

EITF25 Internet--Techniques and Applications

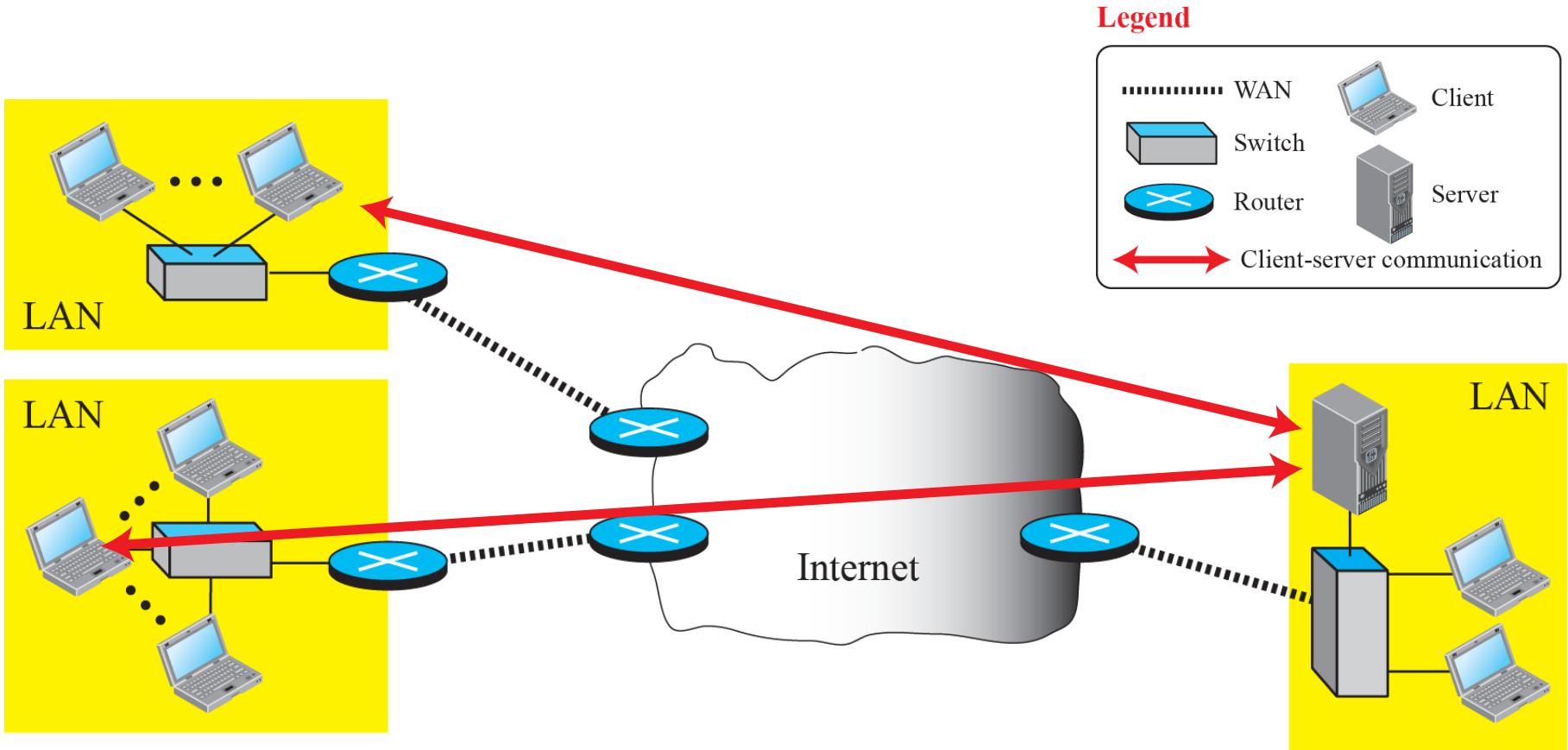
Stefan Höst

L9 Application layer



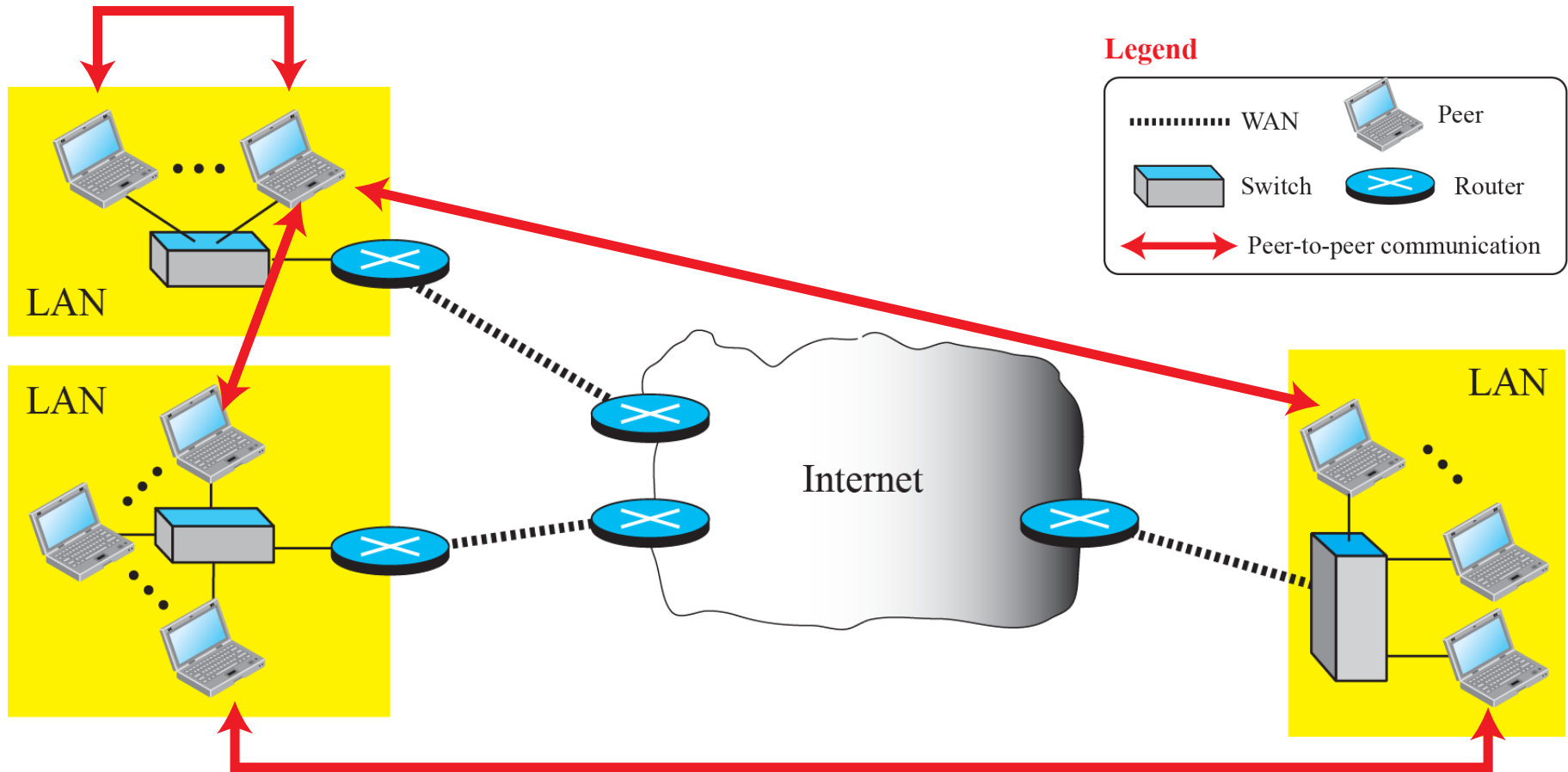
LUND
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Client-server paradigm



E.g. www, IPTV, OTT, Online games, etc

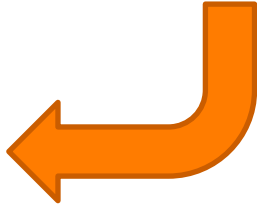
Peer-to-peer paradigm



E.g. BitTorrent, Voddler, Skype, etc

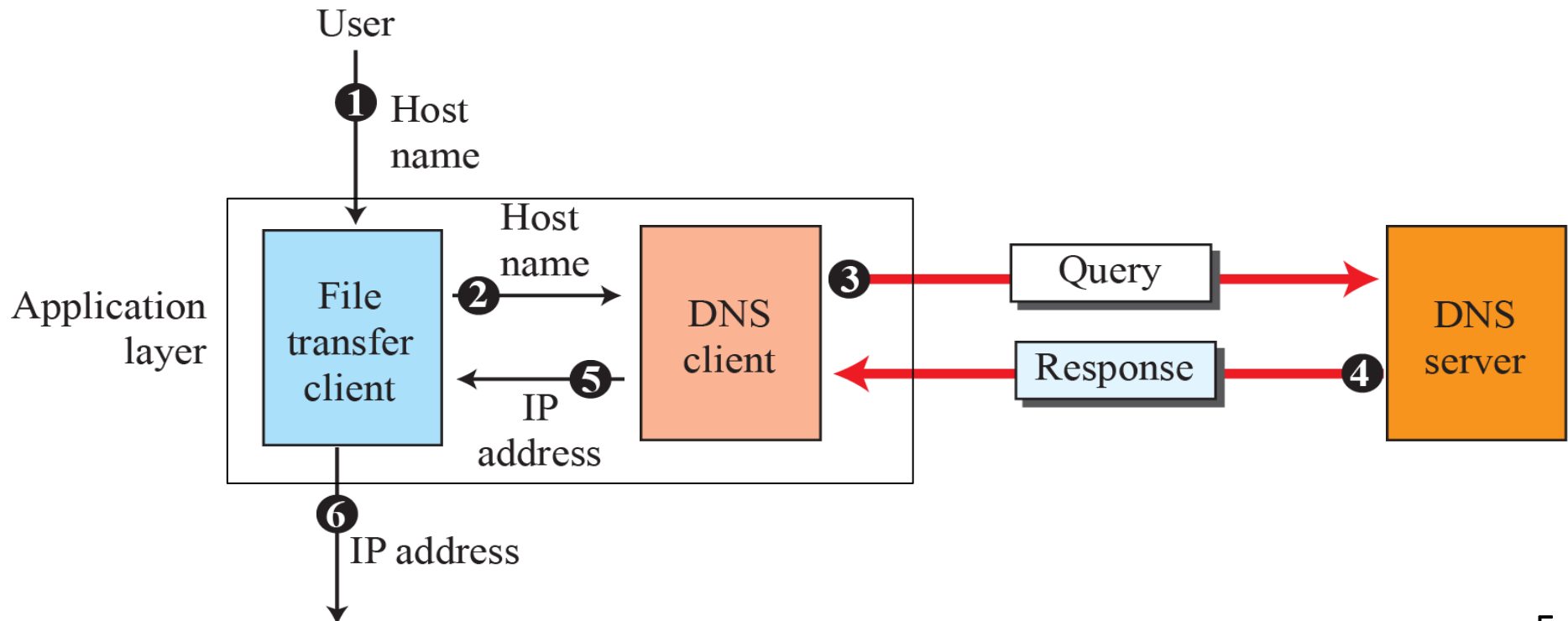
Some applications both paradigms, e.g. Spotify

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

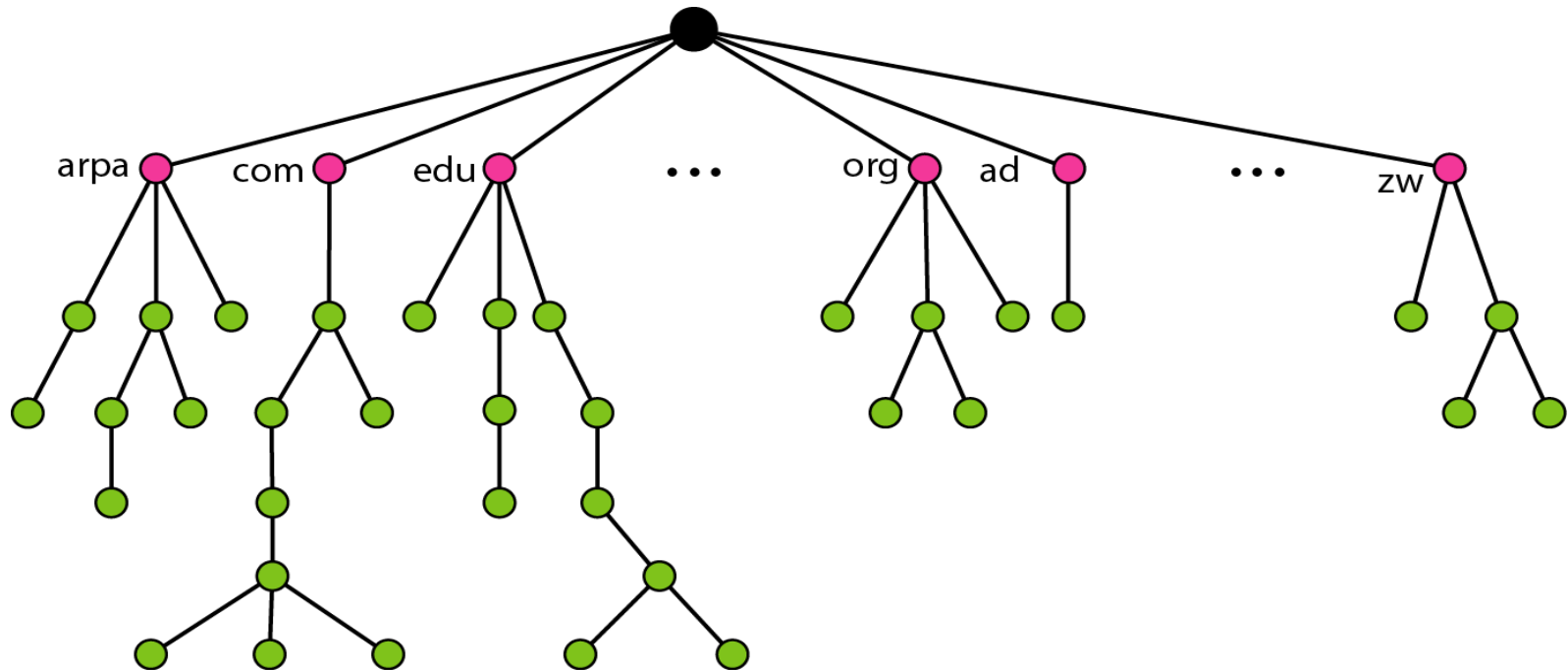
Domain Name System--DNS (1983)

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

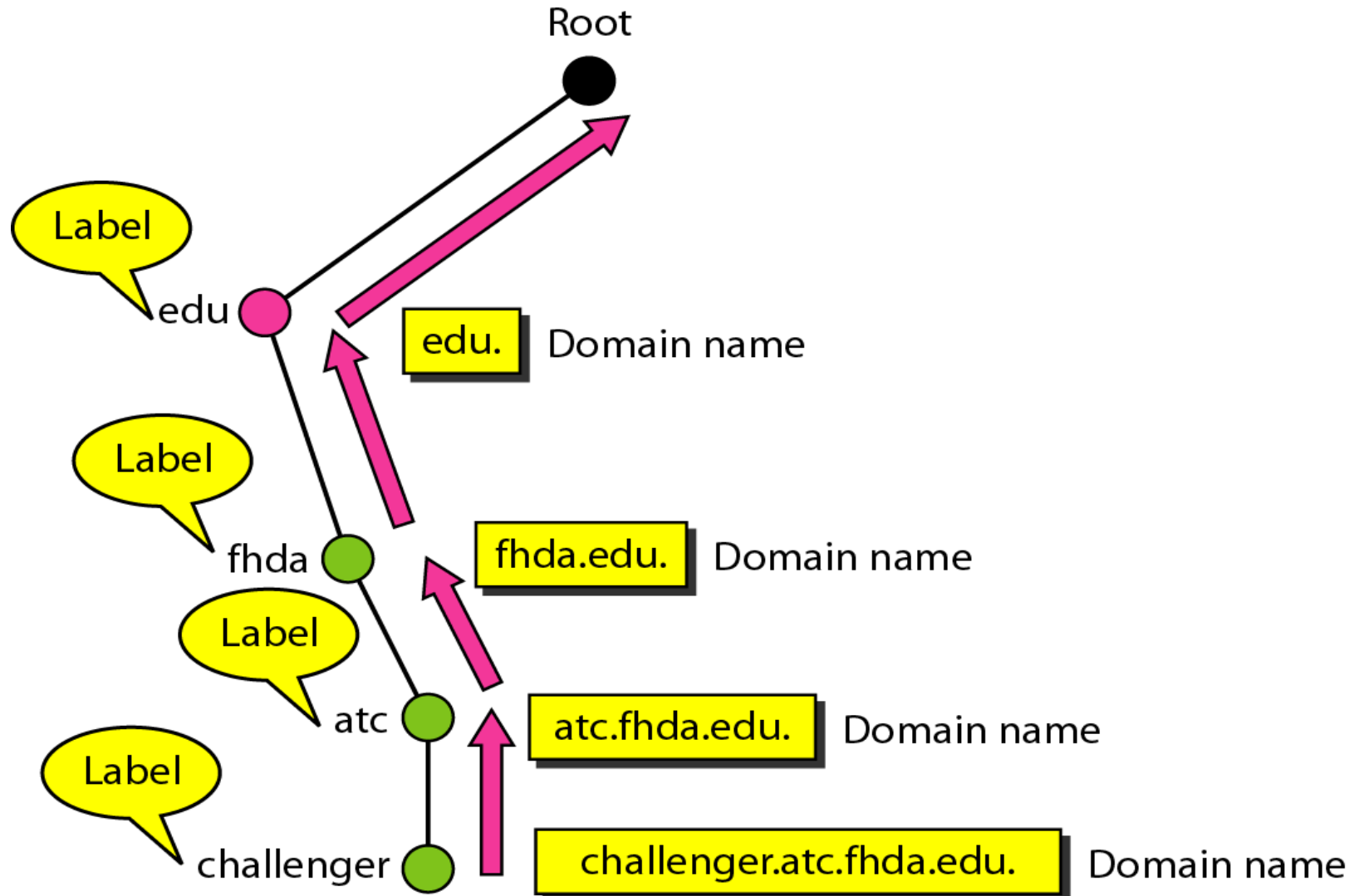


Domain name space

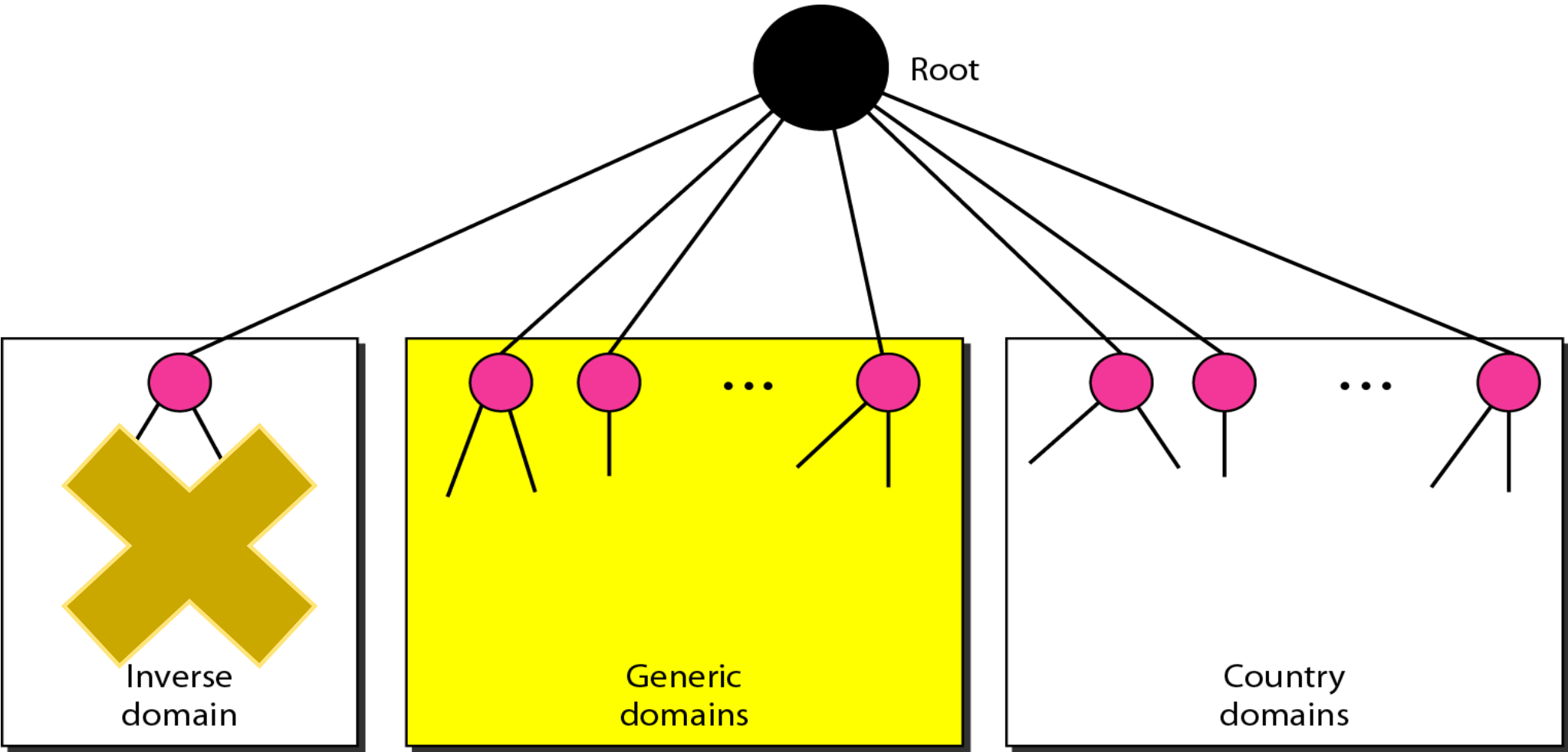
- Names must be unique
 - Complete control needed



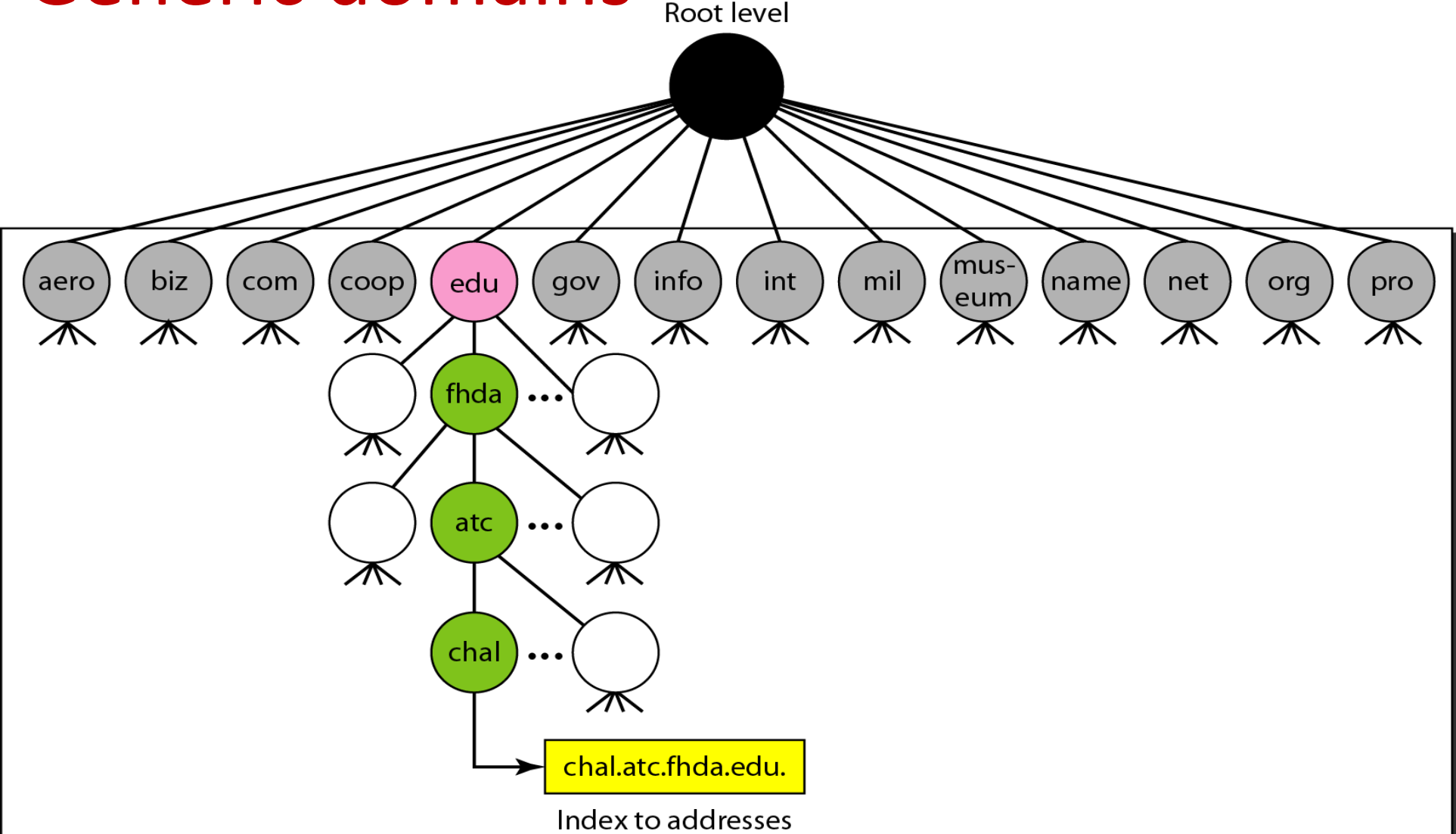
Domain names path in tree



Internet domains

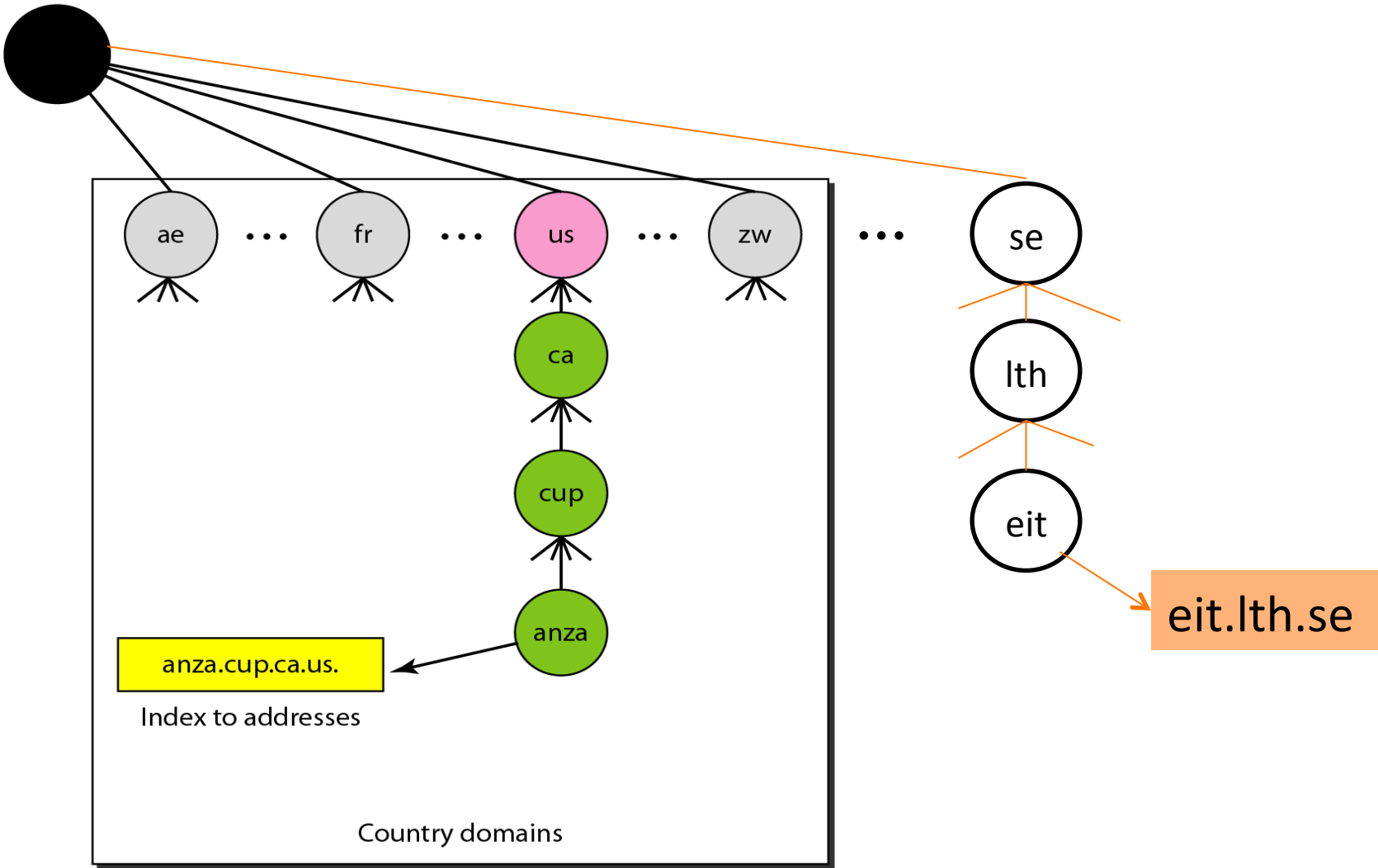


Generic domains



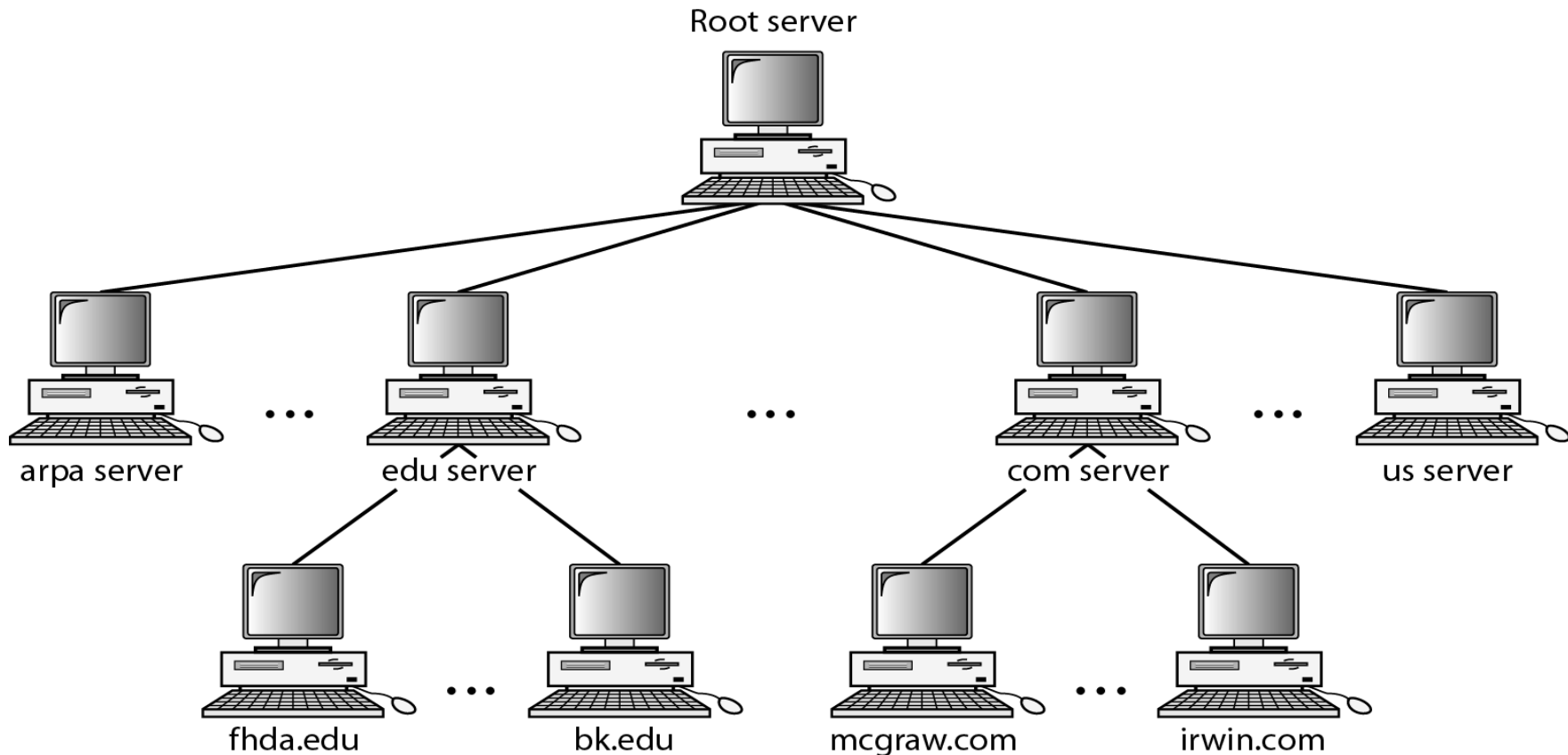
Country domains

Root level

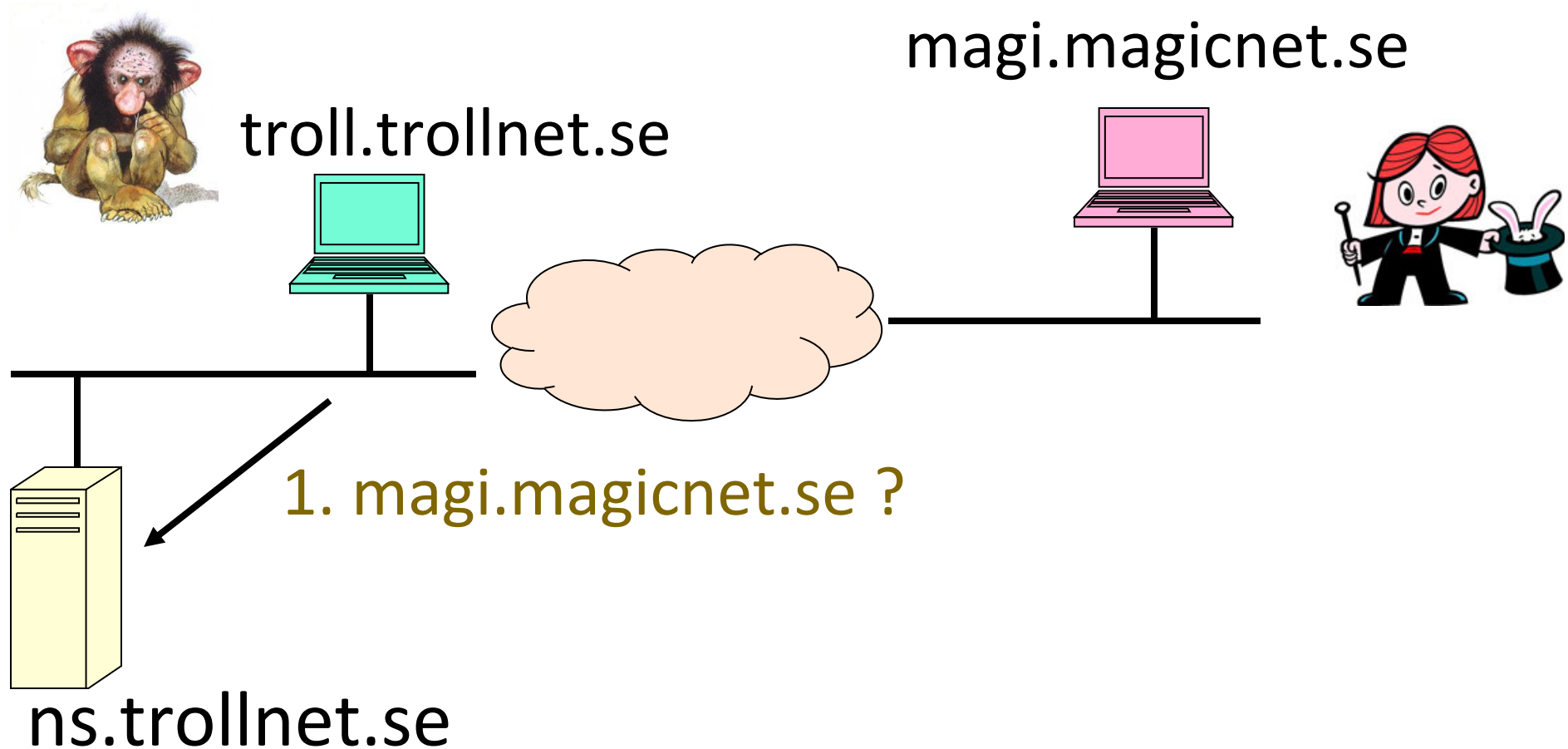


Hierarchy of domain name servers

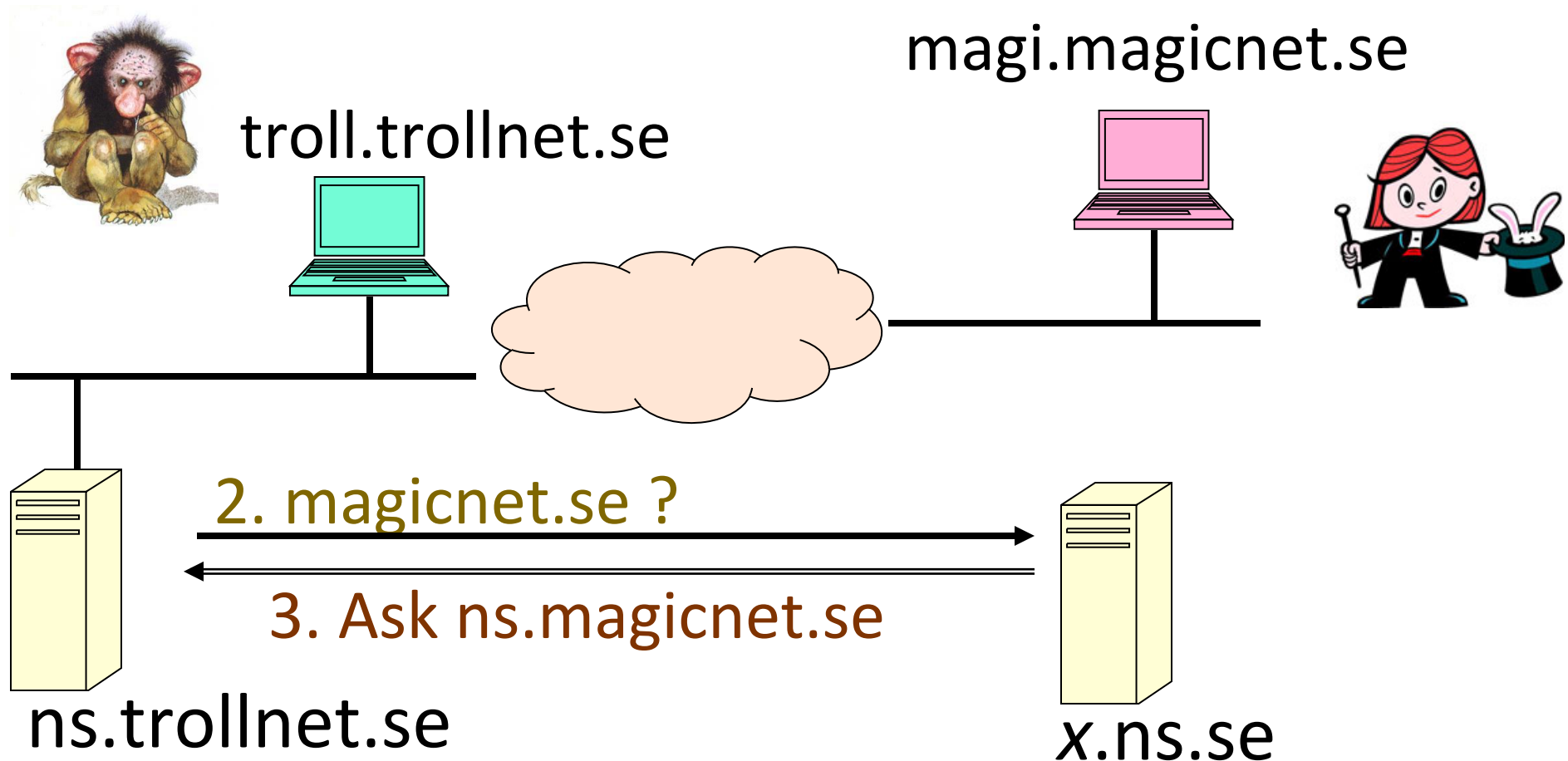
13 logical root name servers implemented by 376 physical servers, see www.root-servers.org



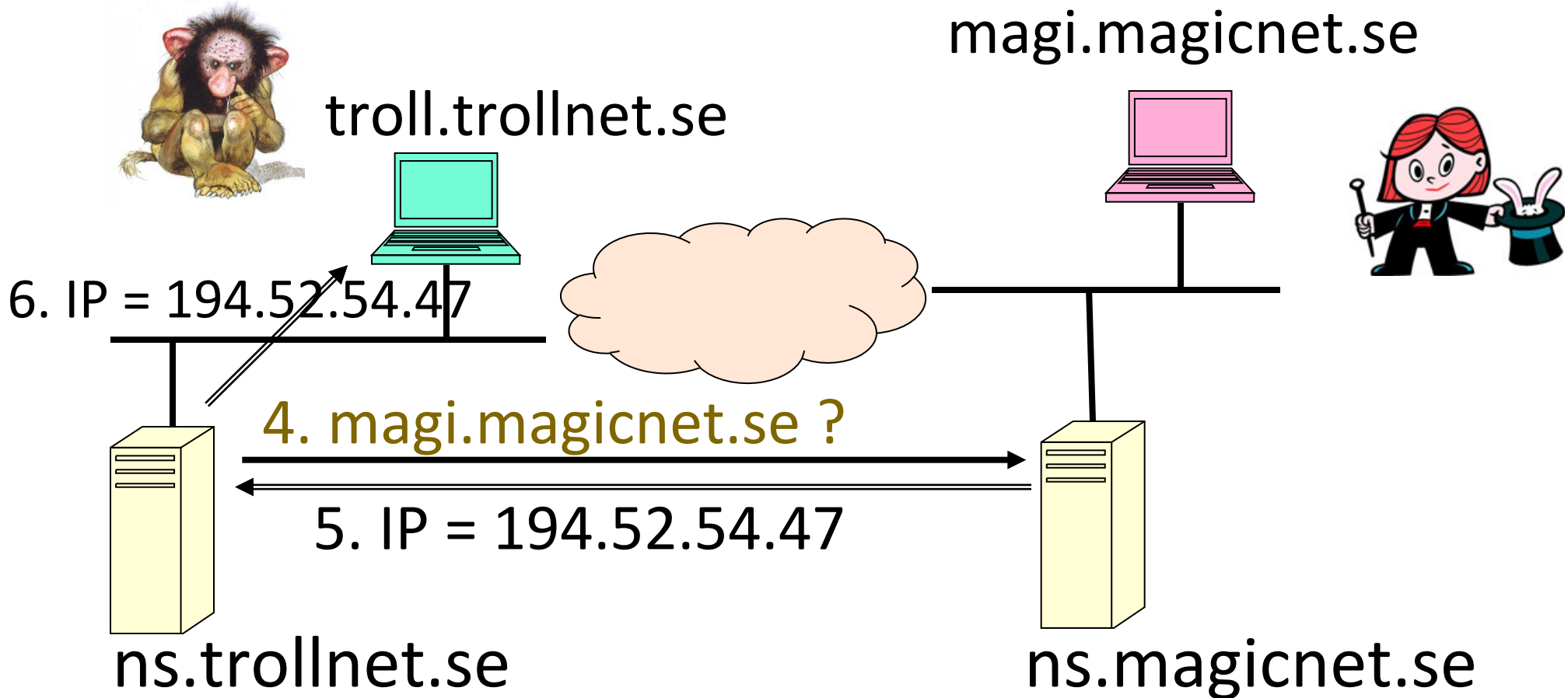
Domain name to IP address (1)



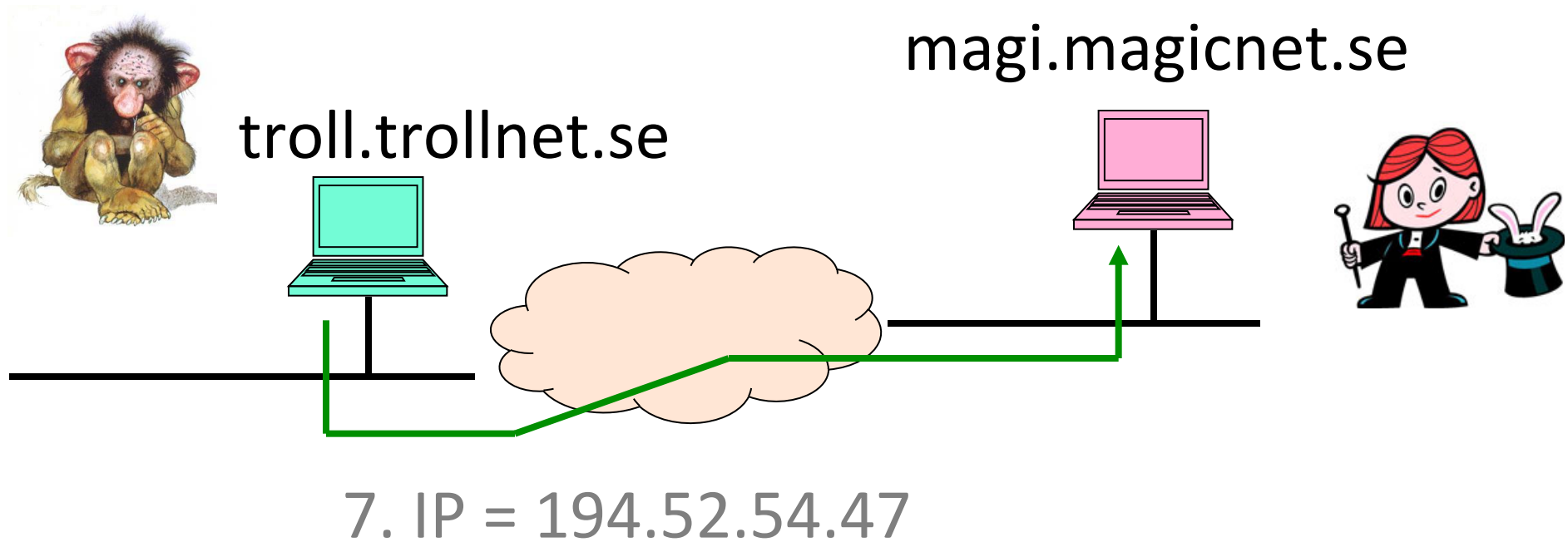
Domain name to IP address (2)



Domain name to IP address (3)



Domain name to IP address (4)



Obtaining an IP address for host

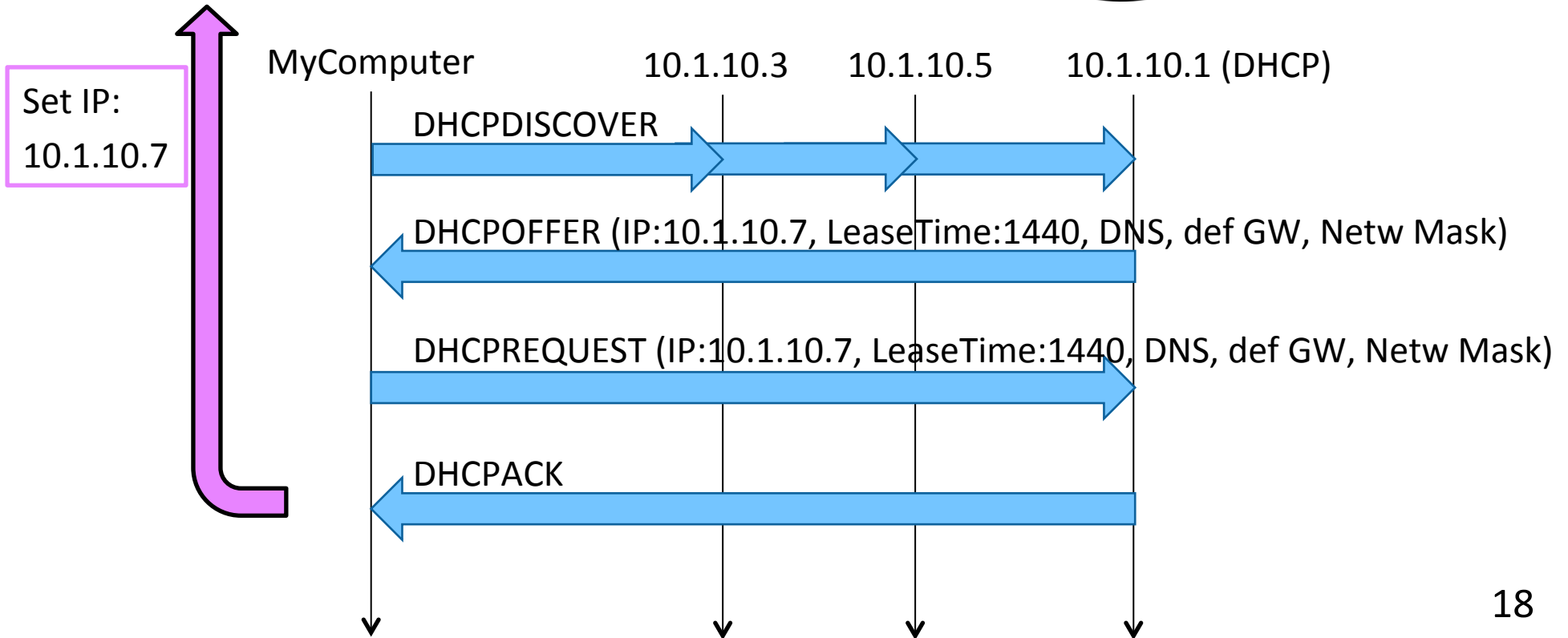
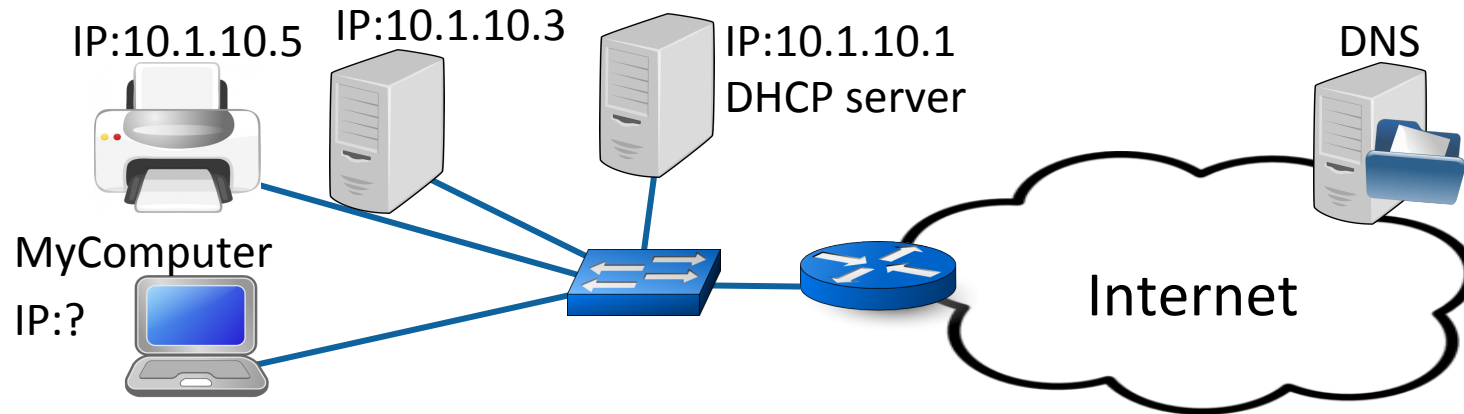
- Dynamic Host Configuration Protocol (DHCP)
Manage and distribute:
 - IP address
 - Allocation from pool or static from table
 - Lease time
 - Network mask
 - Default gateway
 - DNS server(s)

DHCP (1993)

DHCP messages

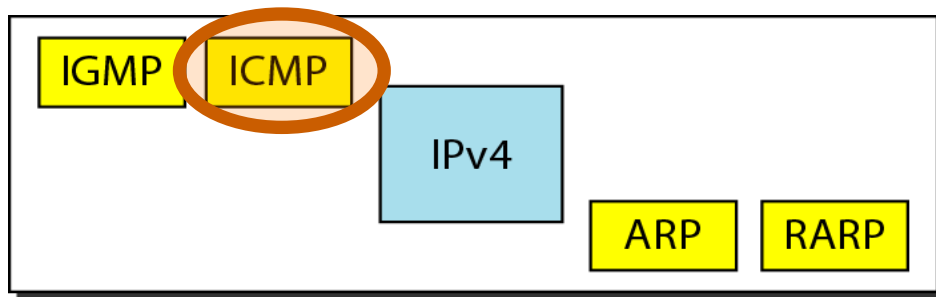
- DHCPDISCOVER
 - Client broadcast
- DHCPOFFER
 - Server->Client offer IP address, etc
- DHCPREQUEST
 - Client->Server accept (or renew)
- DHCPACK
 - Server->Client ACK
- DHCPNACK
- DHCPDECLINE
- DHCPRELEASE
- DHCPINFORM

Connect MyComputer to the network

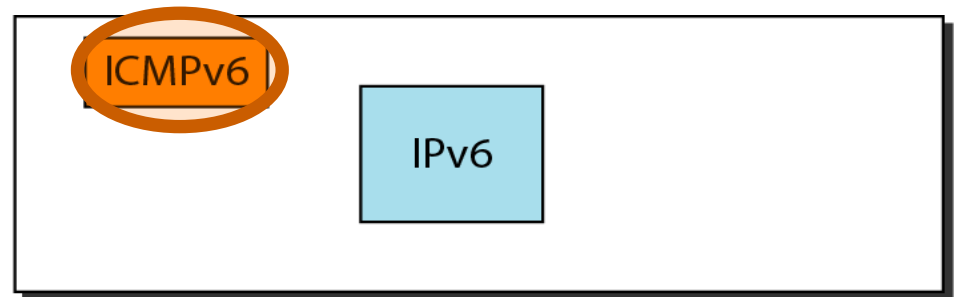


Debugging Tools

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



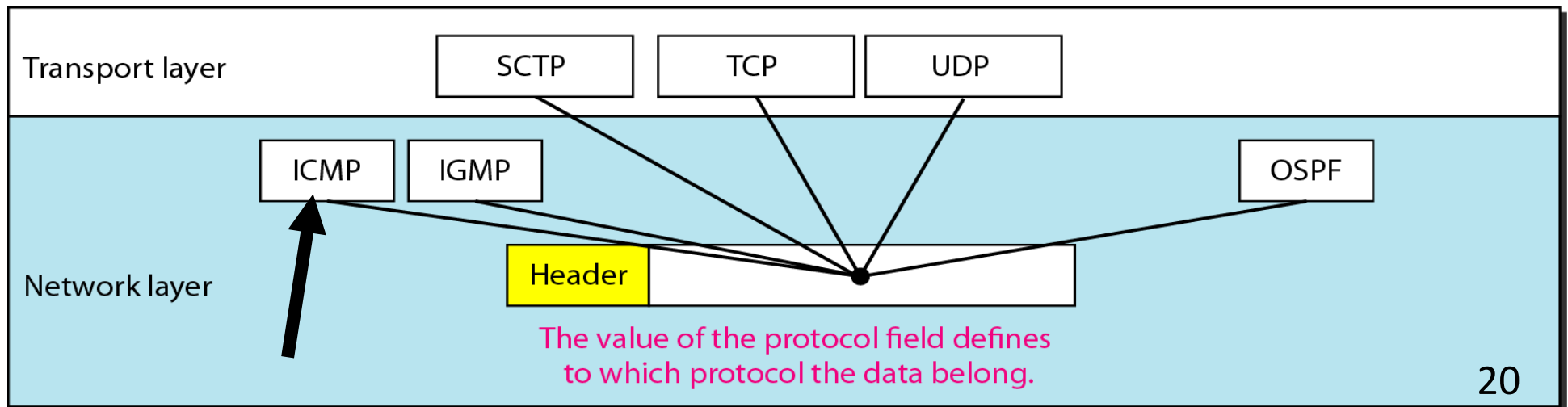
Network layer in version 4



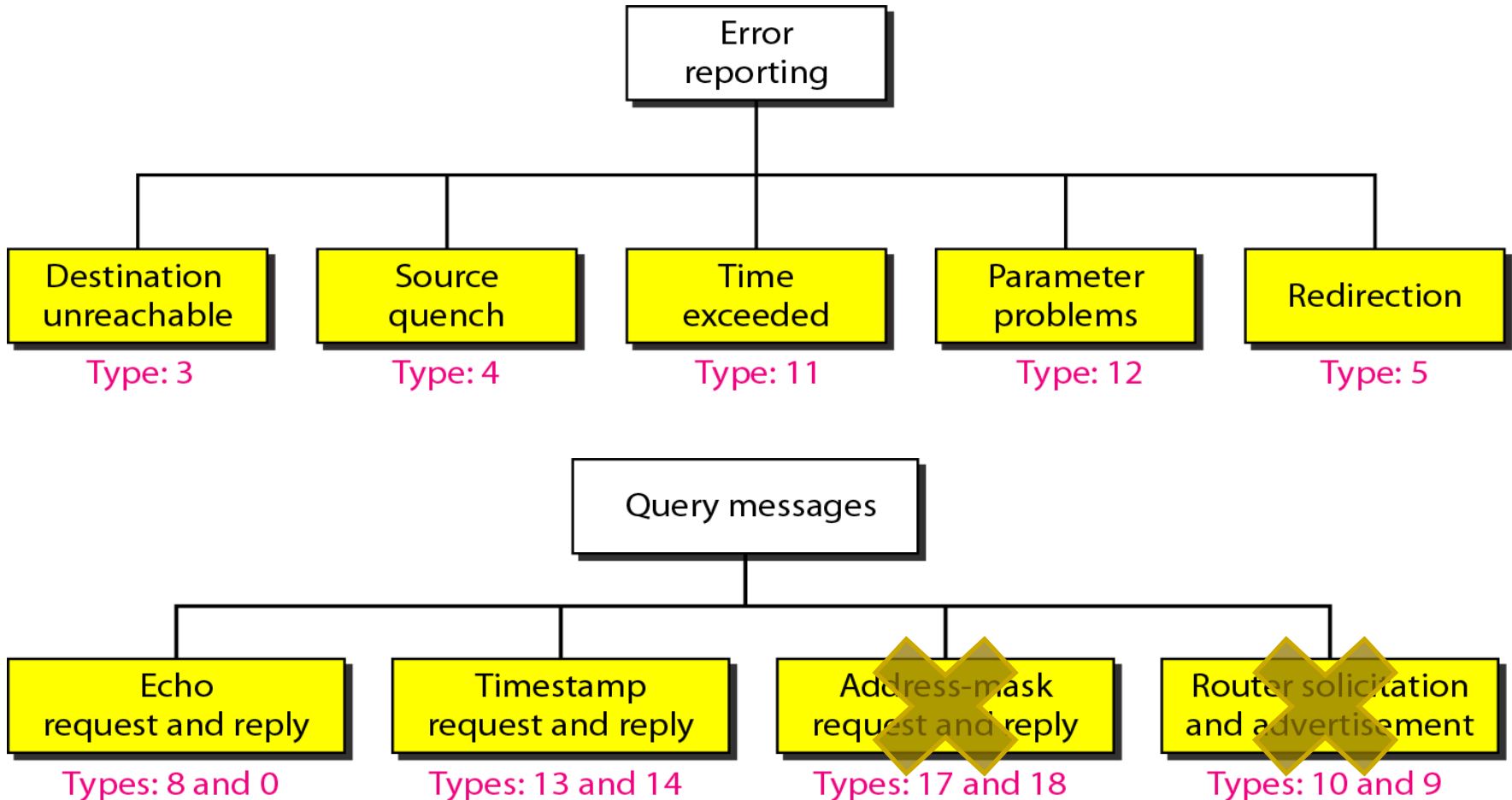
Network layer in version 6

Encapsulation

- ICMP messages encapsulated in IP packets
- Support protocol for IP
 - Error reporting
 - Query



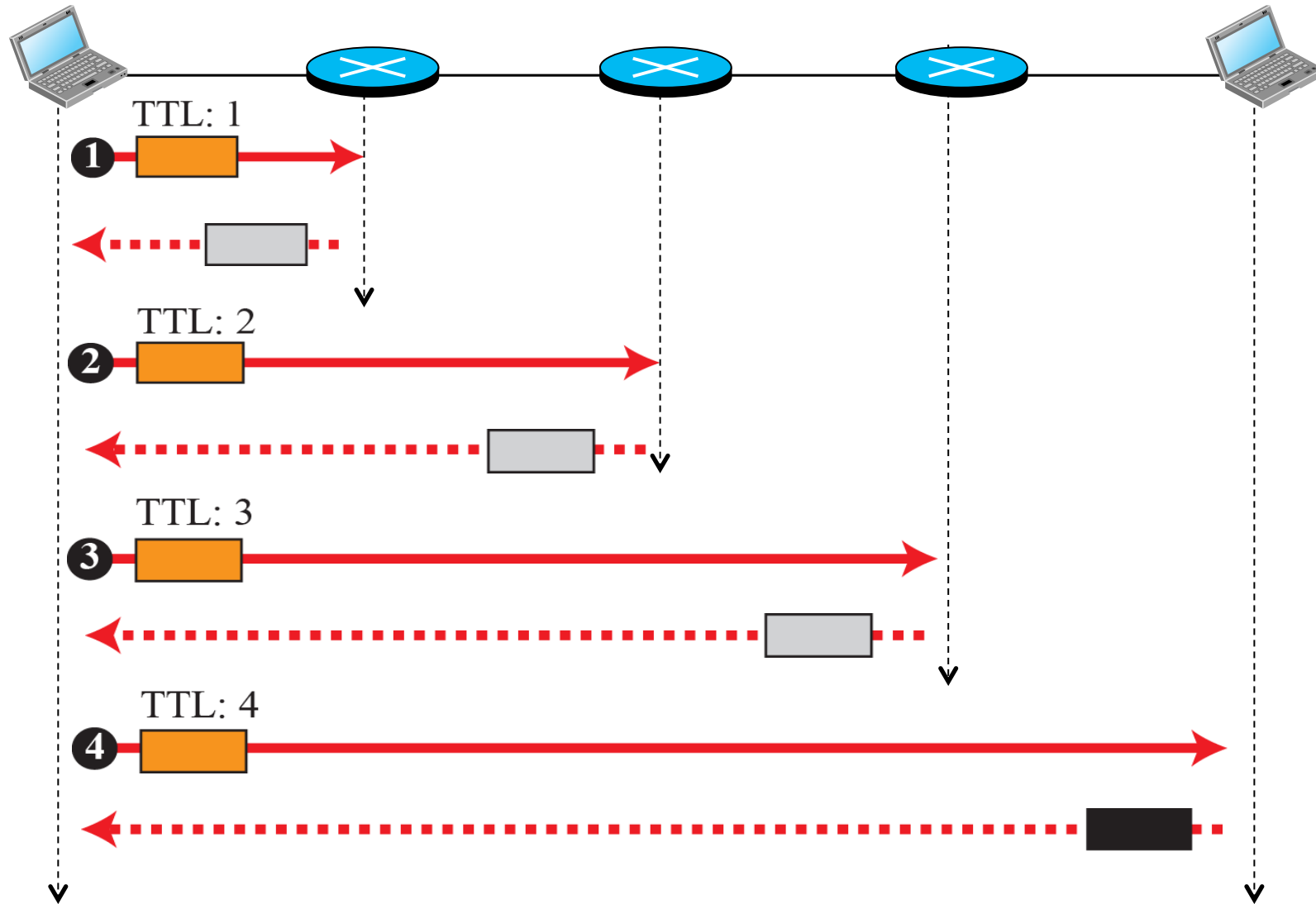
ICMPv4 message types



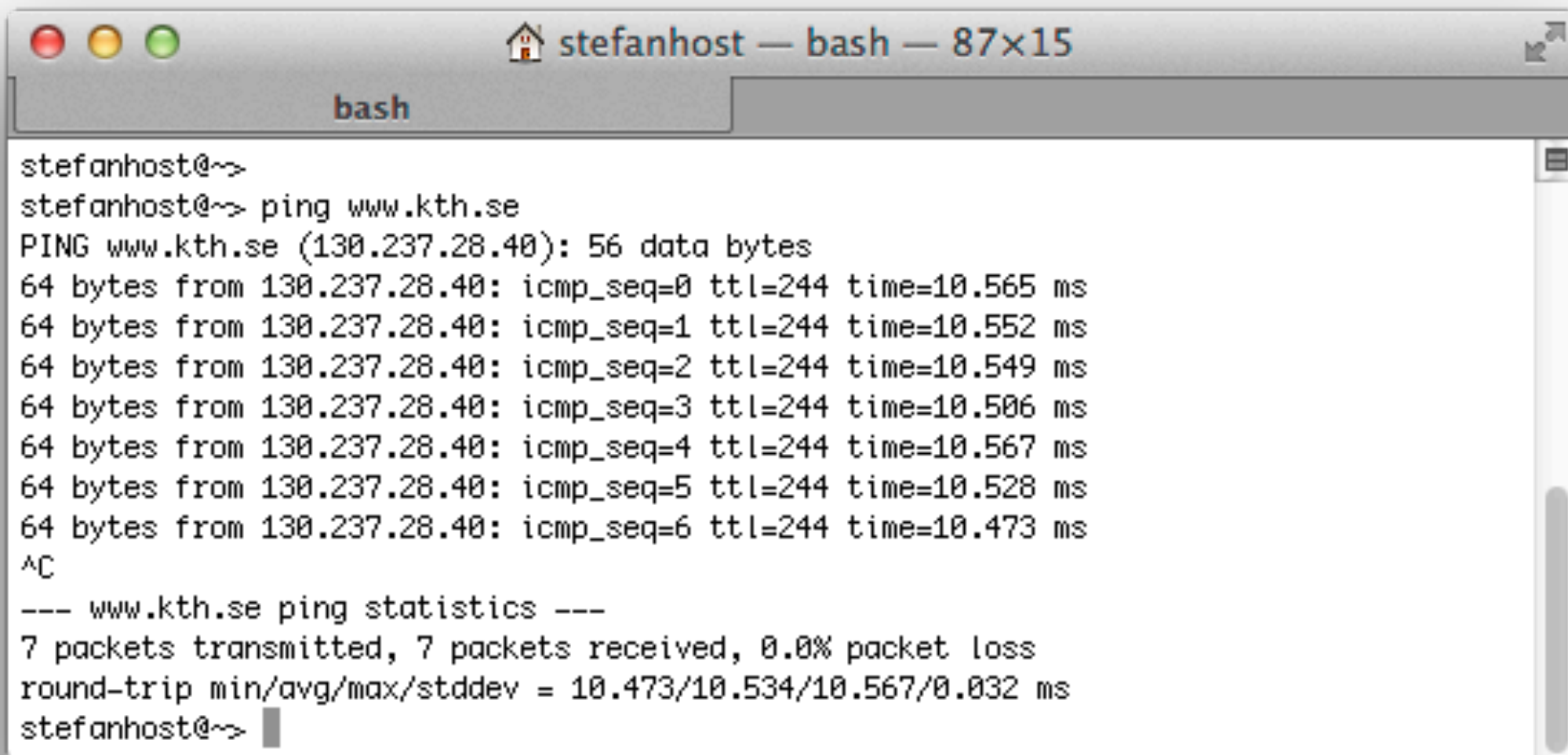
Echo request and reply (query type)

- Ping
 - Is my destination alive?
 - ICMP echo request => ICMP echo reply from destination
- Traceroute
 - Successively increase Time To Live (TTL) in ICMP echo request to find the path to destination

Traceroute

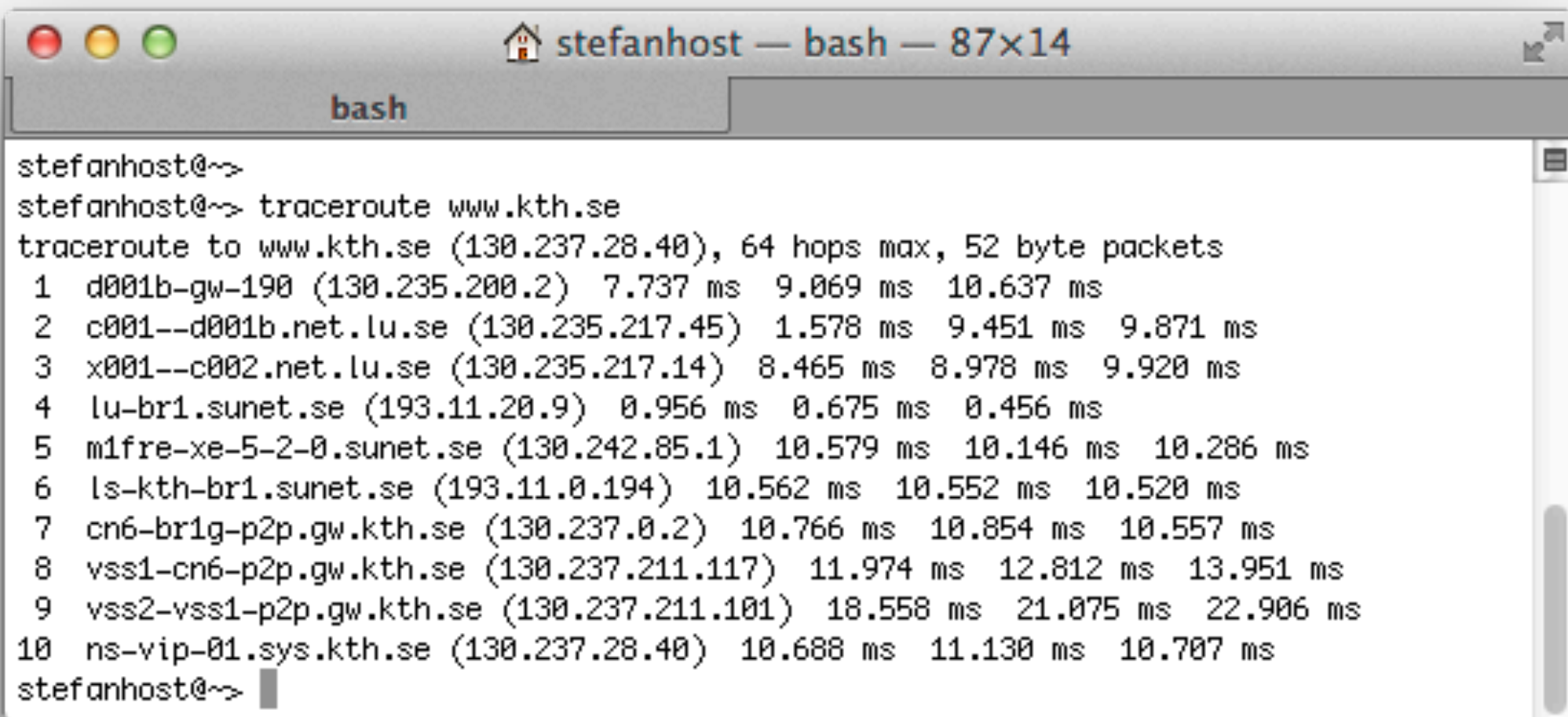


Ping



```
stefanhost — bash — 87x15
bash
stefanhost@~>
stefanhost@~> ping www.kth.se
PING www.kth.se (130.237.28.40): 56 data bytes
64 bytes from 130.237.28.40: icmp_seq=0 ttl=244 time=10.565 ms
64 bytes from 130.237.28.40: icmp_seq=1 ttl=244 time=10.552 ms
64 bytes from 130.237.28.40: icmp_seq=2 ttl=244 time=10.549 ms
64 bytes from 130.237.28.40: icmp_seq=3 ttl=244 time=10.506 ms
64 bytes from 130.237.28.40: icmp_seq=4 ttl=244 time=10.567 ms
64 bytes from 130.237.28.40: icmp_seq=5 ttl=244 time=10.528 ms
64 bytes from 130.237.28.40: icmp_seq=6 ttl=244 time=10.473 ms
^C
--- www.kth.se ping statistics ---
7 packets transmitted, 7 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 10.473/10.534/10.567/0.032 ms
stefanhost@~>
```


Traceroute



The image shows a terminal window titled "stefanhost — bash — 87x14". The terminal content is as follows:

```
stefanhost@~>
stefanhost@~> traceroute www.kth.se
traceroute to www.kth.se (130.237.28.40), 64 hops max, 52 byte packets
 1  d001b-gw-190 (130.235.200.2)  7.737 ms  9.069 ms  10.637 ms
 2  c001--d001b.net.lu.se (130.235.217.45)  1.578 ms  9.451 ms  9.871 ms
 3  x001--c002.net.lu.se (130.235.217.14)  8.465 ms  8.978 ms  9.920 ms
 4  lu-br1.sunet.se (193.11.20.9)  0.956 ms  0.675 ms  0.456 ms
 5  m1fre-xe-5-2-0.sunet.se (130.242.85.1)  10.579 ms  10.146 ms  10.286 ms
 6  ls-kth-br1.sunet.se (193.11.0.194)  10.562 ms  10.552 ms  10.520 ms
 7  cn6-br1g-p2p.gw.kth.se (130.237.0.2)  10.766 ms  10.854 ms  10.557 ms
 8  vss1-cn6-p2p.gw.kth.se (130.237.211.117)  11.974 ms  12.812 ms  13.951 ms
 9  vss2-vss1-p2p.gw.kth.se (130.237.211.101)  18.558 ms  21.075 ms  22.906 ms
10  ns-vip-01.sys.kth.se (130.237.28.40)  10.688 ms  11.130 ms  10.707 ms
stefanhost@~>
```

Win: tracert

WWW (1989)

- 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.
 - First web browser: Mosaic



Components of WWW

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

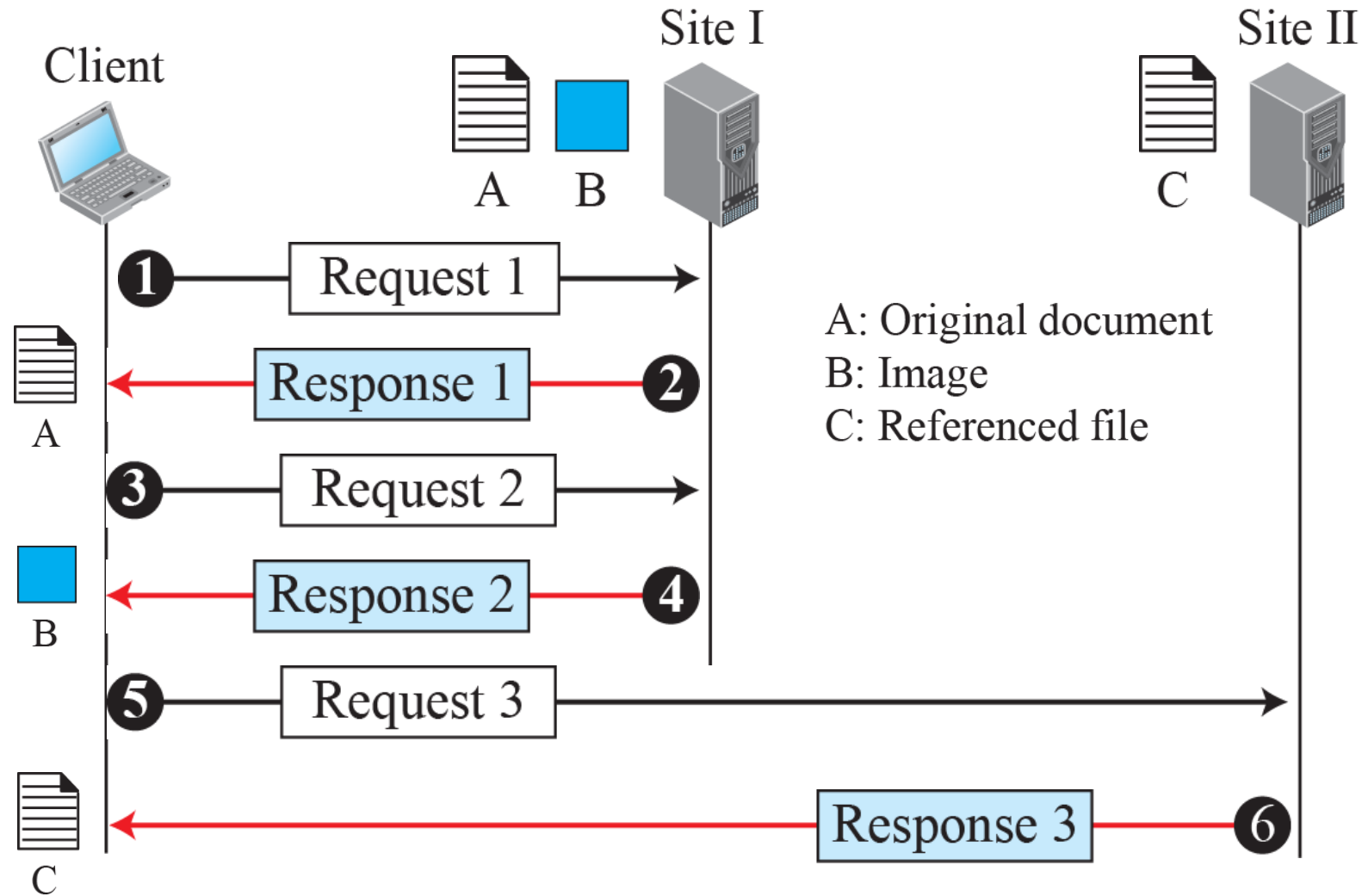
Universal Resource Locator (URL)

- 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
- Sets up and uses a TCP connection
- Two basic types of messages
 - Request and Response

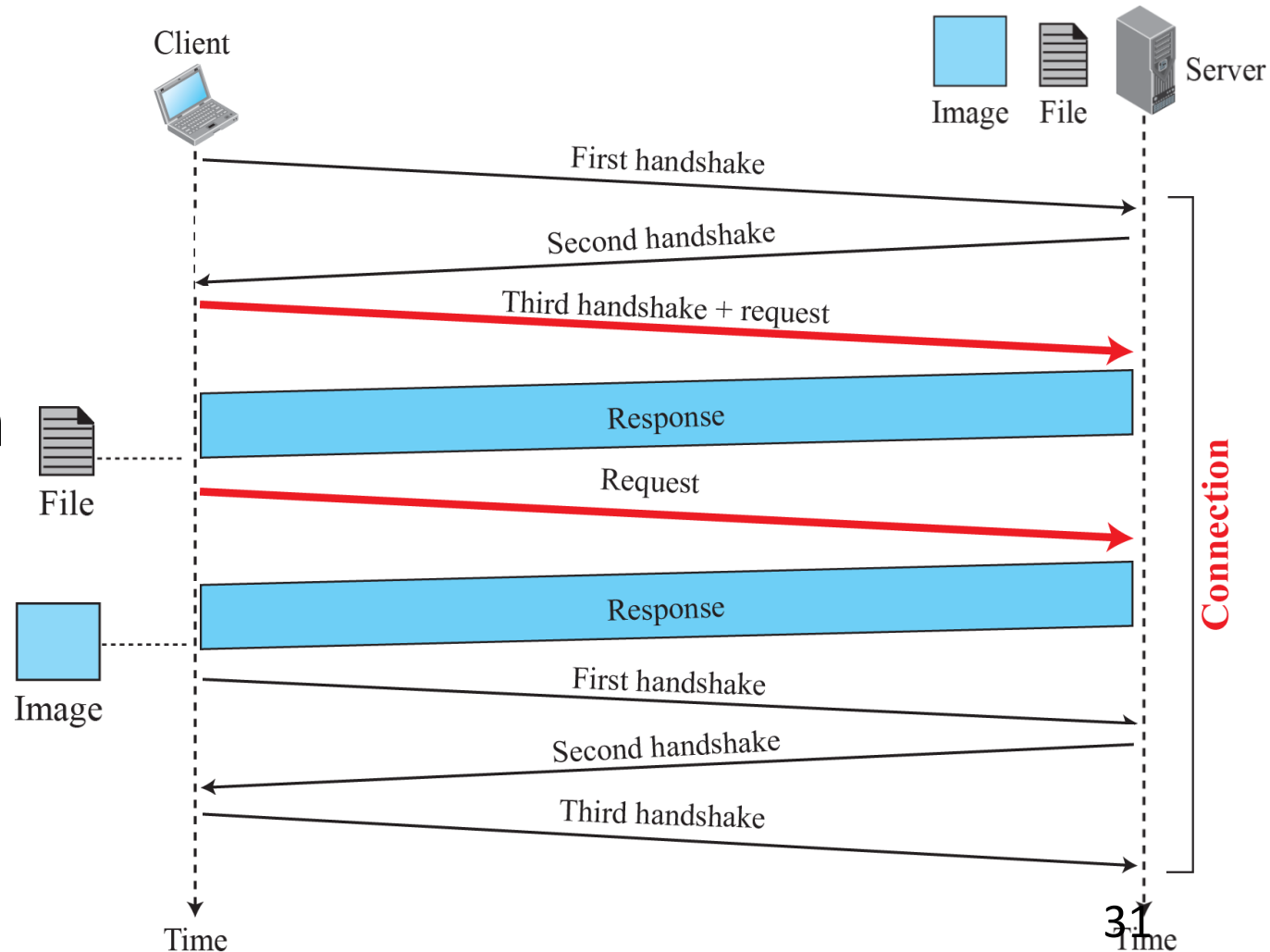
Document retrieval



Operation of HTTP 1.1

Persistent connection

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



HTTP methods in requests

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

GET: Request document from server

HEAD: Request information about document

PUT: Send document to server

POST: Send information to server

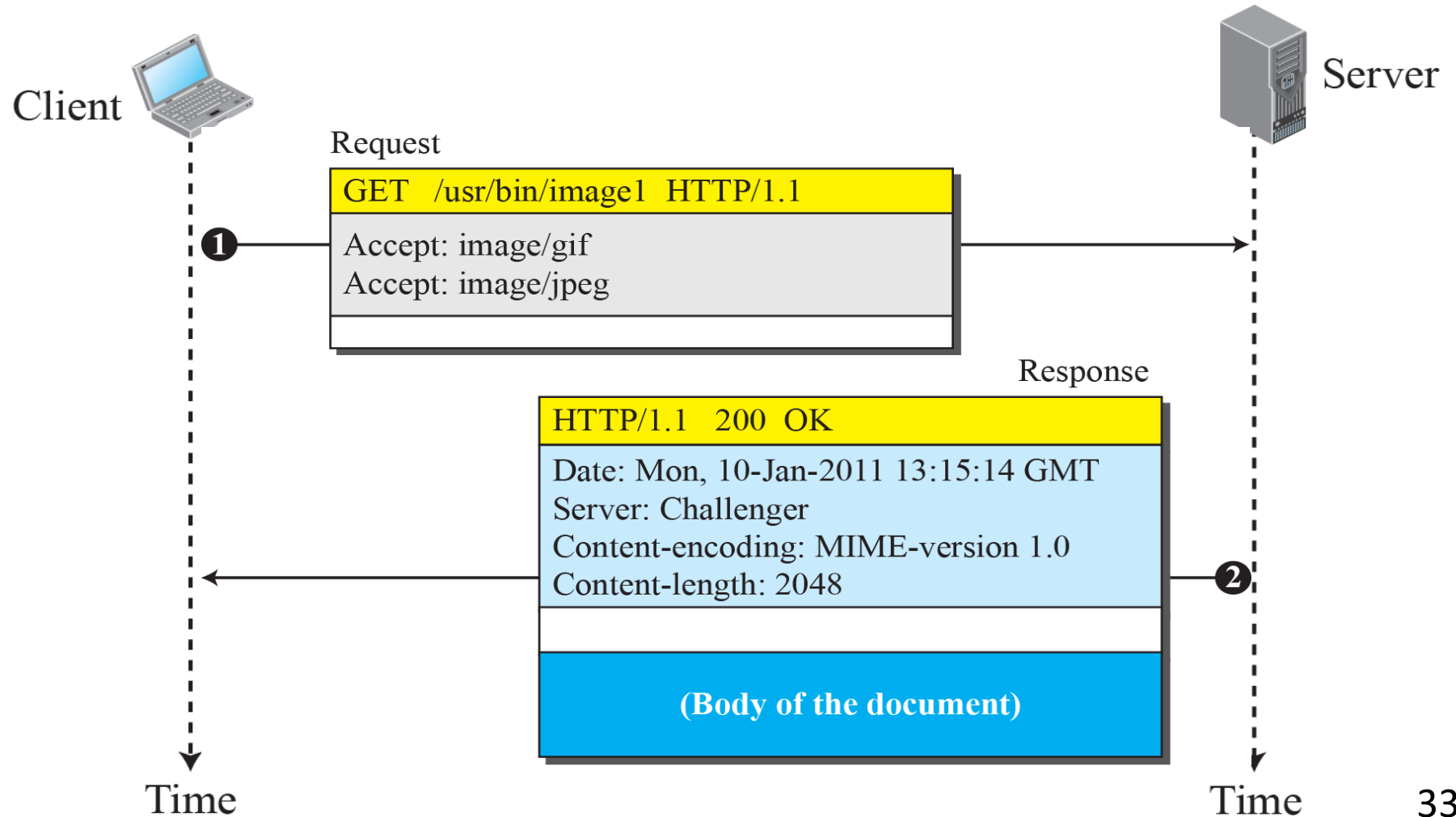
TRACE: Echo incoming request

DELETE: Remove webpage

CONNECT: Reserved

OPTIONS: Inquiry about available options

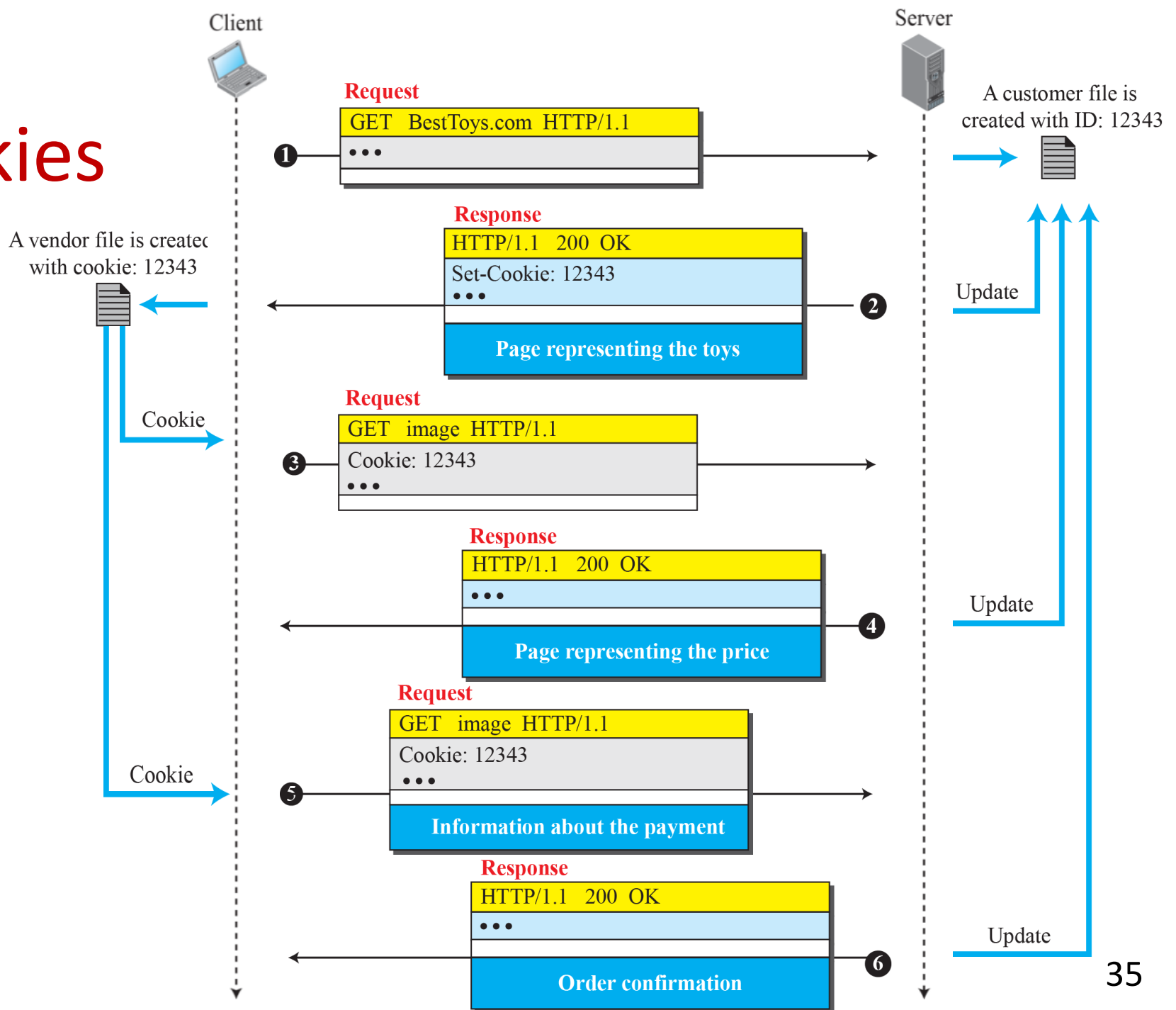
Example request and response



Cookies (1994)

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

Cookies



Electronic mail (e-mail)

1971

- The first e-mail was sent between two computers in the same room.
- Separate user from host with the @ sign. It was unused on the keyboard.



Mail delivery protocols

- SMTP (Simple mail transfer protocol)
 - Transfer mail to receiver mail server
- POP (Post office protocol)
 - Copy/Move mail from server to client
- IMAP (Internet mail access protocol)
 - Copy/Move mail from server to client

Mail delivery system

