شبكات

Introduction to Computer Networking

(Class 1)

By
Dr. Ali Abdulrazzaq

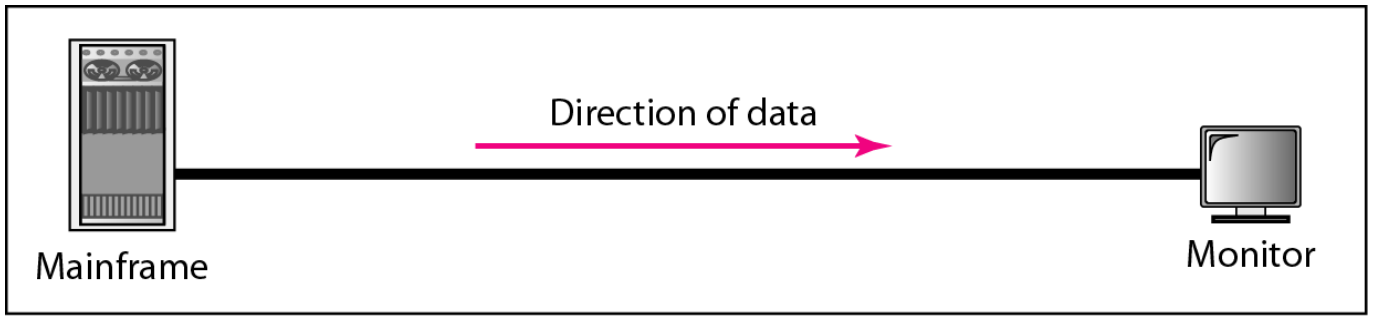
What is a Network?

A network is a set of devices (often referred to as nodes) connected by communication links. A node can be a computer, printer, or any other device capable of sending and/or receiving data generated by other nodes on the network. A link can be a cable, air, optical fiber, or any medium which can transport a signal carrying information.

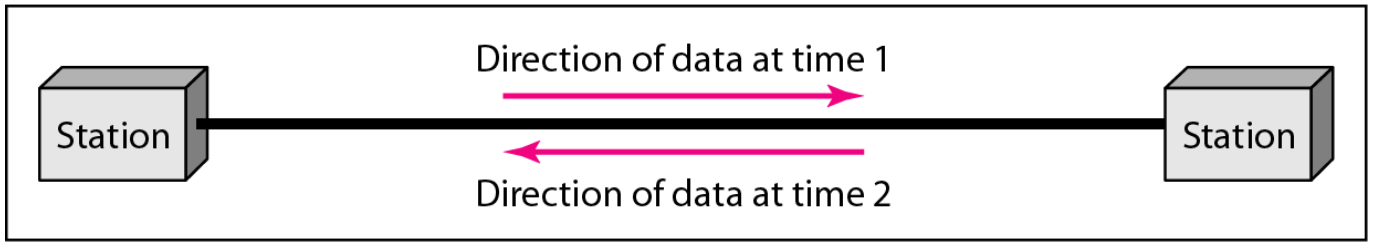
Why we need Networking?

- **Sharing information**
- **Sharing hardware or software.**
- **Centralize administration and support.**

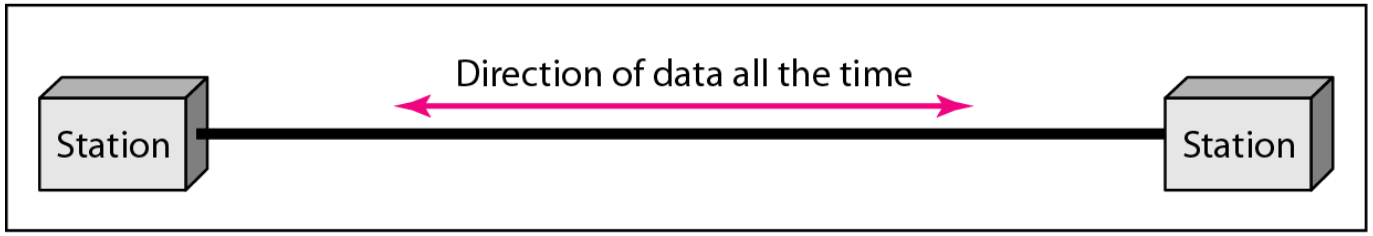
Data flow (simplex, half-duplex, and full-duplex)



a. Simplex



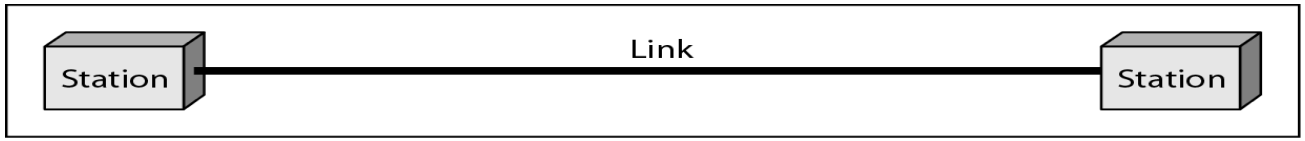
b. Half-duplex



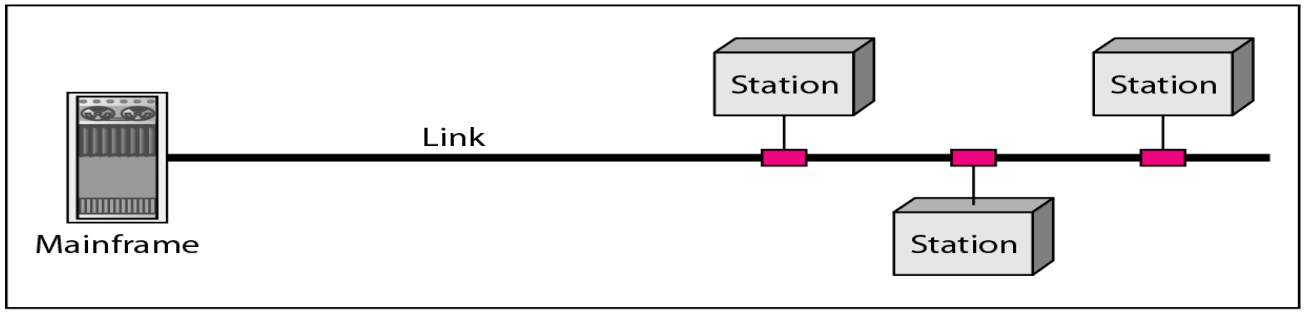
c. Full-duplex

☐Physical Structures

- **Type of Connection**
  - **Point to Point - single transmitter and receiver**
  - **Multipoint - multiple recipients of single transmission**



a. Point-to-point



b. Multipoint

How many kinds of Networks?

- **we can classify networks in different ways:**

- **Based on network size: LAN and WAN (and MAN)**
- **Based on management method: Peer-to-peer and Client/Server**
- **Based on topology (connectivity): Bus, Star, Ring ..**
- **Based on transmission media: Wired (UTP, coaxial cables, fiber-optic cables) and Wireless**

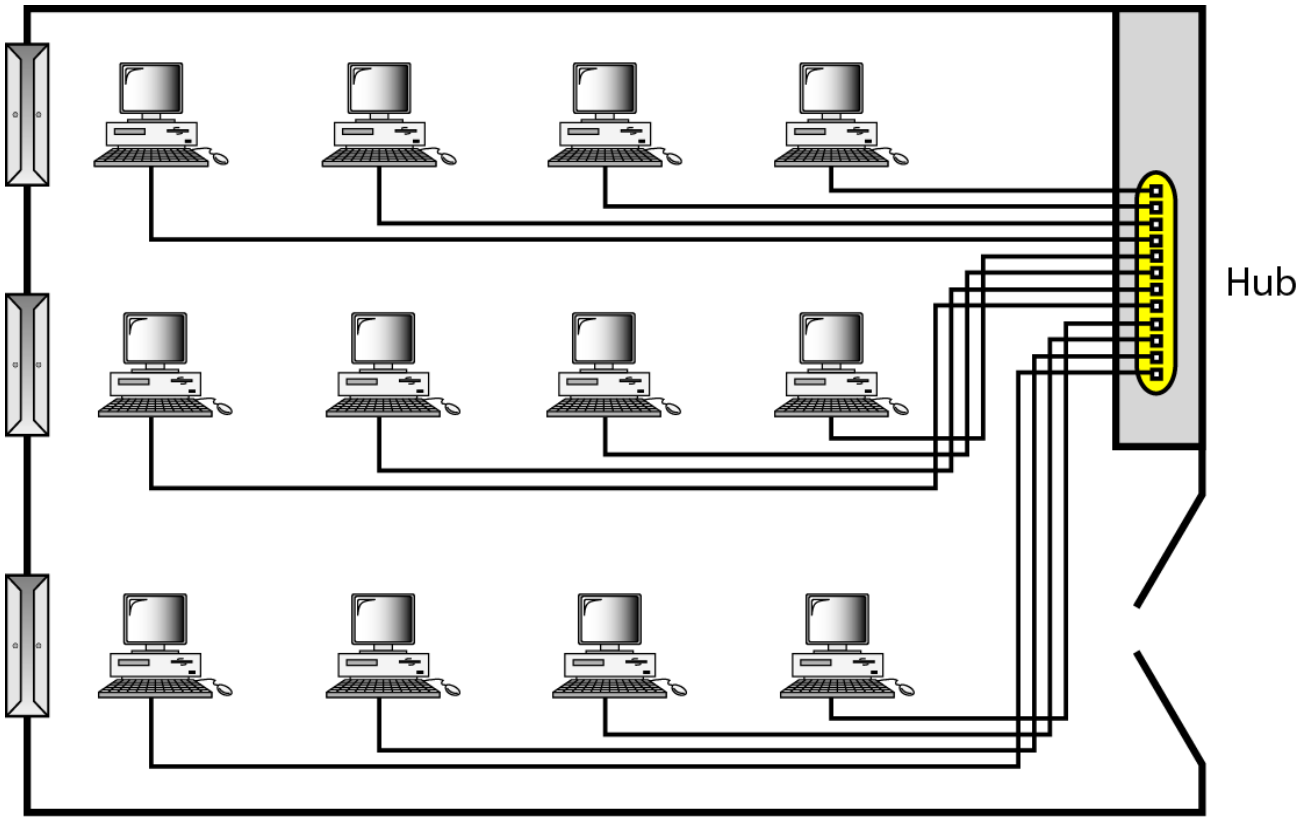
  :

  :

LAN and WAN

- **Local Area Network (LAN)**
  - **Small network, short distance**
    - **A room, a floor, a building**
    - **Limited by number of computers and distance covered**
    - **Serve a department within an organization**
  - **Examples:**
    - **Network inside the Student Computer Room**
    - **Network inside your home**

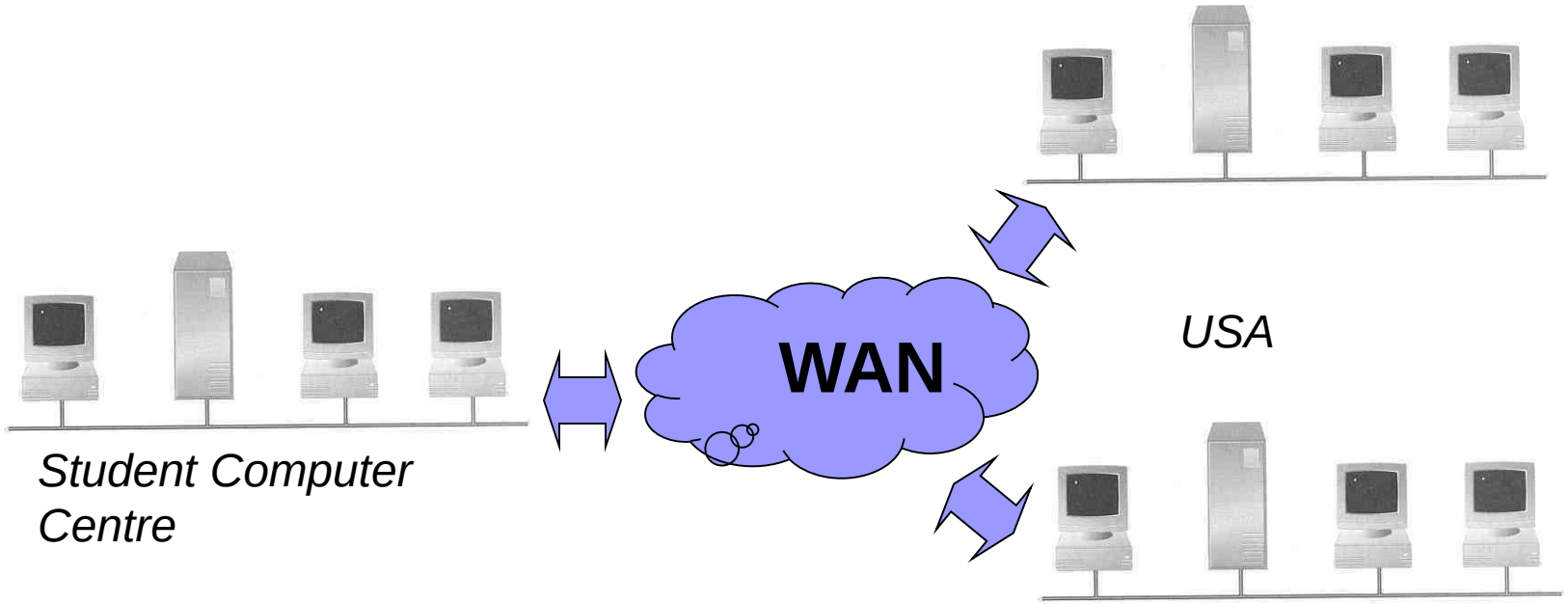
Figure . *An isolated LAN connecting 12 computers to a hub in a closet*



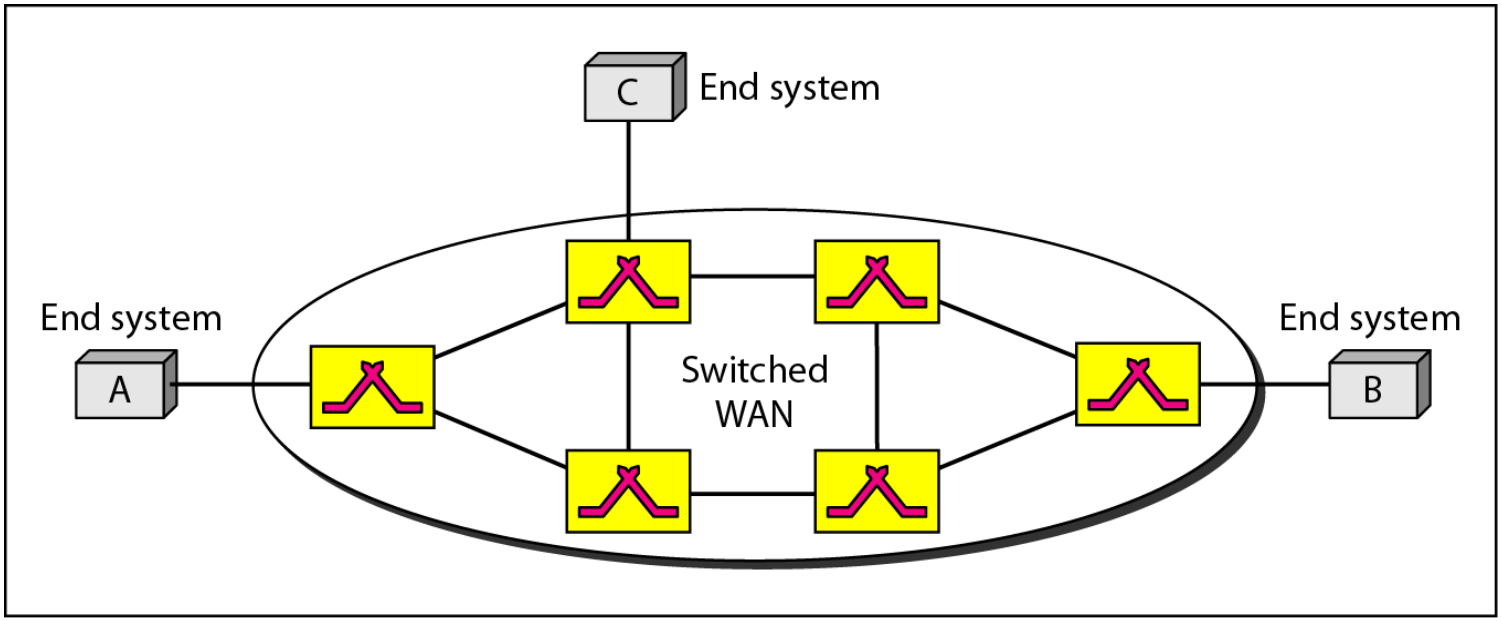
• Wide Area Network (WAN)

- **A network that uses long-range telecommunication links to connect 2 or more LANs/computers housed in different places far apart.**
  - **Towns, states, countries**

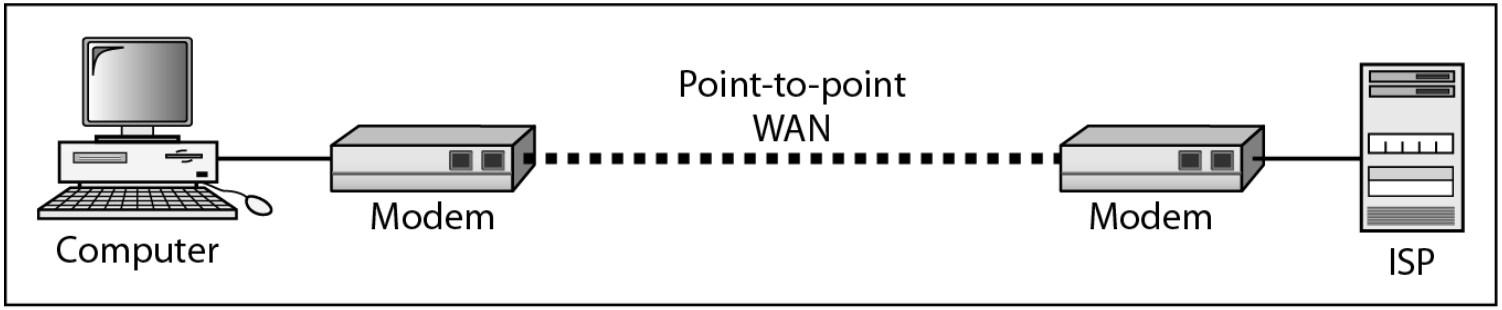
- **Examples: Internet**



WANs: a switched WAN and a point-to-point WAN



a. Switched WAN



b. Point-to-point WAN

- **Syllabus**

- **Network Topology**
- **Network Models OSI**
- **IP Addressing**
- **Classful Addressing**
- **Classless Addressing**
- **Subnetting Addressing**
- **Network Address Translation NAT**

شبكات

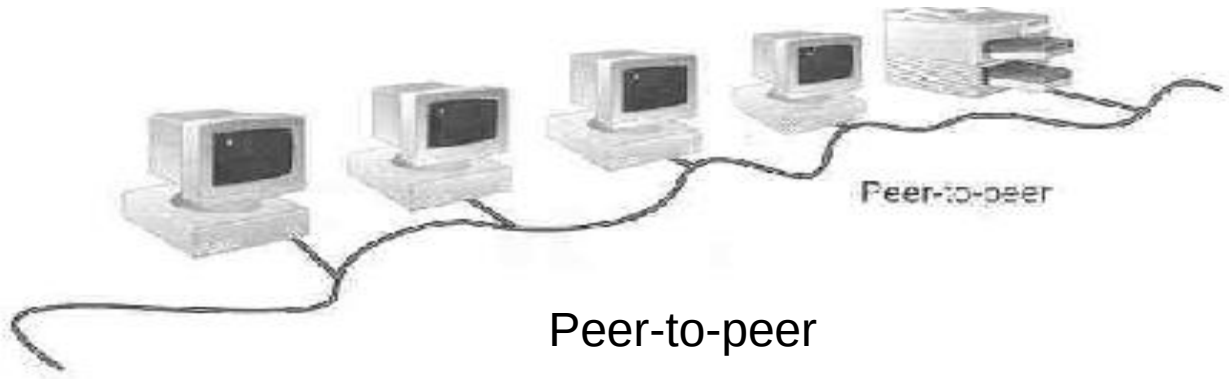
Network Topology

(Class 2)

By
Dr. Ali Abdulrazzaq

Peer-to-Peer Networks

- **No hierarchy among computers ⇒ all are equal.**
- **لا يوجد تدرج بين الاجهزة – الكل متساوية**
- **No administrator responsible for the network.**
- **لا يوجد جهة معينة تدير الشبكة – الكل يساهم في الادارة**
- **Host in a P2P network Provide and Consume Services. اي عنصر داخل الشبكة ممكن ان ينتج ويستهلك خدمات**



Peer-to-peer

- **Advantages of peer-to-peer networks:**
  - Low cost كلفة قليلة
  - Simple to configure سهولة في التشكيل
  - User has full accessibility of the computer ممكن للمستخدمين الوصول الكامل للكومبيوتر
- **Disadvantages of peer-to-peer networks:**
  - Difficult to uphold security policy عدم توفر الامنية الكاملة
  - Difficult to handle uneven loading عدم السيطرة على البيانات الكبيرة
  - Not Scalable: غير قابل للتوسيع
  - Difficult to control, صعوبة في الادارة. لان كل مستخدم هو بحد ذاتة مدير because every user is a network administrator.
- **Where peer-to-peer network is appropriate:**
  - 10 or less users عندما يكون العدد اقل من 10 مستخدمين
  - Security is not an issue عندما تكون الامنية غير مهمة

Clients and Servers

- **Network Clients (Workstation)**
  - **Computers that request network resources or services**
  - **الاجهزة التي تطلب خدمات او موارد**
- **Network Servers**
  - **Computers that manage and provide network resources and services to clients الاجهزة التي تزود الخدمات و الموارد للمستخدمين**
    - **Usually have more processing power, memory and hard disk space than clients عادتا تملك معالجات قوية وذاكرة عالية و سعة خزن كبيرة**
    - **Run Network Operating System that can manage not only data, but also users, groups, security, and applications on the network تعمل على انظمة تشغيل عالية الجودة و مختلفة عن الاجهزة العادية لتكون قادرة على توفير الامنية و ادارة المستخدمين و المجاميع**

• Advantages of client/server networks

- Facilitate resource sharing – سهولة في مشاركة المصادر
- Facilitate system backup سهولة في تامين نسخ احتياطي للنظام
- Enhance security – only administrator can have access to Server
- امنية عالية – بسبب وجود مدير واحد مخول للتحكم بالشبكة
- Support more users – difficult to achieve with peer-to-peer networks دعم عدد كبير من المستخدمين

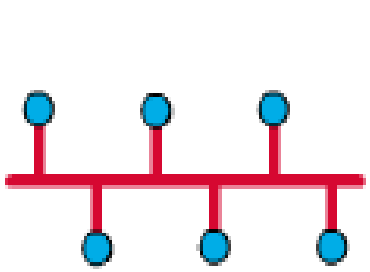
• Disadvantages of client/server networks

- High cost for Servers كلفة عالية
- Need expert to configure the network تحتاج خبراء للعمل والصيانه على تلك الشبكات

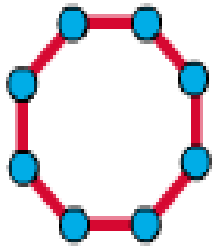
Specialized Servers

- **Type of specialized servers**
  - Application Servers
  - Communication Servers
  - Fax Servers
  - Mail Servers
  - Web Servers
  - File & Print Servers

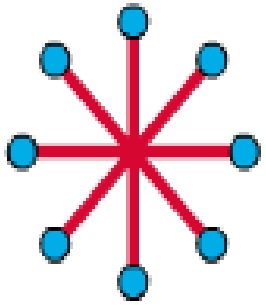
Network Topology



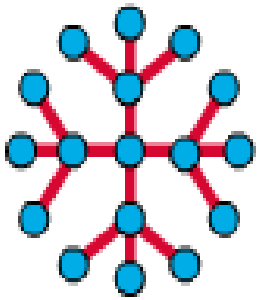
Bus Topology



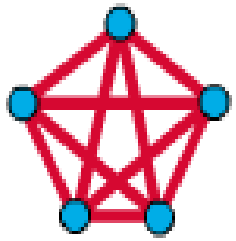
Ring Topology



Star Topology

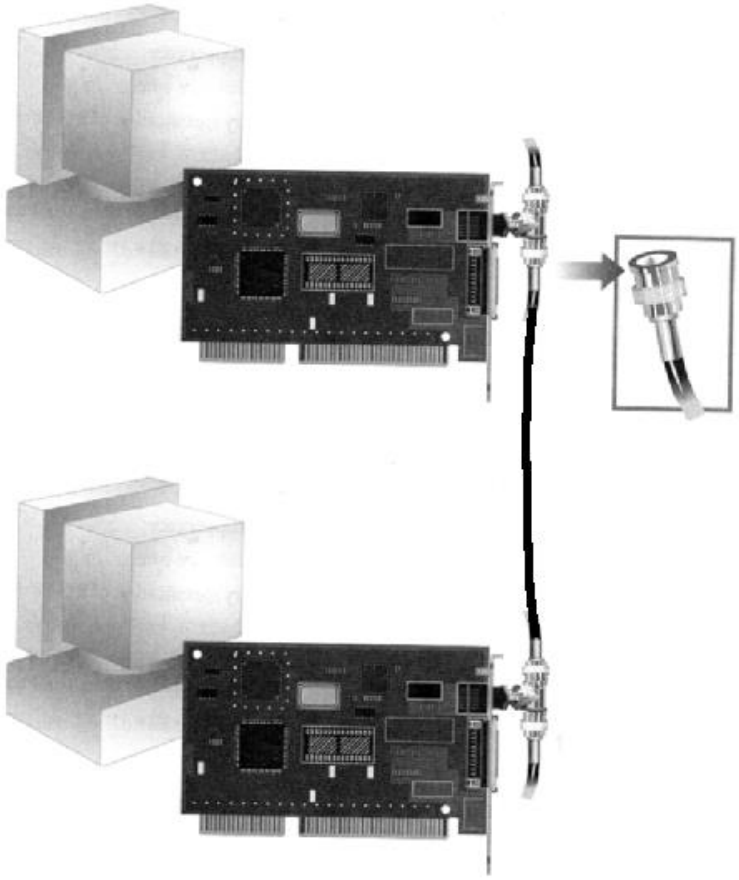


Extended Star Topology

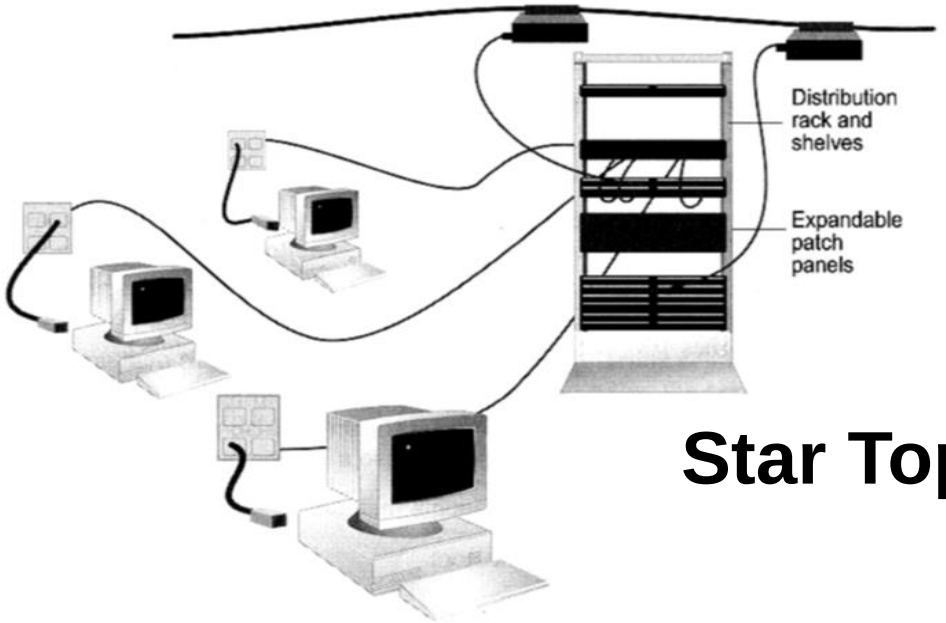


Mesh Topology

- # Bus Topology
  - **Simple and low-cost بسيط و ذو كلفة قليلة**
  - **A single cable called a trunk تحتوي على كيبل واحد يدعى**
  - **Only one computer can send messages at a time فقط كومبويتر واحد ممكن ان يرسل في المرة الواحدة**



- **Star Topology**
  - **Each computer has a cable connected to a single point** كل كومبويتر في الشبكة متصل بنقطة المركز
  - **More cabling, hence higher cost** يحتاج الى توصيلات كثيرة اذن كلفة عالية
  - **All signals transmission through the hub; if down, entire network down** كل البيانات تمر عبر نفطة المركز – اي فشل في تلك النقطة سوف يؤدي الى فشل الشبكة كاملا



Star Topology

Ring Topology

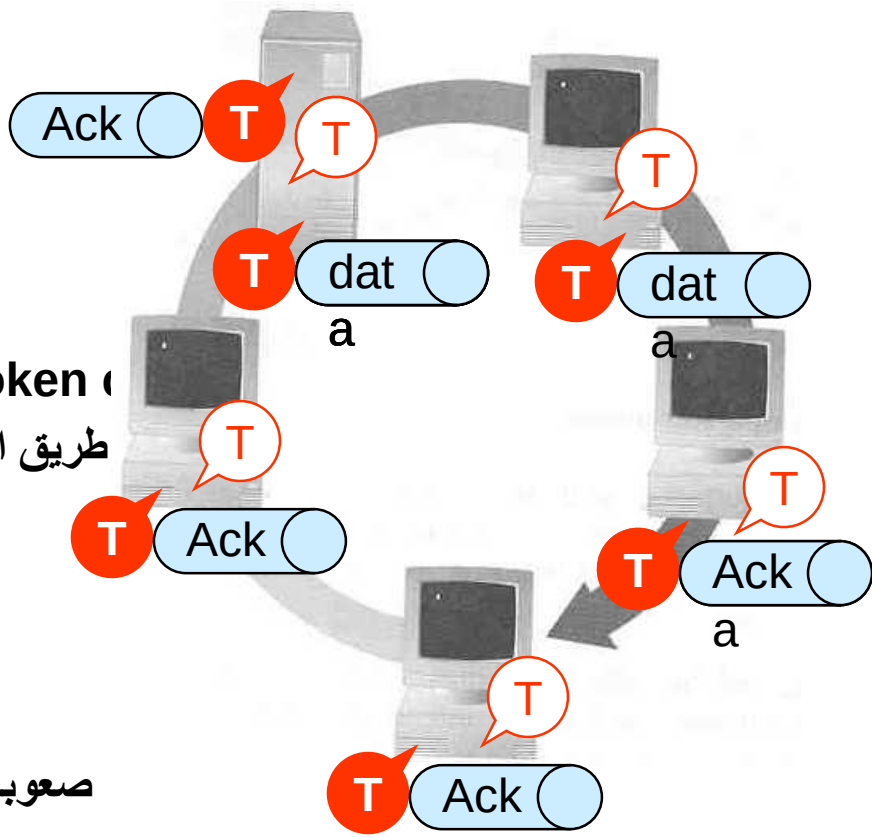
- Every computer serves as a repeater to boost signals

كل كومبويتر يعتبر هنا كمثابت مقوي للاشارة

- Typical way to send data:
  - Token passing
  - only the computer who gets the token (

طريق التكون _ اي كل كومبويتر يحصل على data

التوكن ممكن ان يرسل بيانات

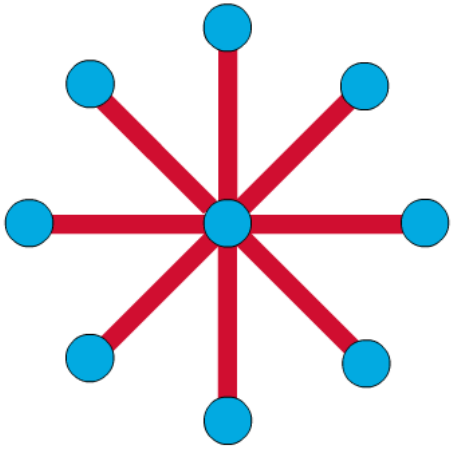


Disadvantages

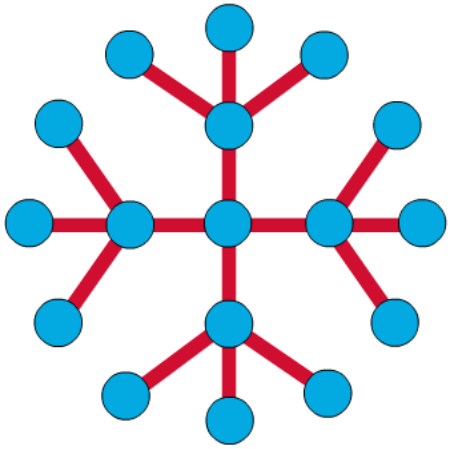
- Difficult to add computers صعوبة اضافة كومبيوتر
- More expensive عالي الكلفة
- If one computer fails, whole network fails فشل كومبويتر واحد يؤدي الى فشل الشبكة كاملا

Star & Tree Topology

- The star topology is the most commonly used architecture in Ethernet LANs. بنية النجمة هو الاكثر استخداما في الوقت الحالي في الشبكات المحلية

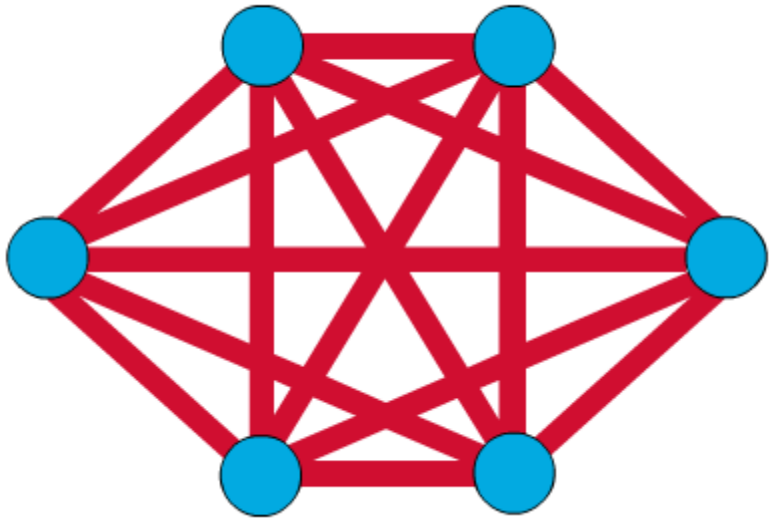


- Larger networks use the extended star topology also called tree topology. When used with network devices that filter frames or packets, like bridges, switches, and routers, this topology significantly reduces the traffic on the wires by sending packets only to the wires of the destination host. الشبكات الكبيرة تسمة بالشجرة وهي عبارة عن مجموعة من شبكات النجمة متصلة مع بعضها عن طريق اجهزة اخرة



Mesh Topology

- The mesh topology connects all devices (nodes) to each other for redundancy and fault tolerance. البنية المشبكة تربط بين جميع عناصر الشبكة مع بعض بشكل مسهب
- Implementing the mesh topology is expensive and difficult. تنفيذ البنية المشبكة يكون عالي الكلفة و صعب



شبكات

Network Models OSI

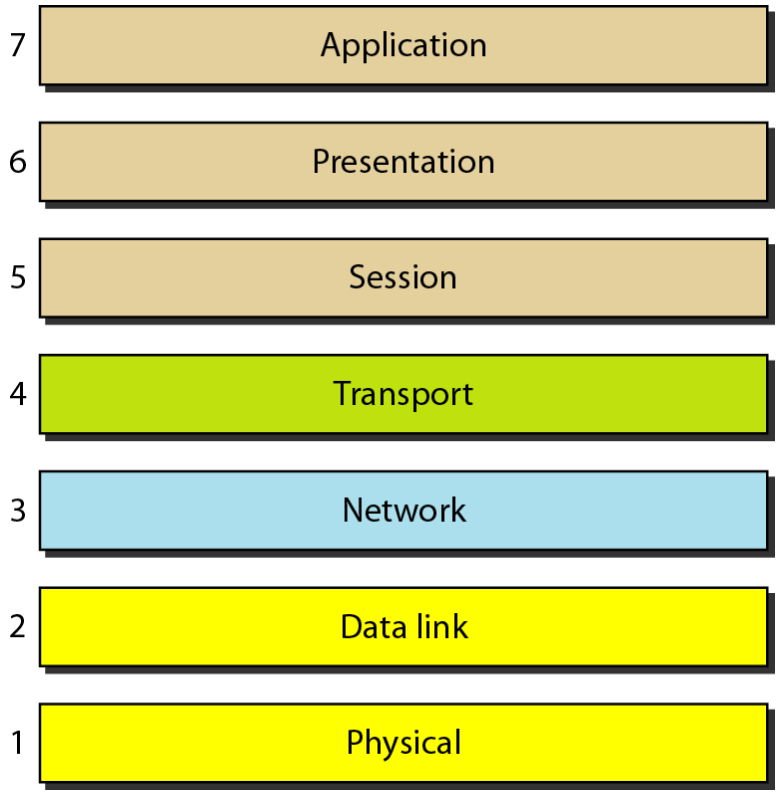
(Class 3)

By
Dr. Ali Abdulrazzaq

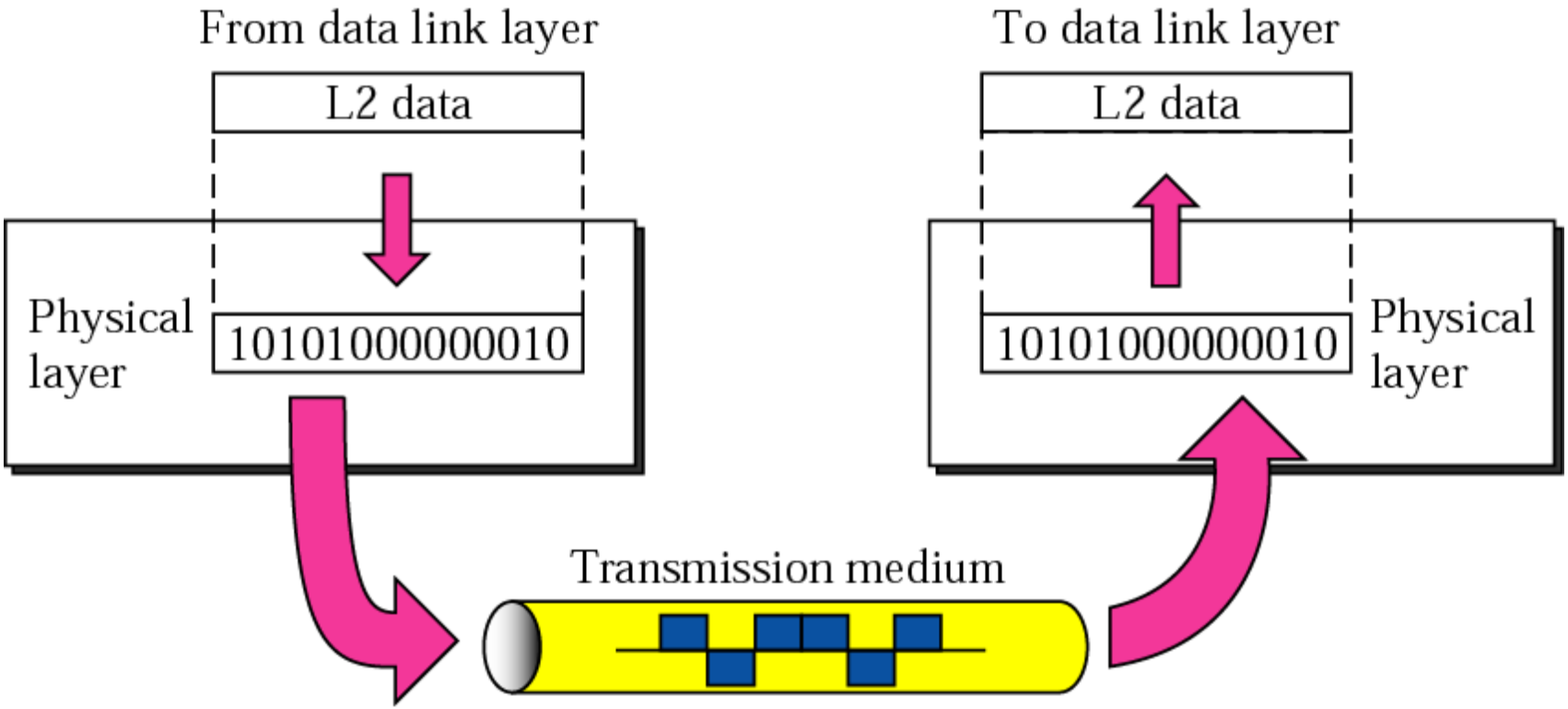
THE OSI MODEL

Established in 1947, the International Standards Organization (ISO). An ISO standard that covers all aspects of network communications is the Open Systems Interconnection (OSI) model. It was first introduced in the late 1970s.

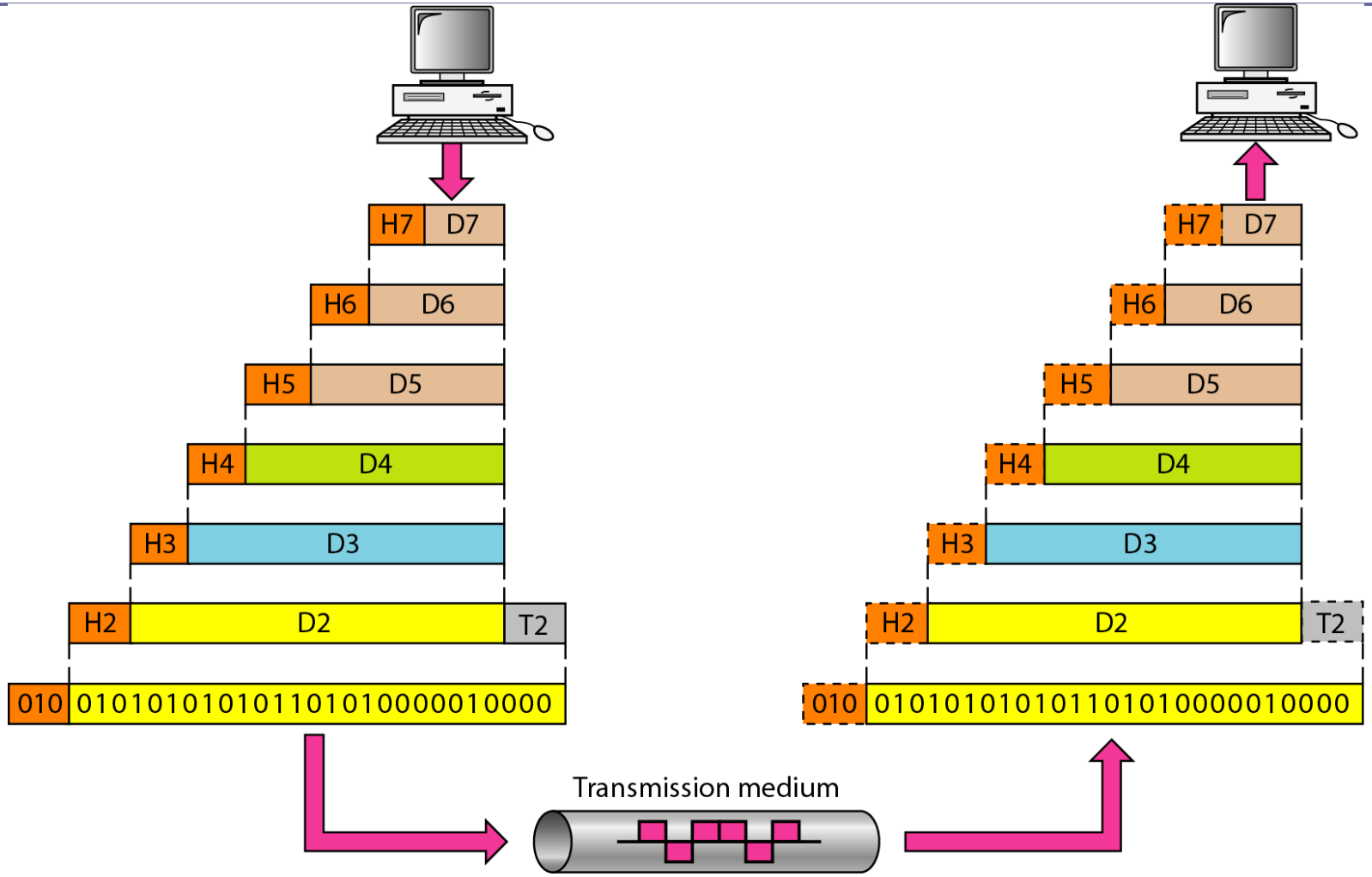
Seven layers of the OSI model



Physical Layer



An exchange using the OSI model

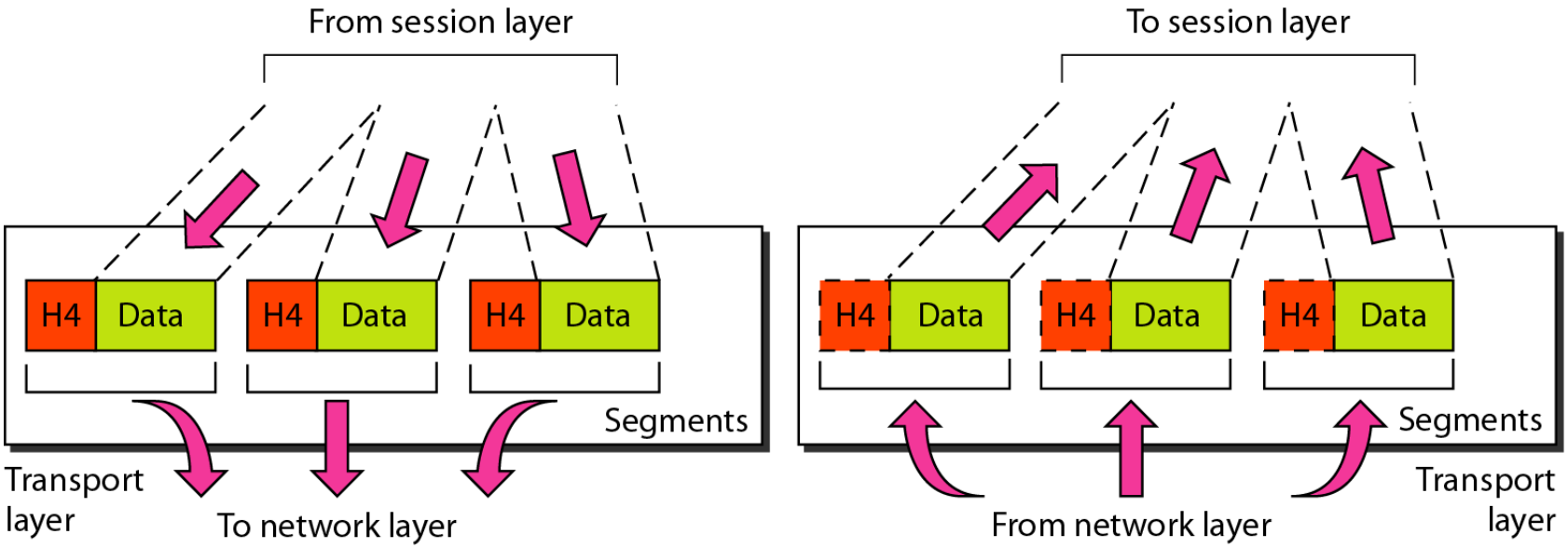


The data link layer is responsible for moving frames from one hop (node) to the next. مسؤول عن نقل اطار البيانات من النقطة الحالية الى النقطة الاحقة

Network layer:

The network layer is responsible for the delivery of individual packets from the source host to the destination host. مسؤول عن توصيل الحزمة من المصدر الى الوجهة النهائية

Transport layer:

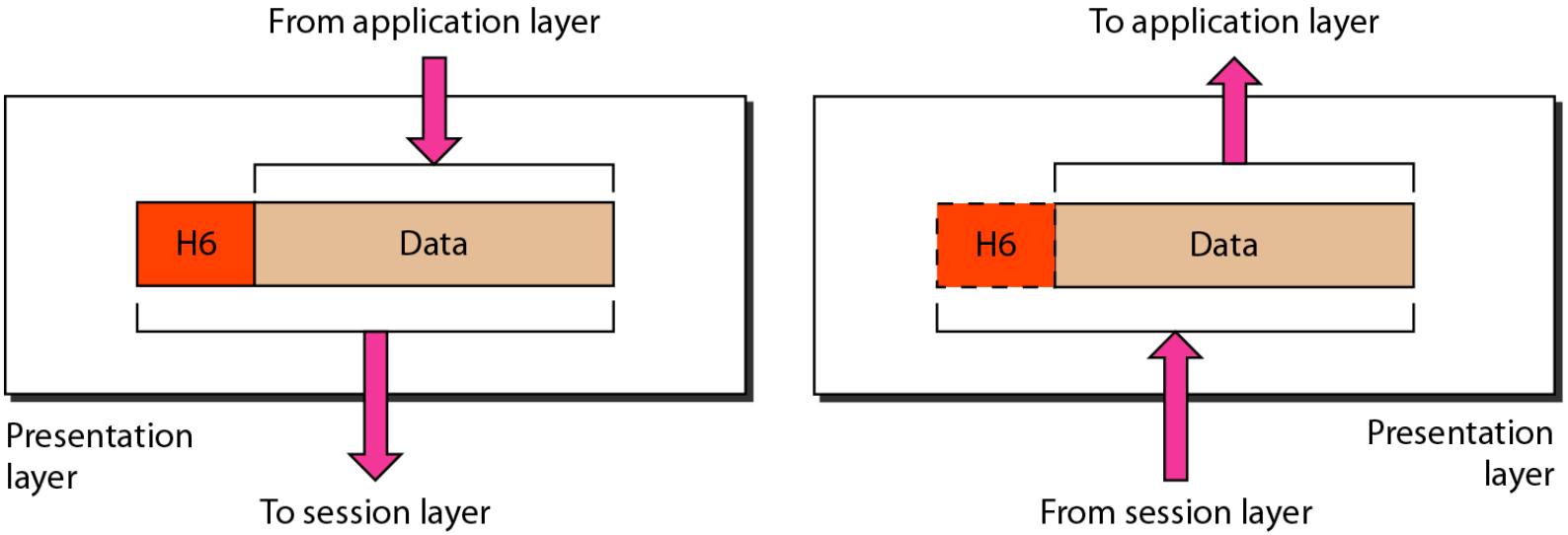


The transport layer is responsible for the delivery of a message from one process to another. مسؤول عن توصيل الرسالة من مرحلة المعالجة الحالية الى التالية

Session layer:

The session layer is responsible for dialog control and synchronization.مسؤول على سيطرة المخاطبة والمزامنة

Presentation layer:

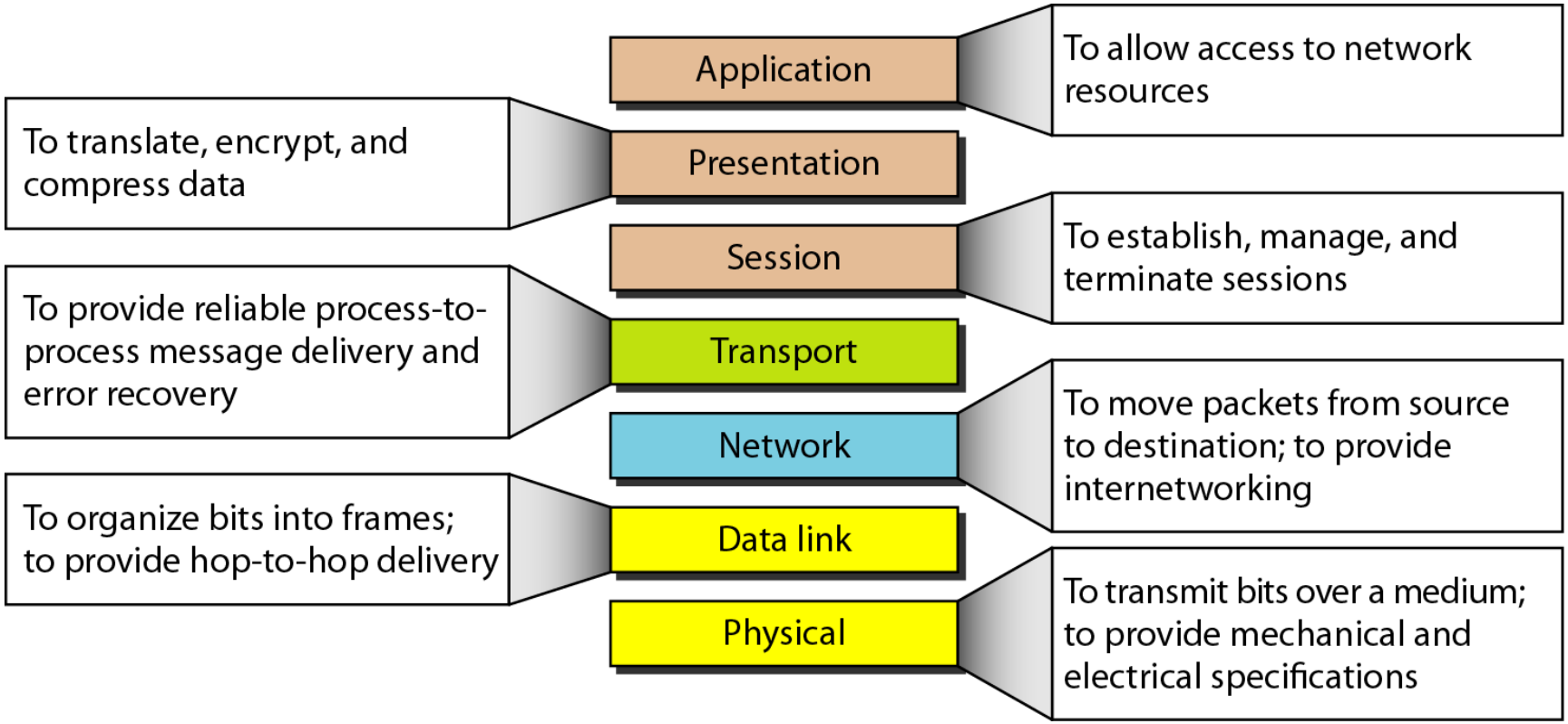


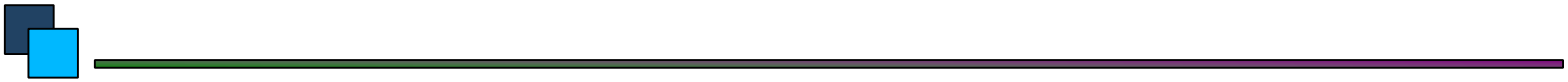
The presentation layer is responsible for translation, compression, and encryption. مسؤول عن الترجمة و الكبس و التشفير

Application layer:

The application layer is responsible for providing services to the user.
مسؤول المباشر عن توصيل الخدمة الى المستخدم

Summary of layers





TCP/IP

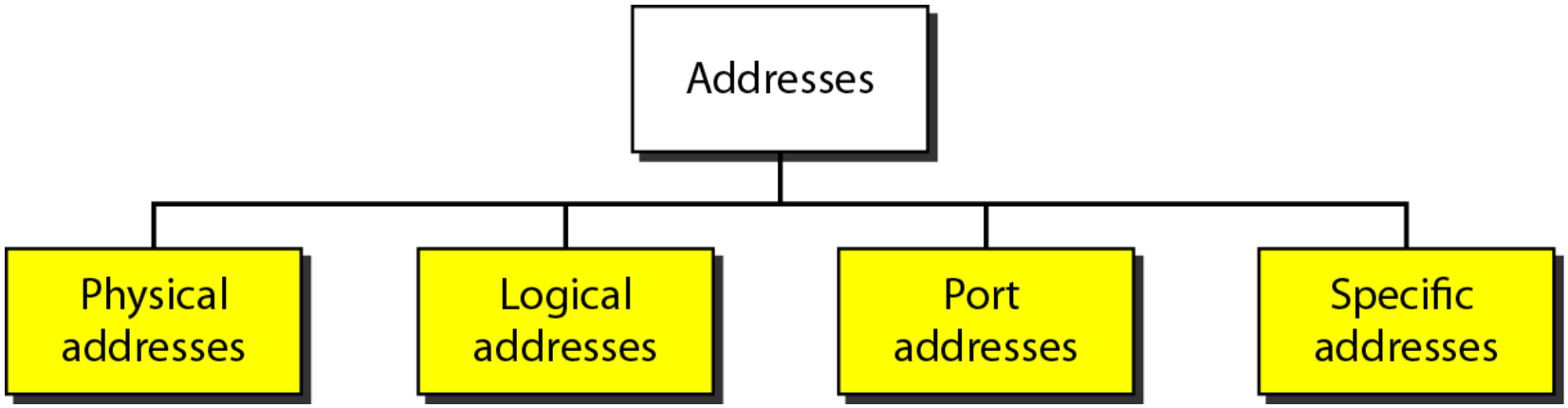
Dr. Lway Faisal

TCP/IP PROTOCOL SUITE

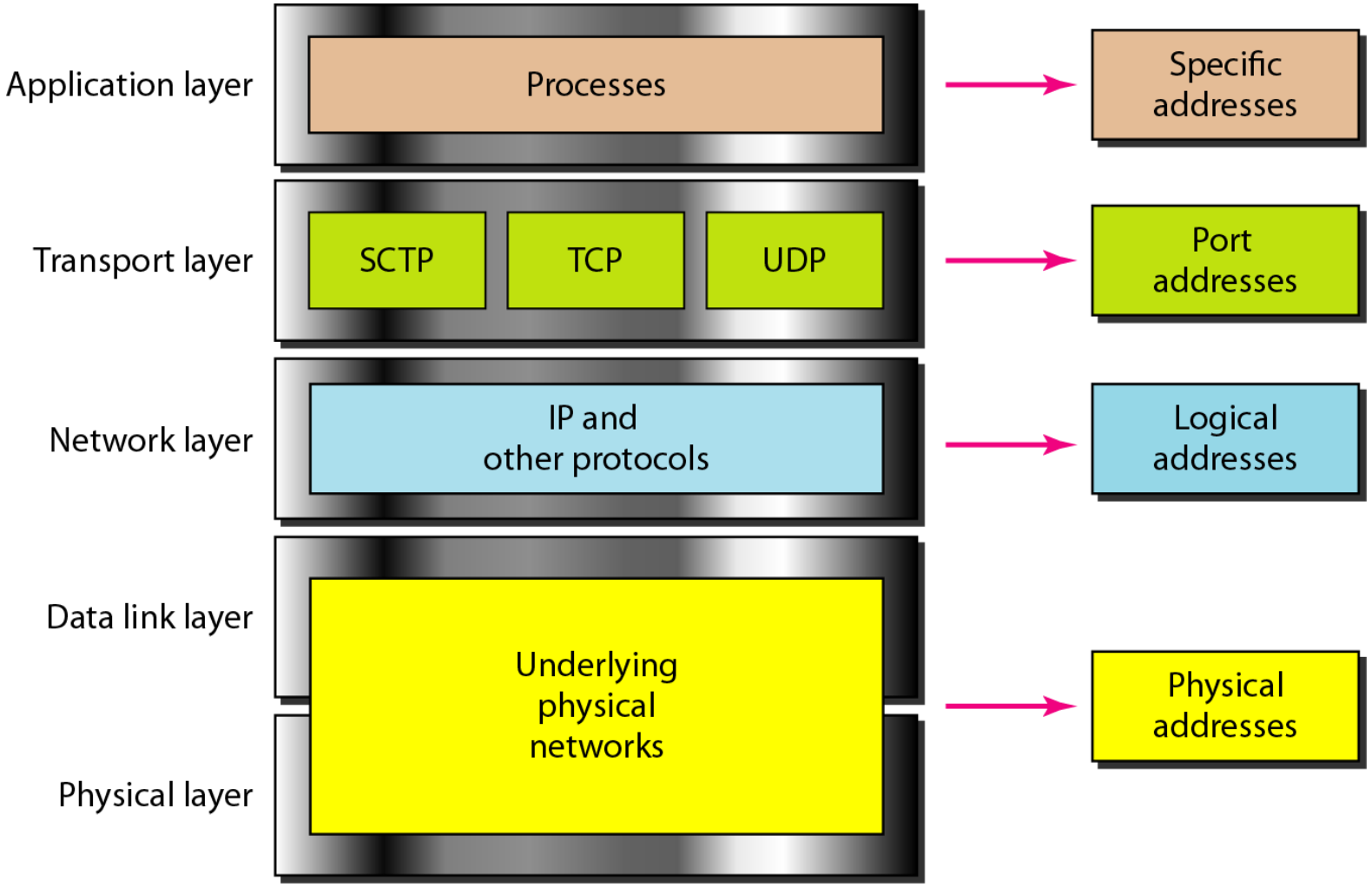
When TCP/IP is compared to OSI, we can say that the TCP/IP protocol suite is made of five layers: physical, data link, network, transport, and application.

ADDRESSING

Four levels of addresses are used in an internet employing the TCP/IP protocols: physical, logical, port, and specific.



Relationship of layers and addresses in TCP/IP



Physical Address

- *Physical address or (hardware Address), or media address control MAC address.*
- *Each node has a unique MAC Address: Globally identifier that burned into your RAM of your network interface card.*
- *MAC Address assigned by manufacturer , each factory has a block of address assigned by IEEE.*
- *No two networks in the world have the same Address.*
- *local-area networks use a 48-bit (6-byte) physical address written as 12 hexadecimal digits; every byte (2 hexadecimal digits) is separated by a colon, as shown below:*

07:01:02:01:2C:4B

A 6-byte (12 hexadecimal digits) physical address.

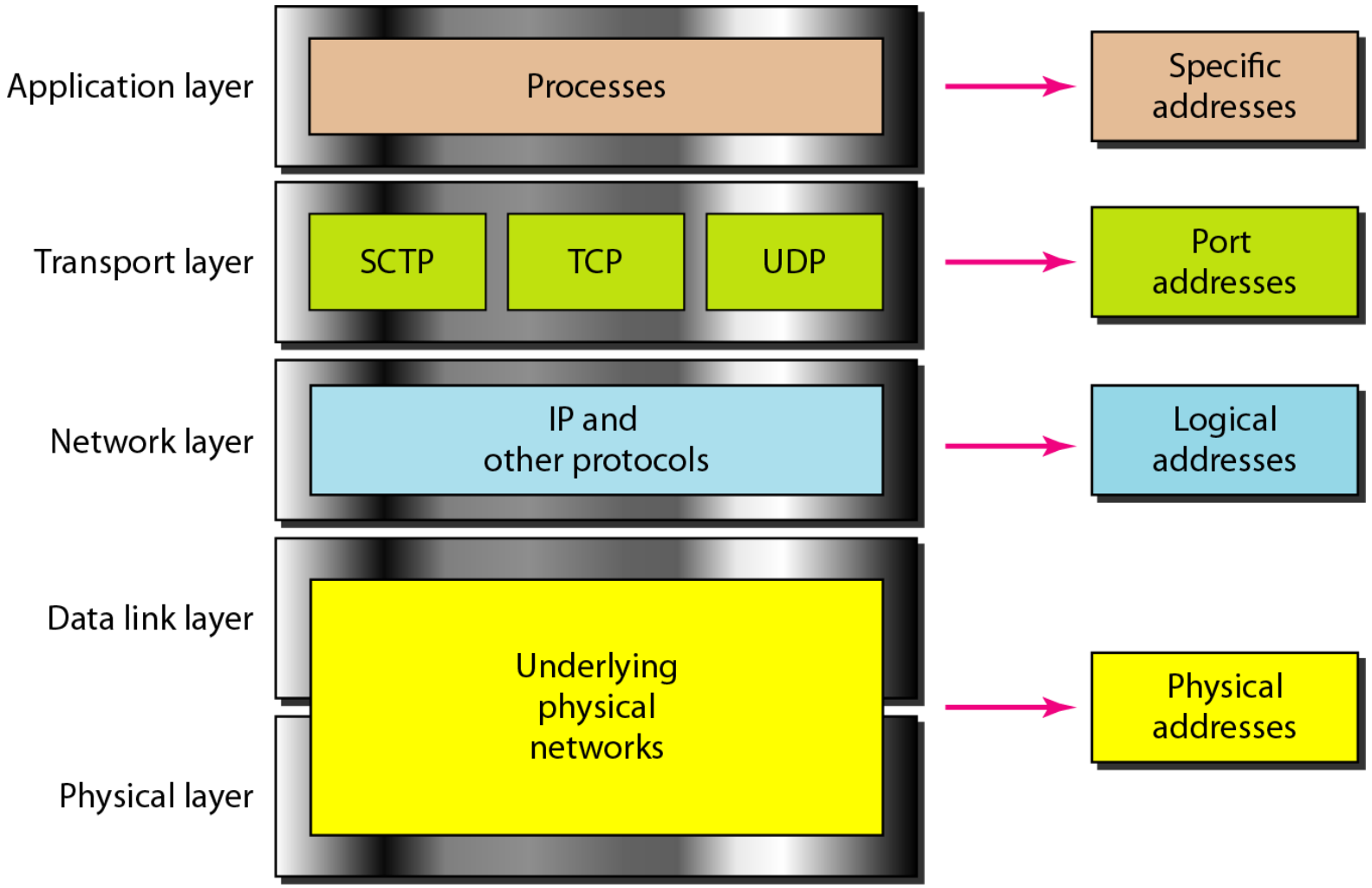
شبكات

IP Addressing

(Class 4)

By
Dr. Ali Abdulrazzaq

TCP/IP Layers



TCP/IP PROTOCOL SUITE

ADDRESSING

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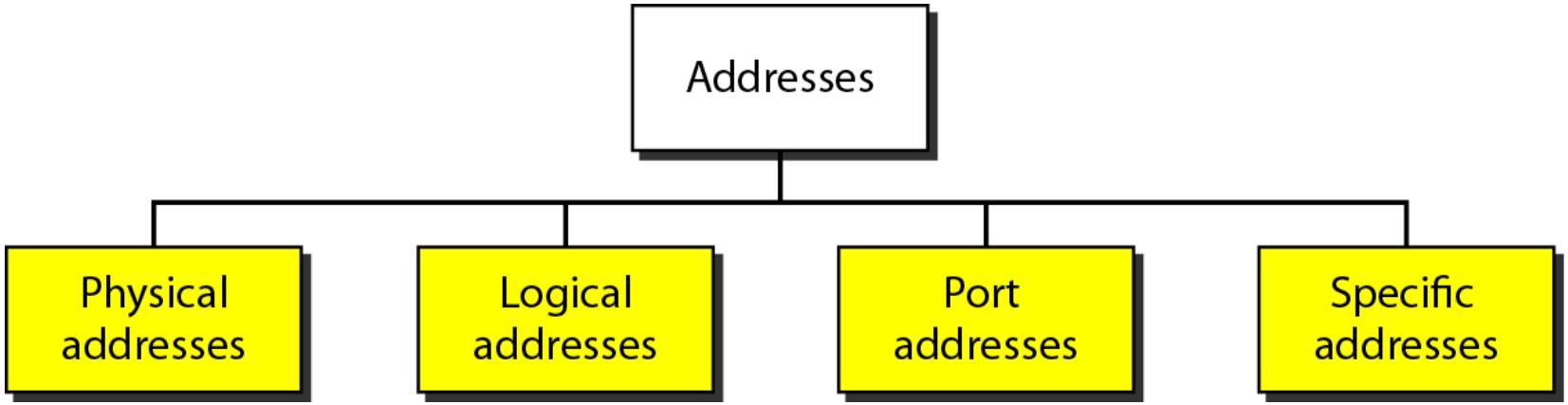


Physical Address

- *Physical address or (hardware Address), or Media Address Control MAC address.*
- *Each node has a unique MAC Address: Globally identifier that burned into your RAM of your network interface card.* كل جهاز يحتوي على عنوان الماك معرف بشكل فريد مسجل على ذاكرة بطاقة الشبكة
- *MAC Address assigned by manufacturer , each factory has a block of address assigned by IEEE.* عنوان الماك محدد من قبل الشركة المصنعة لذلك كل مصنع لدية سلسة من العناوين المحجوزة من قبل مؤسسة IEEE
- *No two networks in the world have the same Address.*
- *local-area networks use a 48-bit (6-byte) physical address written as 12 hexadecimal digits; every byte (2 hexadecimal digits) is separated by a colon, as shown below:*

07:01:02:01:2C:4B

A 6-byte (12 hexadecimal digits) physical address.

Network Layer:
Logical Addressing

An IP address (Internet Protocol Address) or (logical Address) is a unique address that devices use it in order to communicate with each other. العنوان المنطقي يكون بشكل عنوان منفرد لكل جهاز لغرض الاتصال مع الاجهزة الاخرى

IP addresses are managed and created by the Internet Assigned Numbers Authority (**IANA**). كل عناوين الايبي تنشيء و تدار من قبل مؤسسة IANA

IP have two versions:

1. IPv4 is 32bits
2. IPv6 is 128bits

The network layer is responsible for the delivery of individual packets from the source host to the destination host.

IPv4 ADDRESSES

An IPv4 address is 32 bits long, are unique and universal.

A protocol IPv4 has an address space. An address space is the total number of addresses used by the protocol. If a protocol uses *N* bits to define an address, the address space is 2^N.

عنوان ال IPv4يحتوي على فضاء كامل من العناوين . هذا الفضاء يحتوي على العدد الكامل من العناوين المستخدمة من قبل هذا البروتوكول. اذا البروتوكول يستخدم N bits لتعريف العناوين اذن سيكون لدينا 2^N من العناوين

IPv4 uses 32-bit addresses, which means that the address space is 2^{32} or 4,294,967,296 (more than 4 billion). This means that, theoretically, if there were no restrictions, *more than 4 billion devices could be connected to the Internet.* لو استخدمت جميع عناوين الاصدار الرابع كاملا بدون قيود لكانت قادرة على ان تغطي 4 بيليون جهاز حول العالم

Notations

There are two prevalent notations to show an IPv4 address: binary notation and dotted-decimal notation. ممكن تمثيل عنوان الايبي اما بطريقة النظام الثنائي او النظام العشري

Binary Notation

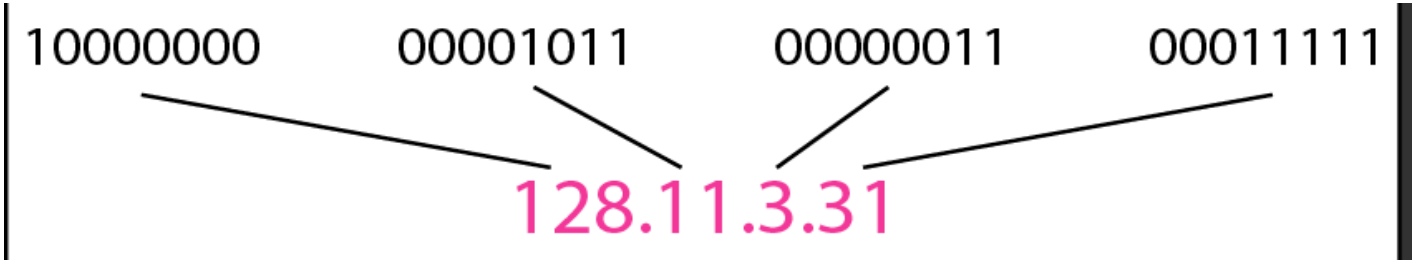
In binary notation, the IPv4 address is displayed as 32 bits. Each octet is often referred to as a byte. So it is common to hear an IPv4 address referred to as a 32-bit address or a 4-byte address. Example: 01110101 10010101 00011101 00000010

النظام الثنائي يتكون من 32-bits او ممثل ب 4-bytes

Dotted-Decimal Notation

To make the IPv4 address more compact and easier to read, Internet addresses are usually written in decimal form with a decimal point (dot) separating the bytes. Example:

لكي يكون عنوان الايبي اكثر اختصارا و سهل القراءة لذلك عادتا يكتب بشكل نظام عشري مقسم على اربعة اقسام معزولة بنقطة



Note that because each byte (octet) is 8 bits, each number in dotted-decimal notation is a value ranging from 0 to 255.

Example 2.1

Change the following IPv4 addresses from binary notation to dotted-decimal notati

a. 10000001 00001011 00001011 11101111

b. 11000001 10000011 00011011 11111111

Solution

We replace each group of 8 bits with its equivalent decimal number and add dots for separation.

a. 129.11.11.239

b. 193.131.27.255

Example 2.2

Change the following IPv4 addresses from dotted-decimal notation to binary no

a. 111.56.45.78

b. 221.34.7.82

Solution

We replace each decimal number with its binary equivalent (see Appendix B).

a. 01101111 00111000 00101101 01001110

b. 11011101 00100010 00000111 01010010

Example 2.3

Find the error, if any, in the following IPv4 addresses.

a. 111.56.045.78

b. 221.34.7.8.20

c. 75.45.301.14

d. 11100010.23.14.67

Solution

a. There must be no leading zero (045). لا يجوز ان يسبق العدد بصفر

b. There can be no more than four numbers. لا يمكن ان يكون اكثر من 4 ارقام

c. Each number needs to be less than or equal to 255. 255 اي رقم لا يتجاوز ال

d. A mixture of binary notation and dotted-decimal notation is not allowed. لا يمكن الخلط بين اكثر من نظامين في ان واحد

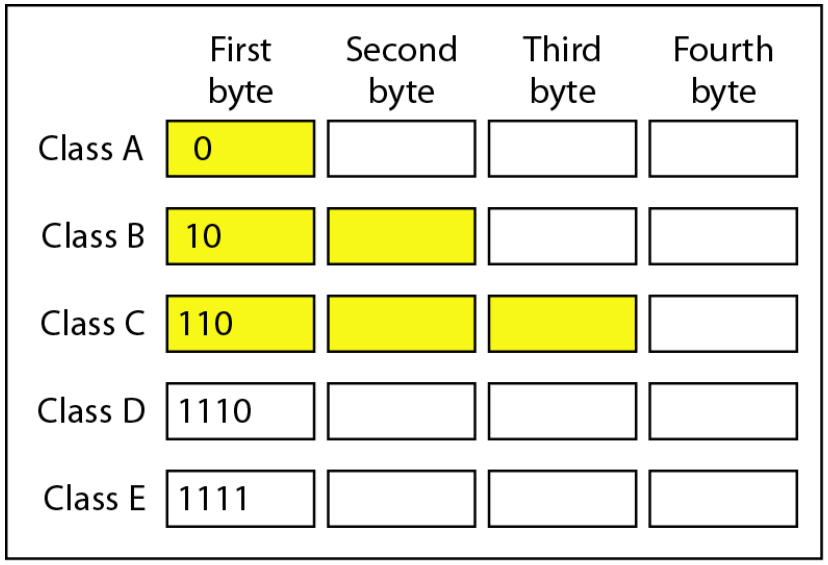
شبكات

Classful Addressing

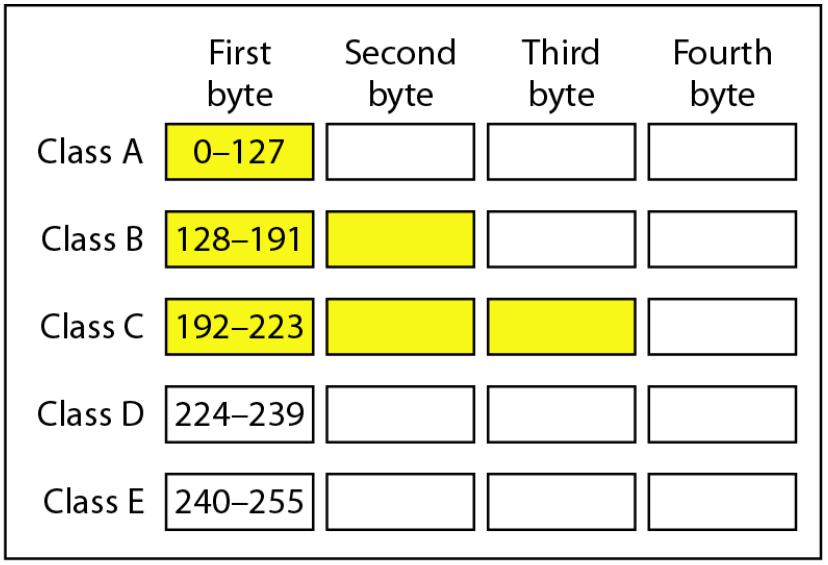
(Class 5)

By
Dr. Ali Abdulrazzaq

In classful addressing, the address space is divided into five classes: A, B, C, D, and E.



a. Binary notation



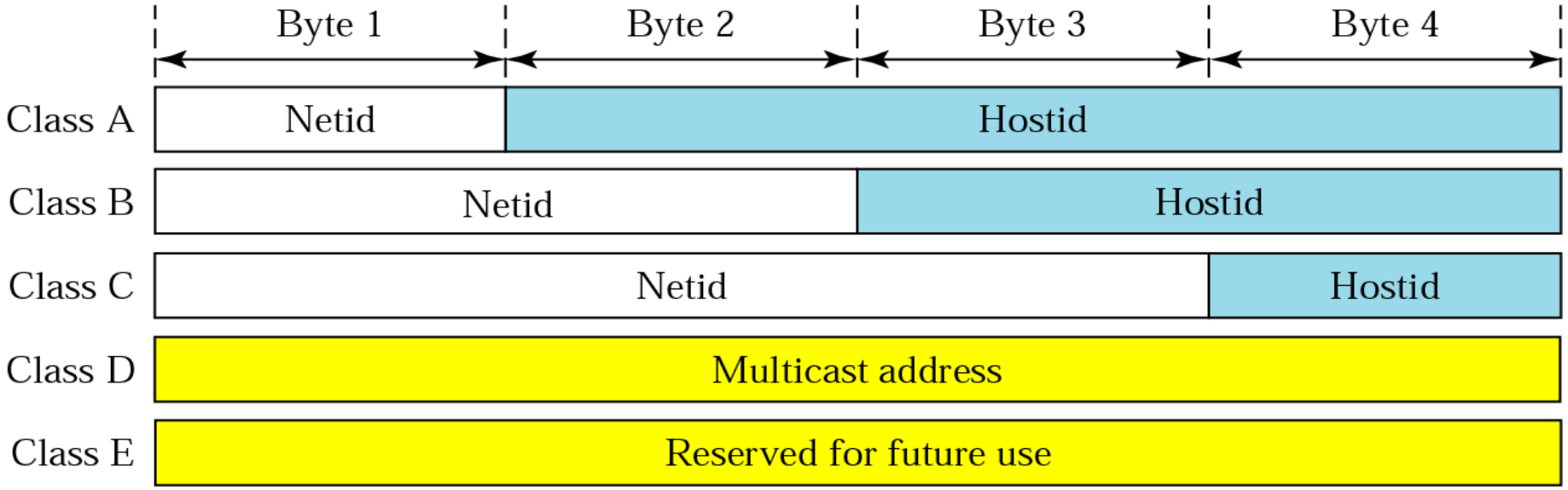
b. Dotted-decimal notation

Finding the classes in binary and dotted-decimal notation

Anatomy of an IP Address

- The IP address consists of two components:
- First component is the network portion of the address, consisting of the network bits.
- Second component is the host portion of the address, consisting of the host bits. They consist of the remaining bits not included with the network bits. The part of an IP address that identifies a host.

IP Address Classes



Class A

Class	Leading Bits	Size of *Network Number* Bit field	Size of *Rest* Bit field	Number of Networks	Addresses per Network	Start address	End address
Class A	0	8	24	128 (2^7)	16,777,216 (2^{24})	0.0.0.0	127.255.255.255

Class B

Class	Leading Bits	Size of *Network Number* Bit field	Size of *Rest* Bit field	Number of Networks	Addresses per Network	Start address	End address
Class B	10	16	16	16,384 (2^{14})	65,536 (2^{16})	128.0.0.0	191.255.255.255

Class C

Class	Leading Bits	Size of *Network Number* Bit field	Size of *Rest* Bit field	Number of Networks	Addresses per Network	Start address	End address
Class C	110	24	8	2,097,152 (2^{21})	256 (2^{8})	192.0.0.0	223.255.255.255

Class D

Class	Leading Bits	Size of *Network Number* Bit field	Size of *Rest* Bit field	Number of Networks	Addresses per Network	Start address	End address
Class D (multicast)	1110	not defined	not defined	not defined	not defined	224.0.0.0	239.255.255.255

Example 2.4

Find the class of each address?

a. 0**0000001** 00001011 00001011 11101111
b. 1**10**00001 10000011 00011011 11111111
c. 1**4**.23.120.8
d. 2**52**.5.15.111

Solution

a. ***The first bit is 0. This is a class A address.***

b. ***The first 2 bits are 1; the third bit is 0. This is a class C address.***

c. ***The first byte is 14; the class is A.***

d. ***The first byte is 252; the class is E.***

Address Depletion

Yet the number of devices on the Internet is much less than the 2^{32} address space. We have run out of class A and B addresses, and a class C block is too small for most midsize organizations. *One solution that has alleviated the problem is the idea of classless addressing.*

Classful addressing: An IPv4 addressing mechanism in which the IP address space is divided into 5 classes: A, B, C, D, and E. Each class occupies some part of the whole address space.

Classless addressing: An addressing mechanism in which the IP address space is not divided into classes.

شبكات

Classless Addressing

(Class 6)

By
Dr. Ali Abdulrazzaq

Classless Addressing

To overcome address depletion and give more organizations access to the Internet, classless addressing was designed and implemented. In this scheme.

Address Blocks

In classless addressing, when an entity, needs to be connected to the Internet, it is granted a block (range) of addresses. The size of the block (the number of addresses) varies based on the nature and size of the entity.

An ISP, as the Internet service provider, may be given thousands or hundreds of thousands based on the number of customers it may serve.

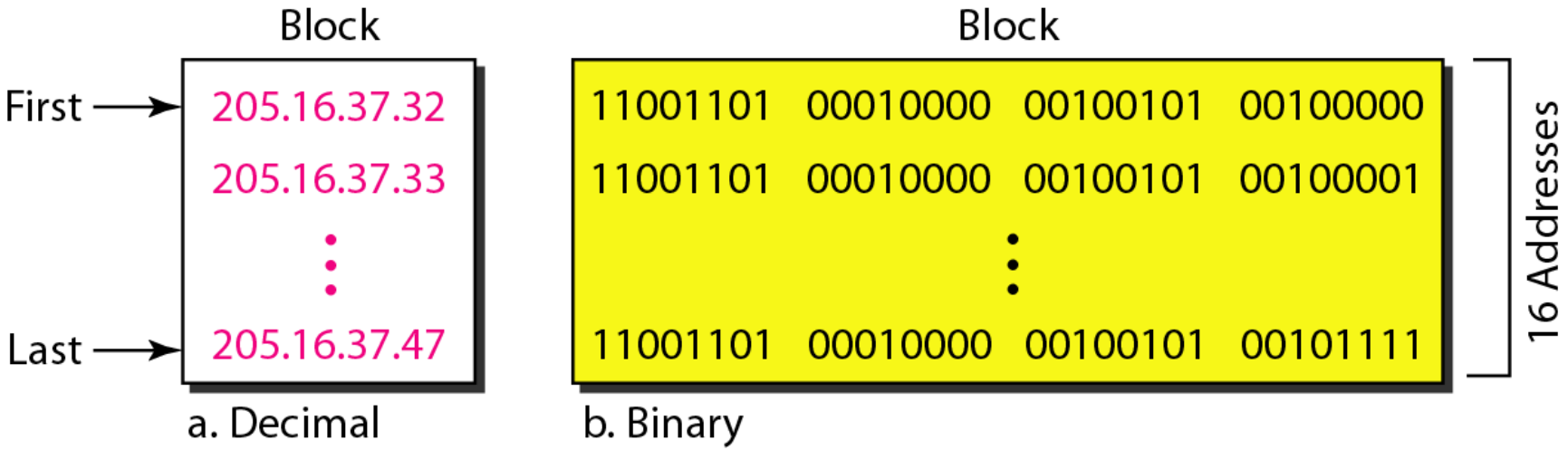
Restriction

To simplify the handling of addresses, the Internet authorities impose **three restrictions** on classless address blocks:

1. The addresses in a block must be contiguous, one after another.
2. The number of addresses in a block must be a power of 2 (1, 2,4,8,.etc)
3. The first address must be evenly divisible by the number of addresses.

Example

Figure 2.3 shows a block of addresses, in both binary and dotted-decimal notation, granted to a small business that needs 16 addresses.



We can see that the restrictions are applied to this block: The addresses are contiguous. The number of addresses is a power of 2 ($16 = 2^4$), and the first address is divisible by 16.

The address and the */n* notation completely define the whole block (the first address, the last address, and the number of addresses).

First Address The first address in the block can be found by setting the 32 - *n* rightmost bits in the binary notation of the address to 0s.

Example

A block of addresses is granted to a small organization. We know that one of the addresses is 205.16.37.39/28. What is the first address in the block?

Solution

The binary representation of the given address is

11001101 00010000 00100101 00100 111

If we set 32−28 rightmost bits to 0, we get

11001101 00010000 00100101 00100000

or

205.16.37.32

Last Address

The last address in the block can be found by setting the 32 - *n* rightmost bits in the binary notation of the address to 1s.

The last address in the block can be found by setting the rightmost : 32 − n bits to 1s.

Example

Find the last address for the block.

205.16.37.39/28

Solution

The binary representation of the given address is

11001101 00010000 00100101 00100111

If we set 32 − 28 rightmost bits to 1, we get

11001101 00010000 00100101 00101111

or

205.16.37.47

The number of addresses in the block can be found by using the formula : 2^{32-n}

Example

Find the number of addresses in Example 6.6.

205.16.37.39/28

Solution

The value of n is 28, which means that number of addresses is 2^{32-28} or 16.

205.16.37.32 → *205.16.37.47*

Example

Another way to find the first address, the last address, and the number of addresses is to represent the mask as a 32bit binary (or 8-digit hexadecimal) number. This is particularly useful when we are writing a program to find these pieces of information. Ex: The 205.16.37.39/28 , /28 can be represented as (Mask Definition)

11111111 11111111 11111111 11110000

(twenty-eight 1s and four 0s).

Find

a. The first address

b. The last address

c. The number of addresses.

Solution

a. **The first address can be found by ANDing the given addresses with the mask. ANDing here is done bit by bit. The result of ANDing 2 bits is 1 if both bits are 1s; the result is 0 otherwise.**

Address:	11001101	00010000	00100101	00100111
Mask:	**11111111**	**11111111**	**11111111**	**11110000**
First address:	11001101	00010000	00100101	00100000

205.16.37.32

b. **The last address can be found by ORing the given addresses with the complement of the mask. ORing here is done bit by bit. The result of ORing 2 bits is 0 if both bits are 0s; the result is 1 otherwise. The complement of a number is found by changing each 1 to 0 and each 0 to 1.**

Address:	11001101	00010000	00100101	00100111
Mask complement:	**00000000**	**00000000**	**00000000**	**00001111**
Last address:	11001101	00010000	00100101	00101111

205.16.37.47

c. **The number of addresses can be found by complementing the mask, interpreting it as a decimal number, and adding 1 to it.**

Mask complement: 00000000 00000000 00000000 00001111

Number of addresses: 15 + 1 = 16

Example:

A block of addresses is granted to a small organization. We know that one of the addresses is 190.100.0.136/26. using Classless and Mask Definition methods

What is the:-

first address in the block: 190.100.0.128

Last address in the block: 190.100.0.191

Number of Addresses in the block: 64

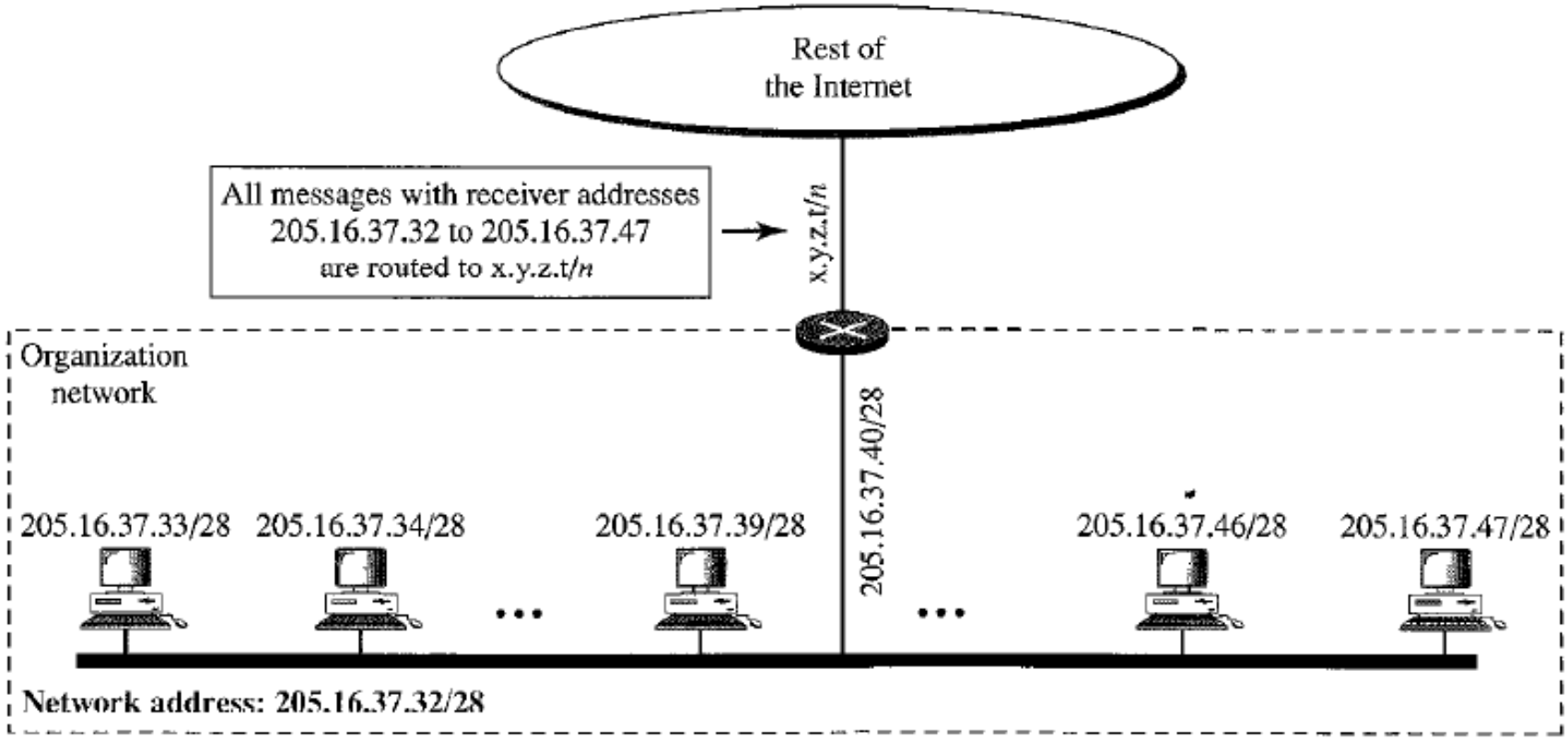
شبكات

Subnetting Addressing

(Class 7)

By
Dr. Ali Abdulrazzaq

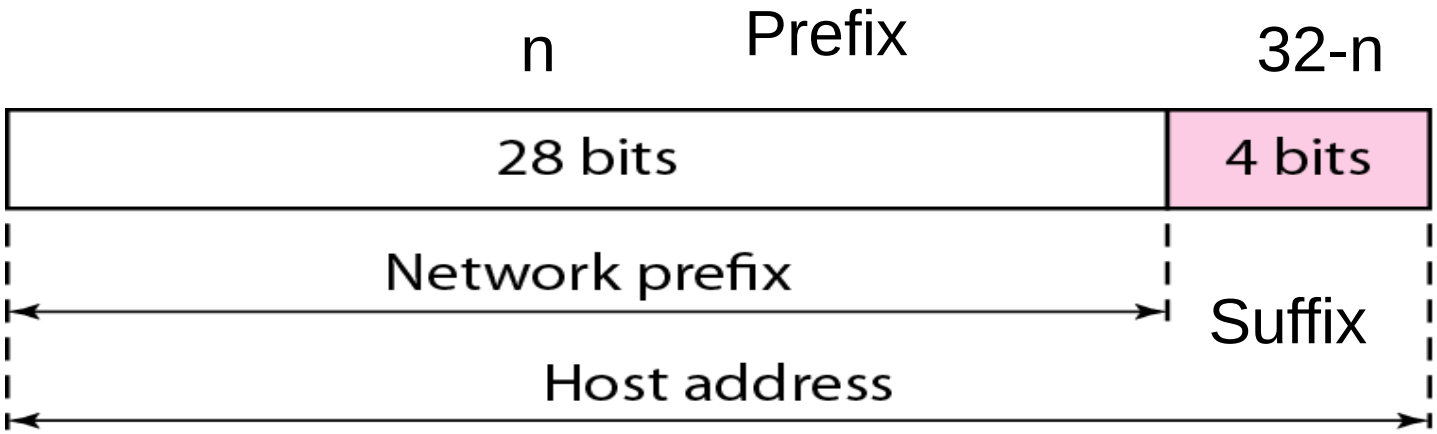
Network Addresses



The first address in a block is normally not assigned to any device; it is used as the network address that represents the organization to the rest of the world.

Two-Level Hierarchy: No Subnetting

An IP address can define only two levels of hierarchy when not subnetted. The *n* leftmost bits of the address *x.y.z.t/n* define the network; the 32 – *n* rightmost bits define the particular host to the network. The part of the address that defines the network is called the **prefix**; the part that defines the host is called the **suffix**.



Three-Levels of Hierarchy: Subnetting

An organization that is granted a large block of addresses may want to create clusters of networks (called subnets) and divide the addresses between the different subnets.

The organization, however, needs to create small sub blocks of addresses, each assigned to specific subnets. The organization has its own mask; each subnet must also have its own.

As an example, suppose an organization is given the block 17.12.14.0/26, which contains 64 addresses. The organization has three offices and needs to divide the addresses into three sub blocks of 32, 16, and 16 addresses. We can find the new masks by using the following arguments:

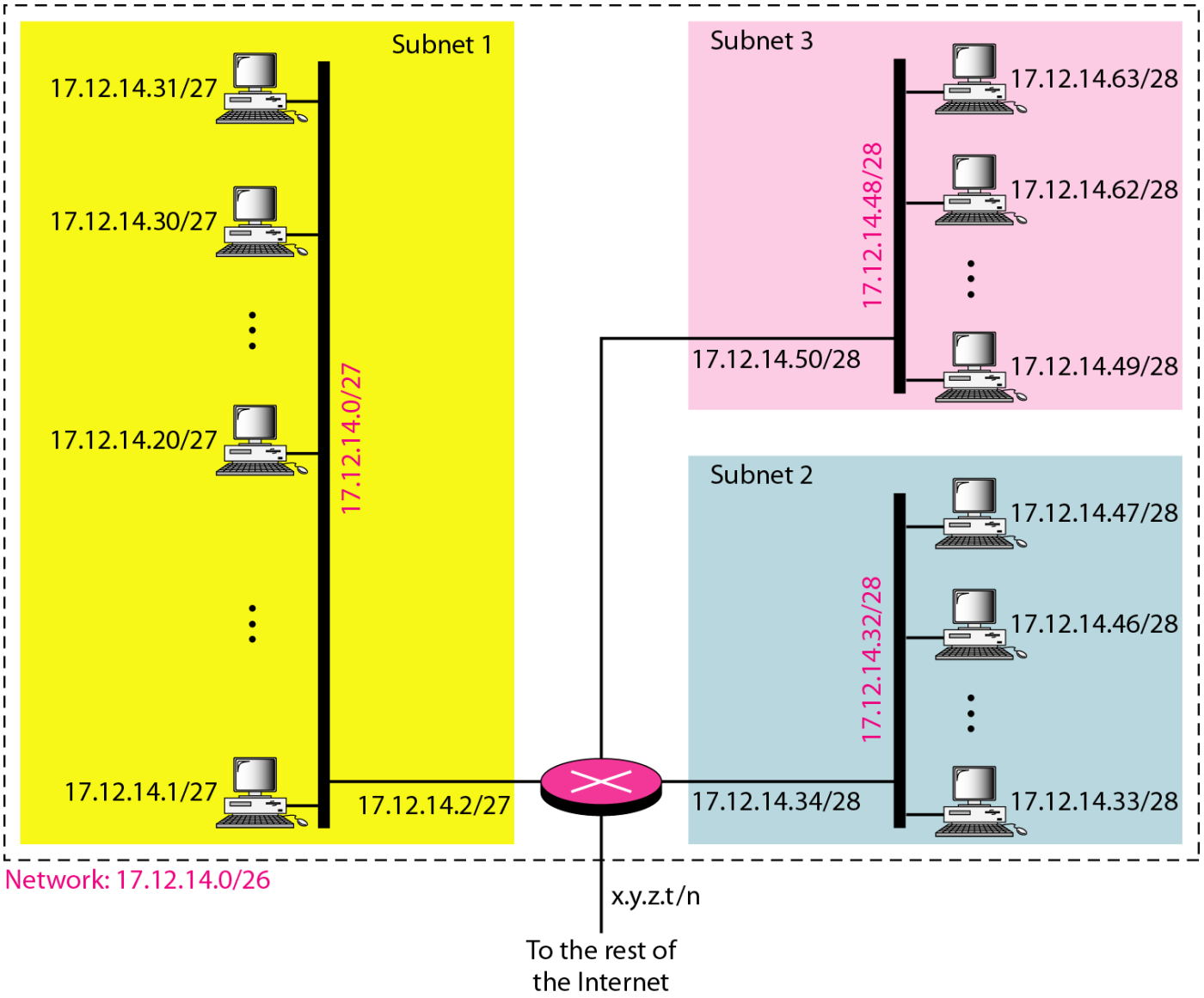
Find the mask for each subnet

1. Suppose the mask for the first subnet is n1, then 2^{32-n1} must be 32, which means that n1 =27.

2 . Suppose the mask for the second subnet is n2, then 2^{32-n2} must be 16, which means that n2 = 28.

3. Suppose the mask for the third subnet is n3, then 2^{32-n3} must be 16, which means that n3 =28.

Configuration and addresses in a subnetted network



Let us check to see if we can find the subnet addresses from one of the addresses in the subnet.

a. In subnet 1, the address 17.12.14.29/27 can give us the subnet address if we use the mask /27 because
Host: 00010001. 00001100. 00001110. 00011101
Mask:11111111 11111111 11111111 11100000 /27 (AND)
Subnet: 00010001 00001100 00001110 00000000 ....
Start (17.12.14.0) end(17.12.14.31)

b. **In subnet 2**, the address 17.12.14.45/28 can give us the subnet address if we use the mask /28 because
Host: 00010001 00001100 00001110 00101101
Mask:11111111 11111111 11111111 11110000 /28 (AND)
Subnet: 00010001 00001100 00001110 00100000 ....
Start (17.12.14.32) end(17.12.14.47)

c. **In subnet 3**, the address 17.12.14.50/28 can give us the subnet address if we use the mask /28 because

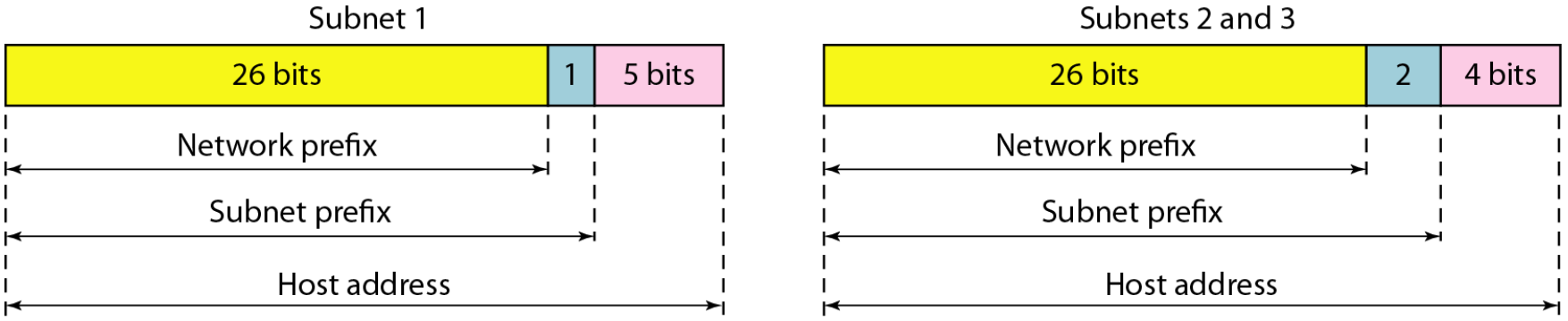
Host: 00010001 00001100 00001110 00110010

Mask:11111111 11111111 11111111 11110000 /28 (AND)

Subnet: 00010001 00001100 00001110 00110000 ....

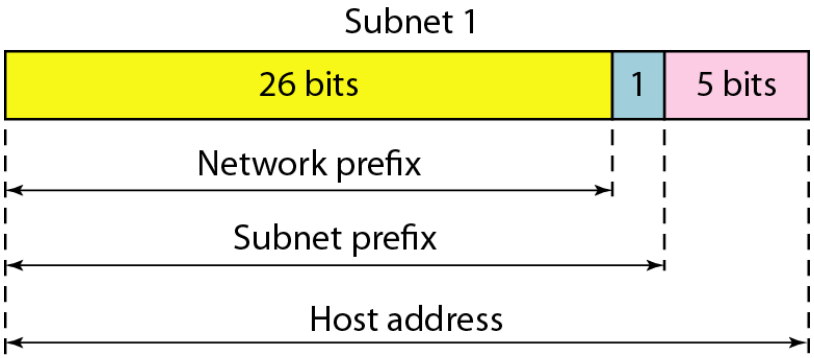
Start (17.12.14.48) end (17.12.14.63)

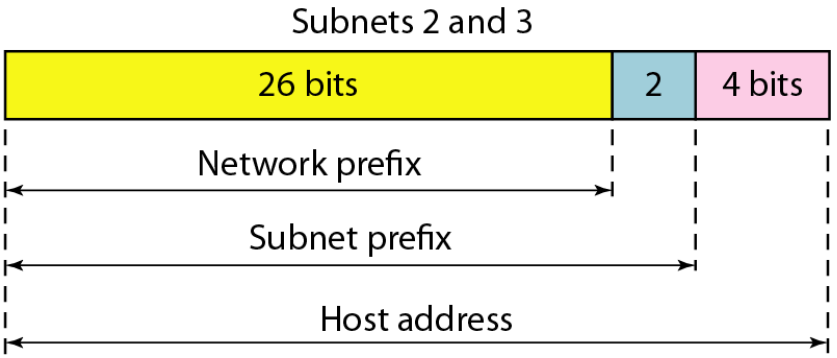
We can say that through subnetting, we have three levels of hierarchy.



Three-level hierarchy in an IPv4 address

Q/Analyze three – level of hierarchy as shown below for this network address 17.12.14.0/26 and draw the network diagram?





شبكات

Subnetting Addressing Group level

(Class 8)

By
Dr. Ali Abdulrazzaq

More Levels of Hierarchy

Large Block →Divide into →Small Blocks →Divide into→ Sub Blocks → Customers

National ISP → Regional ISP → Local ISP → Organization → Several Sub nets.

Address Allocation

How are the blocks allocated? The ultimate responsibility of address allocation is given to a global authority called the *Internet Corporation for Assigned Names and Numbers* (ICANN). However, ICANN does not normally allocate addresses to individual organizations. It assigns a large block of addresses to an ISP. Each ISP, in turn, divides its assigned block into smaller sub blocks and grants the sub blocks to its customers.

ICANN →National ISP → Regional ISP → Local ISP → Organization → Several Sub nets.

Example

An ISP is granted a block of addresses starting with 190.100.0.0/16 (65,536 addresses). The ISP needs to distribute these addresses to three groups of customers as follows:

a. The first group has 64 customers; each needs 256 addresses.
b. The second group has 128 customers; each needs 128 addresses.
c. The third group has 128 customers; each needs 64 addresses.

Design the sub blocks and find out how many addresses are still available after these allocations?

- **An ISP is granted a block of addresses starting with 187.97.0.0/16 (65,536 addresses). The ISP needs to distribute**

these addresses to three groups of customers as follows:

- **The first group has 128 customers; each needs 64 addresses.**

- **The second group has 128 customers; each needs 128 addresses**

- **The third group has 64 customers; each needs 256 addresses.**

Solution

Figure below shows the situation.

Group 1

For this group, each customer needs 256 addresses. This means that 8 ($\log_2$ 256) bits are needed to define each host. The prefix length is then 32 − 8 = 24. The addresses are

1st Customer:	*190.100.0.0/24*	*190.100.0.255/24*
2nd Customer:	*190.100.1.0/24*	*190.100.1.255/24*
. . .		
64th Customer:	*190.100.63.0/24*	*190.100.63.255/24*

Total = 64 × 256 = 16,384

Group 2

For this group, each customer needs 128 addresses. This means that 7 ($\log_2$ 128) bits are needed to define each host. The prefix length is then 32 − 7 = 25. The addresses are

1st Customer:	*190.100.64.0/25*	*190.100.64.127/25*
2nd Customer:	*190.100.64.128/25*	*190.100.64.255/25*
. . .		
128th Customer:	*190.100.127.128/25*	*190.100.127.255/25*

Total = 128 × 128 = 16,384

Group 3

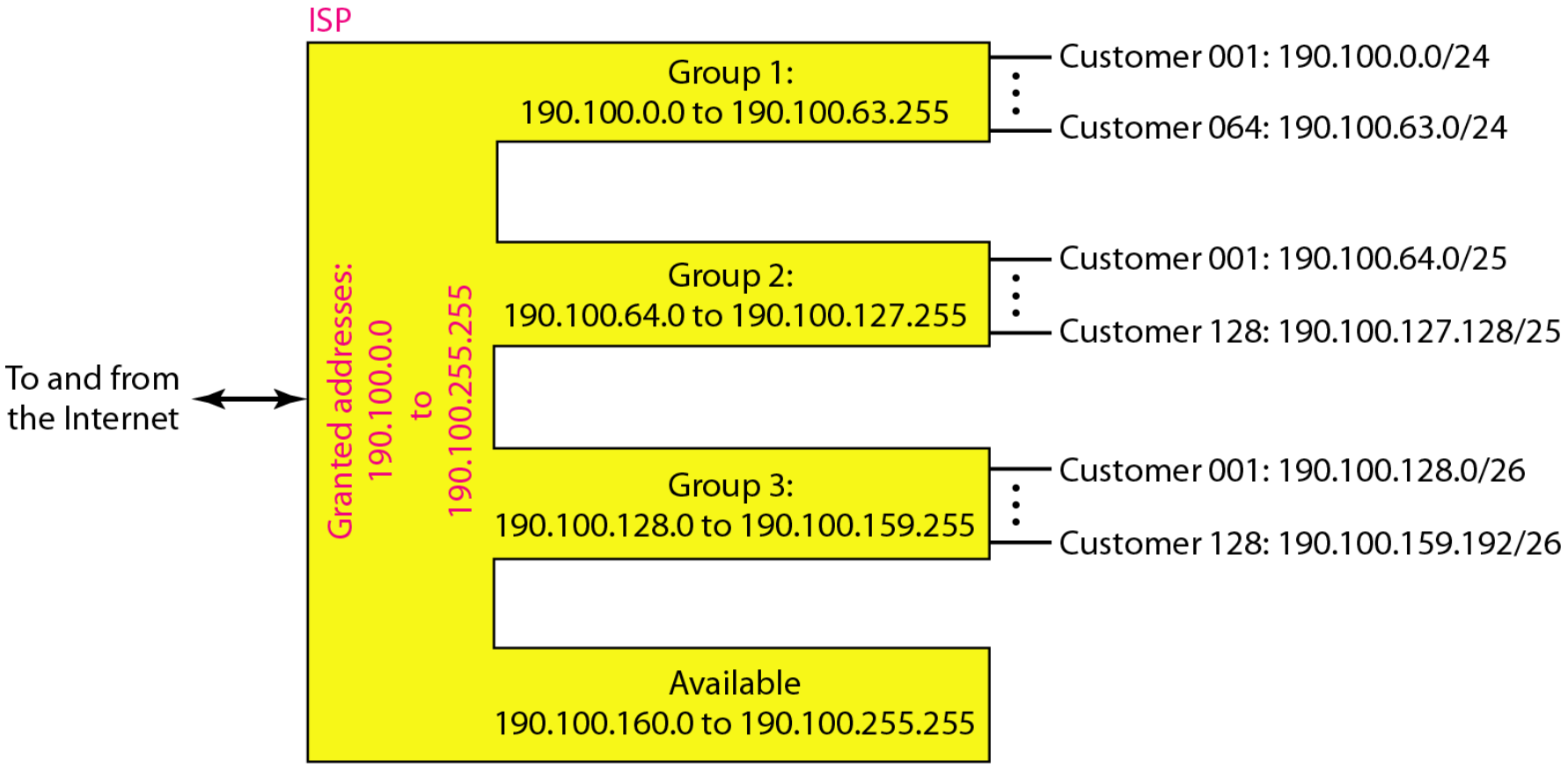
For this group, each customer needs 64 addresses. This means that 6 ($\log_2 64$) bits are needed to each host. The prefix length is then 32 − 6 = 26. The addresses are

1st Customer:	*190.100.128.0/26*	*190.100.128.63/26*
2nd Customer:	*190.100.128.64/26*	*190.100.128.127/26*
. . .		
128th Customer:	*190.100.159.192/26*	*190.100.159.255/26*

Total = 128 × 64 = 8192

Number of granted addresses to the ISP: 65,536
Number of allocated addresses by the ISP: 40,960
Number of available addresses: 24,576

An example of address allocation and distribution by an ISP



شبكات

Network Address Translation NAT

(Class 9)

By
Dr. Ali Abdulrazzaq

Network Address Translation (NAT)

A technology that allows a private network to use a set of private addresses for internal communication and a set of global Internet addresses for external communication.

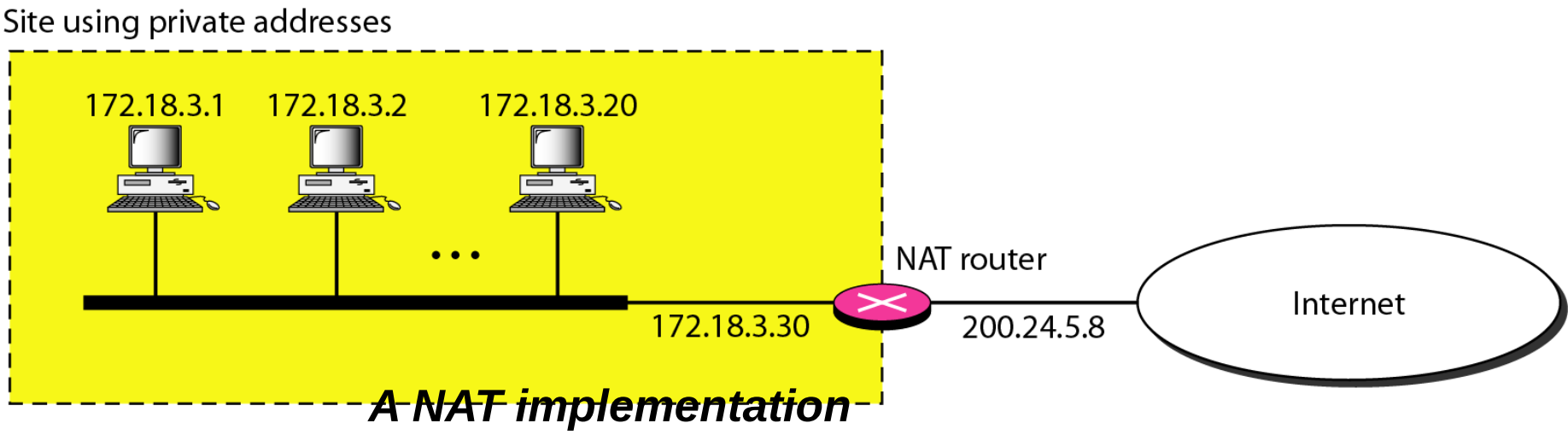
تقنية تسمح للشبكة المحلية باستخدام مجموعة من العناوين الخاصة للاتصال الداخلي و مجموعة من العناوين الخارجية للاتصال الخارجي

It provides a mapping between internal IP addresses and officially assigned external addresses.يكون حلقة وصل بين العناوين الداخلية و العناوين الخارجية

The Internet authorities have reserved three sets of addresses as private addresses, shown below: الجدول ادناه يوضح ثلاث مجموعات من العناوين الخاصة (الداخلية)

Range			*Total*
10.0.0.0	to	10.255.255.255	2^{24}
172.16.0.0	to	172.31.255.255	2^{20}
192.168.0.0	to	192.168.255.255	2^{16}

They are unique inside the organization, but they are not unique globally. No router will forward a packet that has one of these addresses as the destination address. العنوان الداخلي هو عنوان فريد داخل الشبكة و لكن ليس هو الحال في الشبكة الخارجية الانترنيت



A NAT implementation

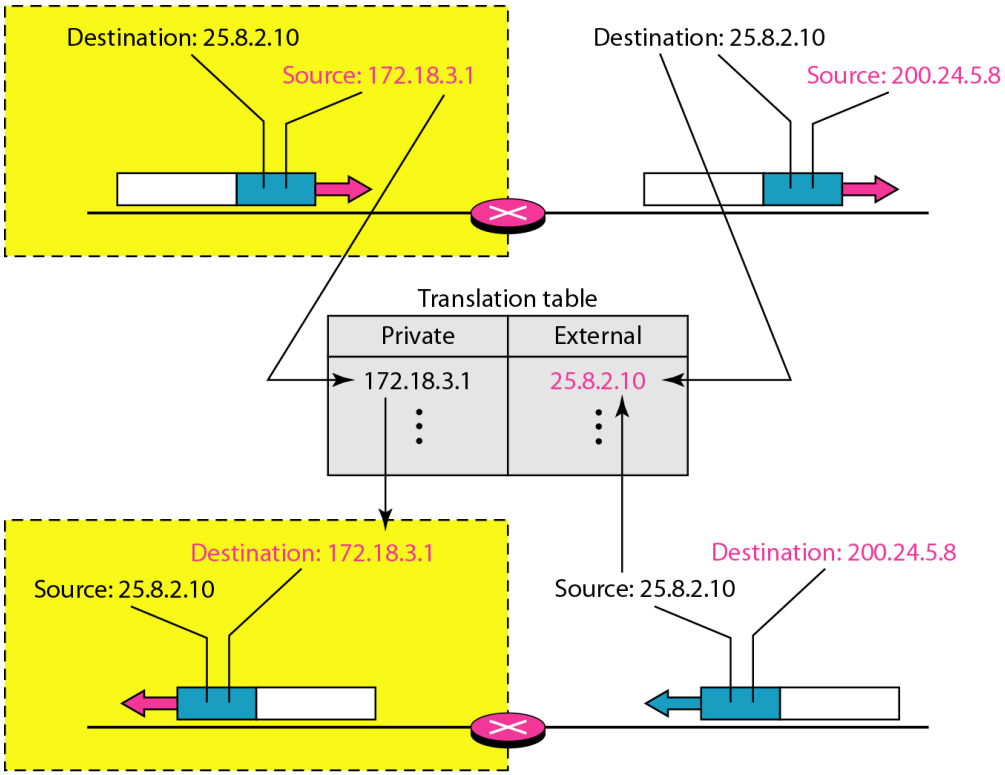
The router that connects the network to the global address uses one private address and one global address. اي راوتر يحتوي على عنوانين : هما عنوان داخلي للشبكة الداخلية و عنوان خارجي للشبكة الخارجية

Translation Table

Types of NAT:

1- One IP Address
2- Pool of IP Addresses
3- Both IP Addresses and Port Numbers

1- One IP Address



1. Using One IP Address:

A translation table has only two columns: the private address and the external address.

في هذا النوع من ترجمة العناوين يكون لكل عنوان داخلي عنوان خارجي يقابله

2. *Using a Pool of IP Addresses*

Since the NAT router has only one global address, only one private network host can access the same external host.

في هذا النوع يكون لكل عنوان خارجي واحد مجموعة (حوض) من العناوين الداخلية. اي ان هناك اتصال واحد لكل عنوان داخلي مع العنوان الخارجي لا يشاركه اي عنوان اخر

3. *Using Both IP Addresses and Port Numbers*

To allow a many-to-many relationship between private-network hosts and external server programs, we need more information in the translation table. في هذا النوع من ترجمة العناوين يمكن لكل عنوان خارجي ان يستخدم مع مجموعة من العناوين الداخلية في نفس الوقت. ذلك يكون عن طريق تخصيص منفذ خاص لكل عنوان داخلي كما موضح في الجدول ادناه

Private Address	*Private Port*	*External Address*	*External Port*	*Transport Protocol*
172.18.3.1	1400	25.8.3.2	80	TCP
172.18.3.2	1401	25.8.3.2	80	TCP
. . .	. . .	. . .	. . .	. . .