Computer Networks Advanced Course

Lesson 1 – Layers model overview

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Presentation Goal

- Combining the knowledge of the basic course with an overview of how the Internet works

Five Layers Model

- Can you name the layers?

5. Application: supporting network applications

HTTP, IMAP, SMTP, DNS

4. Transport: process to process data transfer

TCP, UDP

3. Network: routing of datagrams from source to destination

IP, routing protocols

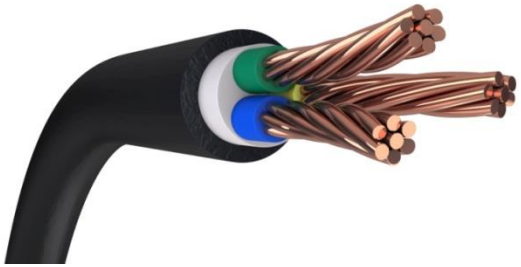
2. Link: data transfer between neighboring network elements

Ethernet, 802.11 (WiFi), PPP

1. Physical: bits “on the wire”

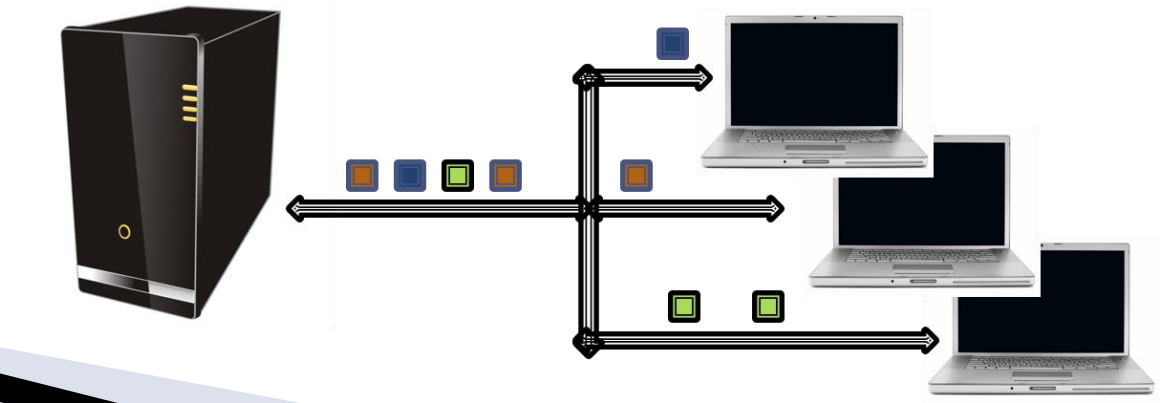
1. Physical Layer

- Task: bits on the wire: represent 0's and 1's
- Which transmission types can you name?



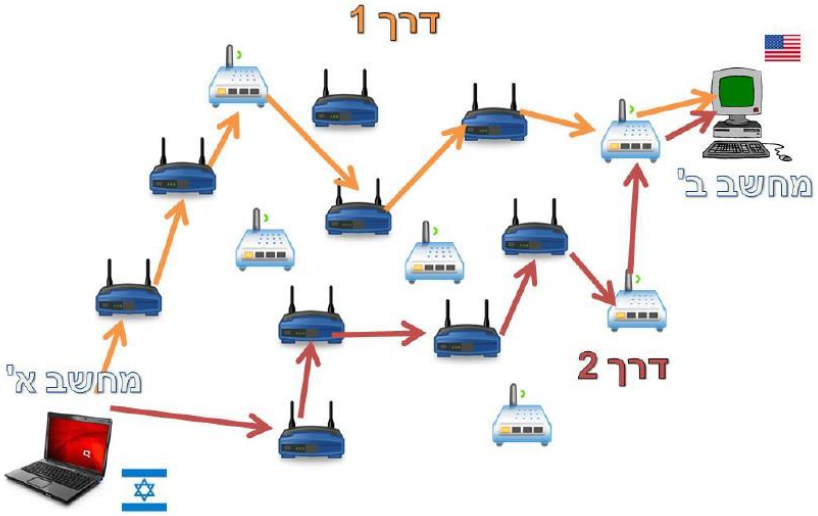
2. Data Link Layer

- Assumption: Physical layer solves communicating one bit
- Goals:
  - Transfer “chunks” of bits between neighbors
  - Share physical layer between users
- Product: LAN
- Can you name data link protocols?



3. Network Layer

- Assumption: LANs exist
- Goal: Connect devices across different LANs from source to destination
- Method: Routing
- Can you name network layer protocols?



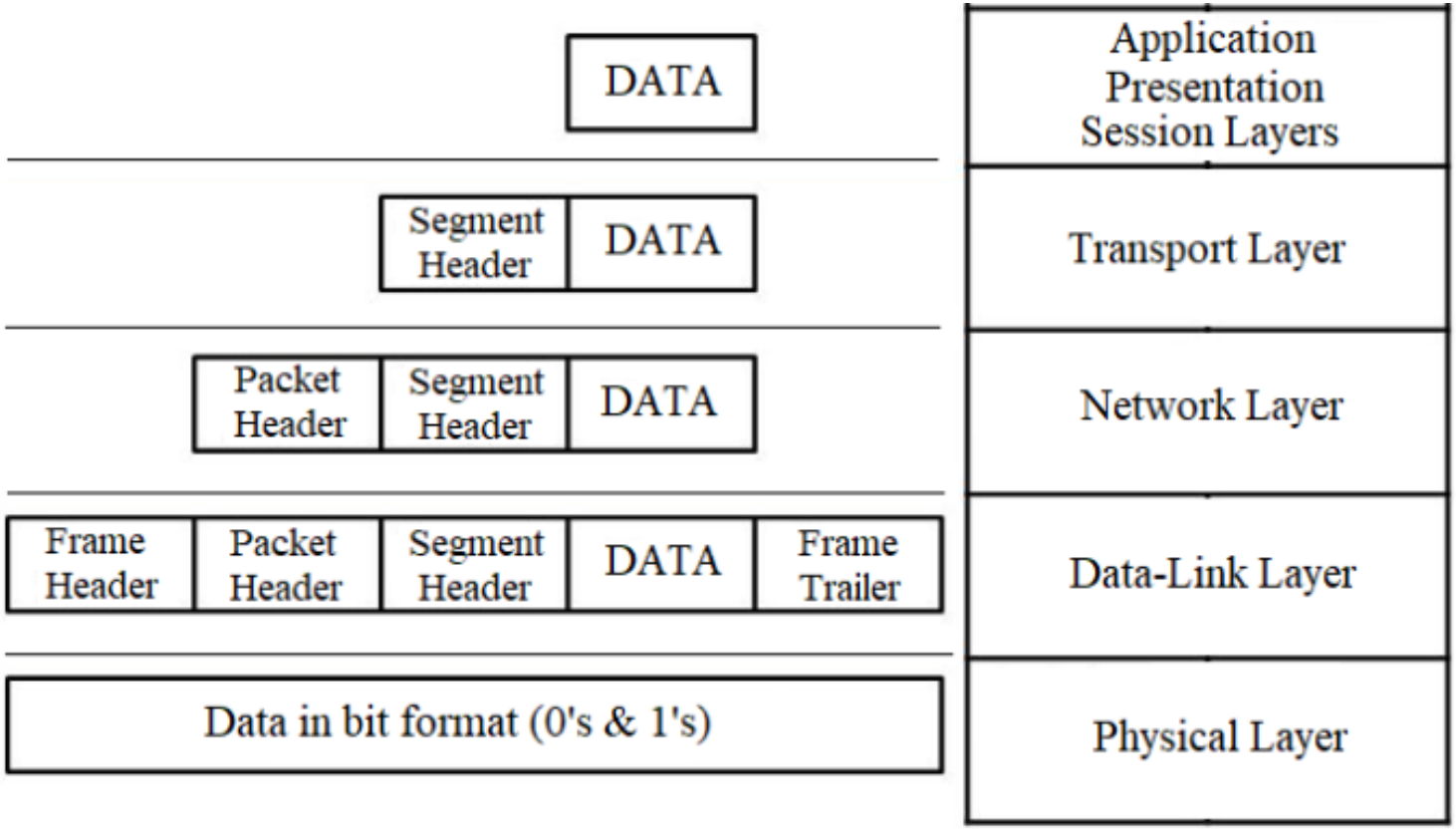
4. Transport Layer

- Assumptions:
  - network connectivity between physical devices
  - Unreliable connection
- Goal: Connect processes, hosted on physical devices
- Method: Ports
- Goal (optional): Provide reliable connections
- Can you name transport layer protocols?

5. Application Layer

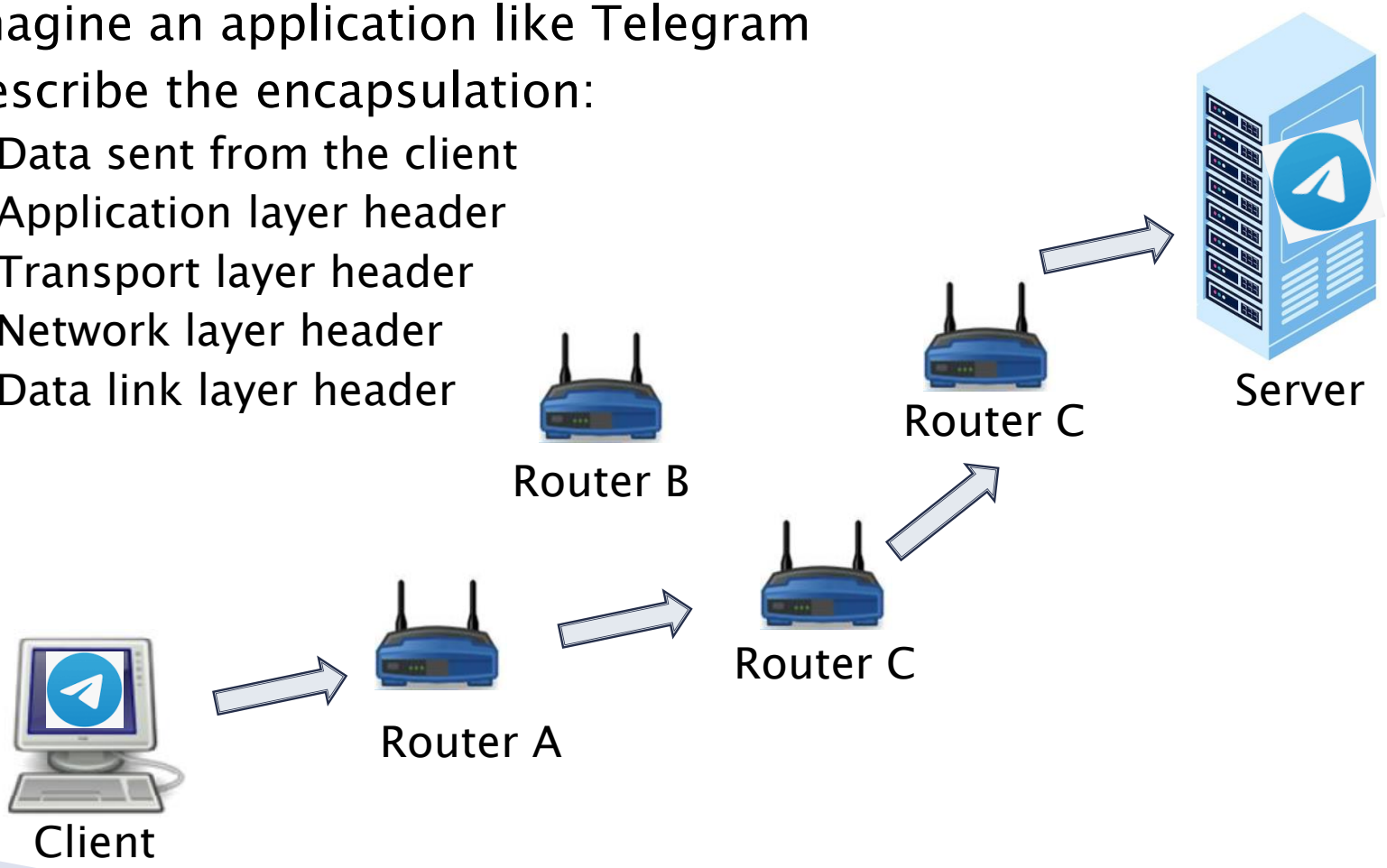
- Assumption: End to end connectivity between processes is solved
- Goal: Enable communications between local and remote programs
- Method: define protocols per specific tasks
  - File download
  - Chat
  - Web browsing etc.

Encapsulation



Encapsulation

- Imagine an application like Telegram
- Describe the encapsulation:
  - Data sent from the client
  - Application layer header
  - Transport layer header
  - Network layer header
  - Data link layer header



Encapsulation – hands on

- Explore with wireshark
- Fire up, then surf:
  - http://info.cern.ch/hypertext/WWW/TheProject.html
- Name the protocol of each layer
- Identify:
  - Source MAC
  - Destination MAC
  - Source IP
  - Destination IP
  - Source port
  - Destination port

Why layering?

- Distribute the numerous functions necessary for communication between applications into different layers that are simpler and easier to implement
- Modularity of the different layers: Ability to transparently modify or replace a layer without affecting other layers
- Maintenance and upgrades without affecting every device in the network.

But only advantages?

The story:

- New computer
- Plugged into the internet for the first time
- We surf to a desired website
- Let us review anything that should happen to succeed at communicating

Interfaces and MAC addresses

- Q1: How does our PC know the MAC address of its interfaces?
  - Burnt on the NIC
  - Example: 00:23:69:0B:30:58

Interfaces and IP Addresses

- Q2: How do our PC's interfaces obtain IP addresses?
  - Using DHCP – **Dynamic Host Configuration Protocol**
- A typical home network router contents:
  - Ethernet Switch
  - Router
  - DHCP server
  - NAT Service
  - Wireless AP
  - Firewall
  - ADSL or Fiber Modem

Obtaining an IP

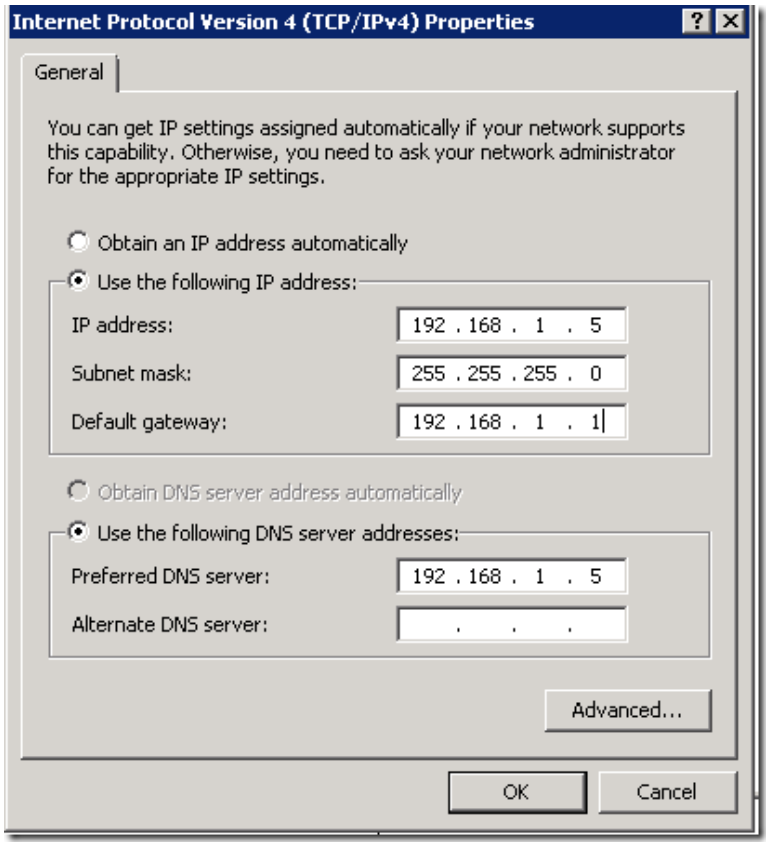
- Q3: How does the PC find a DHCP server?
  - The PC sends DHCP Discover
- Q4: To whom?
  - The PC broadcasts using MAC FF:FF:FF:FF:FF:FF
- Q5: The DHCP server responds with DHCP Offer. To which IP address?
  - 255.255.255.255, as our PC does not yet have an IP

Getting an IP – cont.

- Q6: Name the stages of getting an IP address from the server
  - Answer:

Getting an IP – cont.

- Q7: What does the PC get from the DHCP server?
  - IP address
  - Subnet mask
  - Default gateway IP
  - IP Lease time
  - DNS router address

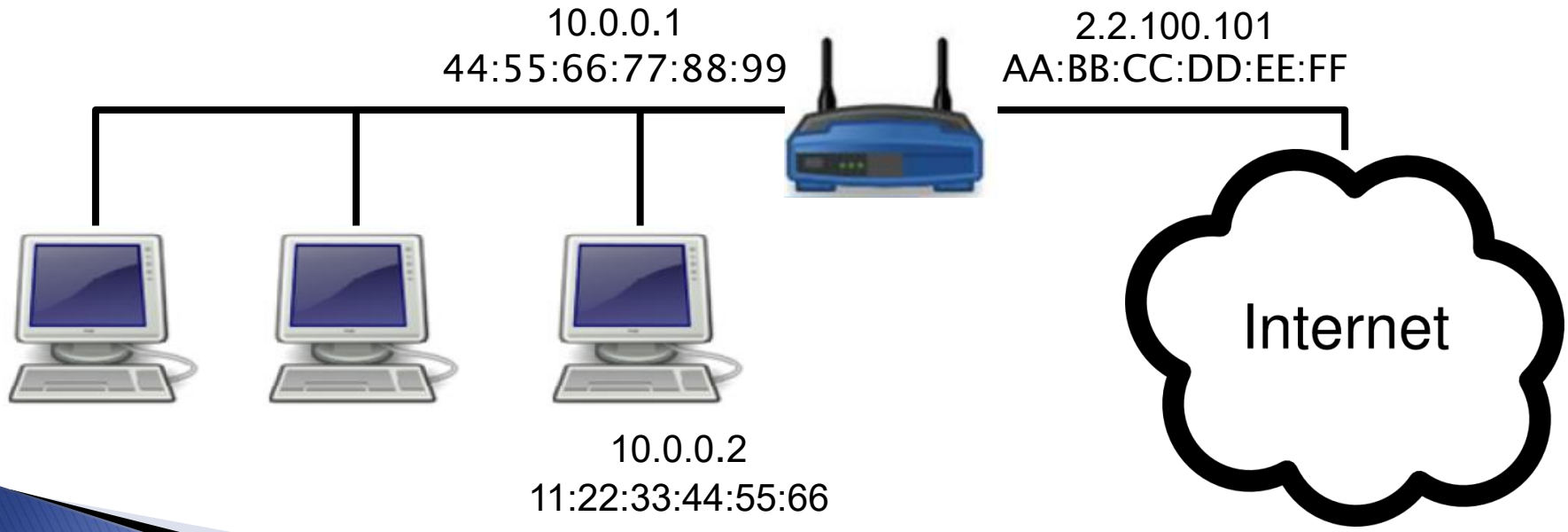


The home router

- Q8: How does the router get its own IP?
  - The ISP allocates an IP address using DHCP

The home router – cont

- Q9: How many IP addresses and how many MAC addresses does the home router have?
  - Two IPs, two MACs (external and internal)



Current status – what our PC has?

- Own MAC address
  - 11:22:33:44:55:66
- Own IP and subnet mask
  - 10.0.0.2
  - 255.255.0.0
- Router's (default gateway) internal IP
  - 10.0.0.1
- DNS server's IP address
  - 2.2.2.2

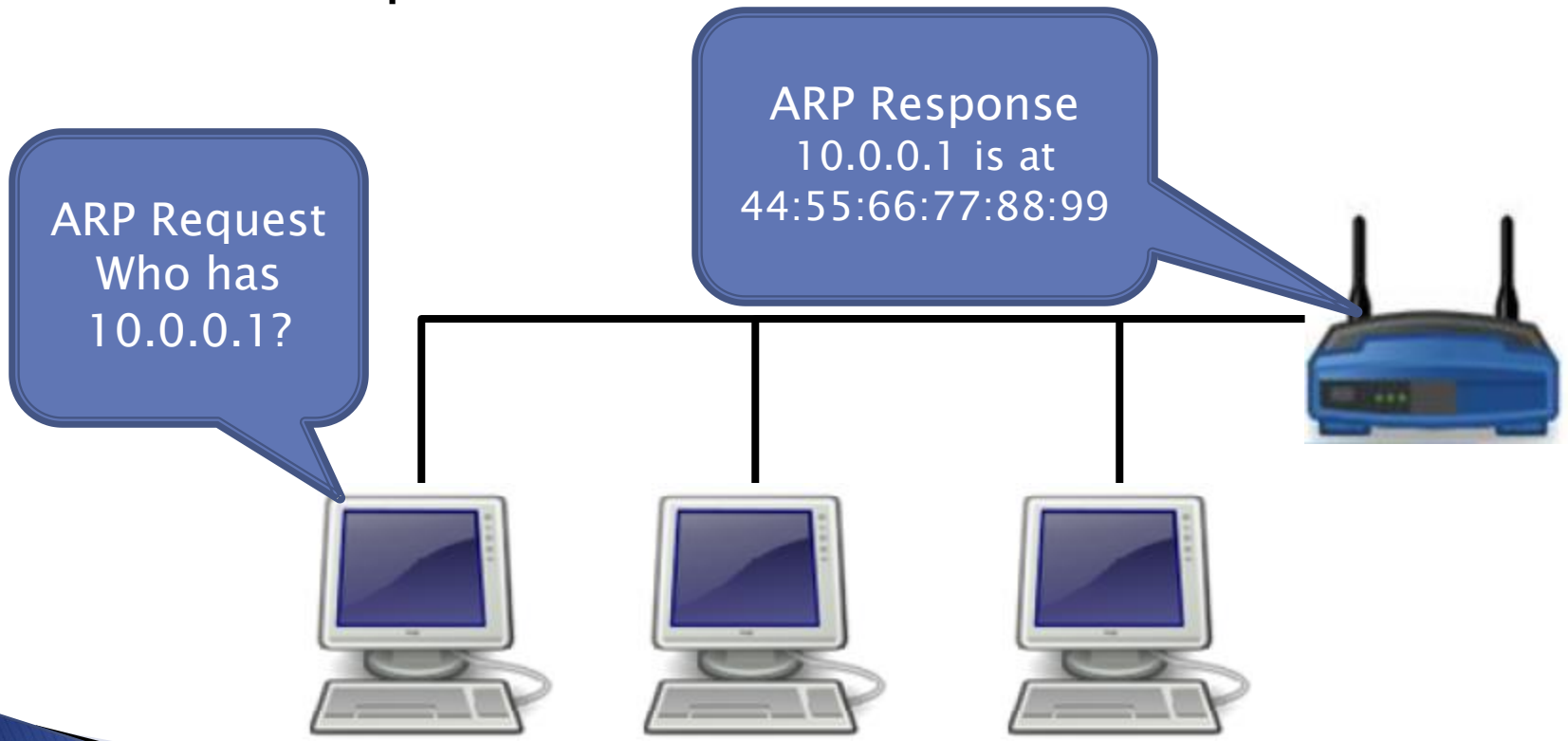



Obtaining Destination IP Address

- Q10: How can our PC obtain the IP address of a chosen website?
  - DNS server
- Q11: Does our PC have all the needed information for sending the DNS request?
  - The MAC address of the default gateway is required.

Obtaining Default Gateway MAC Address

- Q12: How is the gateway's MAC obtained?
  - ARP request



DNS Query

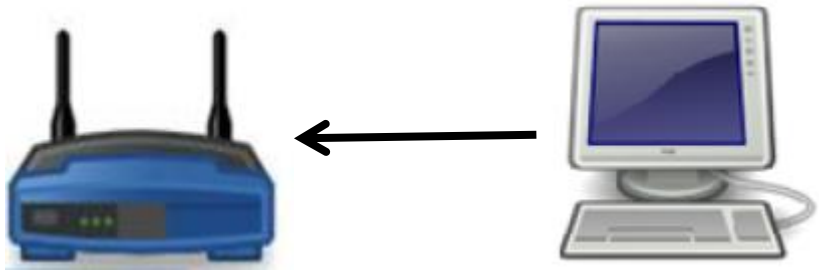
- DNS query is ready to be sent to the DNS server
- There is at least one router between the client and server
- Let's review the query packet:
  - If there is no NAT
  - With NAT (common case)

- Q13: Which transport layer protocol is used?
  - UDP

DNS Query Packet

- What values does the DNS request packet has?

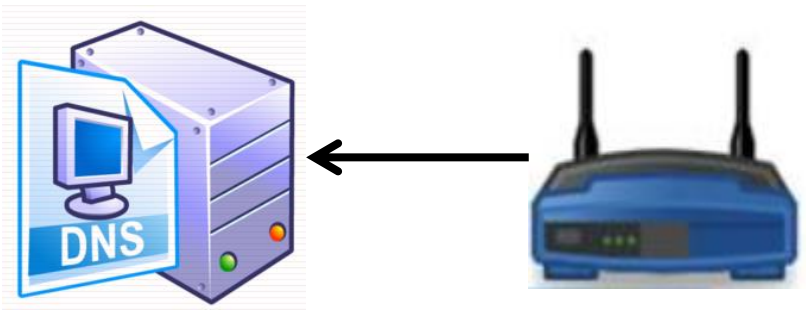
Field	Obtained from
Source MAC	14
Destination MAC	15
Source IP	16
Destination IP	17
Source Port	18
Destination Port	19



DNS Query Packet – from Router to DNS Server

- What values does the DNS request packet has?

Field	Obtained from
Source MAC	20
Destination MAC	21
Source IP	22
Destination IP	23
Source Port	24
Destination Port	25



Communication with Desired Website

- Our PC sends packets with the desired website IP as the destination
- Q26: How do the packets reach the destination?
  - Network layer handles routing
- Bonus: How can we check which routers are on the way? Explain theory

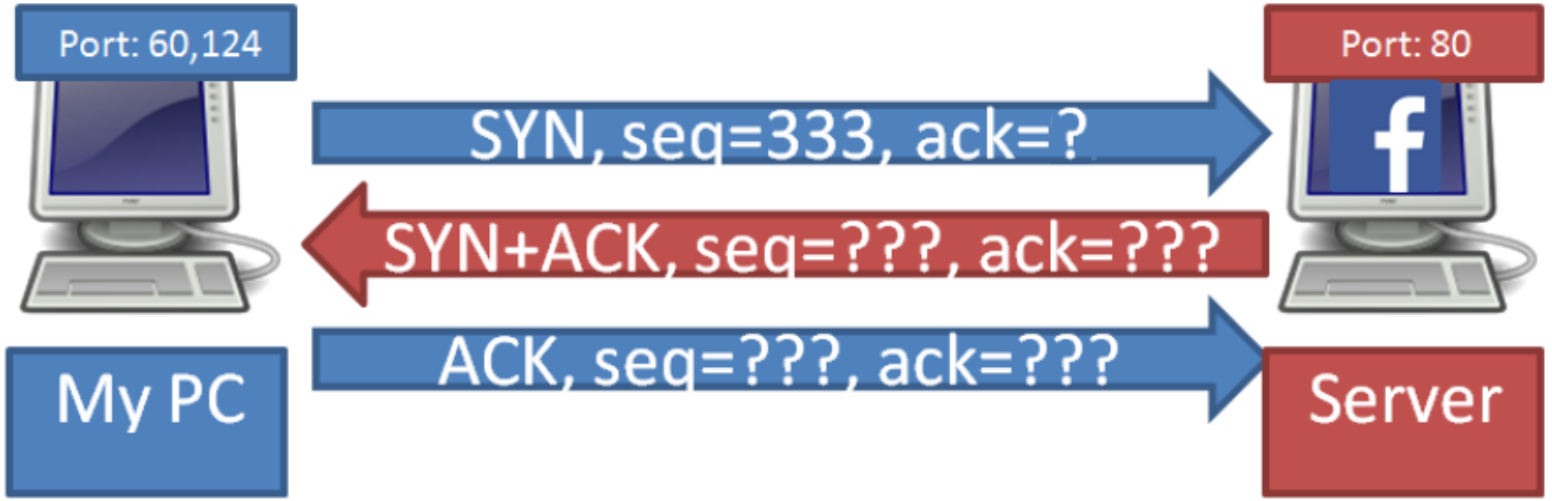
```
C:\Users\ADMIN>tracert www.facebook.com

Tracing route to star-mini.c10r.facebook.com [31.13.92.36]
over a maximum of 30 hops:

  1    <1 ms    <1 ms    <1 ms  Broadcom.Home [10.0.0.138]
  2    15 ms    15 ms    14 ms  85-250-128-1.bb.netvision.net.il [85.250.128.1]

  3    15 ms    15 ms    15 ms  coresw2-hfa-rb3-brk.nv.net.il [212.143.25.61]
  4    16 ms    15 ms    16 ms  gw2-0-2-0-3-core2.hfa.nv.net.il [212.143.7.29]
  5    71 ms    71 ms    70 ms  gw2-fra-0-3-0-3-200-gw2.hfa.nv.net.il [212.143.1
2.12]
  6    74 ms    74 ms    73 ms  10.10.70.1
  7    70 ms    69 ms    70 ms  gw1-fra-be-1-100-gw2-fra-be-1-100.fra.nv.net.il
[212.143.16.134]
  8    69 ms    70 ms    84 ms  ae6.pr03.fra2.tfbnw.net [80.81.194.40]
  9    70 ms    69 ms    69 ms  po101.psw01c.frt3.tfbnw.net [31.13.30.61]
 10    75 ms    74 ms    74 ms  msw1ac.01.frt3.tfbnw.net [173.252.64.30]
 11    71 ms    71 ms    83 ms  edge-star-mini-shv-01-frt3.facebook.com [31.13.9
2.36]

Trace complete.
```

Transport Layer

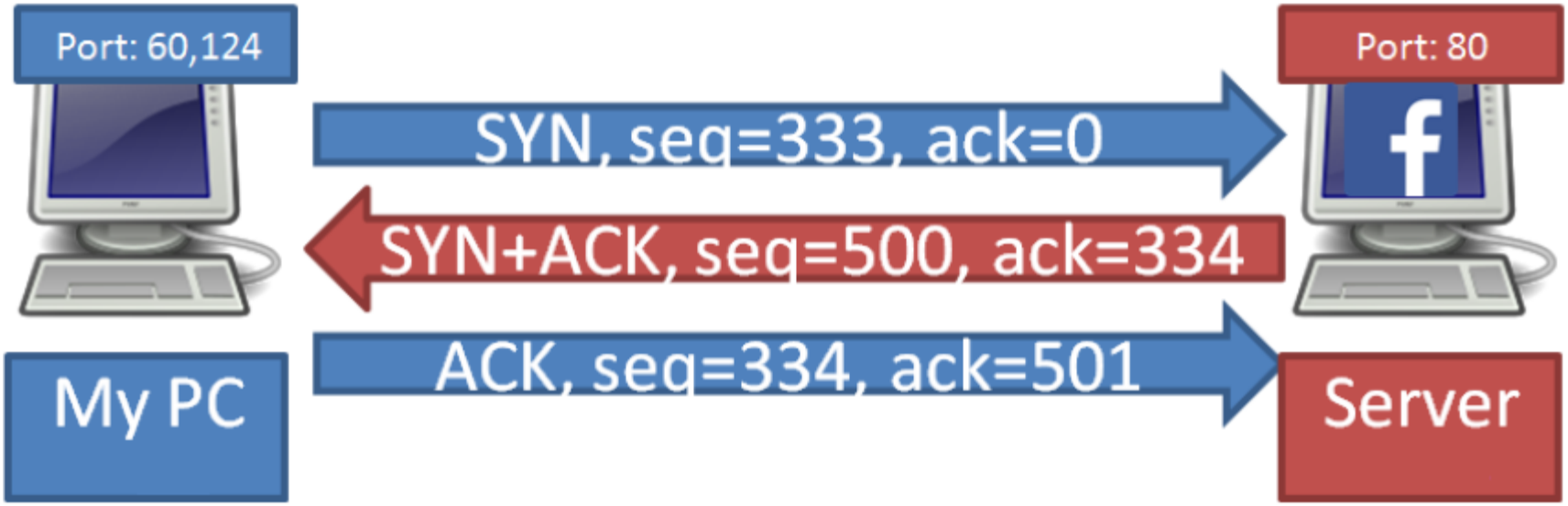
- Q27: Which transport protocol is used for web browsing?
  - TCP
- Q28: Which destination port is used?
  - 80 / 443
- Q29: Which source port is chosen?
  - Random

TCP 3 Way Handshake

- Q30: Complete the missing values. More than one option is possible.



TCP 3 Way Handshake – solution



Application Layer

- Q31: Which protocol is used?
  - HTTP / HTTPS
- Q32: What is the method of the first packet? (1st field)
  - GET
- Q33: What should normally be the response status code?
  - 200 OK

Destination Reached

- Make sure you can explain:
  - DHCP
  - ARP
  - IP
  - UDP
  - DNS
  - TCP
  - HTTP
  - Server
  - Client
  - Router
  - NAT
  - MAC
  - IP
  - Network mask
  - Port

Specific Terminology per Layer

Layer	Message type	Devices
5: Application	Message (מסר)	Host, servers
4: Transport (תעבורה)	Segment (bytes) (סגמנט)	Transport Gateway
3: Network (רשת)	Packet/datagram (bytes) (חבילה)	Router – נתב
2: Data link (קו)	Frame (מסגרת)	Switch / bridge – מתג
1: Physical (פיזית)	bits (סיביות)	Repeater – מגבר

One byte = 8 bit ---- 1 MBps = 8 Mbps

Summary

- ***Five Layer Model:***

1. *Application:* supporting network applications

   HTTP, IMAP, SMTP, DNS

2. *Transport:* process to process data transfer

   TCP, UDP

3. *Network:* routing of datagrams from source to destination

   IP, routing protocols

4. *Link:* data transfer between neighboring network elements

   Ethernet, 802.11 (WiFi), PPP

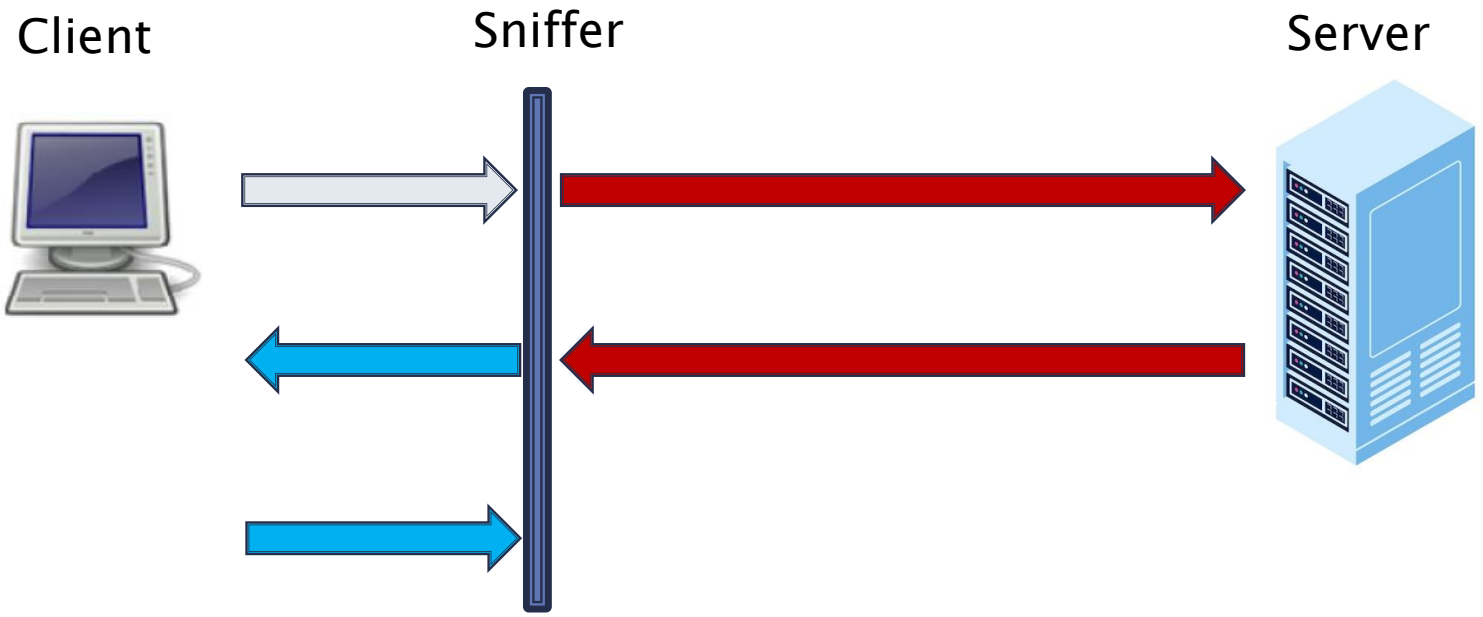
5. *Physical:* bits “on the wire”

- **Review of the protocols involved in a simple Web request**

Wireshark Lab

- In class – 1–4
- Homework – 5 +

#4



SYN time: 4.095223
SYN ACK: 4.144822 Delta = 0.05 Sec
ACK: 4.145175 Delta = 0.0003 Sec