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### Trends in industrial communication

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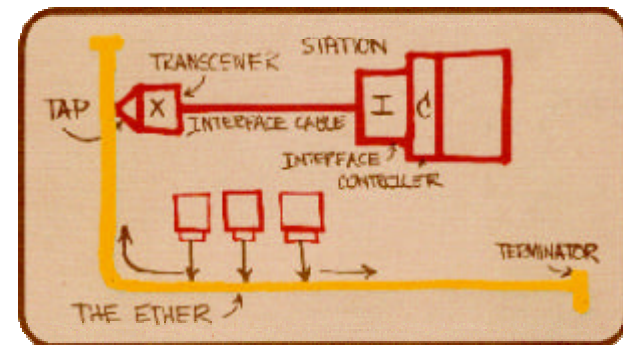
# ETHERNET

## History and present



### ETHERNET history

- developed in 1973 as shared medium
- bandwidth 10 Mbps
- bus topology
- CSMA/CD procedure for media access

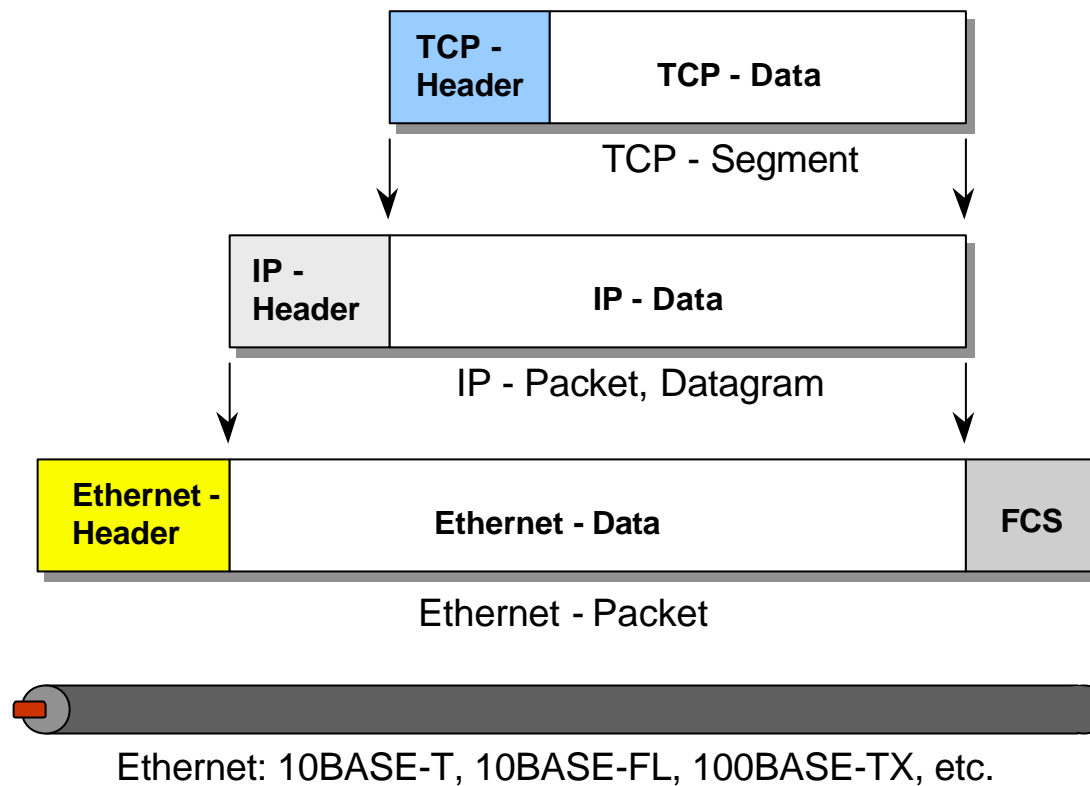


Dr. Robert Metcalfe

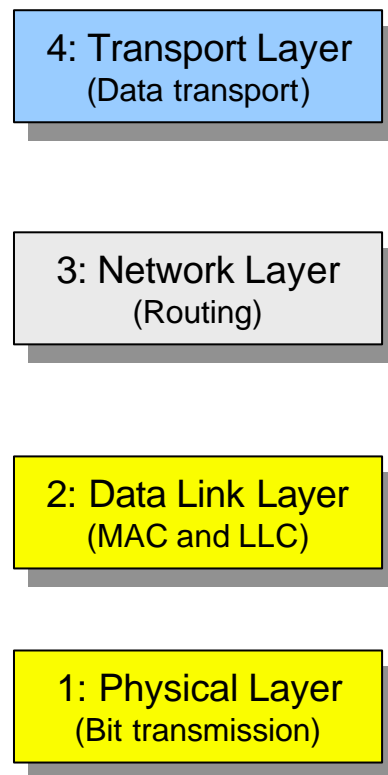
### ETHERNET today

- scalable bandwidth with 10/100/1000 Mbps
- switched “Full Duplex” connection without collisions
- IEEE standards for prioritization and flow control
- standards for Copper, Fiber, Plastic, and Wireless transmission

# ETHERNET ETHERNET - TCP/IP

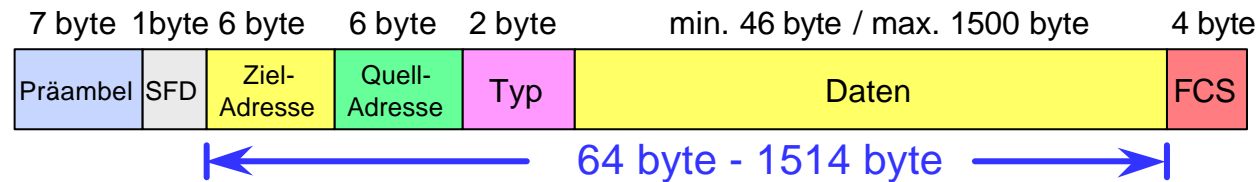


ISO/OSI- model

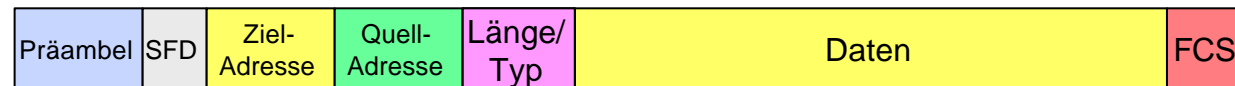


# ETHERNET

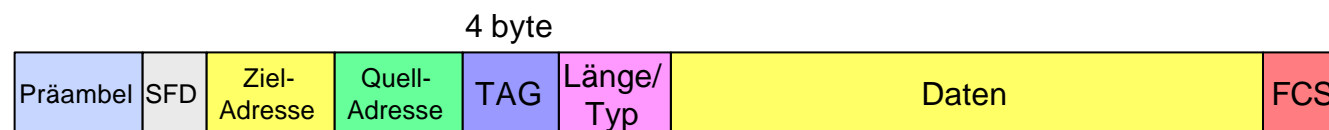
## ETHERNET Frames



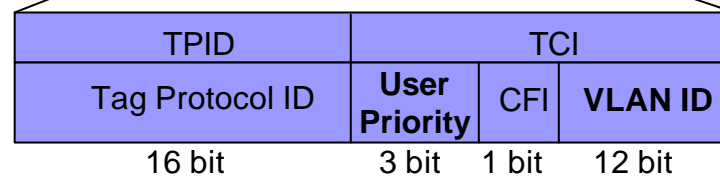
ETHERNET-Frame V 2.0



IEEE-802.3-Frame



IEEE-802.1Q-Frame mit TAG-Feld



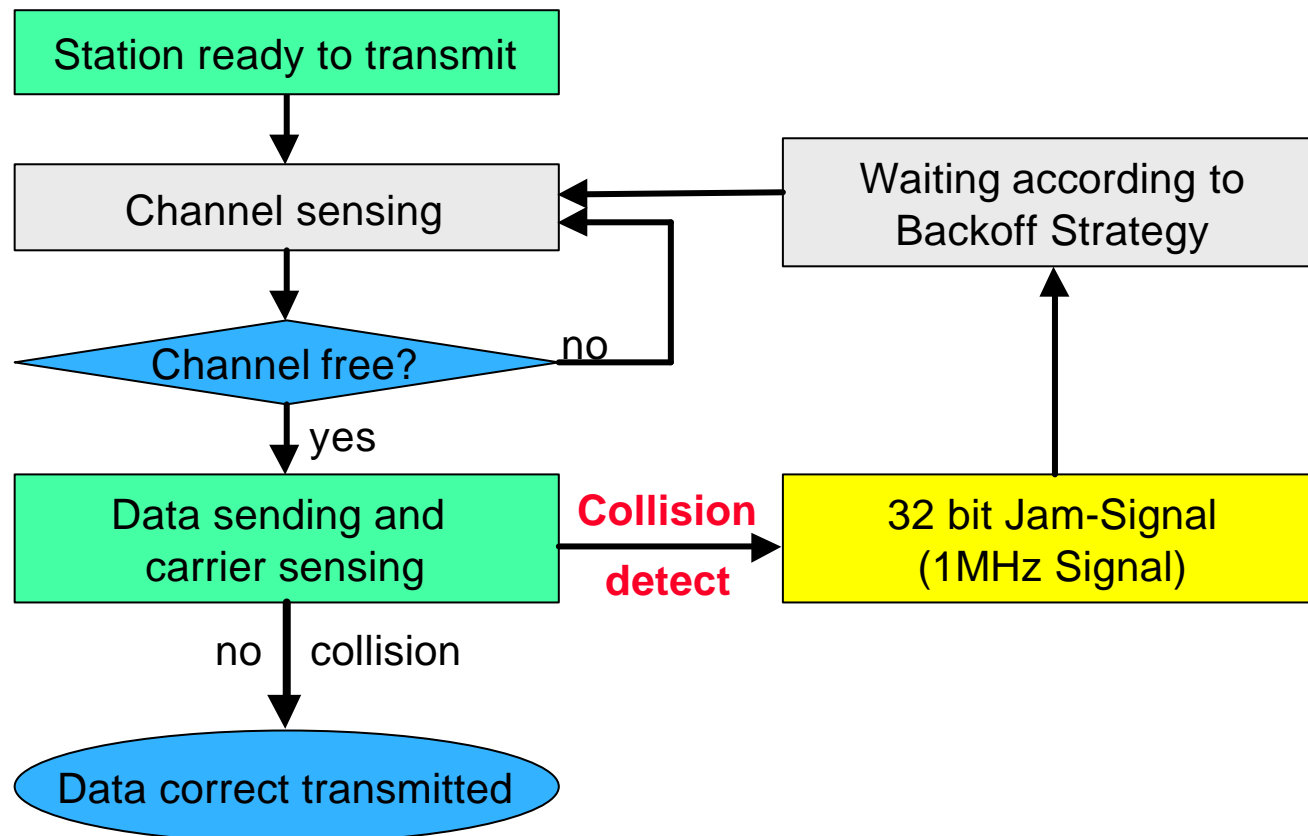
TPID = Tag Protocol Identifier

TCI = Tag Control Information

CFI = Canonical Format Indicator

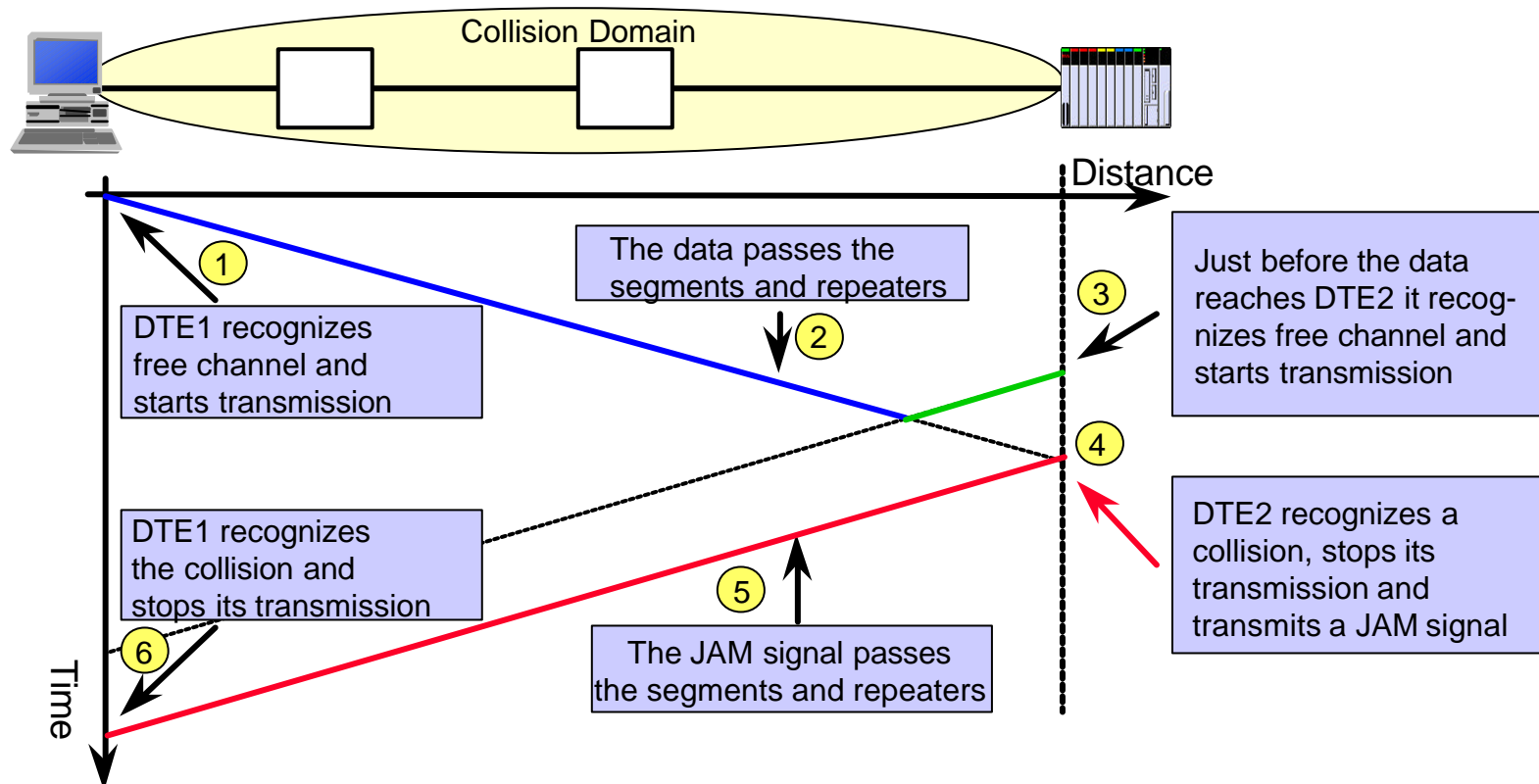
# ETHERNET

## Media access method - CSMA/CD



# ETHERNET

## Collision detection - example



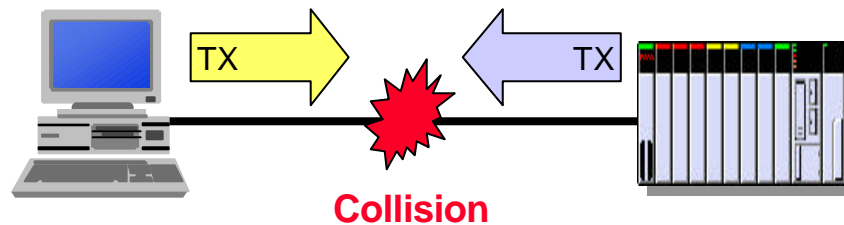
Shortest transfer time of a Datapacket (64Byte) at 10Mbps = 51,2  $\mu$ s

maximum distance within one Collision Domain = 25,6  $\mu$ s x 200,000 km/s = 5,120 m (Theoretical)

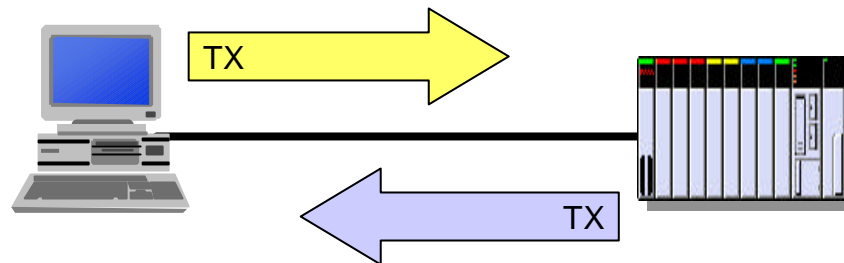


# ETHERNET

## Half duplex (HDX) and full duplex (FDX)



**Half Duplex**  
Sending simultaneously over one path leads to collisions



**Full Duplex**  
Sending simultaneously over one path doesn't lead to collisions

# ETHERNET

## Transceiver, Hub, Switch, Router and Gateway

### Transceiver

- 1. Media convertor within the Rail Family
- 2. Device which converts a signal from an AUI interface to another medium

### Hub

Device which regenerates incoming signals and distributes frames to all other ports.

### Switch

Device which delivers a received data packet only to that port on which the destination station is connected.

### Router

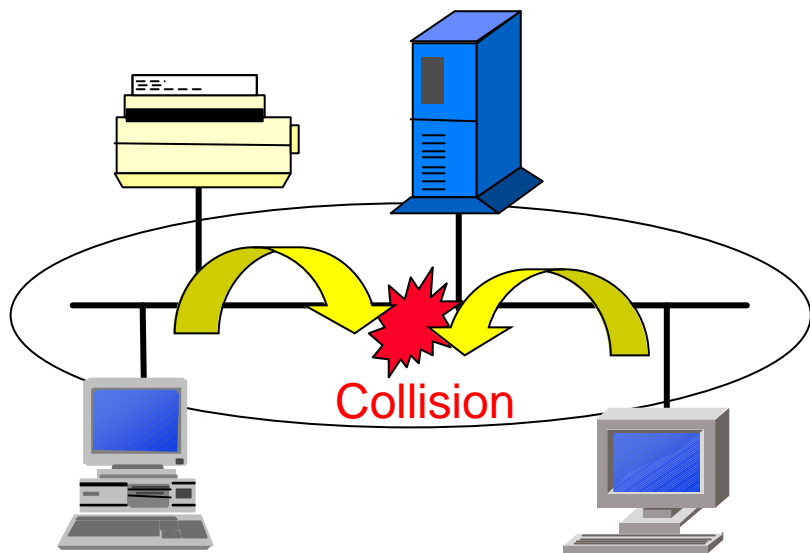
Device which subdivides the network, connects networks with different Layer 3 protocols, and offers alternative routes for data transport.

### Gateway

Device which converts protocols and therefore enables data exchange between individual networks.

# ETHERNET

## Shared network



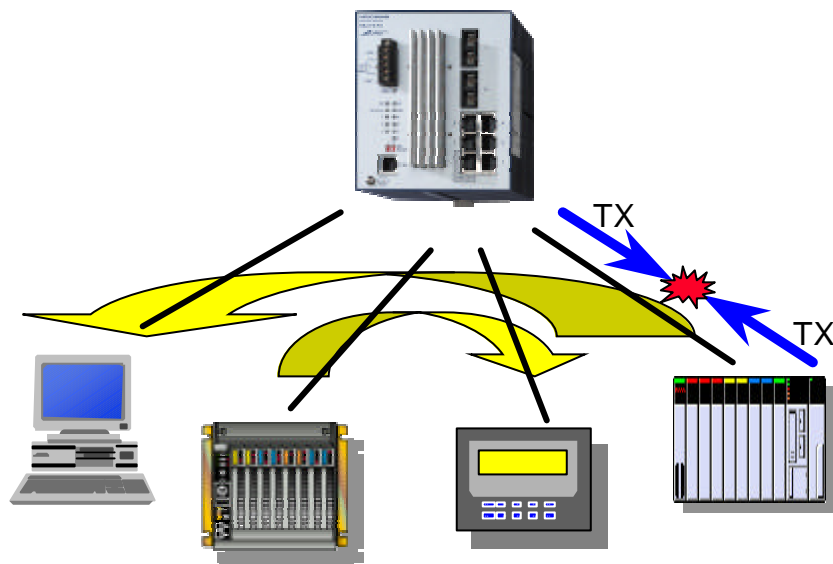
### Features:

- One Collision Domain
- CSMA/CD across total network
- Half Duplex across total network

**Communication is dependent on network users. This may lead to the occurrence of collisions, which will flood over the entire network (one Collision Domain).**

# ETHERNET

## Switched network and HDX operation



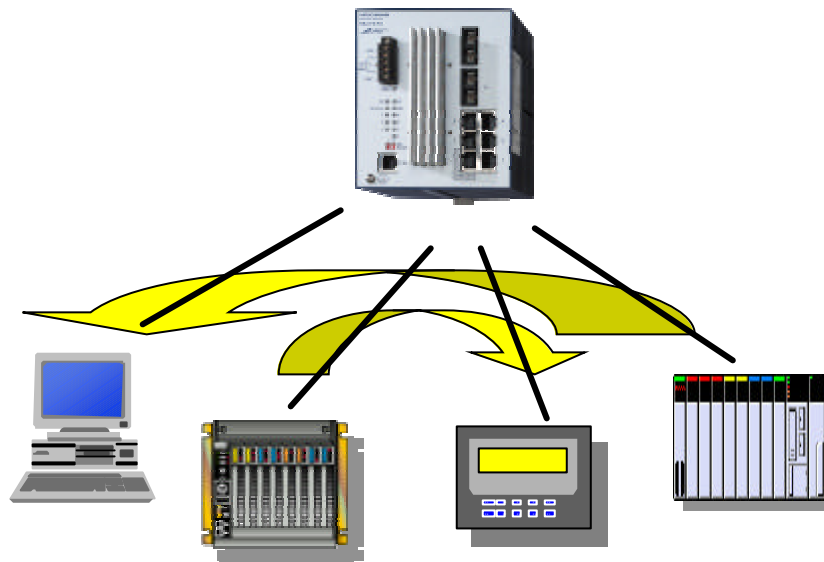
### Features:

- Point-to-Point connections between the devices
- CSMA/CD in every connection (many "Collision Domains")

**Communication between users is independent from each other.  
Possible collisions are limited to individual links.**

# ETHERNET

## Switched network and FDX operation



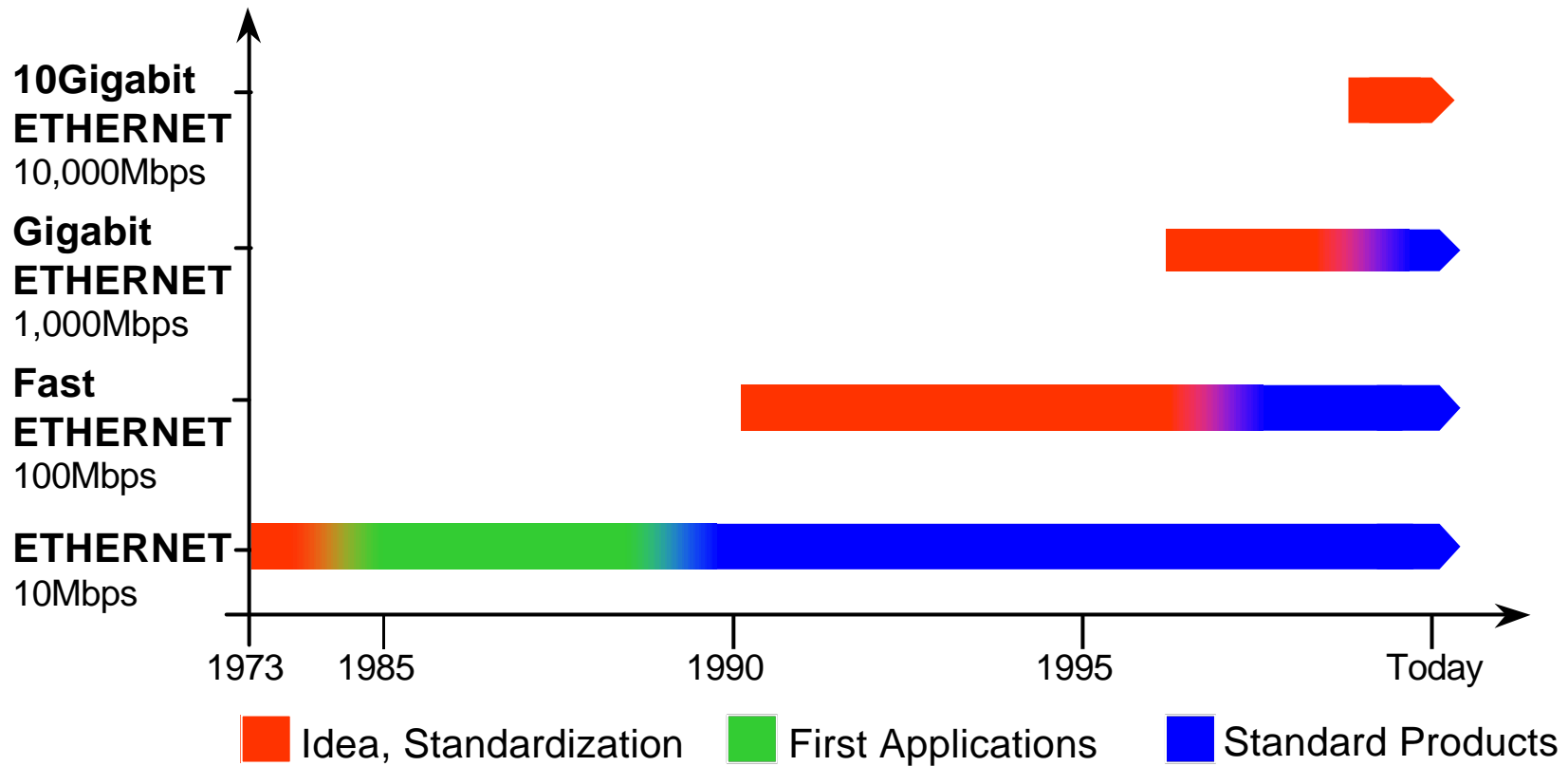
### Features

- Point-to-point connections between the devices
- Transmit / Receive simultaneously (no "Collision Domains")

**Independent communication between users without collisions**

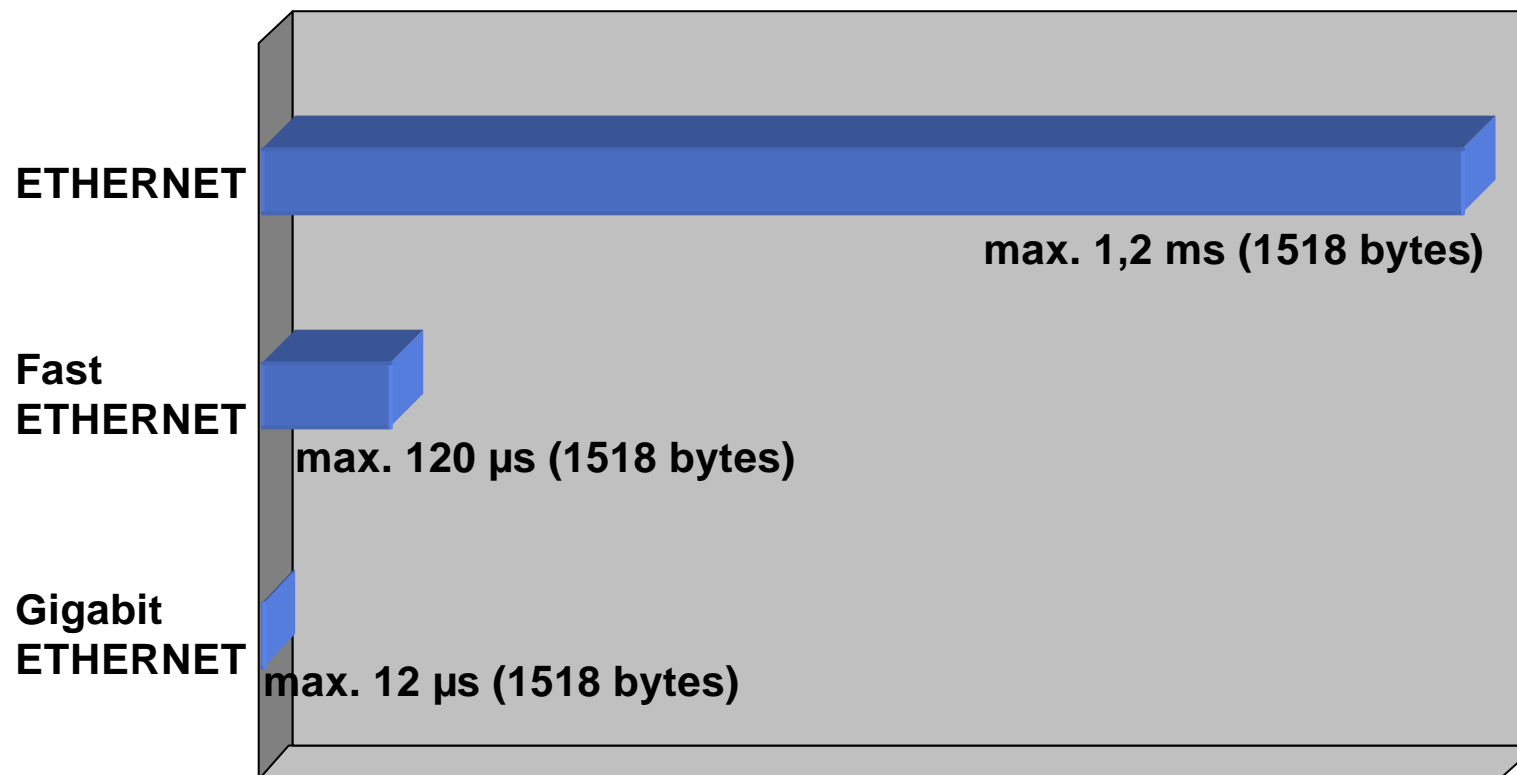
# ETHERNET

## Ethernet, Fast Ethernet, etc.



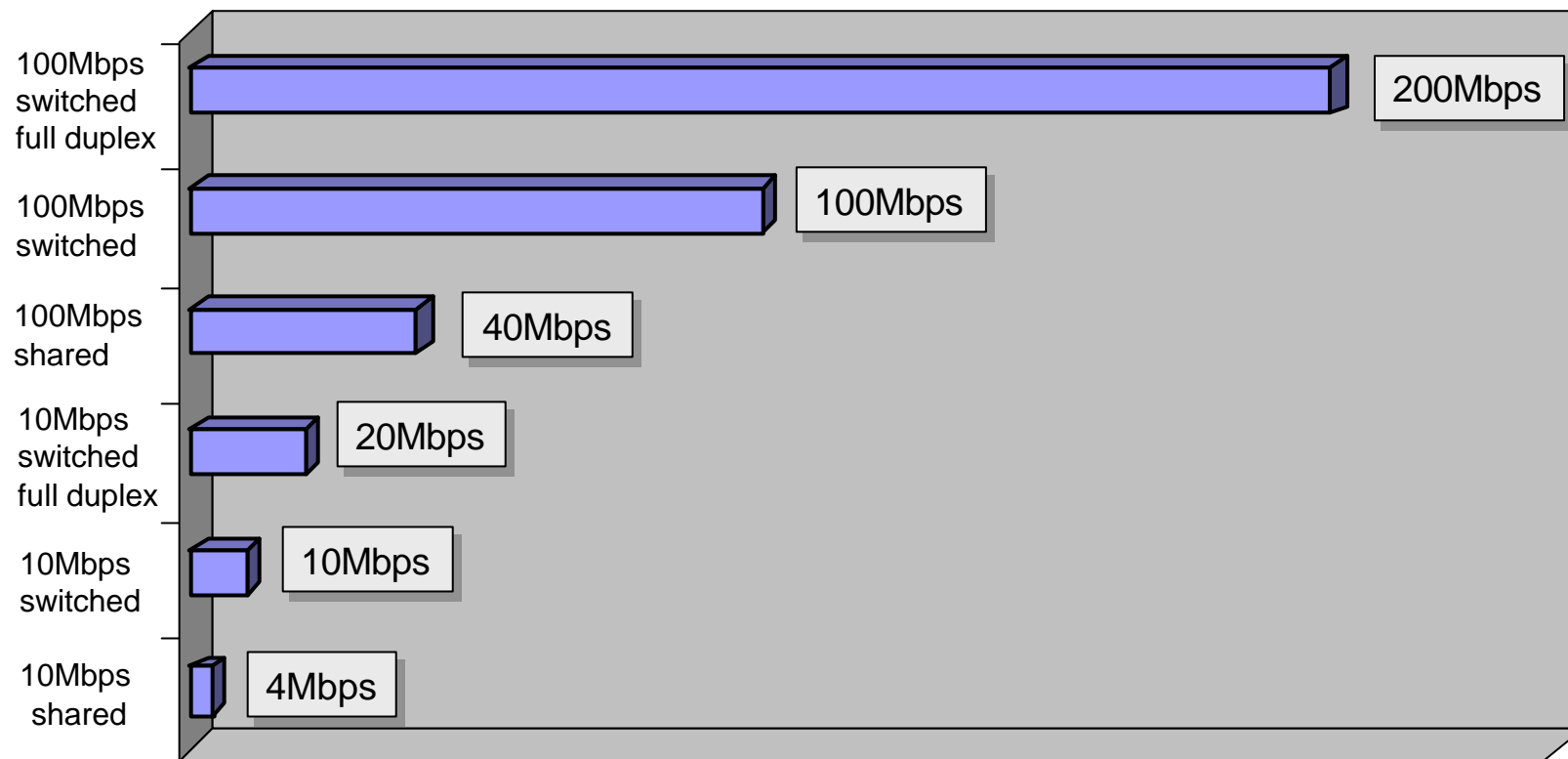
# ETHERNET

## Transmission time of data packets



# ETHERNET

## Maximum throughput





# ETHERNET 10BASE-2

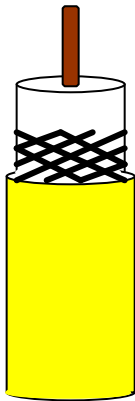


## Thin Ethernet

other names: Cheapernet, Thinwire  
Medium: Coaxial Cable  
Data rate: 10 Mbps  
Segment length: max. 185 m  
Users: max. 30 Transceivers per segment  
Termination: 50 Ohm, 1 Watt  
Connection: via Transceiver with BNC connector



# ETHERNET 10BASE-5



## Standard Ethernet

Other names: Yellow Cable, Thickwire  
Medium: Coaxial cable  
Data rate: 10 Mbps  
Segment length: max. 500 m  
Users: max. 100 Transceivers per segment  
Termination: 50 Ohm, 1 Watt  
Connection: via Transceiver with N-Connector or Vampire tap

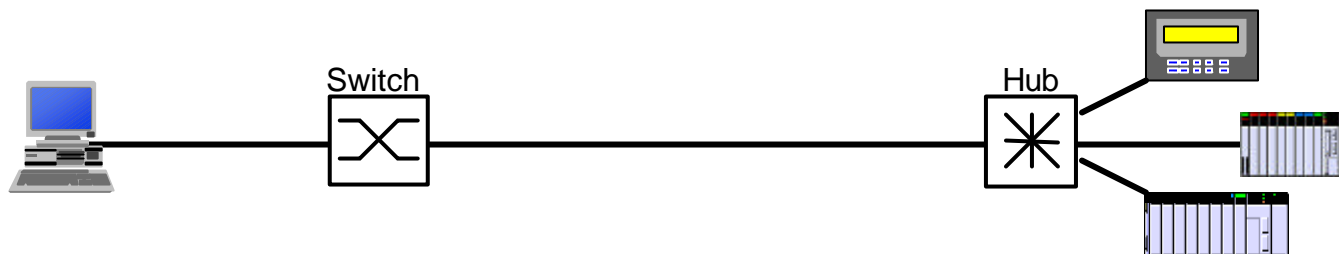
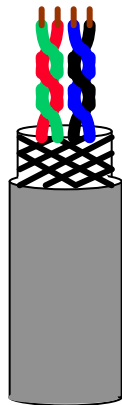


# ETHERNET

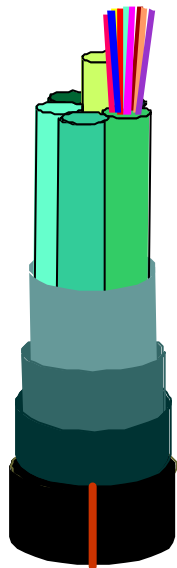
## 10BASE-T, 100BASE-TX

### Twisted Pair Ethernet

Medium: 2-pair Category 5 cable  
Data rate: 10 Mbit/s (10BASE-T),  
100Mbit/s (100BASE-TX)  
Segment length: max.100 m (Point-to-Point)  
Connection: RJ45 Connector



# ETHERNET 10BASE-FL, 100BASE-FX



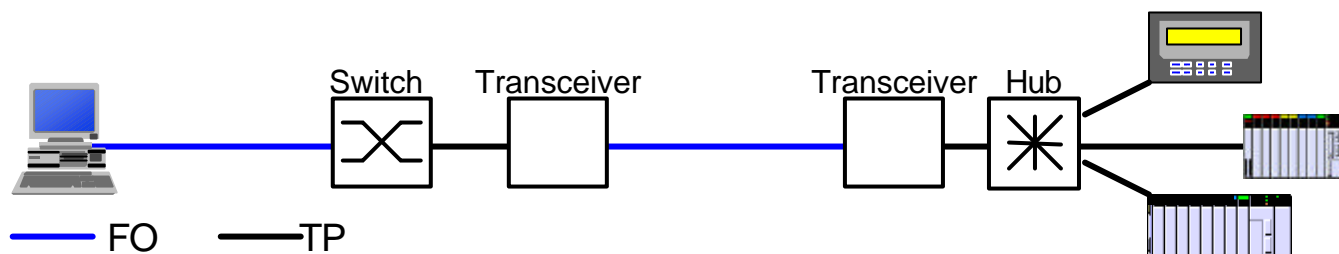
## Fiber Optic Ethernet

Medium: 2 Fibers  
(50/125 or 62,5/125)

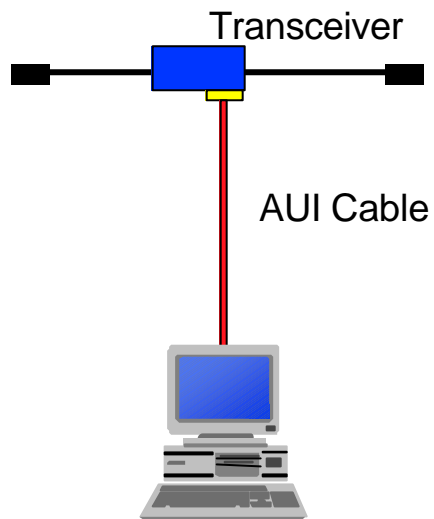
Data rate: 10 Mbps (10BASE-FL)  
100Mbps (100BASE-FX)

Segment length: max. 2000 m (Point-to-Point)

Connection: BFOC / ST Connector (10BASE-FL)  
Duplex SC Connector (100BASE-FX)



# ETHERNET AUI Cable



Other name: Drop Cable, Office Cable

Data rate: 10 Mbit/s

Cable length: max. 50 m

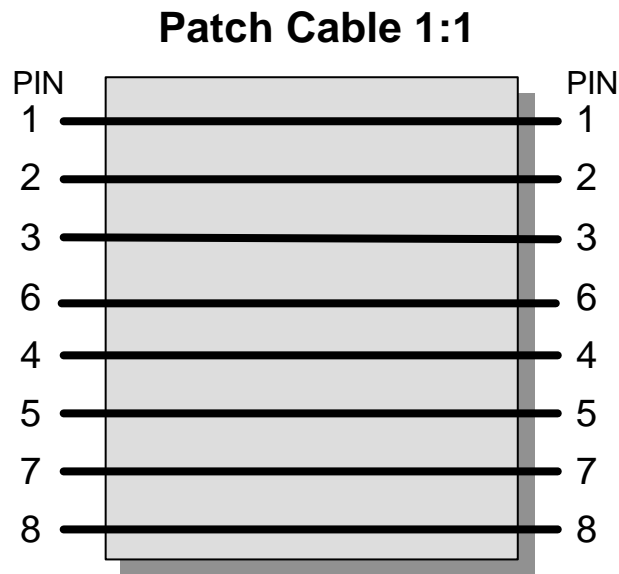
Impedance of wires: 78 Ohm +/- 5 Ohm

Connection: 15 pole Sub-D (DB15)

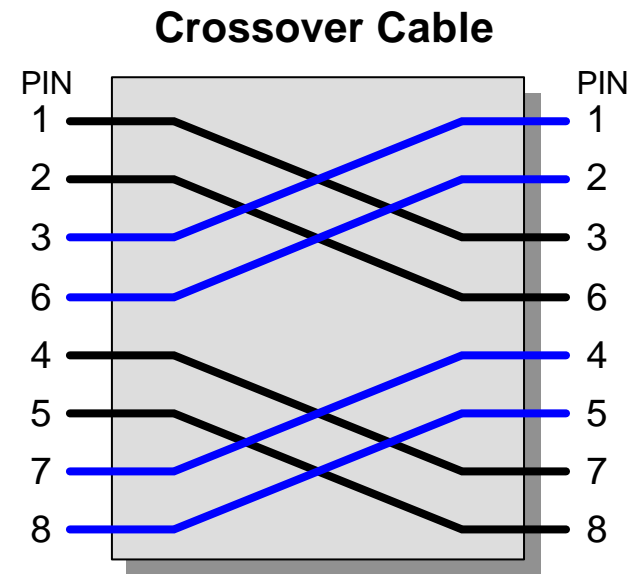
- DB15 (male) for Device, Repeater etc
- DB15 (female) for Transceiver side

# ETHERNET

## Patch cable and crossover cable



**Patch Cables** with 1:1 wiring are usually used for connecting DTE devices (PC, SPS, Server, etc.) to network components (Patch Panels, Hubs, Switches, etc.).



**Crossover Cables** are usually used to connect network components (Hubs, Switches, etc.).

# ETHERNET

## Auto-negotiation and autopolarity

### Auto-negotiation

A Fast ETHERNET communication protocol which allows devices to report their own features, to recognize features of communication partners and to agree a common compatible transmission mode between the two devices.

- Transmission speed: 10Mbps or 100Mbps
- Operating mode: Half Duplex (HDX) or Full Duplex (FDX)
- Pause frames with Full Duplex: Yes or No

Default value, if Auto-negotiation = OFF  $\Rightarrow$  100 Mbps and HDX mode

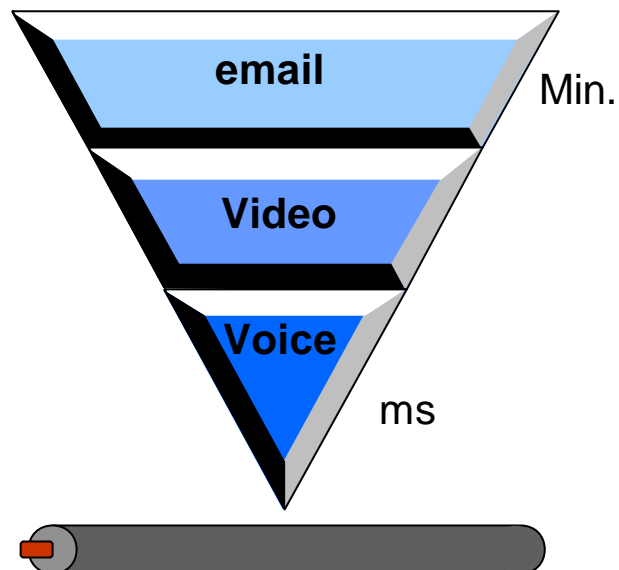
### Autopolarity

Feature of devices conforming to 10BaseT or 100BaseTX to automatically correct wiring errors in twisted pair cables which reverse the polarity of data signals.

# ETHERNET

## Real time requirements and priority allocation

### Real time requirements



### Priority allocation

#### 1. IEEE 802.1Q / 802.1p

- based on ISO/OSI Layer 2
- up to 8 priority queues (3 bits in ETHERNET Header)
- integration in Switching Chips possible
- no ISO/OSI Layer 3 analysis required

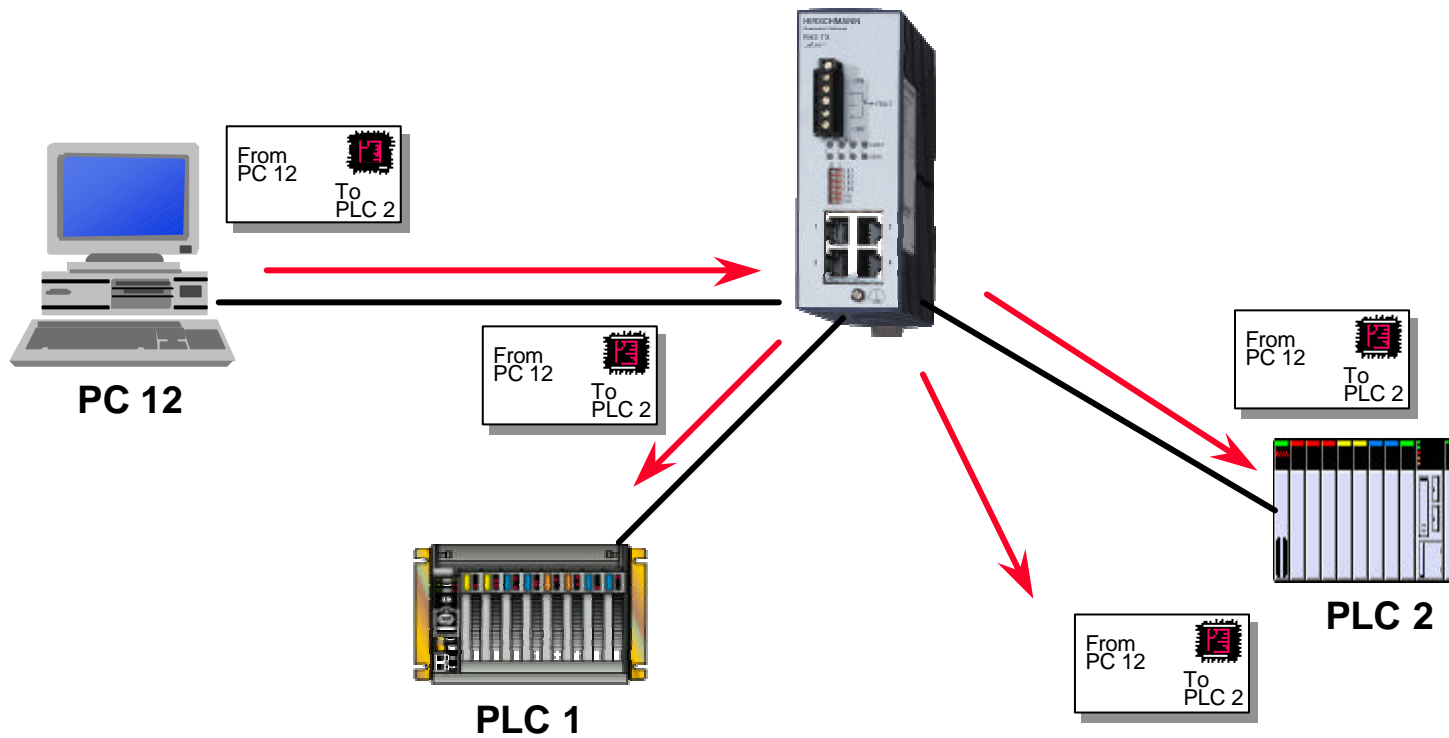
#### 2. TOS

- based on ISO/OSI Layer 3
- „Type of Service“ field in IP header
- currently not standardized
- frequently used for Voice over IP



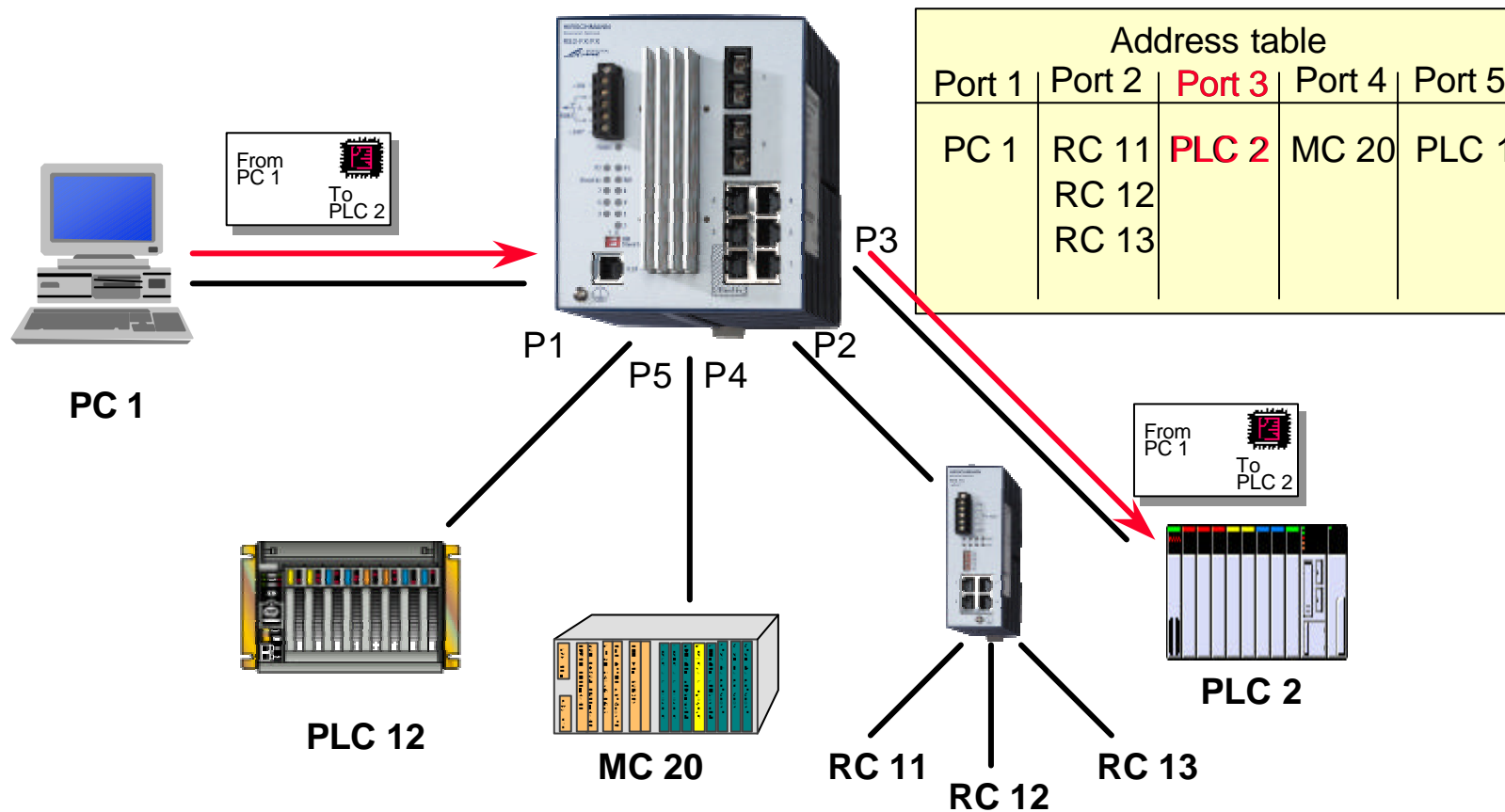
# ETHERNET

## Operating mode of a Hub



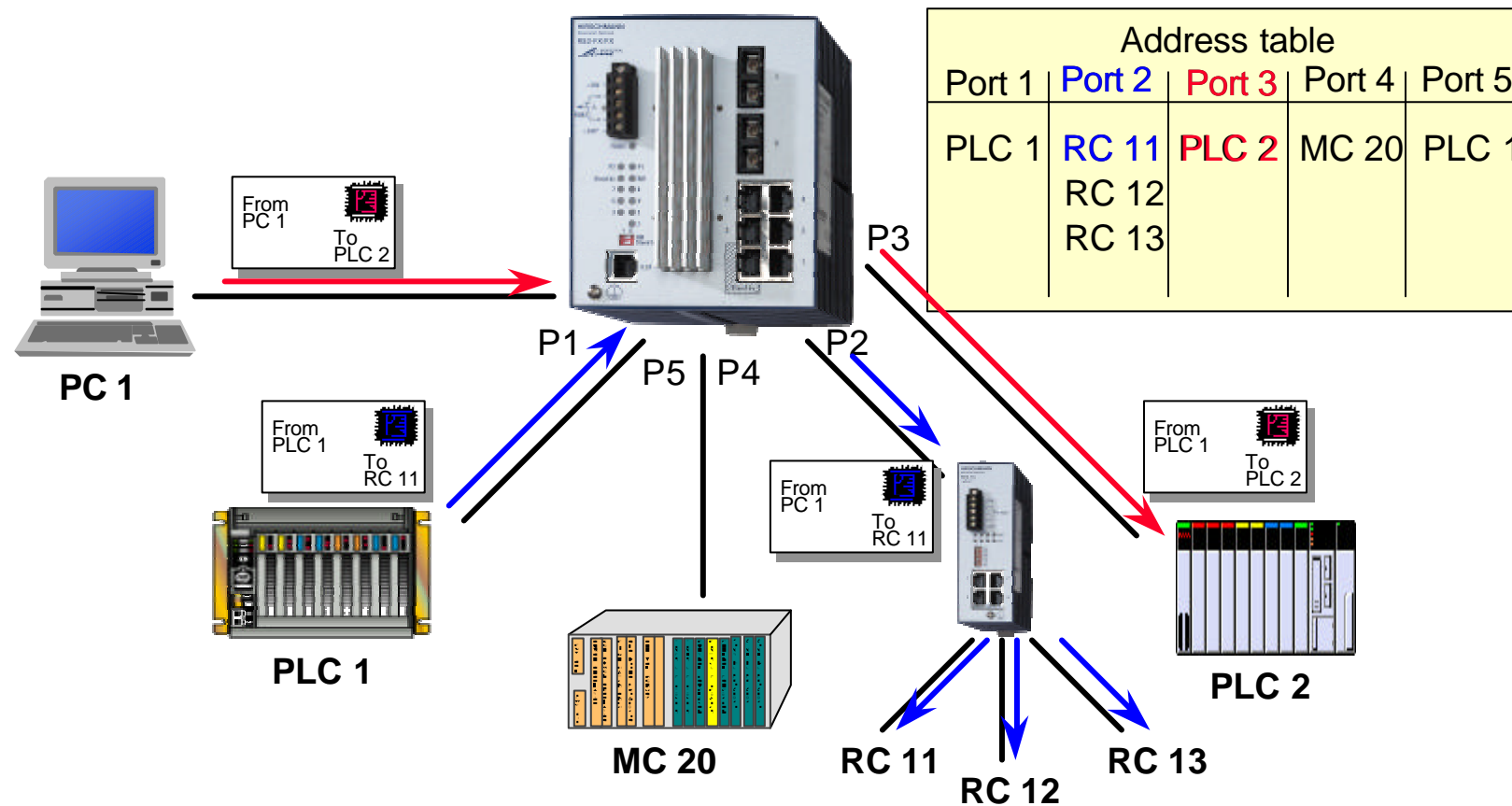
# ETHERNET

## Operating mode of a Switch 1/2



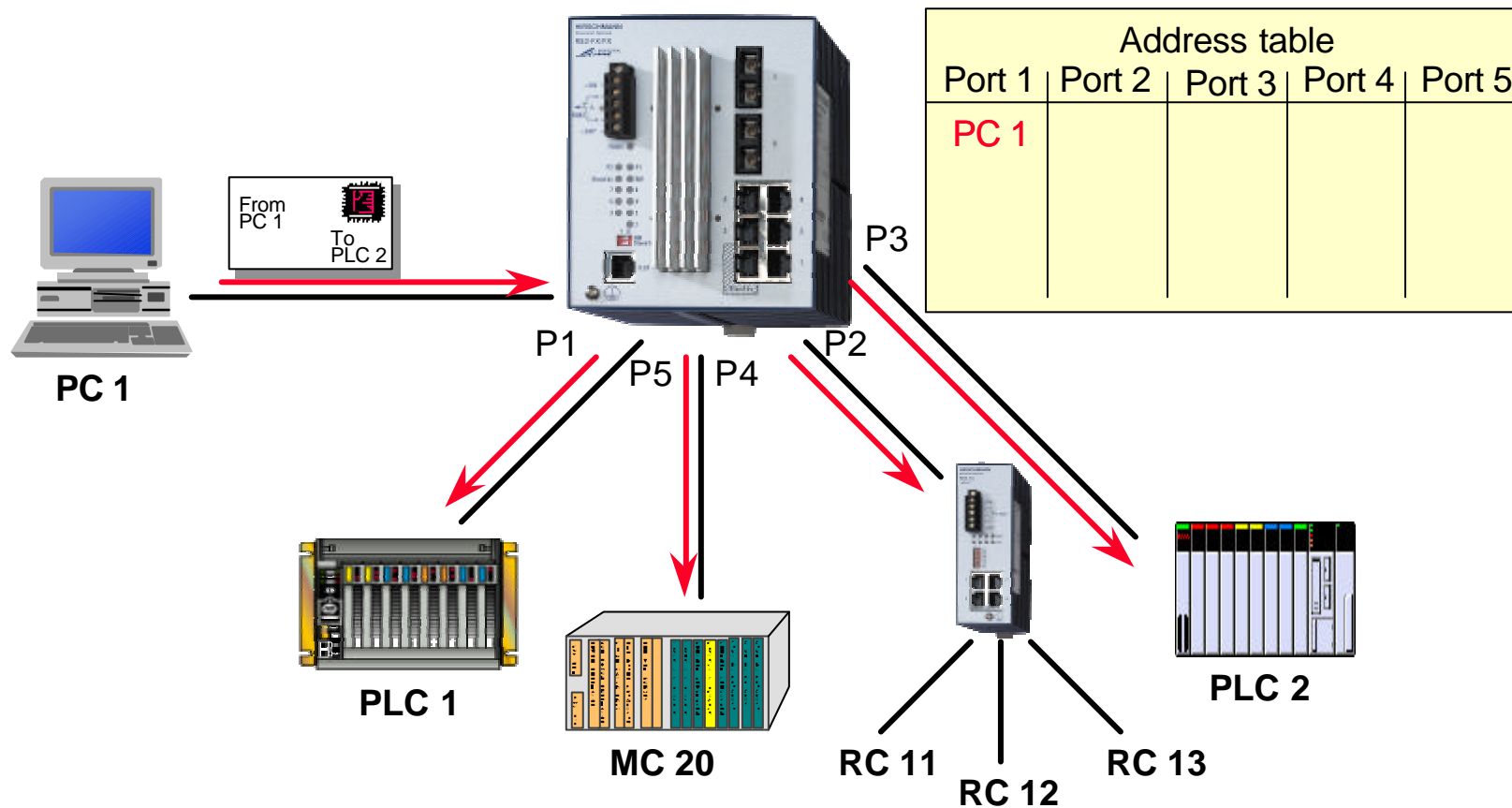
# ETHERNET

## Operating mode of a Switch 2/2



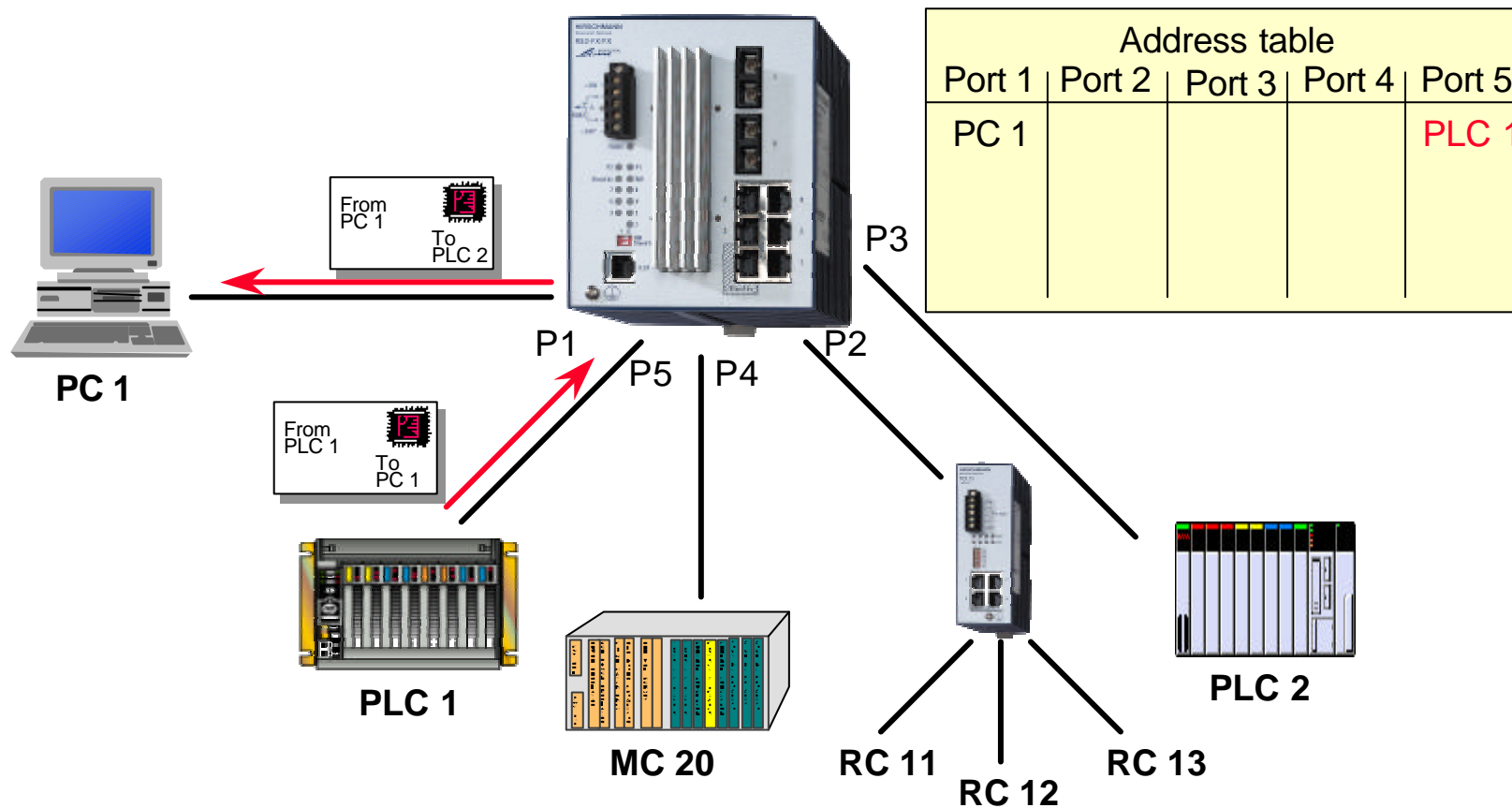
# Switching Technology

## Self learning 1/3



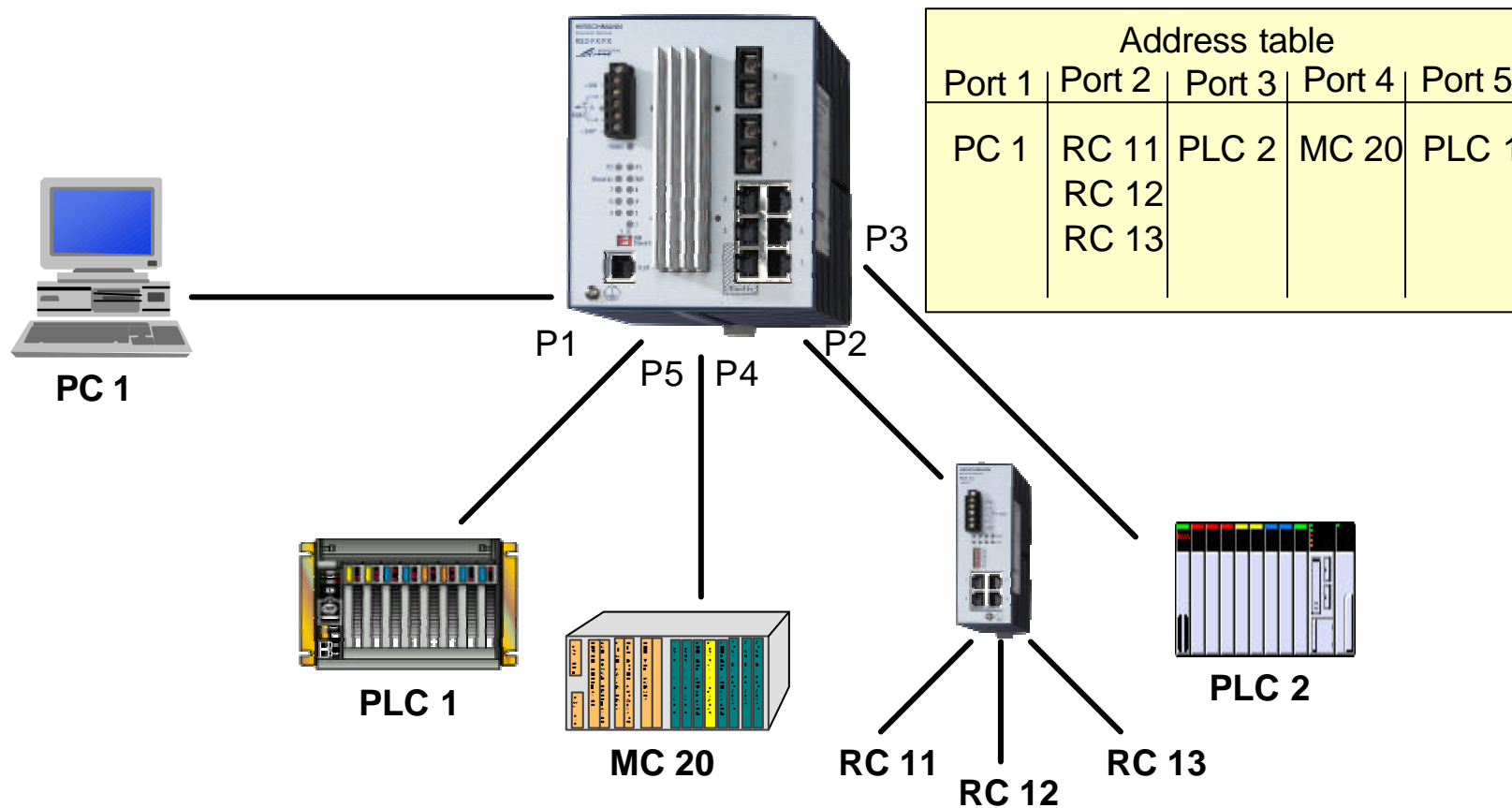
# Switching Technology

## Self learning 2/3



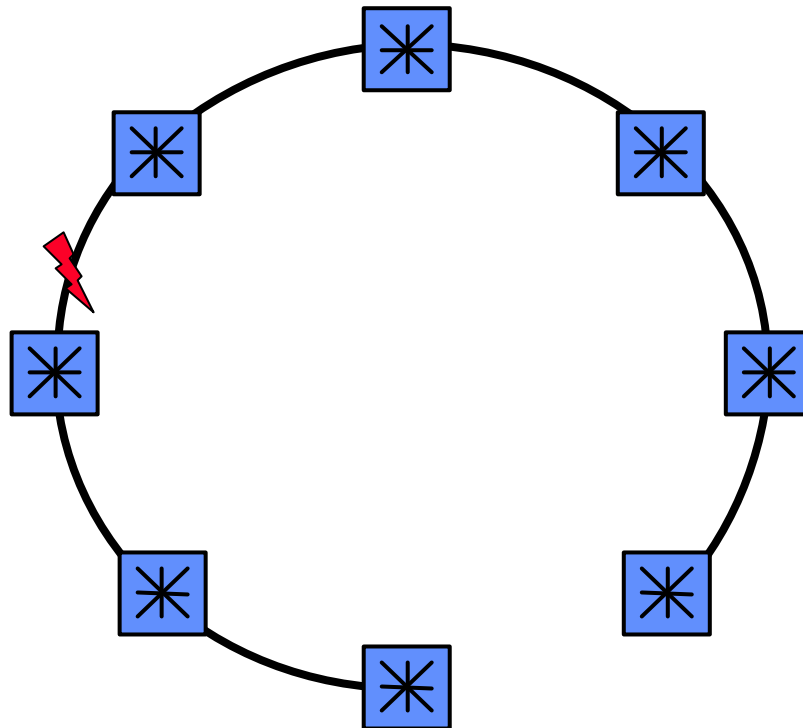
# Switching Technology

## Self learning 3/3



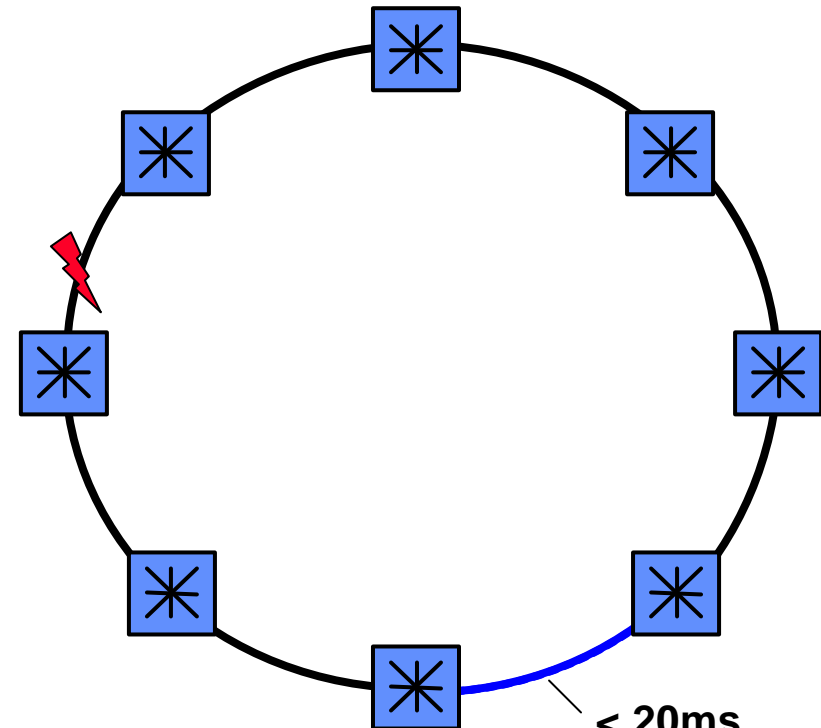
# Redundancy Line and ring topology with Hubs

Line topology





Restricted network and production system reliability

Ring topology

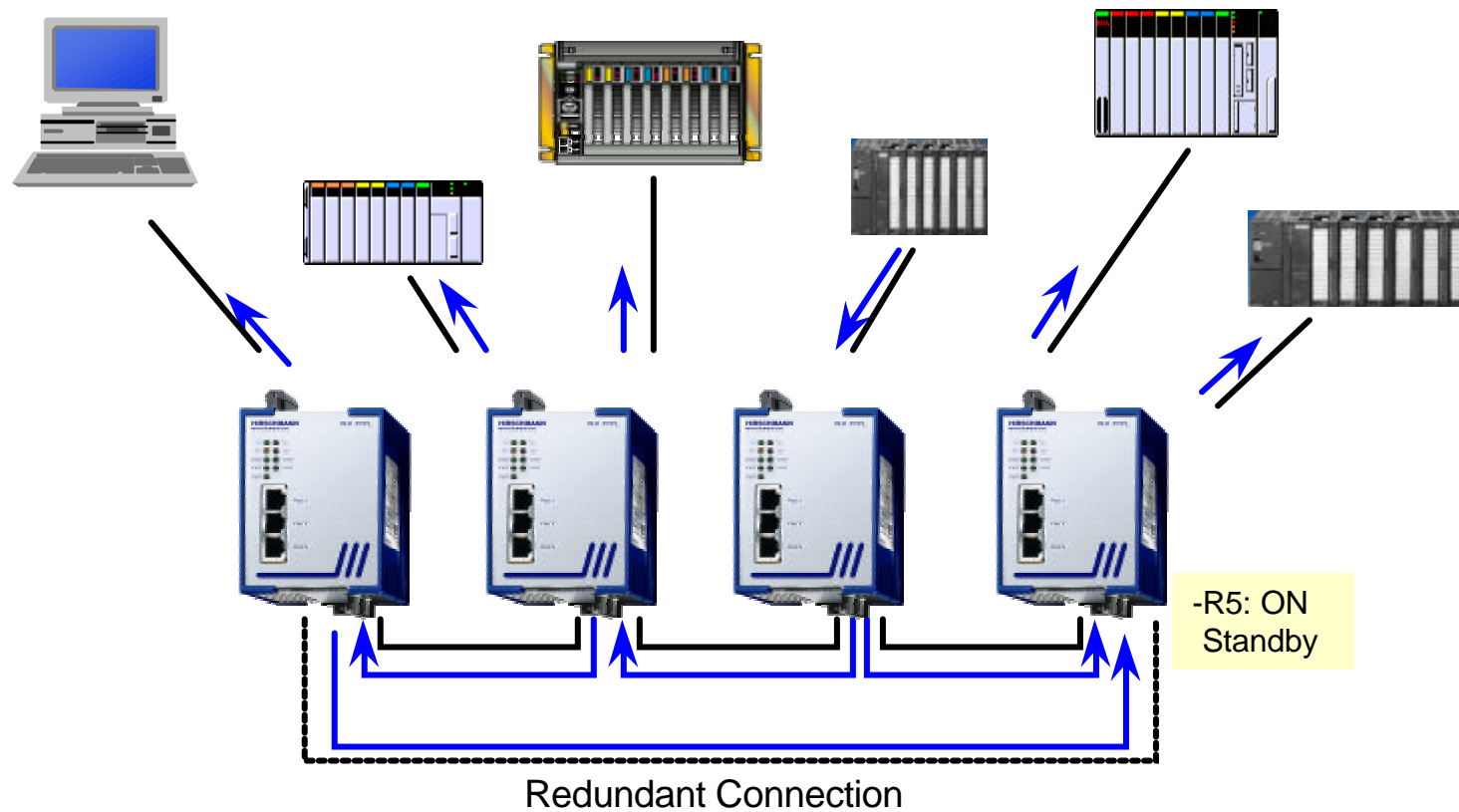


Ultimate network and production system reliability

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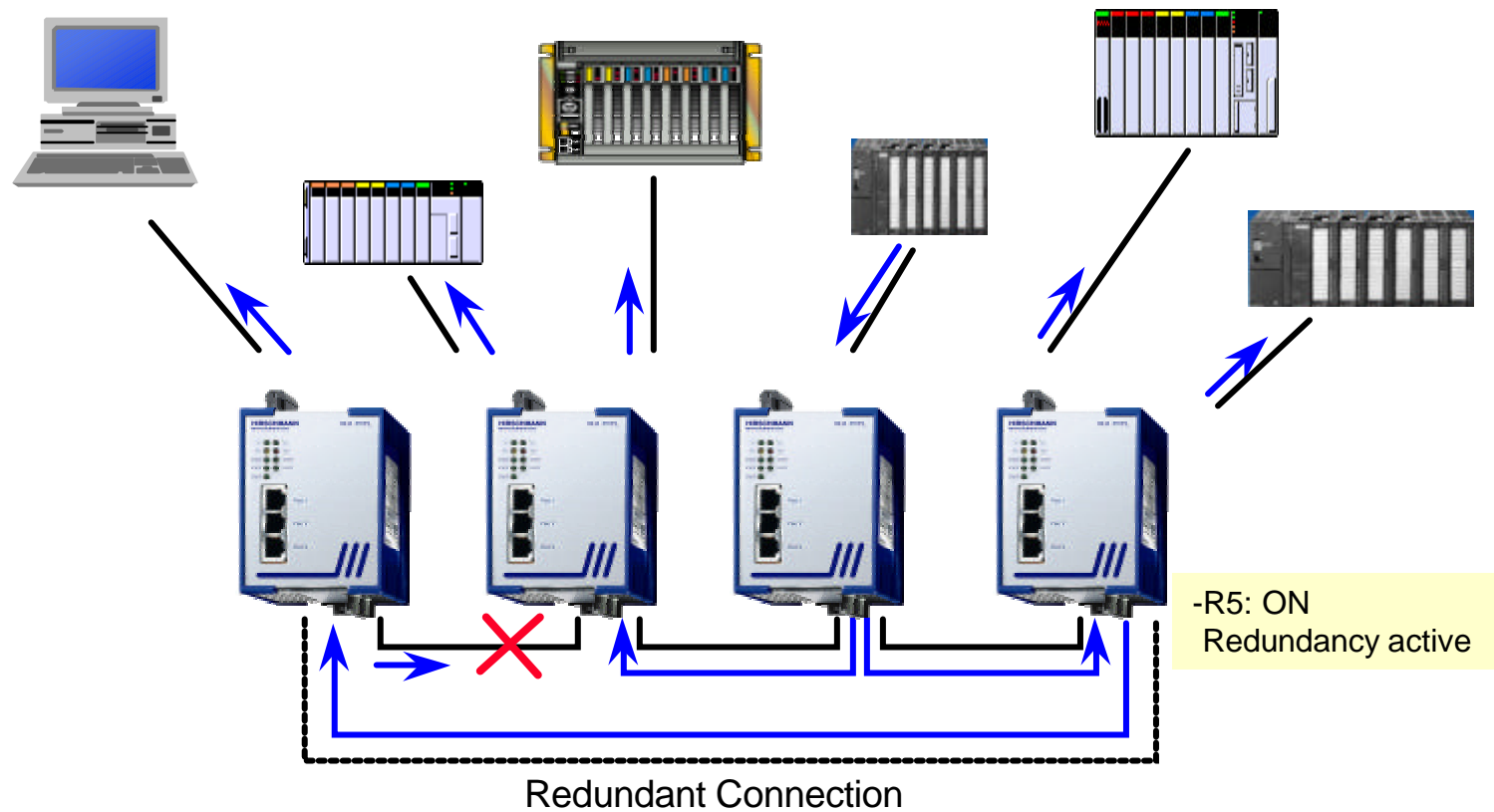
# Ring Topology with RH1-TP/FL

## Function - Redundant connection inactive



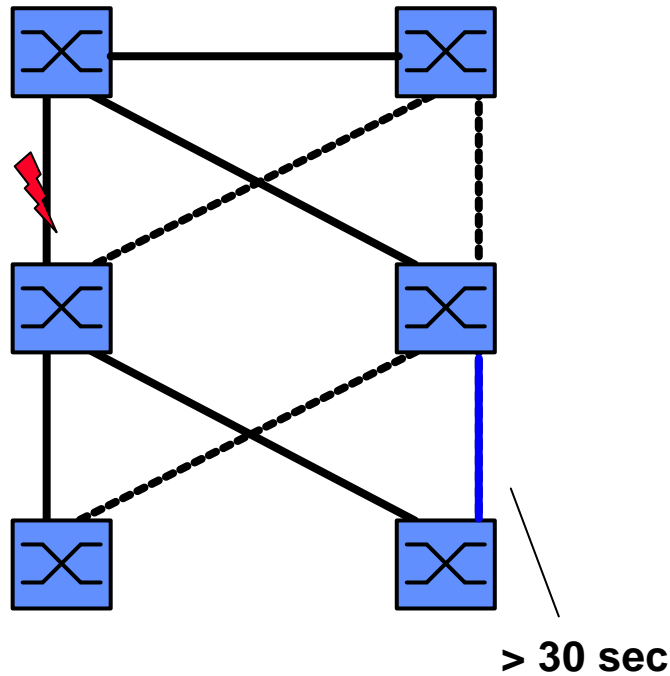


# Ring Topology with RH1-TP/FL Function - Redundant connection activated



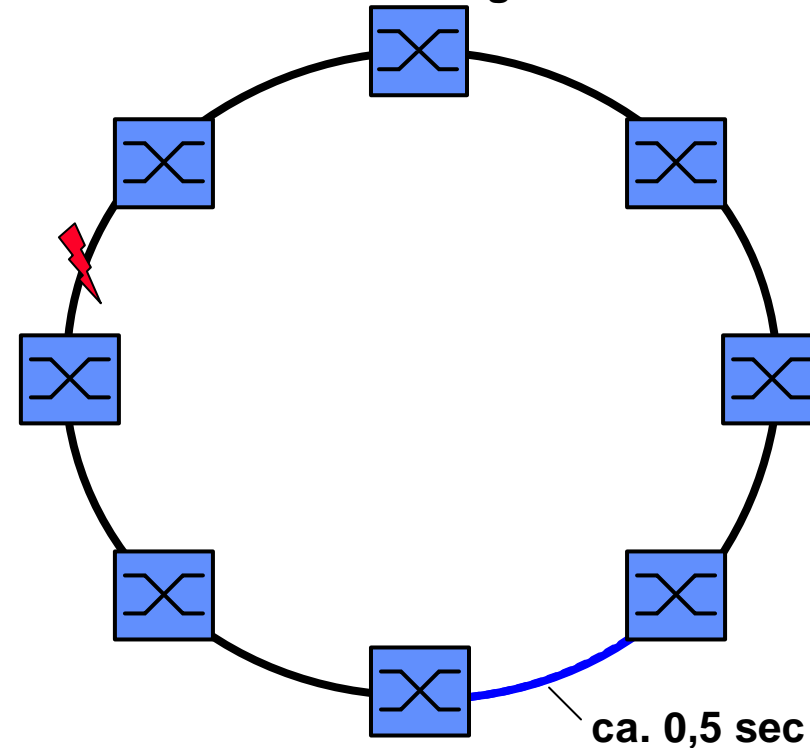
# Redundanz Ringstruktur mit Switches

## Spanning Tree



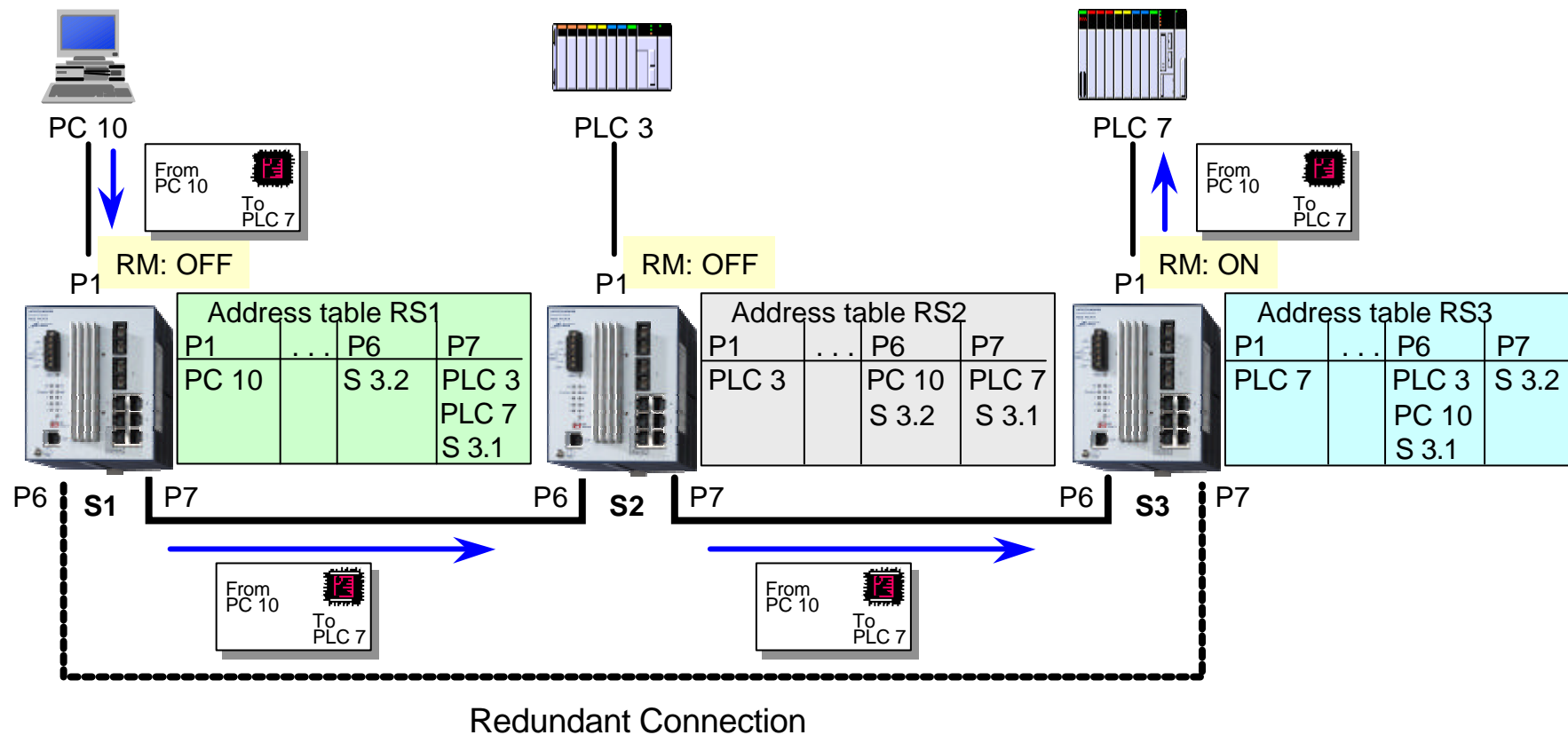
Eingeschränkte Verfügbarkeit  
von Netz und Anlage

## Hirschmann - Ringstruktur

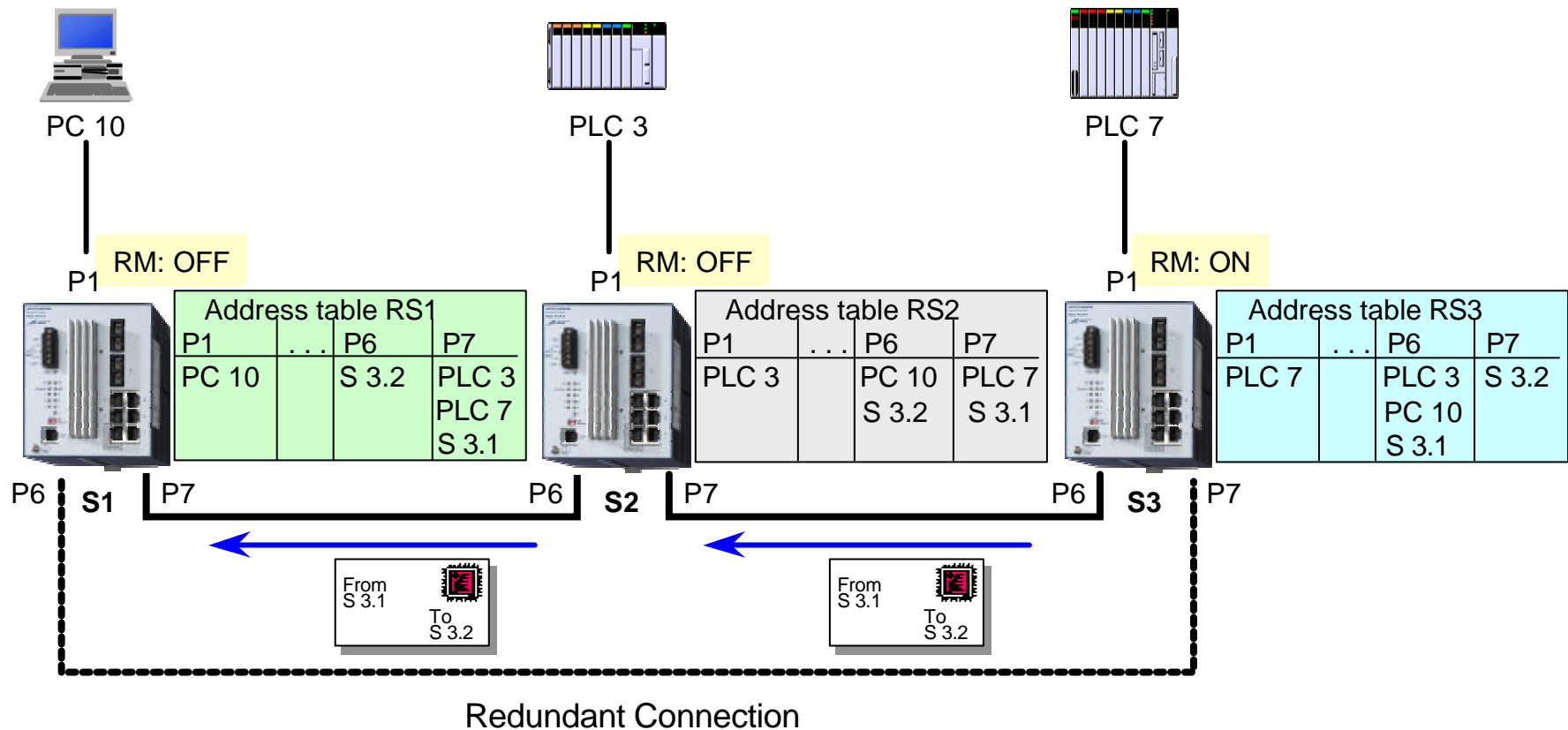


Hohe Verfügbarkeit von Netz und Anlage  
-nur eine zusätzliche Verbindung-

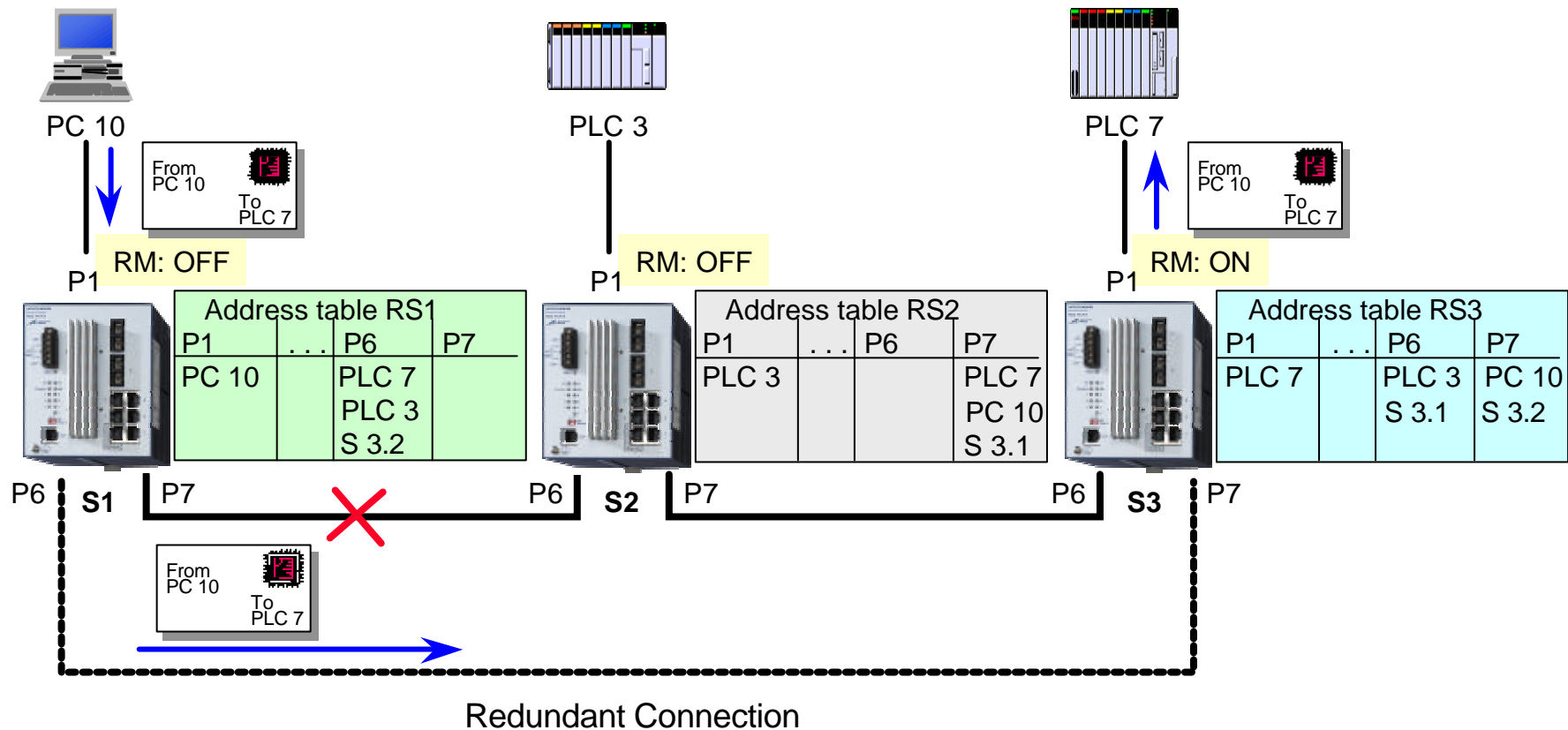
# Ring Topology with RS2 Standby - Standard data transmission



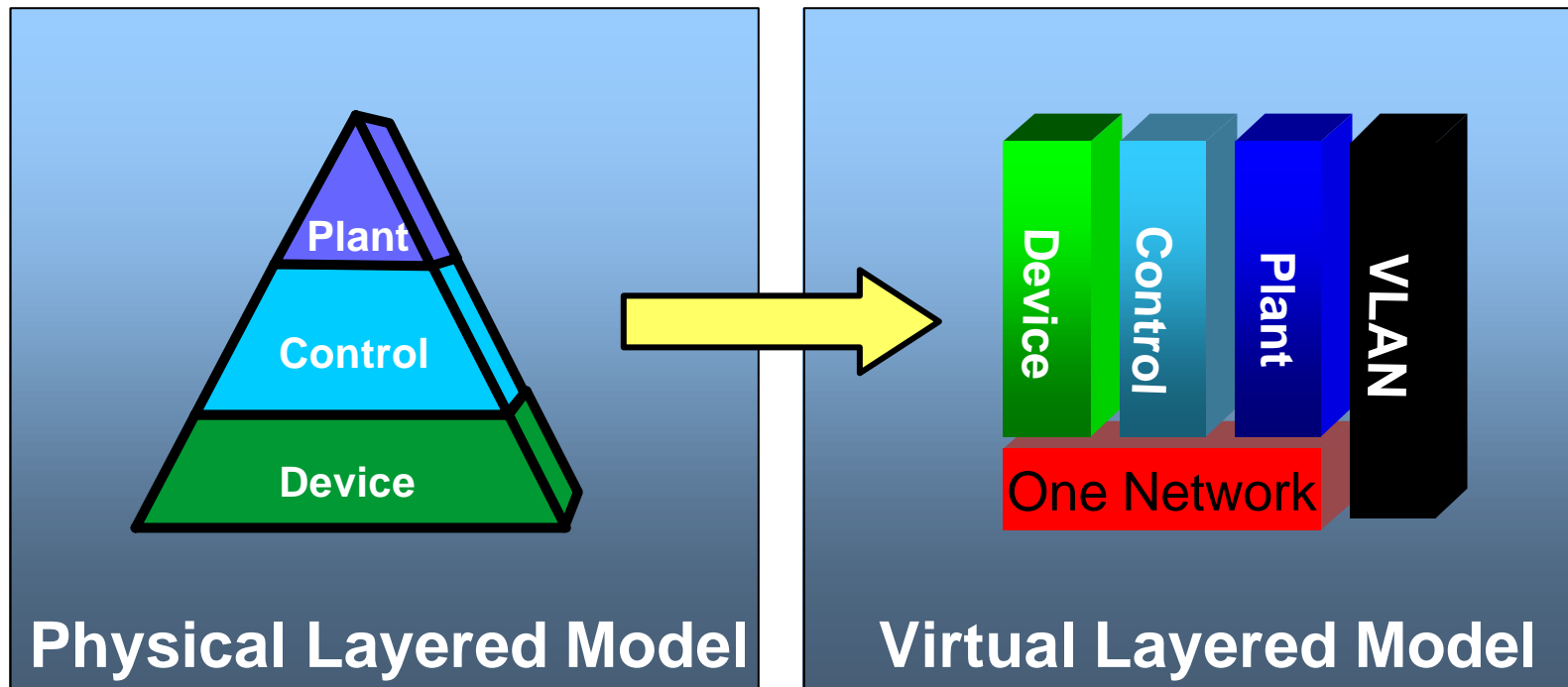
# Ring Topology with RS2 Standby - Supervision 1/2



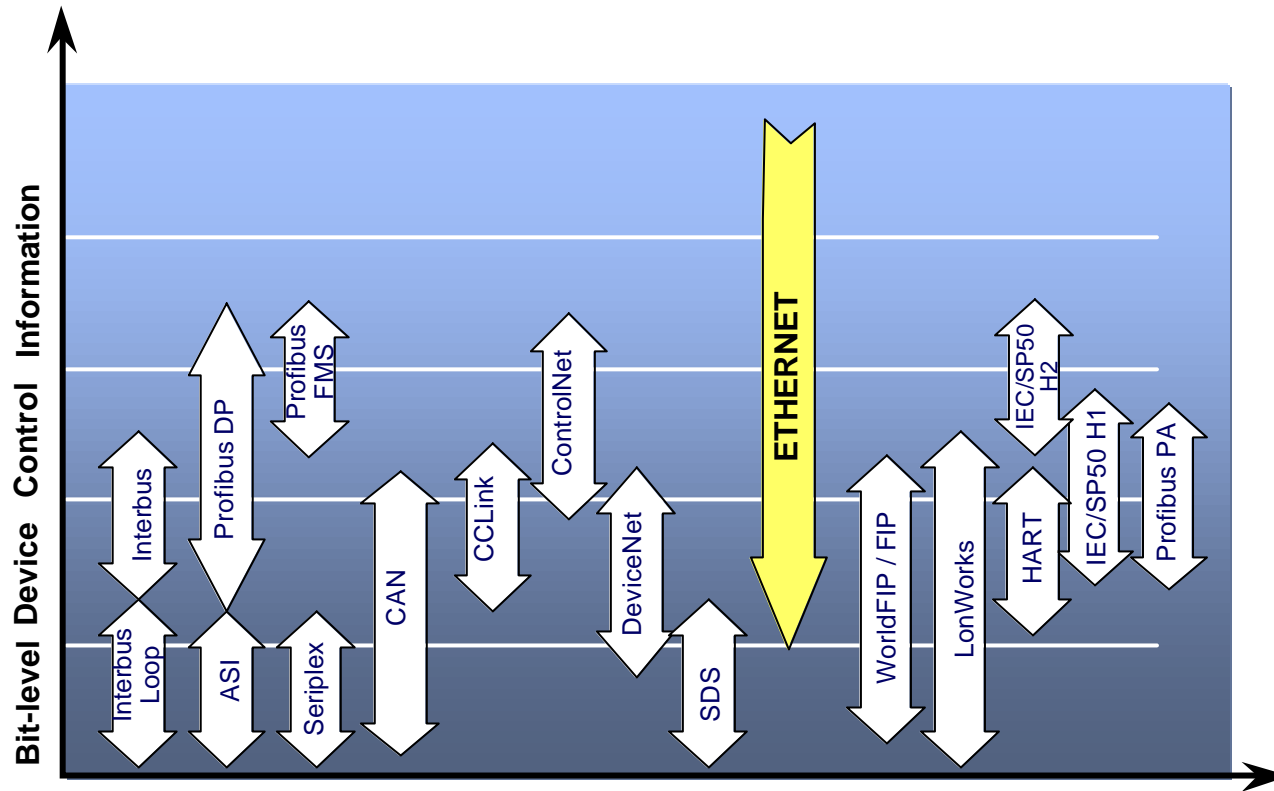
# Ring Topology with RS2 Faulty cable - Data transmission





# Trend Communication models

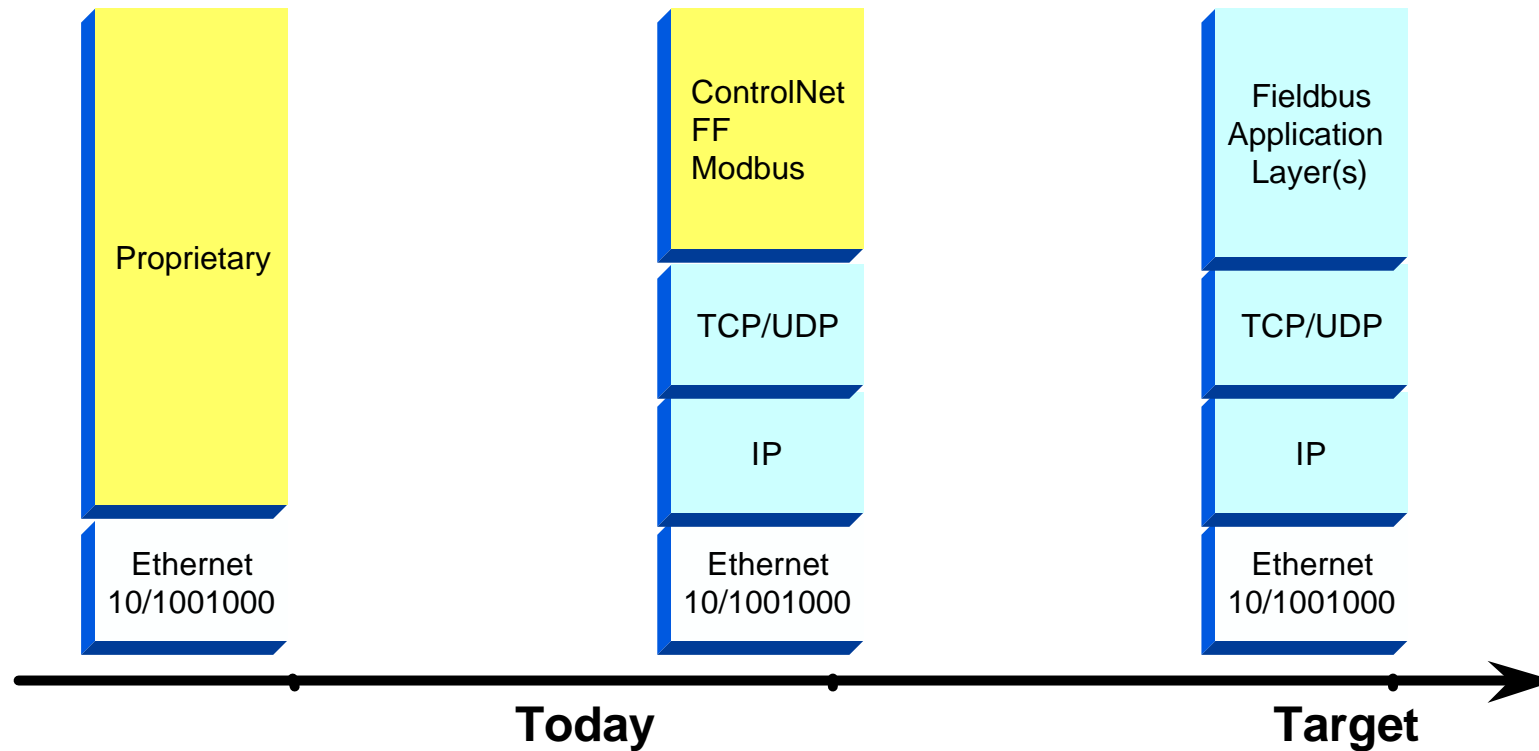


# Trend Networks



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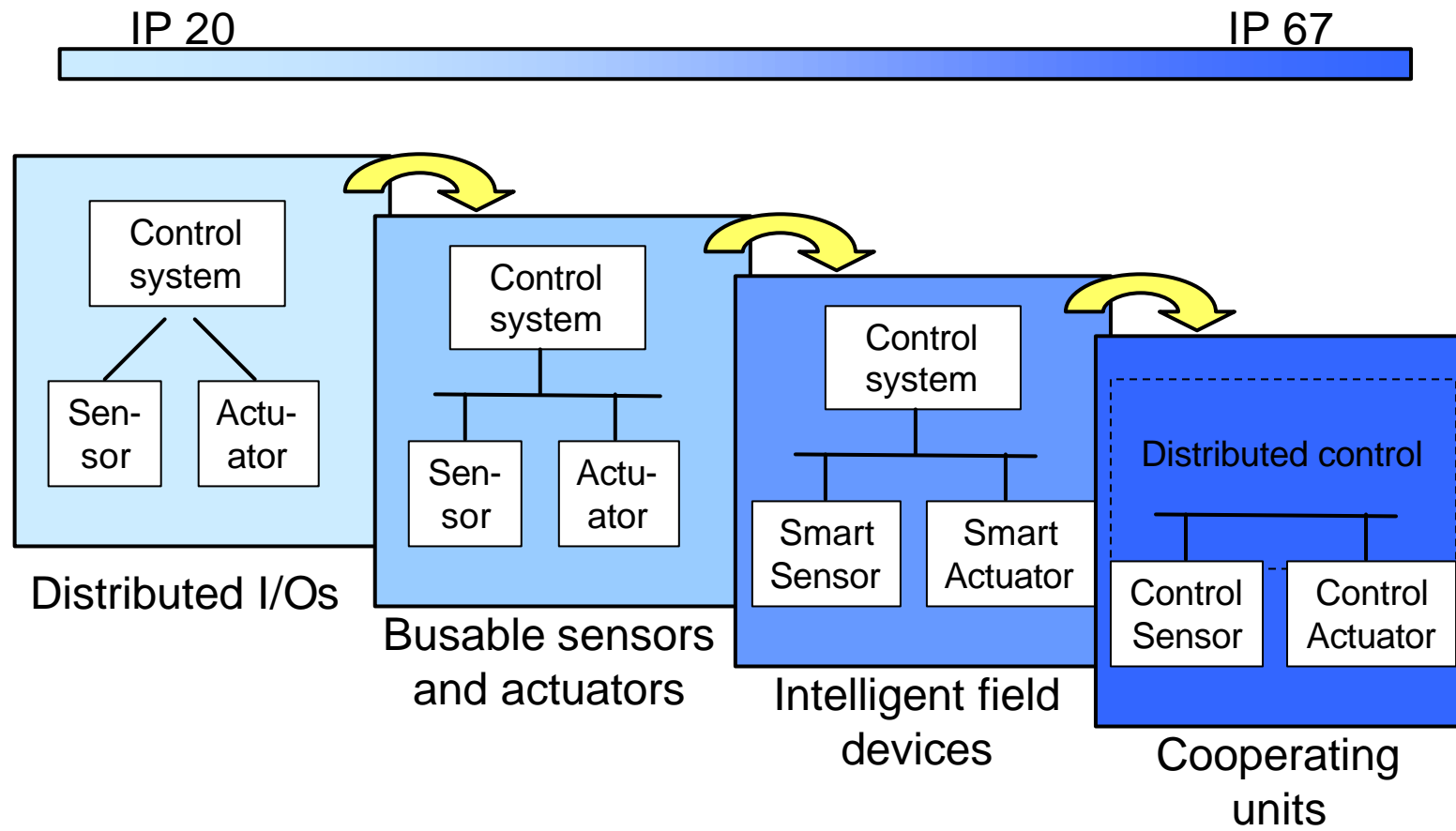
# Trend Protocols



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# Trend Distributed systems



## **Trend**

### **Who drives the changes ?**

#### **End user**

To facilitate major business improvements in cost & productivity, and fuel growth

#### **Intranet/Internet**

Remote diagnostics, remote configuration, automatic alerts/monitoring etc.

#### **Increasing data volume**

Process data + video + audio + file transfer + etc.

#### **Innovative vendors**