



Telecommunication Networks

LAN Networks

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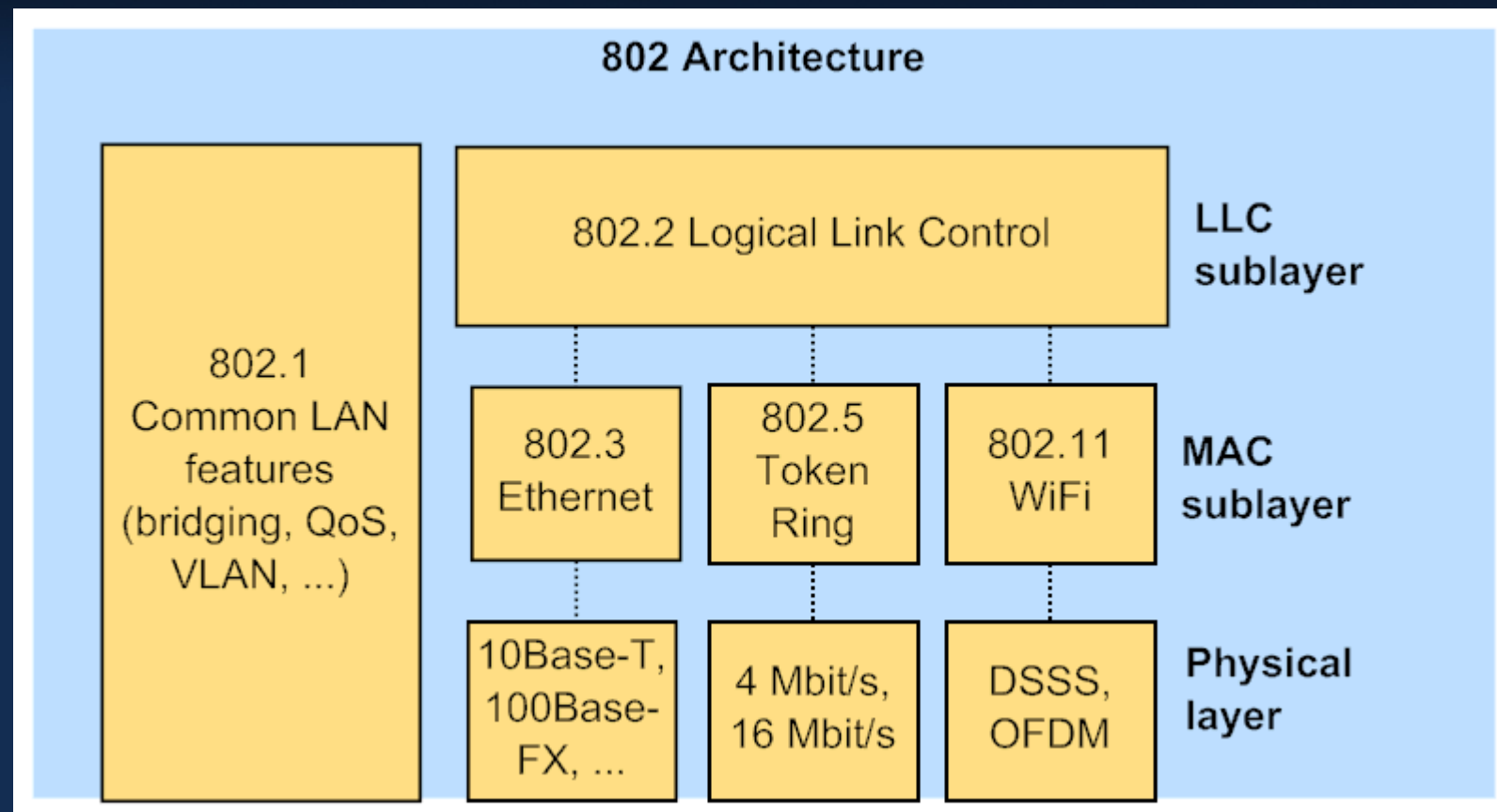
- The goal of LAN networks is to join computers located within the limited area into a computer network.
- A LAN is usually administered by a single organization.
- Important characteristics of LANs:
 - size of the area covered,
 - number of users connected,
 - number and types of services available,
 - required bit rate.
- Wired and also wireless technologies are used in LAN networks.
- Different technologies are used compared to WANs.



LAN Protocol Stack

- LAN technologies implement only the functions of the physical and data link layer.
- **The physical layer** deals with the bit representation by electrical or optical signals or electromagnetic waves, further with cables, connectors, bits encoding etc.
- **The data link layer** has two sublayers – **Logical Link Control (LLC)** and **Media Access Control (MAC)**.
- LLC functions are usually implemented by an appropriate software module of the operating system and MAC functions are implemented both by hardware (network adapter or network interface card) and software (network adapter driver).





**LAN protocol stack according to IEEE
(Institute of Electrical and Electronics Engineers)
(chosen protocols)**



MAC sublayer

- ensures access to the shared medium,
- creates frames,
- transmits frames between end nodes.

Random access is one of the main algorithms used for accessing the shared medium. Its idea is that a station with a frame to transmit tries to send it without coordinating the use of the shared medium with other network nodes. As a result, there is a risk of a collision. This access method doesn't guarantee a frame transmission in a specific time interval.



Deterministic access is another method of accessing shared media. It acquired its name because the maximum waiting time required for access to the medium is always known beforehand. Deterministic access algorithms use two mechanisms: **token passing** and **polling**. Networks with deterministic access methods are better in the QoS (Quality of Service) support and during the high network traffic congestion. On the other hand, networks with random access are more effective and cheaper.



LLC sublayer

- organizes an interface to the network layer, which is directly adjacent to it,
- ensures an error free frame delivery between the source and the destination.

The LLC sublayer enables cooperation of different network layer protocols with different access methods and technologies defined in the MAC sublayer.



Network Topologies

- **Physical topology** – describes how network devices are interconnected.
- **Logical topology** – describes how the data transmission occurs among network devices.
- Examples of topologies: bus, ring, star, extended star.
- Compare: PCs interconnected by a hub – the physical topology is a star, the logical topology is a bus.
PCs interconnected by a switch – both the physical and logical topology are stars.



Ethernet (IEEE 802.3)

- **Ethernet** is currently the most common LAN standard.
- The main reason for Ethernet's success was its simplicity and low costs.
- The term Ethernet usually means a variant of the technology; variants include Fast Ethernet, Gigabit Ethernet, 10G Ethernet, 40G Ethernet and 100G Ethernet.
- In the strict sense of the word, Ethernet is a network standard for data transmission at the rate of 10 Mbit/s that appeared in the late 1970s as a proprietary standard. In the early 1980s, Ethernet was standardized by the IEEE 802.3 workgroup.

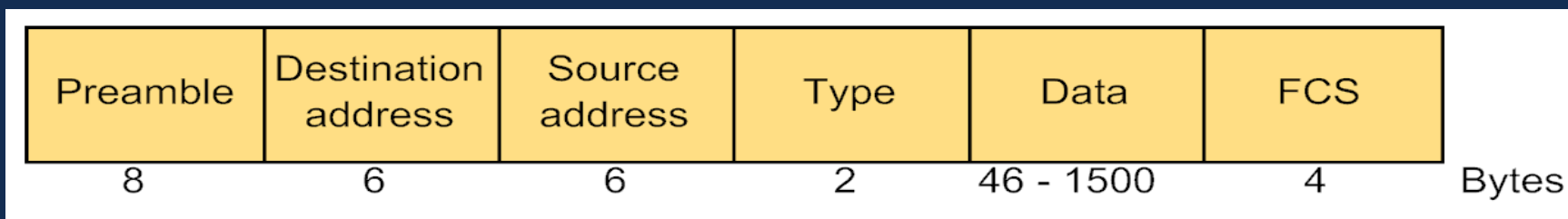


CSMA/CD

- **CSMA/CD (Carrier Sense Multiple Access/Collision Detection)** is an access method commonly used in the Ethernet. It is a random access method.
- Using this algorithm, more stations can try to access the shared medium. If the medium is free (no carrier frequency is detected), the station can send its frame. If the medium is not free, the station has to wait until the medium is free again.
- Carrier sensing does not guarantee the elimination of situations in which two or more stations simultaneously decide that the medium is free and start the transmission of their frames. Such situation is known as a collision. After the collision detection, colliding stations have to stop their transmission and wait for a random time before another transmission. This waiting period grows exponentially if there are more consecutive collisions in the network.



- More versions of Ethernet frames exist – DIX/Ethernet II, 802.3/LLC, Raw 802.3/Novell 802.3, Ethernet SNAP. DIX/Ethernet II is the preferred frame type for IP.
- In Ethernet, MAC addresses are used as physical addresses in the network.



Ethernet frame format (DIX/Ethernet II)



Ethernet Versions

- Variants of Ethernet include:
 - „classical“ Ethernet (bit rate – 10 Mbit/s),
 - Fast Ethernet - IEEE 802.3u (bit rate – 100 Mbit/s),
 - Gigabit Ethernet - IEEE 802.3z for optical and STP cable, IEEE 802.3ab for UTP cable,
 - 10 Gigabit Ethernet - IEEE 802.3ae,
 - 40 Gigabit Ethernet a 100 Gigabit Ethernet - IEEE 802.3ba.
- They differ in the used bits encoding. Variants with higher speed have higher requirements for cable quality.
- 10, 40 and 100 Gigabit Ethernet is intended for full duplex point-to-point connections over optical fibers. It is also possible to use a metallic cable over a short distance (up to 10 m). It is very useful also for MAN and WAN networks. CSMA/CD is made obsolete.



Token Ring (IEEE 802.5)

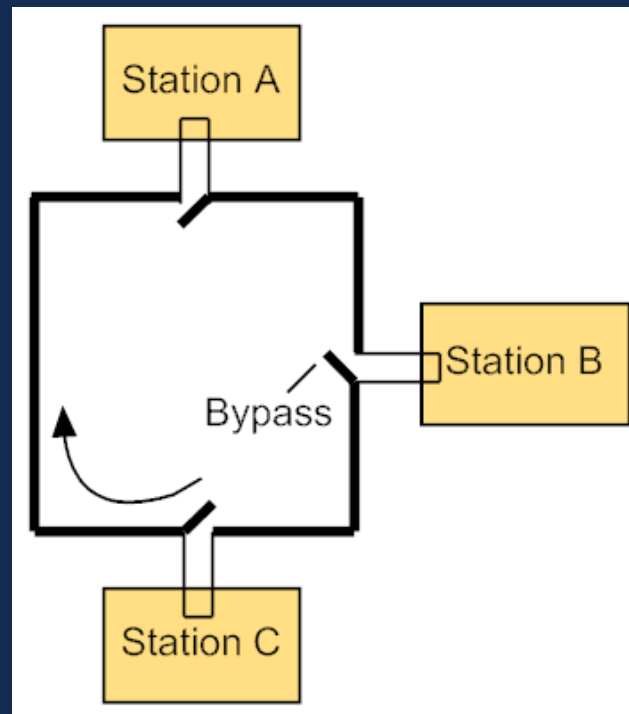
- In the **Token Ring**, a deterministic access method called token passing is used. A ring topology where the sent frame always returns to the sender is used. In some cases, the network is able to correct errors automatically (e.g. a lost token can be restored).
- To control network operation, one of the stations is delegated the role of active monitor.
- **The token passing principle:** In the Token Ring network, each station receives data directly from only one station – the one before it in the ring. Each station transmits the data to its nearest downstream neighbor. Having received the token, the station analyzes it. If this station has no data to transmit, it passes the token to the next station.



When the token is passed to a station that has data for transmission, it withdraws the token from the ring, which gives it the right to access the physical medium to transmit its data. After that, the station sequentially sends a special format frame into the ring. This frame contains a source and destination address. Data being transmitted always travel along the ring in one direction, from station to station. If the frame arrives to the destination node, this station recognizes its address, copies the frame into its internal buffer, and inserts the reception acknowledgment indicator into the frame. The station that sent the data frame into the ring, having received it again with the reception acknowledgment, withdraws the frame from the ring and passes a new token into the network, thus allowing other stations to transmit data.



- Transmission rates: 4 Mbit/s or 16 Mbit/s.
- Max. number of stations is 260, max. length of a Token Ring network is 4 km.
- The Token Ring is more reliable and better supports sensitive data transmission compared to the Ethernet but nowadays is obsolete because of high speed versions of Ethernet.



Token Ring network

FDDI (Fiber Distributed Data Interface)

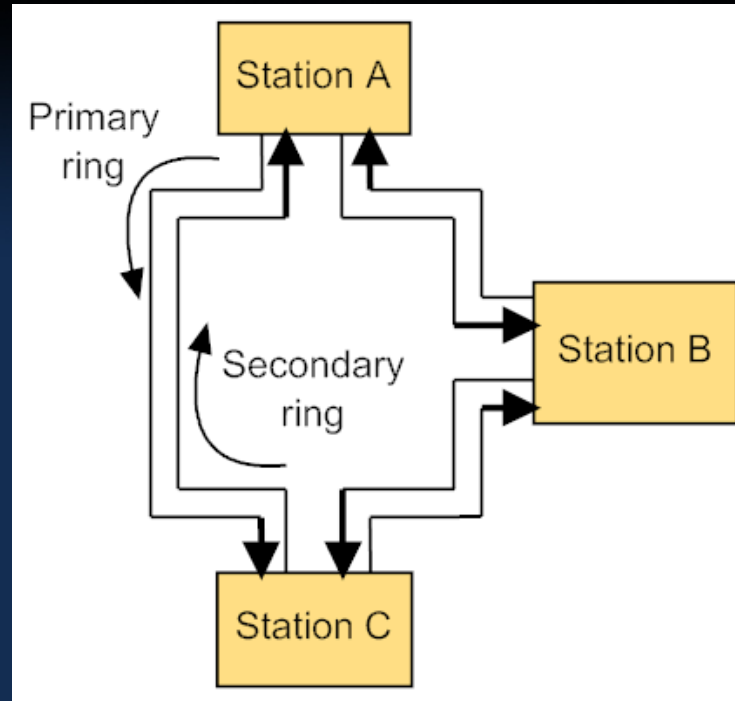
- FDDI was the first LAN technology that used fiber optic cable as a transmission medium (but a twisted copper cable can be also used).
- FDDI is based on Token Ring in many respects.
- FDDI networks are built on the basis of two fiber optic rings that form the main and the protection paths of data transmission between network nodes. The availability of two rings is the main method of improving fault tolerance in FDDI networks.
- Critical nodes that need to benefit from the increased fault tolerance potential must be connected to both rings.
- FDDI standard ensures frame transmission at 100 Mbit/s using dual fiber optic ring up to 100 km long. Maximum number of stations in a ring is 500.



FDDI Operation

- In normal operation mode, the transmitted data pass all nodes and all sections only of the primary ring. This mode is known as the **thru mode**. The secondary ring is not used in this mode.
- If a failure occurs and part of the primary ring cannot transmit data (this can be caused by cable breakdown or node failure), the primary ring is joined to the secondary ring, once again forming a closed ring. This mode of network operation is known as the **wrap mode**.
- FDDI networks can restore usability after the failure of individual elements. In the case of multiple failures, the network is decomposed into several standalone networks, which are not connected to one another.
- FDDI uses token-passing access method (similar to the access method of Token Ring).





FDDI network

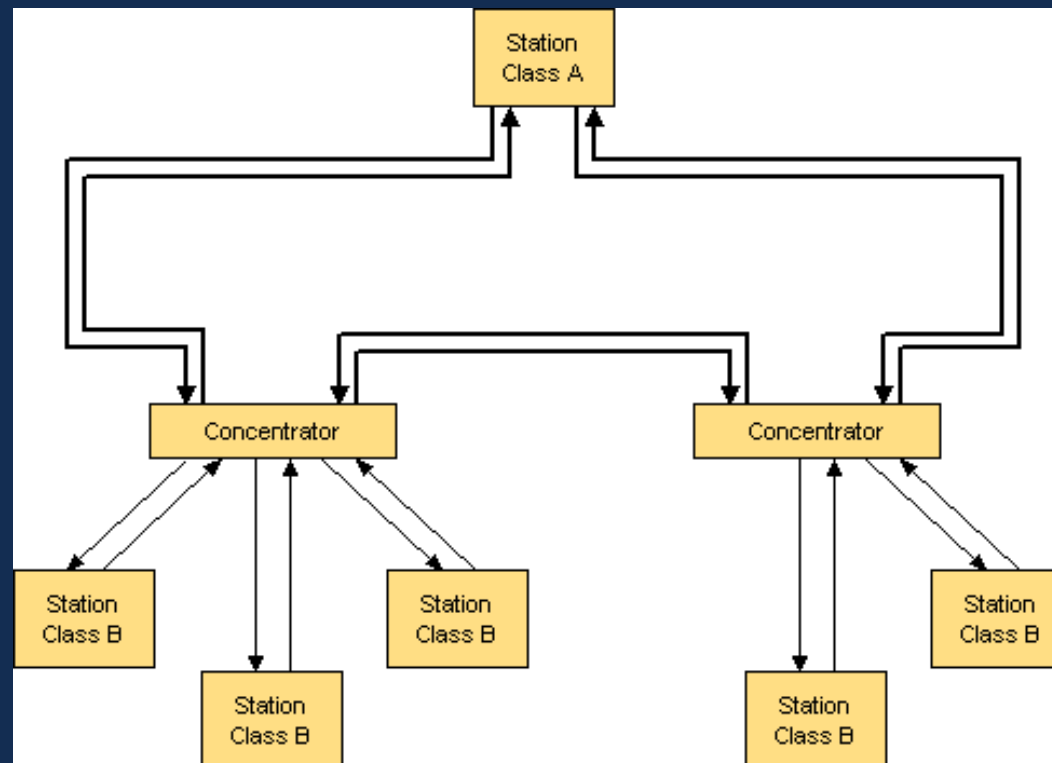
FDDI offers two services:

- **synchronous service** – guarantees the bandwidth to stations. The rest is used for asynchronous services.
- **asynchronous service** – dynamically allocates the bandwidth.



Types of Nodes

- The FDDI standard defines the following types of end nodes:
 - class A station – has a dual attachment (to both rings),
 - class B station – has a single attachment (to the primary ring only),
 - concentrator – connects class B stations to the dual ring.



Using of FDDI

FDDI was developed for use in backbone connections among large networks, such as building networks, as well as to connect high-performance servers to the network.

Advantages:

- high speed data transmission,
- fault tolerance,
- large distances between network nodes.

Disadvantages:

- very expensive.



FDDI II

- FDDI II offers not only synchronous and asynchronous services but also with isochronous (circuit switching) services.

FFOL (FDDI-Follow-On-LAN)

- FFOL was designed for interconnecting of FDDI networks. It offers bit rates 155 Mbit/s and 622 Mbit/s which are based on SDH (Synchronous Digital Hierarchy).



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