CSCI 466: Networks

OSI Model, Packet Forwarding

Reese Pearsall

Fall 2024

Announcements

- TA: **Justin Mau**

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OSI Model

Application Layer

Presentation Layer *

Session Layer *

Transport Layer

Network Layer

Data Link Layer

Physical Layer

Application Layer

Messages from Network Applications

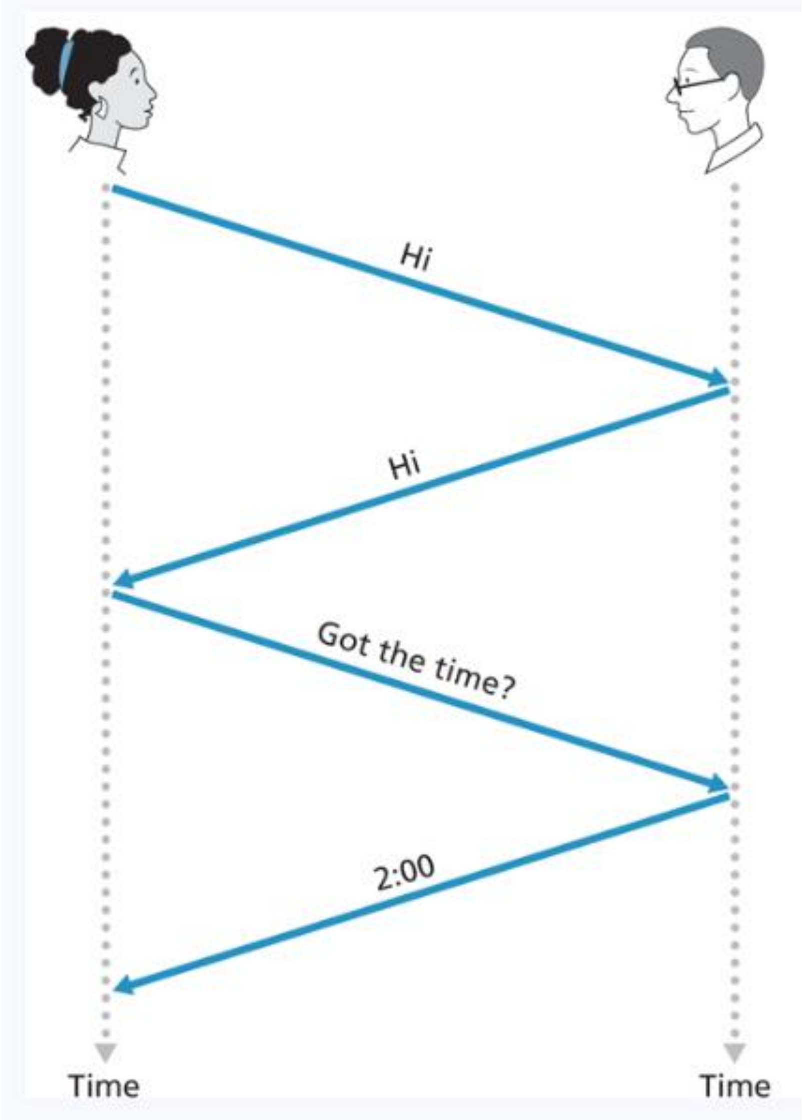
↓

Physical Layer

Bits being transmitted over a copper wire

**In the textbook, they condense it to a 5-layer model, but 7 layers is what is most used*

What is a protocol?



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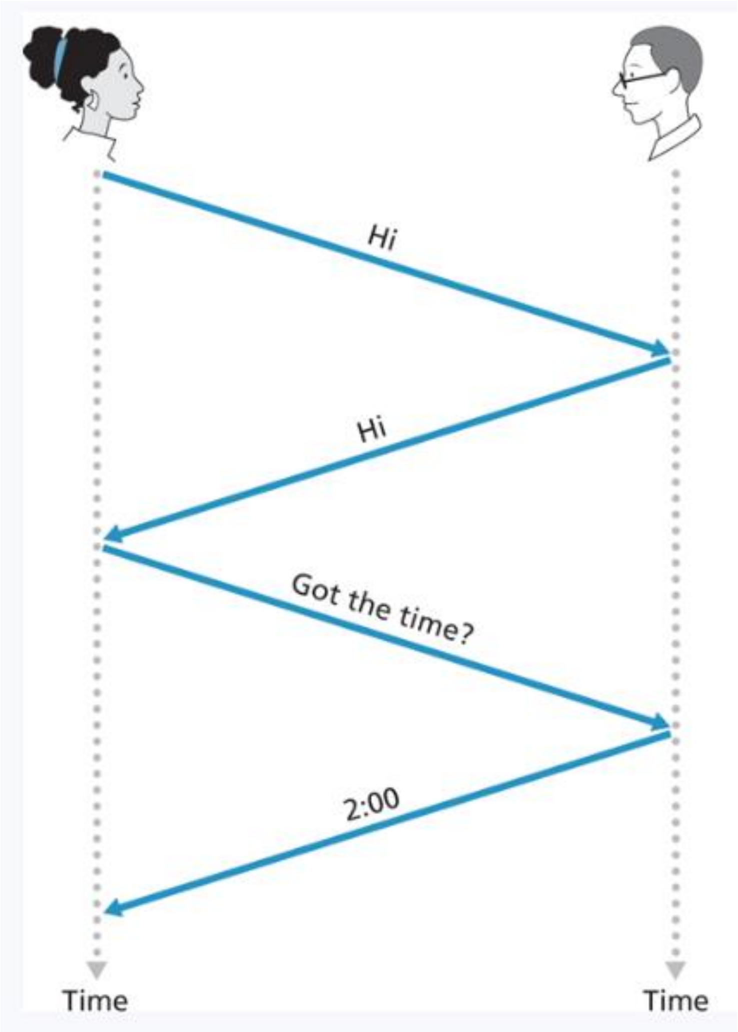

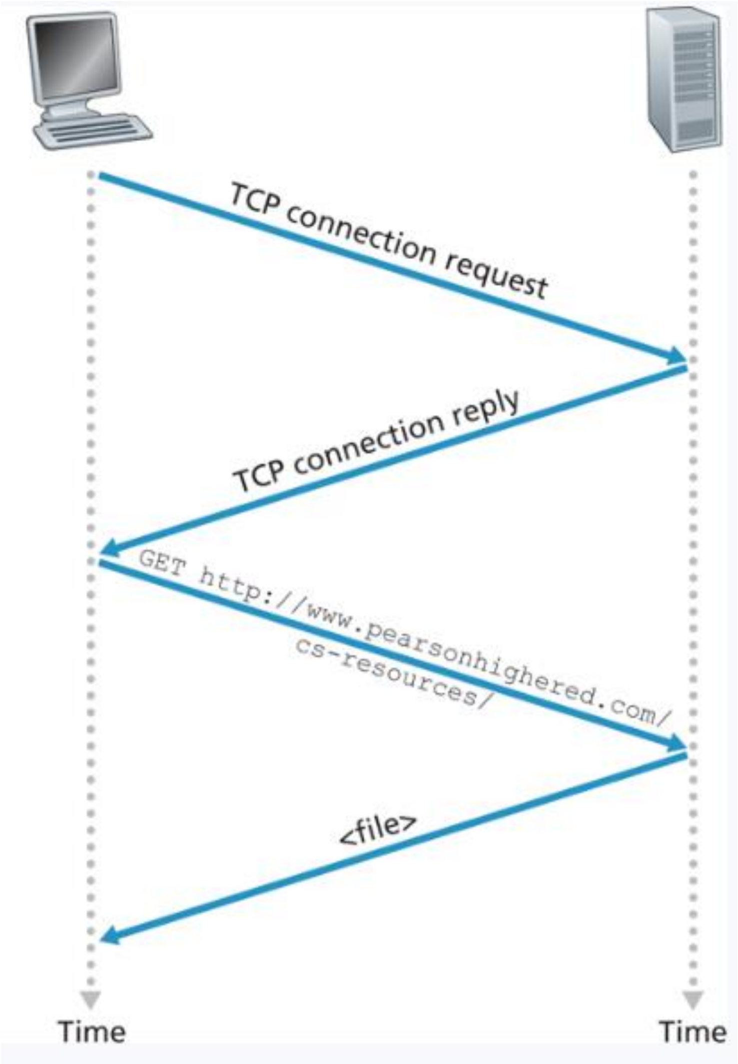

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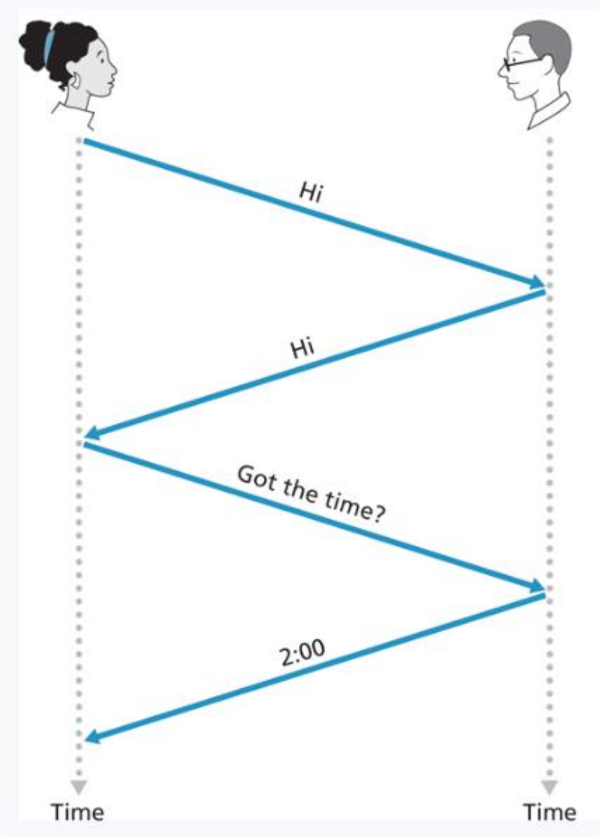
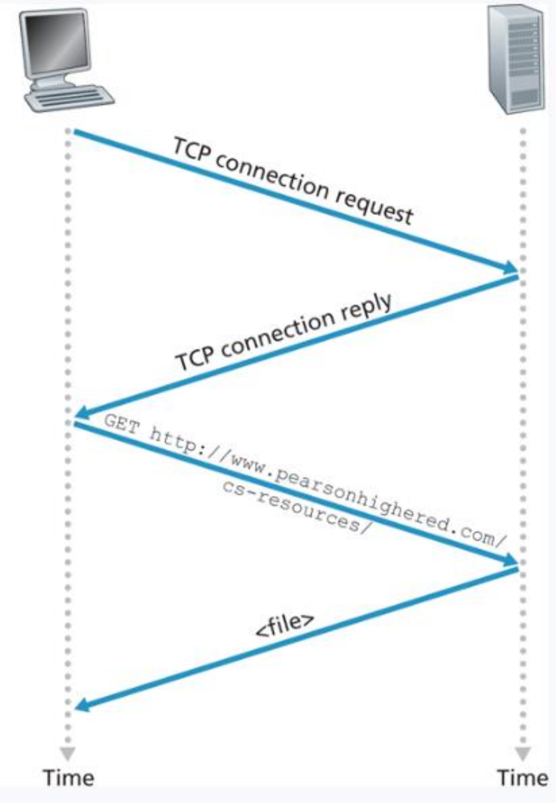




A **protocol** defines the format and the order of messages exchanges between two or more communicating entities, as well as the actions taken on the transmission and/or receipt of the message or event

Application Layer

The layer which interacts directly with applications and provides necessary protocols and services for web applications

Humans interact with this layer

Data from user → Application Layer → Sent to next layer down

Application Layer

The layer which interacts directly with applications and provides necessary protocols and services for web applications

Humans interact with this layer

Data from user → Application Layer → Sent to next layer down

Search query on website →

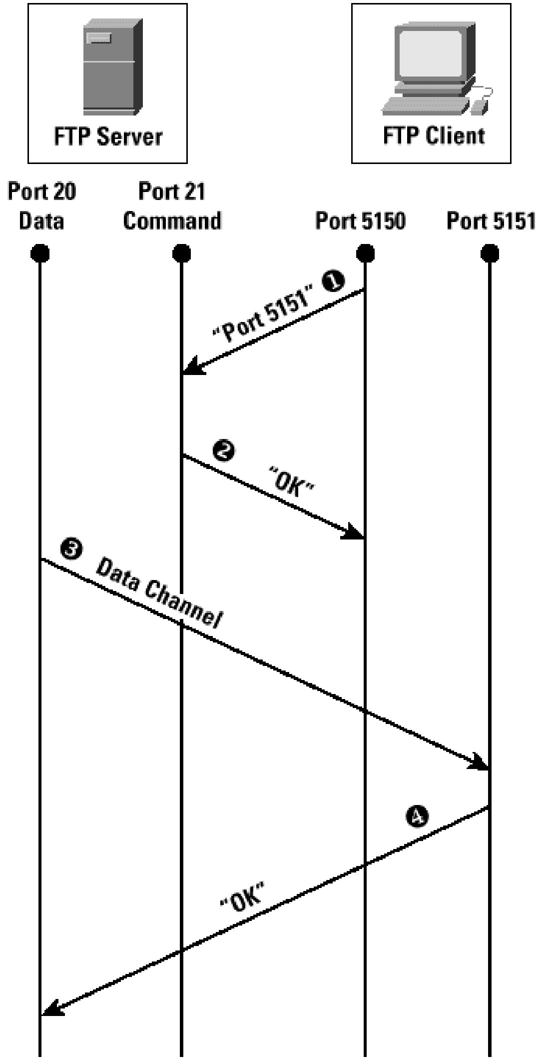
```
GET /index.html HTTP/1.1
Host: www.example.com
User-Agent: Mozilla/5.0
Accept: text/html
Accept-Language: en-US,en;q=0.5
Accept-Encoding: gzip, deflate
Connection: keep-alive
```

→ Sent to presentation layer

Application Layer

The layer which interacts directly with applications and provides necessary protocols and services for web applications

Protocol defines the steps of getting data from application to application



❶ FTP Client opens command channel to server; tells server second port number to use

❷ FTP Server acknowledges

❸ FTP Server opens data channel to clients second port as instructed

❹ Client acknowledges and data flows

Humans interact with this layer

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→ Sent to presentation layer

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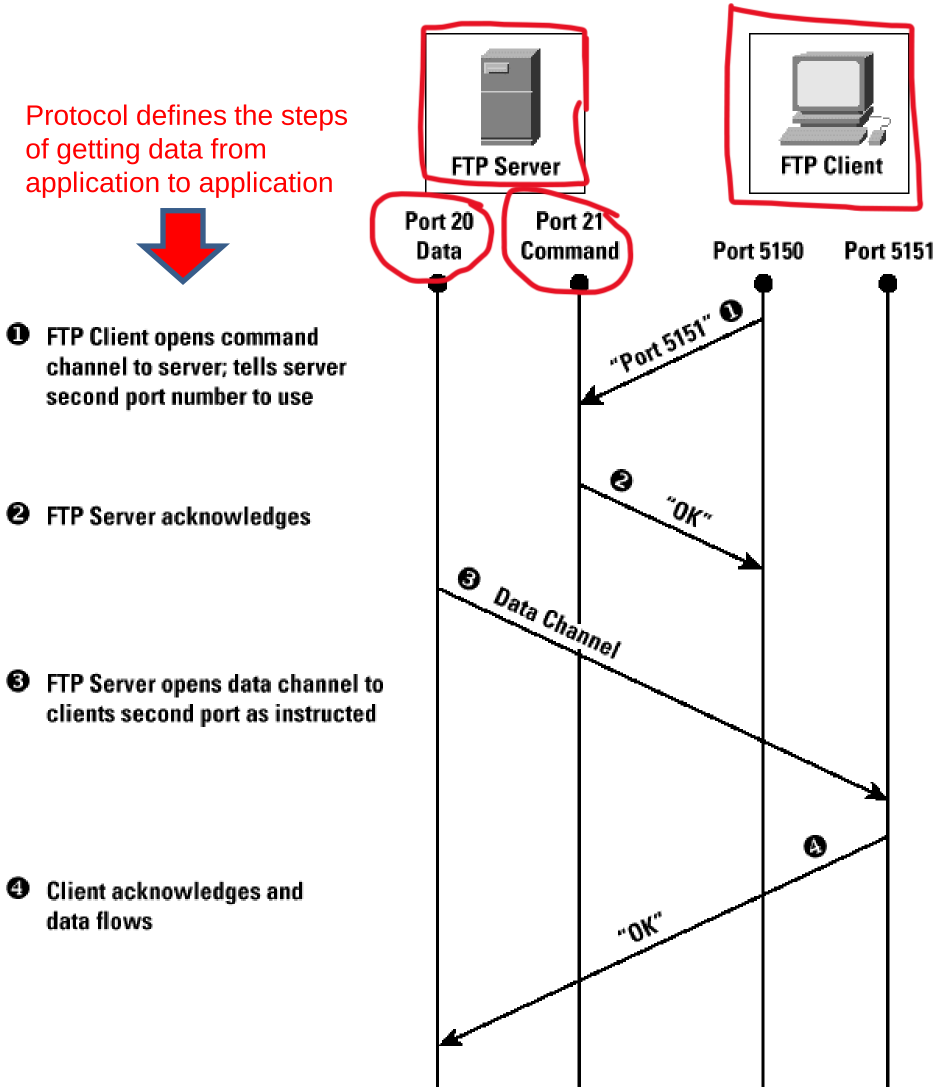


Presentation Layer

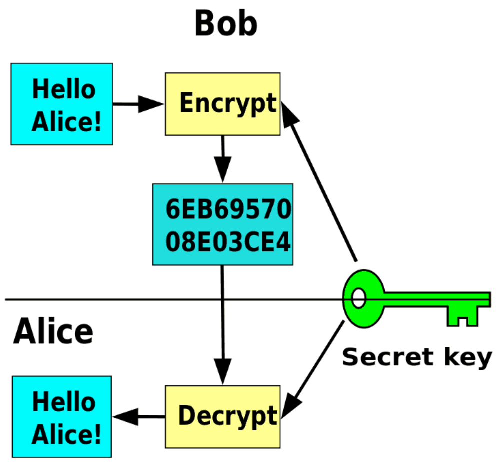
The layer which allows applications to interpret meaning of data

Translation

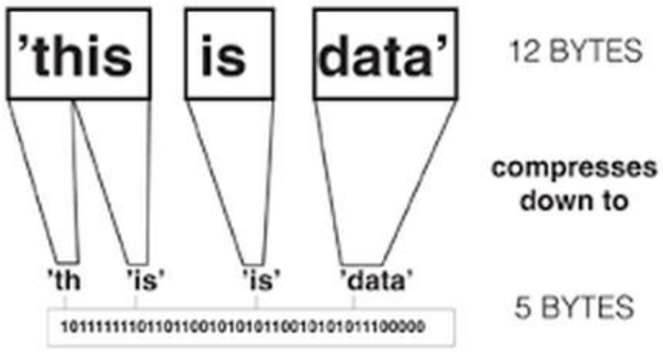
Text encoding → Encoding, Ascii

Bit/Byte order
File Syntax

Encryption



Compression



Session Layer

Manages, monitors, and synchronizing “sessions” between endpoints

Implements checkpoints while data is flowing

Authentication
Authorization

OSI Model

Application Layer

Presentation Layer

Session Layer

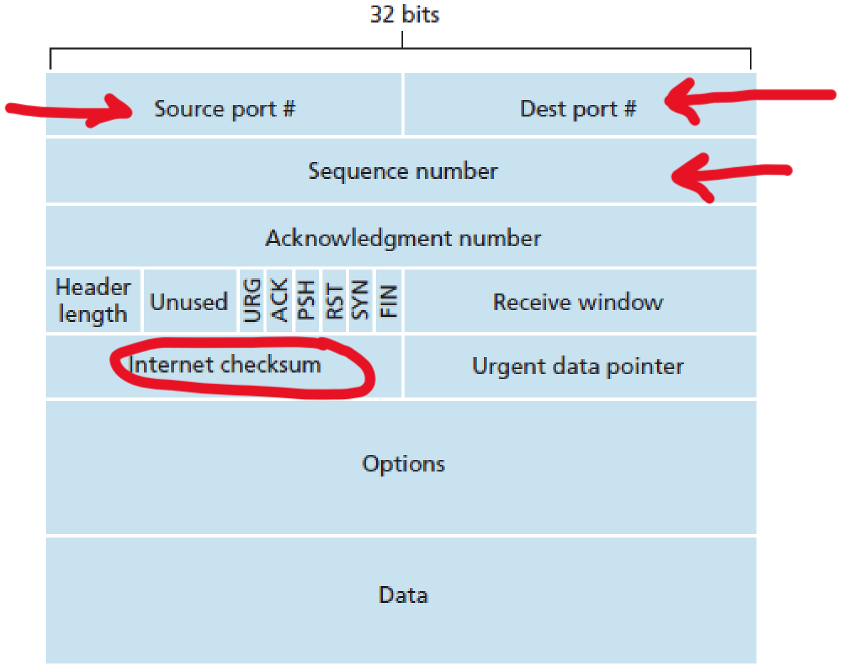
Most of this functionality is handled by our web browsers

Transport Layer

Manges end to end communication and *method* of how data will be transferred

Ensures that the data received at host will be in the same order in which it was transmitted

Splits up packets into smaller **segments**



What should the transmission rate be?

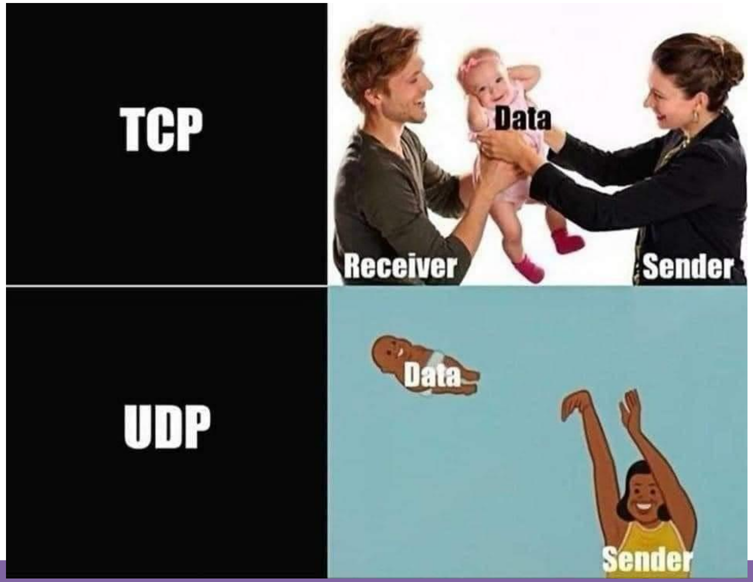
Transport Layer

Transmission Control Protocol (**TCP**)

- Requires an established connection to transmit data.
- Guarantees delivery of data in order
- Extensive error checking and acknowledgement of data

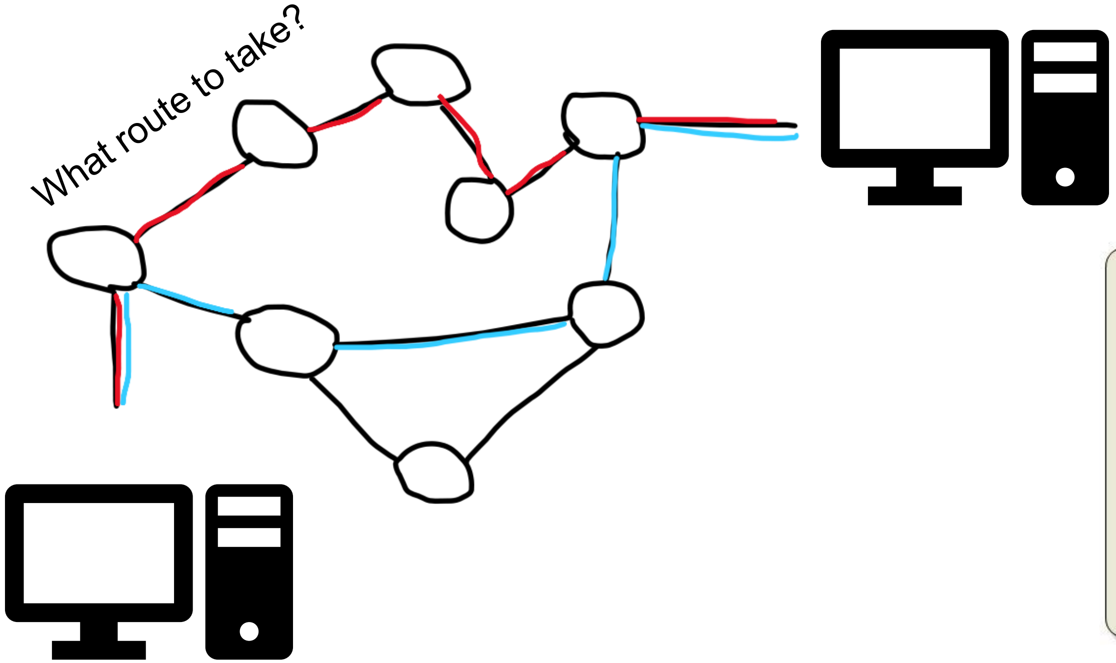
User Datagram Protocol (**UDP**)

- Connectionless protocol
- Faster, Simpler
- Not reliable
- No acknowledgement of data, basic error checking



Network Layer

Primary purpose is to move **datagrams** from one host to another, and to determine physical path to destination



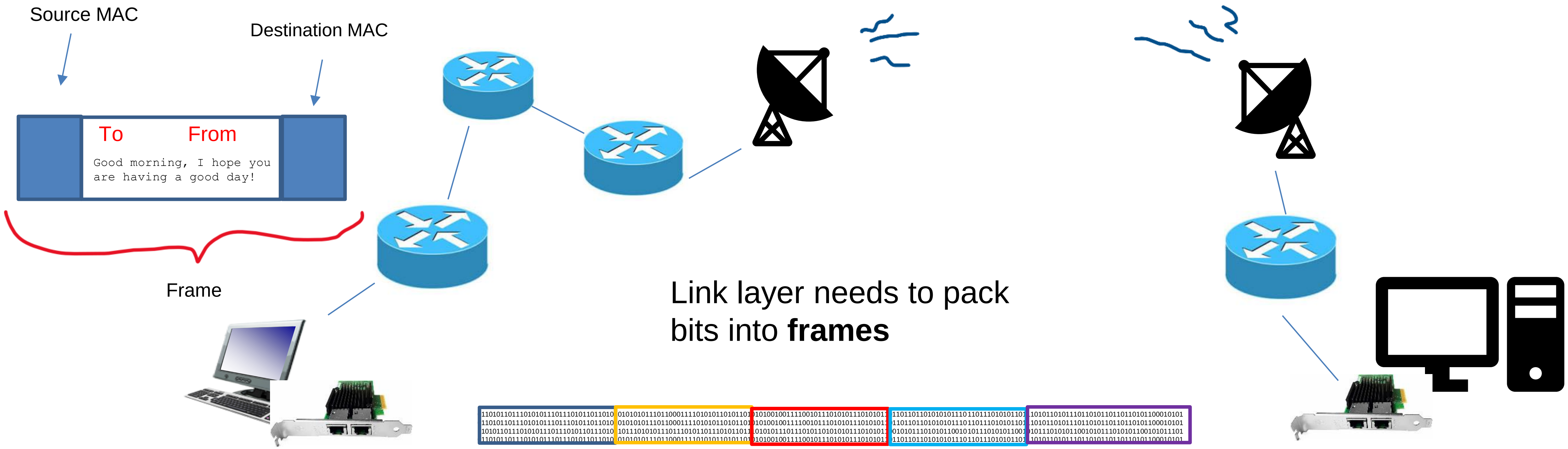
We also assign **IP addresses** to our packet

IPv4 Packet Header Format

Bit #	0	7	8	15	16	23	24	31
0	Version	IHL	DSCP	ECN	Total Length			
32	Identification				Flags	Fragment Offset		
64	Time to Live		Protocol		Header Checksum			
96	Source IP Address							
128	Destination IP Address							
160	Options (if IHL > 5)							

Data Link Layer

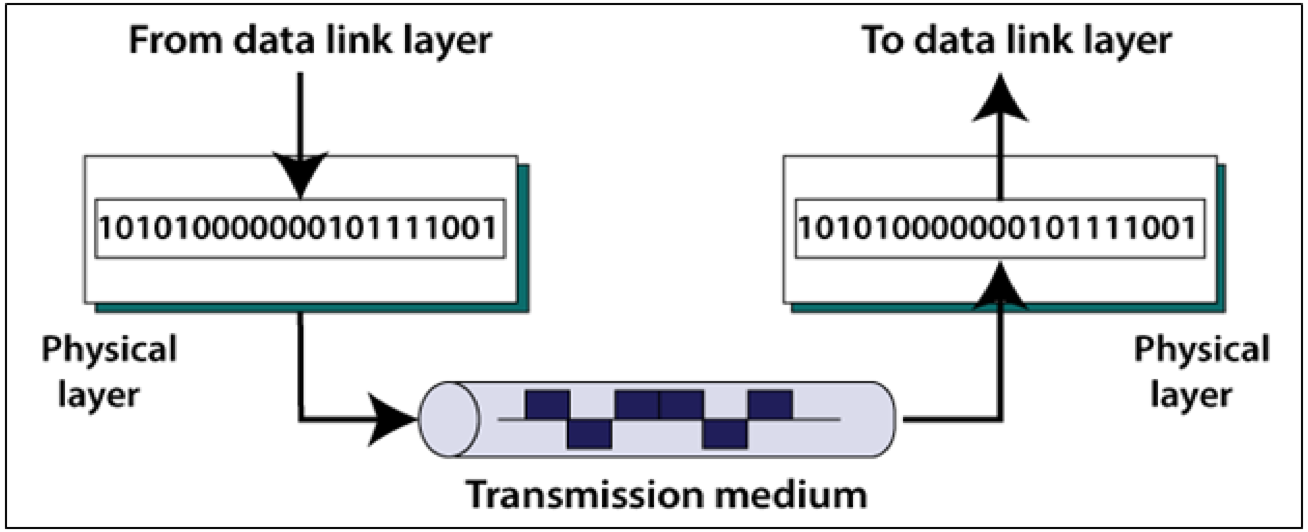
Handles the formatting and physical addressing of the "packet" before reaching the destination



Link layer needs to pack bits into **frames**

Physical Layer

Transmits bits into physical signals over some medium



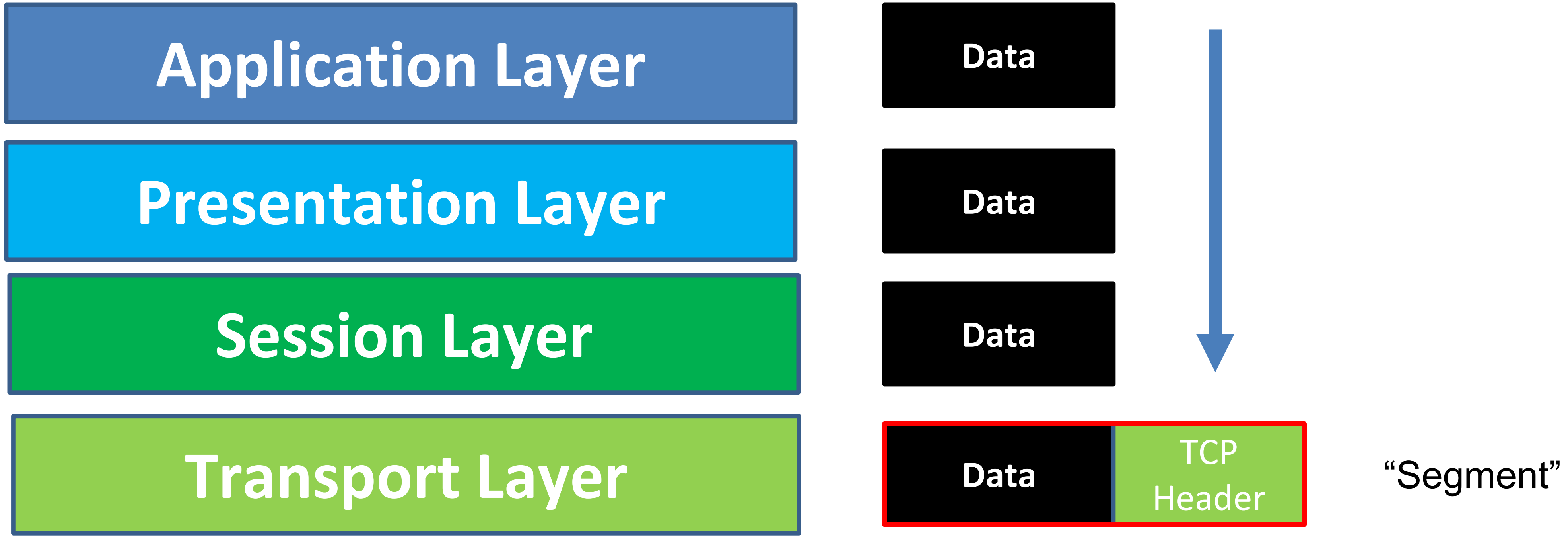
Encapsulation

Application Layer | Data

Presentation Layer | Data

Session Layer | Data

Encapsulation



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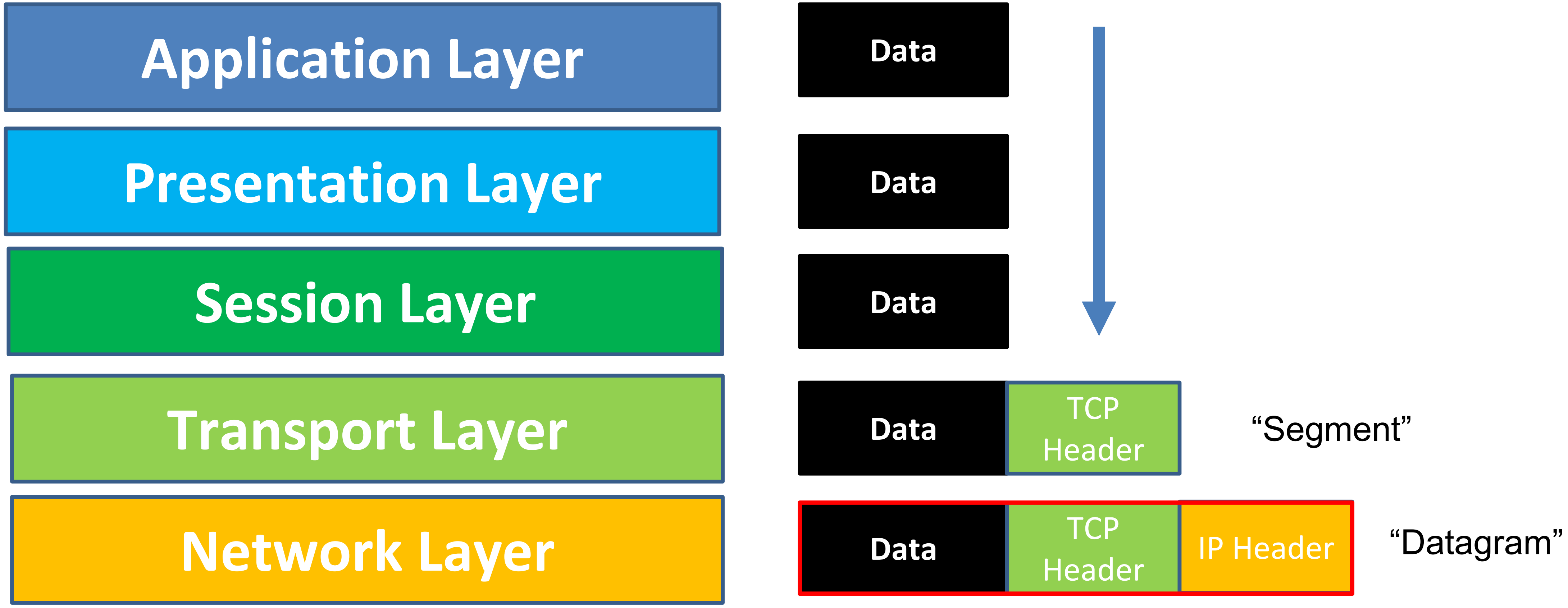

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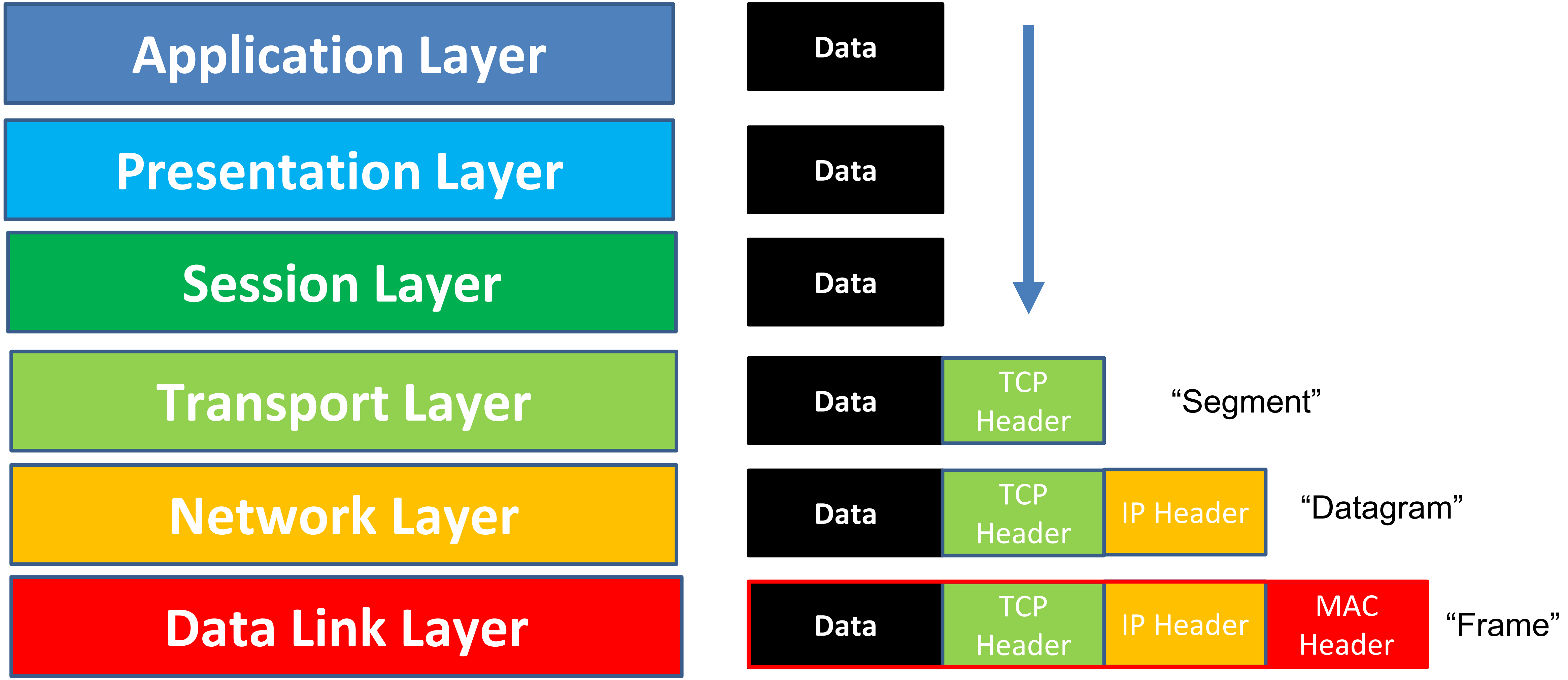

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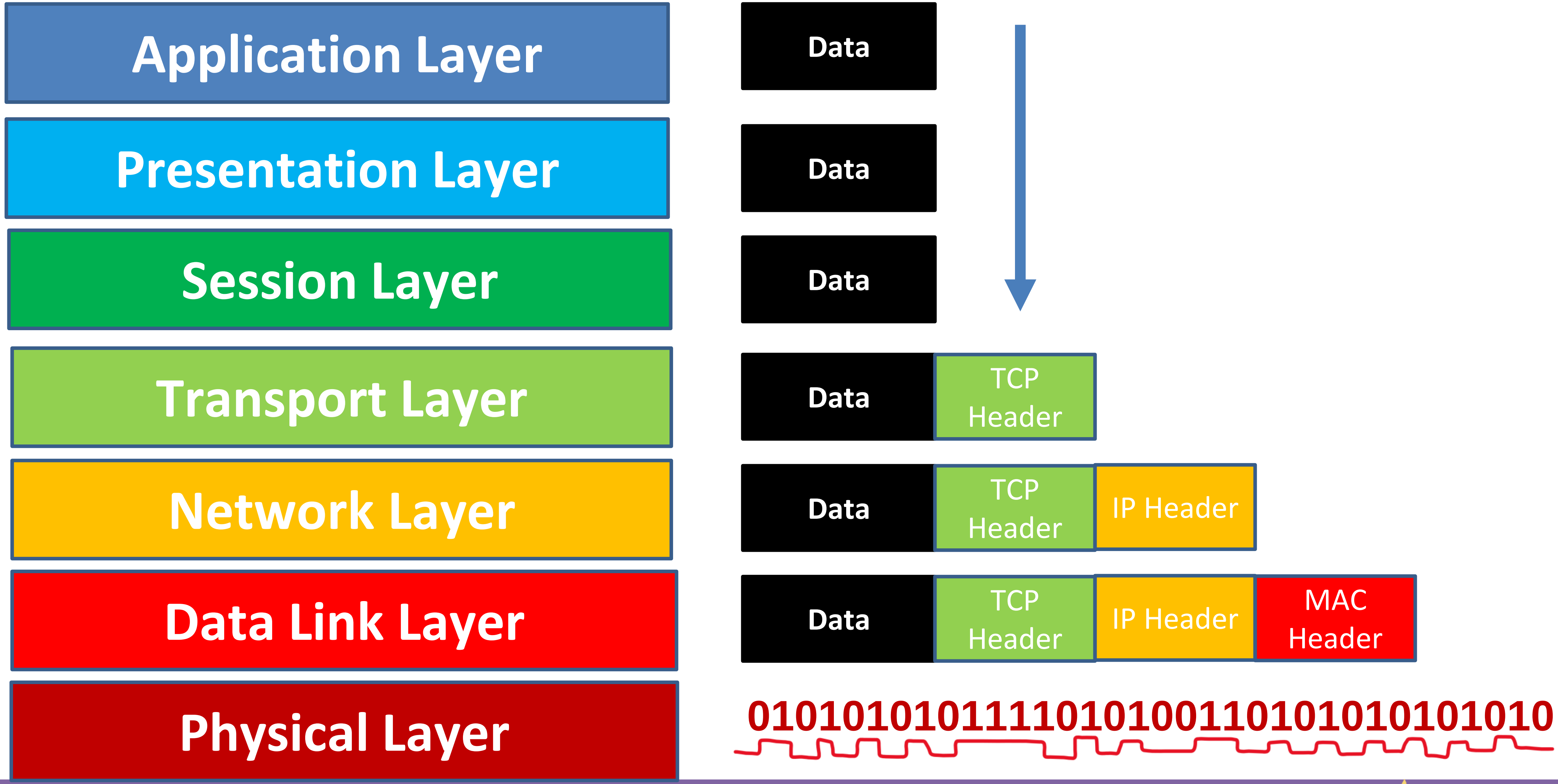

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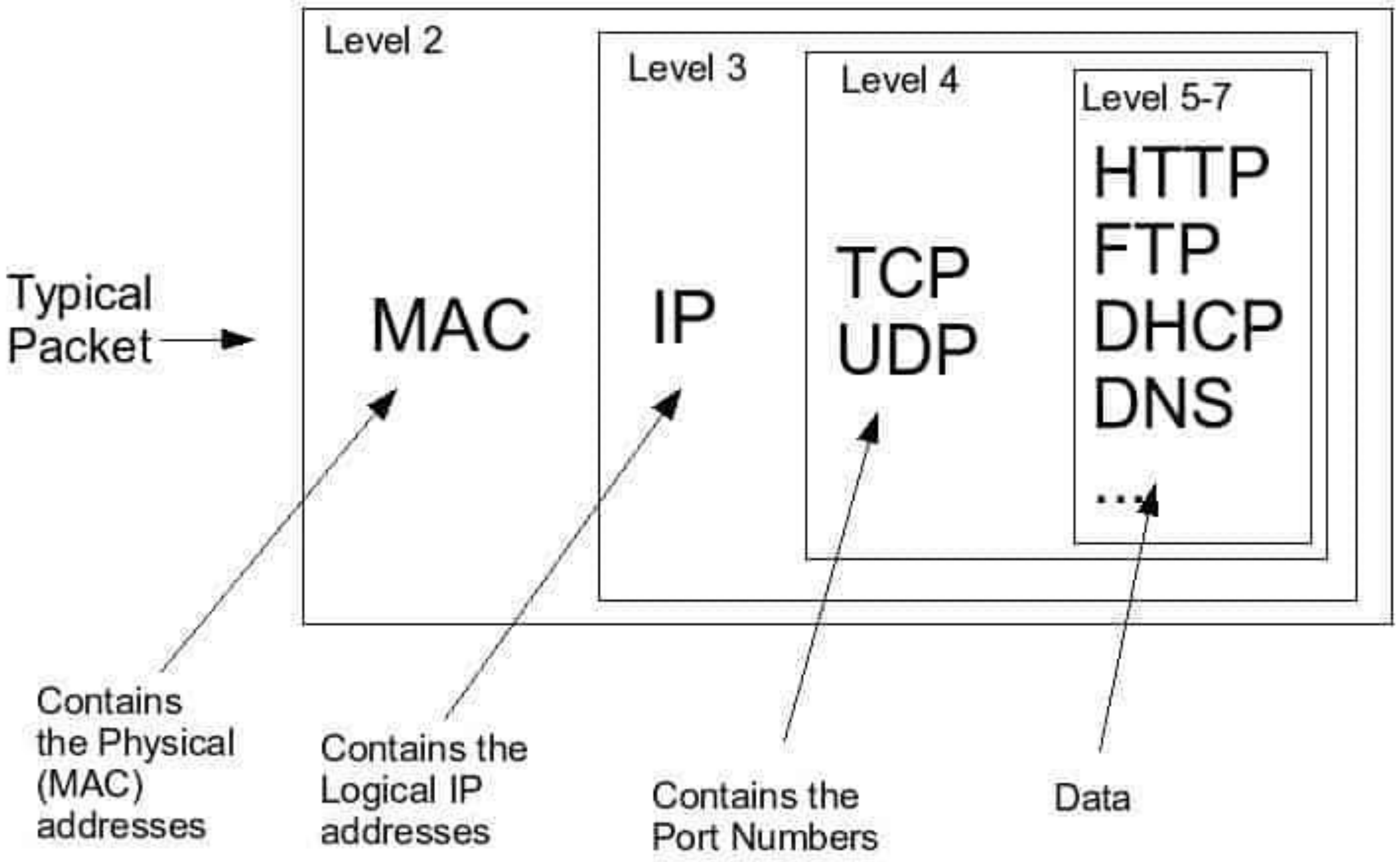


Ticket (purchase)

OSI Model

Ticket (purchase)

Baggage (Check)

OSI Model

Ticket (purchase)

Baggage (Check)

Gates (load)

OSI Model

Ticket (purchase)

Baggage (Check)

Gates (load)

Runway Takeoff

OSI Model

Ticket (purchase)

Baggage (Check)

Gates (load)

Runway Takeoff

Airplane Routing

OSI Model

Ticket (purchase)

Baggage (Check)

Gates (load)

Runway Takeoff

Airplane Routing

Airplane Routing

OSI Model

Ticket (purchase)

Baggage (Check)

Gates (load)

Runway Takeoff

Airplane Routing

Runway landing

Airplane Routing

OSI Model

Ticket (purchase)

Baggage (Check)

Gates (load)

Runway Takeoff

Airplane Routing

Gates (unload)

Runway landing

Airplane Routing

OSI Model

Ticket (purchase)

Baggage (Check)

Gates (load)

Runway Takeoff

Airplane Routing

Baggage (claim)

Gates (unload)

Runway landing

Airplane Routing

OSI Model

Ticket (purchase)

Baggage (Check)

Gates (load)

Runway Takeoff

Airplane Routing

Tickets (complain)

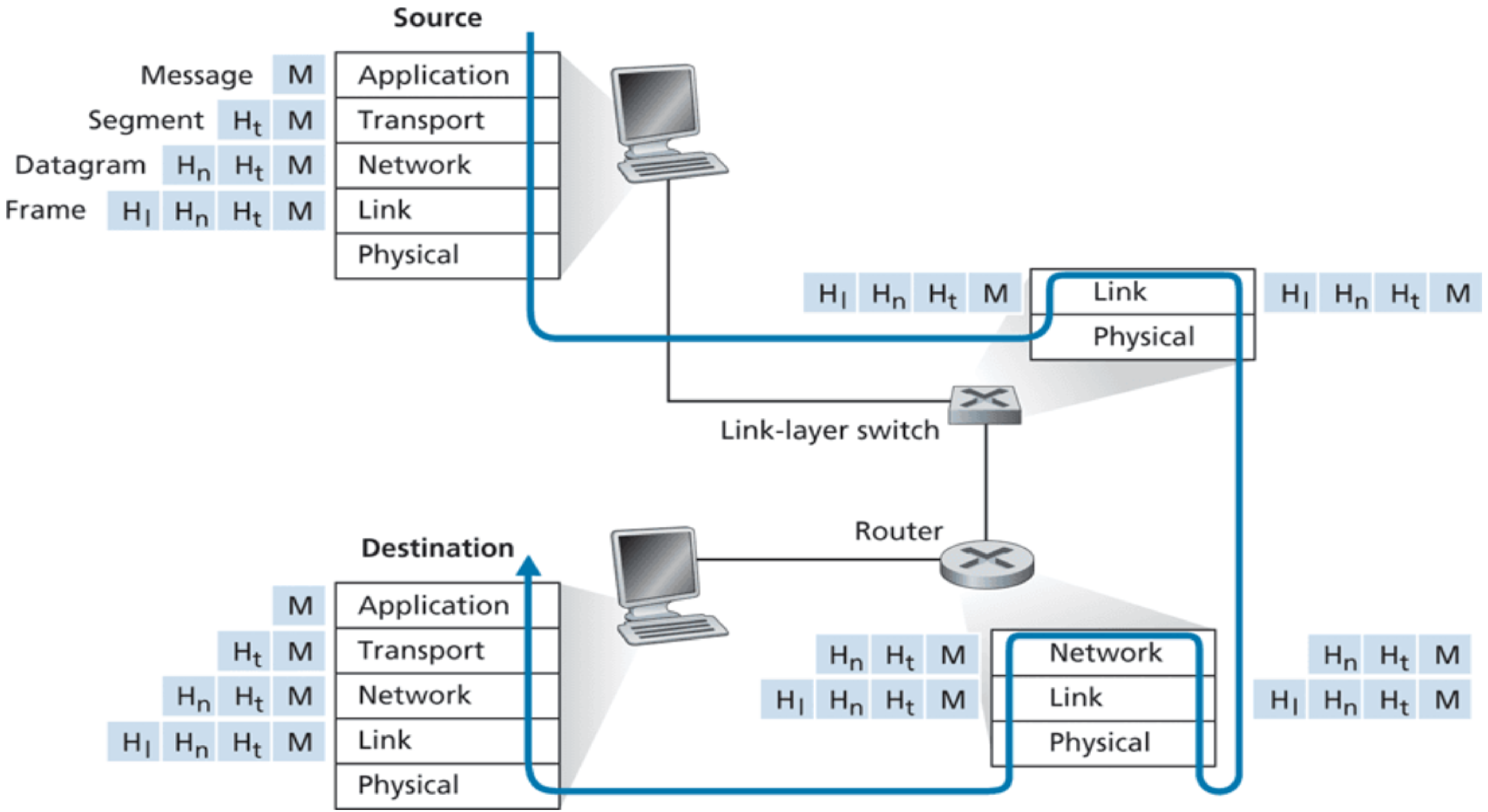
Baggage (claim)

Gates (unload)

Runway landing

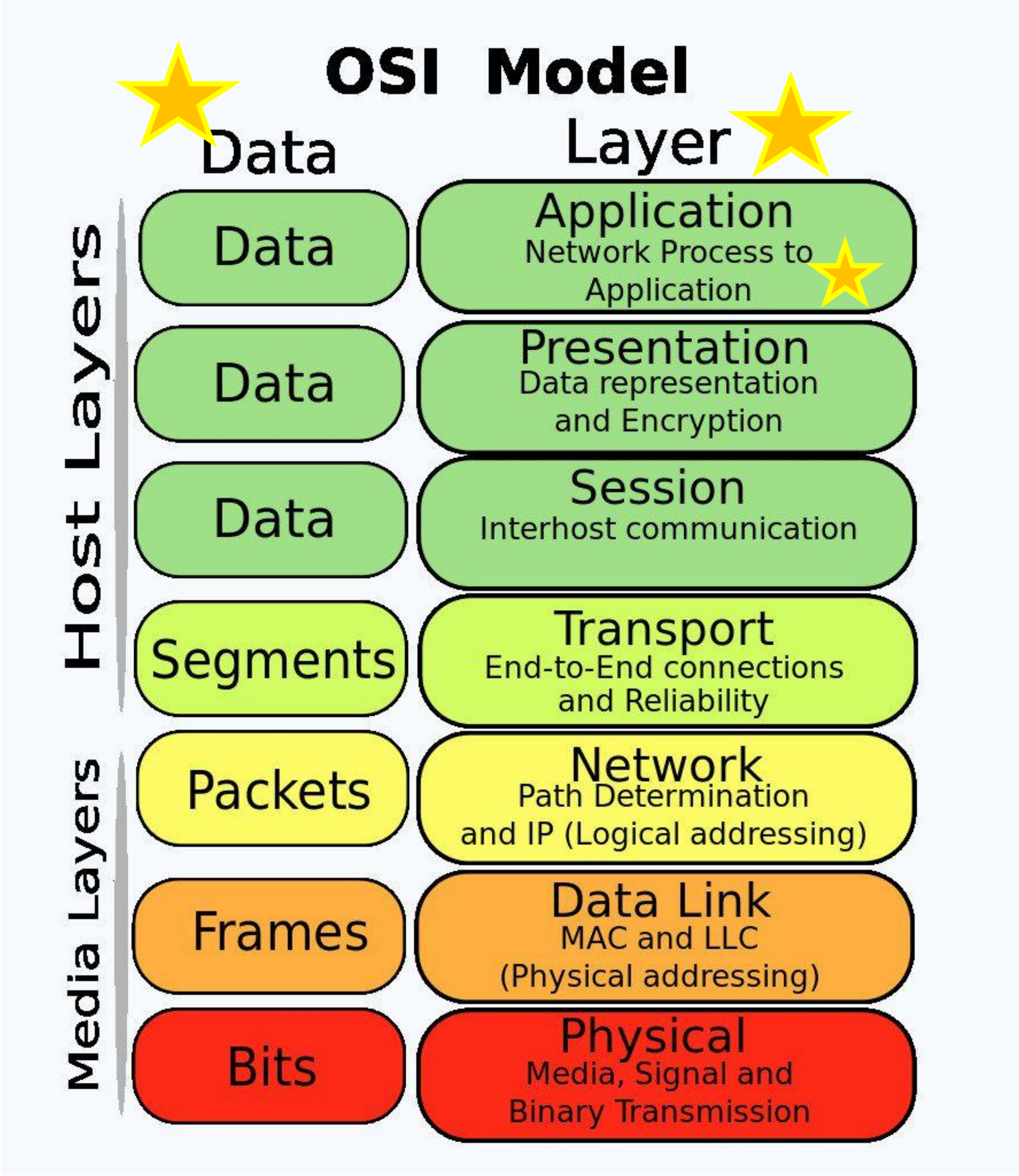
Airplane Routing

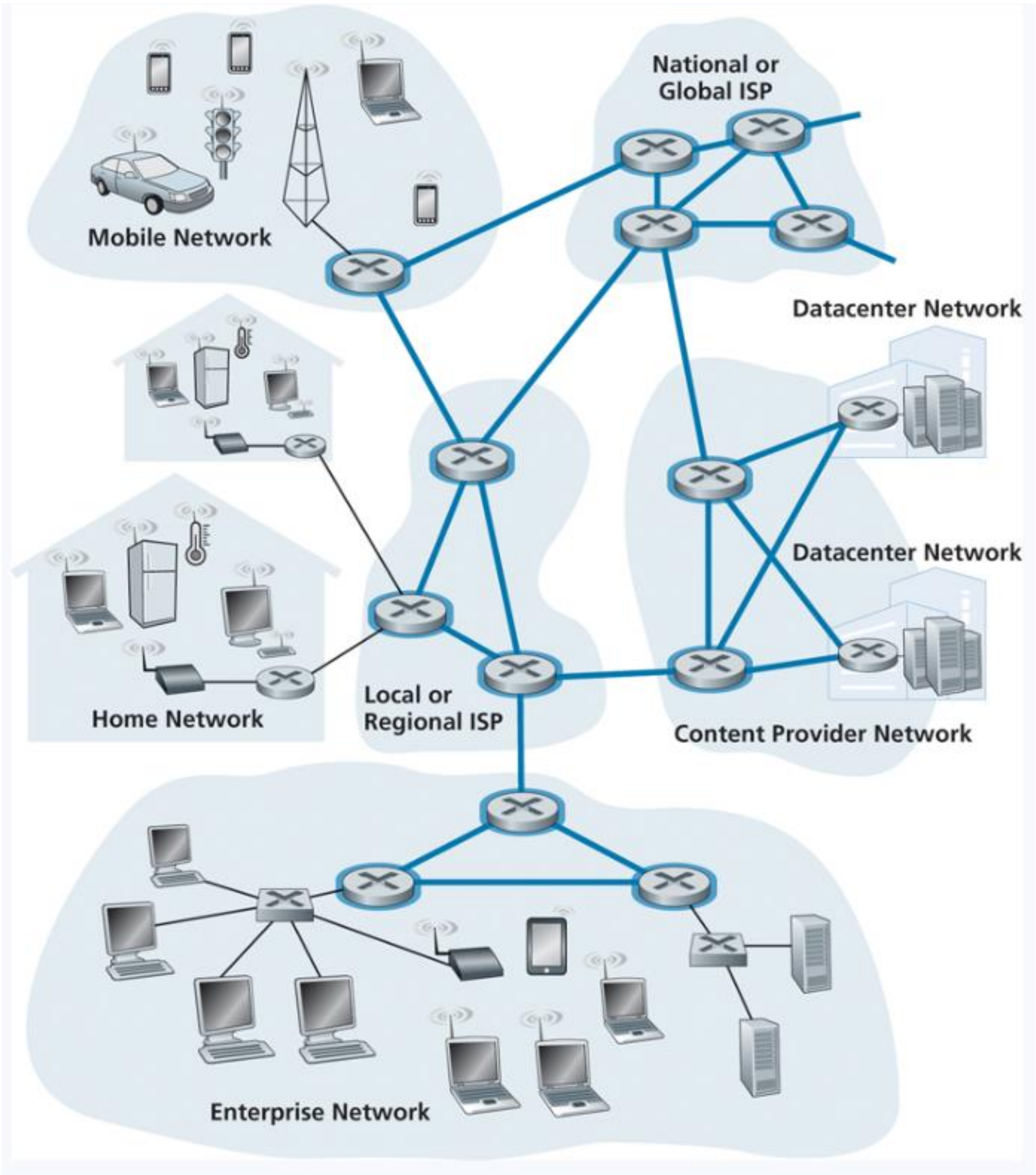
OSI Model



Source
Message
Segment
Datagram
Frame
M
H_t M
H_n H_t M
H_l H_n H_t M
Application
Transport
Network
Link
Physical
Link
Physical
Link-layer switch
Router
Network
Link
Physical
Destination

OSI Model


OSI Model
Data
Layer
Host Layers
Media Layers
Data
Application
Network Process to Application
Data
Presentation
Data representation and Encryption
Data
Session
Interhost communication
Segments
Transport
End-to-End connections and Reliability
Packets
Network
Path Determination and IP (Logical addressing)
Frames
Data Link
MAC and LLC (Physical addressing)
Bits
Physical
Media, Signal and Binary Transmission



The internet is a *network of networks*, connected by **packet switches** and **communication links**

Messages going from A to B are split into **packets**

"Good morning, I hope you are having a good day!"

To: Host A John Paxton 192.42.98.11	From: Host B Reese Pearsall 192.5.223.42

Good morning, I hope you
are having a good day!

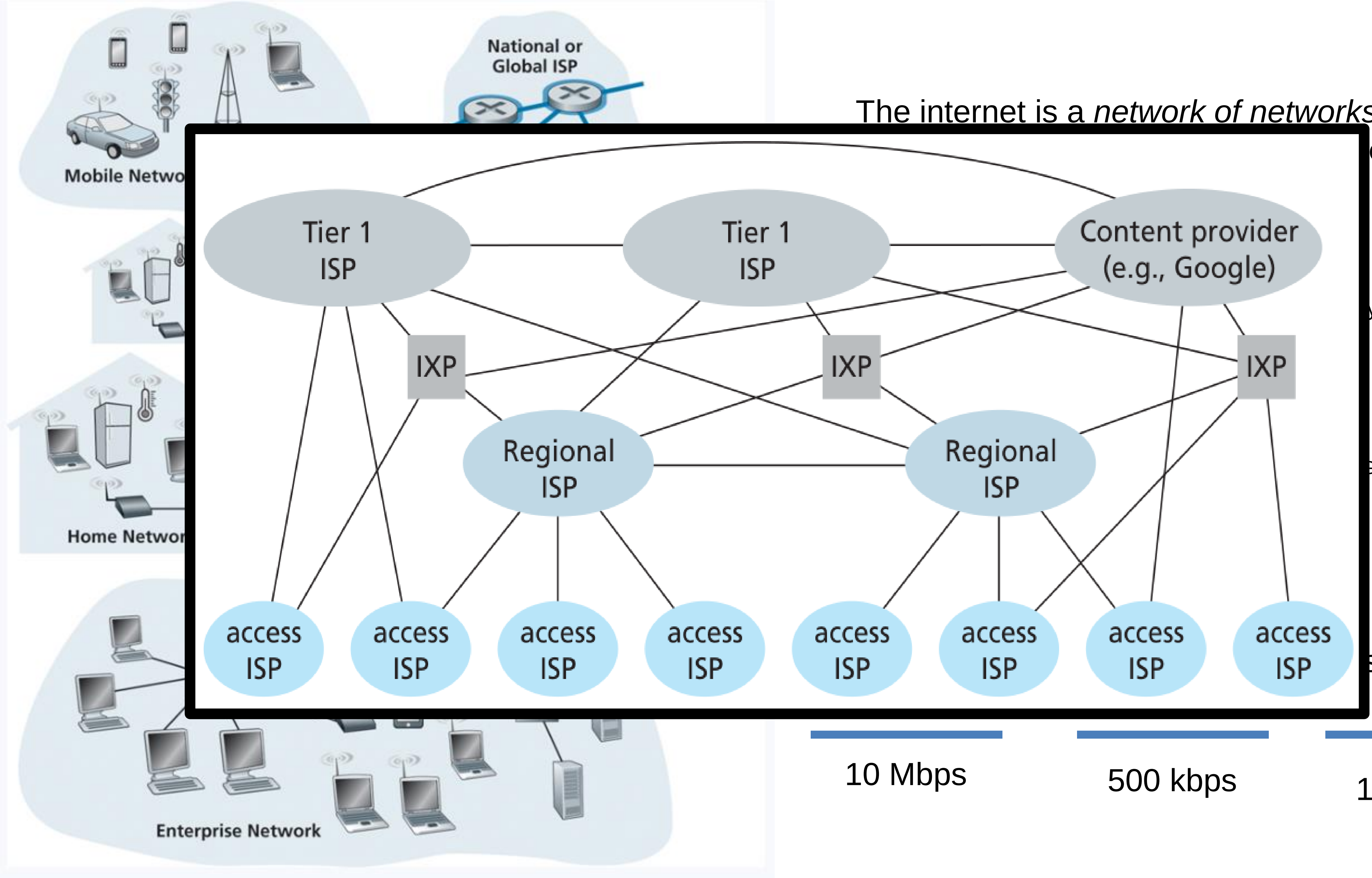
Generated Packet

Communication links have different transmission rates

10 Mbps

500 kbps

100 kbps



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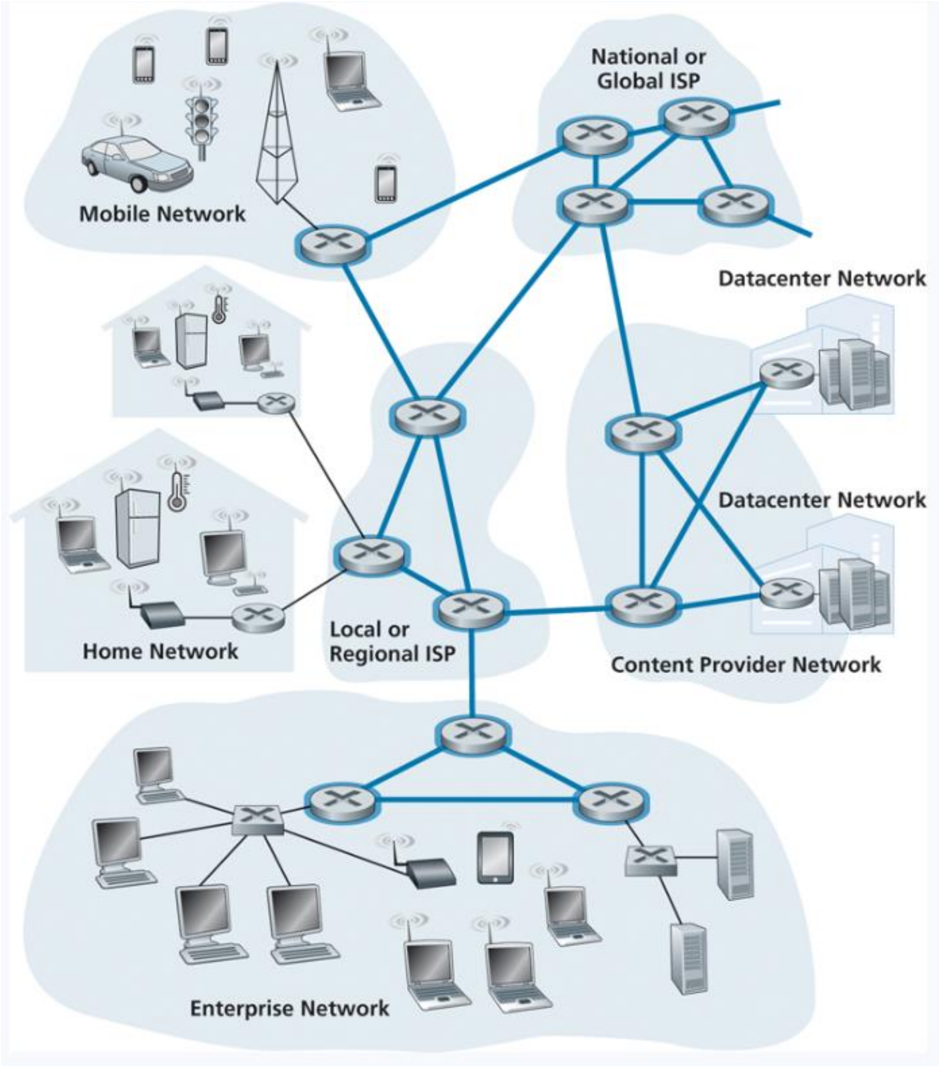
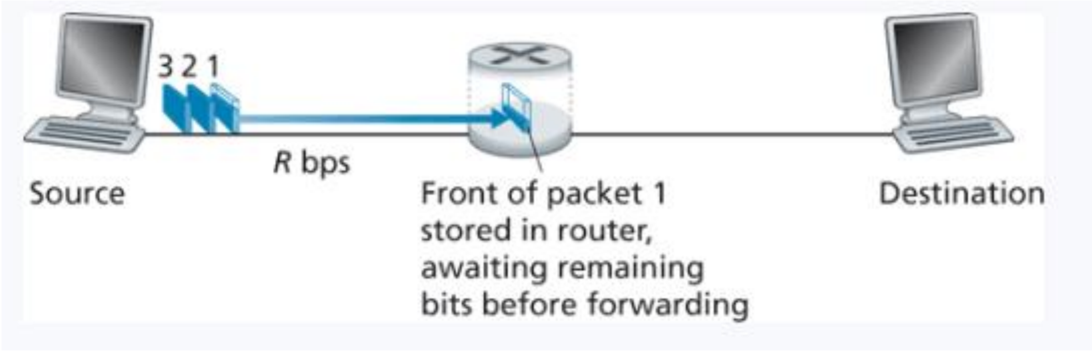
Data Forwarding



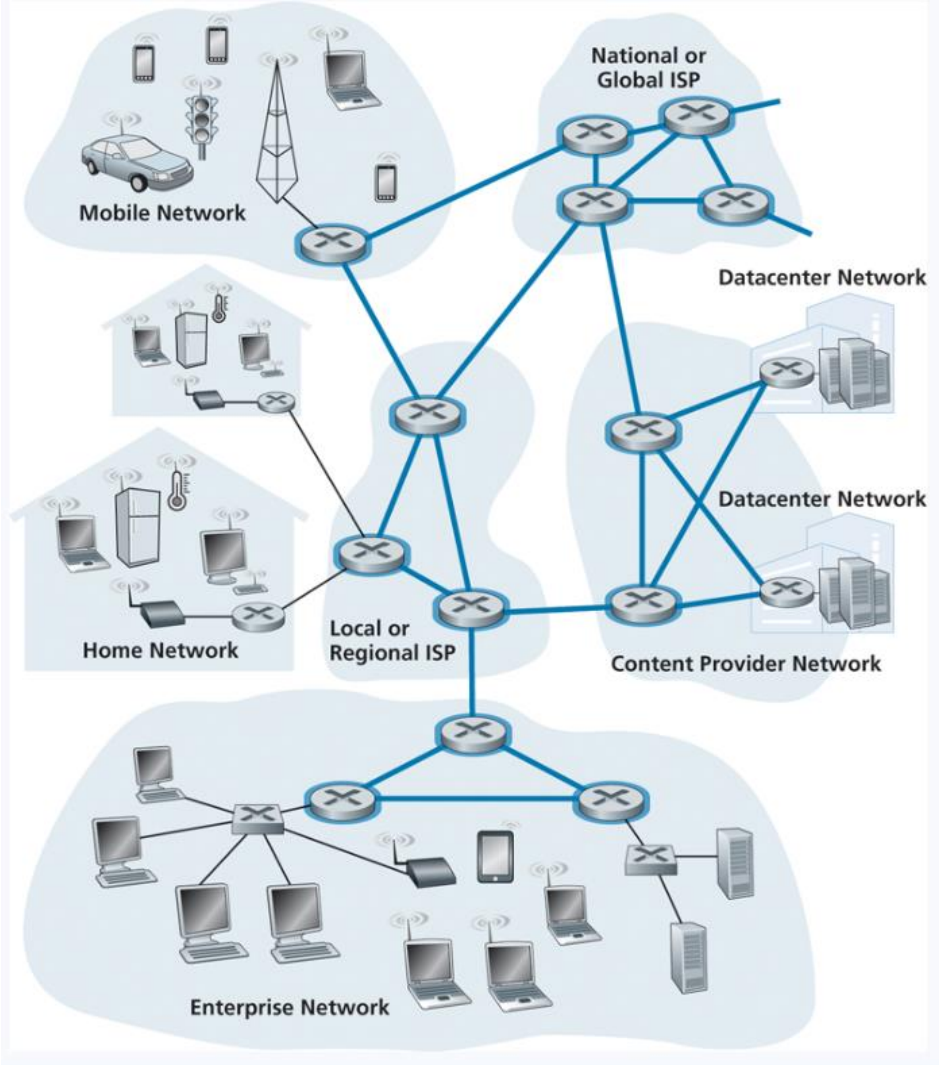
Packet Switching

Uses **store-and-forward** transmission

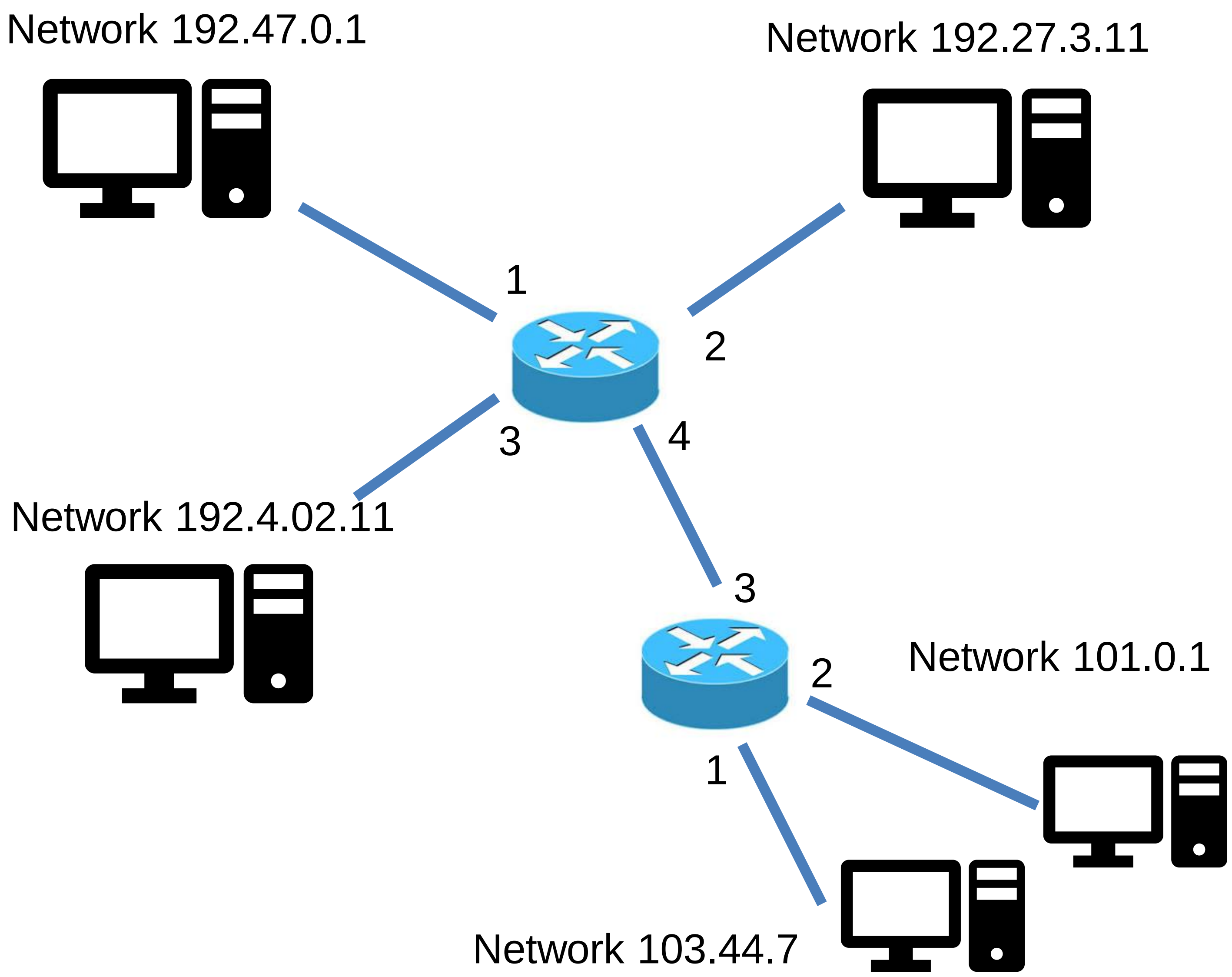


Store and forward- wait for the entire packet to arrive, check value(s) of packet, and then forward to next location

Data Forwarding



Routing Table



Data Forwarding

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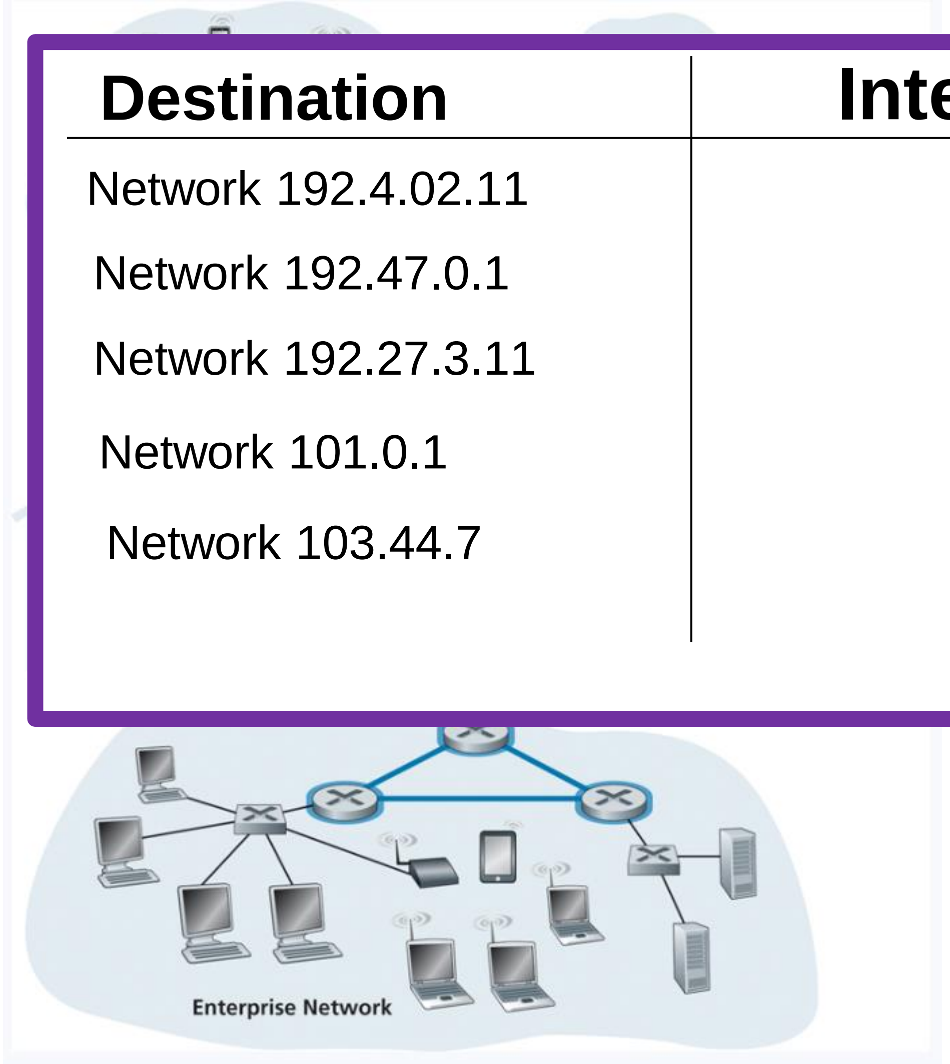
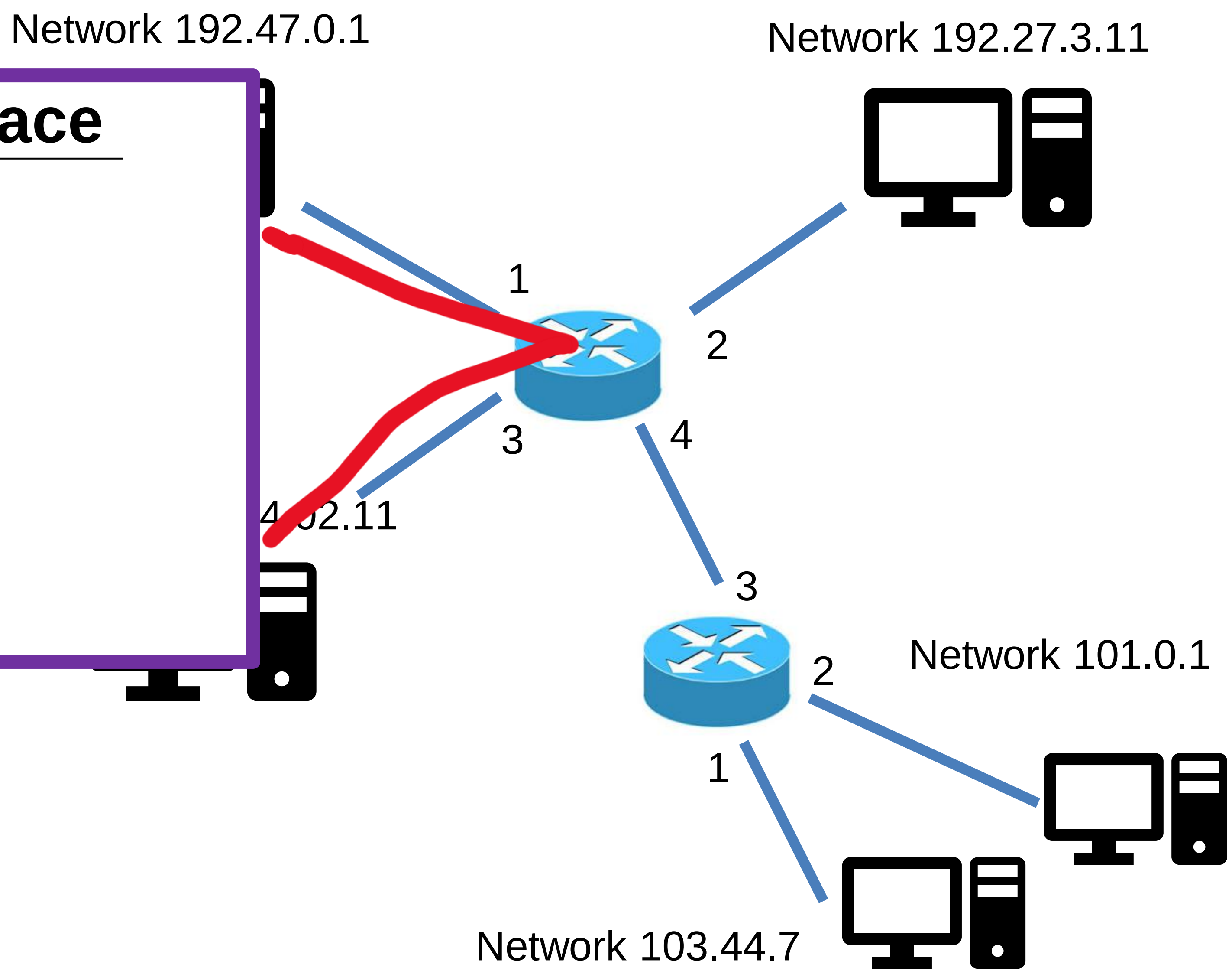


Destination	Interface
Network 192.4.02.11	3
Network 192.47.0.1	1
Network 192.27.3.11	2
Network 101.0.1	4
Network 103.44.7	4



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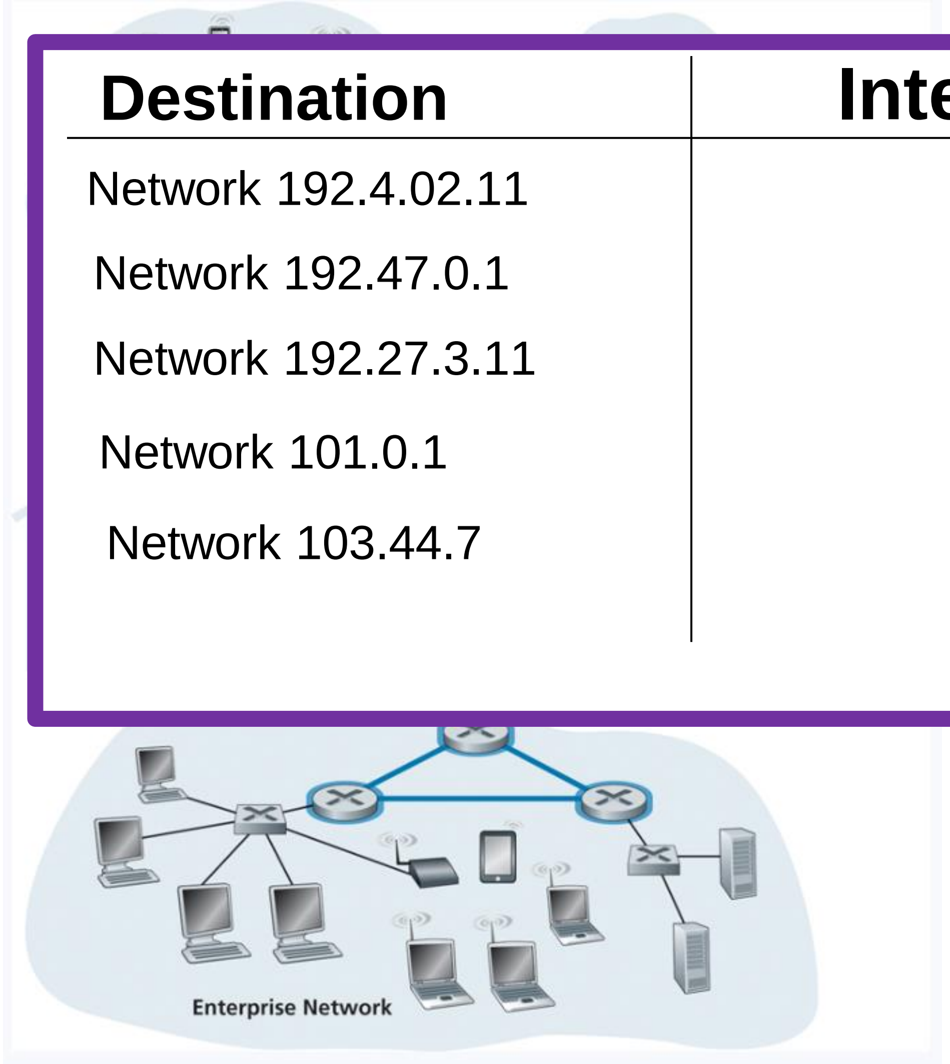
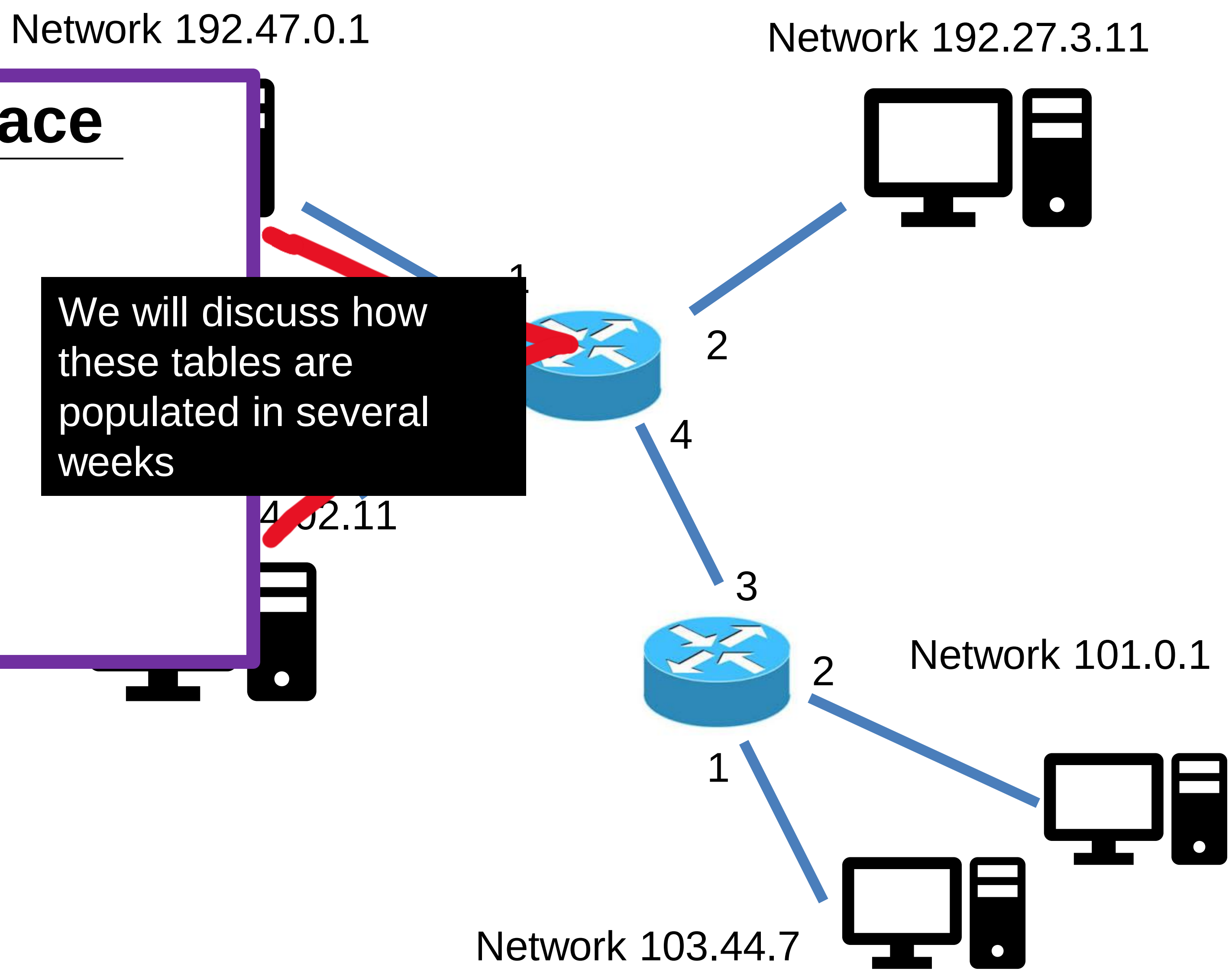


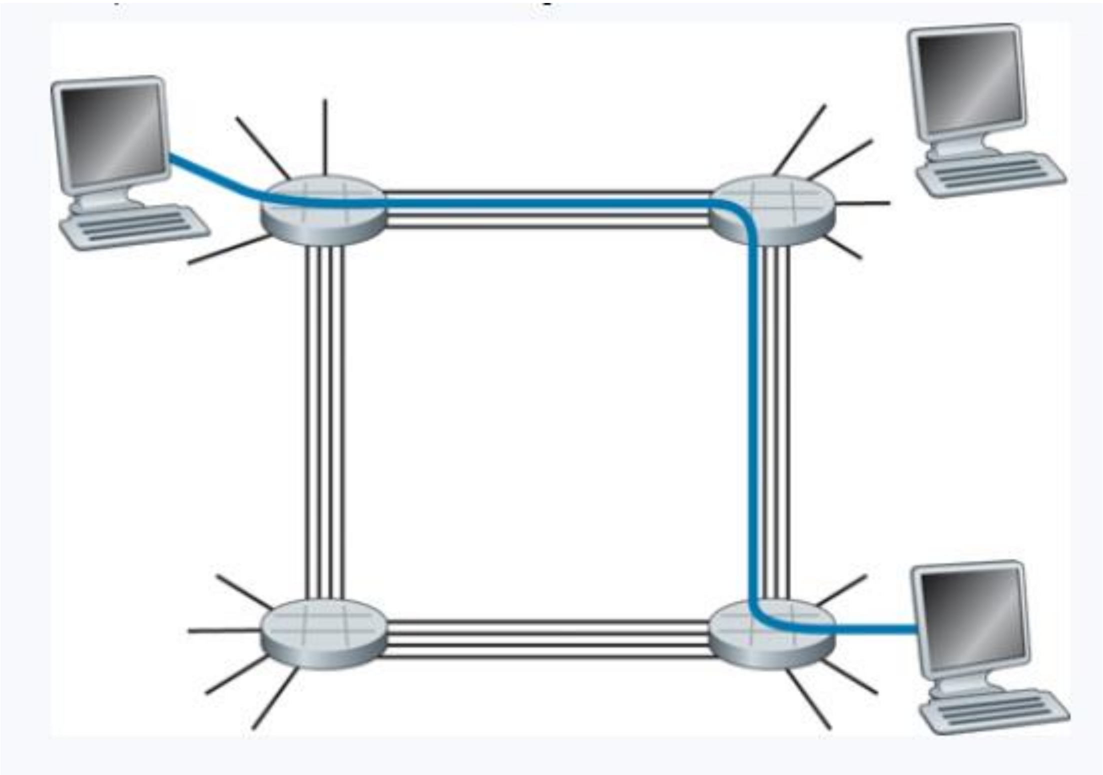


We will discuss how these tables are populated in several weeks

Data Forwarding

In circuit switching, the path and resources for transmitting from A to B is **reserved**

Communication links are divided into **circuits**, which allow for concurrent usage of the link



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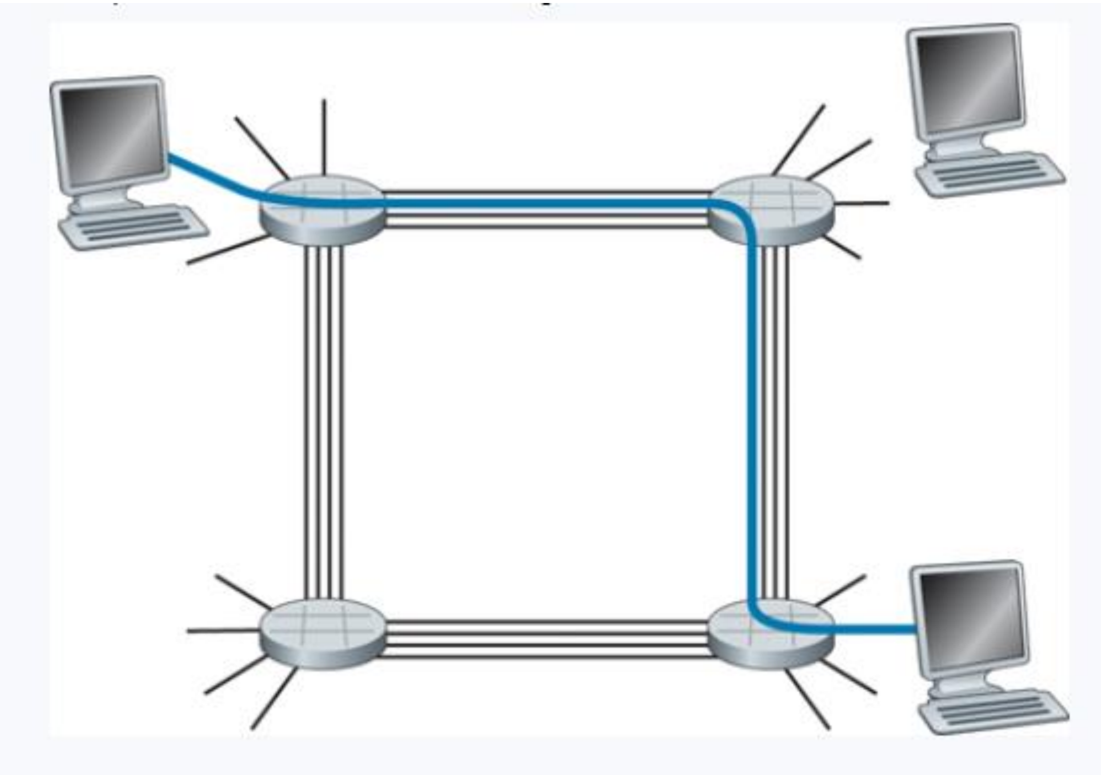
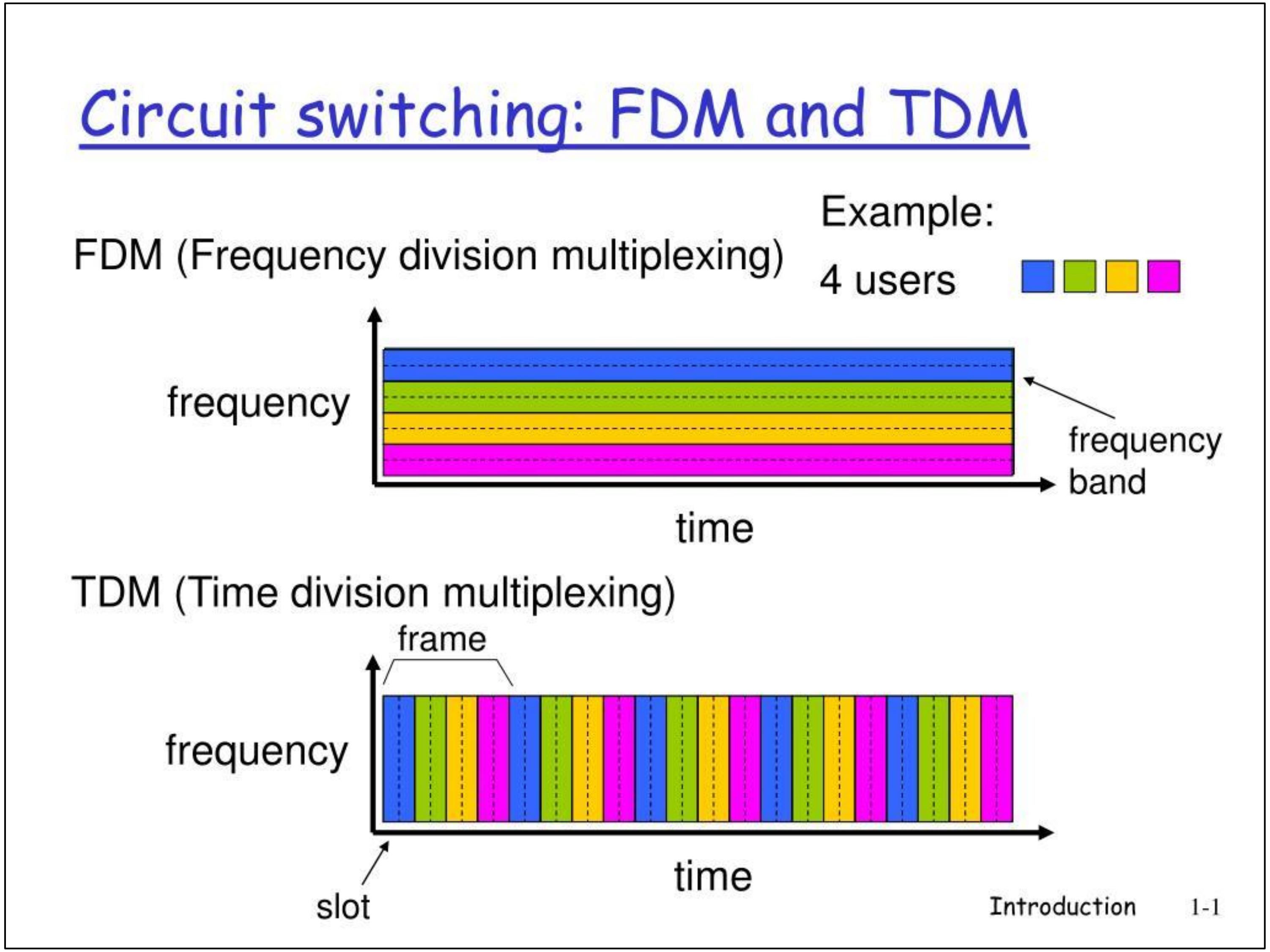


Reserved spaces that are not in use result in **silent periods**

How are links “reserved” ?



Traceroute

Network diagnostic tool that displays route taken to destination and RTT for each hop

```
C:\Users\Reese Pearsall>tracert google.com

Tracing route to google.com [172.217.14.238]
over a maximum of 30 hops:

  1    <1 ms    <1 ms    <1 ms  gateway119.254.msu.montana.edu [153.90.119.254]
  2     *        *        *     Request timed out.
  3     *        *        *     Request timed out.
  4    <1 ms    <1 ms    <1 ms  153.90.125.254
  5    <1 ms    <1 ms    <1 ms  10.196.6.10
  6     1 ms     1 ms    <1 ms  rnedge-prodfw.msu.montana.edu [192.105.205.131]
  7    15 ms    15 ms    16 ms  ae13--538.icar-sttl1-2.infra.pnw-gigapop.net [209.124.190.212]
  8    15 ms    15 ms    15 ms  209.124.190.202
  9    17 ms    17 ms    17 ms  142.251.70.99
 10    16 ms    16 ms    16 ms  209.85.254.247
 11    15 ms    15 ms    15 ms  sea30s02-in-f14.1e100.net [172.217.14.238]

Trace complete.
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Hop #

RTT time for each packet

Destination

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Trace complete.
```

whois- provides registration data of a domain or IP address

172.217.14.238 address profil

Whois Diagnostics

IP Whois

```
NetRange:       172.217.0.0 - 172.217.255.255
CIDR:           172.217.0.0/16
NetName:        GOOGLE
NetHandle:      NET-172-217-0-0-1
Parent:         NET172 (NET-172-0-0-0-0)
NetType:        Direct Allocation
OriginAS:       AS15169
Organization:   Google LLC (GOGL)
RegDate:        2012-04-16
Updated:        2012-04-16
Ref:            https://rdap.arin.net/registry/ip/172.217.0.0


OrgName:        Google LLC
OrgId:          GOGL
Address:        1600 Amphitheatre Parkway
```

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NetHandle:      NET-172-217-0-0-1
Parent:         NET172 (NET-172-0-0-0-0)
NetType:        Direct Allocation
OriginAS:       AS15169
Organization:   Google LLC (GOGL)
RegDate:        2012-04-16
Updated:        2012-04-16
Ref:            https://rdap.arin.net/registry/ip/172.217.0.0


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  3     *        *        *     Request timed out.
  4    <1 ms    <1 ms    <1 ms  153.90.125.254
  5    <1 ms    <1 ms    <1 ms  10.196.6.10
  6     1 ms     1 ms    <1 ms  rnedge-prodfw.msu.montana.edu [192.105.205.131]
  7    15 ms    15 ms    16 ms  ae13--538.icar-sttl1-2.infra.pnw-gigapop.net [209.124.190.212]
  8    15 ms    15 ms    15 ms  209.124.190.202
  9    17 ms    17 ms    17 ms  142.251.70.99
 10    16 ms    16 ms    16 ms  209.85.254.247
 11    15 ms    15 ms    15 ms  sea30s02-in-f14.1e100.net [172.217.14.238]

Trace complete.
```

whois- provides registration data of a domain or IP address

153.90.119.254 address pro

Whois Diagnostics

IP Whois

```
NetRange:       153.90.0.0 - 153.90.255.255
CIDR:           153.90.0.0/16
NetName:        MSU
NetHandle:      NET-153-90-0-0-1
Parent:         APNIC-ERX-153 (NET-153-0-0-0-0)
NetType:        Direct Allocation
OriginAS:       AS13476
Organization:   Montana State University (MSU-2-Z)
RegDate:        1991-09-23
Updated:        2021-12-14
Ref:            https://rdap.arin.net/registry/ip/153.90.0.

OrgName:        Montana State University
OrgId:          MSU-2-Z
Address:        Information Technology Center
Address:        P. O. Box 173240
City:           Bozeman
```