Nettech

11.10.2021

Coarse Classification

- LAN Local Area Network
- WAN Wide Area Network

Coarse Classification

- (PAN) Personal Area Network
- LAN Local Area Network
- MAN Metropolitan Area Network
- WAN Wide Area Network
- (GAN) Global Area Network

ISO/OSI 7-Layer-model

International Standards Organisation / Open System Interconnections

	Layer	**Typical**
• 7	Application	Apps, WWW, Servers,
• 6	Presentation	html, mp3, H.264, PGP,
• 5	Session	SQL, Time-service,
• 4	Transport	UDP, TCP, Port-number,
• 3	Network	Internet, Router, IP,
• 2	Datalink	Ethernet, switch, MAC,
• 1	Physical (PHY)	Cable, wavelength, code,

Point to Point

- circuit swiched

– Simple
  - no Media-access-control
  - no Addressing
  - less Overhead
– Fast (depending from other parameters)
– „eating“ lots of media-capacity (dedicated)
– Quite bad using of resources
– Statically and nearly not to scale

That what we call a network

- Packet oriented (packet switched)
  - Less resources needed
  - Flexible und scalable
  - Complex
    - Media-Access-Control an Addressing needed
    - Special Protocols for Administration (many!)
    - Big to huge Overhead
    - SLOWLY !!!!!
  - Standards mandatory

Requirements

- Fast (Data rate „Bits/sec“)
- Fast (Latency / „Ping-rate“) QoS
- Save (Hacker, Malware…)
- Save (Fault tolerance)
- Stability / reliability (up-time)
- Scalable (able to grow)
- Open (Standard)
- Less total costs (cost of ownership)
- Able to administrate or all automatic

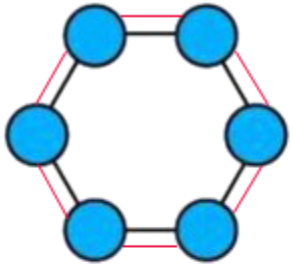
Network Types

- Mainframe with Terminals (Serial) old!!!
- Field-busses (RS485,CAN-Bus,Profibus,KNX,I2C,…)
- Interfaces (RS232,SATA,USB,IEEE1394,NFC,…)
- Proprietary networks (many field-busses)
- Infrastructure networks
- AD-HOC-Networking

Physical topologies

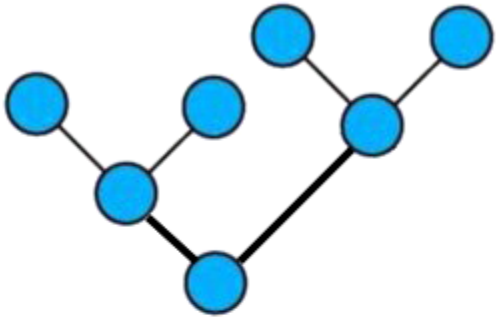
- Bus
- Star
- extended Star
- Hierarchical
- Ring, double ring …
- Mesh
- Cellular
- Irregular

Topologies

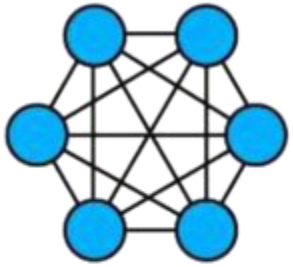


Ring or
Double-Ring

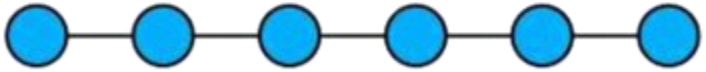
Star



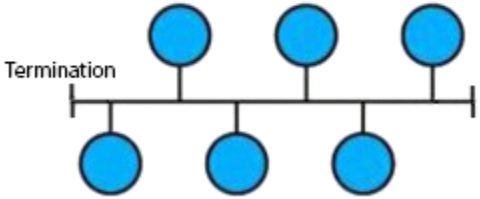
extended Star
or hierachical



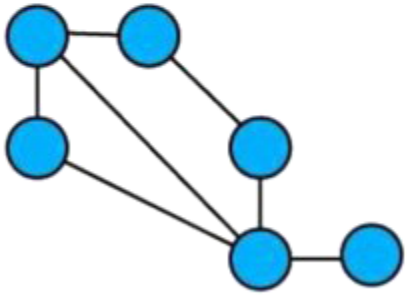
(full-) Mash



BUS (Daisy-Chain)



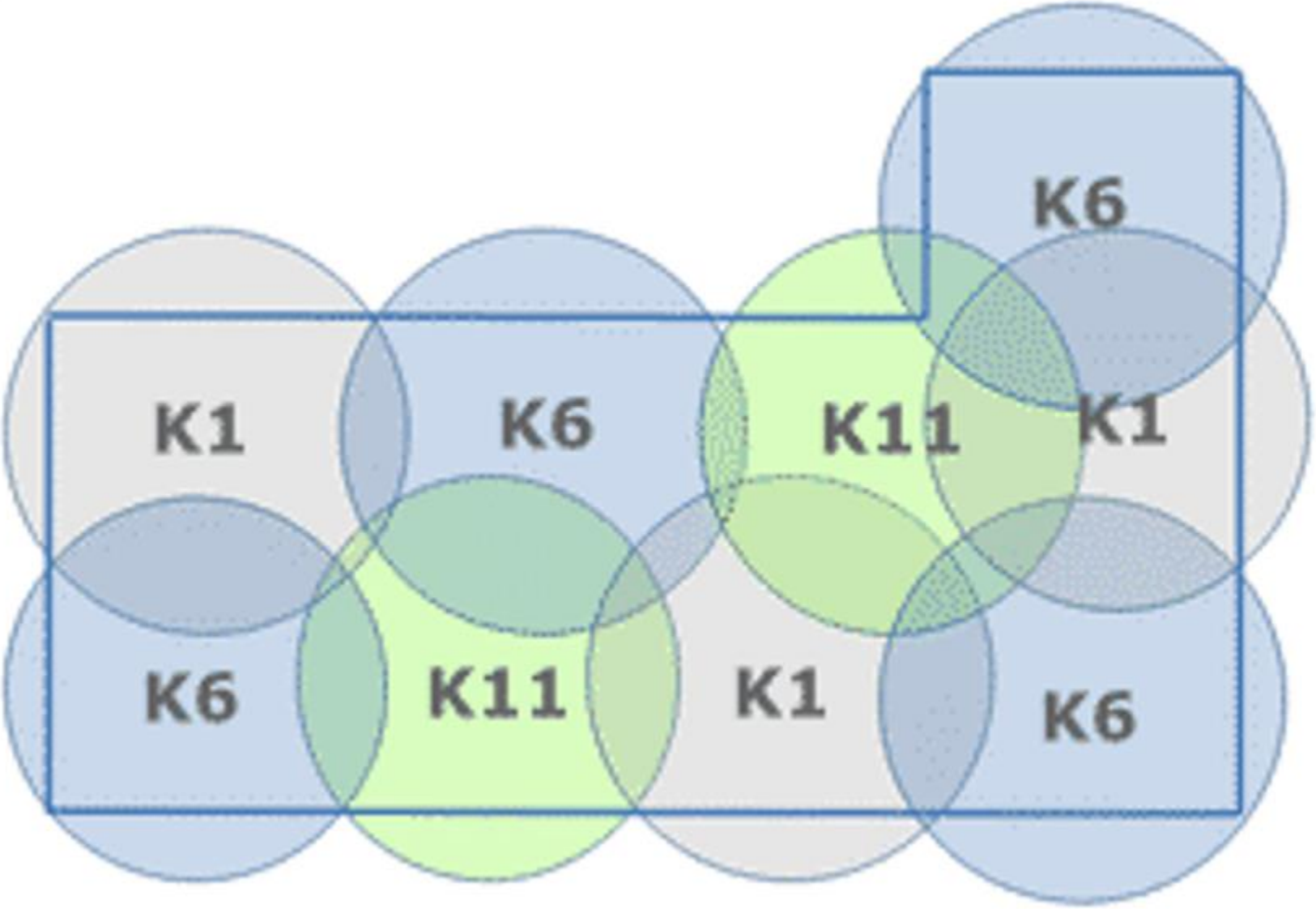
BUS



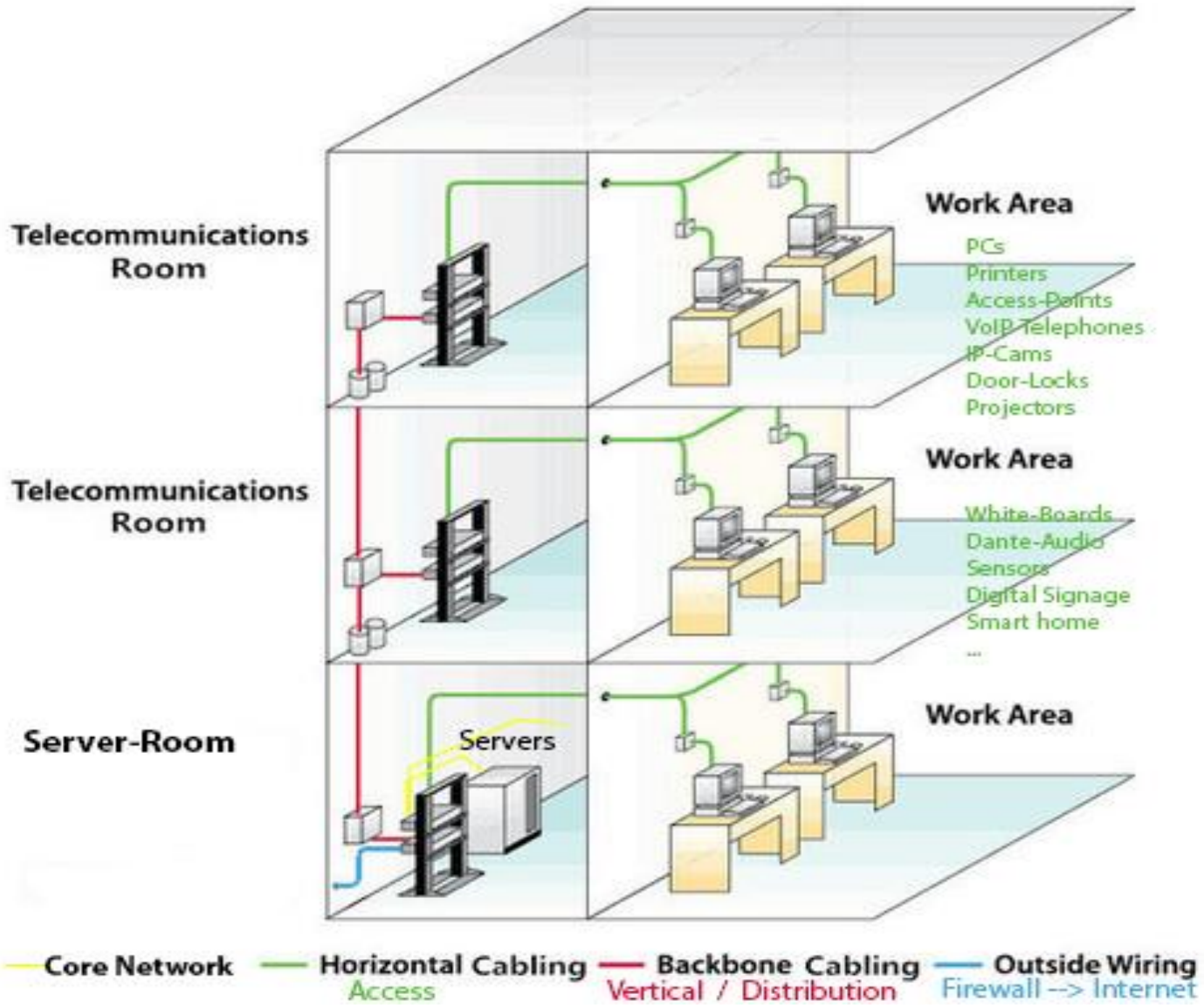
Irregular

DTE = Data Terminal Equipment (User-Device)
DCE = Data Center Equipment (central Device)

Cellular e.g. WiFi



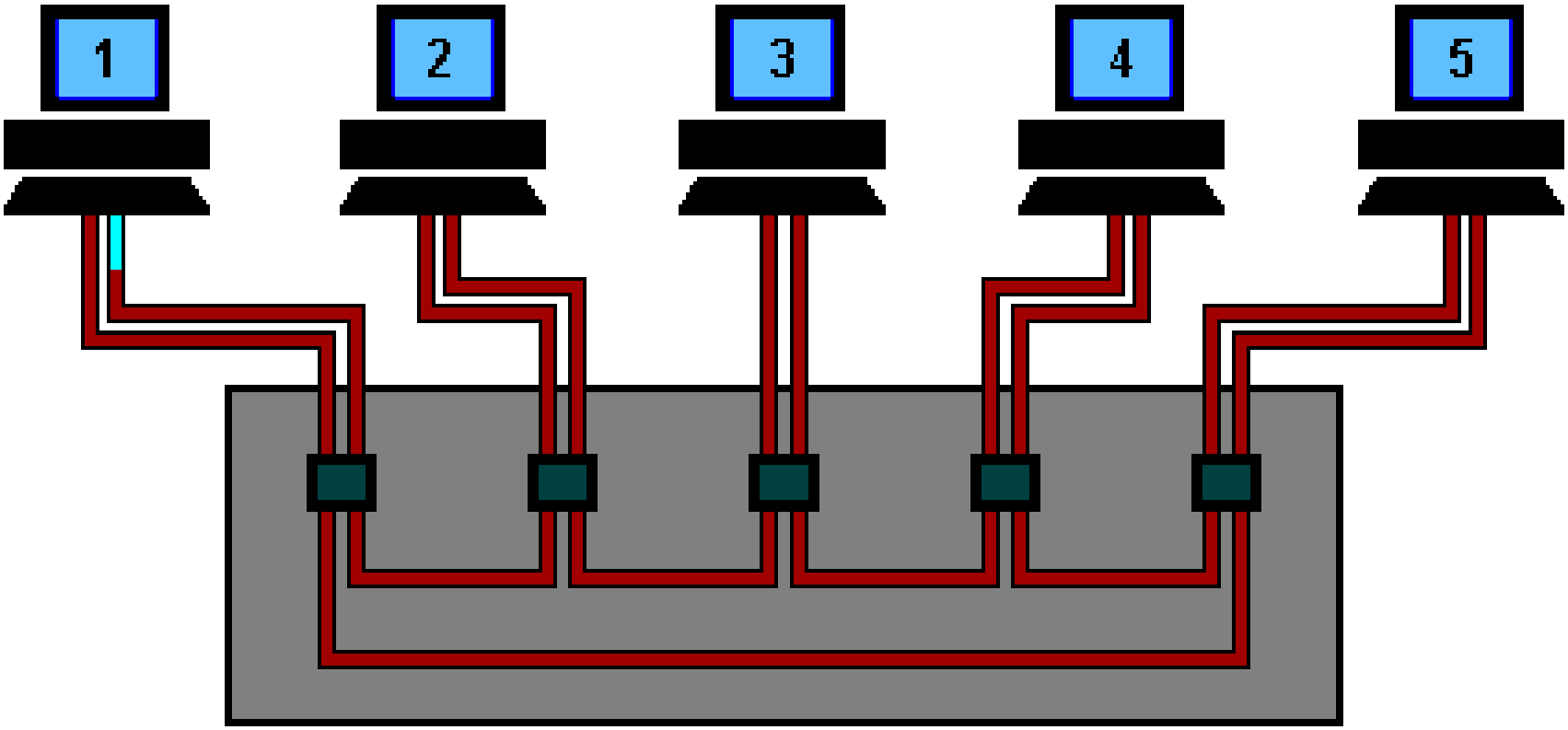
3-Layer-Model



Logical topologies

- Data / bit flow
- Order of media access
  - Can be totally differnet do physical topology!!!
    - e.g..: TOKEN-RING:
      - » Logical: RING
      - » Physical: STAR

Token Ring



Concentrator / MAU

Network hardware

- Passive Components: (physical effect only)
  - Cable (Medium), patchfields, jacks, outlets, antennas, adapters, optical multiplexer,…
- Active Components: (needs electric power)
  - Repeater, amplifier, hub, switch, NIC, router, media-converter, transceiver, Access-Points, …

Data „merging“

- Narrowband – (Baseband)
  - Telephone, RS232, ISDN (BA) …
- Broadband – (multiplex)
  - ISDN (PM), DSL, Ethernet …
    - Time
    - Code
    - Frequency / wavelength
    - Polarisation (wireless only)

Multiplexing

- Multiplexing MUX
  - Different Signals combined to one signal
- Demultiplexing DMUX
  - Split the combined Signal into serveral single signals

- Paket oriented: Time-multiplex, Code
  - Networks, busses, Interfaces,
- Circuit oriented: Modulation…
  - Telephone, Kable-TV, Radio (analog)

Cables
Copper

- Coaxial: UNBALANCED
  - RG58, RG59…
- Twisted-Pairs: BALANCED
    - » UTP
    - » S-UTP / F-UTP / SFTP
    - » STP
    - » S-STP
  - CAT 1, 2, 3, 4, 5, 5e, 6, 6e, 6xg, 7, 8, …

Cable Categories

Copper cable - COAX

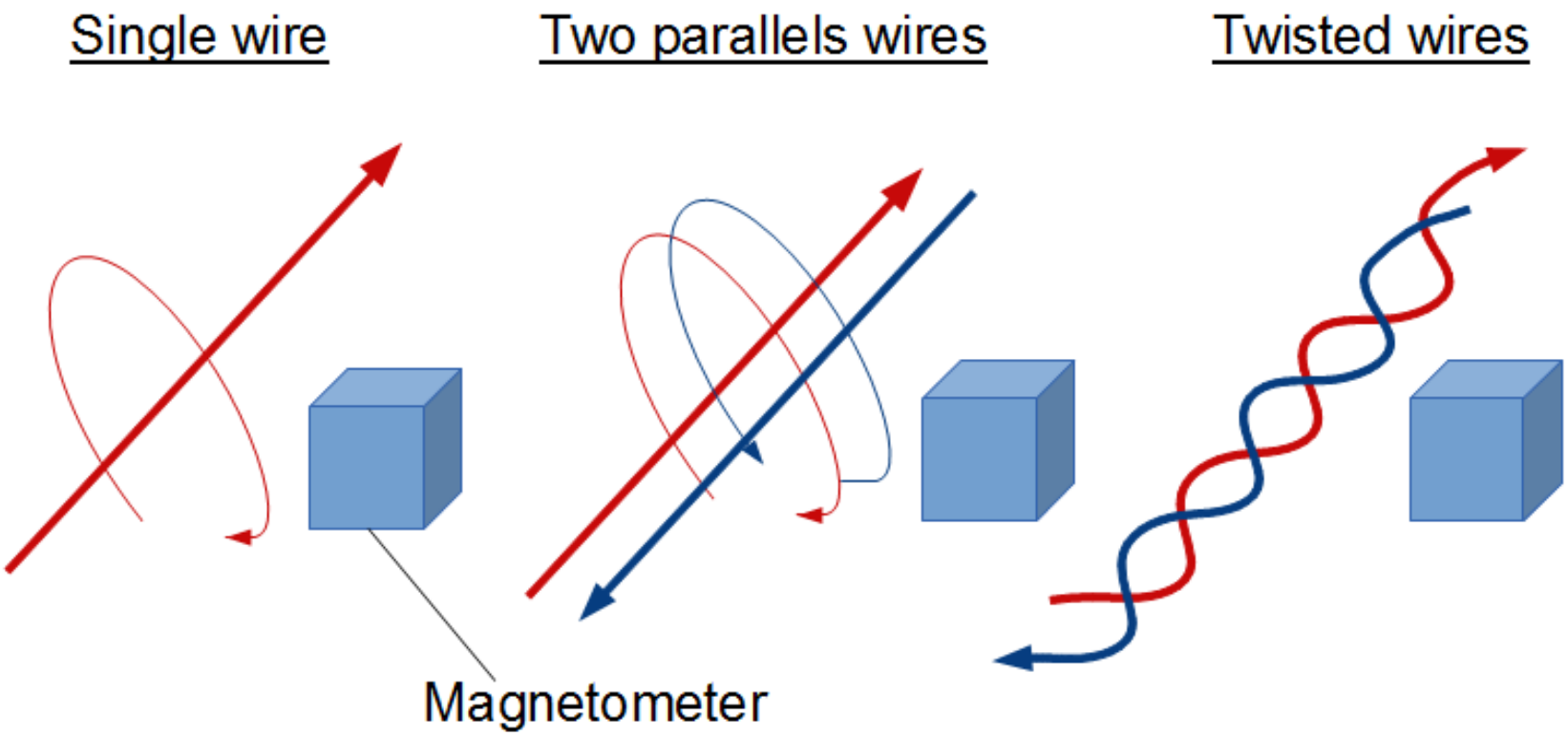
type	Impedance / OHM	Used for
RG-58/U	53,5	Ethernet, cheap
RG58A/U	50	10Base2
RG-58C/U	50	10Base2
RG-59	75	VIDEO
RG-62	93	ARCNet, SNA(3270)

Cable categories

Copper cable - Twisted Pair

type	Class	Specified up to	Impendance / OHM	Used for
STP	-	20 MHz	150	Token-Ring (4/16 MBit), 3270, 5250-Terminals
UTP-1 Cat. 1	A	-	100	Vocie (analog), Telephone
UTP-2 Cat. 2	A	-	100	IBM-Cabeling Typ 3 (Volice), EIA 232
UTP-3 Cat. 3	B	16 MHz	100	10BaseT, 4 Mbit/s Token-Ring, ISDN
UTP-4 Cat. 4	C	20 MHz	100	16 MBit Token-Ring
UTP-5 Cat. 5(e)	D	100 MHz (300 MHz)	100	100BaseTX, ATM (155 MBit) (1000BaseTx)
Cat. 6	D, E	200 MHz	100	See Cat. 5e
Cat. 7	F	600 MHz …1500MHz	100	See Cat. 5e, 10000BaseTx, HDbaseT
Cat. 8	G?	>1200 MHz	100	See Cat. 7, TV, future…

Cancellation



Emission ⇔ Transmission

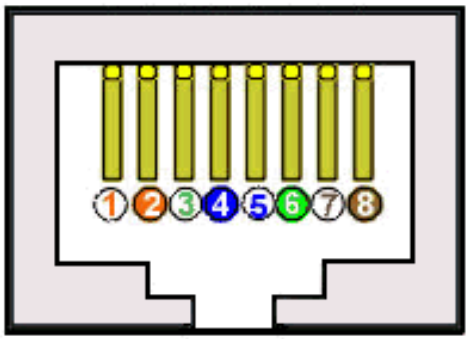
SSTP – Cat. 7

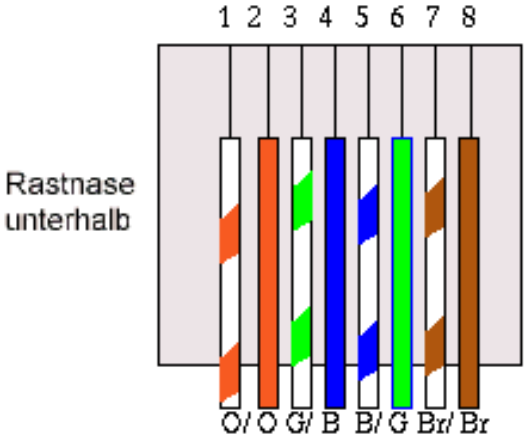

Flame-retardant PVC
Tinned Copper Braiding
Aluminum-Mylar Foil
Foam Insulation
23 AWG Copper Conductor

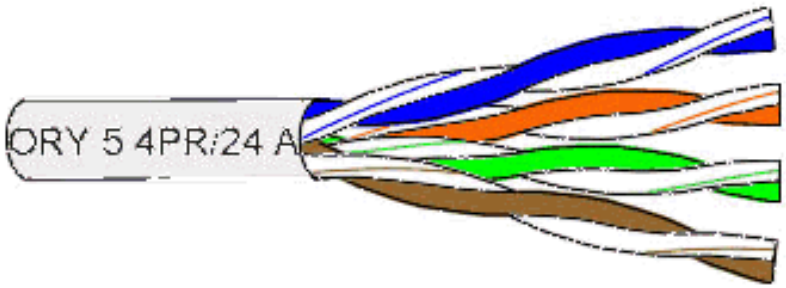
AWG

20 22 24 26 28 30

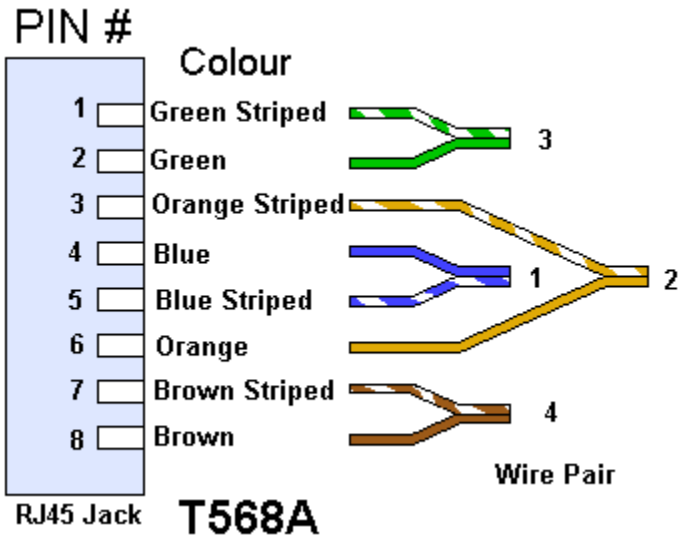
UTP-/STP-Cable

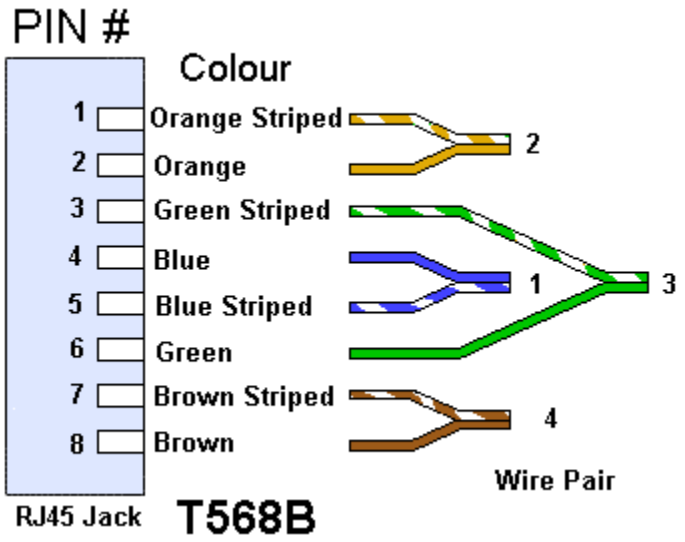






Wire pairs

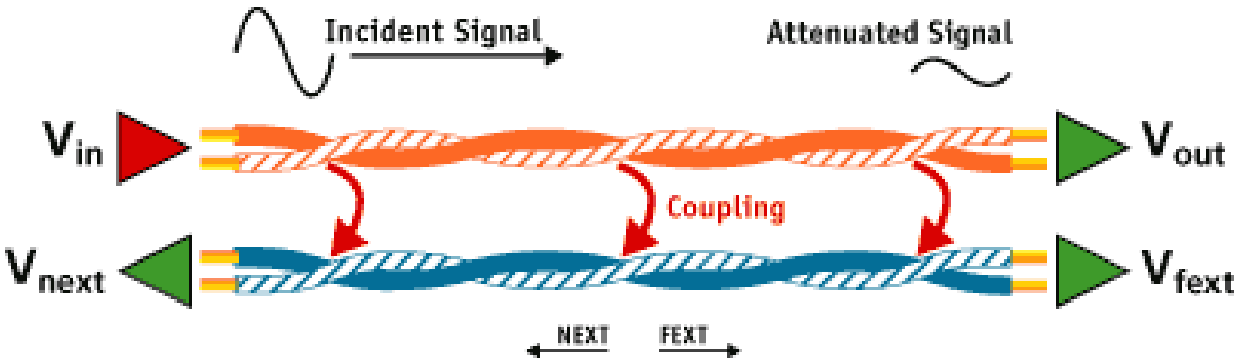




Pin mapping EIA/TIA 568A

Telephone / ISDN UK0 /AS 400 / DSL	Paar 1
IBM 3270	Pair 3
ISDN S0 / Token-Ring	Pair 1,2
ATM	Pair 3,4
10/100 Base Tx	Pair 2,3
100 Base T4 / 1000 Base Tx	Pair 1,2,3,4

Signal interferences



- NEXT / FEXT (Crosstalk)
- ACR = Amplitude vs. Crosstalk Relationship
- Attenuation
- DC-Potentials
- Interferences (LF, RF)
- Propagation Delay
- Noise (thermal – Brown movement) SNR

Optical Fibre

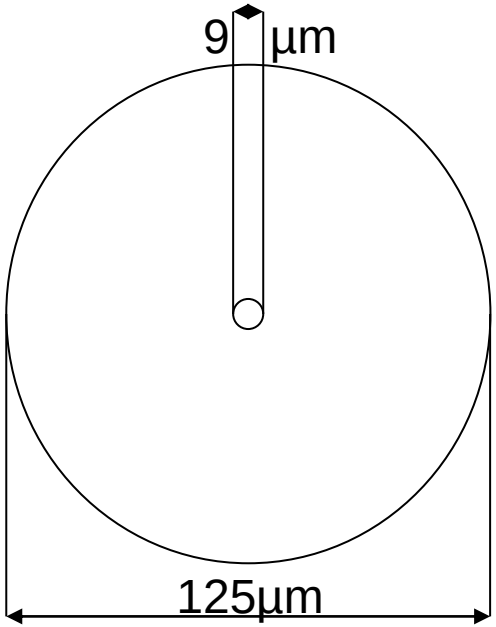
- polymere→TOS-Link (Audio – AC3…)
- Glass:
  - Multimode Step-Index
  - Multimode Gradient-index
  - Singlemode (mono-mode)

advantage: galvanical insulation
EMF/RF-resistance

disadvantage: Complex and expensive
mechanical weak

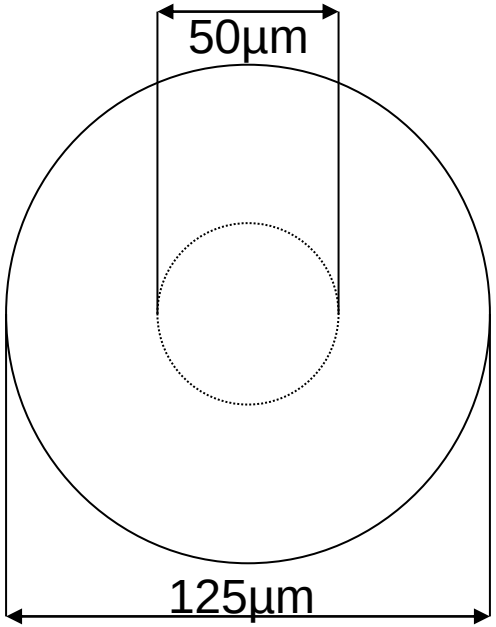
Typs of optical fibers

SINGLE-Mode



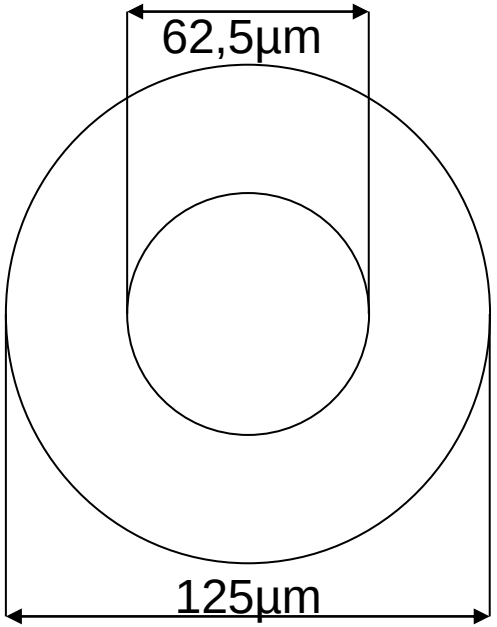
Step-Index

MULTI-Mode



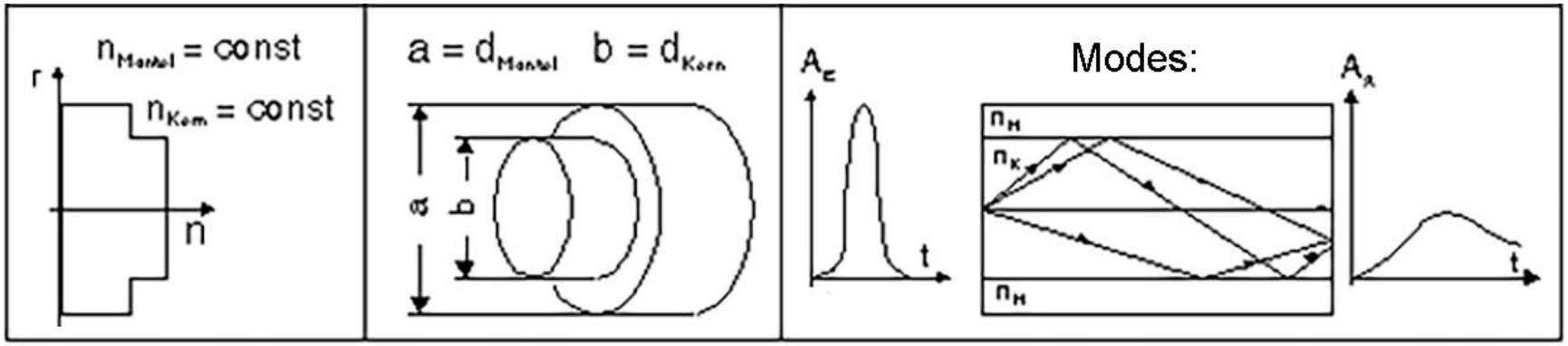
Gradient-Index

MULTI-Mode



Step-Index

Step-index multimode fibre



Profile:
Refractive Index:
Core: 1.517
Cladding: 1.527

Construction:
Diameter:
Core: 62.5 µm
Cladding: 125 µm

input wave length: **850 nm** output
many different ways (modes) for photons so big differences in time of arrival (big mode dispersion)
Bandwidth-Length-Product < 100Mbit/s ● 1km (poor!!!)

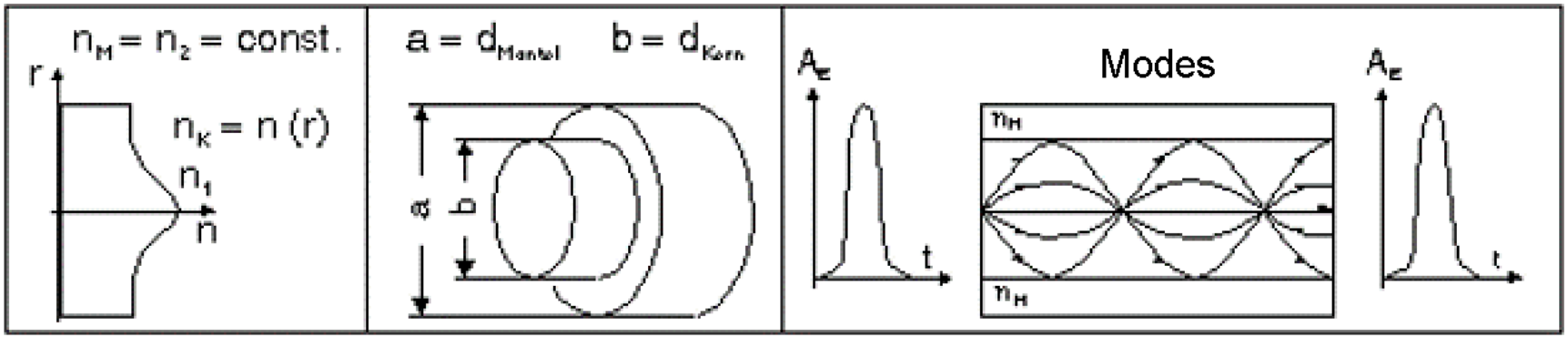
Advantage: simple to splice
simple and cheap connectors
cheap active components (LED)

Disadvantage: short distances (< 1km)
low bandwidth (< 1Gbit/s length <100m)
no WDM possible

Used for: Backbone – inside buildings old !!!
not for new installations !!!

Old-fashioned – not longer in use !!!

Gradiend-index-multimode fibre



Profile:		Construction:	
Refractive Index (mix):		Diameter:	
Core: (start)	1.540	Core:	50 µm
Cladding:	1.562	Cladding:	125 µm

input wave length: **850 nm** output

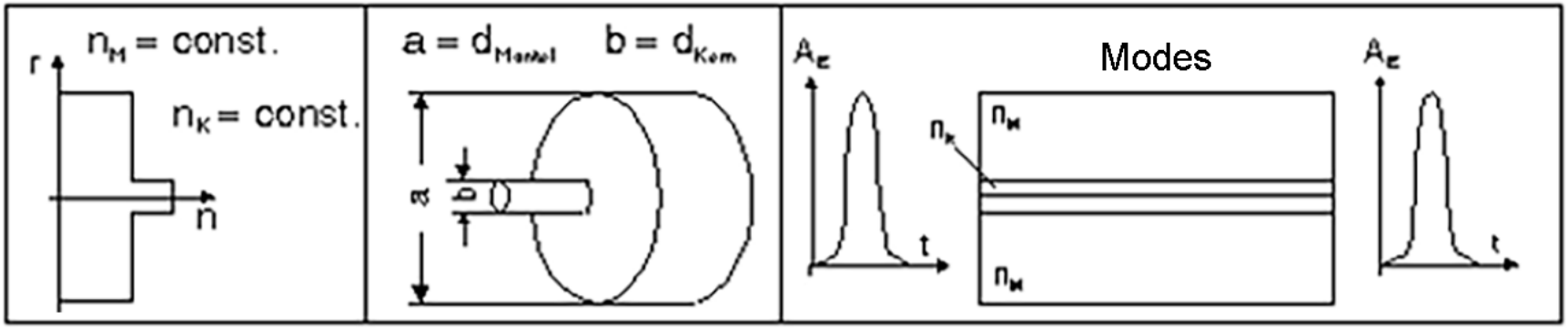
many different ways (modes) for photons but less differences in time of arrival (little mode dispersion)

Bandwidth-Length-Product < 1Gbit/s ● 1km (moderate)

Advantages:	simple and cheap jacks
	cheap active components (LED)
	higher bandwith (< 1Tbit/s)
Disadvantages:	more complex to splice
	short distances (< 3km)
	no WDM possible
Used for:	Backbone – inside an outside buildings

Standard fibre for Campus and Companies

(mono-) Single-mode fibre



Profile:		Construction:	
Refractive Index:		Diameter:	
Core:	1.457	Core:	9 µm
Cladding:	1.471	Cladding:	125 µm

input wave length: **1260-1680 nm** output

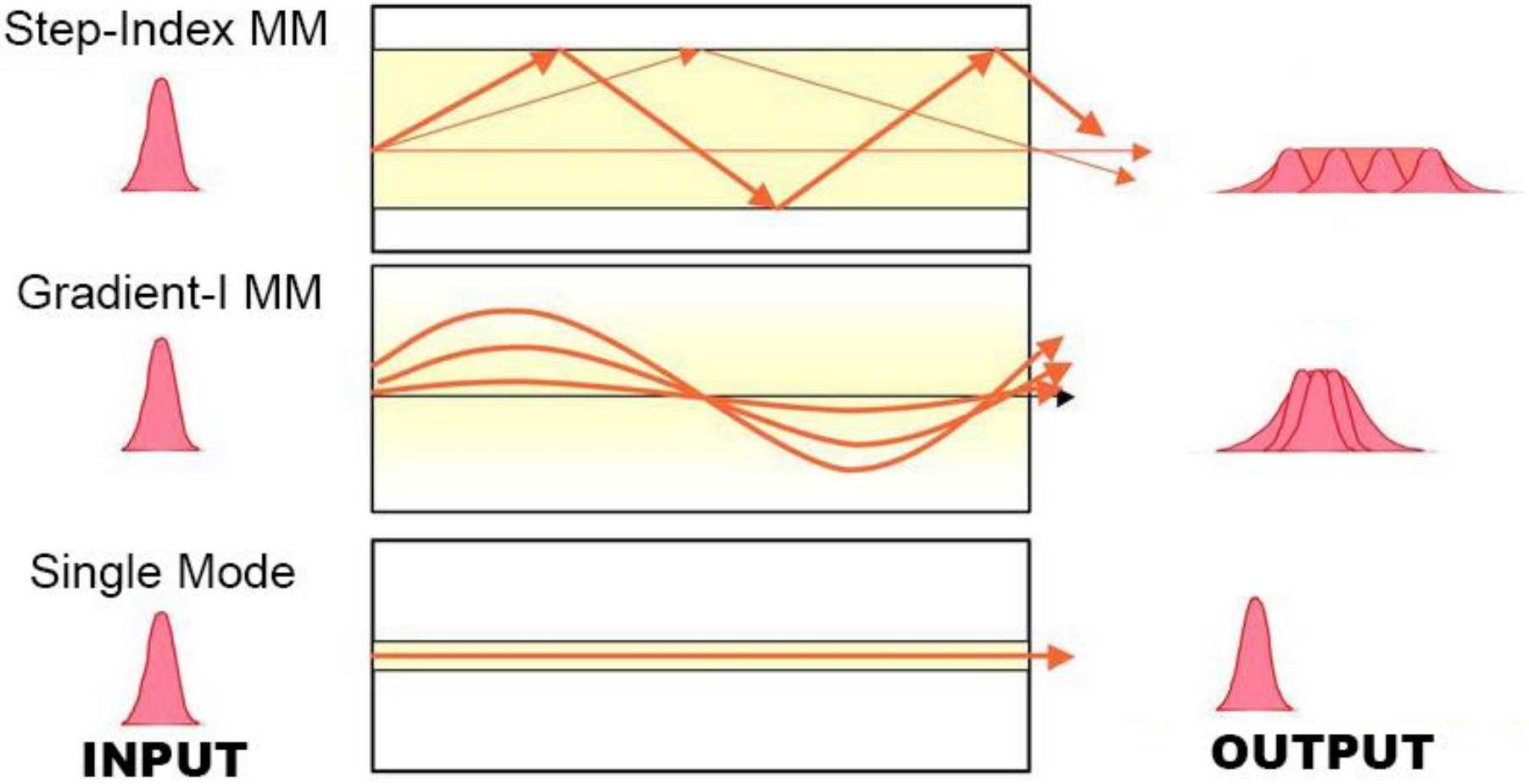
one way only (mono-mode) for photons. So **NO** differences in time of arrival (**no** mode dispersion)

NO Bandwidth-Length-Product – **NO LIMIT!**

Advantage:	Long distances (w/o repeater 70km)
	biggest bandwidth (> 1Ebit/s)
	WDM is possible
Disadvantage:	expensive active components (Laser)
	extremely difficult to splice
	high accurate jacks needed
Used for:	Long distances – WAN / Trans-Ocean
	more often: indoor / LAN / Backbone

Fibre of the future – for all purposes !!!

Mode-dispersion



OM and OS types

Type of fibre	**OM1** **G62,5/125**	**OM2** **G50/125** **G62,5/125**	**OM3** **G50/125**	**OM4** **G50/125** **optimized**	**OS1** **E9..10/125**	**OS2** **E9..10/125**
Attenuation at 850nm	3,5 dB/km	3,5 dB/km	3,5 dB/km	3,5dB/km	Not defined	Not defined
Attenuation at 1300nm	1,5 dB/km	1,5 dB/km	1,5 dB/km	1,5 dB/km	1,5 dB/km	1,5 dB/km
B x L at 850nm	200 MHz x km	500 MHz x km	1500 MHz x km	3500 MHz x km	Not defined	Not defined
B x L at 1300nm	500 MHz x km	500 MHz x km	500 MHz x km	500 MHz x km	Not defined	Not defined
Modal Bandwidth	Not defined	Not defined	2000 MHz x km	4700 MHz x km	Not defined	Not defined

Optical jacks / connectors

SFPs

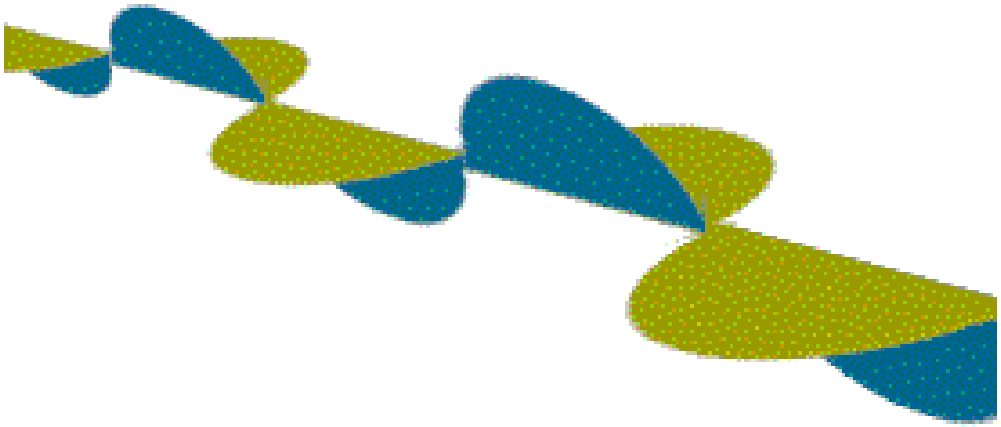

MikroTik
S-31DLC20D
1.25G DDM SFP 1310nm 20KM


Aptek
GIGABIT ETHERNET MEDIA SWITCH
10/100/1000BASE-TX TO 1000BASE-SX/LX
LAN1
LAN2
LAN3
LAN4
TX RX
TX RX

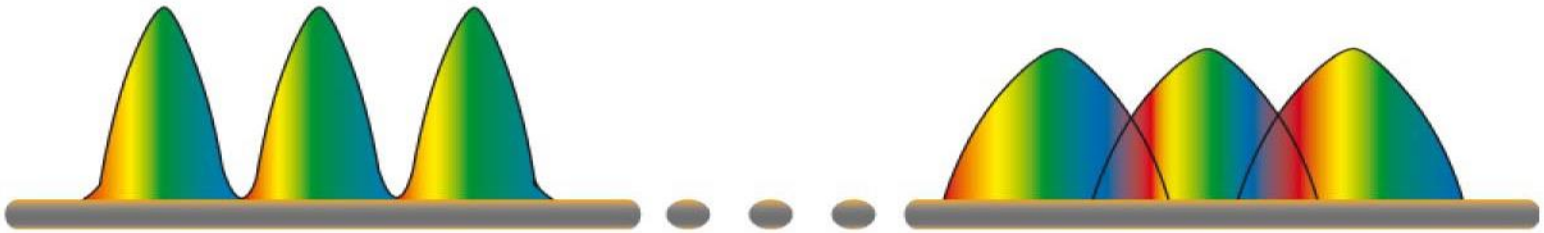

MikroTik
S-53LC20D
1.25G DDM SFP 20KM TX:1550nm RX:1310nm
MikroTik
S-35LC20D
1.25G DDM SFP 20KM TX:1310nm RX:1550nm

Optical transmission problems

- Mode dispersion
- Polarisation-mode-dispersion
- 4-wave-interfences
- Chromatic Dispersion
- …



Chromatic Dispersion



Pan Dacom Direkt
Nets get connected.

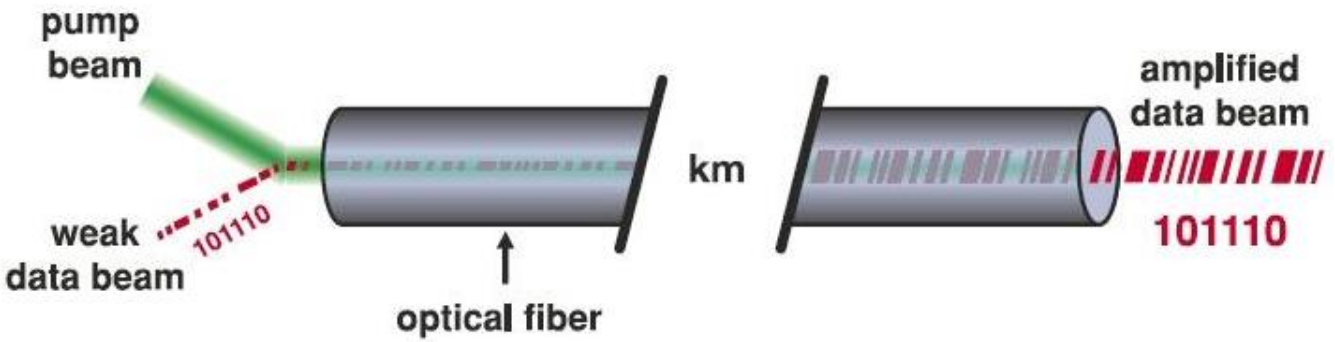
In single-mode-fibres is a limit for cable length without signal-refresh caused by E=h•f (h=Planck's constant $6.62607004 \cdot 10^{-34}$ m²•kg/s)

but c=λ•f (c=speed of light in vacuum 299792485 m/s) $E \approx \frac{1}{\lambda}$

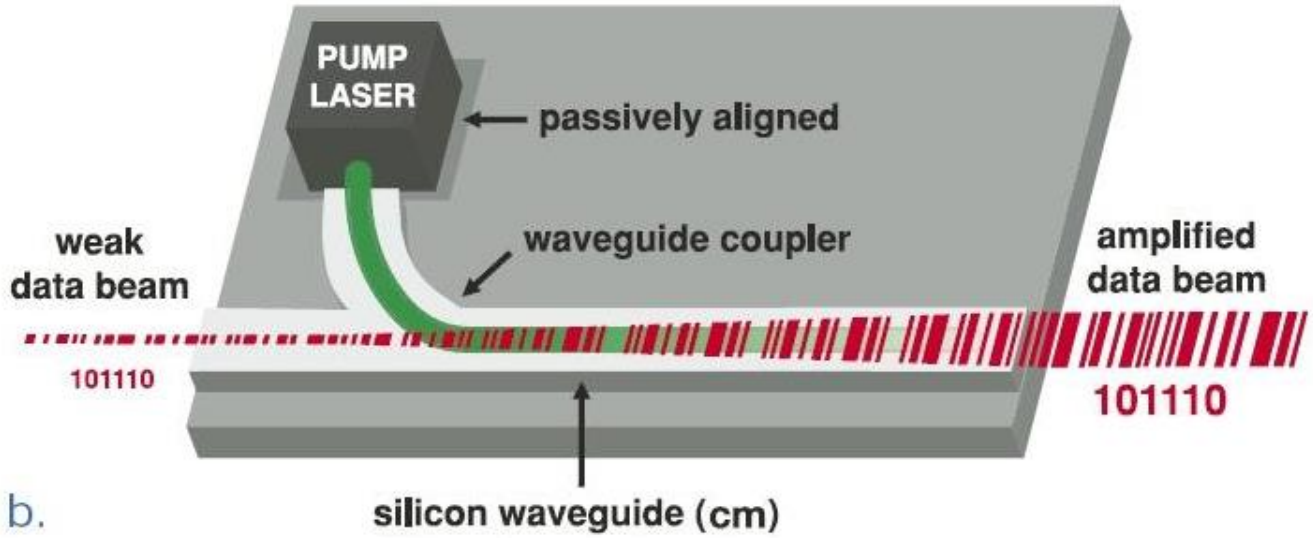
So loosing energy causes shift in colour because λ=wavelength=colour

After every 70km the optical signal must be refreshed (repeated)

EDF-Repeater (Erbium-Doped-Fibre)

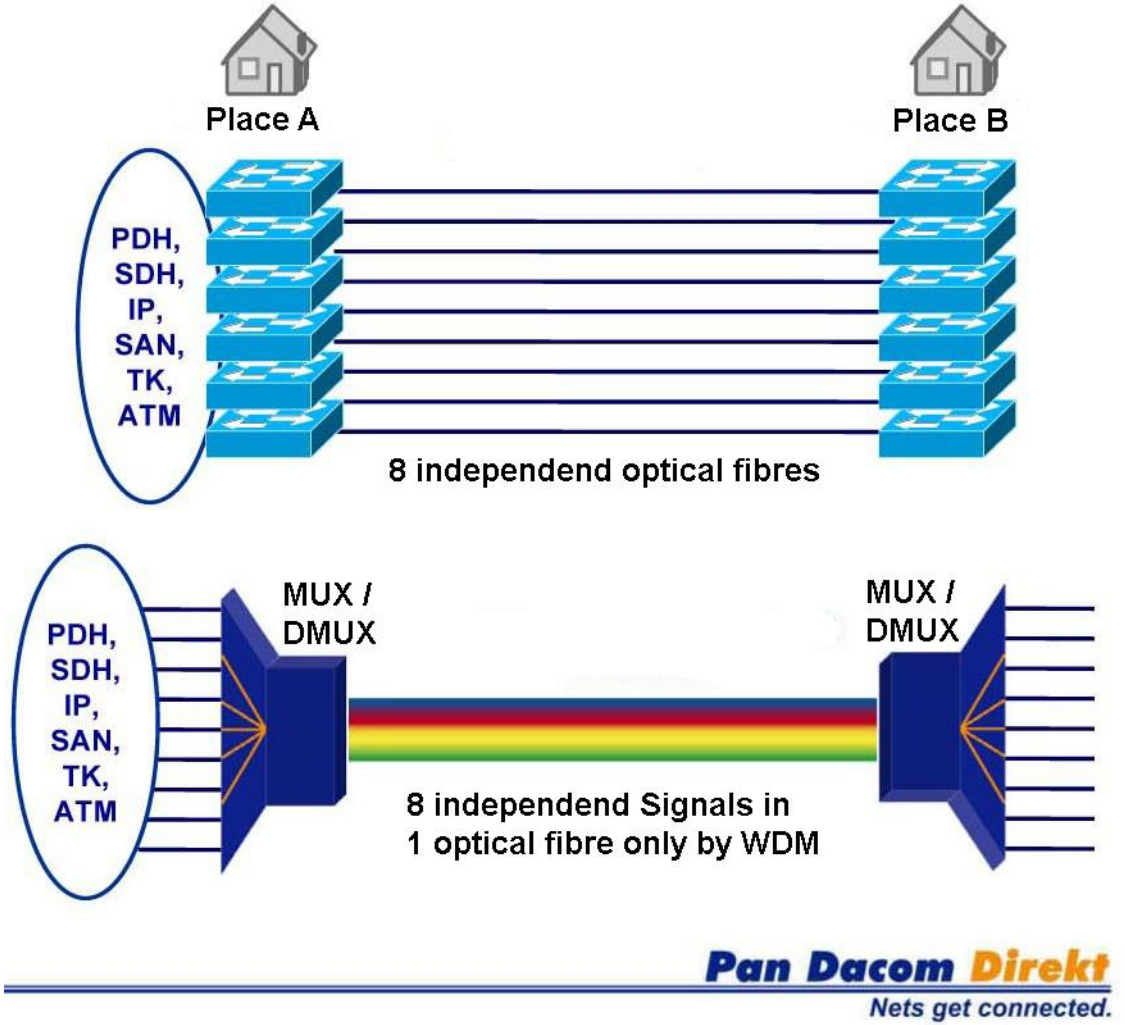


a.



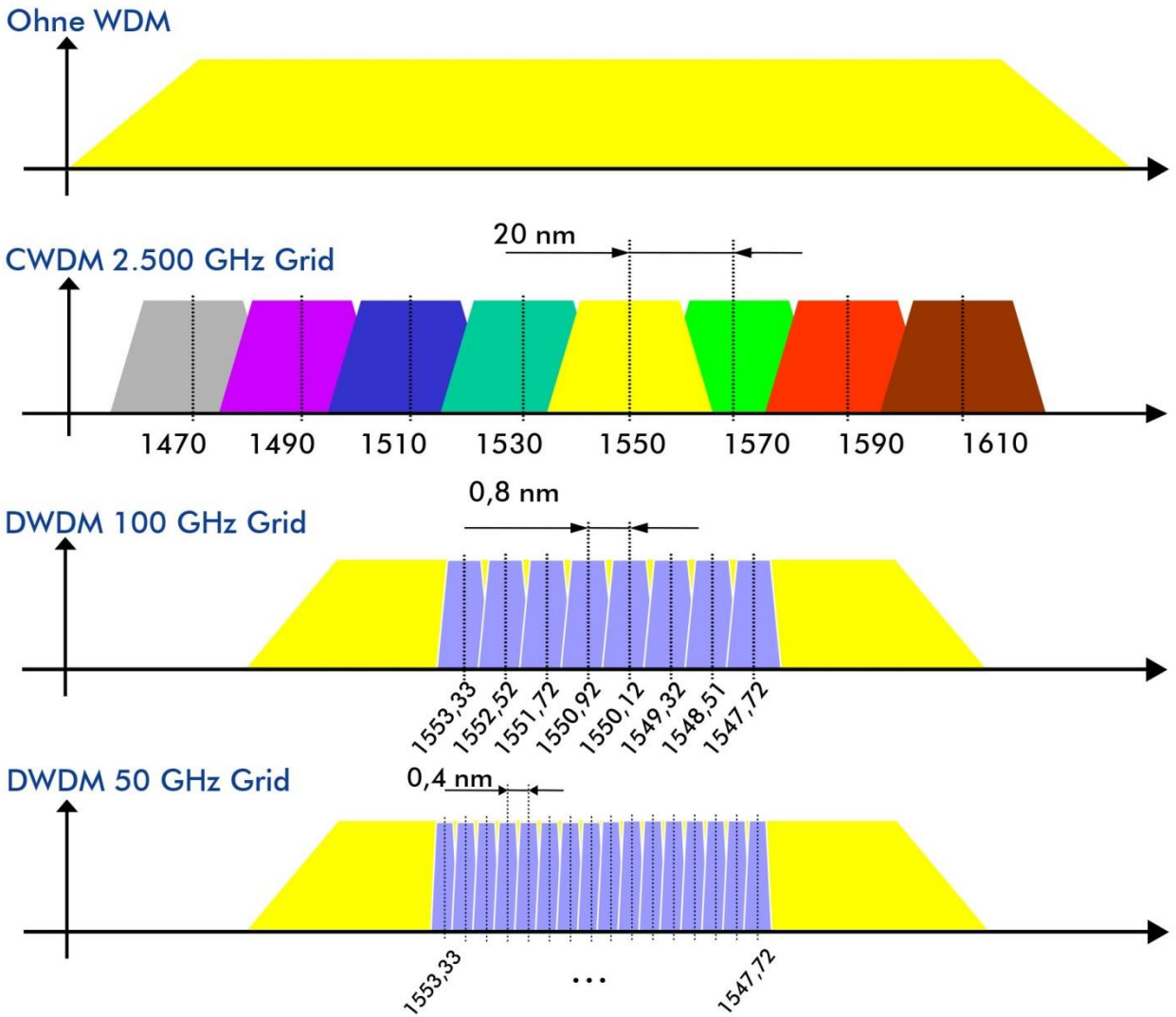
b.

„single color“ vs. WDM



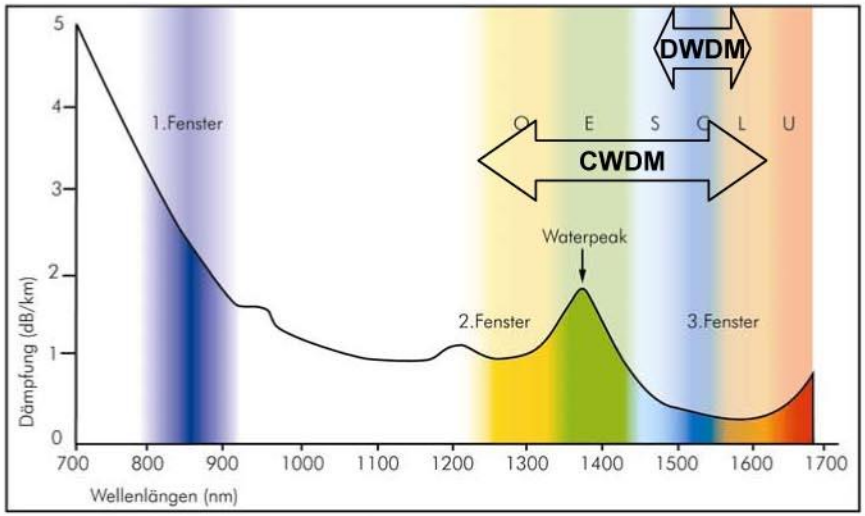
Pan Dacom Direkt
Nets get connected.

WDM types


Ohne WDM
1x 10 Gbit/s =
10 Gbit/s
CWDM 2.500 GHz Grid
20 nm
1470
1490
1510
1530
1550
1570
1590
1610
16x 10 Gbit/s =
160 Gbit/s
DWDM 100 GHz Grid
0,8 nm
1553,33
1552,52
1551,72
1550,92
1550,12
1549,32
1548,51
1547,72
40x 10 Gbit/s =
400 Gbit/s
DWDM 50 GHz Grid
0,4 nm
1553,33
...
1547,72
80x 10 Gbit/s =
800 Gbit/s

Optical bands

Übertragungsstrecke



Typische Dämpfungswerte

Bei MMF	λ =	850 nm ca. 3,0 dB/km
	λ =	1310 nm ca. 0,8 dB/km
Bei SMF	λ =	1310 nm ca. 0,4 dB/km
	λ =	1550 nm ca. 0,25 dB/km

CWDM
ITU-T G.694.2
λ : 1271 – 1611 nm
max. 18 Kanäle
Kanalabstand: 20 nm

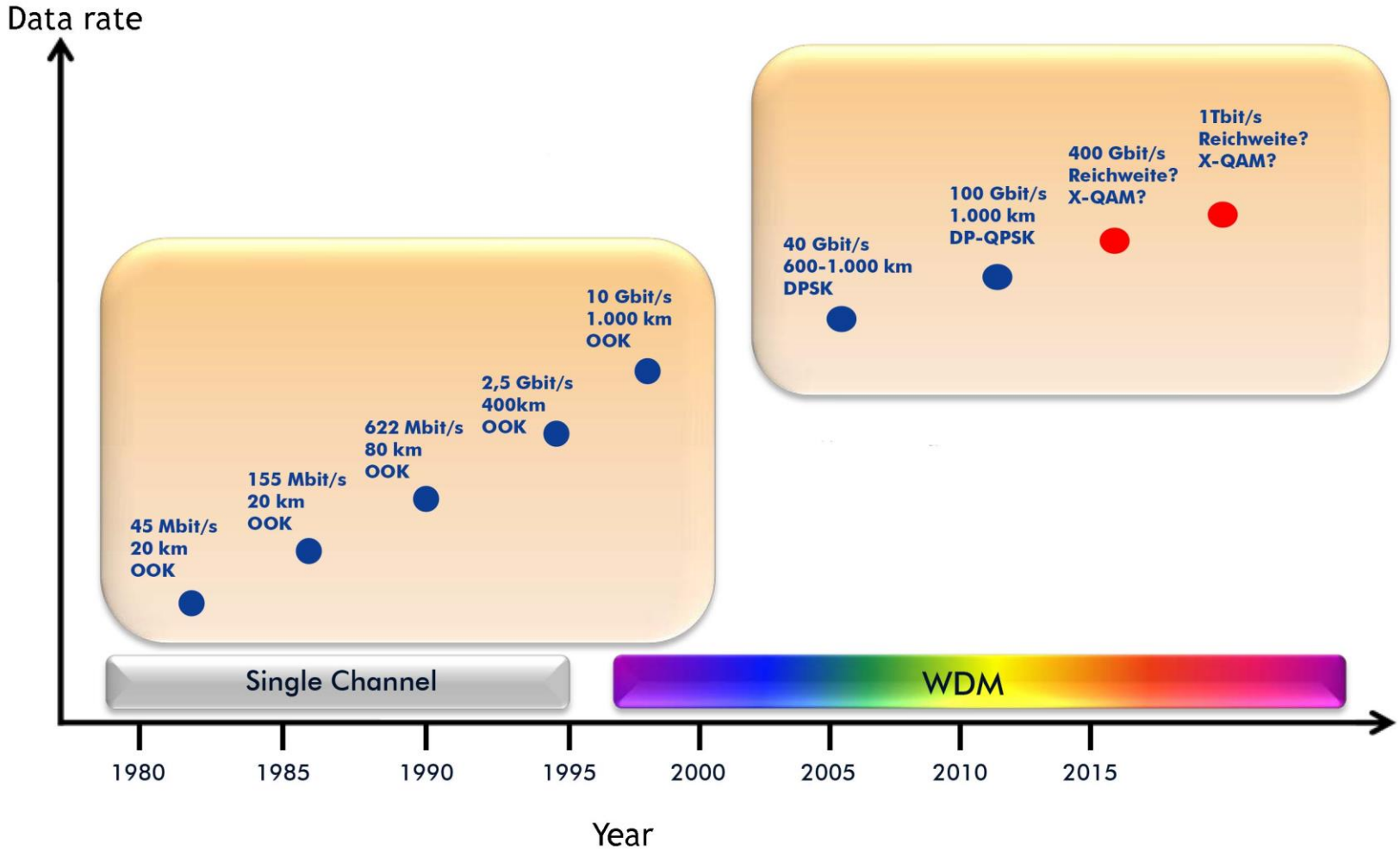
DWDM
ITU-T G.694.1
C-Band λ : 1530 – 1565 nm
max. 360 Kanäle (12,5 GHz grid)
L-Band λ : 1565 – 1625 nm
max. 560 Kanäle (12,5 GHz grid)

Optische Bänder	Wellenlängenbereiche
O (Original)-Band	1260 – 1360 nm
E (Extended)-Band	1360 – 1460 nm
S (Short)-Band	1460 – 1530 nm
C (Conventional)-Band	1530 – 1565 nm
L (Long)-Band	1565 – 1625 nm
U (Ultralong)-Band	1625 – 1675 nm

Maximale Anzahl der Kanäle (DWDM)

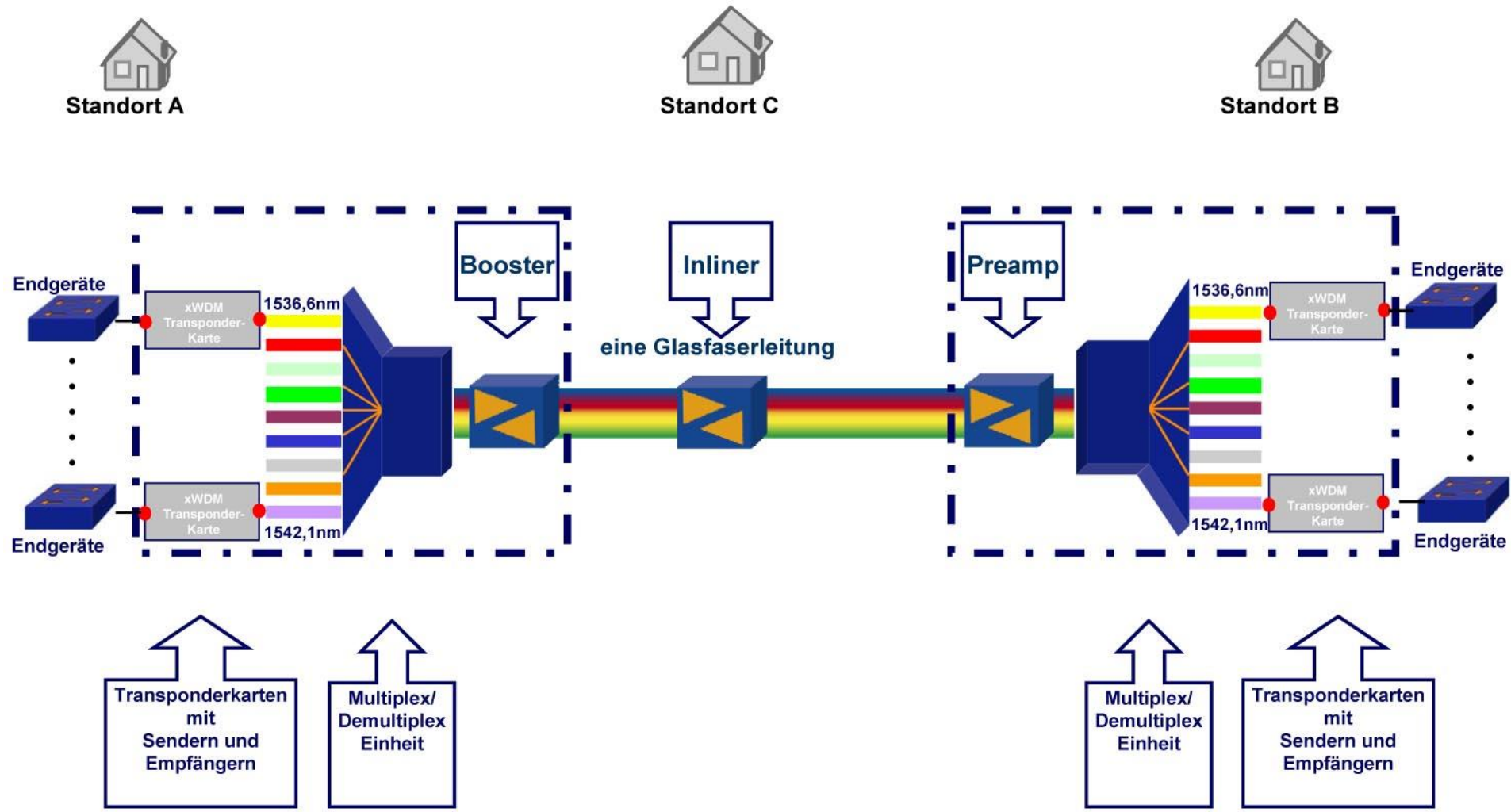
Kanalabstand [GHz]	200	100	50	25	12.5
Kanalabstand [nm]	1.6	0.8	0.4	0.2	0.1
C-Band	22	45	90	180	360
L-Band	35	70	140	280	560

Optical Multiplexer / DeMUX



Quelle: Fujitsu Network Communications. Inc.

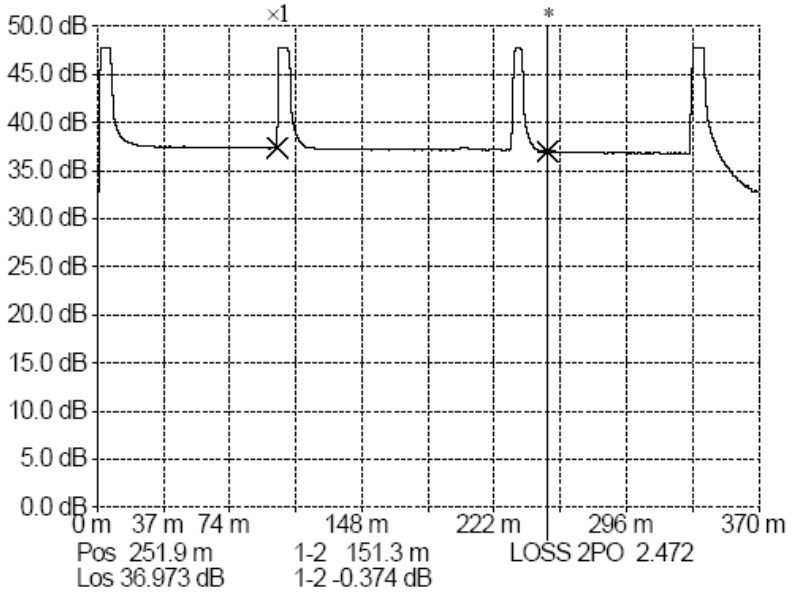
Long distace



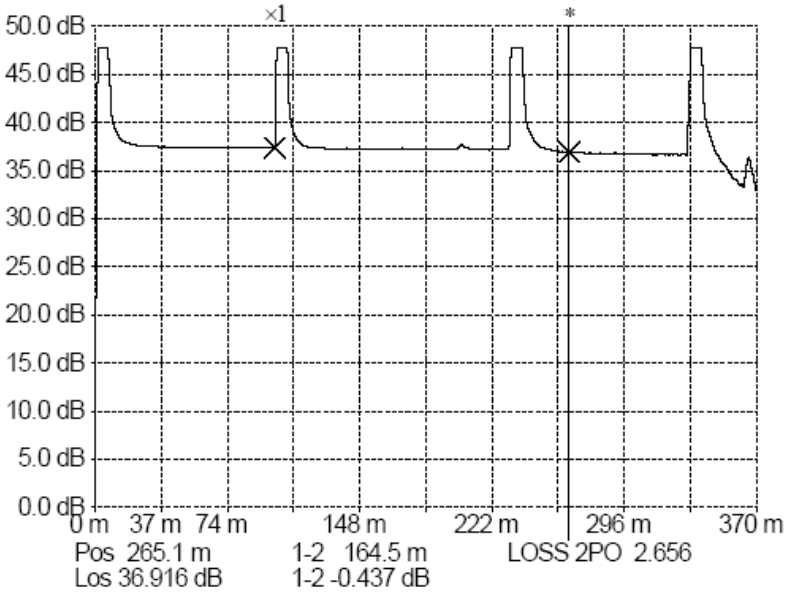
Typical Protocol

Logischer Name:	Fachhochschule Heidelberg
Datum:	09.08.2004
Uhrzeit:	15:10:00
Meßart:	Anfang-Ende
Meßstrecke:	Server zu Tower E5
Meßort:	Verteiler
Lage Meßort:	Serverraum
Lage Gegenstelle:	Verteiler Tower E5
Kabelnummer:	

Kabeltyp:	12G 50/125
Streckenlänge:	252 Meter
Faserlänge:	151 Meter
Vorlaufstrecke:	101 Meter
Brechungsindex:	1.477000
Planungsrichtwert:	
Meßgerät:	Anritsu MW9070A
Wellenlänge:	1300 nm
Einschub:	MW0975J



Fachhochschule Heidelberg : Faser1 Anfang-Ende



Fachhochschule Heidelberg : Faser2 Anfang-Ende

Protocl patch-cable

LWL - Prüfprotokoll

Messung nach IEC 874-1

Bezeichnung	Patchkabel	
Fasertyp	50/125	
Länge	1 m	
Kabelhersteller	Brugg	
Steckerhersteller	AMP	
	Ende A	Ende B
Steckertyp	SC	SC

Meßmethode 6

Einfügedämpfung Ende A1/B1 0,25 db

Einfügedämpfung Ende A2/B2 0,40 db

Meßmethode 7	A1 (db)	A2 (db)	B1 (db)	B2 (db)
Einfügedämpfung				
	A1 (db)	A2 (db)	B1 (db)	B2 (db)
Rückflußdämpfung				
	850 nm	1300 nm	1550 nm	
Wellenlänge	☒	○	○	

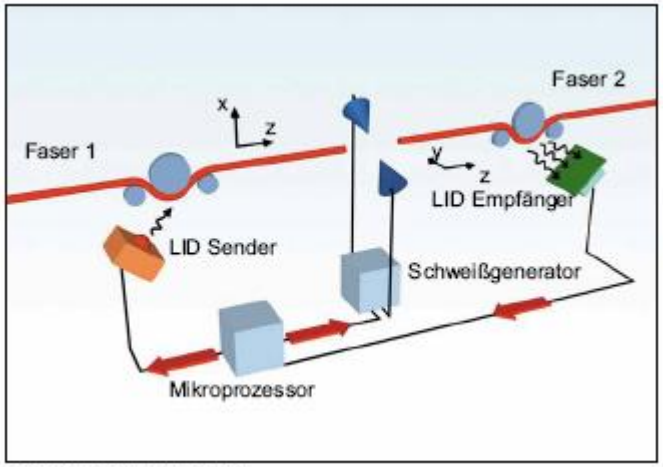
Bandbreiten-Längenprodukt Mhzxkm	850nm	1300nm
	>400	>600

Fertigungsnummer 62 221 101.1.

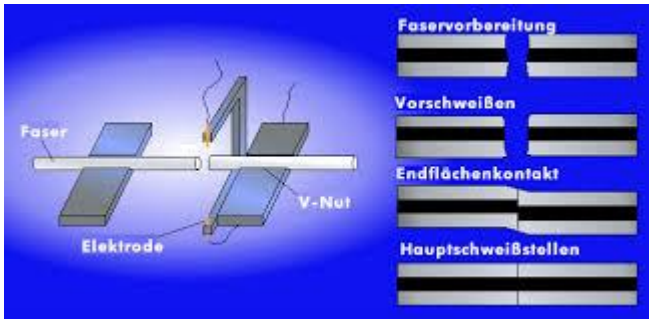
Prüfdatum 7. 2. 2001

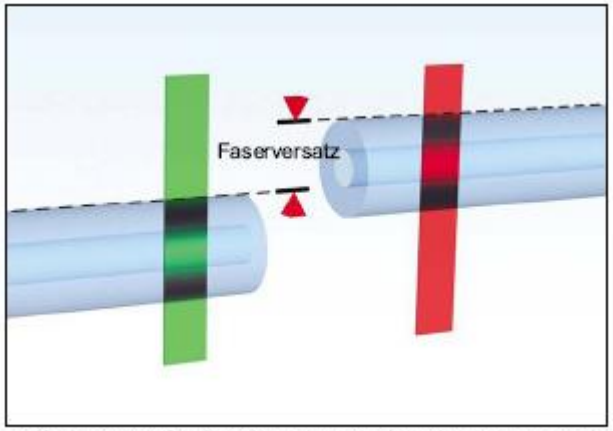
Unterschrift Ruch

Splice optical fibers

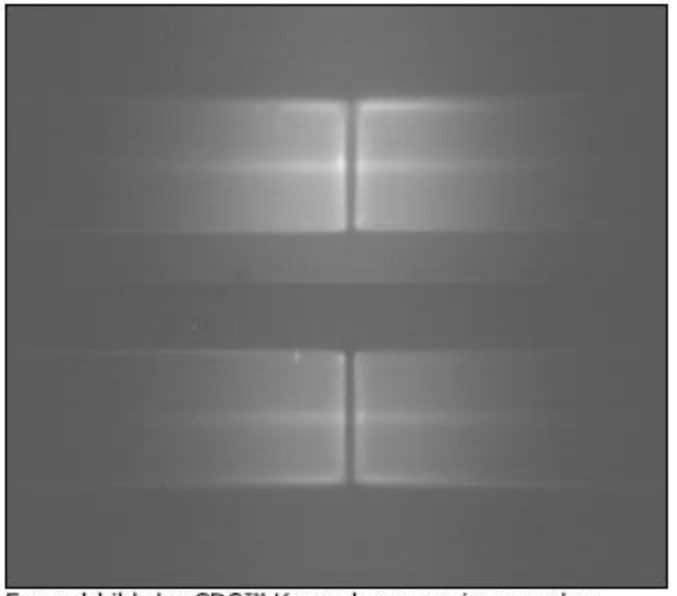


Prinzip LID-System™

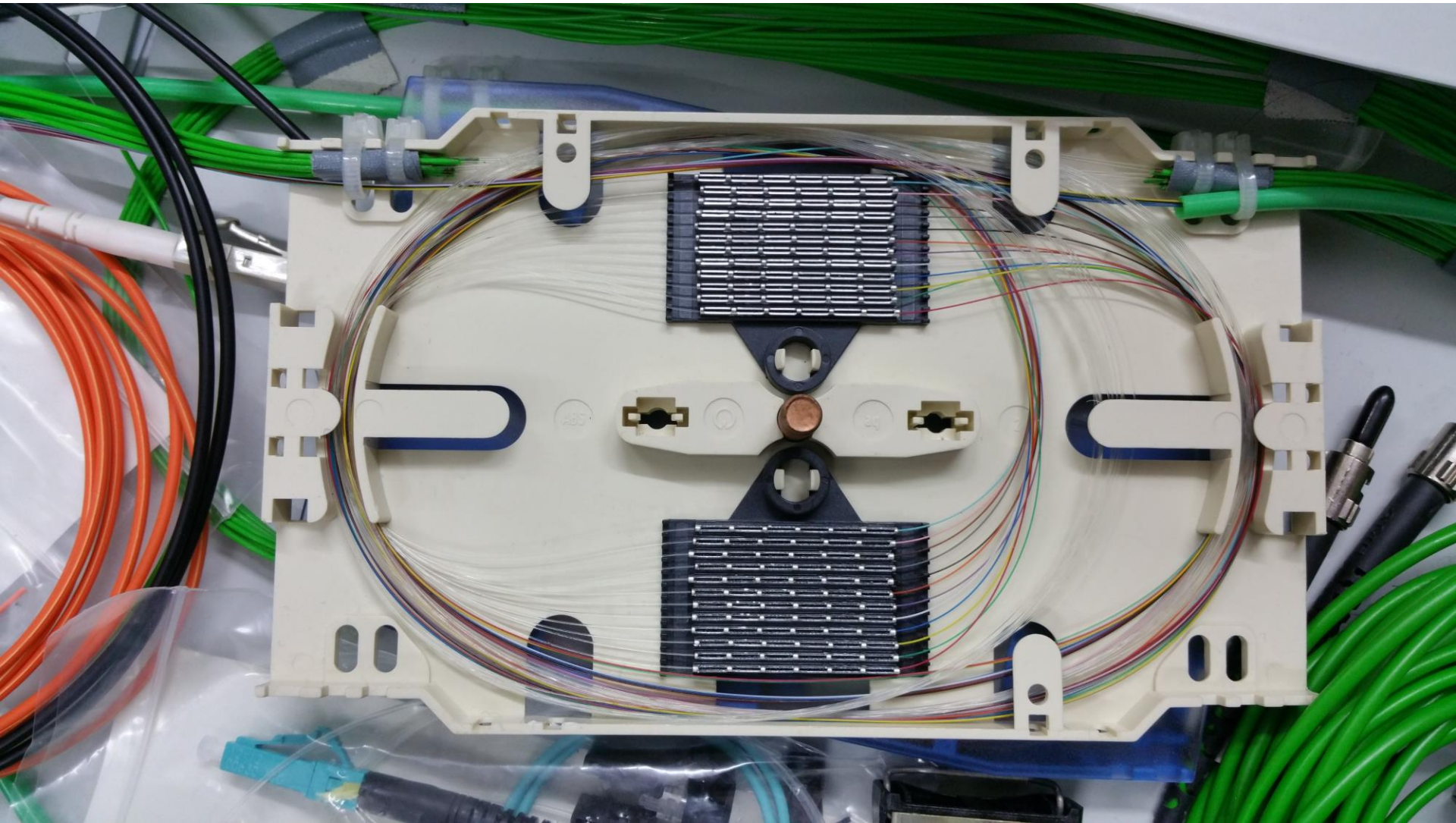




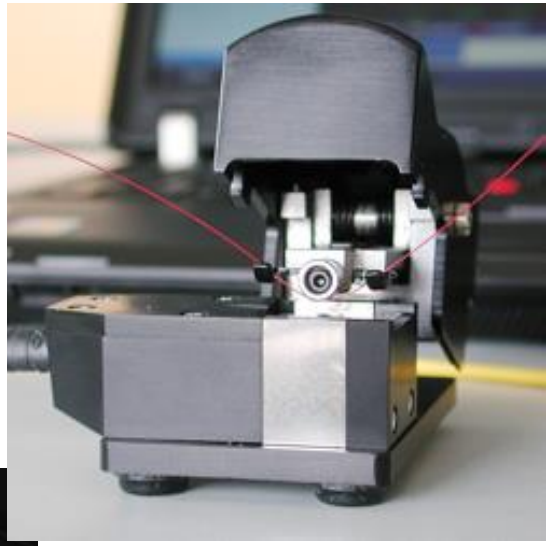
Helligkeitsprofile beider Faserenden in einer Ansicht

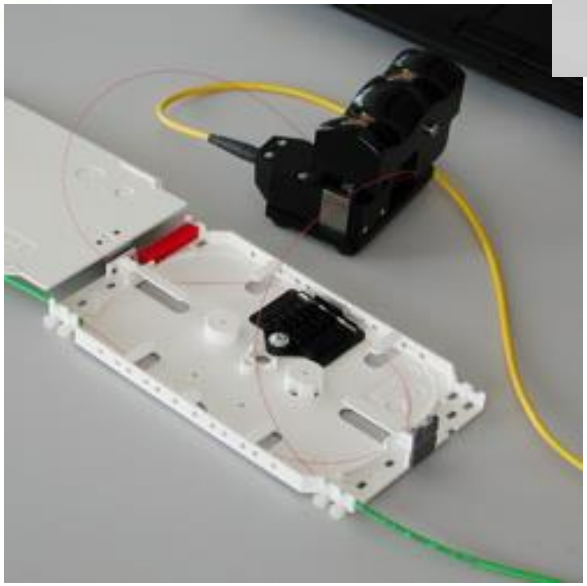

Faserabbild der CDS™ Kernerkennung in x- und y-Ansicht

Splice-box

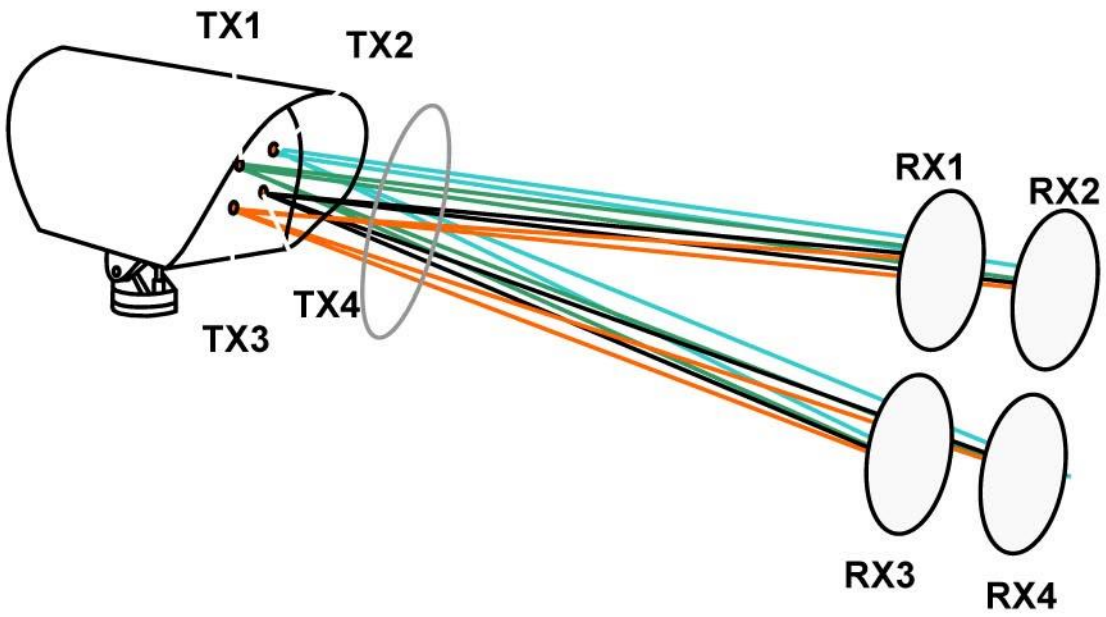


How „spy“ into a optical fibre?





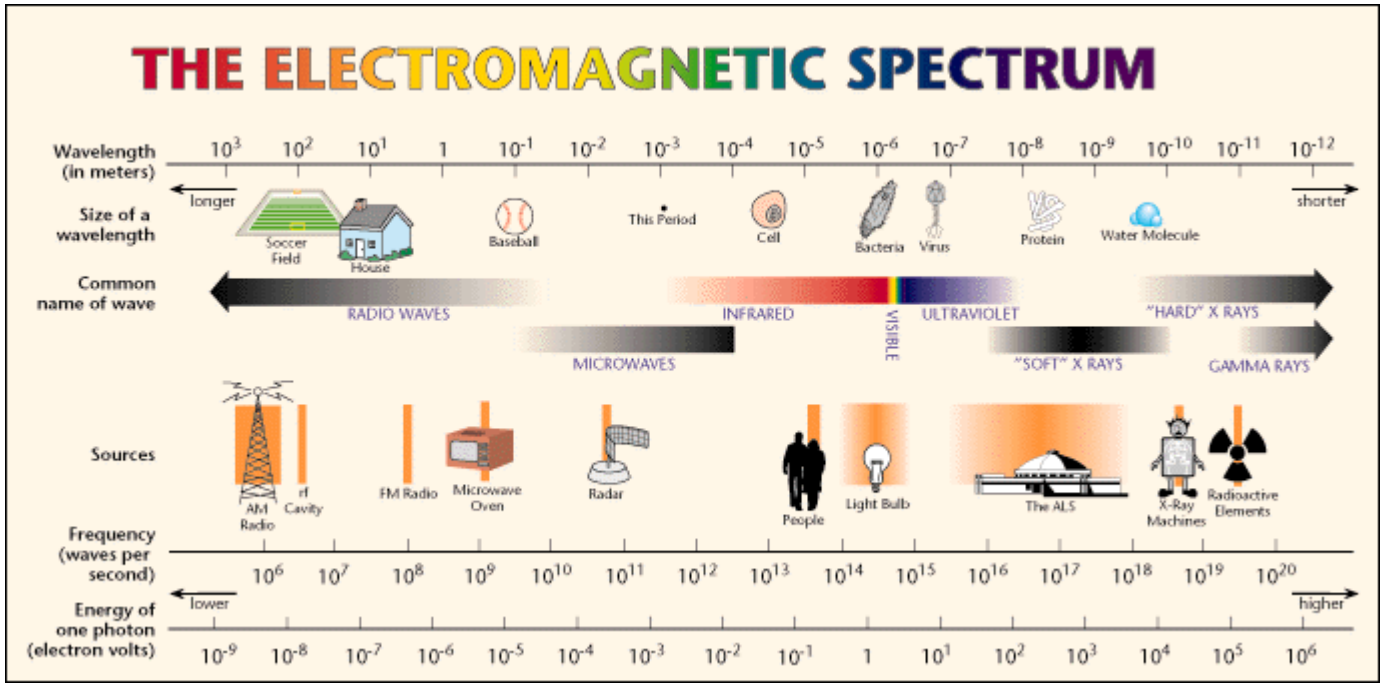
Laserlink – optical roof to roof



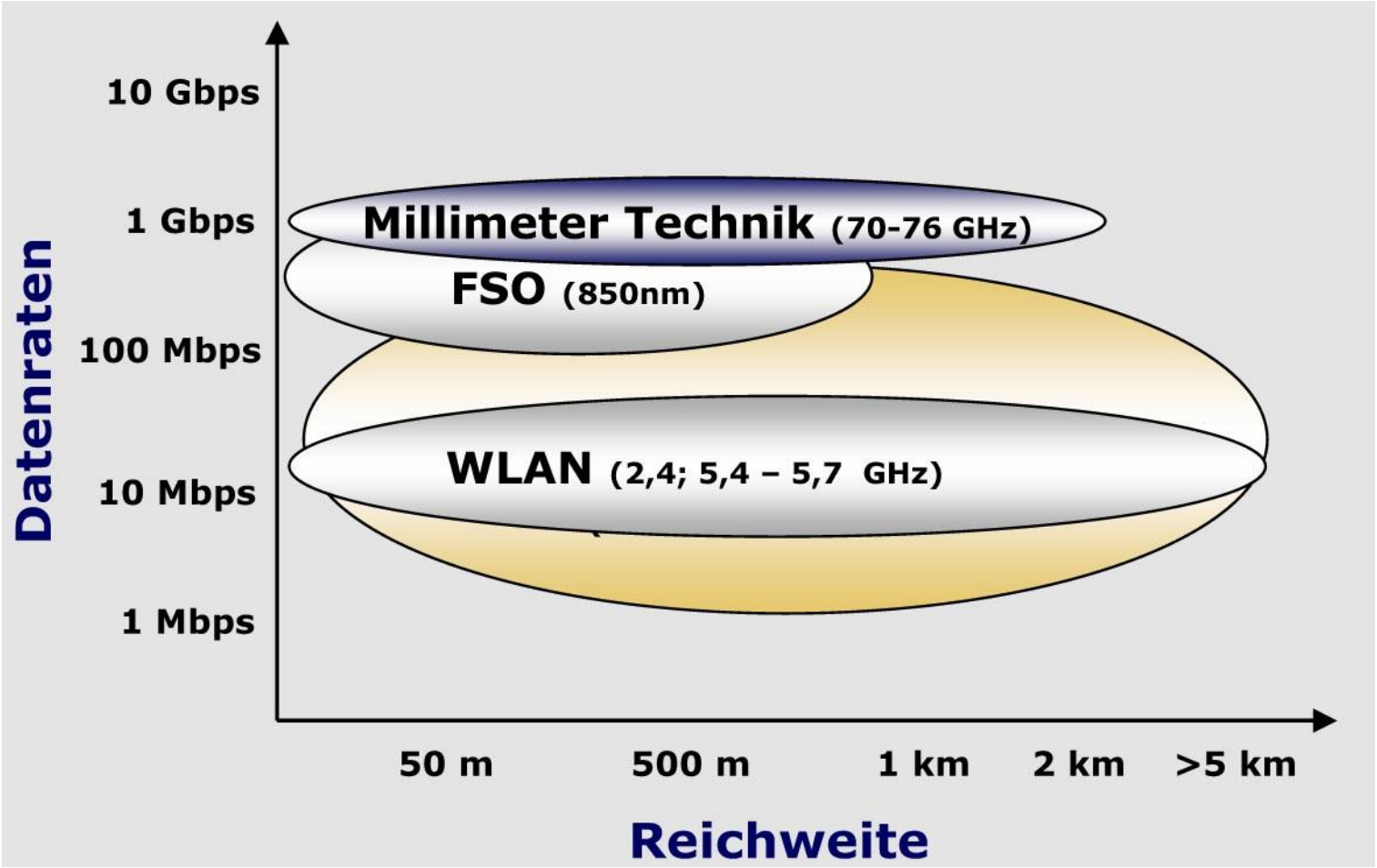
Highlights Mehrstrahlsysteme

- 16-fache Ausfallsicherheit (4 Tx und 4 Rx)
- Automatische Dämpfungskontrolle
- Autotracking für temperaturbedingte Verbiegung oder gebäudebedingte Schwankung
- Glasfaserschnittstelle
- SNMP-Management

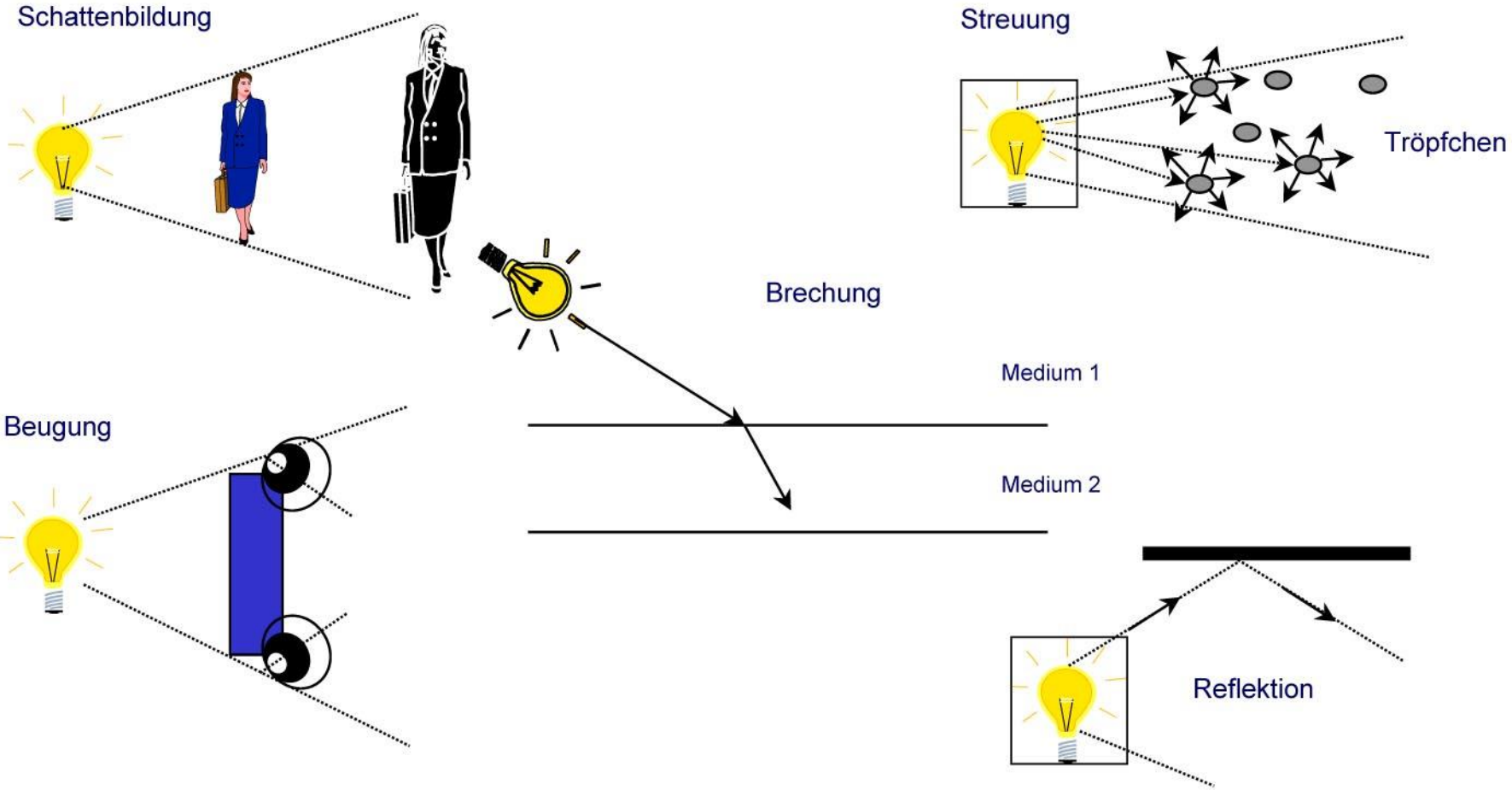
EM-Sprectrum



RF distances



Optical efects (quasi-optical)



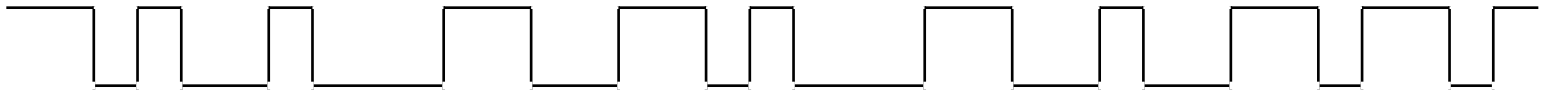
Data-rates

Interface	Maximum stations	Maximum length	Bandwidth bit/s
PCI	-	cm	1056M
AGP 1x … 8x	2	cm	2128M … 16G
FSB	2	cm	… T
SDRAM 133	-	cm	8,8G
RAMBUS	-	cm	up to 80G
IDE/UDMA	3	<1m	1064M
SCSI1…LVD360	(7+1) / (15+1)	Bis 3m	264M … 2880M
RS232	2	30m	115k
RS485	32	1200m	10M
USB 1.0, 1.1, 2.0	127	5 (*6 mit Hubs)	1,5M / 12M / 480M
IEEE1394 I,II	64	4,5m	400M / 800M
IRDA, FastIRDA	2	2m	115k / 4,5M
Bluetooth	8 +	1m/ 10m/ 100m	786k
Ethernet 10base2	30 *5	185m/ 925m	10M
Ethernet x baseT	30 *n	100m/500m/ -	10M 100M 1G 10G
Token-Ring	4096 *n	200m *n	4M / 16M / 100M
IEEE802.11x	-	up to 100m	11M / 22M / 54M
LWL Multimode	2	2-3 km	100M / 1G / 10G
LWL Singlemode	2 *n	up to 150 km	1GB … 1EB
Modem V.92	2	>1000 km	9,6k … 54k
ISDN BA	2	km	64000 *2 (+128)
ISDN S2M	2 / 30+1	km	2M / 64000*30
xDSL	2	200m – km	500k … 200M
Cable-Television	-	800m	(>10G)

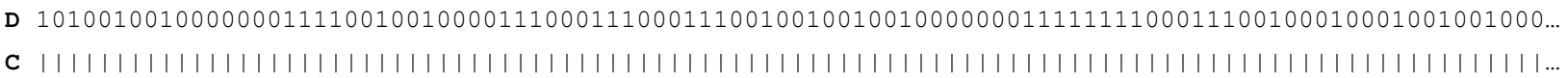
Clock

- Asynchronous without clock-signal transmittig
  - » z.B.: RS232, ISDN, … <10Mbit/s
  - less bits with Start/Stop-marker (8/N/1)

B10010001PSS B10001100PSS B1101…



- Synchronous with clock-signal transmitting
  - » z.B.: PCI, IDE, SCSI, Ethernet, … >10Mbit/s
  - many bits with parallelly synchro-signal



Transmission-codes

Also called: Line-codes

- NRZ / inv. NRZ
- Manchester / inv. Manchester
- Diff. Manchester / inv. Diff. Manchester
- …

Transmission-codes

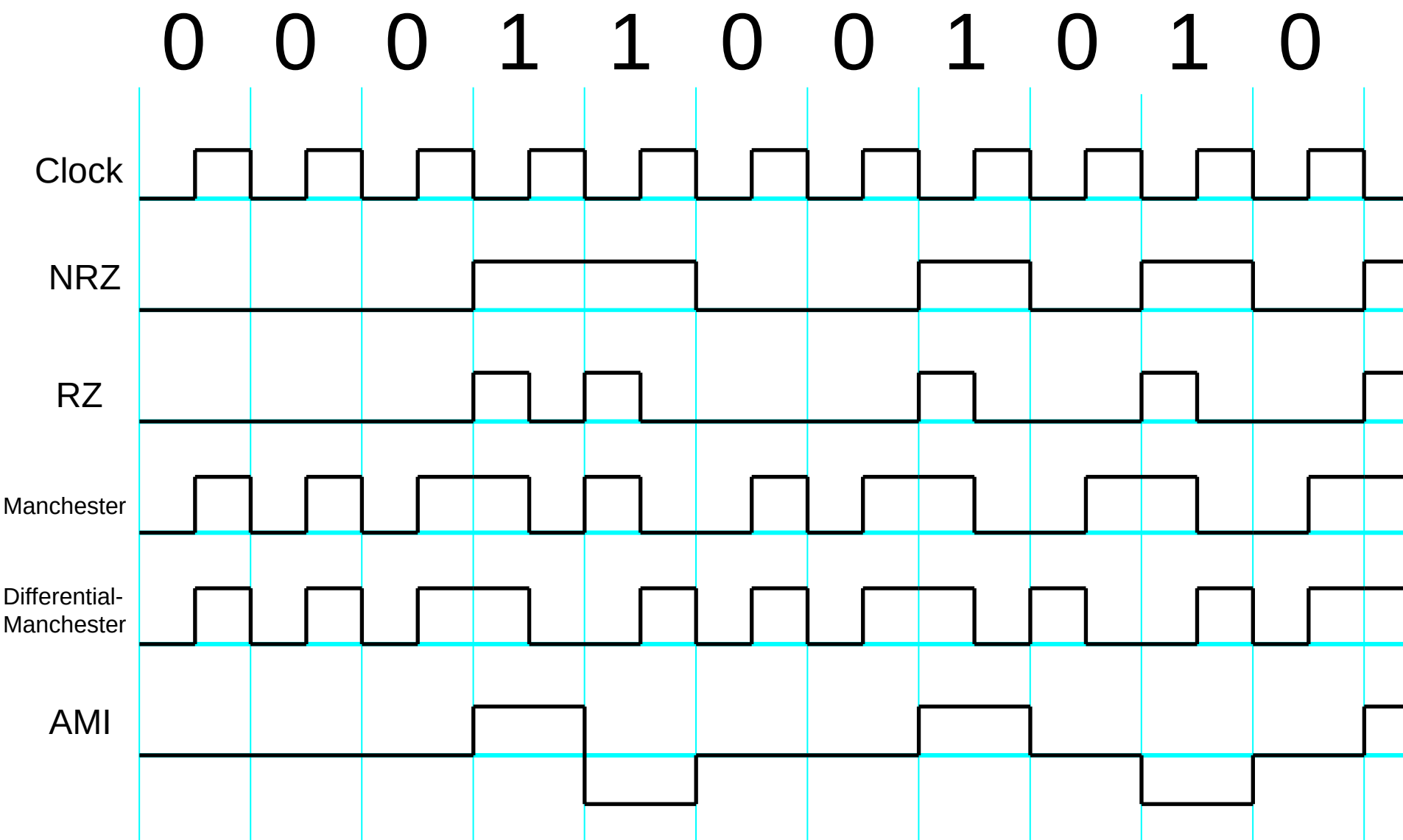
- NRZ / inv. NRZ
- Manchester / inv. Manchester
- Diff. Manchester / inv. Diff. Manchester
- AMI, Aiken, 4B5B, RZ, 2B1Q, 4B3T…

Add clock-signal

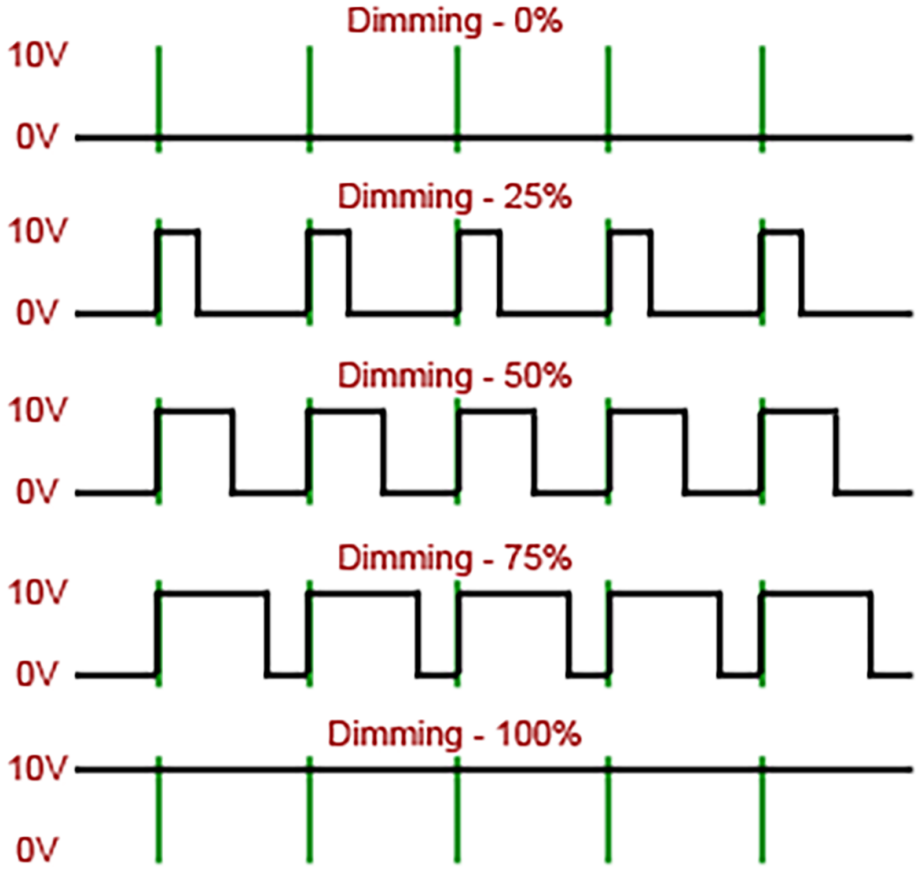
Reduce maximum frequency

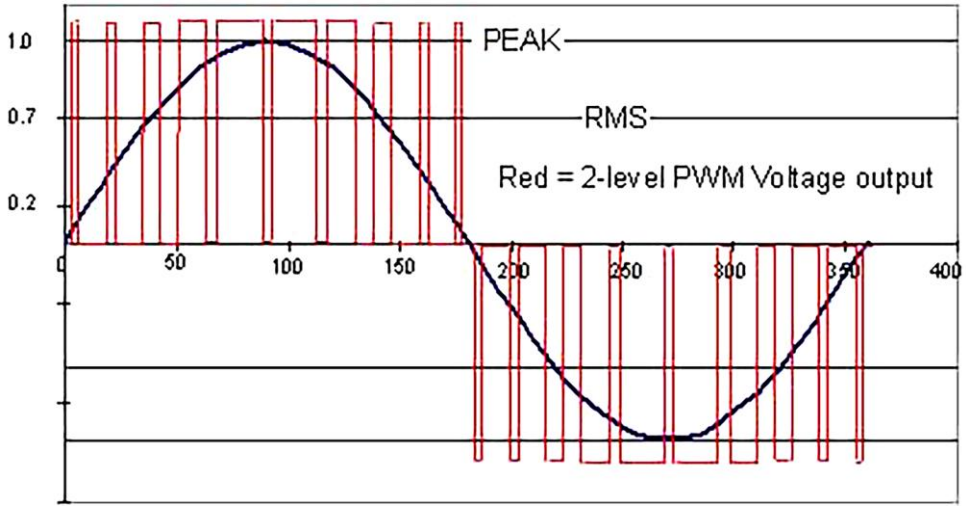
DC-Voltage-free (if needed)

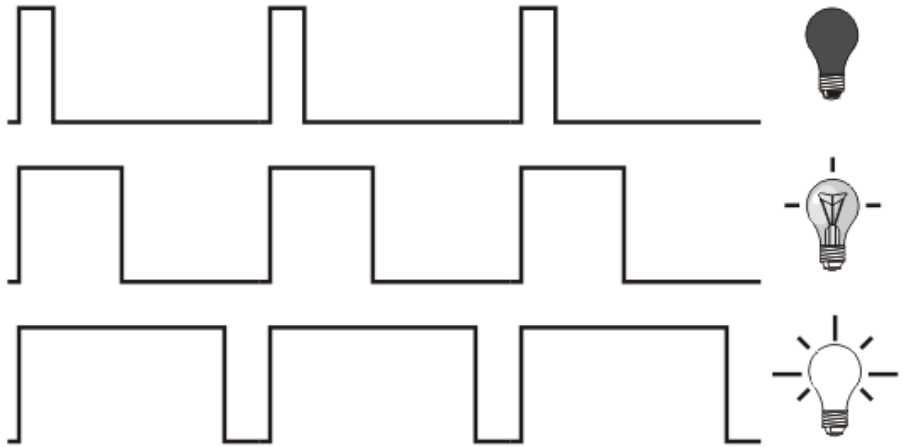
Transmission-codes



PWM







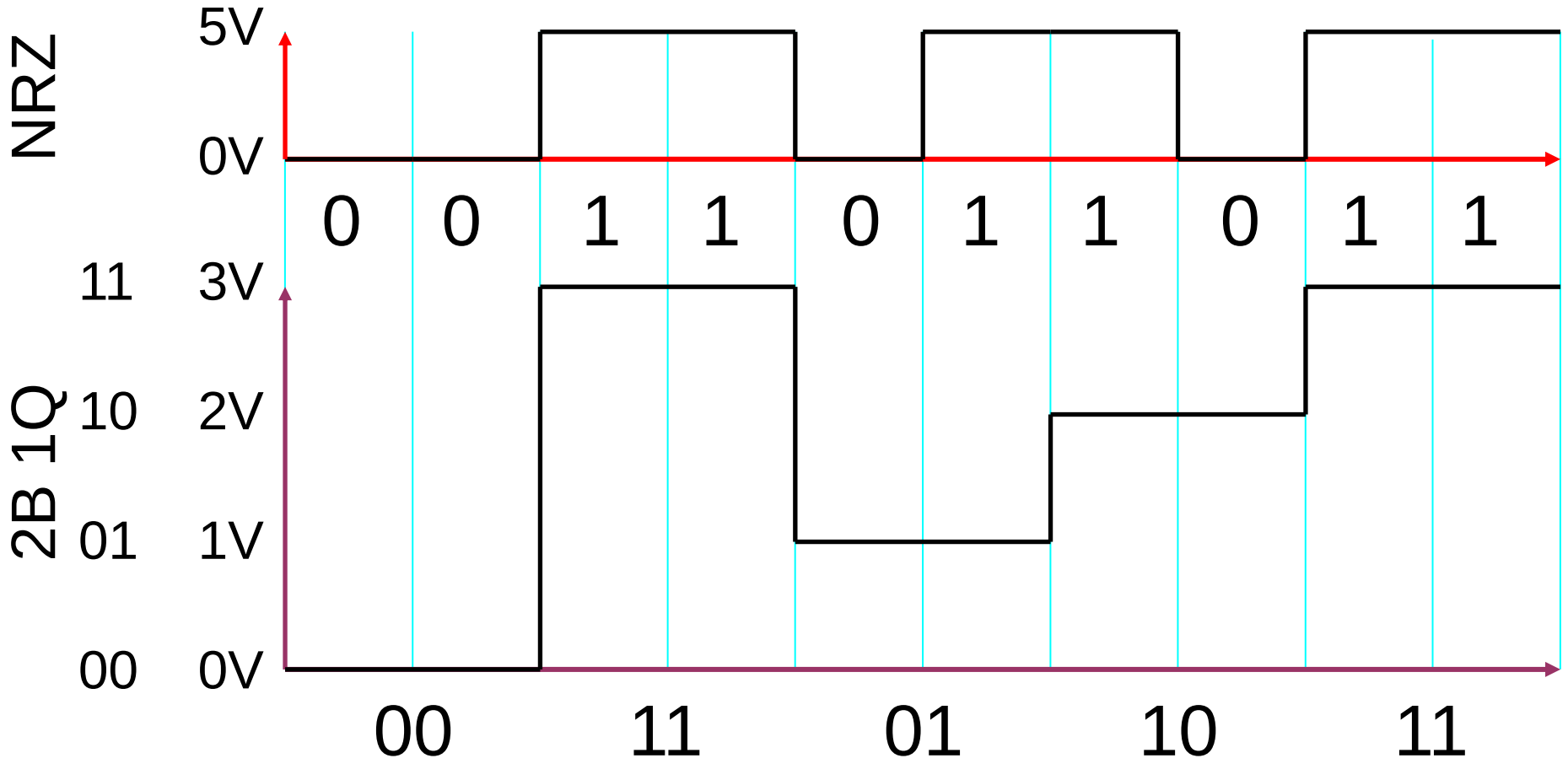
e.g. 25% = 64 / 256
50% = 128 / 256

Bit-rate / BAUD-rate

- BAUD ➔ transmissions (symbols) per second
- Or symbols per second → Symbol-rate
- How many bits are transmitted per transmission?
- Bit/second = digital bandwidth

- Binary codes → Bit-rate = Baud-rate → 1 bit/BAUD
- 3-state codes / pseudo 3-state codes → 1 bit/BAUD
- 4-state codes (2B 1Q) $2^2=4$ → 2 bits/BAUD
- DQAM 16 $2^4=16$ → 4 bits/BAUD
- DQAM 256 $2^8=256$ → 8 bits/BAUD
- DQAM 4096 $2^{12}=4096$ → 12 bits/BAUD
- …

2B1Q



4B/5B-Coding

e.g. 100 Mbit/s Ethernet

Daten Kodierung

Symbol	Binärcode <3:0>	PCS 4B/5B Code [4:0]
0	0000	11110
1	0001	01001
2	0010	10100
3	0011	10101
4	0100	01010
5	0101	01011
6	0110	01110
7	0111	01111
8	1000	10010
9	1001	10011
10	1010	10110
11	1011	10111
12	1100	11010
13	1101	11011
14	1110	11100
15	1111	11101

```
Decimal   0    0    0    0    7    0    2    4
Binary    0000.0000.0000.0000. 0111.0000. 0010.0100.
4B/5B     1111011110111101111 0111111110 1010001010
                                8x"1"      3x"0"
```

how many same bits without change (worst case)

Kontrol Kodierung

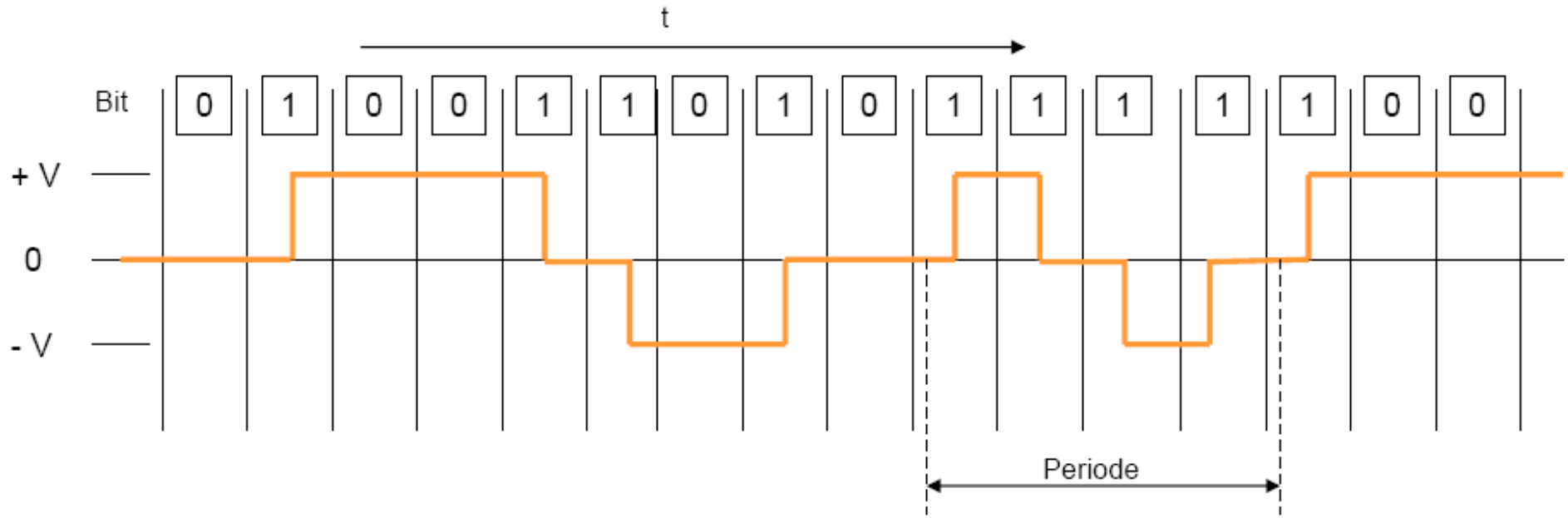
Symbol	4B/5B Code	Bedeutung
I	11111	Idle
J	11000	Start of Stream Part 1
K	10001	Start of Stream Part 2
T	01101	End of Stream Part 1
R	00111	End of Stream Part 2
H	00100	Empfangsfehler

All others 10 possibilities are false

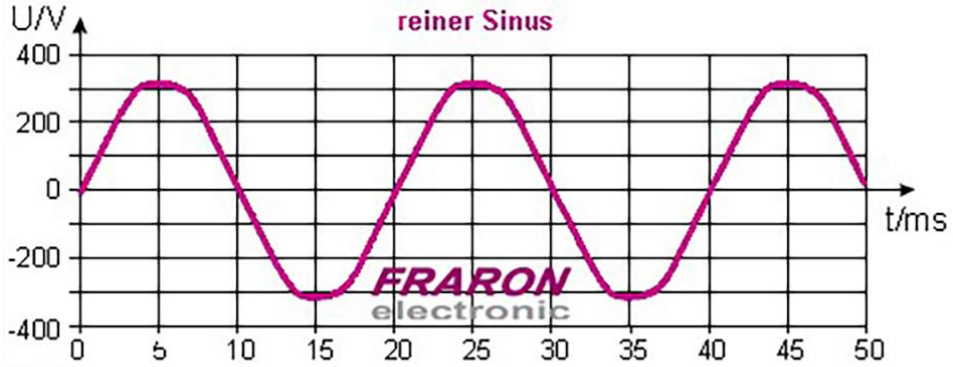
Transmission-codes

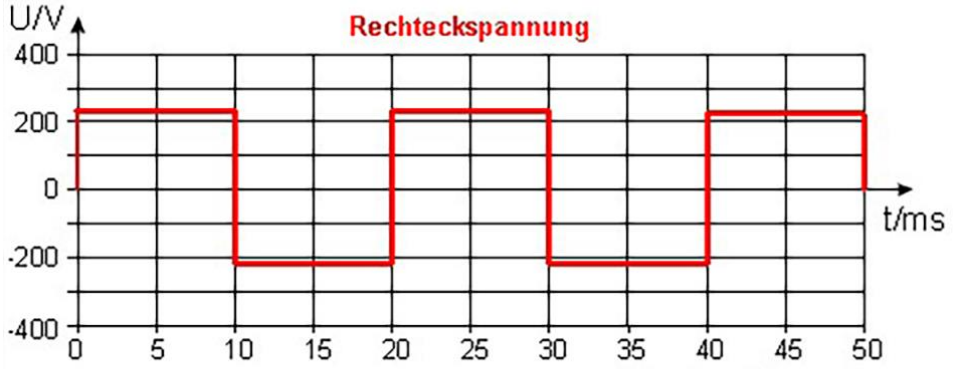
MLT3 – Coding (Multi Level Transmission)

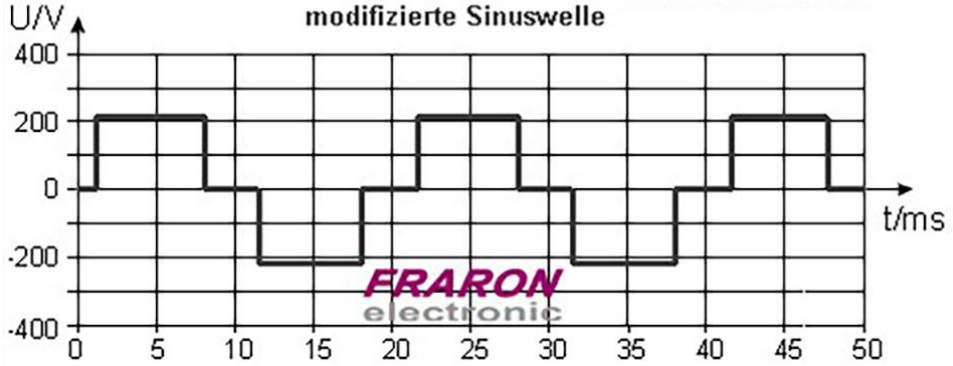
- **Coding with but not by 3 different voltages +V, 0, -V**
- **Bits with state 1: Voltage is changing.**
- **Bits with state 0: Voltage is constant.**
- **One period is at least 4 Bits wide.**

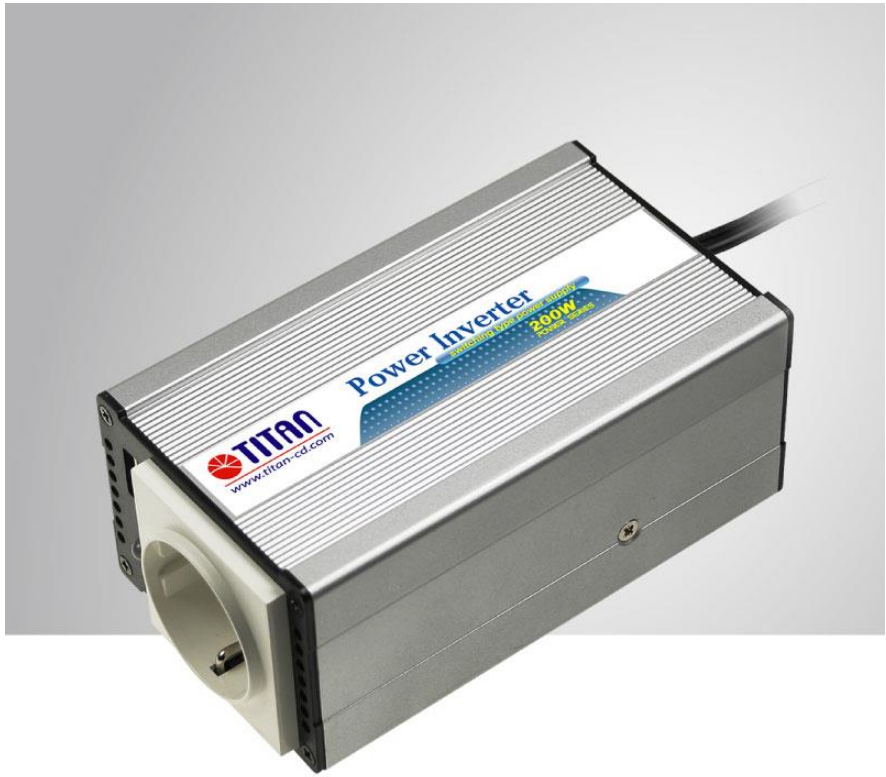


AC-converter / UPS





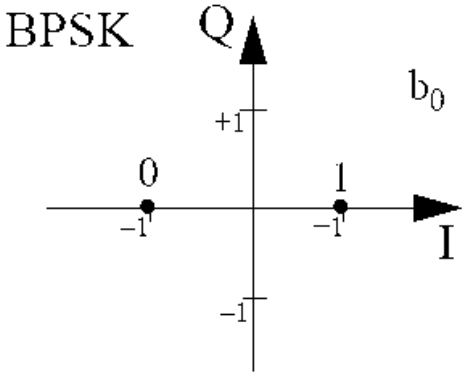


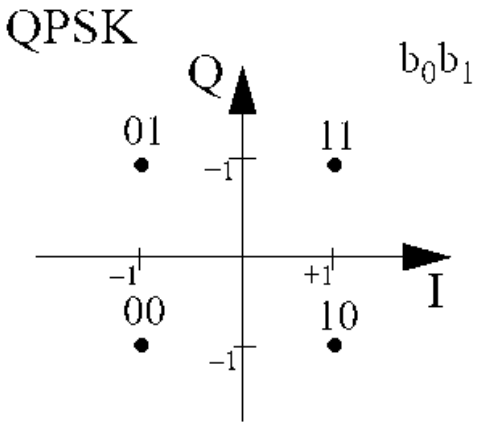


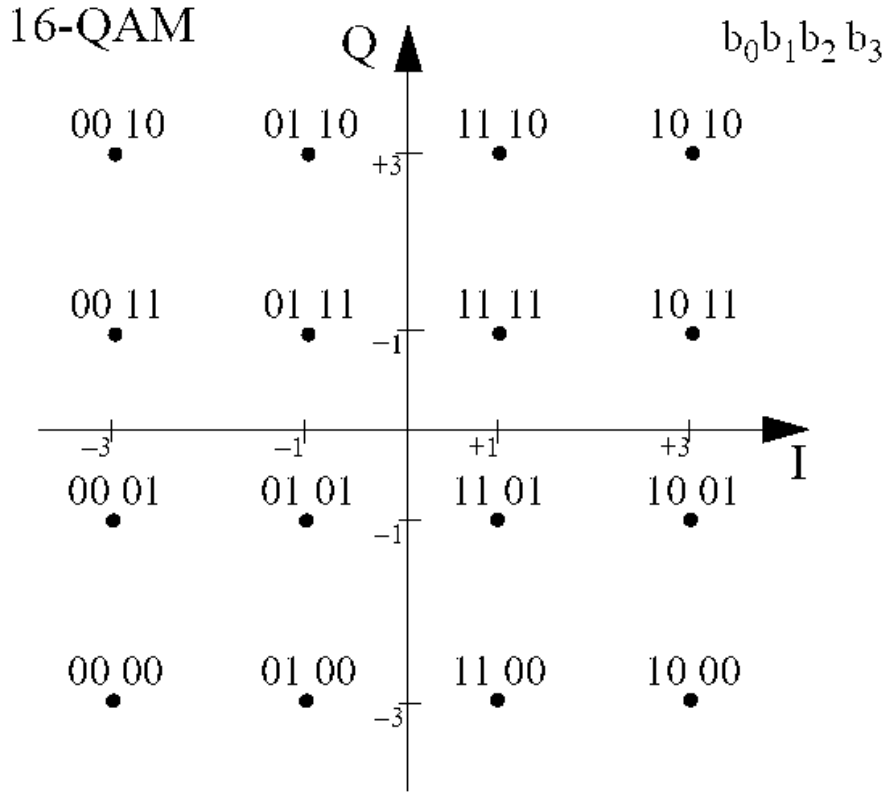
Modulations

- Baseband / no Carrier → Coding only
- Amplitude-modulation AM
- Frequency-modulation FM
- Phase-shift-modulation PM
- Single-side-band-modulation SSB
- Binary-phase-shift-keying BPSK
- Quadratary-phase-shift-keying QPSK
- Quadratur-amplitude-modulation (D-)QAM
- Spread spectrum, DSSS, UWB …

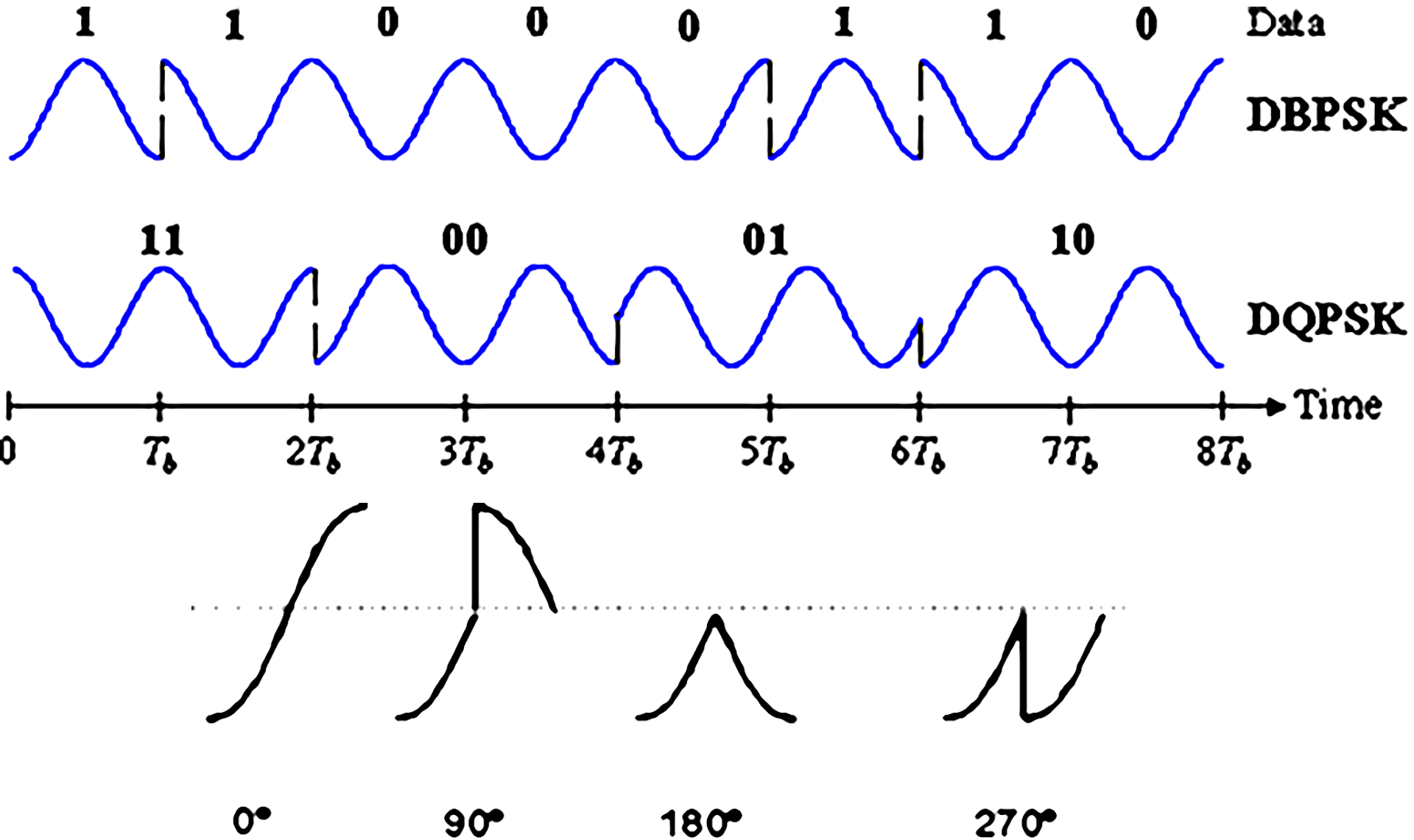
D-QAM-16


BPSK
Q
b_0
+1
0
1
−1
−1
−1
I

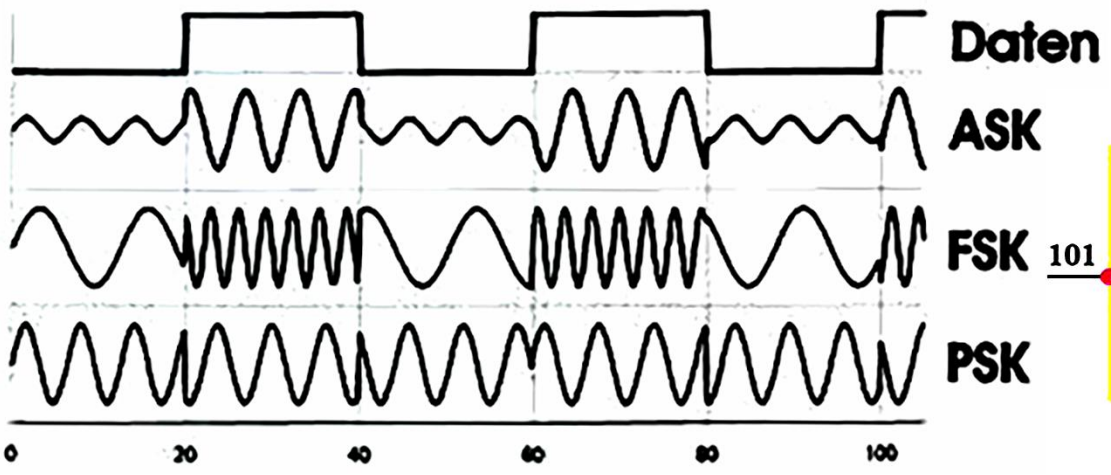

QPSK
Q
b_0b_1
01
11
−1
−1
+1
I
00
10
−1

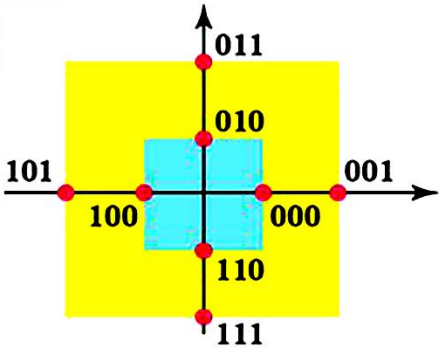

16-QAM
Q
$b_0b_1b_2b_3$
00 10
01 10
11 10
10 10
+3
00 11
01 11
11 11
10 11
−1
−3
−1
+1
+3
I
00 01
01 01
11 01
10 01
−1
00 00
01 00
11 00
10 00
−3

PSK in real

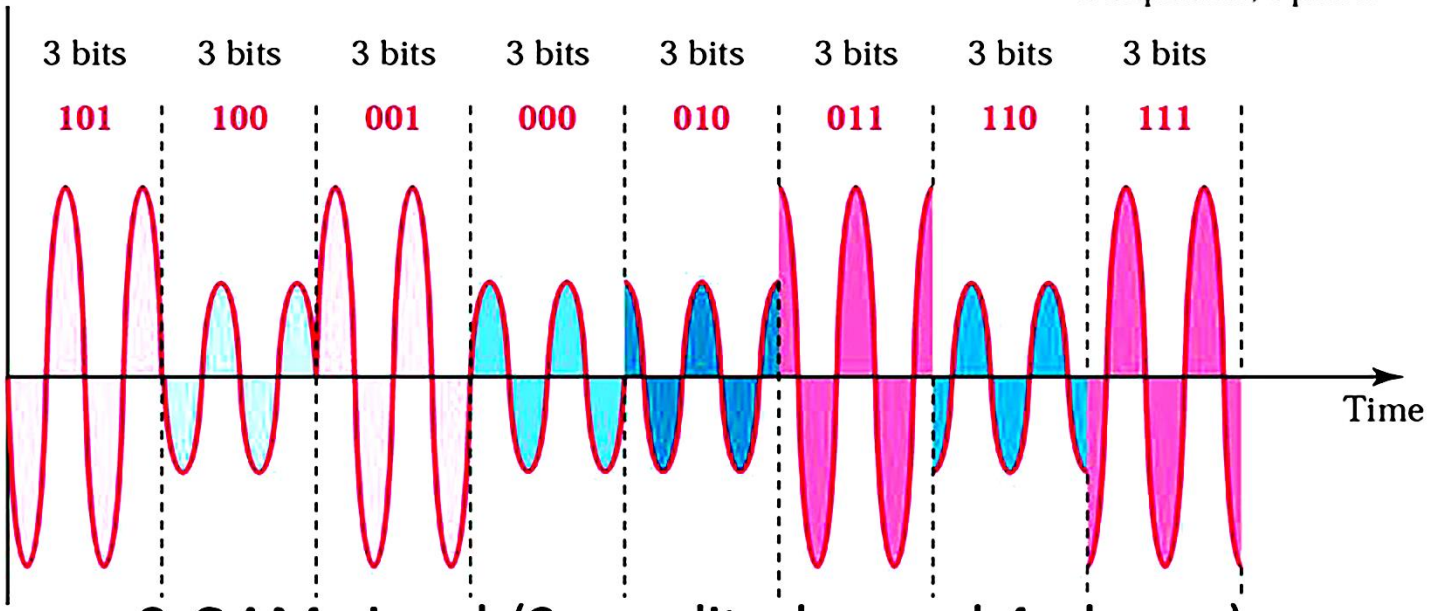

1 1 0 0 0 1 1 0
Data
DBPSK
11 00 01 10
DQPSK
Time
0
T_b
$2T_b$
$3T_b$
$4T_b$
$5T_b$
$6T_b$
$7T_b$
$8T_b$
0°
90°
180°
270°

PSK + ASK



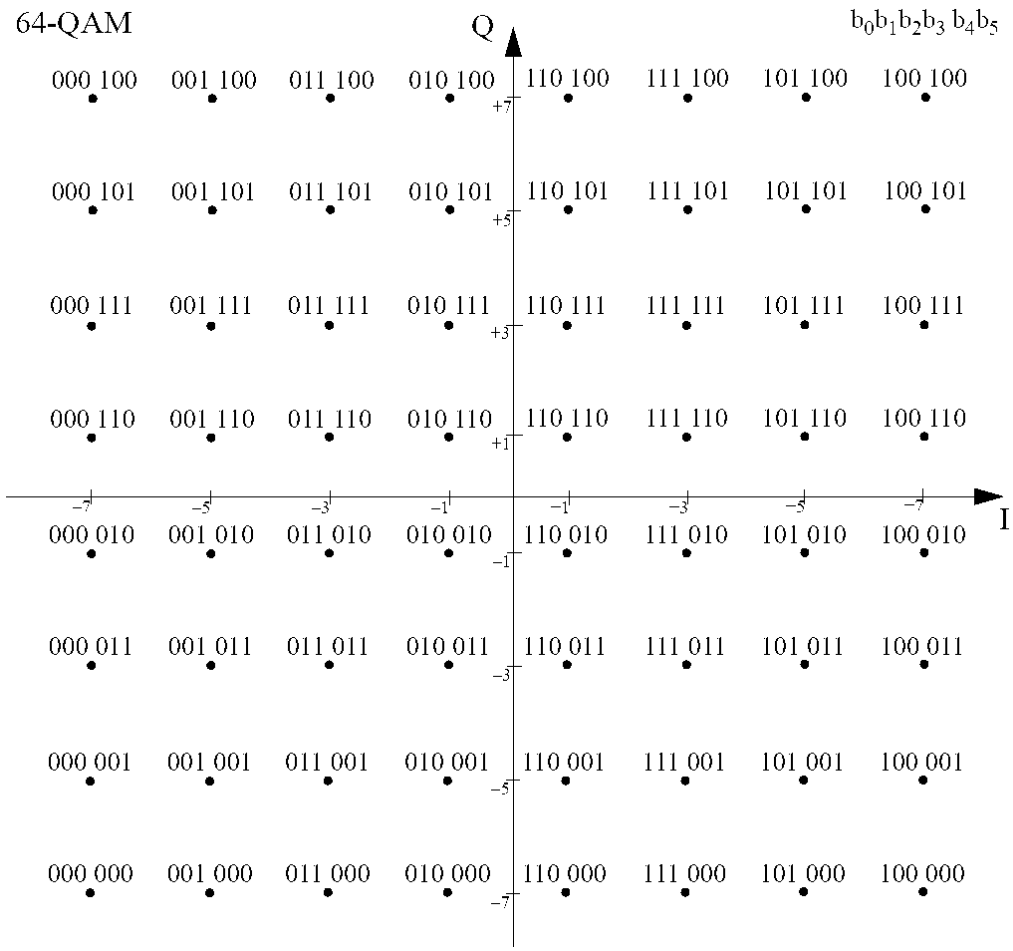


8-QAM
2 amplitudes, 4 phases

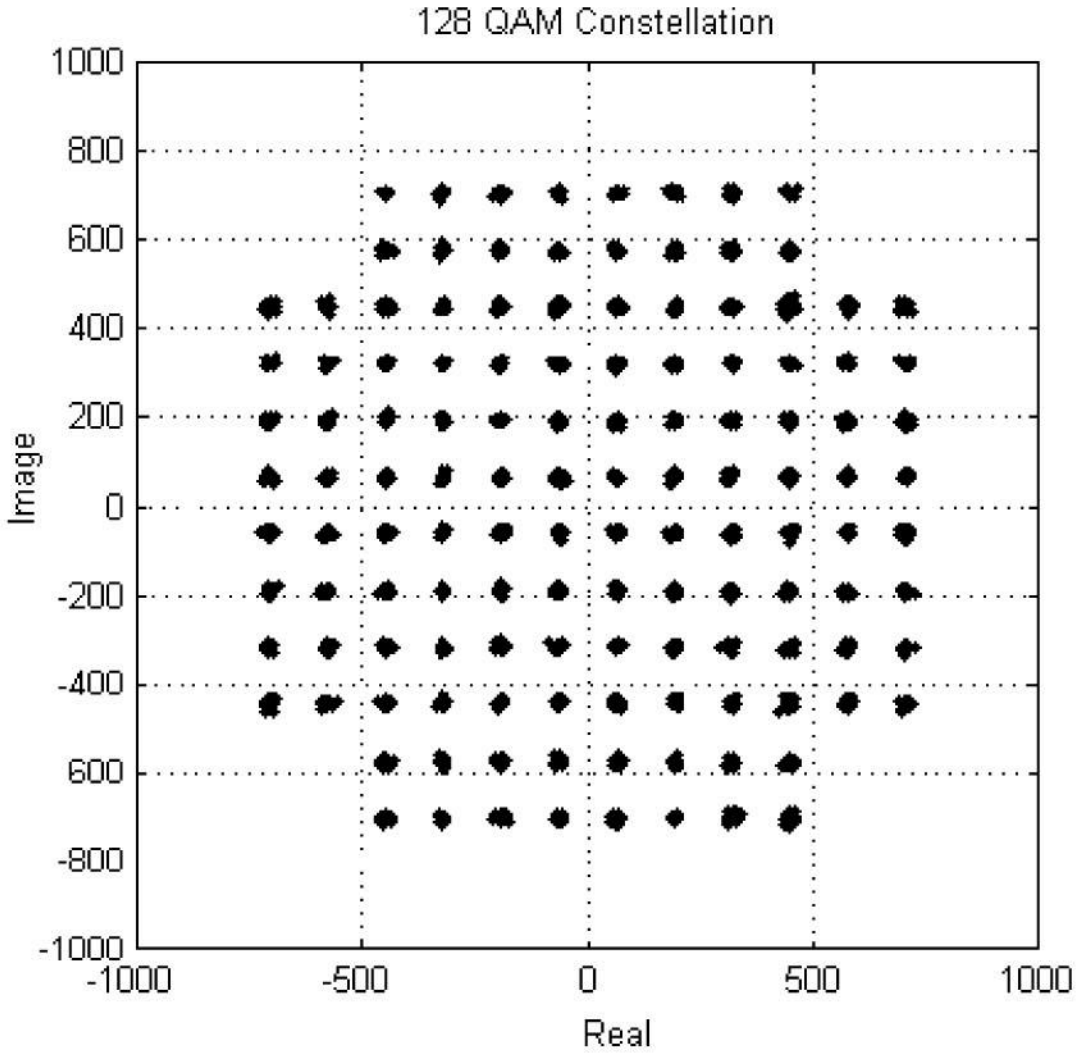


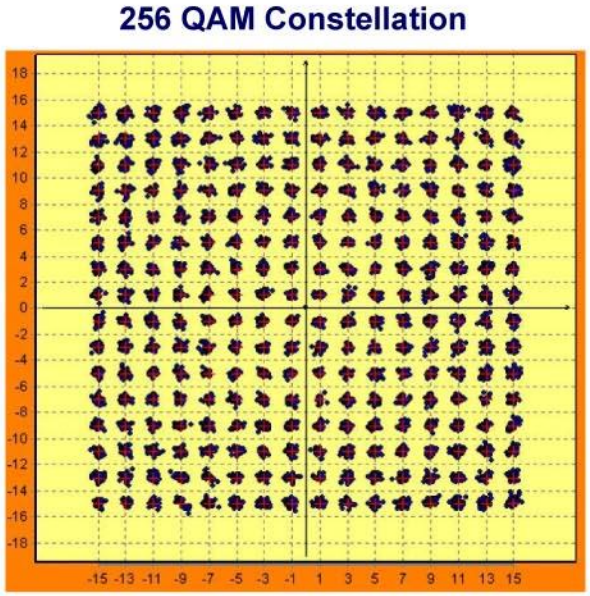
8-QAM signal (2 amplitudes and 4 phases)

D-QAM-64

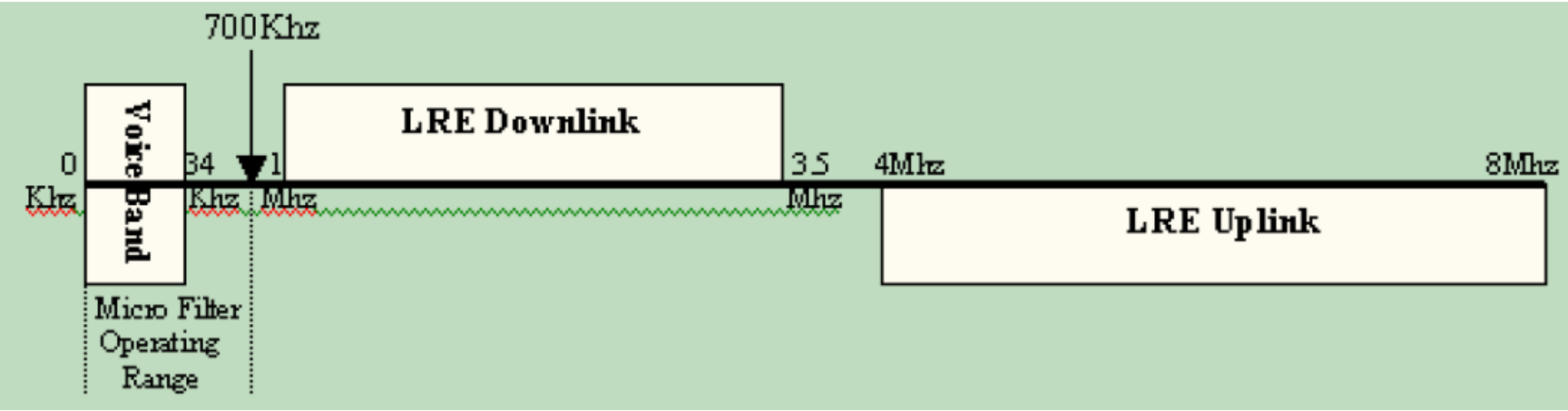

64-QAM
Q
$b_0b_1b_2b_3\ b_4b_5$
I
000 100 001 100 011 100 010 100 110 100 111 100 101 100 100 100
000 101 001 101 011 101 010 101 110 101 111 101 101 101 100 101
000 111 001 111 011 111 010 111 110 111 111 111 101 111 100 111
000 110 001 110 011 110 010 110 110 110 111 110 101 110 100 110
000 010 001 010 011 010 010 010 110 010 111 010 101 010 100 010
000 011 001 011 011 011 010 011 110 011 111 011 101 011 100 011
000 001 001 001 011 001 010 001 110 001 111 001 101 001 100 001
000 000 001 000 011 000 010 000 110 000 111 000 101 000 100 000
+7
+5
+3
+1
−1
−3
−5
−7
−7
−5
−3
−1
−1
−3
−5
−7

D-QAM 128 / 256 in real

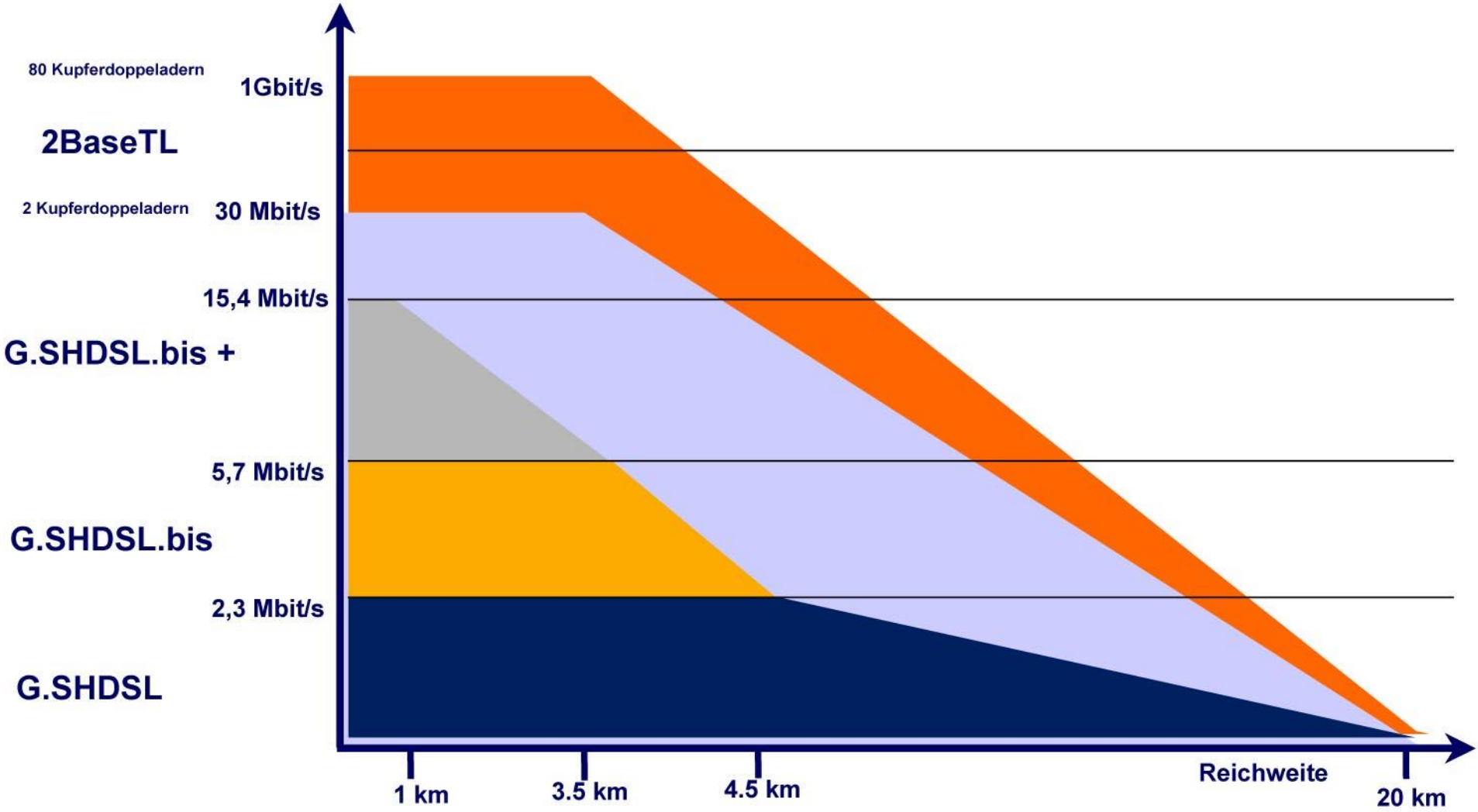




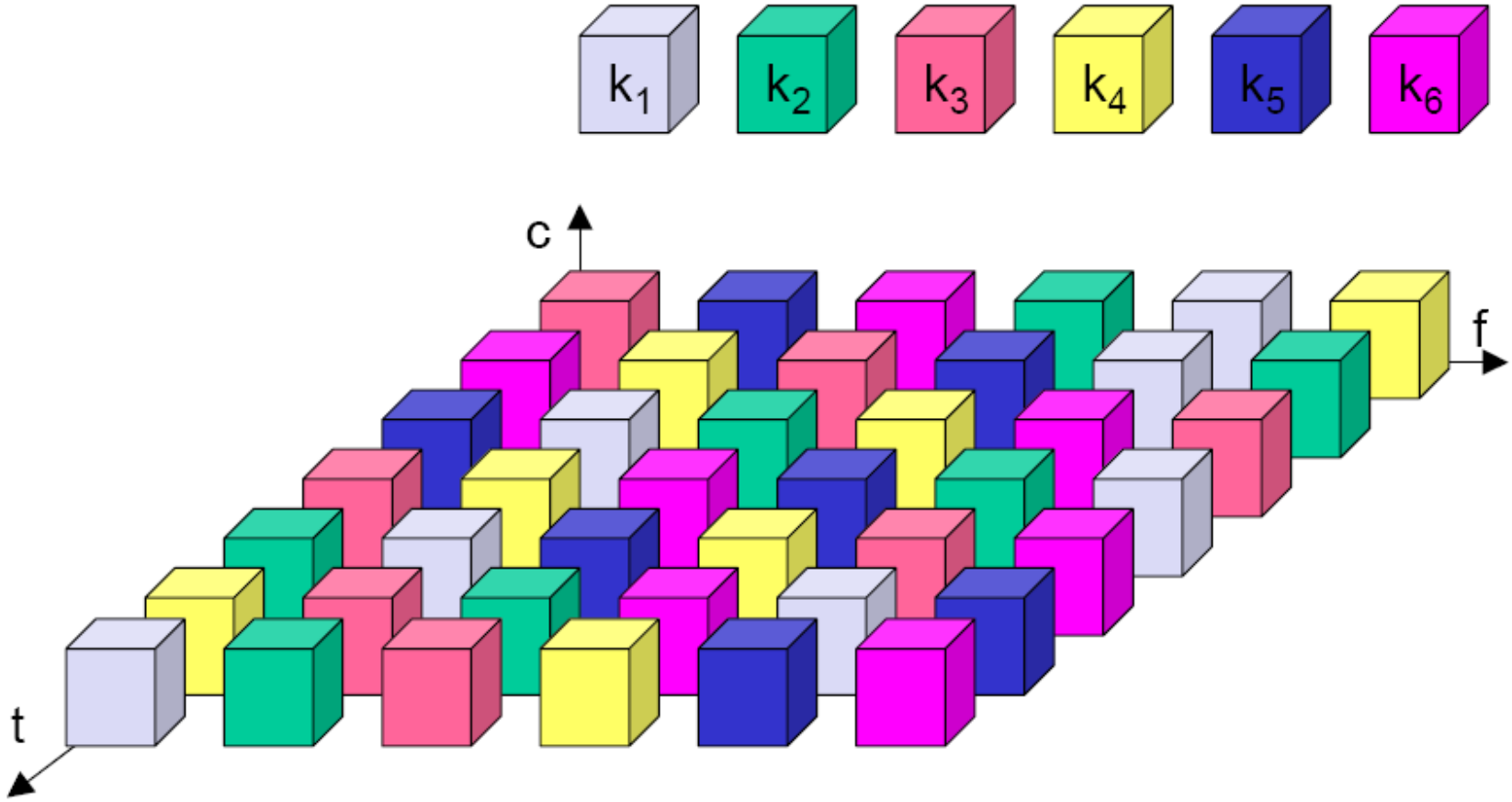
SDSL


700Khz
Voice Band
LRE Downlink
0
Khz
34
Khz
1
Mhz
3.5
Mhz
4Mhz
8Mhz
LRE Uplink
Micro Filter
Operating
Range

DSL Bandwidth / Length



Time and frequency-MUX (GSM)



Two-way-transmissions

- Simplex — one by one — 1 Way

– E.g.: CB/Ham-Radio, Railway with one rail only.

» 10base2, 10base5, WIFI!!! (all cell-based)

- Half-duplex — one by one — 2 Ways

– E.g.: Radio with separated Transmitter and receiver, but one antenna only (also known as)

» 10/100BaseT with Hub (semi-Duplex)

- Full-duplex — parallel speaking — 2 Ways

– E.g.: Telephone, Railway with two rails

» 10/100/1000baseT with Crossover or Switch

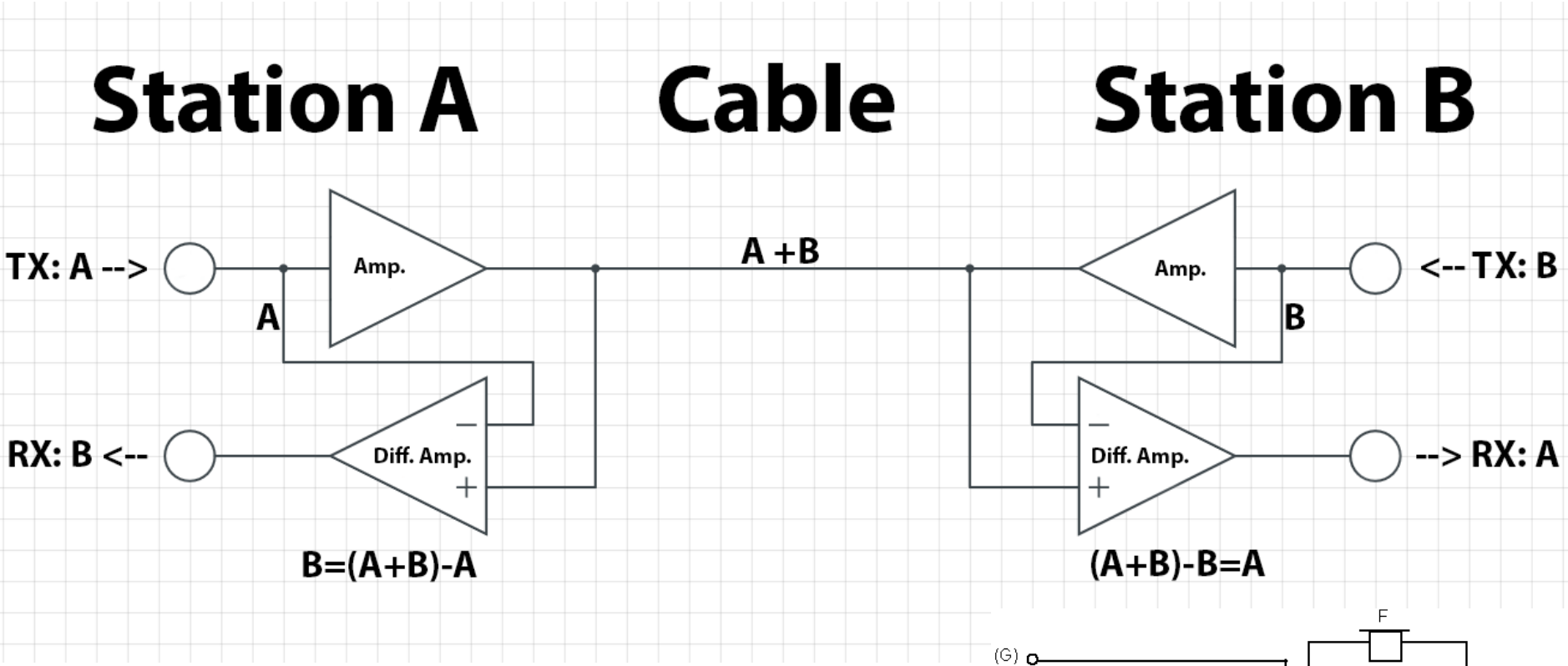
10/100/1000baseFx, optical fibre, ring-system

- Cast — one way only!!! — 1 Way

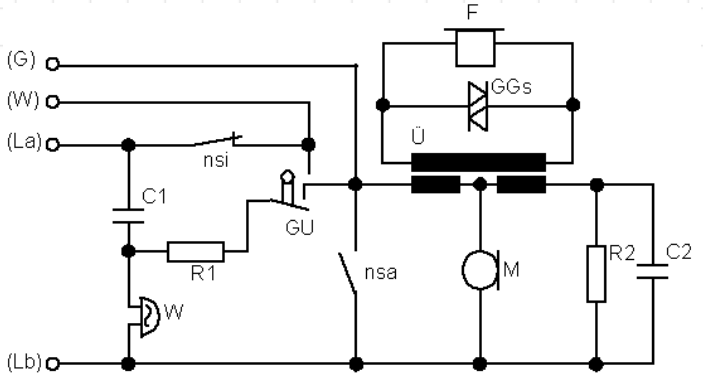
– E.g.: Radio, TV, DAB, DVB, … NO WAY BACK!!!

(unicast (singecast), multicast, broadcast)

Full-duplex at one wire



e.g. analogue telephone and
Gigabit Ethernet (1000baseT)



Media-access-control-systems

- ALOHA — listen before transmit…
- CSMA/CD — Ethernet — IEEE 802.3x
  - Carrier Sense Multiple Access / Collision Detection
- CSMA/CA — WIFI — IEEE 802.11x
  - Carrier Sense Multiple Access / Collision Avoidence
- Token-passing — Token-Ring, FDDI — IEEE 802.5x
- Time-slot — GSM / sensor networks
- Master / Slave — WIFI (RTS/CTS), Bluetooth
- Priority — CAN-Bus

Shared Medium

- All users have to use the same Medium and must find a solution to share
  - Like CB/Ham-Radio:
    - Listen before transmit! (ALOHA, CSMA …)
  - Networks based on busses or as Star / extended Star with Repeater (Hub), Powerline, Kabel-Internet or cellular (Wifi …)

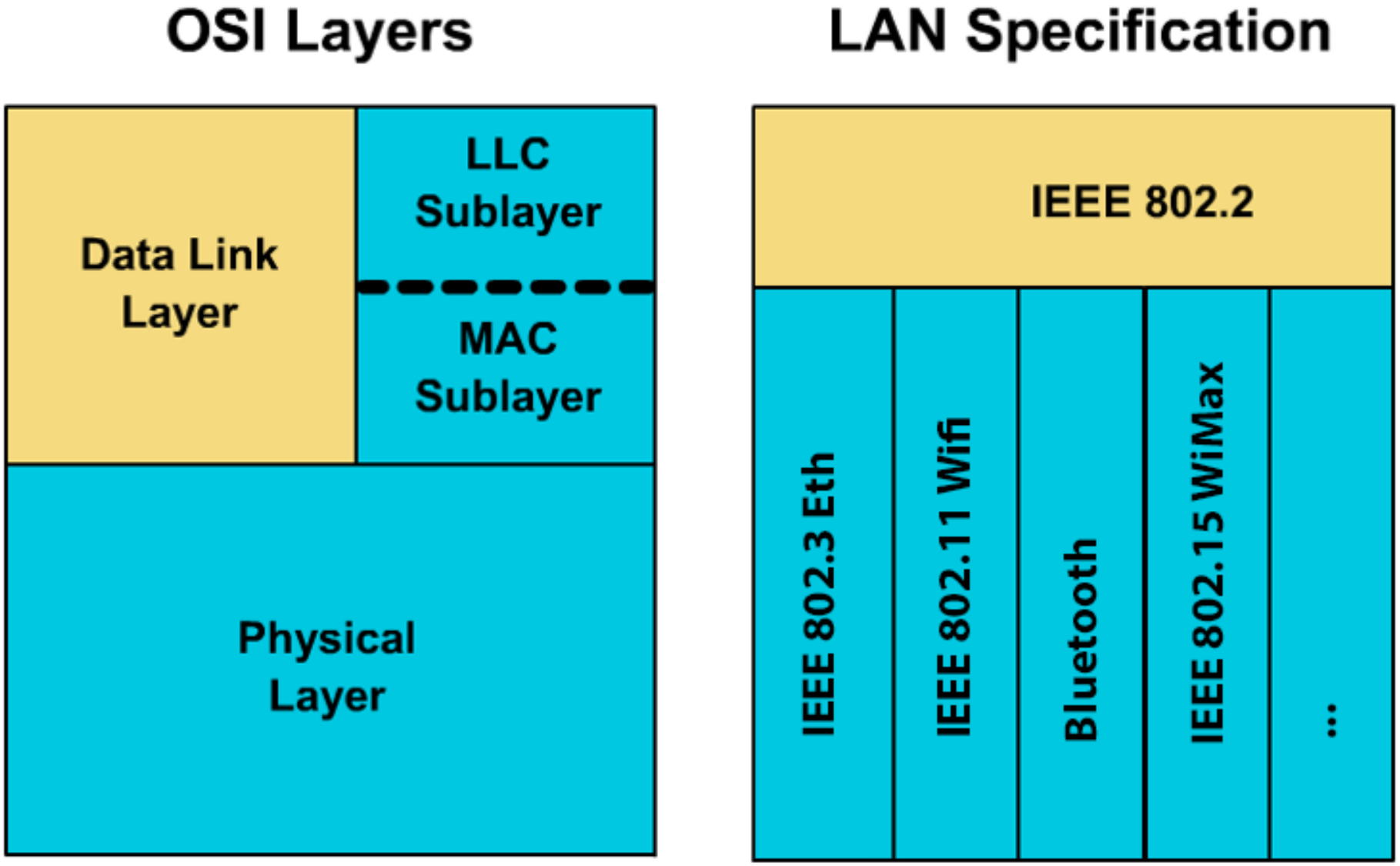
Real digital bandwidths

All values are the maximum transmission-rate per cable!

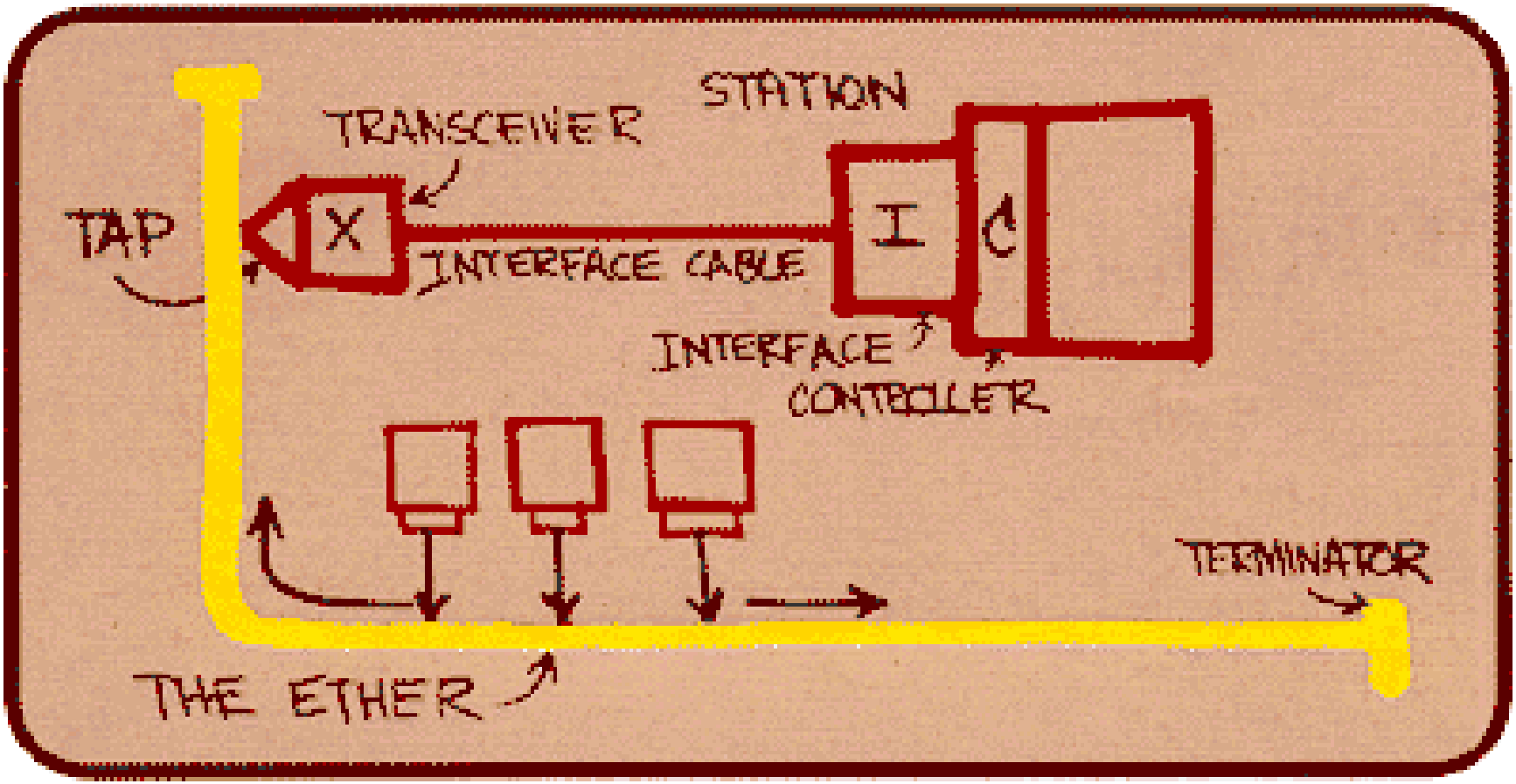
• Ethernet 10base2 /5	Σ: 10MBit/s	→ 10MBit/s
• Ethernet 10/100baseT HUB:	Σ: 10/100Mbit/s	→ 10/100MBit/s
• Ethernet 10/100baseT switch:	Σ: 20/200MBit/s	→ 10/100MBit/s
• Token-Ring 16MBit/s	Σ: 250*16MBit/s	→ 16MBit/s
• Wifi 802.11b	Σ: <11MBit/s	→ <5,5MBit/s
• Wifi 802.11n	Σ: <300MBit/s	→ <150MBit/s
• …		

the netto-Data-rate (Payload) ist depending to: other Proocols, there Overhead and load-behavior of the network (all devices and cabeling)!

Specifications IEEE/ISO



Ethernet – first idea



Ethernet transmisson-modes

- Base-band „base“ (all Ethernets)
- Carrier-band „Cxxx“ (only 10MBits/s)

e.g.:

MBit/s	Mode	Medium
10	base	2, 5
100	C400	Tx, T4
1000	C600	T, T2, Fx…

Outdated technology in GRAY

Ethernet – 10 base 5

- 500m „Yellow-Cable“ (Segment)
- Max. 100 stations per segment
- Anschluss with TAP/MAU
  via AUI-Kabel (max. 50m)
- Min. distance between two stations 2,5m

Ethernet – 10 base 2

- 185m Coaxial RG58 – 50Ohm
- Maximum 30 Stationen / Segment
- Bus – no extensions!
- Min. distance between two stations

Ethernet – 10/100 base Tx

- 100m TwistedPair – Cat. 5-8 100Ohm
- Star – extended Star

Collision-domains

- It‘s the ethernet definition of a „Shared Medium“ but with defined
- Nothing can be done parallely
- Can be extended in size by using repeaters
- Limitation in size
- Can be cutted in smaller parts (segments)

54321-Rule (4-Repeater-Rule)

- **Inside an Ethernet-Kollisionsdomain (using a BUS or HUBs) are maximum:**

5 Segments (all)

4 Repeater

3 „live“ segments

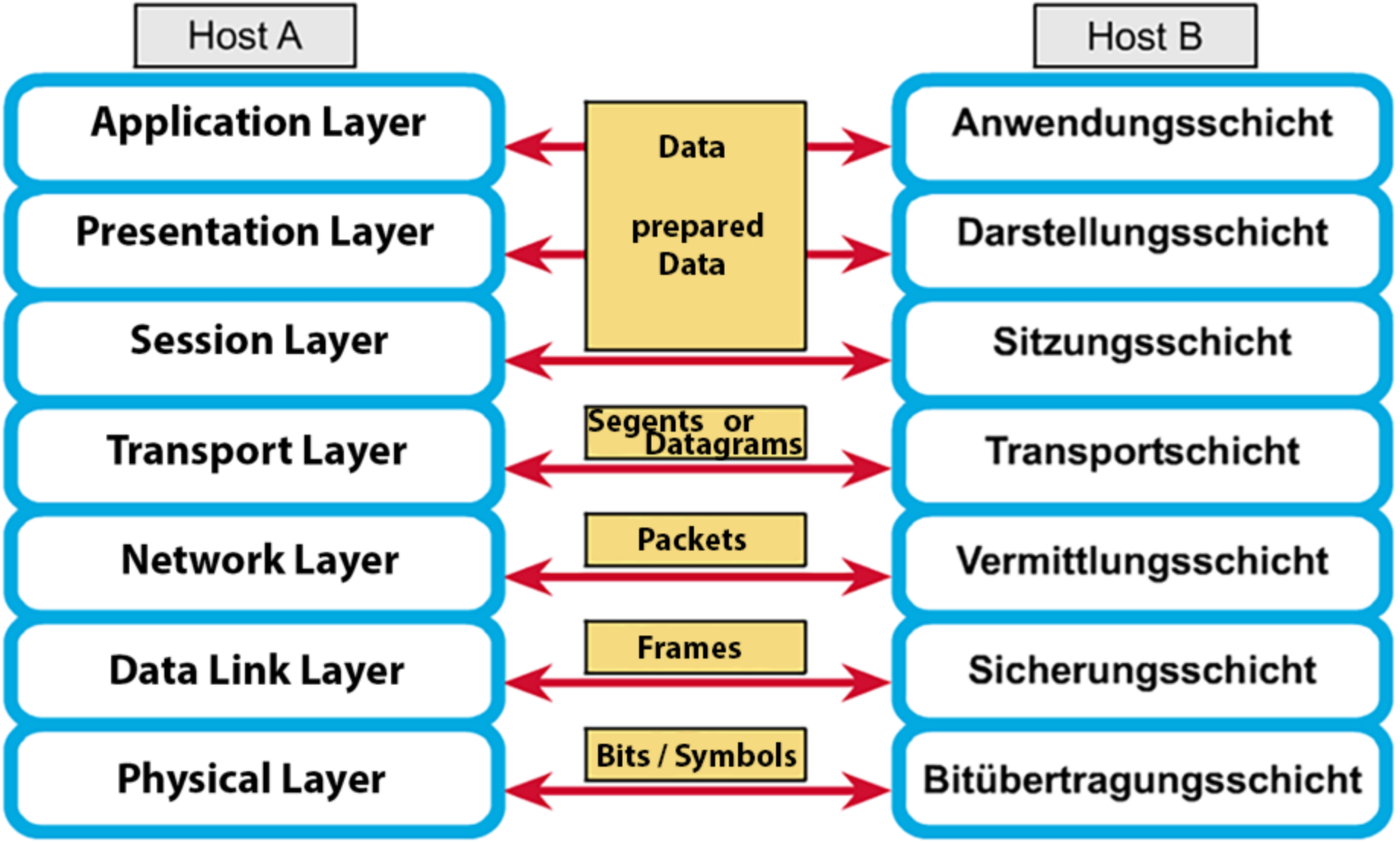
2 Transit segments (using 3 live segments)

1 Collision-Domain

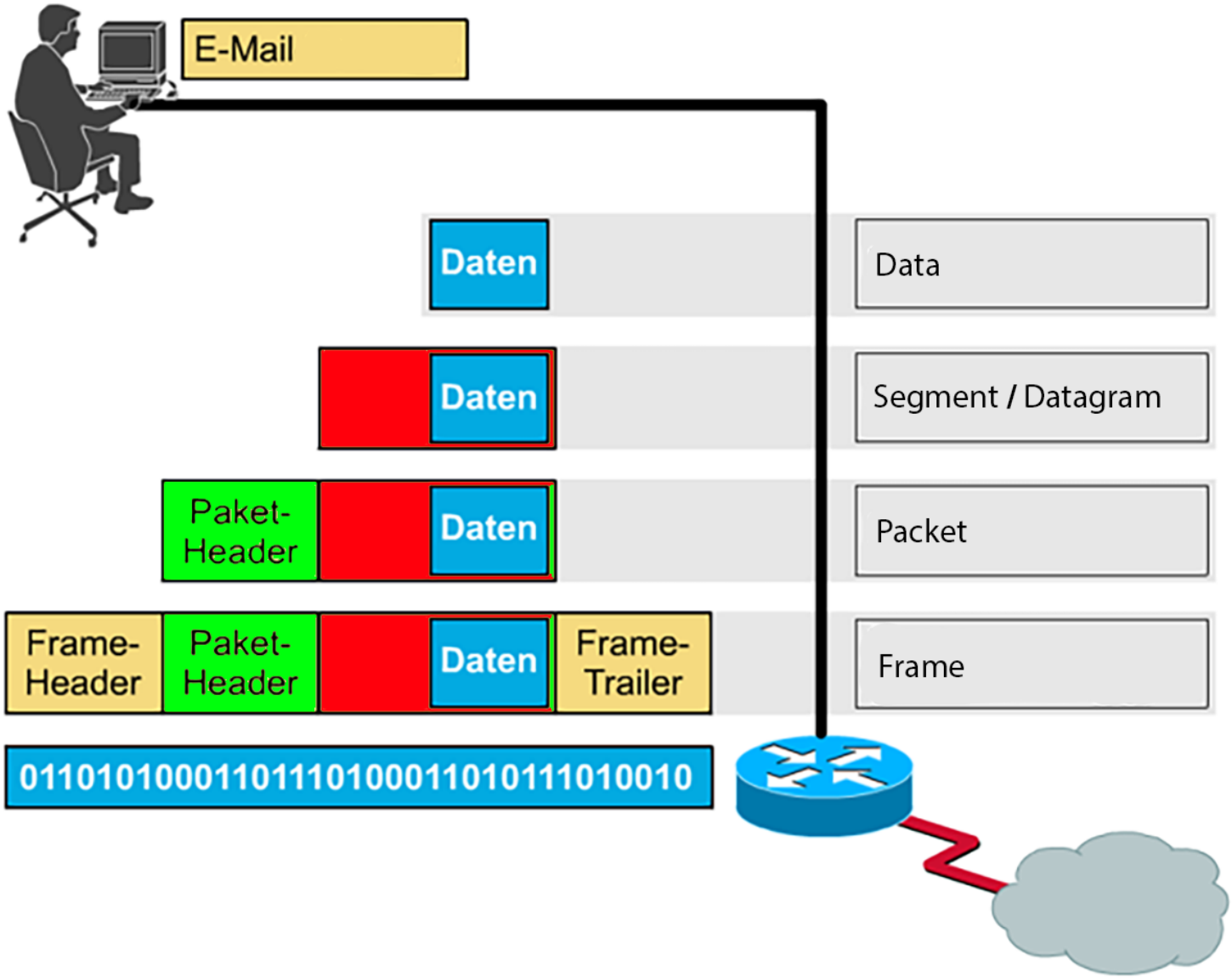
BUT:

not logner needed if Switches are used!

Peer-to-Peer-communication



PDUs


E-Mail
Daten
Data
Daten
Segment / Datagram
Paket-
Header
Daten
Packet
Frame-
Header
Paket-
Header
Daten
Frame-
Trailer
Frame
01101010001101110100011010111010010

generic Frame

Feldnamen					
A	B	C	D	E	F
Start Frame-Feld	Address-Feld	Typ-/ Länge-Feld	Daten-Feld	FCS-Feld	Frame-stopp-Feld

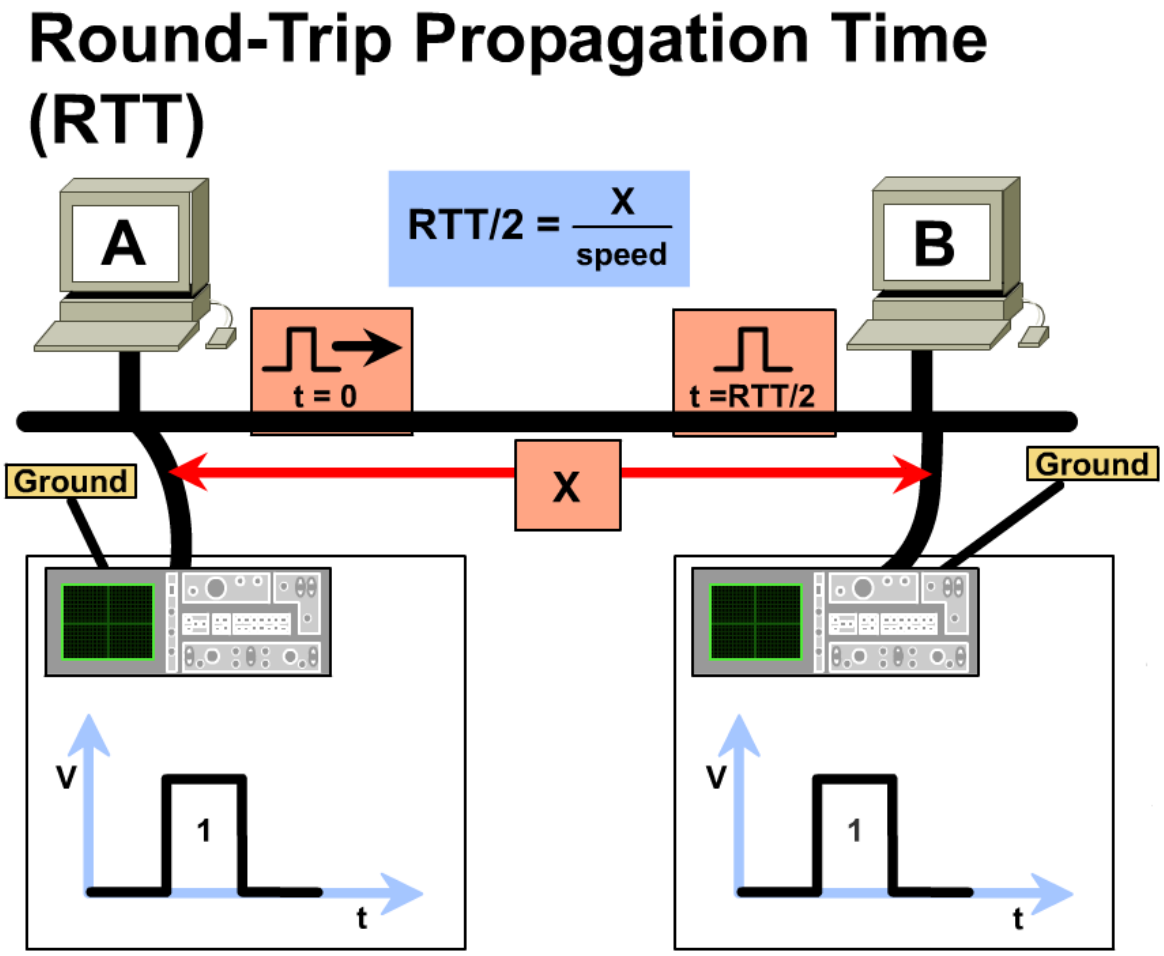
Ethernet-frame

IEEE 802.3		size in Bytes:				
7	1	6	6	2	46-1500	4
Preamble	Start of frame delimiter	Destination Address	Source Address	Length	802.2 Header and Data	Frame Check Sequence

10101010101010101010101010101010101010101010101010101010101010101010101011

Preamble (7xAA) SFD (AB)

Propagation time



BIT-Intervals

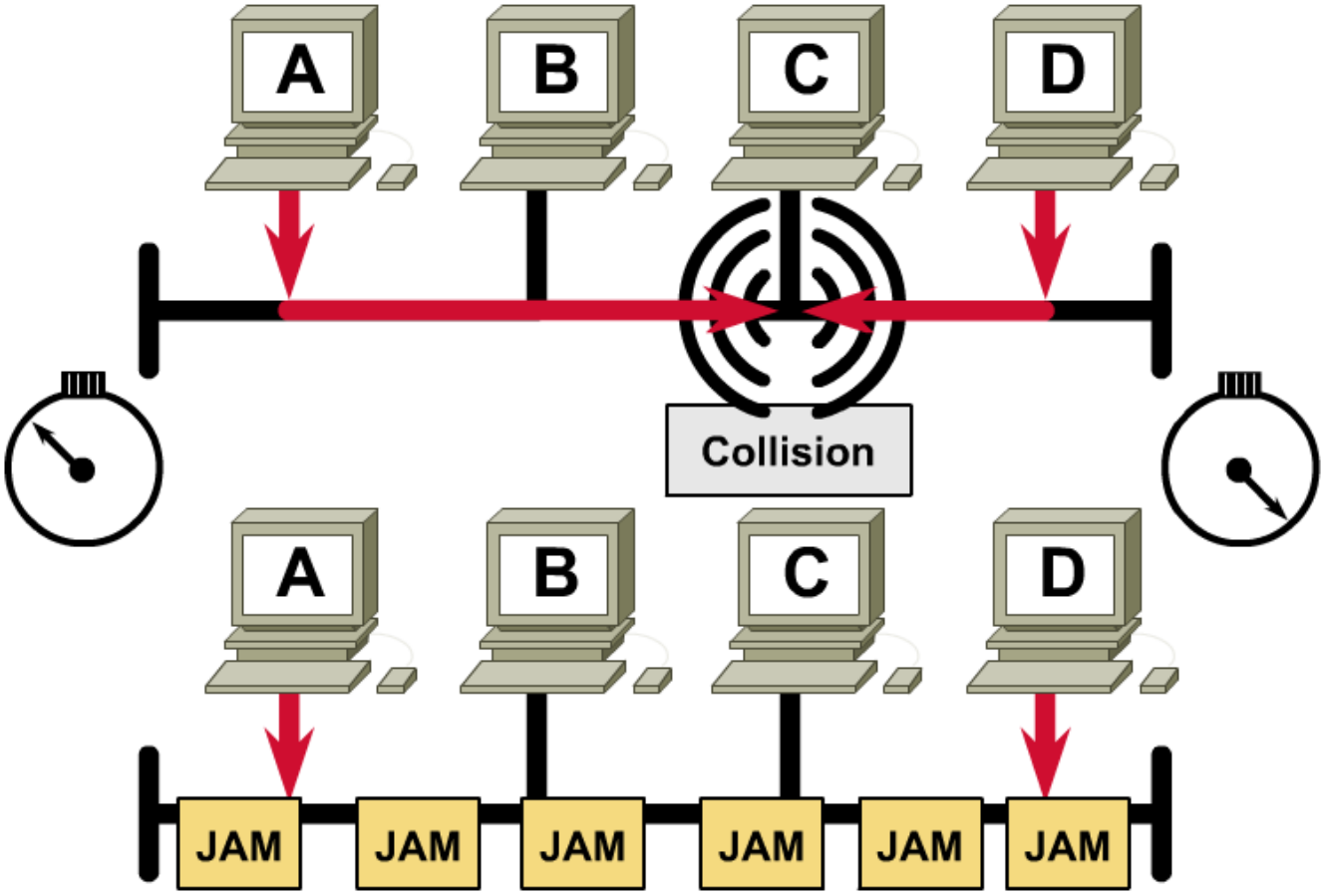
Ethernet Speed	Bit-Interval
• 10 MBit/s	100 ns
• 100 MBit/s	10 ns
• 1000 MBit/s	1 ns
• 10000 MBit/s	0,1 ns

Interframe-gaps IFG

- If a Ethernet-NIC has dedected a cable as non-used it has to wait a IFG before starting transmission.

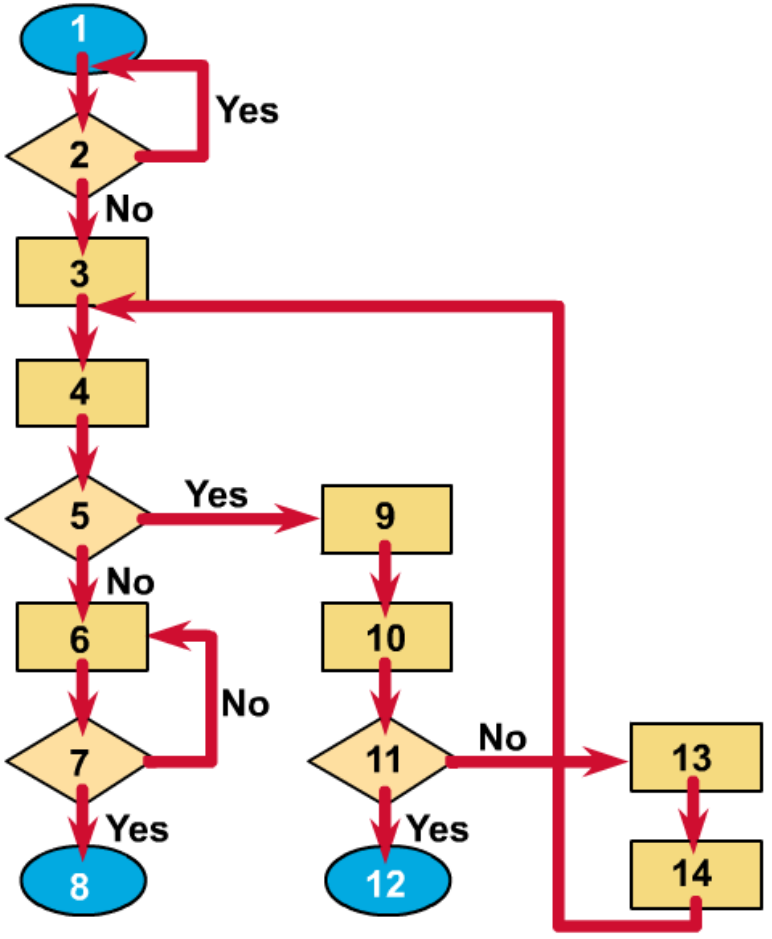
Speed		IFG	as time
10	MBit/s	96 Bits	9,6 us
100	MBit/s	96 Bits	0,96 us
1000	MBit/s	96 Bits	0,096 us
10000	MBit/s	96 Bits	0,0096 us

Collisionen



CSMA/CD

1. Host wants to transmit
2. Is carrier sensed?
3. Assemble frame
4. Start transmitting
5. Is a collision detected?
6. Keep transmitting
7. Is the transmission done?
8. Transmission completed
9. Broadcast jam signal
10. attempts = attempts + 1
11. attempts > too many?
12. Too many collisions; abort transmission
13. Algorithm calculates backoff
14. Wait for t seconds



Backoff-Algorithem

- **After recognized Collision all stations ready for transmission have to wait a with Backoff-Algorithmus generated multiple of *Slot Time*. This multiplicator will calculate each station for itself:**

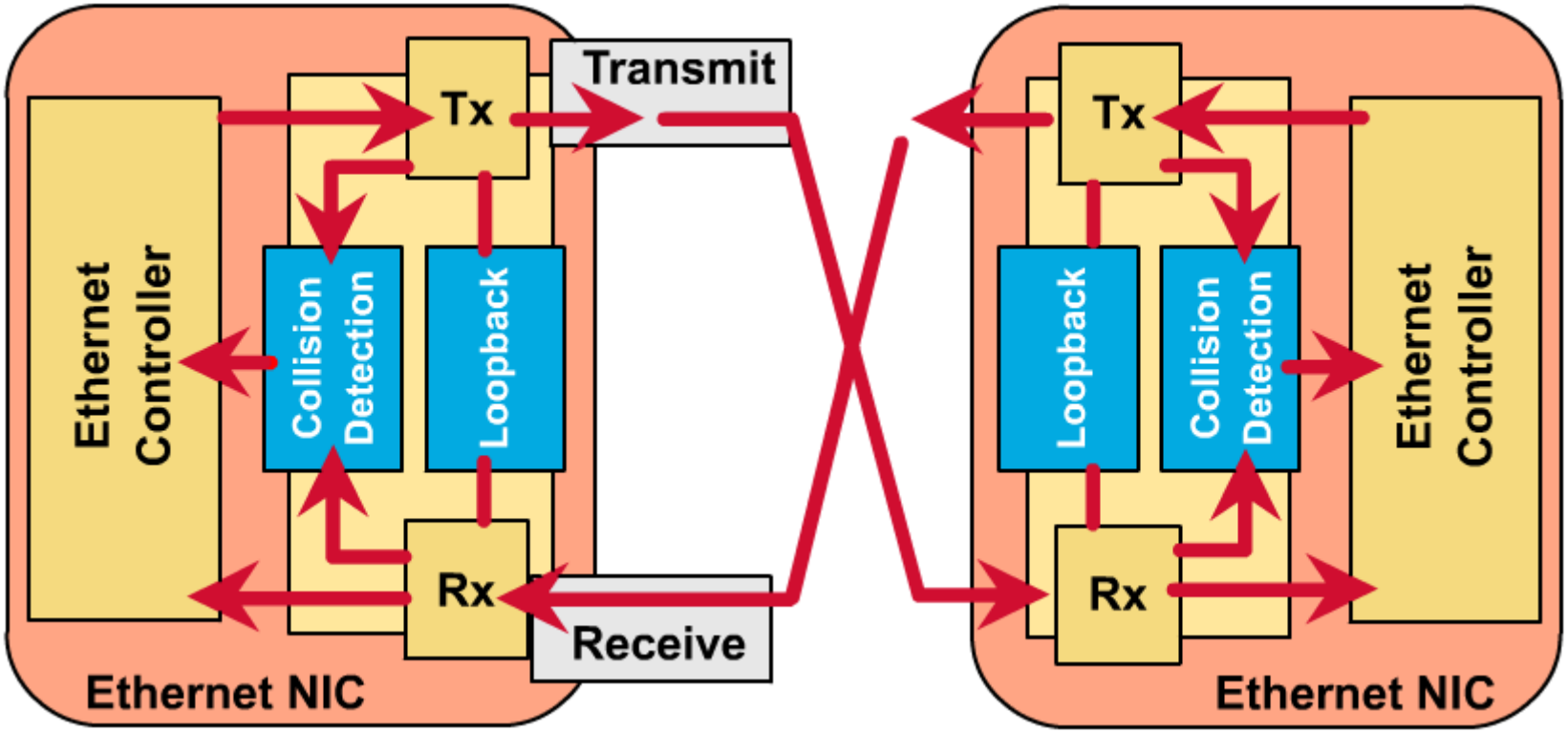
- **Waiting-time after**
  1. Collision: {1} x Slot time
  2. Kollision: {2^2-1} x Slot time
  3. Kollision: {2^3-1} x Slot time
  i. Kollision: {2^i-1} x Slot time

- **after 10 Collisions, (max. 1023 x Slot times) it will be not more and after 16 Collisionen the transmisson cancelled.**

How collisions are dedected?

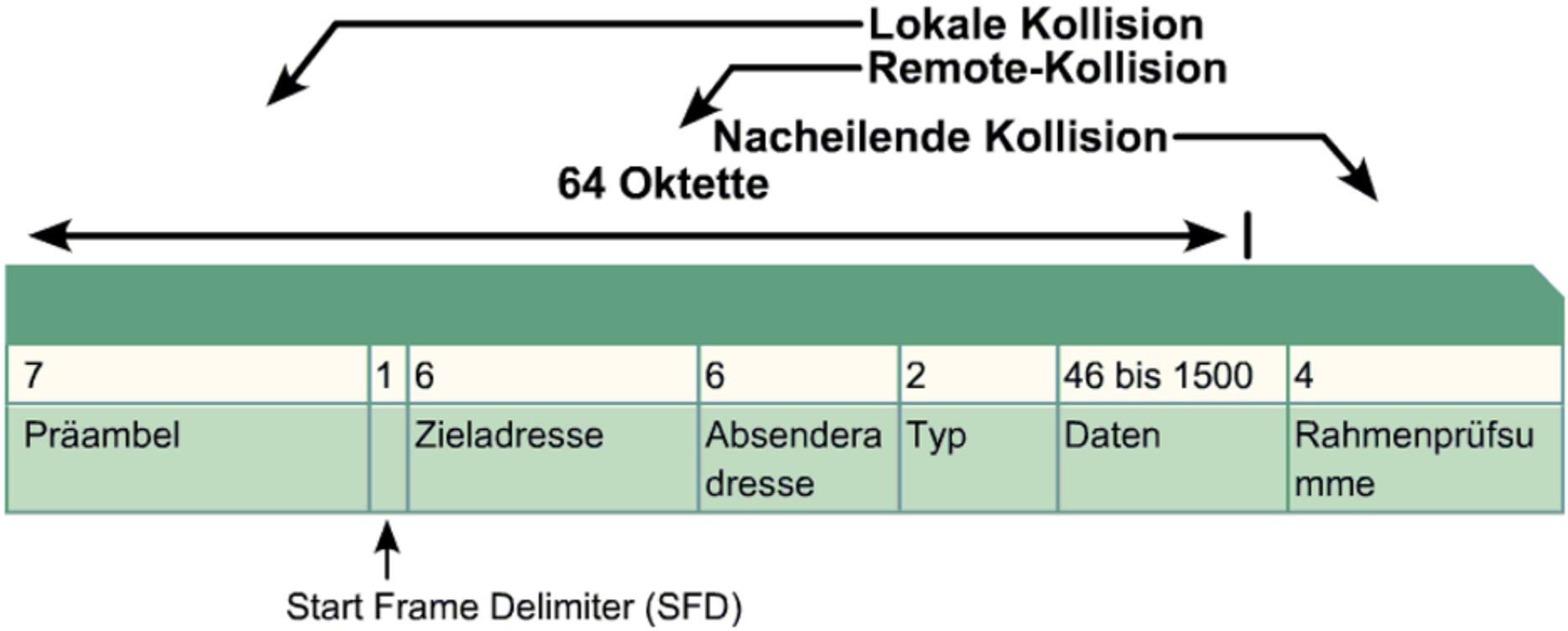
- Pricipe of Interference-addition of 2 or more signals.
- Normal transmissions: maximun Voltages of 1293mV (1,3V)
- Collisions: Addition of signals to Voltages of 1448mV to 1590mV
- Each NIC is doing this check independendly paralelly to normal operation.
- the JAM-Signal is 4x AA (like Preamble but 4x)

CSMA/CD dedection



Collision types

- Local
- Remote
- Late (nacheilend)



Errors in Ethernet

- **Collision oder Runt** – prallel transmission while preamble
- **Late Collision** – prallel transmission after preamble
- **Jabber** – toooo long frame
- **Collision-fragment or Runt** – to short transmission
- **FCS-Error** – Chechsum test failed
- **Frame-sychronisation-error** – to many or less bits
- **Ghost or Jabber** – not ending Preamble very long Jam-signal

Ethernet transmissions

- Singlecast (unicast) → one to one
- Multicast → one to some
- Broadcast → one to all
- A NIC copies the frame data to higher layers when:
  - The frame-MAC-address is identically with the own,
  - It‘s a broadcast-address,
  - The NIC is set to „Promiscous Mode“ (driver)

- „Best Effort Delivery“ :

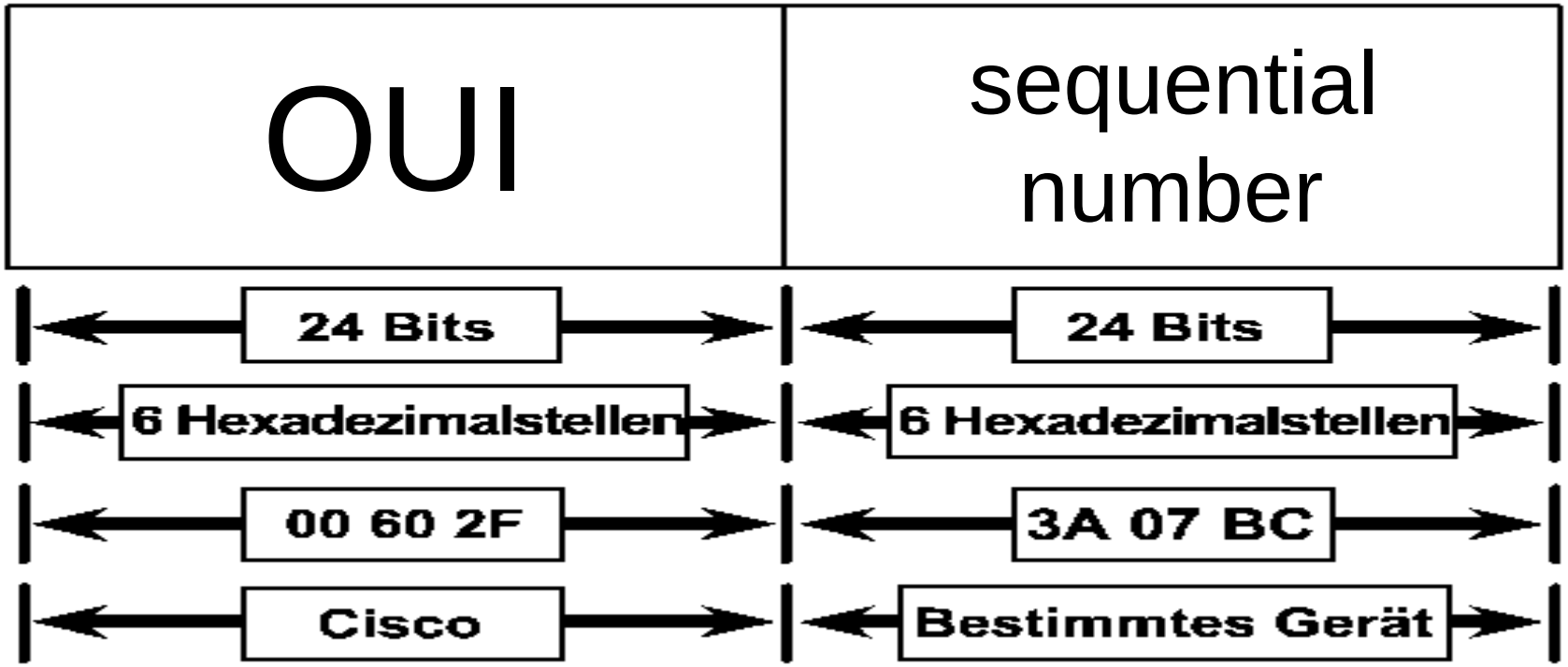
There is never a feedback or ACK!!!!!

MAC-Addresses

- Also known as hardware-address or physical-address
- 48 Bit-Number (6 Byte) normally written as Hex
- 2^{48} combinations ➔ $281x10^{12}$
  MAC-Adresses (2 per $1m^2$ land-surface at Planet Earth)
- Combined from Organizationally Unique Identifier and sequential number (Device No. 0, 1, 2, 3, …)
- The OUI will be given by IEEE
  Institute of Electrical and Electronic Engineers
  (http://standards.ieee.org/regauth/oui/)

- Broadcastaddress: ff-ff-ff-ff-ff-ff
  111111111111111111111111111111111111111111111111

MAC-Adresses



Active network components

• 1	Transceiver / Media converter
• 1	Repeater
• 1	HUB (Multiport repeater)
• 1 2	NIC → PC up to Layer 7
• 1 2	Bridge
• 1 2	Switch (Multiport bridge)
• 1 2 3	Router (L3-Switch)
• 1 2 3 4 …	Multilevel-Router, Brouter, ML-Switch …, Gateway…

Ethernet-bridges

- Segmentation = Parallelisation !!!
- Layer2-device means: will make decisions based on MAC-addresses
- It‘s a „smart filter“ for frames
- “transparent” (can’t be seen by other devices)
- Generates and uses MAC-address-tables
  - Will be learned by listening to incoming frames
  - Each entry not in use for 300s will be deleted
- Today normally as a function in other devices
- Forward all MAC-broadcasts

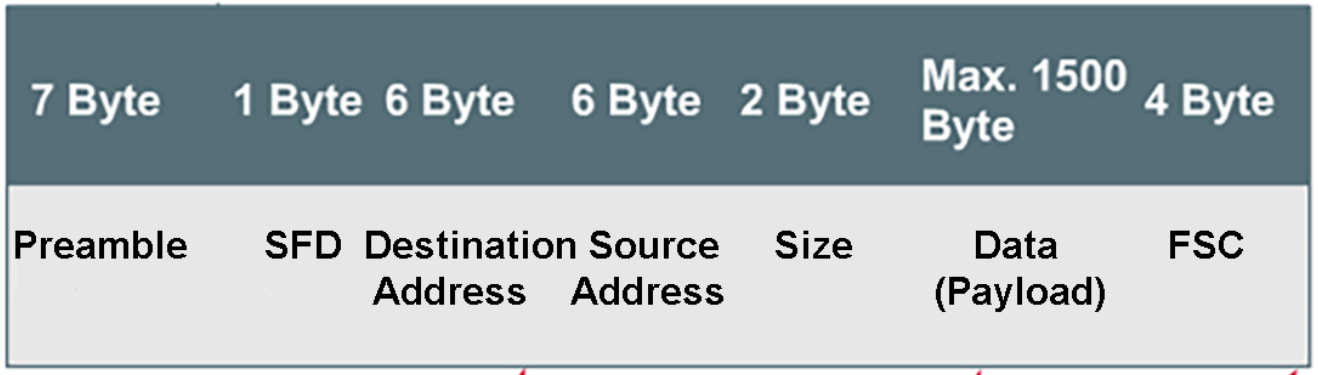
  (Broadcast-Domain)

Ethernet-Switches

- „real name“: Ethernet-Switching-Hub
- Also called: „Multiport Bridge“ (same rules)
- Hardware-based
- ONLY Switches → „micro-segmentation“
- Switching-Modes:
  - Store and Forward
  - Cut-Through
    - Fragmet free
    - Fast-Forward

Idea of switching-process

Switching-modes

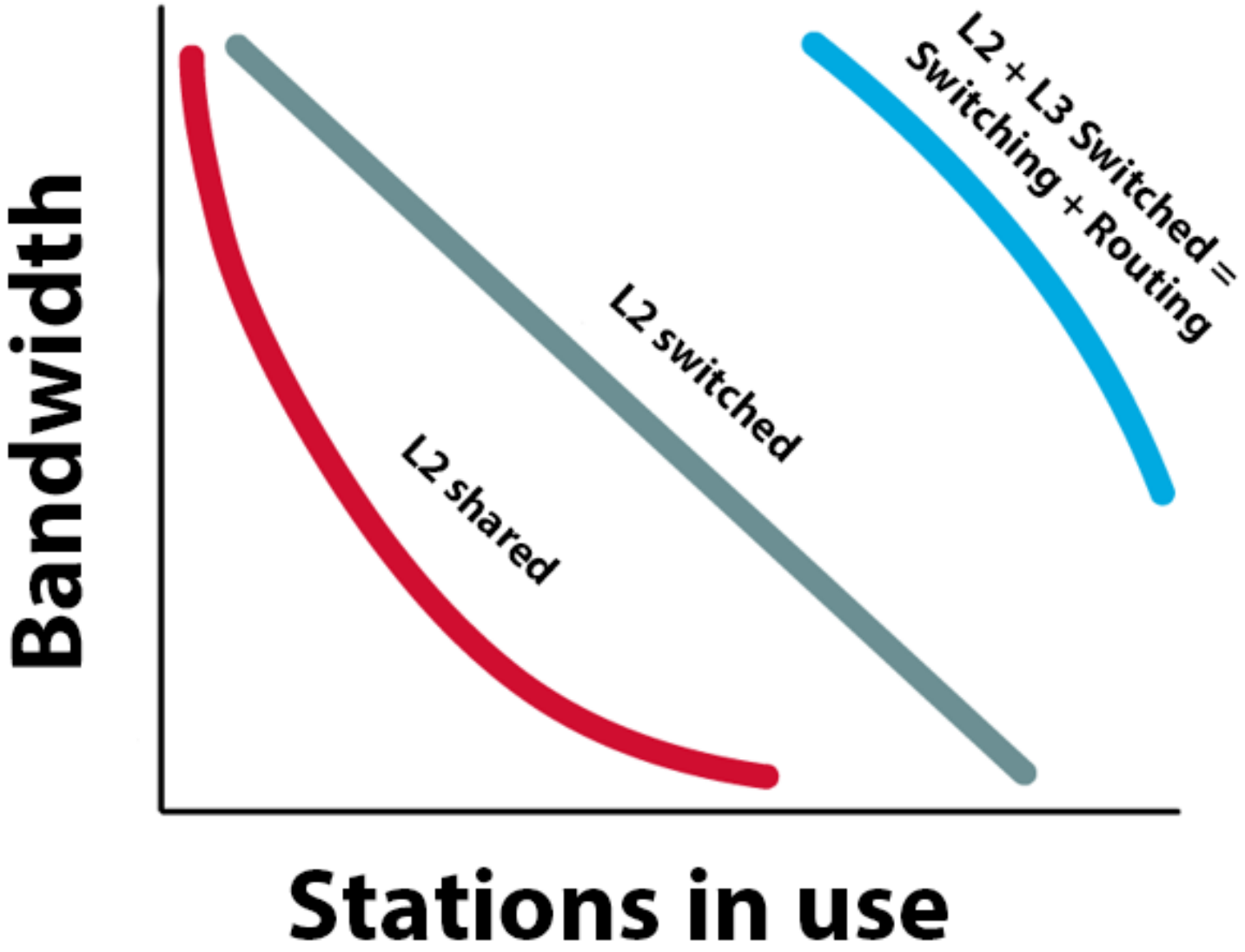


Fast-forward
shortest latency
NO check for errors
(most better switches)

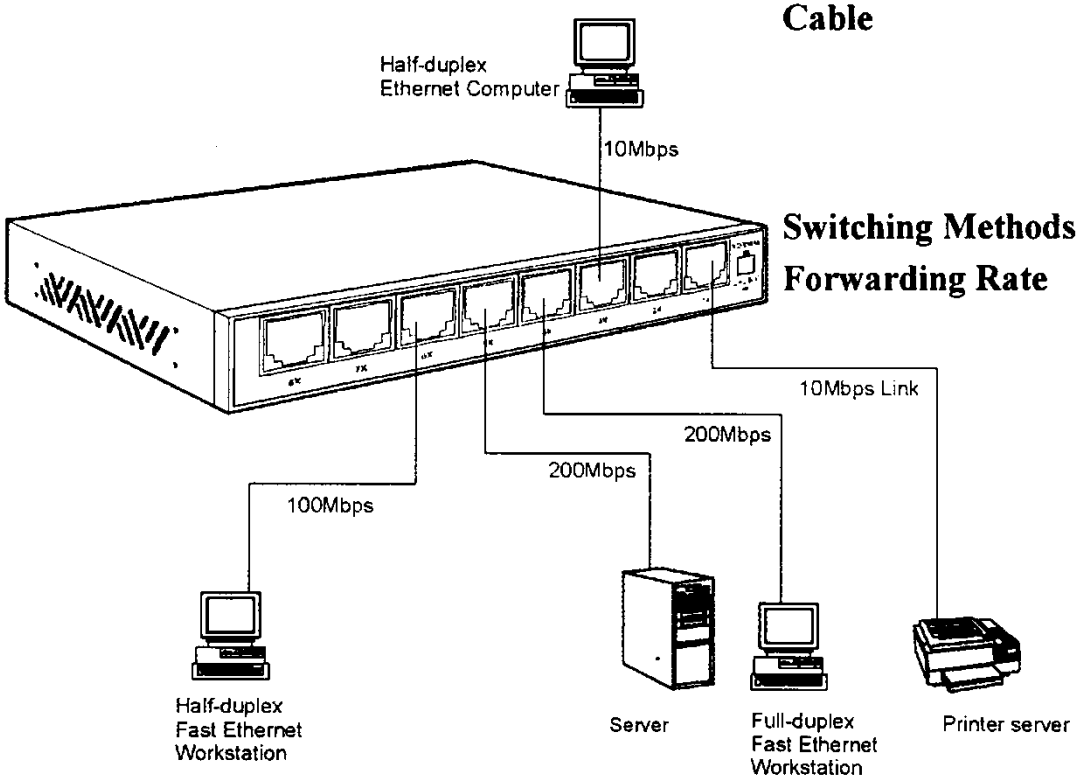
Store-and-Forward
longest latency
find / drop all errors
(every switch)

Fragement-Free
short latency
find / drop most errors
(special / expensive feature)

Bandwidth efficency



Typical SOHO-Switch:



Applicable Standards	10BASE-T, IEEE 802.3 100BASE-TX, IEEE 802.3u
Cable	10BASE-T 2-pair UTP/STP Cat. 3,4,5, Up to 100m(328ft) 100BASE-TX 2-pair UTP/STP Cat.5, Up to 100m(328ft)
Switching Methods	Store-and-Forward
Forwarding Rate	148,80pps for 10Mbps, 148,800pps for 100Mbps

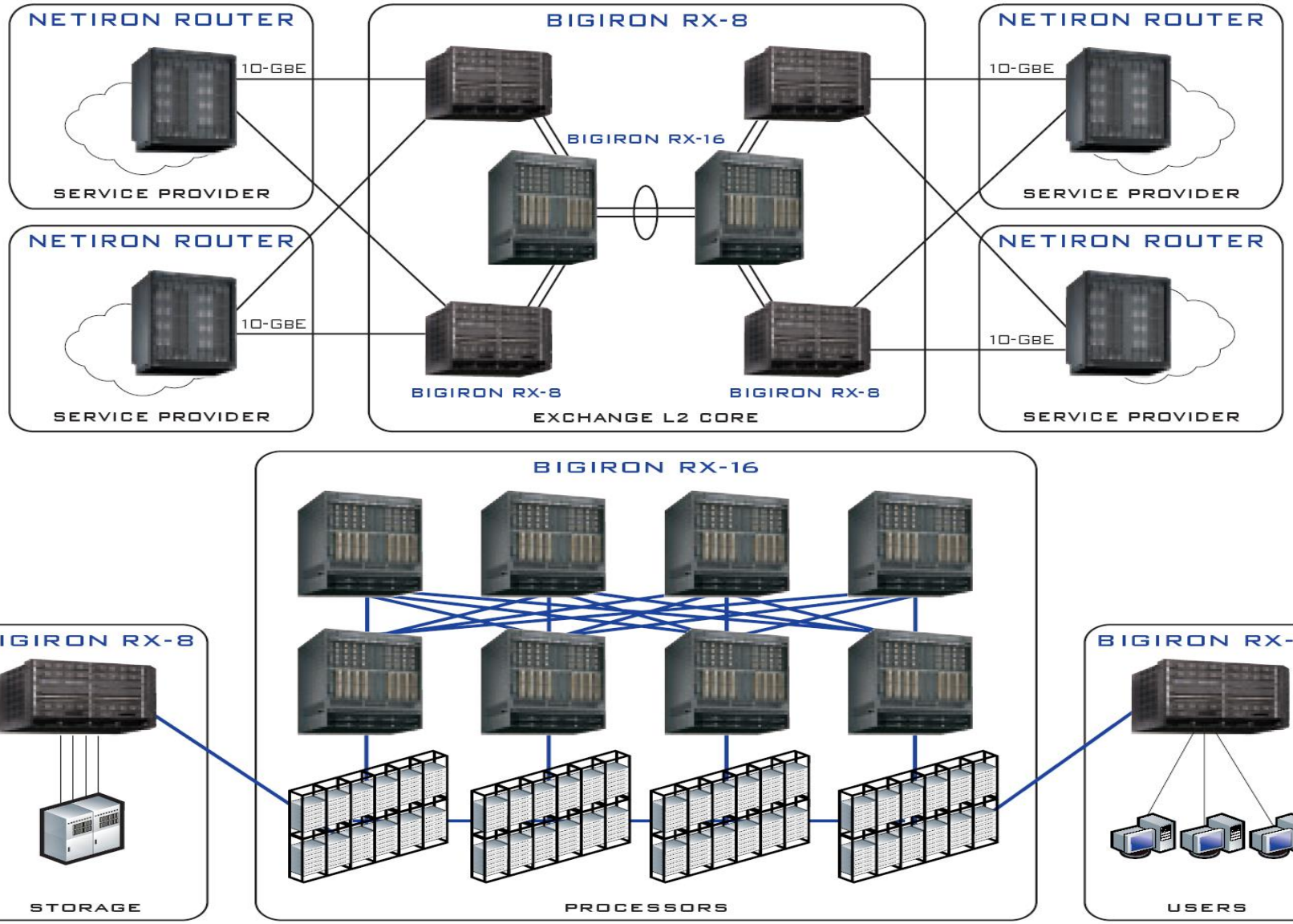
FoundryNet BIGIRON-Series:

System Summary

Feature	BigIron RX-4	BigIron RX-8	BigIron RX-16
I/O Module Slots	4	8	16
Switching capacity per system			
Available data capacity	384 Gbps	768 Gbps	1.54 Tbps
Total switch capacity	960 Gbps	1.92 Tbps	3.84 Tbps
Packet forwarding capacity per system	286 Mpps	571 Mpps	1,142 Mpps
Max 10-GbE ports per system	16	32	64
Max 10-GbE ports per 7' rack	176	192	192
Max 1-GbE ports per system	192	384	768
Max 1-GbE ports per 7' rack	2,112	2,304	2,304
Power supply redundancy	M+N	M+N	M+N

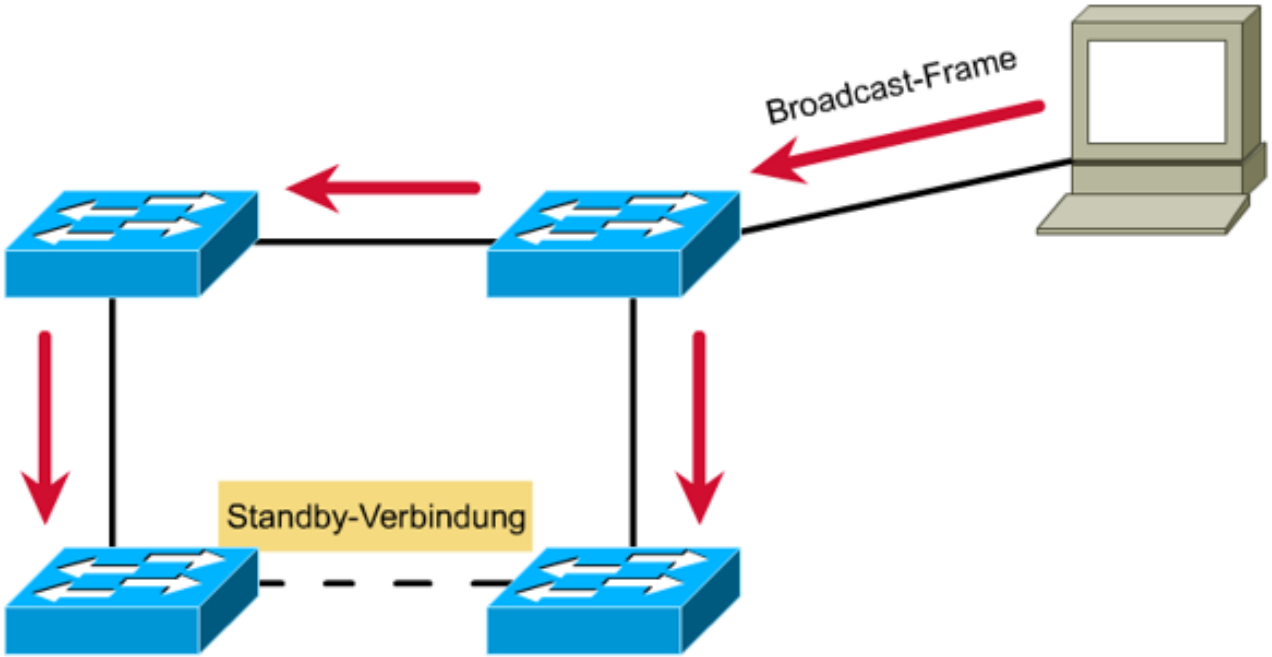
(M = Number of supplies needed for fully loaded system and N = 1 to M supply redundancy)

Infrastruktures…



CISCO CRS-3 (322 TB/s)

Spanning-Tree



- Switches will forward Broadcast-Frames
- Prevent switching-loops
- Provides redundant connections
- Cuts the topology to what is really needed
- Good for: redundancy, errors by devices/users

STP switch port states

Blocking

A port that would cause a switching loop if it were active. No user data is sent or received, but it may go into forwarding mode if the other links in use fail and the spanning tree algorithm determines the port may transition to the forwarding state.

Listening

The switch processes BPDUs and waiting for possible new information that would cause it to return to the blocking state. It does not update the MAC address table and it does not forward frames.

Learning

While the port does not yet forward frames it does learn source addresses from frames received and adds them to the filtering database (switching database). It updates the MAC address table, but does not forward frames.

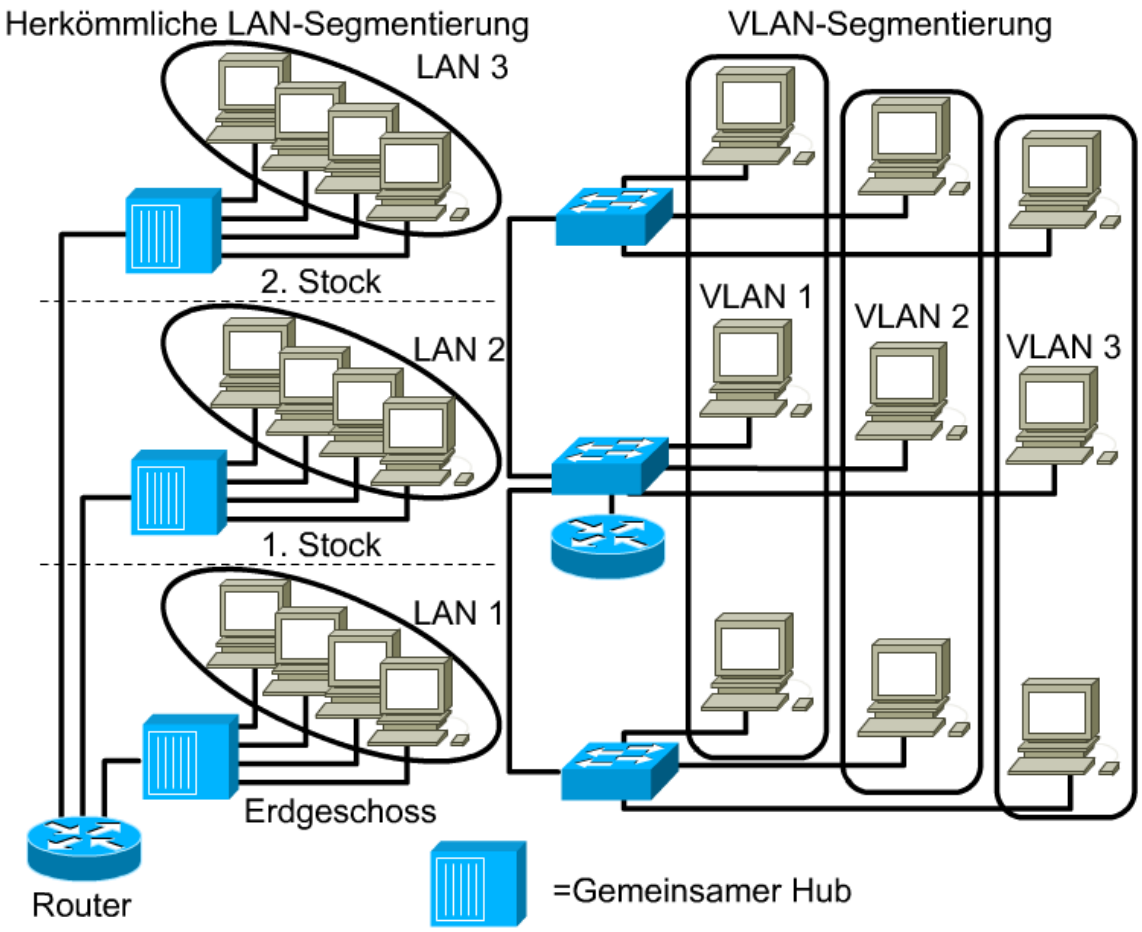
Forwarding

A port receiving and sending data in Ethernet frames, normal operation. The Forwarding port monitors incoming BPDUs that would indicate it should return to the blocking state to prevent a loop.

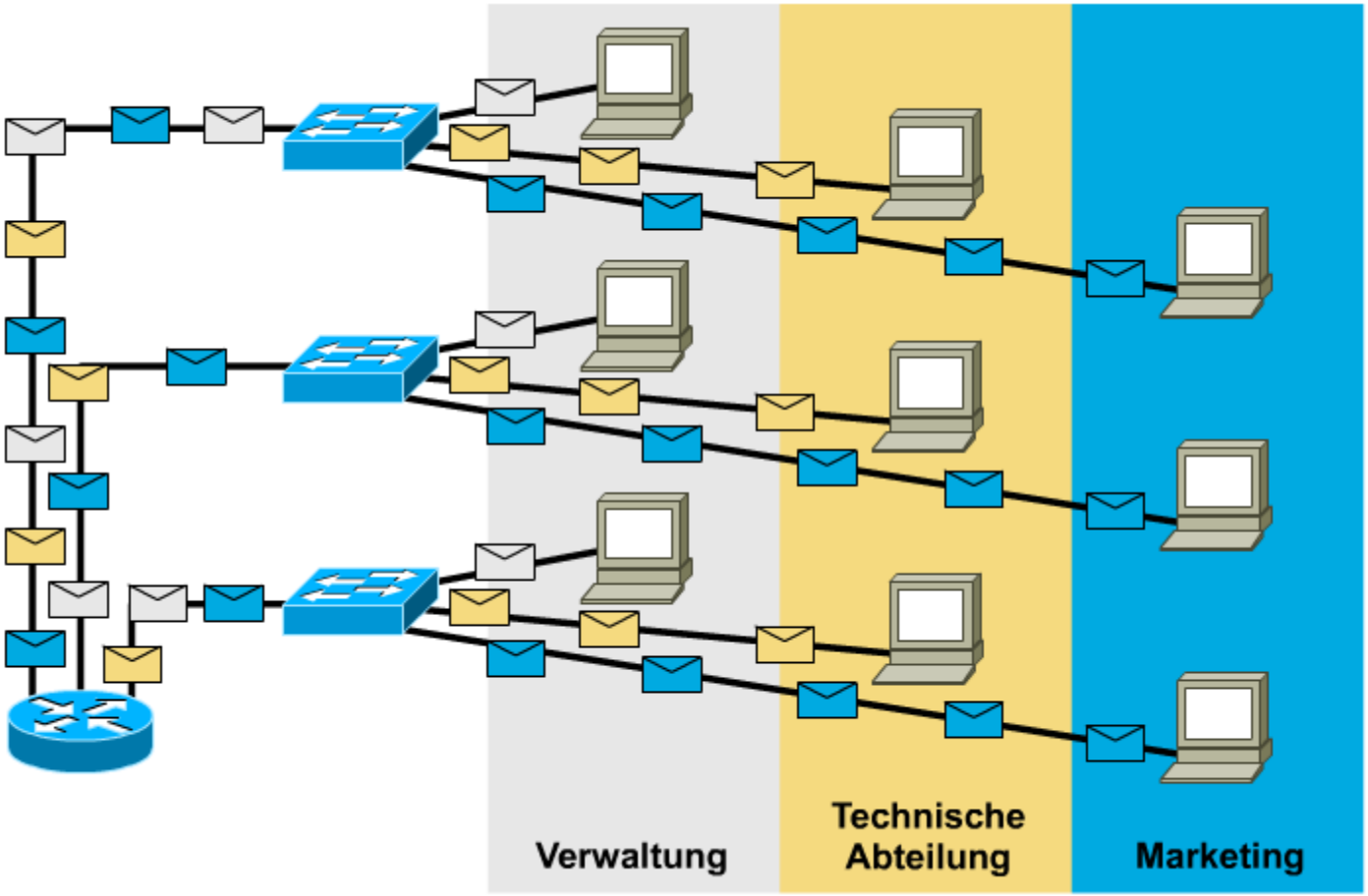
Disabled

A switch port is manually by administrator.

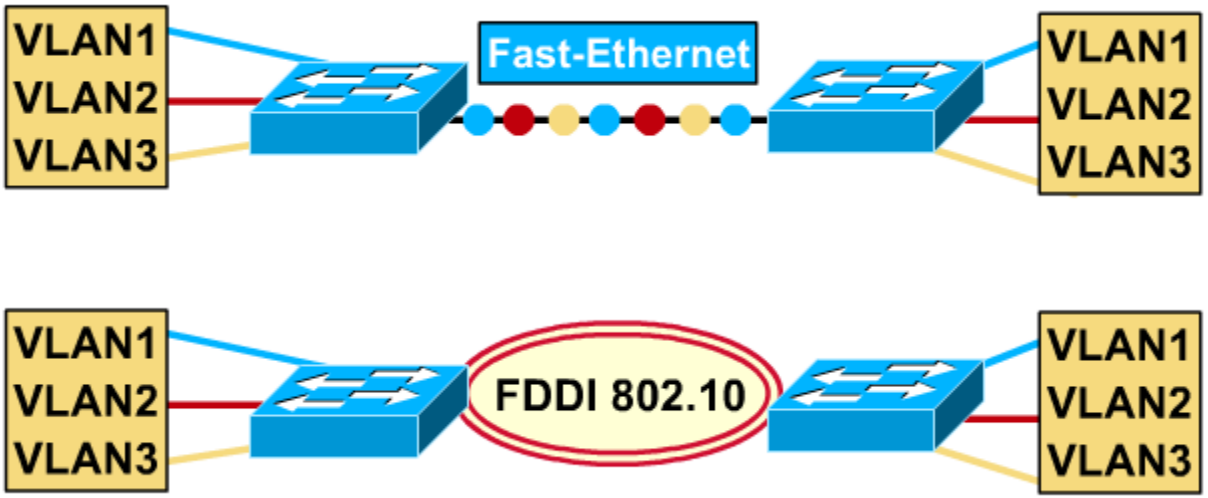
VLANs


Herkömmliche LAN-Segmentierung
LAN 3
2. Stock
LAN 2
1. Stock
LAN 1
Erdgeschoss
Router
VLAN-Segmentierung
VLAN 1
VLAN 2
VLAN 3
=Gemeinsamer Hub

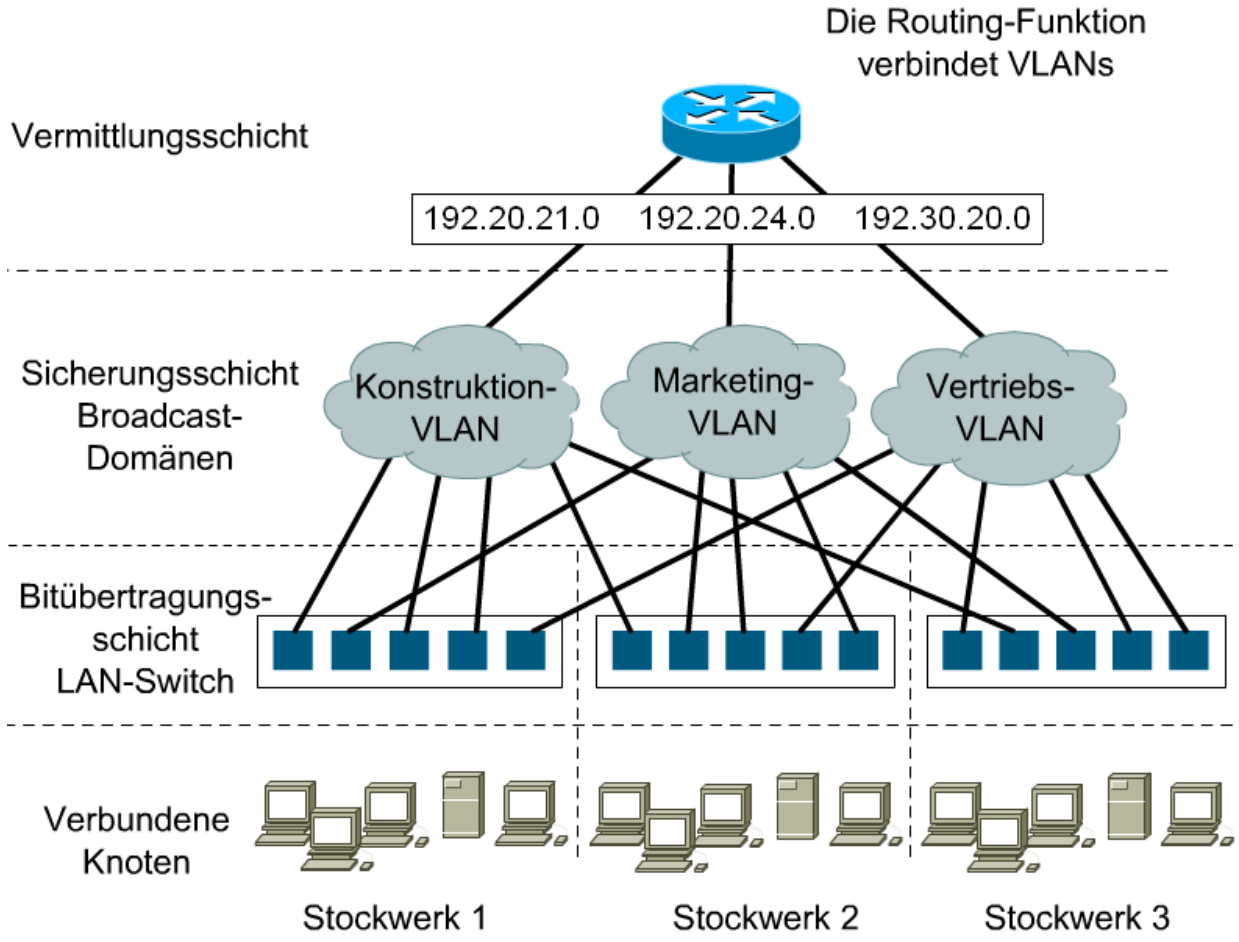
trunking



IEEE 802.1q – Frame-tagging



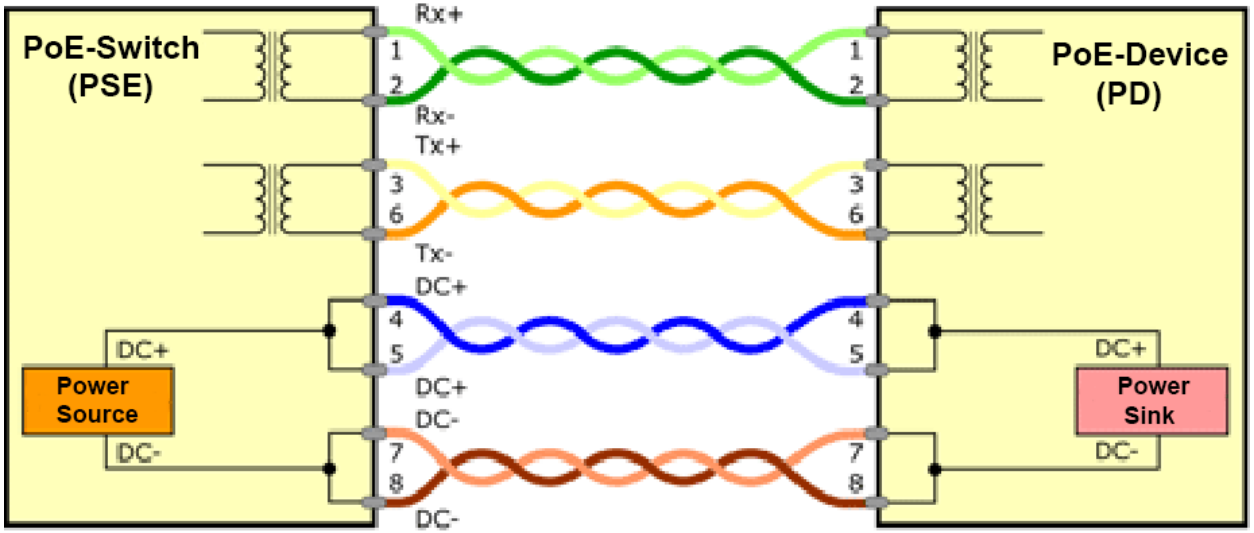
VLAN – Interface-mapping



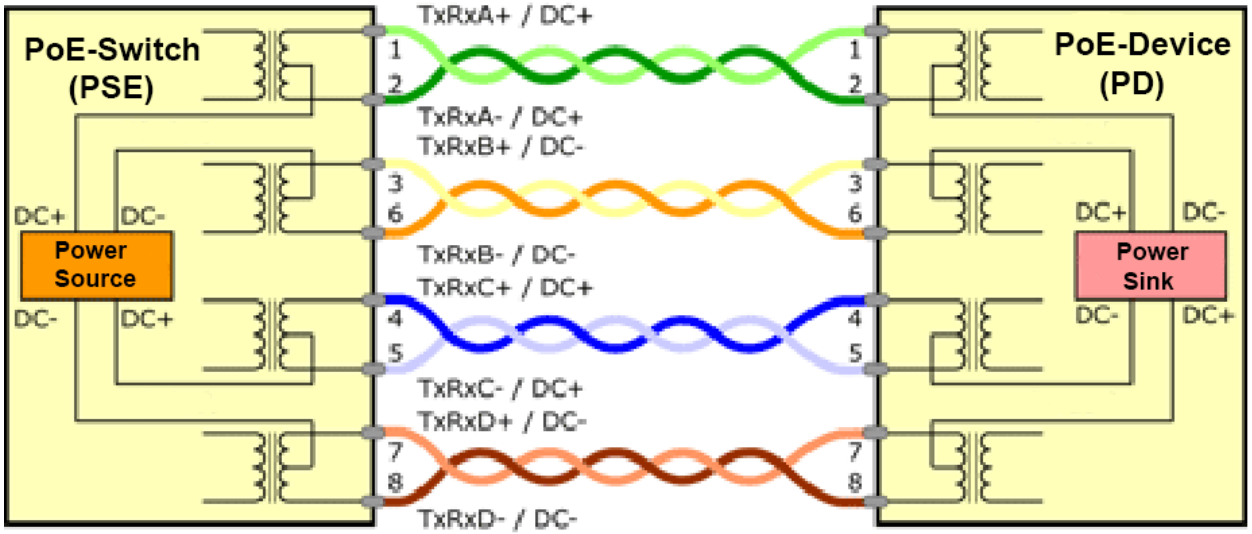
PoE Power over Ethernet

Class	Used for	Maximum input-power (PSE)	Maximum output-power (PD)
0	default	15,4 W	0,44 bis 12,95 W
1	optional	4,0 W	0,44 bis 3,84 W
2	optional	7,0 W	3,84 bis 6,49 W
3	optional	15,4 W	6,49 bis 12,95 W
4	optional	(reserved)	15,4 W

Mode A – Mode B

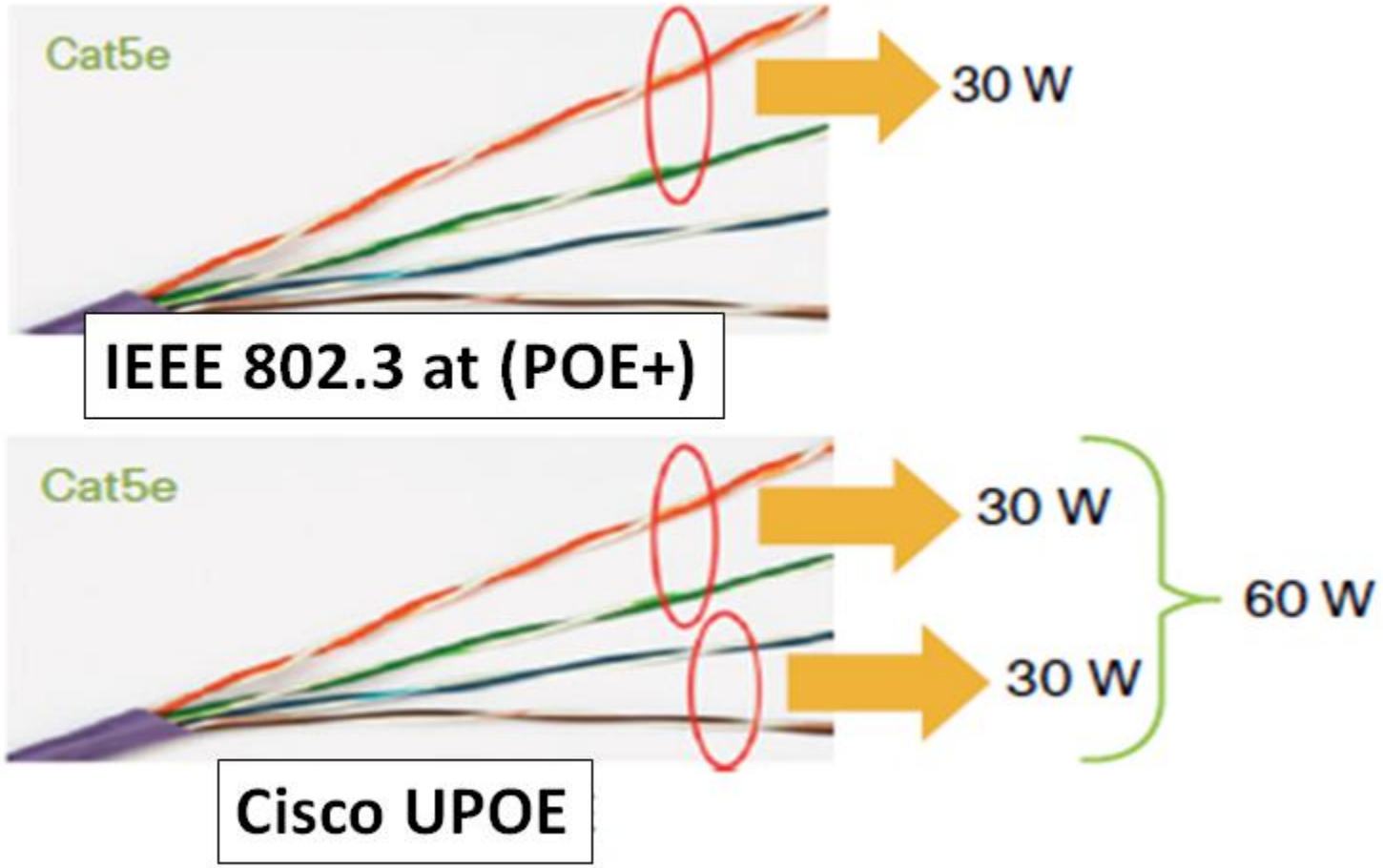


Spare-Pair-Injection
Mode A

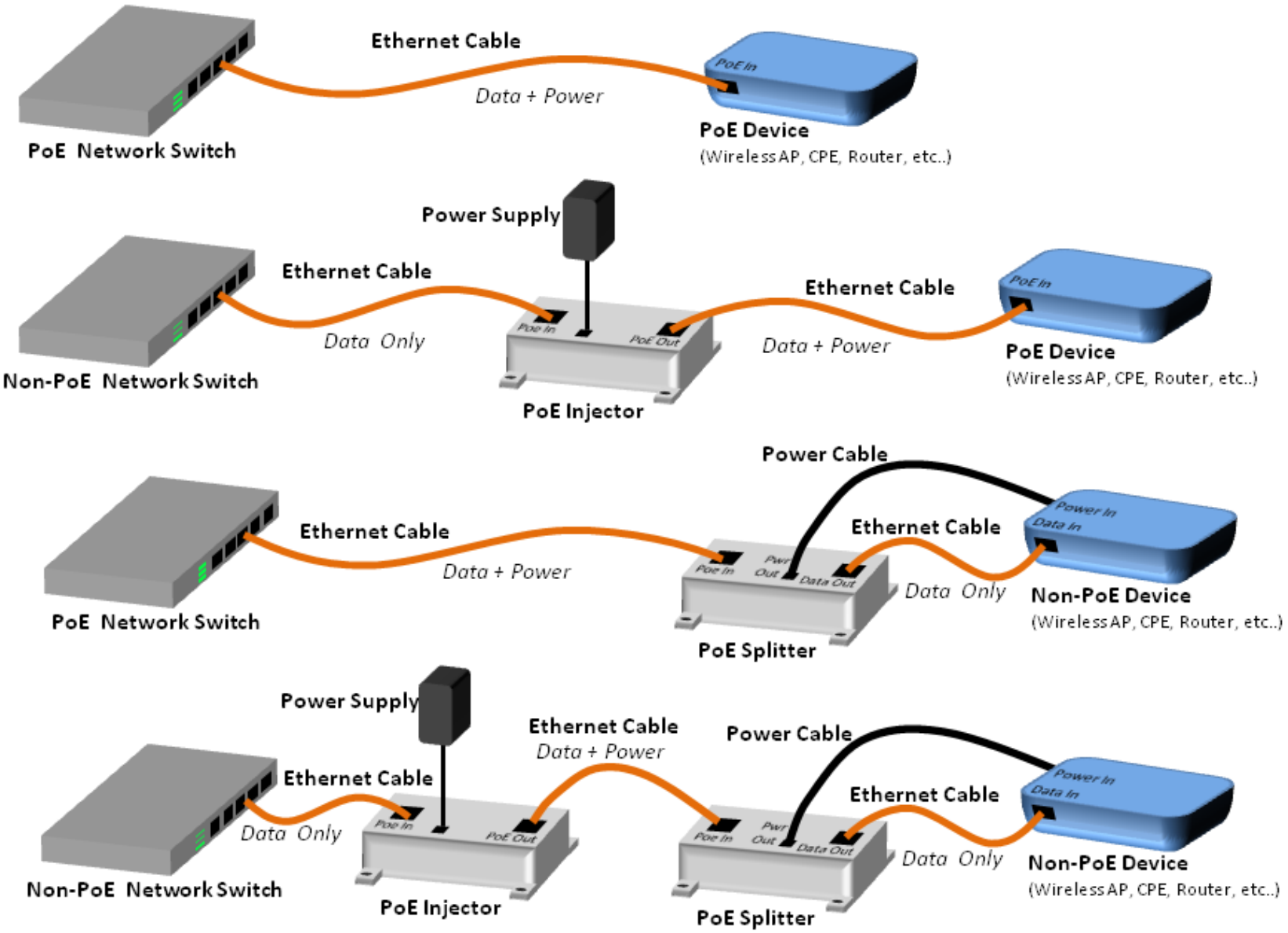


Phantom-Injection
Mode B

PoE+ UPoE



PoE - Power in and out



Checksums, FCS and Co…

Error-dedection or Error-correction !?!

Which error will be recognized?

What do we really need?

- Parity
- Field-parity
- CRC (Cyclic Redundancy Check)
- Internet-checksum
- Hash

Parity

Data-word	Parity-bit	Type
1011.0111	0	even
1011.0111	1	odd (-even)
1011.0110	1	even
1011.0110	0	odd (-even)

Count all ones!!!

Data-word **+** Parity-bit

By changeing a bit-value also the parity will be changed
→ Hamming-distance = 2

Field-parity

1	1	0	0	0
1	0	0	1	0
0	1	1	1	1
1	0	0	0	1
1	0	1	0	P

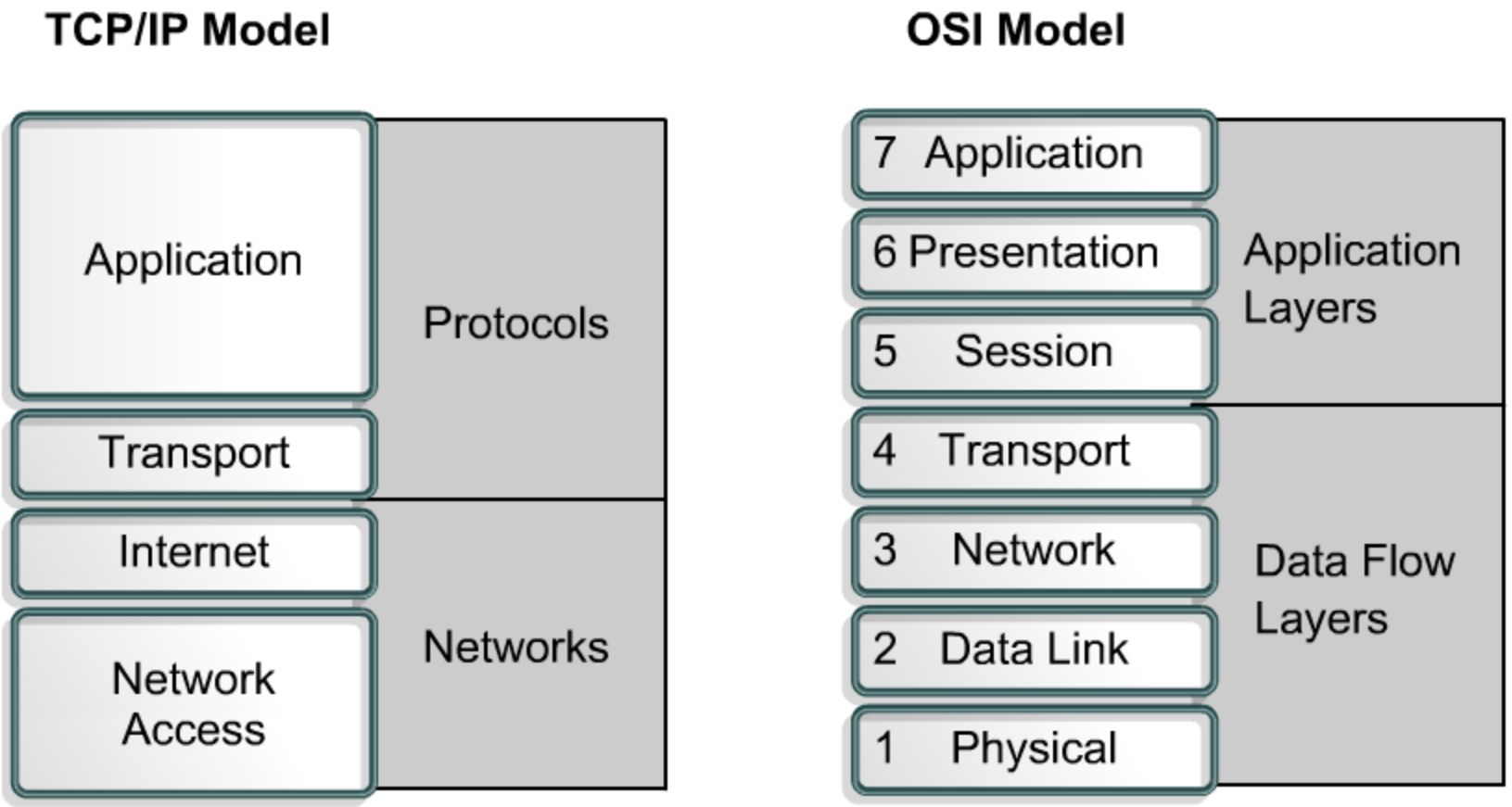
Hamming-distance = 3

Layer 3 Protocols

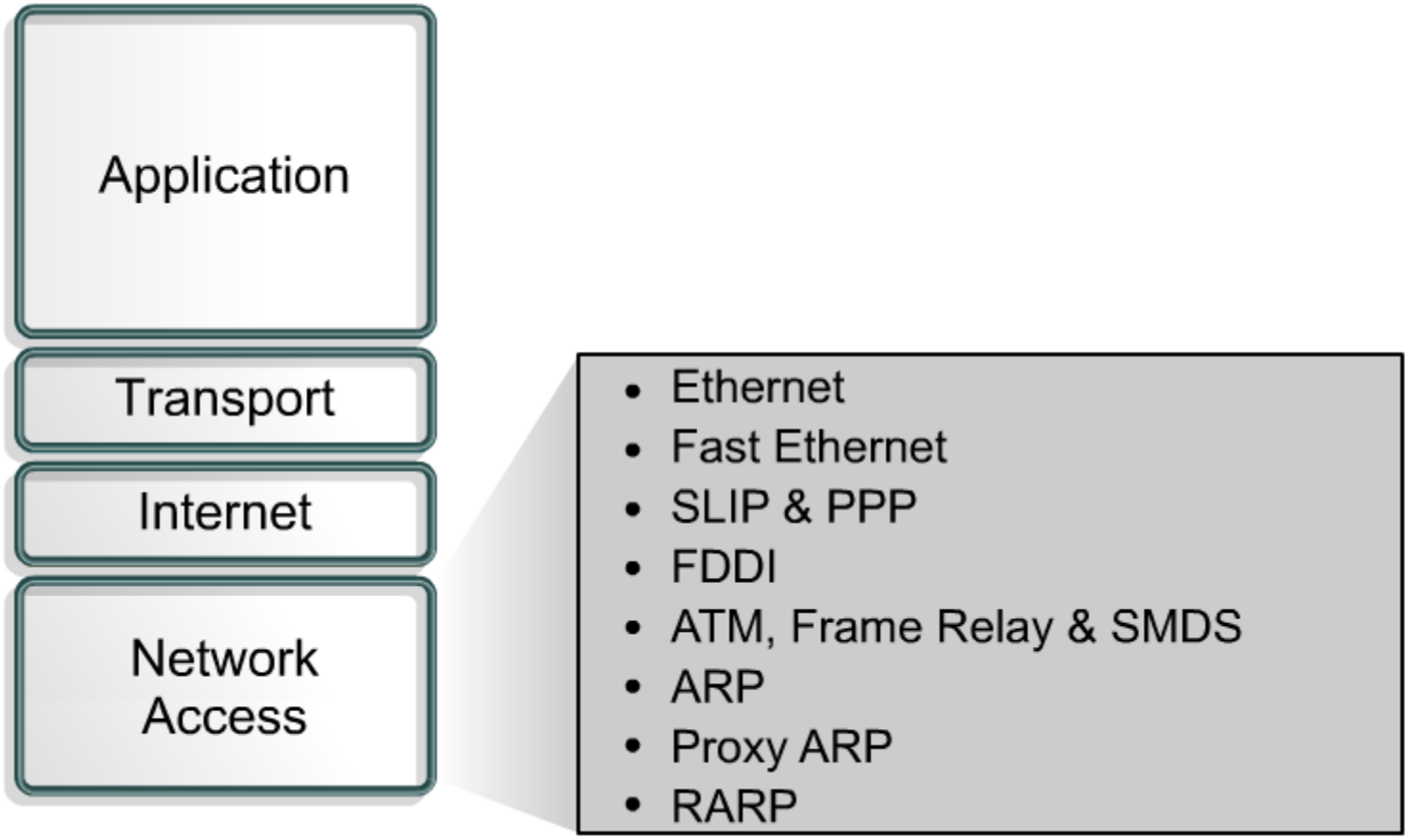
Layer-3 Function → Path-determination (Routing): different networks!!!

- Layer-3 functionality:
  - Apple Talk
  - IPX (IPX/SPX from Novell)
  - IP (TCP/IP)
- NO Layer-3 functionality:
  - NetBEUI (Microsoft)
  - …

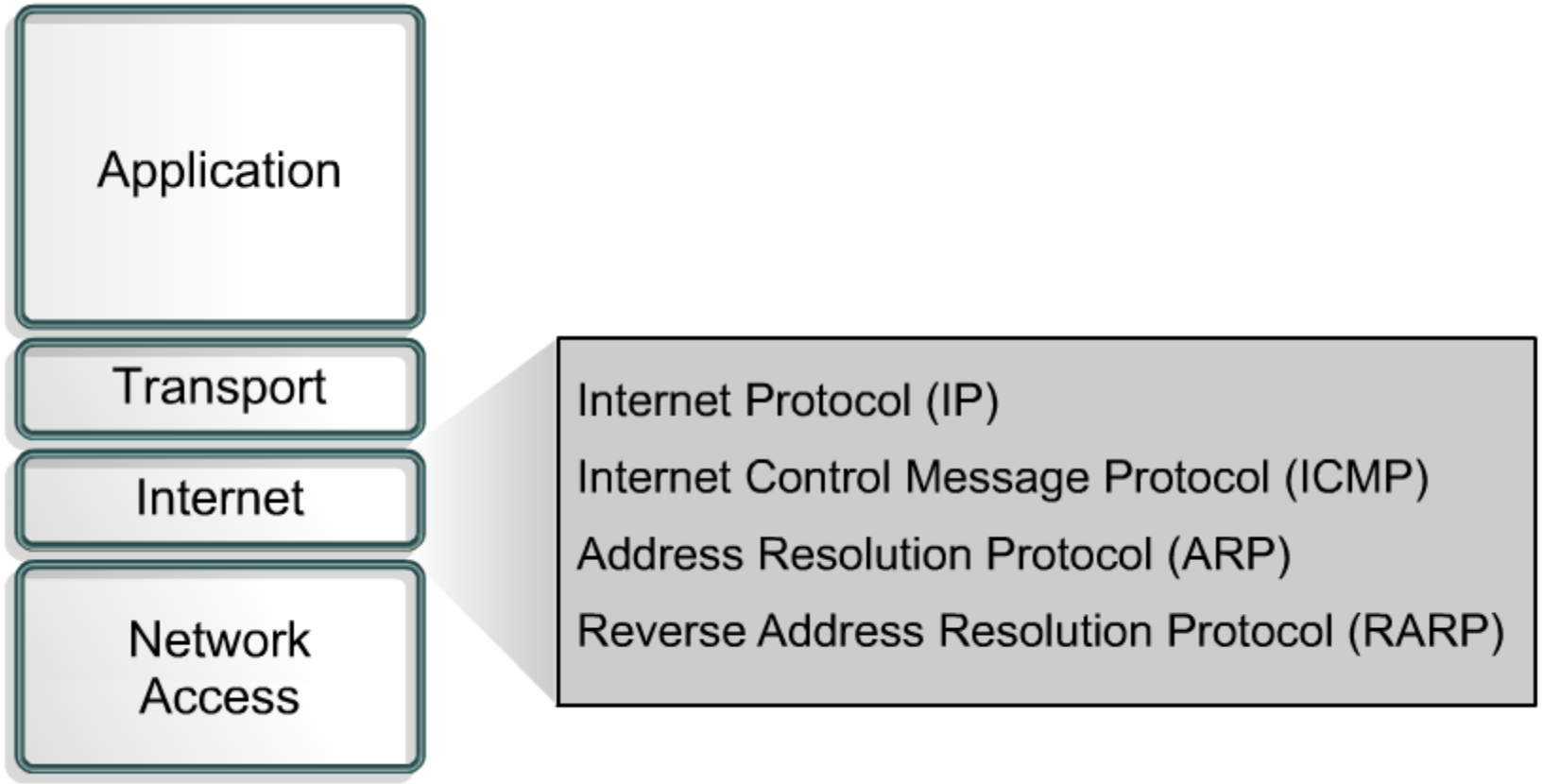
TCP/IP layer-model



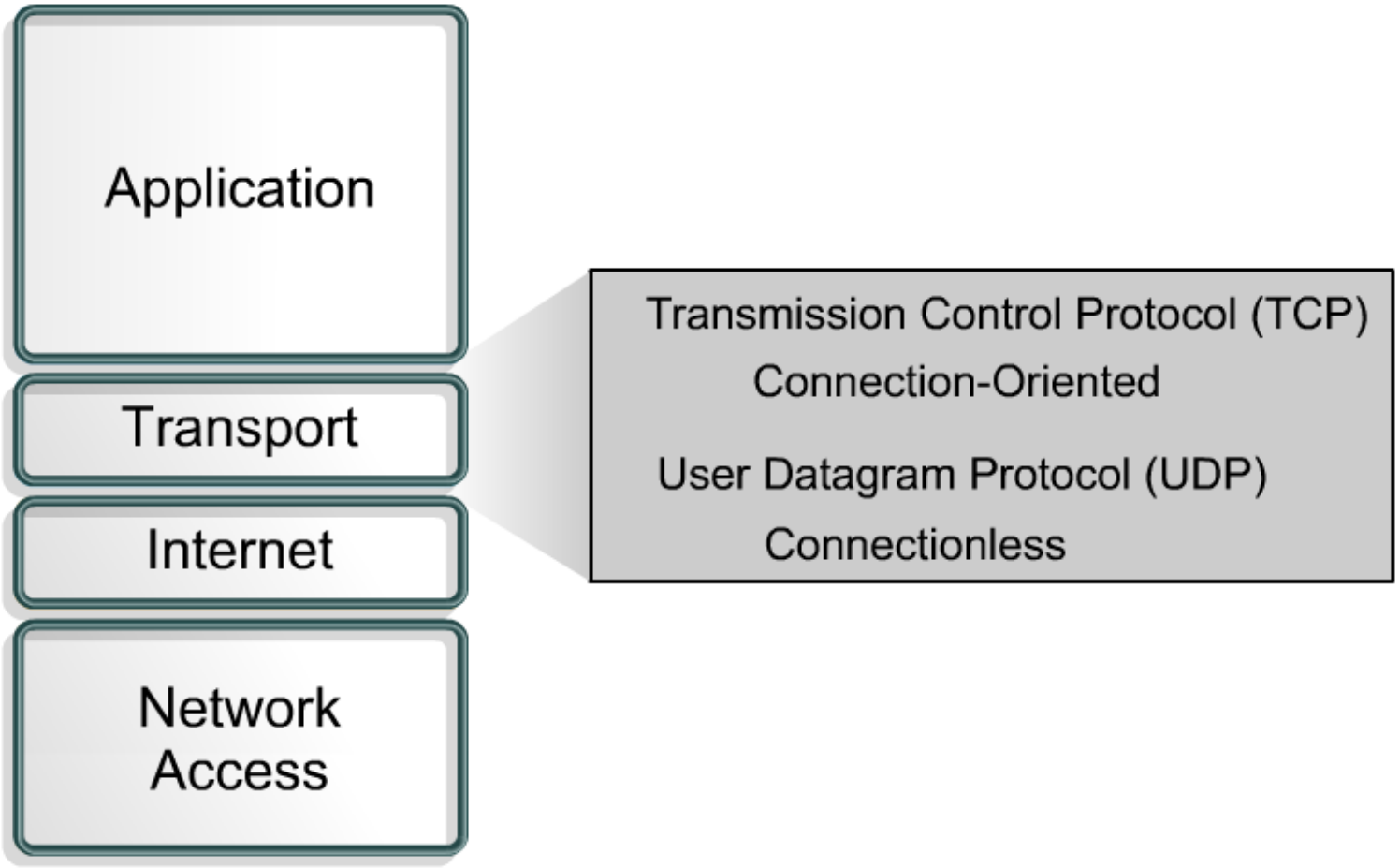
Network-Access Protocols



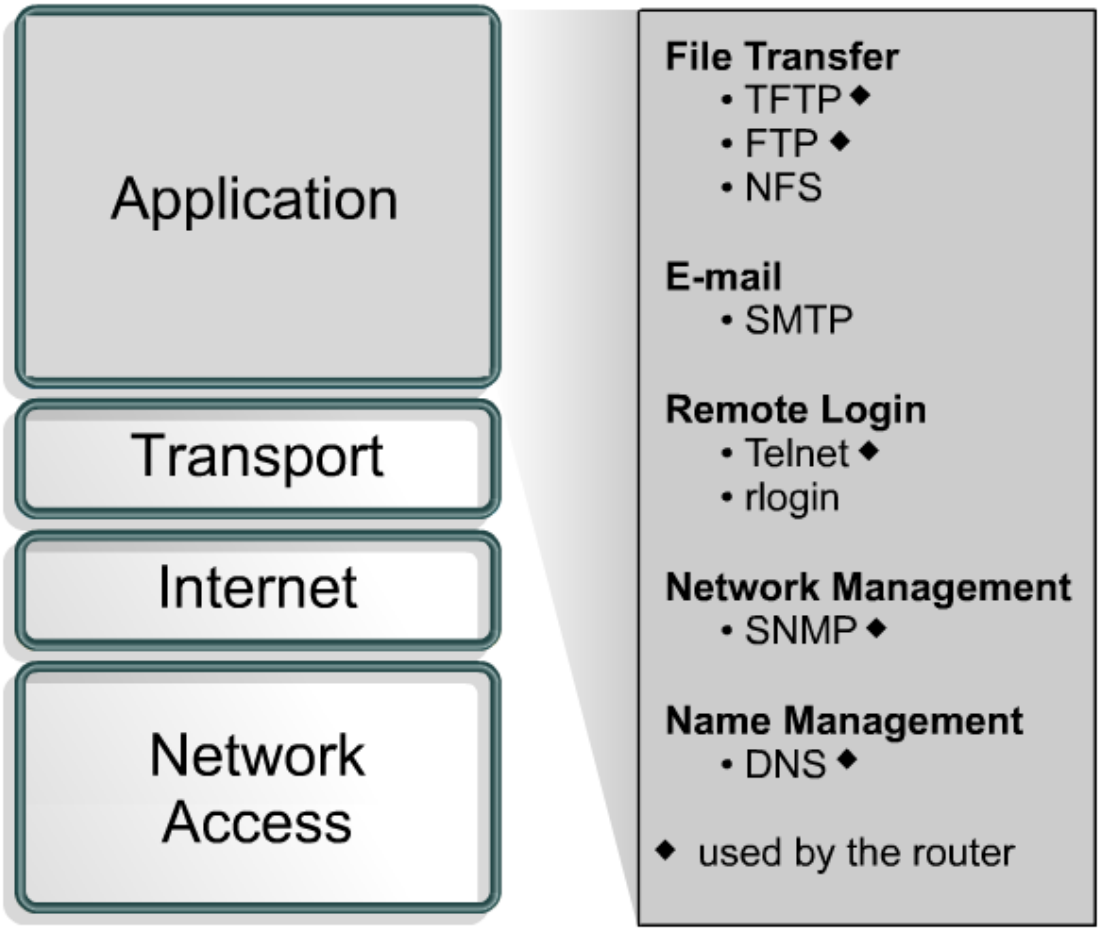
Internet-Layer Protocols



Transport-Layer Protocols



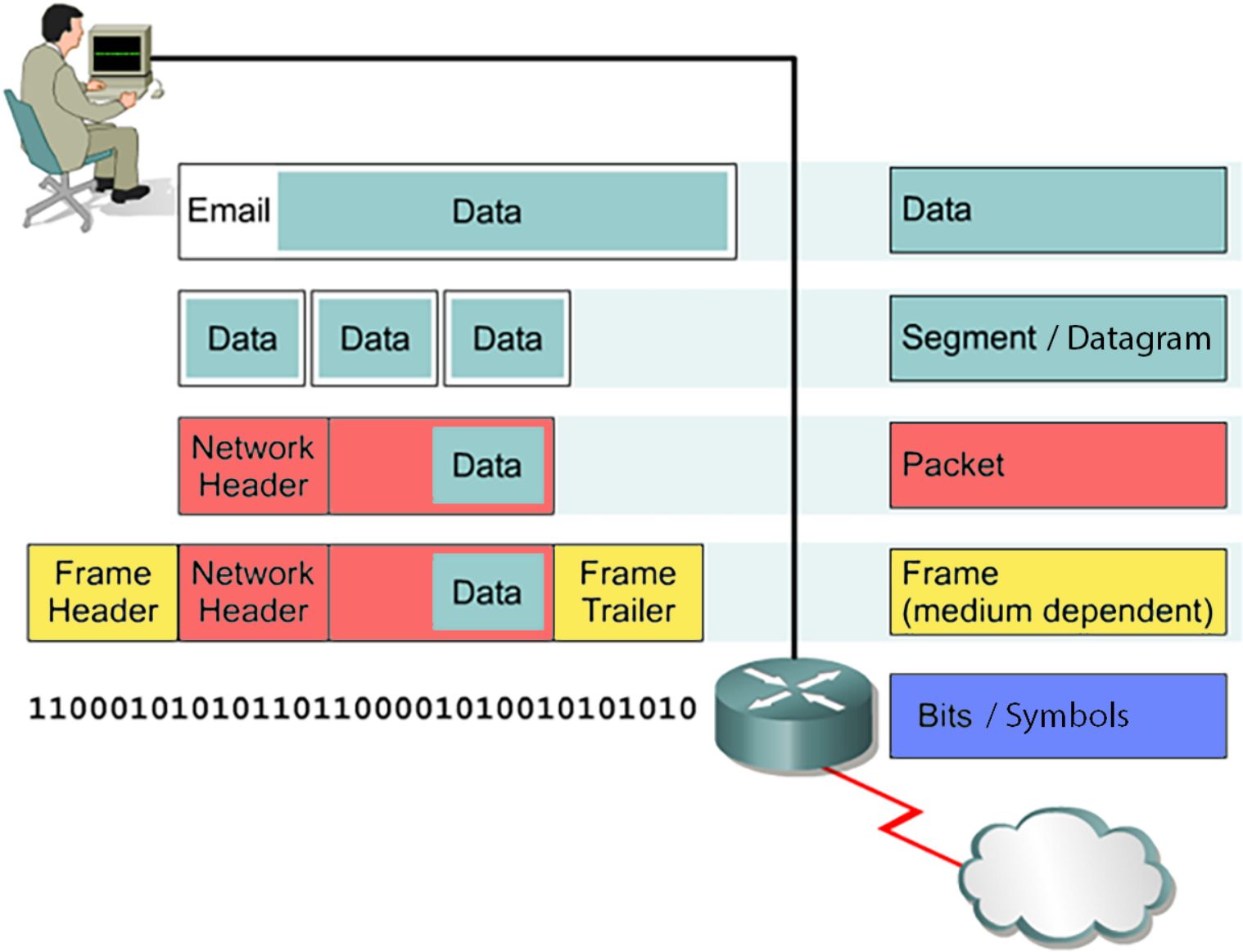
Application-Layer Protocols



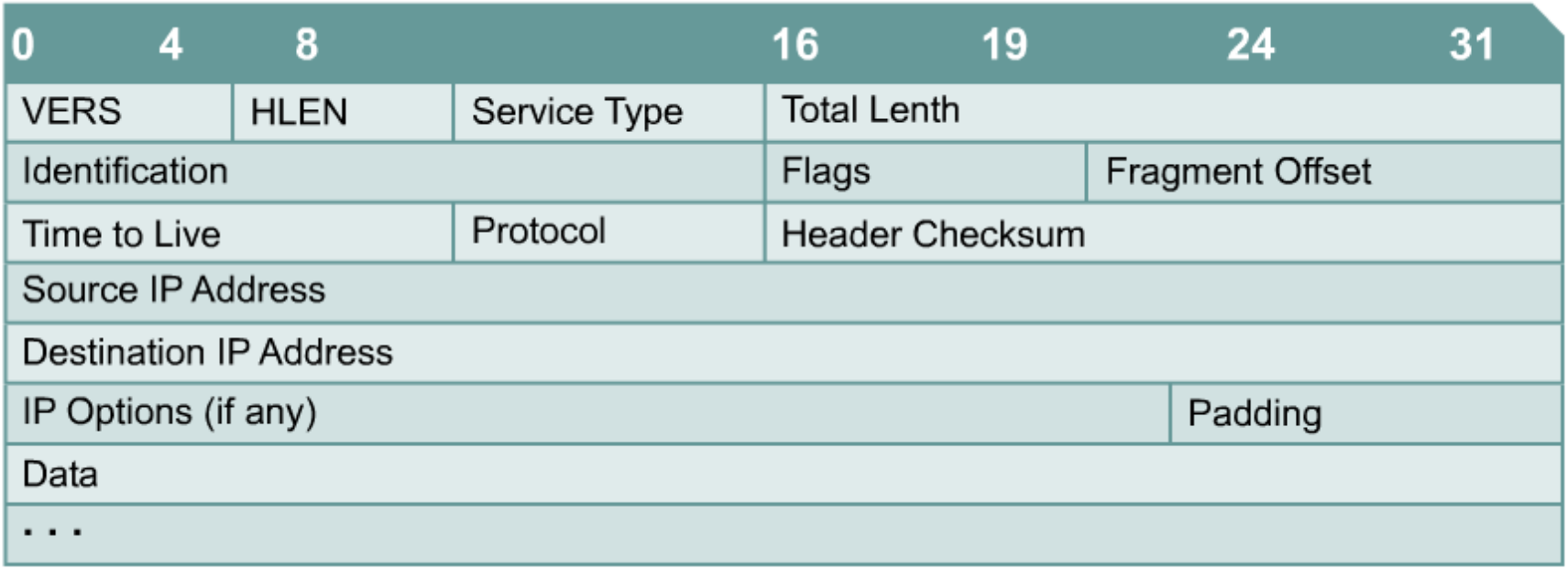
IP-Addresses

- MAC:
  - Flat, but unique
  - No logical mapping to networks
  - Nearly impossible for us to remember
- IP:
  - seperation in networks/(Subnets)/Hosts
  - Logical system ☺ … ☹ (Administrator)
  - Problem of beeing unique

IP-Packet inside OSI-Model



Layer3-PDU: the IP-Packet



IP-Packet

- **Version** – Indicates the version of IP currently used; four bits. If the version field is different than the IP version of the receiving device, that device will reject the packets.
- **IP header length (HLEN)** – Indicates the datagram header length in 32-bit words. This is the total length of all header information, accounting for the two variable-length header fields.
- **Type-of-service (TOS)** – Specifies the level of importance that has been assigned by a particular upper-layer protocol, eight bits.
- **Total length** – Specifies the length of the entire packet in bytes, including data and header, 16 bits. To get the length of the data payload subtract the HLEN from the total length.
- **Identification** – Contains an integer that identifies the current datagram, 16 bits. This is the sequence number.
- **Flags** – A three-bit field in which the two low-order bits control fragmentation. One bit specifies whether the packet can be fragmented, and the other specifies whether the packet is the last fragment in a series of fragmented packets.
- **Fragment offset** – Used to help piece together datagram fragments, 13 bits. This field allows the previous field to end on a 16-bit boundary.
- **Time-to-live (TTL)** – A field that specifies the number of hops a packet may travel. This number is decreased by one as the packet travels through a router. When the counter reaches zero the packet is discarded. This prevents packets from looping endlessly.
- **Protocol** – indicates which upper-layer protocol, such as TCP or UDP, receives incoming packets after IP processing has been completed, eight bits.
- **Header checksum** – helps ensure IP header integrity, 16 bits.
- **Source address** – specifies the sending node IP address, 32 bits.
- **Destination address** – specifies the receiving node IP address, 32 bits.
- **Options** – allows IP to support various options, such as security, variable length.
- **Padding** – extra zeros are added to this field to ensure that the IP header is always a multiple of 32 bits.
- **Data** – contains upper-layer information, variable length up to 64 Kb.

IPv6 Addresses

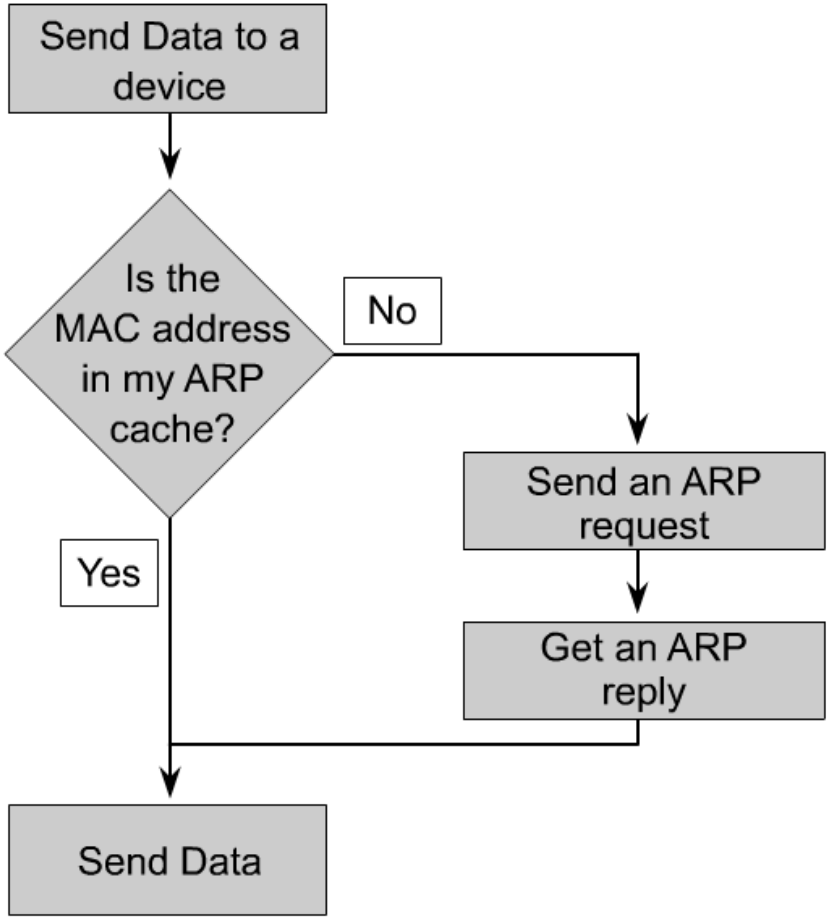
My subnet is bigger than your Internet!

- There are $2^{128} = 3.4*10^{35}$ IPv6 addresses!!
- It‘s about $6.6*10^{18}$ addresses per m² Earth
- 2711:CD87:ABCD:FAFA:0000:0000:0000:540B
- simplified: 2711:CD87:ABCD:FAFA:540B
- old IPv4: 0:0:0:0:0:FFFF:7F00:0001
- BUT: you are not the owner of your IP-address!

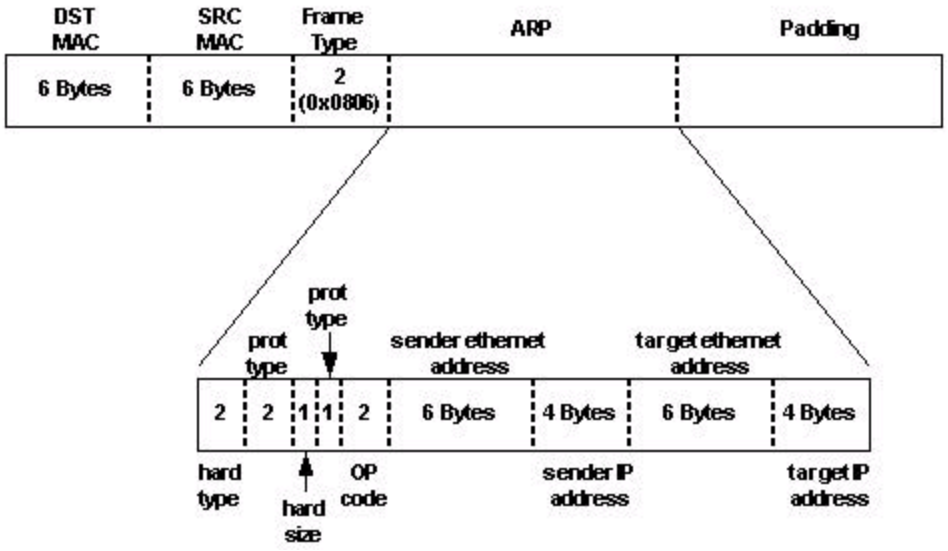
IPv6 Header

- **DescriptionVersion** 4Bit
- IP-version of this packet.
- **Priority** 4Bit
- Value of priority of this packet.
- **Flow Label** 24Bit
- the Flow Label marks packets for faster routing. (The MPLS will make this obsolete)
- **Data-length** 16Bit
- Exact size of data in payload-field. (must be calculated IPv4)
- **Next Header** 8Bit
- What protocol ise used inside payload-field. (IPv4 –name: Protokoll)
- **Hop Limit** 8Bit
- Exactly like IPv4 TTL-Field.
- **Source-IP-Address** 128Bit
- Transmitters IP-Address.
- **Destination-IP-Address** 128Bit
- Receivers IP-Address.
- **IPv6-Header-Extensions, all 64 Bit (8 Byte)**
- Optional informations in separately header added to IP-header. This informations will be normally ignored by routers.

Address-Resolution-Protocol



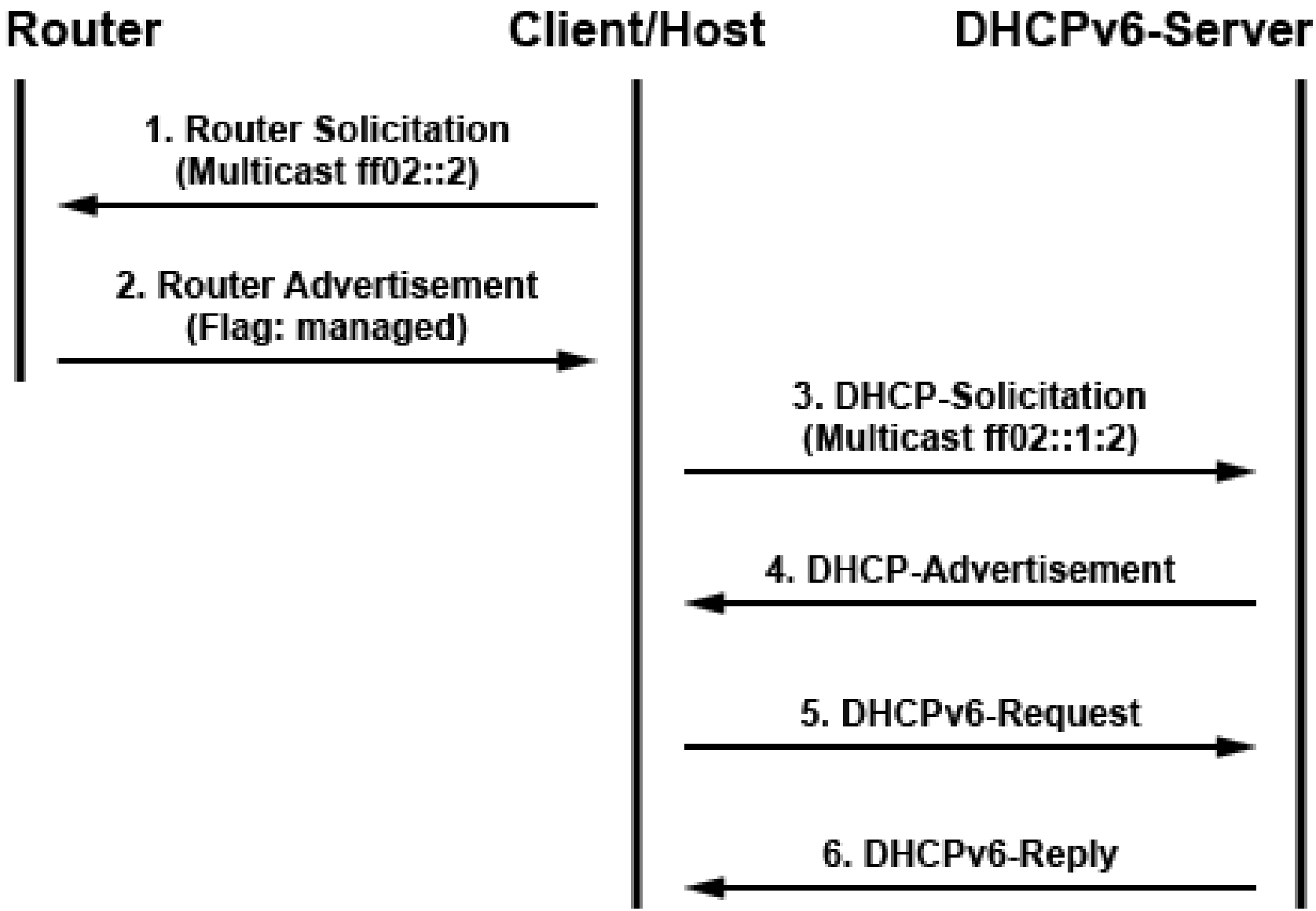
ARP in Ethernet-Frame



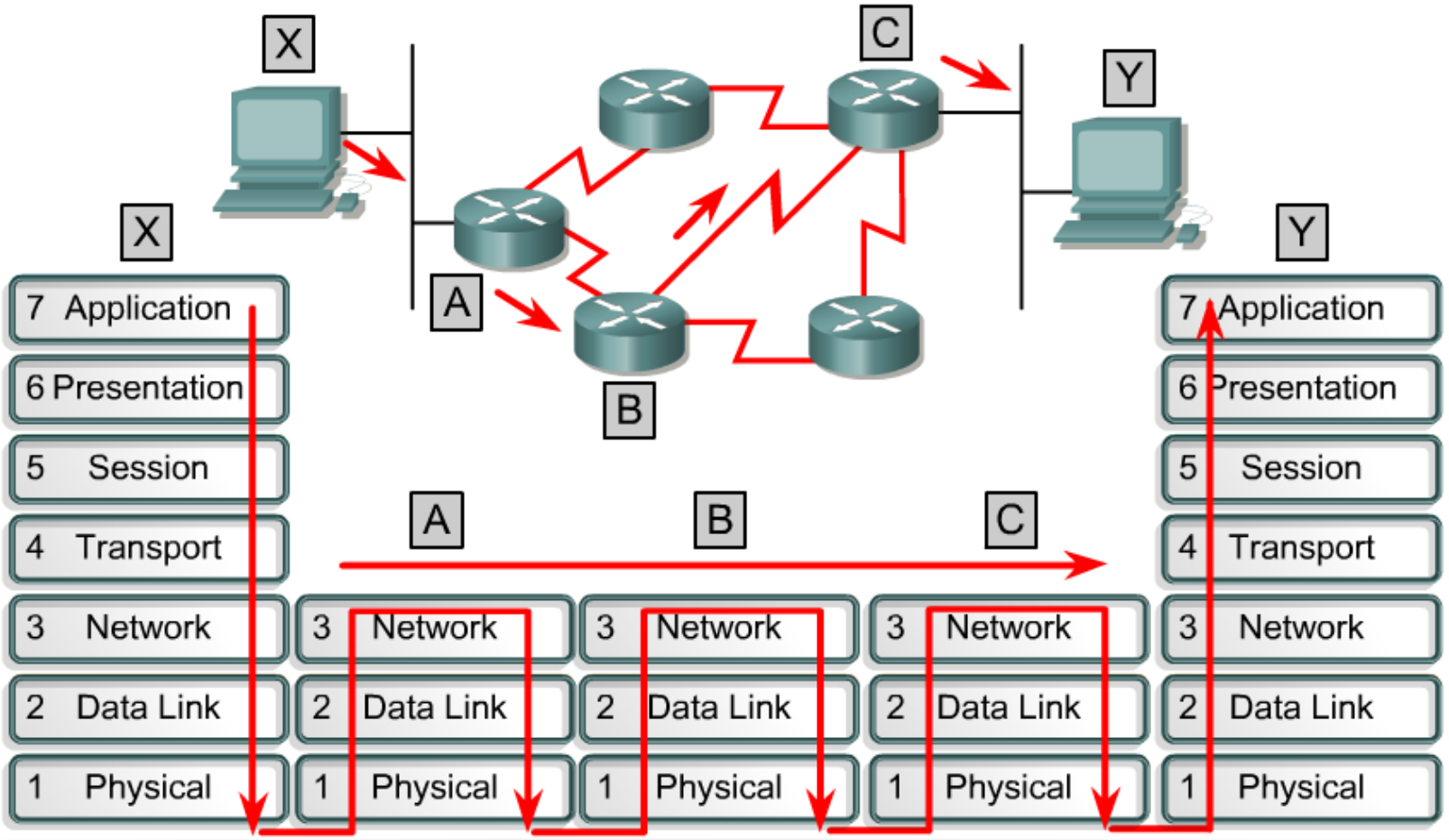
Getting an IP-Address

- Static (manually at each host)
- Dynamic (per protocol)
  - RARP (Reverse ARP)
    - IP-Address ONLY
  - BOOTP (Bootstrap Protocol)
    - IP-Adr. Router-Adr. Server-Adr. Extended data
  - DHCP (Dynamic Host Configuration Protocol)
    - like BOOTP + more addresses…
    - Server is dynamic - no fixed tables needed!

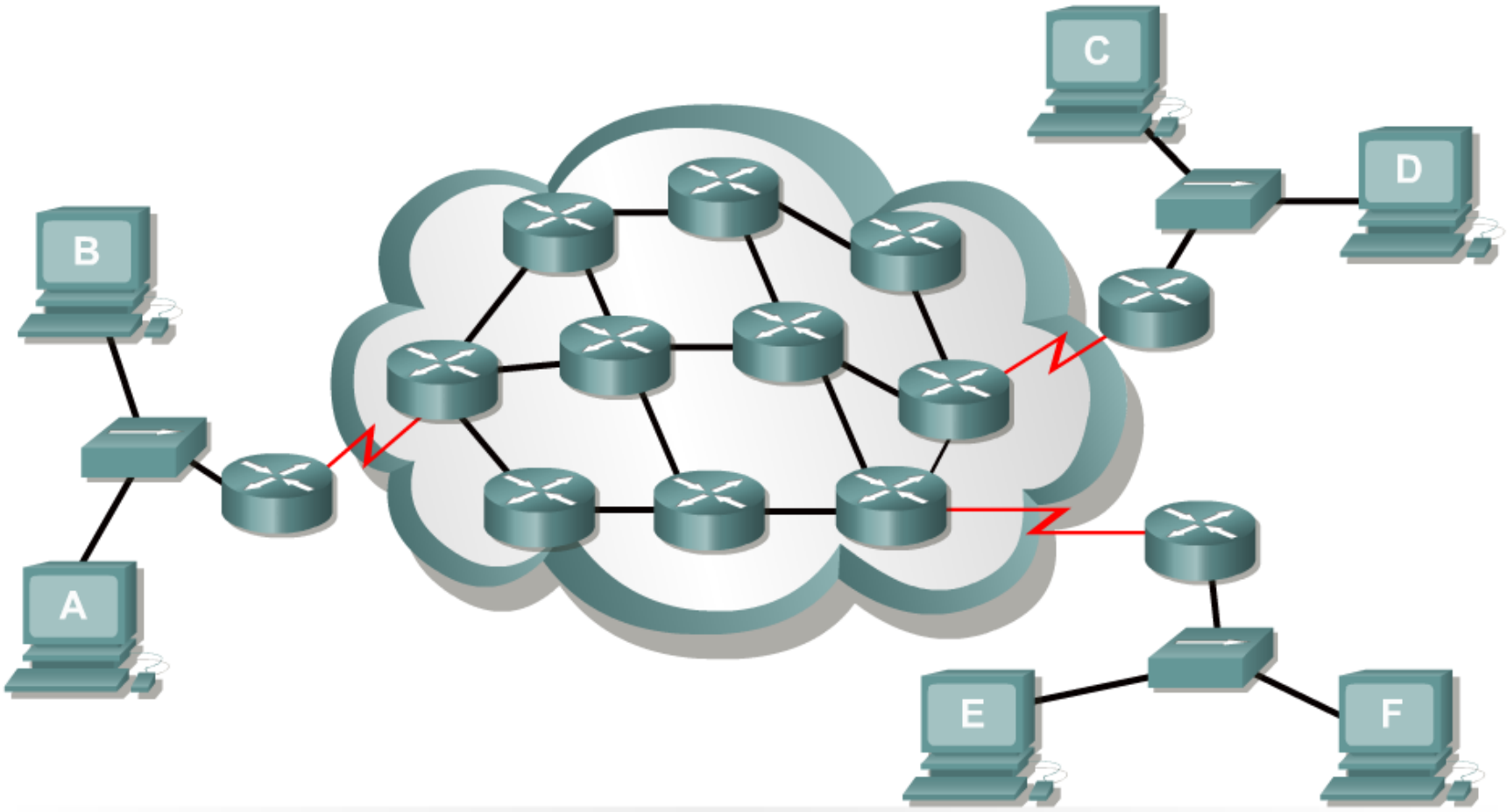
DHCP / auto-configuration



An ordinary transport…



Why Routing?



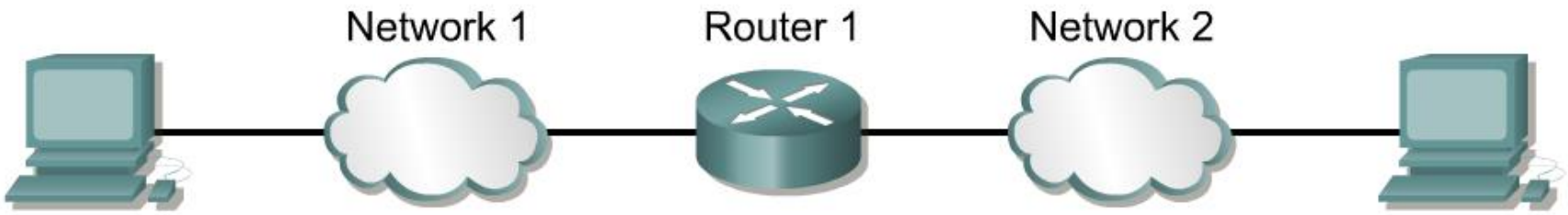
Routing

- Static manually by administrator
- Dynamic automatically by routing-protocol
  - Internal IGP
  - External EGP

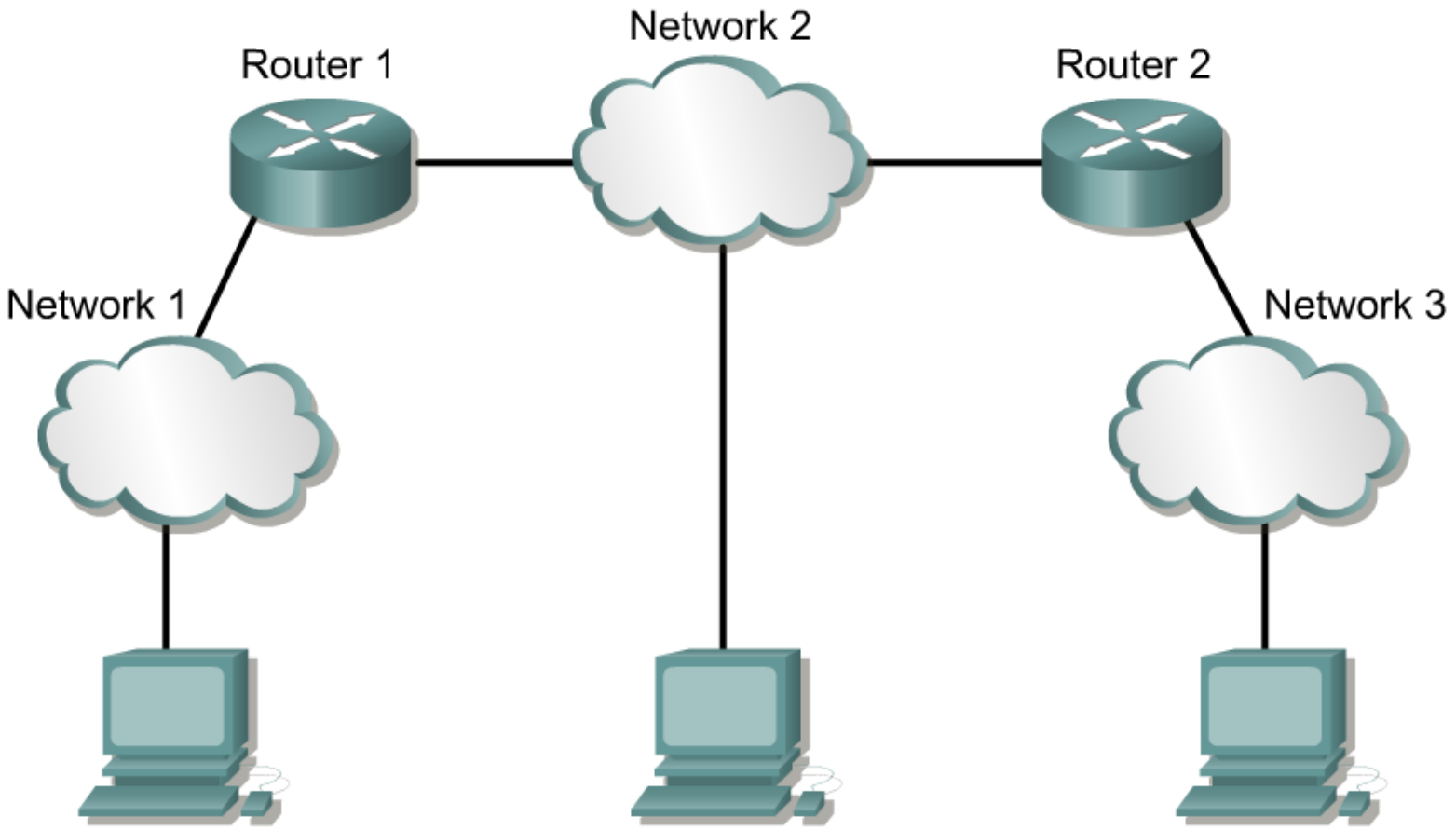
Types:

Distance-Vector	(RIP, IGRP…)
Hybrid	(EIGRP…)
Link-State	(OSPF, BGP…)

Adresses 1

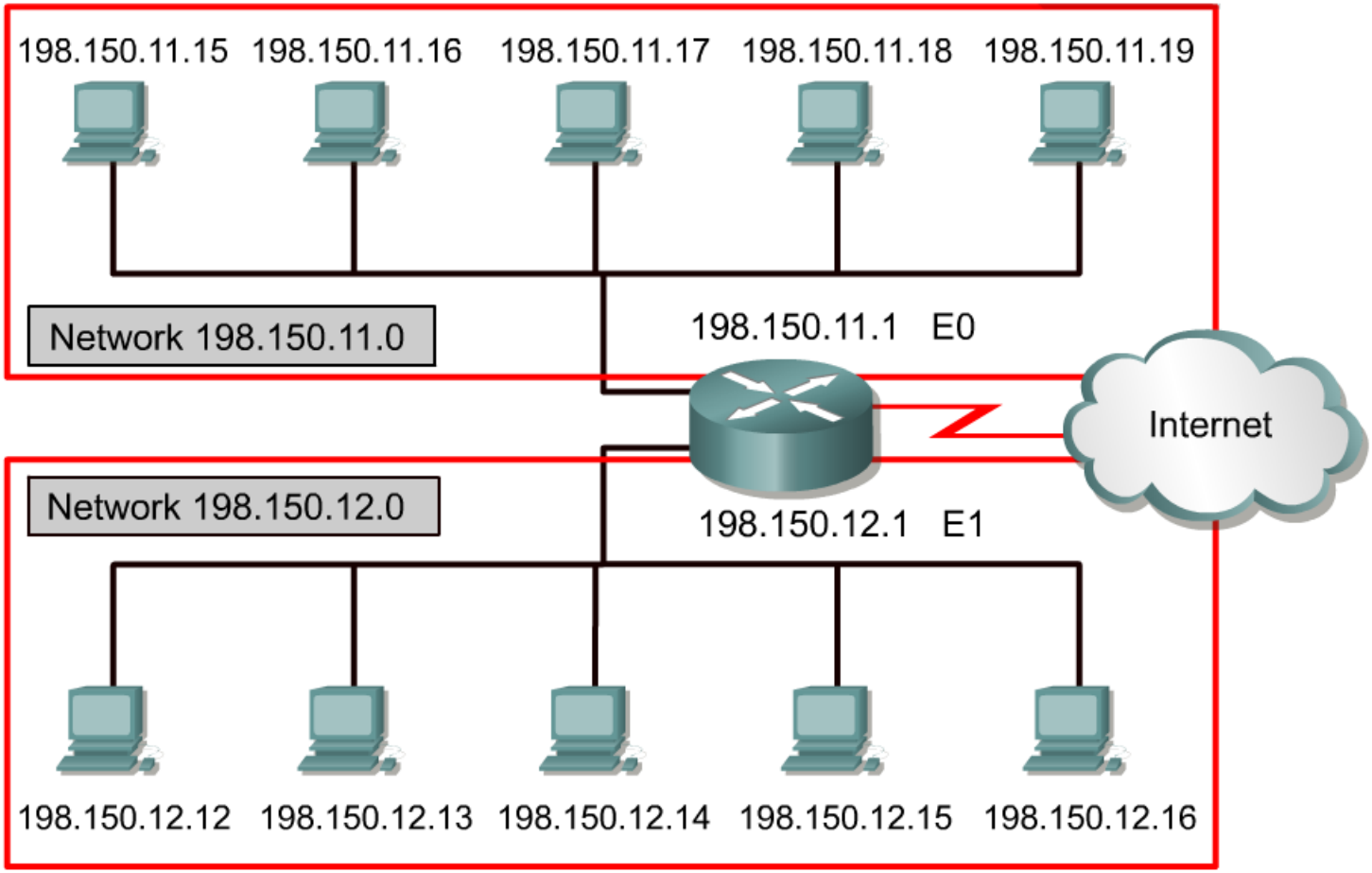


Adresses 2

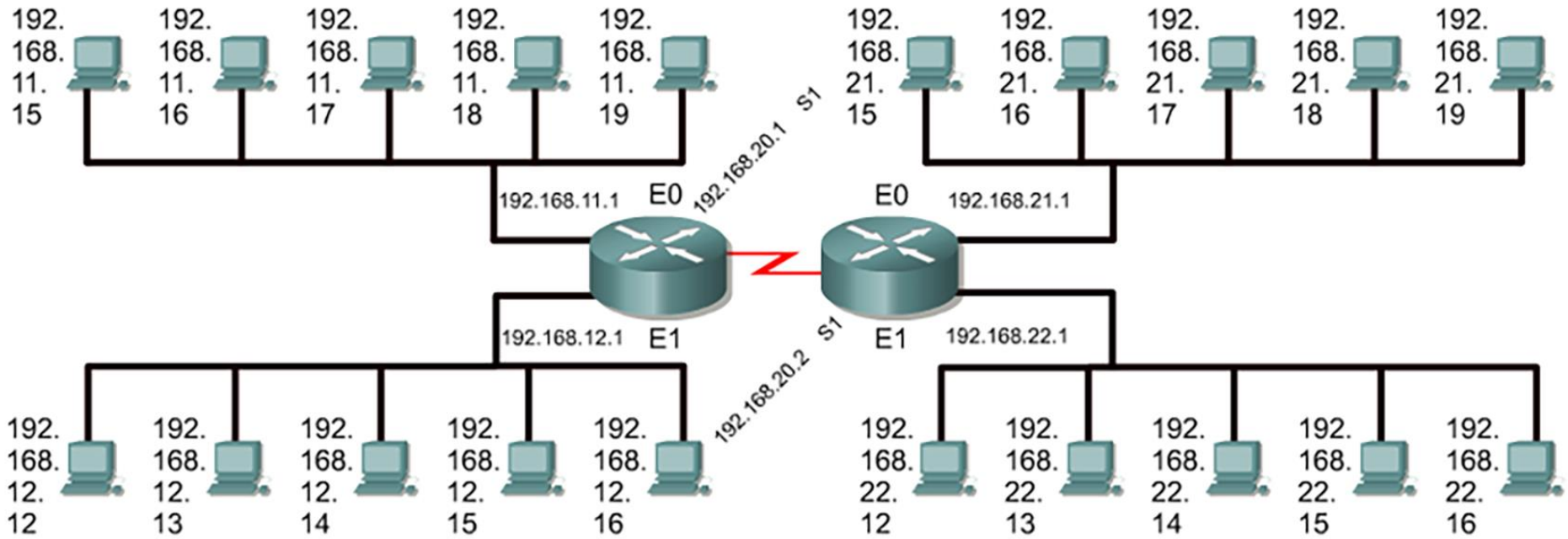


Default-route

Gateway of last resort 0.0.0.0



Routing tables



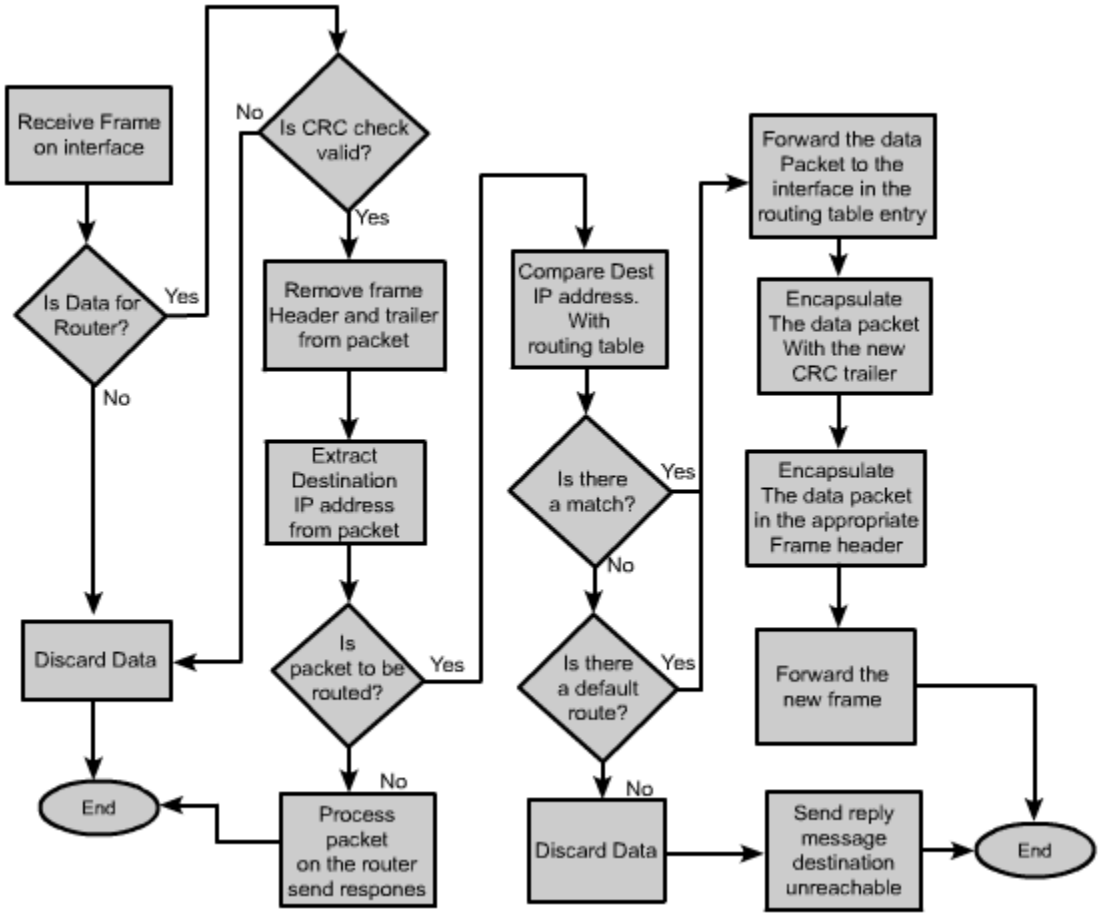
Routing Table

Learned	Network Address	Hop	Interface
C -	192.168.11.0	0	E0
C -	192.168.12.0	0	E1
C -	192.168.20.0	0	S0
R -	192.168.21.0	1	S0
R -	192.168.22.0	1	S0

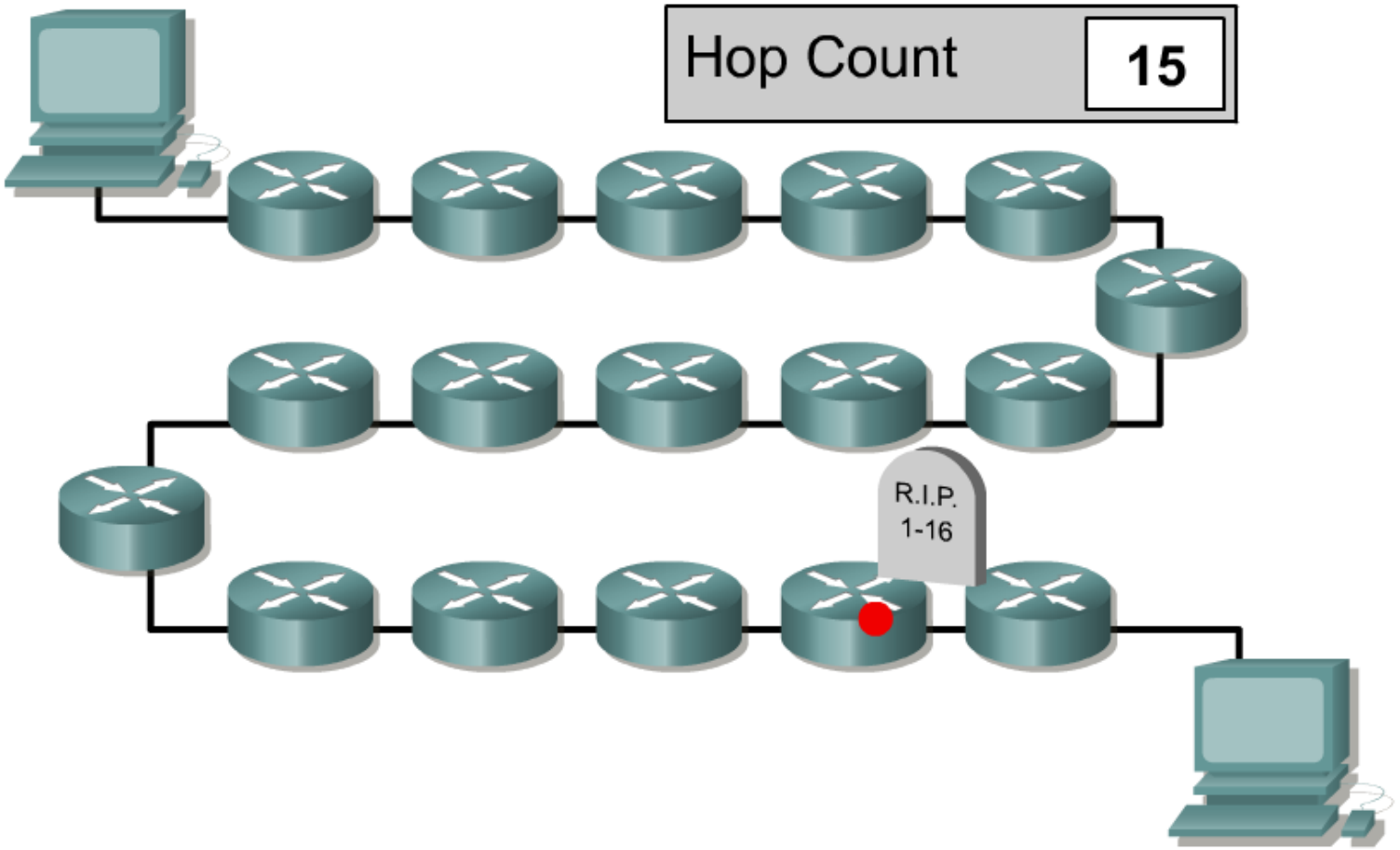
Routing Table

Learned	Network Address	Hop	Interface
C -	192.168.21.0	0	E0
C -	192.168.22.0	0	E1
C -	192.168.20.0	0	S1
R -	192.168.11.0	1	S1
R -	192.168.12.0	1	S1

Routing-process

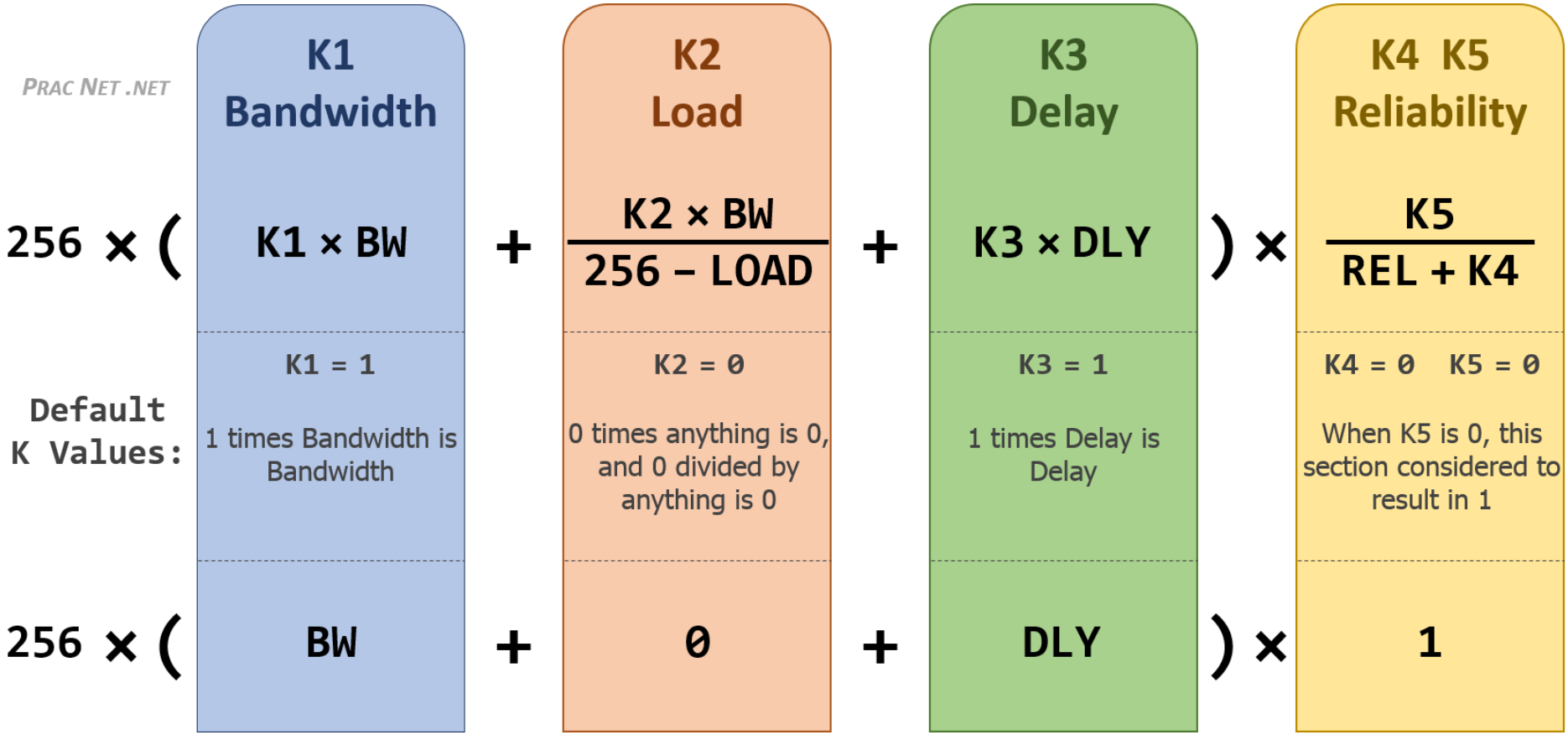


RIP



Metric calculation

- Example: **EIGRP**



Metric calculation: EIGRP

$$\left[\left(K_1 \cdot \text{Bandwidth}_E + \frac{K_2 \cdot \text{Bandwidth}_E}{256 - \text{Load}} + K_3 \cdot \text{Delay}_E\right) \cdot \frac{K_5}{K_4 + \text{Reliability}}\right] \cdot 256$$

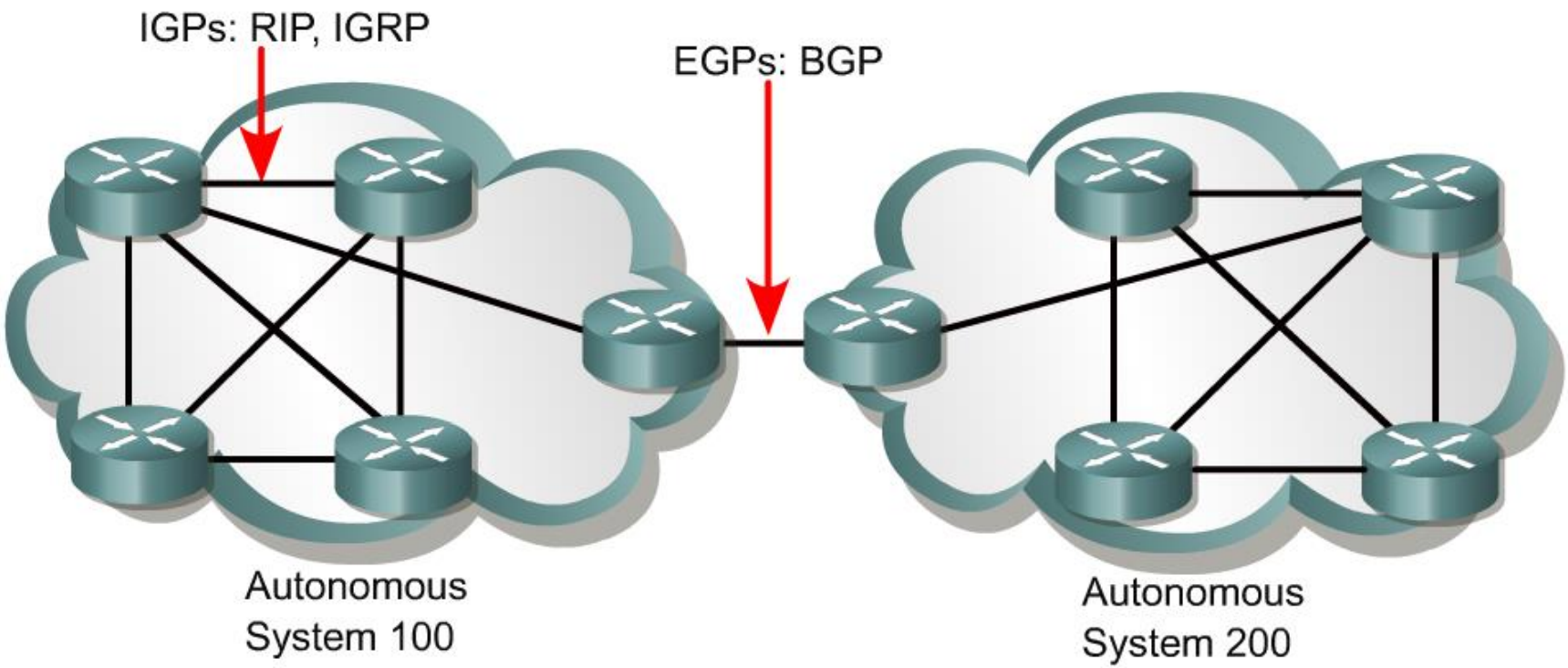
$$256 \cdot \left[\left(\frac{10^7}{100000}\right) + \left(\frac{100 + 100 + 5000\mu sec}{10}\right)\right]$$

$$= 256 \cdot \left[(100) + \left(\frac{5200}{10}\right)\right]$$

$$= 256 \cdot 620$$

$$= 158720$$ Woohoo, we got it!!

internal / external



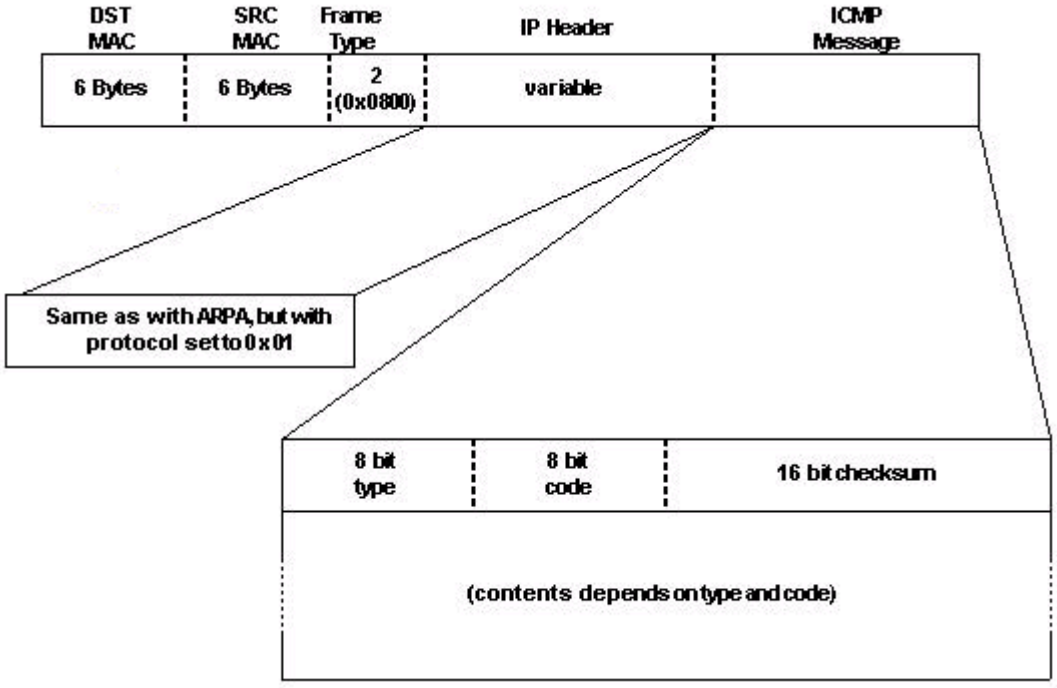
Administrative distance

Route Source	Default Distance Values
Connected interface	0
Static route	1
Enhanced Interior Gateway Routing Protocol (EIGRP) summary route	5
Internal Border Gateway Protocol (BGP)	20
Internal EIGRP	90
IGRP	100
OSPF	110
Intermediate System-to-Intermediate System (IS-IS)	115
Routing Information Protocol (RIP)	120
Exterior Gateway Protocol (EGP)	140
On Demand Routing (ODR)	160
External EIGRP	170
External Border Gateway Protocol (BGP)	200
Unknown*	255

ICMP

- Internet-Configuration-and-Management-Protocol
- Commands using ICMP:
  - Ping
  - Traceroute (tracert)
  - (pathping)
  - (Ipconfig)
  - (netstat)

ICMP in Ethernet-Frame



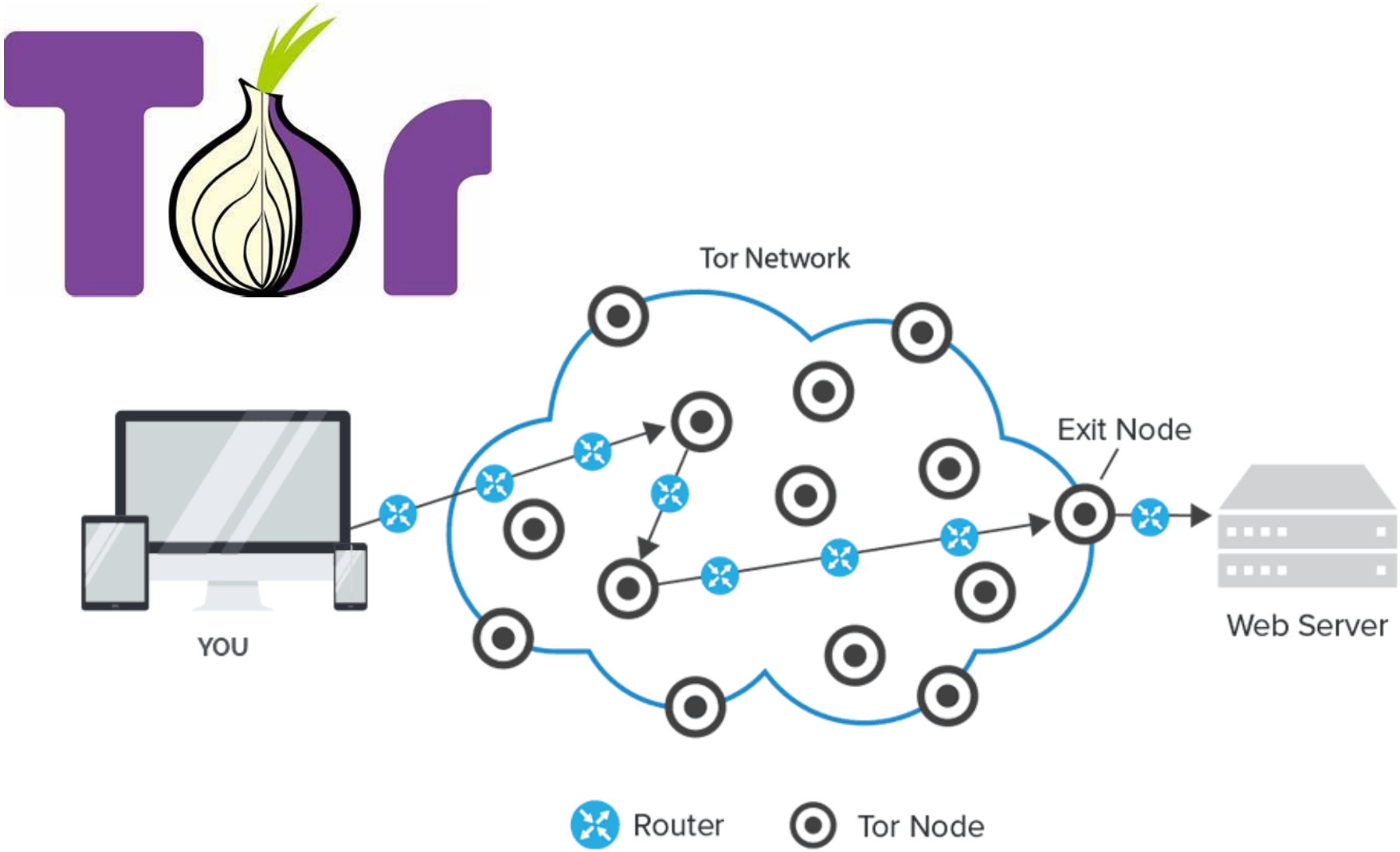
Intranet / Extranet – Internet?

- Problem: how to access from a internal (private) network to internet?
  - NAT / PAT (e.g. Home-router)
  - Masquerading
  - Proxy-Server
  - (VPN)

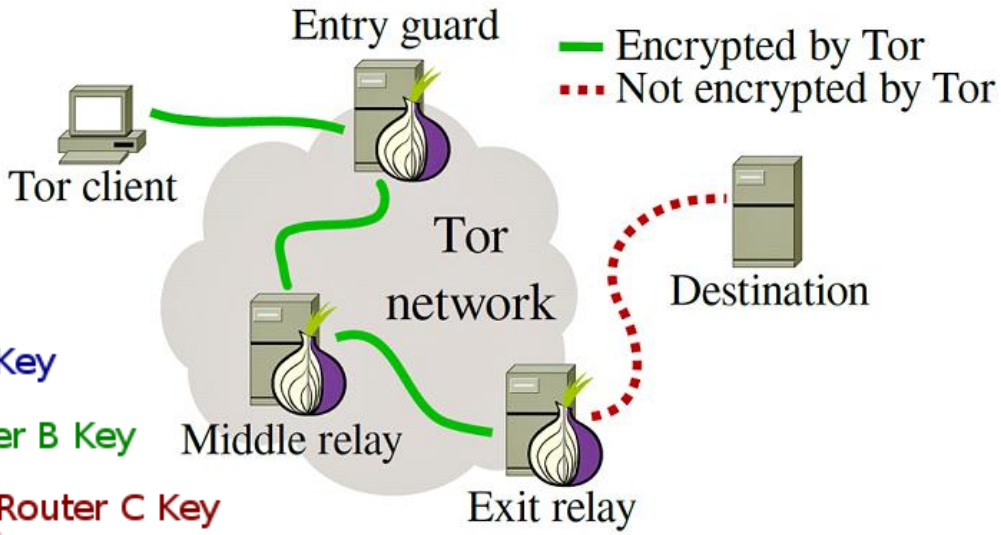
  Question: What should/must allowed/forbidden?

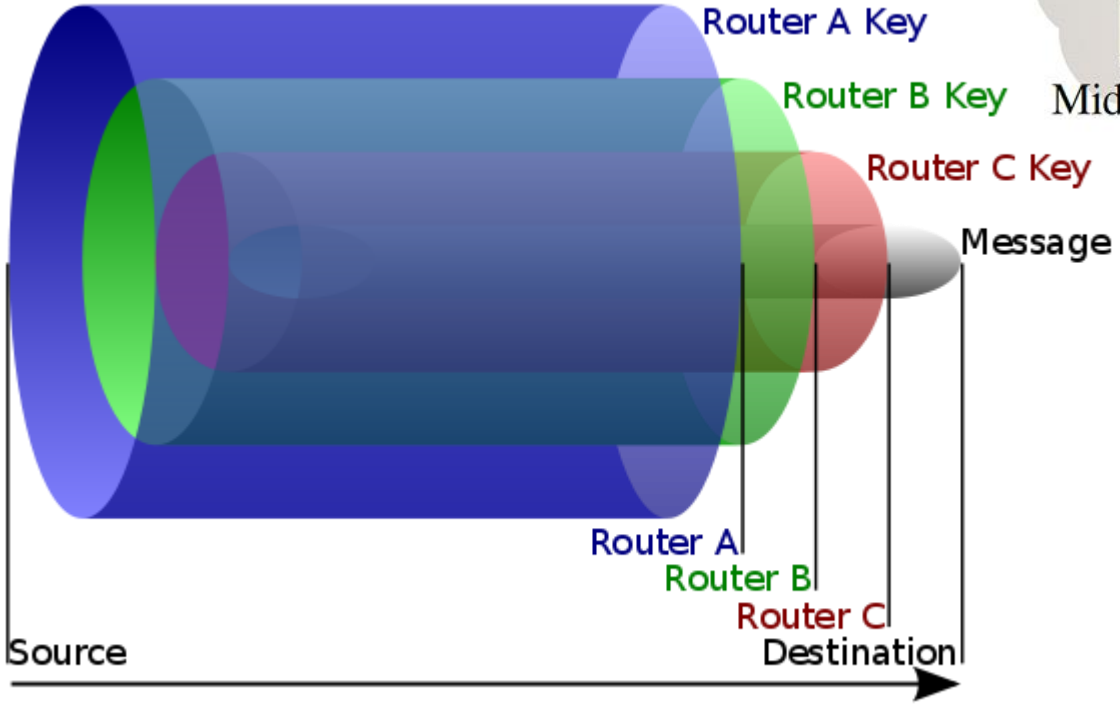
  → Firewall - Concepts

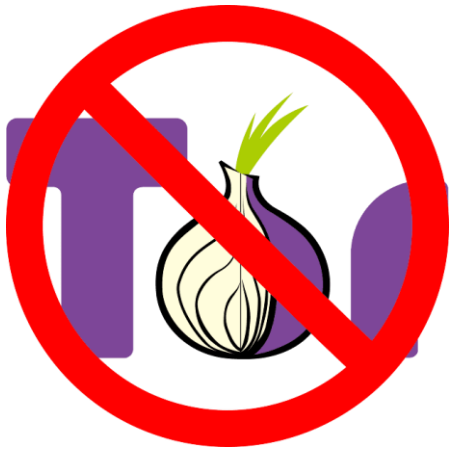
Tor = dark net?



Tor-Layers


Entry guard
Encrypted by Tor
Not encrypted by Tor
Tor client
Tor network
Destination
Middle relay
Exit relay


Router A Key
Router B Key
Router C Key
Message
Router A
Router B
Router C
Source
Destination



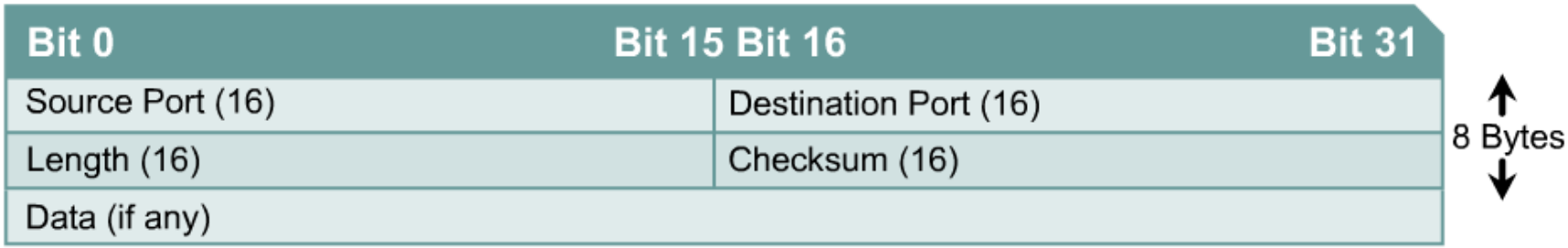
Transport-Layer

- Non reliable UDP
  - User Datagram Protocol
    - Must be transmitted as “it is”!!! → Datagrams
    - MTU-Size!!! (Maximum Transmission Unit – Payload-Size of IP-Packet)

- reliable TCP
  - Transmission Control Protocol
    - Able to be splitted in segments. → Segments

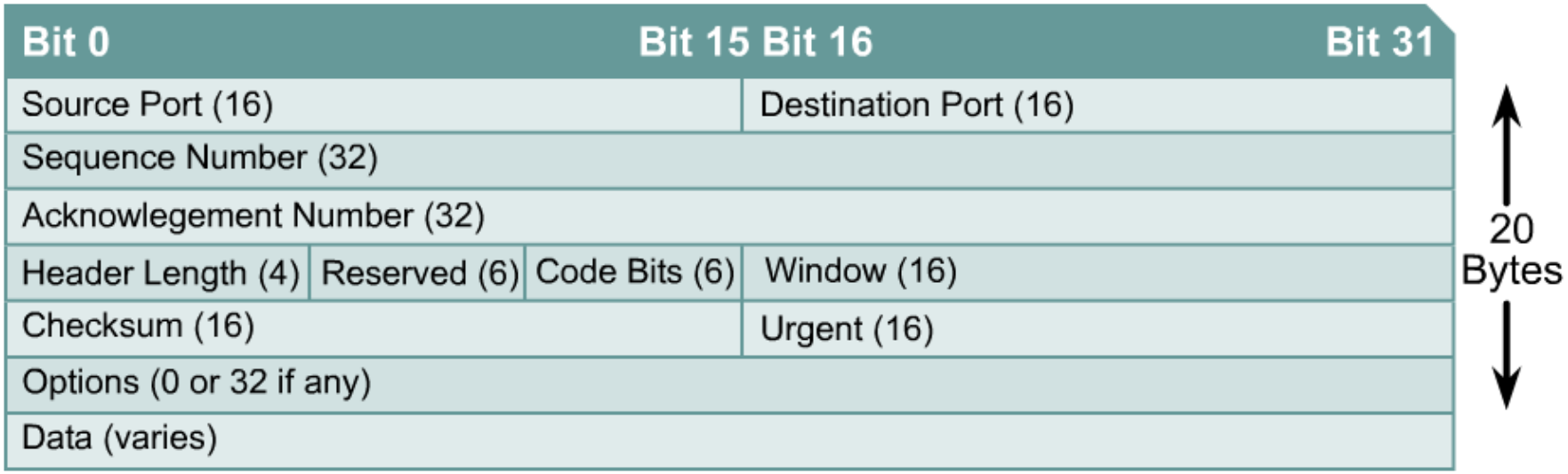
UDP

- Non reliable → no ackowledge!
  - Multicasting only here possible!!!
    - TFTP (Trivial File Transfer Protocol)
    - SNMP (Simple Network Management Protocol)
    - DHCP (Dynamic Host Control Protocol)
    - DNS (Domain Name System) – if message shorter 1 IP-Packet
    - Broadcasts
    - VoIP / IP-Audio / IP-TV



TCP

- Reliable - acknowledges / Data flow control
  - Three-Way-Handshaking / Sliding-Windowing
    - FTP (File Transfer Protocol)
    - HTTP (Hypertext Transfer Protocol)
    - SMTP (Simple Mail Transfer Protocol)
    - Telnet…
    - DNS – if message bigger 1 IP-Paket



Layer-4-Addresssystem - Ports

- Used by UDP and TCP
- addresses applications or services
- IP and Port → Socket
- RFC1700:

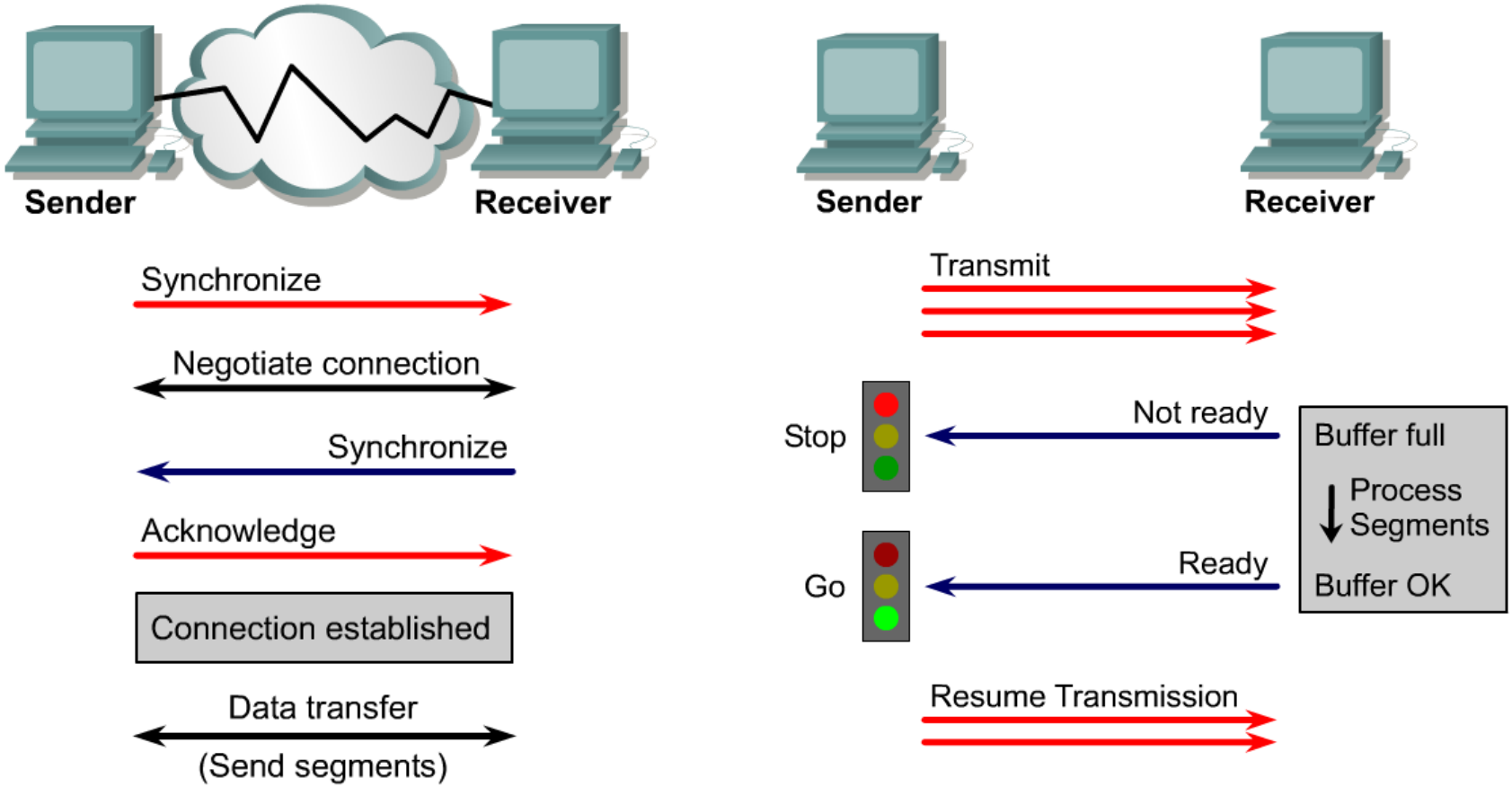
0-255	Public Applications
256-1023	comercial applications
1024-65535	Not defined

but some there are registered - means fixed!

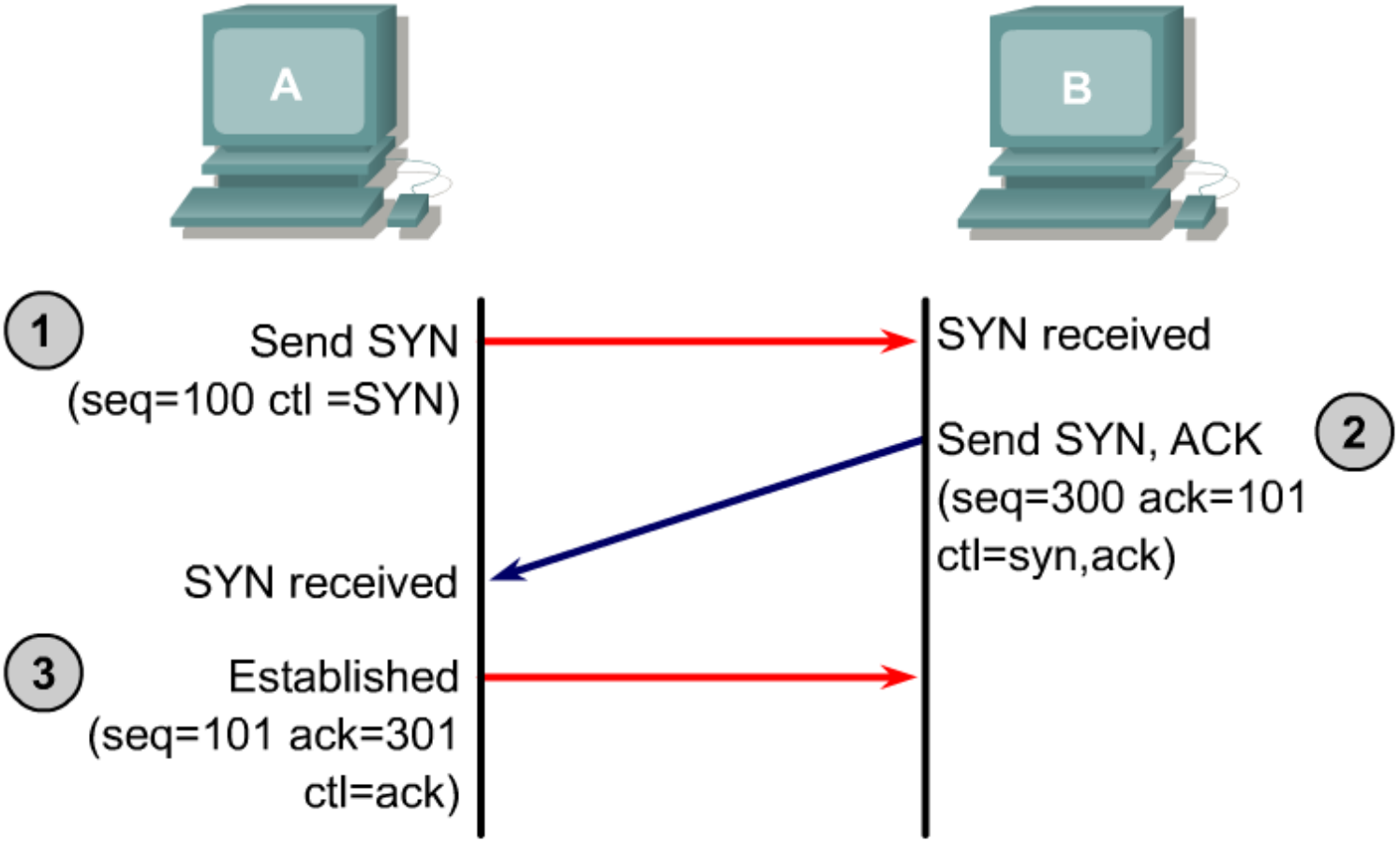
Some „well known“ Ports

Protocol	Port	Protocol	Port
FTP data port (active mode)	TCP 20	NetBIOS (TCP rarely used)	TCP/UDP 137
FTP control port	TCP 21	NetBIOS	UDP 138
SSH	TCP 22	NetBIOS	TCP 139
SCP (uses SSH)	TCP 22	IMAP4	TCP 143
SFTP (uses SSH)	TCP 22	LDAP	TCP 389
Telnet	TCP 23	HTTPS	TCP 443
SMTP	TCP 25	SMTP SSL/TLS	TCP 465
TACACS+	TCP 49	IPsec (for VPN with IKE)	UDP 500
DNS name queries	UDP 53	LDAP/SSL	TCP 636
DNS zone transfers	TCP 53	LDAP/TLS	TCP 636
TFTP	UDP 69	IMAP SSL/TLS	TCP 993
HTTP	TCP 80	POP SSL/TLS	TCP 995
Kerberos	UDP 88	L2TP	UDP 1701
POP3	TCP 110	PPTP	TCP 1723
SNMP	UDP 161	Remote Desktop Protocol (RDP)	TCP/UDP 3389
SNMP trap	UDP 162	Microsoft SQL Server	TCP 1433

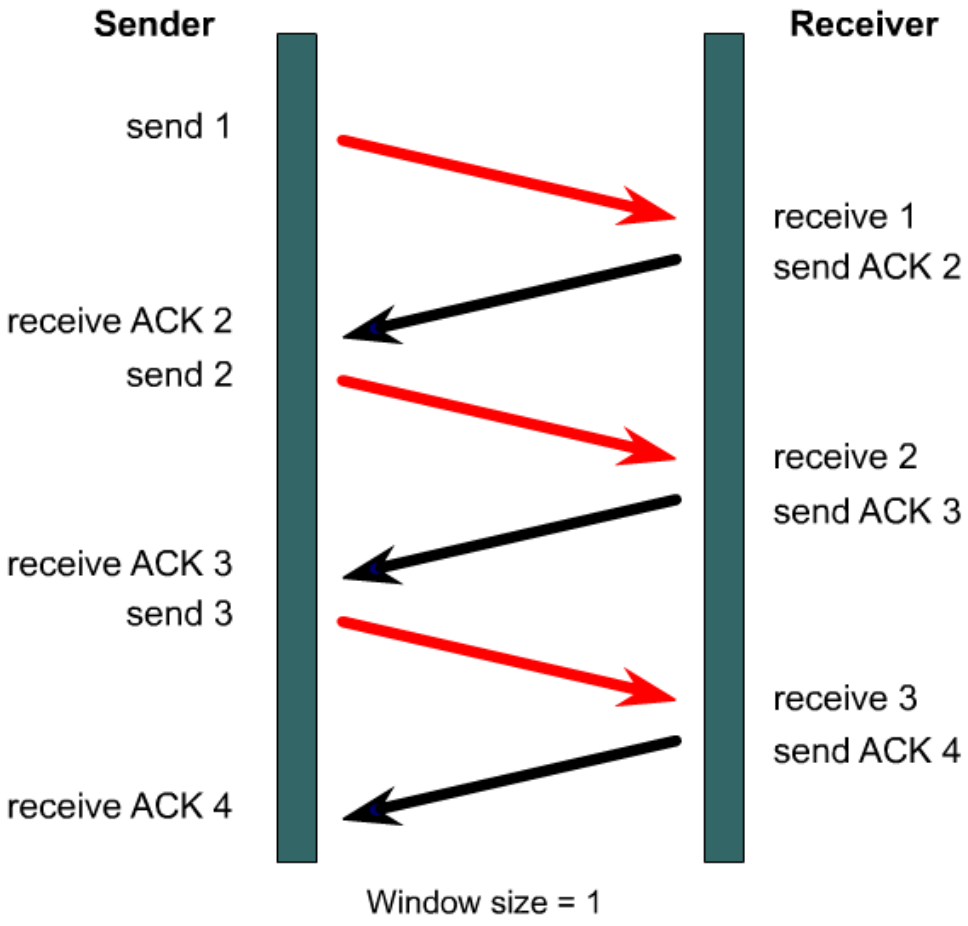
Three-Way-Handshaking



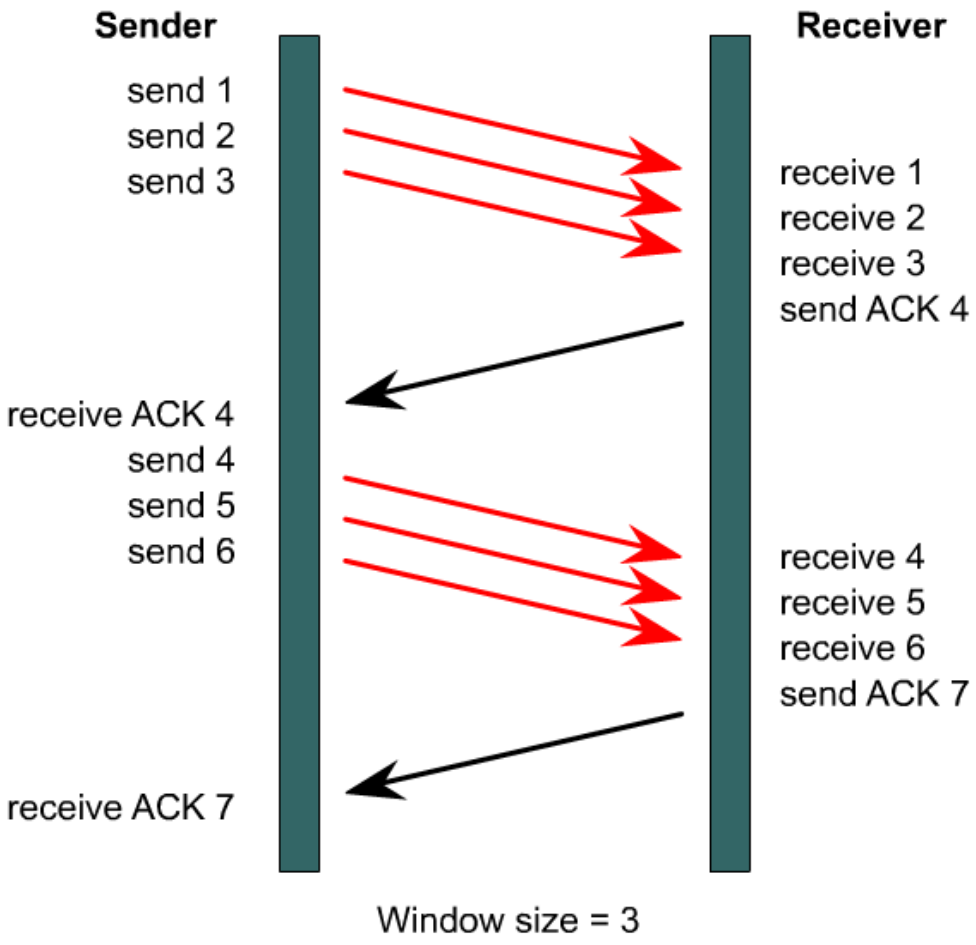
Establish a TCP-connection



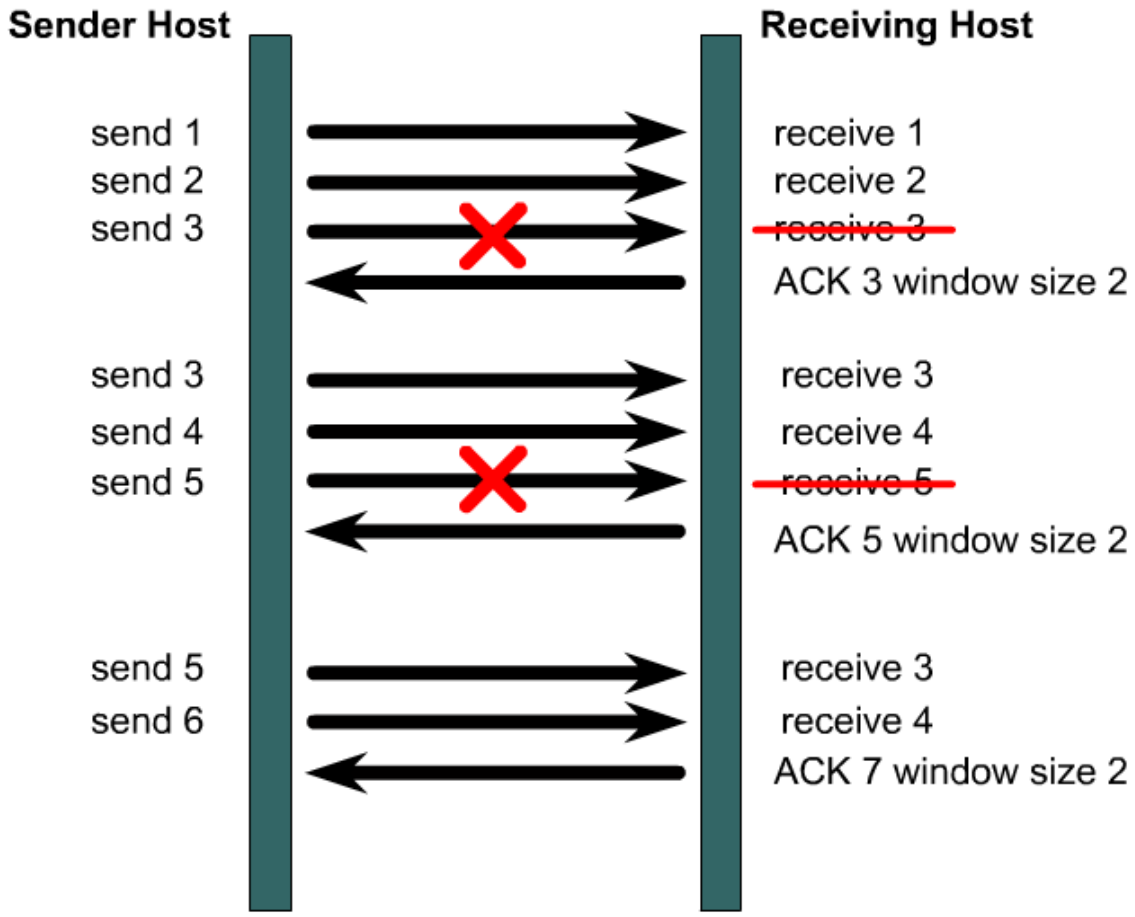
TCP Handshaking



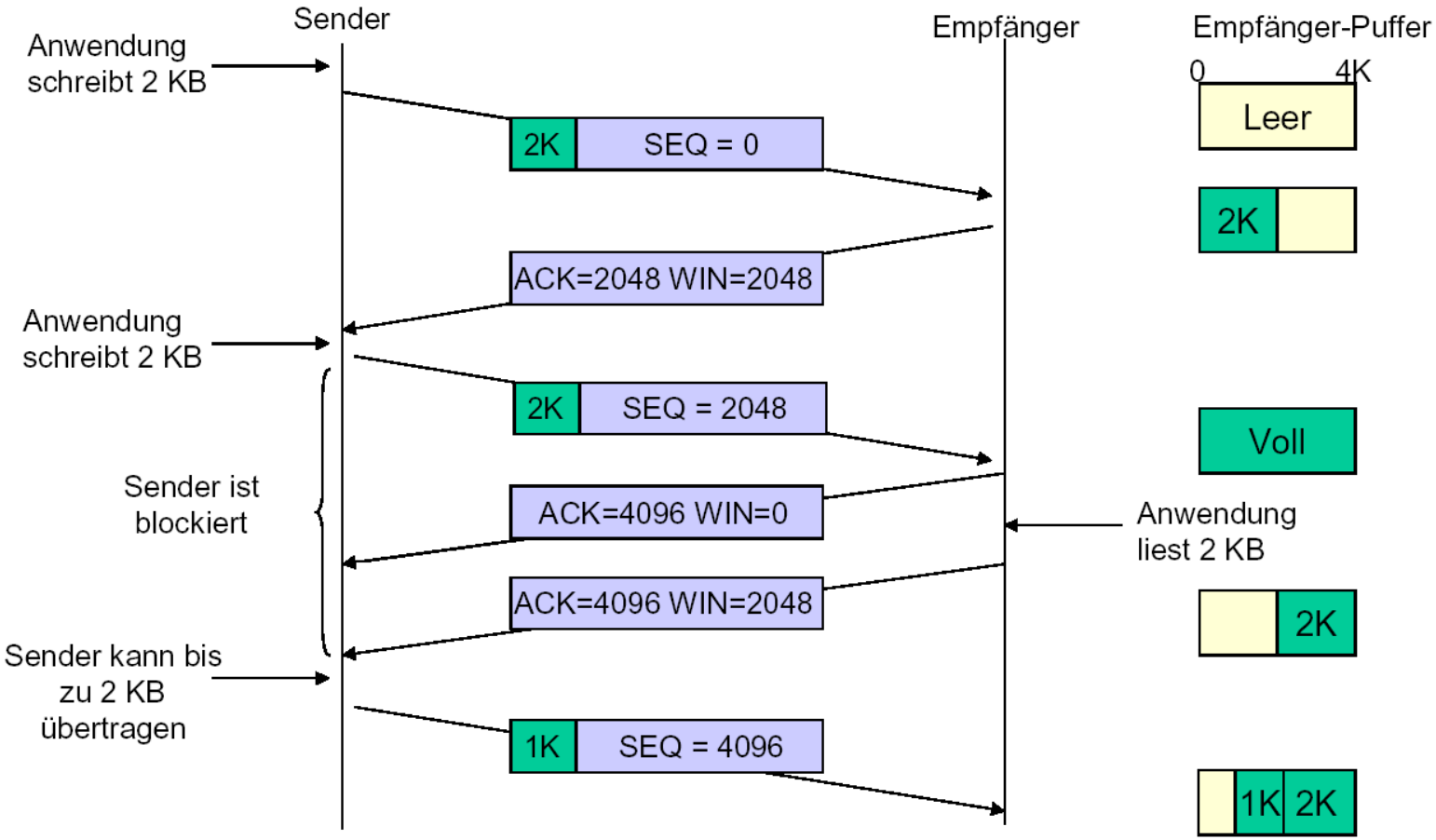
Sliding Window



Behavior if transmission fails



Sliding window in real
(Data flow control)

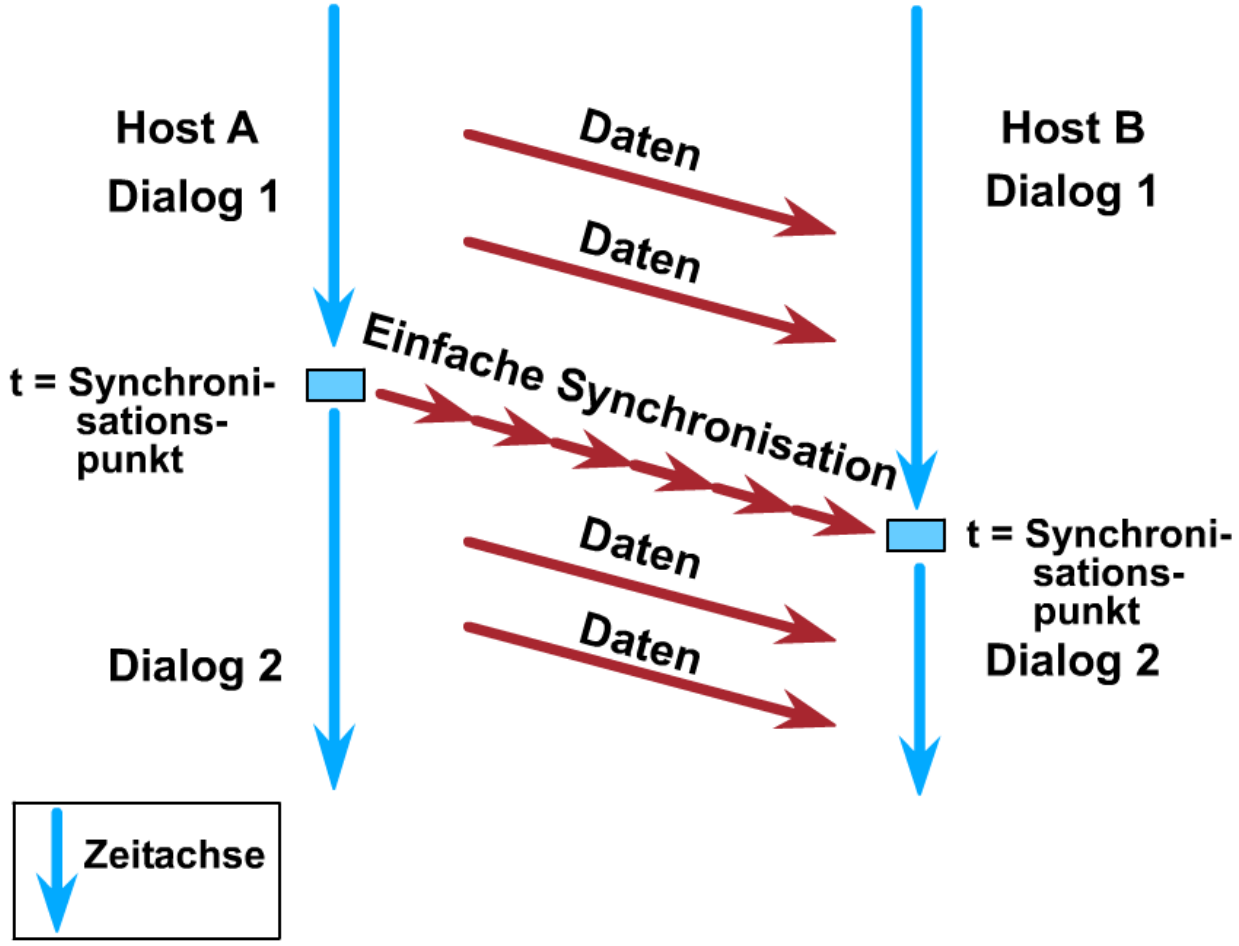


"Hi, I'd like to hear a TCP joke."
"Hello, would you like to hear a TCP joke?"
"Yes, I'd like to hear a TCP joke."
"OK, I'll tell you a TCP joke."
"Ok, I will hear a TCP joke."
"Are you ready to hear a TCP joke?"
"Yes, I am ready to hear a TCP joke."
"Ok, I am about to send the TCP joke. It will last 10 seconds, it has two characters, it does not have a setting, it ends with a punchline."
"Ok, I am ready to get your TCP joke that will last 10 seconds, has two characters, does not have an explicit setting, and ends with a punchline."
"I'm sorry, your connection has timed out. ... Hello, would you like to hear a TCP joke?"

Session-Layer

- **The session-layer establish sessions between applications, control and close them.**
- Dialog control:
  - TWS → Two Way Simultaneous
    - Must be controlled by higher layers!
    - possible L-5-Collisions (logical collisions)
  - TWA → Two Way Alternate
    - uses **Tokens**

Dialog seperation



Session-Layer protocols

- Network File System (NFS)
- Structured Query Language (SQL)
- Remote-Procedure Call (RPC)
- X-Window System
- AppleTalk Session Protocol (ASP)
- Digital Network Architecture Session Control Protocol (DNA SCP)

Presentation-Layer

- Data formatting (mark-up)
  - HTML, ASCII, Unicode, PDF, PS, …
- Data encryption
  - PGP, …
- Data compression
  - JPEG, MPEG, mp3, Zip, RAR, PDF, PS, …

Application-Layer

- Software, services, www, …
- Snchronisation between corresponding applications
- control of Data integrity (software dependend)

Typical L7-Applications

- Client/Server
- Redirector (Network-drives, Printers)
- Classic internet: E-Mail, Telnet, FTP, …
- HTTP and Domain Name System (DNS)
- = WWW
- User control (e.g. MS-AD)
- Database
- Remote control (remote desktop)

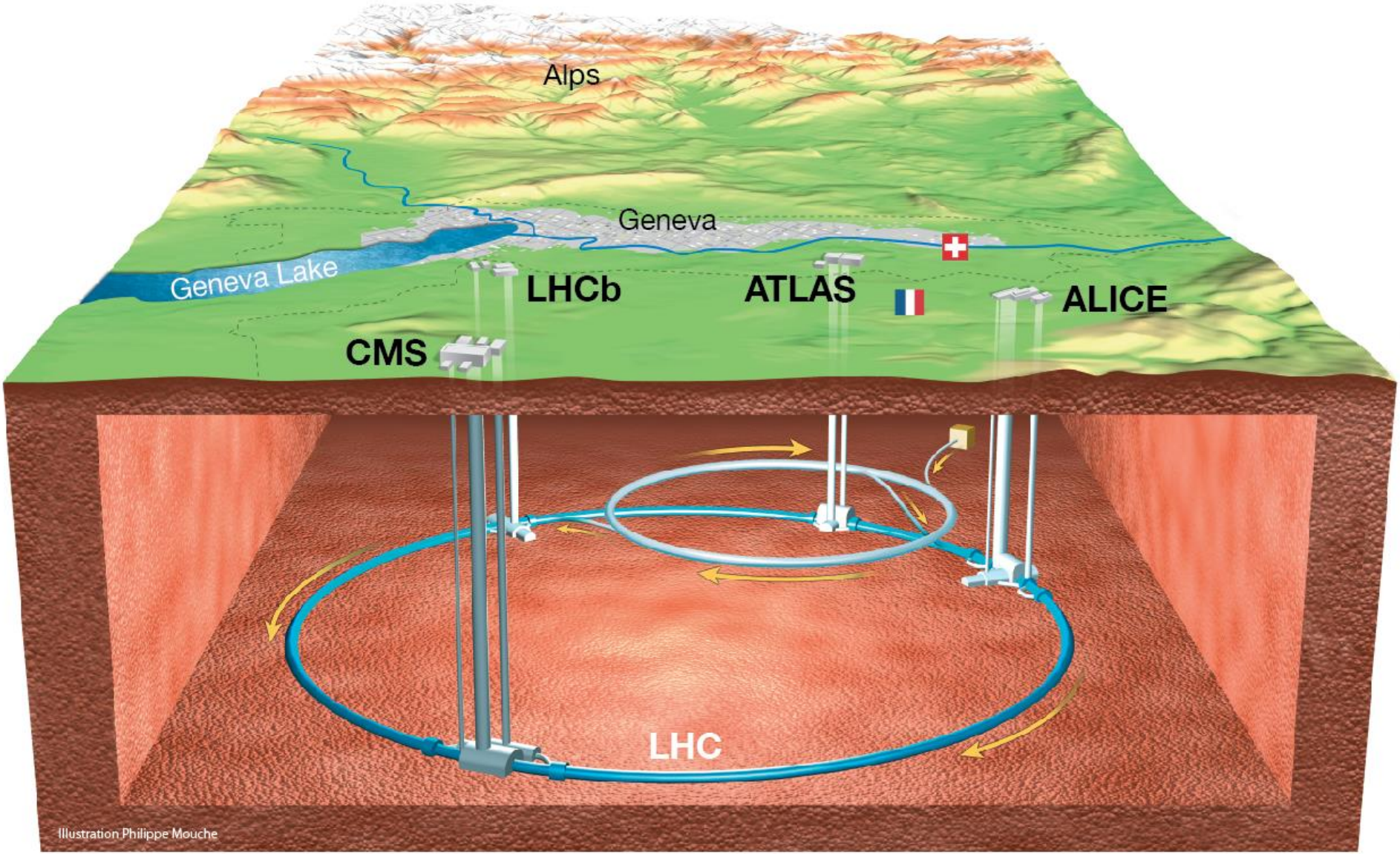
Redirector (requester)

- The Redirector is a protocol, working with Computer-opertingsystems and Network-clients. NOT with spezialiced applications!
  - Apple File Protocol
  - NetBIOS Extended User Interface (NetBEUI)
  - IPX/SPX-Protocols from Novell
  - Network File System (NFS) from TCP/IP-Protokol-stack
  - Microsoft Printing

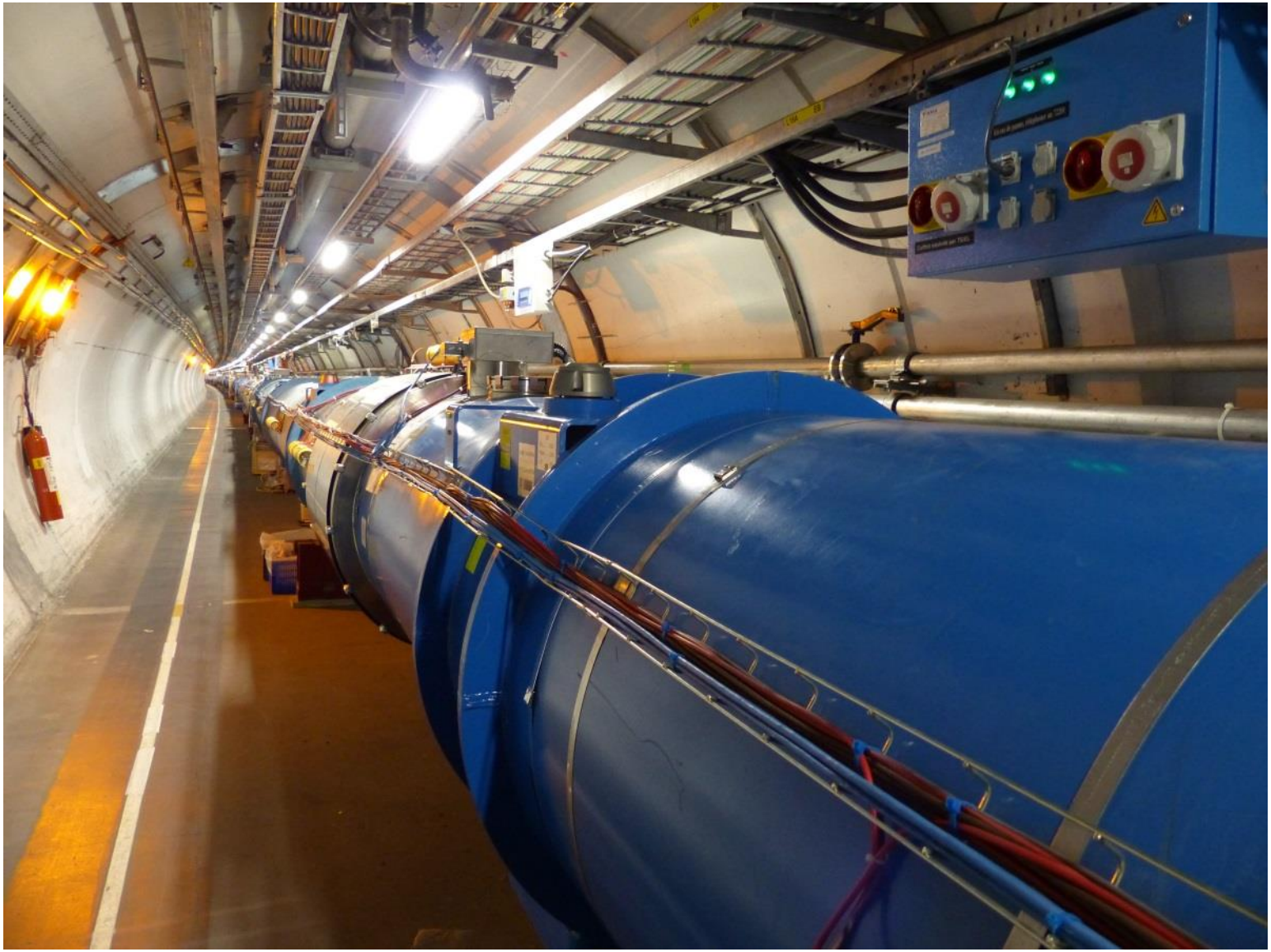
L7-connections (sessions)

- This is NOT a L5-Session!
- Lots of temporarily connections:
  - E.g.: Webbrowser
- There are some longer connections only:
  - E.g.: Telnet / Teams

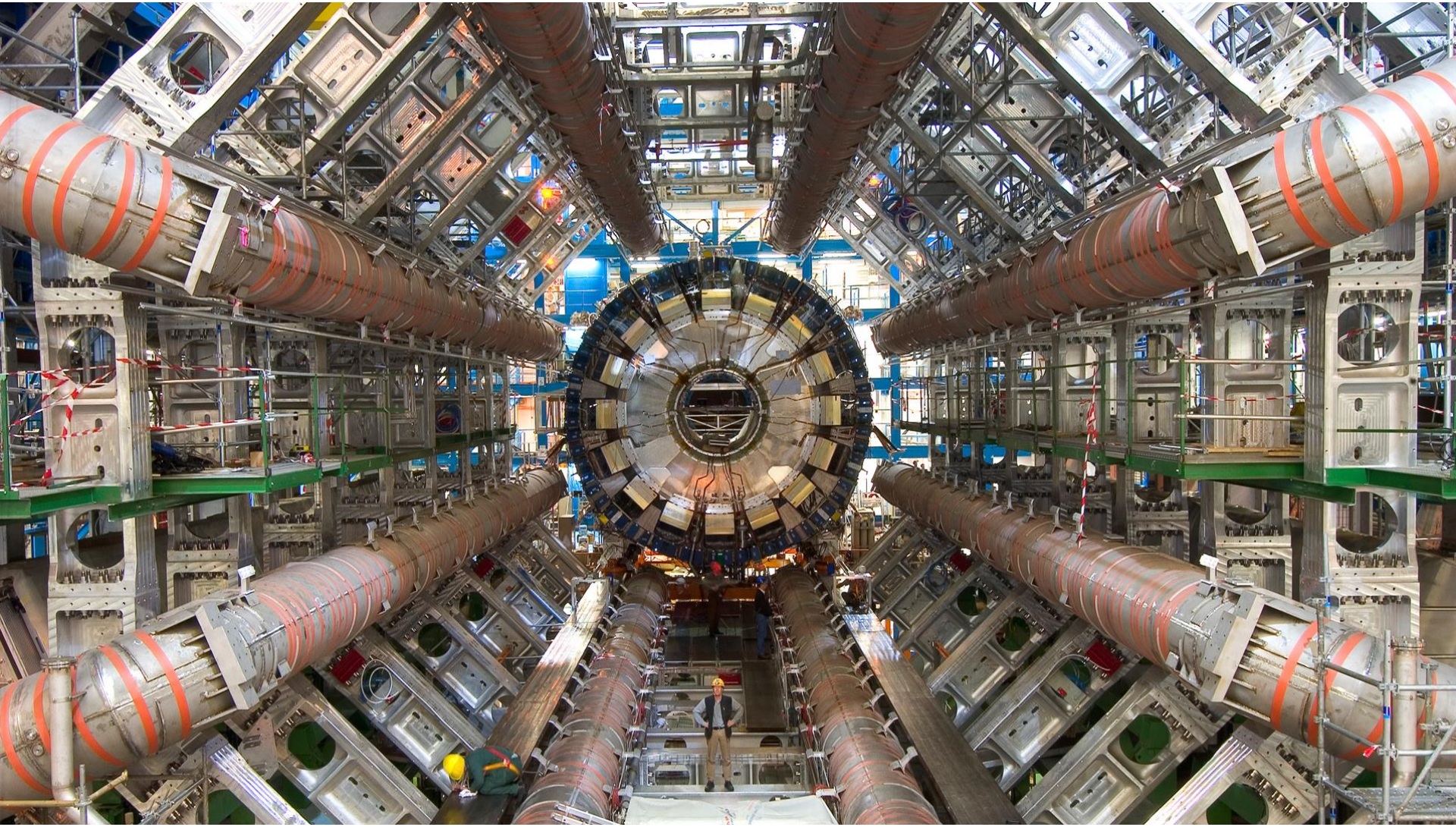
LHC – CERN start of www



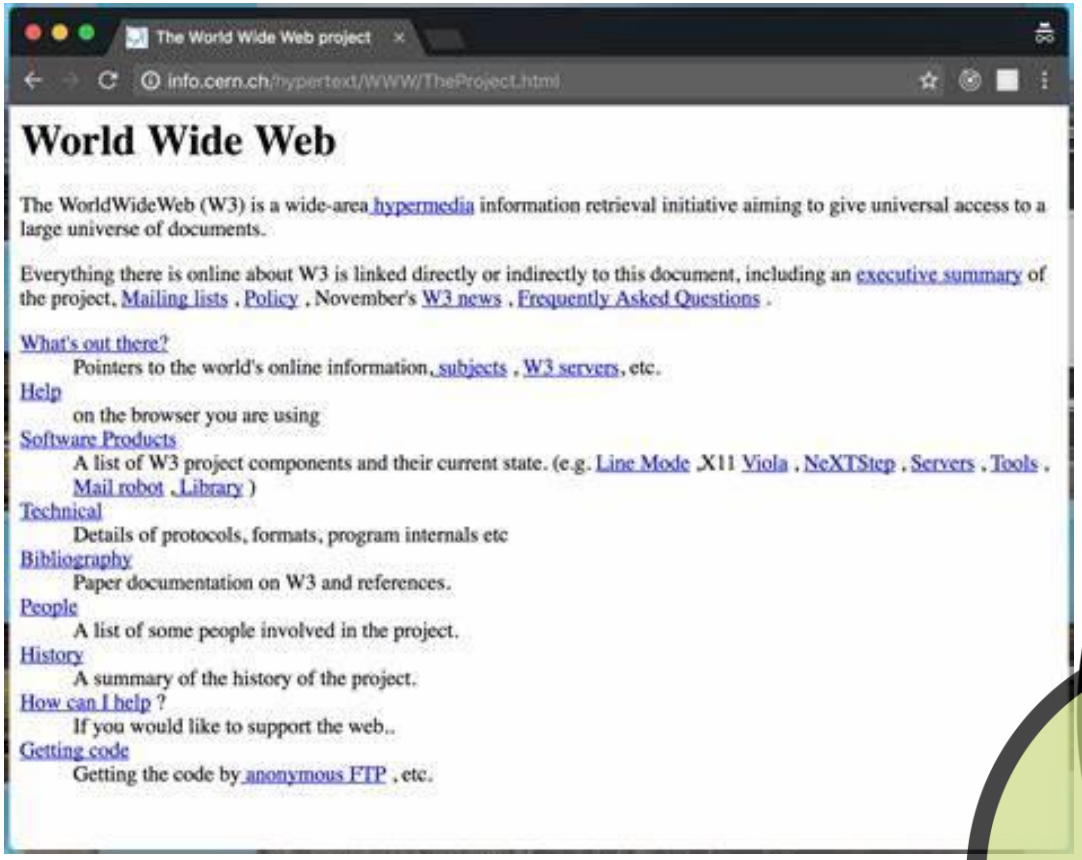
Lot‘s of data…

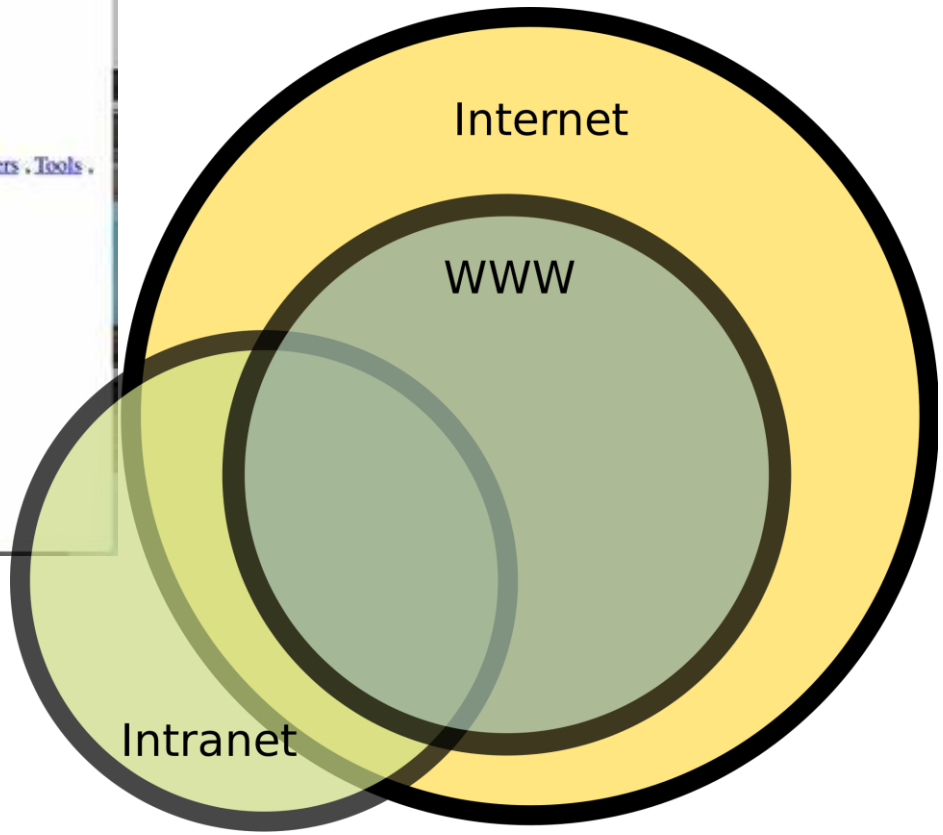


How to handle it / find it?



First web-page 1991-08-06





By Tim Berners-Lee – first Idea 1989

DNS

- Translate URLs into IP-Adresses.
- First look to own table – if no entry:
  Ask next higher DNS-server
- Worldwide 13 Root-Server only.
  - 10 USA, 1 Stockholm, 1 London, 1 Tokyo

  Each provider must have at least two independend DNS-Servers…

Additonal topics…☺☹

- etxtended Switching and Routing
- Firewalls / ACL
- xDSL / WAN…
- WIFI / Bluetooth / WIMAX / LoRaWAN
- 2G / 3G / 4G / 5G
- SDN / SDW
- Analyze Networks e.G. by WireShark
- …