EITF25 – Internet: Technology and Applications

Application Layer
-1-
Network Tools

2013, Lecture 06

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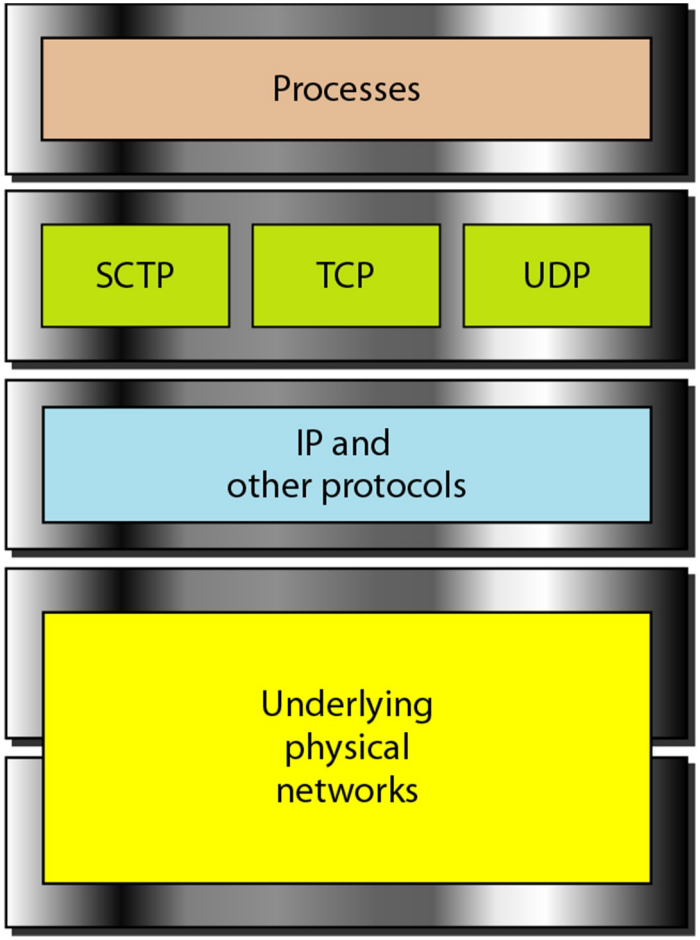
Previously on EITF25

Transport Layer

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



Today: Application Layer (1)

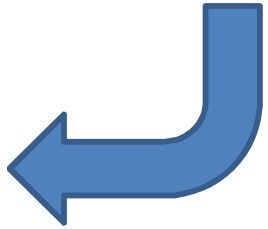
- Domain Name System, DNS
  [Forouzan ed.5 ch.26.6]
- Host Configuration, DHCP
  [Forouzan ed.5 ch.18.4.4]
- Debugging Tools, ICMP
  [Forouzan ed.5 ch.19.2]
- World-Wide Web, HTTP
  [Forouzan ed.5 ch.26.1]

**[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

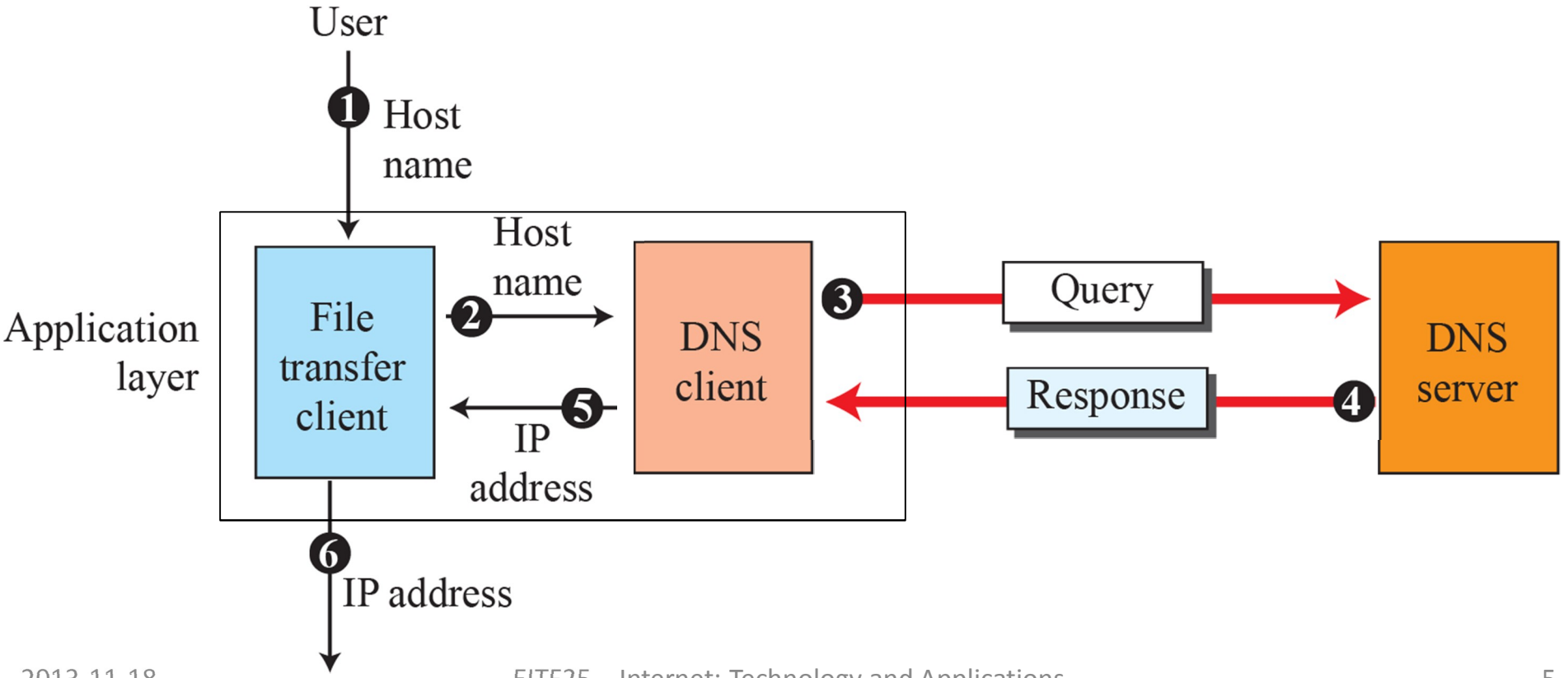
- Domain Name System (DNS)



  - Domain name space
  - Domain name resolution
- www.lth.se ≡ 130.235.209.220

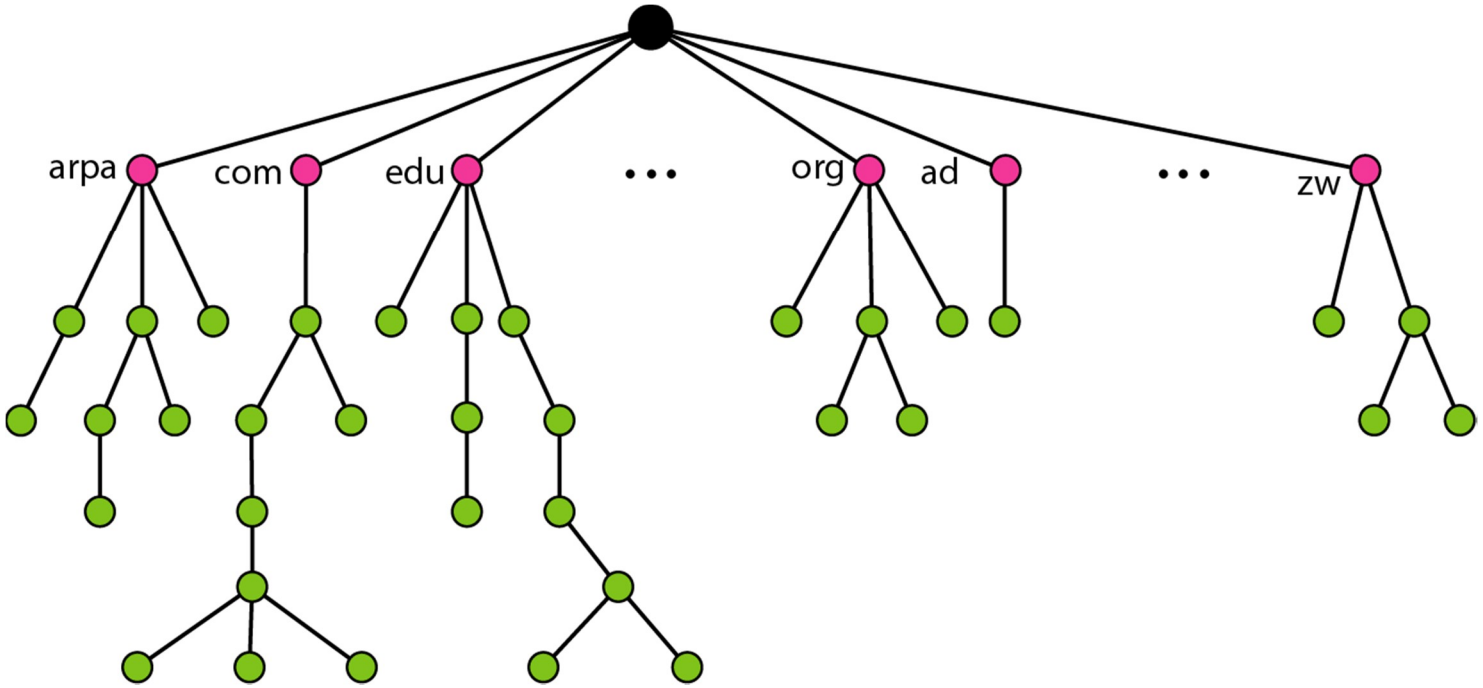
Domain Name System (DNS)

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

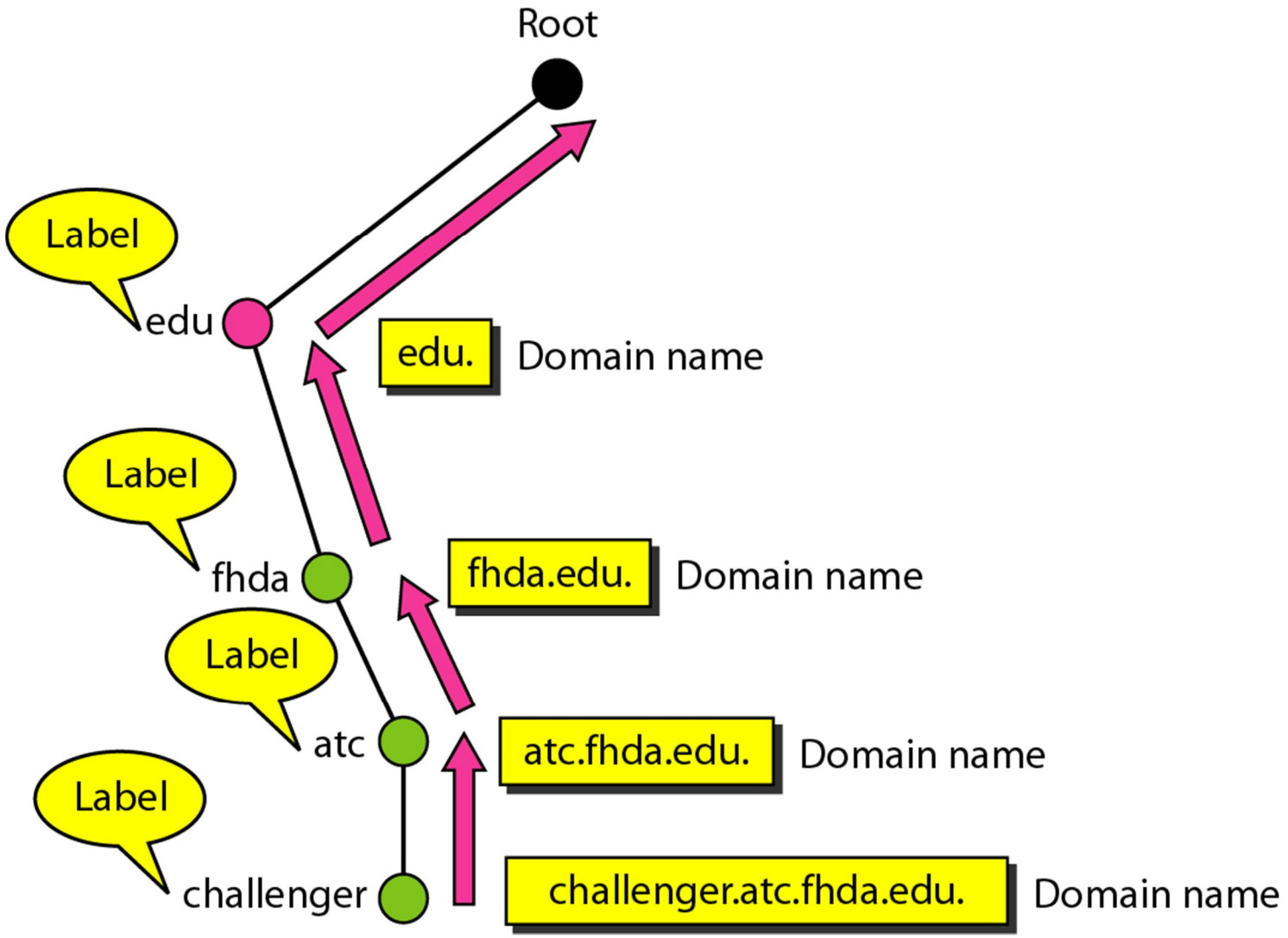


Domain name space

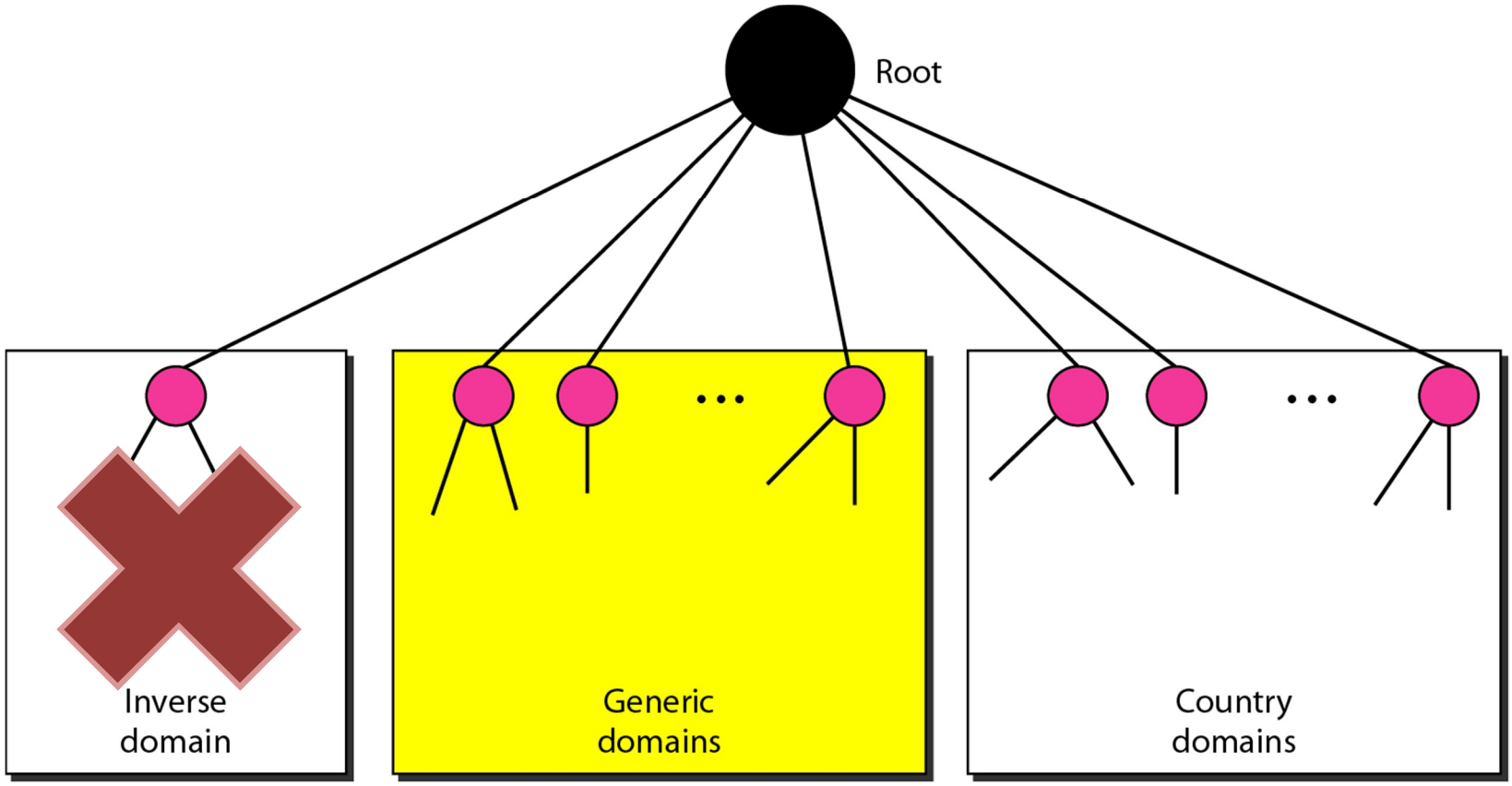
- Names must be unique
  - Complete control needed



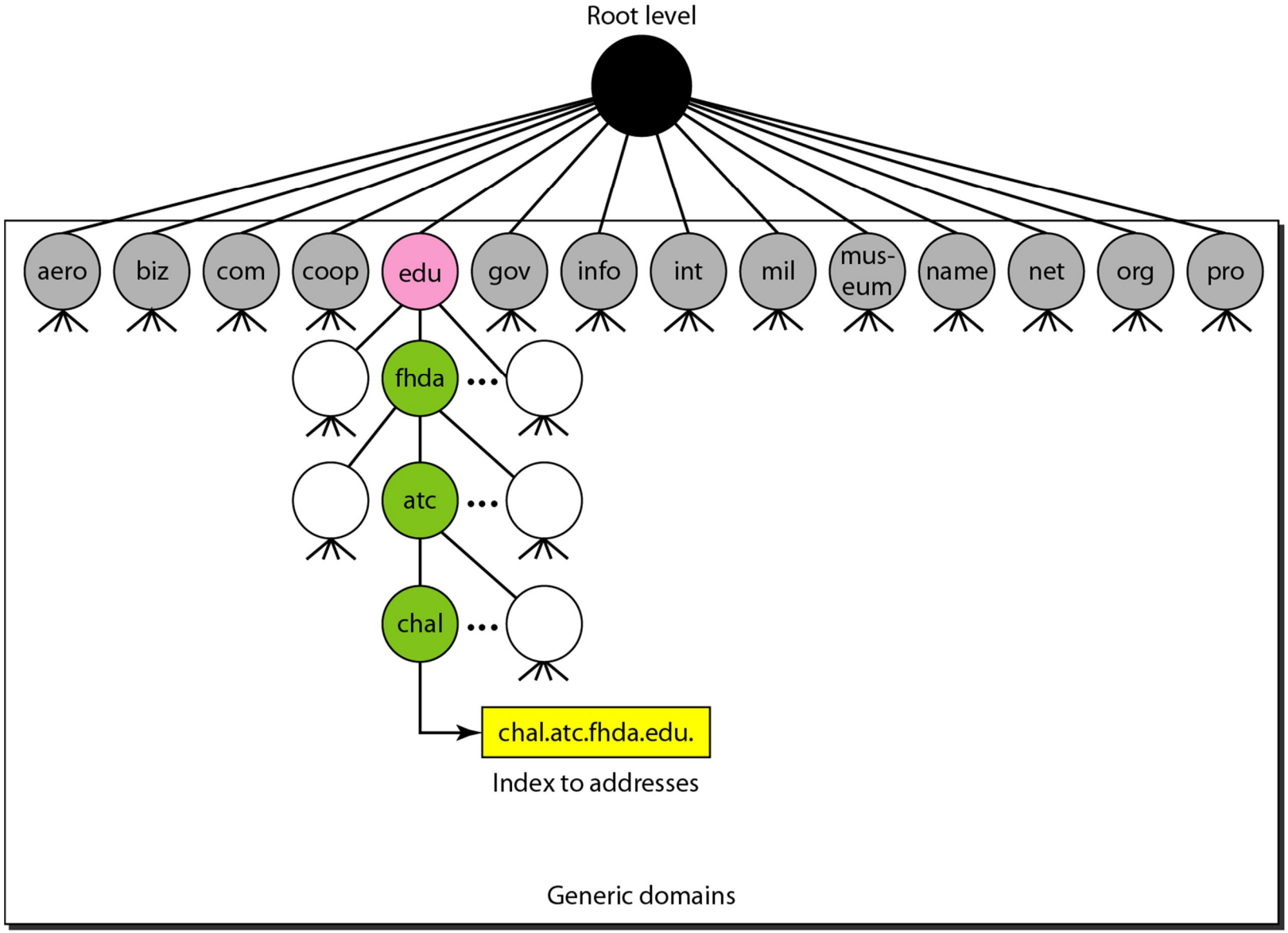
Domain names and labels



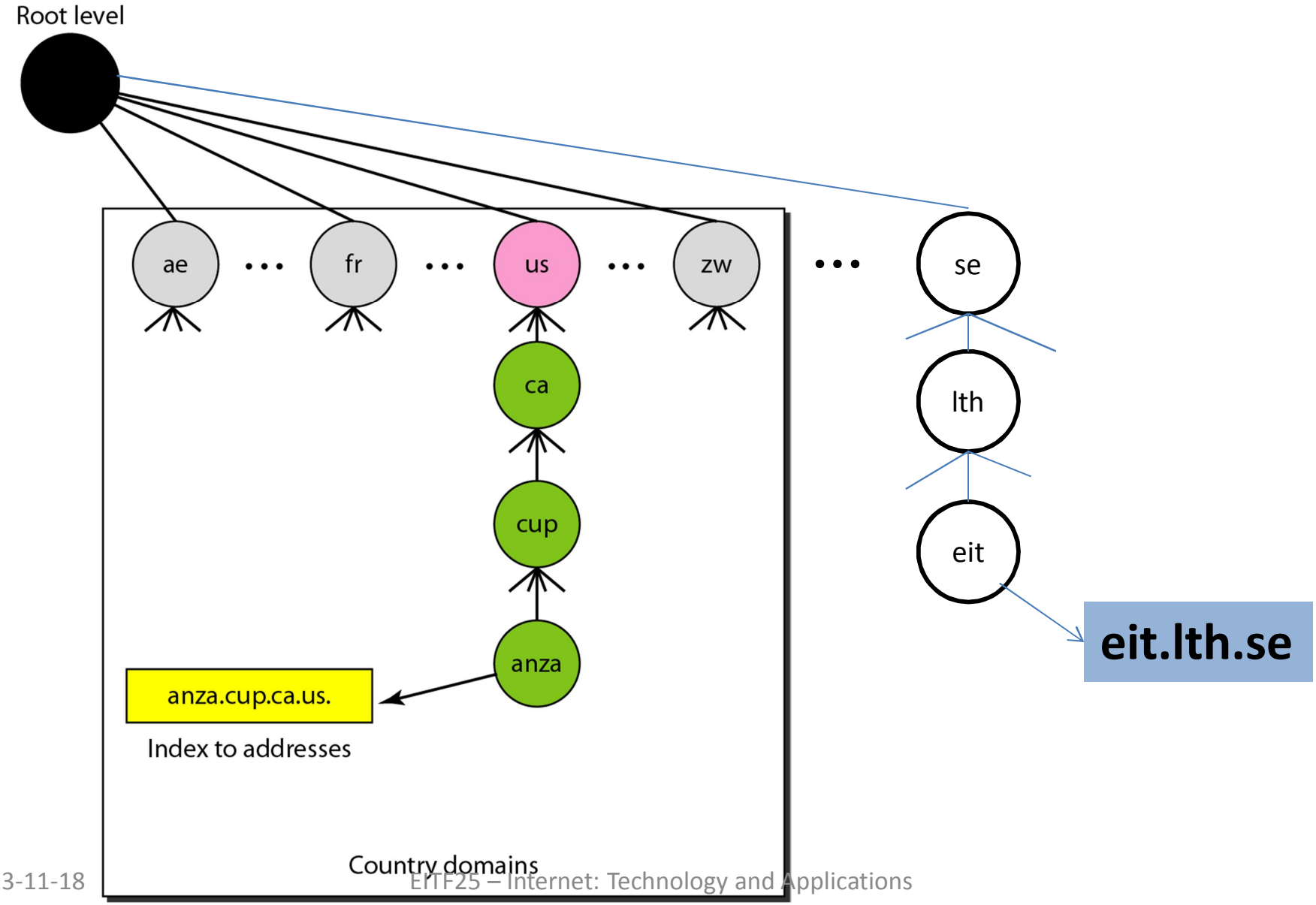
Internet domains



Generic domains

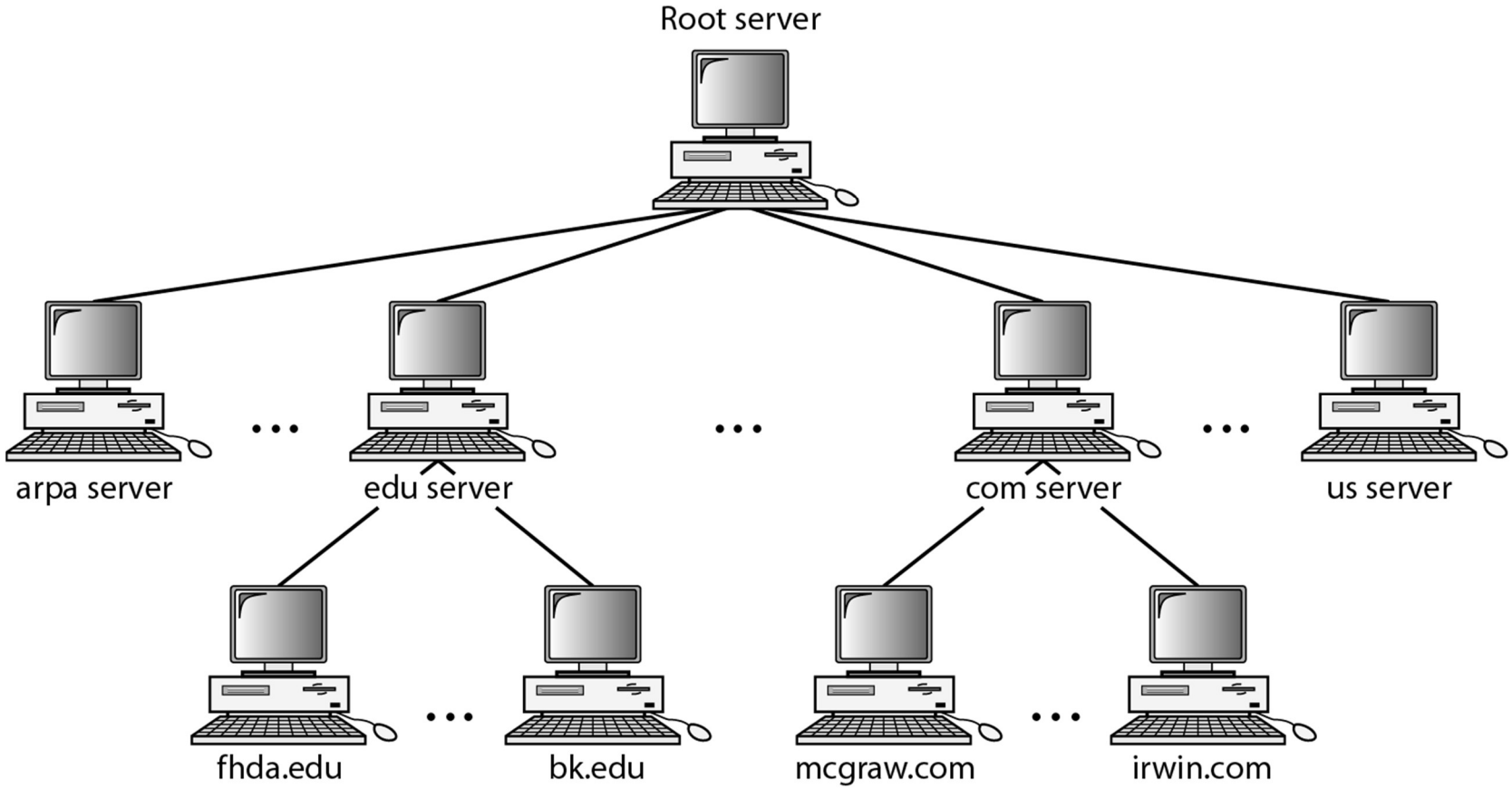


Country domains



Hierarchy of domain name servers

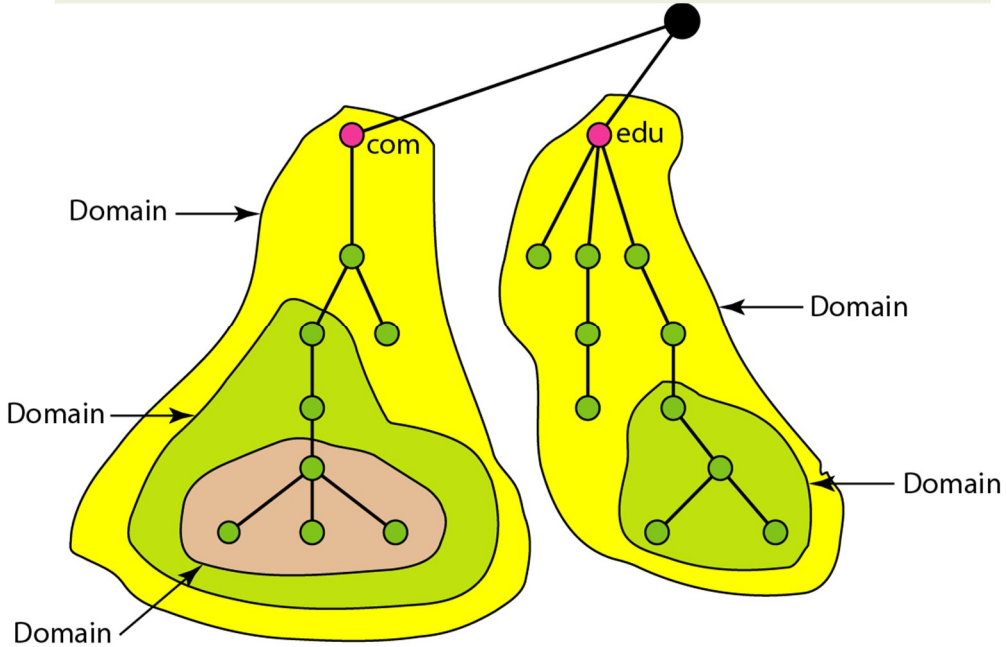
- 13 logical root name servers
  - implemented by 376 physic al servers



Domains, subdomains, zones

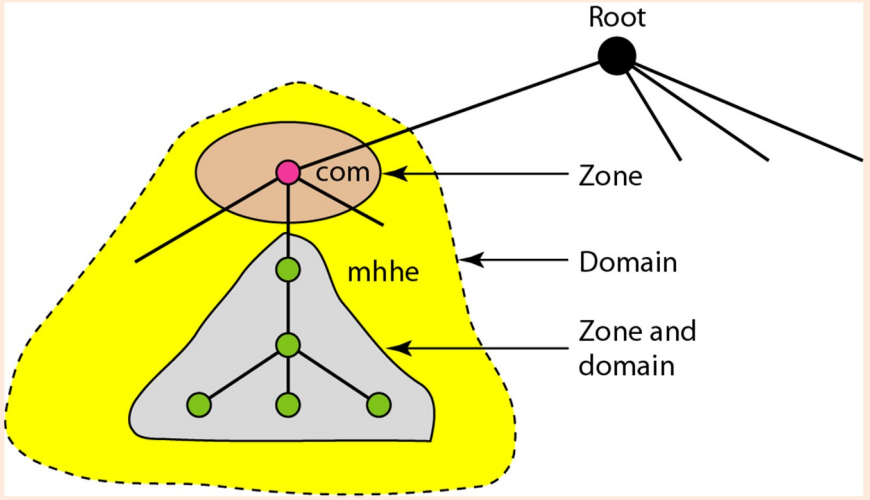
Domain

- Subtree of DNS



Zone

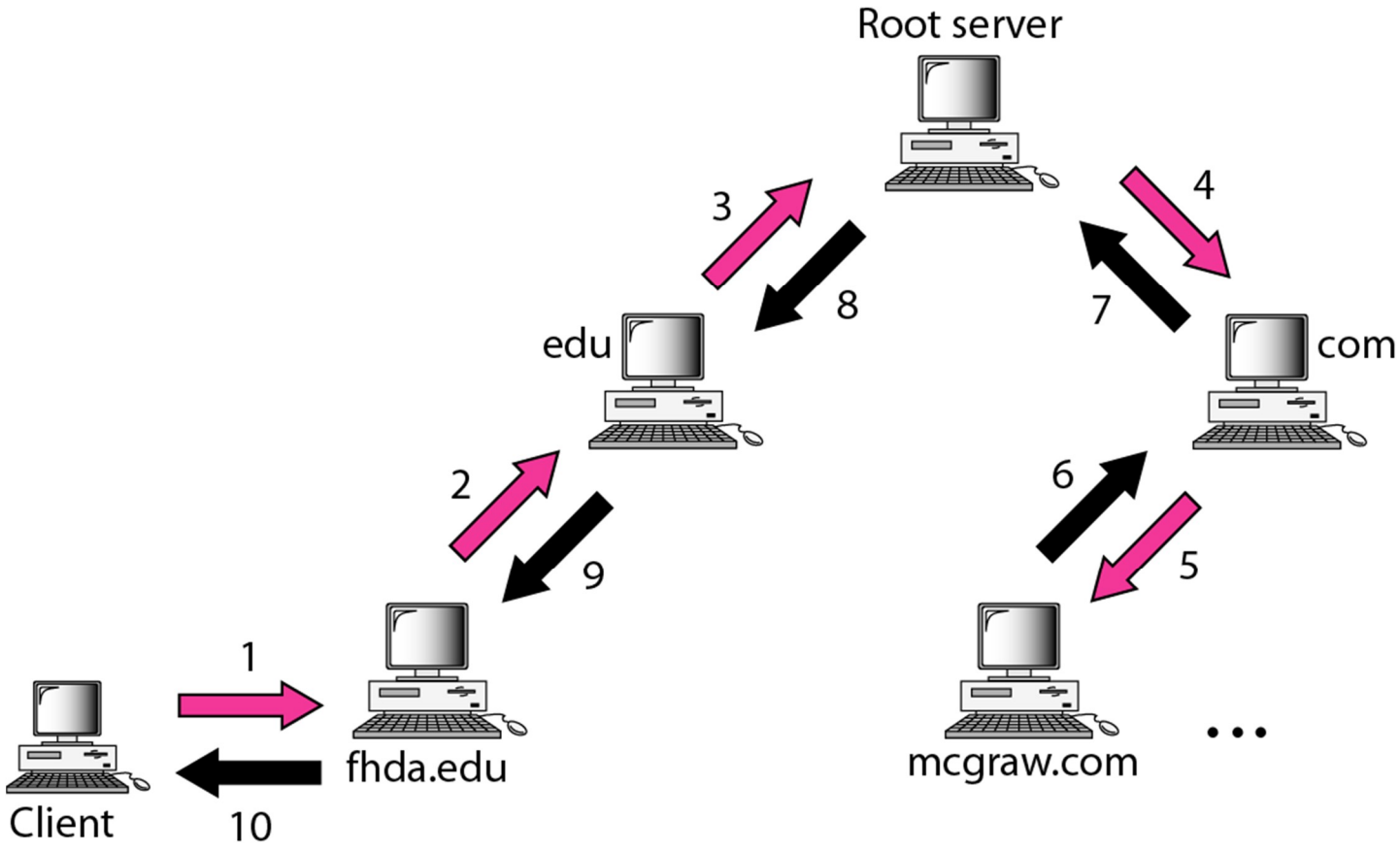
- Servers' control area



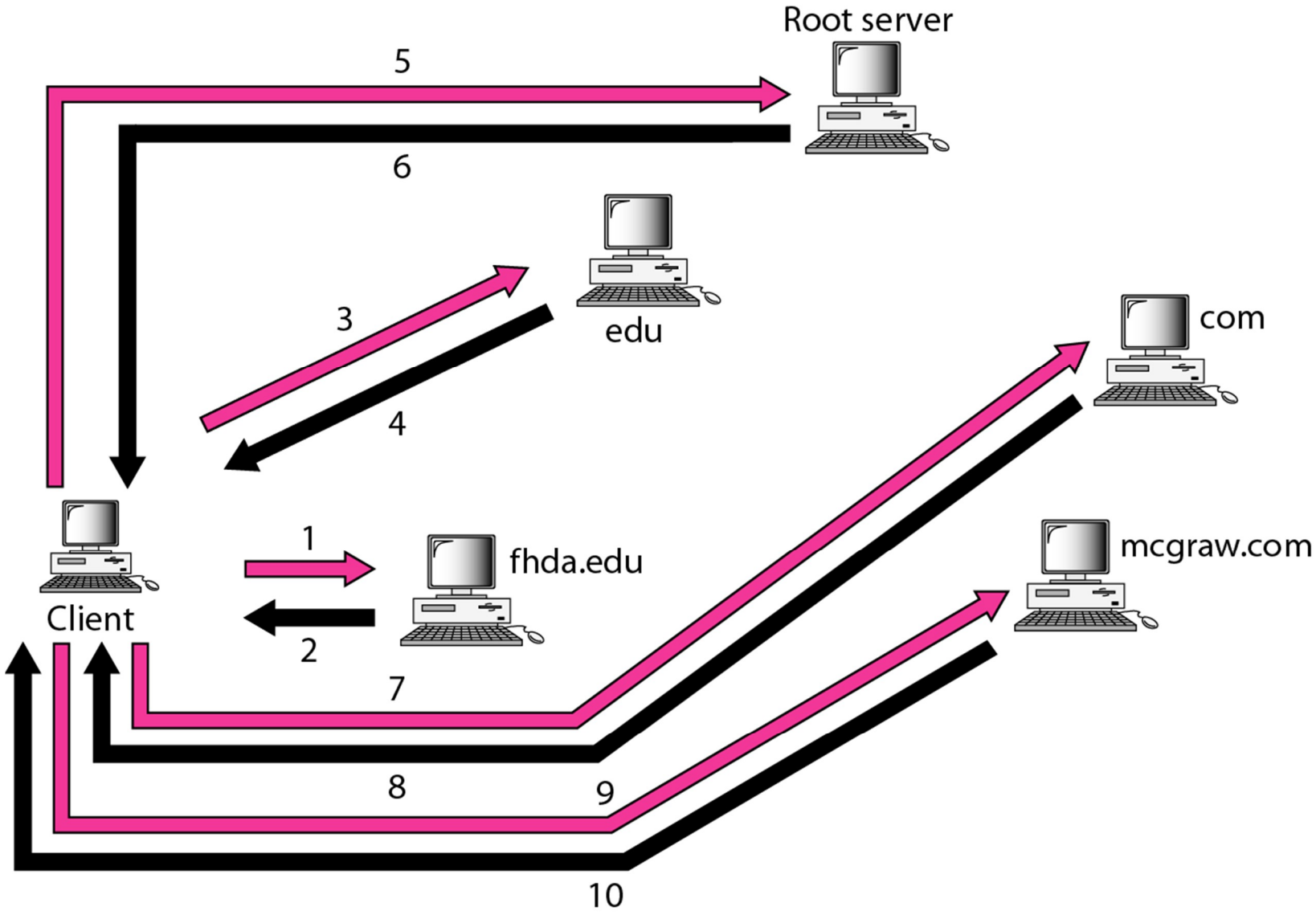
Domain name resolution

- 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!

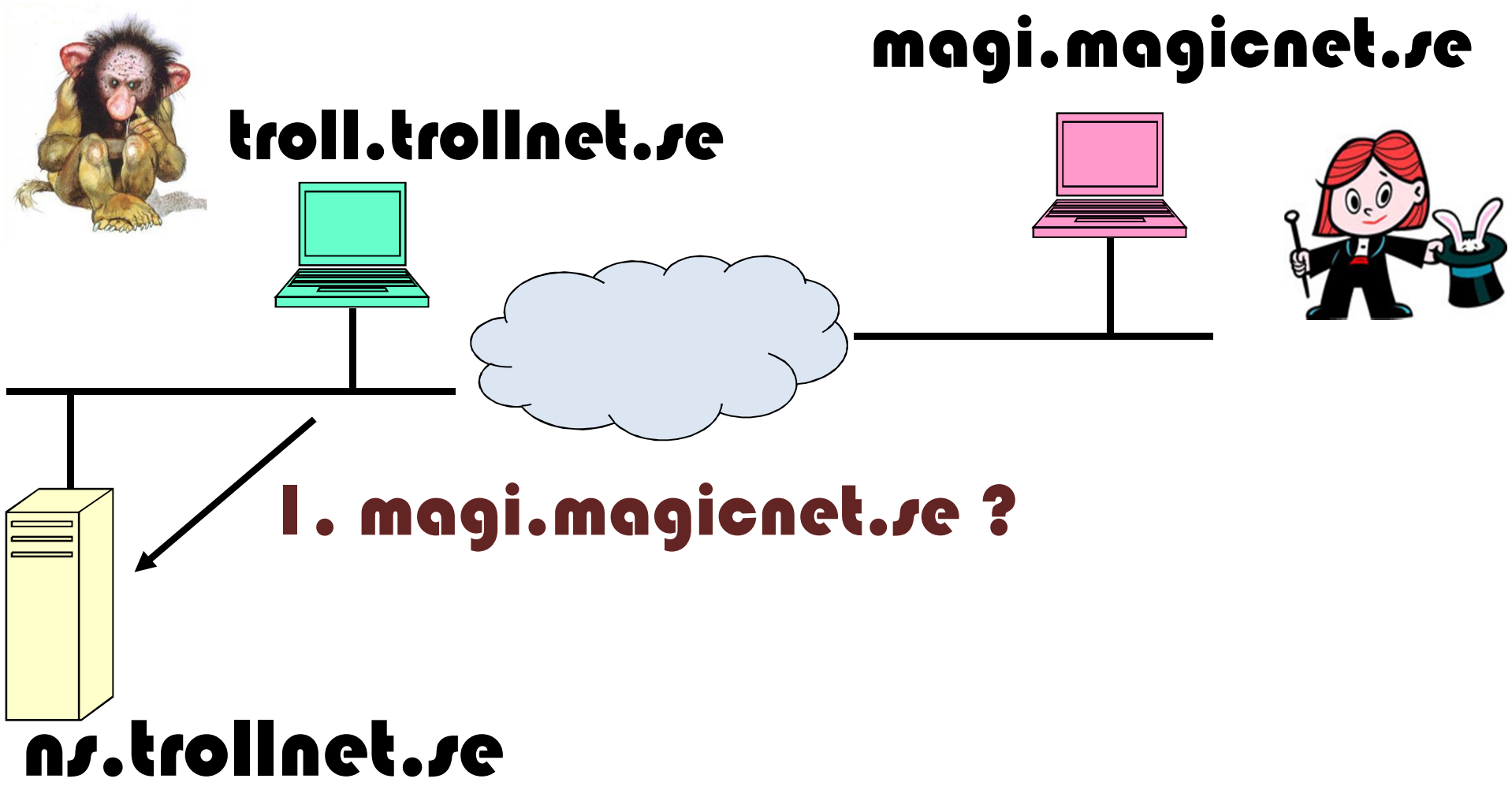
Recursive resolution



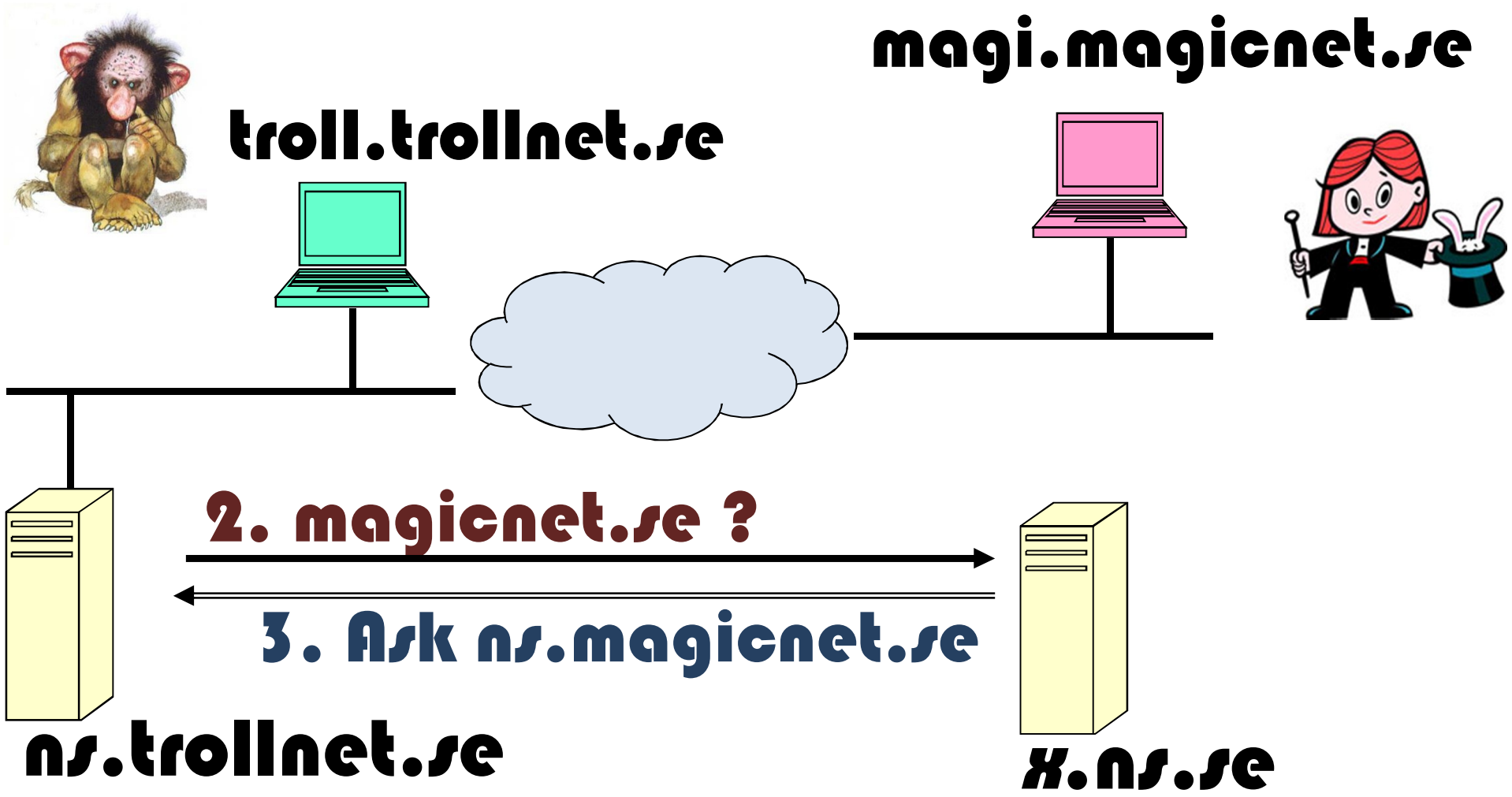
Iterative resolution



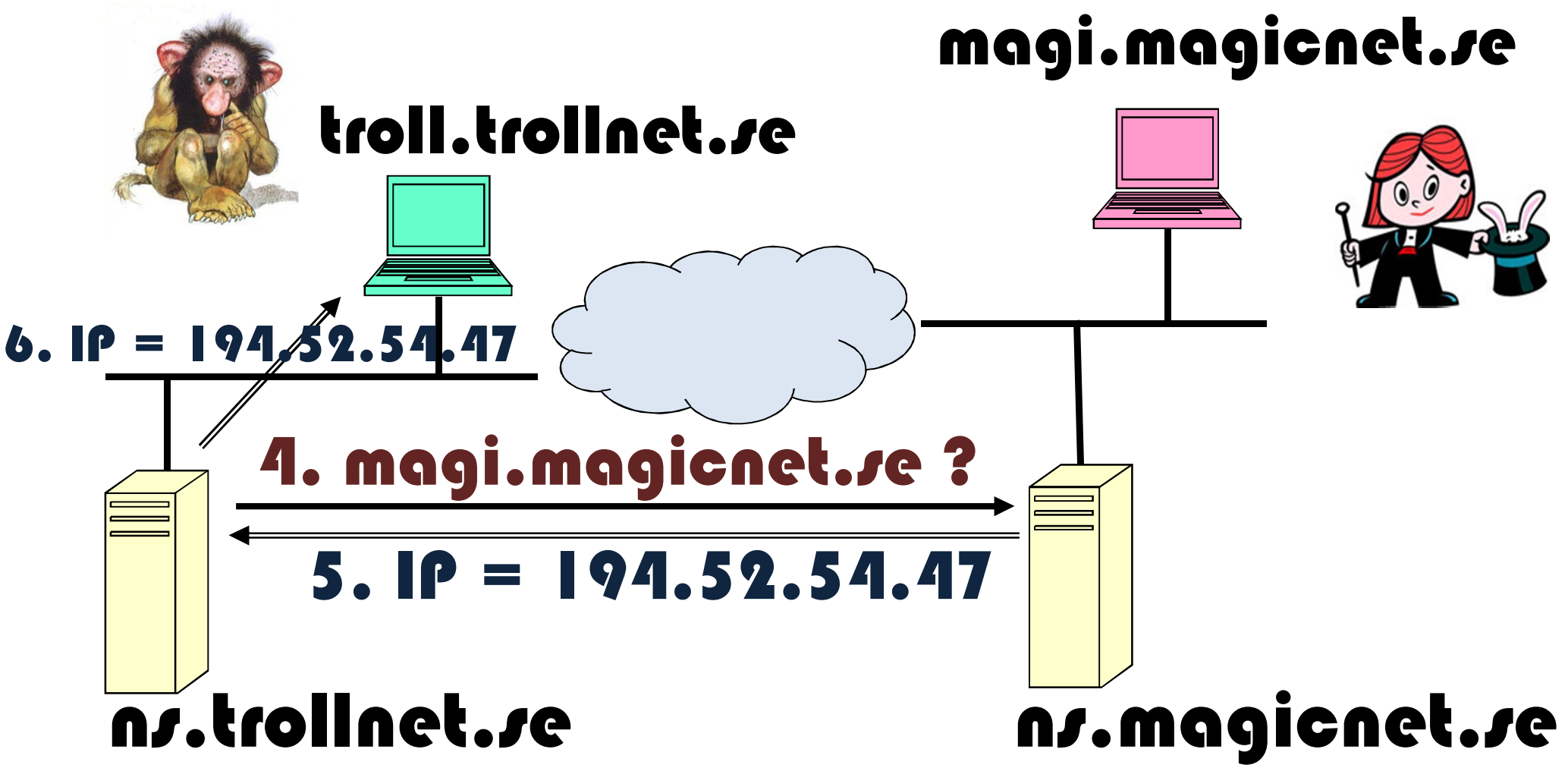
Domain name to IP address (1)



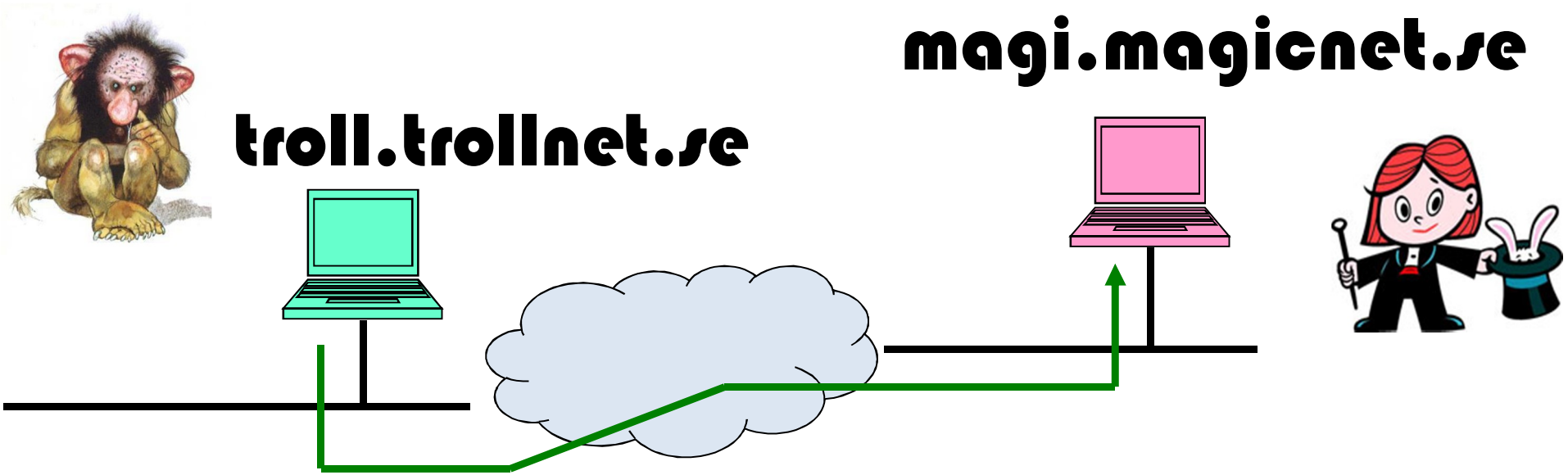
Domain name to IP address (2)



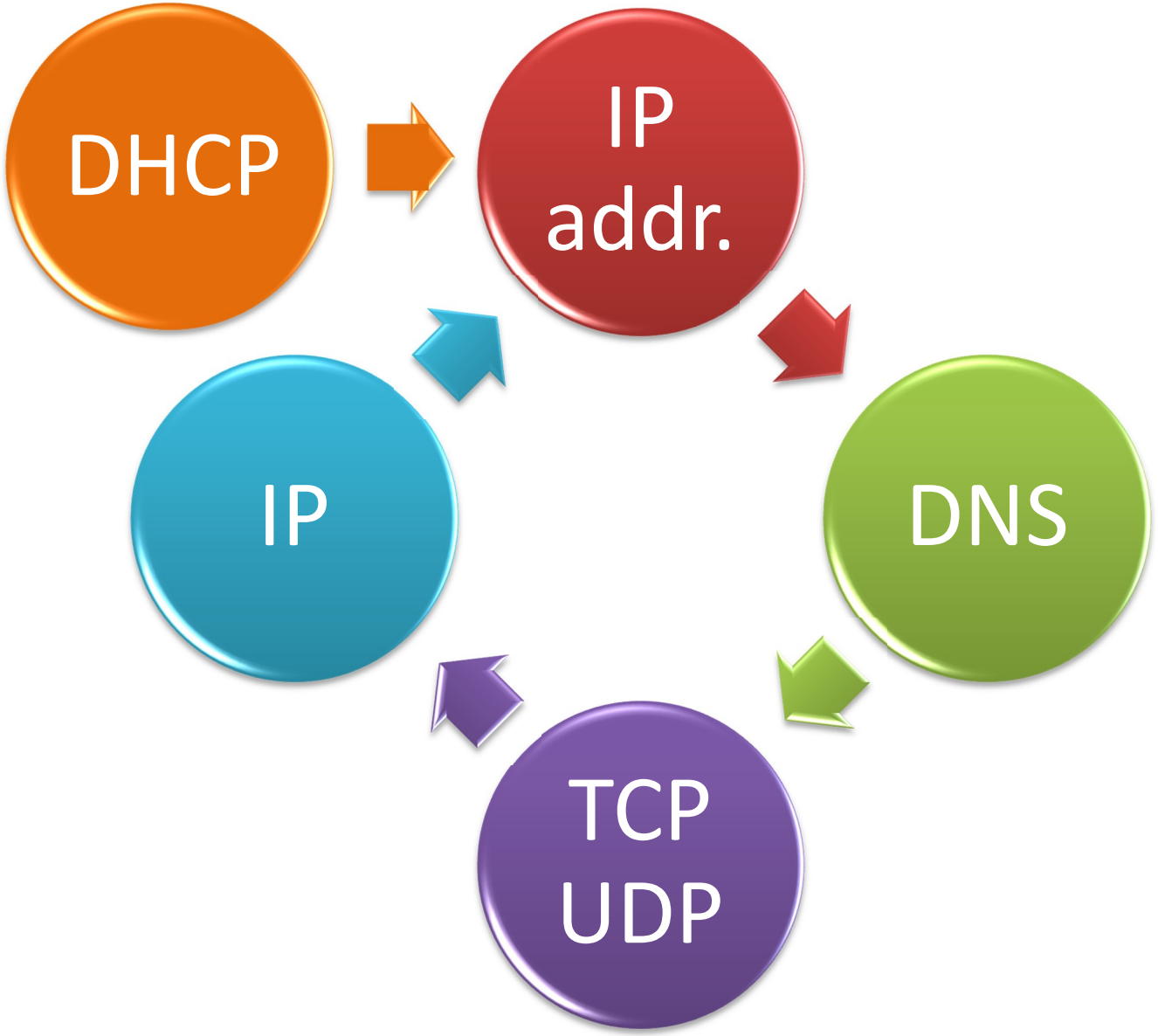
Domain name to IP address (3)



Domain name to IP address (4)



Exercise: Break this vicious cycle!

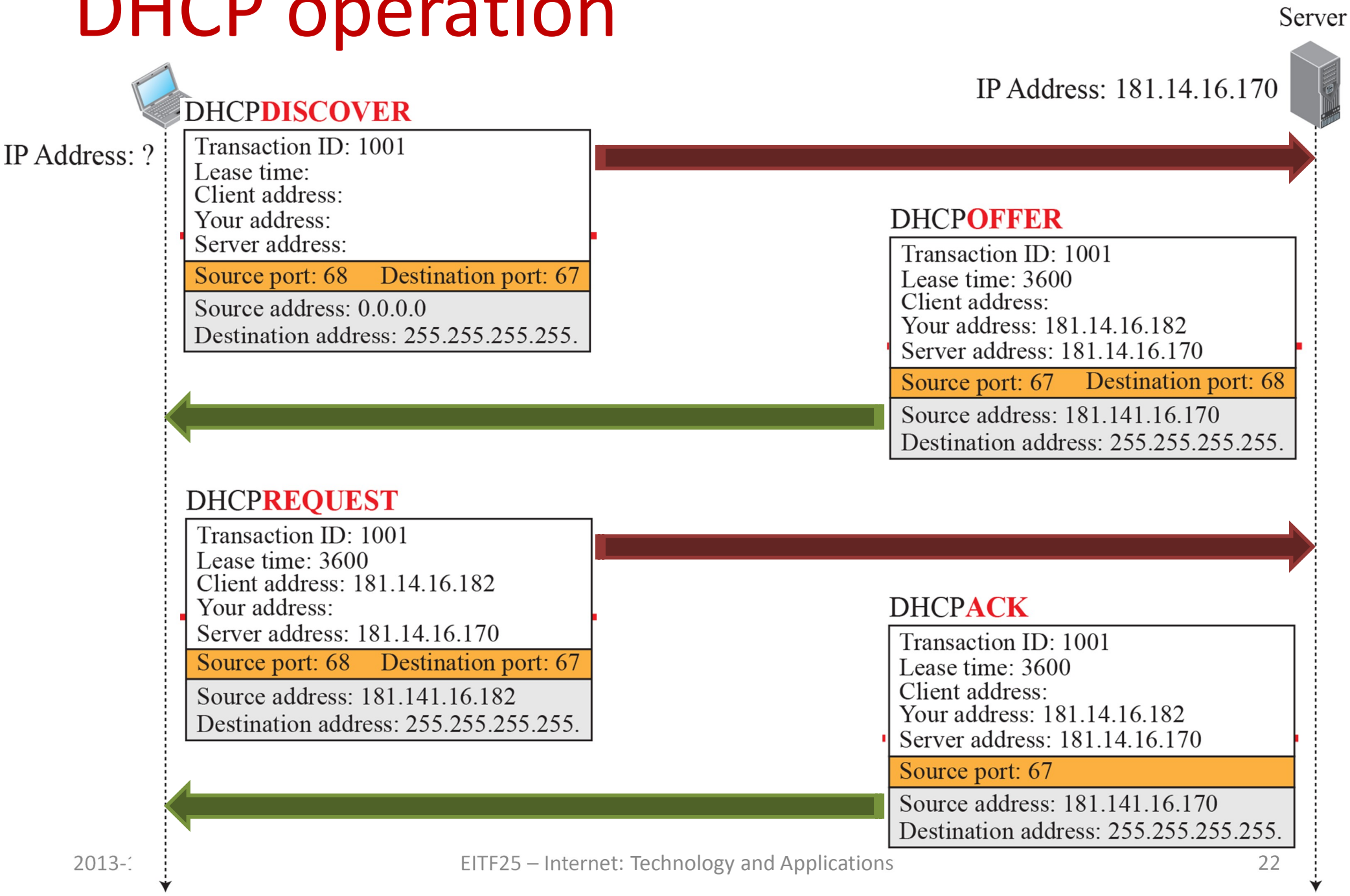


Obtaining an IP address

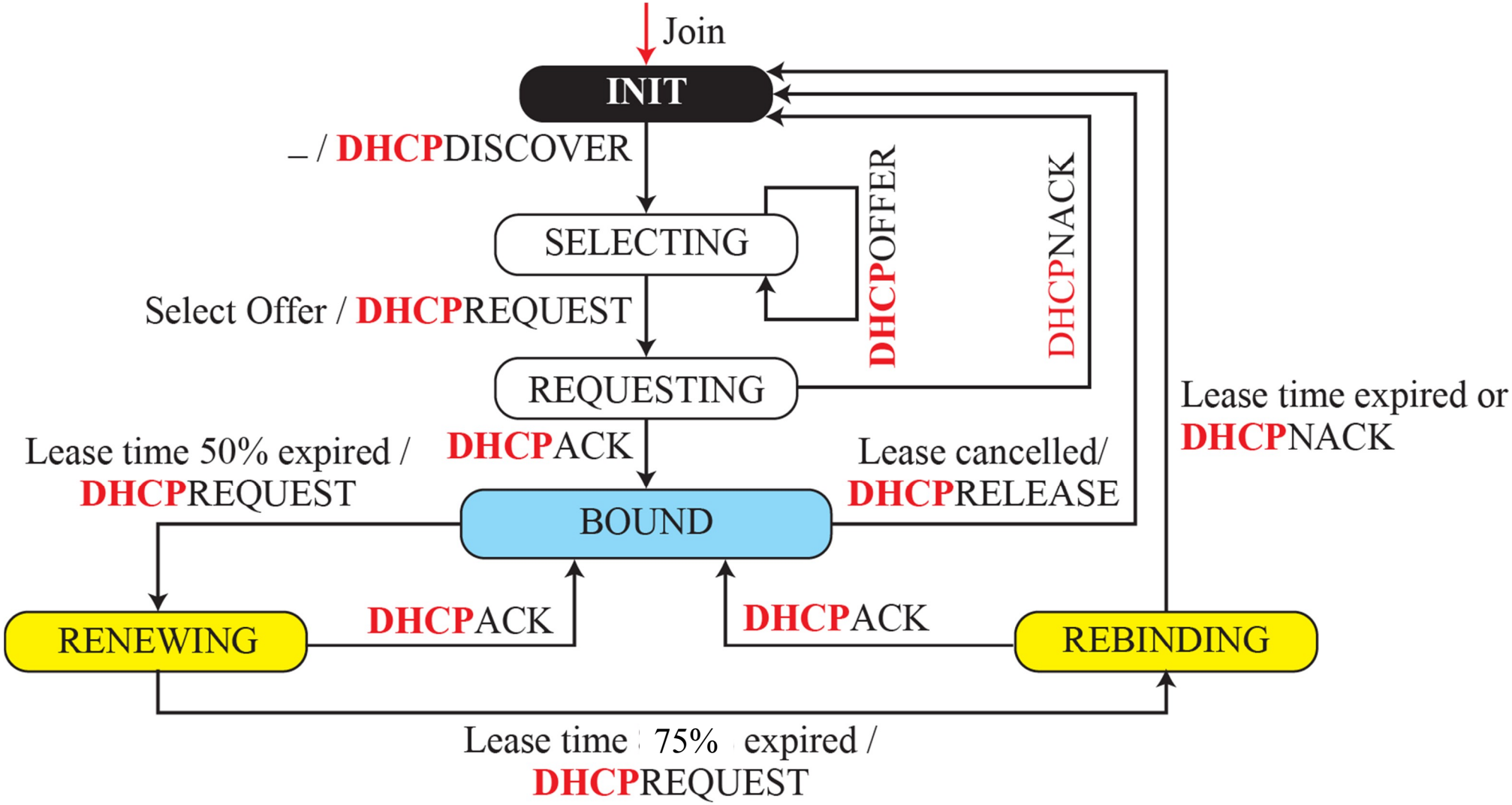
- Dynamic Host Configuration Protocol
  - Application layer

- DHCP
  - IP address
    - Allocation from pool or static
  - Network mask
  - Default gateway
  - DNS server(s)

DHCP operation



DHCP states

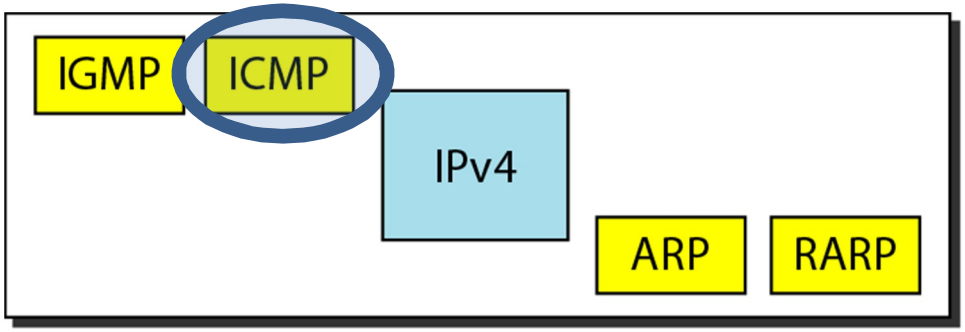

Join
INIT
– / DHCPDISCOVER
SELECTING
DHCPOFFER
DHCPNACK
Select Offer / DHCPREQUEST
REQUESTING
Lease time expired or DHCPNACK
Lease time 50% expired / DHCPREQUEST
DHCPACK
Lease cancelled/ DHCPRELEASE
BOUND
RENEWING
DHCPACK
DHCPACK
REBINDING
Lease time 75% expired / DHCPREQUEST

See you in 15’ :)

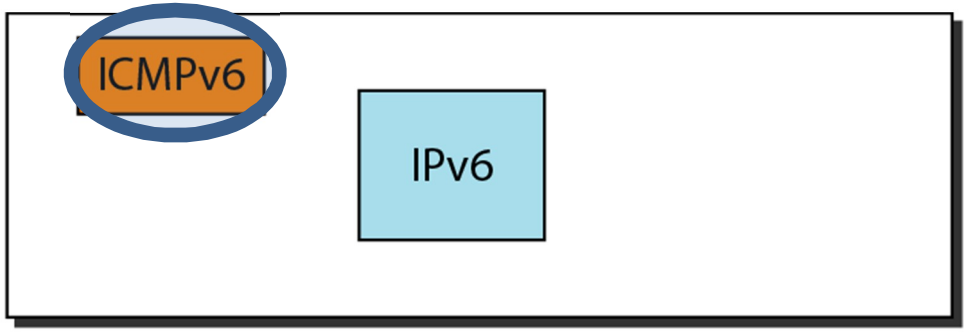
- After the break
  - Network debugging
  - ICMP
  - World-wide web

Debugging Tools

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

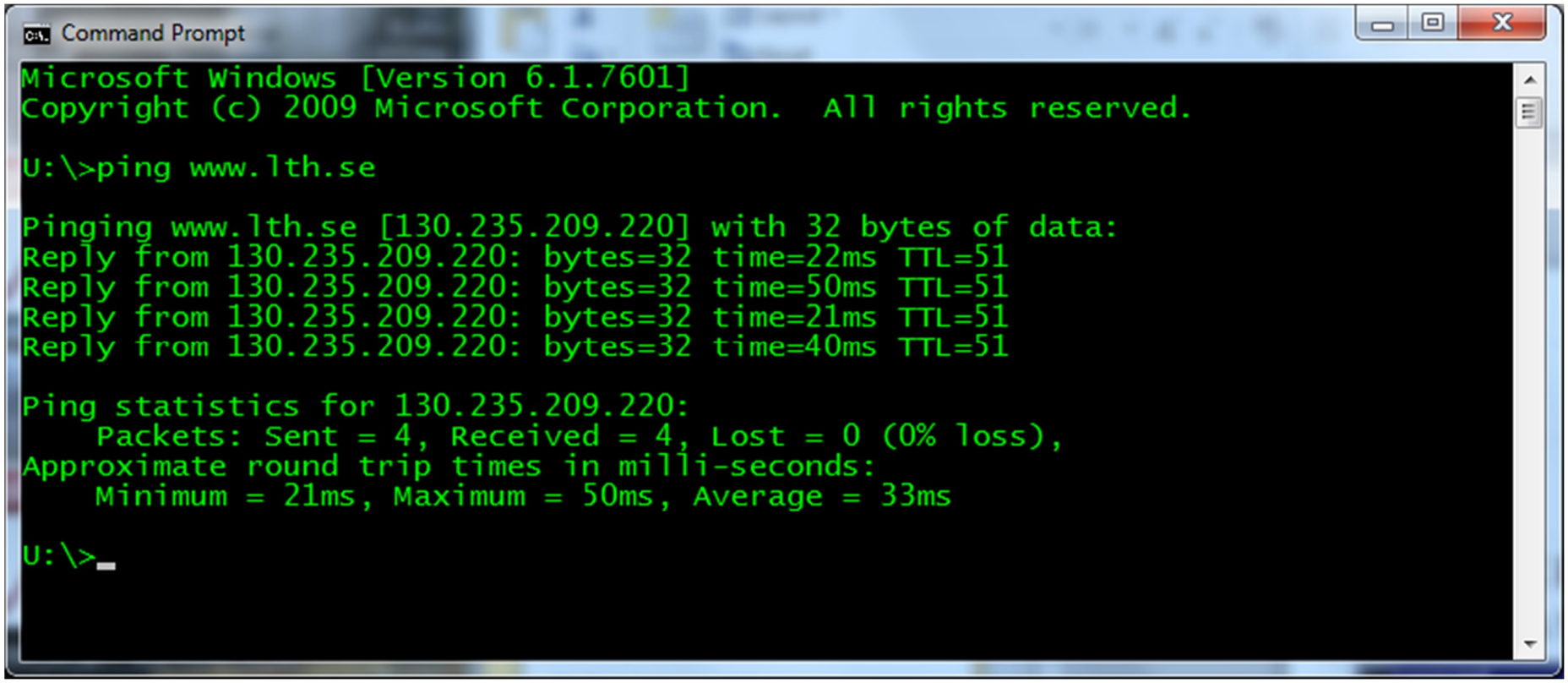


Network layer in version 4

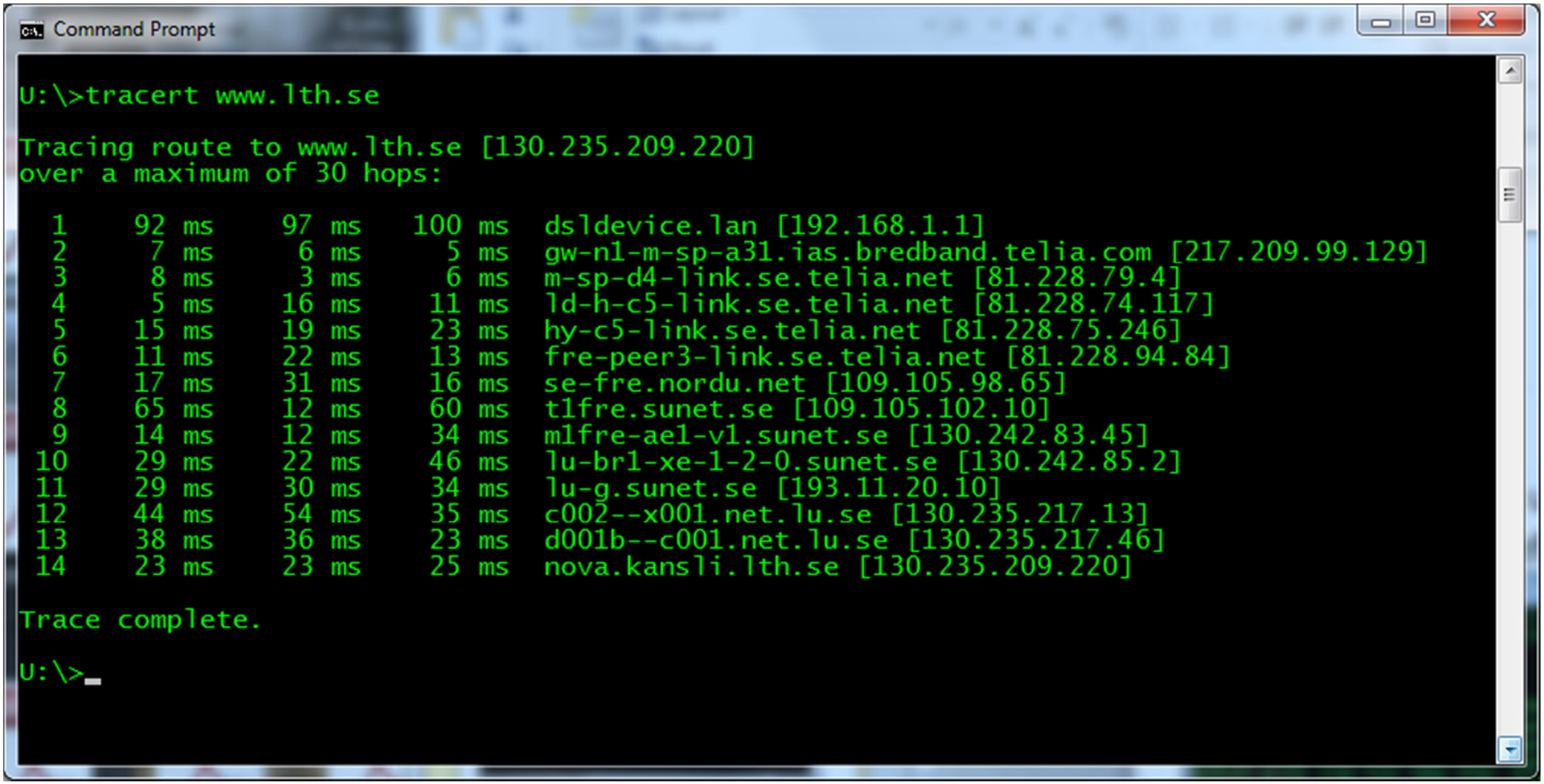


Network layer in version 6

Ping

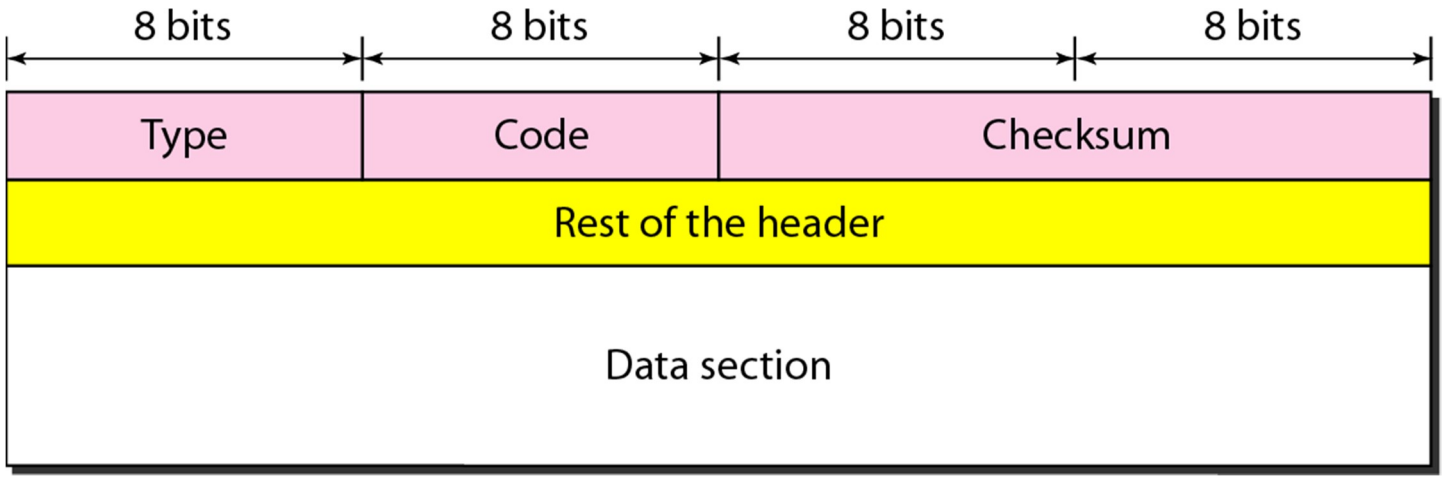

Command Prompt
Microsoft Windows [Version 6.1.7601]
Copyright (c) 2009 Microsoft Corporation. All rights reserved.
U:\>ping www.lth.se
Pinging www.lth.se [130.235.209.220] with 32 bytes of data:
Reply from 130.235.209.220: bytes=32 time=22ms TTL=51
Reply from 130.235.209.220: bytes=32 time=50ms TTL=51
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 dsldevice.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 t1fre.sunet.se [109.105.102.10]
9 14 ms 12 ms 34 ms m1fre-ae1-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:\>

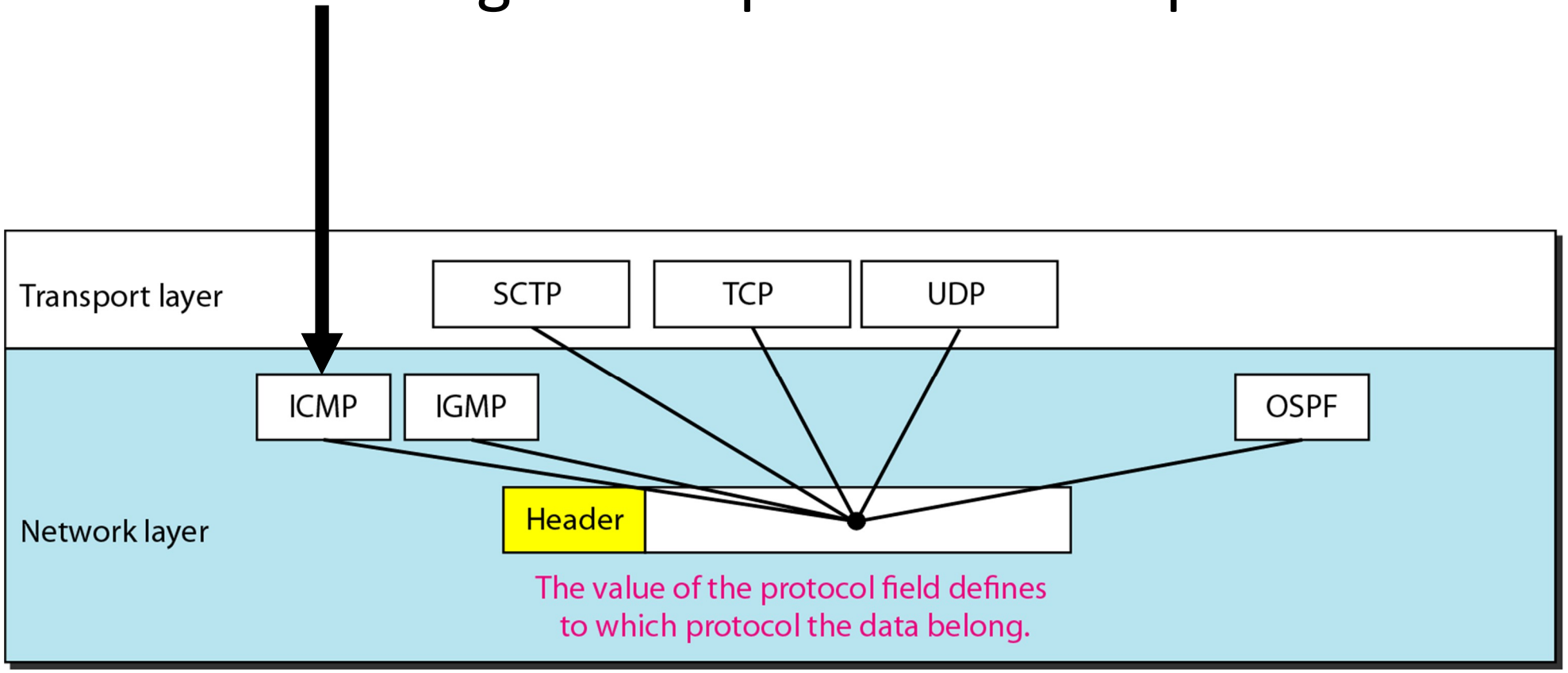
Internet Control Message Protocol

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



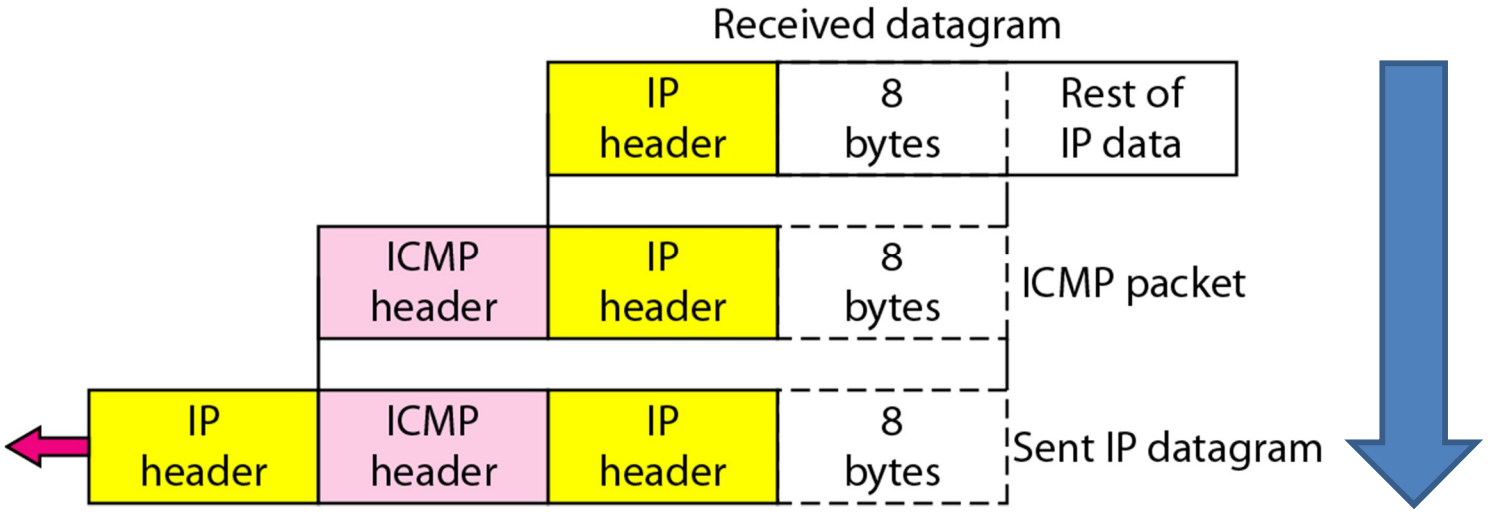
Encapsulation

- ICMP messages encapsulated in IP packets

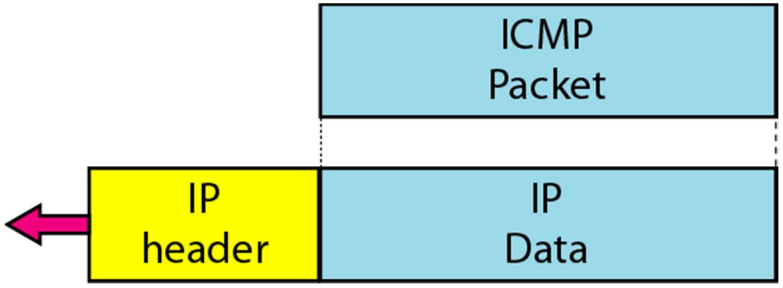


ICMP message formats

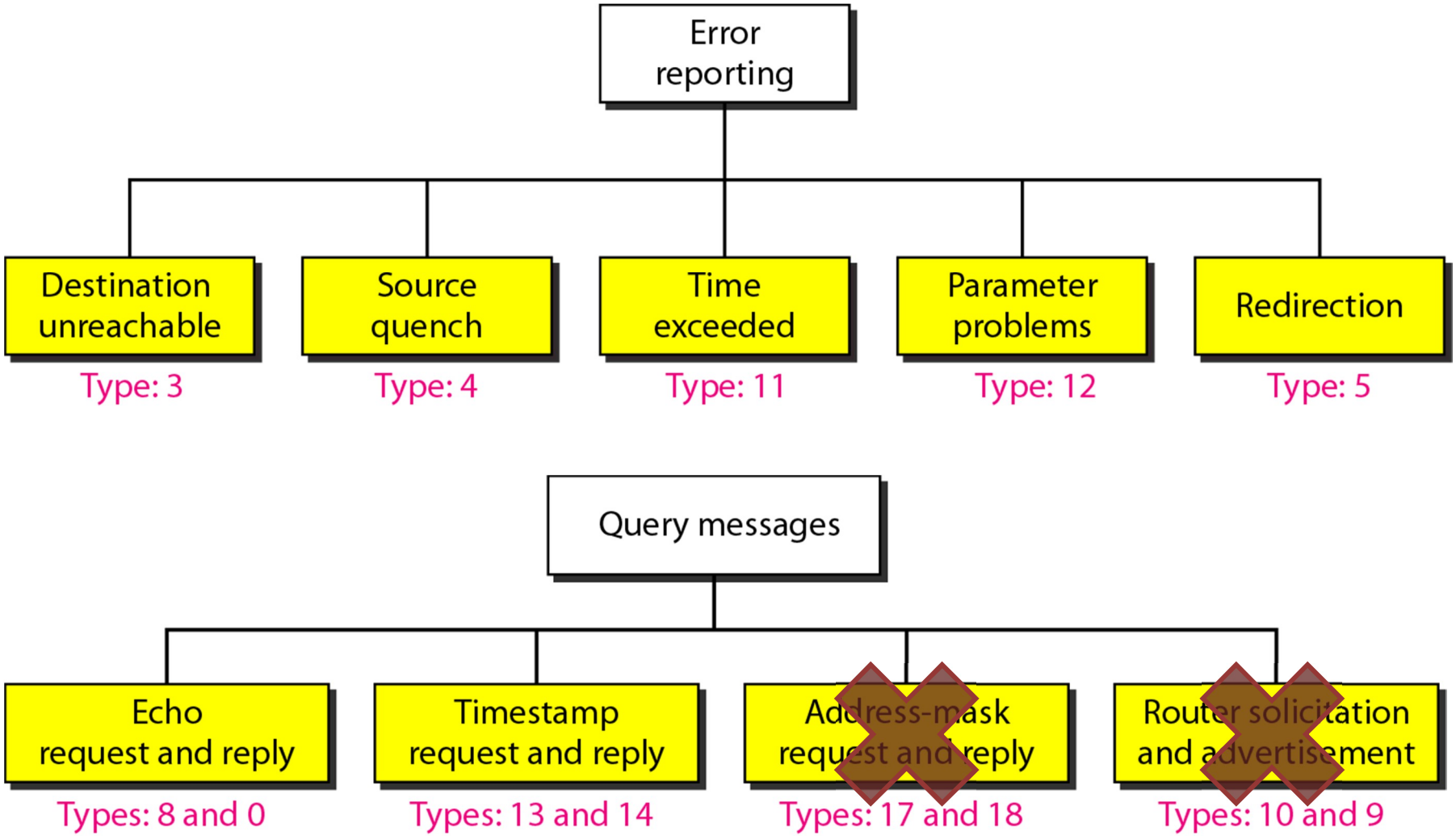
- Error reporting



- Query messages

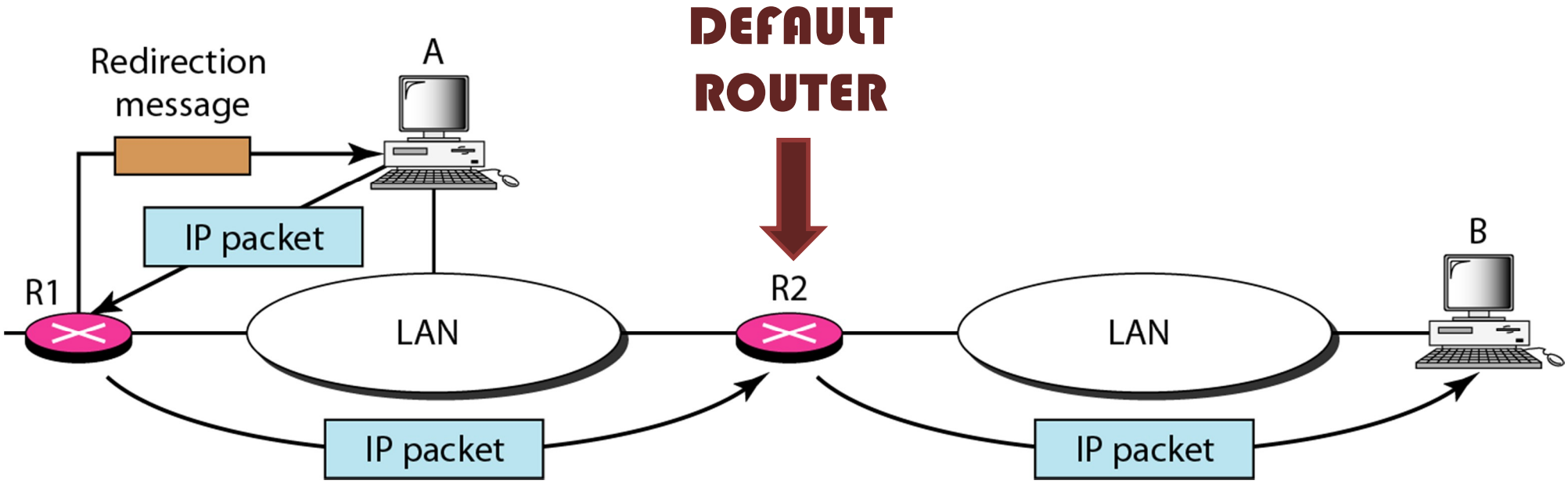


ICMPv4 message types



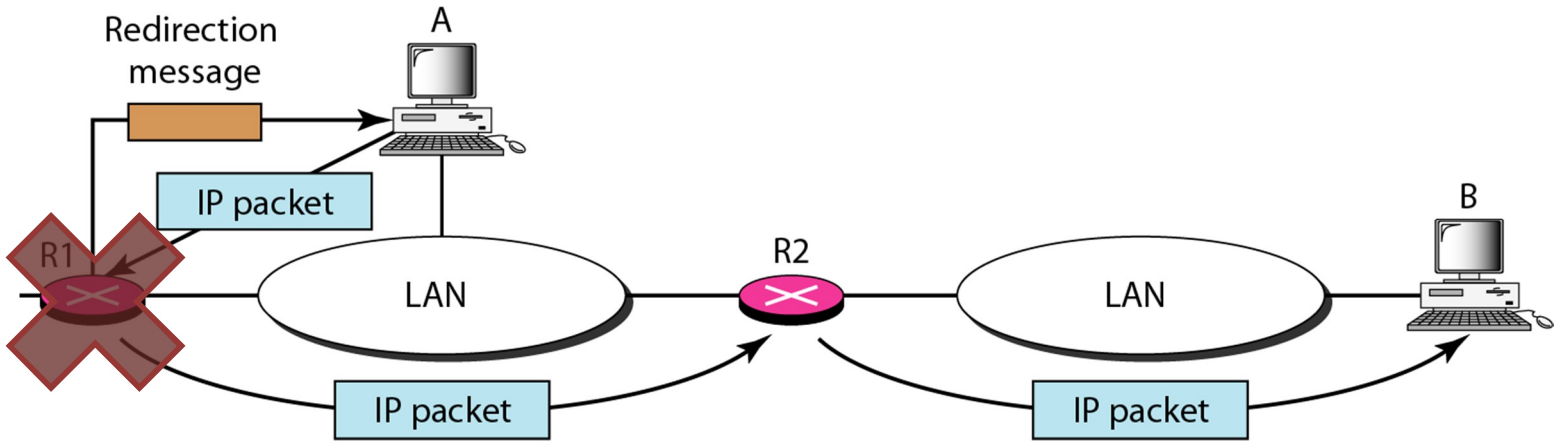
Redirection (error reporting type)

- 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)

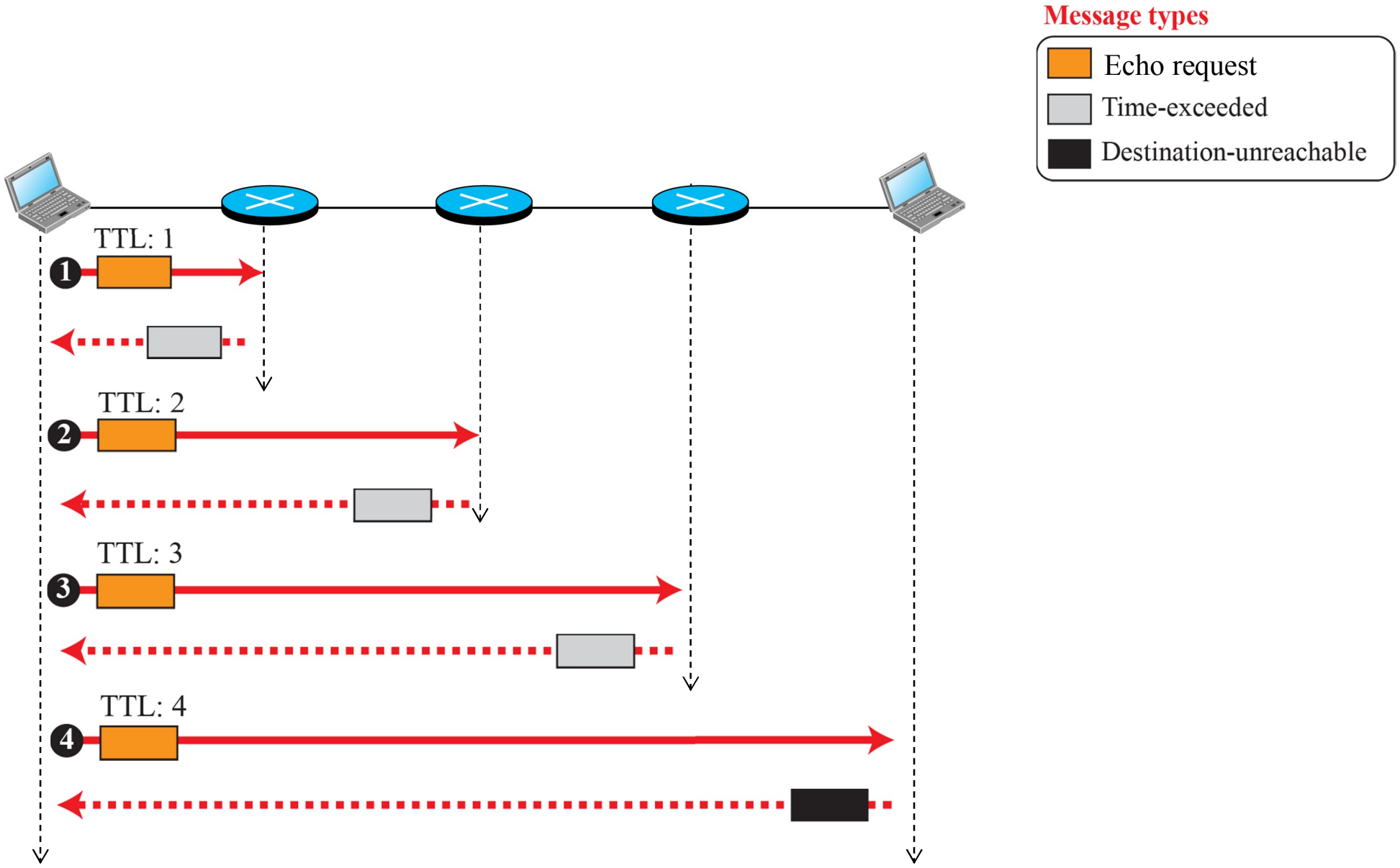
- Is my destination alive?

- 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

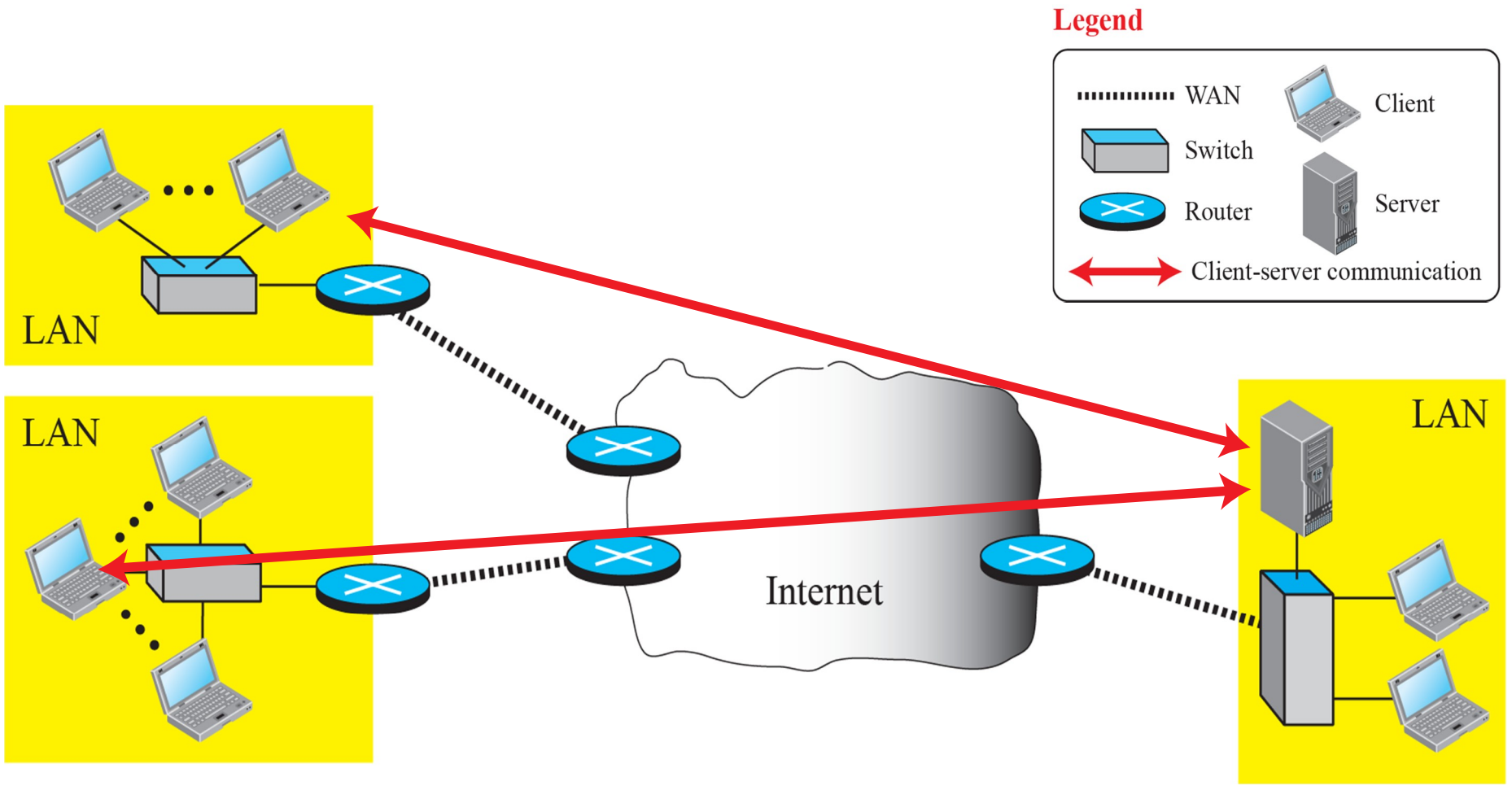
Traceroute


Message types
Echo request
Time-exceeded
Destination-unreachable
TTL: 1
1
TTL: 2
2
TTL: 3
3
TTL: 4
4

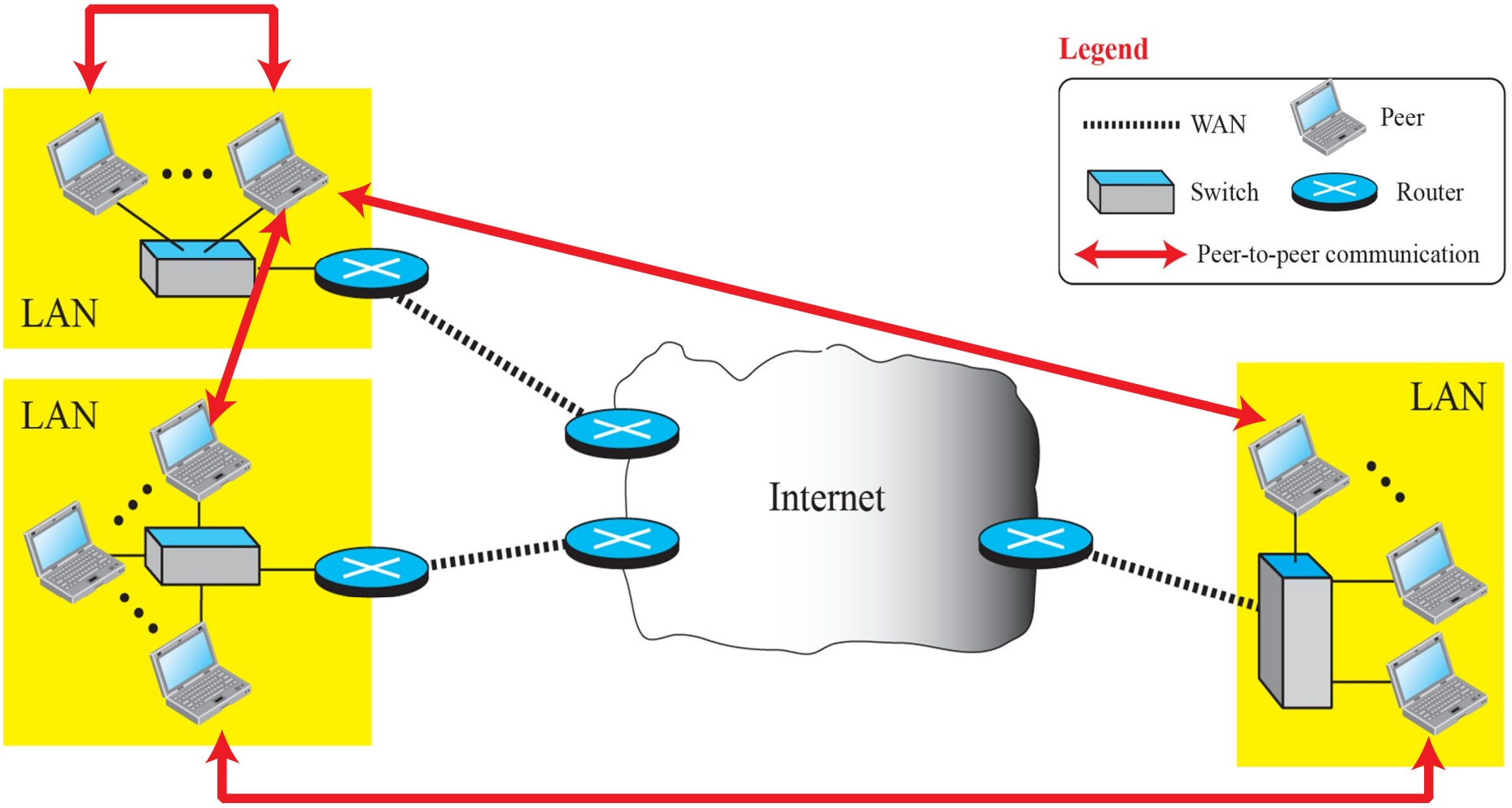
Application layer paradigms

- 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

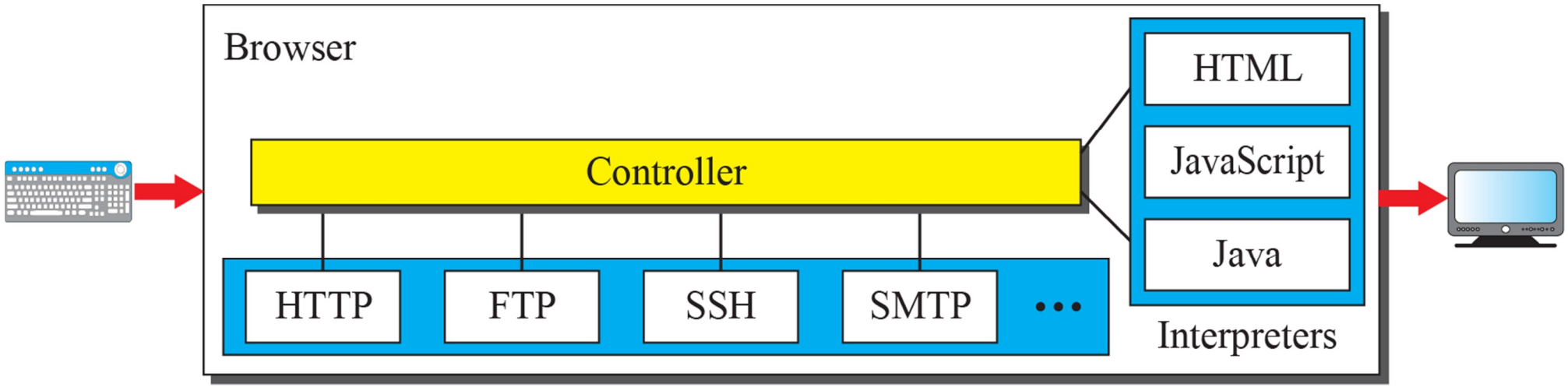
- Web documents (pages)
  - HyperTextMarkup Language (HTML) for static web pages
  - Script languages (PHP, ASP, JSP, CGI etc.) for dynamic
- Universal Resource Locator (URL)
  - Standard way to identify location of web documents
- HyperText Transfer Protocol (HTTP)
  - Protocol to access documents on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

Universal Resource Locator (URL)

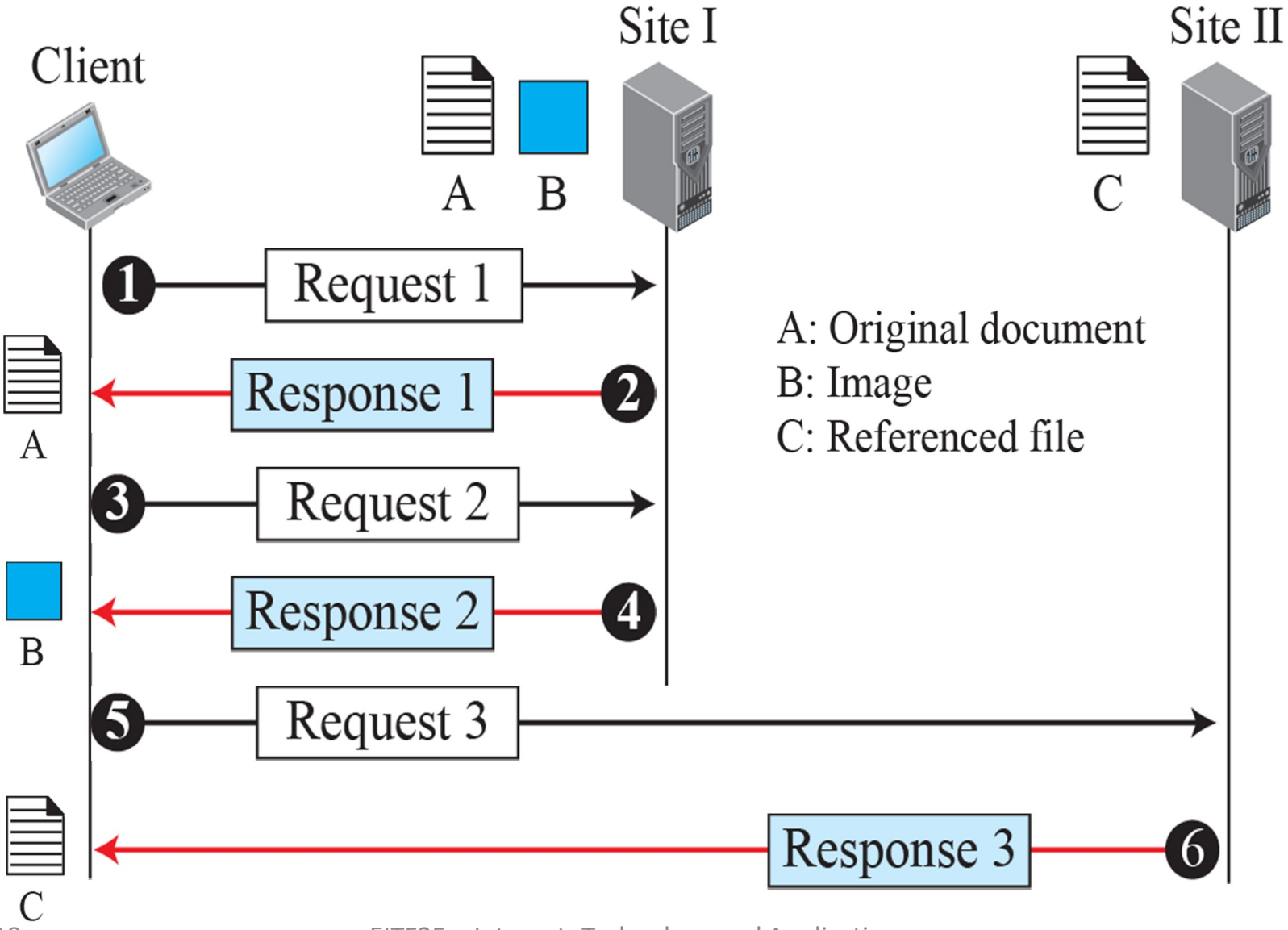
- A web document has four identifiers
  - Protocol, Host, Port and Path.
- A URL is defined as
  - **protocol://host:port/path**
- Standard HTTP port 80 is is omitted
  - **http://www.eit.lth.se/course/eitf25**

Hypertext Transfer Protocol (HTTP)

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

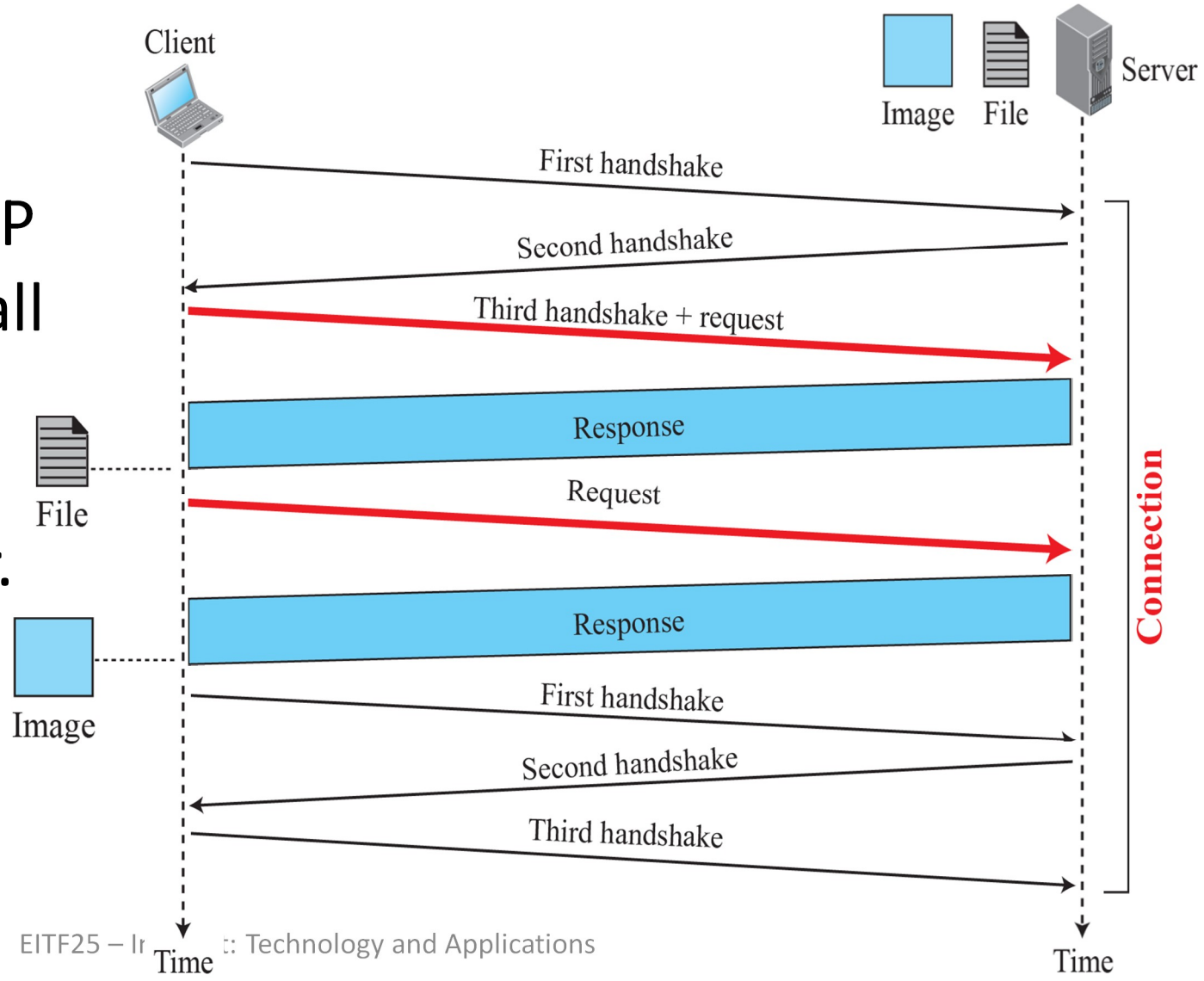


Document retrieval

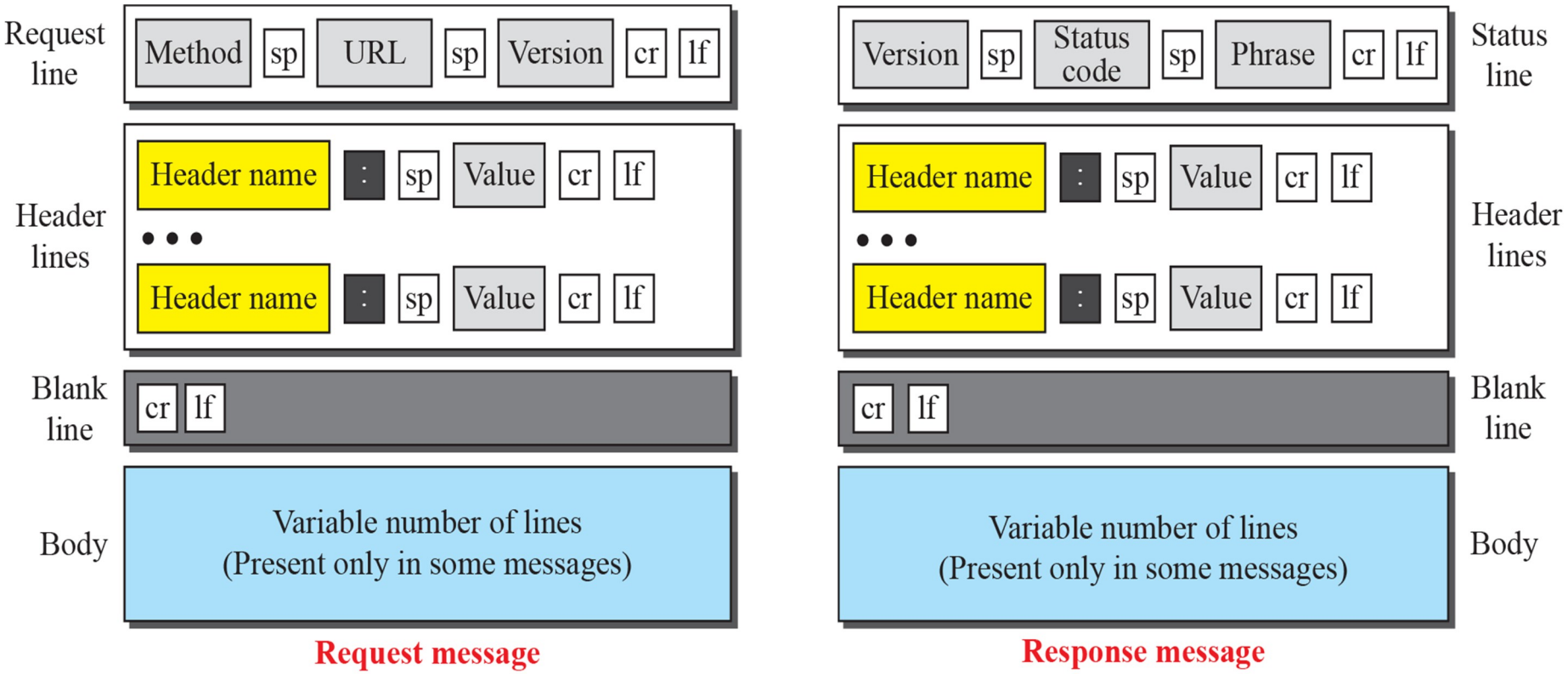


Operation of HTTP 1.1

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



HTTP request and response format



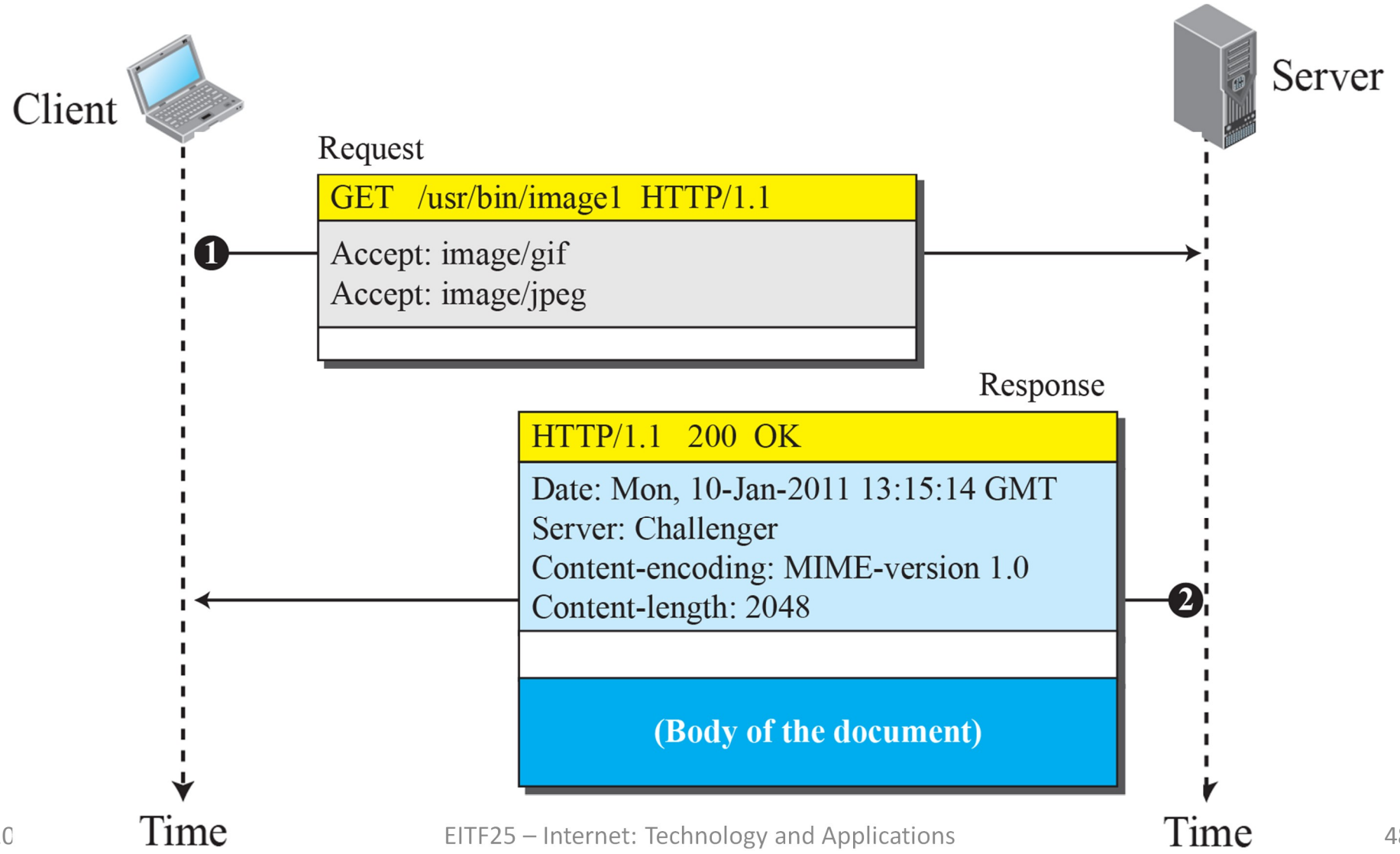
Legend sp: Space cr: Carriage Return lf: Line Feed

HTTP methods in requests

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

Method	*Action*
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

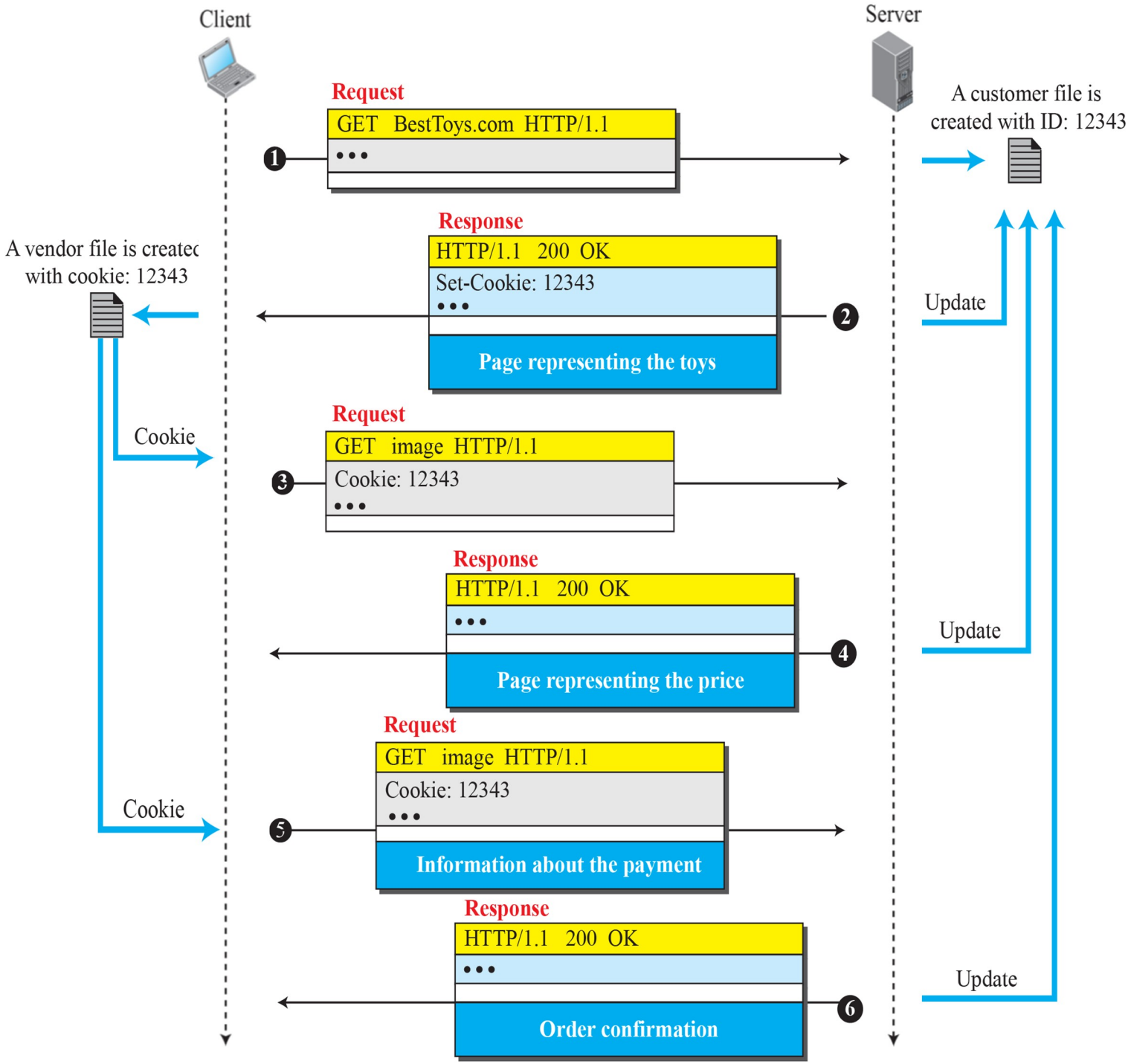
Example request and response



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


Client
Server
Request
GET BestToys.com HTTP/1.1
A customer file is created with ID: 12343
Response
HTTP/1.1 200 OK
Set-Cookie: 12343
Page representing the toys
A vendor file is created with cookie: 12343
Update
Cookie
Request
GET image HTTP/1.1
Cookie: 12343
Response
HTTP/1.1 200 OK
Page representing the price
Update
Request
GET image HTTP/1.1
Cookie: 12343
Cookie
Information about the payment
Response
HTTP/1.1 200 OK
Order confirmation
Update

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