DNS: Domain Name System

People: many identifiers:

- SSN, name, Passport #

Internet hosts, routers:

- Always: IP address (32 bit) - used for addressing datagrams
- Often: "name", e.g., nif-c14.wsu.edu - used by humans

Q: How do we map between names and IP addresses?

A: Domain Name System (DNS):

- *distributed database* implemented in hierarchy of many *name servers*
- *application-layer protocol* hosts, name servers communicate to *resolve* names (name/address translation)
  - note: this is a core Internet function implemented as application-layer protocol
  - complexity at network's "edge"

DNS: Domain Names

- Names are hierarchical
  - www.eecs.wsu.edu.
- Each suffix corresponds to a zone
  - .
  - edu.
  - wsu.edu.
  - eecs.wsu.edu.
- Each zone has at least two authoritative servers

- Top-level domains
  - edu.
  - com.
  - mil.
  - us.
  - uk.
  - fr.

DNS name servers

- no server has all name-to-IP address mappings

local name servers:

- each ISP, company has *local (default) name server*
- host DNS query first goes to local name server

authoritative name server:

- for a host: stores that host's IP address, name
- can perform name to address translation for that host's name

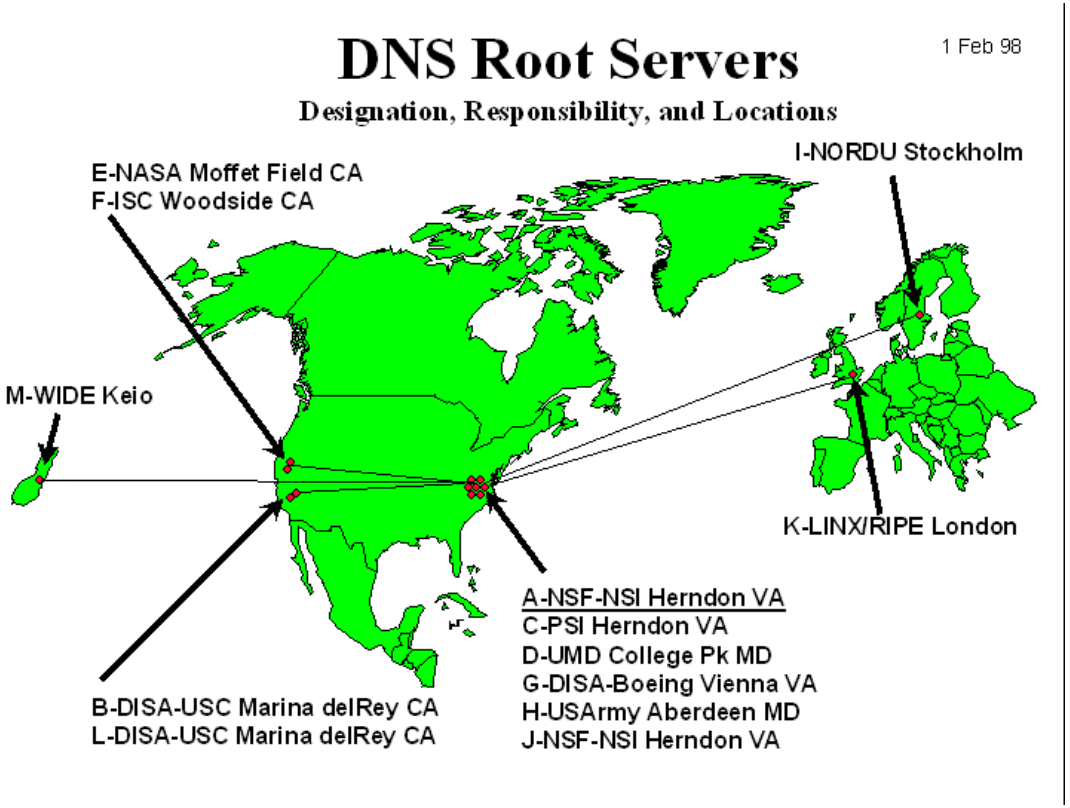
Why not centralize DNS?

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

doesn't *scale!*

DNS: Root name servers

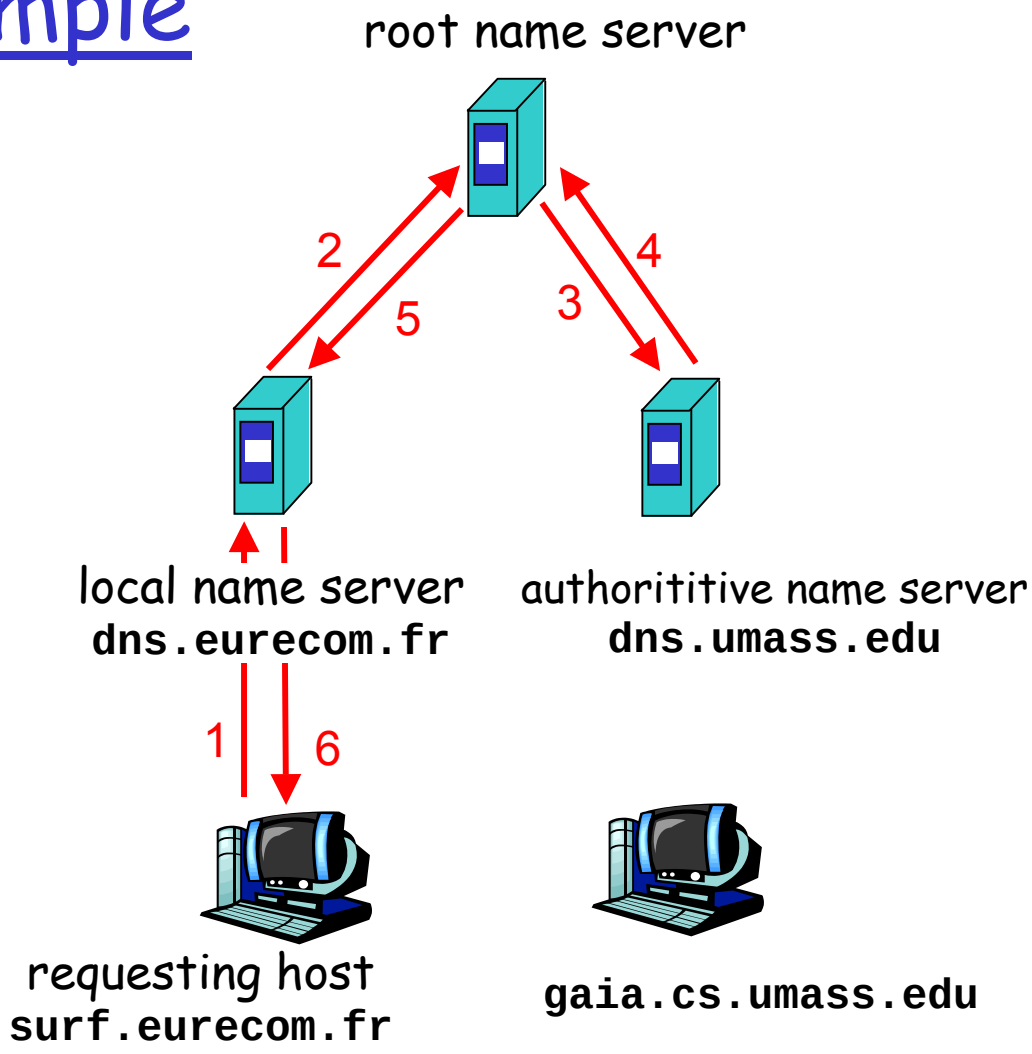
- contacted by local name server that can not resolve name
- root name server:
  - contacts authoritative name server if name mapping not known
  - gets mapping
  - returns mapping to local name server
- ~ dozen root name servers worldwide



Simple DNS example

host **surf.eurecom.fr** wants IP address of **gaia.cs.umass.edu**

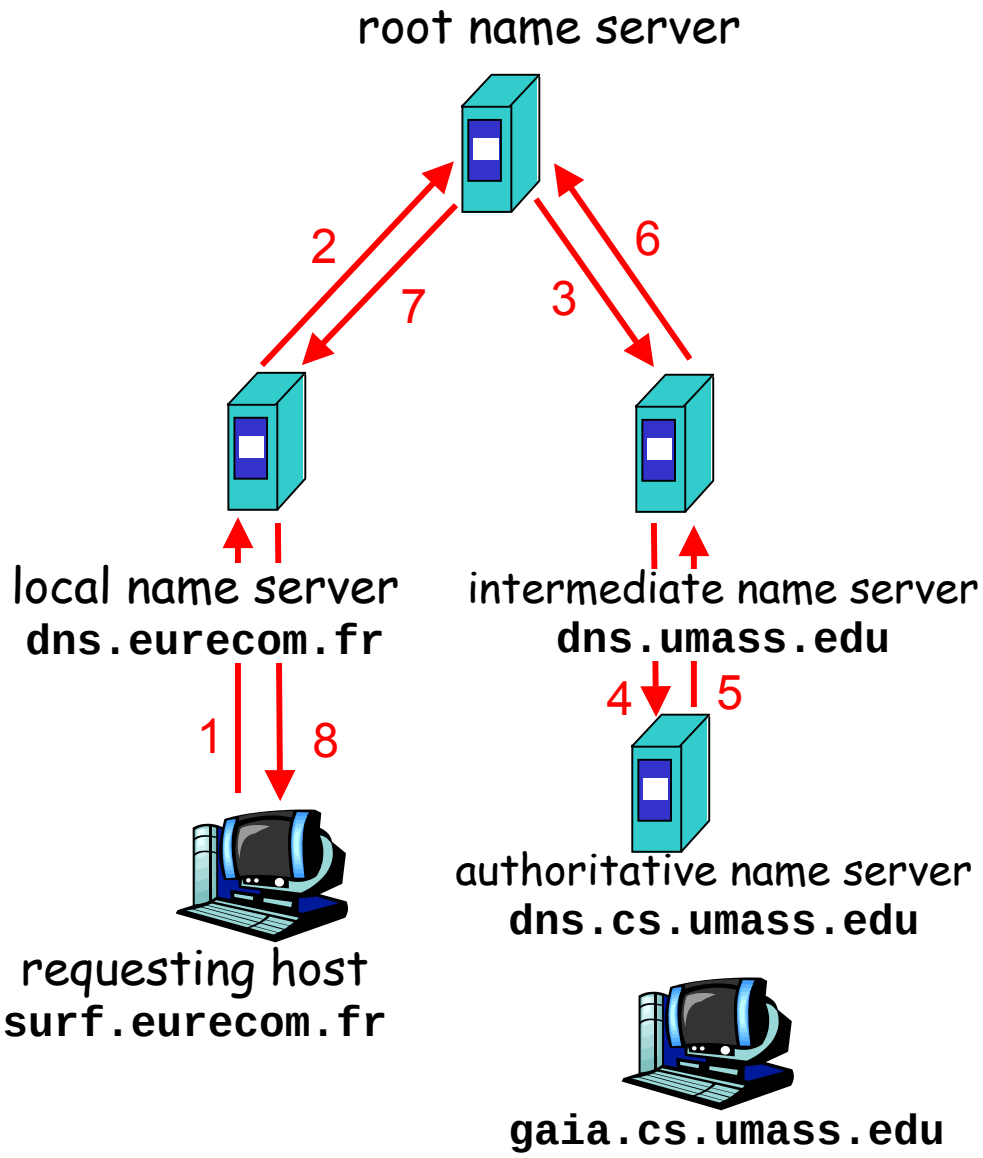
1. Contacts its local DNS server, **dns.eurecom.fr**
2. **dns.eurecom.fr** contacts root name server, if necessary
3. root name server contacts authoritative name server, **dns.umass.edu**, if necessary



DNS example

Root name server:

- may not know authoratiative name server
- may know *intermediate name server:* who to contact to find authoritative name server



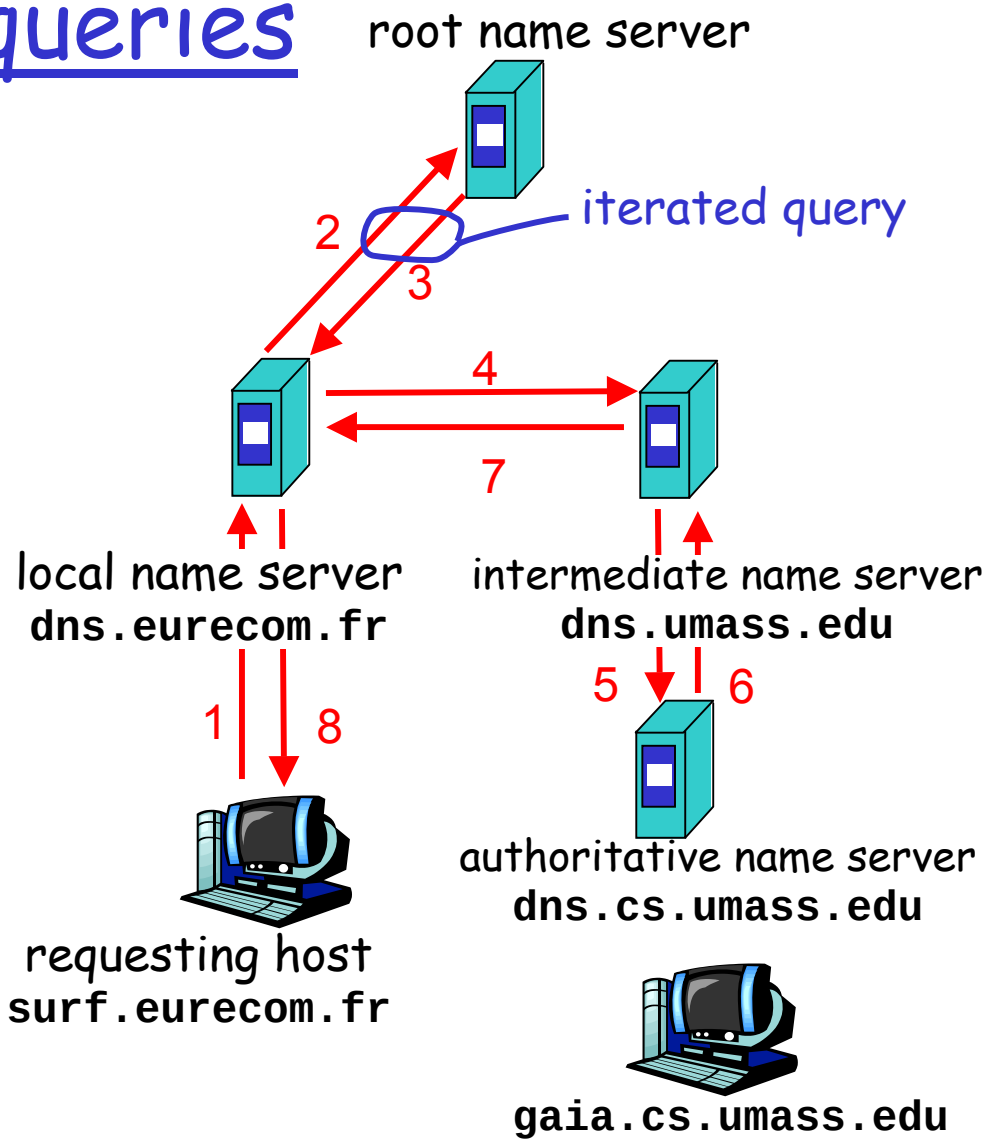
DNS: iterated queries

recursive query:

- puts burden of name resolution on contacted name server
- heavy load?

iterated query:

- contacted server replies with name of server to contact
- "I don't know this name, but ask this server"



DNS: caching and updating records

- once (any) name server learns mapping, it *caches* mapping
  - cache entries timeout (disappear) after some time
- update/notify mechanisms under design by IETF
  - RFC 2136
  - http://www.ietf.org/html.charters/dnsind-charter.html

DNS records

DNS: distributed db storing resource records (RR)

RR format: **(name, value, type,ttl)**

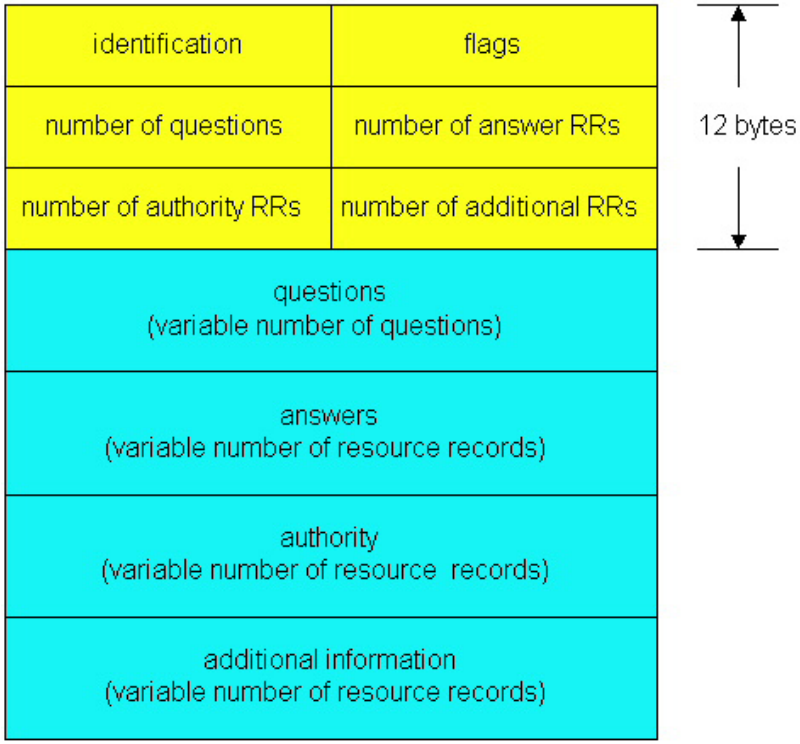
- Type=A
  - **name** is hostname
  - **value** is IP address
- Type=NS
  - **name** is domain (e.g. foo.com)
  - **value** is IP address of authoritative name server for this domain
- Type=CNAME
  - **name** is an alias name for some "cannonical" (the real) name
  - **value** is cannonical name
- Type=MX
  - **value** is hostname of mailserver associated with **name**

DNS protocol, messages

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

msg header

- identification: 16 bit # for query, reply to query uses same #
- flags:
  - query or reply
  - recursion desired
  - recursion available
  - reply is authoritative



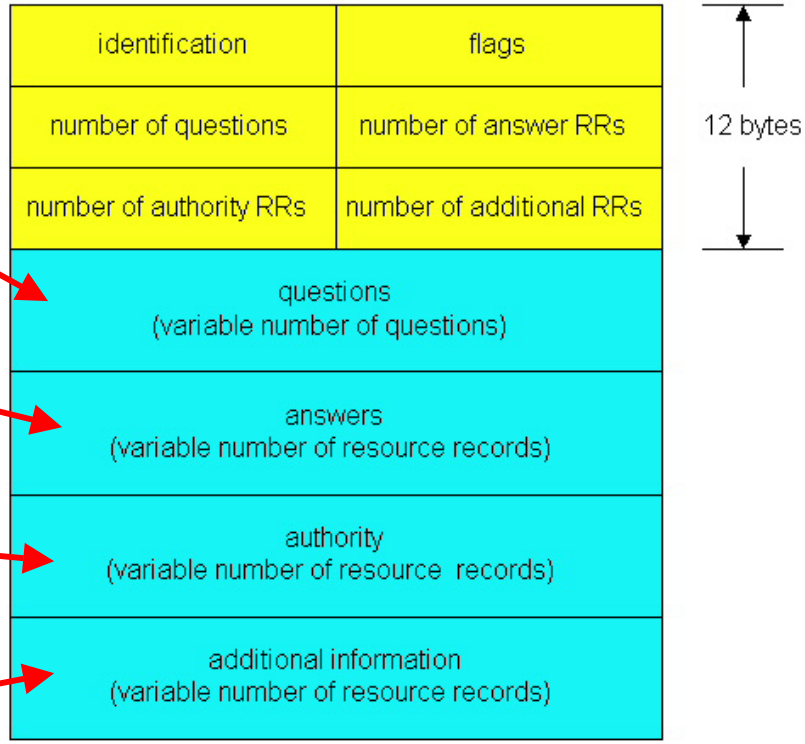
DNS protocol, messages

Name, type fields for a query

RRs in reponse to query

records for authoritative servers

additional "helpful" info that may be used



Example: Java client (TCP)

```
import java.io.*;
import java.net.*;
class TCPClient {

    public static void main(String argv[]) throws Exception
    {
        String sentence;
        String modifiedSentence;

        BufferedReader inFromUser =
          new BufferedReader(new InputStreamReader(System.in));

        Socket clientSocket = new Socket("hostname", 6789);

        DataOutputStream outToServer =
          new DataOutputStream(clientSocket.getOutputStream());
```

Create input stream

Create client socket, connect to server

Create output stream attached to socket

Example: Java client (TCP), cont.

Create input stream attached to socket

```
BufferedReader inFromServer =
  new BufferedReader(new
  InputStreamReader(clientSocket.getInputStream()));

sentence = inFromUser.readLine();

outToServer.writeBytes(sentence + '\n');

modifiedSentence = inFromServer.readLine();

System.out.println("FROM SERVER: " + modifiedSentence);

clientSocket.close();

    }
}
```

Send line to server

Read line from server

Example: Java server (TCP)

```
import java.io.*;
import java.net.*;

class TCPServer {

  public static void main(String argv[]) throws Exception
   {
     String clientSentence;
     String capitalizedSentence;

     ServerSocket welcomeSocket = new ServerSocket(6789);

     while(true) {

       Socket connectionSocket = welcomeSocket.accept();

      BufferedReader inFromClient =
        new BufferedReader(new
        InputStreamReader(connectionSocket.getInputStream()));
```

Create welcoming socket at port 6789

Wait, on welcoming socket for contact by client

Create input stream, attached to socket

Example: Java server (TCP), cont

Create output stream, attached to socket

```
DataOutputStream  outToClient =
  new DataOutputStream(connectionSocket.getOutputStream());
```

Read in line from socket

```
clientSentence = inFromClient.readLine();

capitalizedSentence = clientSentence.toUpperCase() + '\n';
```

Write out line to socket

```
outToClient.writeBytes(capitalizedSentence);
            }
        }
    }
```

End of while loop, loop back and wait for another client connection

Example: Java client (UDP)

```
import java.io.*;
import java.net.*;

class UDPClient {
   public static void main(String args[]) throws Exception
   {

     BufferedReader inFromUser =
       new BufferedReader(new InputStreamReader(System.in));

     DatagramSocket clientSocket = new DatagramSocket();

     InetAddress IPAddress = InetAddress.getByName("hostname");

     byte[] sendData = new byte[1024];
     byte[] receiveData = new byte[1024];

     String sentence = inFromUser.readLine();

     sendData = sentence.getBytes();
```

Create input stream

Create client socket

Translate hostname to IP address using DNS

Example: Java client (UDP), cont.

Create datagram with data-to-send, length, IP addr, port

Send datagram to server

Read datagram from server

```
                DatagramPacket sendPacket =
                  new DatagramPacket(sendData, sendData.length, IPAddress, 9876);

                clientSocket.send(sendPacket);

                DatagramPacket receivePacket =
                   new DatagramPacket(receiveData, receiveData.length);

                clientSocket.receive(receivePacket);

                String modifiedSentence =
                    new String(receivePacket.getData());

                System.out.println("FROM SERVER:" + modifiedSentence);
                clientSocket.close();
                }

            }
```

Example: Java server (UDP)

```
import java.io.*;
import java.net.*;

class UDPServer {
  public static void main(String args[]) throws Exception
   {

    DatagramSocket serverSocket = new DatagramSocket(9876);

    byte[] receiveData = new byte[1024];
    byte[] sendData  = new byte[1024];

    while(true)
     {

     DatagramPacket receivePacket =
       new DatagramPacket(receiveData, receiveData.length);

     serverSocket.receive(receivePacket);
```

Create datagram socket at port 9876

Create space for received datagram

Receive datagram

Example: Java server (UDP), cont

```
String sentence = new String(receivePacket.getData());

InetAddress IPAddress = receivePacket.getAddress();

int port = receivePacket.getPort();

        String capitalizedSentence = sentence.toUpperCase();

sendData = capitalizedSentence.getBytes();

DatagramPacket sendPacket =
   new DatagramPacket(sendData, sendData.length, IPAddress,
                      port);

serverSocket.send(sendPacket);
    }
  }
}
```

Get IP addr port #, of sender

Create datagram to send to client

Write out datagram to socket

End of while loop, loop back and wait for another datagram

Chapter 2: Summary

- application service requirements:
  - reliability, bandwidth, delay
- client-server paradigm
- Internet transport service model
  - connection-oriented, reliable: TCP
  - unreliable, datagrams: UDP
- specific protocols:
  - http
  - ftp
  - smtp, pop3
  - dns
- socket programming
  - client/server implementation
  - using tcp, udp sockets

Chapter 2: Summary

Most importantly: learned about *protocols*

- typical request/reply message exchange:
  - client requests info or service
  - server responds with data, status code
- message formats:
  - headers: fields giving info about data
  - data: info being communicated

- control vs. data msgs
  - in-based, out-of-band
- centralized vs. decentralized
- stateless vs. stateful
- reliable vs. unreliable msg transfer
- "complexity at network edge"
- security: authentication