

SMTTP    FTP    TFTP    DNS    SNMP    ...    BOOTP

**EITF25 – Internet: Technology and Applications**

SCTP    TCP    UDP

# Application Layer

**-1-**

IGMP    ICMP

# Network Tools

ARP    RARP

**2015, Lecture 08**

**Kaan Bür**

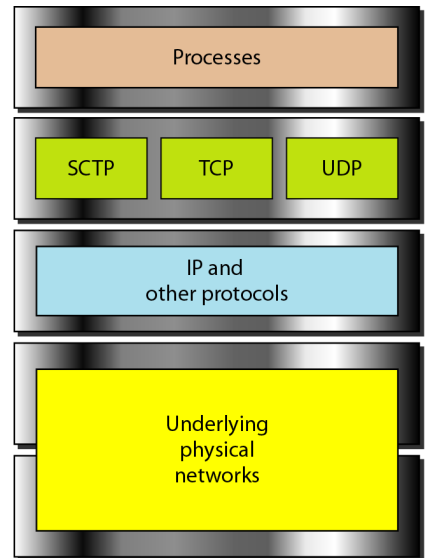
Underlying LAN or WAN  
technology



# Previously on EITF25

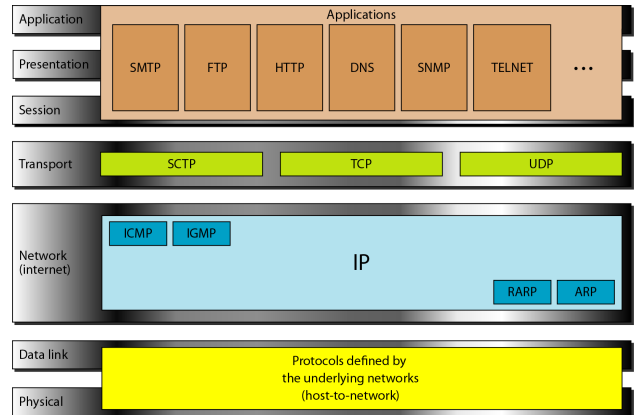
## Transport Layer

- Addressing above IP
  - Ports, sockets
- Process-to-process delivery
- Transport layer protocols
  - TCP
  - UDP
- Quality of Service



# Application layer

- Principles of digital communications
  - From electrical signals to bits to packets
- Using the physical infrastructure
  - Network access
- Finding your way
  - Addressing, routing
- **Making use of it all**
  - **Applications**




# Today: Application Layer

(1)

- Domain Name System, DNS  
*[S24.2][F26.6]*
- Host Configuration, DHCP  
*[S21.5][F18.4.4]*
- Debugging Tools, ICMP  
*[S14.3][F19.2]*
- World-Wide Web, HTTP  
*[S24.3][F26.1]*

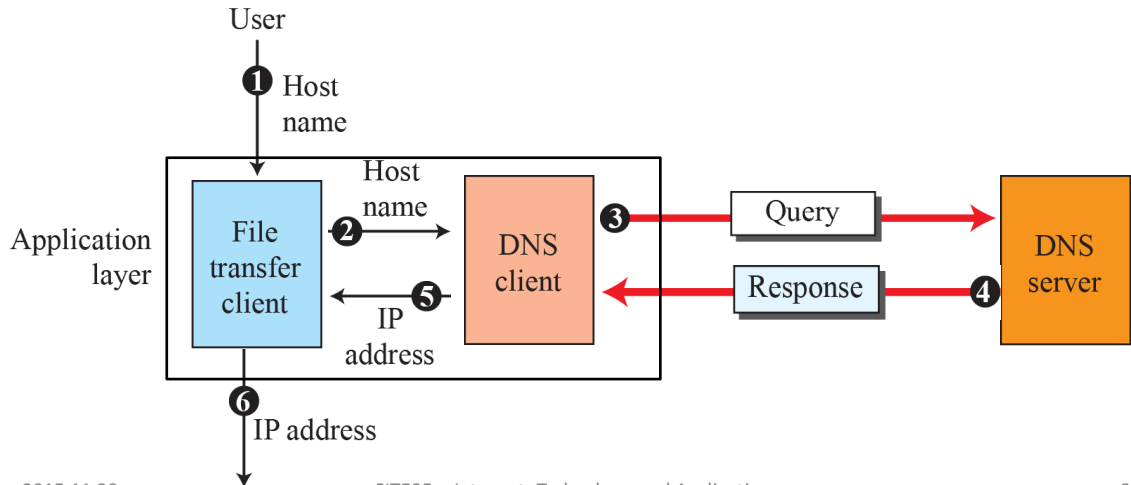
*\*[Kihl & Andersson: 7.5, 7.7, 7.9, 12.4]*

# Mapping host name to IP address

- Application protocols use host names
- TCP/IP protocol suite uses IP addresses
- Mapping from host name to IP addresses
- Domain Name System (DNS) 
  - Domain name space
  - Domain name resolution
- [www.lth.se](http://www.lth.se)  $\equiv$  130.235.209.220

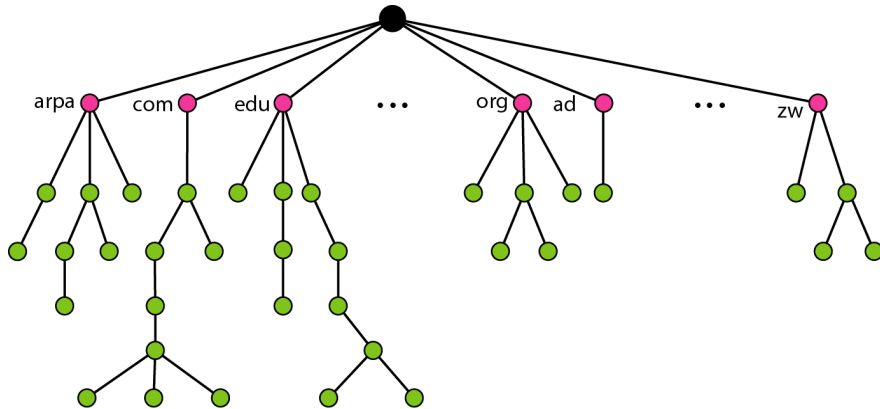
# Domain Name System (DNS)

- Internet's telephone book: Address  $\leftrightarrow$  name
  - One of the most important systems on the Internet

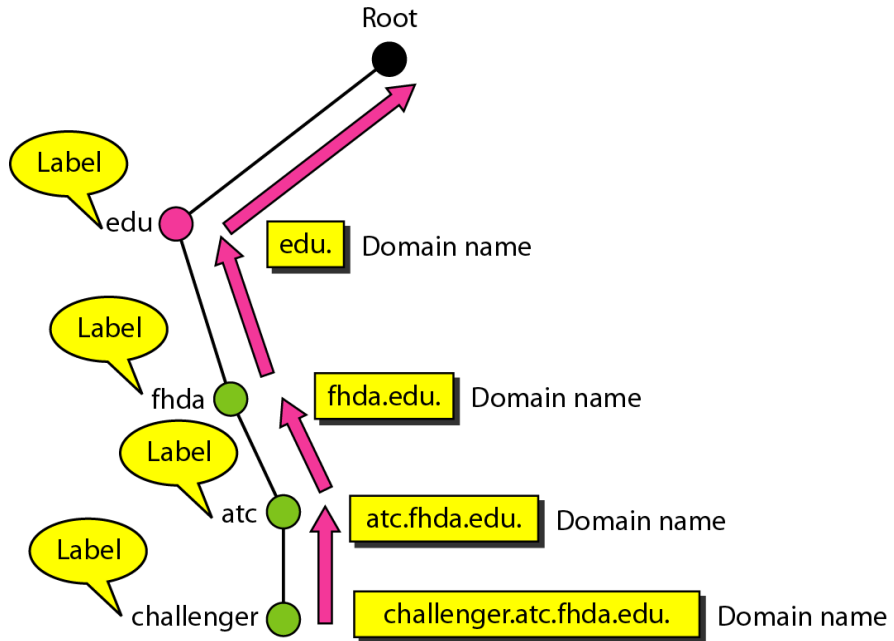


# Domain name space

- Names must be unique
  - Complete control needed

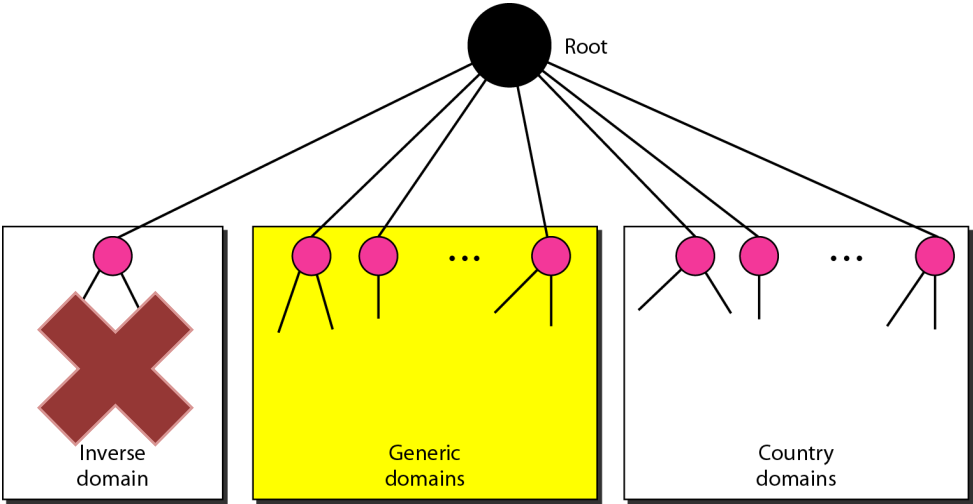


# Domain names and labels

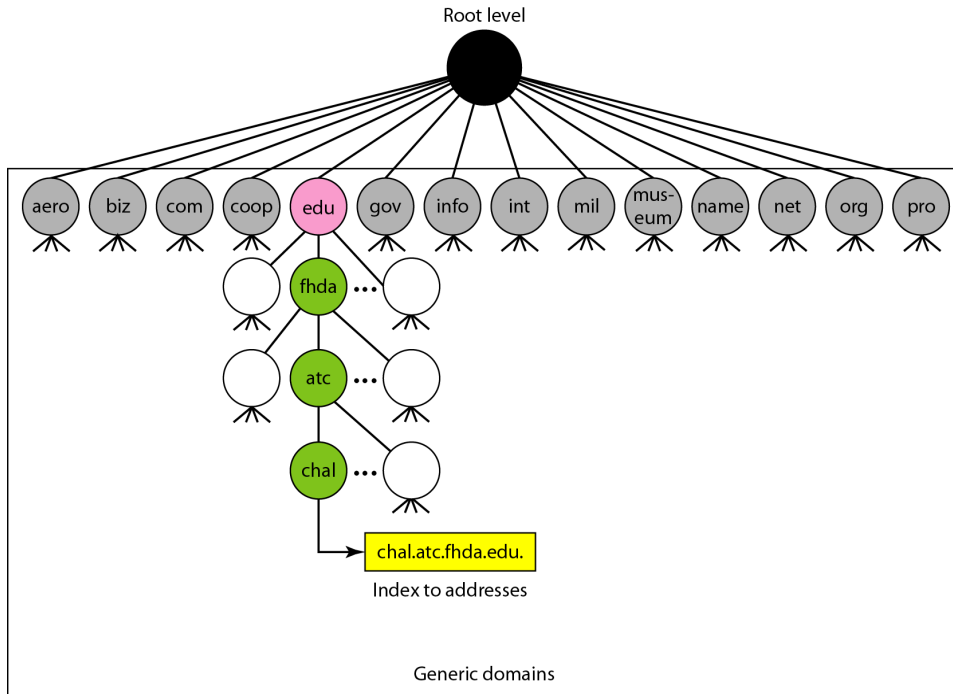




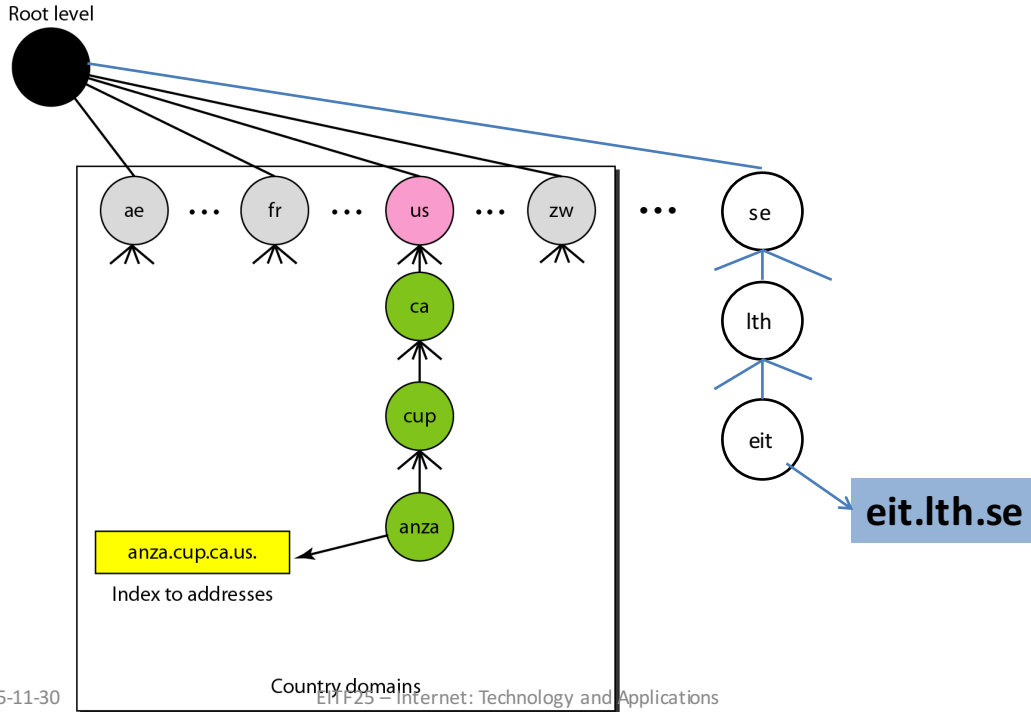
# Internet domains



# Generic domains

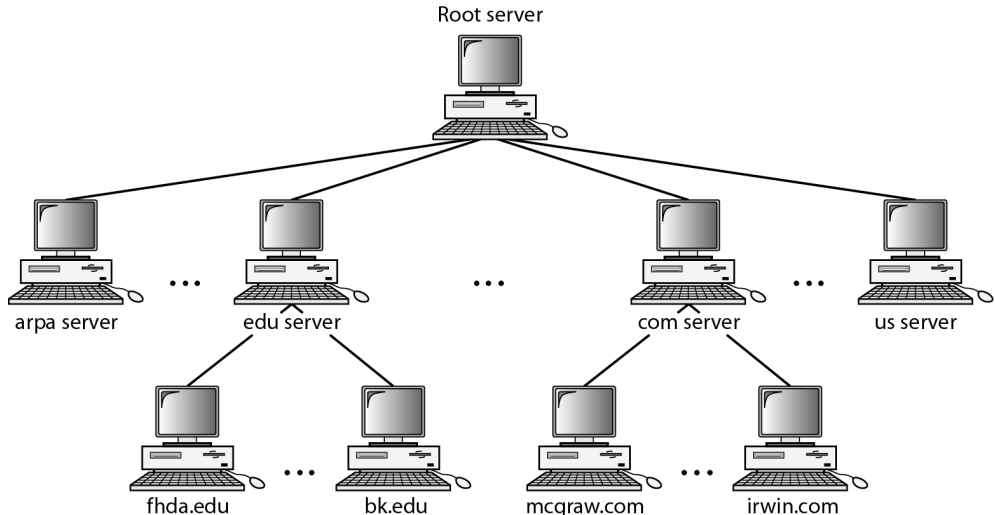


# Country domains



# Hierarchy of domain name servers

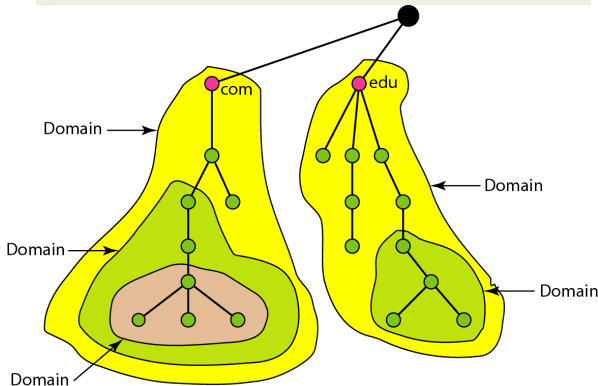
- 13 logical root name servers
  - implemented by 376 physical servers



# Domains, subdomains, zones

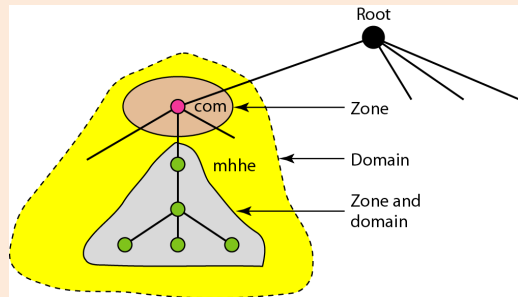
## Domain

- Subtree of DNS



## Zone

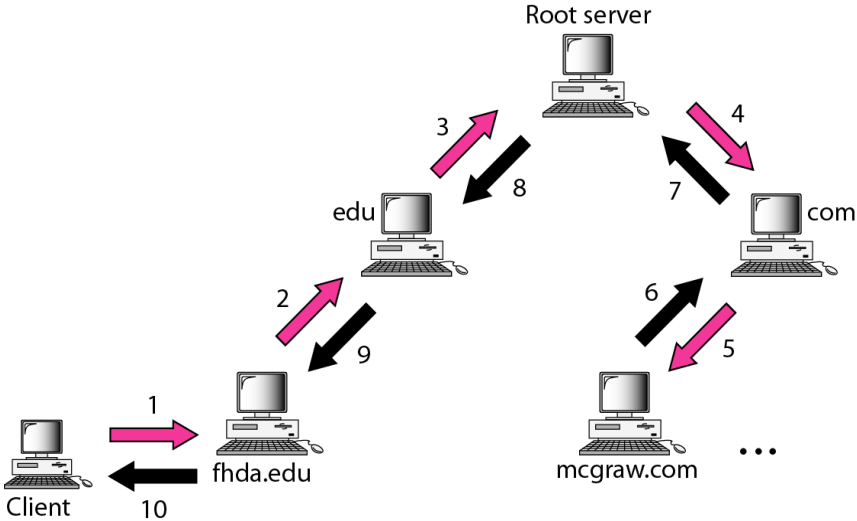
- Servers' control area



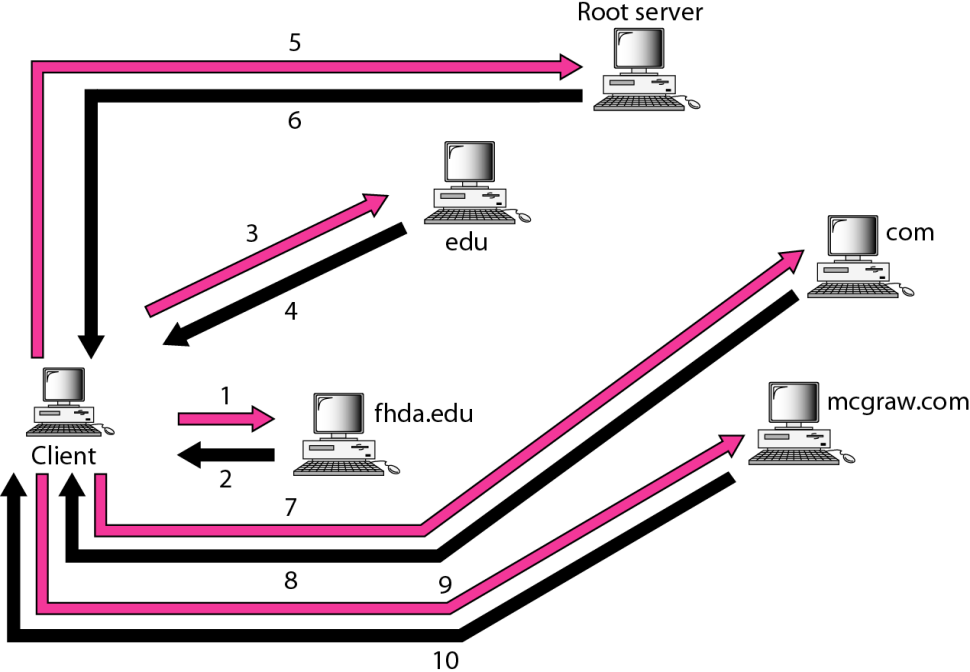
# Domain name resolution

- Action of address mapping
  - Client = resolver
  - Server = DNS
- One server cannot have all the answers!
  - How to ask others?
  - What to do with the answer?
- Caching
  - Remember what you've learned!

# Recursive resolution

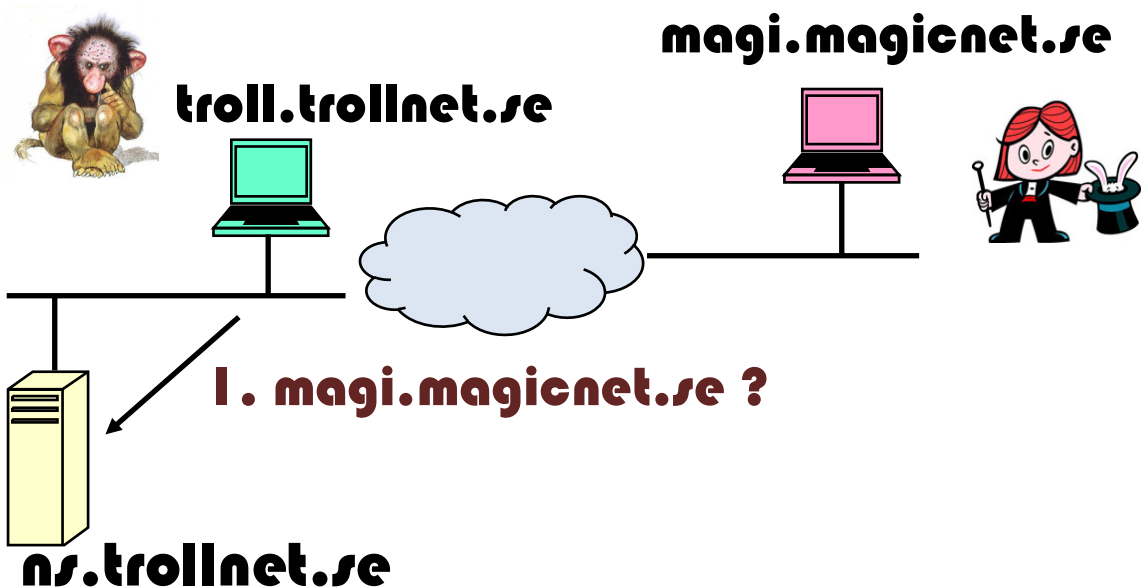


# Iterative resolution

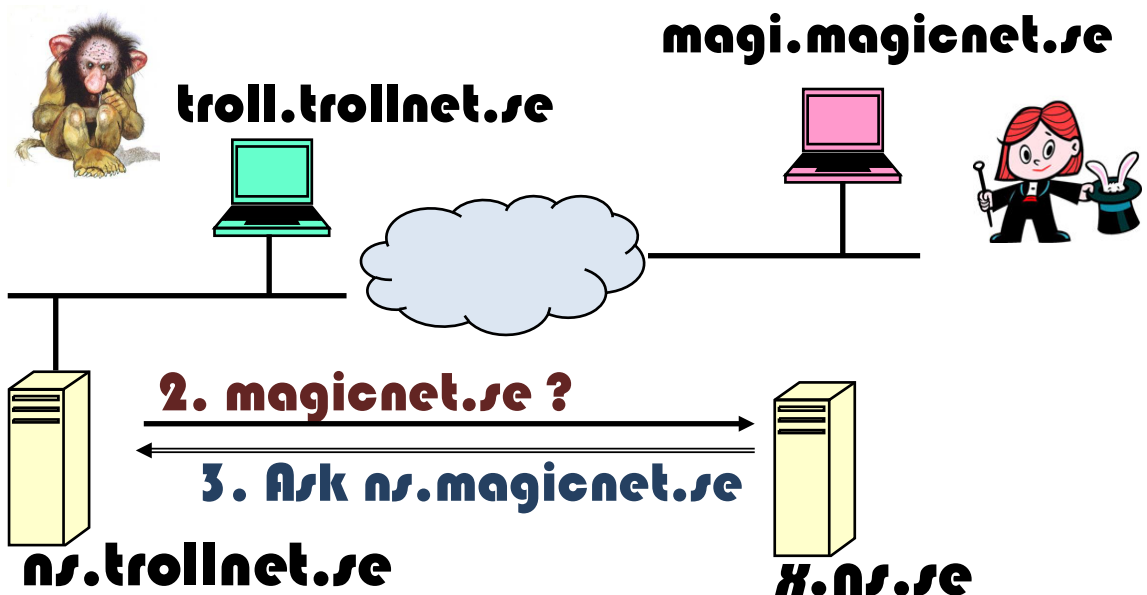




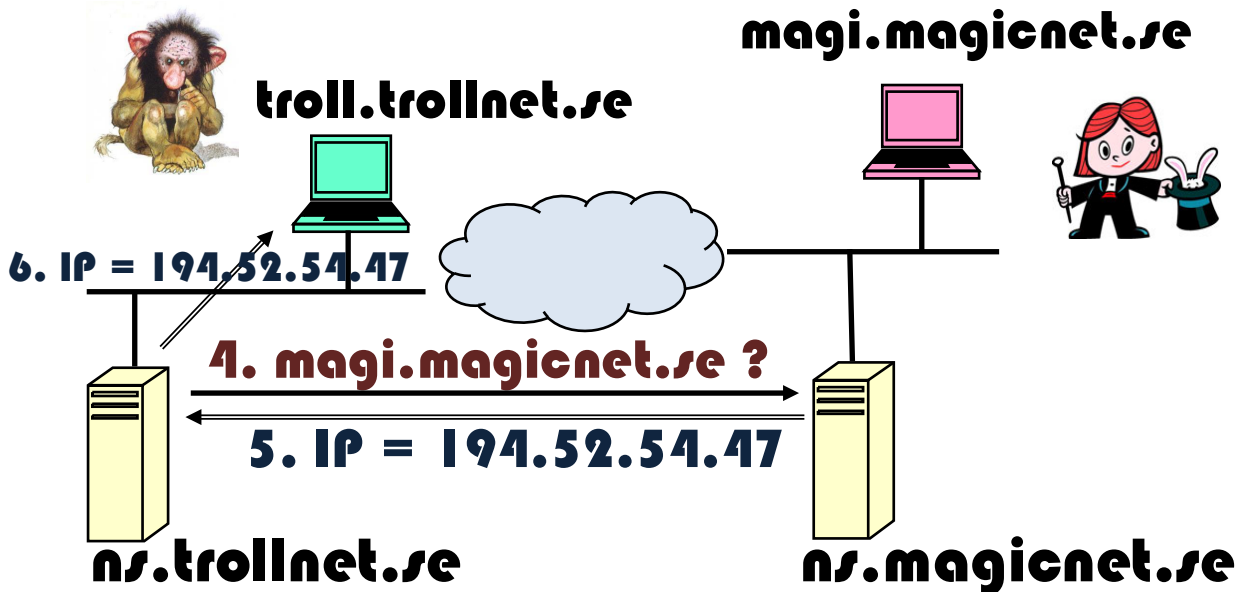
# Domain name to IP address (1)



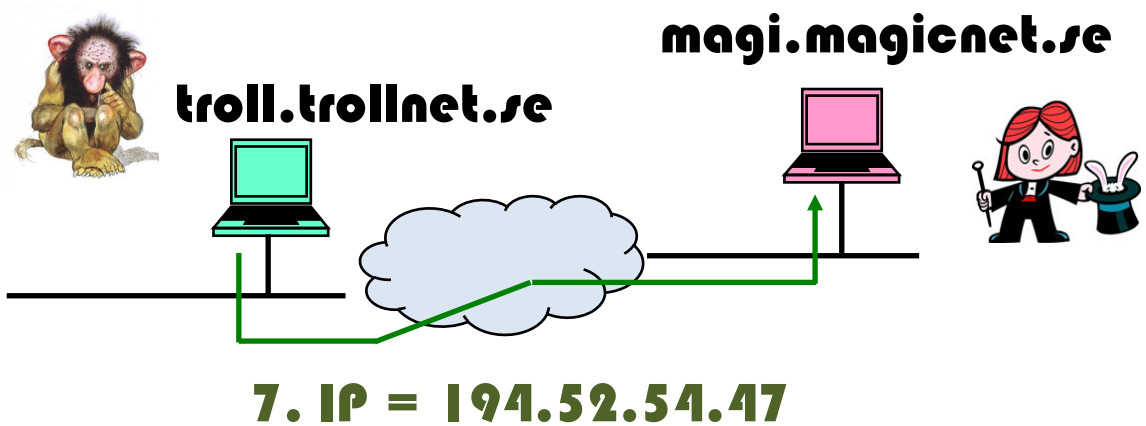
# Domain name to IP address (2)



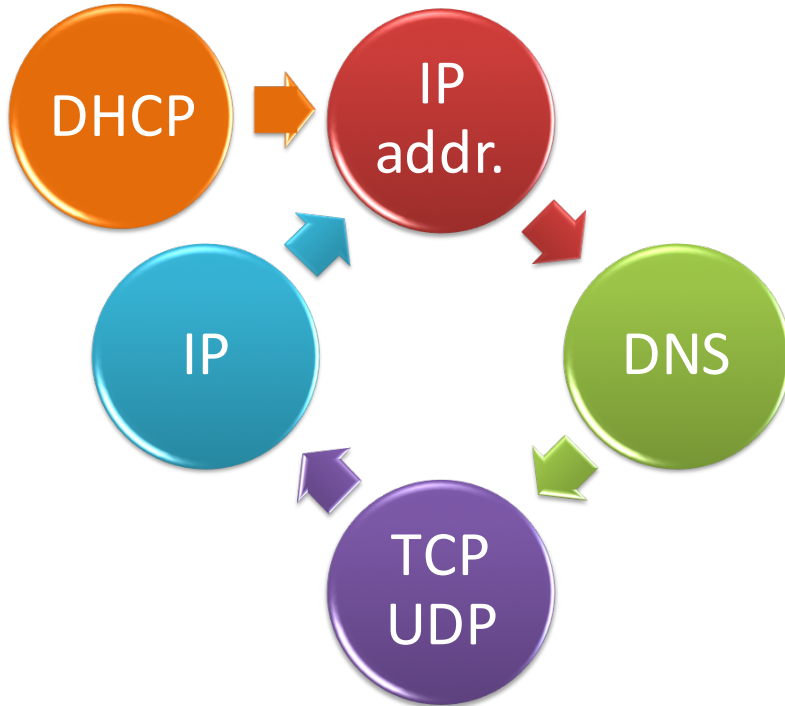
# Domain name to IP address (3)



# Domain name to IP address (4)



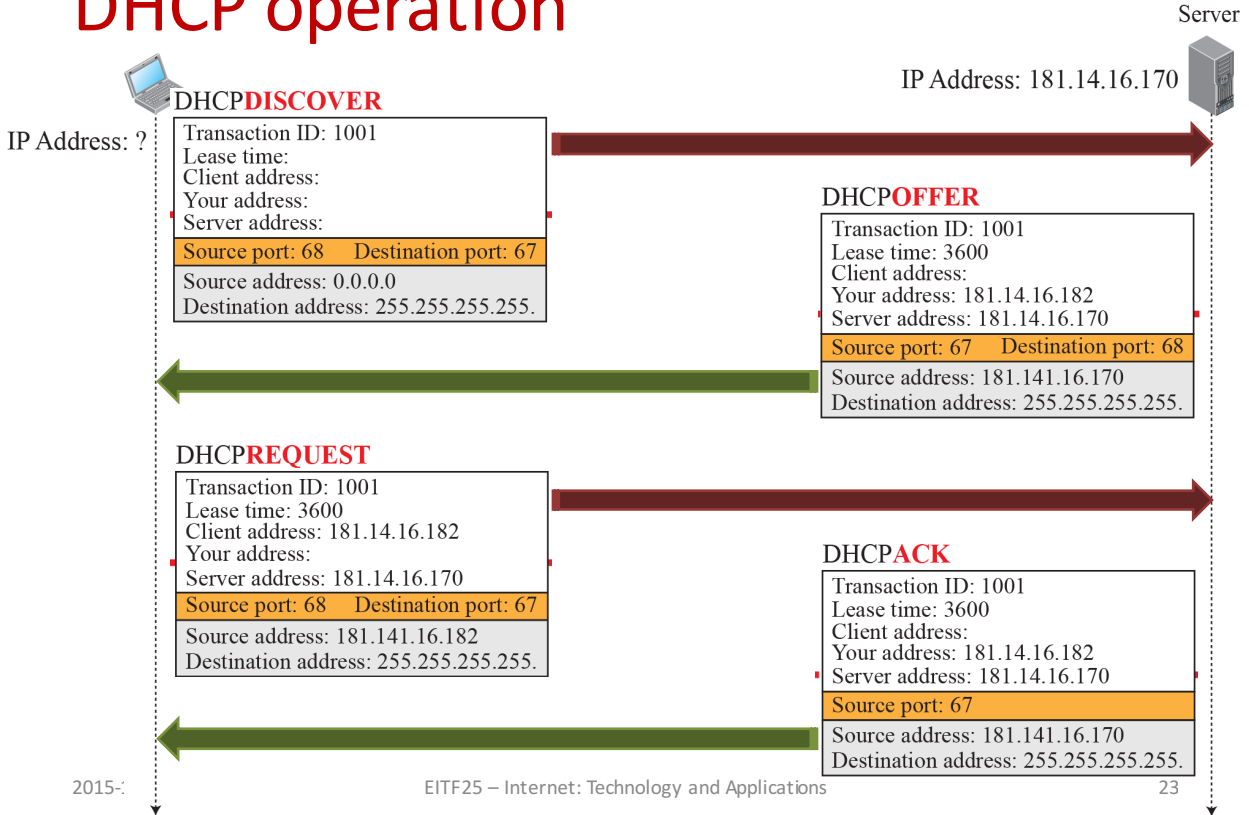
# *Exercise: Break this vicious cycle!*



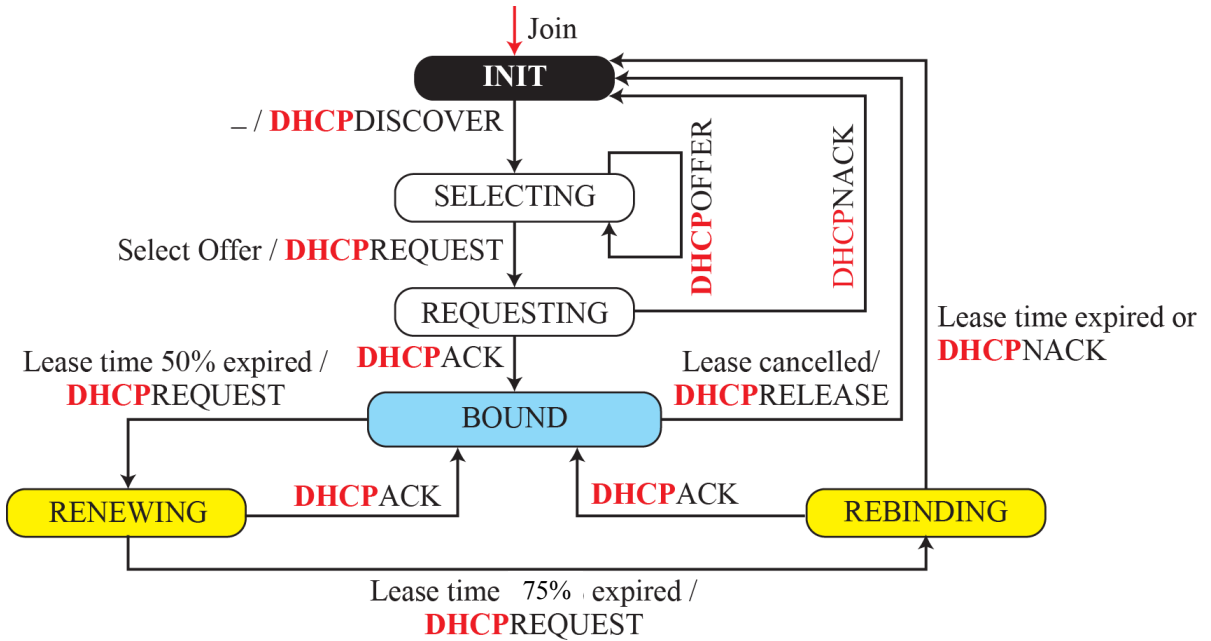
# Obtaining an IP address

- Dynamic Host Configuration Protocol
  - Application layer
- DHCP
  - IP address
    - Allocation from pool or static
  - Network mask
  - Default gateway
  - DNS server(s)

# DHCP operation



# DHCP states





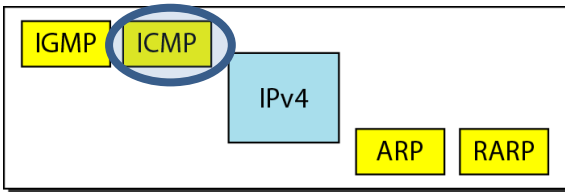
# See you in 15' :)



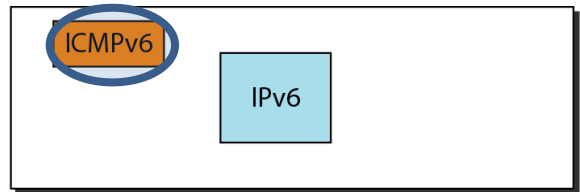
- After the break
  - Network debugging
  - ICMP
  - World-wide web

# Debugging Tools

- Applications used for debugging
- Two examples
  - Ping
  - Traceroute

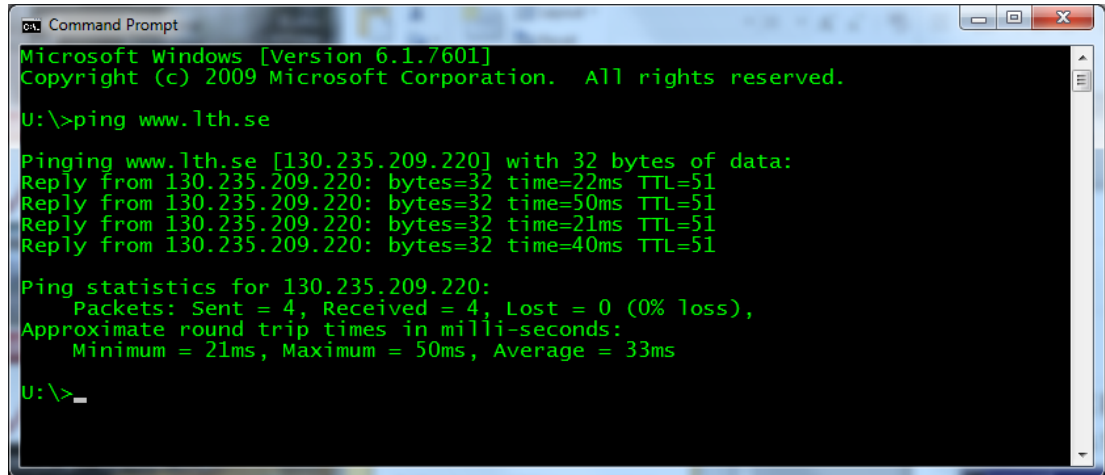


Network layer in version 4



Network layer in version 6

# Ping



```
Microsoft Windows [Version 6.1.7601]
Copyright (c) 2009 Microsoft Corporation. All rights reserved.

U:\>ping www.lth.se

Pinging www.lth.se [130.235.209.220] with 32 bytes of data:
Reply from 130.235.209.220: bytes=32 time=22ms TTL=51
Reply from 130.235.209.220: bytes=32 time=50ms TTL=51
Reply from 130.235.209.220: bytes=32 time=21ms TTL=51
Reply from 130.235.209.220: bytes=32 time=40ms TTL=51

Ping statistics for 130.235.209.220:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 21ms, Maximum = 50ms, Average = 33ms

U:\>_
```

# Traceroute

```
Command Prompt

U:\>tracert www.lth.se

Tracing route to www.lth.se [130.235.209.220]
over a maximum of 30 hops:

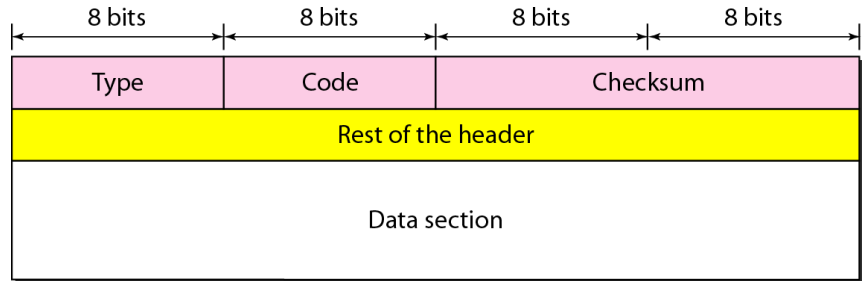
  1    92 ms    97 ms    100 ms    dslddevice.lan [192.168.1.1]
  2     7 ms     6 ms     5 ms     gw-n1-m-sp-a31.ias.bredband.telia.com [217.209.99.129]
  3     8 ms     3 ms     6 ms     m-sp-d4-link.se.telia.net [81.228.79.4]
  4     5 ms    16 ms    11 ms    ld-h-c5-link.se.telia.net [81.228.74.117]
  5    15 ms    19 ms    23 ms    hy-c5-link.se.telia.net [81.228.75.246]
  6    11 ms    22 ms    13 ms    fre-peer3-link.se.telia.net [81.228.94.84]
  7    17 ms    31 ms    16 ms    se-fre.nordu.net [109.105.98.65]
  8    65 ms    12 ms    60 ms    tlfre.sunet.se [109.105.102.10]
  9    14 ms    12 ms    34 ms    mlfre-ael-v1.sunet.se [130.242.83.45]
 10   29 ms    22 ms    46 ms    lu-br1-xe-1-2-0.sunet.se [130.242.85.2]
 11   29 ms    30 ms    34 ms    lu-g.sunet.se [193.11.20.10]
 12   44 ms    54 ms    35 ms    c002--x001.net.lu.se [130.235.217.13]
 13   38 ms    36 ms    23 ms    d001b--c001.net.lu.se [130.235.217.46]
 14   23 ms    23 ms    25 ms    nova.kansli.lth.se [130.235.209.220]

Trace complete.

U:\>_
```

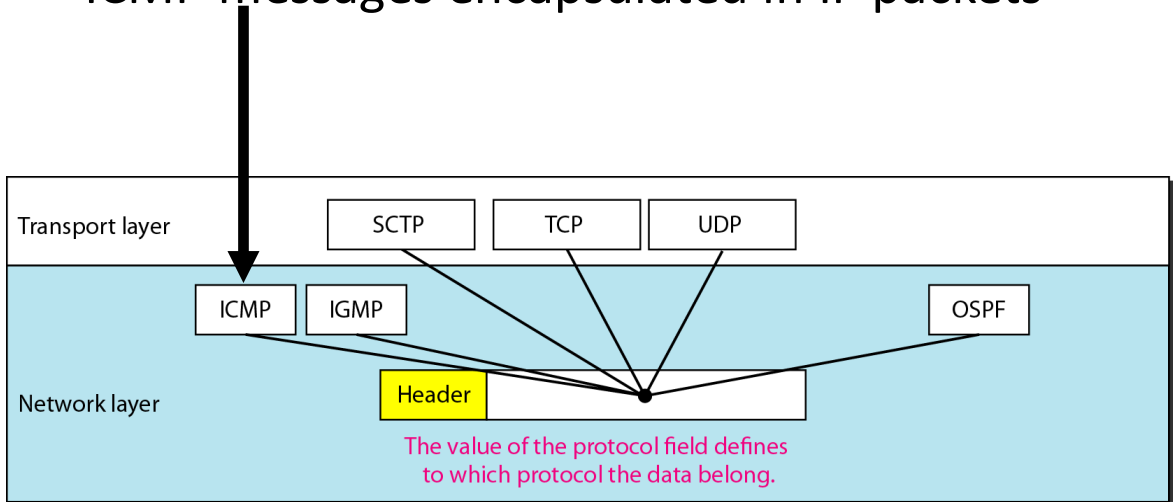
# Internet Control Message Protocol

- **ICMP**
- Support protocol for IP
  - Error reporting
  - Query



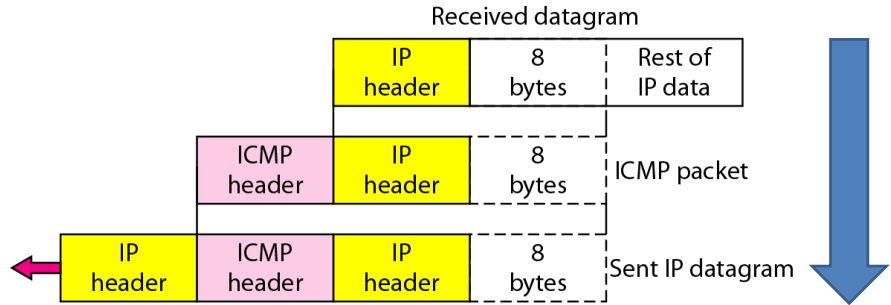
# Encapsulation

- ICMP messages encapsulated in IP packets

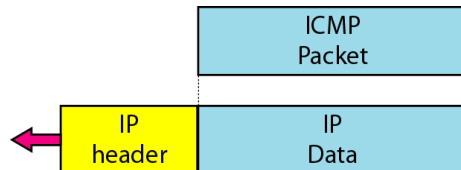


# ICMP message formats

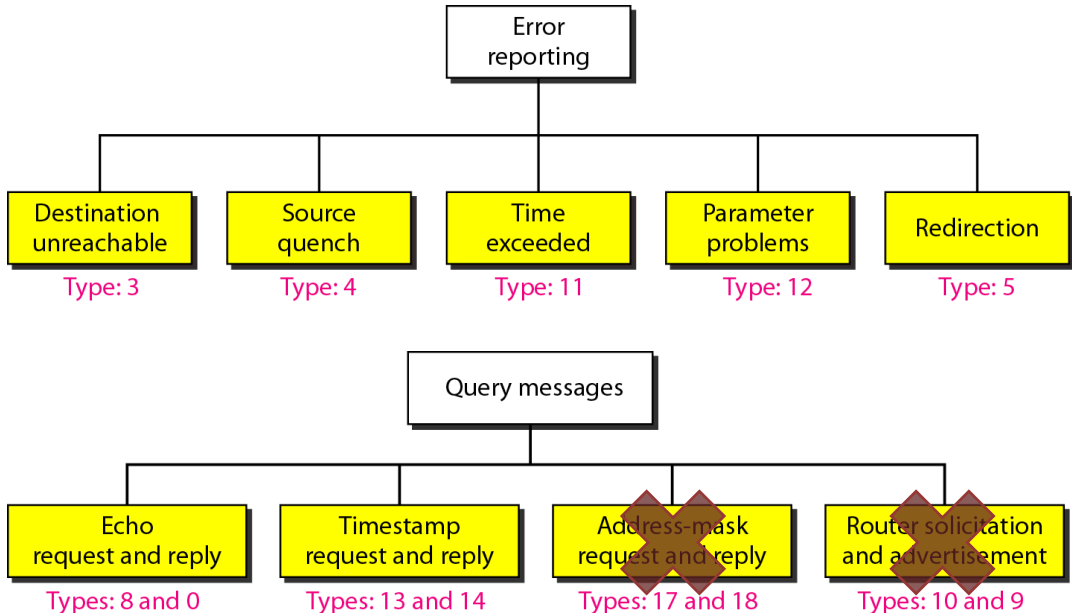
- Error reporting



- Query messages



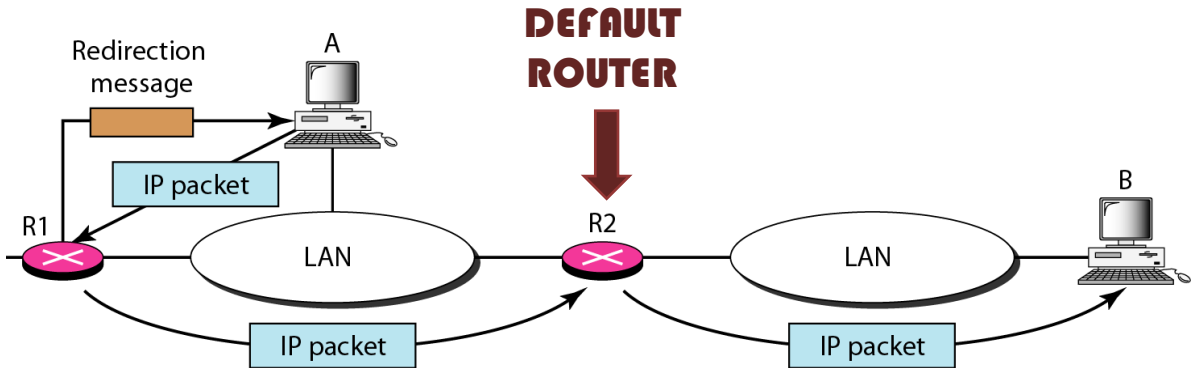
# ICMPv4 message types





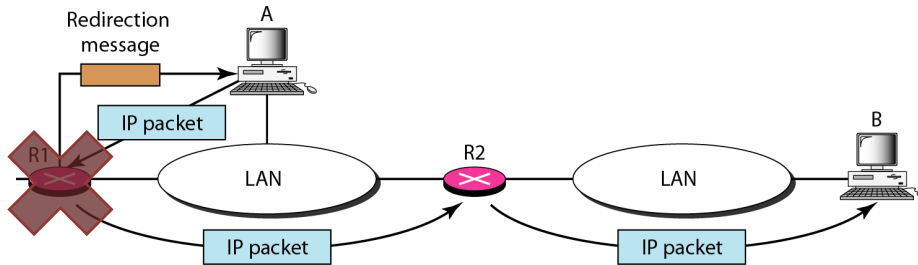
# Redirection (error reporting type)

- Routing update for hosts
  - More efficient when too many hosts



# Exercise: ICMP in action

**Q:** In what kind of network can a host never receive a redirection message?



**A:** In a network with only one router

# Echo request and reply (query type)

- Is my destination alive?
- Network diagnostics
  - IP layer
- Debugging tools
  - Ping
  - Traceroute

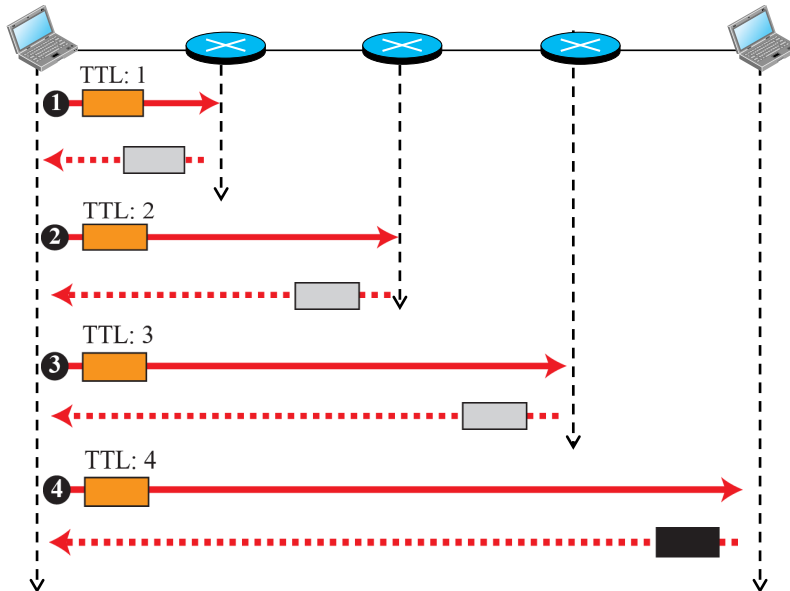
# Traceroute

- Used to trace a packet's route from source to destination
- Uses three ICMP messages
  - Echo Request (query)
  - Time Exceeded (error)
  - Destination Unreachable (error)
- Manipulates TTL field in IP header
- Uses **'wrong'** port number

# Traceroute

## Message types

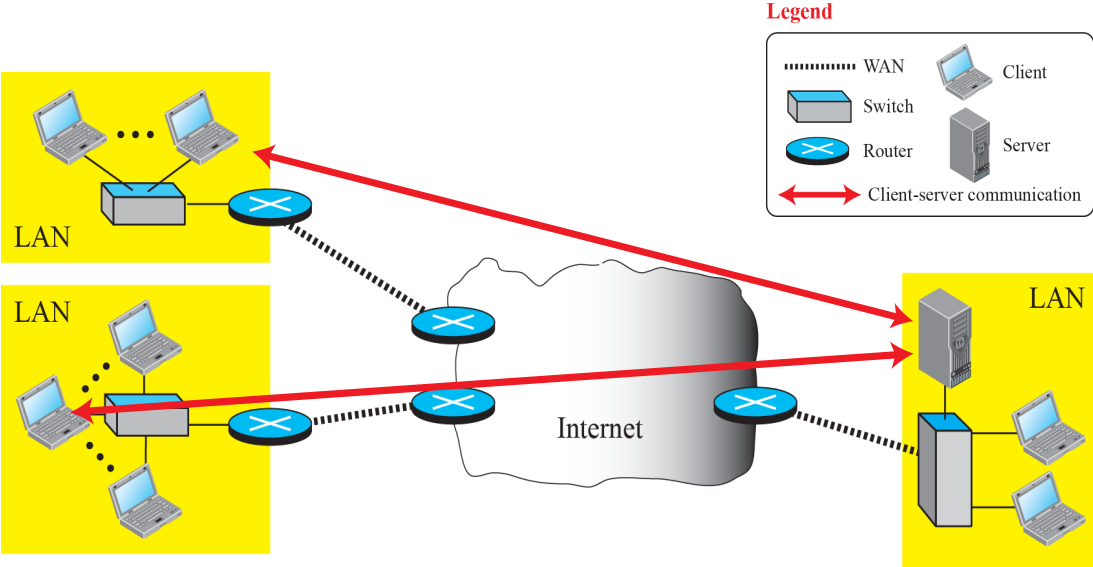
- Echo request
- Time-exceeded
- Destination-unreachable



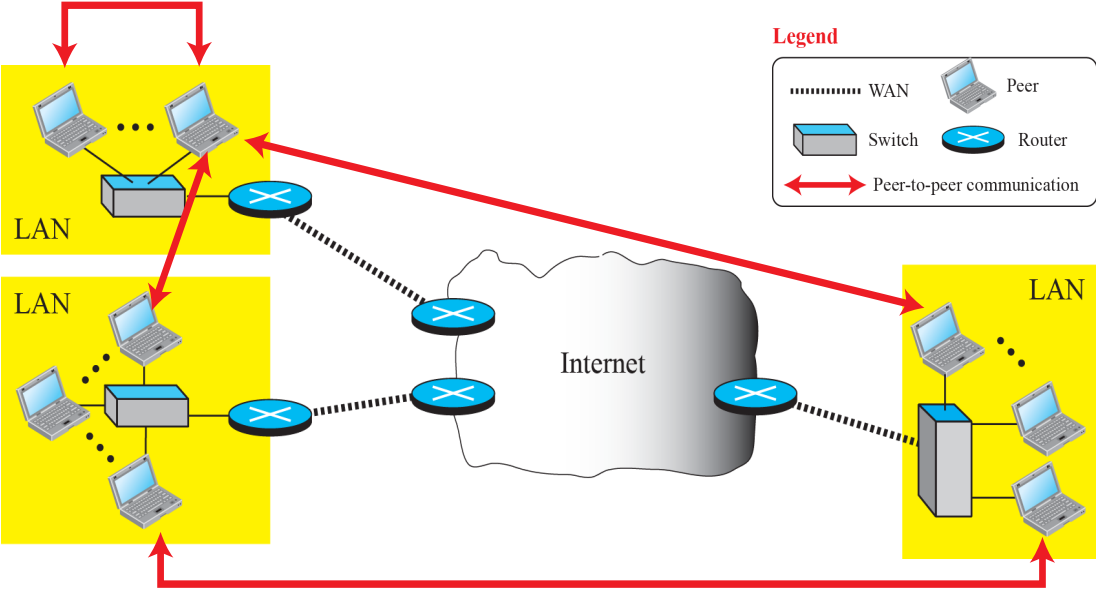
# Application layer paradigms

- Client-server paradigm
  - WWW, Online games, Web TV, Facebook
- Peer-to-peer paradigm
  - BitTorrent, Voddler, Skype
- Some applications use both paradigms
  - Spotify

# Client-server paradigm



# Peer-to-peer paradigm





# Application: WWW

- The idea of the World-Wide Web (WWW) was first proposed by Tim Berners-Lee in 1989 at CERN, the European Organization for Nuclear Research
- The purpose was to allow all CERN researchers at different locations throughout Europe to access each others' results
- The commercial Web started in 1993.

# Components of WWW

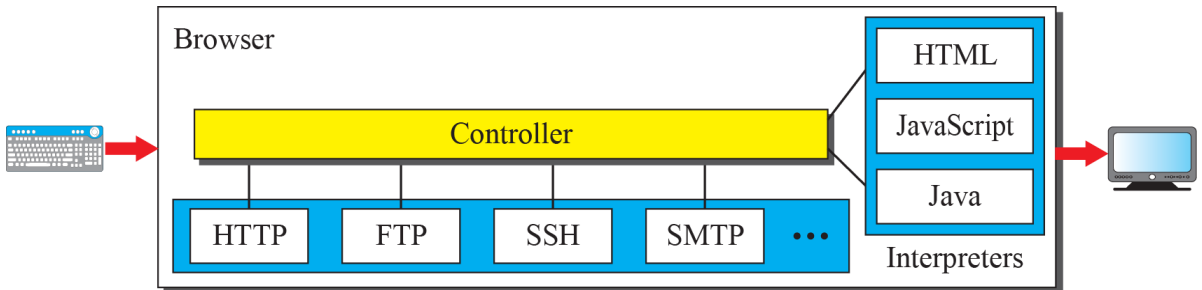
- Web documents (pages)
  - HyperTextMarkup Language (HTML) for static web pages
  - Script languages (PHP, ASP, JSP, CGI etc.) for dynamic
- Universal Resource Locator (URL)
  - Standard way to identify location of web documents
- HyperText Transfer Protocol (HTTP)
  - Protocol to access documents on a web server

# Universal Resource Locator (URL)

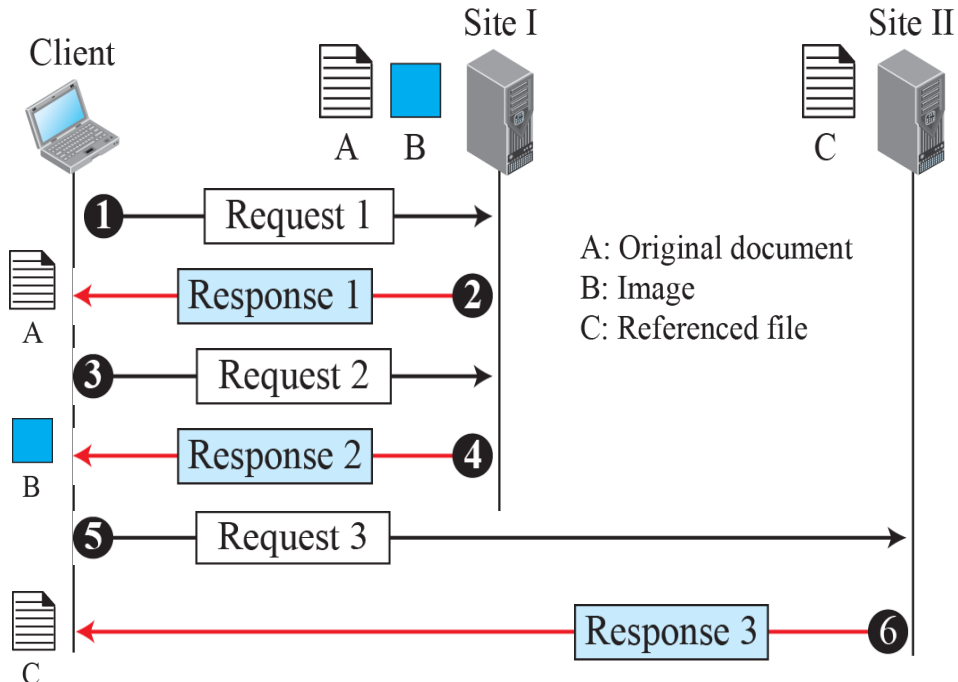
- A web document has four identifiers
  - Protocol, Host, Port and Path.
- A URL is defined as
  - [protocol://host:port/path](#)
- Standard HTTP port 80 is omitted
  - <http://www.eit.lth.se/course/eitf25>

# Hypertext Transfer Protocol (HTTP)

- Text-based protocol
- Two basic types of messages
  - Requests and Responses
- Sets up and uses a TCP connection

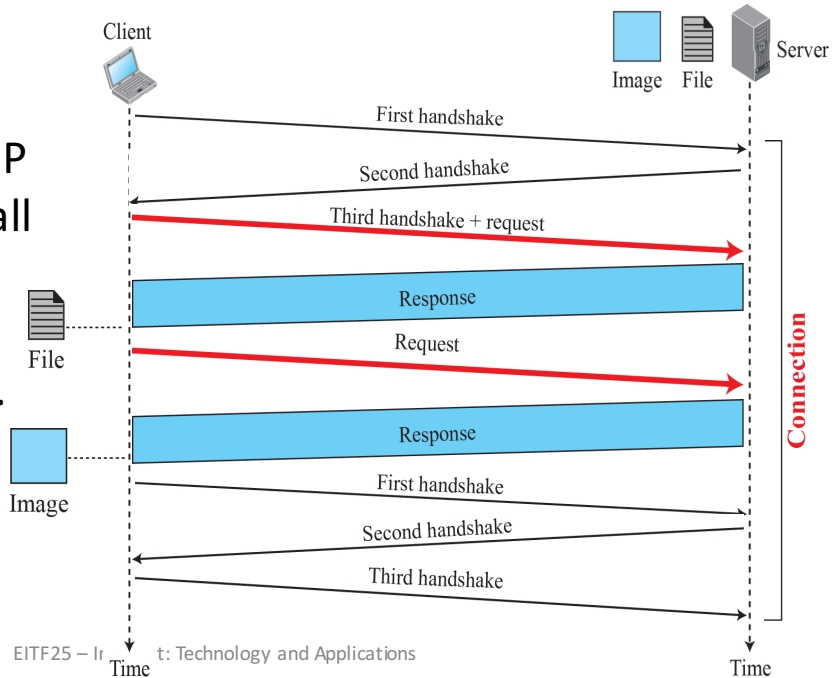


# Document retrieval

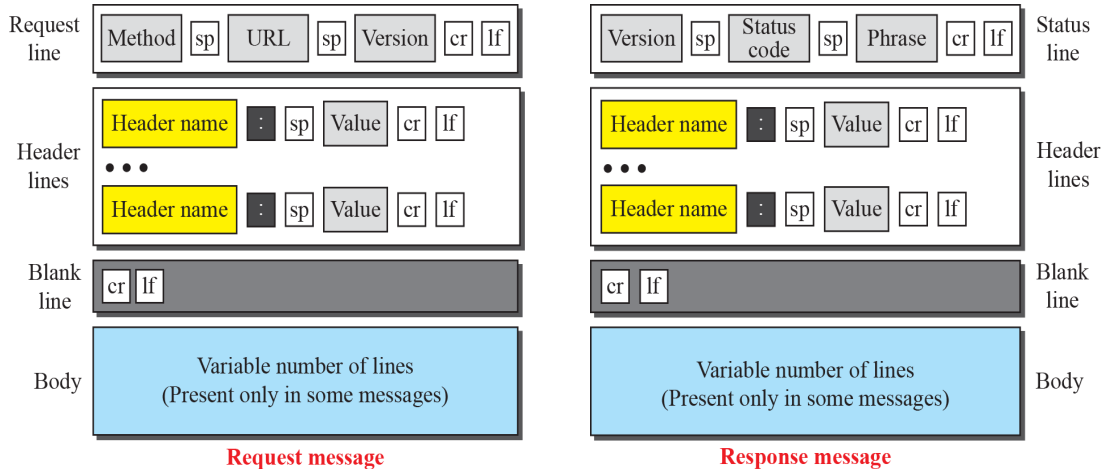


# Operation of HTTP 1.1

- Persistent connection
  - Only one TCP session for all requests from the same server.



# HTTP request and response format



**Legend** sp: Space cr: Carriage Return lf: Line Feed

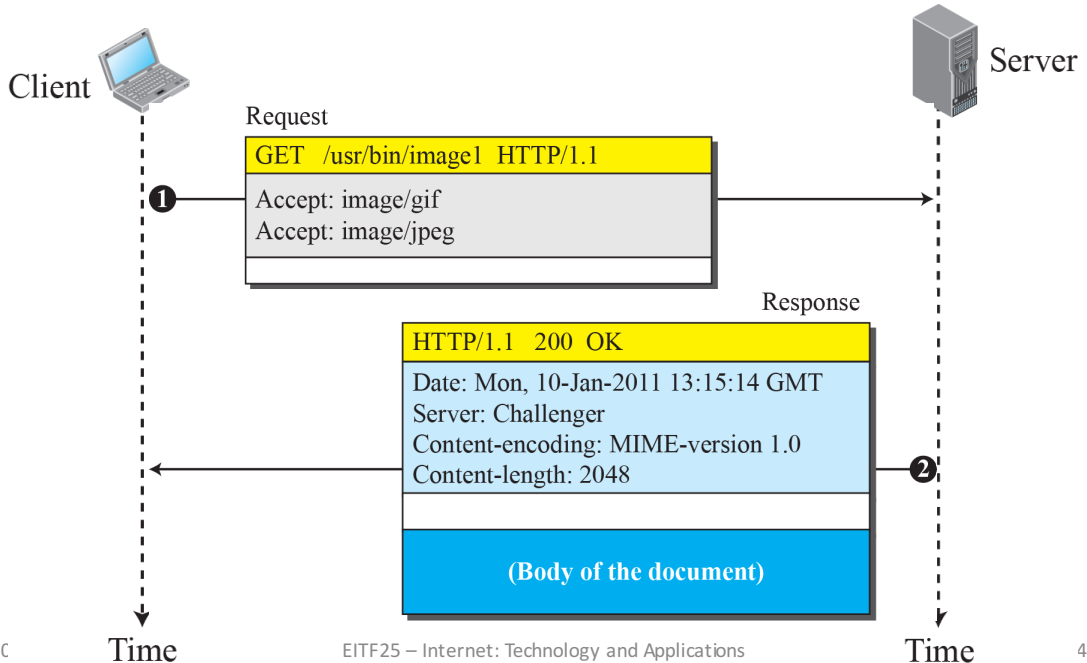
# HTTP methods in requests

- Using these 'methods', clients may request corresponding actions from server.

<i>Method</i>	<i>Action</i>
GET	Requests a document from the server
HEAD	Requests information about a document but not the document itself
PUT	Sends a document from the client to the server
POST	Sends some information from the client to the server
TRACE	Echoes the incoming request
DELETE	Removes the web page
CONNECT	Reserved
OPTIONS	Inquires about available options



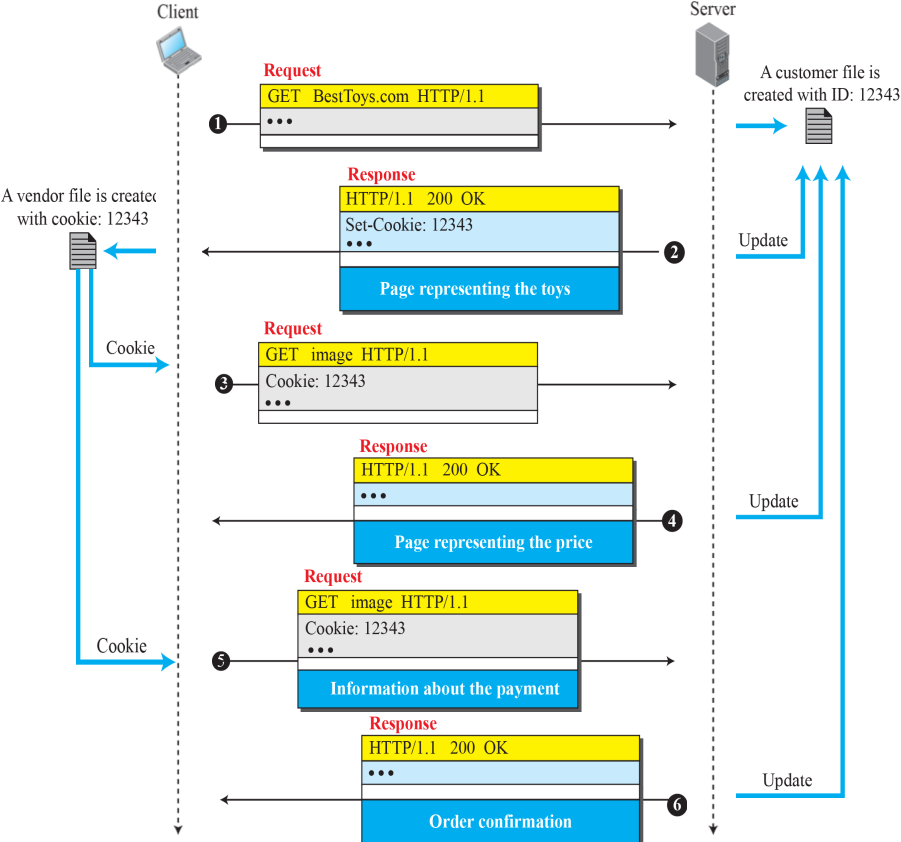
# Example request and response



# Cookies

- Original WWW was stateless
  - Each request/response treated separately
  - No history of previous messages
- Cookies
  - store information about client
  - introduce concept of a user session
- Implementation (creation and storage) of cookies can be different, but same concept

# Cookies



# Summary: Application Layer (1)

- Domain Name System
  - Mapping host names to IP addresses
- Host configuration
  - Obtaining an IP address
- Debugging tools
  - Ping, traceroute, ICMP
- Client-server vs. P2P applications
  - www, http, cookies