

# The Application Layer: Sockets, DNS

CS 352, Lecture 3

<http://www.cs.rutgers.edu/~sn624/352-S19>

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# App-layer protocol

- Types of messages exchanged,
  - e.g., request, response
- Message format:
  - Syntax :what fields in messages & how fields are delineated
  - Semantics: meaning of information in fields
- Rules for when and how processes send & respond to messages

## Public-domain protocols:

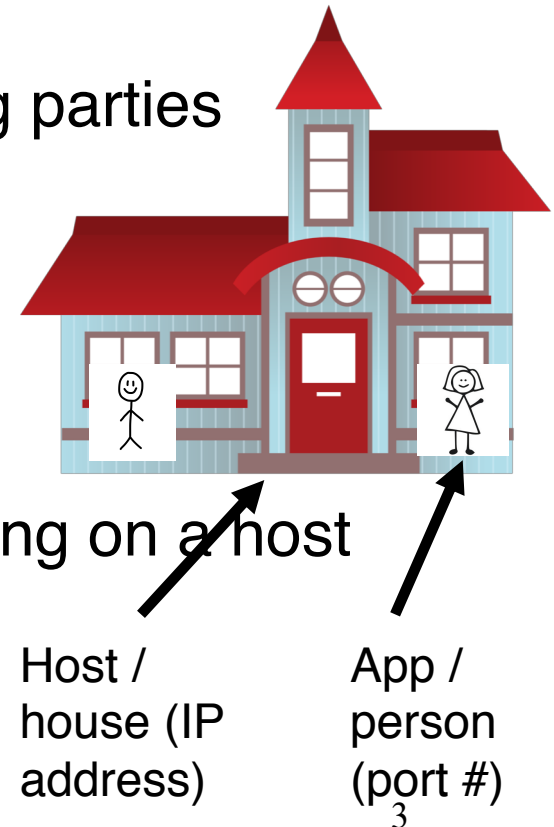
- defined in RFCs
- allows for interoperability
- e.g., HTTP, SMTP

## Proprietary protocols:

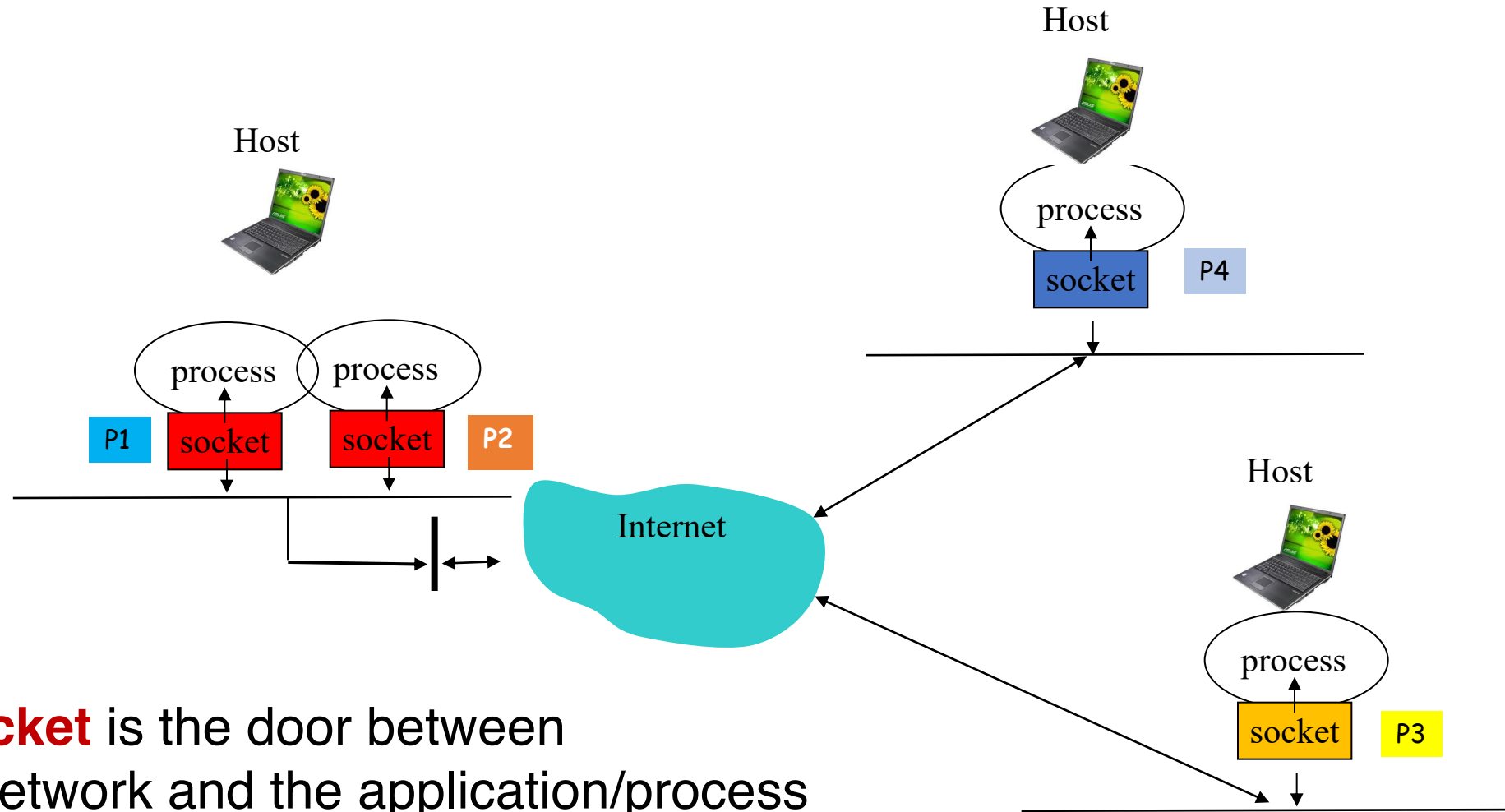
- e.g., Skype, Microsoft Exchange

# Application “addresses”

- We usually think of an application executing on a single host.
- However, applications can reside on, say, 2 different hosts connected by a network
- In order to communicate, need to identify the communicating parties
- Telephone network: phone number (10 digits)
- Computer network: IP address
  - IPv4 (32 bits) 128.6.24.78
  - IPv6 (128 bits) 2001:4000:A000:C000:6000:B001:412A:8000
- Suppose there is more than one networked program executing on a host
  - In addition to host address, we need one more address
  - “Which Program to talk to?”
- Another identity for an application: port #

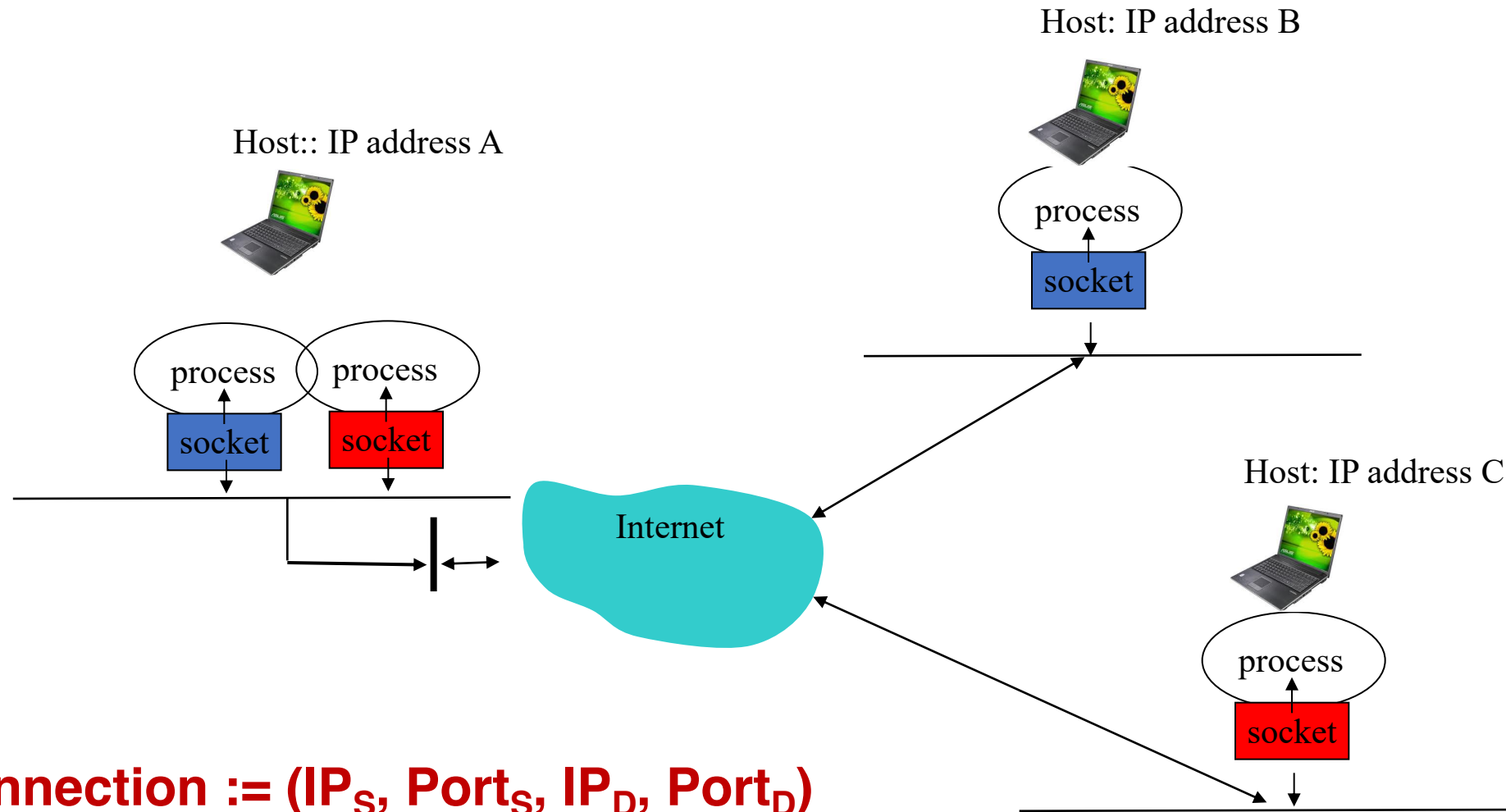


# IP address & port number

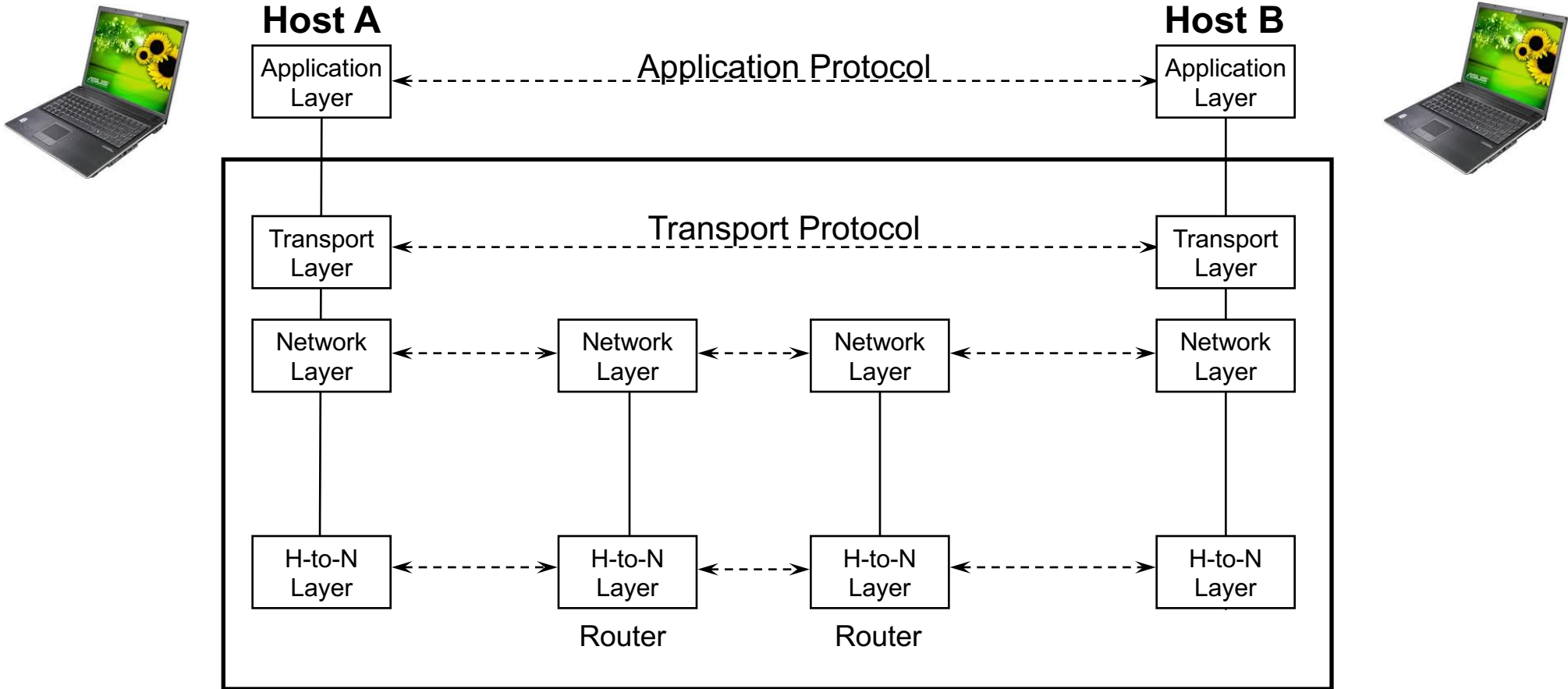


A **socket** is the door between OS/network and the application/process

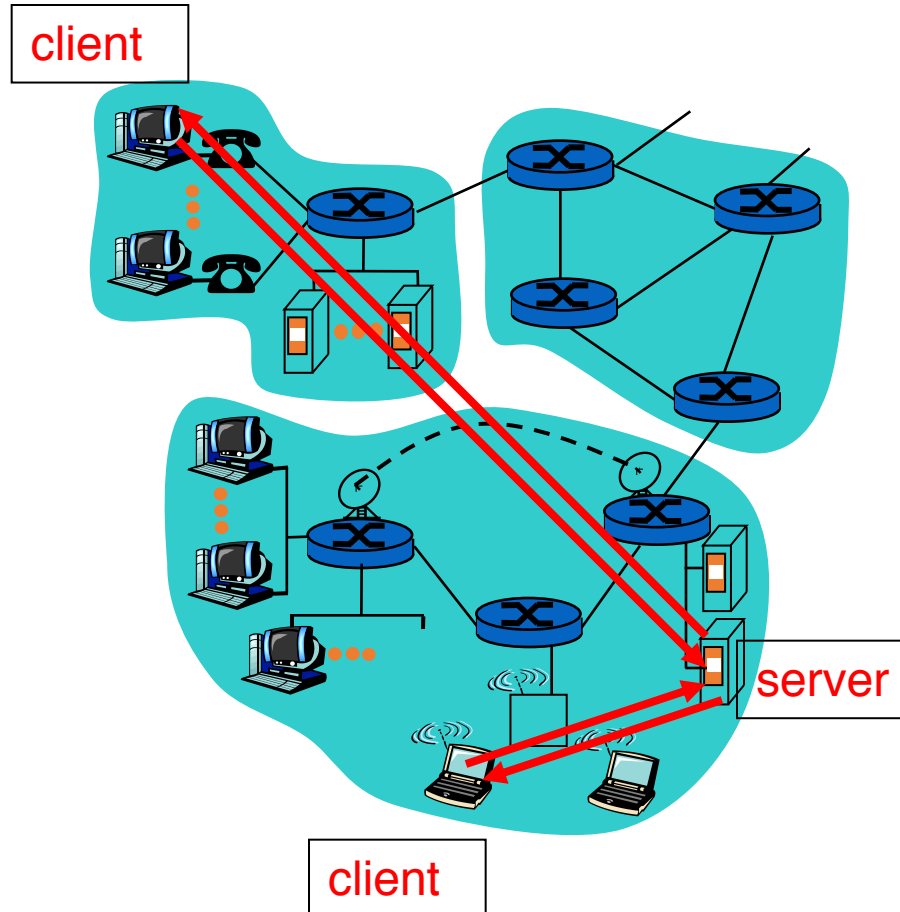
# A network connection is a 4-tuple



# Recall: Services provided by lower layers



# Client-server architecture



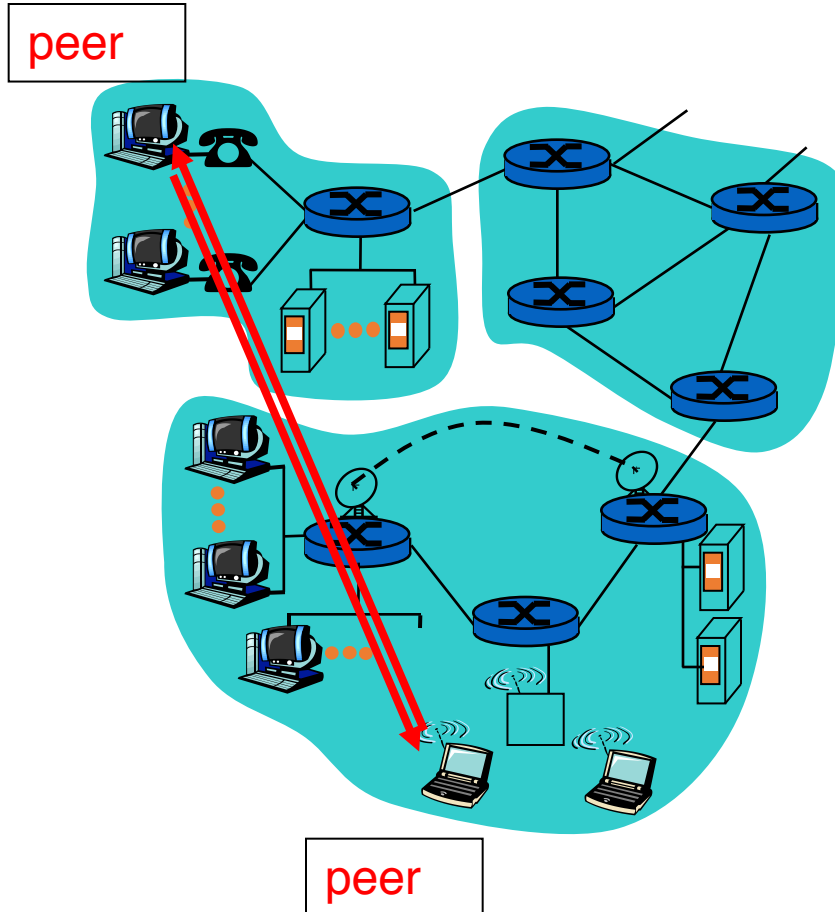
## Server:

- always-on host
- permanent IP address
- server farms (“data centers”) for scaling

## Clients:

- communicate with server
- may be intermittently connected
- may have dynamic IP addresses
- do not communicate directly with each other

# Peer-to-peer (P2P) architecture



- **Peers:**
  - Intermittently connected hosts
  - Directly talking to each other
- Little to no reliance on always-up servers
  - Examples: BitTorrent, Skype
- Today, many applications use a hybrid model
  - Example: Skype “supernodes”



# Domain Name System (DNS)

“You have my name. Can you lookup my number?”

# Domain Name System (DNS)

- Problem statement:
  - Average brain can easily remember 7 digits for a few names
  - On average, IP addresses have 12 digits
  - We need an easier way to remember IP addresses
- Solution:
  - Use alphanumeric names to refer to hosts
  - Just as a contacts or telephone directory (white pages)
  - Add a service (called DNS) to map between alphanumeric host names and binary IP addresses
  - We call this **Address Resolution**

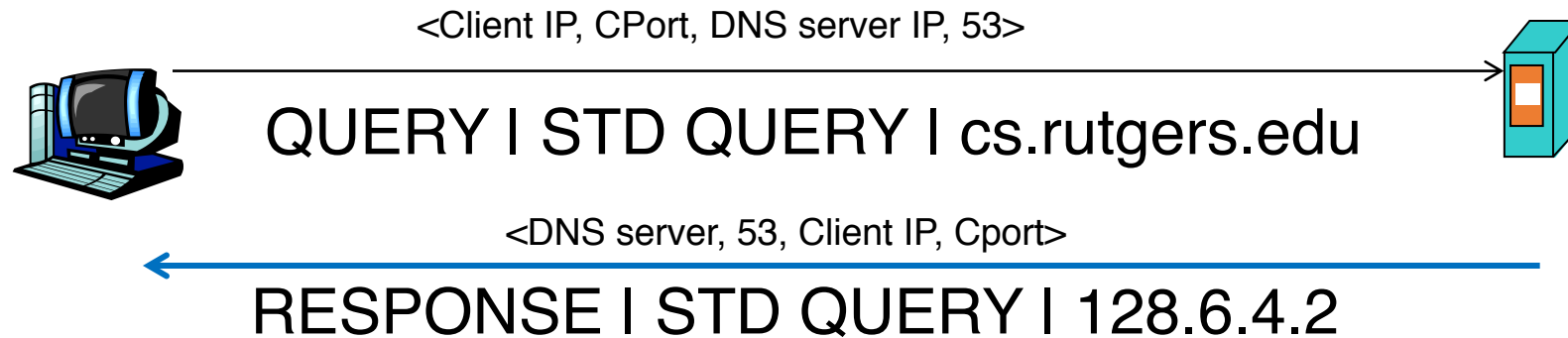
# Simple DNS

- Idea (1): What if every host has a local directory?
- /etc/hosts.txt
  - How things worked in the early days of the Internet!
- What if hosts moved around? How do you keep this up to date?

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Haushaltung Leiter 10 14 81 Büro 10 14 81 Wohnung 10 14 81 Einkaufsabt. 10 31 89 Verkaufsabt. u. Großhandlung 10 26 25 Abt. Branntweinreinigung 10 16 77 Leiter 10 04 05 <b>Spiro Gertrud</b> Verk. v. Spirit. u. Zigaretten Nowiniarskastr 2 11 00 21 <b>Spiro Gertrud</b> Geschäftsfüh- r. Sienastr 18 224 04 <b>Spiro Wacław</b> Ing. Arch. Pietekstr 9 12 50 15 <b>Spitzbarth-Benda Karol</b> + Schauspieler Neue Welt 30 248 76 <b>Spiz</b> Arbeitsgenossenschaftl. Un- tern. I. Tief- u. Hochbauarb. Kro- caskastr 14 960 62 <b>Spizowski Jan</b> Zahnarzt Javo- rinskistr 7 723 12 <b>Splawa-Neyman Helena</b> Neue Burgstr 10 998 49 <b>Splawa-Neyman Jan</b> Ing.-Arch. Radomer Str 43 946 28	<b>Grasynastr 15</b> * 401 40 verbindet mit sämtlichen Abteilungen u. Referaten. Zucker-, Kunststoffs-, Narmelade- Konserven- u. Petroleum-Refer- ate 448 05 Baureferat Grasynastr 22 418 39 Genossenschaftl. Korrespondenz- kurse Wiktorskastr 16 434 45 Zweigstelle Warschau 427 24 Leiter u. Büro 427 24 Verkaufsabt. 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# Simple DNS

DOMAIN NAME	IP ADDRESS
www.yahoo.com	98.138.253.109
cs.rutgers.edu	128.6.4.2
www.google.com	74.125.225.243
www.princeton.edu	128.112.132.86



- Idea (2): Implement a server that looks up a table
  - Simple, but does not scale
- Every new host needs to be entered in this table
- Performance?
- Failure?

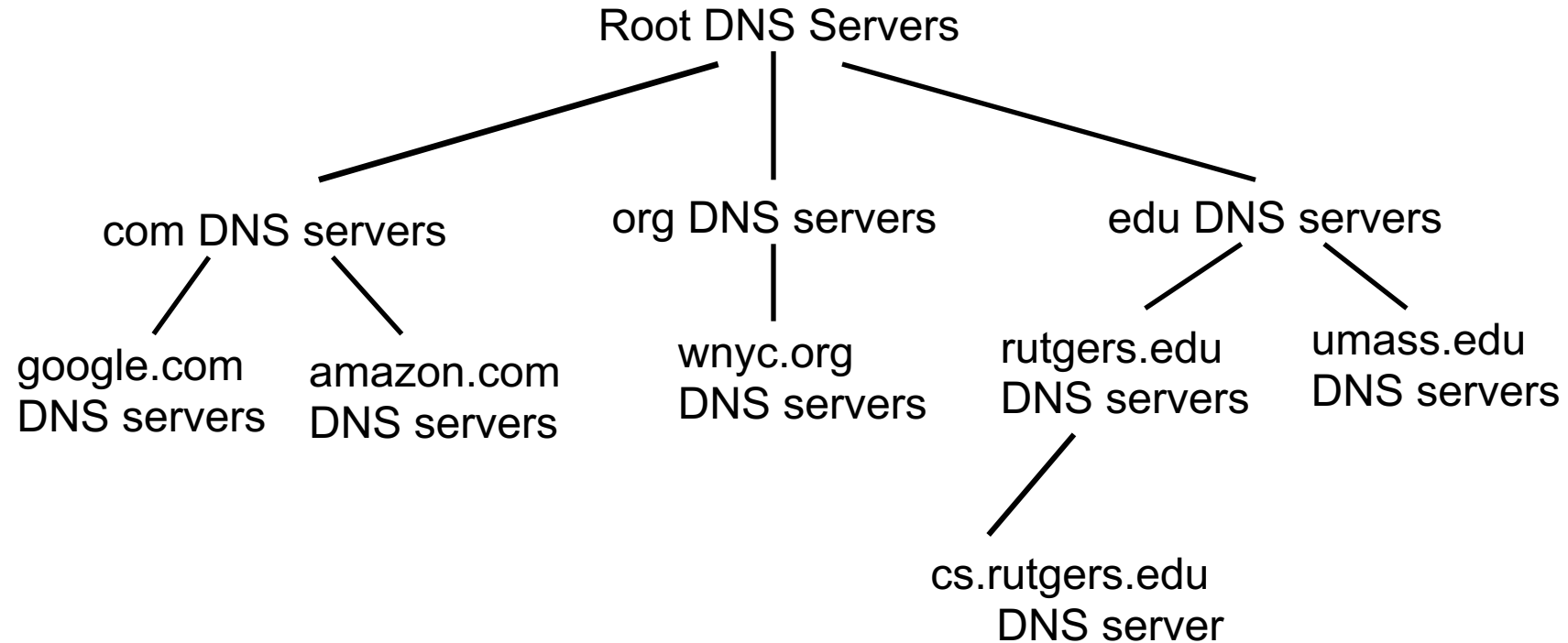
# DNS design

A centralized DNS design (ex: single server) is problematic.

- single point of failure
- traffic volume
- distant centralized database
- security
- maintenance

It doesn't *scale* to the requirements of the Internet.

# Distributed and hierarchical database



RFC 1034

# DNS protocol

- Client and Server
- Client connects to Port 53
- DNS server address should be known
  - Either manually configured or automatically (more on this to come...)
- Two types of messages
  - Queries
  - Responses
- Type of Query (OPCODE) methods
  - Standard query (0x0)
    - Request domain name for a given IP address
  - Updates (0x5)
    - Provide a binding of IP address to domain name
- Each type has a common message format that follows the header

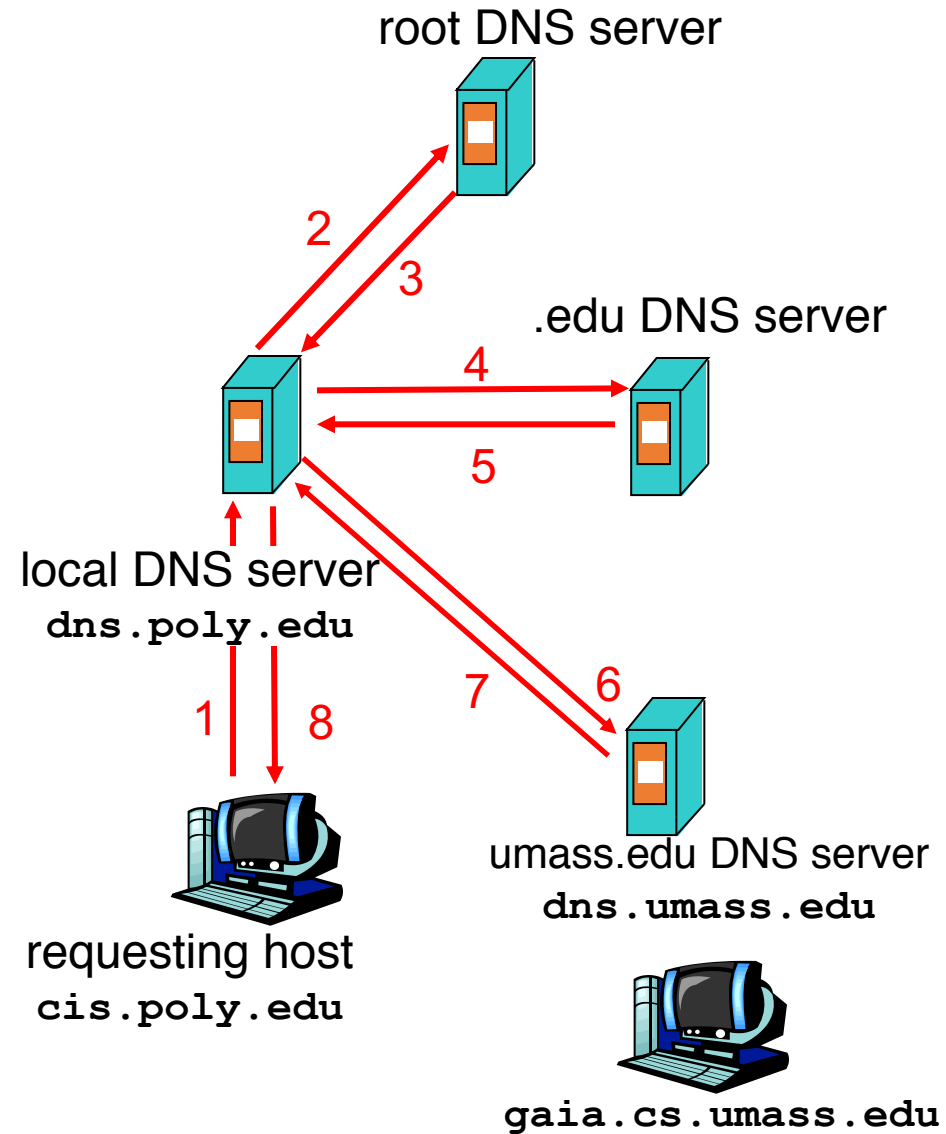
# DNS Protocol

- When client wants to know an IP address for a host name
  - Client sends a DNS query to the “local” name server in its network
  - If name server contains the mapping, it returns the IP address to the client
  - Otherwise, the name server forwards the request to the root name server
  - The request works its way down the tree toward the host until it reaches a name server with the correct mapping



# Example

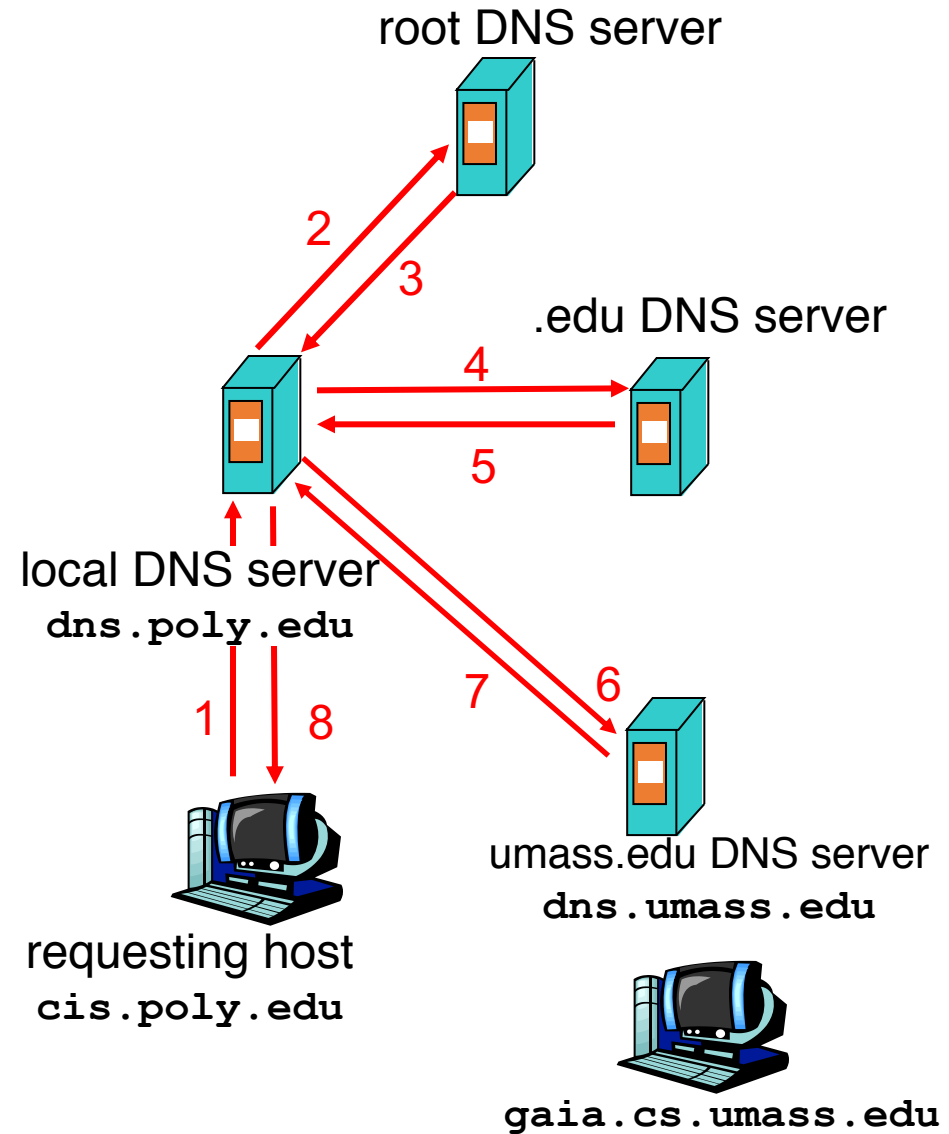
- Host at cis.poly.edu wants IP address for gaia.cs.umass.edu
- Local DNS server
- Root DNS server
- TLD DNS server
- Authoritative DNS server



# Query type

## Iterated query:

- Contacted server replies with name of server to contact
- “I don’t know this name, but ask this server”



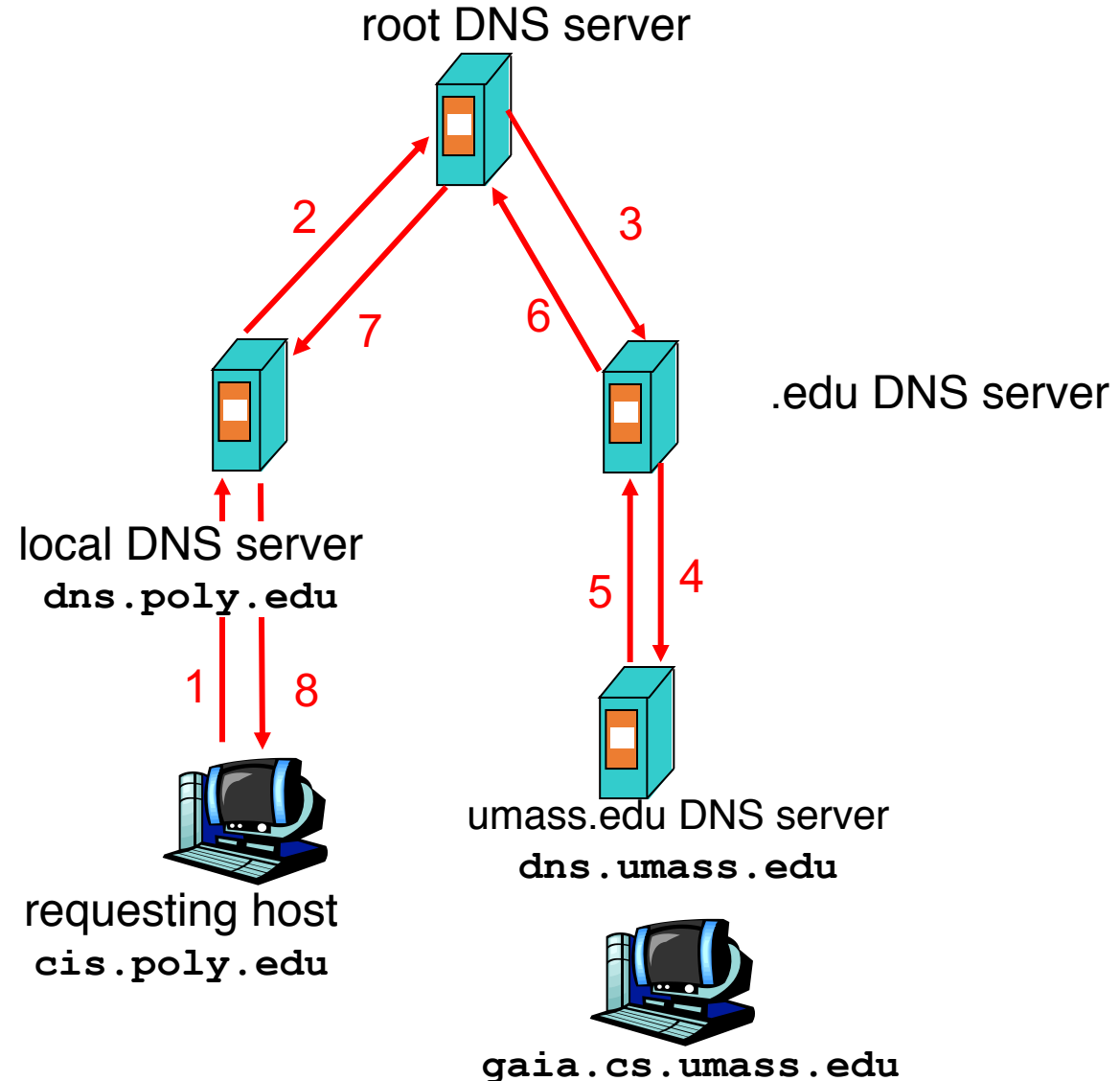
# Query type

## Recursive query:

- Puts burden of name resolution on the contacted name server

Problem: think about the root DNS server.

- Must it answer every DNS query?



# DNS caching and updating records

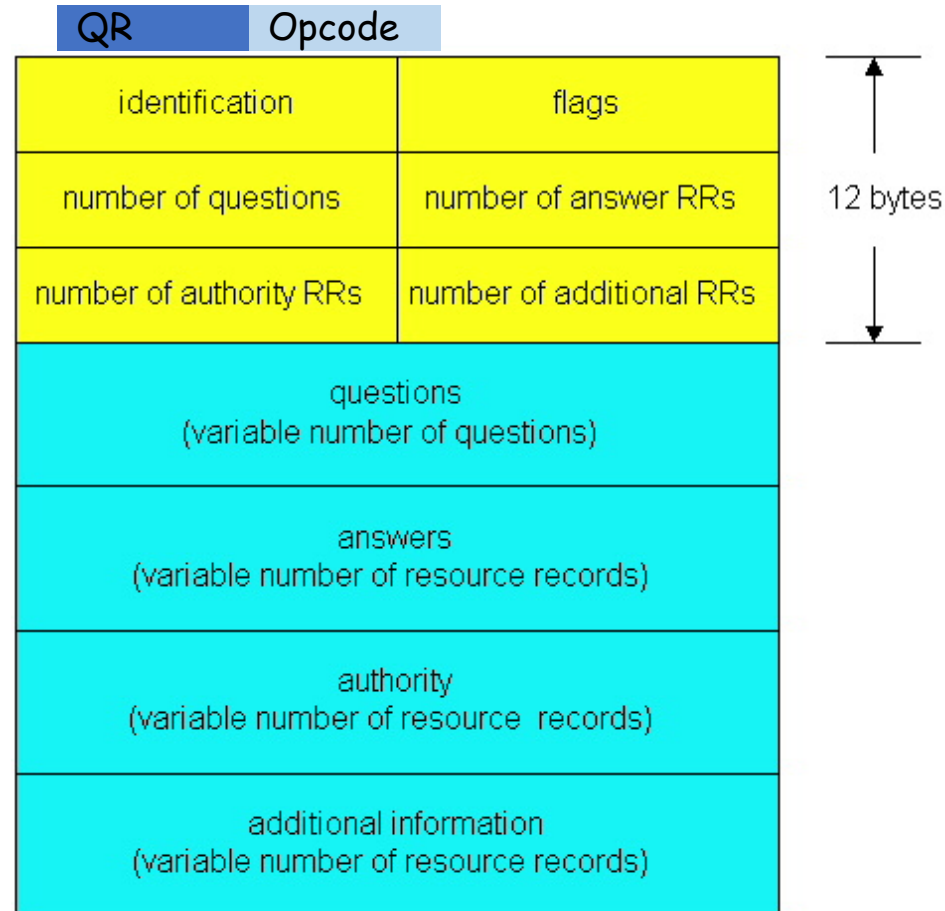
- Once (any) name server learns a name to IP address mapping, it *caches* the mapping
  - Cache entries timeout (disappear) after some time
  - TLD servers typically cached in local name servers
  - In practice, root name servers aren't visited often

# DNS protocol messages

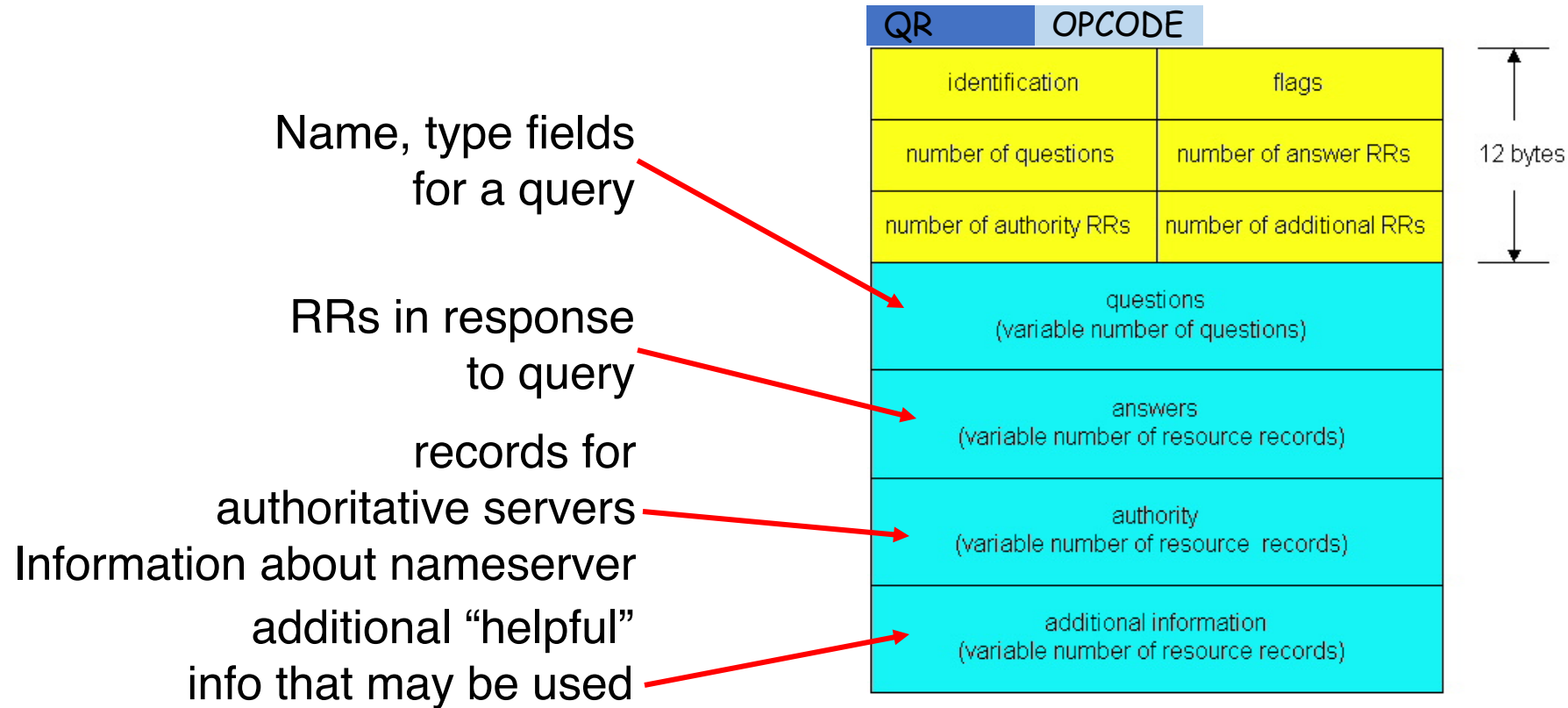
DNS protocol : *query* and *reply* messages, both with same *message format*

## Message header

- QR = 0 for Query, 1 for response
- Opcode= 0 standard
- identification: 16 bit # for query, reply to query uses same #
- flags:
  - Authoritative answer
  - recursion desired
  - recursion available
  - reply is authoritative



# DNS protocol, messages



# DNS records

DNS: distributed db storing resource records (RR)

RR format: (name, type, class, ttl, addr)

Type=A

- ❖ **name** is hostname
- ❖ **value** is IP address

Type=AAAA

- ❖ **name** is hostname
- ❖ **value** is IPv6 address

• Type=NS

- **name** is domain (e.g. foo.com)
- **value** is hostname of authoritative name server for this domain

Type=CNAME

- ❖ **name** is alias name for some “canonical” (the real) name  
www.ibm.com is really  
serveeast.backup2.ibm.com
- ❖ **value** is canonical name

Type=MX

- ❖ **value** is name of mailserver associated with **name**

# DNS Record example

RRs in response  
to query

NAME	Design.cs.rutgers.edu
TYPE	A
CLASS	IN
TTL	1 day(86400)
ADDRESS	192.26.92.30

records for  
authoritative  
servers  
Information about  
nameserver

NAME	Cs.rutgers.edu
TYPE	NS
CLASS	IN
TTL	1 day(86400)
NSDNAME	Ns-lcsr.rutgers.edu



# DNS summary

## DNS service:

- Hostname to IP address translation
- Host aliasing
  - Canonical and alias names
- Mail server aliasing
- Load distribution
  - Replicated Web servers: set of IP addresses for one canonical name
- Caching
- Hierarchical structure for scaling
- Multiple layers of indirection

# Bootstrapping DNS

- How does a host contact the name server if all it has is the name and no IP address?
- IP address of at least 1 nameserver must be given a priori
  - or with another protocol (DHCP, bootp)
- File `/etc/resolv.conf` in unix
- Start -> settings-> control panel-> network -> TCP/IP -> properties in windows

# Themes

- Request/response nature of these protocols
- How Messages are structured
  - HTTP, SMTP, FTP - simple ASCII protocols
- Caching
- Name Lookup
  - Division of concerns (e.g. zones)
  - Hierarchy structure