

EITF25 – Internet: Technology and Applications

Application Layer -2-

User Applications

2013, Lecture 07

Kaan Bür, Stefan Höst

Underlying LAN or WAN
technology



Previously on EITF25

Application Layer (1)

- From domain names to IP addresses: DNS
- Host configuration: DHCP
- Debugging tools: ICMP, ping, traceroot
- World-wide Web: HTTP

Today: Application Layer

(2)

- File Transfer Protocol, FTP
[Forouzan ed.5 ch.26.2]
- Electronic mail, SMTP, POP, IMAP
[Forouzan ed.5 ch.26.3]
- Peer-to-peer networks, P2P
[Forouzan ed.5 ch.29.1, 29.5]
- Voice over IP, VoIP
[Forouzan ed.5 ch.28.4.4-5]

**[Kihl & Andersson: 12.3, 12.5-6, 12.8]*

World wide web (www)

- 1989-1990: HTTP, HTML by Tim Berners-Lee
- 1991 a first web browser
- 1991 www goes public
 - <http://info.cern.ch>
 - First website
- 1991: The Trojan Room coffee pot
 - <http://www.cl.cam.ac.uk/coffee/coffee.html>
 - First webcam (real time images)
- 1993: Mosaic becomes public



World wide web (www)

- 1994: Pizza Hut (first online webshop)
- 1994: Yahoo
- 1995: AltaVista
- 1997: AOL instant messenger
- 1997: sixdegrees.com (first modern social net)
- 1997: Google

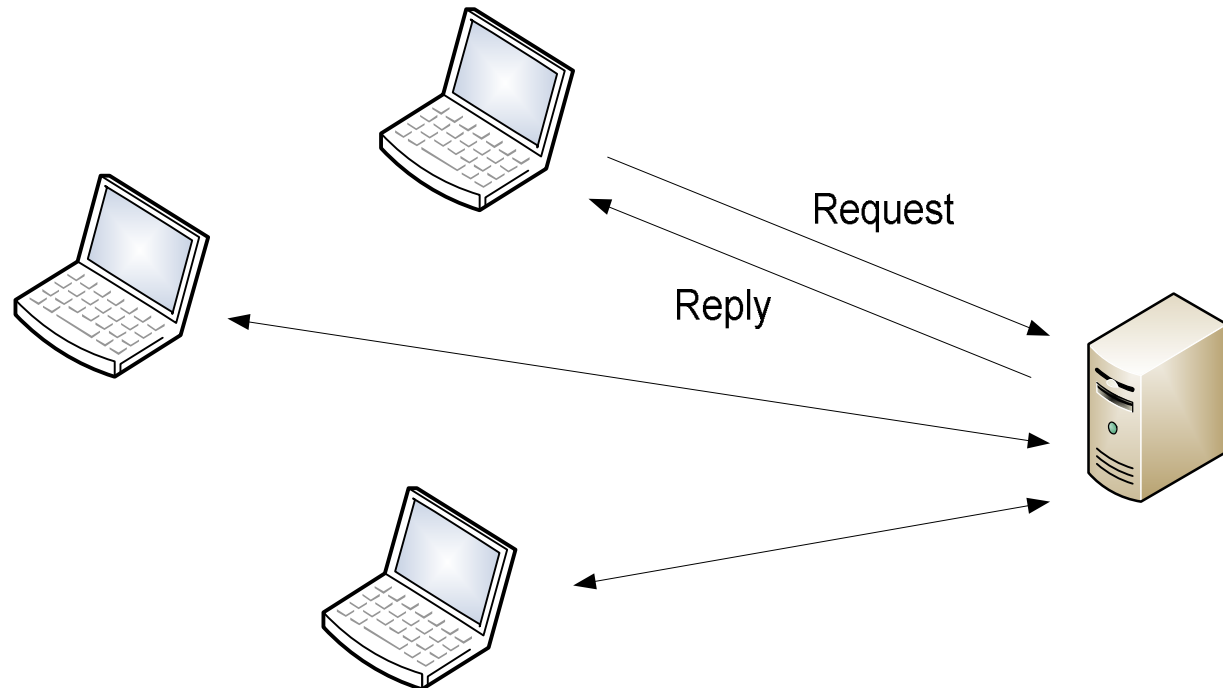
Then came the digital age...

- 1999: Napster
- 1999: Blogger
- 2001: BitTorrent
- 2001: Wikipedia
- 2003: Skype
- 2003: WordPress
- 2004: Gmail
- 2004: Flickr
- 2005: YouTube
- 2005: Facebook
- 2006: Twitter
- 2008: Spotify
- 2009: Google Docs
- 2009: Angry Birds



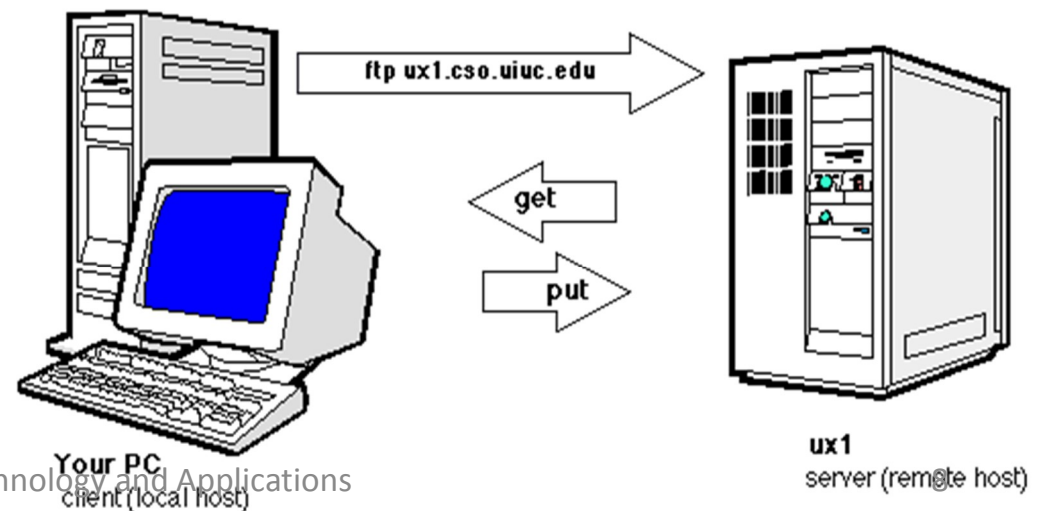
Client/server paradigm

- Most early applications were based on it
 - http
 - ftp
 - e-mail



File Transfer Protocol (FTP) - 1971

- File transfer between two computers
- TCP/IP
- Not so straightforward
 - File conventions
 - Data representations
 - Directory structures



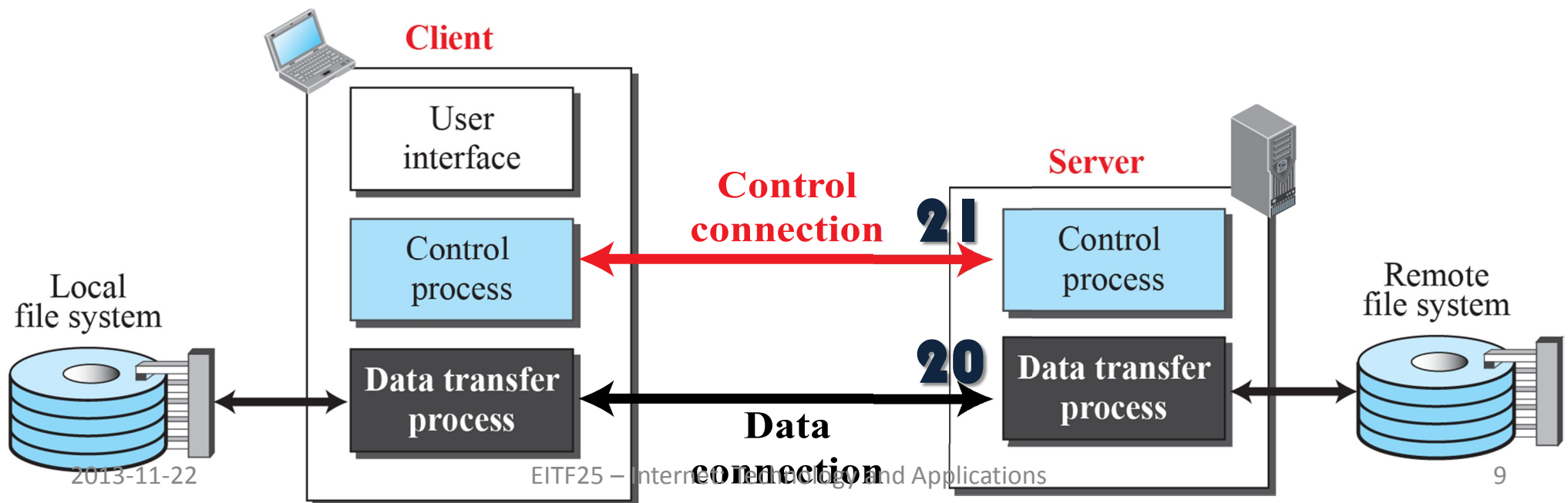
FTP: basic model

Control connection

- Open for entire session
- Commands & responses
 - ASCII

Data connection

- New one for each file



FTP: Data connection

- Client issues **passive open**
 - Sends **PORT#** to server
- Server issues **active open**
 - server:port20 \leftrightarrow client:port #
- All preparations through control connection

FTP: Control connection

COMMANDS

<i>Command</i>	<i>Argument(s)</i>	<i>Description</i>
ABOR		Abort the previous command
CDUP		Change to parent directory
CWD	Directory name	Change to another directory
DELE	File name	Delete a file
LIST	Directory name	List subdirectories or files
MKD	Directory name	Create a new directory
PASS	User password	Password
PASV		Server chooses a port
PORT	port identifier	Client chooses a port
PWD		Display name of current directory
QUIT		Log out of the system
RETR	File name(s)	Retrieve files; files are transferred from server to client

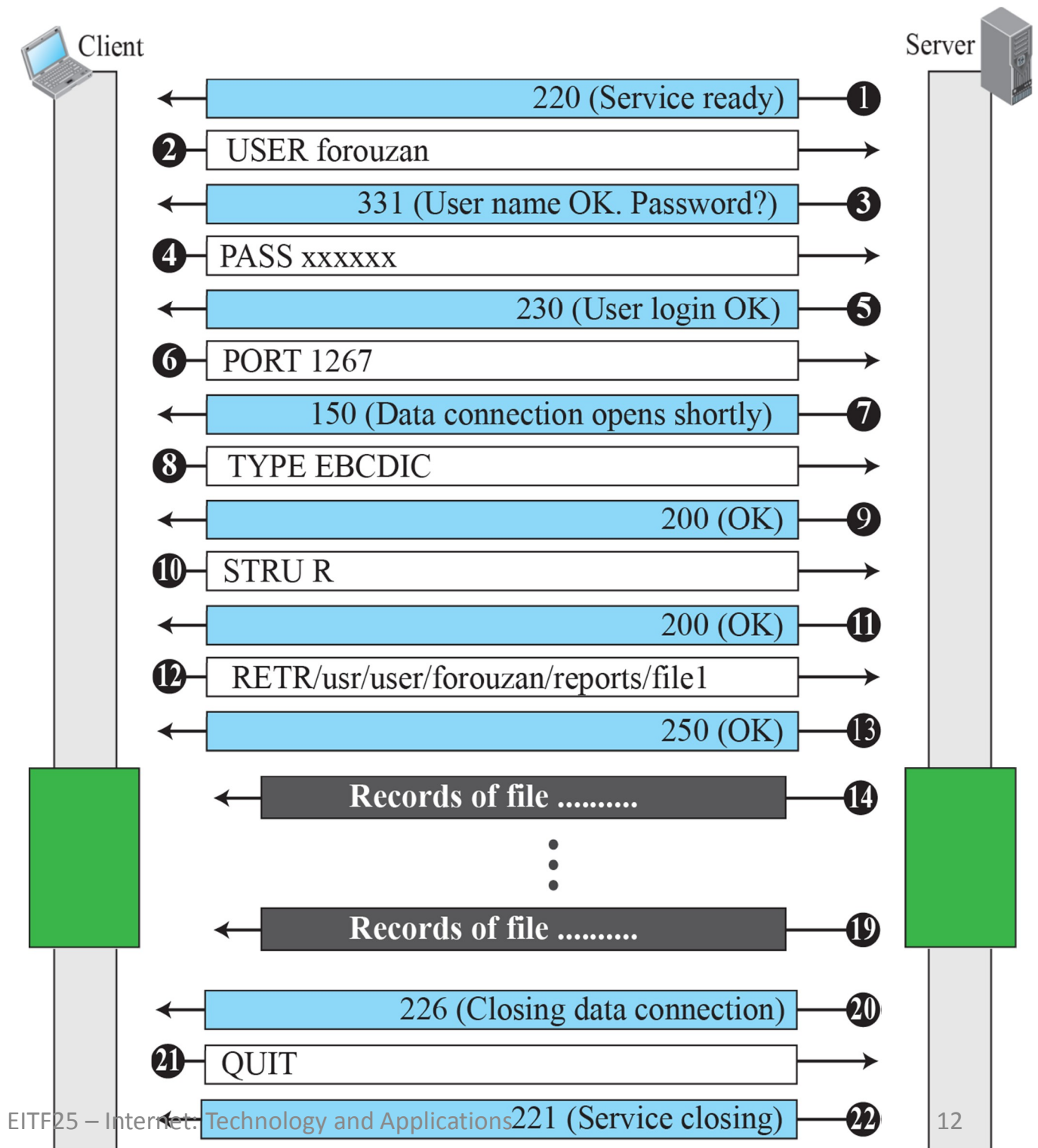
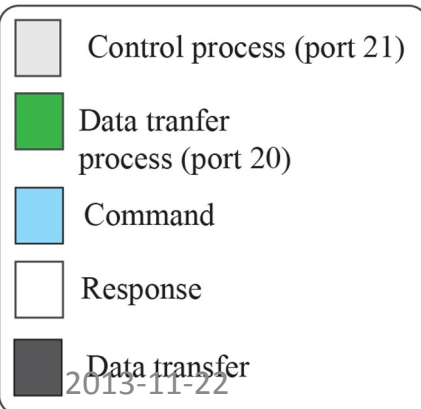
RESPONSES

<i>Code</i>	<i>Description</i>	<i>Code</i>	<i>Description</i>
125	Data connection open	250	Request file action OK
150	File status OK	331	User name OK; password is needed
200	Command OK	425	Cannot open data connection
220	Service ready	450	File action not taken; file not available
221	Service closing	452	Action aborted; insufficient storage
225	Data connection open	500	Syntax error; unrecognized command
226	Closing data connection	501	Syntax error in parameters or arguments
230	User login OK	530	User not logged in

FTP

- Session

Legend

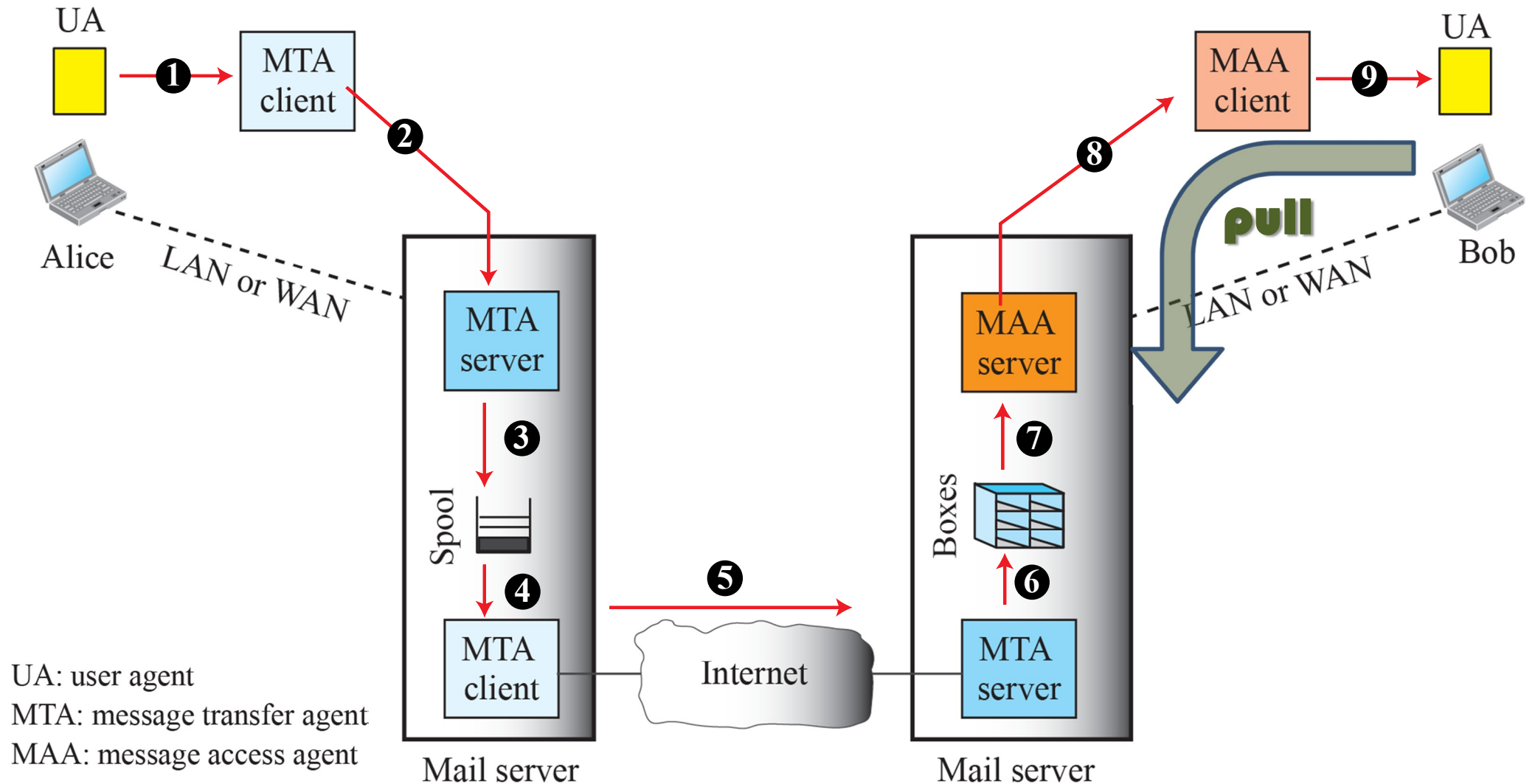


Electronic mail (e-mail) - 1971

- The first e-mail was sent between two computers in the same room.
- To separate the user from the host computer, the @ sign was inserted. It was unused on the keyboard.

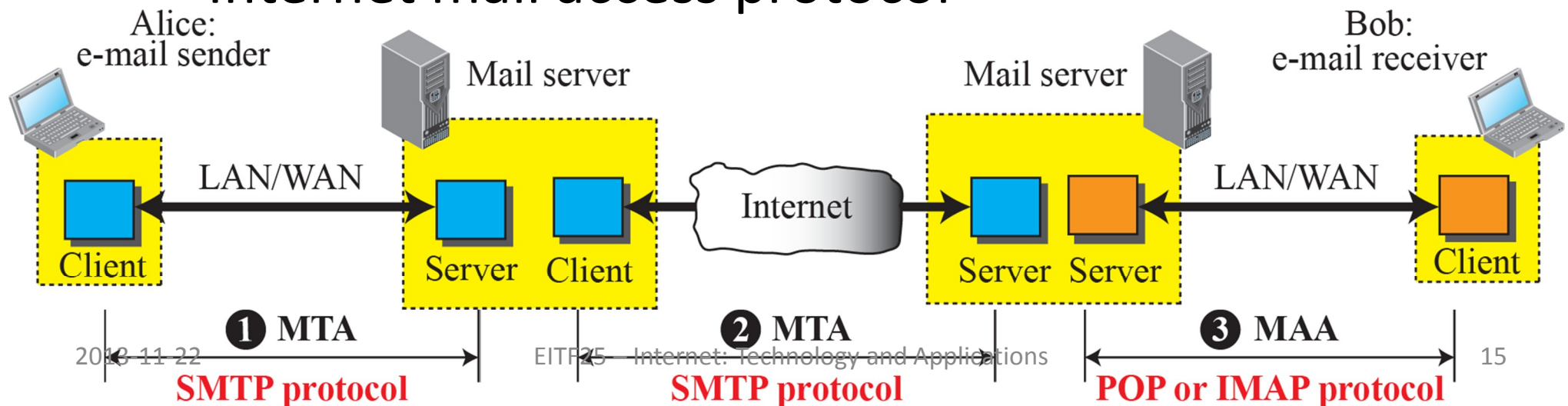
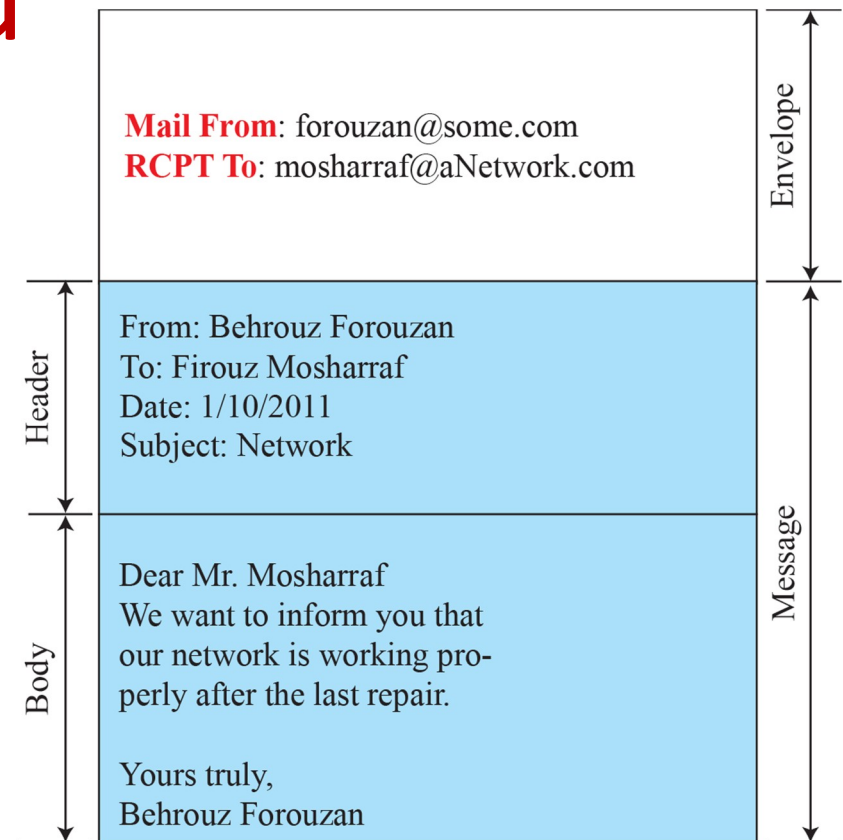


E-mail: basic model



E-mail: protocols used

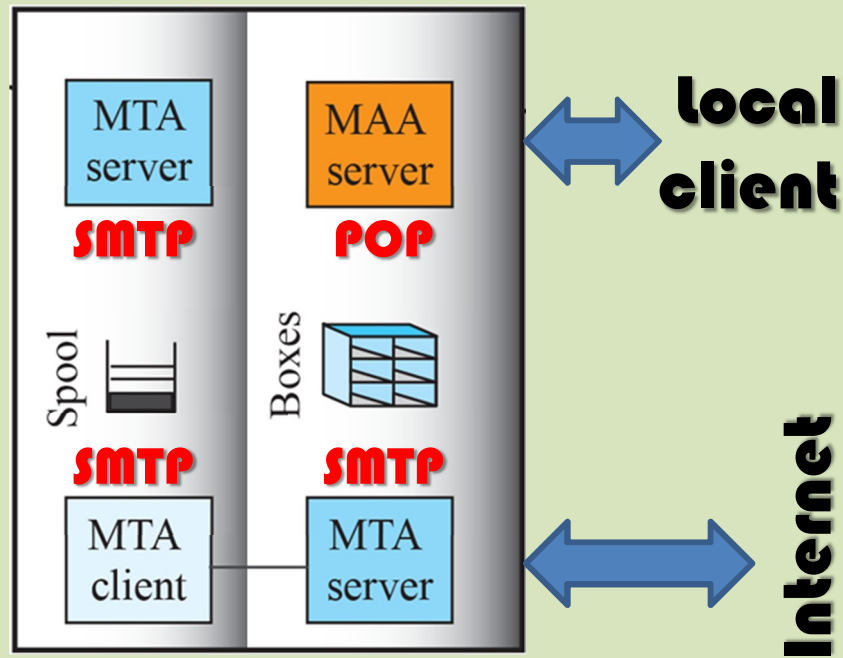
- SMTP
 - Simple mail transfer protocol
- POP
 - Post office protocol
- IMAP
 - Internet mail access protocol



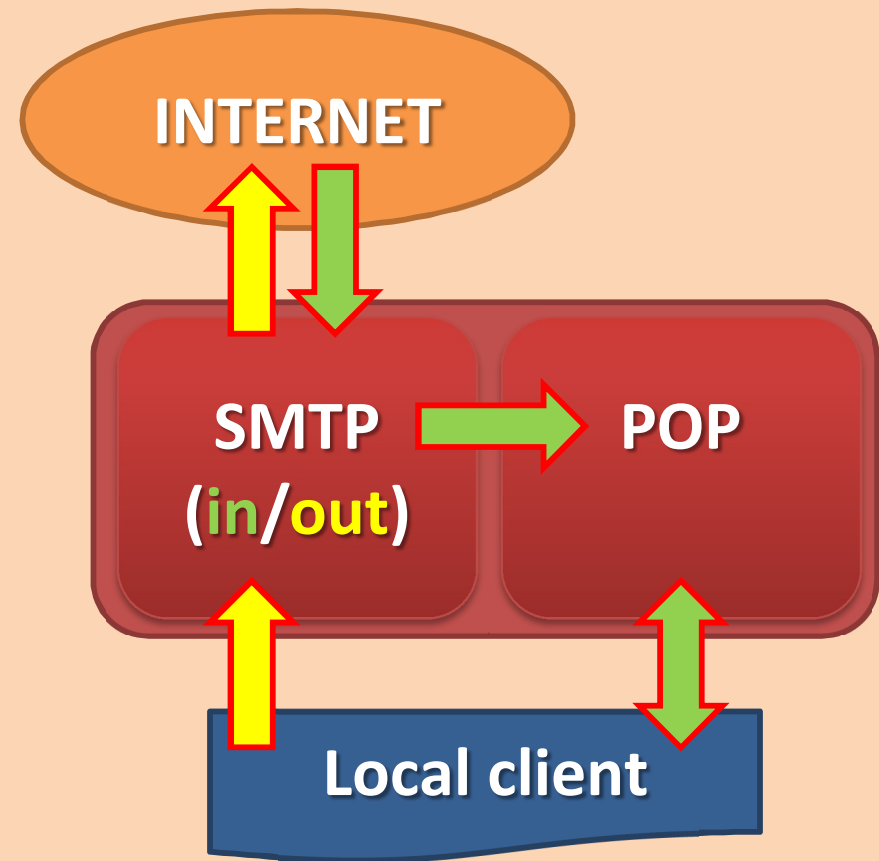
E-mail: server architecture

Sender & receiver in one

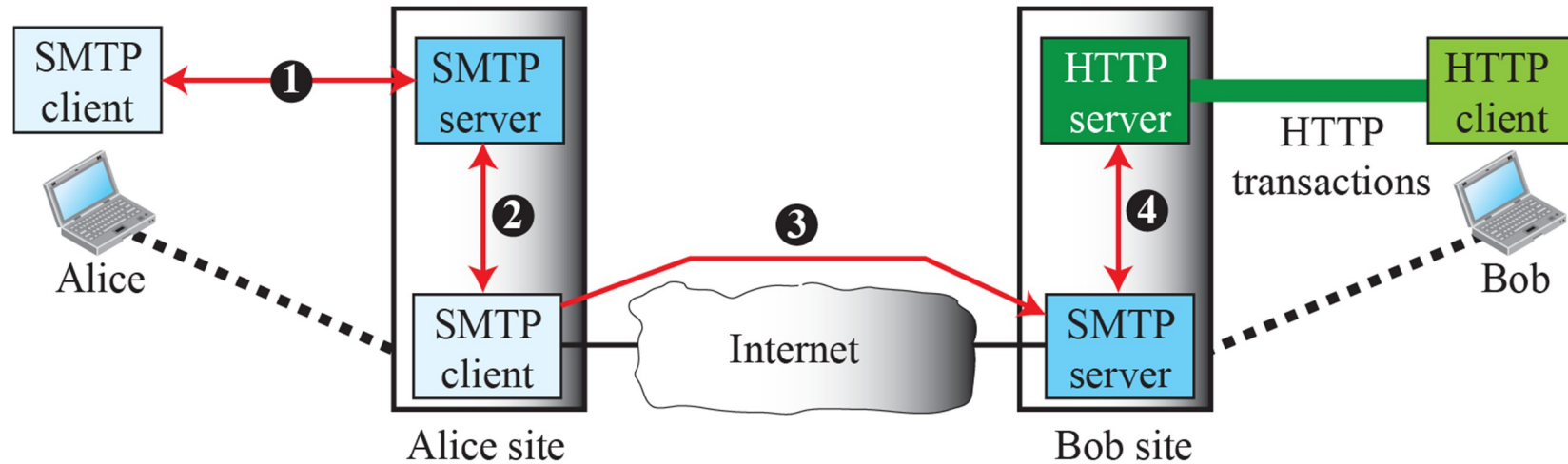
- Not a very good representation!



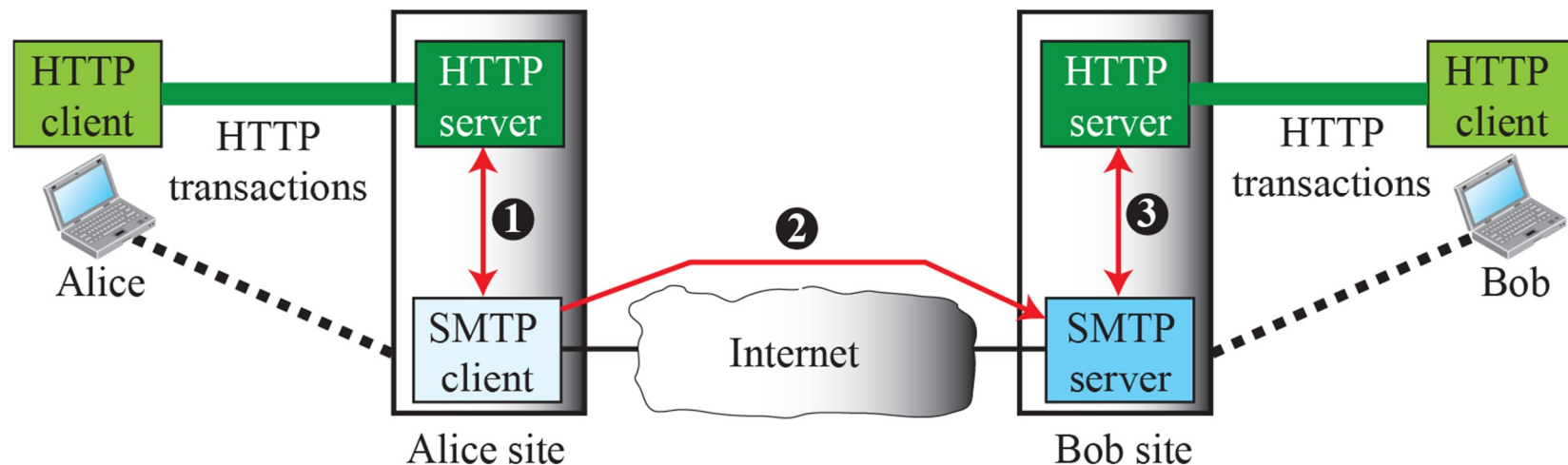
A holistic view



E-mail: Web-based services



Case 1: Only receiver uses HTTP



Case 2: Both sender and receiver use HTTP

See you in 15' :)



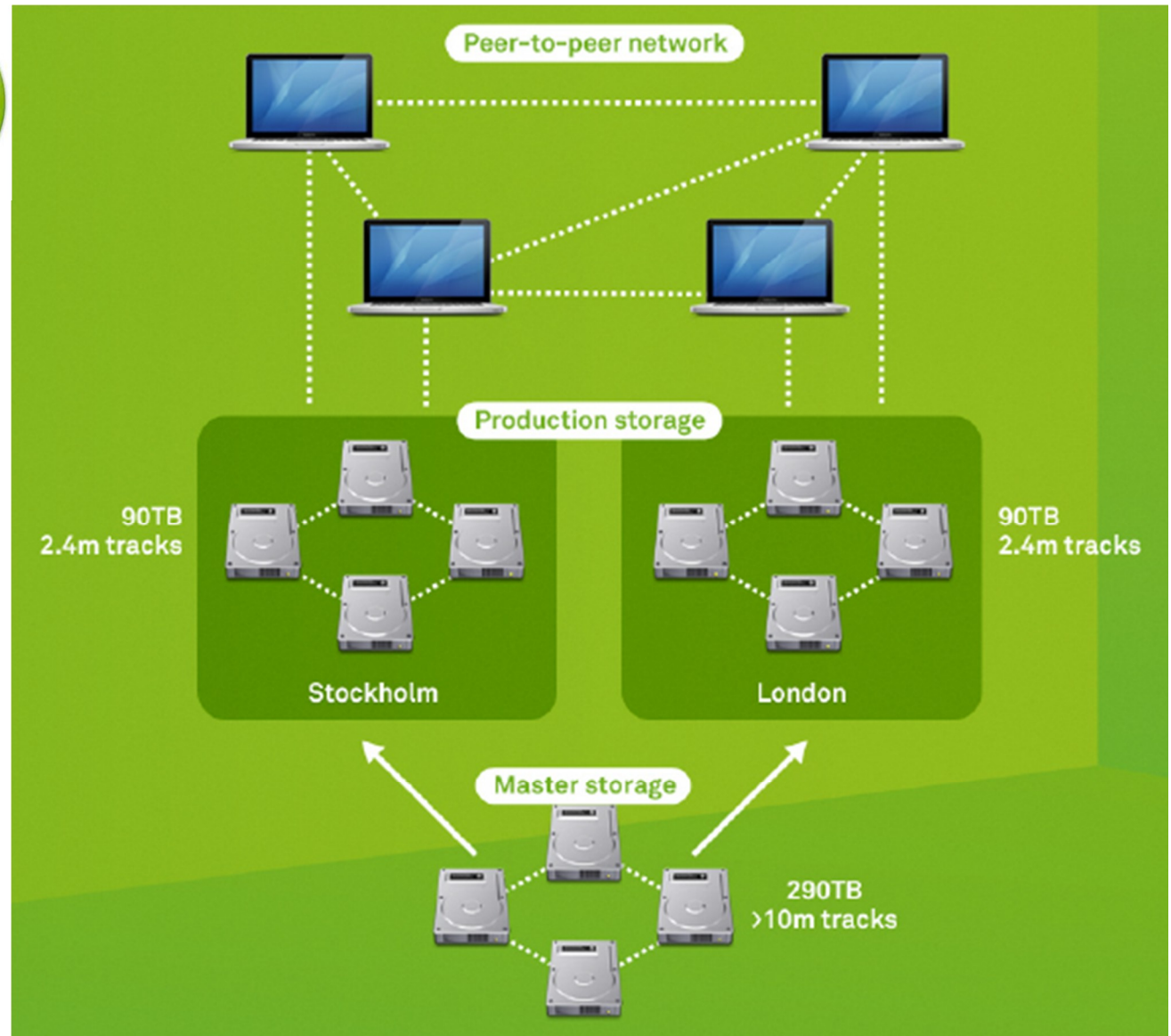
- After the break
 - P2P, BitTorrent
 - VoIP, Skype

Performance challenges

- Client/server architectures
 - Standardized protocols like HTTP
 - Heavy traffic load on network infrastructure
 - Unicast transmission
 - Delays due to overloaded access networks
 - Single point of failure

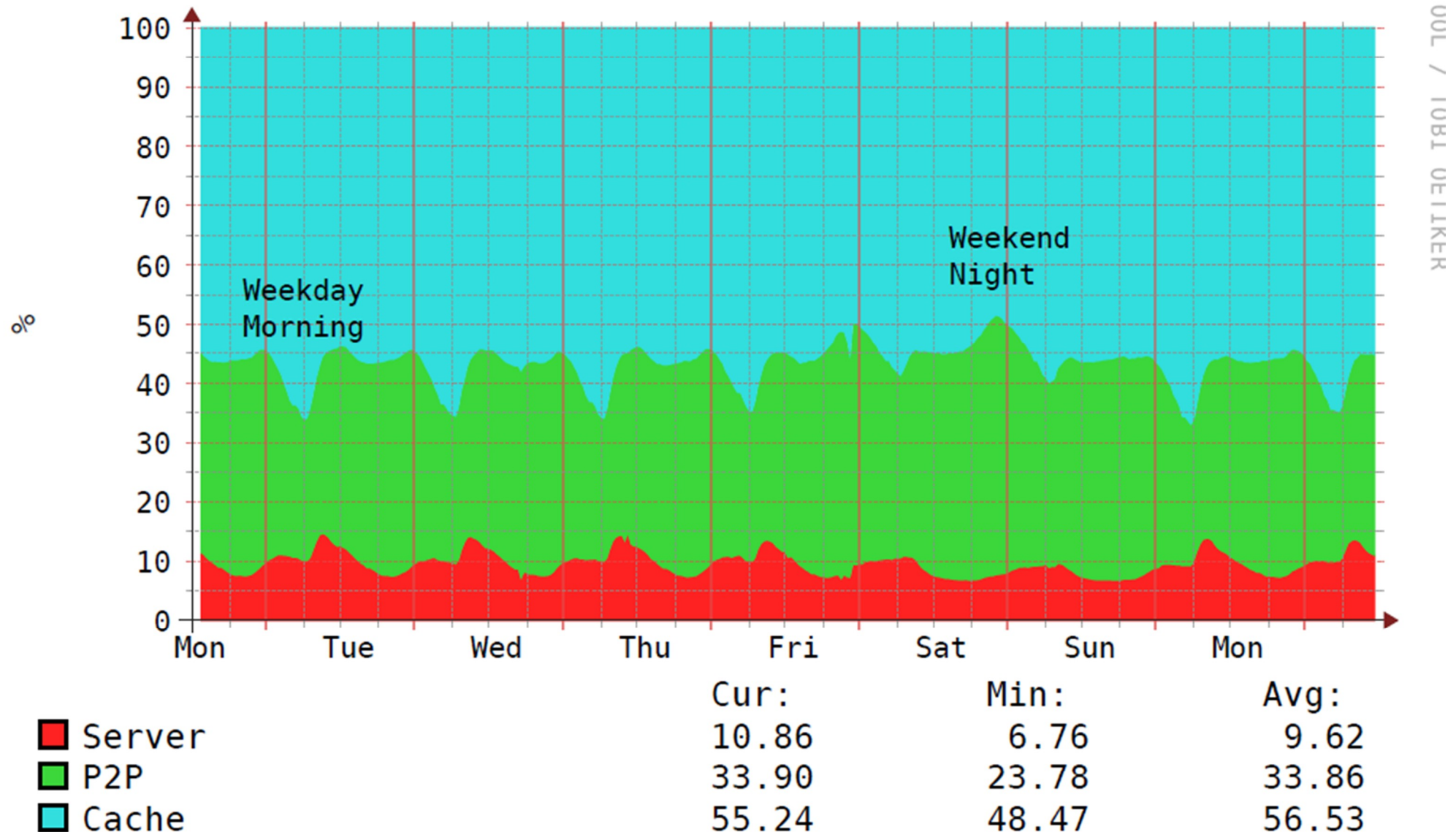
One solution: P2P (and caches)

- Spotify



Result: better load distribution

Data source - ratio - by week



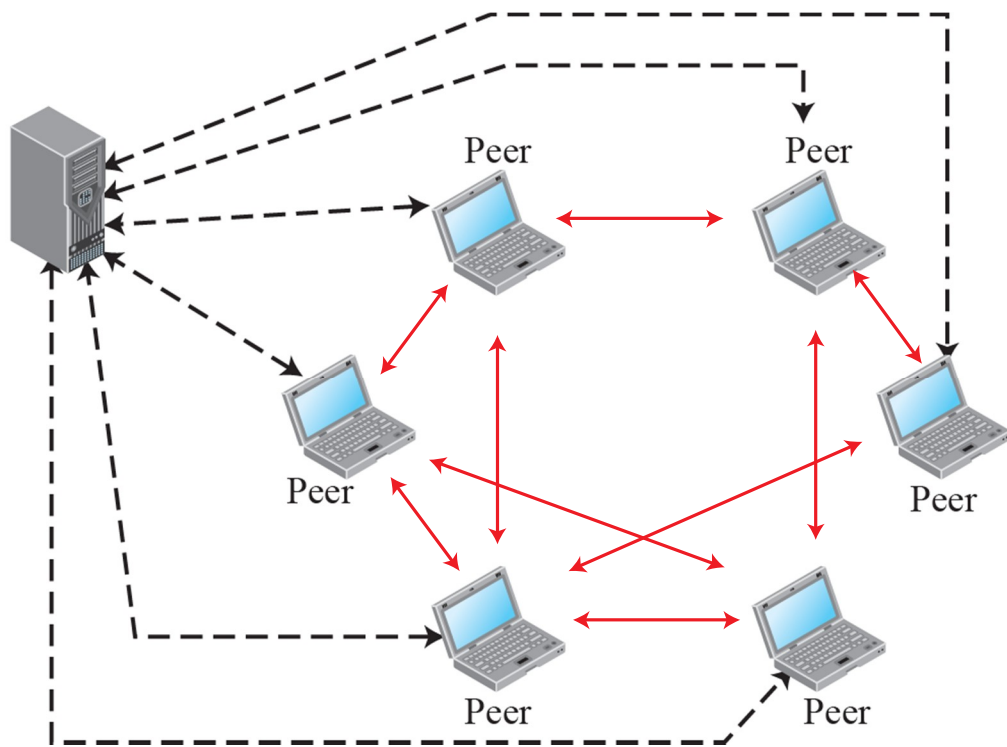
Peer-to-peer (P2P) paradigm

- Users sharing data form network of peers
- First P2P file sharing 1987
 - WWIVnet bulletin board by Wayne Bell
- Gained popularity 1999
 - Napster by Shawn Fanning

P2P networks

Centralised

- Directory server



Decentralised

- Overlay network
 - Logical on top of physical
- A) unstructured
 - Nodes linked randomly
 - Queries flood network
- B) structured
 - Nodes linked with rules (DHT)
 - More efficient query resolving
- Initial list of nodes provided

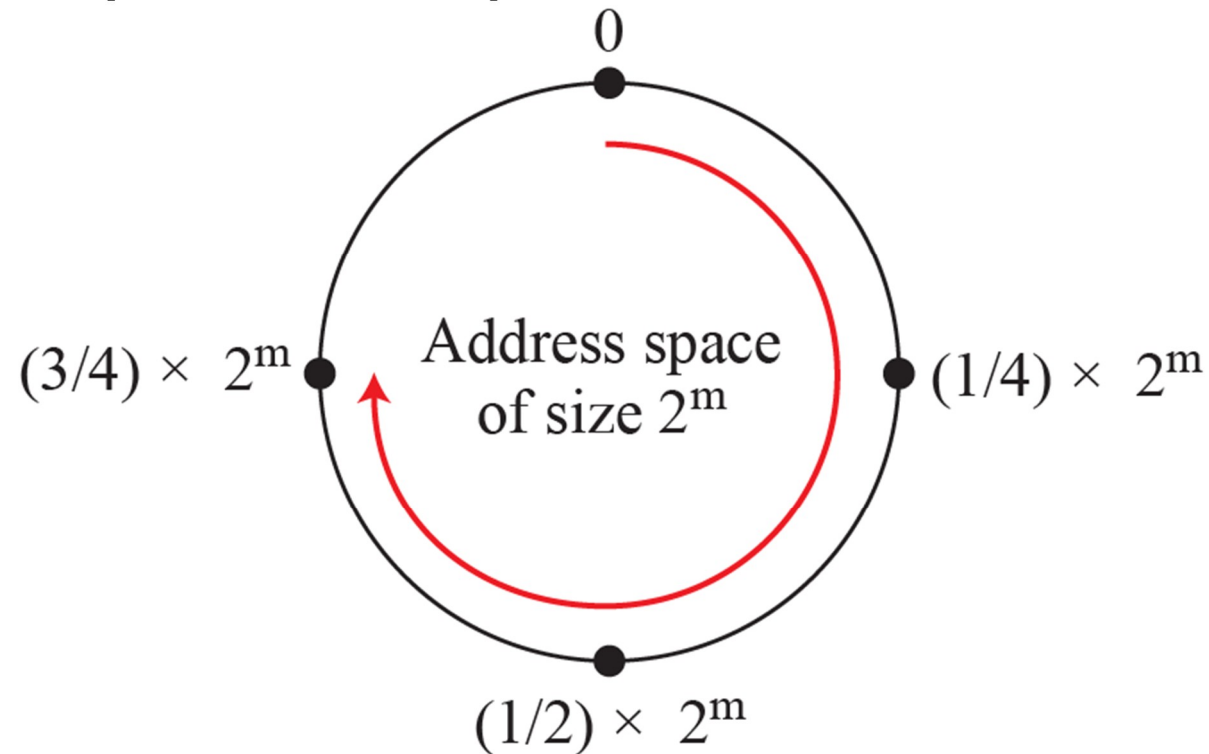


Distributed Hash Tables (DHT)

- A hash function is an algorithm that maps data of variable length to data of fixed length. (*m bits*)
 - Node ID = hash (peer IP address)
 - Key = hash (file name)
- DHT distributes data among a set of nodes.
 - Each peer is responsible for a portion of data.
- DHT routes a query to responsible node
 - Peers have partial knowledge about whole net.

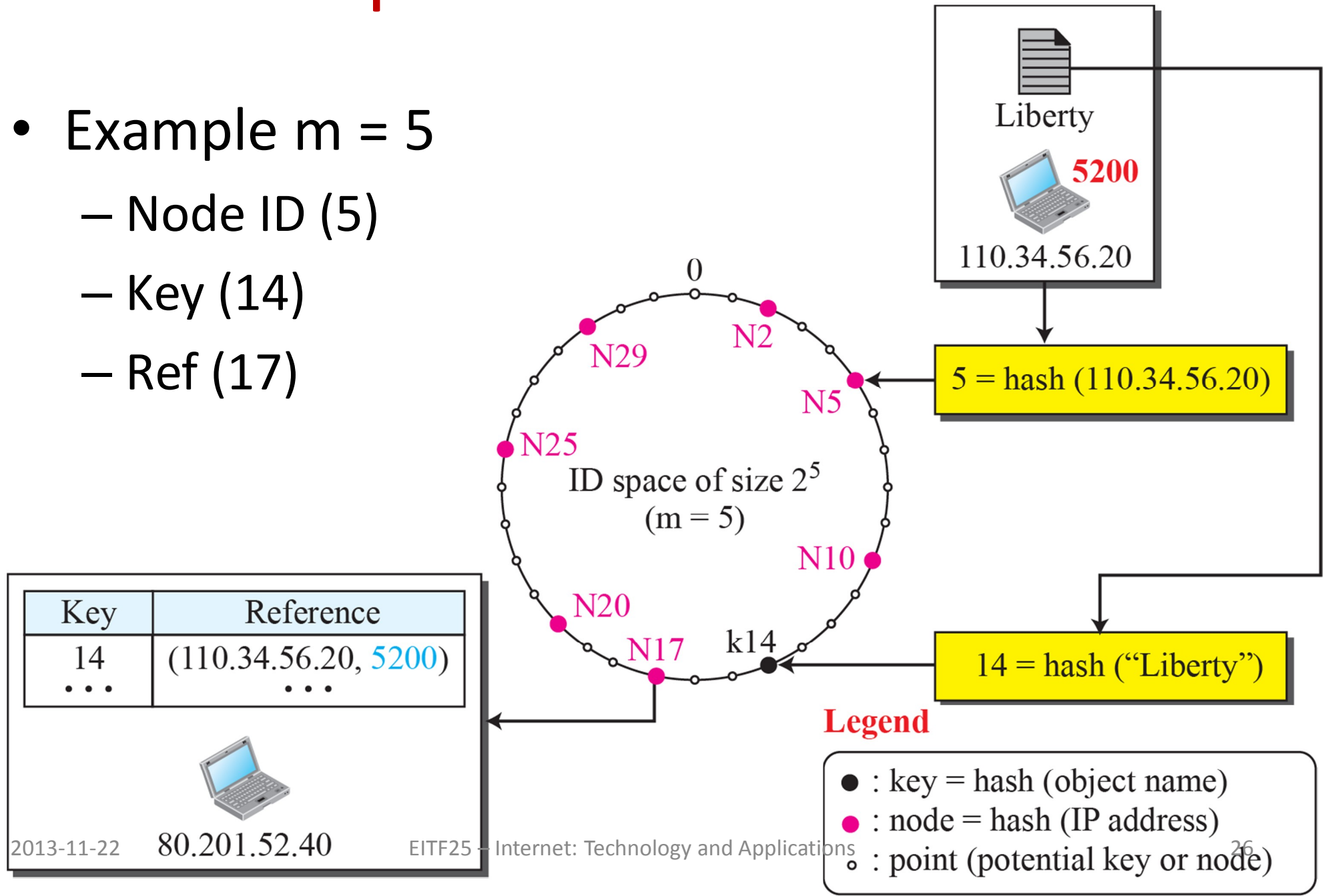
DHT address space

- Node ID = hash (peer IP address)
- Key = hash (file name)



DHT example

- Example $m = 5$
 - Node ID (5)
 - Key (14)
 - Ref (17)

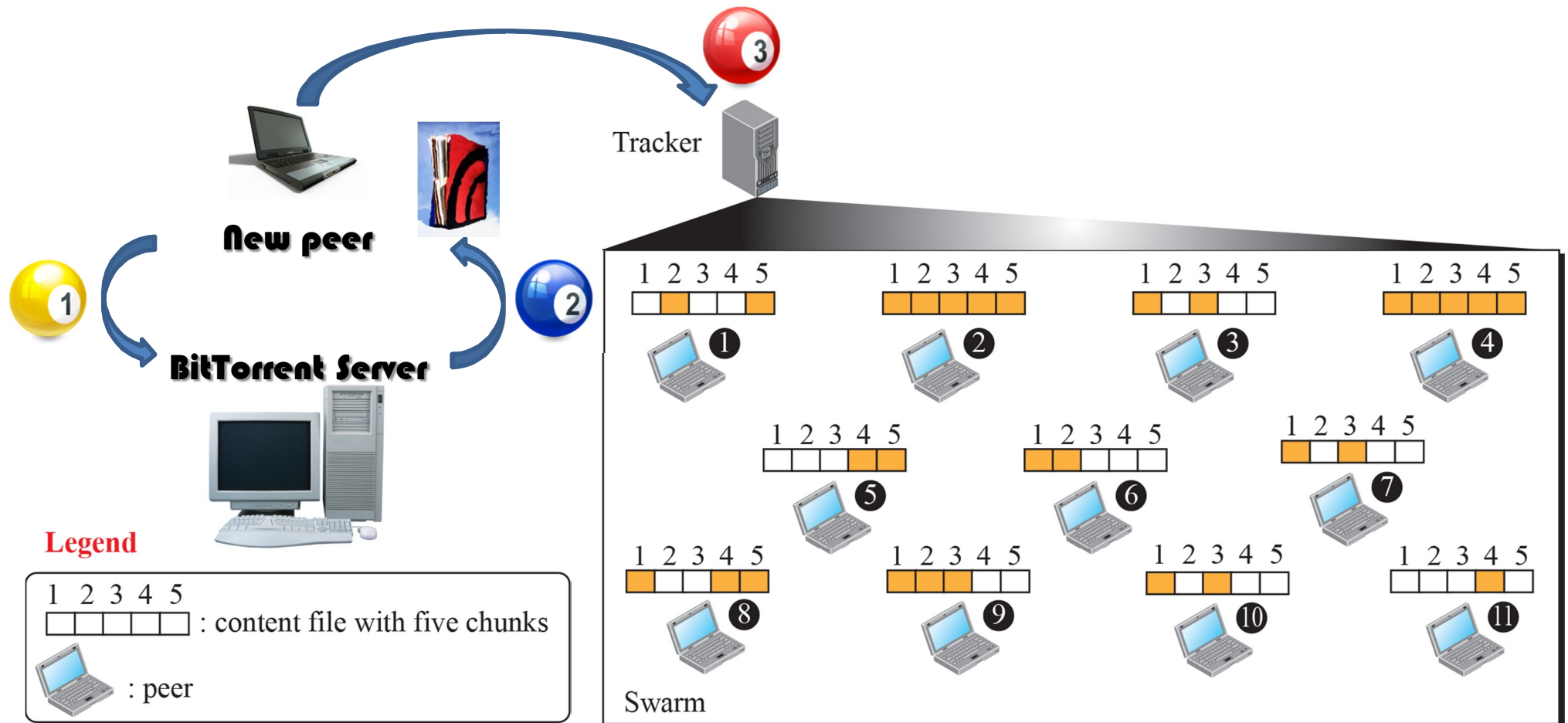


P2P example: BitTorrent

- Group of peers work together to give all peers a copy of shared file.
 - Torrent
 - Swarm
 - Seed
 - Leech
 - Tracker
- No downloading whole file from one peer

Tracker

- Provides list of peers for given torrent



Voice over IP (VoIP)

- Internet telephony
 - Uses two protocols

SIP

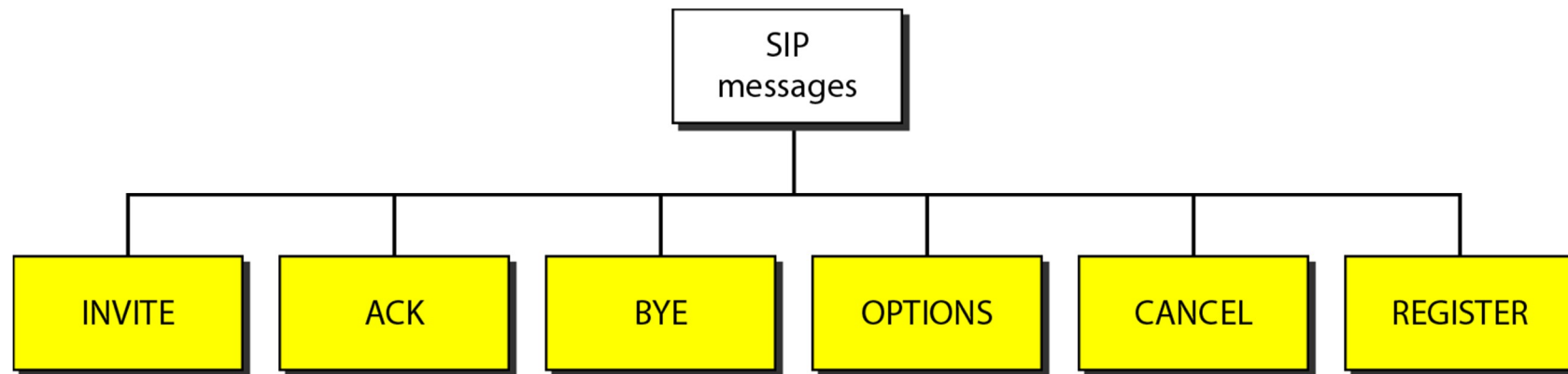
- Session Initiation Protocol
- IETF standard

H.323

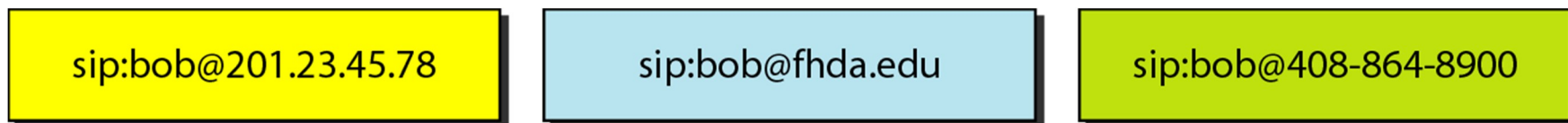
- Communication (telephone, computer)
- ITU-T standard

Session Initiation Protocol (SIP)

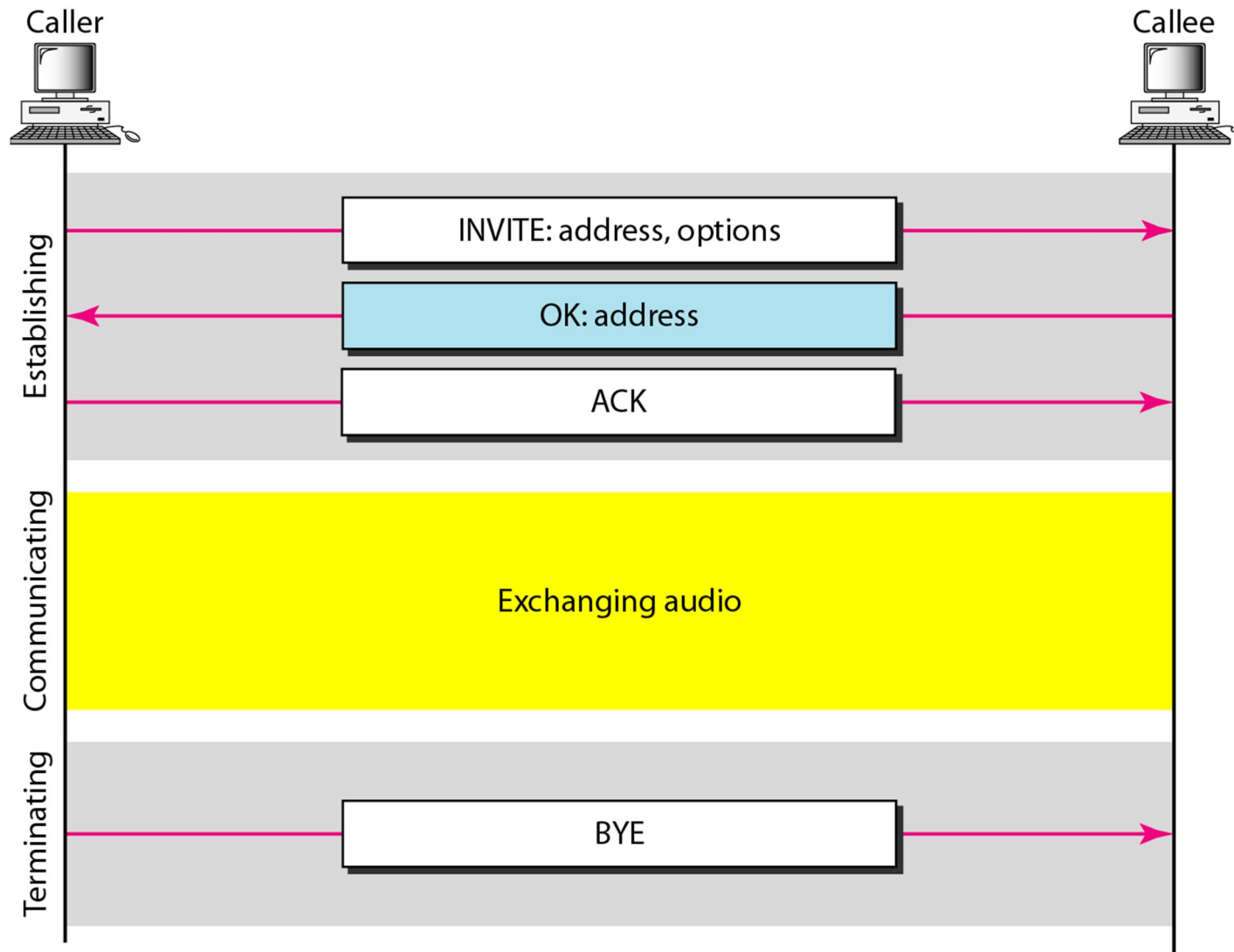
- Application layer protocol
- Multimedia session management
- Text-based messages



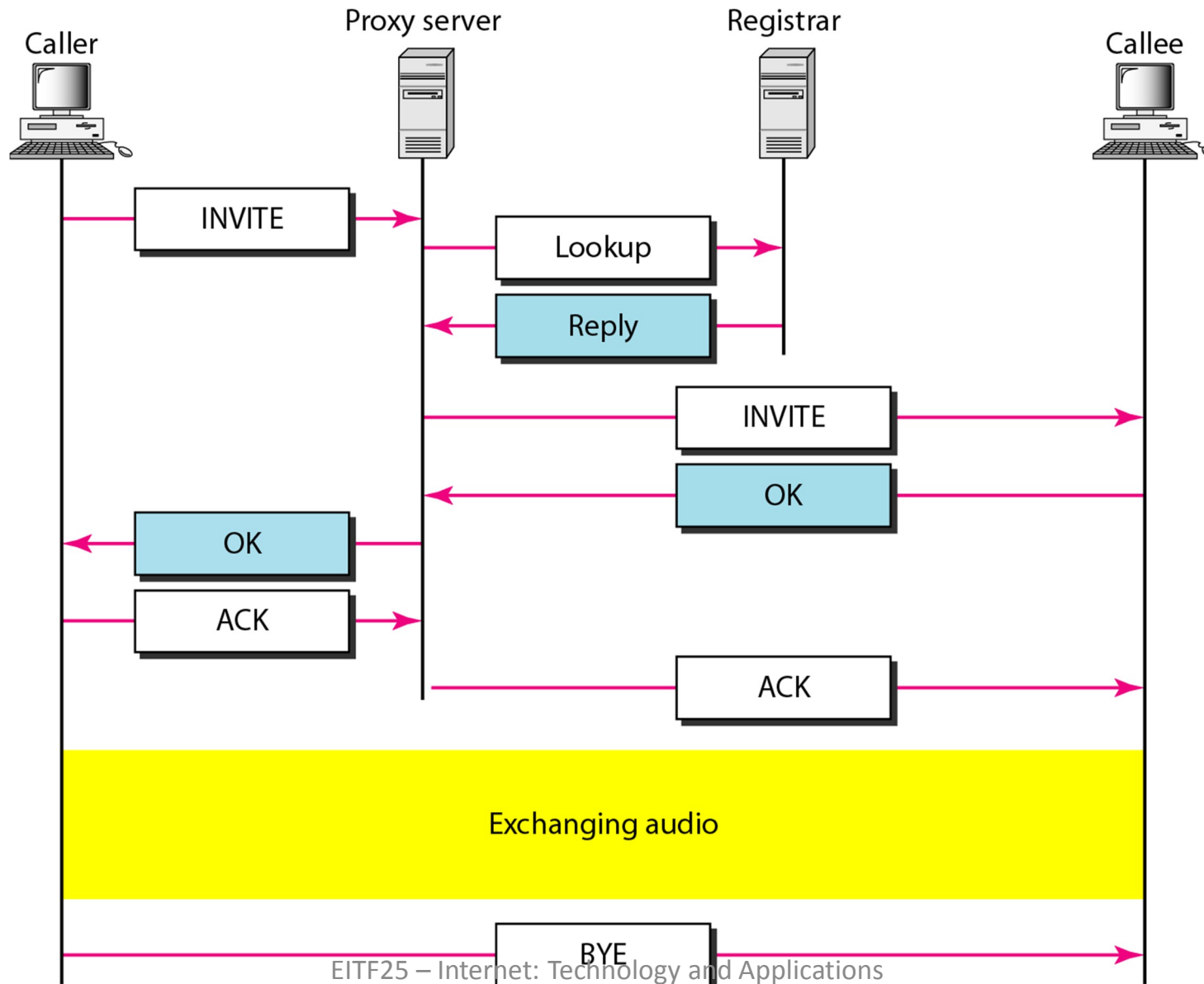
- Various address types



A simple SIP session

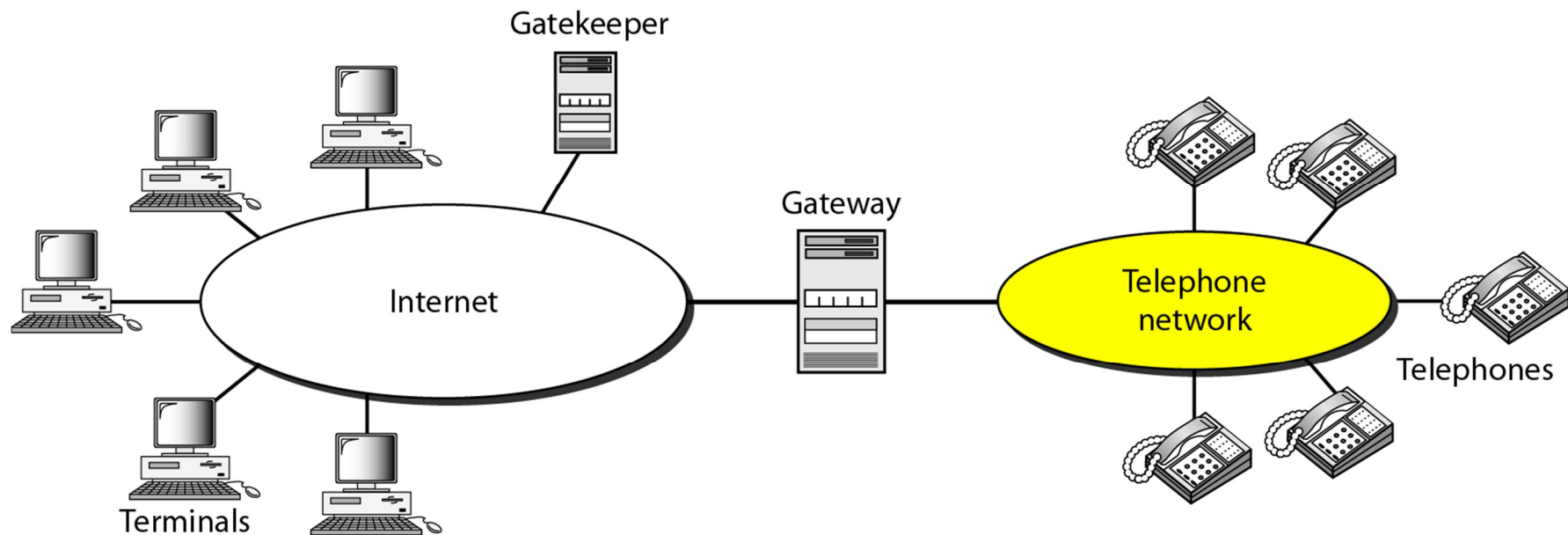


Tracking the callee

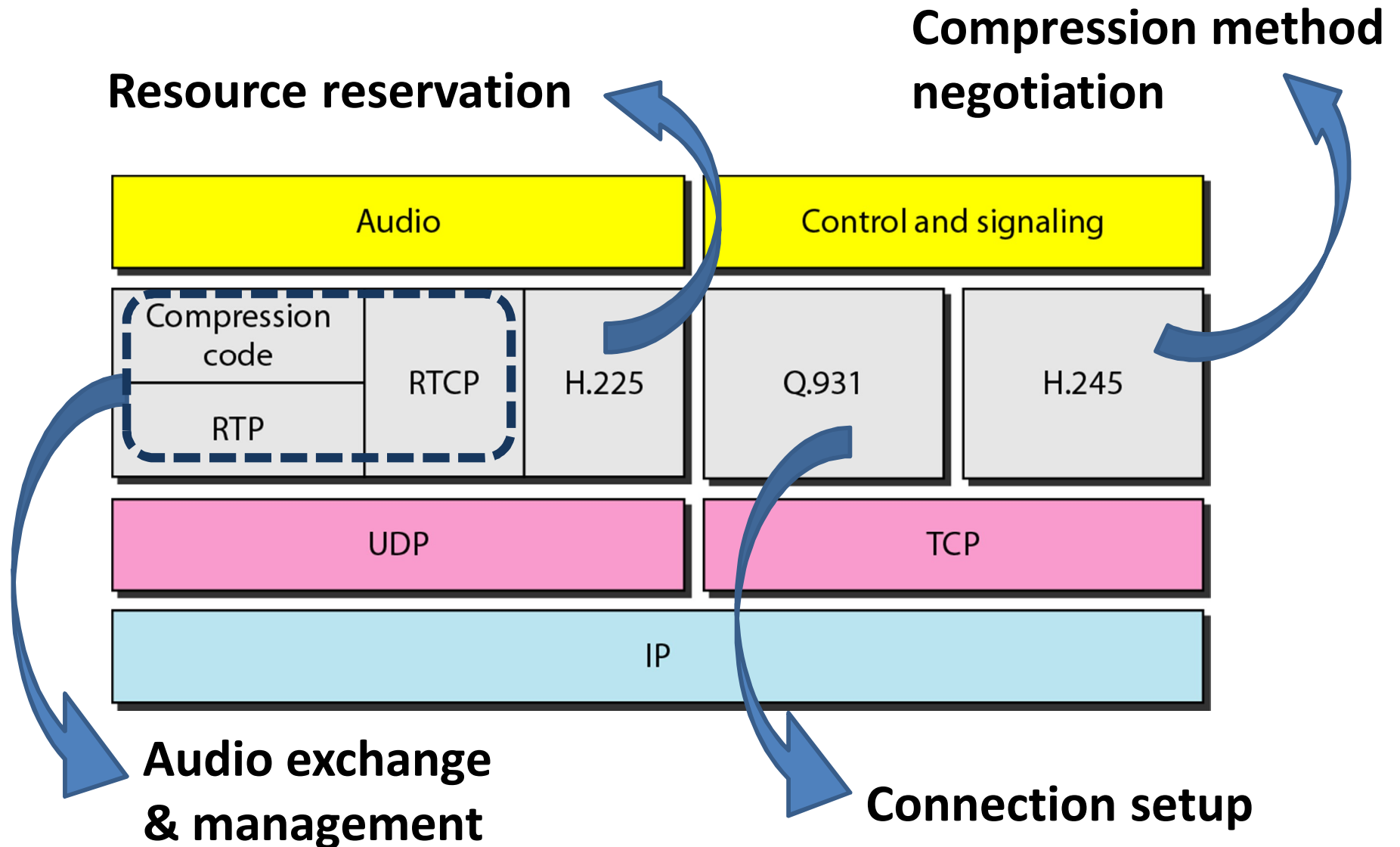


H.323

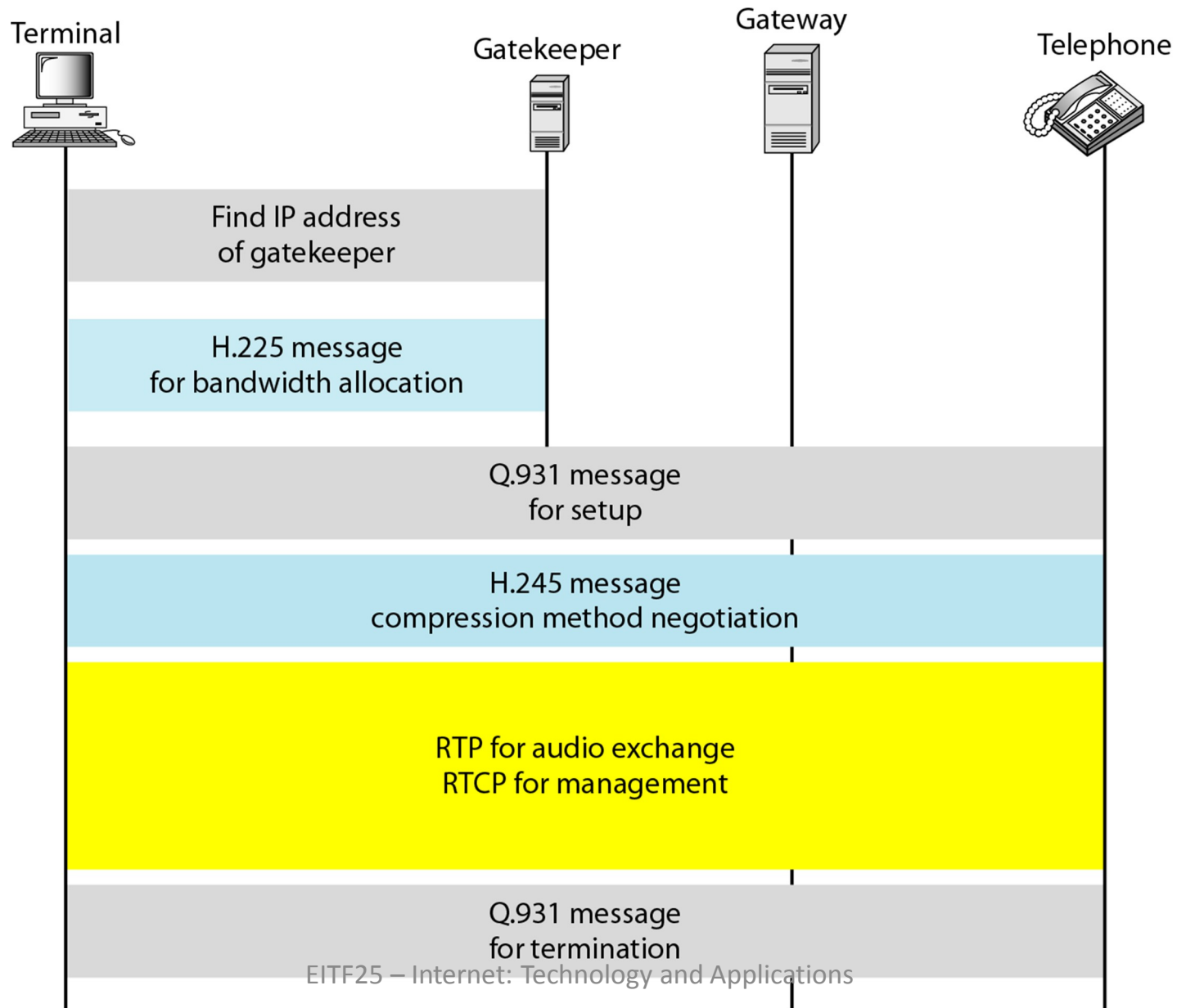
- Communication (telephone, computer)
 - Gateway = 5-layer translation device
 - Gatekeeper = registrar



H.323 protocols

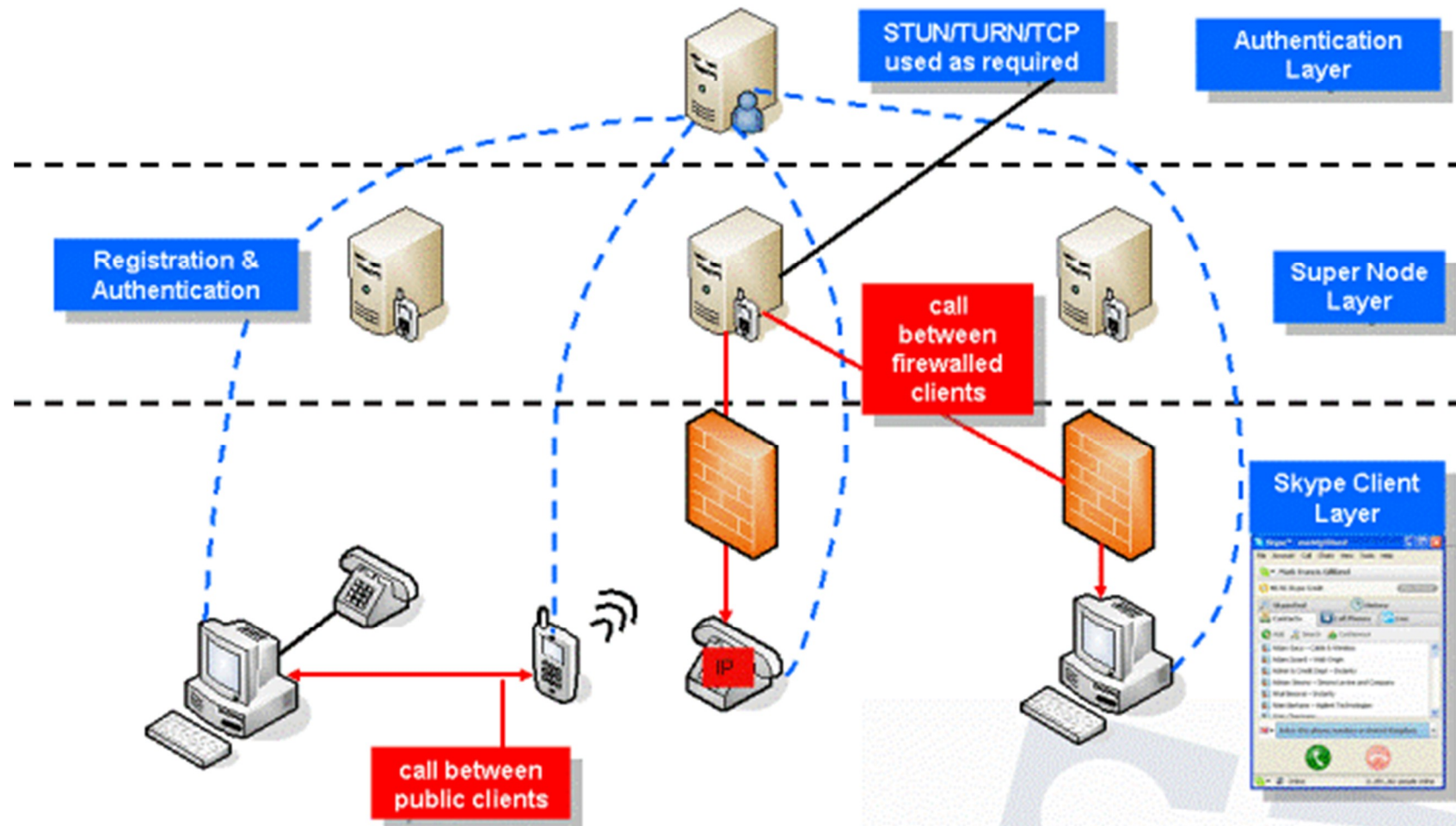


H.323 session



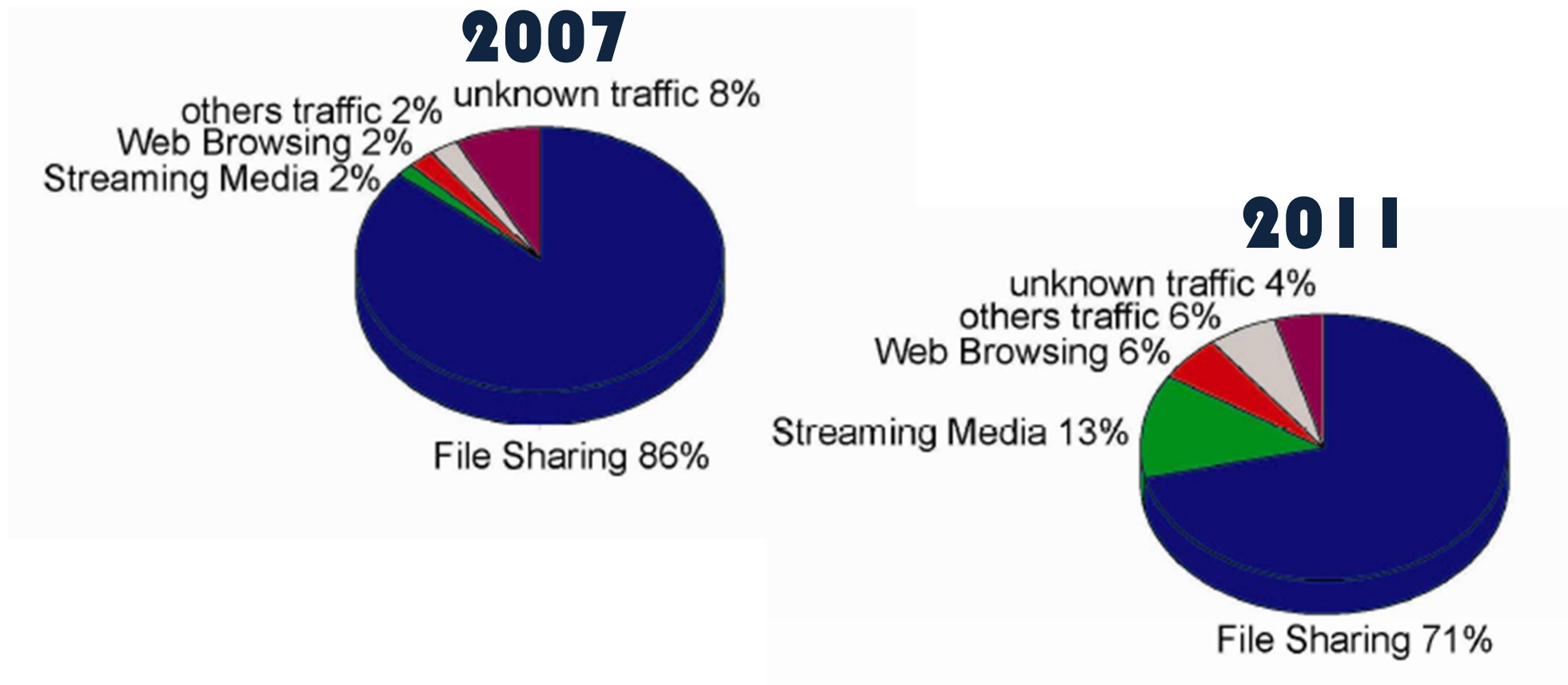
Counter-example: Skype

Skype Architecture



Evolution of Internet usage

- Traffic volumes generated by users



J. Li, A. Aurelius, V. Nordell, M. Du, Å. Arvidsson, M. Kihl:

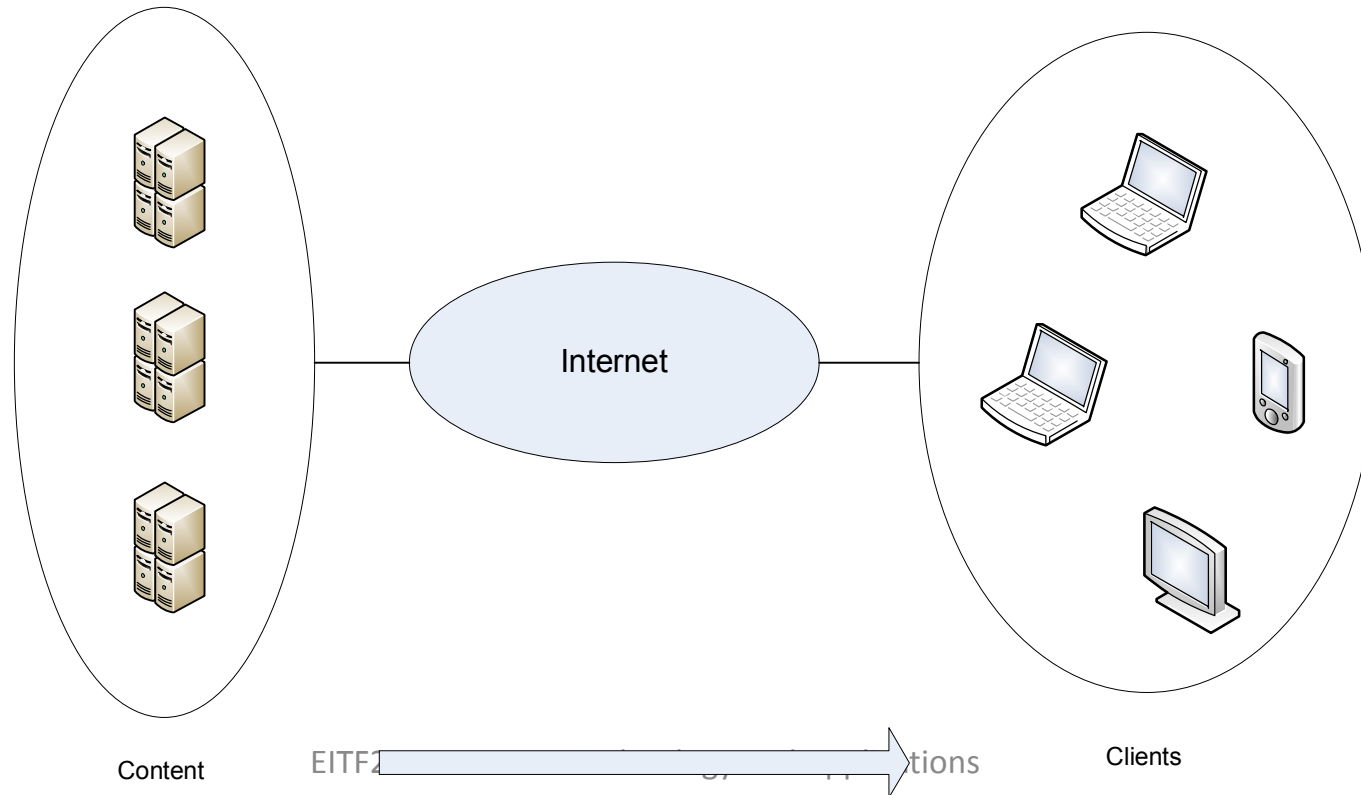
A five year perspective of traffic pattern evolution in a residential broadband access network

2013-11-22
Future Network & Mobile Summit 2012

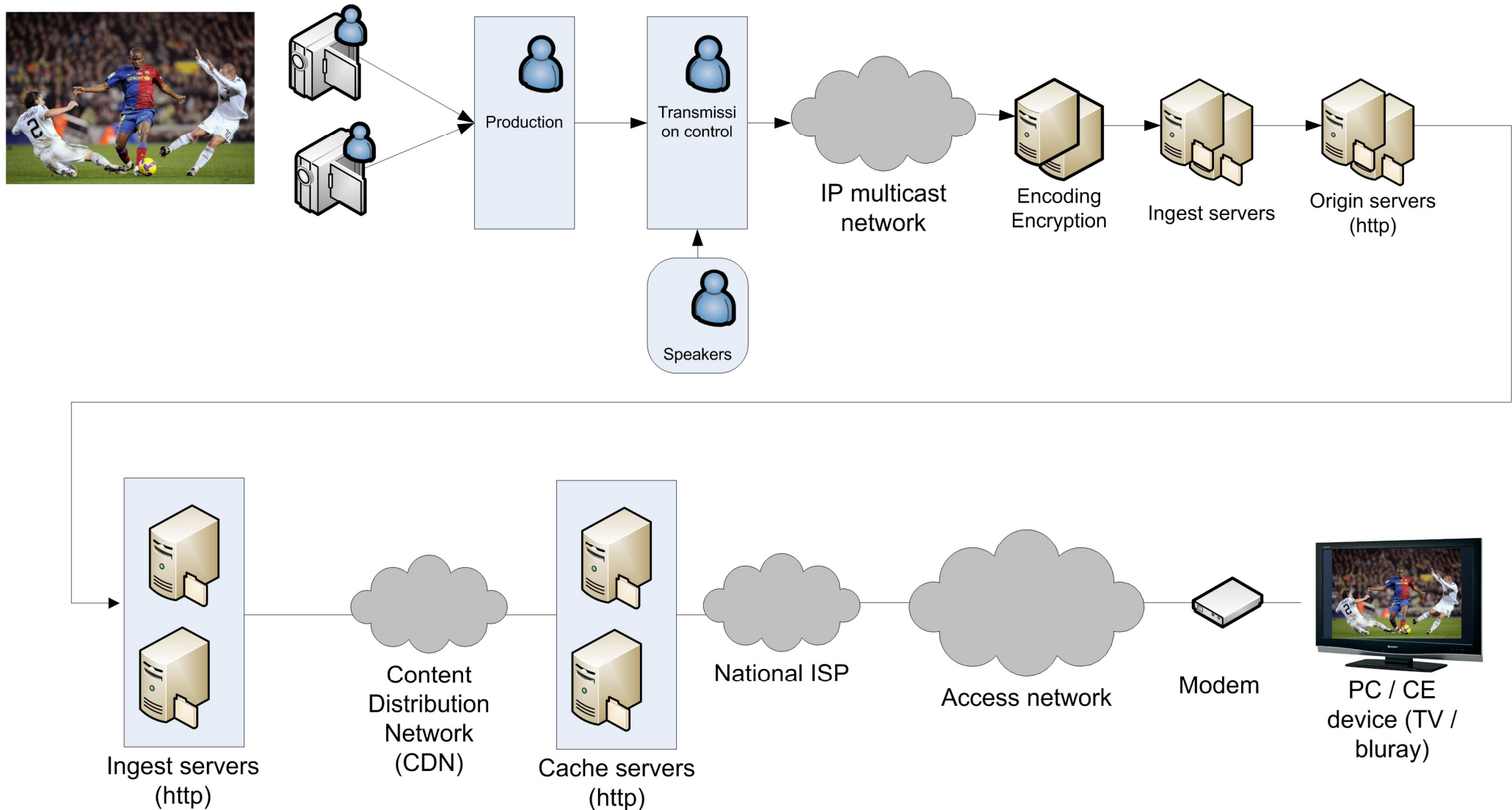
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Content distribution architectures

- Multimedia
 - Content stored in back-end server clusters (cloud)
 - Distributed to clients upon requested



Example: Live sport channel at TV4



Summary: Application Layer (2)

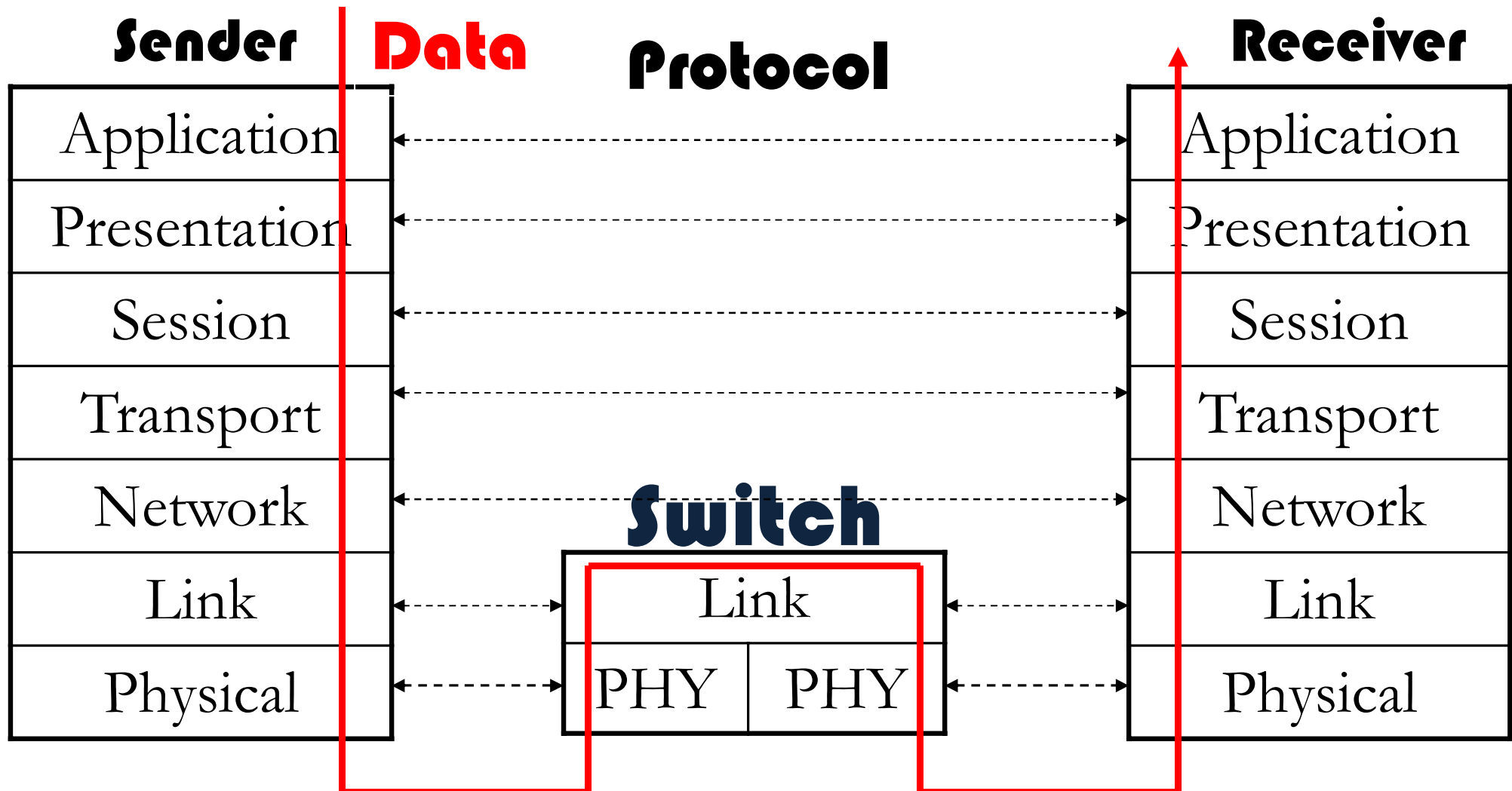
- A little history behind WWW
- Client/server applications
 - ftp, file transfer
 - e-mail, message exchange
- P2P applications
 - Bittorrent, file sharing
 - Skype, Internet telephony
- Streaming multimedia applications

Appendix

Connecting Devices

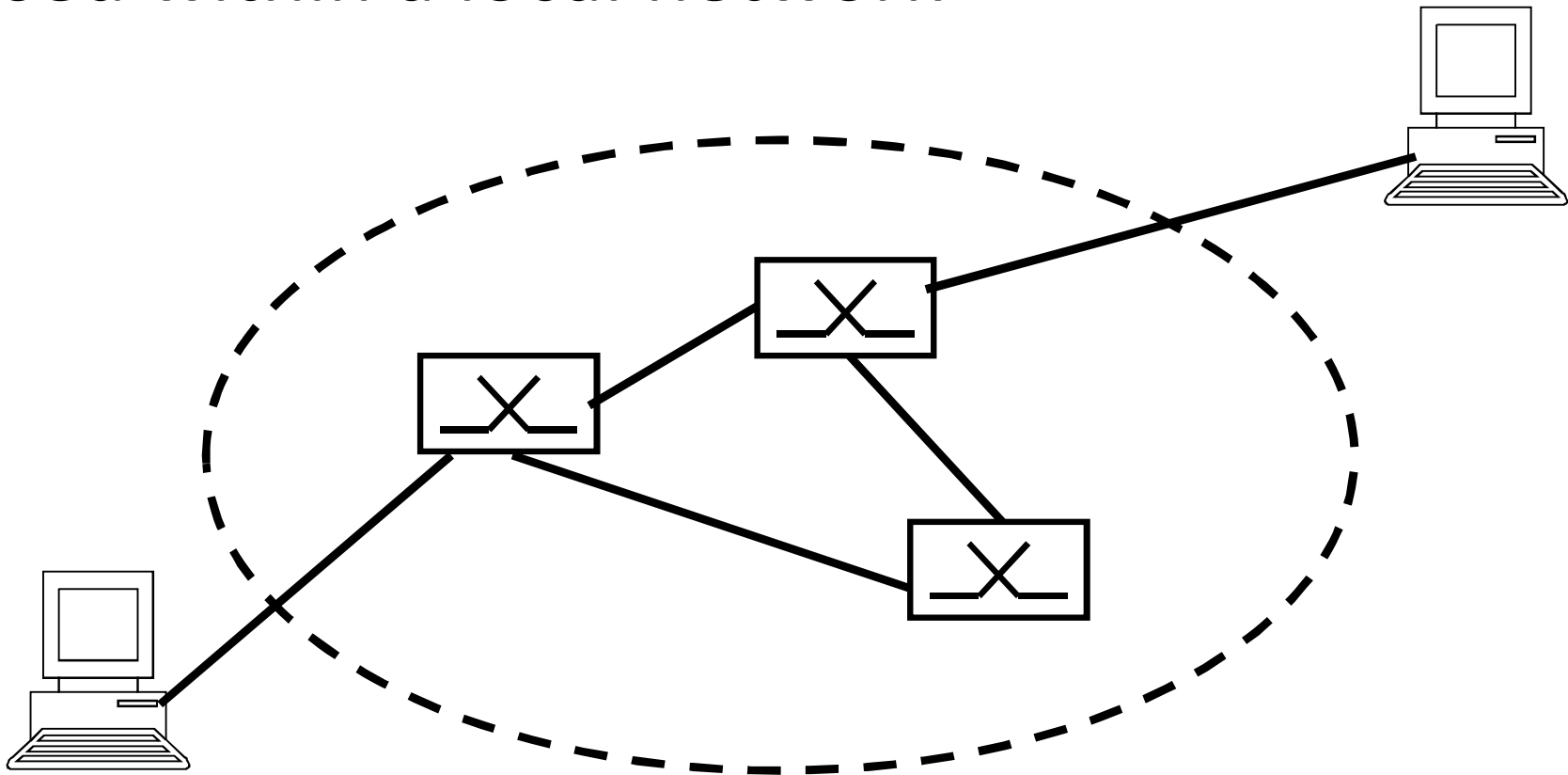
Connecting devices

(1)



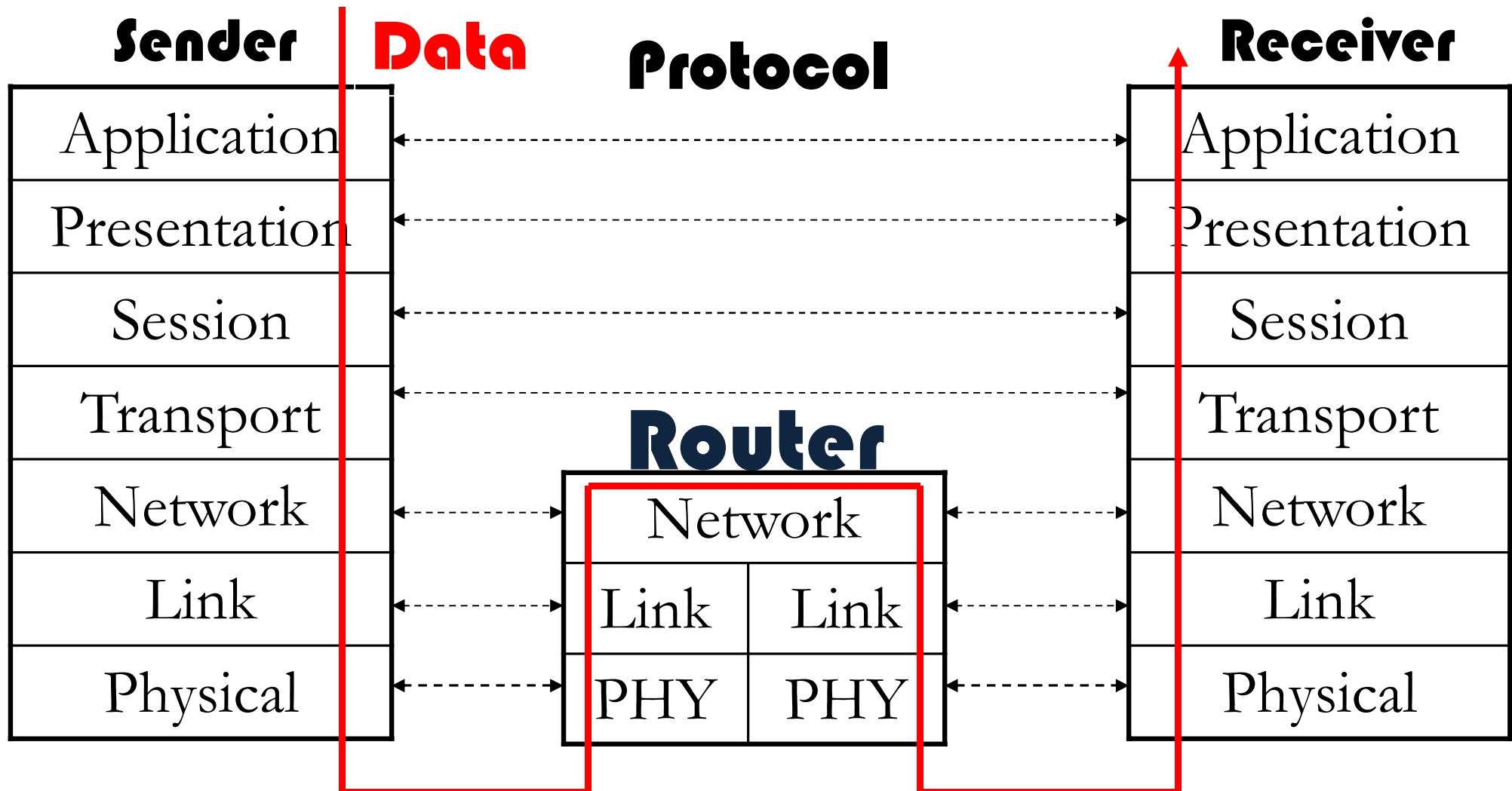
Switch

- used within a local network



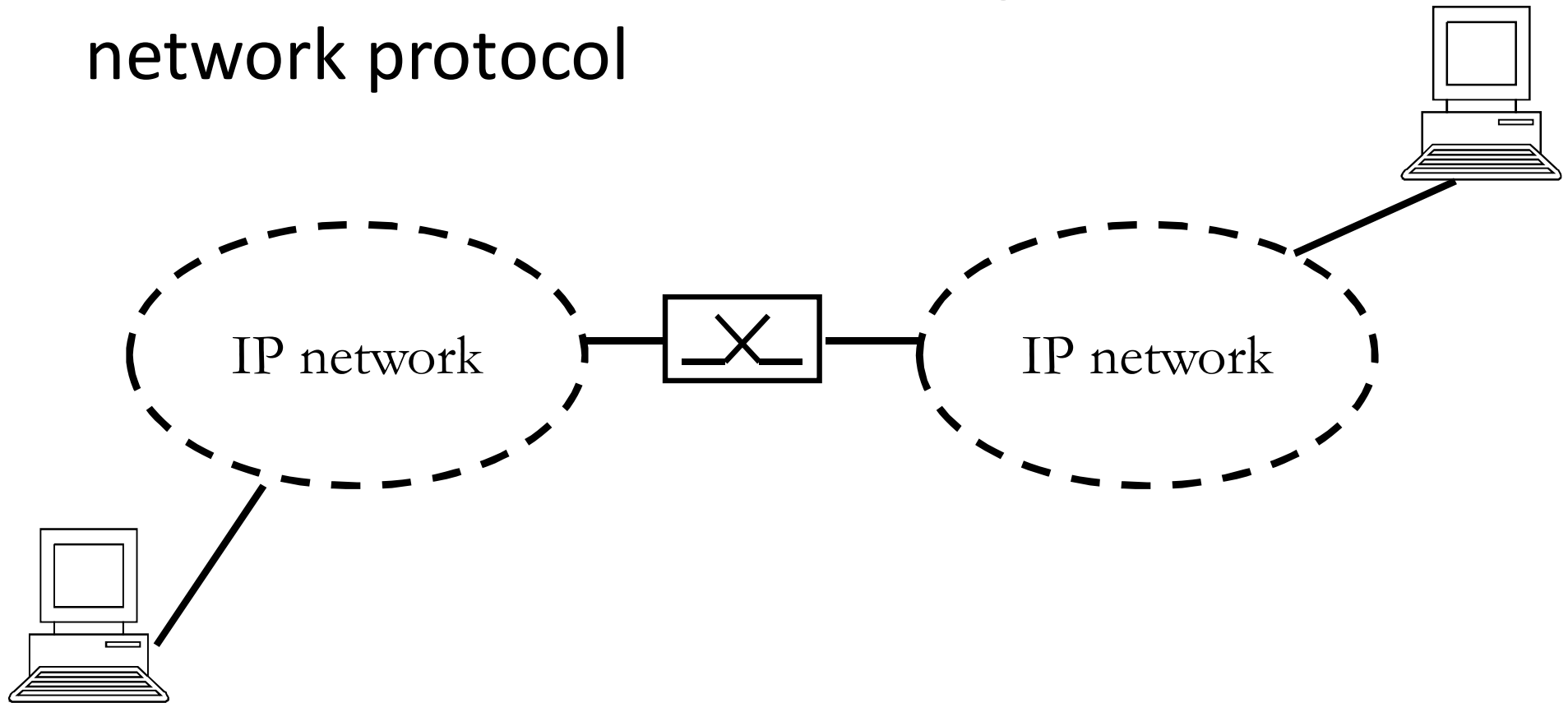
Connecting devices

(2)



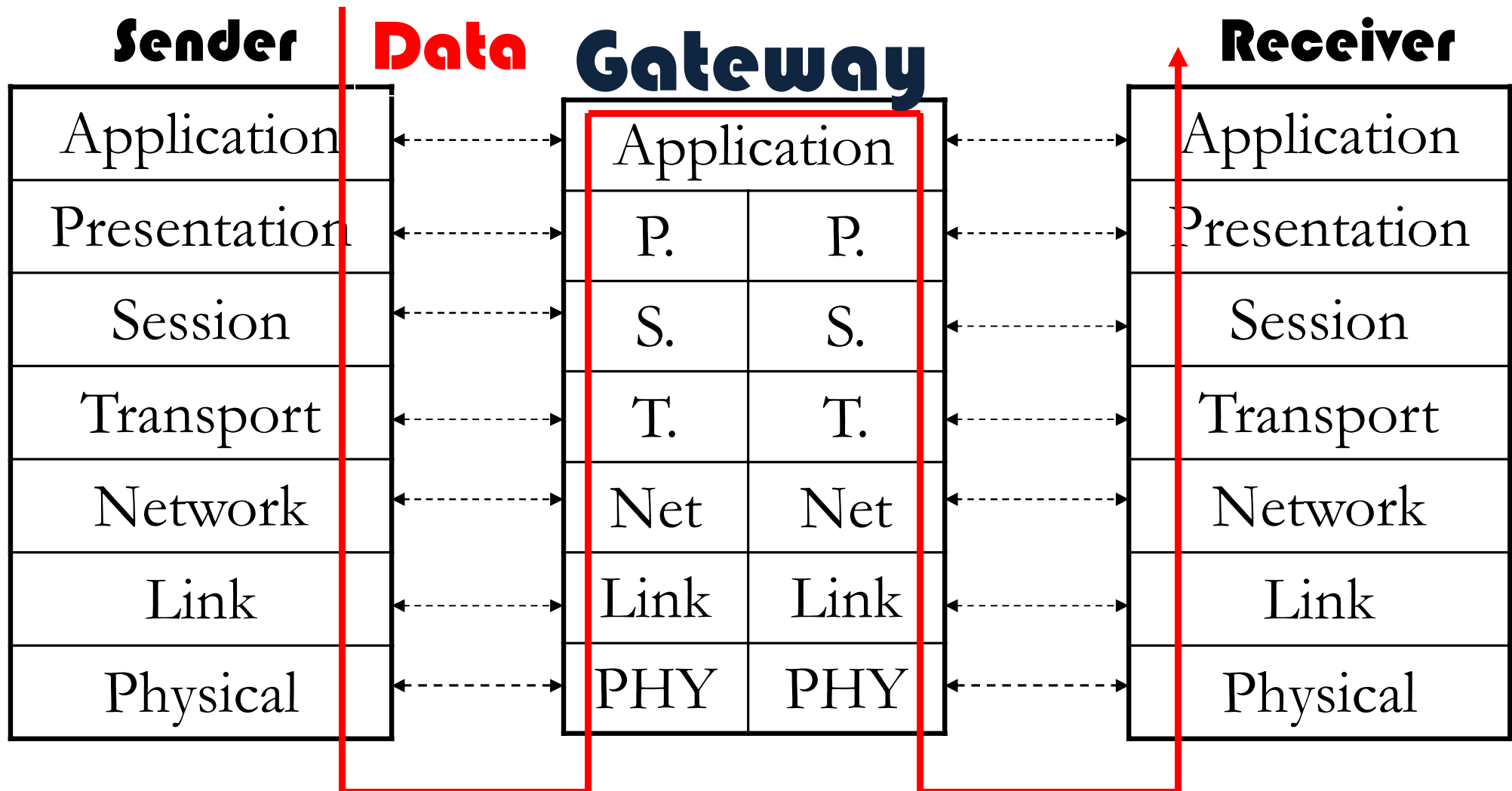
Router

- used between networks using the same network protocol



Connecting devices

(3)



Gateway

- used between networks of different types

