The Ethernet Specifications

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1 Ethernet Basics

Ethernet Basics

- **Communication standard** for network devices **wired** to a local area network (LAN)
- Provides specifications for the **physical** and **data link** layers
- Formalized by Institute of Electrical and Electronics Engineers (IEEE) as the **IEEE 802.3** standard (mid-80s)
    - *Aside: IEEE 802.11 is the WiFi standard (wireless)*

What Ethernet Defines

Physical Layer

- Cabling
- Connectors
- … and more …

Data Link Layer

- Device addresses (“MAC Address”)
- Media access control
- Data frames
- … and more …

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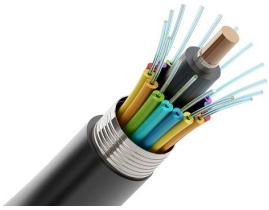
Ethernet at the Physical Layer

Layer 1 - Cabling & Connectors

Bandwidth	Common Name	Informal name	IEEE name	Cable Type	Max Dist.	Connector
10 Mbps	Ethernet	10Base-T	802.3	Unshielded Twisted Pair (UTP) - “Cat 3”	100m	RJ45
100 Mbps	Fast Ethernet	100Base-T	802.3u	UTP - “Cat 5”	100m	RJ45
1000 Mbps	Gigabit Ethernet	1000Base-LX	802.3z	Fiber	5000m	SFP/SC
1000 Mbps	Gigabit Ethernet	1000Base-T	802.3ab	UTP - “Cat 6”	100m	RJ45
10 Gbps	10 Gigabit Ethernet	10GBase-T	802.3an	UTP - “Cat 6”	100m	RJ45

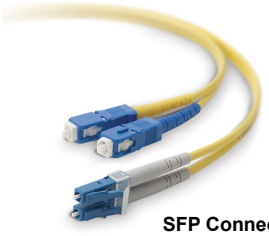
Cables & Connector Examples

Unshielded Twisted Pair “Cat x”



Fiber Optic Cable

RJ45 Connector



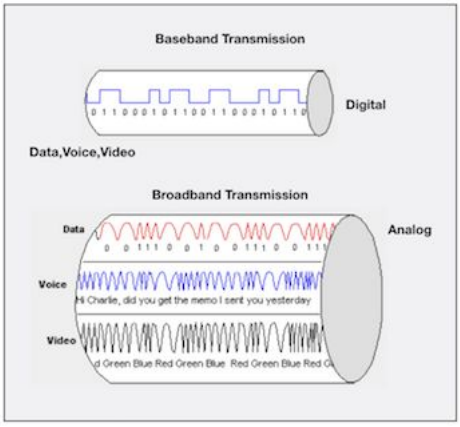
SC Connector

SFP Connector

Ethernet Basics

Broadband/Baseband

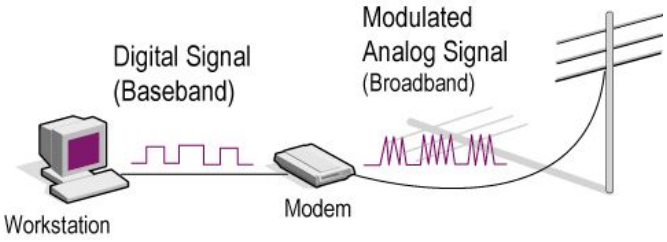
- Baseband
  - Uses digital signals and single channel
  - Communication is bidirectional
  - Short distance
- Broadband
  - Uses analog signals
  - Multiple transmissions are possible
  - Communication is unidirectional
  - Long distance



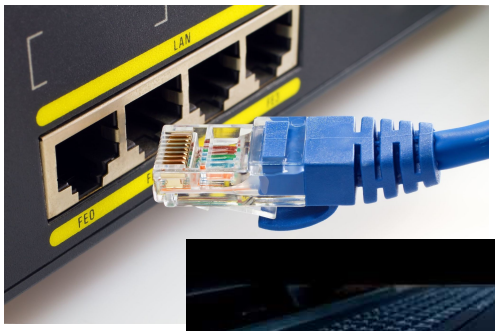
Ethernet Basics

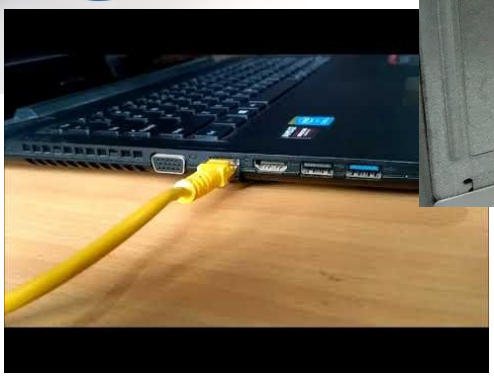
Broadband/Baseband

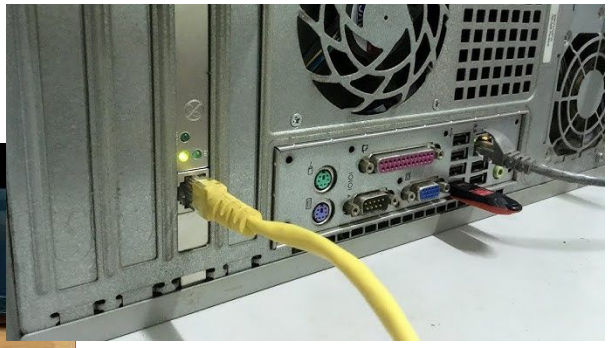
If you are using a broadband internet connection for your home internet, the signals from your ISP up to your broadband router are broadband signals. But, the signals used inside your Ethernet LAN are baseband signals.



Ethernet - Layer 1 meet Layer 2







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Ethernet at the Data Link Layer

Device addresses ("MAC Address")

Data frames

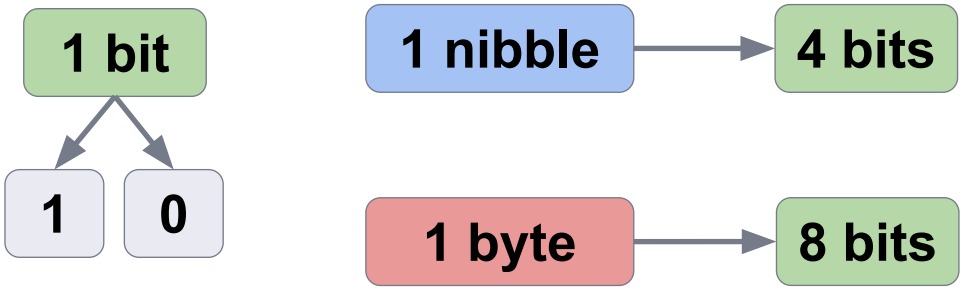
Media access control

MAC Addresses

- Ethernet cable plugs into a "**network interface card**" (**NIC**)
- Each NIC has a unique "**MAC**" address
- Ethernet at the Data Link layer is responsible for **Ethernet addressing** (hardware or MAC addressing)
- Ethernet MAC addresses are made up of hexadecimal addresses

Ethernet at the Data Link Layer

Binary to Decimal and Hexadecimal Conversion



Ethernet at the Data Link Layer

Binary to Decimal Conversion

Binary Value	Decimal Value
10000000	128
11000000	192
11100000	224
11110000	240
11111000	248
11111100	252
11111110	254
11111111	255

Ethernet at the Data Link Layer

Binary to Decimal and Hexadecimal Conversion

Binary Value	Hexadecimal Value	Decimal Value
0000	0	0
0001	1	1
0010	2	2
0011	3	3
0100	4	4
0101	5	5
0110	6	6
0111	7	7

Binary Value	Hexadecimal Value	Decimal Value
1000	8	8
1001	9	9
1010	A	10
1011	B	11
1100	C	12
1101	D	13
1110	E	14
1111	F	15

Ethernet at the Data Link Layer

Binary to Decimal and Hexadecimal Conversion

Example:

What is the binary value of **0x4E (or 4Eh)?**
(0x and h means that the value is hexadecimal or hex)

binary: **4 = 0100**
E = 1110

01001110

Binary to Decimal and Hexadecimal Conversion

Ethernet at the Data Link Layer

What is the binary value of **27h**?

Binary to Decimal and Hexadecimal Conversion

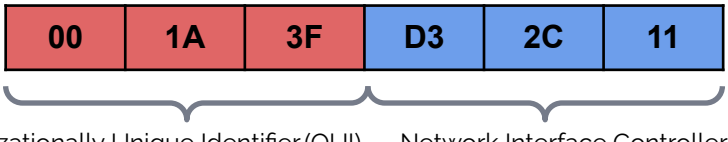
Ethernet at the Data Link Layer

What is the binary value of **0xF9**?

Ethernet at the Data Link Layer

Ethernet Addressing

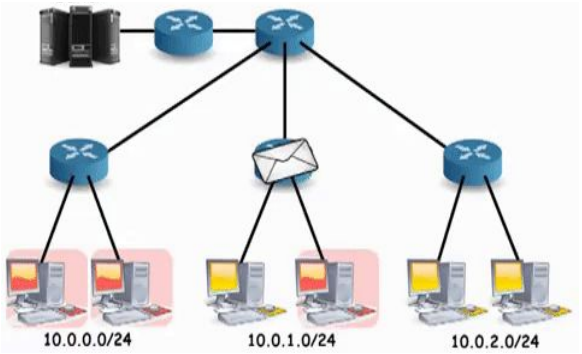
- MAC (Media Access Control) Address
  - 48-bit (6 bytes or 12-digit hex) hardware number
  - unique
  - embedded into the network card, not changeable
  - represented as **00:1A:3F:D3:2C:11** or **00-1A-3F-D3-2C-11**



Ethernet at the Data Link Layer

Types of MAC Address

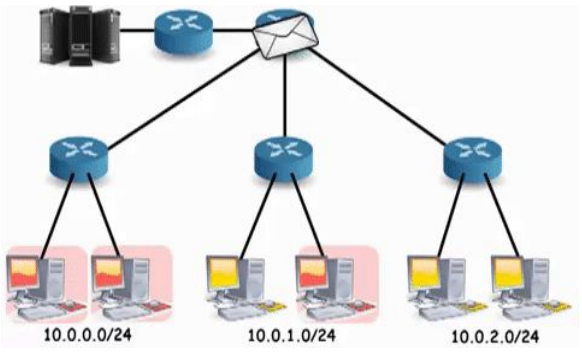
1. Unicast:
    - A specific NIC on the network
    - Only one sender and only one receiver



Ethernet at the Data Link Layer

Types of MAC Address

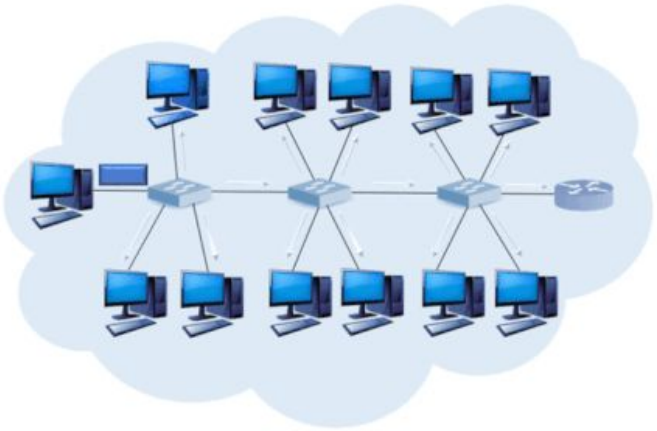
2. Multicast:
    - A group of receivers
    - OUI is **01:00:5E**



Ethernet at the Data Link Layer

Types of MAC Address

3. Broadcast:
    - All devices on the network are recipients
    - MAC Address is: **FF:FF:FF:FF:FF:FF**



Ethernet at the Data Link Layer

Device addresses ("MAC Address")
Media access control
Data frames

CSMA/CD

- **C**arrier **S**ense **M**ultiple **A**ccess/**C**ollision **D**etection is the protocol that is used to transmit frames

- **Multiple** devices can **simultaneously access** the same media, only **one** can **transmit**
  - Protocol must **sense** existing transmissions
  - Protocol must **detect collisions** and retransmit

CSMA/CD Example: WITHOUT Collision

- Sending device senses line
  - If busy, wait
  - If not busy, send frame and detect if collision occurs

- **No Collision**!
  - Send the frame
  - Monitor the wire for other signals
    - If detected, send extended "jam" signal
  - All devices receive the frame
  - Check if the MAC address matches
    - If match, continue processing
    - If no match, discard frame

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WAY TO REINVENT YOURSELF

Break
return @ 9pm

CSMA/CD Example: WITH Collision

- Sending device senses line
  - If busy, wait
  - If not busy, send frame and detect if collision occurs

- **Collision**!
  - Two devices have tried to send signals at nearly the same time
  - First one to sense collision sends out "jamming" code ("busy signal")
  - Respond to jamming signal by waiting a specific period of time
  - Time is determined by "backoff algorithms"
  - Retransmit
  - Repeat, and timeout after 15 collisions

Collision Domain

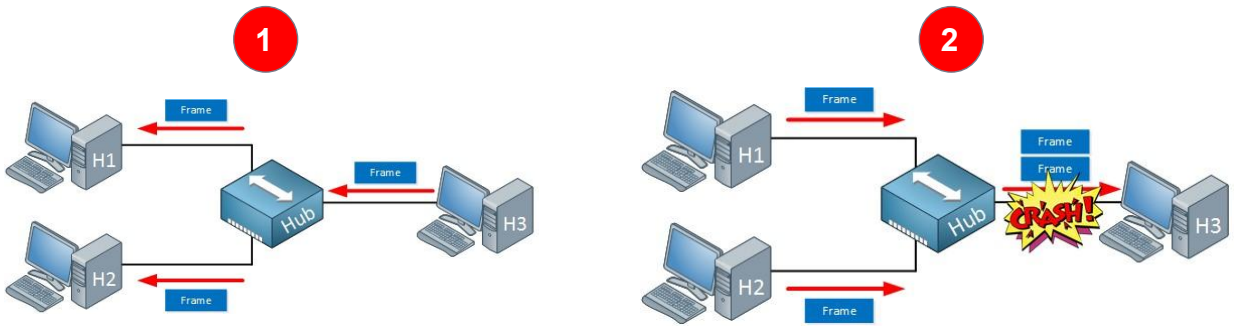
The term collision domain is used to describe a part of a network where packet collisions can occur

Collisions occur when two devices on a shared network segment send packets simultaneously

The colliding packets must be discarded and sent again, which reduces network efficiency

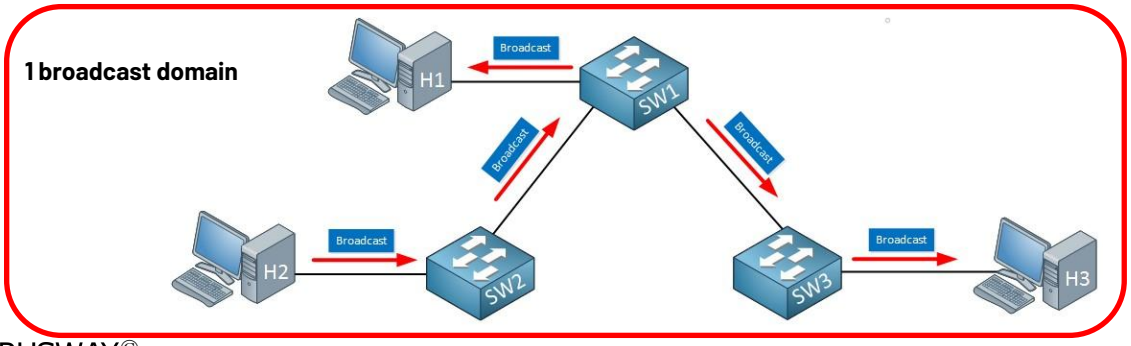
Collisions with Hubs

Collisions occur often in a hub environment



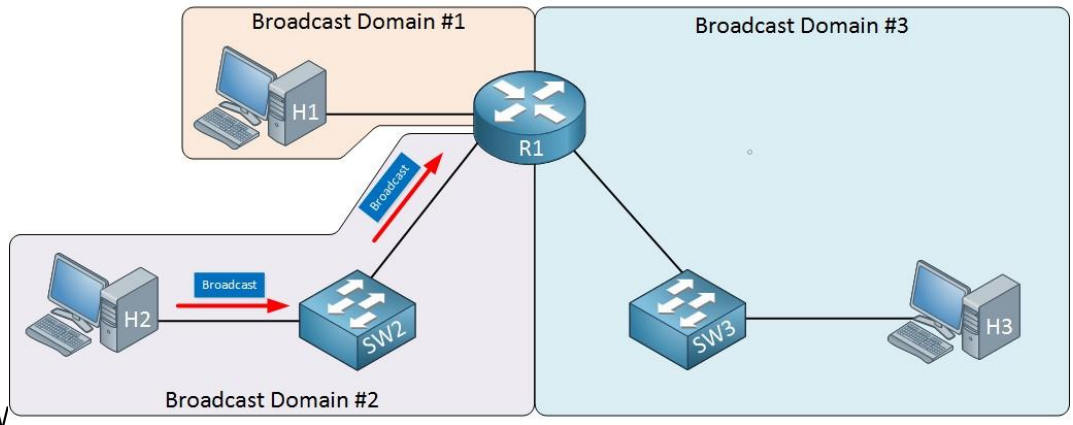
Broadcast Domains

A broadcast domain is a collection of network devices that receive broadcast traffic from each other



Limiting Broadcast and Collision Domains

The more broadcast domains the more efficient network



Ethernet at the Data Link Layer

Device addresses ("MAC Address")
Media access control
Data frames

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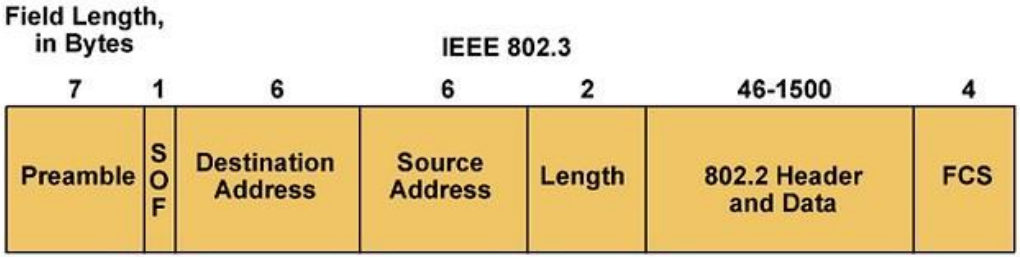
Ethernet at the Data Link Layer

Ethernet Frames

- Encapsulated data defined by the Network Access layer is called an Ethernet frame
- The Ethernet frame structure is defined in the IEEE 802.3 standard



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THANKS!

Any questions?

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