

# Network Computing courses

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ENSIBS - UBS

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Figure : [teaching.auzias.net](http://teaching.auzias.net)

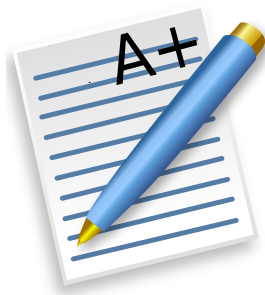
# Course details

## Objectives

- ▶ How do *computers* communicate?
- ▶ What are the mechanisms **under** an HTTP request or a telegram message?
- ▶ Networks are all around us, better study them!



# Course details



## Evaluation

- ▶ Short test at the beginning of every lesson (5 min) ?
- ▶ Project
- ▶ Final exam (1 hour)
- ▶ All same weighting

## Material

- ▶ Slides available at [teaching.auzias.net](https://teaching.auzias.net) (github too)

# Presentation Outline

## Introduction

- Definitions and presentation

- Network classification

- HTTP request/response example

- Models overview (OSI and TCP/IP)

## Layers

- Physical

- Data Link

- Network

  - IP addressing

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- ▶ **IP:** Internet **Protocol** provides the functions necessary to deliver a package of bits from a source to a destination over a network
- ▶ **(world wide) Web: network** consisting of a collection of Internet websites using HTTP



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- ▶ **RFC:** Request For Comments (Internet Draft (ID), RFC, Internet Standard)

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- ▶ **NAT:** Network Address Translation, router modifying IP address into another IP address.

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- ▶ **Thin client: application** where most functions are carried out on a central server

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- ▶ **WAN:** Wide Area Networks cover a broad area (Internet)

# Topologies

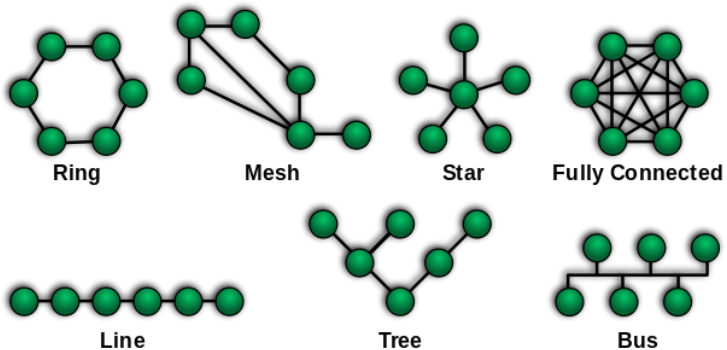


Figure : [upload.wikimedia.org](http://upload.wikimedia.org)



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- ▶ **Tree:** hierarchical topology, such as a binary tree.

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## Bonus

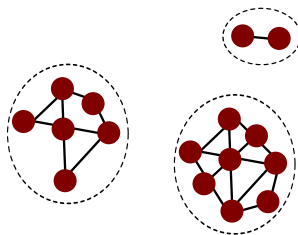


Figure : Disconnected MANET illustration [?]

# Bonus

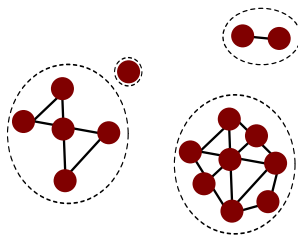


Figure : Store-carry-and-forward [?]

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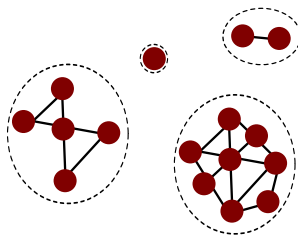


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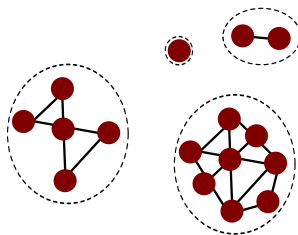


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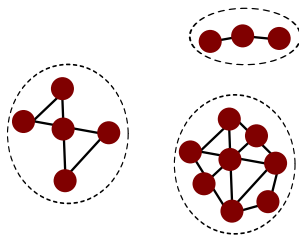


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Source	Destination	Protocol	Length	Info
192.168.0.48	208.67.222.222	DNS	76	Standard query 0x4797 A getbootstrap.com
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127.0.0.1	127.0.0.13	TCP	74	36159 > http [SYN] Seq=0 Win=43690 Len=0 MSS=65495 SACK_PERM=1 TSval=12
127.0.0.13	127.0.0.1	TCP	74	http > 36159 [SYN, ACK] Seq=0 Ack=1 Win=43690 Len=0 MSS=65495 SACK_PERM
127.0.0.1	127.0.0.13	TCP	66	36159 > http [ACK] Seq=1 Ack=1 Win=43776 Len=0 TSval=122257 TSecr=12225
127.0.0.1	127.0.0.13	HTTP	356	GET /index.html HTTP/1.1
127.0.0.13	127.0.0.1	TCP	66	http > 36159 [ACK] Seq=1 Ack=291 Win=44800 Len=0 TSval=122259 TSecr=122
127.0.0.13	127.0.0.1	HTTP	354	HTTP/1.1 200 OK (text/html)
127.0.0.1	127.0.0.13	TCP	66	36159 > http [ACK] Seq=291 Ack=289 Win=44800 Len=0 TSval=122259 TSecr=1
127.0.0.1	127.0.0.13	HTTP	357	GET /favicon.ico HTTP/1.1
127.0.0.13	127.0.0.1	HTTP	565	HTTP/1.1 404 Not Found (text/html)
127.0.0.1	127.0.0.13	TCP	66	36159 > http [ACK] Seq=582 Ack=788 Win=45952 Len=0 TSval=122269 TSecr=1

Figure : HTTP request/response



# How do messages reach their destination?

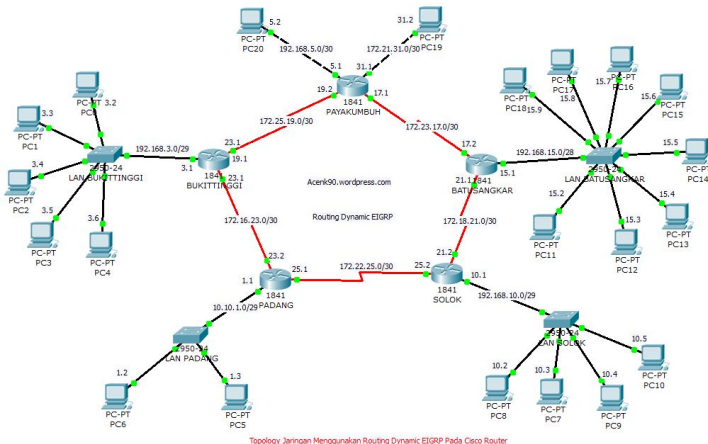
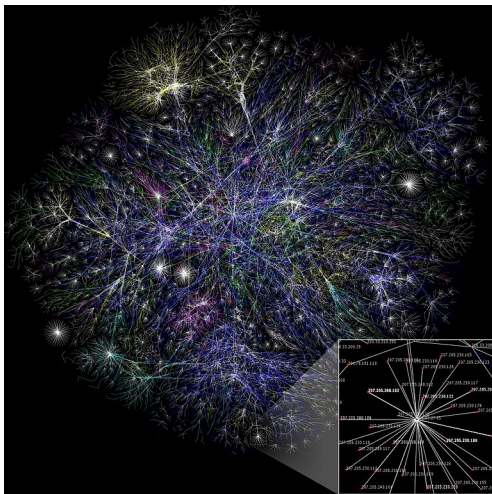


Figure : [acenk90.files.wordpress.com](http://acenk90.files.wordpress.com)

More like this...



## How does it work? From signal to application...

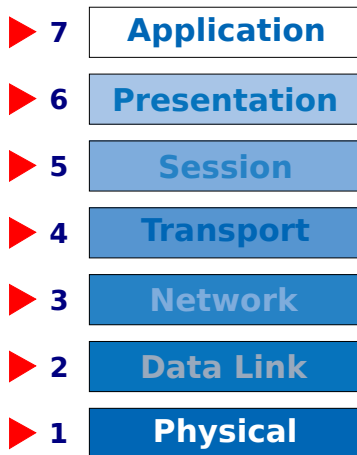
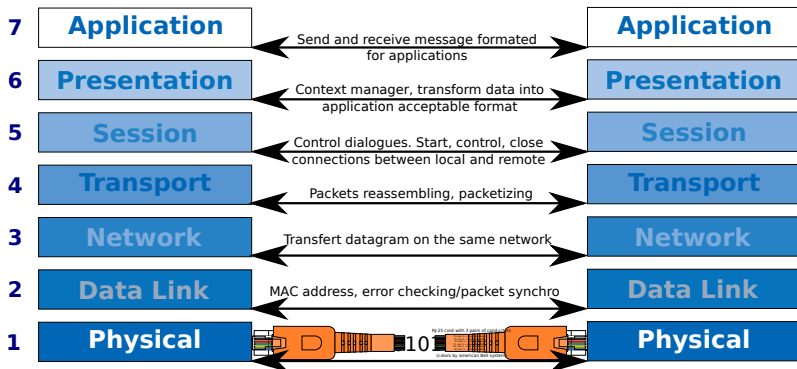
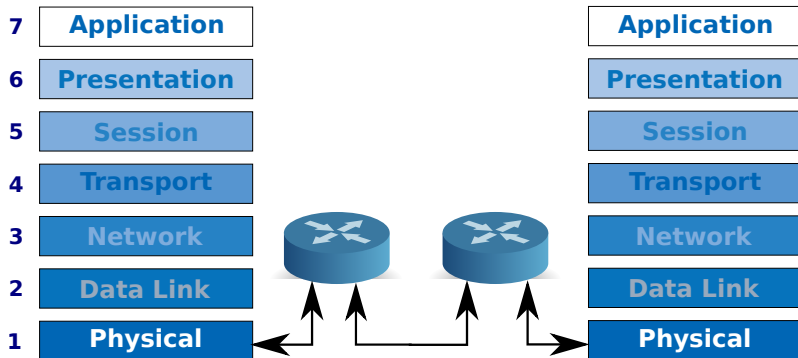


Figure : OSI model

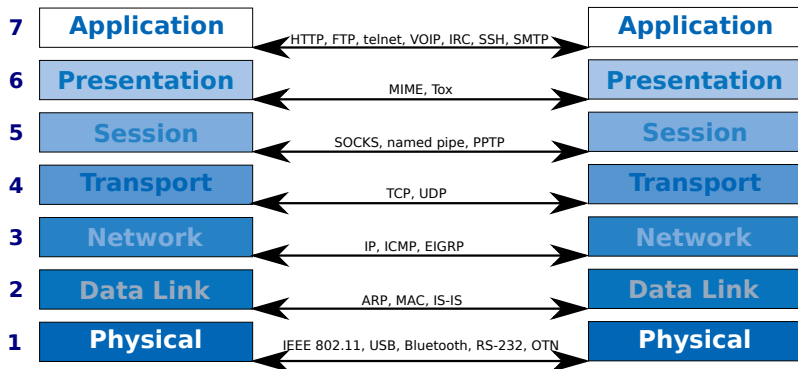
# $N^{\text{th}}$ layer communicate with $N^{\text{th}}$ layer..



.. thanks to 3<sup>th</sup> layers



# One single protocol, one single layer



# Encapsulation

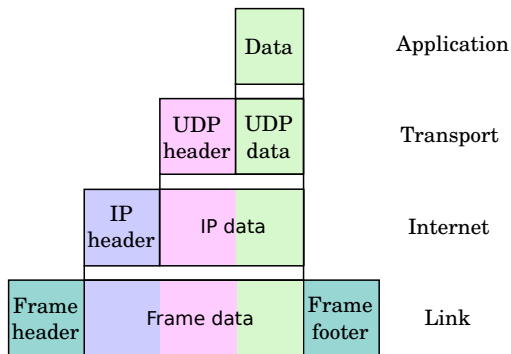


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HTTP request/response example

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Data Link

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IP addressing



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- ▶ (De)Encode,
- ▶ Transmit: 1 after 0 (after 0 or 1, after 0... or 1)

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- ▶ USB, serial port such as RS-232...

## Hardware medium: IEEE 802.3 (Ethernet)



Figure : RJ45 connector

## Hardware medium: IEEE 802.15.1 (Bluetooth)

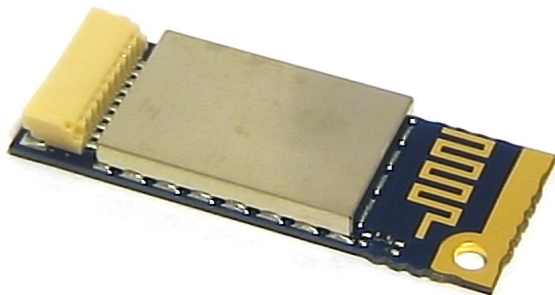


Figure : Bluetooth card

## Hardware medium: IEEE 802.15.4 (ZigBee)

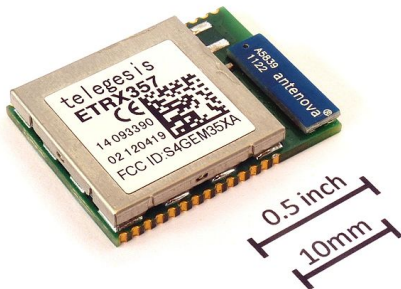


Figure : ZigBee card

## Hardware medium: IEEE 802.16 (Wi-Max)



Figure : Wi-Max antenna

## Hardware medium: IEEE 1394 (Firewire)



Figure : Firewire connector

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## Encoding: Multi-Level Transmit

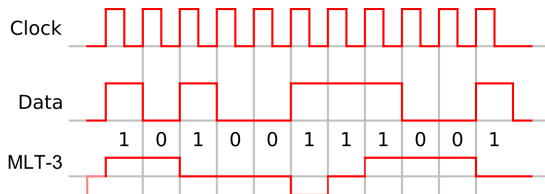


Figure : Multi-Level Transmit

## Encoding: Alternate Mark Inversion

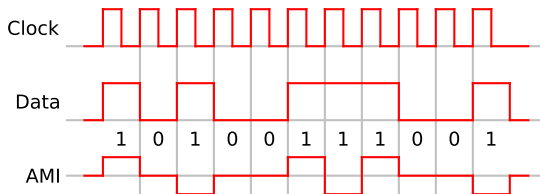


Figure : Alternate Mark Inversion

# Encoding: Manchester

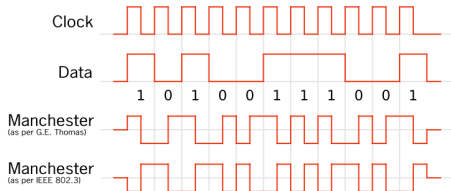


Figure : Manchester

## Encoding: Biphas Mark Code

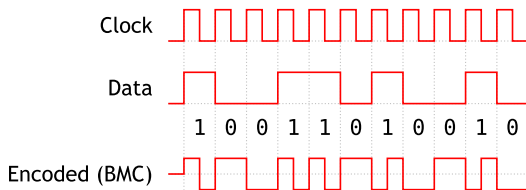


Figure : Biphas Mark Code



# Transmitting

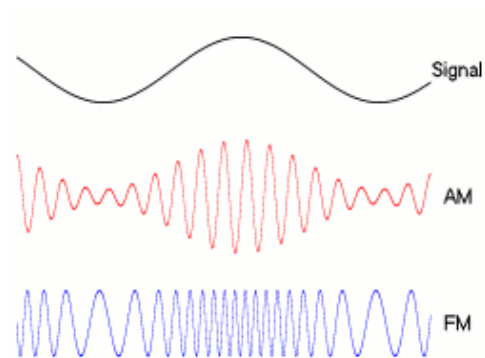


Figure : Amplitude and phase modulation

# Error detection

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# Error correcting

- ▶ Repetition (again)



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- ▶ Hamming

# Error correcting

- ▶ Repetition (again)
- ▶ Hamming
- ▶ MDPC (Multidimensional parity-check code)

## Correction: MDPC

Raw data to send: 0x01 02 03 04

0x01	0x02	0x03
0x03	0x04	0x07
0x04	0x06	

Figure : Data received with MDPC

Data sent (with MDPC): 0x01 02 03 03 04 07 04 06

# Aims

- ▶ Interface network layer,

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- ▶ Delivery to unique(?) hardware addresses,

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- ▶ Delivery to unique(?) hardware addresses,
- ▶ Framing,
- ▶ Data transfer

## Layer composition (of its two sublayers)

1. Logical Link Control (LLC):
  - ▶ end to end flow control
  - ▶ end to end error control
  - ▶ (transmitting/receiving) protocols, over MAC sublayer, multiplexing



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1. Logical Link Control (LLC):
  - ▶ end to end flow control
  - ▶ end to end error control
  - ▶ (transmitting/receiving) protocols, over MAC sublayer, multiplexing
2. Media Access Control (MAC):
  - ▶ physical (hardware) addressing
  - ▶ collision detection and retransmission
  - ▶ data packet scheduling (and queuing)
  - ▶ QoS
  - ▶ VLAN

# Carrier Sense Multiple Access with Collision Avoidance

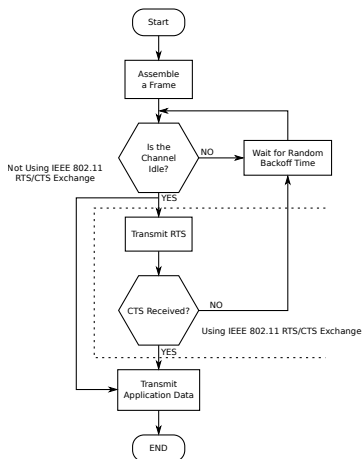


Figure : CSMA CA

## Layer 2 Ethernet packet

MAC dest. (6)	MAC src. (6)	VLAN tag* (4)	Ethertype (2)
Payload (42-1500)		Frame check sequence (4)	

Figure : Layer 2 Ethernet packet

optional, Content (size in bytes)

Ethertype 0x	Protocol
0800	IPv4
0806	ARP
0842	Wake-on-LAN
86dd	IPv6

Figure : Data received with MDPC

## ARP example

<b>0000</b>	ff	ff	ff	ff	ff	ff	fa	ba	00	ab	ab	af	08	06	00	01
<b>0010</b>	08	00	06	04	00	01	fa	ba	00	ab	ab	af	ac	11	22	37
<b>0020</b>	00	00	00	00	00	00	ac	11	00	f9	00	00	00	00	00	00
<b>0030</b>	00	00	00	00	00	00	00	00	00	00	00	00				

Figure : ARP request

MAC address destination MAC address source Ethertype Hardware  
type Protocol type OpCode (1 request, 2 reply) IP address source  
IP address destination

# ARP example

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<b>0030</b>	00	00	00	00	00	00	00	00	00	00	00	00				

Figure : ARP reply

MAC address destination MAC address source Ethertype Hardware  
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# ARP example

<b>0000</b>	fa	ba	00	ab	ab	af	be	be	00	00	eb	eb	08	06	00	01
<b>0010</b>	08	00	06	04	00	01	be	be	00	00	eb	eb	ac	11	00	f9
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- ▶ Routing, load balancing

# Concepts

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- ▶ Classfull IP addressing,
- ▶ Subnet and VLSM (Variable length subnet masks),
- ▶ CIDR (Classless inter-domain routing).

# IP addressing fundamentals

## IP address

32 bits (4x4 bytes)

mask	
Networks part	Host part

Figure : IP address parts



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## Masks

- ▶ Separates **network** and **host** bits,

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## Masks

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- ▶ Indicates how many bits are used for the **network** part:
  - ▶ A 8-bit **mask** leaves 24 bits for the **hosts**,
  - ▶ A 16-bit **mask** leaves 16 bits for the **hosts**,
  - ▶ A 24-bit **mask** leaves 8 bits for the **hosts**,
  - ▶ A N-bit **mask** leaves  $32-N$  bits for the **hosts**.

# IP addressing fundamentals

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  - ▶ A N-bit **mask** leaves 32-N bits for the **hosts**.
- ▶ Two different **masks** (differences seen further):
  - ▶ Network **mask**,
  - ▶ Subnet **mask**.

# IP addressing fundamentals

## IP address

32 bits (4x4 bytes)

Networks part	Host part

Figure : IP address parts and mask

# IP addressing fundamentals

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ones mask	zeros mask
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Is that an address?

- ▶ Network address,

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- ▶ Broadcast address has ones for **host** bits:  $x.x.x.1^*$ .

## IP addressing fundamentals

Mask /24 254 hosts	255 11111111	255 11111111	255 11111111	0 00000000
Network address	192 11000000	168 10101000	1 00000001	0 00000000
First host	192 11000000	168 10101000	1 00000001	1 00000001
Last host	192 11000000	168 10101000	1 00000001	254 11111110
Broadcast address	192 11000000	168 10101000	1 00000001	255 11111111

Figure : IP address example 1

## IP addressing fundamentals

Mask /16 65.534 hosts	255 11111111	255 11111111	0 00000000	0 00000000
Network address	172 10101100	64 01000000	0 00000000	0 00000000
First host	172 10101100	64 01000000	0 00000000	1 00000001
Last host	172 10101100	64 01000000	255 11111111	254 11111110
Broadcast address	172 10101100	64 01000000	255 11111111	255 11111111

Figure : IP address example 2

# IP addressing fundamentals

**Formula:** how many **hosts** with a N-bit mask?

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- ▶ 16-bit **mask**:  $2^{32-16} - 2 = 2^{16} - 2 = 65.534$  **hosts**
- ▶ 8-bit **mask**:  $2^{32-8} - 2 = 2^{24} - 2 = 16.777.214$  **hosts**

# IP addressing fundamentals

## Public addresses

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## Private addresses

- ▶ Private addresses are A, B and C classes (note all, see after)
- ▶ No registration needed
- ▶ Not routed across the Internet
- ▶ Proxy, NAT and private addresses solved IPv4 shortage.

---

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# Classful IP Addressing

Class	A	B	C
First octet	1 - 126	128 - 191	192 - 223
First octet 0b	0*	10*	110*
Network mask	255.0.0.0 /8	255.255.0.0 /16	255.255.255.0 /24
IP addresses range	1.0.0.0 126.0.0.0	128.0.0.0 191.255.0.0	192.0.0.0 223.255.255.0
Private range	10.0.0.0 10.255.255.255	176.16.0.0 176.31.255.255	192.168.0.0 192.168.255.0
Number of hosts	16.777.214	65.534	254

Figure : Three main classes

Where did 127.0.0.0/8 go ?!

# Classful IP Addressing

## Class D

- ▶ First octet: 224 - 239

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# Classful IP Addressing

## Class D

- ▶ First octet: 224 - 239
- ▶ First octet pattern: 1110\*
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## Class E

- ▶ Everything left
- ▶ Experimental class.



# Classful IP Addressing

## Reserved addresses

- ▶ 0.0.0.0 used in routing (seen further)

# Classful IP Addressing

## Reserved addresses

- ▶ 0.0.0.0 used in routing (seen further)
- ▶ 127.0.0.0/8: loopback addresses (127.0.0.1 - 127.255.255.254).

# Classful IP Addressing

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Means to limit the number of nodes on a network (regardless of the class) and, thus, improve the manageability, are needed. Three means for it:

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- ▶ Subnet
- ▶ VLSM (Variable Length Subnet Mask)
- ▶ CIDR (Classless Inter-Domain Routing).

# Subnet and VLSM

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# Subnet and VLSM

Mask /16 65.534 hosts	255 11111111	255 11111111	0 00000000	0 00000000
Network address	172 10101100	64 01000000	0 00000000	0 00000000
First host	172 10101100	64 01000000	0 00000000	1 00000001
Last host	172 10101100	64 01000000	255 11111111	254 11111110
Broadcast address	172 10101100	64 01000000	255 11111111	255 11111111

Figure : IP address example 2

# Subnet and VLSM

Mask /12 1.048.574 hosts	255 11111111	240 11110000	0 00000000	0 00000000
Network address	172 10101100	64 01000000	0 00000000	0 00000000
First host	172 10101100	64 01000000	0 00000000	1 00000001
Last host	172 10101100	79 01001111	255 11111111	254 11111110
Broadcast address	172 10101100	79 01001111	255 11111111	255 11111111

Figure : IP address example 3

# Subnet and VLSM

Mask /10 4.194.302 hosts	255 11111111	192 11000000	0 00000000	0 00000000
Network address	172 10101100	64 01000000	0 00000000	0 00000000
First host	172 10101100	64 01000000	0 00000000	1 00000001
Last host	172 10101100	127 01111111	255 11111111	254 11111110
Broadcast address	172 10101100	127 01111111	255 11111111	255 11111111

Figure : IP address example 4

# Lessons are going on!

To be continued... ;)

Hope you liked it and learnt about networking!



Figure : [teaching.auzias.net](http://teaching.auzias.net)