Computer Networks Fundamentals

Basic Network Elements (Software)

TCP/IP Protocol Suite

Basic Network Elements (Software)

TCP/IP

- **Transmission Control Protocol/Internet Protocol.**
- TCP/IP is **open standard protocol**
  - Not tied to one vendor
- TCP/IP is the internet protocol
- Now internet use TCP/IP v4
- Next version TCP/IP v6
- It is the default protocol for all modern operating systems
  - Microsoft Operating Systems
  - UNIX Operating Systems
  - LINUX Operating Systems

Basic Network Elements (Software)

TCP/IP Advantages and Disadvantages

- Advantages
  - Standard
  - Direct access to the Internet
  - Routable
  - Cross Platform
- Disadvantages
  - Difficulty of setup
  - Slower than other protocols like IPX/SPX & NetBEUI

Basic Network Elements (Software)

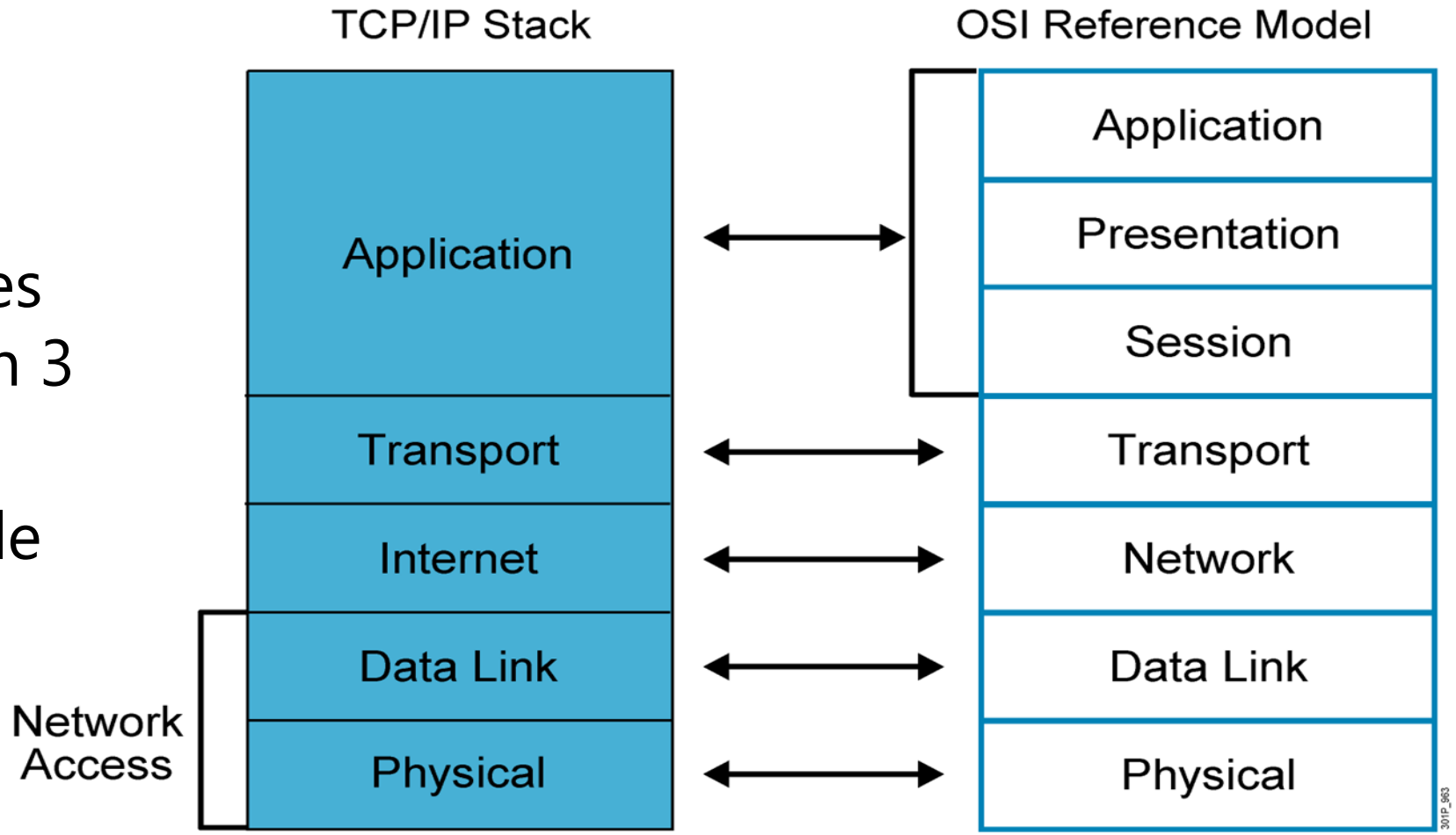
Major Networking Protocols

- TCP/IP _ free / standard
- IPX/SPX _ by Novel/ not free/not standard
- NetBEUI – not routable
- Apple Talk
- Data Link Control (DLC)

Basic Network Elements (Software)

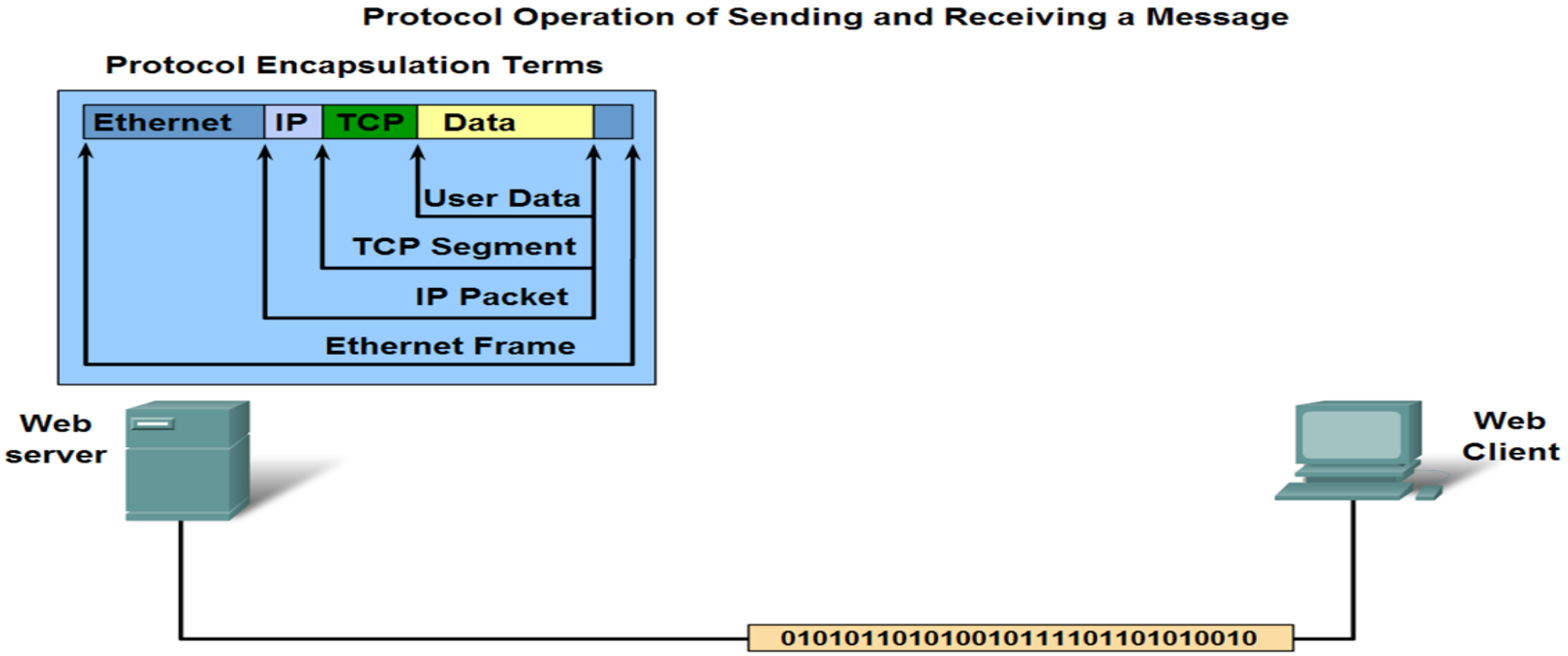
TCP/IP VS. OSI Model

- Defines four layers
- Uses different names for Layers 1 through 3
- Combines Layers 5 through 7 into single application layer



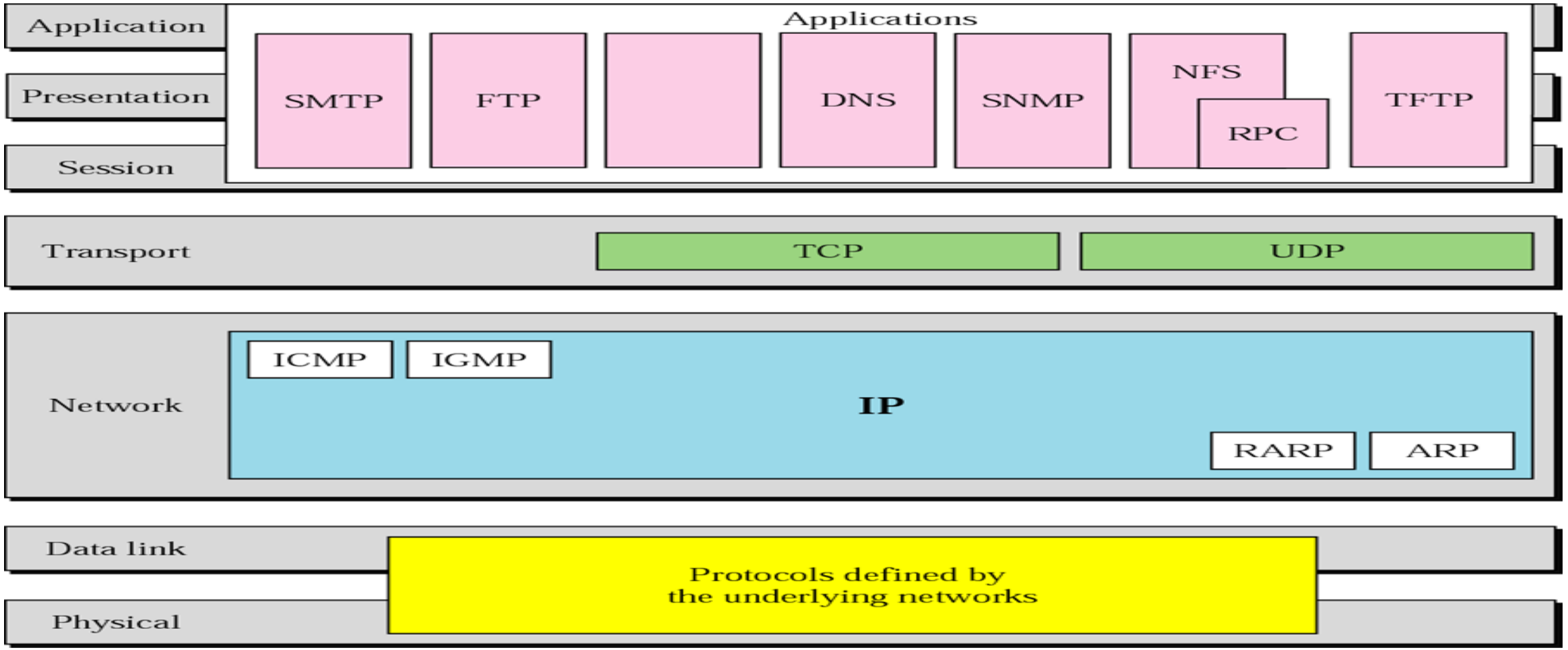
Basic Network Elements (Software)

Data Encapsulation



Basic Network Elements (Software)

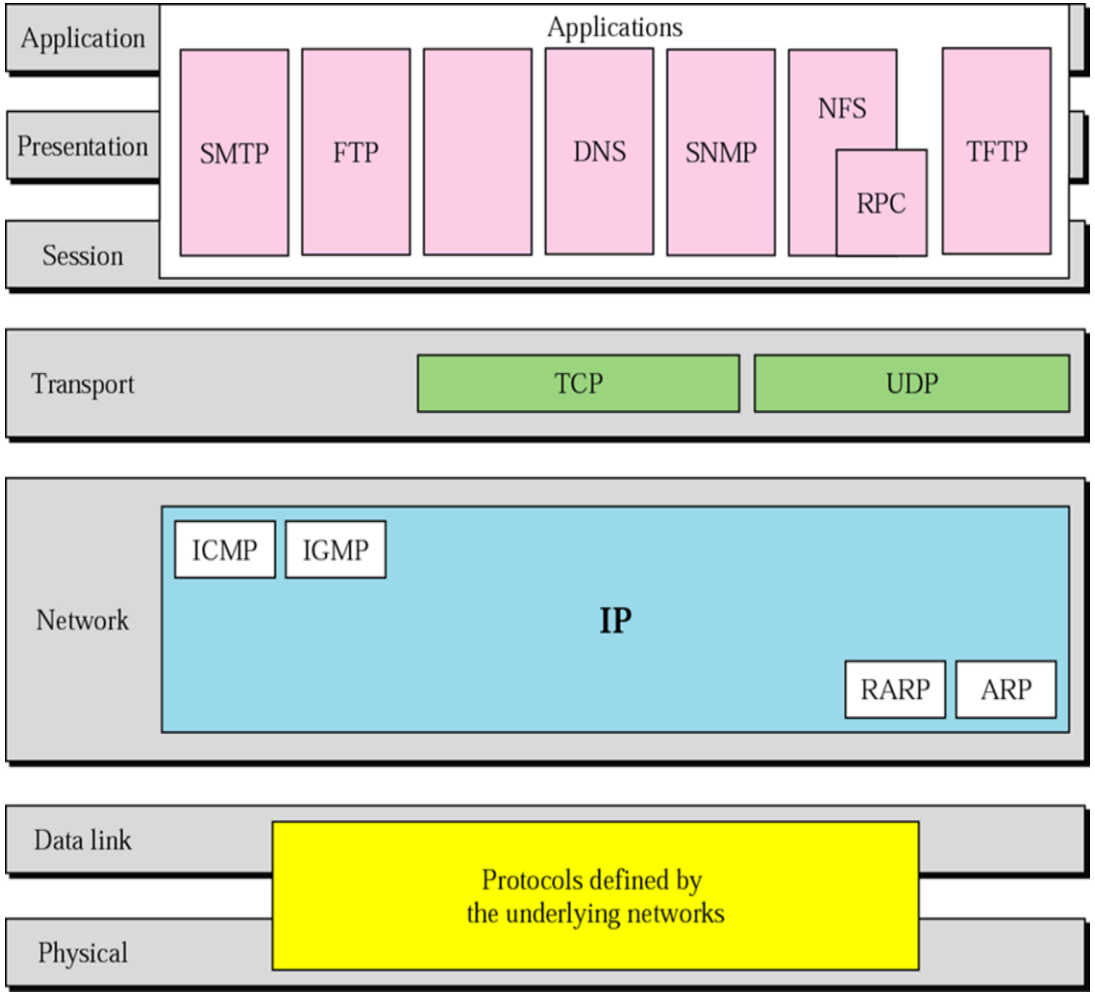
Some Protocols in TCP/IP Suite



Basic Network Elements (Software)

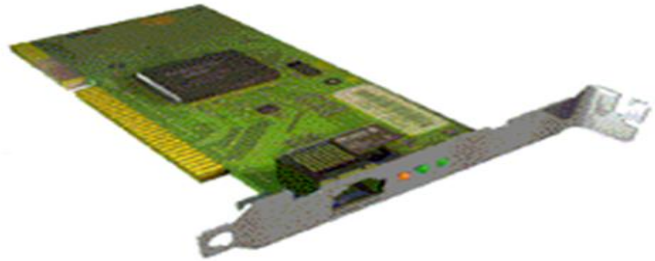
TCP/IP Protocol Architecture

- Network Access Layer
  - **Physical Layer**
    - Transmission medium
    - Signal rate
  - **Datalink Layer**
    - Logical interface between end system and network
    - Hop to Hop addressing
    - Error detection Mechanism

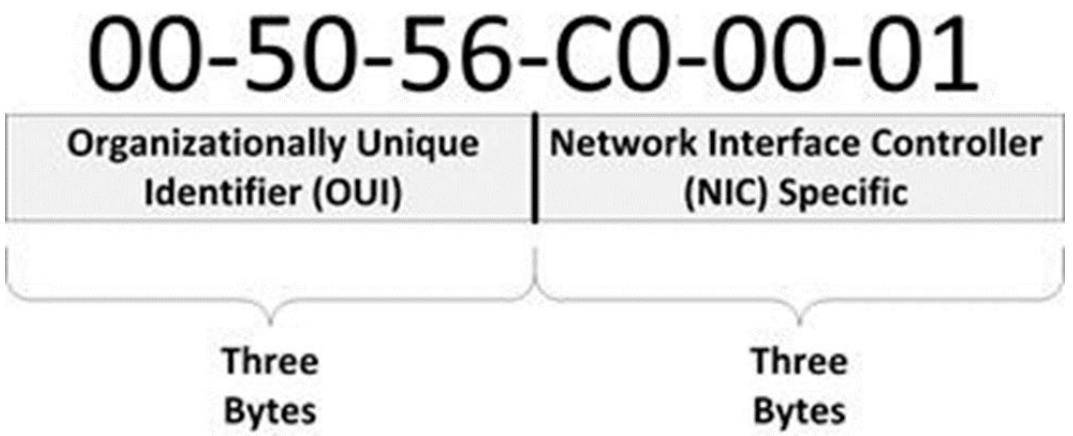


Basic Network Elements (Software)

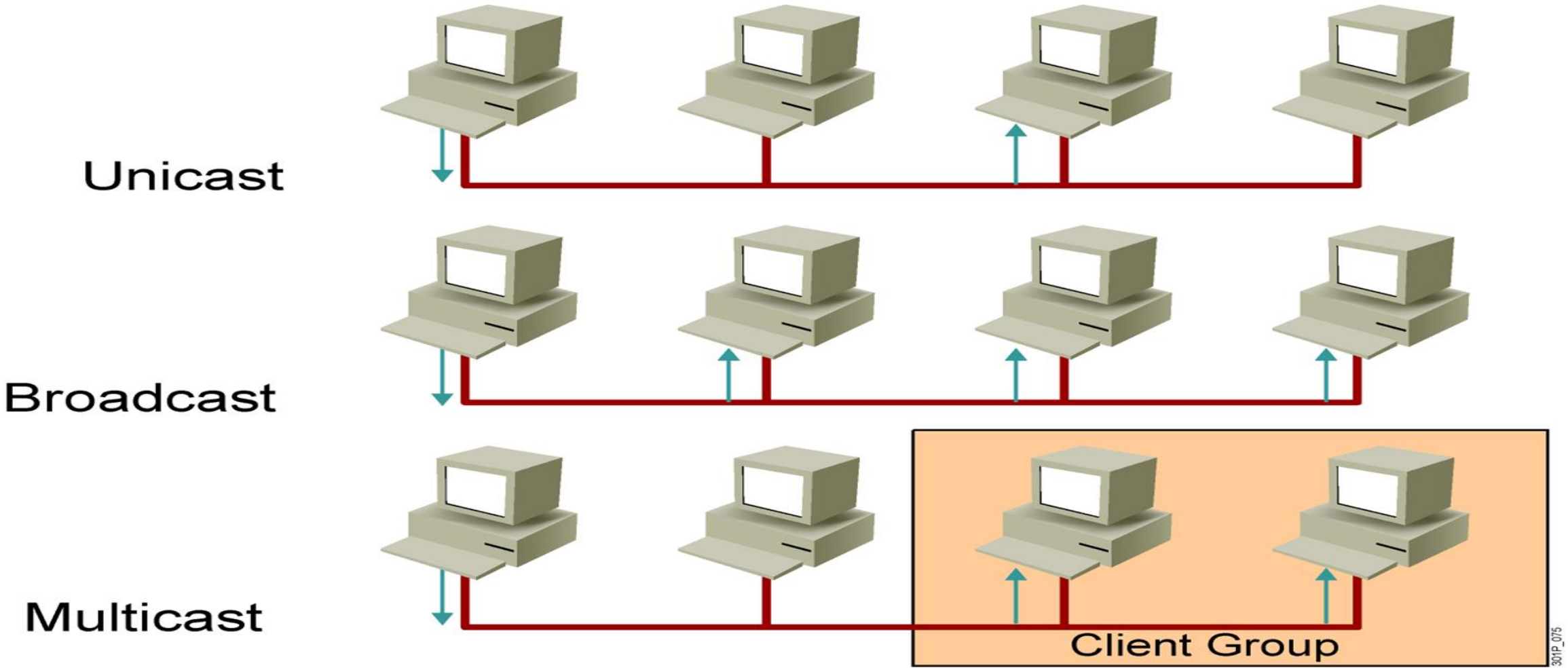
Physical (Mac) Addresses



- **Physical Address** burned on the card
- **Unique** address over the world
- called Mac address.
- **48-bit** (6-byte) written as **12 hexadecimal** digits; every byte (2 hexadecimal digits) is separated by a colon **:**
- Physical addresses can be either
  - **unicast**
  - **multicast**
  - **broadcast**



Communicating Within the LAN



Basic Network Elements (Software)- LAB

Physical Addresses

- To check your physical address: -
  - **Ipconfig /all**
  - **GetMac**

Example Physical Address
07:01:02:01:2C:4B

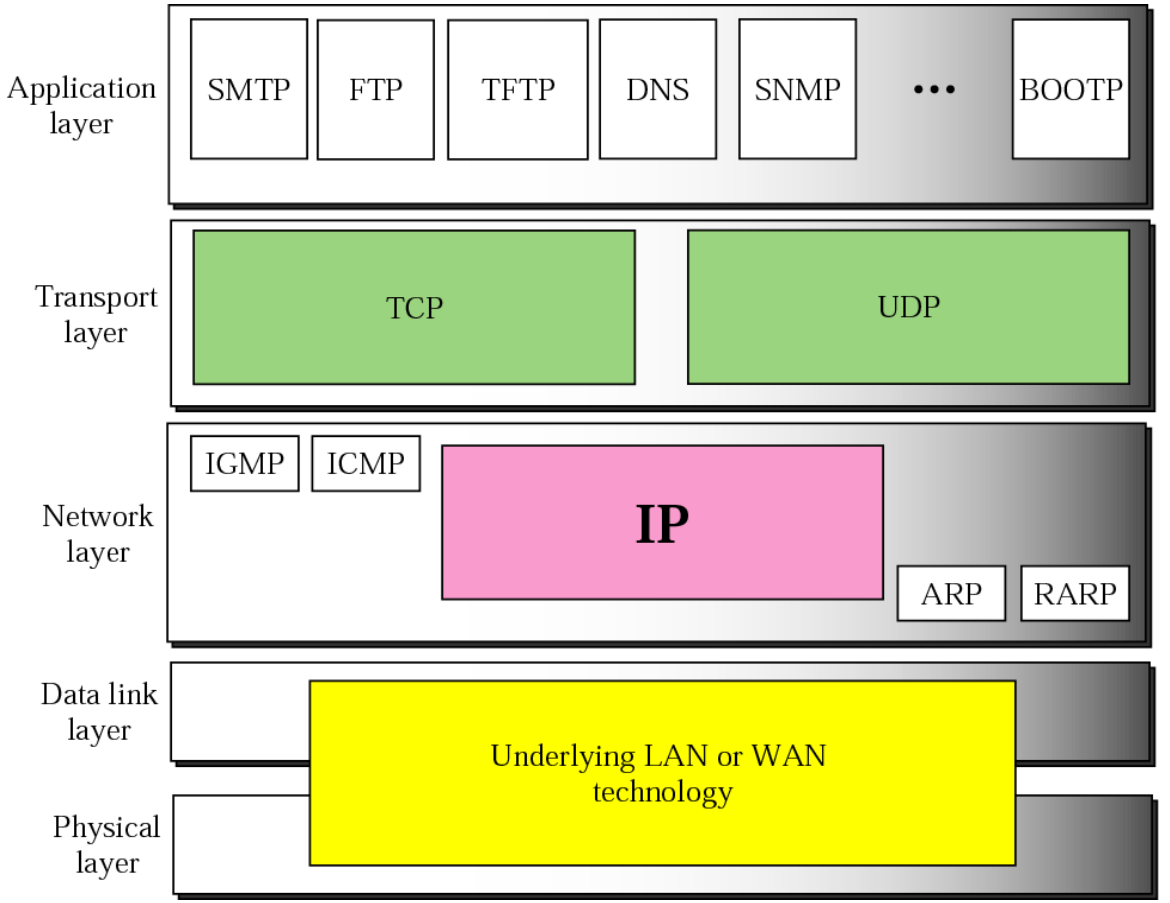
```
   Connection-specific DNS Suffix  . :
   Description . . . . . . . . . . . : Qualcomm QCA61x4A 802.11ac Wireless Adapter
   Physical Address. . . . . . . . . : 74-40-BB-80-37-3D
   DHCP Enabled. . . . . . . . . . . : Yes
   Autoconfiguration Enabled . . . . : Yes
   IPv6 Address. . . . . . . . . . . : fd9c:c172:b05a:8700:bc38:bbc1:e959:4f54(Preferred)
   Temporary IPv6 Address. . . . . . : fd9c:c172:b05a:8700:e597:12c5:be0:3a7c(Preferred)
   Link-local IPv6 Address . . . . . : fe80::bc38:bbc1:e959:4f54%18(Preferred)
   IPv4 Address. . . . . . . . . . . : 192.168.1.2(Preferred)
   Subnet Mask . . . . . . . . . . . : 255.255.255.0
   Lease Obtained. . . . . . . . . . : Saturday, September 28, 2019 9:12:55 AM
   Lease Expires . . . . . . . . . . : Sunday, September 29, 2019 9:12:53 PM
   Default Gateway . . . . . . . . . : 192.168.1.1
   DHCP Server . . . . . . . . . . . : 192.168.1.1
   DHCPv6 IAID . . . . . . . . . . . : 108282043
   DHCPv6 Client DUID. . . . . . . . : 00-01-00-01-22-DA-1F-5D-54-BF-64-2B-09-81
   DNS Servers . . . . . . . . . . . : 192.168.1.1
                                       192.168.1.1
   NetBIOS over Tcpip. . . . . . . . : Enabled

Tunnel adapter Teredo Tunneling Pseudo-Interface:
```

```
C:\Users\ITD-mabdsalam>getmac

Physical Address    Transport Name
=================== ============================================================
74-40-BB-80-37-3D   \Device\Tcpip_{AF590558-C7CC-40B4-95A4-9F4476D1DDEC}
54-BF-64-2B-09-81   Media disconnected
N/A                 Hardware not present
00-50-56-C0-00-01   \Device\Tcpip_{D37FF6B5-F7BA-498B-979F-AE0B4A6B42E1}
00-50-56-C0-00-08   \Device\Tcpip_{AA96FF0D-8253-4B8C-9233-DD61B6501B22}

C:\Users\ITD-mabdsalam>
```

Basic Network Elements (Software)

Internet Layer (IP Layer)

- **Network layer protocol**
- Packet in the IP layer is called **Datagram**
- Datagram consist of TWO parts
  - Header
  - Data
- Routing of data
- Logical addressing IPV4 , IPV6



Basic Network Elements (Software)

Internet Protocol (IP V4)

- Uniquely identify each device on an IP network layer.
- Some times we called it the **logical address**
- Every host (computer, networking device, peripheral) must have a **unique address** at the same network
- The IP address **32 bit** divided into **4 octets** each octet 8 bit

Basic Network Elements (Software)

IP Address Format: Dotted Decimal Notation

32 Bits

	Example			
An IP address is a 32-bit binary number	10101100	00010000	10000000	00010001
For readability, the 32-bit binary number can be divided into four 8-bit octets	10101100	00010000	10000000	00010001
Each octet (or byte) can be converted to decimal	172	16	128	17
The address can be written in dotted decimal notation	172.	16.	128.	17

301P_311

1 octet = 8 bit each represents from 0 to 255 separated with dots

- **The address space of IPv4 is 2^{32} or 4,294,967,296**

Basic Network Elements (Software)

IP ADDRESS RANGES

IP Address Class	First Octet Binary Value	First Octet Decimal Value	Possible Number of Hosts
Class A	1-126	00000001 to 01111110*	16,777,214
Class B	128-191	10000000 to 10111111	65,534
Class C	192-223	11000000 to 11011111	254

IP Address Classes: The First Octet

A B C ... Easy as 1 2 3

Class A ... First 1 bit fixed — 0 x x x x x x x . Host . Host . Host

Class B ... First 2 bits fixed — 1 0 x x x x x x . Network . Host . Host

Class C ... First 3 bits fixed — 1 1 0 x x x x x . Network . Network . Host

Class D	1110	Multicast address
Class E	1111	Reserved for future use

Class D 224.0.0.0 Multicast Address — 239.255.255.255 Multicast Address

Class E 240.0.0.0 Reserved — 255.255.255.255 Reserved

Basic Network Elements (Software)

PUBLIC IP ADDRESSES (REAL IP)

Class	Public IP Ranges
A	1.0.0.0 to 9.255.255.255 11.0.0.0 to 126.255.255.255
B	128.0.0.0 to 172.15.255.255 172.32.0.0 to 191.255.255.255
C	192.0.0.0 to 192.167.255.255 192.169.0.0 to 223.255.255.255

327P_104

Private IP Addresses (Local IP)

Class	Private Address Range
A	10.0.0.0 to 10.255.255.255
B	172.16.0.0 to 172.31.255.255
C	192.168.0.0 to 192.168.255

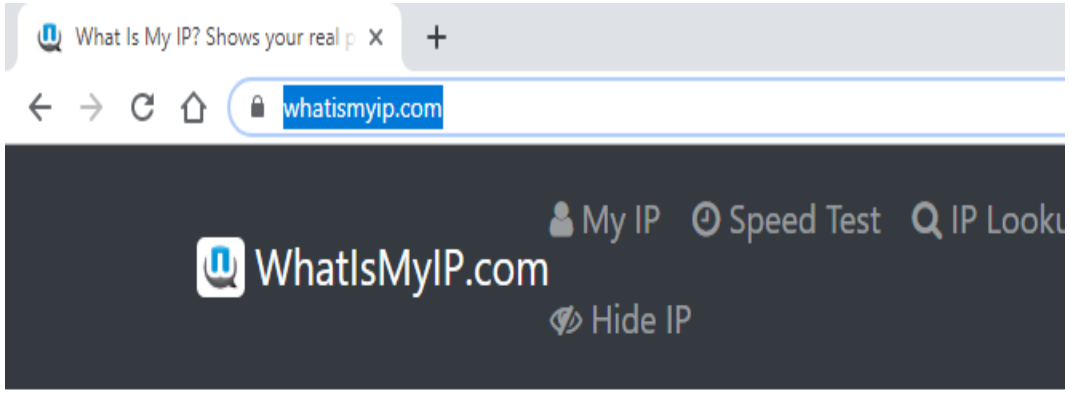
- **Nat** is used to Translate the private IP address to public IP addresses.

Basic Network Elements (Software) - LAB

- To know your real IP addresses
https://www.whatismyip.com/

-To get bulk of the Public IP address you get it from your service provider

- With the grow the of the pubic IP address we used NAT and IPV6



Your Public IPv4 is: 41.236.145.96

Your IPv6 is: Not Detected

Location: Al Jizah, GZ EG

ISP: TE Data

Basic Network Elements (Software) - LAB

❖ Ipconfig

Ipconfig is a command line utility in Microsoft Windows.

ipconfig allows you to get the IP address information of a Windows computer

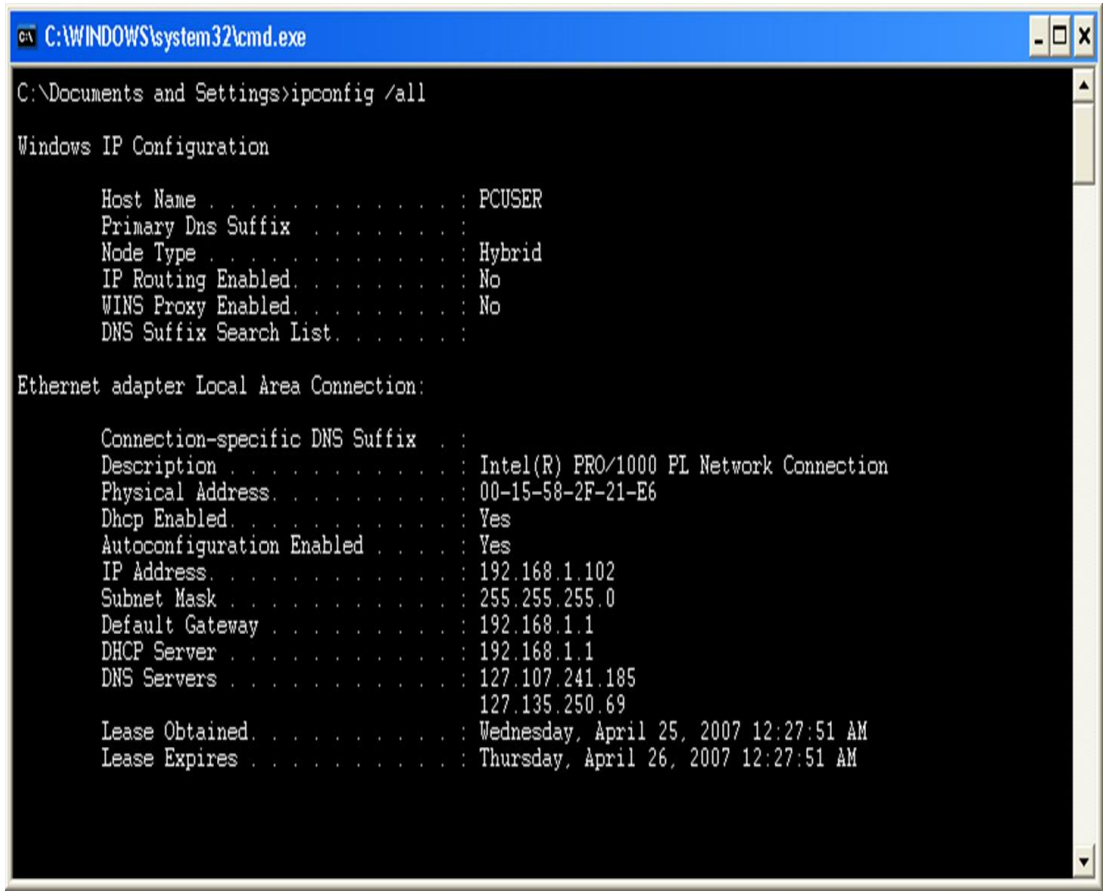
MAC Address

IP address

Default gateway

Subnet mask

DNS server



❖ To know your Private IP addresses

- Ipconfig
- Ipconfig /all
- Ipconfig /release
- Ipconfig /renew

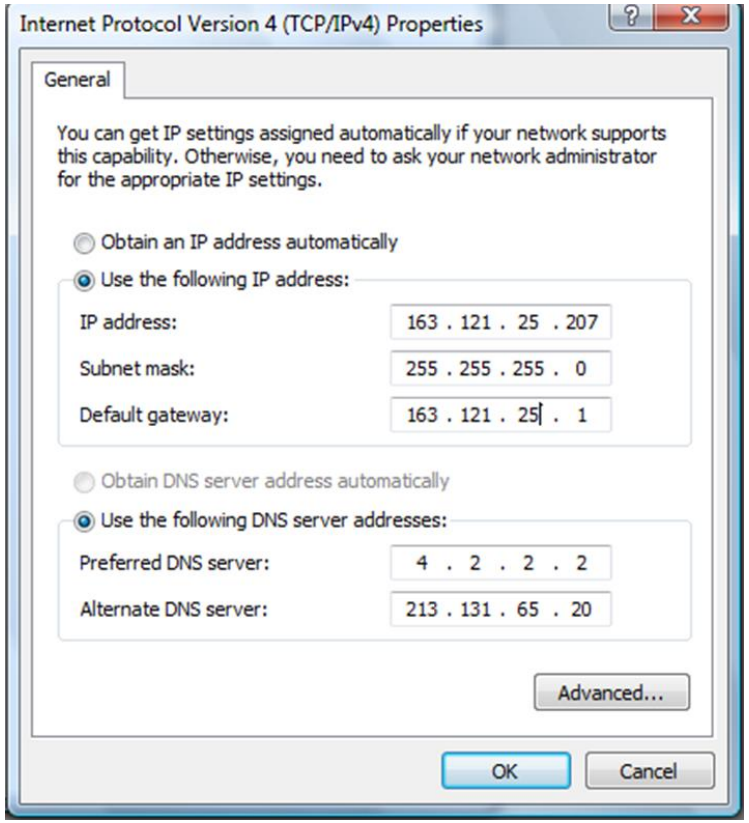
Basic Network Elements (Software) - LAB

❖ How to assign IP address to device

- Manually
- Automatic
- APIPA

- Manually

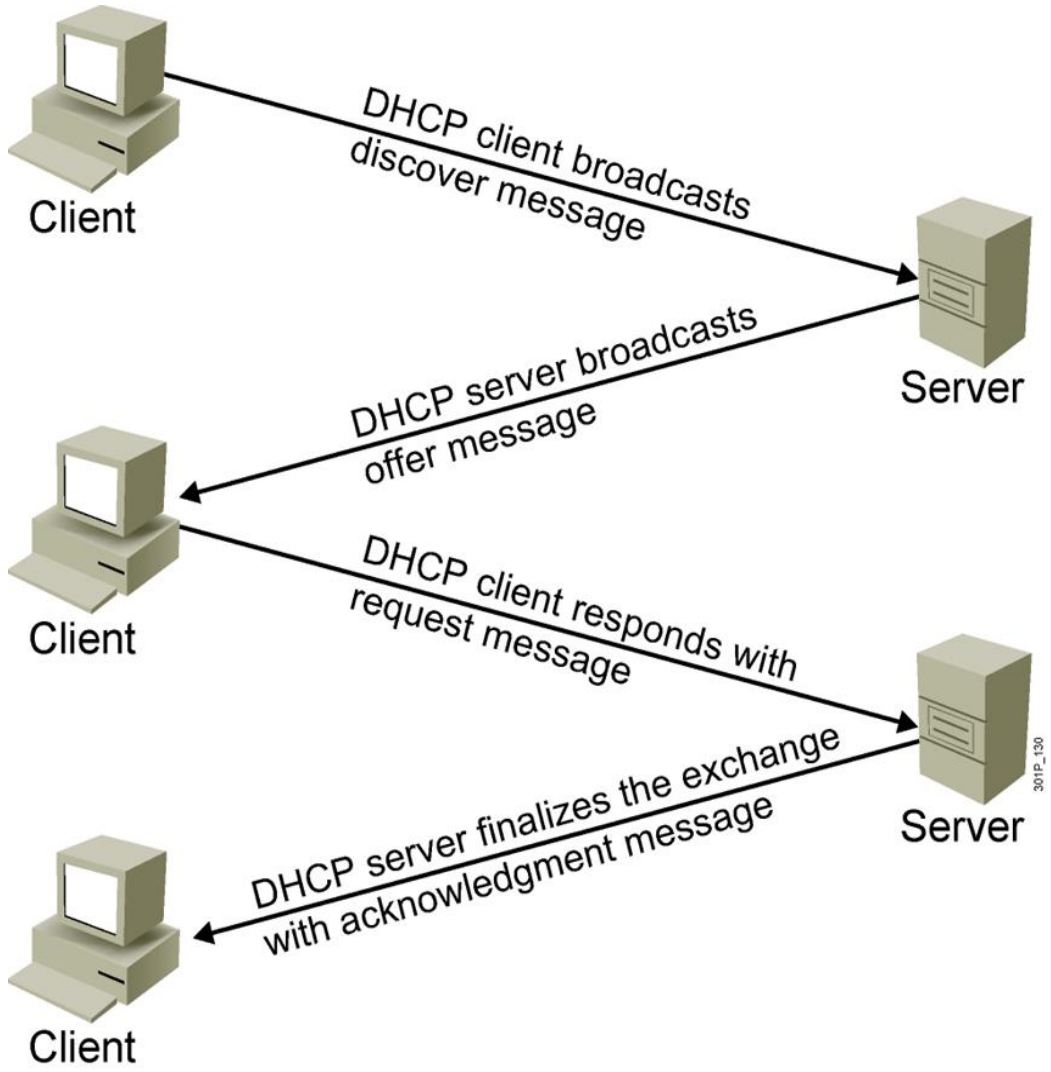
- Set IP address
- Set Subnet mask
- Set IP default-Gateway
- Set DNS server



Basic Network Elements (Software) - LAB

❖ Assign IP address Automatic

- DHCP Server
- used to assign dynamically the IP Configuration including (Host IP, Subnet mask, Default Gateway, DNS server IP and the Lease Time)
- **Dora** (discover –offer-request-acknowledgment)



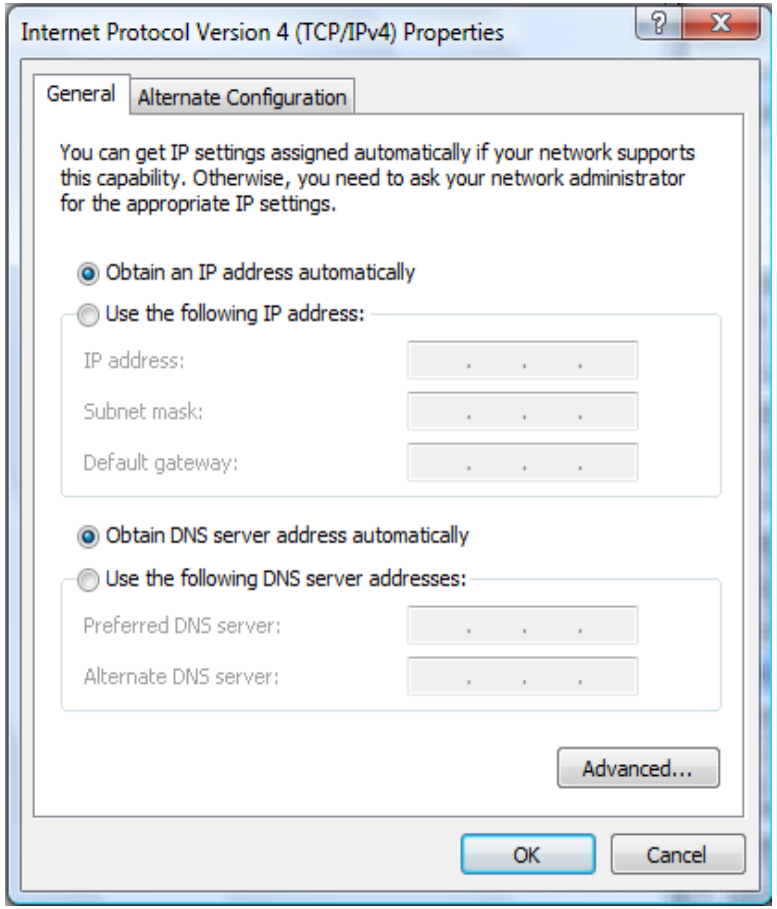
Basic Network Elements (Software) - LAB

❖ Assign IP address Automatic

- APIPA (***A**utomatic **P**rivate **IP** **A**ddress)*

- If **no DHCP server** is available the APIPA is used
- Auto configuration IP address
- used to let LAN users talk to Each other if the DHCP fails
- Can **not** be Routed
- **Rang : 169.254.0.0 To 169.254.255.255**

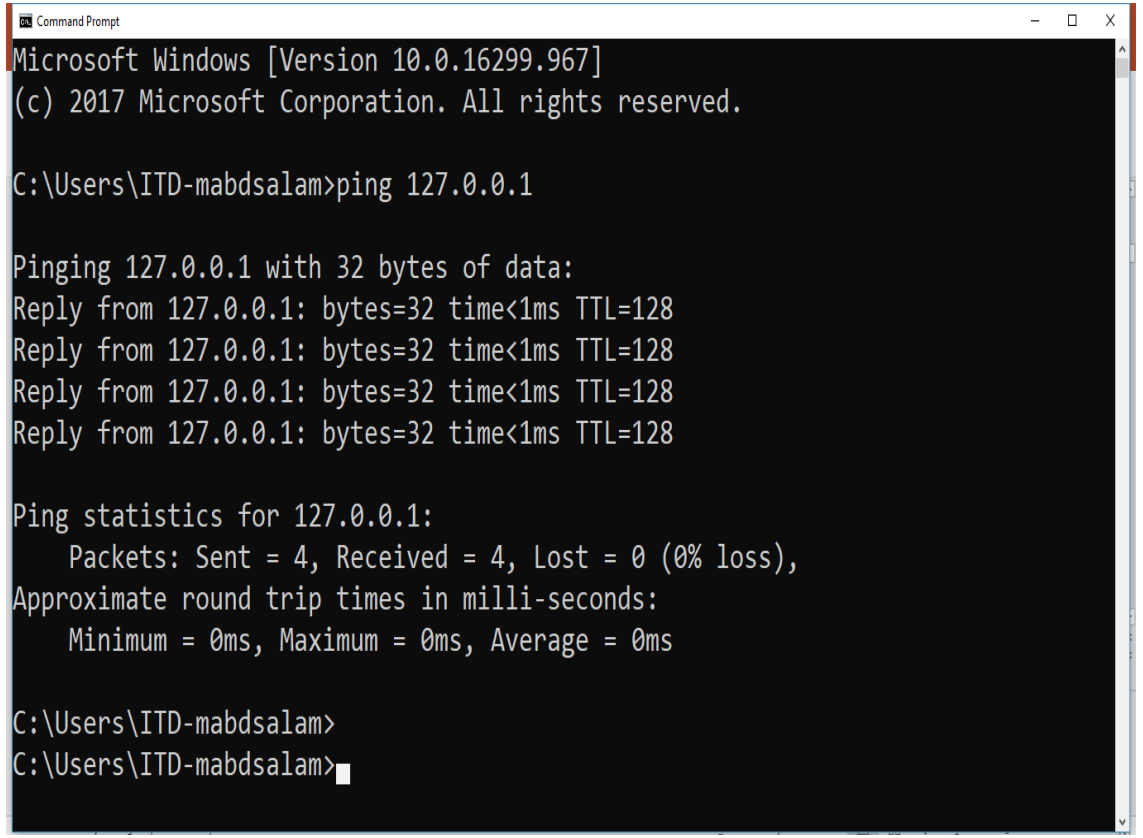
- APIPA



Basic Network Elements (Software) - LAB

❖ ICMP → Ping

- Ping is a command line utility in Microsoft Windows.
- Ping allows you to check connectivity with other devices
- Ping is a tool of DOS attack



❖ **Tray in your lab**

- Ping IP
- Ping URL
- Ping IP -l
- Ping IP -n
- Ping IP -t

Basic Network Elements (Software)

RESERVED ADDRESS

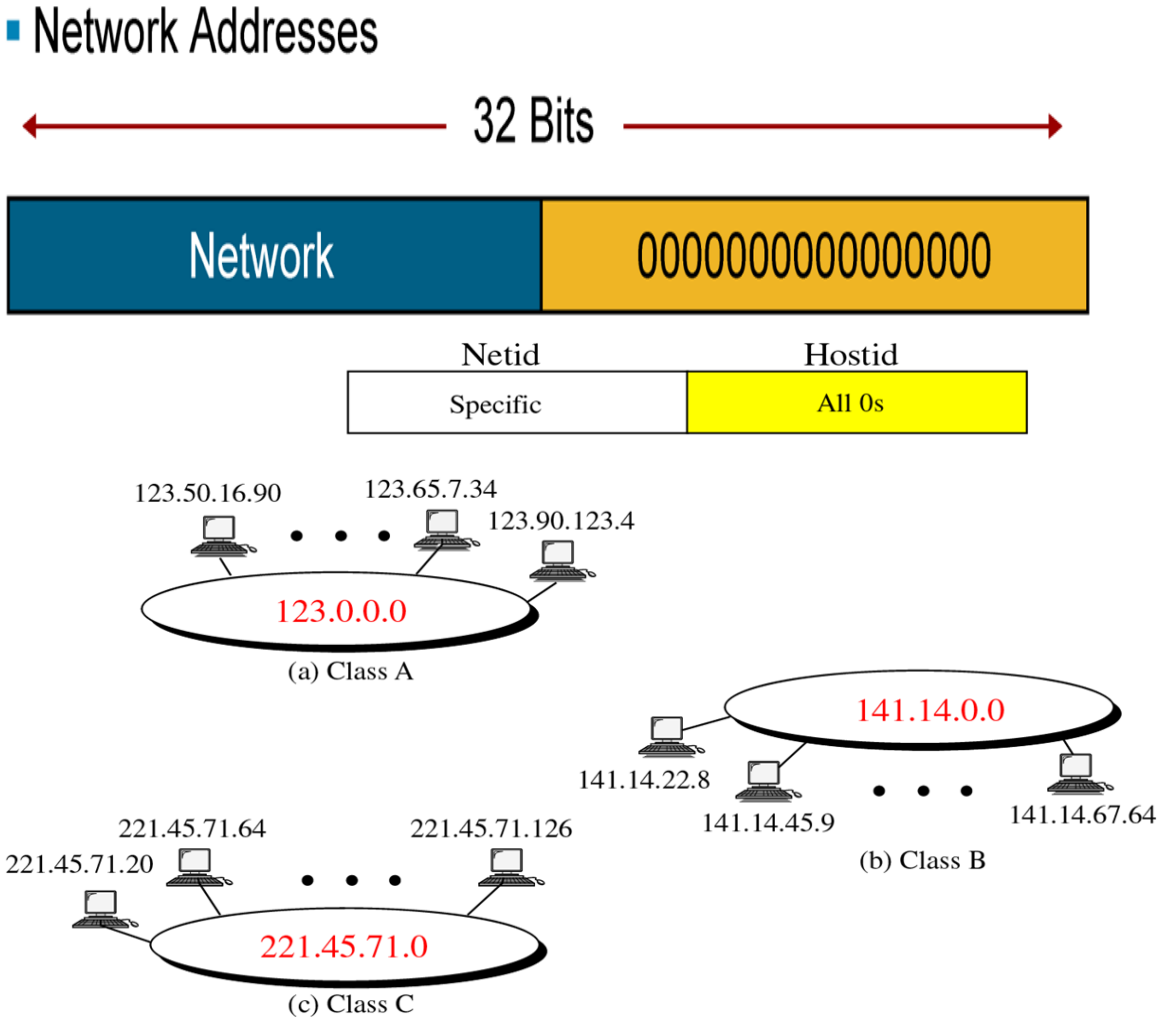
❖ **Network address:**

- reserved
- can not be assigned to any device
- used for routing by the router

Class A:10.0.0.0

Class B: 172.16.0.0

Class C:192. 168.1.0

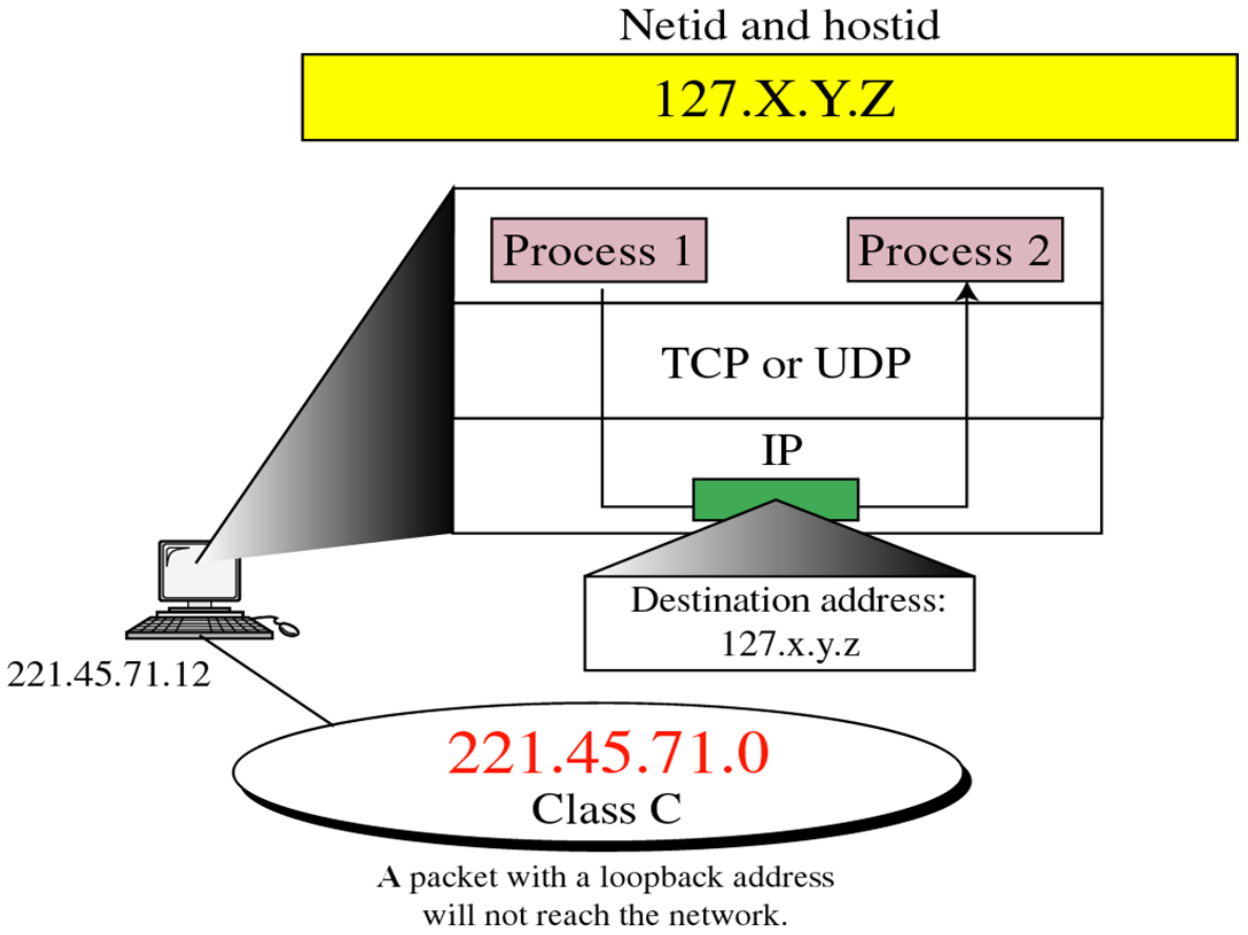


Basic Network Elements (Software)

RESERVED ADDRESS

Loop back Address

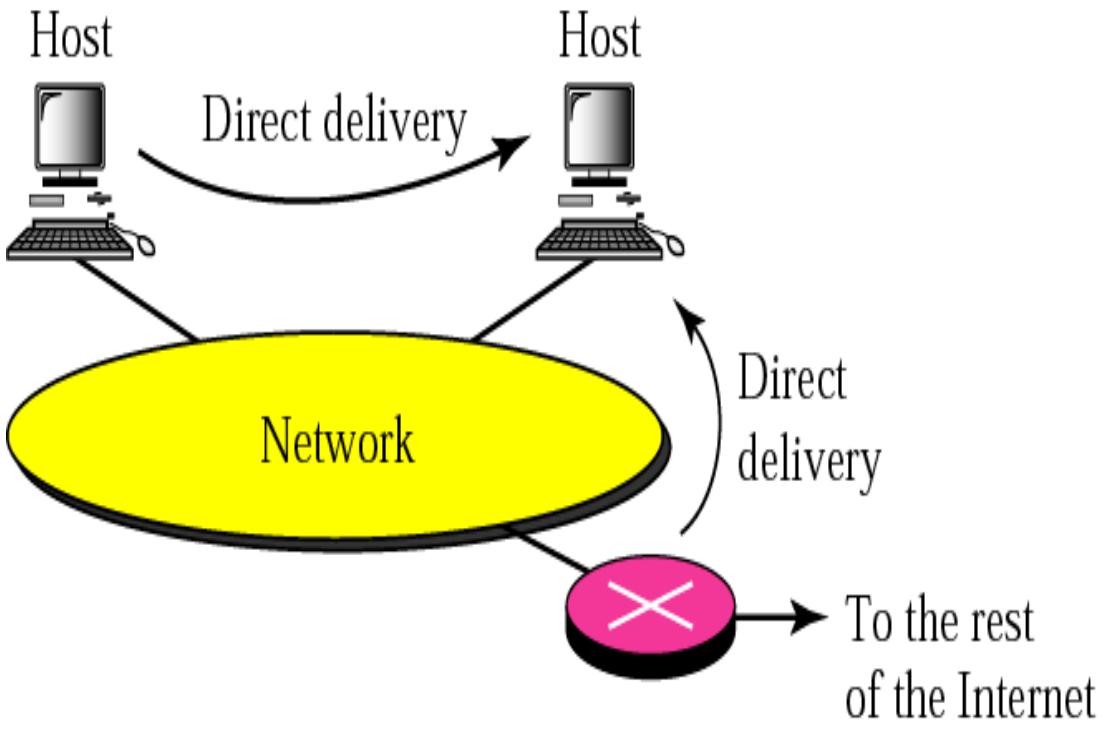
- Loopback address: It is used just for testing
-the TCP/IP Protocol Suit
127.0.0.1 example test NIC



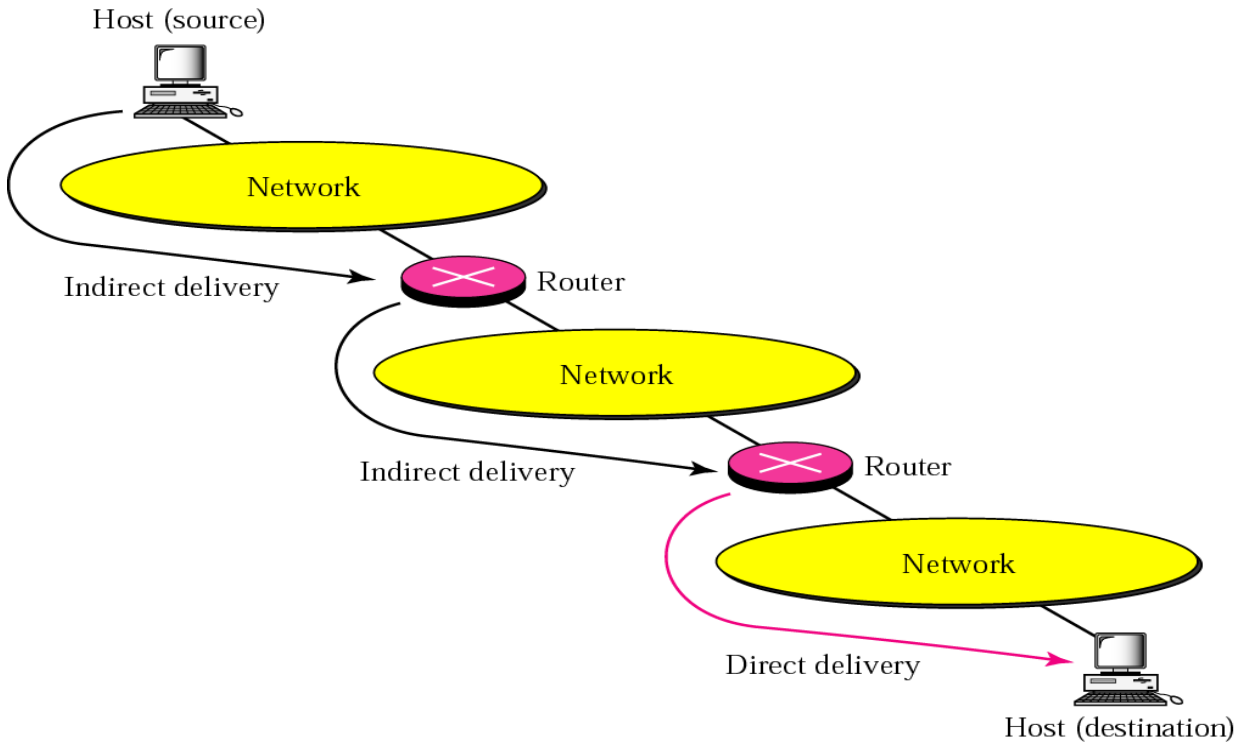
A packet with a loopback address will not reach the network.

DELIVERY OF IP PACKETS

Direct delivery

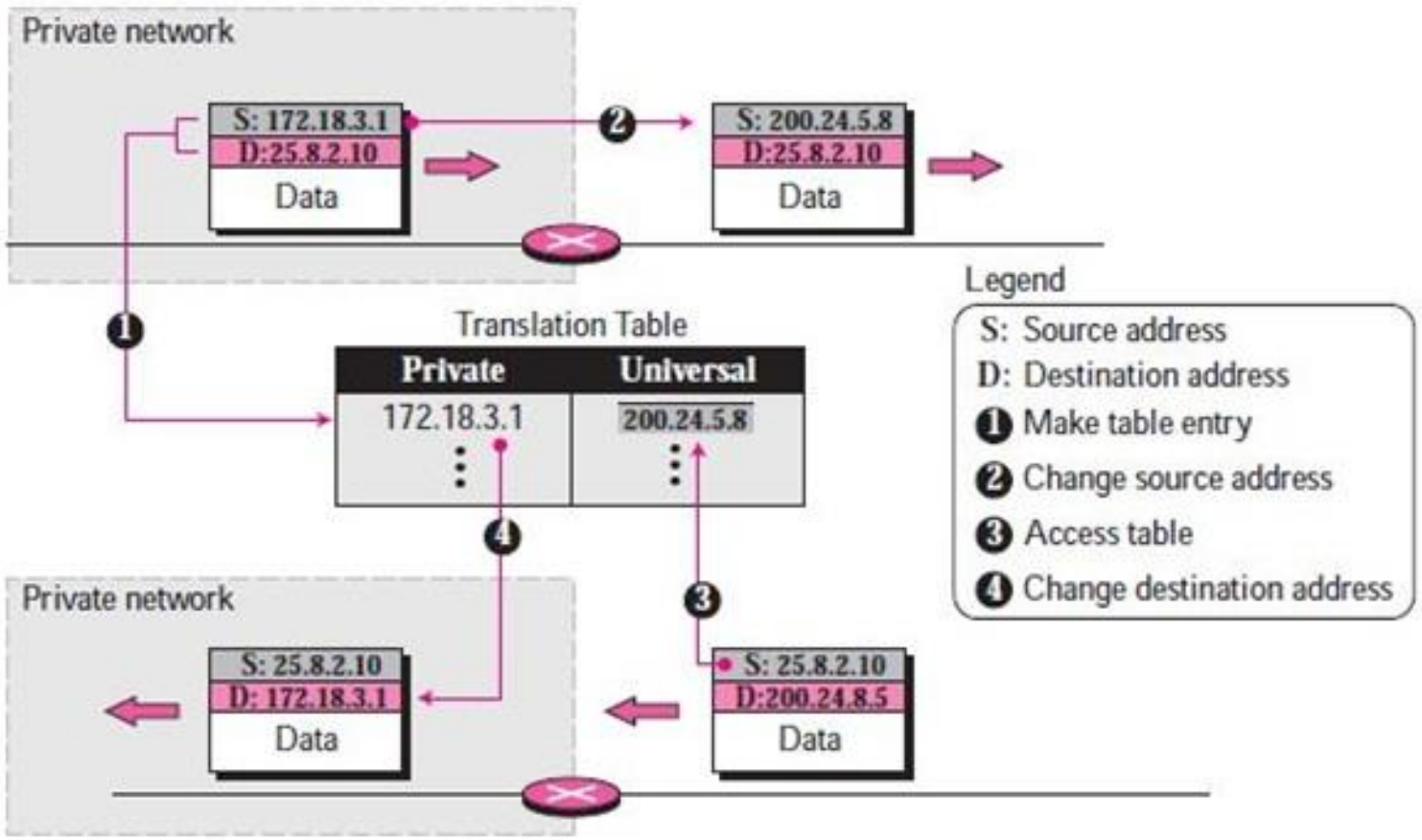


Indirect delivery



Network Address Translation(NAT)

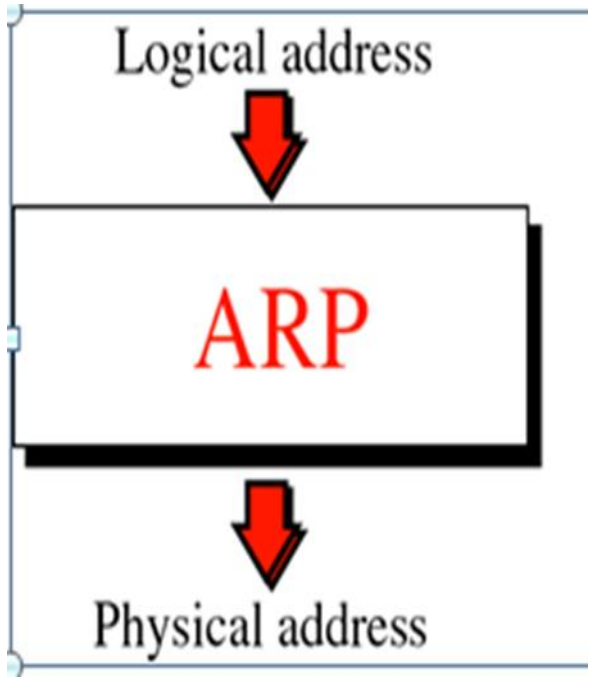
The technology allows a site to use a set of private addresses for internal communication and a set of global Internet addresses (at least one) for communication with the rest of the world



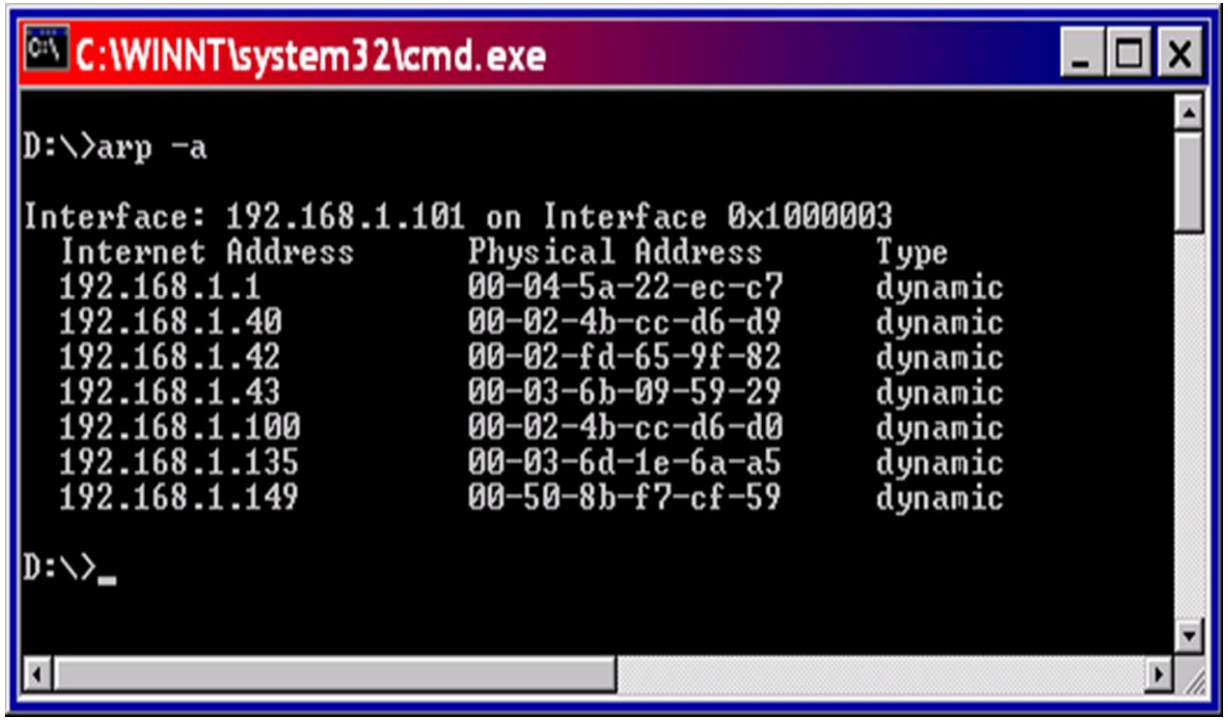
Basic Network Elements (Software) - LAB

❖ **ARP** (ADDRESS RESOLUTION PROTOCOL)

Arp -a

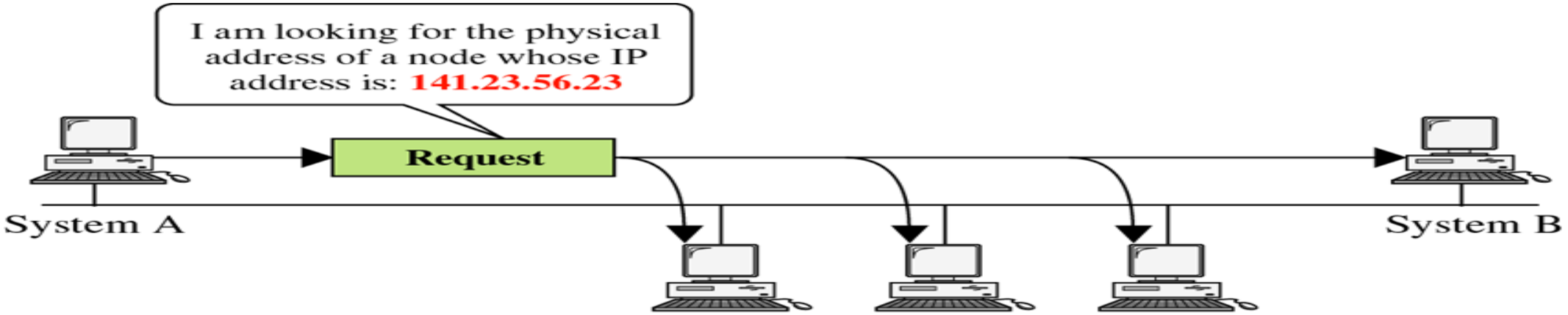


ARP TABLE

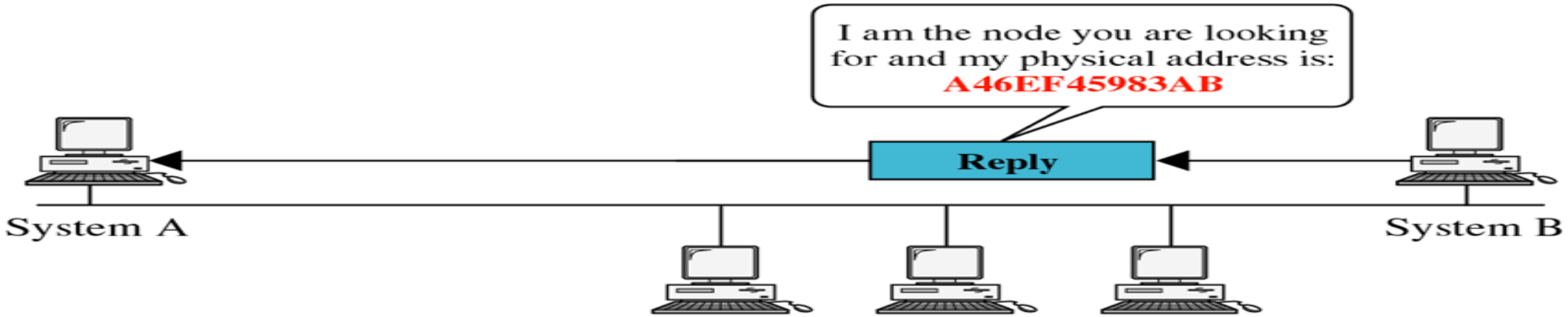


Basic Network Elements (Software)

❖ ARP OPERATION



a. ARP request is broadcast



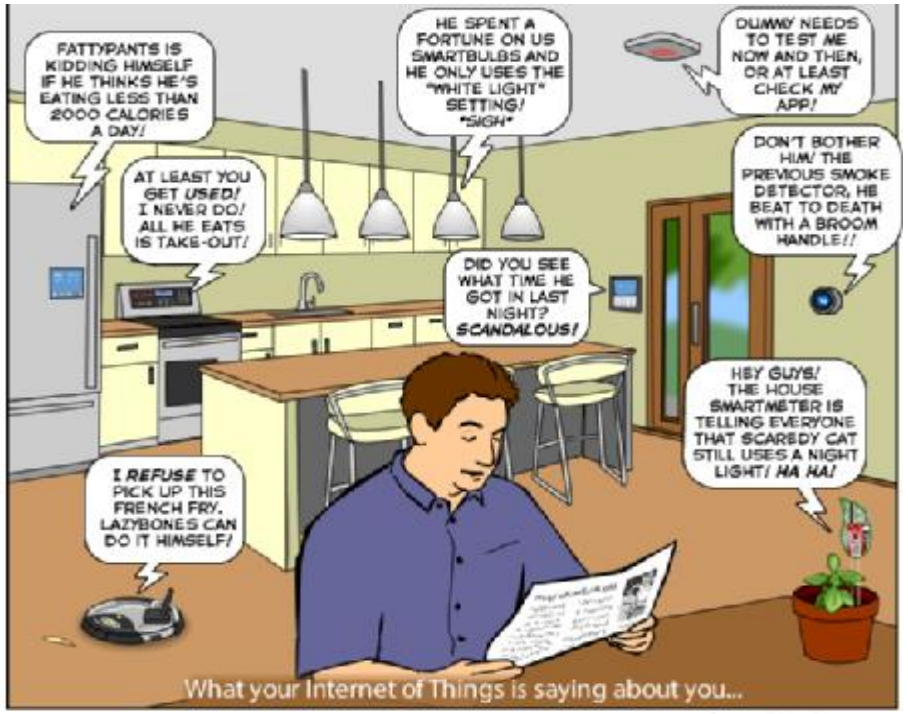
b. ARP reply is unicast

Basic Network Elements (Software)

Internet Of Things (IOT)

- Rapidly growing technology
- Aims connect all devices to the existing Internet infrastructure.
- "things" that sense and collect data and send it to the internet.
- (Eg:- coffee maker, A.C, Washing Machine, Ceiling Fan, lights , any thing) having sensors can be connected with internet.
- PRACTICAL APPLICATIONS:-

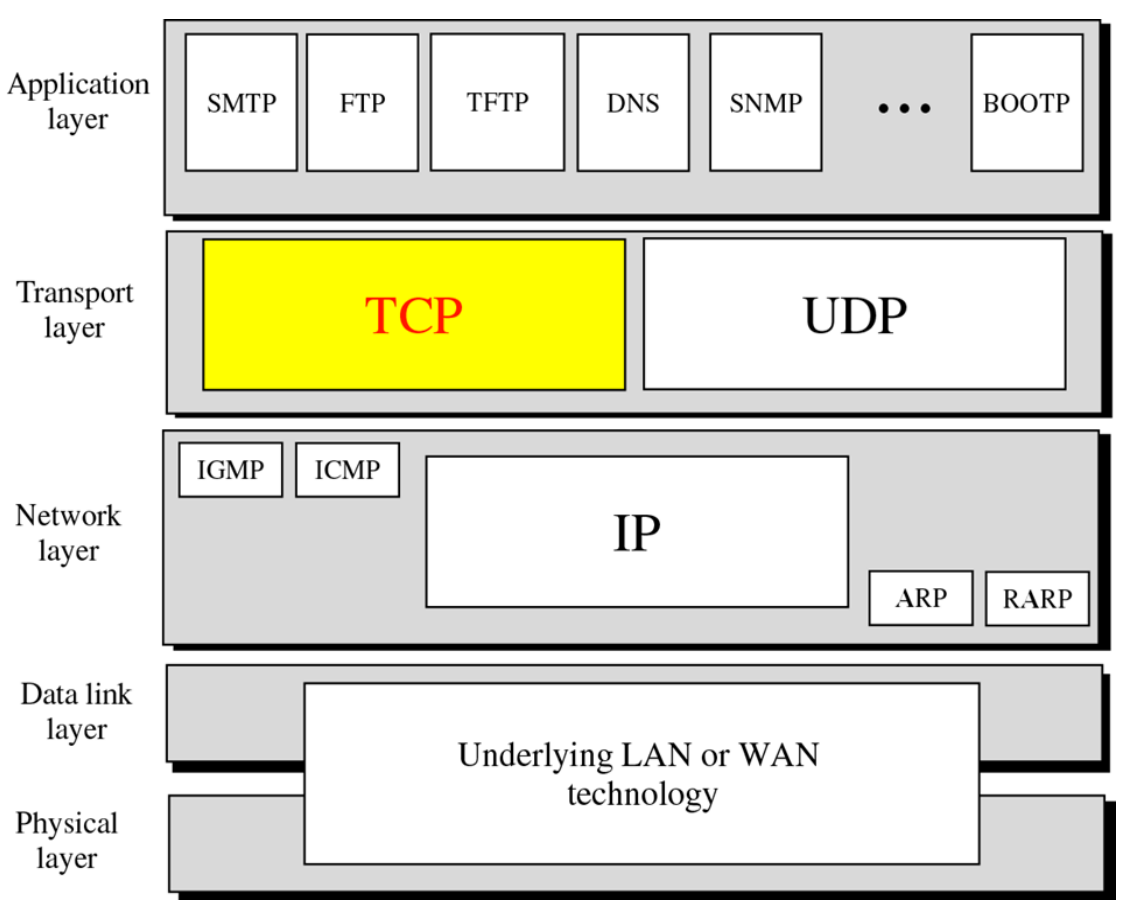
Smart Homes -Smart Cities-Energy - Environment monitoring- healthcare- Management

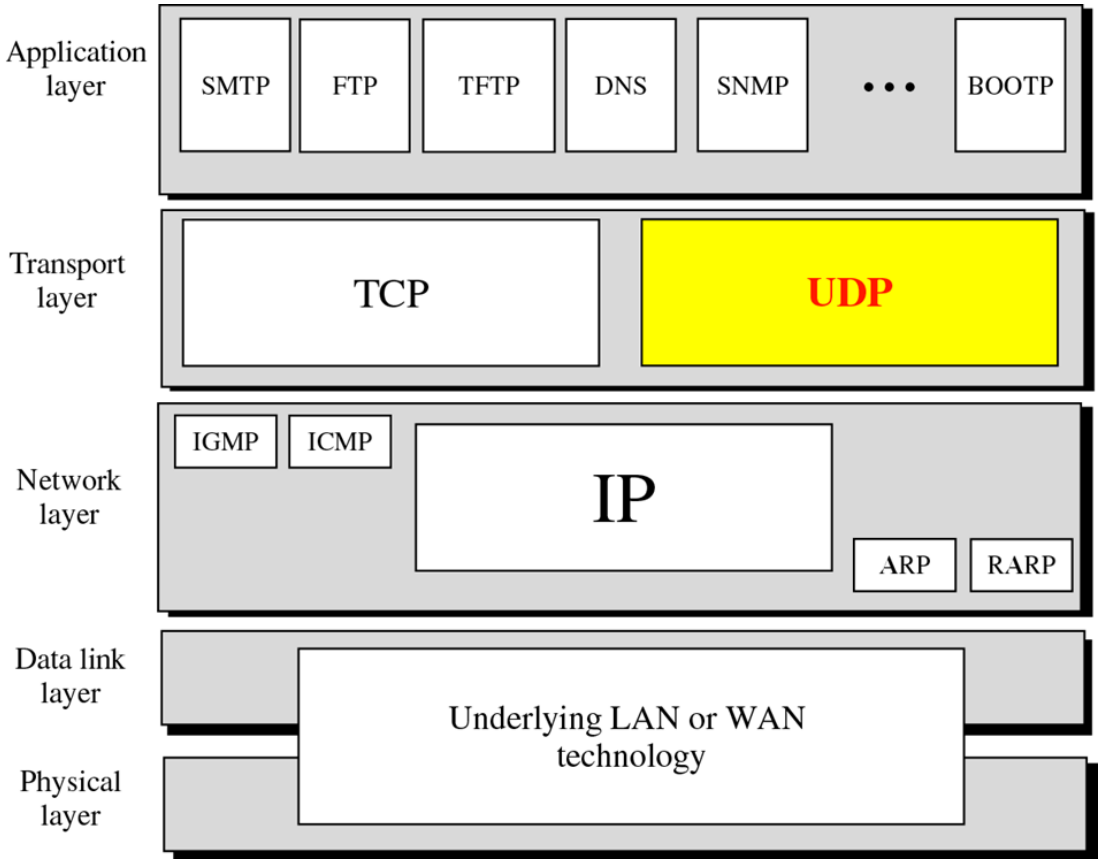


Kuva 1. Internet of Things. Lähde: Huffington Post

Basic Network Elements (Software)

TCP/IP Protocol Architecture





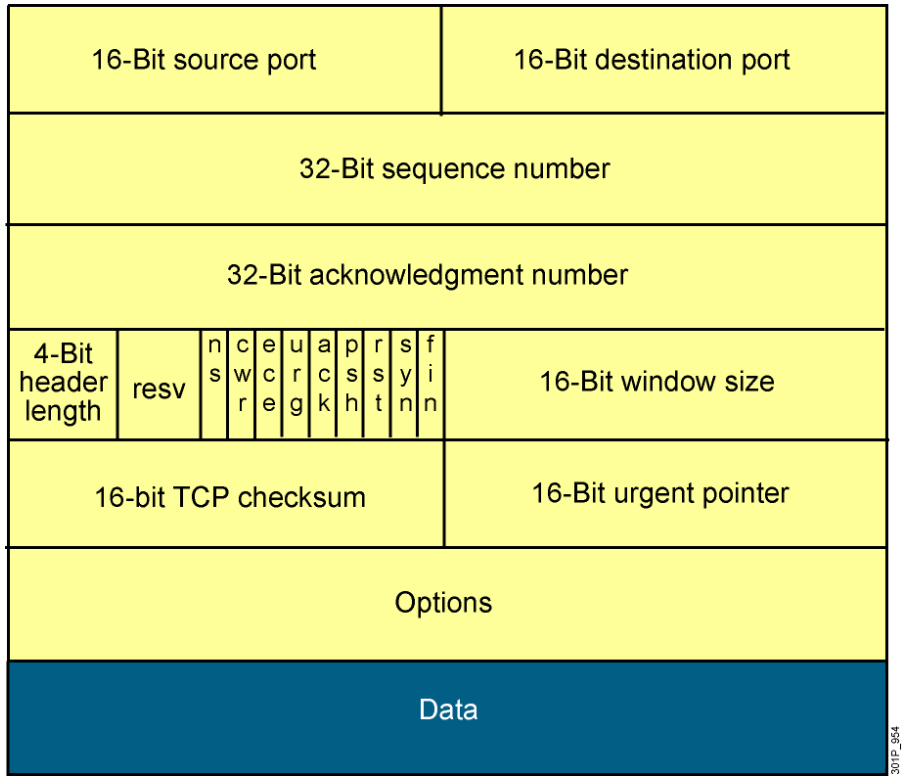
Basic Network Elements (Software)

TCP Characteristics

- Transmission Control Protocol
- Transport layer protocol
- Use port numbers
- Reliable (Acknowledgement of receipt)
- **Connection oriented(**synchronization)
- **Full duplex**
- Error control(Error checking(checksum)
- **Flow control**
  - Data-recovery features
  - Sequencing of data packets

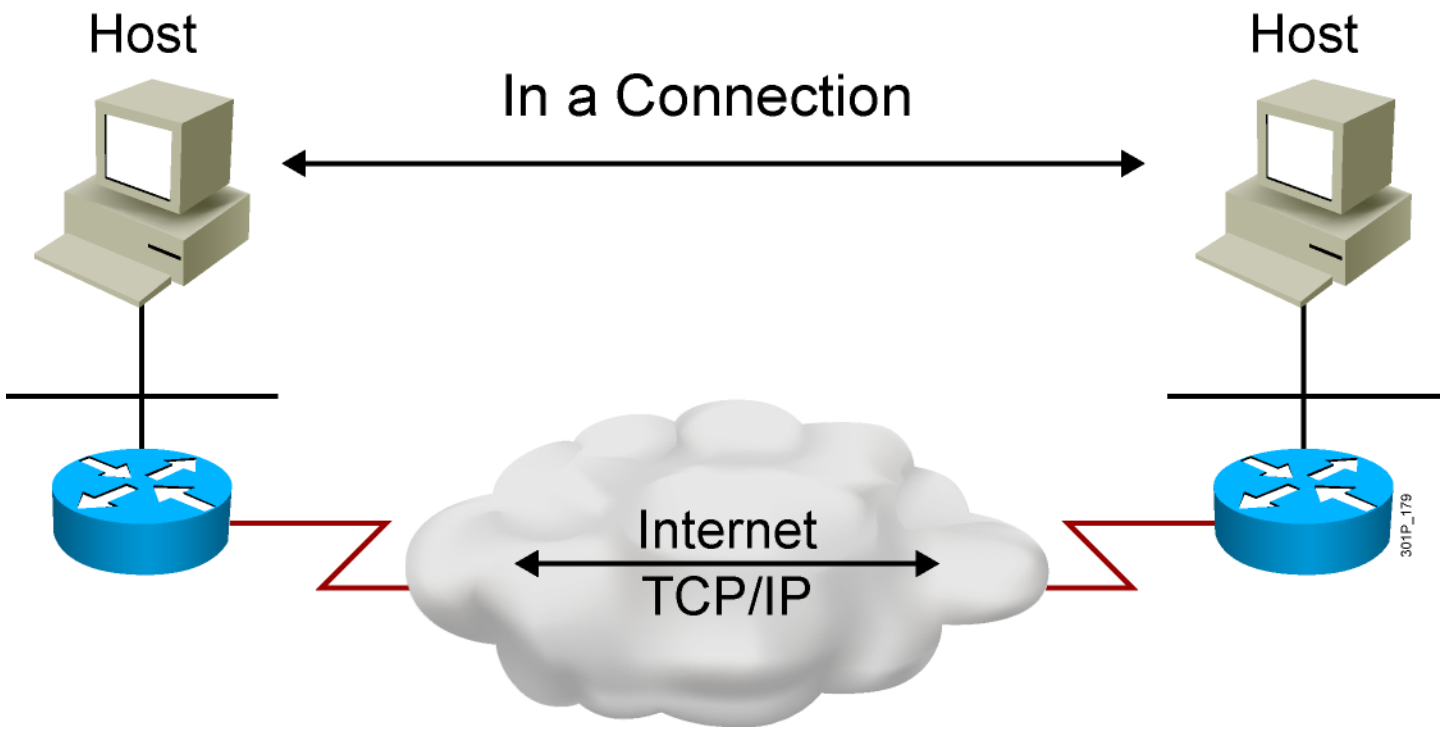
No internet

TCP Header

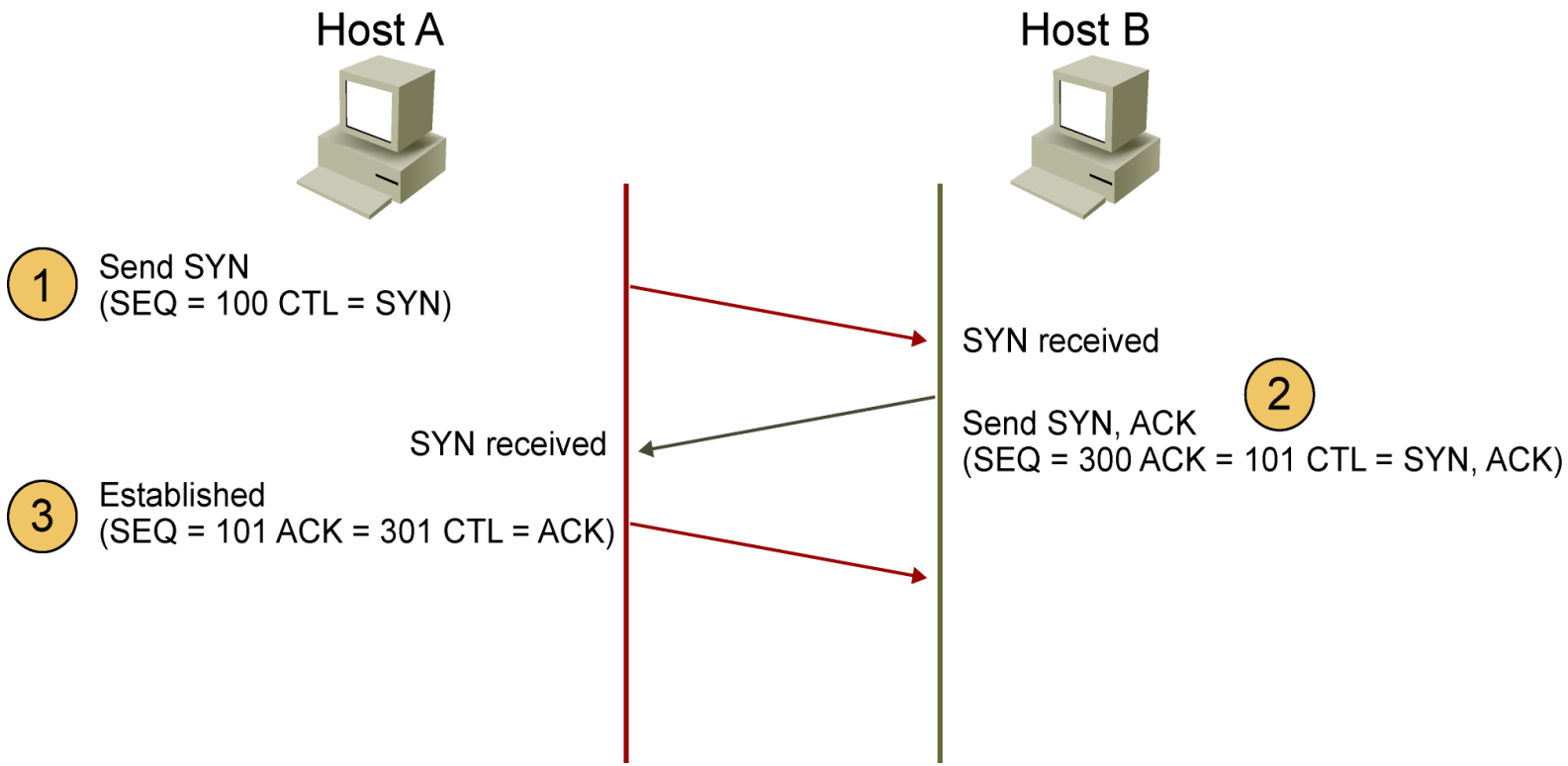


Basic Network Elements (Software)

ESTABLISHING A CONNECTION



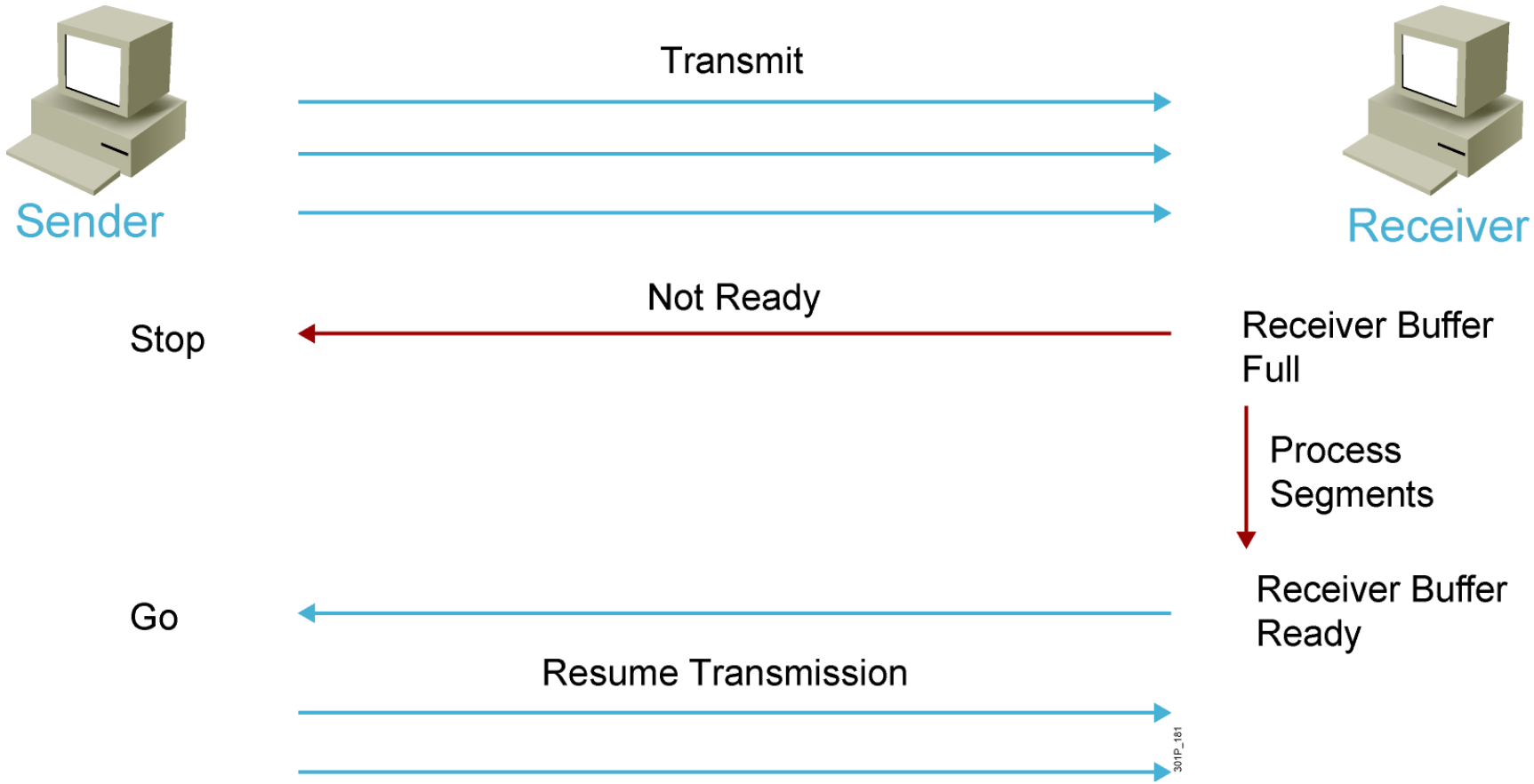
THREE-WAY HANDSHAKE



CTL = Which control bits in the TCP header are set to 1

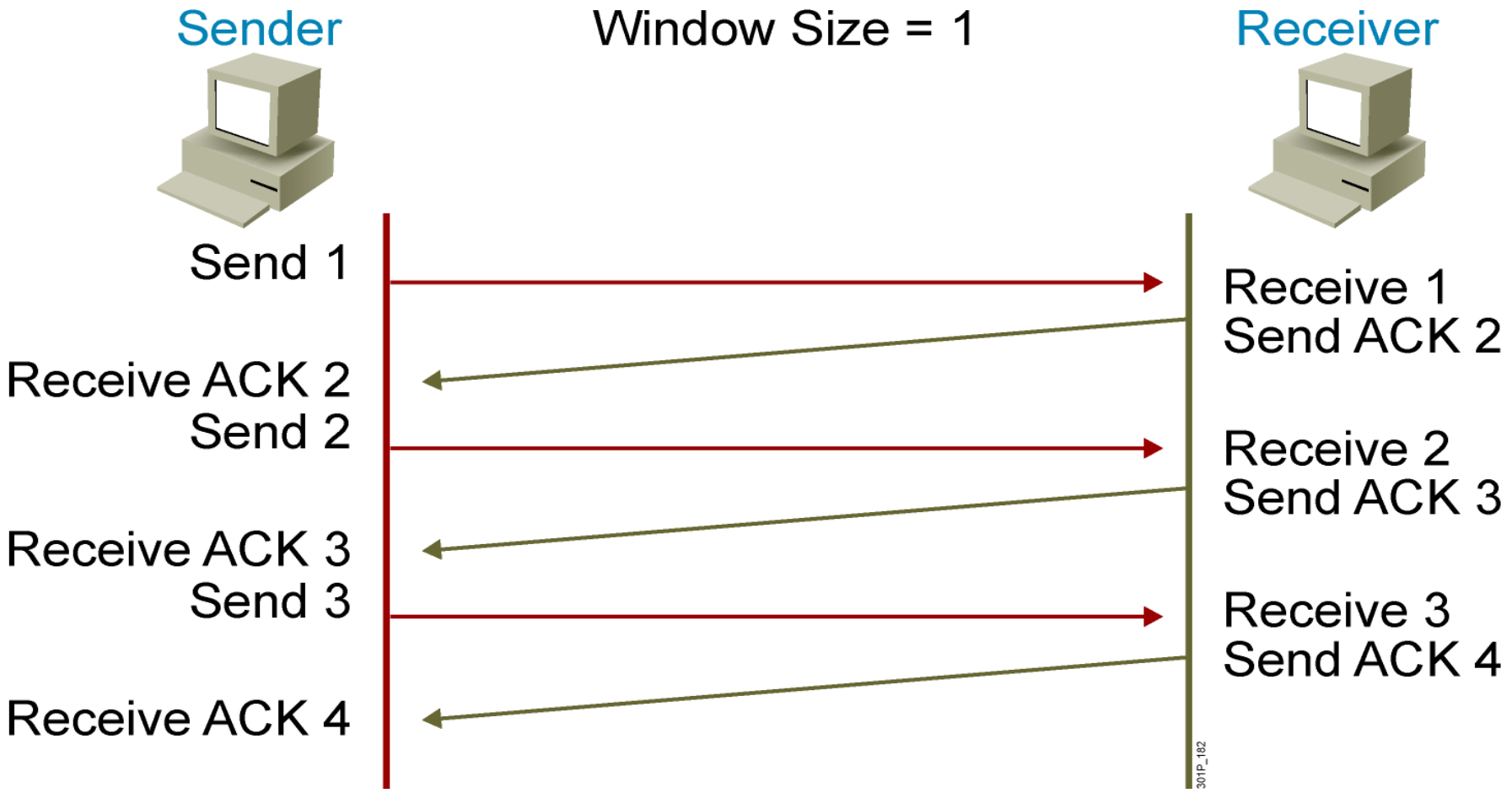
Basic Network Elements (Software)

Flow Control



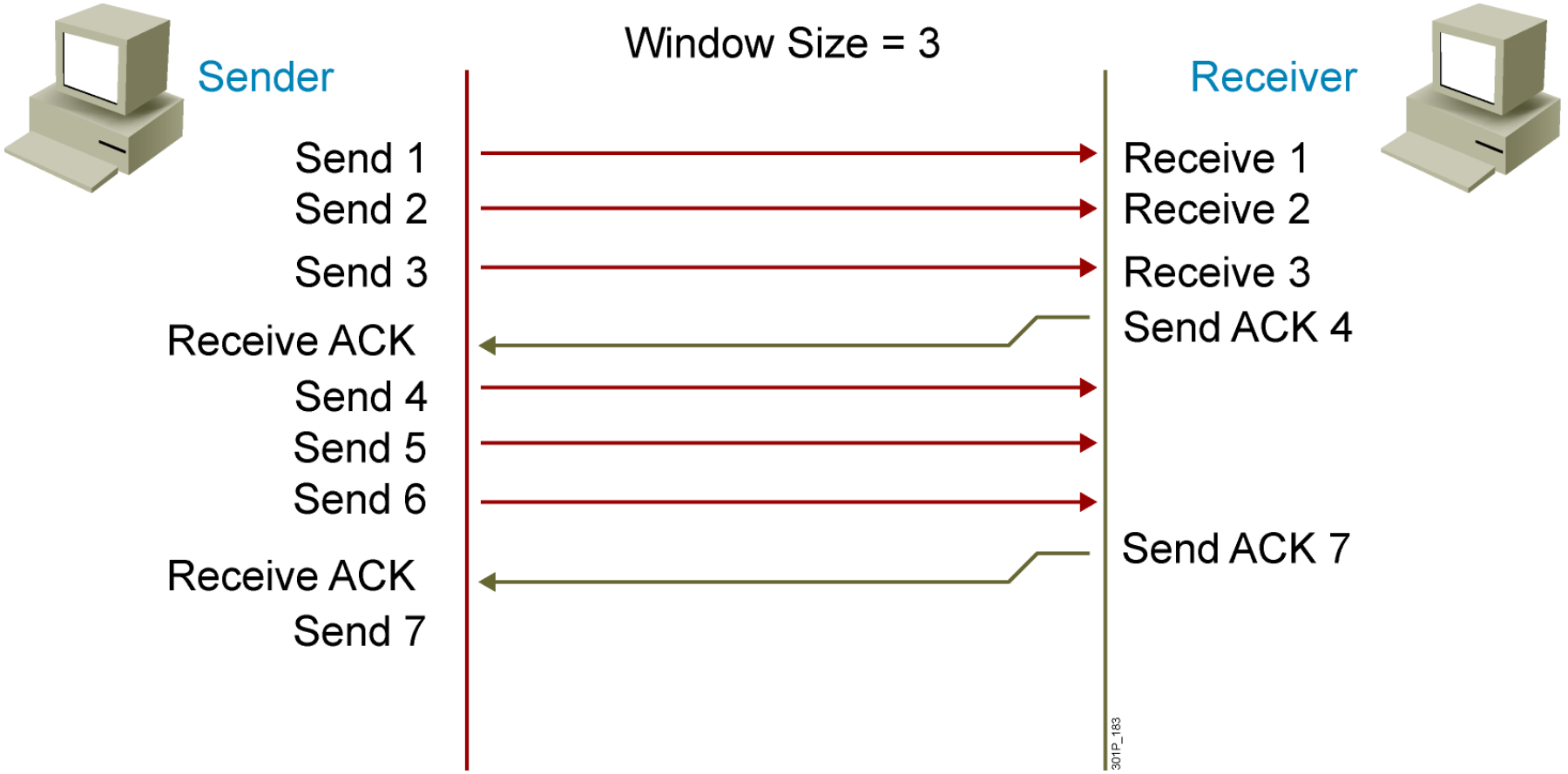
Basic Network Elements (Software)

TCP Acknowledgment



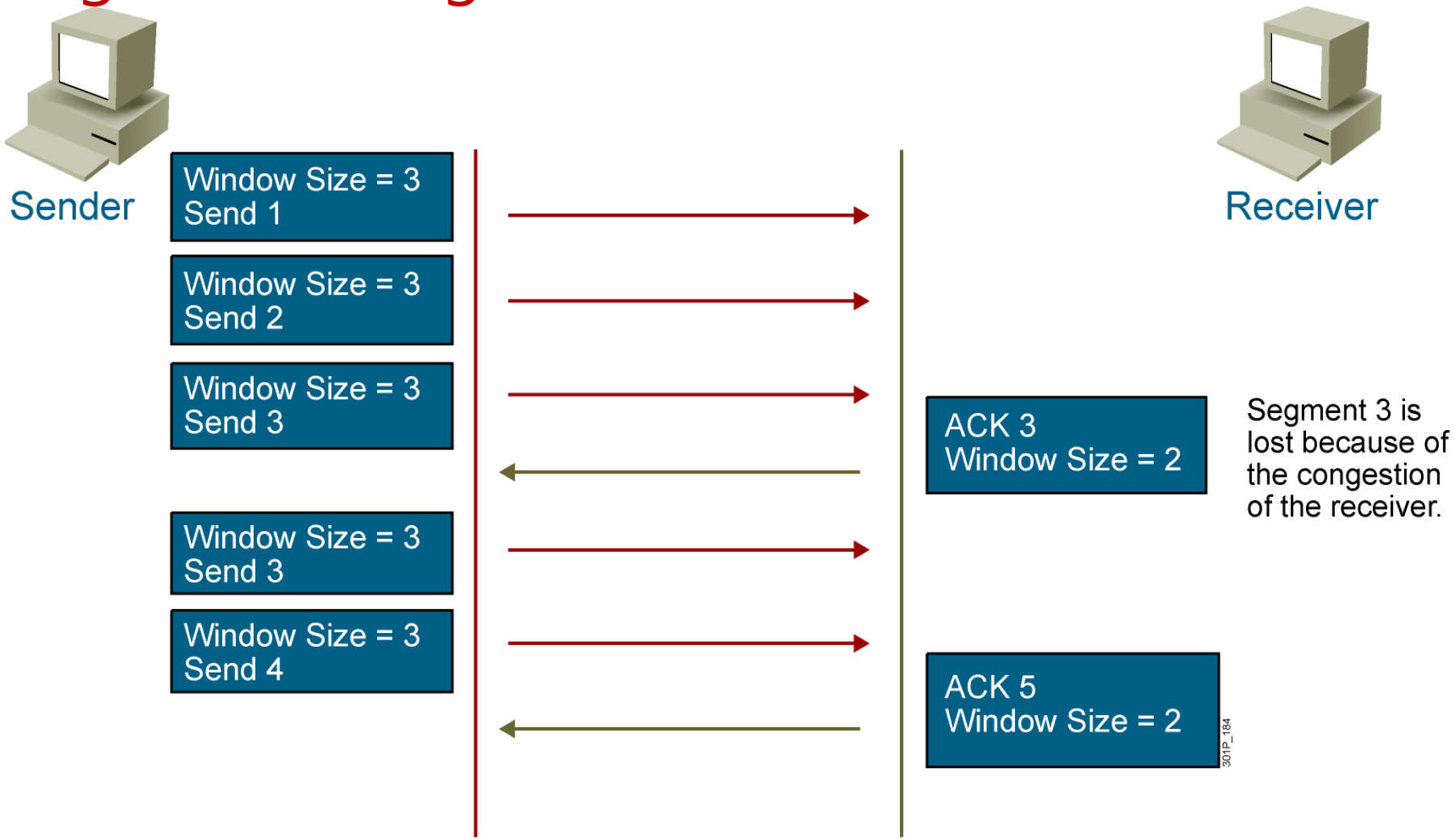
Basic Network Elements (Software)

Fixed Windowing



Basic Network Elements (Software)

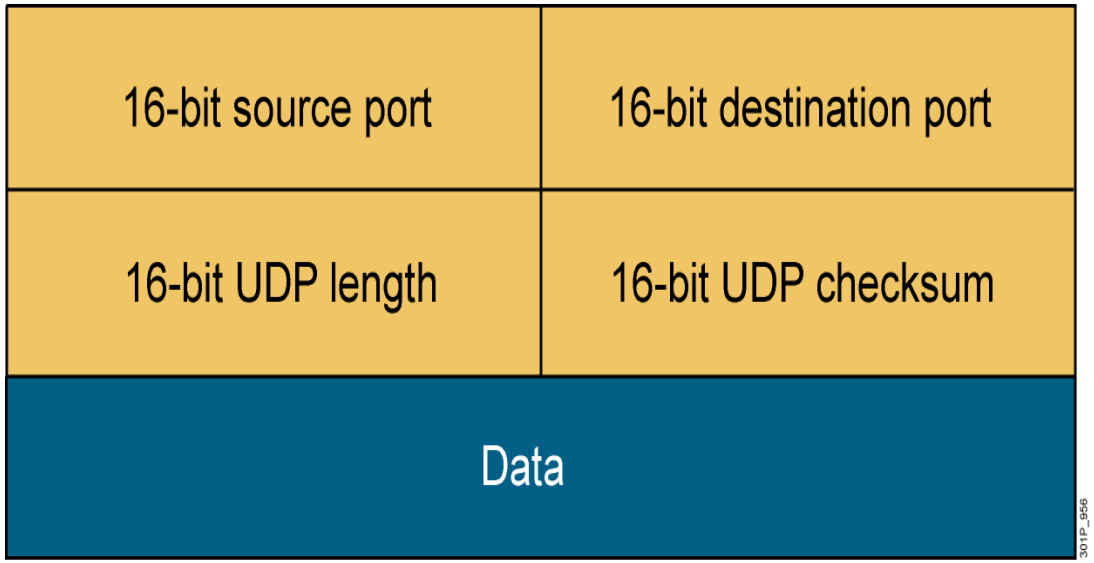
TCP Sliding Windowing



UDP Characteristics

- User Datagram Protocol / Transport layer protocol
- Process to process communication
  - Use port numbers
- **Connectionless** (no notification)
- Unreliable
- **Perform very limited error checking**
- Very simple using a minimum of overhead
- Provides best-effort delivery
    - The data may be dropped due to:
        - Routing Error,
        - Duplicate data due to redundancy
        - Data loss in its way due to TTL.
- **Has no data-recovery features**

UDP Header



TCP (Reliable) vs. UDP (Best-Effort Comparison)

	Reliable	Best-Effort
Connection Type	Connection-oriented	Connectionless
Protocol	TCP	UDP
Sequencing	Yes	No
Uses	▪ E-mail ▪ File sharing ▪ Downloading	▪ Voice streaming ▪ Video streaming

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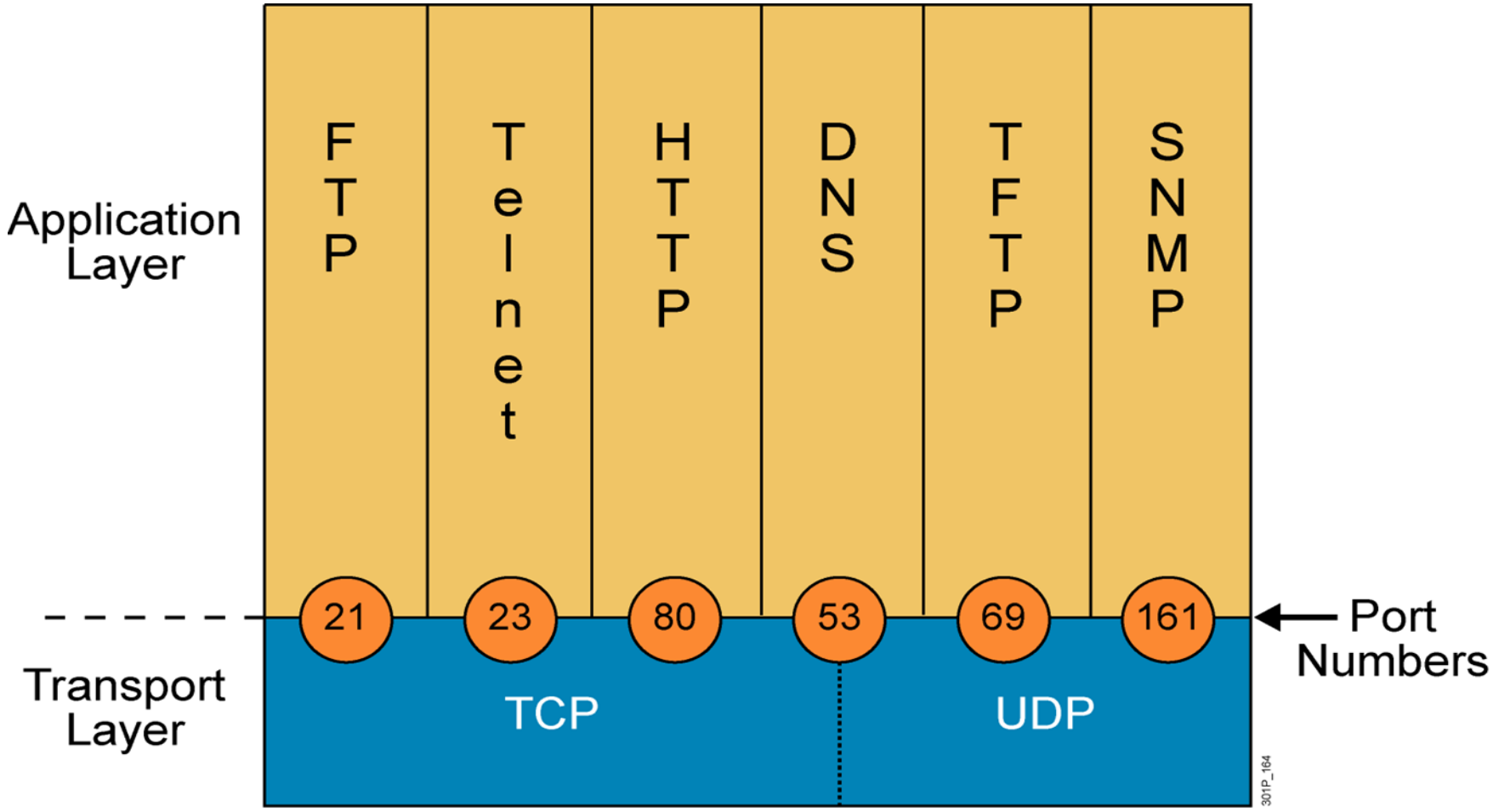
Mapping Layer 4 to Applications

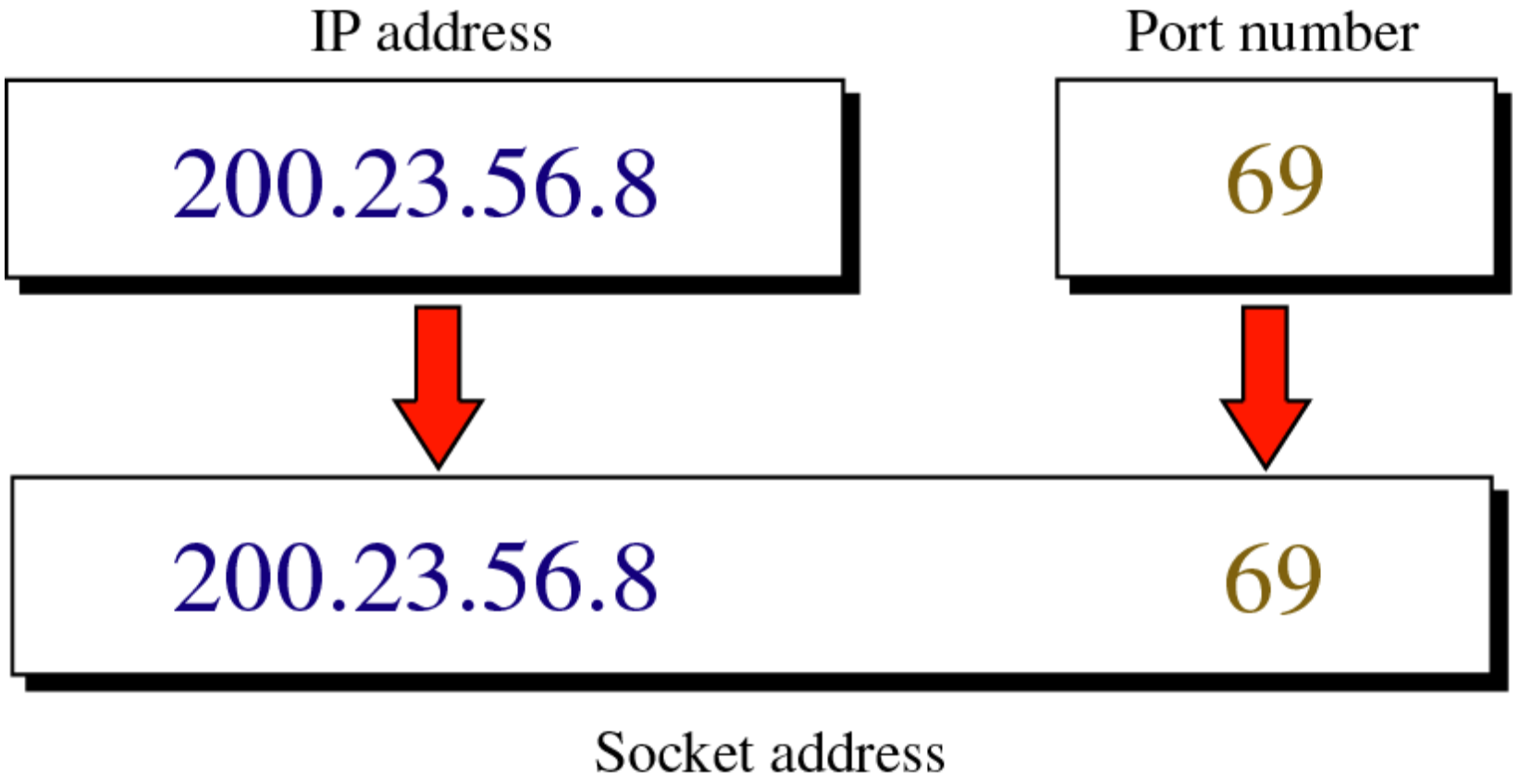


Basic Network Elements (Software)

Port Numbers

- **Well Known ports**
  - Range from 0 to 1,023 are assigned and controlled by ICANN
- **Registered ports**
  - Range from 1,024 to 49,151 not assigned or controlled by ICANN but can be registered at ICANN to avoid duplication
- **Dynamic ports**
  - Range from 49,152 to 65,535 are neither controlled nor registered

Socket Address

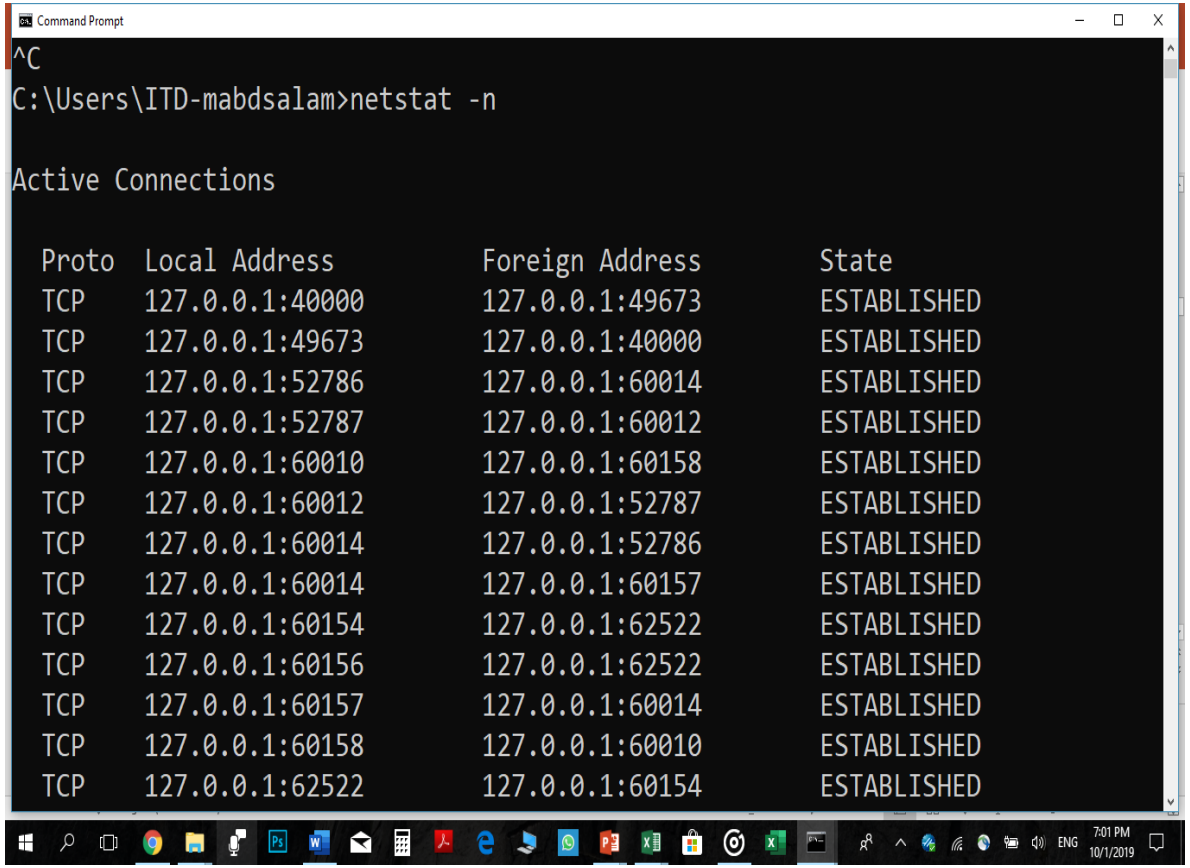


Basic Network Elements (Software) - LAB

❖ **NETSTATE**

Netstat –n
netstat -a

To know session and ports on your device



Thanks