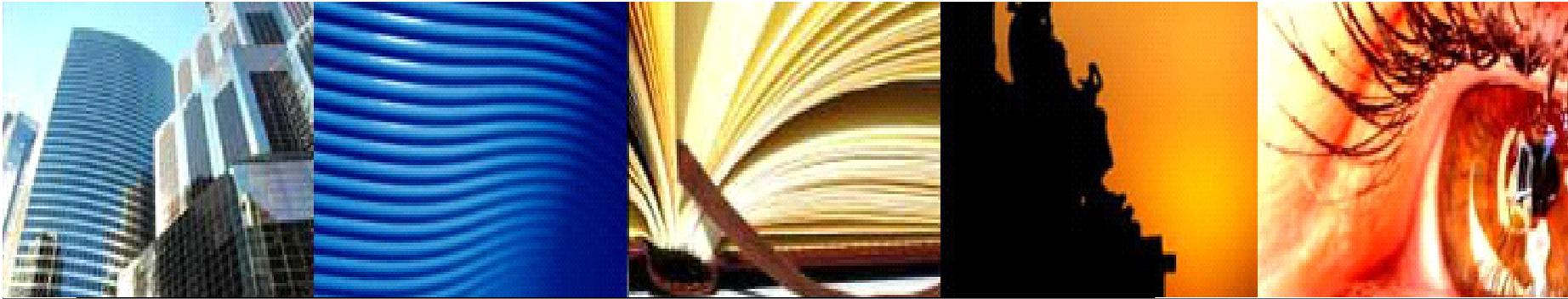
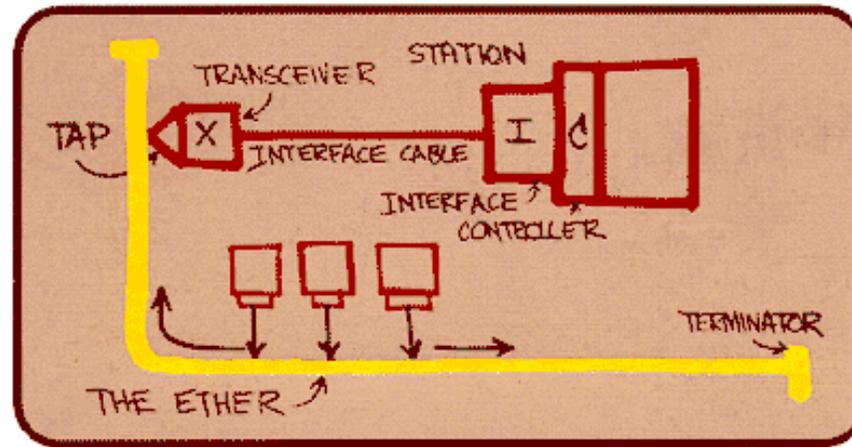


Ethernet Basics



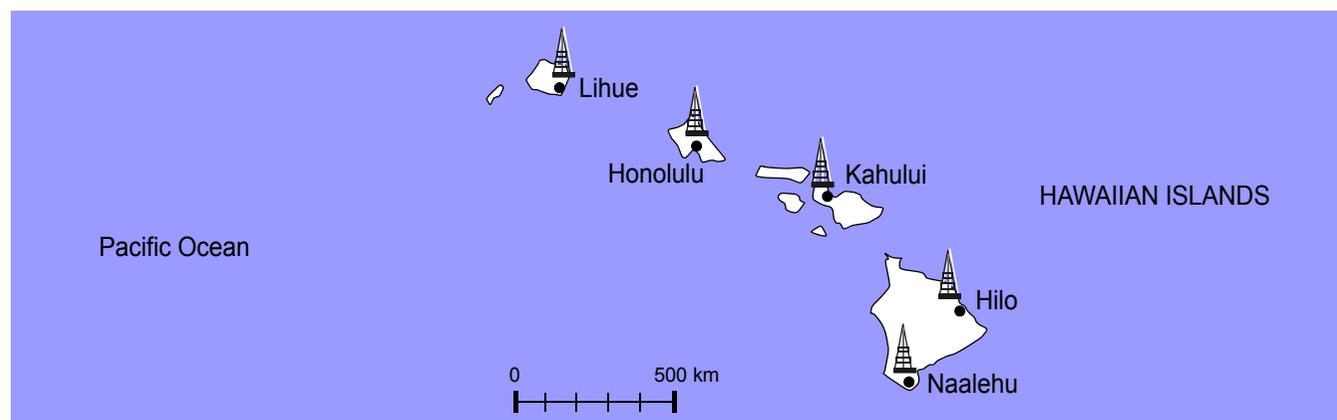
Ethernet Basics



Ethernet refers to a family of technologies initially designed for LAN that have some things in common:

- Packet-oriented and statistical multiplexing technology.
- Very efficient for data transport.
- MAC layer and frame formats (common to all Ethernet).
- Connectionless; requires a bridging procedure of constant address learning.
- Low cost, scalable, multiple transmission media.
- Distributed control plane.
- L2 VPNs: Point and multipoint configurations.

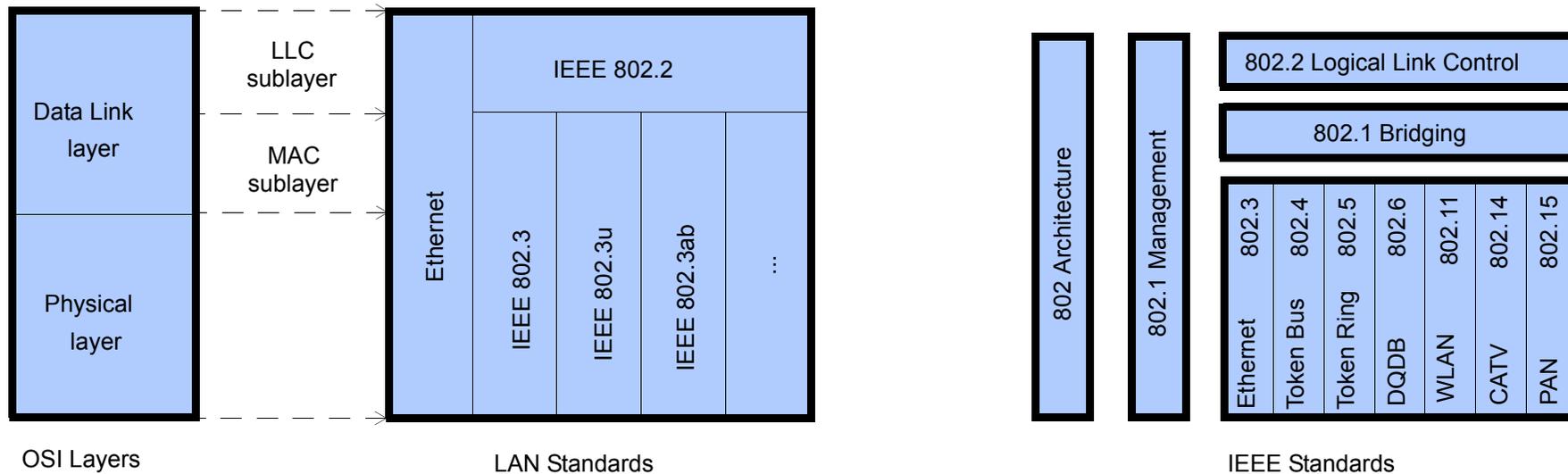
Alohanet, developed in the late 1960s at the university of Haway, is the Ethernet predecessor. It was designed to allow two or more radio stations to share the same medium without interfering between them.



In 1973, Robert Metcalfe and his Team in Xerox designed the first version of Ethernet (Ethernet I). The new technology allowed communication of computers connected to a shared medium (coaxial cable).

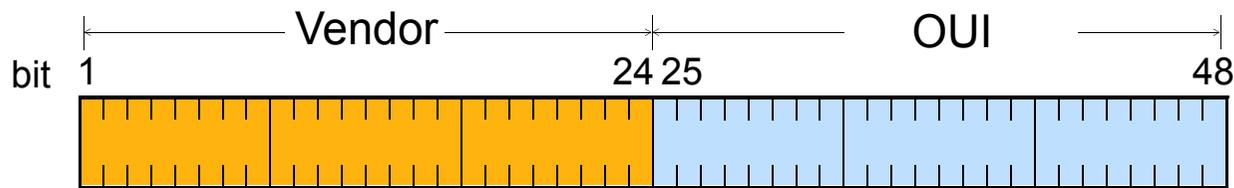
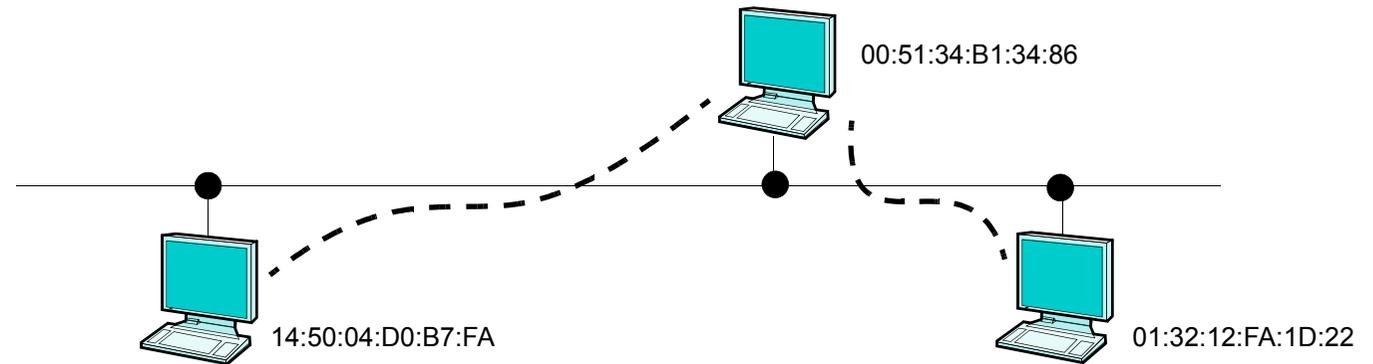
In 1982, it was released the first Ethernet standard by a consortium formed by Digital Equipment Company, Intel and Xerox. This standard was a success from the beginning.

In 1985 the IEEE published the first release of the 802.3 standard based on Ethernet. Since that moment, Ethernet has not stopped its evolution.



- The Open System Interconnection (OSI) reference model defines the architecture of a layered communication system. The layers defined by the OSI model are: Physical, data link, network, transport, session, presentation, application.
- Ethernet is compatible with the OSI model. Specifically, Ethernet defines the *physical* and *data link* layers.
- The data link layer is composed by two sublayers: Media Access Control (MAC) and Logical Link Layer (LLC).
- IEEE 802.1 for bridging is located at the data link layer and is shared between Ethernet and other IEEE layer 2 technologies.

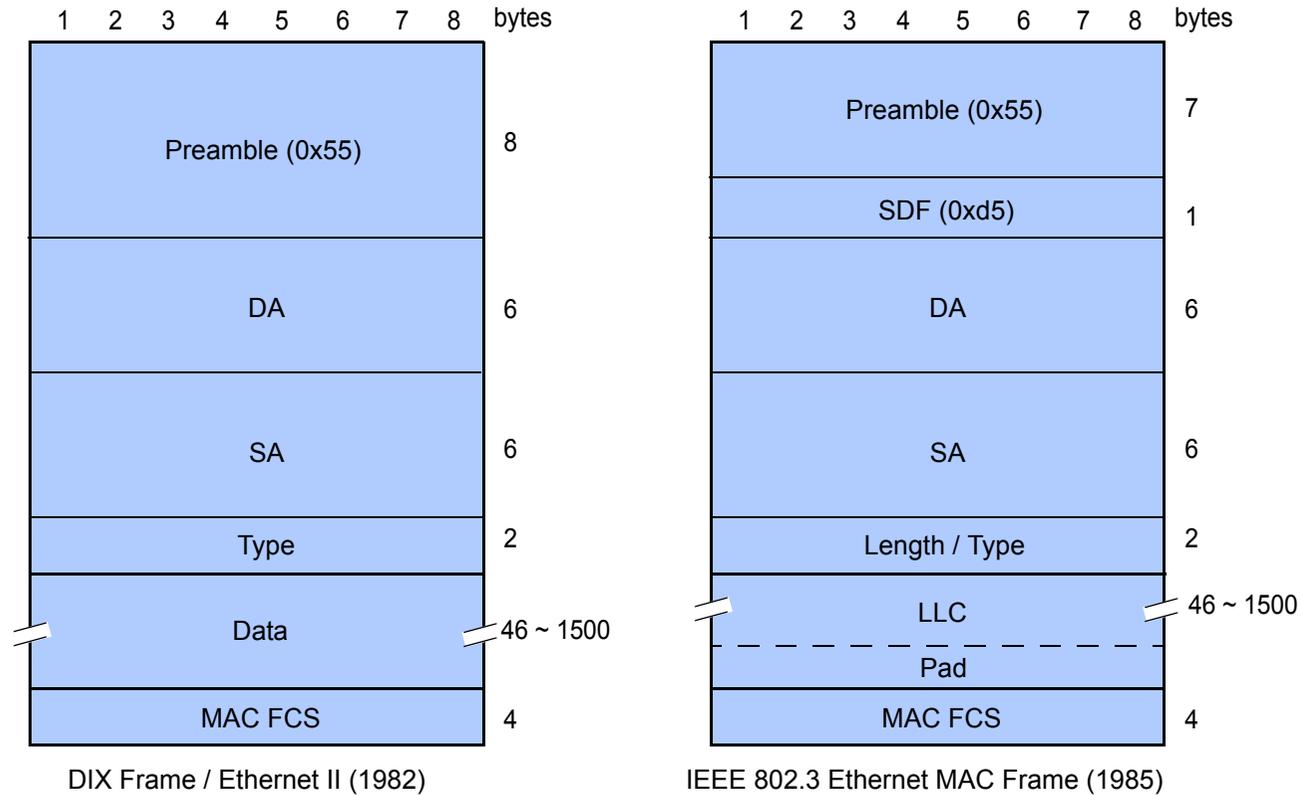
MAC Addresses



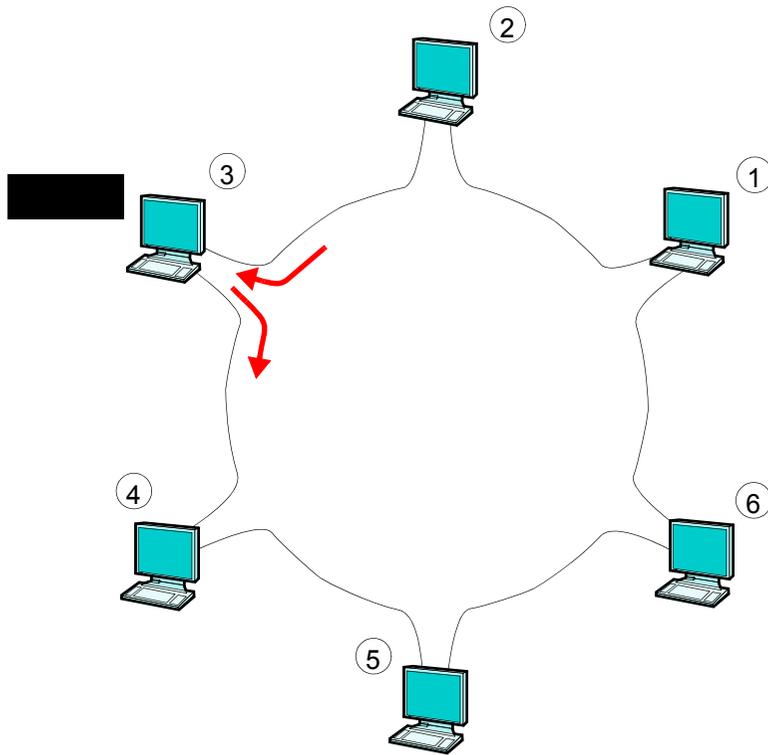
OUI (Organizationally Unique Identifier), IEEE administrated code
Vendor Code administrated by the manufacturer

- The MAC layer was defined for communication of adjacent Ethernet stations.
- Ethernet links are multipoint and therefore, an addressing scheme is necessary to identify stations connected to this link.
- In switched Ethernet, MAC addresses are used for switching frames.

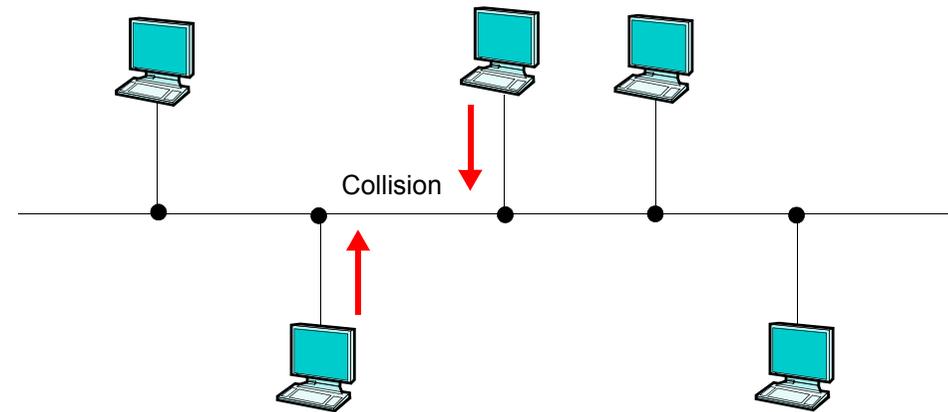
Framing



- There are more than one accepted MAC framing. The **IEEE 802.3 frame** is backwards compatible with the older **DIX frame**.
- The most important difference between DIX and 802.3 framings is the way user data is encapsulated. In the DIX framing the contents type is given by the **Type** field in the 802.3 frame the contents is identified by its length. The type is specified by means the LLC encapsulation.



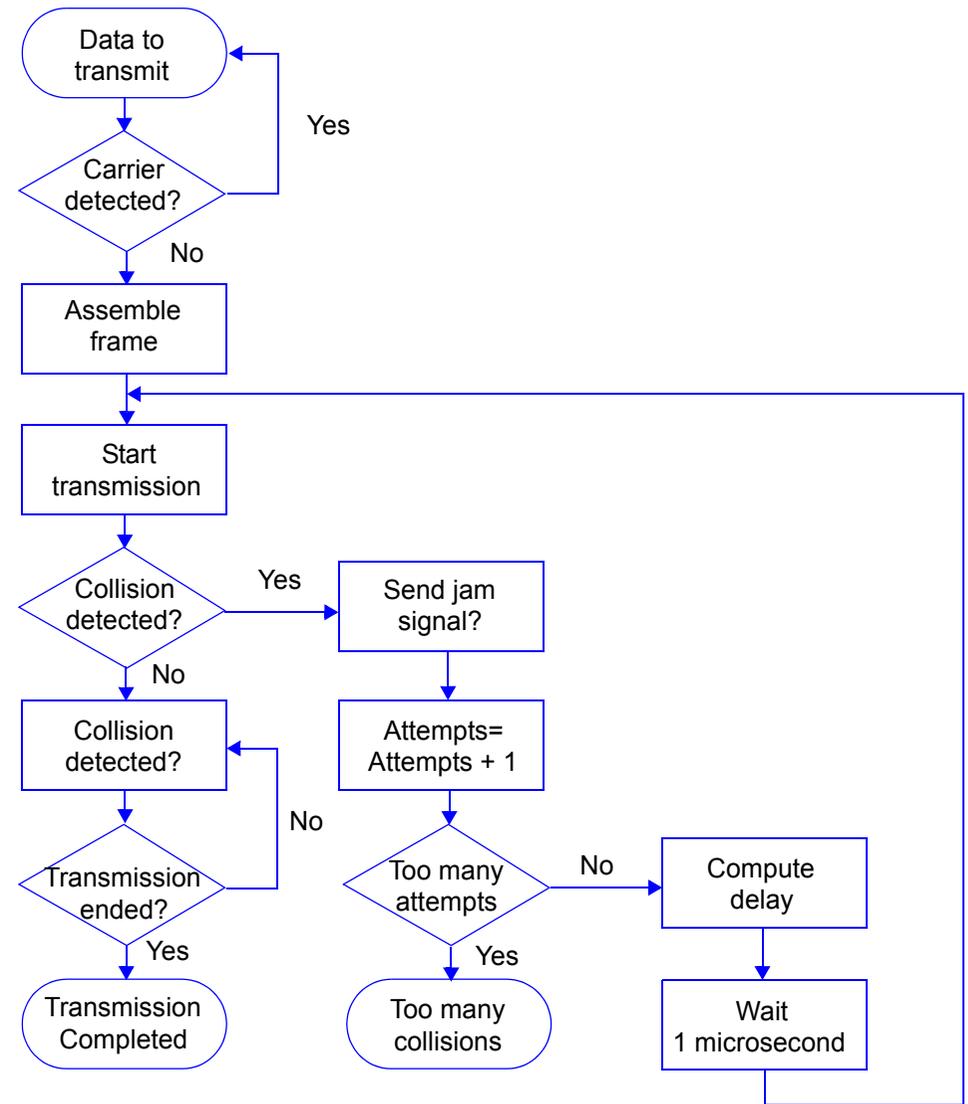
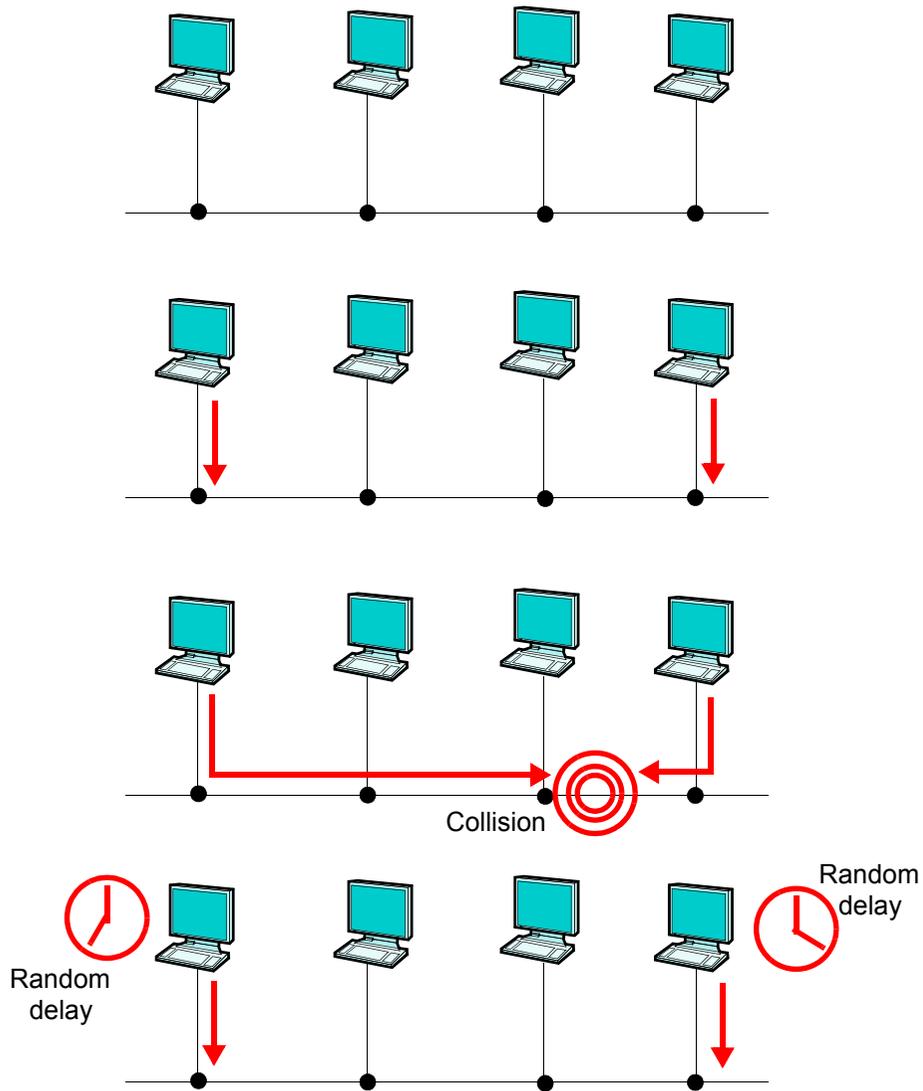
Deterministic MAC

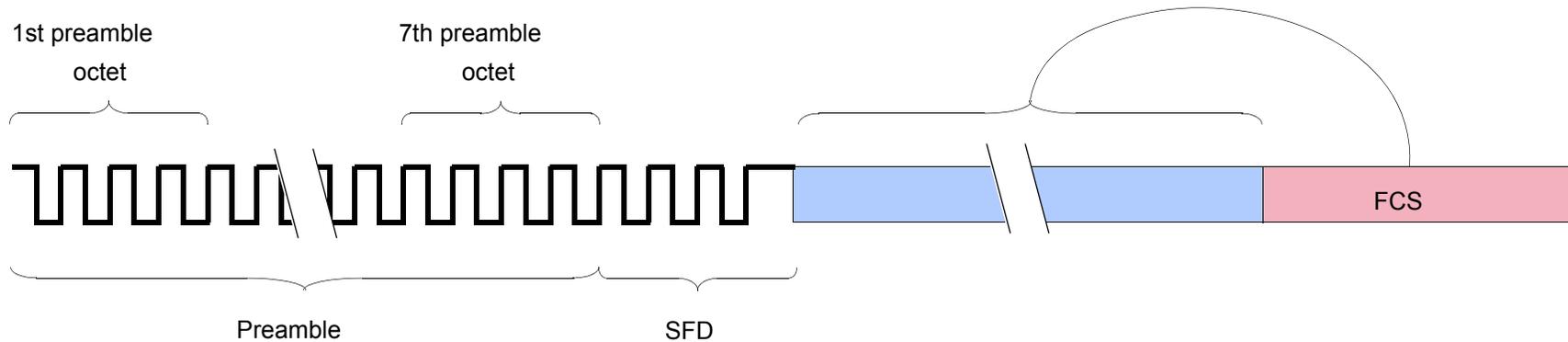


Non-deterministic MAC

- There are many MAC protocols. The IEEE defines alternative MAC layers for other technologies like Token Ring.
- MAC protocols are commonly classified in deterministic and non-deterministic.
- The Ethernet MAC protocol is non-deterministic with First-Come First-Serve (FCFS) philosophy.

CSMA/CD

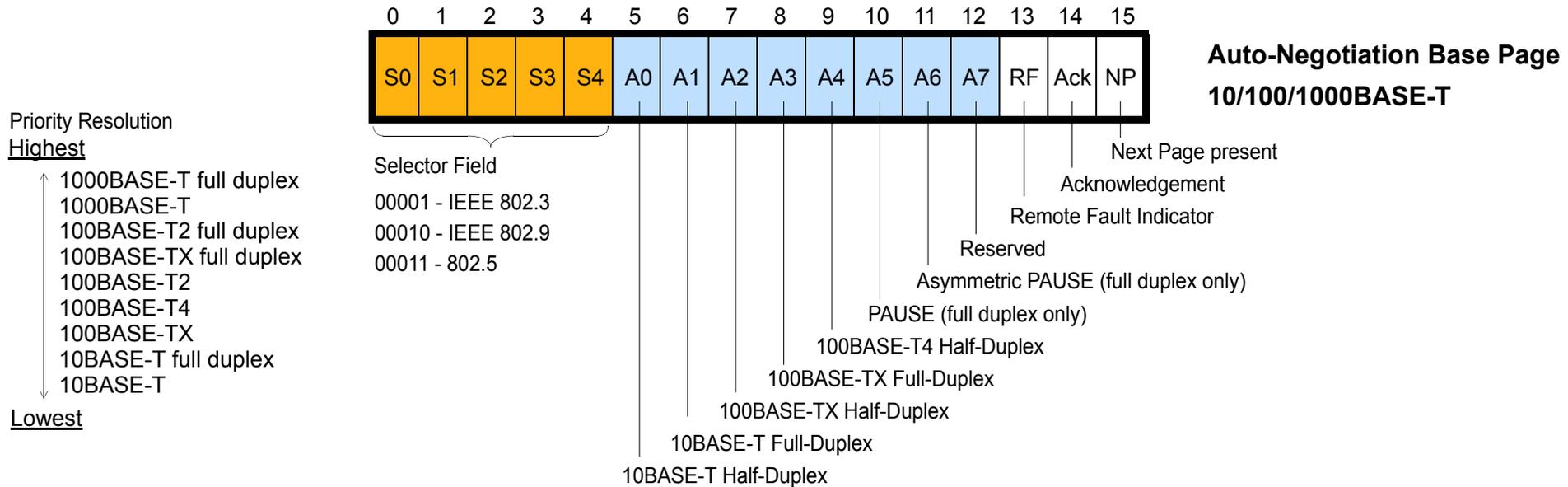




- The transmitter station sends 64 bits (8 bytes) at the beginning of each frame that enables the receiver to synchronize with the incoming data.
- The first 7 transmitted bytes are known as “preamble”, the 8th byte is the “Start of Frame Delimiter”. This byte is useful for the receiver to recognize the beginning of the frame.
- The DIX version of the Ethernet frame doesn't have SFD and it has an 8-byte preamble.
- High bit rate Ethernet use to work in full duplex mode. In this case, Ethernet stations can operate in synchronous mode and the preamble is not necessary. However, it is maintained for compatibility of all frame formats.

- **Error (jabber):** It is defined in the IEEE 802.3 as a transmission of at least 20000 or 50000 bits.
- **Long frame:** These kind of frames are defined to be frames longer than the maximum allowed size (1518). VLAN labeled frames are not considered to be long frames even if they exceed this maximum size.
- **Short frame:** Short frames are shorter than the minimum allowed size with a valid FCS.
- **Runt:** It designates frames shorter than the minimum allowed size, usually, collision fragments. Therefore, runts have an invalid FCS.
- **FCS Error:** This kind of errors happens when a frame (with legal size) is received with an invalid FCS due to transmission errors or other reason.
- **Alignment Error:** It happens when there is not an integer number of bytes in the frame. Usually is at the same time is registered an FCS error.
- **Range Error:** This error is computed when the value of the length field does not match the actual size of the data field. The Out of Range error is registered when the value of the length field is too big to be valid.
- **Ghost:** This error designates energy (noise) found in the transmission media that appears to be a frame without a valid FCS. This kind of errors is usually related with cabling problems.

Auto-Negotiation



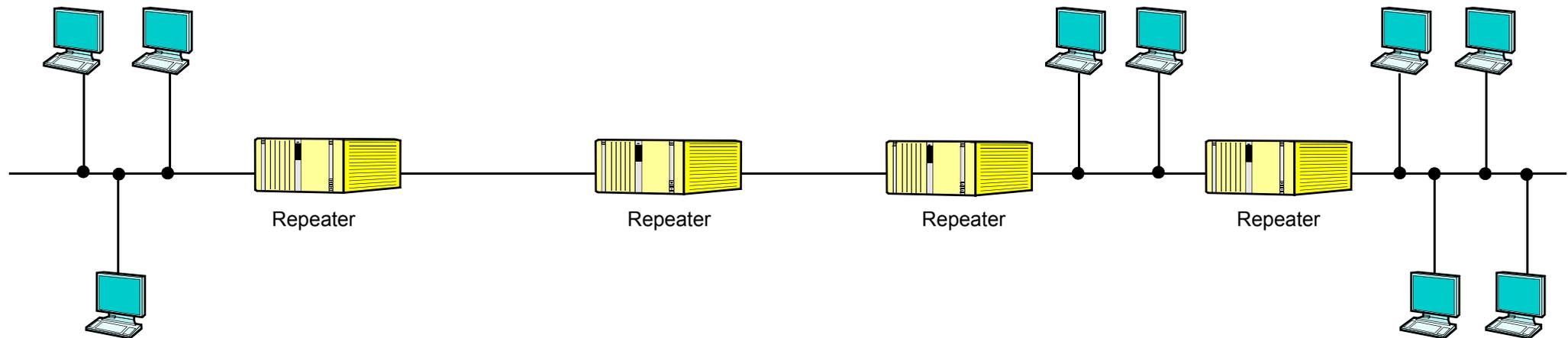
Some of the many Ethernet versions can talk to each other by means of *Auto negotiation*:

1. Inform the far end on which Ethernet version and options have been implemented.
2. Acknowledge features that both stations share, and reject those that are not shared.
3. Configure each station for highest-level mode of operation that both can support.

The 5-4-3 Rule

The 5-4-3 Rule limits the size of the broadcast domain in half duplex ethernet networks:

- 5 Cable segments.
- 4 Repeaters.
- 3 Populated segments (this rule only counts for coaxial implementations).

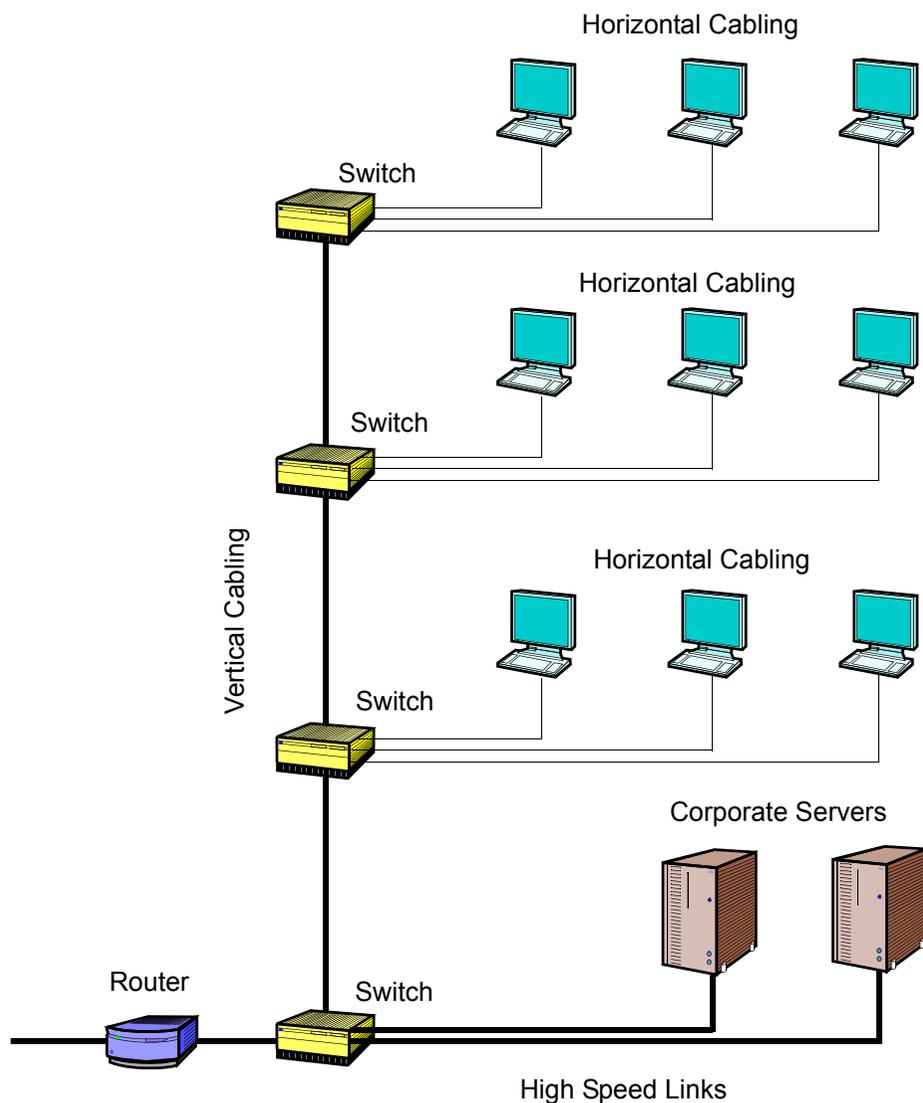


The 5-4-3 rule and the minimum frame size prevents undetected collisions.

<i>Interface</i>	<i>Fiber</i>	<i>Wavelength</i>	<i>Modal bandwidth</i>	<i>Range</i>
10GBASE-LX4	62.5 μ m MMF	~ 1300 nm	500 MHz*km	2 ~ 300 m
	62.5 μ m MMF	~ 1300 nm	400 MHz*km	2 ~ 240 m
	50 μ m MMF	~ 1300 nm	500 MHz*km	2 ~ 300 m
	10 μ m MMF	~ 1300 nm	-	2 ~ 10 km
10GBASE-S	62.5 μ m MMF	850 nm	160 MHz*km	2 ~ 26 m
	62.5 μ m MMF	850 nm	200 MHz*km	2 ~ 33 m
	50 μ m MMF	850 nm	400 MHz*km	2 ~ 66 m
	50 μ m MMF	850 nm	500 MHz*km	2 ~ 82 m
	50 μ m MMF	850 nm	2000 MHz*km	2 ~ 300 m
10GBASE-L	8 ~ 10 μ m SMF	1310 nm	-	2 ~10 km
10GBASE-E	8 ~ 10 μ m SMF	1550 nm	-	2 ~40 km

10Gbit/s Ethernet is specified in standard IEEE 802.3ae, released in 2002. The new standard makes Ethernet suitable for WAN applications for first time.

- 10GbE abandons half duplex operation mode with shared links. It relies on IEEE 802.1 bridging for operation in topologies beyond simple point-to-point.
- It also abandons copper transmission. Only interfaces based on optical fiber are defined.
- Some interfaces like 10GBASE-LX4 are specially designed for LAN applications using existing fibre cabling.
- The 10GBASE-W interfaces improves convergence and inter-operability between TDM and Ethernet technologies.

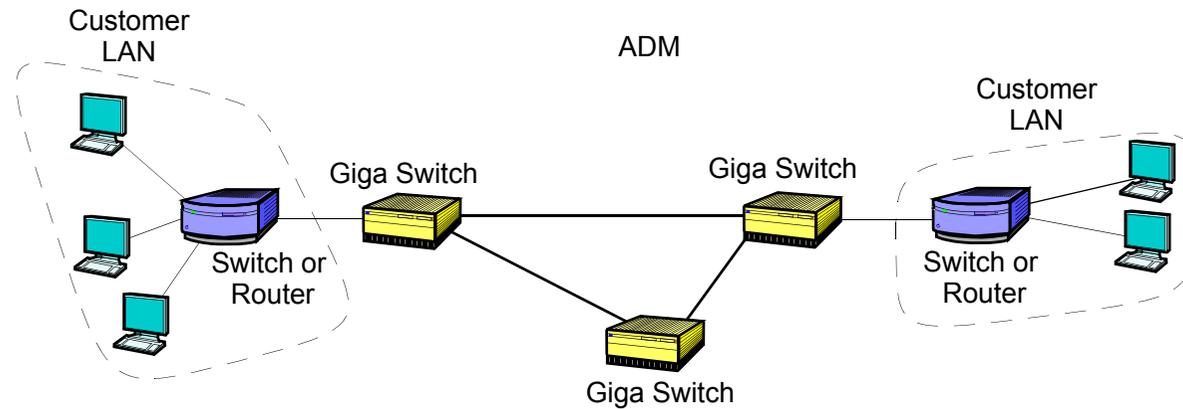


In LAN, the new Ethernet interfaces are used where legacy Fast Ethernet interface has become a bottleneck. Some of these LAN applications are:

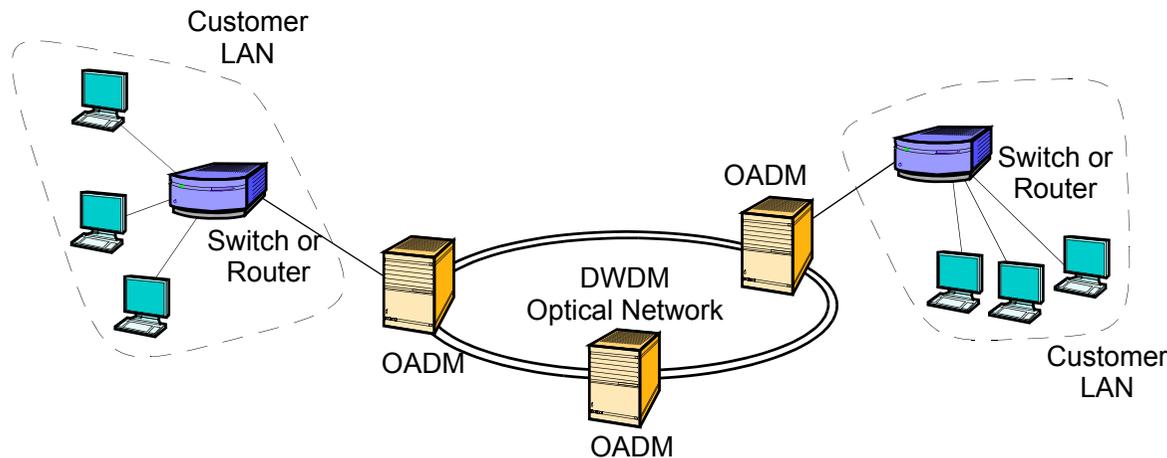
- Aggregation of multiple lower-rate segments in switch/server links.
- High-traffic between switches trunk links.
- Interconnection of servers in clusters of servers.
- LAN extension between buildings in campus applications, or communication between remote LANs.

Two gigabit interfaces have been especially designed to reuse the installed LAN infrastructure, 1000BASE-T and 10GBASE-LX4.

Ethernet over Dark Fibre



Ethernet over Dark Wavelength



MANs are one of the most interesting application fields for GbE and 10GbE.

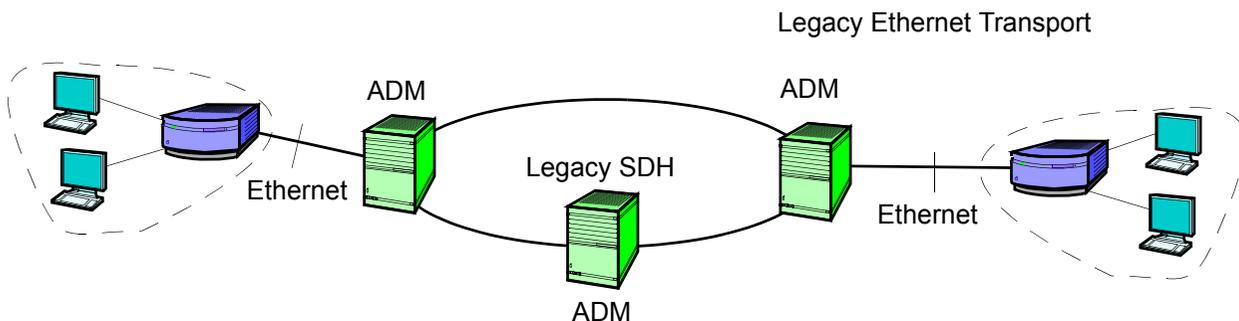
Currently, Ethernet tends to replace TDM infrastructure in this scenario.

-Ethernet over dark fiber serves to simple deployments with few users requiring high bandwidth.

-Thanks to the efforts of the MEF, IETF, IEEE and ITU, native Ethernet solutions are gaining scalability and popularity.

-If metro WDM or SDH rings are available, it is possible to take advantage of them by means solutions like Ethernet over dark wavelength or NG-SDH.

Gigabit Ethernet applications for WAN

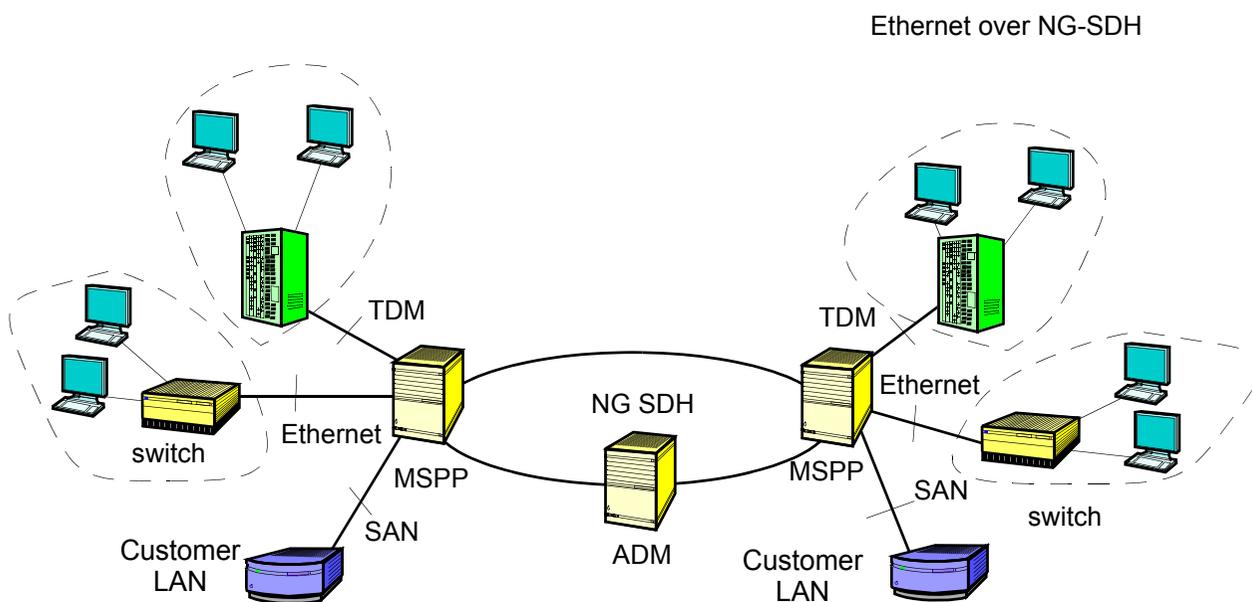


WAN are becoming are becoming a new application of Ethernet.

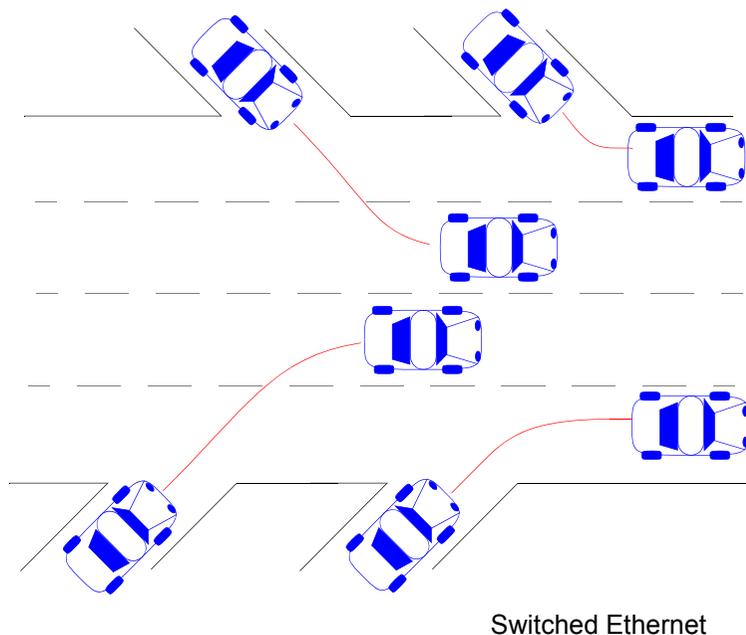
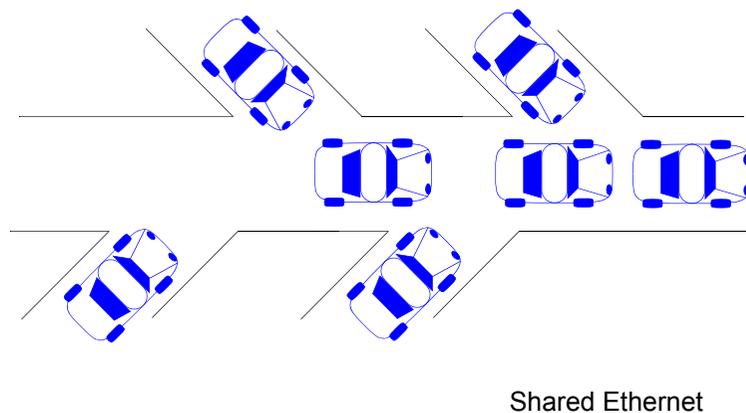
In this scenario, Ethernet and TDM/WDM are becoming cooperative technologies.

Solutions like Ethernet over NG-SDH are likely to achieve strong acceptance in this scenario. Because they get the best of packet and circuit switching.

Standardization of 100GbE puts a new challenge to TDM. This new technology may turn Ethernet into the dominant technology for WAN applications.



Switched Ethernet



-Ethernet is a shared technology where all users in the same segment compete by the same bandwidth.

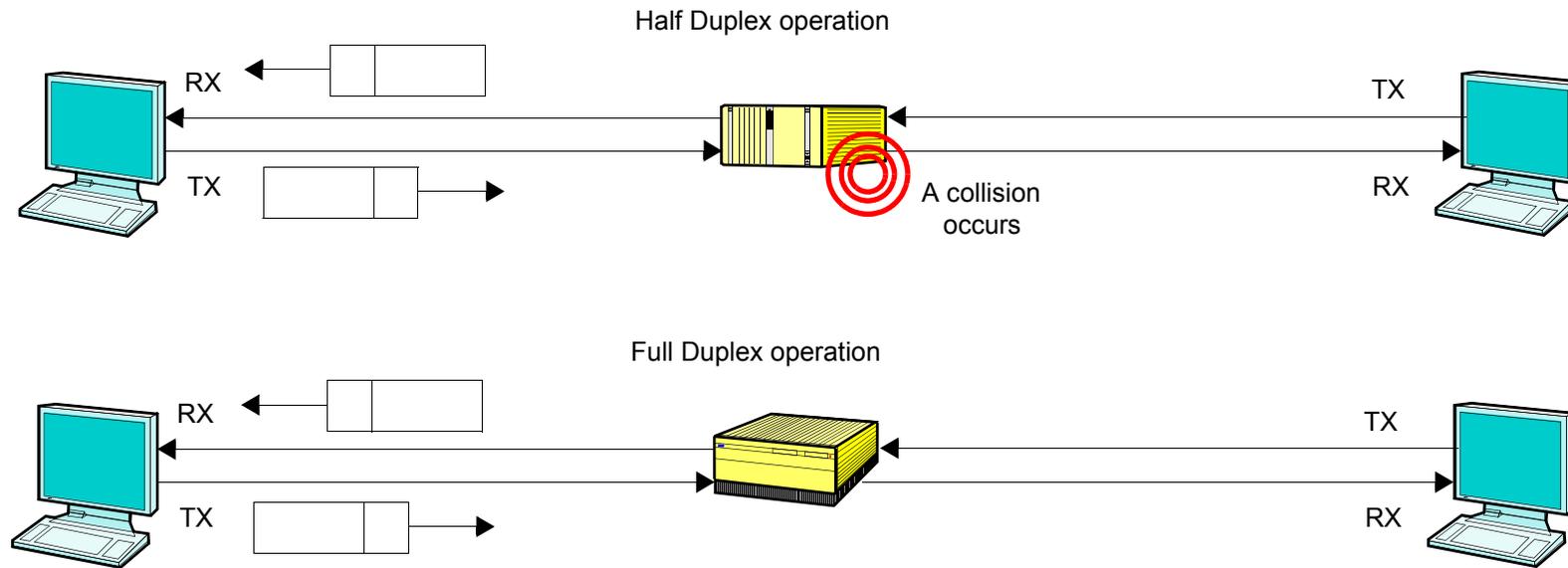
-In Ethernet based in coaxial cable collisions happen in the own cable. In UTP implementations, collisions happen in **hubs**.

-Excessive collisions may reduce dramatically the performance of Ethernet and they make the network unsuitable for QoS-demanding applications.

-Switched Ethernet is the alternative to shared Ethernet.

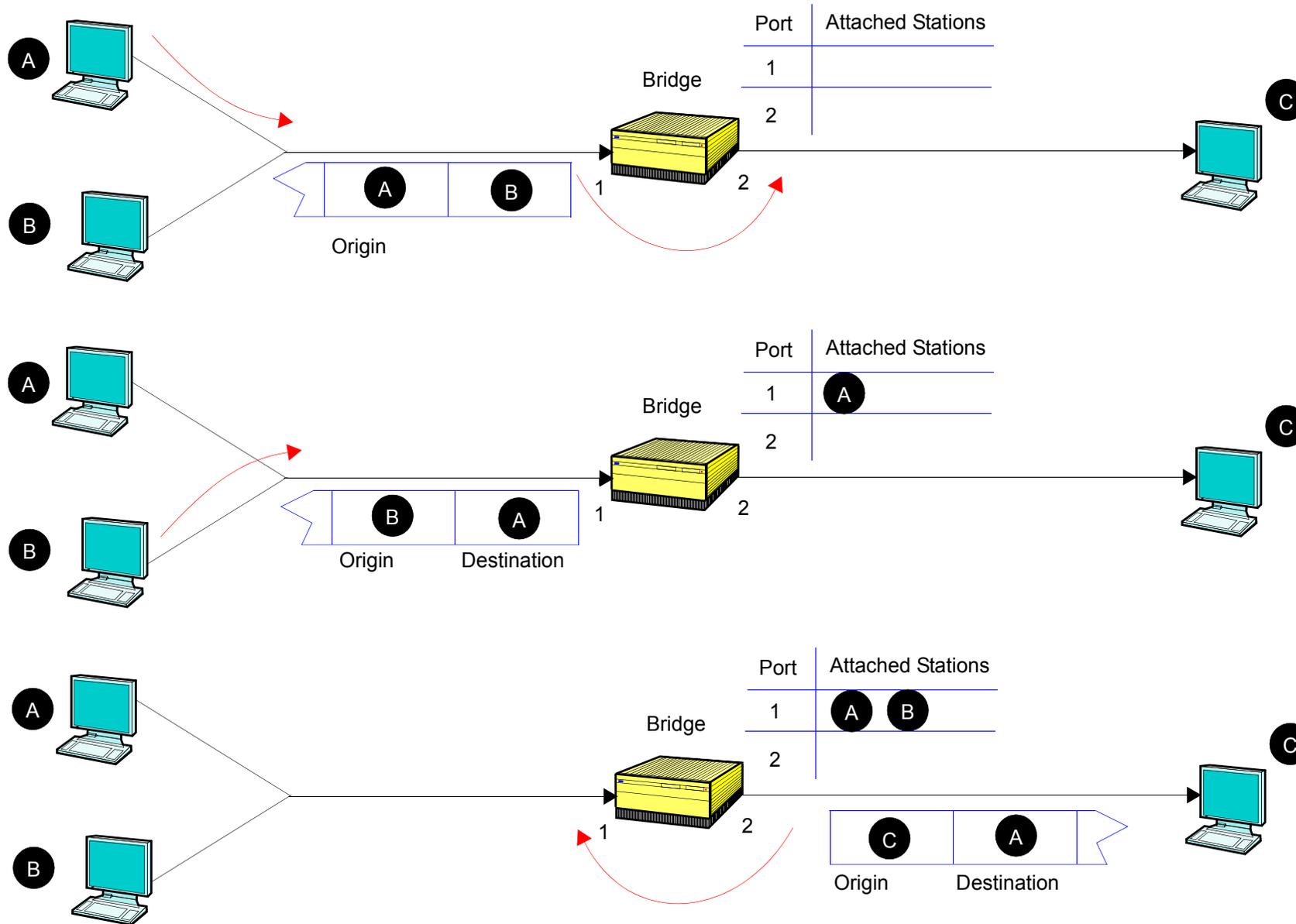
-Switches use 802.1 bridging to create dedicated paths between the communication parties, avoiding collisions.

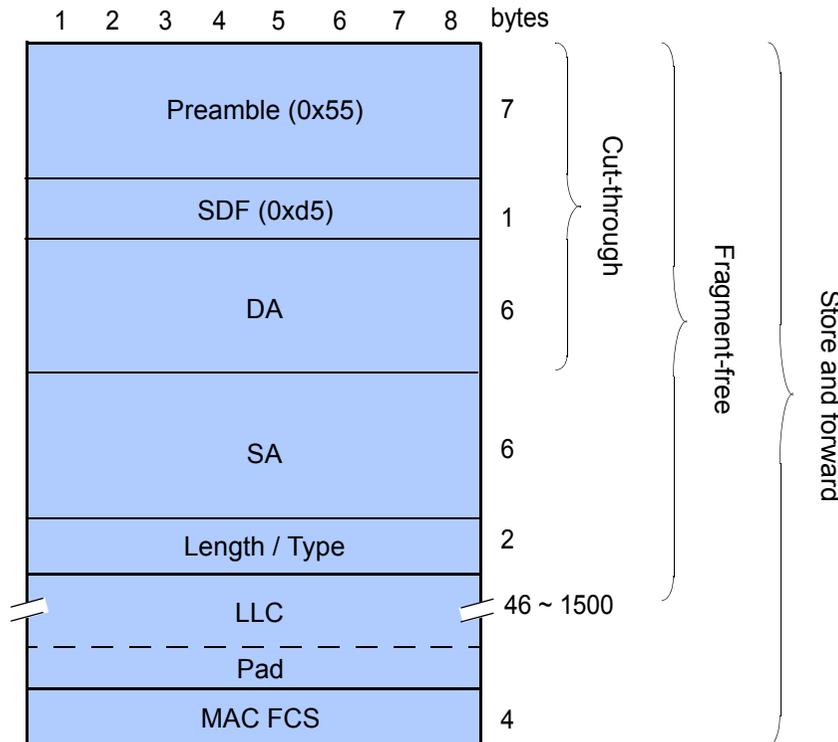
Semi duplex and Duplex operation



- First Ethernet devices only were able to work in half duplex mode. That means that they were not capable to send and receive data simultaneously.
- If the shared media is replaced by a dedicated media, it is possible to transmit and receive at the same time. However, full duplex operation is only possible if the shared transmission media is replaced by dedicated transmission media.
- Full duplex operation makes unnecessary the CSMA/CD protocol.

802.1 Bridging





Ethernet use IEEE 802.1 bridging to improve the performance of Ethernet.

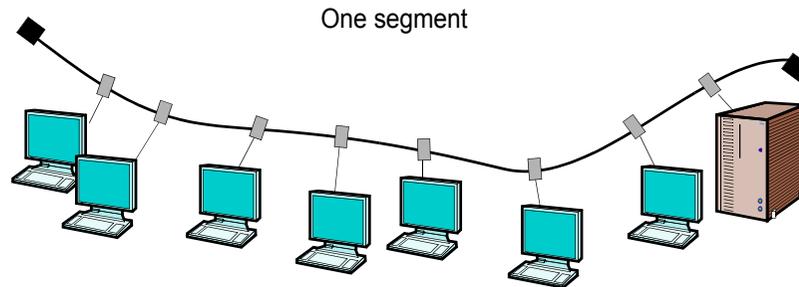
Switches are layer 2 devices while hubs operate at layer 1. The advantages of switches over hubs are:

- They store in queues packets when the transmission media is busy to avoid collisions.
- Allow connection of heterogeneous links. For example links operating at 100 Mbit/s and at 1 Gbit/s.

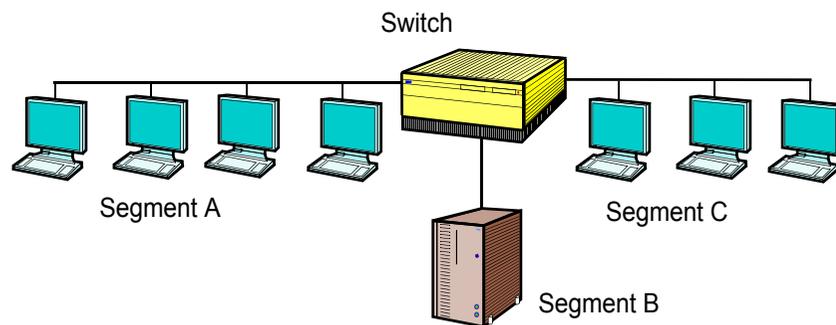
There exist various switching technologies:

- Store and forward: The switch reads the complete frame, checks for FCS errors, it decides the outgoing port and finally, it transmit it.
- Cut-through: The switch reads the frame up to the destination MAC address and it starts transmission.
- Fragment-free: The switch waits to verify that the incoming packet is not a collision fragment before start transmission.

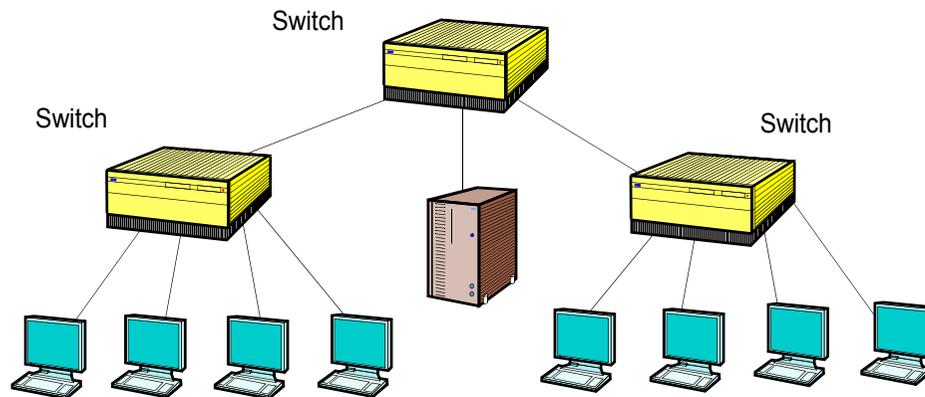
Segmentation and Micro-segmentation



Legacy Ethernet networks are made up by a single segment (collision domain). Data transmitted is received by all the stations connected to the network.

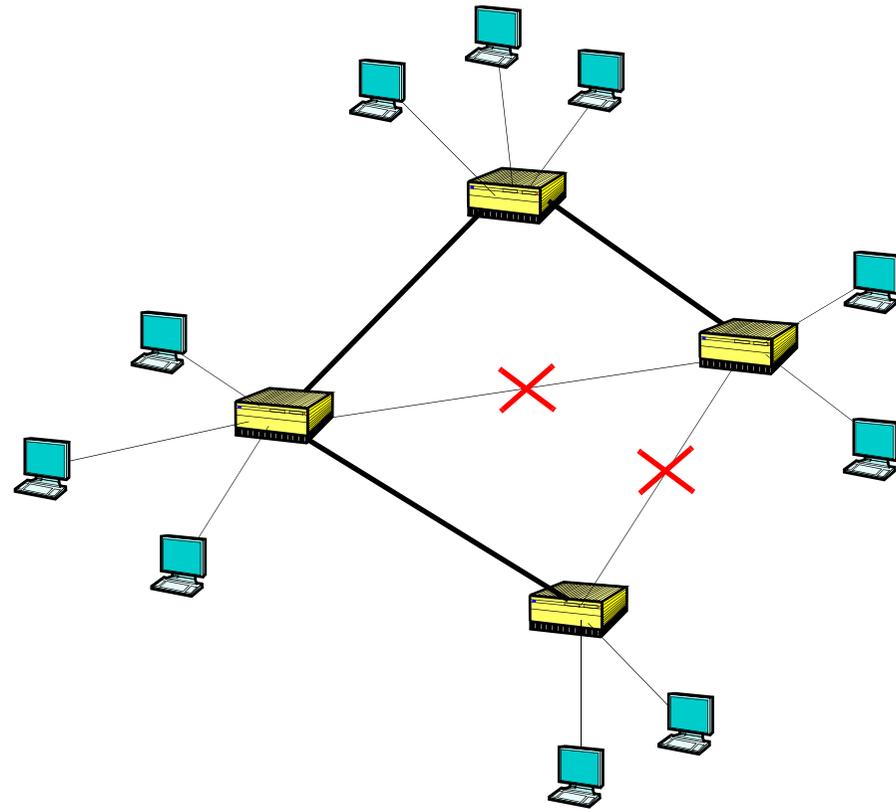
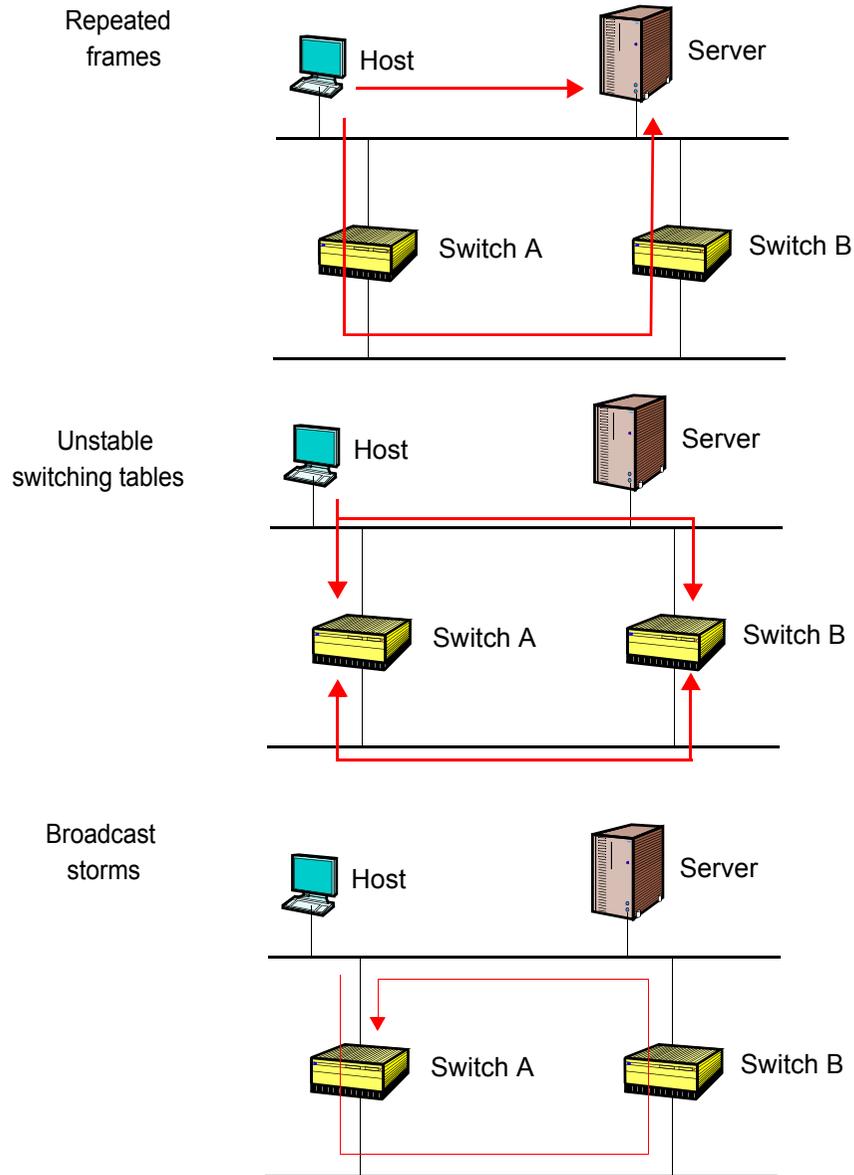


As the number of stations connected to the network increases, the number of collisions increases as well. To avoid performance degradation, the network can be segmented with switches.

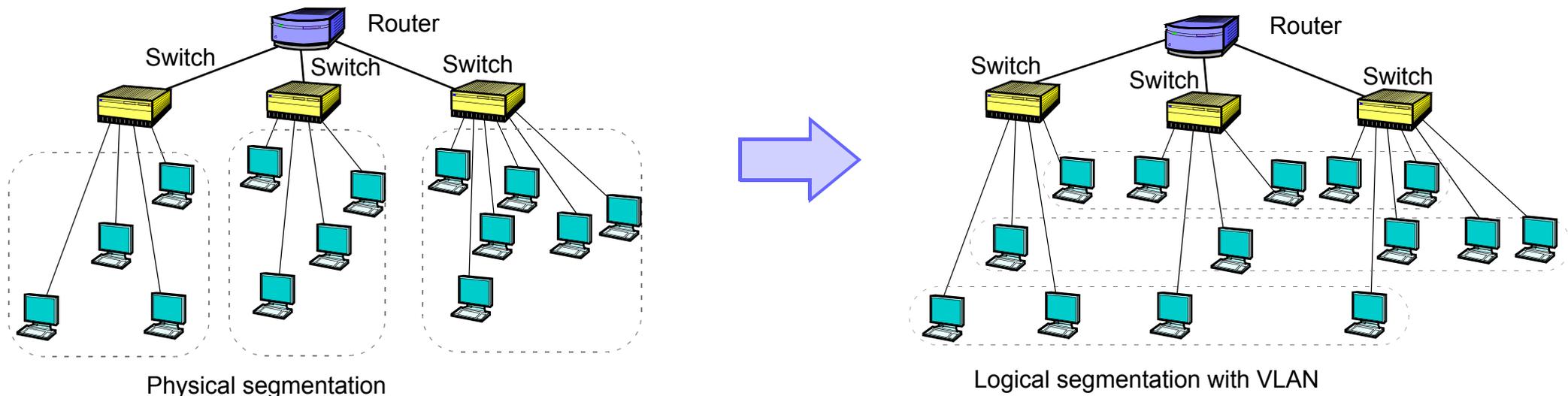


Micro-segmentation means that every station has its own collision domain. In other words, collisions disappear from the Ethernet network.

Limitations of bridging: The STP



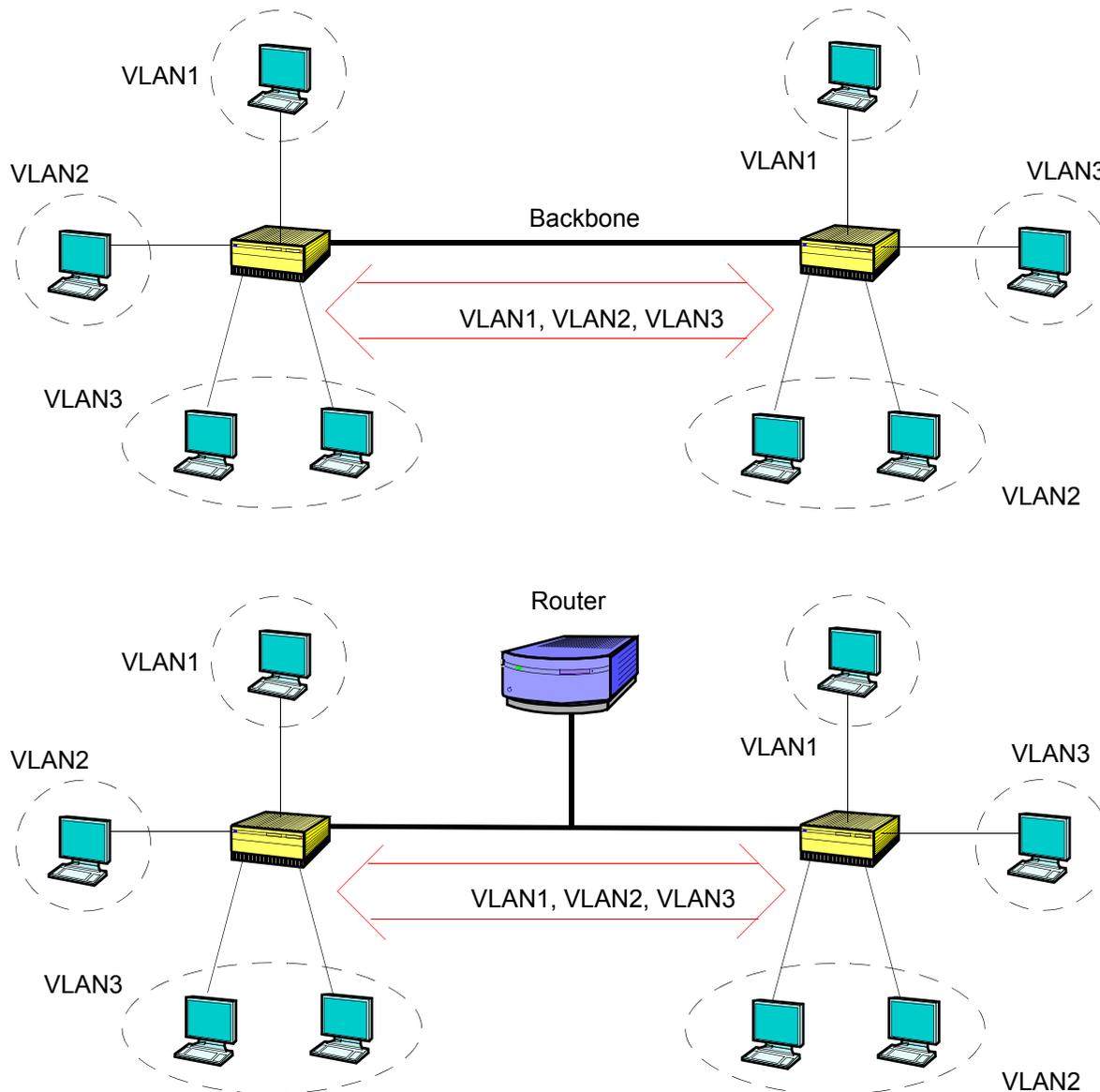
- The bridging mechanism imposes restrictions to the network topology: Loops are incompatible with IEEE 802.1.
- The Spanning Tree Protocol (STP) removes loops in switched Ethernet networks to ensure proper operation.



VLANs split a broadcast domain in several smaller broadcast domains. The advantages of this approach are the following:

- However, switches need to send broadcast information to operate. In big bridged networks the amount of broadcast traffic can degrade the overall performance of the network.
- Network administrators may want to isolate some users between them for administrative reasons. For them is useful to define VLANs not only by the ports of the switch but also by MAC addresses or other parameters.

Ethernet Trunking

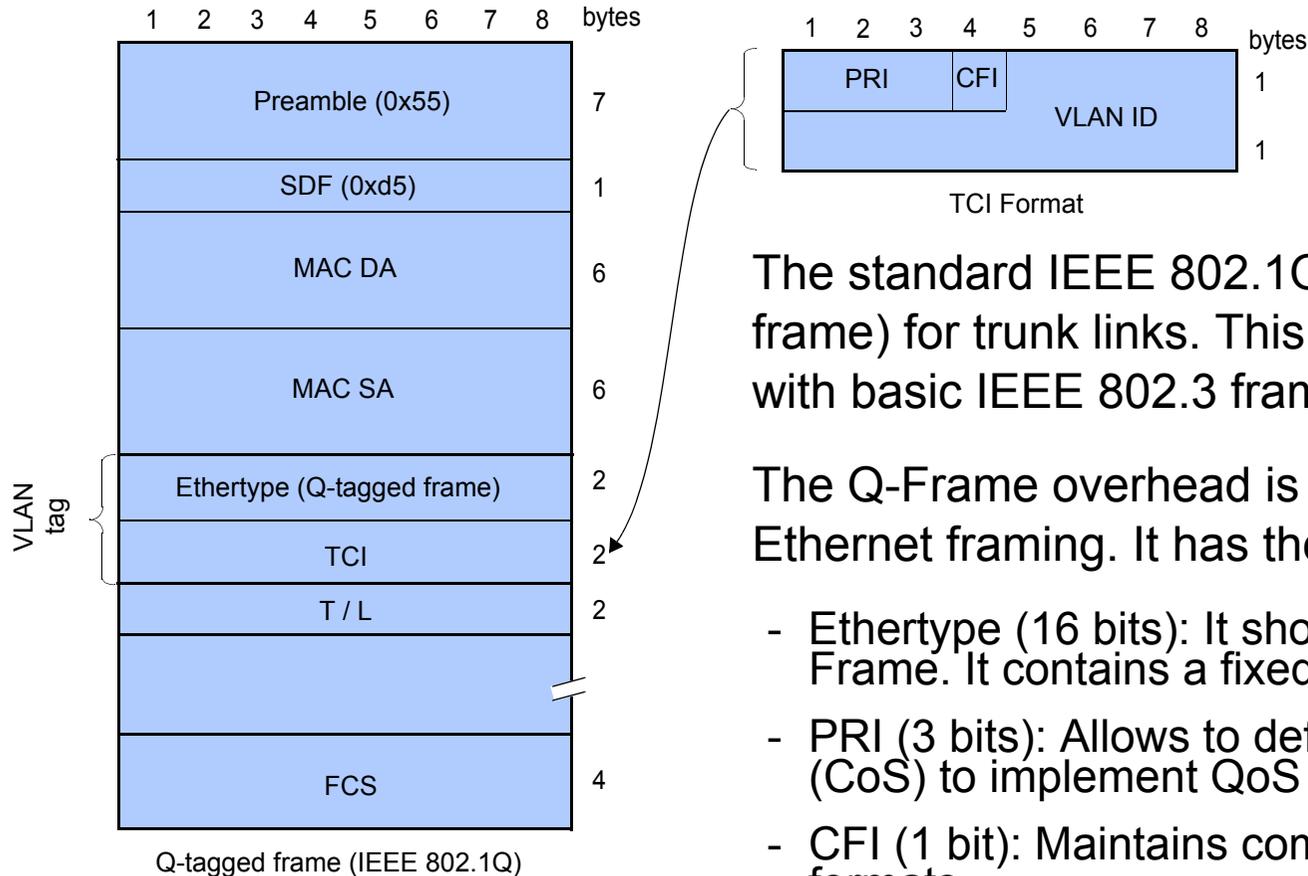


When all the stations belonging to the same VLAN are attached to the same switch, then management is easy. Delivery of Ethernet frames between VLANs when stations are spread across several switches is more difficult.

Switches need to know the destination VLAN when they receive a frame. In order to make this possible the IEEE 802.3 frame structure has to be modified with an VLAN ID. The new frame structure is defined in IEEE 802.1Q.

IP addressing must take into account the VLAN structure of the network. Specifically, different VLANs must be mapped to different IP subnetworks.

An IP router with a single physical interface can be used to interconnect many VLANs by means subinterfaces.



The standard IEEE 802.1Q specifies a frame format (Q-frame) for trunk links. This frame format is incompatible with basic IEEE 802.3 framing.

The Q-Frame overhead is 4-bytes longer than standard Ethernet framing. It has the following new fields:

- Ethertype (16 bits): It shows that the frame is in fact a Q-Frame. It contains a fixed value of 0x8100.
- PRI (3 bits): Allows to define up to 8 Classes of Service (CoS) to implement QoS policies.
- CFI (1 bit): Maintains compatibility with other IEEE frame formats.
- VLAN ID (14 bits): Contains the own VLAN identifier. There are 4096 possible identifiers.

That's all



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