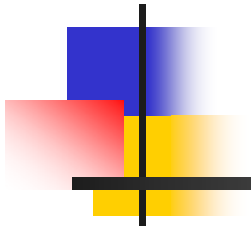


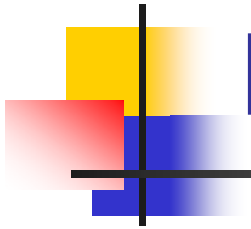
DNS Basics

BUPT/QMUL

2010-11-09

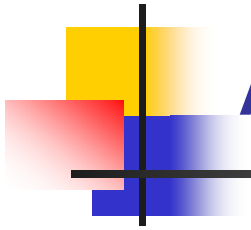
北京郵電大學
BEIJING UNIVERSITY OF POSTS AND TELECOMMUNICATIONS

Electronic Engineering



Related Information

- Basic function of DNS
- Host entry structure in Unix
- Two system calls for DNS database retrieving
  - gethostbyname ()
  - gethostbyaddr ()



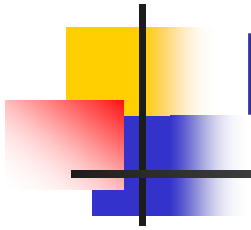
Agenda

- Brief introduction to DNS
- Elements of the DNS
- DNS services
- DNS Protocols
- DNS tools

Refer to Chapter 23 of textbook

Brief Introduction to DNS

- Basic functions of DNS
- A short history of DNS

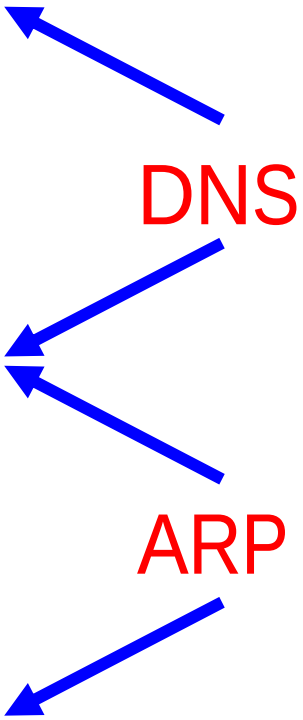


Basic Functions of DNS (1)

- Generally, applications refer to hosts/mailboxes and network resources by **ASCII strings** - such as
  - www.bupt.edu.cn
  - www.qmul.ac.uk
  - webmaster@company-a.com
- Nevertheless, the network itself only understands **binary addresses**, so some mechanism is required to convert the ASCII string to network addresses and vice versa.
- Low-level name: IP address
- High-level name: hostname

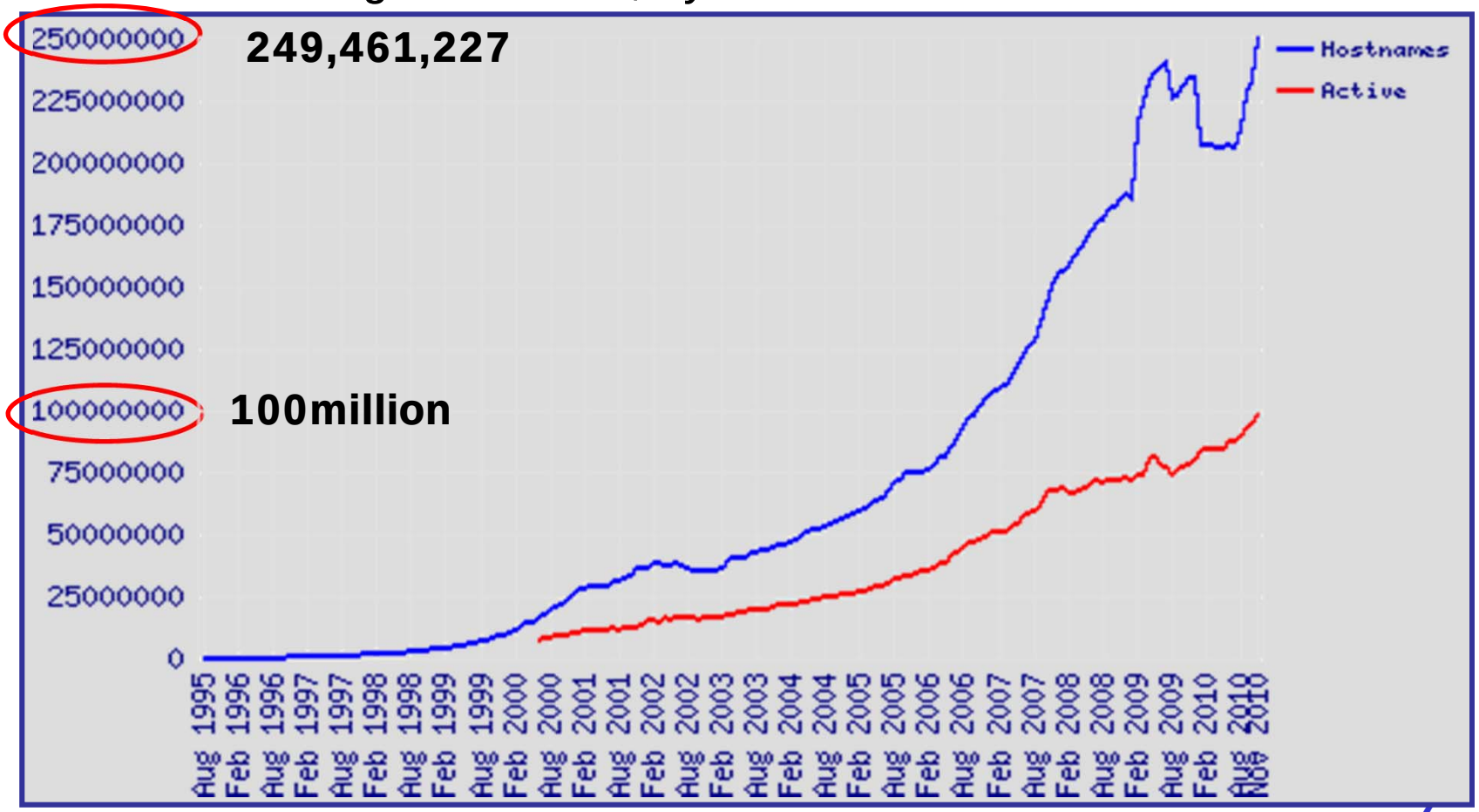
Basic Functions of DNS (2)

- Translating between addresses
  - Hostname (www.company-a.com)
    - Convert between Domain Name and IP
  - IP address (128.9.32.254)
    - Convert between IP and MAC
  - MAC address (C2-67-3E-95-C5-F1)



A Short History (1)

- Hostnames growth trend, by Nov. 2010



(From: http://news.netcraft.com/)

A Short History (2)

– from flat namespace to hierarchical namespace

- Original status
  - there was simple a file, ***hosts.txt***, that listed all the hosts and their IP addresses

    flat structure
  - Every night all the hosts would collect this file from the host that maintained it

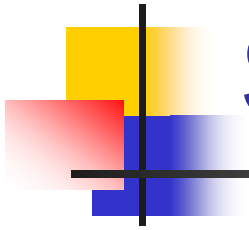
    Centralized control
  - Incurred problems
    - Each name had to be unique because the namespace was flat
    - Excessive access to the machine maintaining the list
    - Difficult to maintain when the network grew

    Not scalable

A Short History (3)

– from flat namespace to hierarchical namespace

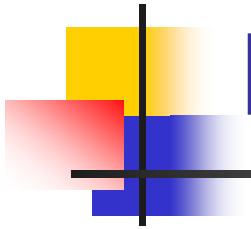
- Nowaday status
  - ***Hierarchical structure***
  - ***Distributed database***
  - ***Efficient, reliable, general purpose***
  - It is primarily used for mapping host names and email destinations to IP addresses - but can be used for other purposes
  - It is a query / response protocol running on top of UDP/TCP, with default port number 53



Summary: What is DNS?

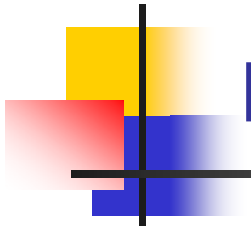
- Domain Name System
- A distributed database providing mapping between Domain name and IP address
  - Implemented in hierarchy of many name servers
- An application protocol
  - Used by hosts and name servers to communicate to resolve names

Elements Of The DNS



Elements Of DNS

- Domain namespace and resource records
- Name servers
- Name resolvers
- Protocol

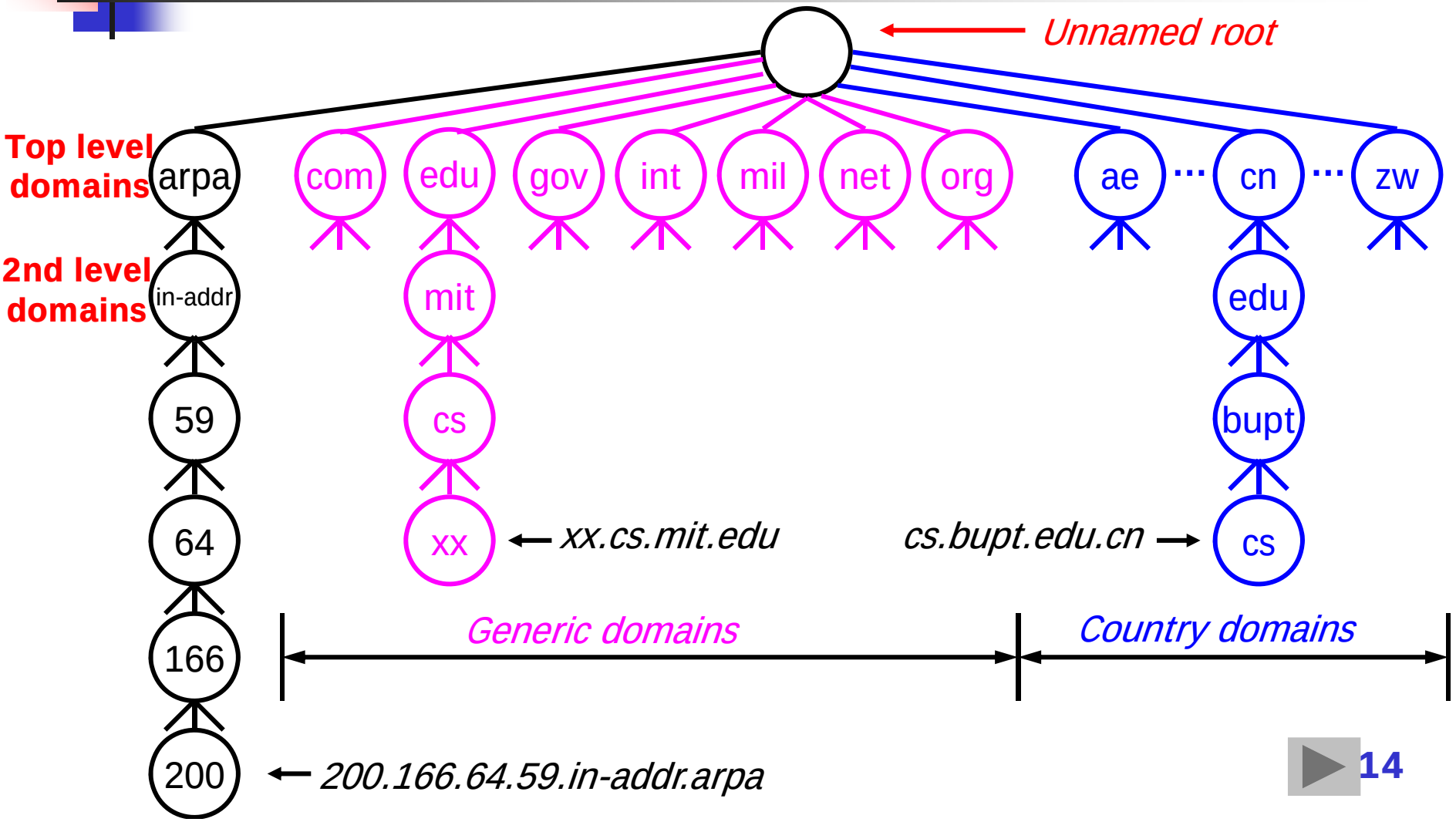


Domain namespace and resource records

- Domain namespace is of a hierarchical structure like an upended tree
- RR (Resource Record) is the data associated with a particular name

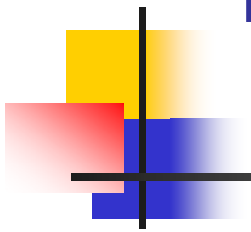
Domain Namespace (1)

– the hierarchical structure



Domain Namespace (2)

– organization of domains



- Each element of the hierarchy is referred to as a domain
- At the top of the hierarchy is the root domain, known as simply “.”
- Subdomains directly underneath the root domain are called top-level domains
- Domains directly underneath top-level domains are called second-level domains, and so on

Domain Namespace (3)

– the domain names

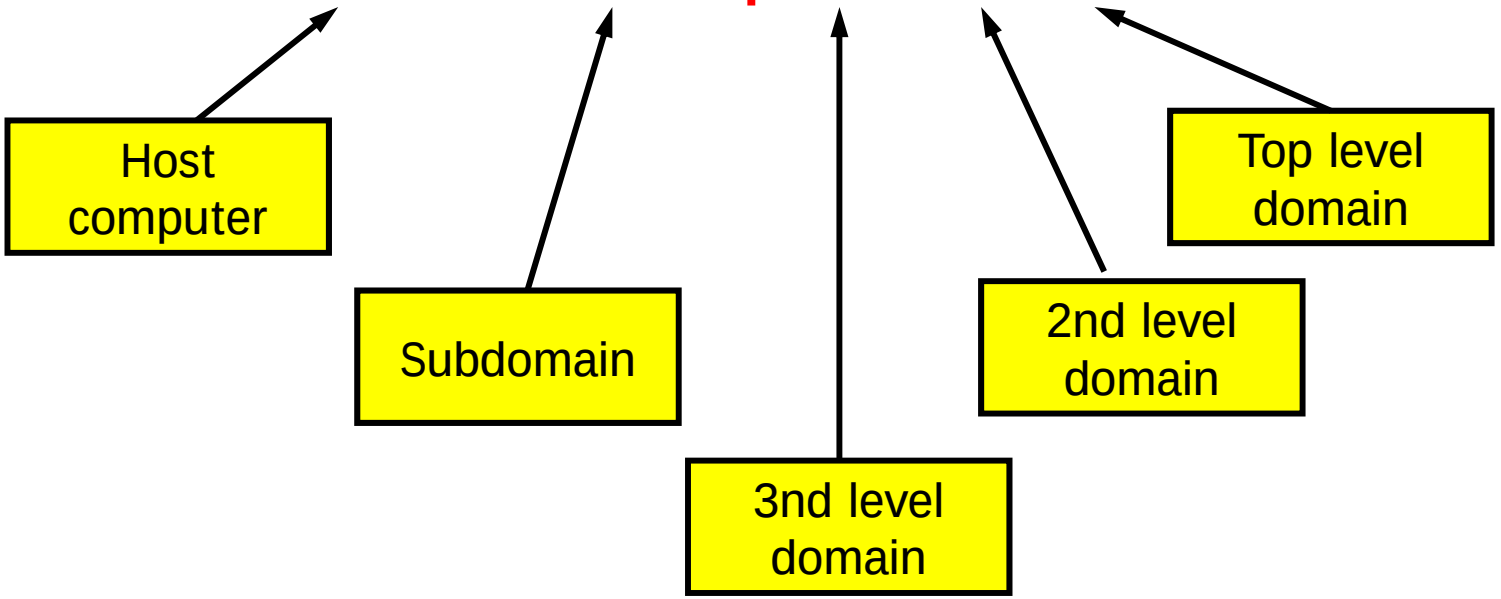
- The domain name of a node is the list of the labels on the path from the node to the root of the tree separated by dots(“.”)
- Conventionally printed or read left to right, from the most specific (lowest, farthest from the root) to the least specific (highest, closest to the root)
  - eg. www.bupt.edu.cn
- Case insensitive
- Components can be up to 63 characters long, the full pathname must not be more than 255 characters
- The full name of a domain is also called its Fully Qualified Domain Name (FQDN)

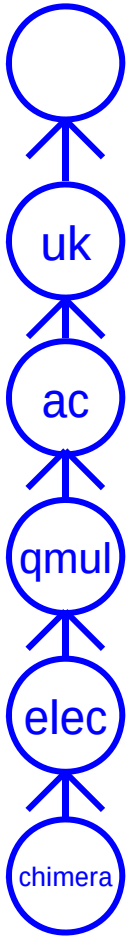
Domain Namespace (4)

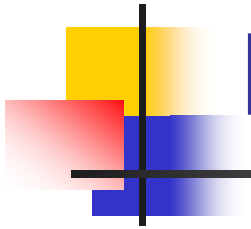
– the domain names

- Example of domain name

chimera.elec.qmul.ac.uk

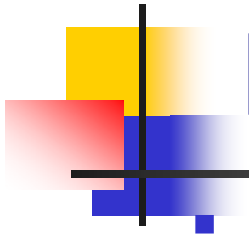






Resource Record

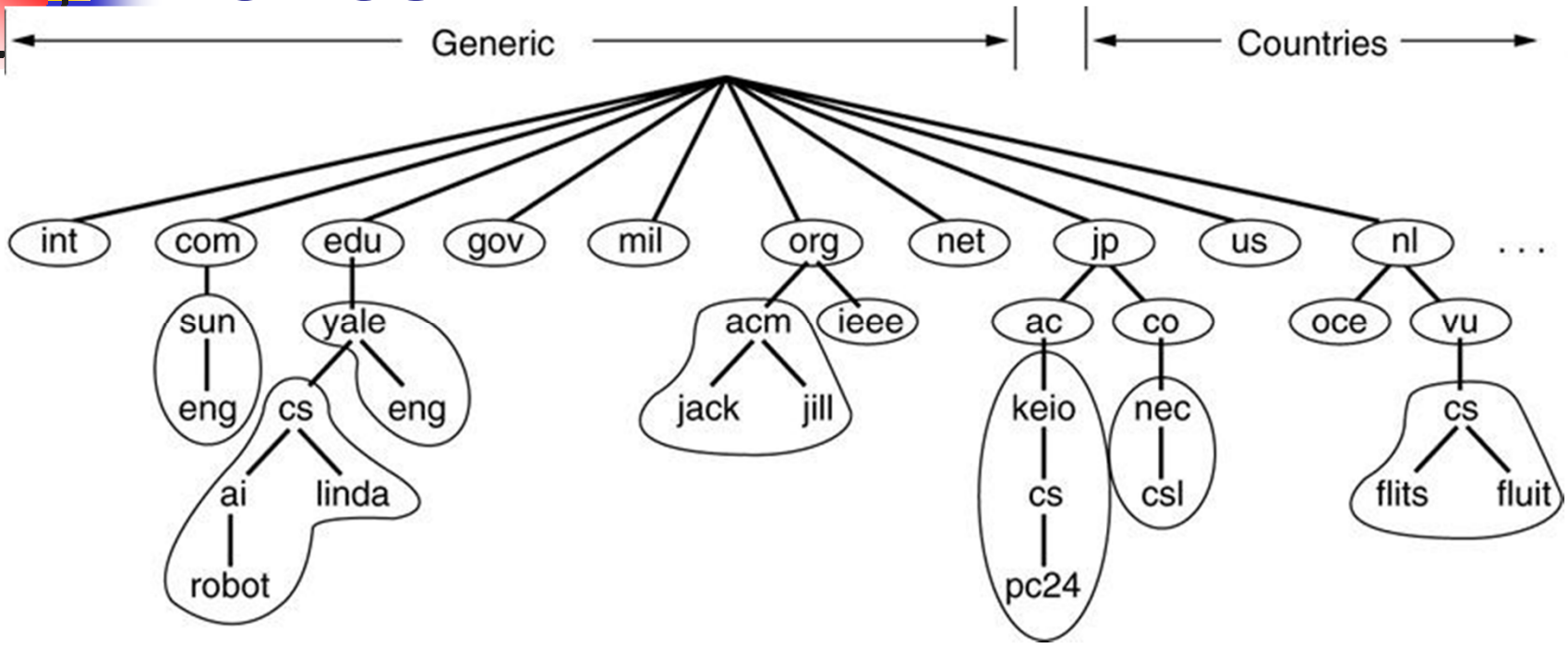
- Each domain in the DNS has one or more Resource Records (RRs), which are fields that contain information about that domain
- Each RR has the following information
  - Owner: the domain name where the RR is found
  - Type: specifies the type of the resource in this RR
    - A – Host Address
    - MX – Mail Exchanger
    - ...
  - Class: specifies the protocol family to use
    - IN – the Internet system
  - TTL: specifies the Time To Live (in unit of second) of the cached RRs
  - RDATA: the resource data



Name Servers (1)

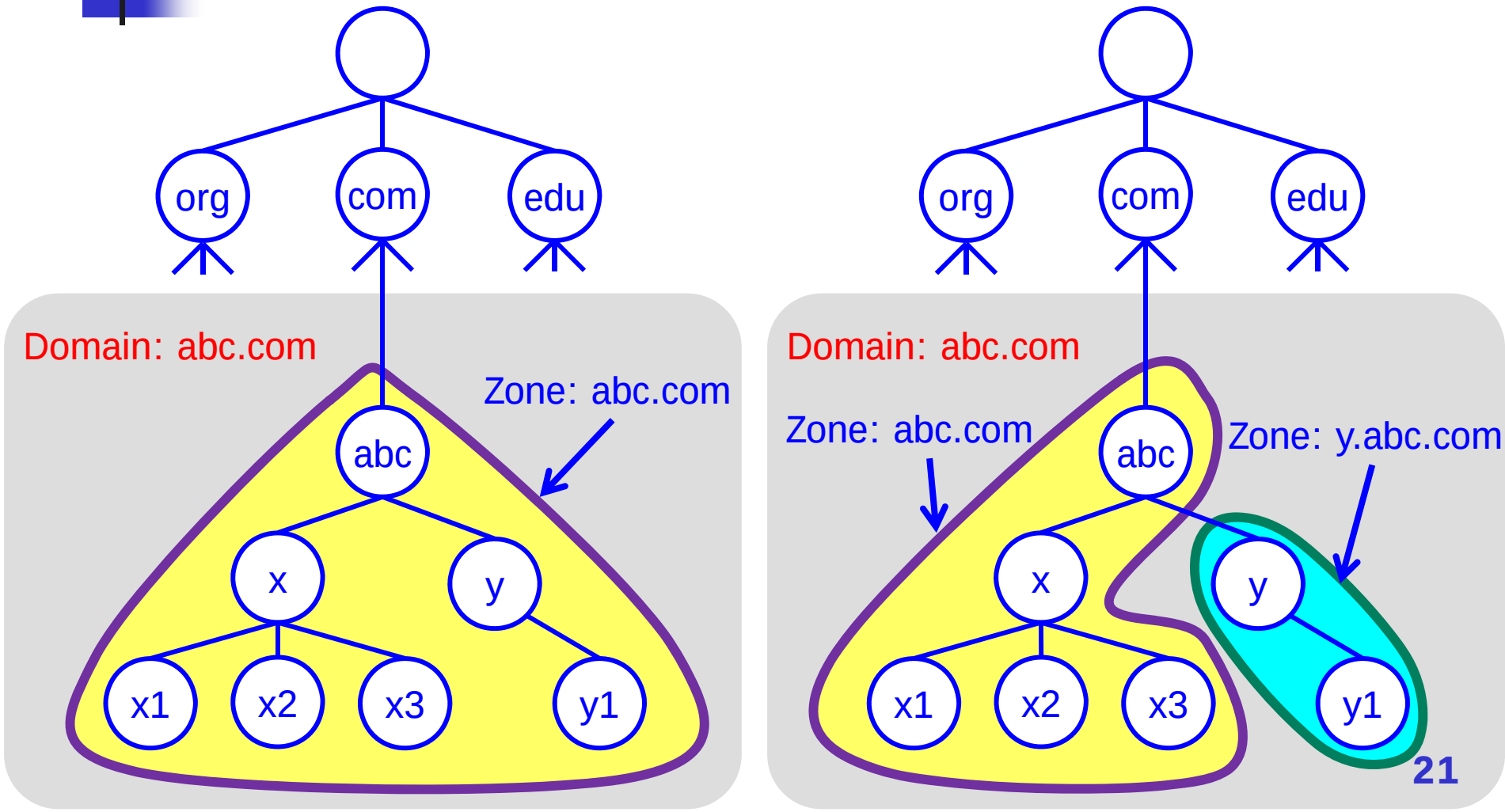
- Name servers are the repositories of information that make up the domain database.
- The database is divided up into sections called zones, which are distributed among the name servers. A zone may be one or more domains or even a sub-domain
- Each name server handles one or more zones. And the essential task of a name server is to answer queries using data in its zones.
- Name servers can answer queries in a simple manner. The response can always be generated using only local data, and either contains the answer to the question or a referral to other name servers "closer" to the desired information.
- A given zone will be available from several name servers to ensure its availability.

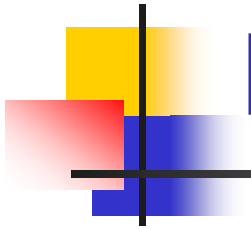
Zones



- A zone corresponds to an administrative authority that is responsible for that portion of the hierarchy
- Eg. bupt controls *x.bupt.edu.cn*

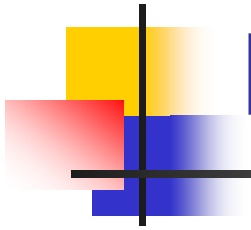
Example of Zone and domain





Name Servers (2)

- Primary server / Authoritative server
  - holds in its database the name-to-address mappings for the group of hosts it administers
  - knows the official answer
- Secondary server
  - maintains a copy of the Primary Server's database
- Caching server
  - asks DNS queries to other servers but maintains a cache of the responses together with a "time to live" value
  - non-authoritative data about other parts of the tree

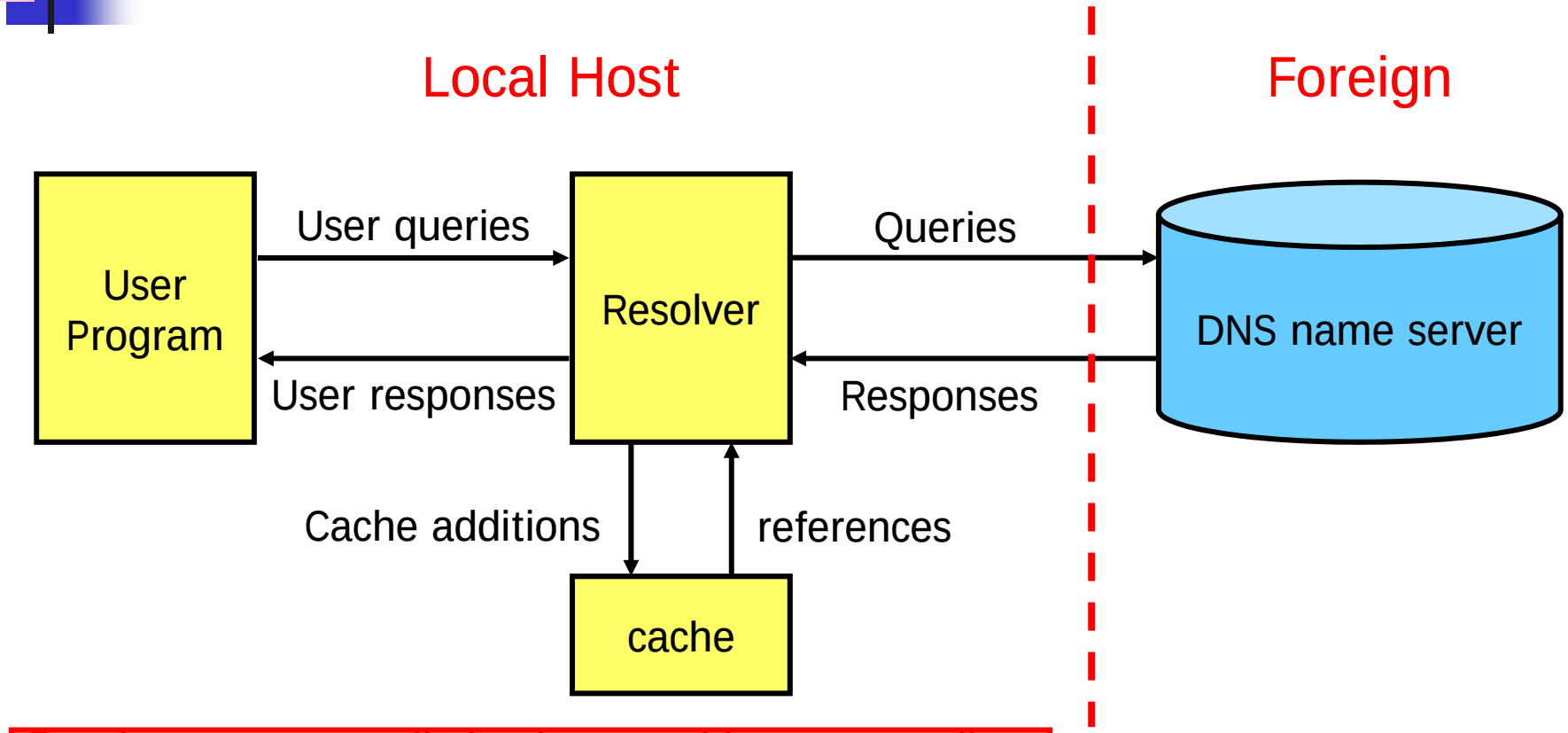


Name Resolvers (1)

- The client side of DNS

- A resolver is the interface between the user program and the domain name servers
  - A resolver receives a request from a user program (e.g., mail programs, TELNET, FTP)
  - asks questions to the DNS system on behalf of the application
  - returns the desired information

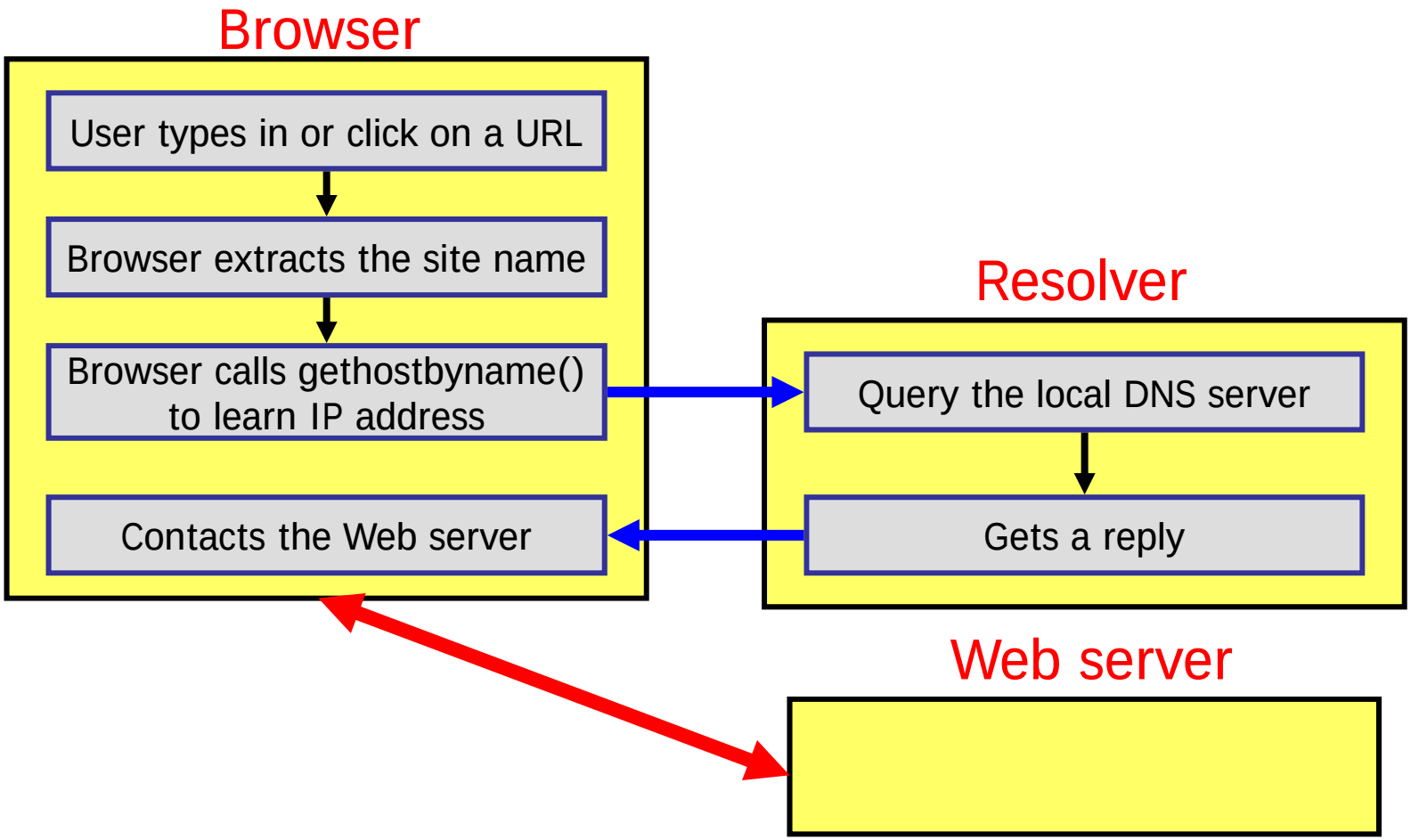
Name Resolvers (2)
– communication model



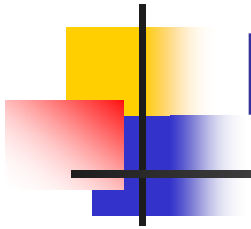
Resolvers are normally implemented in system calls.
E.g. gethostbyname(), gethostbyaddr()

Name Resolvers (3)
– an example

- DNS working together with HTTP application



DNS Services

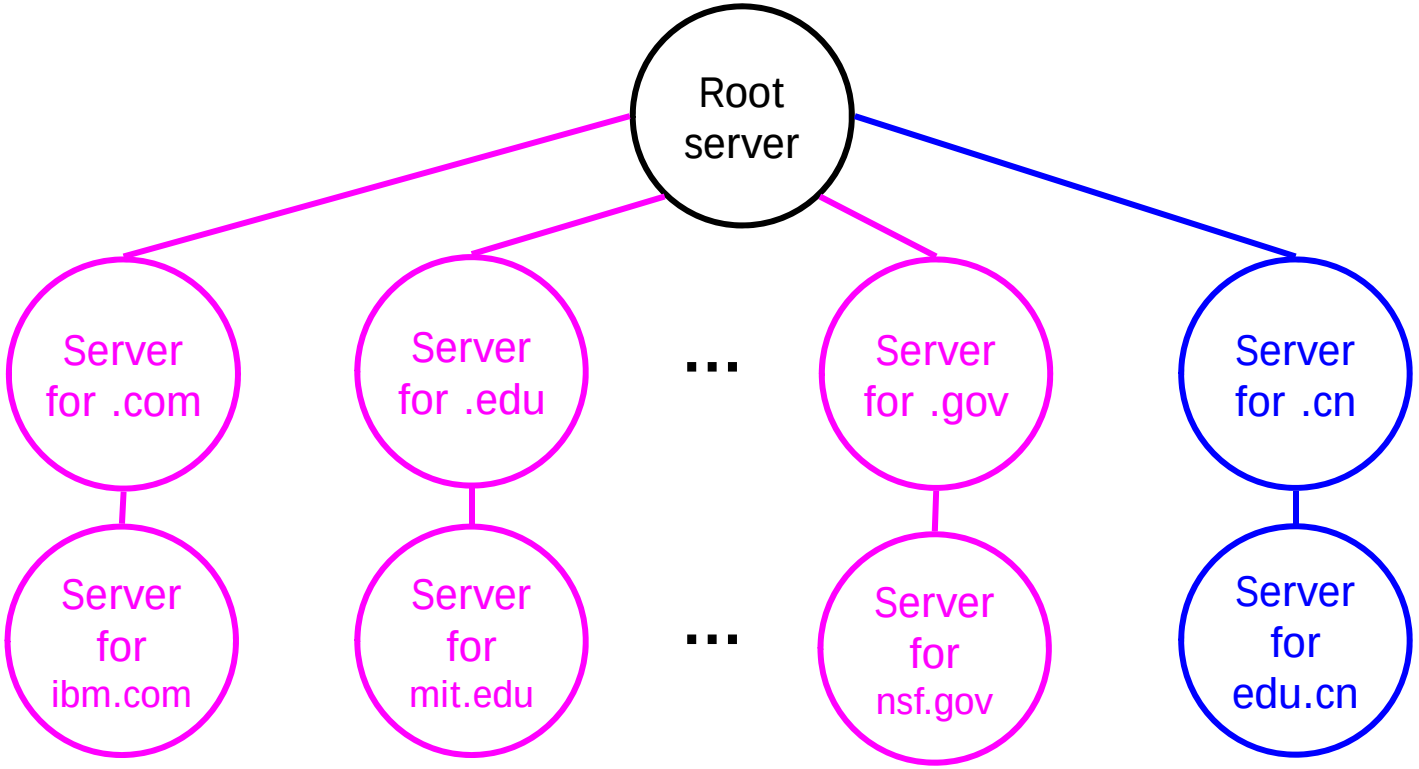


DNS Services

- Mapping domain name to addresses
- Inverse queries (optional)
- Pointer queries

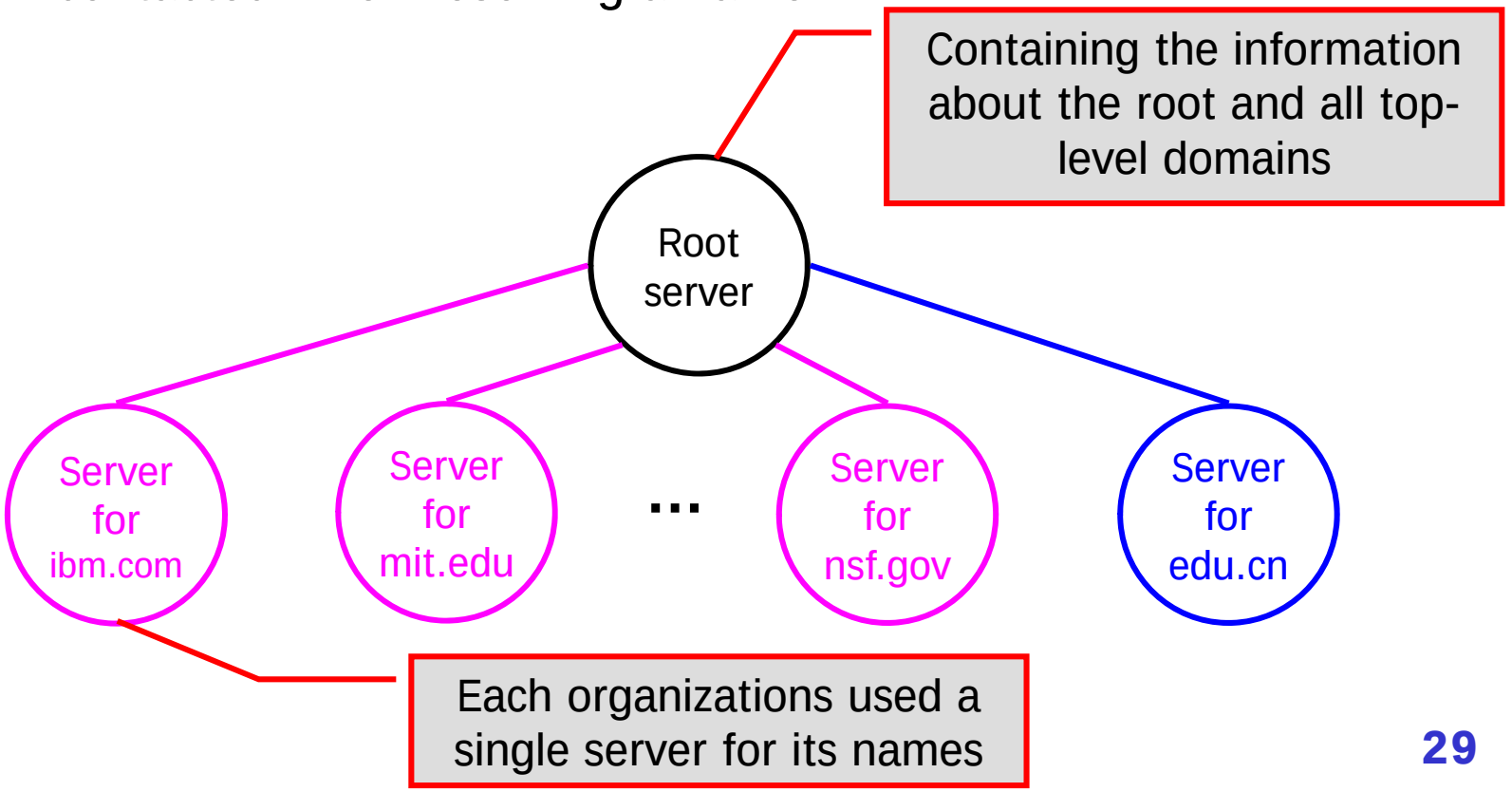
Mapping Domain Names to Addresses (1) – arrangement of name servers

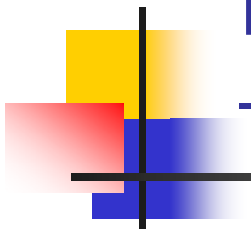
- Conceptual arrangement of name servers in a **tree** that corresponding to the name hierarchy
- Each server knows the addresses of all lower-level servers for all subdomains within the domain it handles



Mapping Domain Names to Addresses (2) – arrangement of name servers

- A more realistic organization of name servers
- The tree is broad and flat and fewer servers need to be contacted when resolving a name

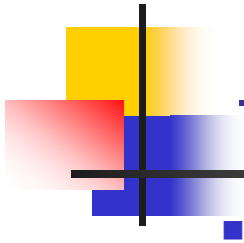




Mapping Domain Names to Addresses (3) – name resolution process

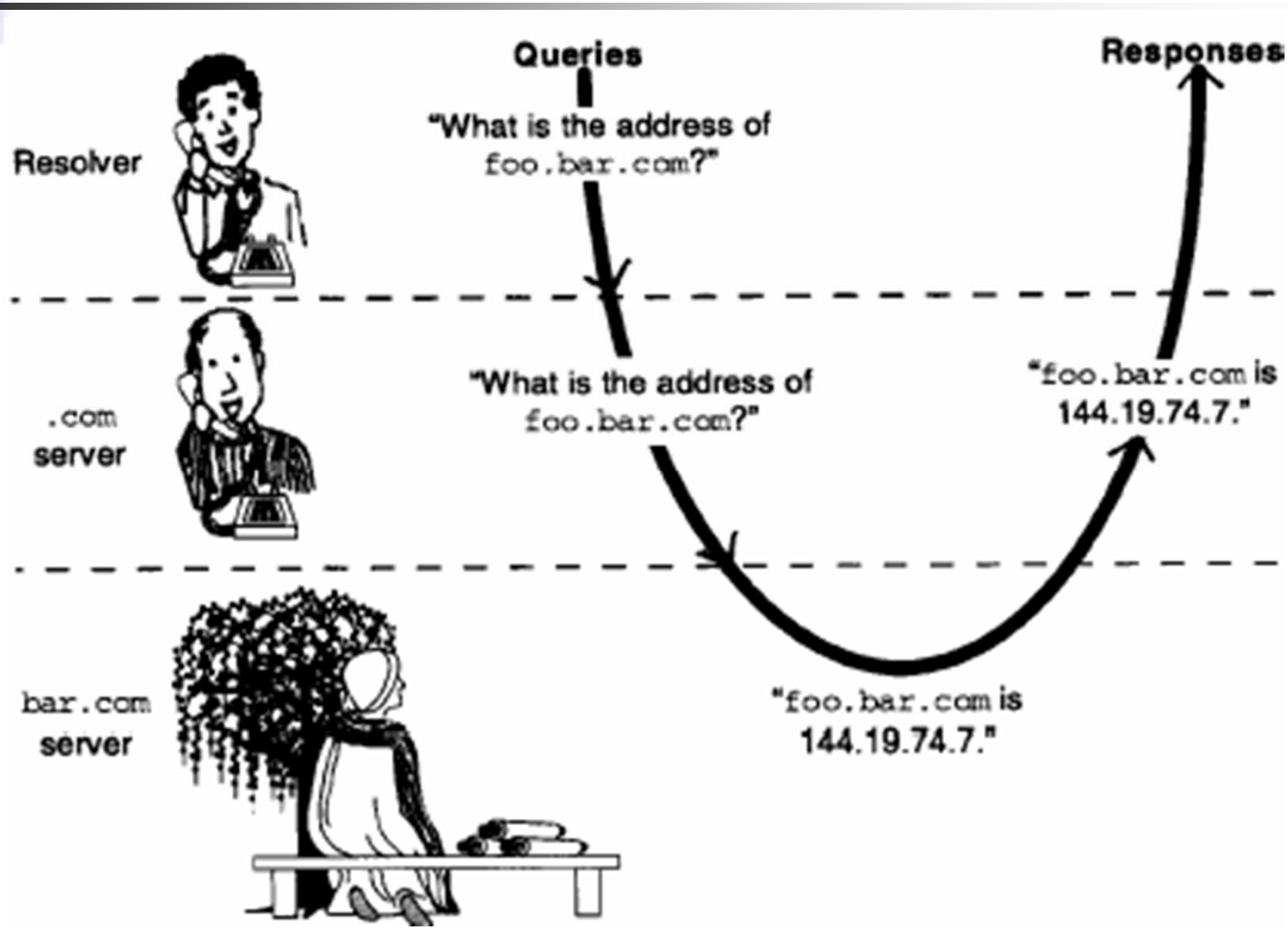
- Two-step name resolution process
  - Beginning with the local name server (default name server)
  - If the local server can not resolve a name, the query must be sent to another server in the domain system
- It can improve the query efficiency because most queries to name servers refer to local name.

Mapping Domain Names to Addresses (4) – two name resolution methods

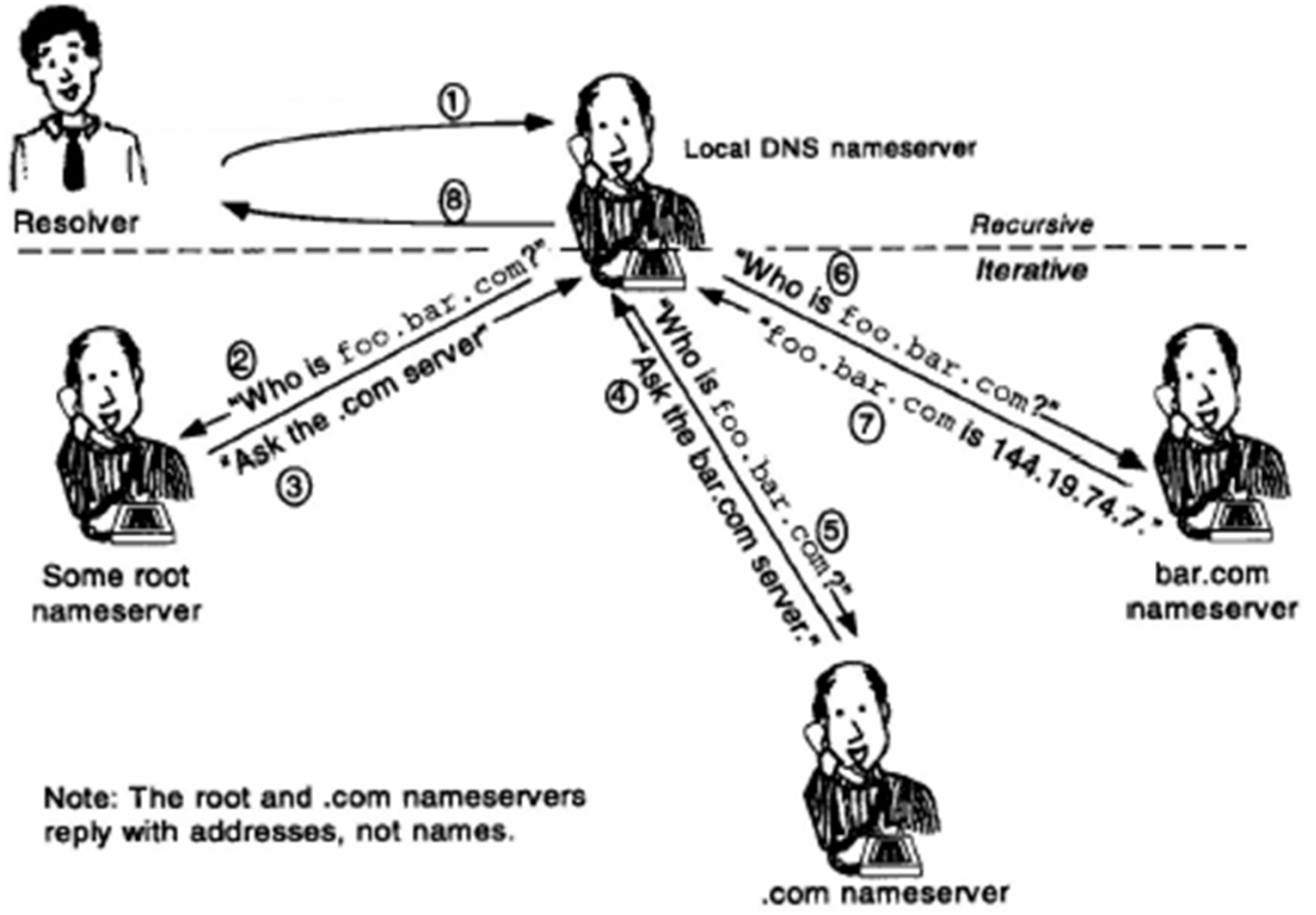


- A query is made to a local name server. If local name server can not resolve the name, then it will query another server.
- Recursive resolution:
  - If the queried server does not have the information, it must make the appropriate query or queries to get the information
  - Generally, a server fulfills a recursive query either with data in its own memory or by making another recursive query
- Iterative resolution: If the queried server does not have the information, it may then respond with the address of another server; the local name server (on behalf of resolver)then queries that server (which might respond with the address of another server, and so on)
  - Commonly used by name servers on the Internet

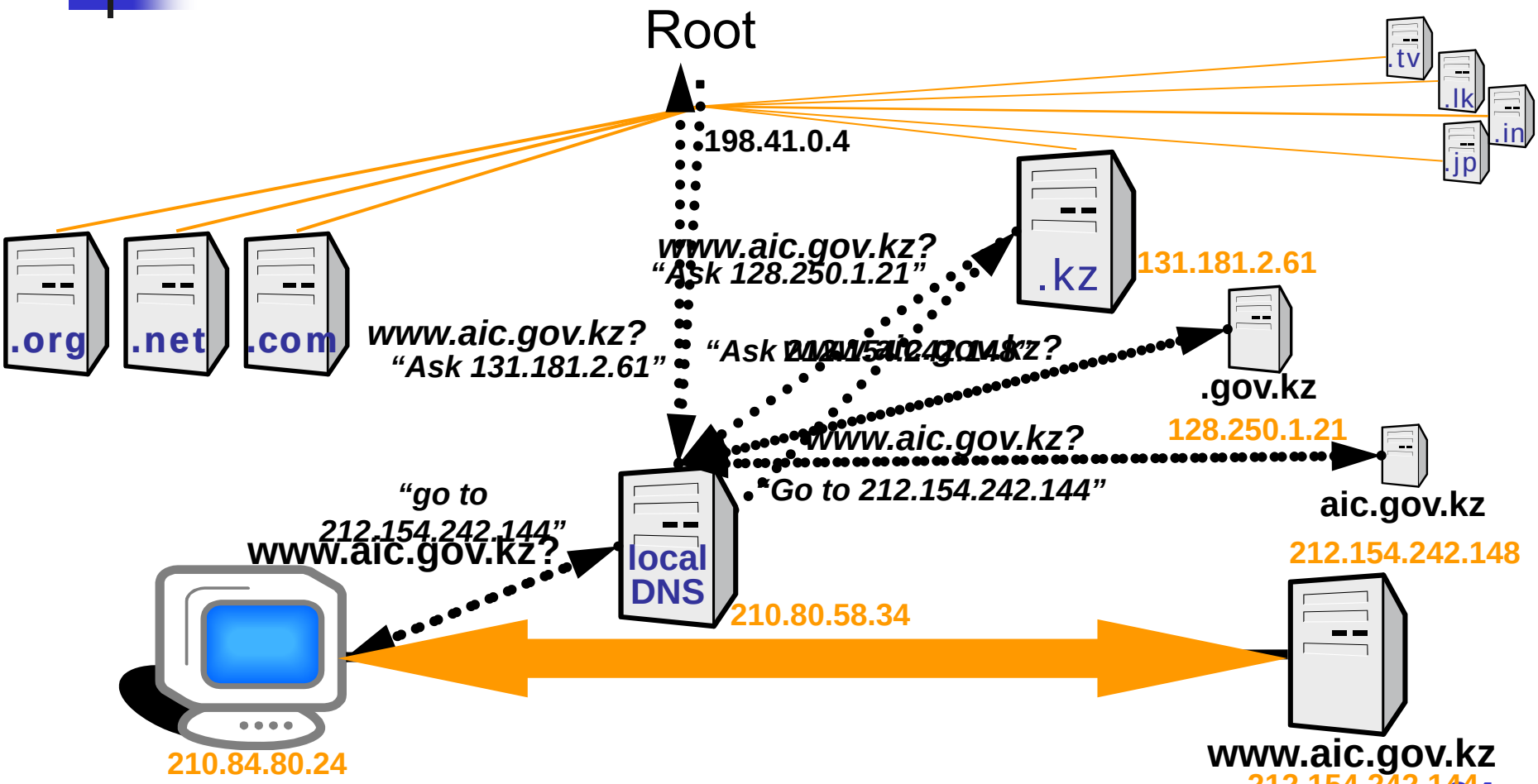
Mapping Domain Names to Addresses (5) – example of recursive resolution



Mapping Domain Names to Addresses (6) – example of iterative resolution



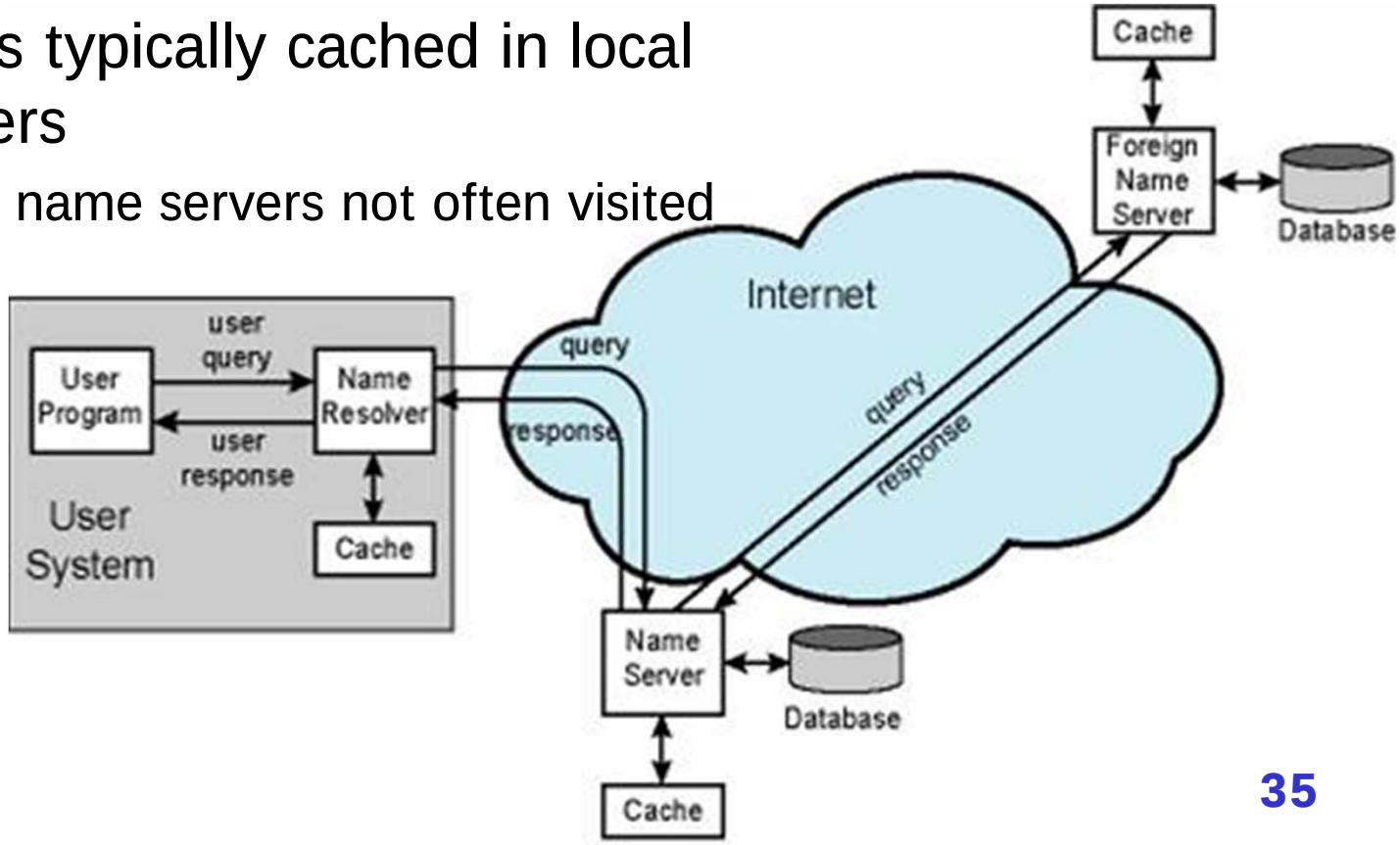
Internet addressing: an example of DNS

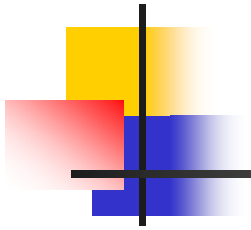


Mapping Domain Names to Addresses (7)

– caching mechanism to improve efficiency

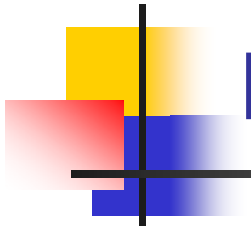
- Caching at the name servers
- Caching at the hosts
- TLD servers typically cached in local name servers
  - Thus root name servers not often visited





Inverse Queries

- Mapping a particular resource to a domain name or domain names that have that resource
  - Standard query: mapping a domain name to a resource
  - Inverse query: mapping a resource to a domain name
- Optional part of DNS
- Generally NOT used because there is often no way to find the server that can resolve the query without searching the entire set of servers
- NOT an acceptable method of mapping host addresses to host names, use the IN-ADDR.ARPA domain instead

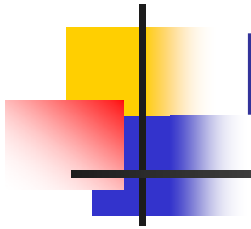


Pointer Queries

- Using IN-ADDR.ARPA domain for address to host mapping
  - An IP address in dotted-decimal format is included in the query
  - The correct domain name for the machine with the specific IP address

- Note: Since the IN-ADDR.ARPA special domain and the normal domain for a particular host or gateway will be in different zones, the possibility exists that that the data may be inconsistent

DNS Protocols

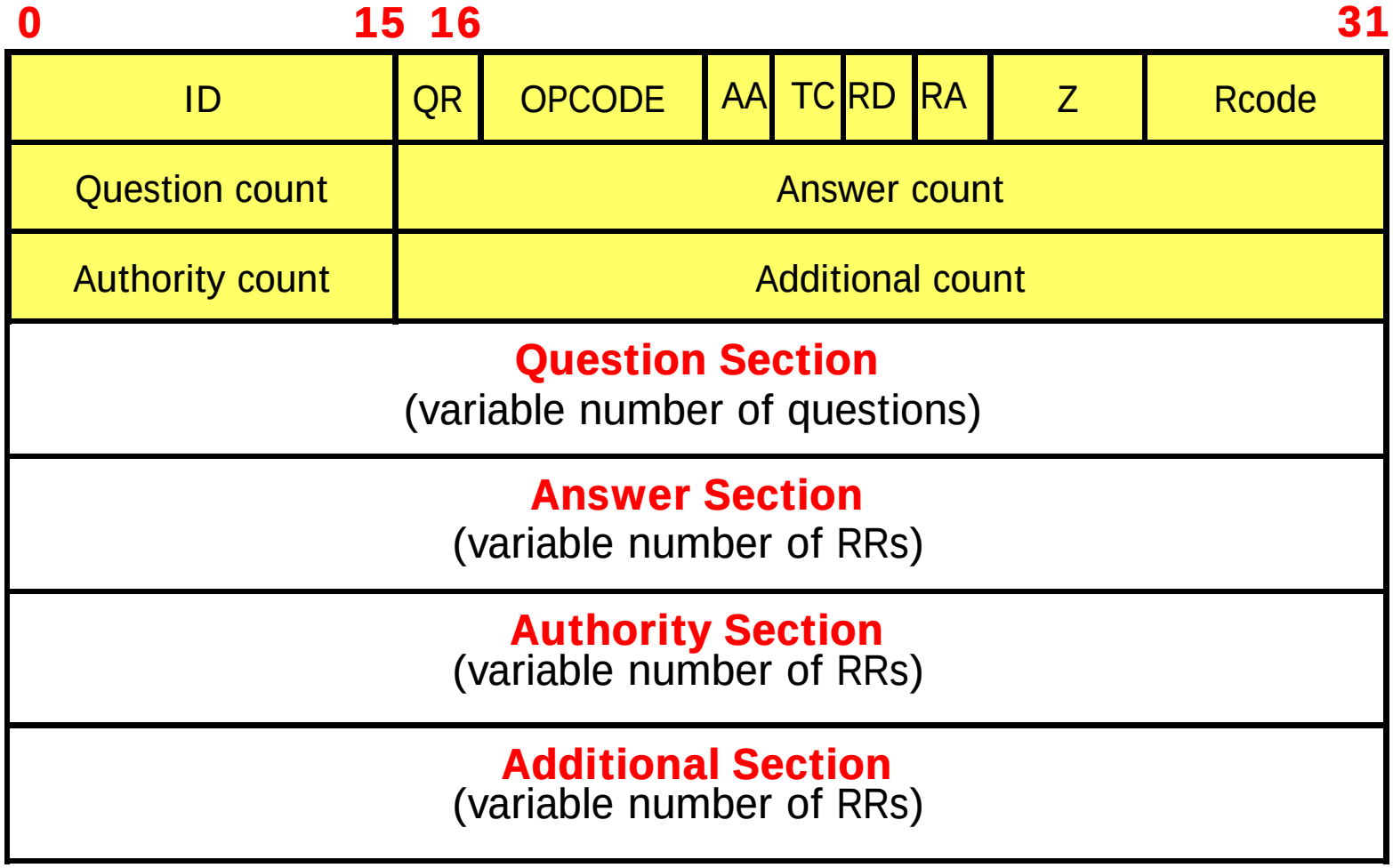


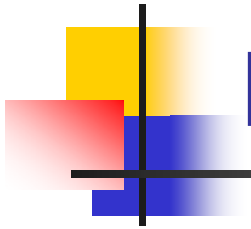
Related RFCs

- **RFC1034**, DOMAIN NAMES - CONCEPTS AND FACILITIES
- **RFC1035**, DOMAIN NAMES - IMPLEMENTATION AND SPECIFICATION
- Over 137 DNS related RFCs
  - See webpage at http://www.dns.net/dnsrd/rfc/

DNS Message Format (from RFC 1035)

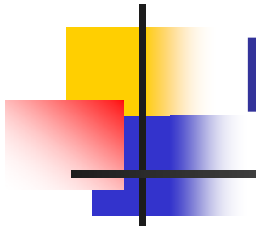
- *Query* and *Response* messages, both with *same message format*





DNS Message Header Structure(1)

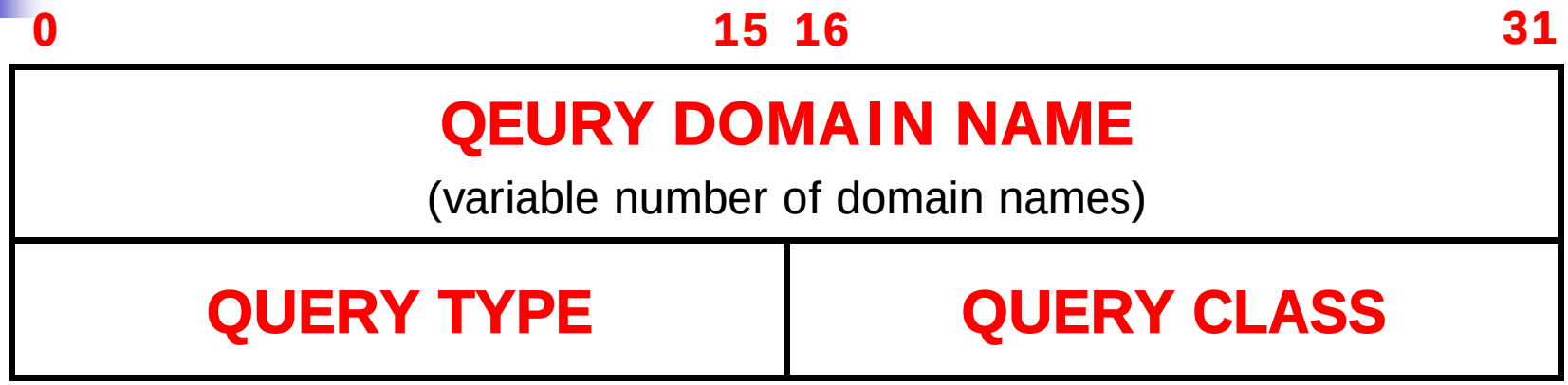
- ID: 16-bit field used to correlate queries and responses.
- QR: 1-bit field that identifies the message as a query (0) or response (1).
- OPCODE: 4-bit field that describes the type of query:
  - 0: Standard query (name to address). 1: Inverse query (address to name). 2: Server status request.
- AA: Authoritative Answer. 1-bit field. When set to 1, identifies this response is made by an authoritative name server.
- TC: Truncation. 1-bit field. When set to 1, indicates the message has been truncated due to length greater than that permitted.
- RD: Recursion Desired. 1-bit field. Set to 1 by the resolver to request recursive service by the name server.
- RA: Recursion Available. 1-bit field. Set to 1 by name server to indicate recursive query support is available.
- Z: 3-bit field. Reserved for future use. Must be set to 0.



DNS Message Header Structure(2)

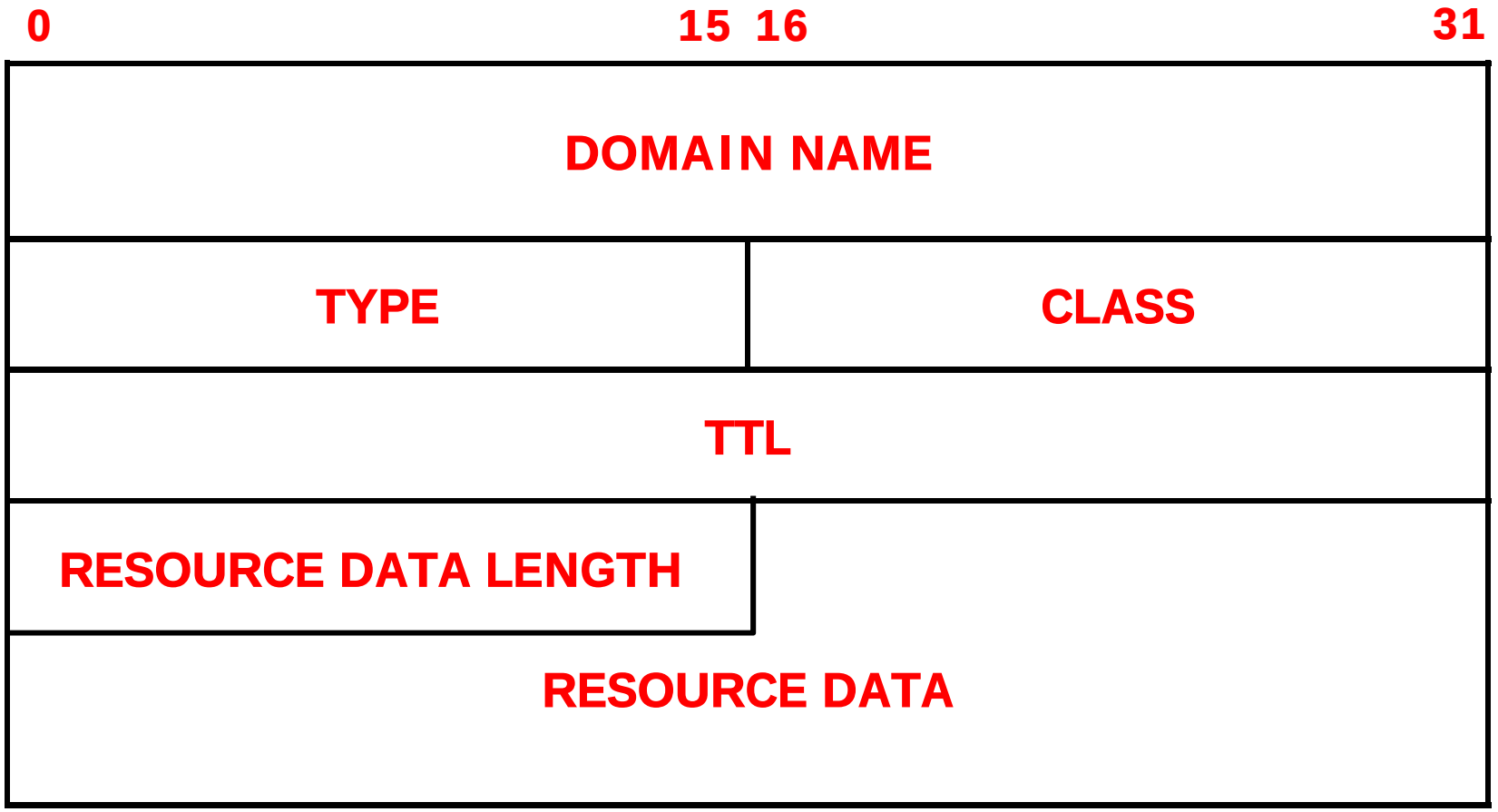
- RCODE: Response Code. 4-bit field that is set by the name server to identify the status of the query:
  - 0: No error condition. 1: Unable to interpret query due to format error. 2: Unable to process due to server failure. 3: Name in query does not exist. 4: Type of query not supported. 5:Query refused for policy reasons.
- QDCOUNT(Question count): 16-bit field that defines the number of entries in the question section.
- ANCOUNT(Answer count): 16-bit field that defines the number of resource records in the answer section.
- NSCOUNT(Authority count): 16-bit field that defines the number of name server resource records in the authority section.
- ARCOUNT(Additional count): 16-bit field that defines the number of resource records in the additional records section.

Question Section Format

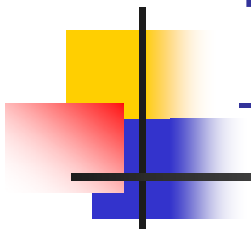


- QUERY TYPE: 16-bit field used to specify the type of the query
  - A – Host address
  - MX – Mail exchanger for the domain
  - ...
- QUERY CLASS: 16-bit field used to specify the class of the query
  - IN – Internet system
  - ...

Resource Record Format (1)

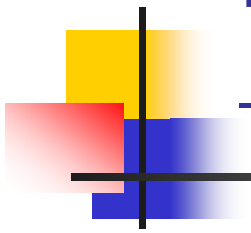


Resource Record Format (2) – type field



- SOA
  - Start Of Authority--identifies the domain or zone and sets a number of parameters
- NS
  - Maps a domain name to the name of a computer that is authoritative for the domain
- A
  - Maps the name of a system to its address. If a system (e.g., a router) has several addresses, then there will be a separate record for each.
- CNAME
  - Maps an alias name to the true, canonical name
- MX
  - Mail Exchanger. Identifies the systems that relay mail into the organization

Resource Record Format (3) – type field



- TXT
  - Provides a way to add text comments to the database. For example, a txt record could map abc.com to the company's name, address, and telephone number
- WKS
  - Well Known Services. Can list the application services available at the host. Used sparingly, if at all
- HINFO
  - Host Information, such as computer type and model. Rarely used
- PTR
  - Maps an IP address to a system name. Used in address-to-name files.

Example of Resource Records(1)

- Type=A
  - Name= Domain name , Value= IP Address

ns.bupt.edu.cn 86400 IN A 202.112.10.37

- Type=NS
  - Name= Domain, eg. bupt.edu.cn
  - value= Domain name of Authoritative Name Server

bupt.edu.cn 86400 IN NS ns.bupt.edu.cn

Example of Resource Records (2)

- Type=CNAME
  - Name= canonical name
  - Value= the name

dns.bupt.edu.cn 86400 IN CNAME ns.bupt.edu.cn

- Type=MX
  - Name= Domain name
  - Value= canonical name of mail server

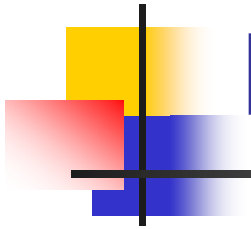
bupt.edu.cn 86400 IN MX mail.bupt.edu.cn

DNS Tools

DNS Tools: nslookup

- Function: query Internet name servers interactively
- Examples:

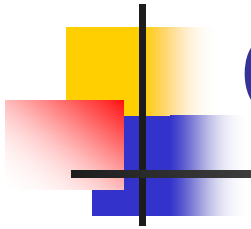
```
[shiyan@localhost]$ nslookup mail.263.net
Server:         202.106.0.20
Address:        202.106.0.20#53

Non-authoritative answer:
Name:   mail.263.net
Address: 211.150.96.52
Name:   mail.263.net
Address: 211.150.96.51

[shiyan@localhost]$ nslookup 211.150.96.52
Server:         202.106.0.20
Address:        202.106.0.20#53
Non-authoritative answer:
52.96.150.211.in-addr.arpa      name = mail.263.net.
```



DNS Tools: dig

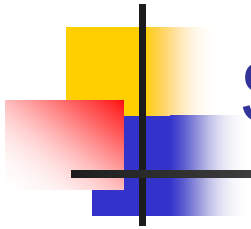
- Function: a flexible tool for interrogating DNS name servers
- Performs DNS lookups and displays the answers that are returned from the name server(s)

```
[shiyan@localhost]$ dig bupt.edu.cn

[shiyan@localhost]$ dig +norecurse bupt.edu.cn

[shiyan@localhost]$ dig +trace bupt.edu.cn

[shiyan@localhost]$ dig -x 211.68.71.130
```



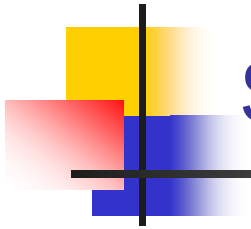
Other Issues

- Dynamic DNS (DDNS)
  - RFC2136
- IDNS
  - Internationalized Domain Names (IDN)
- DNSSEC and other security issues
  - Security concern on DNS information exchange
- DNSv6
  - New frontier for next generation Internet
- ENUM
  - Convergence with telephony?
- More advanced topics
  - Digital Object Identifier, http://www.doi.org/faq.html
  - Handle System, http://www.handle.net/



Summary of Important Terms in DNS

- Domain / domain name
- Domain namespace
- Resource Record
- Name server
- Resolver
- Zone
- Query / response
- Standard query / inverse query / pointer query
- recursive resolution / iterative resolution
- Primary server/ secondary server / caching server



Some procedures should be understood

- How does DNS work together with the user programs (e.g. TELNET, FTP, HTTP) ?
- How is the recursive resolution and iterative resolution?
- What are the mechanisms in DNS that are possible to improve the querying efficiency?

Example of DNS Response(1) (RFC1034)

The query would look like:

Header	OPCODE=SQUERY
Question	QNAME=SRI-NIC.ARPA., QCLASS=IN, QTYPE=A
Answer	<empty>
Authority	<empty>
Additional	<empty>

The response from C.ISI.EDU would be:

Header	OPCODE=SQUERY, RESPONSE, AA
Question	QNAME=SRI-NIC.ARPA., QCLASS=IN, QTYPE=A
Answer	SRI-NIC.ARPA. 86400 IN A 26.0.0.73 86400 IN A 10.0.0.51
Authority	<empty>
Additional	<empty>

Example of DNS Response(2)

6.2.3. QNAME=SRI-NIC.ARPA, QTYPE=MX

This type of query might be result from a mailer trying to look up routing information for the mail destination HOSTMASTER@SRI-NIC.ARPA. The response from C.ISI.EDU would be:

Header	OPCODE=SQUERY, RESPONSE, AA			
Question	QNAME=SRI-NIC.ARPA., QCLASS=IN, QTYPE=MX			
Answer	SRI-NIC.ARPA.	86400 IN	MX	0 SRI-NIC.ARPA.
Authority	<empty>			
Additional	SRI-NIC.ARPA.	86400 IN	A	26.0.0.73
			A	10.0.0.51

Example of DNS Response(3)

6.2.6. QNAME=BRL.MIL, QTYPE=A

If this query is sent to C.ISI.EDU, the reply would be:

Header	OPCODE=SQUERY, RESPONSE			
Question	QNAME=BRL.MIL, QCLASS=IN, QTYPE=A			
Answer	<empty>			
Authority	MIL.	86400 IN	NS	SRI-NIC.ARPA.
		86400	NS	A.ISI.EDU.
Additional	A.ISI.EDU.		A	26.3.0.103
	SRI-NIC.ARPA.		A	26.0.0.73
			A	10.0.0.51