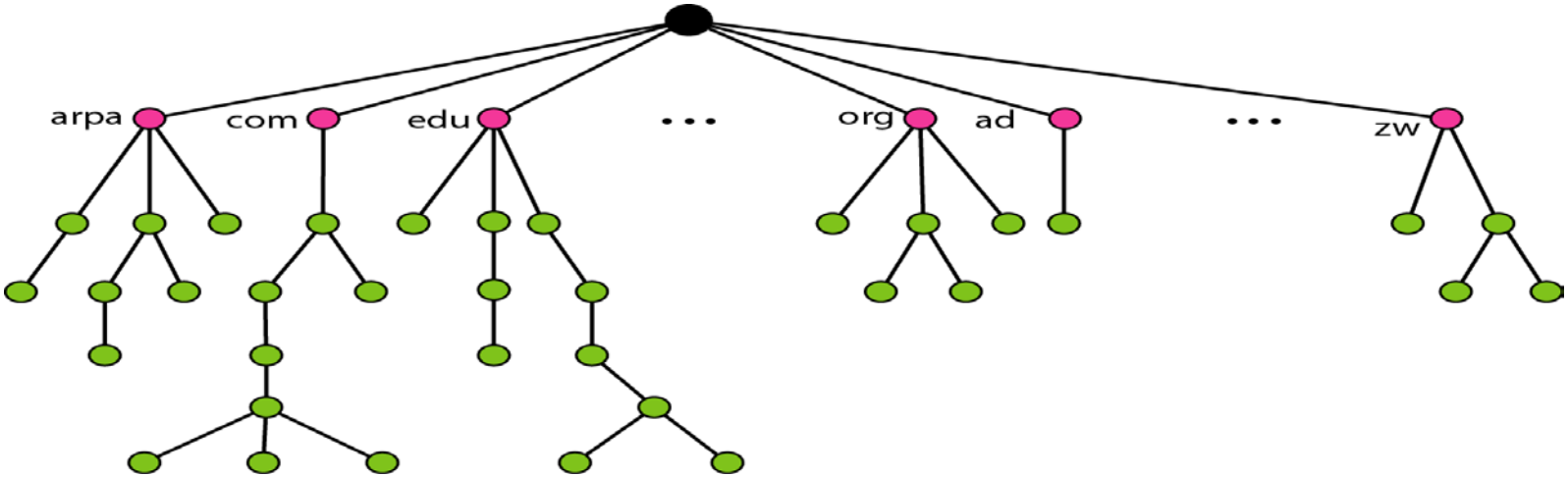


Figure 2. Domain name space

- Label
- Each node in the tree has a label, which is a string with a maximum of 63 characters. The root label is a null string (empty string). DNS requires that children of a node (nodes that branch from the same node) have different labels, which guarantees the uniqueness of the domain names.



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# DOMAIN NAME SPACE (continue…)

- Domain Name
- Each node in the tree has a domain name. A full domain name is a sequence of labels separated by dots (.). The domain names are always read from the node up to the root. The last label is the label of the root (null). This means that a full domain name always ends in a null label, which means the last character is a dot because the null string is nothing, as shown in figure 3.

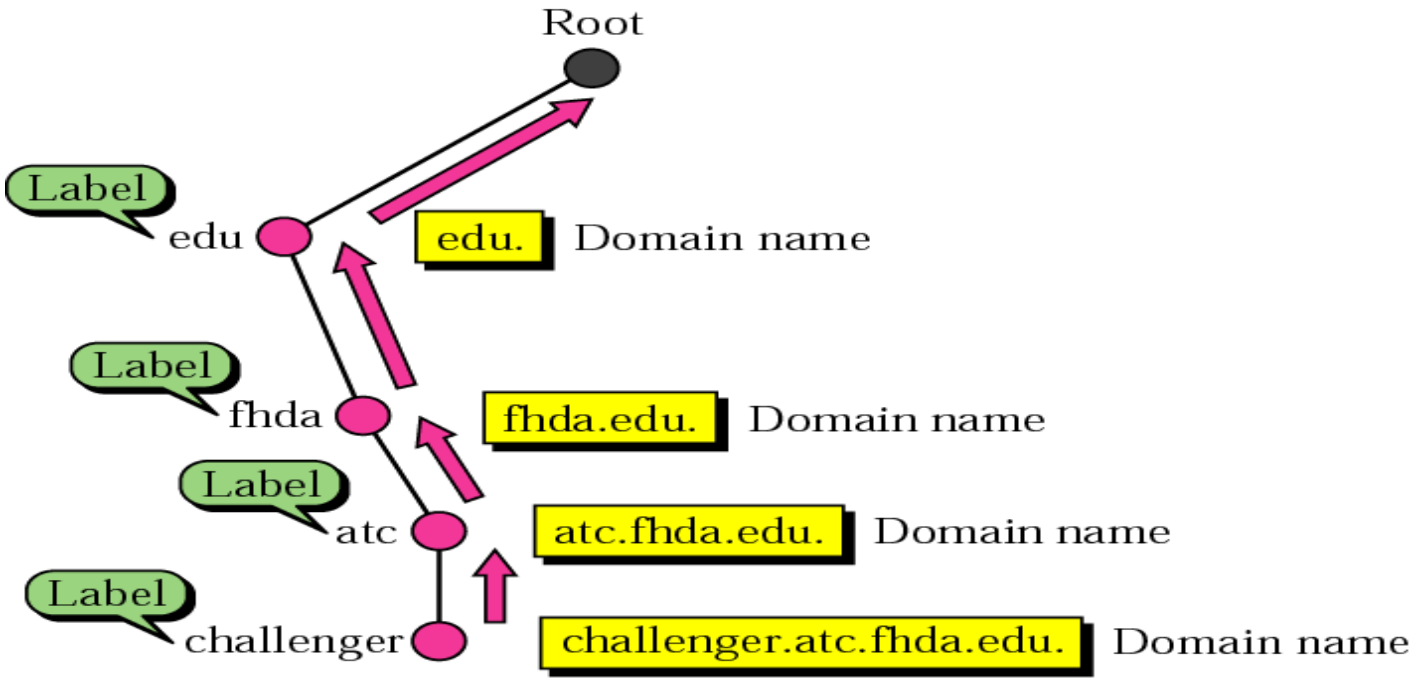


Figure 3. Domain names and labels



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# DOMAIN NAME SPACE (continue…)

- Domain Name (continue…)
- Fully Qualified Domain Name
- If a label is terminated by a null string, it is called a fully qualified domain name (FQDN). An FQDN is a domain name that contains the full name of a host. It contains all labels, from the most specific to the most general, that uniquely define the name of the host. For example, the domain name.

  challenger.ate.tbda.edu.
- Partially Qualified Domain Name
- If a label is not terminated by a null string, it is called a partially qualified domain name (PQDN). A PQDN starts from a node, but it does not reach the root. It is used when the name to be resolved belongs to the same site as the client. Here the resolver can supply the missing part, called the suffix, to create an FQDN. For example, if a user at the jhda.edu. site wants to get the IP address of the challenger computer, he or she can define the partial name.

  challenger
- The DNS client adds the suffix atc.jhda.edu. before passing the address to the DNS server. The DNS client normally holds a list of suffixes. The following can be the list of suffixes at De Anza College. The null suffix defines nothing. This suffix is added when the user defines an FQDN.
  - atc.fhda.edu
  - fhda.edu
  - Null



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# DOMAIN NAME SPACE (continue…)

- Partially Qualified Domain Name (continue…)

| FQDN | PQDN |
| --- | --- |
| challenger.atc.fhda.edu. | challenger.atc.fhda.edu |
| cs.hmme.com. | cs.hmme |
| www.funny.int. | www |

Figure 4. FQDN and PQDN

- Domain
- A domain is a subtree of the domain name space. The name of the domain is the domain name of the node at the top of the subtree. Figure 5. shows some domains. Note that a domain may itself be divided into domains (or subdomains.

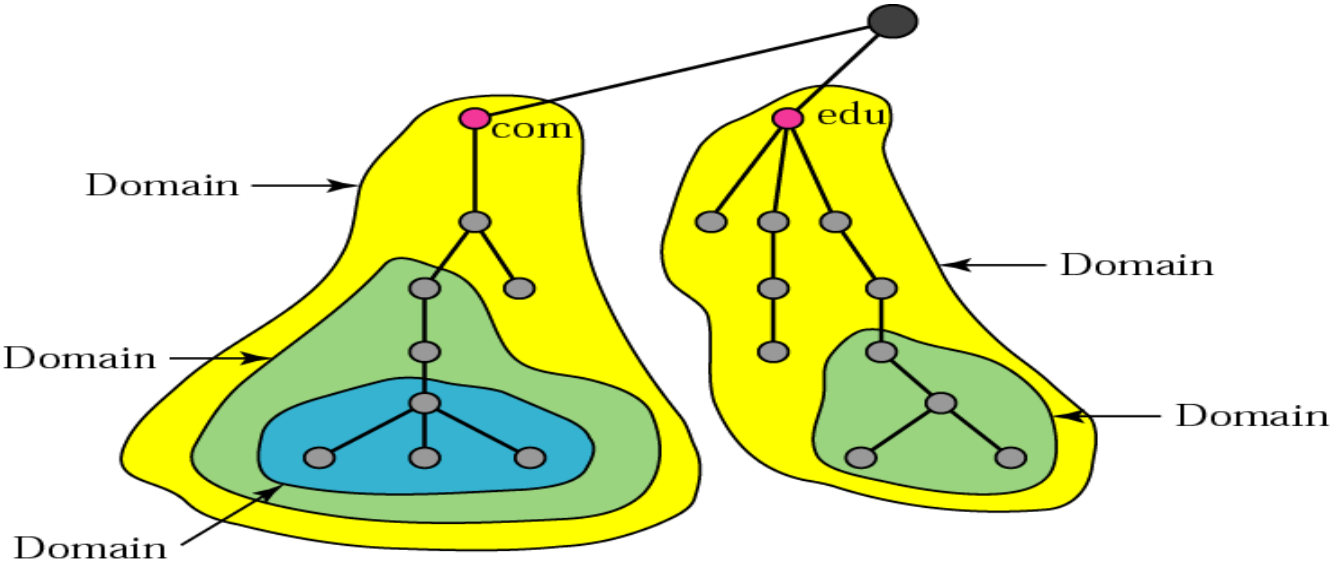


Figure 5. Domains



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# DISTRIBUTION OF NAME SPACE

- The information contained in the domain name space must be stored. However, it is very inefficient and also unreliable to have just one computer store such a huge amount of information.
- Hierarchy of Name Servers
- The solution to these problems is to distribute the information among many computers called DNS servers. One way to do this is to divide the whole space into many domains based on the first level.
- In other words, we let the root stand alone and create as many domains (subtrees) as there are first-level nodes. Because a domain created in this way could be very large, DNS allows domains to be divided further into smaller domains (subdomains), as shown in figure 6.

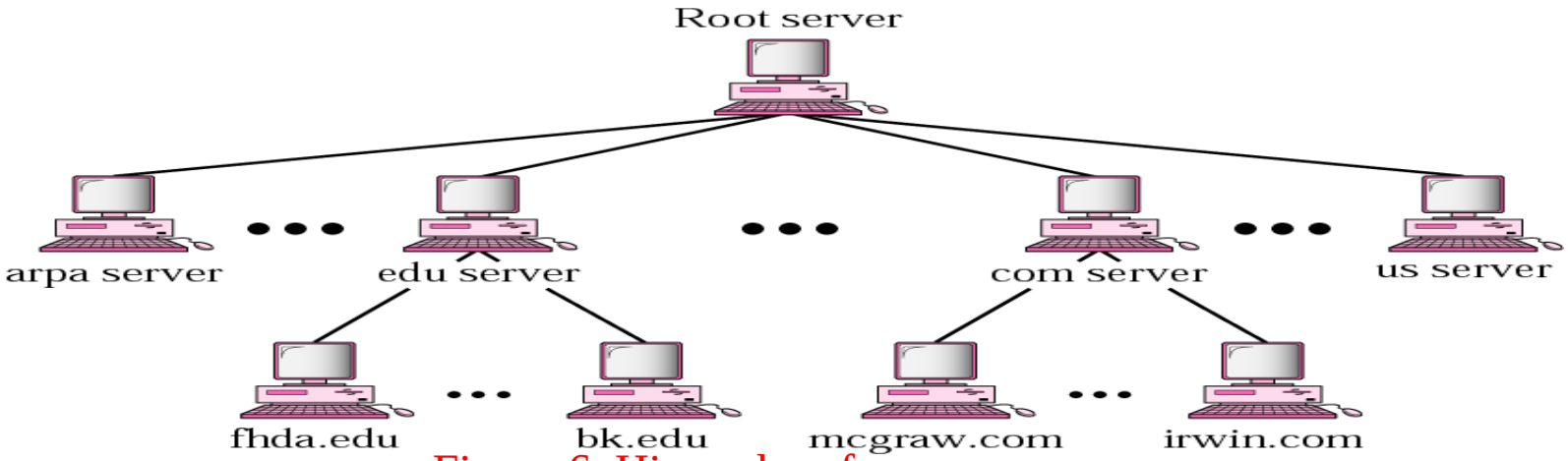


Figure 6. Hierarchy of name servers



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# DISTRIBUTION OF NAME SPACE (continue…)

- Zone
- Since the complete domain name hierarchy cannot be stored on a single server, it is divided among many servers. What a server is responsible for or has authority over is called a zone. We can define a zone as a contiguous part of the entire tree. If a server accepts responsibility for a domain and does not divide the domain into smaller domains, the domain and the zone refer to the same thing.
- The server makes a database called a zone file and keeps all the information for every node under that domain. However, if a server divides its domain into subdomains and delegates part of its authority to other servers, domain and zone refer to different things, as shown in figure 7.

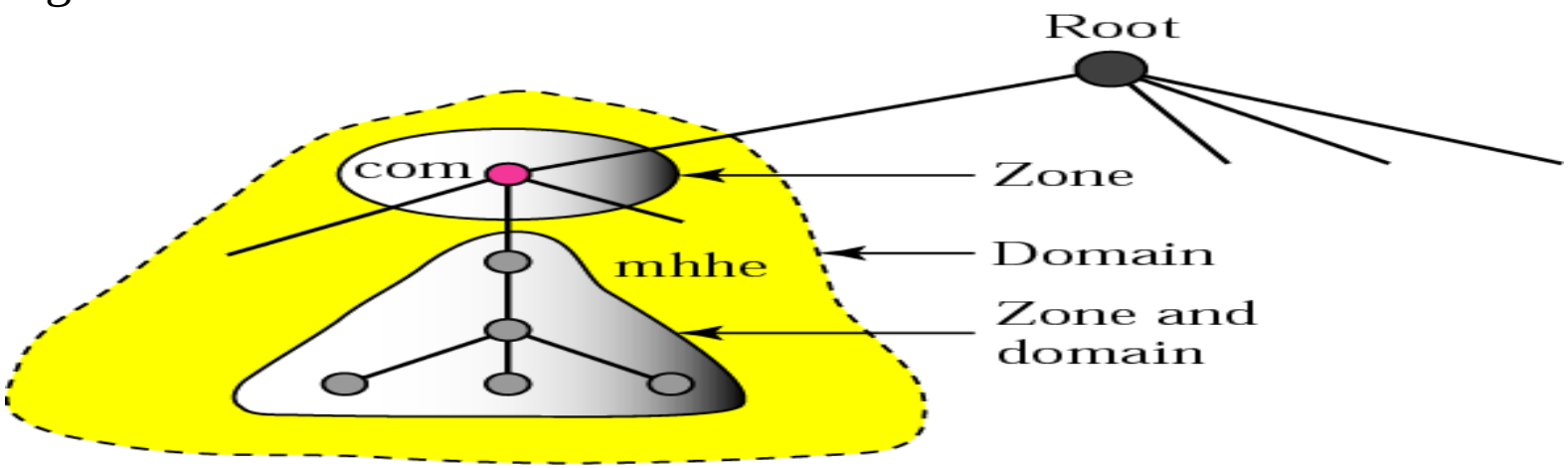


Figure 7. Zones and domains



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# DISTRIBUTION OF NAME SPACE (continue…)

- Root Server
- A root server is a server whose zone consists of whole tree. A root server usually does not store any information about domains but delegates its authority to other servers, keeping references to those servers.
- There are several root servers, each covering the whole domain name space. The servers are distributed all around the world.

- Primary and Secondary Servers
- A primary server loads all information from the disk file; the secondary server loads all information from the primary server. When the secondary downloads information from the primary, it is called zone transfer.



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# DNS IN THE INTERNET

- DNS is a protocol that can be used in different platforms. In the Internet, the domain name space \ (tree) is divided into three different sections: generic domains, country domains, and the inverse domain, as shown in figure 8.

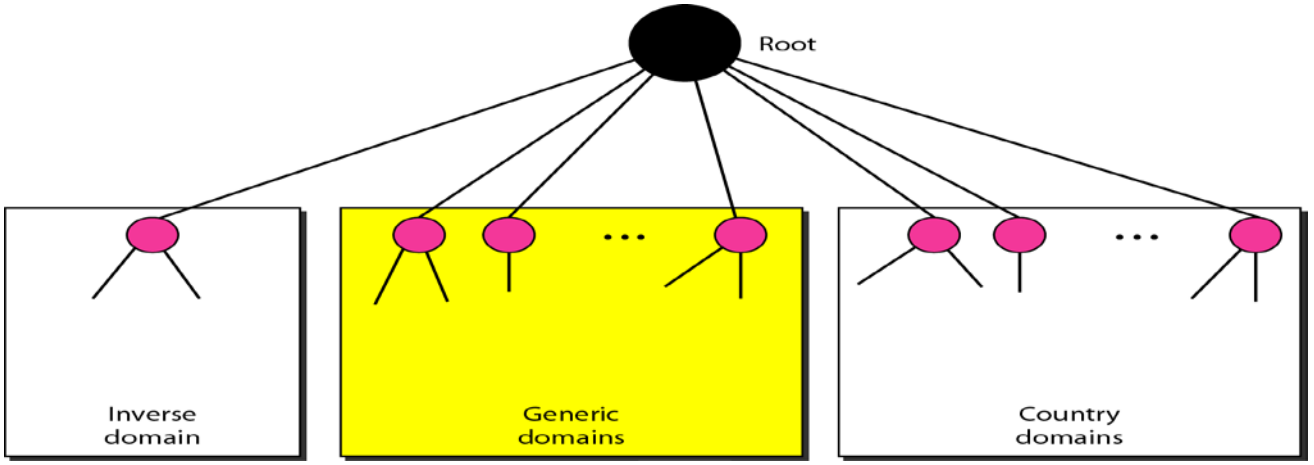


Figure 8. DNS used in the Internet

- Generic domains
- Generic domains define registered hosts according to their generic behavior. Each node in the tree defines a domain, which is an index to the domain name space database, as shown in figure 9.



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# DNS IN THE INTERNET(continue…)

- Generic domains (continue…)

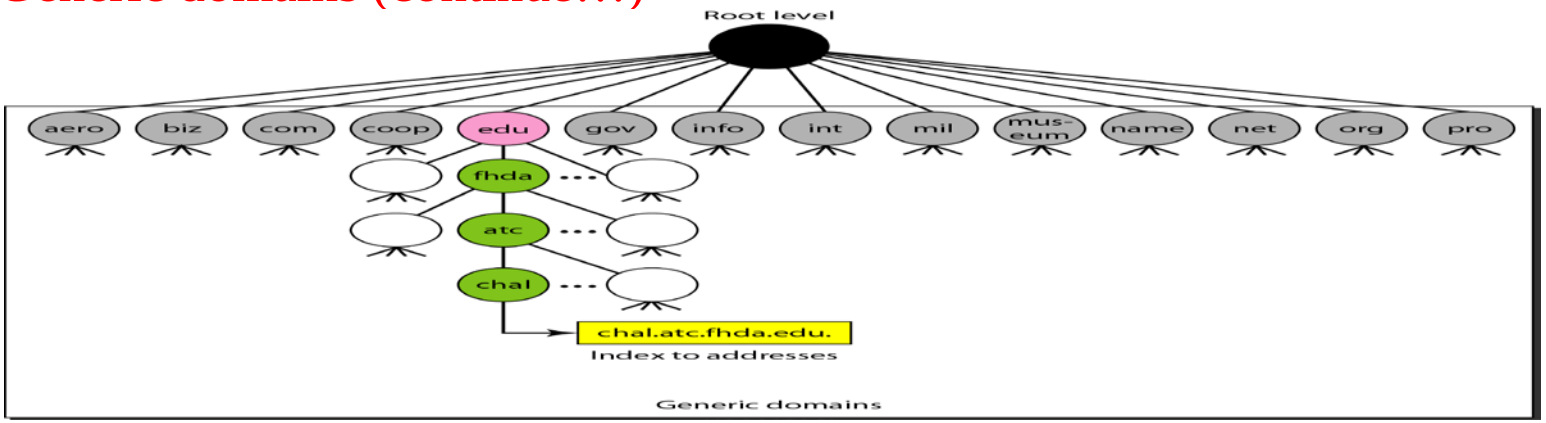


Figure 9. Generic domains

- These labels describe the organization types as listed in Table 1.

Table 1. Generic domain labels

| *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** | Government institutions |
| **info** | Information service providers |
| **int** | International organizations |
| **mil** | Military groups |
| **museum** | Museums and other nonprofit organizations |
| **name** | Personal names (individuals) |
| **net** | Network support centers |
| **org** | Nonprofit organizations |
| **pro** | Professional individual organizations |



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# DNS IN THE INTERNET(continue…)

- Country Domains
- The country domains section uses two-character country abbreviations (e.g., 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.).
- Figure 10. shows the country domains section. The address anza.cup.ca.us can be translated to De Anza College in Cupertino, California, in the United States.

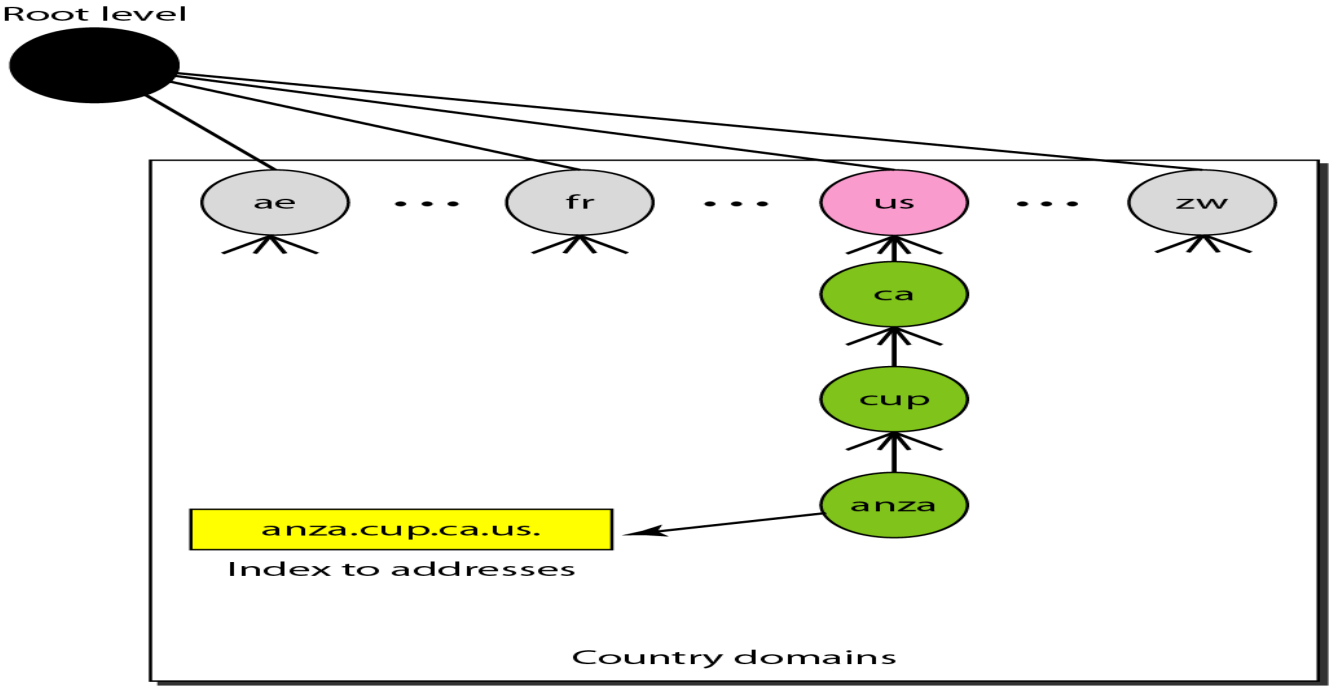


Figure 10. Country domains



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# DNS IN THE INTERNET(continue…)

- 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, as shown in figure 11.

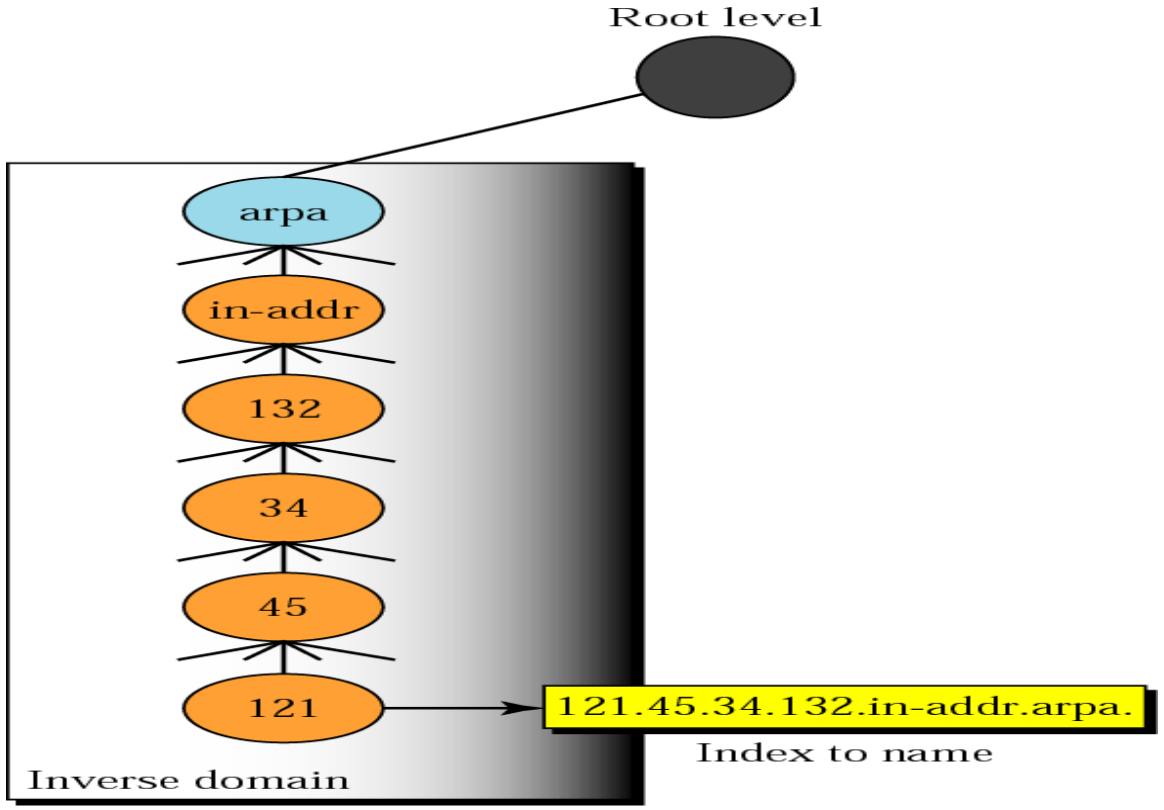


Figure 11. Inverse domain



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# RESOLUTION

- Resolver
- DNS is designed as a client/server application. A host that needs to map an address to a name or a name to an address calls a DNS client called a resolver. The resolver accesses the closest DNS server with a mapping request. If the server has the information, it satisfies the resolver; otherwise, it either refers the resolver to other servers or asks other servers to provide the information. After the resolver receives the mapping, it interprets the response to see if it is a real resolution or an error, and finally delivers the result to the process that requested it.

- Mapping Names to Addresses
- Most of the time, the resolver gives a domain name to the server and asks for the corresponding address. In this case, the server checks the generic domains or the country domains to find the mapping.
- If the domain name is from the generic domains section, the resolver receives a domain name such as "chal.atc.jhda.edu.". The query is sent by the resolver to the local DNS server for resolution.
- If the local server cannot resolve the query, it either refers the resolver to other servers or asks other servers directly. If the domain name is from the country domains section, the resolver receives a domain name such as "ch.jhda.cu.ca.us.".



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# RESOLUTION (continue…)

- Resolver (continue…)
- Mapping Addresses to Names
- A client can send an IP address to a server to be mapped to a domain name. This type of query is called an inverse or pointer (PTR) query. DNS uses the inverse domain.
- For example, if the resolver receives the IP address 132.34.45.121, the resolver first inverts the address and then adds the two labels before sending. The domain name sent is "121.45.34.132.in-addr.arpa." which is received by the local DNS and resolved.
- Recursive Resolution
- The client (resolver) can ask for a recursive answer from a name server. This means that the resolver expects the server to supply the final answer. If the server is the authority for the domain name, it checks its database and responds.
- If the server is not the authority, it sends the request to another server (the parent) and waits for the response.
- If the parent is the authority, it responds; otherwise, it sends the query to yet another server. When the query is finally resolved, the response travels back until it finally reaches the requesting client. This is called recursive resolution, as shown in figure 12.



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# RESOLUTION (continue…)

- Recursive Resolution (continue…)

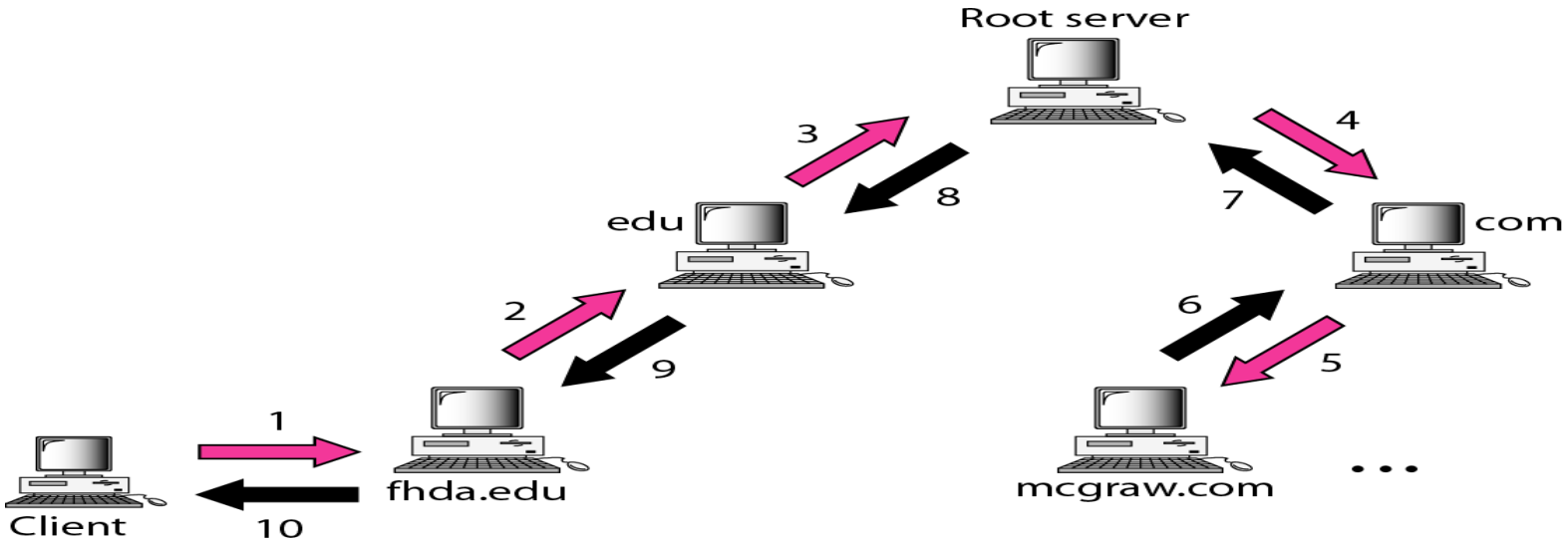


Figure 12. Recursive resolution

- Iterative Resolution
- If the client does not ask for a recursive answer, the mapping can be done iteratively. If the server is an authority for the name, it sends the answer. If it is not, it returns (to the client) the IP address of the server that it thinks can resolve the query. The client is responsible for repeating the query to this second server. If the newly addressed server can resolve the problem, it answers the query with the IP address; otherwise, it returns the IP address of a new server to the client, as show in figure 13.



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# RESOLUTION (continue…)

- Iterative Resolution (continue…)

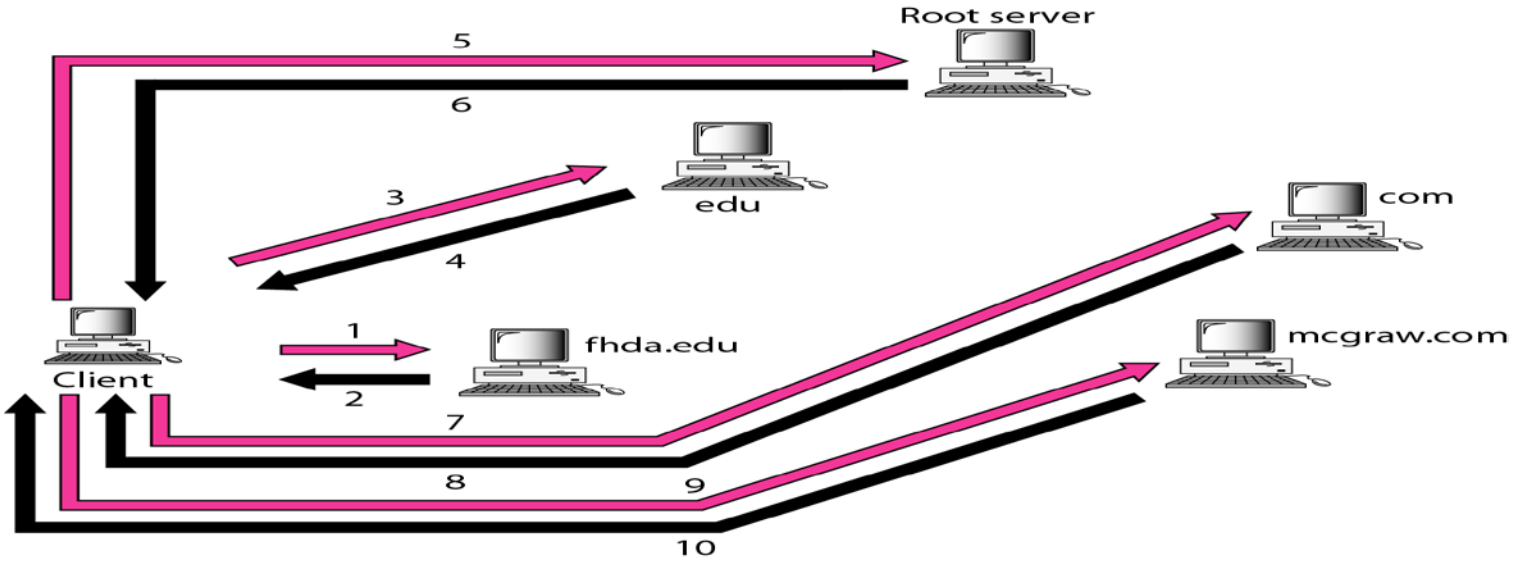


Figure 13. Iterative resolution

- Caching
- Each time a server receives a query for a name that is not in its domain, it needs to search its database for a server IP address. Reduction of this search time would increase efficiency. DNS handles this with a mechanism called caching. When a server asks for a mapping from another server and receives the response, it stores this information in its cache memory before sending it to client. If same or another client asks for same mapping, it can check its cache memory and solve problem.



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# DNS MESSAGES

- DNS has two types of messages: query and response. Both types have the same format. The query message consists of a header and question records; the response message consists of a header, question records, answer records, authoritative records, and additional records, as shown in figure 14.
- Header
- Both query and response messages have the same header format with some fields set to zero for the query messages. The header is 12 bytes, as shown in figure 15.

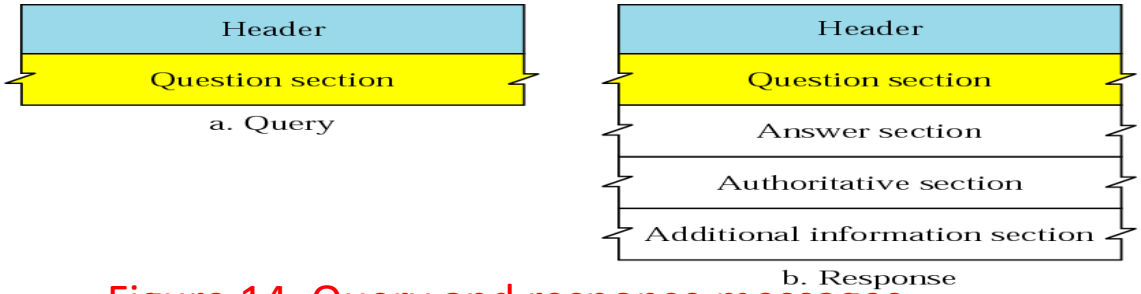


Figure 14. Query and response messages

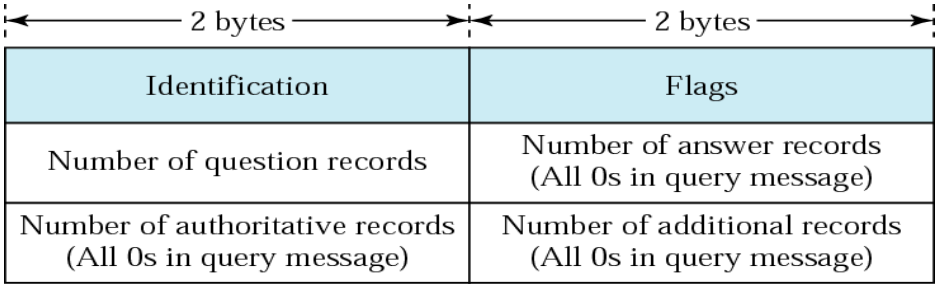


Figure 15. Header format



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# TYPES OF RECORDS

- There are two types of records are used in DNS. The question records are used in the question section of the query and response messages. The resource records are used in the answer, authoritative, and additional information sections of the response message.
- Question Record
- A question record is used by the client to get information from a server. This contains the domain name.
- Resource Record
- Each domain name (each node on the tree) is associated with a record called resource record. The server database consists of resource records. Resource records are also what is returned by the server to client.

## ➢ REGISTRARS

- How are new domains added to DNS? This is done through a registrar, a commercial entity accredited by Internet Corporation for Assigned Names and Numbers (ICANN). A registrar first verifies that the requested domain name is unique and then enters it into the DNS database. A fee is charged.



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# DYNAMIC DOMAIN NAME SYSTEM (DDNS)

- The DNS master file must be updated dynamically. The Dynamic Domain Name System (DDNS) therefore was devised to respond to this need. In DDNS, when a binding between a name and an address is determined, the information is sent, usually by Dynamic Host Configuration Protocol (DHCP) to a primary DNS server. The primary server updates the zone. The secondary servers are notified either actively or passively.

➢ ENCAPSULATION

- DNS can use either UDP or TCP. In both cases the well-known port used by the server is port 53. UDP is used when the size of the response message is less than 512 bytes because most UDP packages have a 512-byte packet size limit. If the size of the response message is more than 512 bytes, a TCP connection is used.



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# Summary

- The Domain Name System (DNS) is a client/server application that identifies each host on the Internet with a unique user-friendly name.
- D DNS organizes the name space in a hierarchical structure to decentralize the responsibilities involved in naming.
- DNS can be pictured as an inverted hierarchical tree structure with one root node at the top and a maximum of 128 levels.
- Each node in the tree has a domain name.
- A domain is defined as any subtree of the domain name space.
- The name space information is distributed among DNS servers. Each server has jurisdiction over its zone.
- A root server's zone is the entire DNS tree.
- A primary server creates, maintains, and updates information about its zone.
- A secondary server gets its information from a primary server.
- The domain name space is divided into three sections: generic domains, country domains, and inverse domain.
- There are 14 generic domains, each specifying an organization type.
- Each country domain specifies a country.
- The inverse domain finds a domain name for a given IP address. This is called address-to-name resolution.



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# Summary(continue…)

- Name servers, computers that run the DNS server program, are organized in a hierarchy.
- The DNS client, called a resolver, maps a name to an address or an address to a name.
- In recursive resolution, the client sends its request to a server that eventually returns a response.
- In iterative resolution, the client may send its request to multiple servers before getting an answer.
- Caching is a method whereby an answer to a query is stored in memory (for a limited time) for easy access to future requests.
- A fully qualified domain name (FQDN) is a domain name consisting of labels beginning with the host and going back through each level to the root node.
- A partially qualified domain name (PQDN) is a domain name that does not include all the levels between the host and the root node.
- There are two types of DNS messages: queries and responses.
- There are two types of DNS records: question records and resource records.
- Dynamic DNS (DDNS) automatically updates the DNS master file.
- DNS uses the services ofUDP for messages of less than 512 bytes; otherwise, TCP is used.



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