Networking Basics

02 - Ethernet

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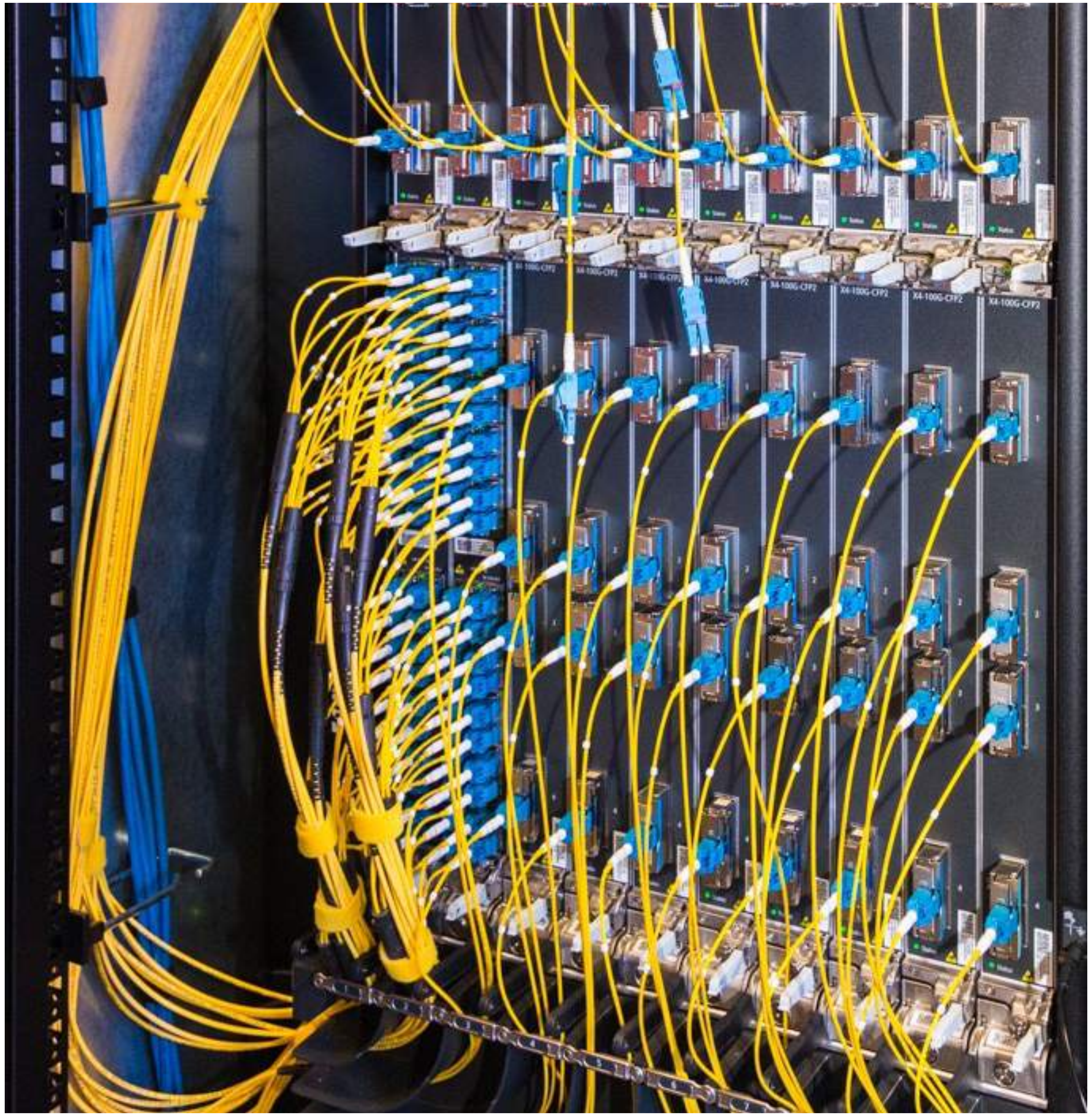
Networking Basics
DE-CIX Academy

Ethernet

A Modern Ethernet Device

Nokia 7950

- As used by DE-CIX
- Connects 100s of devices
- using optical interfaces
- with speeds up to 400Gbps



Attribution: DE-CIX

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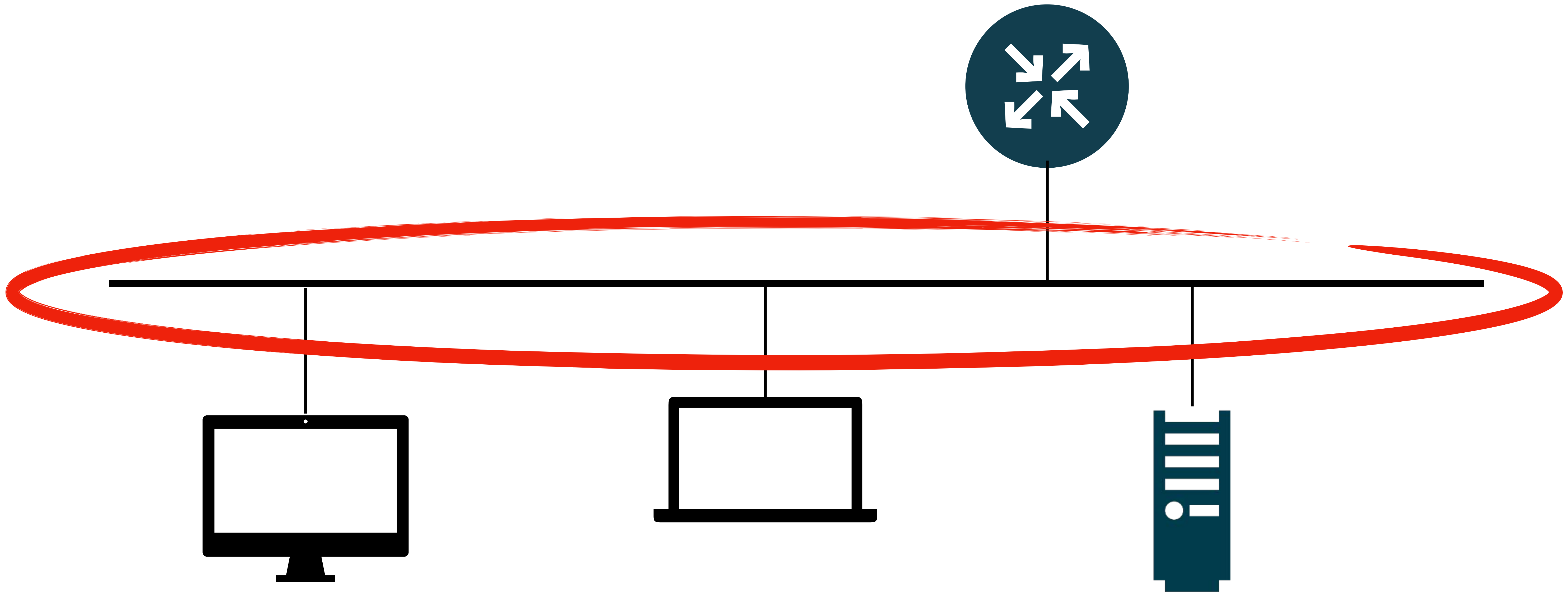
Another Modern Ethernet Device

Fritzbox

- as used at home
- connects 4 devices directly
- using copper interfaces
- with speeds up to 1Gbps

Attribution: Wolfgang Tremmel

So why does the symbolic drawing of Ethernet look like this?



1971

It began in Hawaii: ALOHA-Net

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ALOHA-Net

University of Hawaii, 1971

- Radio based network
- To interconnect sites
- Simple principle:
    - If you have data to send, send it
    - If you receive something while sending, stop and try again later

1973

Robert Metcalfe - Xerox PARC

Ethernet

Xerox PARC, 1973

- Instead of radio, uses a coax cable
  - For higher bandwidth
  - And more reliability
- Inspired by ALOHAnet
- Standardized in 1980
- Ethernet II in 1982, standardized as IEEE 802.3 in 1983

Attribution: Coolcaesar at the English language Wikipedia
https://commons.wikimedia.org/wiki/File:Parcentrance.jpg

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10BASE5

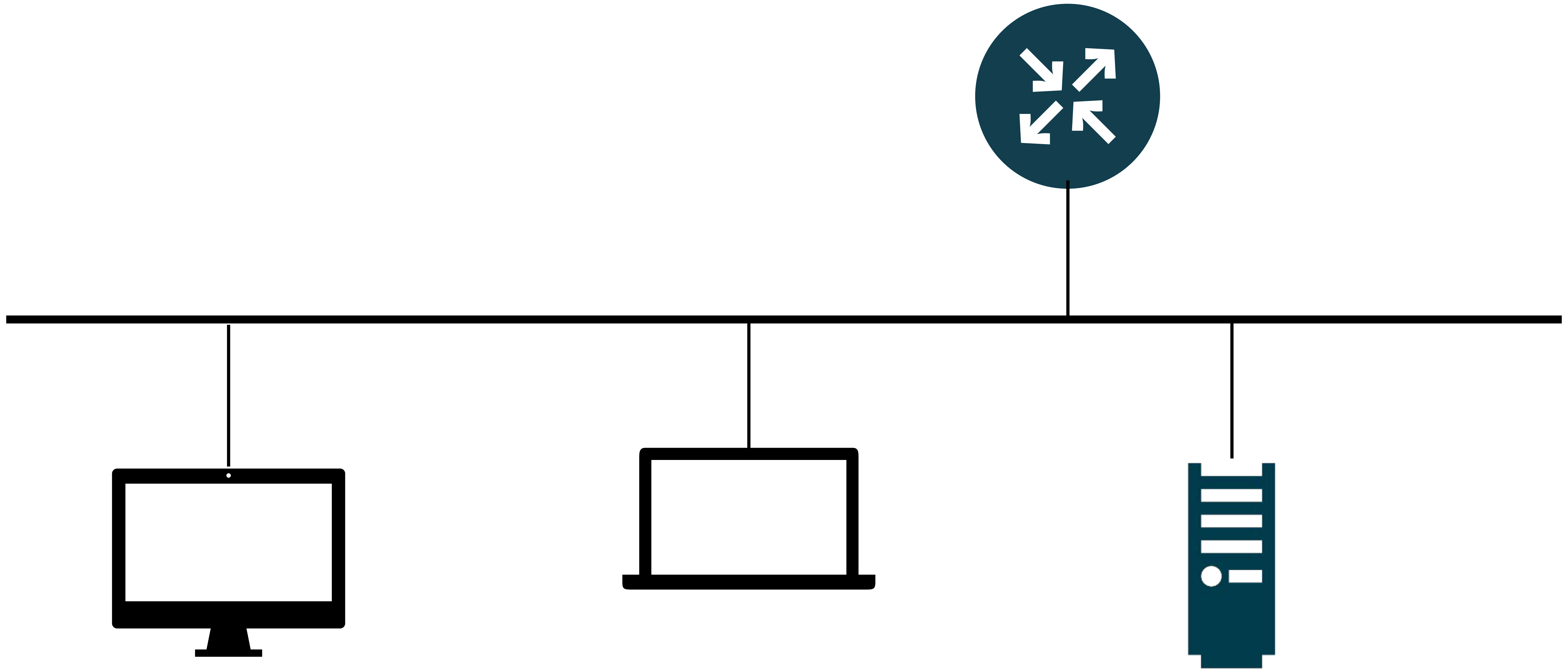
10 Mbit/s Ethernet

- 10 - Mbit/s
- BASE - uses baseband modulation
- 5 - 500m max. segment length
- Hardware:
  - 1cm thick coax cable
  - "Vampire-Tap" Transceivers

Attribution: Robert.Harker at English Wikipedia
https://commons.wikimedia.org/wiki/File:10Base5transcievers.jpg

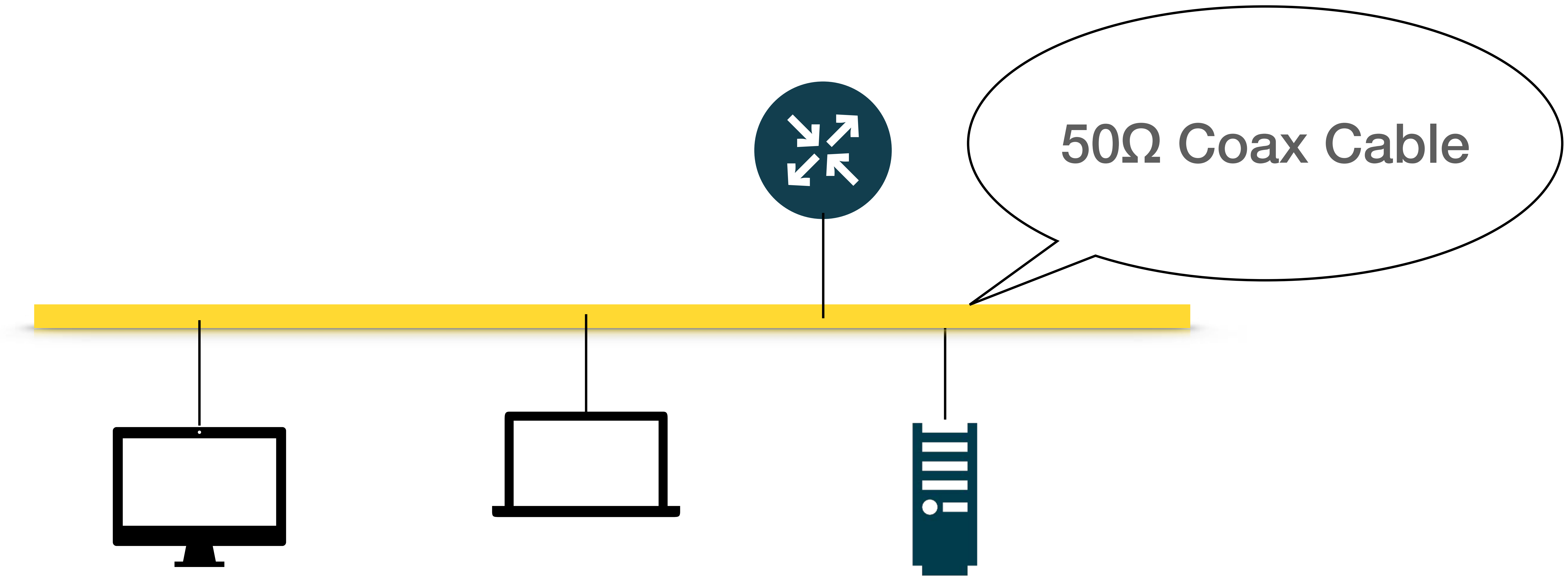
10Base5 Ethernet

Remember the drawing



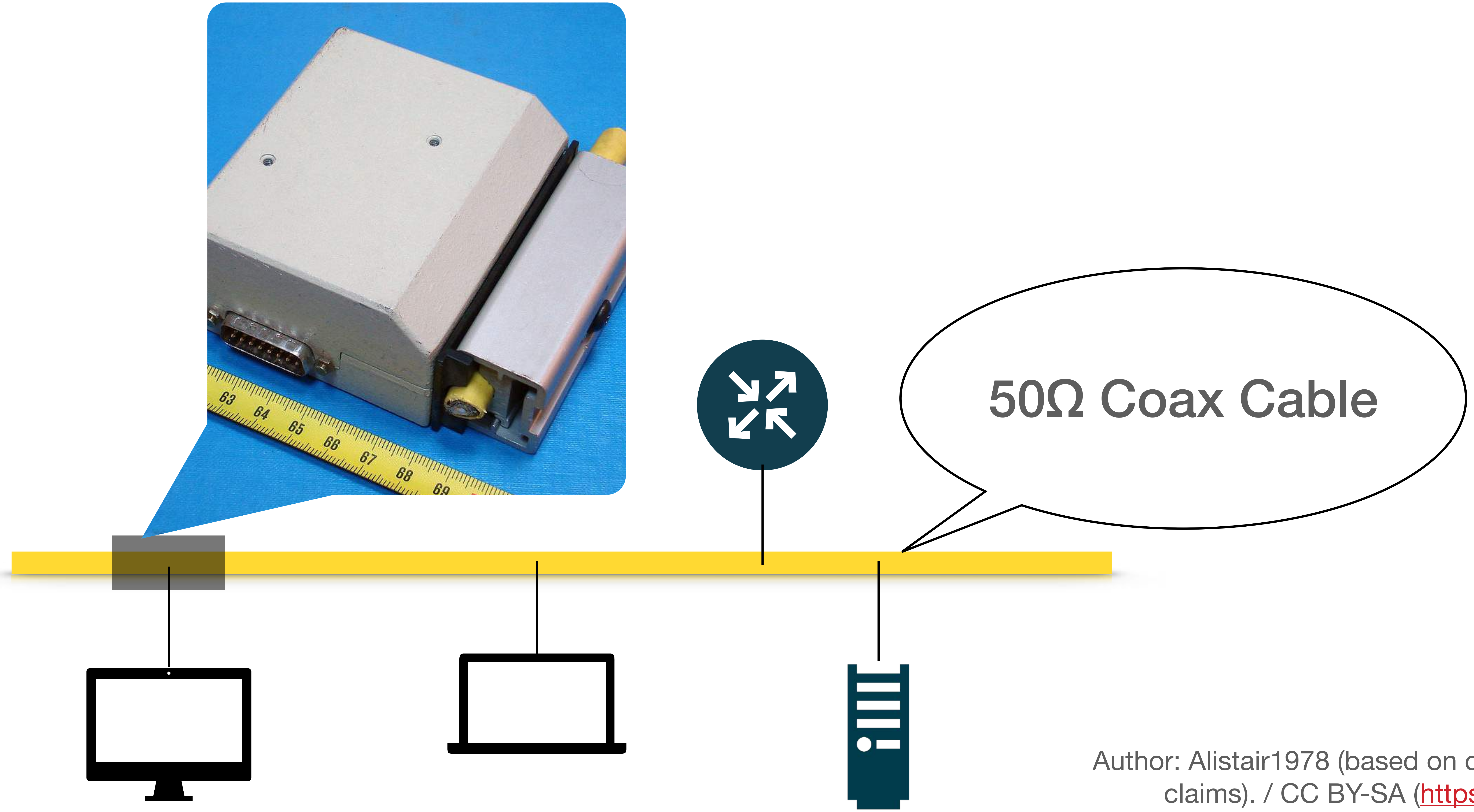
10Base5 Ethernet

Remember the drawing



10Base5 Ethernet

Remember the drawing

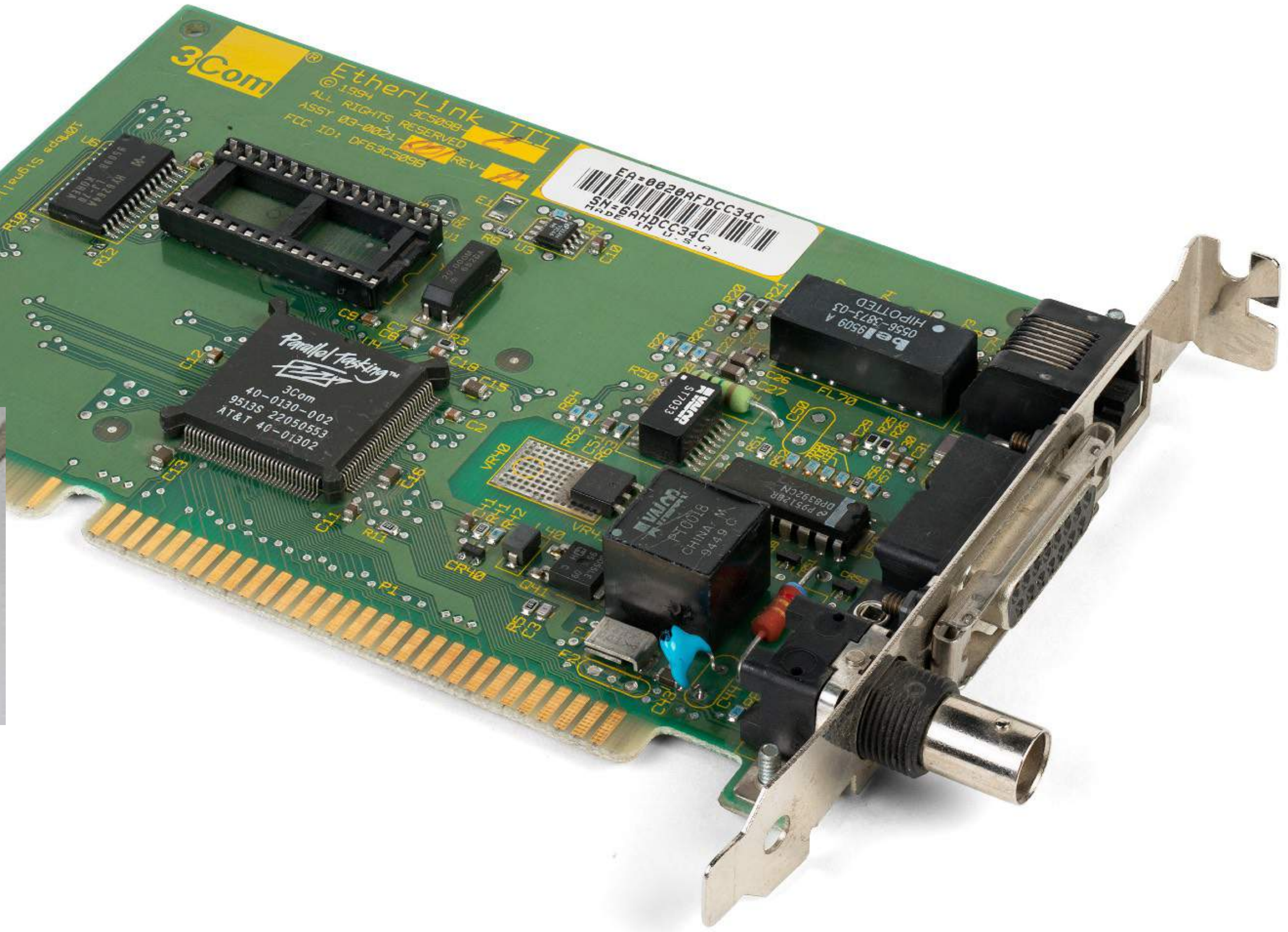


10BASE2

still only 10 Mbit/s Ethernet

- Hardware:
    - thin coax cable
    - BNC-"T"-connectors
- Up to 200m total length
- "Cheapernet"
- mid to late 1980s

Attribution: @the_mutax
https://twitter.com/the_mutax/status/1303700688745226240



Attribution: Dmitry Nosachev
https://commons.wikimedia.org/wiki/File:3Com_3C509BC_Ethernet_NIC.jpg

10Base-T

still only 10 Mbit/s Ethernet

- Hardware:
  - two pairs of twisted copper wires
  - 8P8C (RJ45) plastic connector
- Since 1988
- Needs an active component (hub or switch) to interconnect

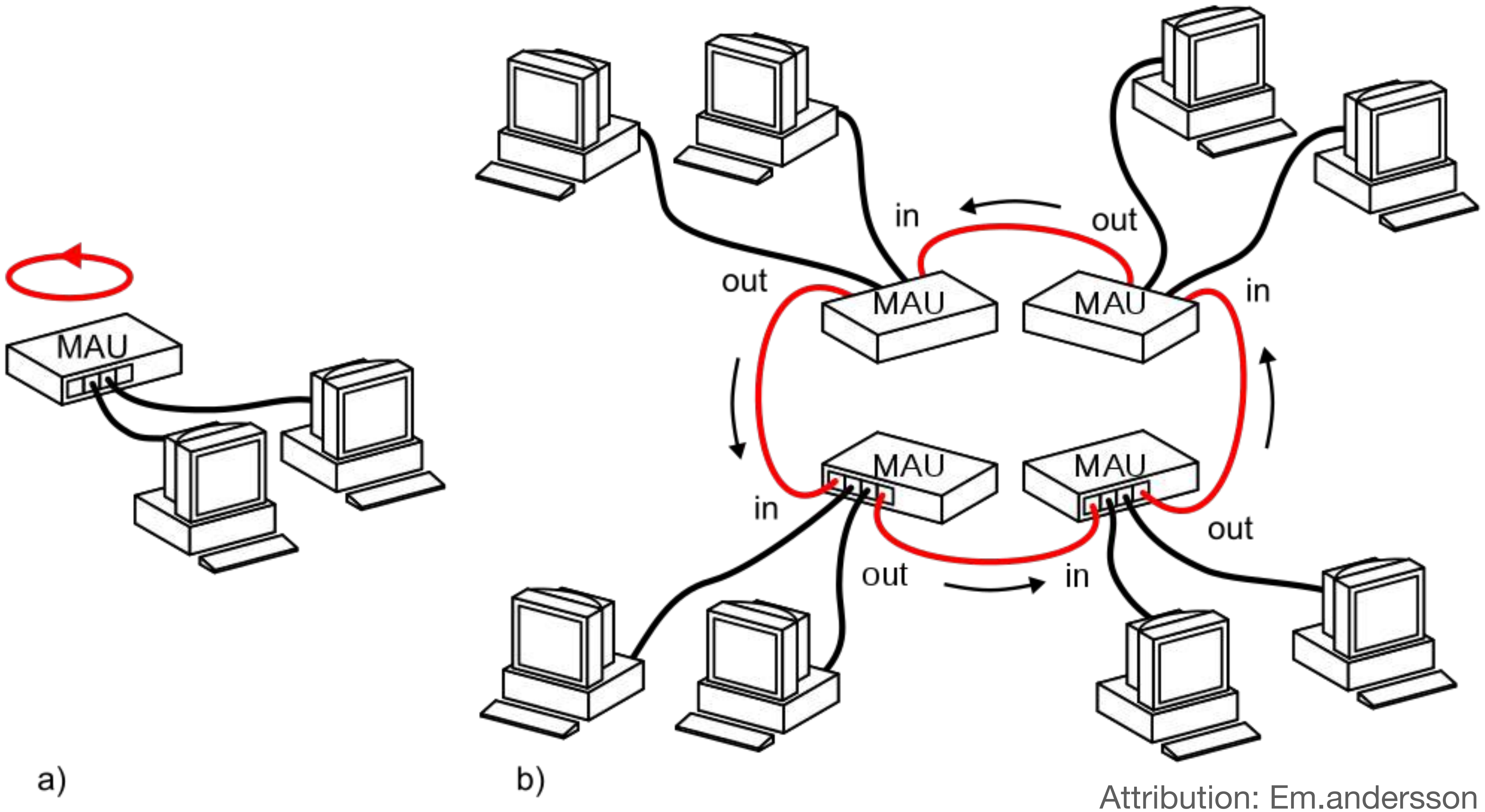
Attribution: Dmitry Nosachev
https://commons.wikimedia.org/wiki/File:3Com_3C509BC_Ethernet_NIC.jpg

Competing standards

Token Ring

1984 - 1990s

- Developed by IBM
- 4Mbit/s, later 16Mbit/s
- Deterministic access
- Needs central Multistation Access Unit
- More complex than Ethernet
- More expensive than Ethernet

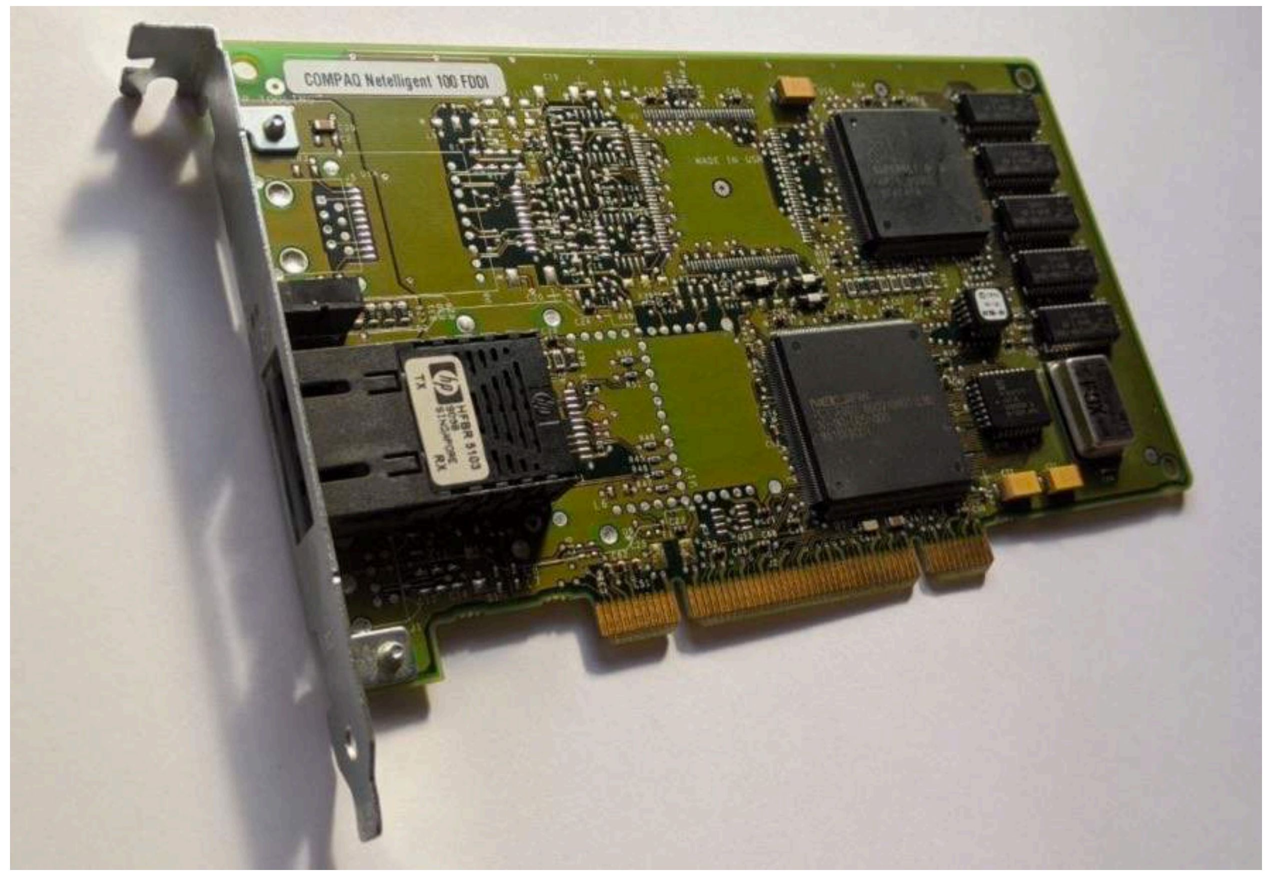


Attribution: Em.andersson
https://en.wikipedia.org/wiki/File:Token_ring.png

Attribution: Jens Link
https://commons.wikimedia.org/wiki/File:IBM_PCMCIA_Token_Ring_Card.jpg

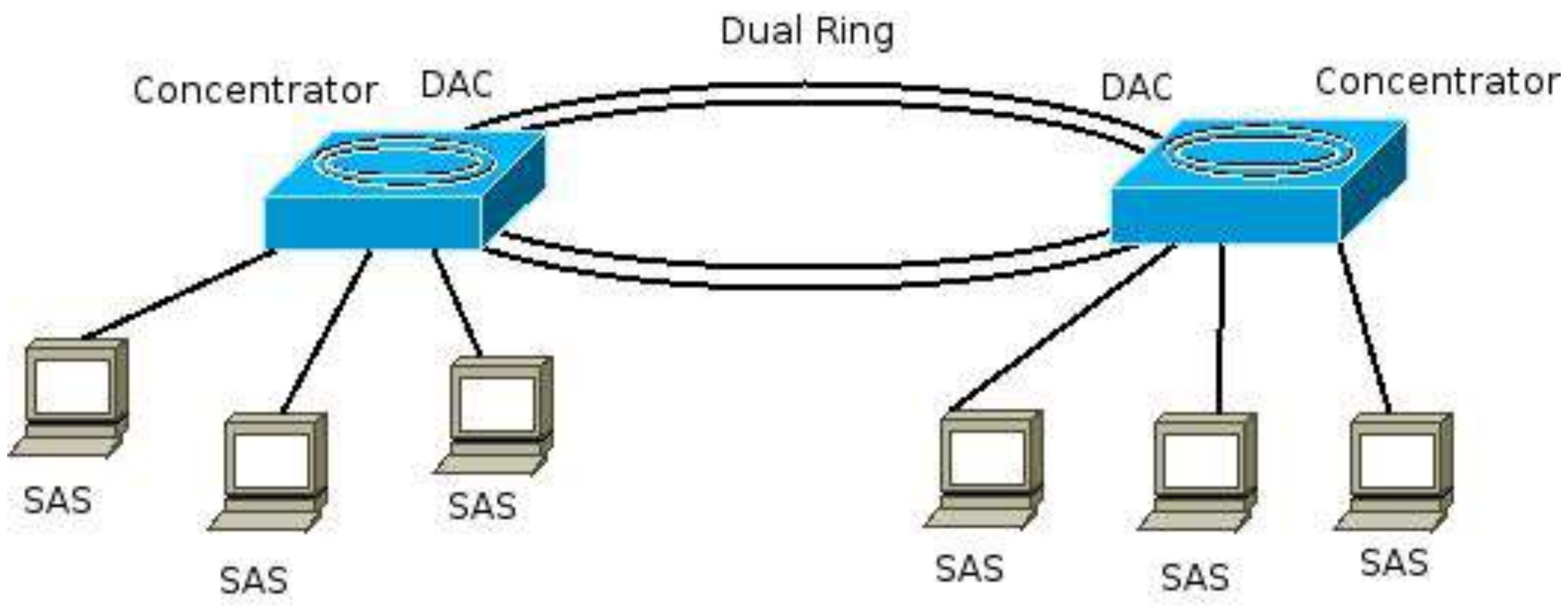
FDDI

late 1980s - 1990s



Attribution: Maximilian Wilhelm

- Fiber Distributed Data Interface
- Optical network
- 100Mbit/s speed, up to 200km size
- Frame-size of 4352 bytes
- double ring topology
- made obsolete by GigabitEthernet



Attribution: Vincent van der kussen at nl.wikibooks
https://commons.wikimedia.org/wiki/File:FDDI_Concentrator.jpeg

Back to Ethernet

Ethernet is a ***broadcast*** network where all devices are connected to a ***shared*** medium

Broadcast network

One is sending, everybody is receiving

- All stations share one medium
- Only one station at a time can send data
- If two stations start sending at the same time, a *collision* occurs
  - Both stop sending, wait for a random time, then retry
  - This was one of the main criticisms (no guaranteed delivery)

Broadcast network

One is sending**, everybody is receiving**

- Everybody is receiving everything
- How to avoid overload / unnecessary processing of data?
    - Each station has a unique 48-Bit address
    - Receivers address is at the beginning of each frame
    - And can be processed by the network card
    - Only frames with matching address or broadcast frames are forwarded to the CPU

Ethernet

Frame Structure

Preamble				SFD	Destination MAC Address	Source MAC Address	Ethertype	Payload	Checksum
10101010	10101010	10101010	10101010	10101011	48 Bits 6 Octets	48 Bits 6 Octets	16 Bits 2 Octets	46 - 1500 Octets	32 Bits 4 Octets

Ethernet

Frame Structure

- Preamble - 56 bits of 10101010....
- Start of frame marker - 8 bits: 10101011
- Destination MAC address
- Source MAC address
- EtherType (or length)
- Payload
- 32 bit checksum

Preamble				SF D	Destination MAC Address	Source MAC Address	Ethertype	Payload	Checksum
10101010	10101010	10101010	10101010	10101011	48 Bits 6 Octets	48 Bits 6 Octets	16 Bits 2 Octets	46 - 1500 Octets	32 Bits 4 Octets

Ethernet

Addressing

- 48 Bit address - 6 octets
- 281 trillion possible addresses
- managed by IEEE
  - you can purchase blocks of addresses
- notation examples:
  - 00:26:b0:d8:3d:8a
  - 0026.b0d8.3d8a
  - 00-26-b0-d8-3c-8a

Preamble				SFD	Destination MAC Address	Source MAC Address	Ethertype	Payload	Checksum
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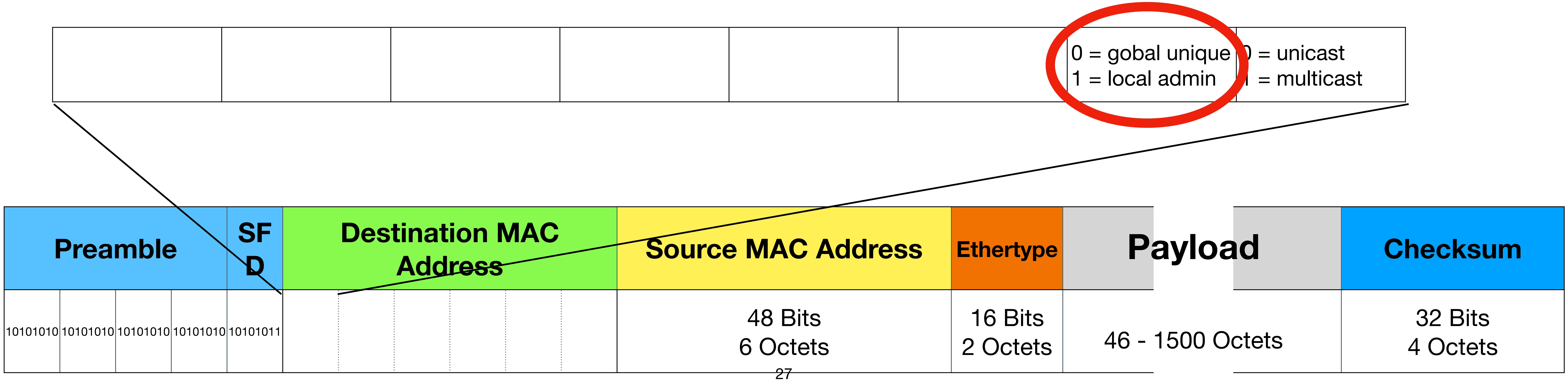
Ethernet

Addressing

- Two bits in first octect have special meaning
- one for local vs. globally unique addresses
  - unique: usually "burned" into the hardware by manufacturer
- one for unicast vs. multicast



Ethernet
Special Addresses

- **FF:FF:FF:FF:FF:FF**

  The ***broadcast*** address

- Received by all nodes

Preamble				SFD	Destination MAC Address	Source MAC Address	Ethertype	Payload	Checksum
10101010	10101010	10101010	10101010	10101011		48 Bits 6 Octets	16 Bits 2 Octets	46 - 1500 Octets	32 Bits 4 Octets

Ethernet

Ethertype

- Was once used to indicate size of payload
  - Using values up 1500
- → Ethertype values start at 1536
- Some well-known values:

0x0800	IPv4
0x86dd	IPv6
0x0806	ARP
0x8100	VLAN Tagged

Preamble				SFD	Destination MAC Address	Source MAC Address	Ethertype	Payload	Checksum
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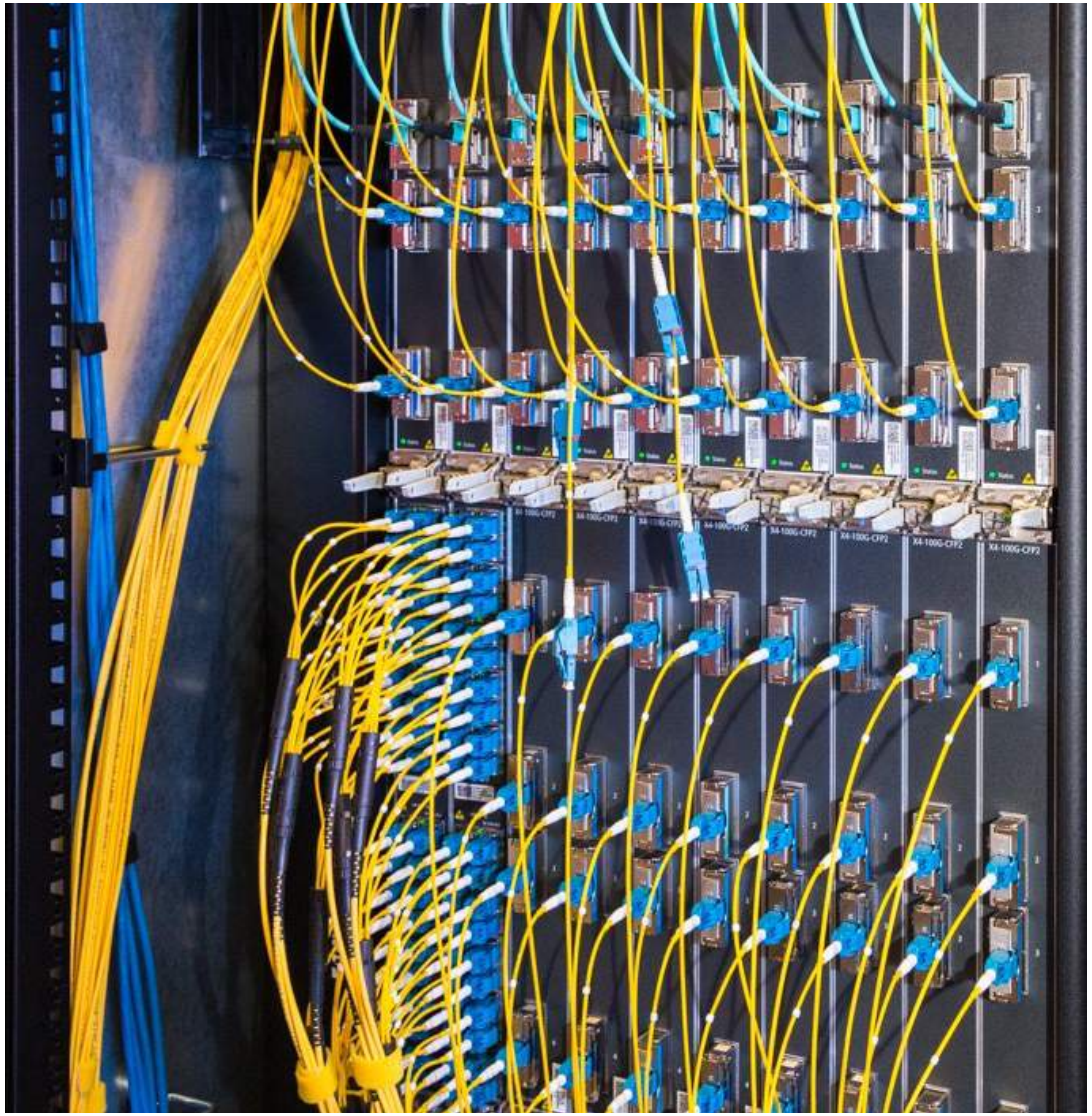
Ethernet Today

Ethernet connections

In data centers

- Usually optical fibres are used
- Various types exist (single mode, multi mode)
- Speeds are 1 GBit/s, 10 GBit/s, 100 GBit/s or 400 GBit/s
- Connections are between a *switch* and an end device



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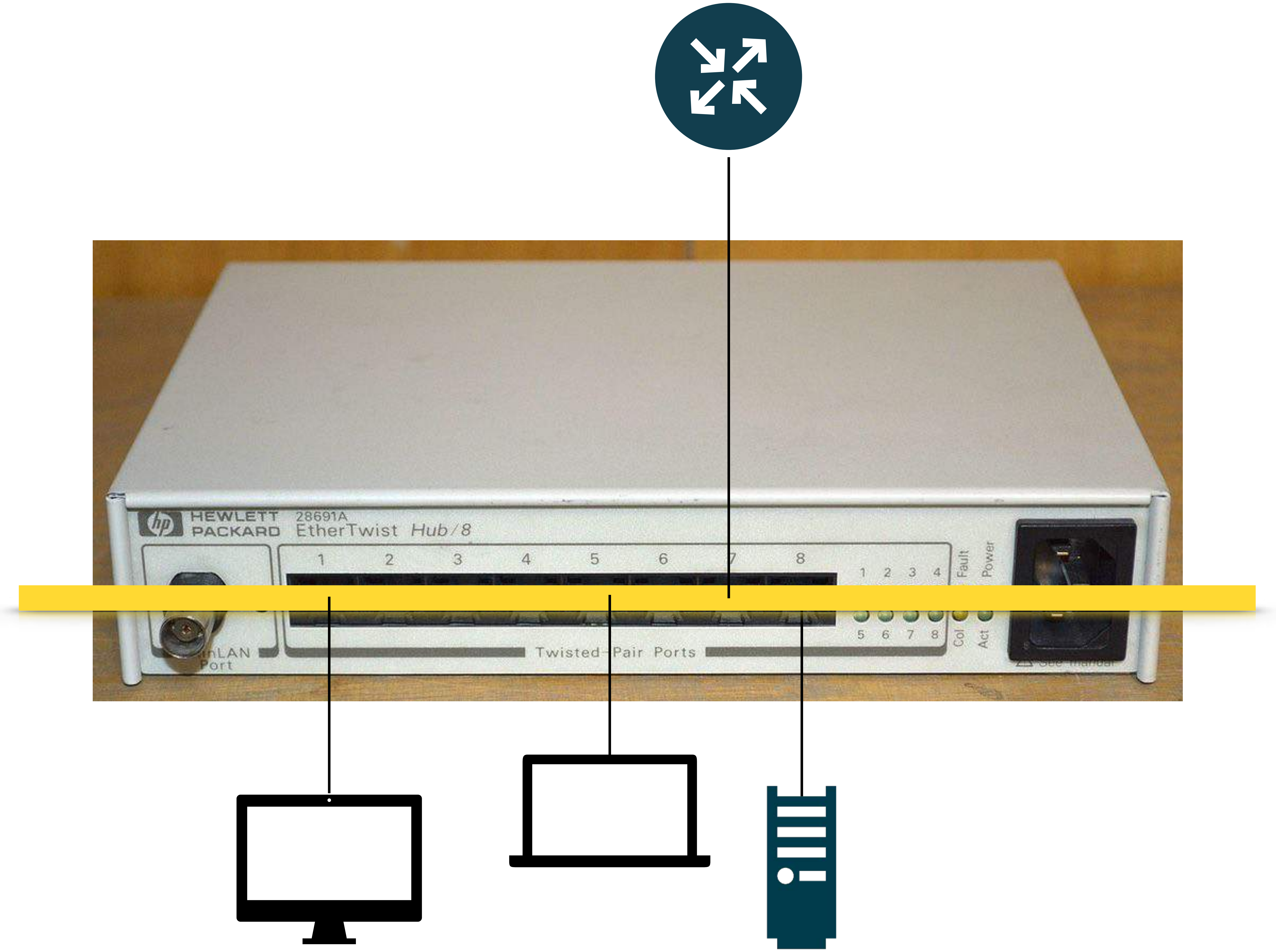
Ethernet at home
10Base-T

- Only wire-based connections are in use
- Speeds are 100Mbit/s or 1Gbit/s
- With a *switch* as a center
- Wireless Ethernet - WIFI is most common

Ethernet at home

10Base-T

- 10Base-T (twisted pair) requires a central device
- To replace the yellow coax cable
- Early devices: a *hub*
  - Function: What is received on one port is broadcasted out on all other ports
  - Just like the yellow coax cable



Attribution: Zac67
https://commons.wikimedia.org/wiki/File:HP_EtherTwist_Hub8.jpg

Ethernet Switch

Ethernet today

- Instead of a hub, a switch is common today
- Advantage:
    - a switch learns which devices are connected to which port
    - and only sends frames on ports they are destined to
    - fallback: unknown destinations are still broadcasted on all ports

Attribution: Wolfgang Tremmel

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But...

Ethernet still....

- ...usually has a max payload size of 1500 octets
  - "jumbo frames" with 9000 octets exist, but are not commonly used
- ...uses 48-bit addresses
- ...is a broadcast medium.
  - but today *switches* are used and connections are point-to-point

Network layers - Internet Model

Ethernet: Link Layer

- Data units are called "Frames"
- Provides node-to-node data transfer
- Examples:
  - Point-to-Point Protocol (PPP)
  - Ethernet

Layer	Name
5	Application
4	Transport
3	Internet
2	Link
1	Physical

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Conclusion

Please remember....

Facts about Ethernet

- Ethernet is a **broadcast** network
- It uses **48-Bit** addresses
  - Which are globally **unique**
- Ethernet frames have usually max. 1500 octets **payload**
- Today ***switches*** interconnect devices

Thank you!

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Links used in the presentation

History of Ethernet

- ALOHAnet
- Robert Metcalfe and Xerox PARC
- Ethernet
  - Wikipedia entry for Ethernet
  - IEEE Standard for Ethernet
- Various types of Ethernet
  - 10Base5
  - 10Base2
  - 10Base-T
- more speed
  - FastEthernet - 100Mbit/s
  - GigabitEthernet - 1000Mbit/s / 1GBit/s
  - 10 Gigabit Ethernet - 10GBit/s
  - 100 Gigabit Ethernet (and 40 Gigabit Ethernet)

Other protocols

Now mostly obsolete

- Token Ring
- FDDI
- Arcnet
- Econet
- AppleTalk

Ethernet hardware

Then and now

- Historical hardware
  - Vampire tap for 10Base5
  - Attachment Unit Interface
  - Coax cable and BNC-Connector for 10Base2
  - Ethernet Hub for 10Base-T

- Currently used hardware
  - Twisted pair cables: Cat5, Cat6, RJ45 connector
  - Optical fibres: Single-mode and multi-mode
  - Ethernet switch

Standards

- IEEE standards
  - 802.3-2018 current standard, also here
  - IEEE 802 committee website

- Registered information:
  Ethertype list at IANA, Public register at IEEE

- Some Internet RFCs regarding Ethernet
  - IP over Ethernet: RFC894, RFC895
  - IPv6 over Ethernet: RFC1972, RFC2464

Software

- Wireshark

- TCPDump