Computer Networks

General characteristics of LAN networks - Basics of LAN networks functioning

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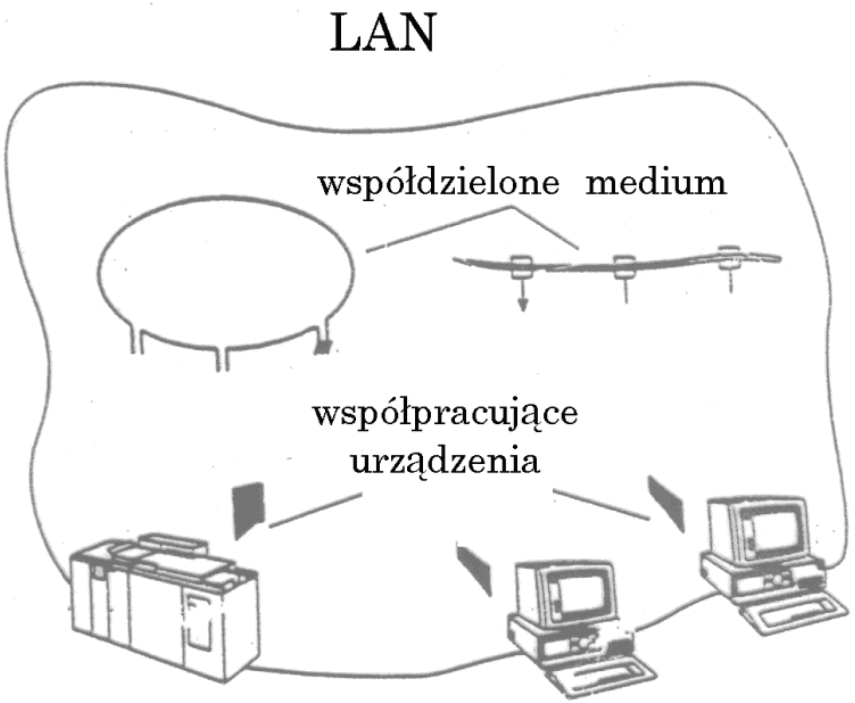
Basics of LAN network functioning

- Typical applications and features of modern LAN networks
- Layered model (LLC, MAC, PHY)
- Topologies
- Standard solutions

LANs

Classic definition:

- A set of various end devices,
- located in a small area,
- connected by a common communication medium and
- implementing a decentralized algorithm of access to this medium (equipment, medium, protocol)



LANs

- LANs cover only a small geographic area;
- LANs are owned and maintained by a single organisation (that uses them);
- LAN internal data rates are usually much higher than WAN networks (it does not have to be clearly visible now);
- In classic LAN networks, the broadcast mode of operation dominates - data sent by one user can be received by all the others (all nodes / workstations can receive the same data);
- Since the transmission medium is shared (in classic LANs), only one workstation can successfully transmit at a given time slot;
- The Ethernet standard is definitely the basic solution for LAN networks (classic Ethernet uses broadcast mode).

Features of LAN networks

Typical characteristics of modern LAN networks:

- Number of stations: 10 ... 1000;
- High transmission rates: 10,16,100Mb/s (in case of classic solutions) to several dozen Gb/s (and more) for modern LANs based on optical fibers;
- High-quality of transmission media and services performed;
- High speed of work and high reliability of interconnecting and switching devices;
- Ease to expand;
- Simplified network administration rules;
- Range: 0.1, .., 1 .., 10 km for a single LAN network (up to 100 km for fiber optic solutions and MAN networks).

LAN tasks

- **Sharing** of costly resources, e.g. large computers, optical discs, laser printers, scanners, plotters;
- **Coordination** of concurrent processes in distributed computer systems (automatic production control, enterprise management) and **management** of the transfer of various types of data (local mail, digital telephony, telemetry);
- **Organization** of joint access to external systems, e.g. public data transmission networks, data banks.

LAN tasks

- **File server** - A large storage disk drive that acts as a central storage repository.
- **Print server** - Provides the authorization to access a particular printer, accept and queue print jobs, and provides a user access to the print queue to perform administrative duties.
- **Interconnection** - A LAN can provide an interconnection to other LANs and to wide area networks.

LAN tasks

- **Data processing**

(data entry, job processing, harvest transfer, interactive work, batch processing);

- **Office automation**

(document handling / word processing, e-mail, automatic copying / faxing);

- **Production automation**

(CAD / CAM, warehouse management, control of production processes);

LAN tasks

- **Video transfers** - High speed LANs are capable of supporting video image and live video transfers.
- **Manufacturing support** - LANs can support manufacturing and industrial environments.
- **Distributed processing** - LANs can support network operating systems which perform the operations of distributed processing.

LAN tasks

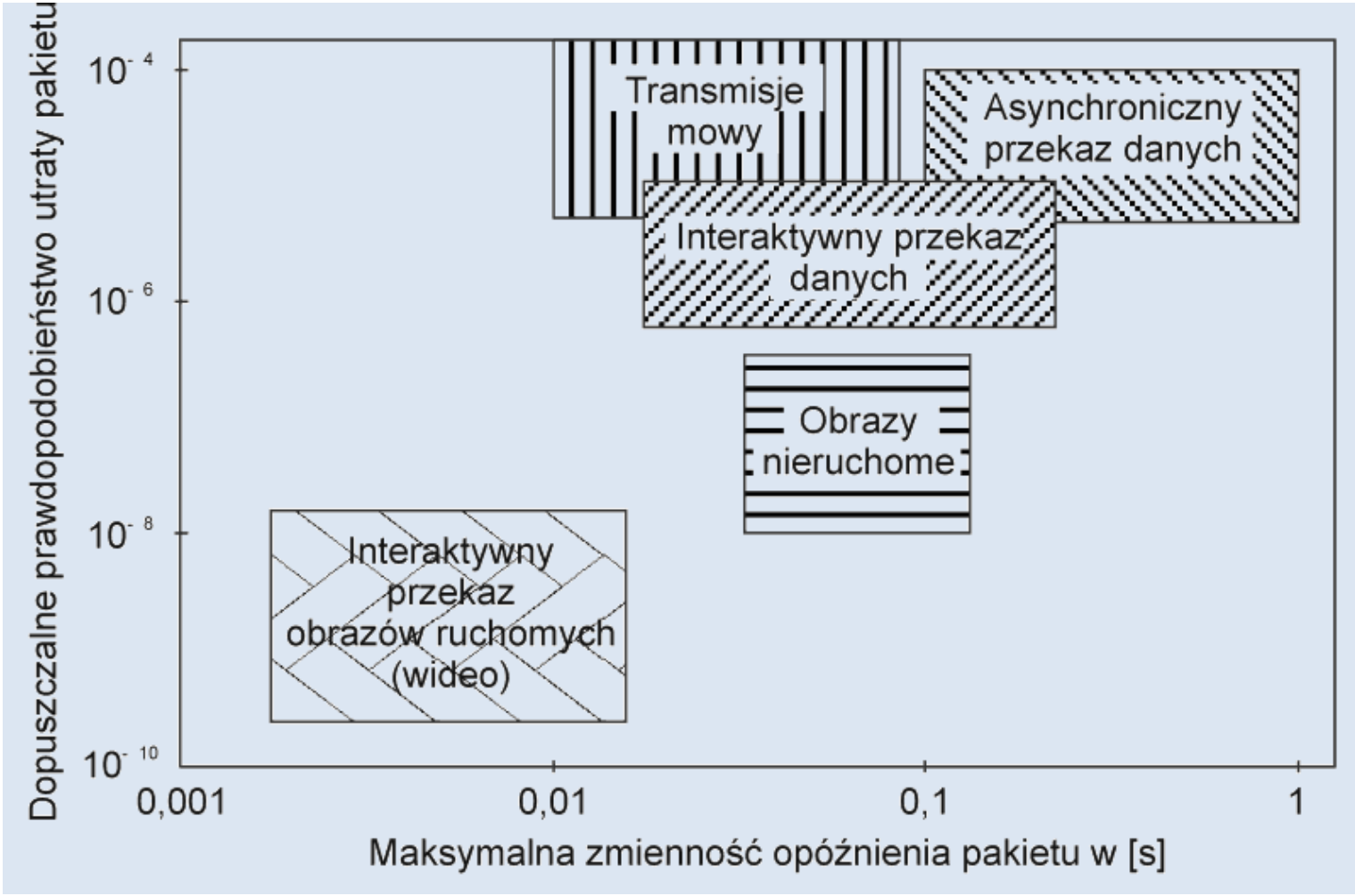
- **Management of energy systems** (heating, ventilation, air conditioning);

- **Improving security**, supervising the operation of sensors, monitoring alarm devices, cameras and monitors;

- **Digital telephony**: VoIP, IPTV;

- **Multimedia technics**

Quality requirements for network applications

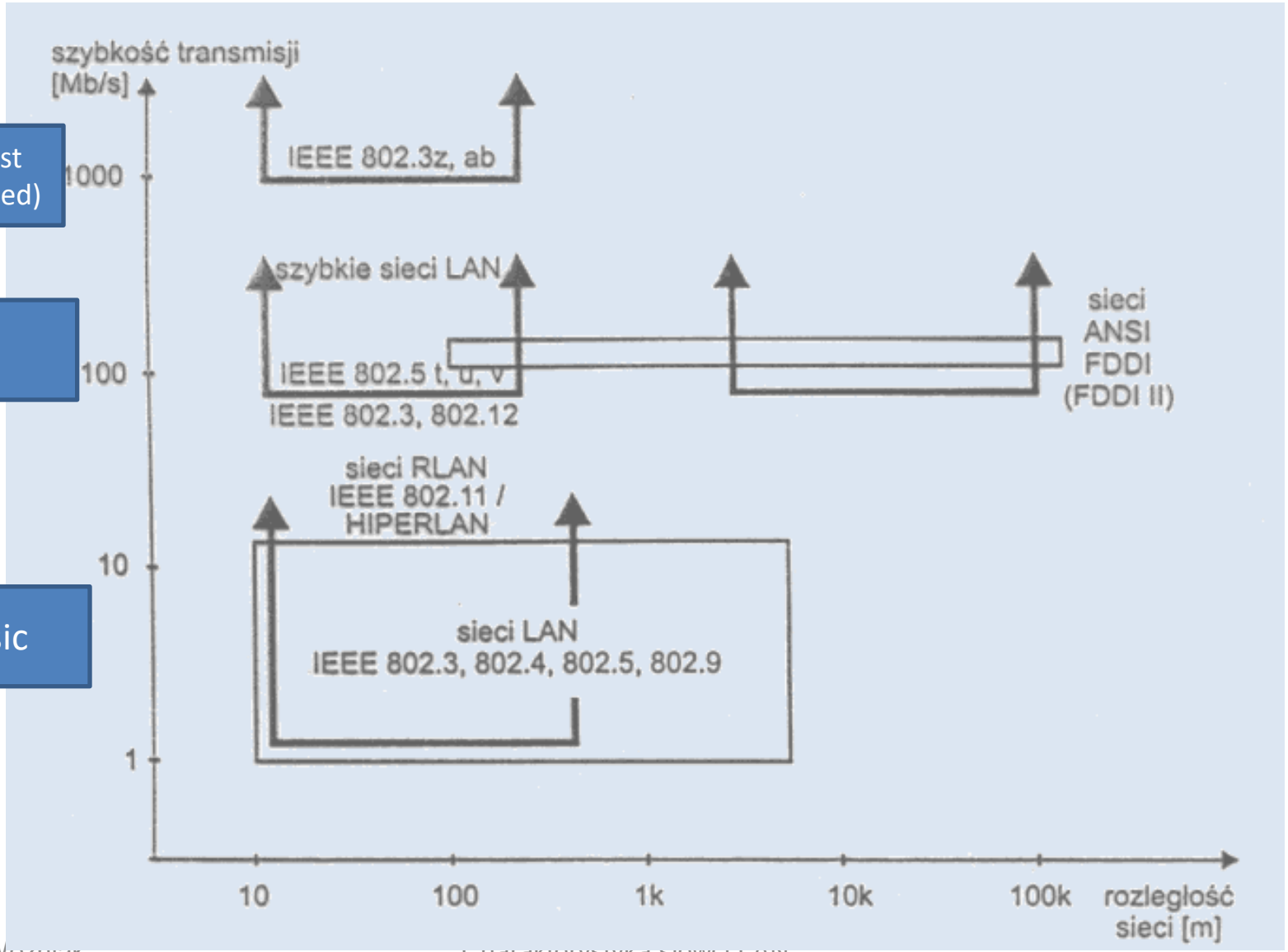


Stages in LAN standardization

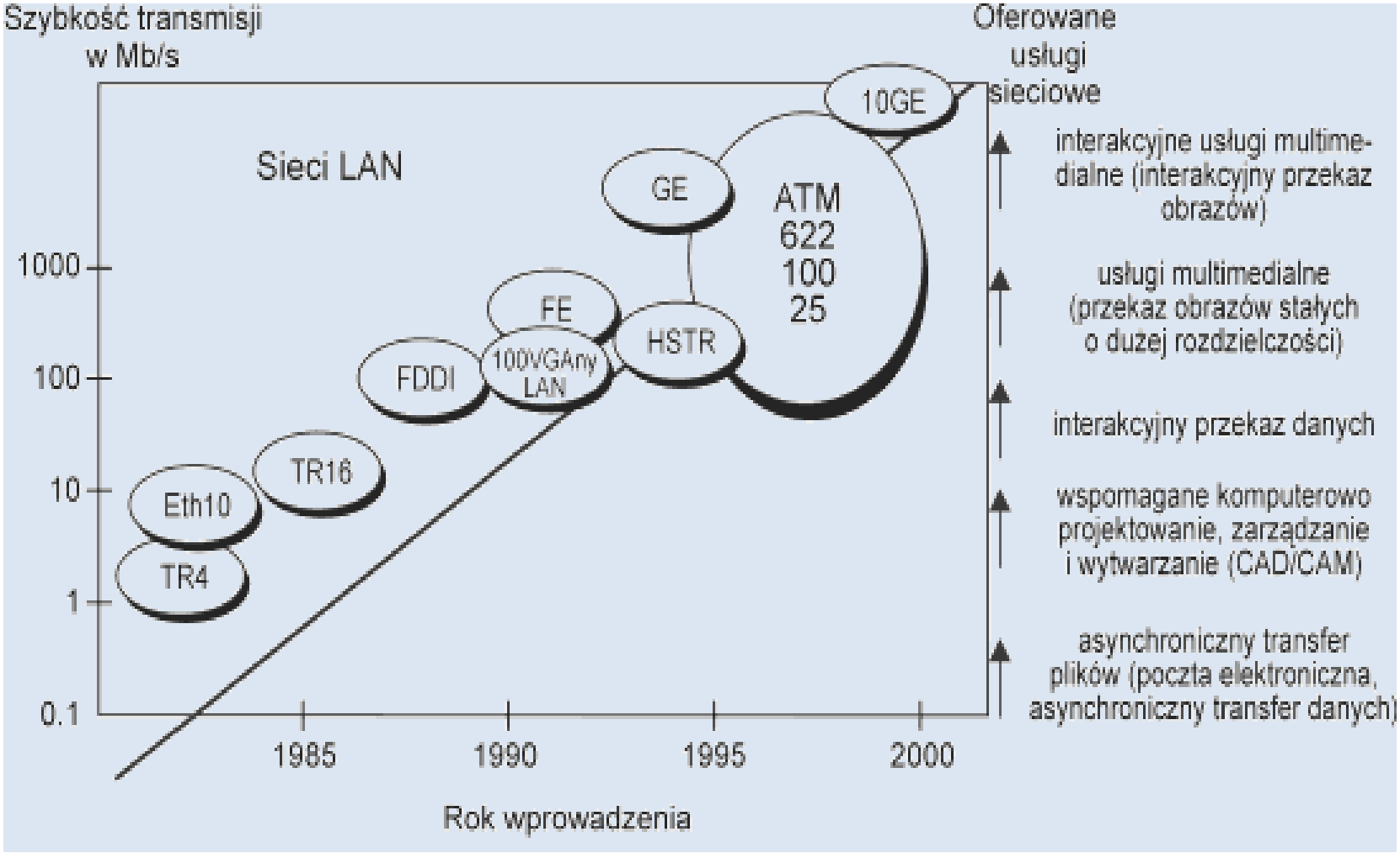
Very fast (high speed)

fast

classic

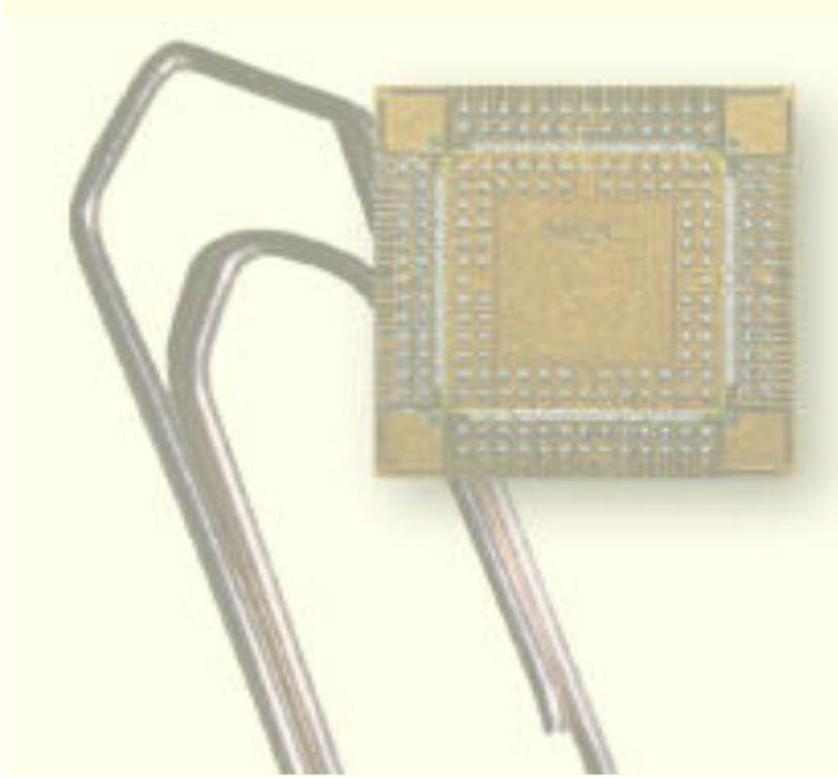


The evolution of LAN technology



The influence of microelectronics on the development of ICT

- **It was observed that every two to three years:**
- The area of the smallest possible circuit (an integrated circuit – IC/ VLSI – Very Large Scale of Integration) decreases by 1.4 times;
- The maximum number of elements (transistors) in an IC circuit is increased by 6 times;
- The maximum speed of operation increases by 3 times.

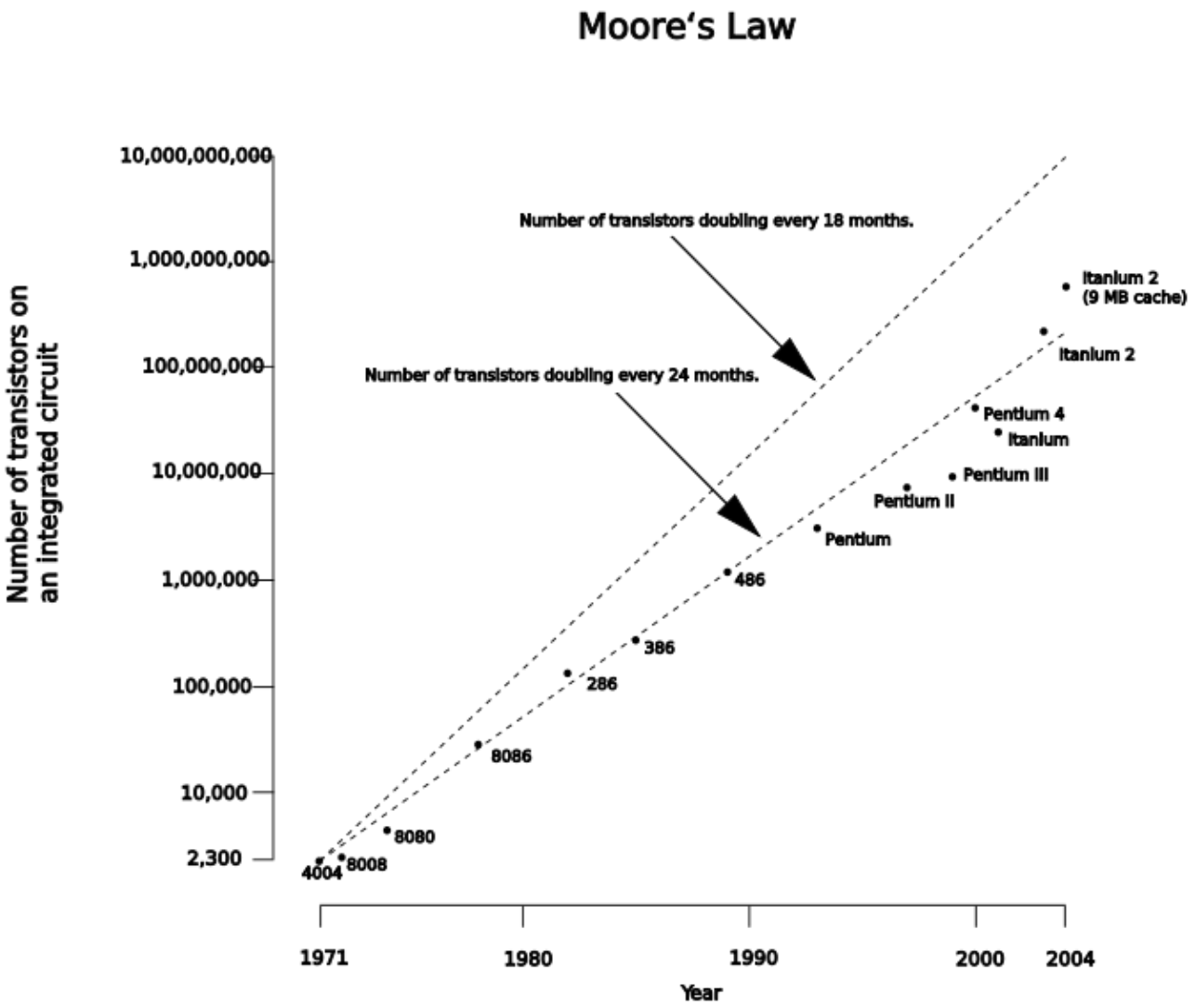


Moore's law

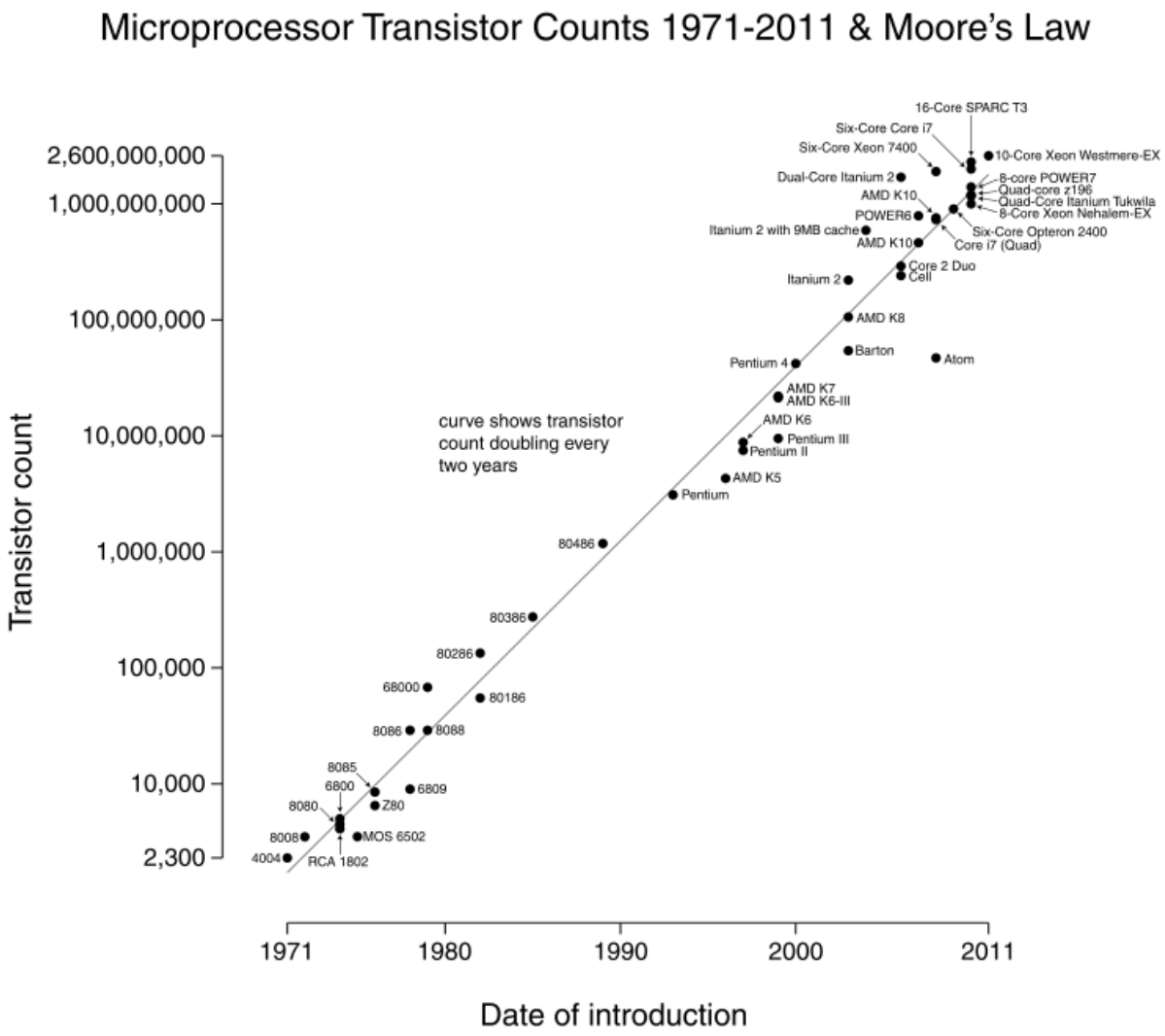
These observations are commonly attributed to Gordon Moore, one of the founders of Intel. Because of this, they are referred to as Moore's Laws.

Moore's Law (PM) as originally formulated says that „The economically optimal number of transistors in an integrated circuit doubles every 18-24 months”.

Moore's laws


Moore's Law
Number of transistors on an integrated circuit
10,000,000,000
1,000,000,000
100,000,000
10,000,000
1,000,000
100,000
10,000
2,300
Number of transistors doubling every 18 months.
Number of transistors doubling every 24 months.
Itanium 2 (9 MB cache)
Itanium 2
Pentium 4
Itanium
Pentium III
Pentium II
Pentium
486
386
286
8086
8080
8008
4004
1971
1980
1990
2000
2004
Year

Moore's law


Microprocessor Transistor Counts 1971-2011 & Moore's Law
Transistor count
2,600,000,000
1,000,000,000
100,000,000
10,000,000
1,000,000
100,000
10,000
2,300
curve shows transistor count doubling every two years
16-Core SPARC T3
Six-Core Core i7
Six-Core Xeon 7400
10-Core Xeon Westmere-EX
Dual-Core Itanium 2
8-core POWER7
Quad-core z196
AMD K10
Quad-Core Itanium Tukwila
8-Core Xeon Nehalem-EX
POWER6
Itanium 2 with 9MB cache
Six-Core Opteron 2400
AMD K10
Core i7 (Quad)
Core 2 Duo
Cell
Itanium 2
AMD K8
Barton
Atom
Pentium 4
AMD K7
AMD K6-III
AMD K6
Pentium III
Pentium II
AMD K5
Pentium
80486
80386
80286
68000
80186
8086
8088
8085
6800
6809
8080
Z80
8008
MOS 6502
4004
RCA 1802
1971
1980
1990
2000
2011
Date of introduction

It wouldn't be if it wasn't for …

Jan Czochralski (23 October 1885 – 22 April 1953) a Polish chemist who invented the Czochralski process, which is used for growing single crystals **and in the production of semiconductor wafers**. He is the most cited Polish scholar.

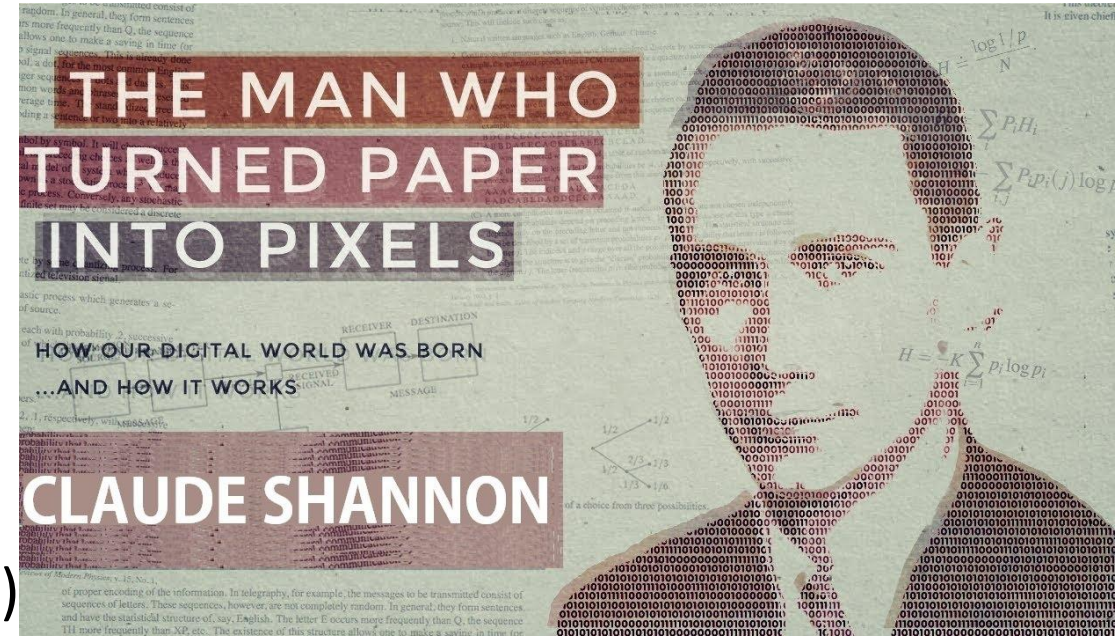
He is undoubtedly the father of world electronics - Bill Gates spoke with great appreciation about his achievements!

By decision of the Senate of Poland, 2013 was the year of Prof. Czochralski.

In 2006 the Polish Materials Science Society, the Polish Society for Crystal Growth and the Polish Academy of Sciences joined with the European Materials Research Society to establish the International Chapter of the Jan Czochralski Award.

Digital world - pixel world

Ability to replace analog information with digital equivalents thanks to the use of (almost) lossless transformations is undoubtedly due to many people (including *Nyquist, Kotelnikow, Shannon*) among whom *Claude Shannon definitely stands out*.



He is the undisputed *father of classical information theory*, the statistical theory of signal reception. The author of important theorems in code theory, or fundamental estimates of system capacity, etc.

Claude Shannon was born on April 30, 1916 in Petoskey, Michigan.

THE MAN WHO TURNED PAPER INTO PIXELS

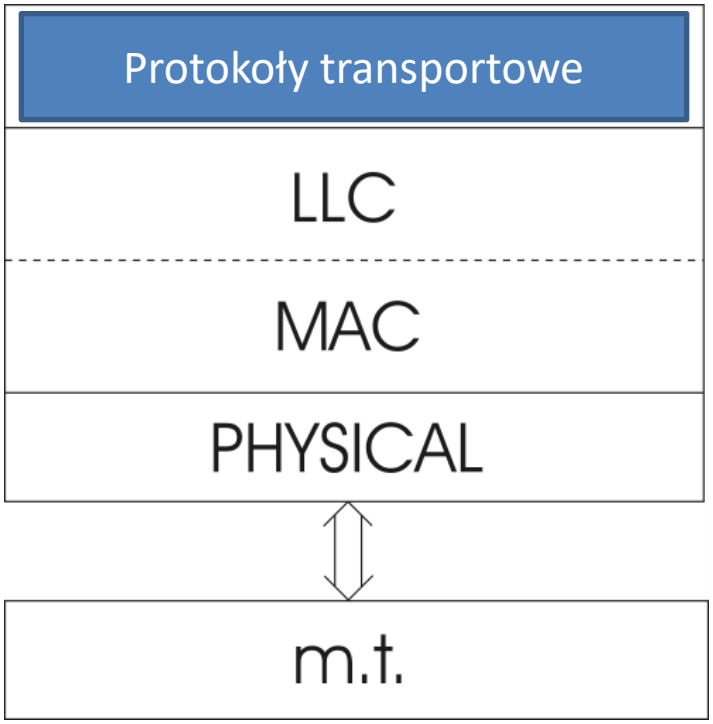
HOW OUR DIGITAL WORLD WAS BORN

...AND HOW IT WORKS

CLAUDE SHANNON

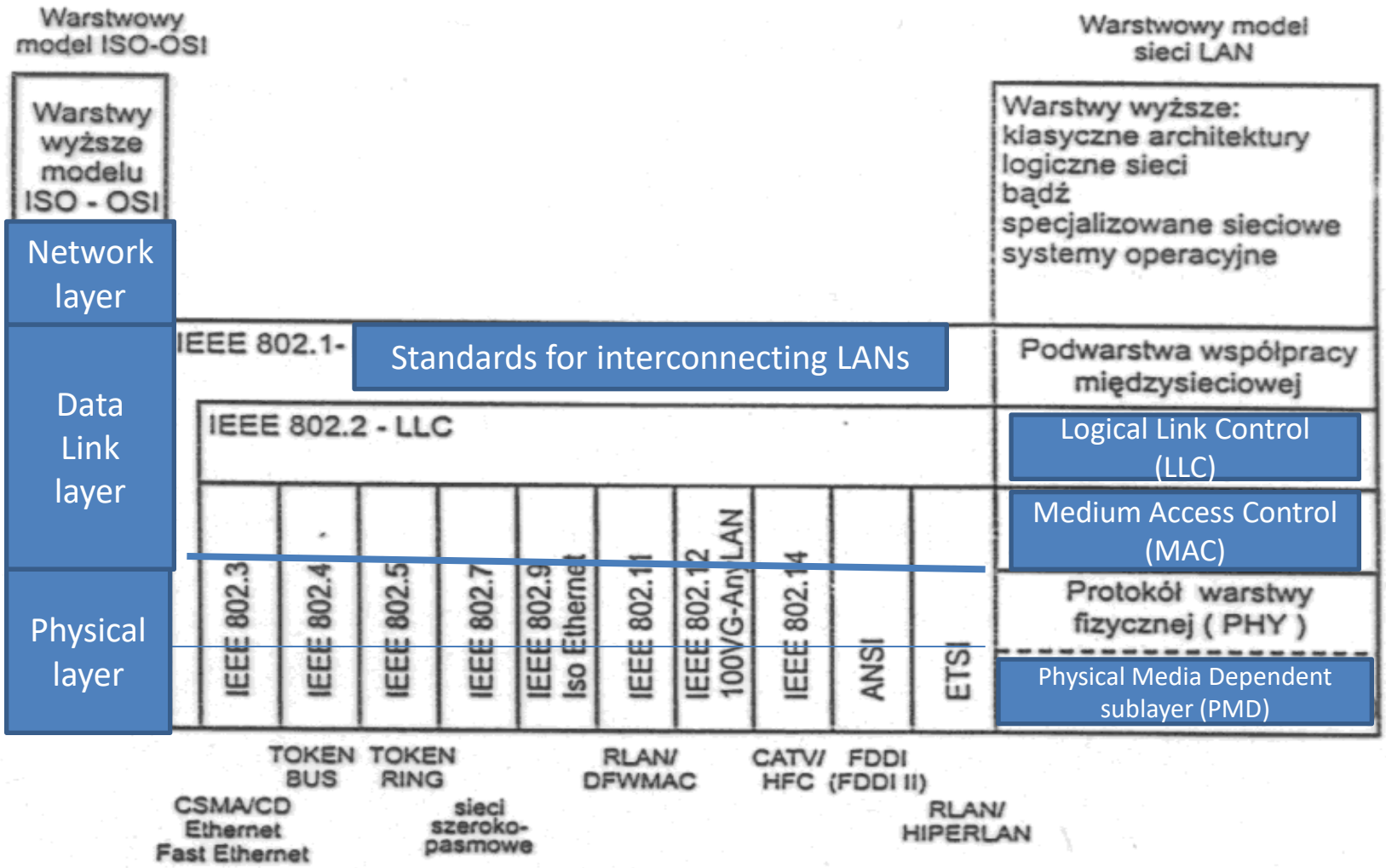
Layered model of the LAN

The specification of „classic" LANs assumes the broadcast nature of the transmission;
This requires access arbitration - settling the possibility of transmitting by individual devices over a shared transmission medium - in order to avoid collisions.



Therefore, the OSI model, following the IEEE 802.x standards, distinguishes 2 sublayers in the data link layer:
Logical Link Control (LLC) sub-layer - responsible eg. for data flow control;
Medium Access Control (MAC) sub-layer - involved in the arbitration of access to the transmission medium
.

Relationships between the IEEE 802 standards and the ISO-OSI model



Data Link Layer Functions

- **Ensuring a properly defined contact** (interface) with the network layer, and the provision of transport services for this layer;
- **Defining the rules of grouping bits** received from the physical layer in frames and the method of creating frames when sending them;
- **Supervision over the correctness** of transmission of frames sent by noisy digital channels,
- **Controlling the flow of frames** to prevent flooding a receiving station , with excessive number of transmitted frames,
- **Channel access management** (access arbitration).

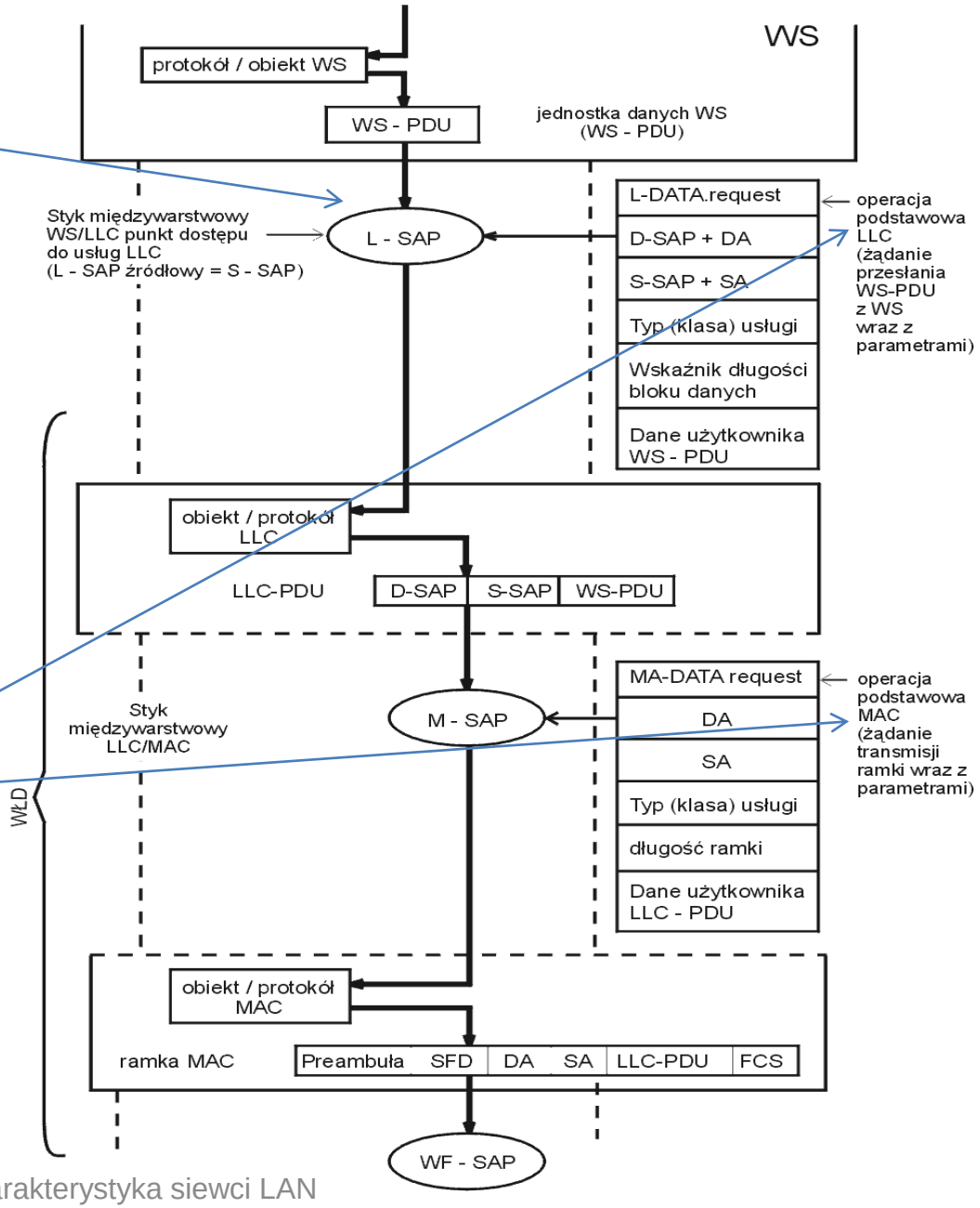
LLC sublayers in local networks

•**LLC sublayer** - **unified for all LANs** - communicates with the network layer via a set of basic operations - LLC primitives;
The transport services offered by the LLC sub-layer are made available to the higher layer through the so-called Service Access Points (SAP) - creating logical contacts between adjacent layers;
Three types of LLC services - frame flow control are defined:
LLC1 - Connectionless and non-notification services using unnumbered frames.
LLC2 – connection-oriented with acknowledgment using standard information frames.
LLC3 - connectionless with confirmation.
The LLC sublayer communication with the MAC sublayer is accomplished using appropriate LLC/MAC primitives;
Layered information transfer between LLC objects in communicating network stations takes place through the exchange of LLC sublayer data units (and dedicated fields).

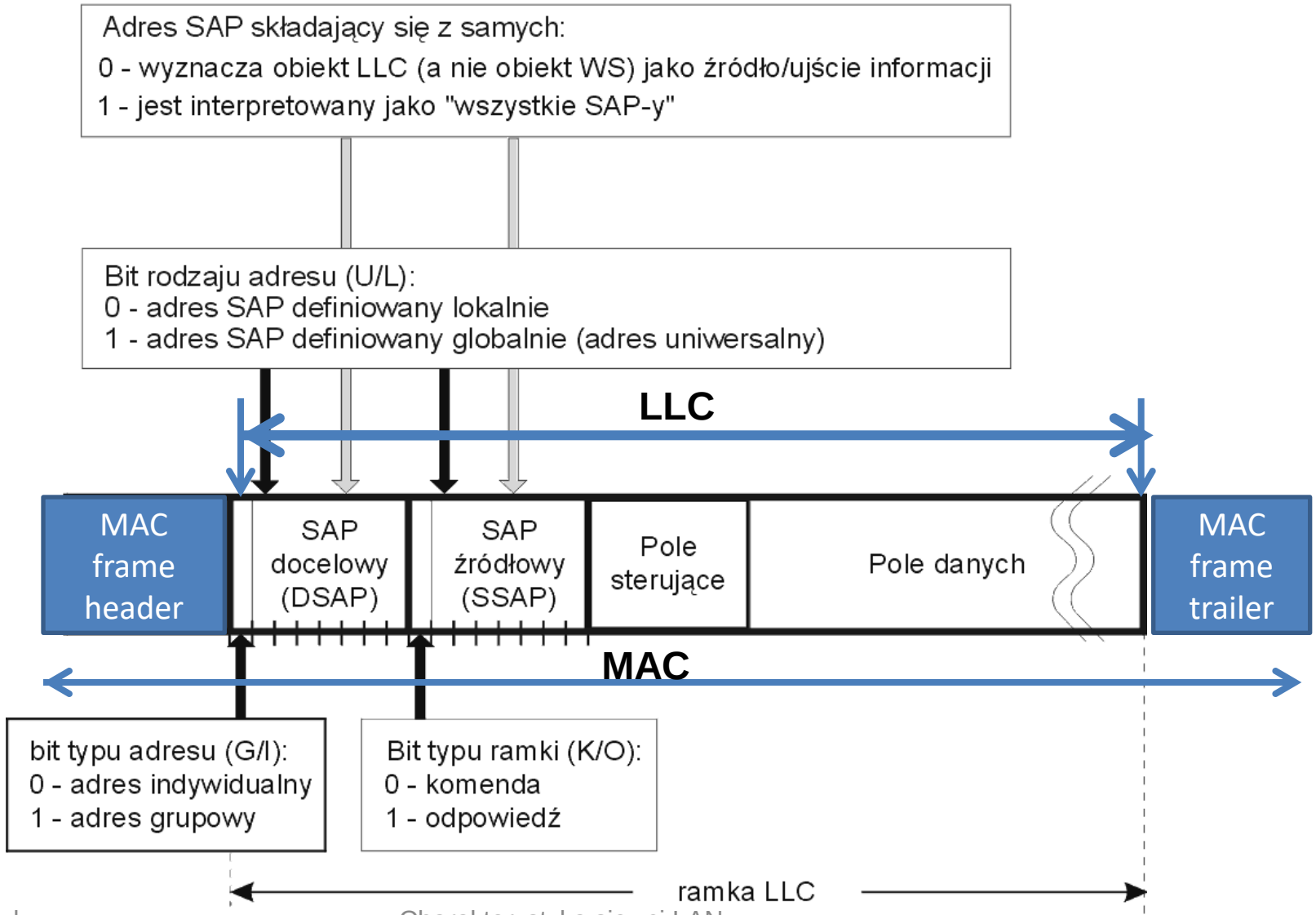
Principles of cooperation
of the Data Link Layer (WŁD)
with the Network Layer (WS)

Organization of the Data Link Layer *LLC/MAC*

Exchange of basic operations
(primitives – requests/responses)
with parameters
Creation of LLC and MAC frames
Specification of addresses



LLC frame format

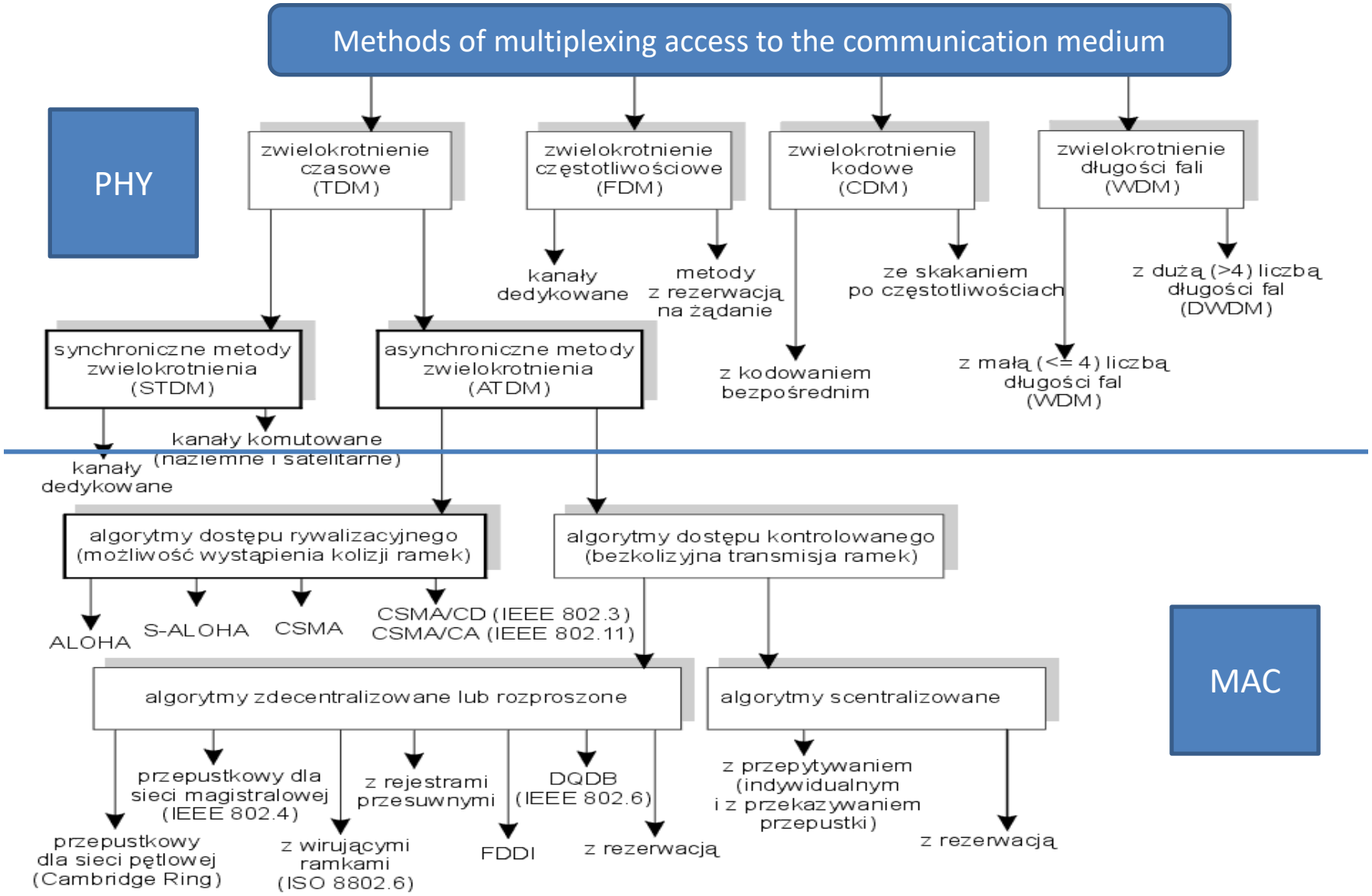


Basic characteristics of LAN networks

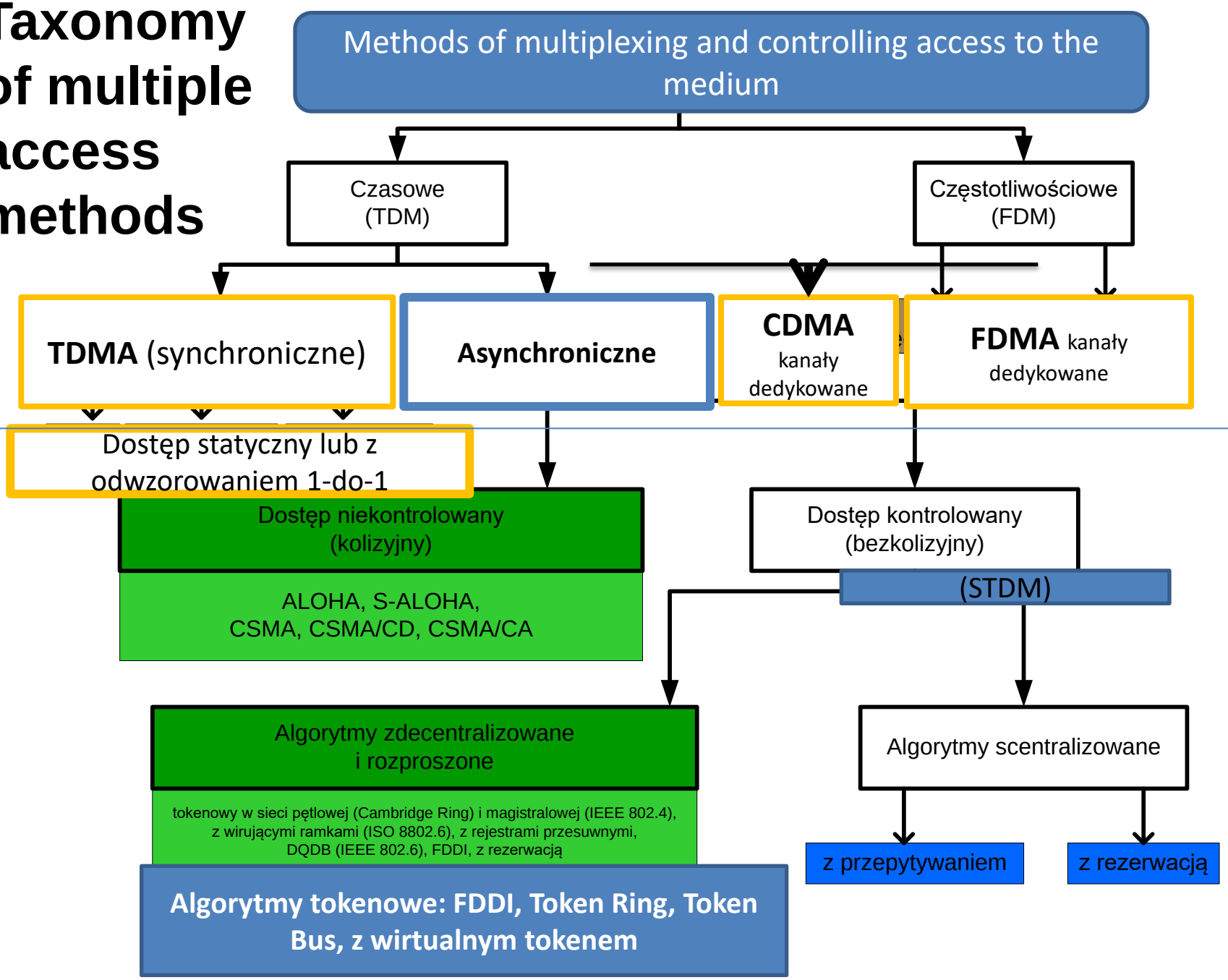
- **Network topology**: bus, ring, tree or star.
- **Type of medium** / a cabling system: wired (UTP/STP – TP- twisted pair, concentric, optical fiber), wireless (radio transmissions, infrared and/or visible light),
- **Transmission technique**: **the baseband** – with no frequency conversion and/or modulated band transmission; or **carrier- and broadband** transmissions, very often with special spectrum spreading,
- **Method of connecting the station** to the transmission medium: serial, parallel, insertion into the cable core,

Media access algorithm: centralized, decentralized, random/ contention type (competitive), contentionless - with reservation, with polling.

Taxonomy of multiple access methods

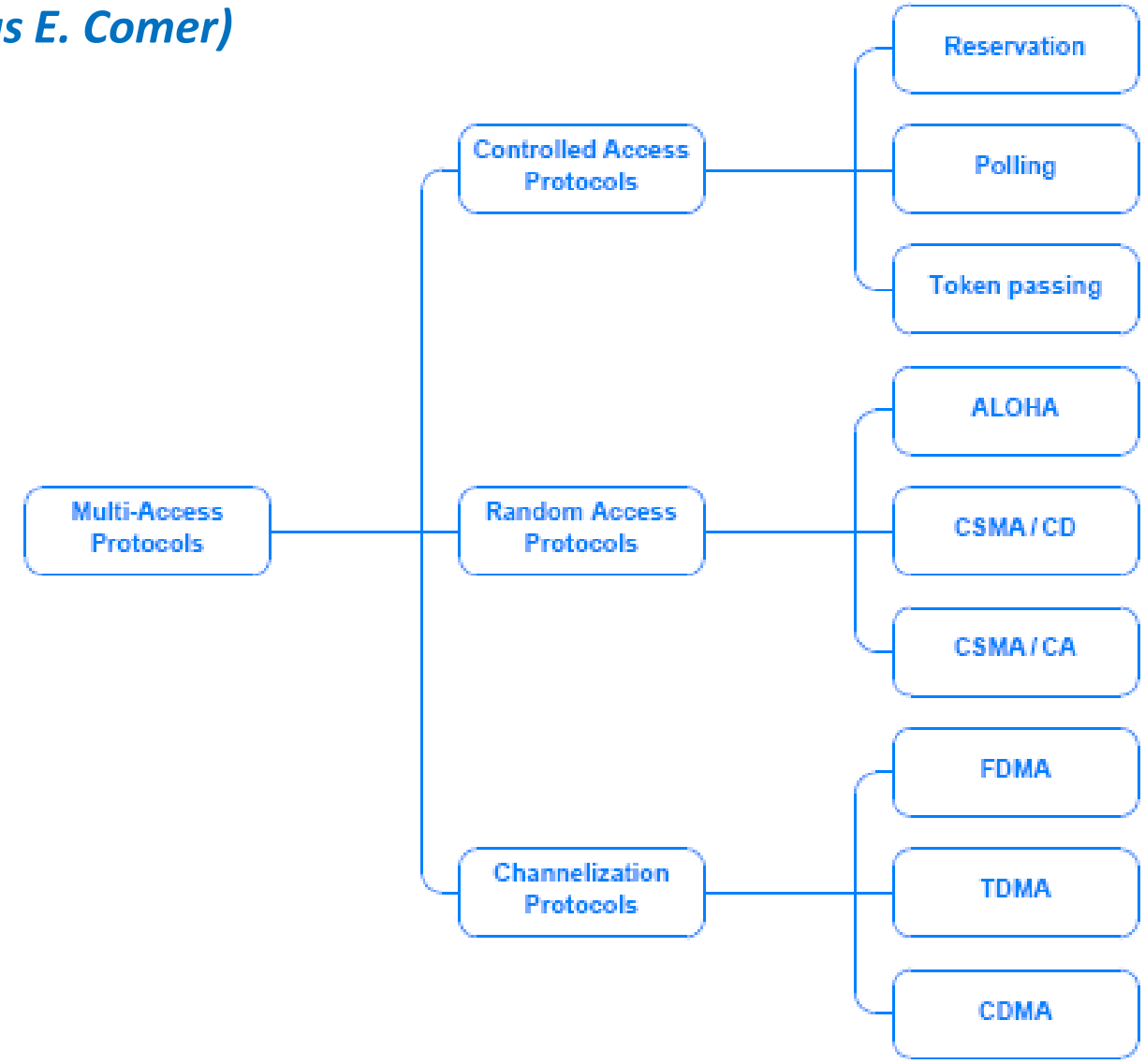


Taxonomy of multiple access methods



Taxonomy of multi-user protocols

(by Douglas E. Comer)



MAC - medium access sublayer
Random access protocols

Properties of contention type (with competition) algorithms – eg. CSMA /CD

- In low traffic, they ensure low delays in accessing the medium,
- with heavy traffic, they cause large and, what is worse, (theoretically) nondeterministic values of this delay,
- guarantee fair service of all stations,
- introduce restrictions on the minimum length of transmitted frames,
- require listening to the channel before and during realized transmissions,
- not suitable for rt applications.

MAC medium access sublayer

Properties of the CSMA/CD (Carrier Sense Multiple Access/ Collision Detection) algorithm (IEEE 802.3) - a contention type (with competition vel with random access).

•A station having a frame to send must first determine the state of the channel through its listening (carrier sense) and only in the case of a free channel it can initiate its transmission (channel listening is required both before and during the transmissions).

• In the case of random access algorithms, we must take into account the possibility of collisions.

Similar algorithm – CSMA/CA (Carrier Sense Multiple Access with Collision Avoidence) - used in WLAN IEEE 802.11 (Wi-Fi)

MAC medium access sublayer

Features of the token passing algorithm used in bus solutions (token bus – IEEE 802.4):

- **A dedicated frame is used to control access to the medium.**
- **Only the station that is the current token holder (captured the token) can transmit frames.**
- effective use of the transmission link, especially with high network load,
- the maximum delay time in getting access to the medium is limited (so-called Token Rotation Time is monitored),
- no restrictions on the minimum length of transmitted frames,
- the ability to enforce frame priorities (internally), while ensuring fair handling of frames within a specific (reserved) priority class,
- collision-free transmission of frames - without the need to "listen" to the channel.

MAC medium access sublayer

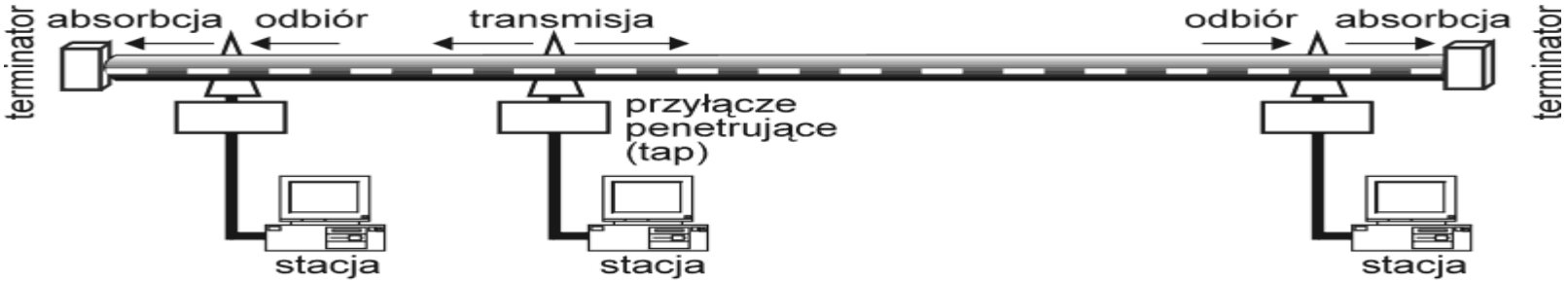
Features of the token passing algorithm used in token ring solutions (IEEE 802.5, FDDI):

- **A dedicated frame is used to control access to the medium.**
- **Only the station that is the current token holder (captured the token) can transmit frames.**
- clear management of the logical (and physical) loop within, which stations access the medium,
- the ability to handle synchronous traffic,
- immediate acknowledgment of receipt of frames at the MAC sublayer level,
- simplification of the token flow control and management access to the medium (in relation to the token-bus solution),
- fair enforcement of frame priorities, with the ability to reserve a token with a specific (reserved) prioriy.

Bus configuration for baseband transmission

a) thin coaxial cable (0.25 ”) used indoors

b) thick (0.5 ") coaxial cable used in corridors, installation shafts, etc.



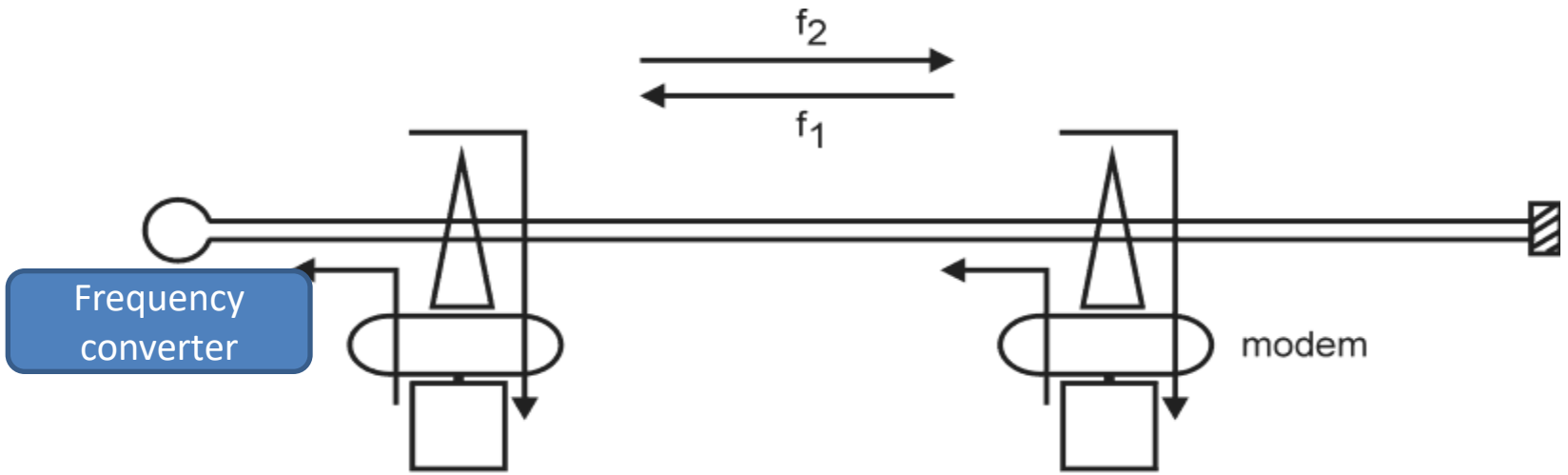
•transmission from the station takes place in both directions,
•number of connected stations (recommended): up to 100 over a distance of 500 m,
•method of station connection: penetrating connection, transceiver.

Bus configuration for broadband transmission

•In the case of carrier or broadband solutions, transmissions from the station are realized in one direction.
•A CATV (75Ω) coaxial cable with a transmission band of 400 MHz is used, in which TV, video, data transmission and other sub-channels are separated.
•The physical range can reach tens of kilometers.

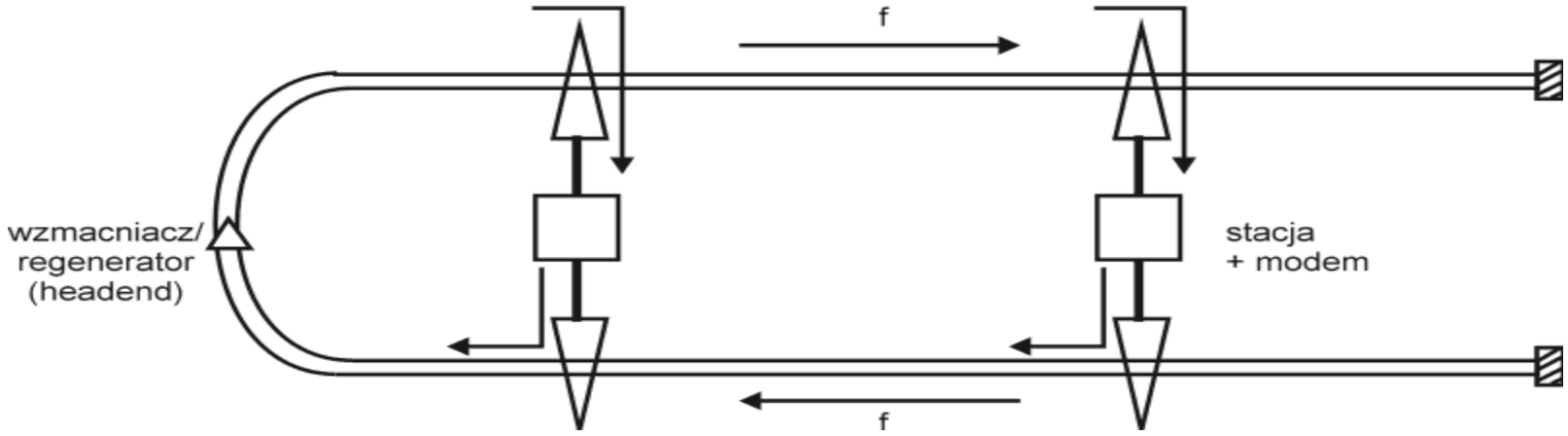
•Due to the unidirectional nature of the transmission (in the broadband bus), two solutions are possible:
1. with separation of transmit and receive frequency bands,
2. with the same frequency in transmitting and receiving parts of a bus.

Separation of transmit and receive bands (split)



1. Cable terminated with a frequency converter (remodulation). Transmission towards the converter at frequency f1, reception away from the converter at frequency f2.
The pair of sub-channels - f1, f2 - forms a unidirectional data transmission channel.

Transmit and receive bus (dual cable)



2. Cable terminated with an amplifier/regenerator that re-transmits signals from the transmitting (for all stations) to the receiving bus;
The fixed carrier frequency channel forms a bidirectional data channel.

Ring configuration

The loop (ring) can actually be regarded as cascading connection of point-to-point (P2P) data links.
The element connecting each station to the ring is a coupler/repeater (a **trunk coupling unit**).
It also enables
connection with NIC.
The transmission rates/speeds achieved in this case were typically: up to 16 Mb/s, when using shielded twisted pairs, or 100 Mb/s and more while using optical fibers.