Lecture Computer Networks

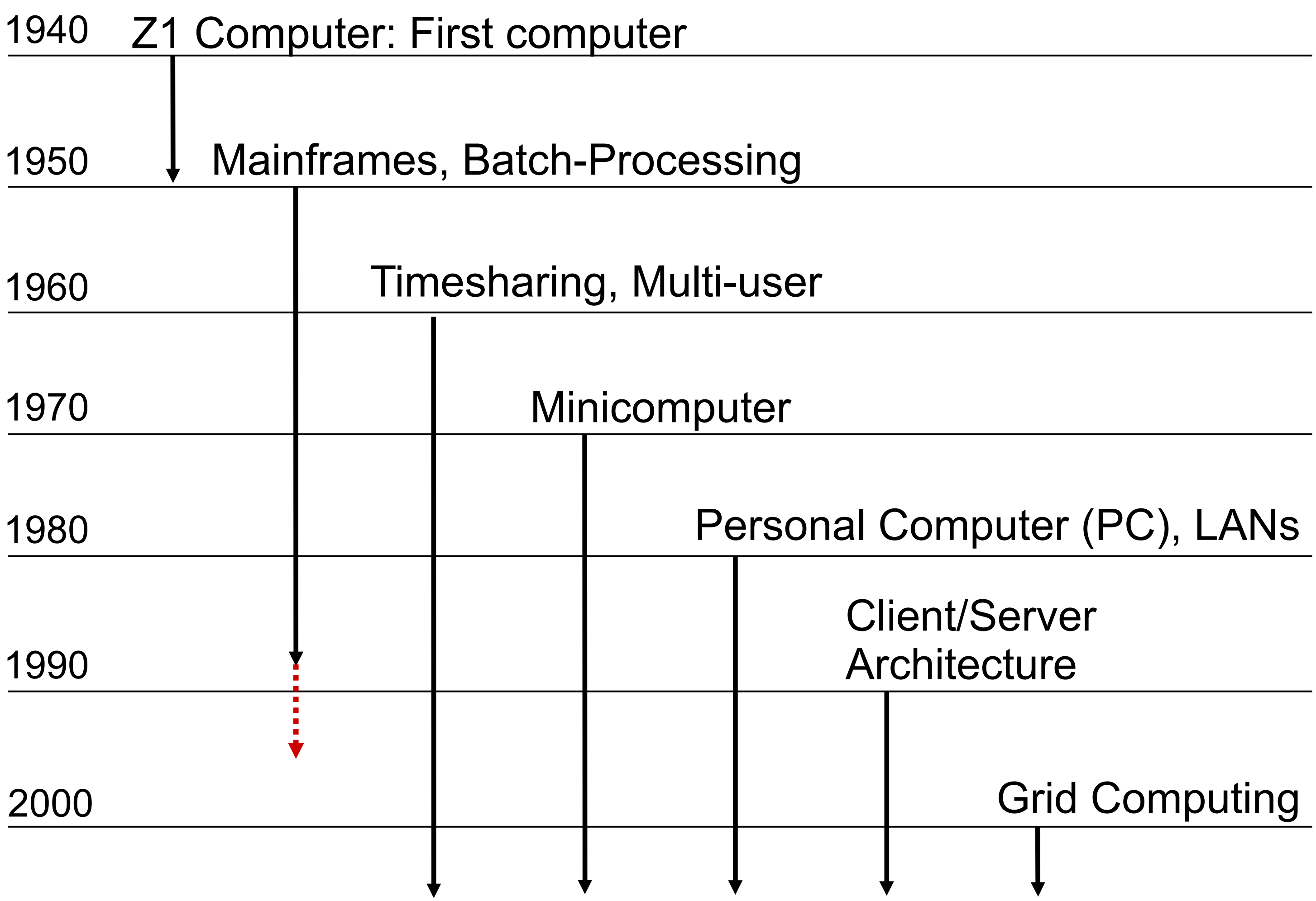
Introduction, Motivation

Prof. Dr. Hans Peter Großmann mit M. Rabel sowie
H. Hutschenreiter und T. Nau | Sommersemester 2012 |
Institut für Organisation und Management von
Informationssystemen

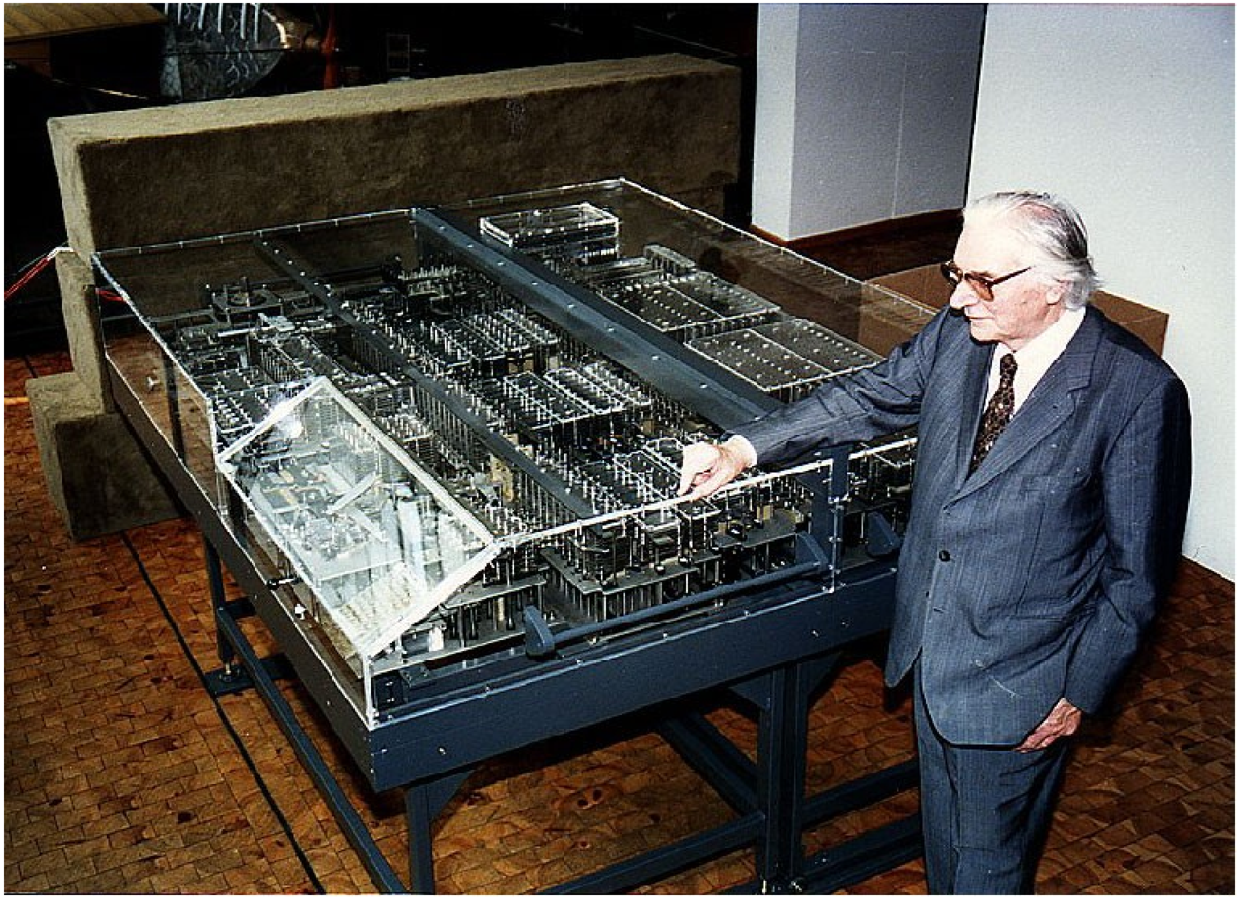
Content

- Introduction
  - History
- Motivation: Real-World Network Implementations
  - Data/Computer Network
    - Uni Ulm Campus Network
  - Uni Ulm Campus PBX System
  - Networking in Automation
    - Pumped Storage Hydro Power Plant
    - Engine synchronization
  - In-Car Networks
  - Data Exchange between Mobile Systems
    - Example: VANET

Computer Development

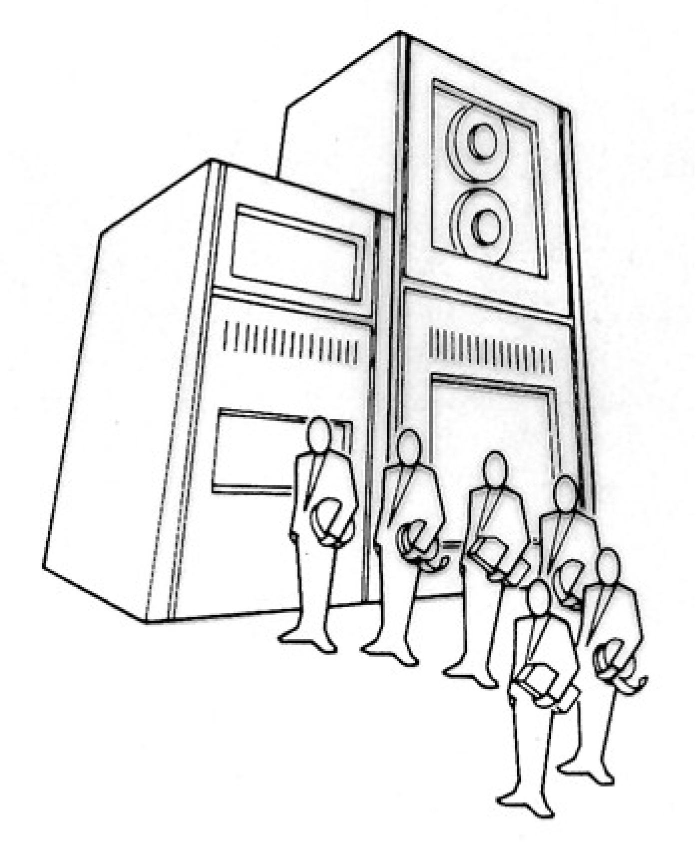


Z1 Computer



Konrad Zuse and the rebuilt Z1 in the Deutsches Technikmuseum Berlin in 1989
http://irb.cs.tu-berlin.de/~zuse/Konrad_Zuse/en/Rechner_Z1.html

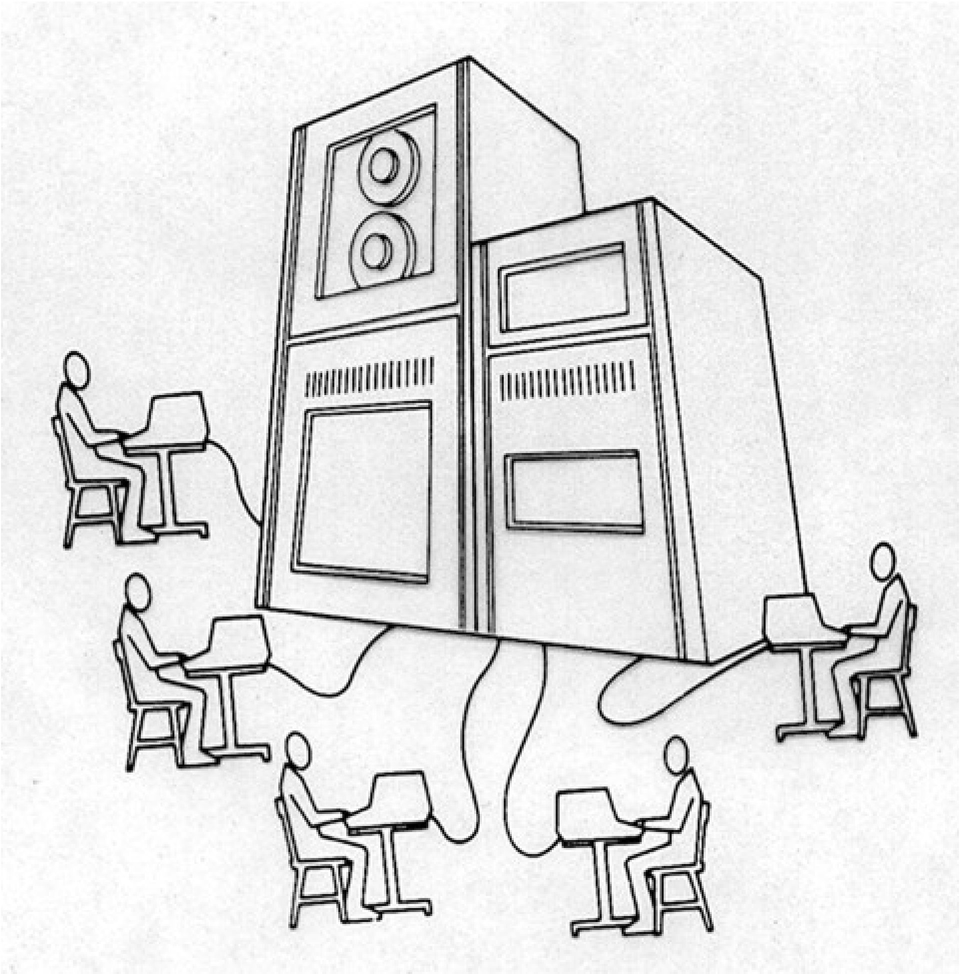
Mainframes (Batch Processing)



1950

- Batch environment
- no direct communication
- CPU is busy with one process at a time
- Punched cards and magnetic tapes for source codes

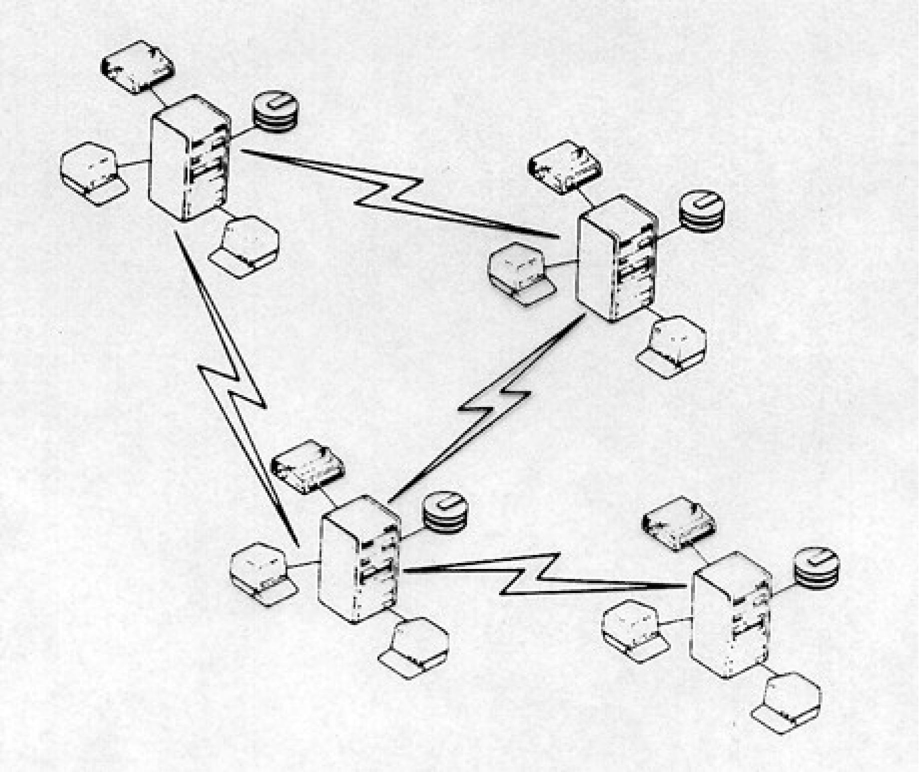
Time Sharing



1960

- Time Sharing
- Slow Point-to-Point network
- "Star" Network

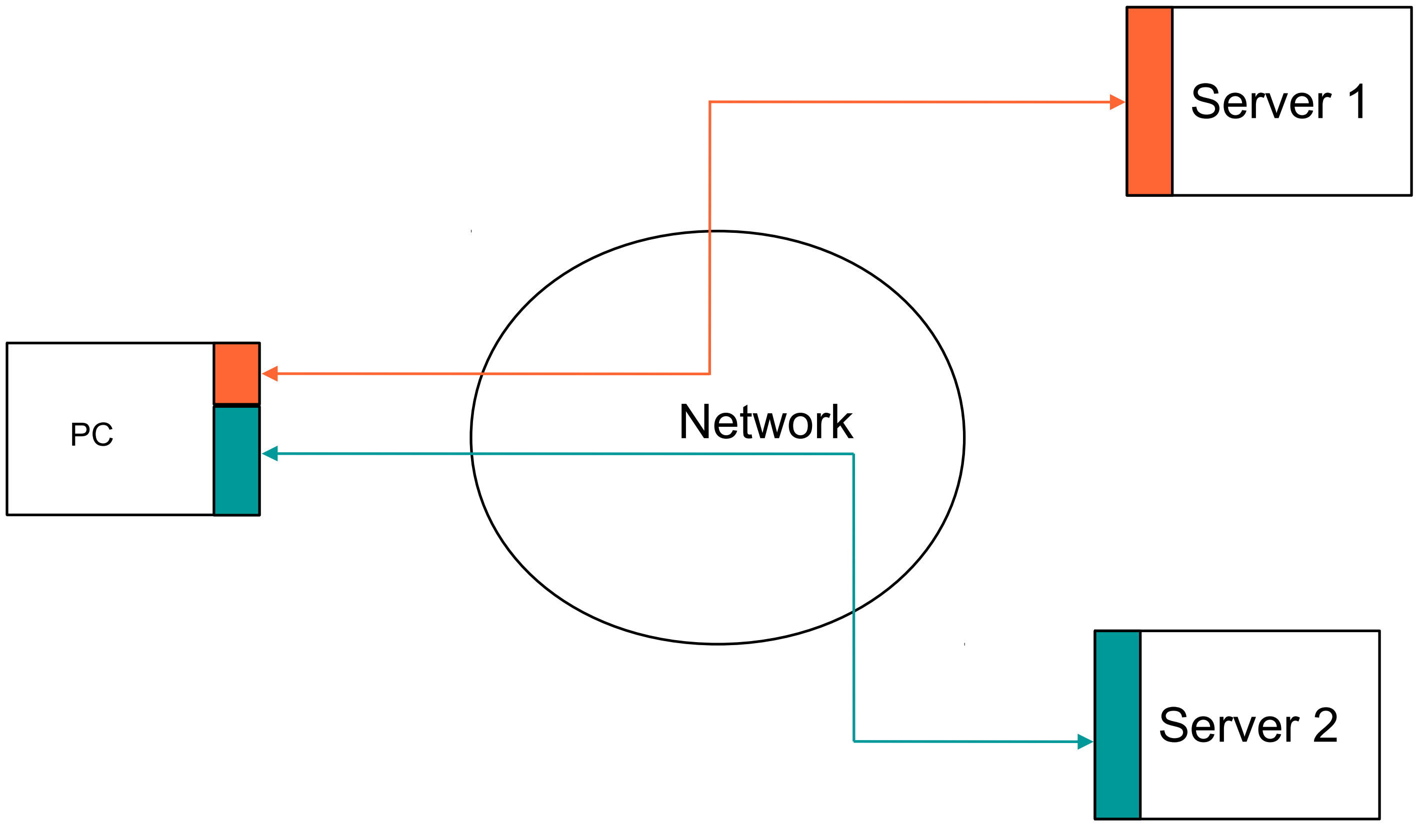
Distributed Processing



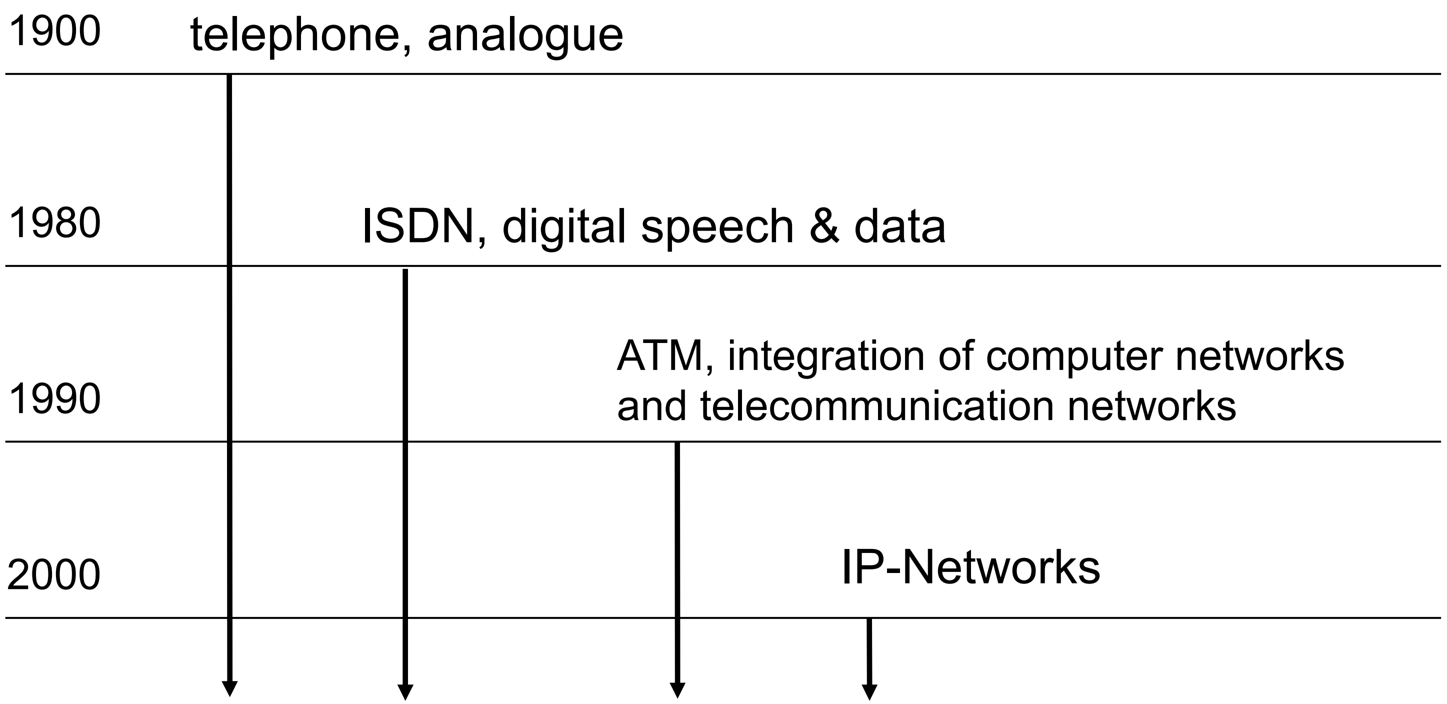
1970

- Distributed Processing
- Computer-Computer-Communication
- Fast “Bus/Ring”-Networks

Client/Server Architecture



Telecommunication Evolution



Up to the 80s, the architecture of telecommunication networks and computer networks were developed independently

Media Development (analog/digital)

1500 Print media (book, newspaper), *analog*

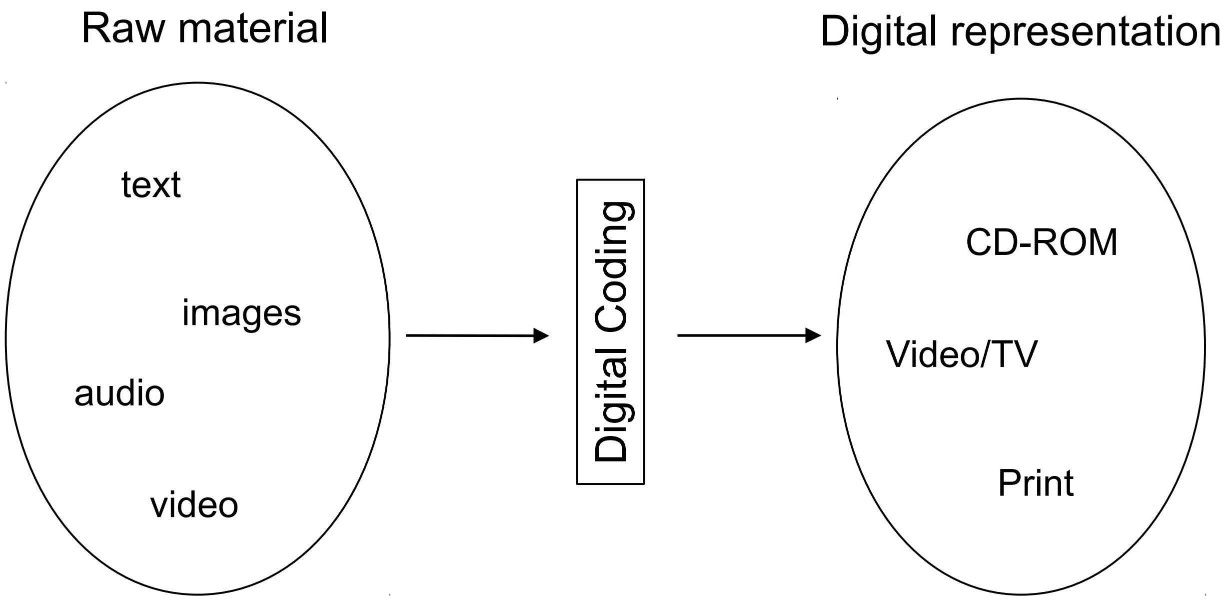
1900 radio, *analog*

1940 TV, *analog*

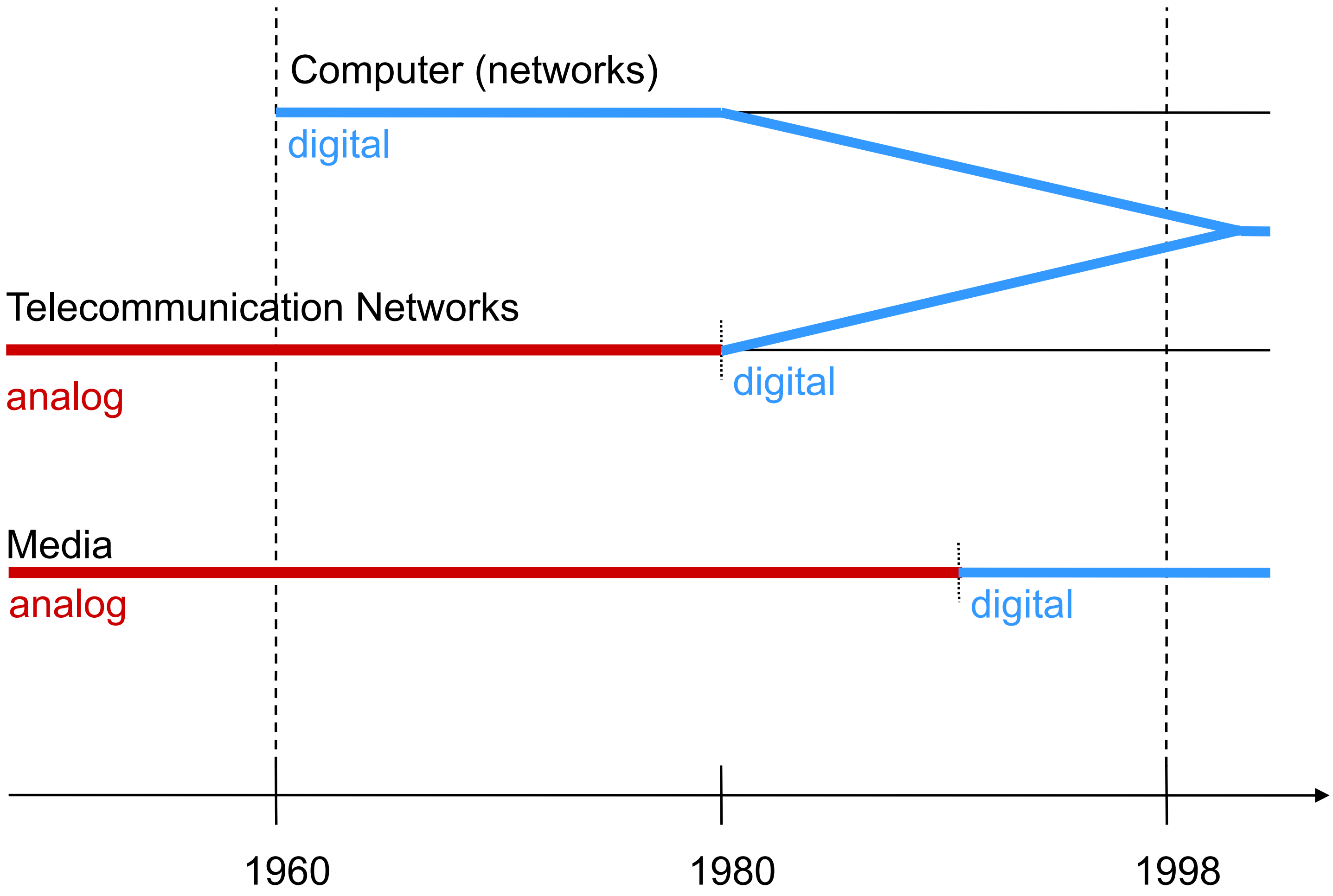
1996 Video on Demand, DAB, electronic journals, Interactive CD, DVB, *digital*

Media Transmission

- Digital coded data is required for an efficient transmission of different transport media



Convergence



Aspects of Networking

- Why communication networks?
  - voice communication
  - data transfer
  - ...

- For what purpose?
  - exchange of messages
  - exchange of data
  - long distance telephony / video conferencing
  - monitoring/control (sensor-/actor-networks)
  - ...

Aspects of Networking II

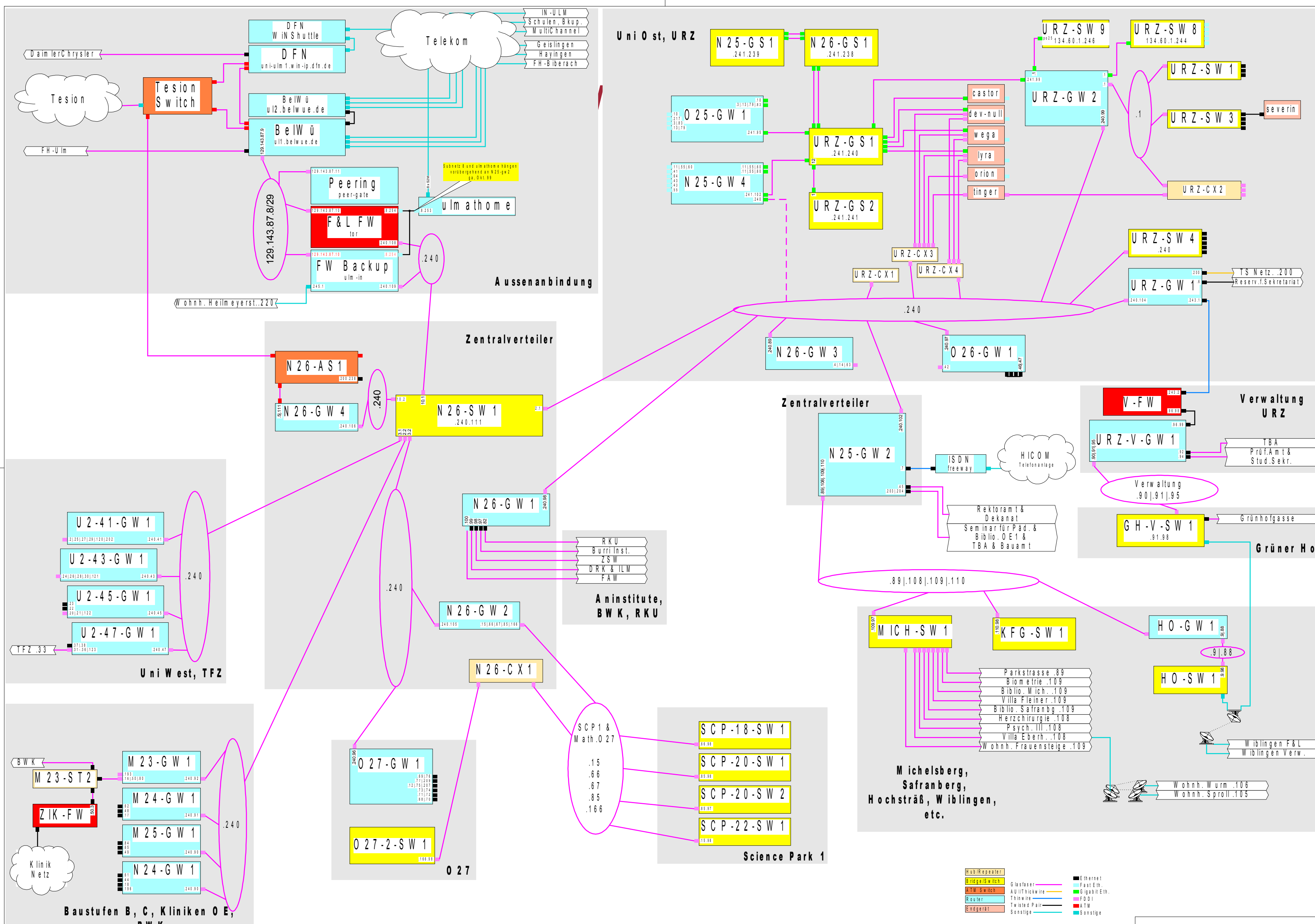
- Expansion
  - 0.01 m ... 1 m — processorboards, (multi-)prozessorsystems
  - 1 m ... 10 m — PAN (Personal Area Network)
  - 10 m … 1 km — LAN (Local Area Network), Field-Bus-Systems
  - some 10 km — MAN (Metropolitan Area Network)
  - 100 km ... 1000 km — WAN (Wide Area Network)
  - global — connected networks

- Different needs for different applications
  - (native) Computer Networks
  - Connecting Computer Clusters
  - Field- Bus-Systems
  - Ad-hoc Networks
  - ...

Real-World Example: Data/Computer Network

- Uni Ulm Campus Network

  Status as of the year 2000


Telekom
Tesion
Tesion Switch
DaimlerChrysler
FH-Ulm
DFN WiN Shuttle
DFN
BelWü
Peering
F&L FW
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Aussenanbindung
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MultiChannel
Geislingen
Hayingen
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URZ-GS1
URZ-GS2
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URZ-SW8
URZ-GW2
URZ-SW1
URZ-SW3
severin
URZ-CX2
castor
dev-null
wega
lyra
orion
tinger
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URZ-CX3
URZ-CX4
URZ-SW4
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RKU
Burri Inst.
ZSW
DRK & ILM
FAW
Aninstitute, BWK, RKU
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Zentralverteiler
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ISDN freeway
HICOM Telefonanlage
Rektoramt & Dekanat
Seminar für Päd. &
Biblio. OE1 &
TBA & Bauamt
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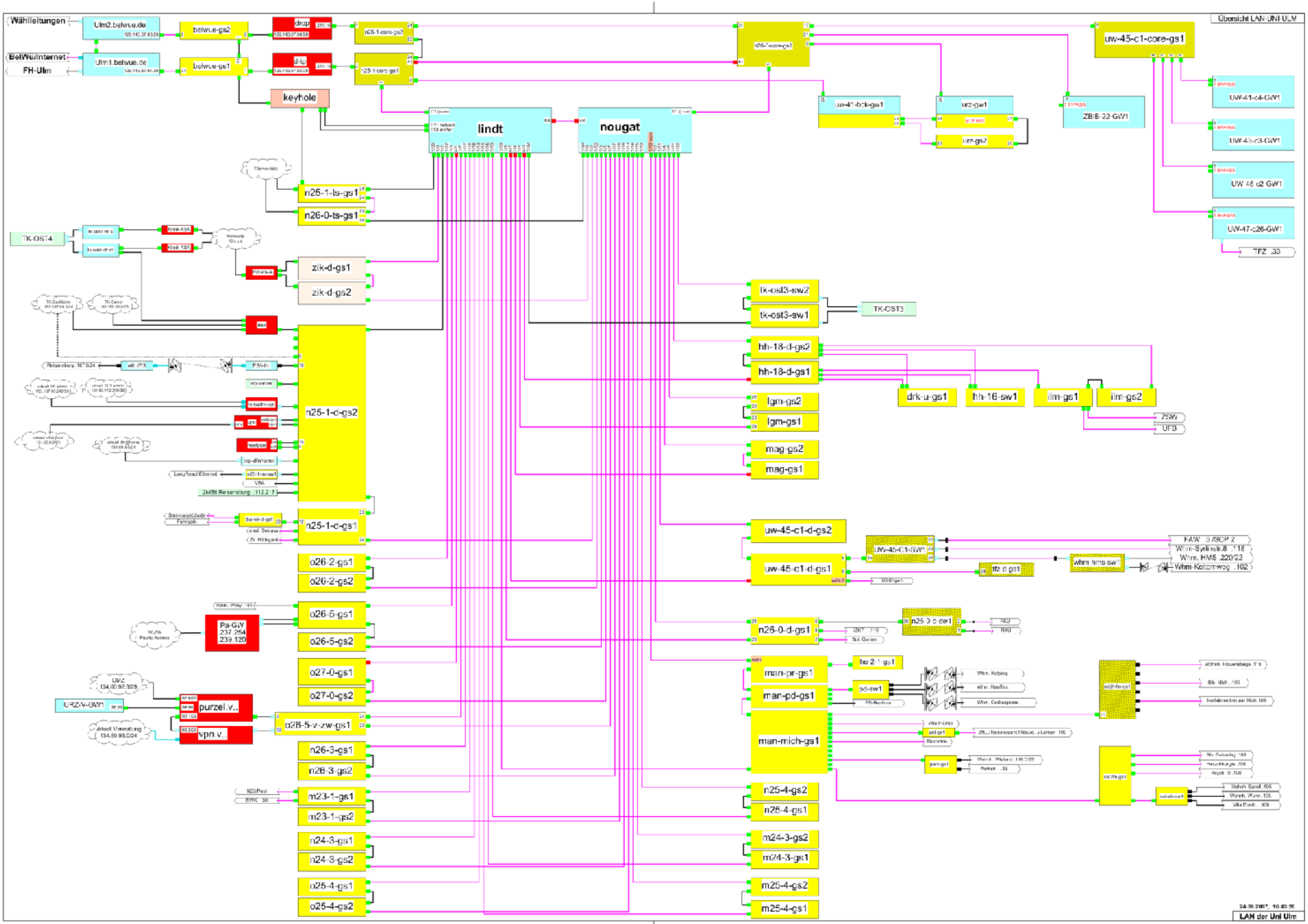
Wiblingen Verw.
Wohnh. Wurm .106
Wohnh. Sproll .105
Michelsberg, Safranberg, Hochsträß, Wiblingen, etc.
U2-41-GW1
U2-43-GW1
U2-45-GW1
U2-47-GW1
TFZ .33
Uni West, TFZ
O27-GW1
O27-2-SW1
O27
SCP1 & Math. O27
.15
.66
.67
.85
.166
SCP-18-SW1
SCP-20-SW1
SCP-20-SW2
SCP-22-SW1
Science Park 1
BWK
M23-ST2
ZIK-FW
Klinik Netz
M23-GW1
M24-GW1
M25-GW1
N24-GW1
Baustufen B, C, Kliniken OE, BWK
Hub/Repeater
Bridge/Switch
ATM Switch
Router
Endgerät
Glasfaser
AUI/Thickwire
Thinwire
Twisted Pair
Sonstige
Ethernet
Fast Eth.
Gigabit Eth.
FDDI
ATM
Sonstige

Real-World Example: Data/Computer Network

- Uni Ulm Campus Network

  Status as of september 2007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urz-gs2
ZBIB-22-GW1
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UW-43-c3-GW1
UW 46 c2 GW1
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TK-OST4
TK-OST3
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zik-d-gs2
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tk-ost3-sw1
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drk-u-gs1
hh-16-sw1
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ilm-gs2
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man-pd-gs1
man-mich-gs1
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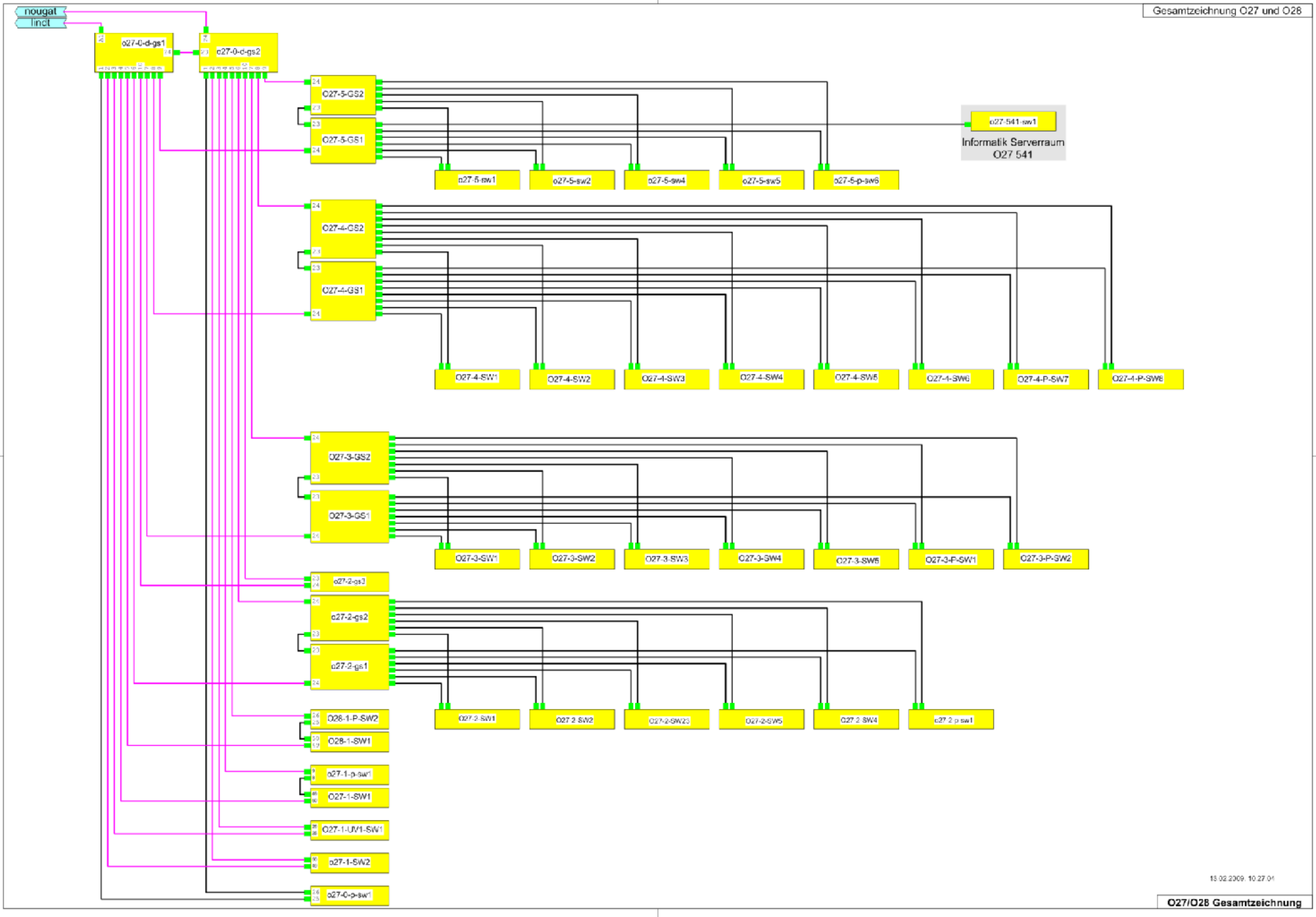
m24-3-gs1
m25-4-gs2
m25-4-gs1
LAN der Uni Ulm


Gesamtzeichnung O27 und O28
nougat
lind
o27-0-d-gs1
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o27-541-sw1
Informatik Serverraum
O27 541
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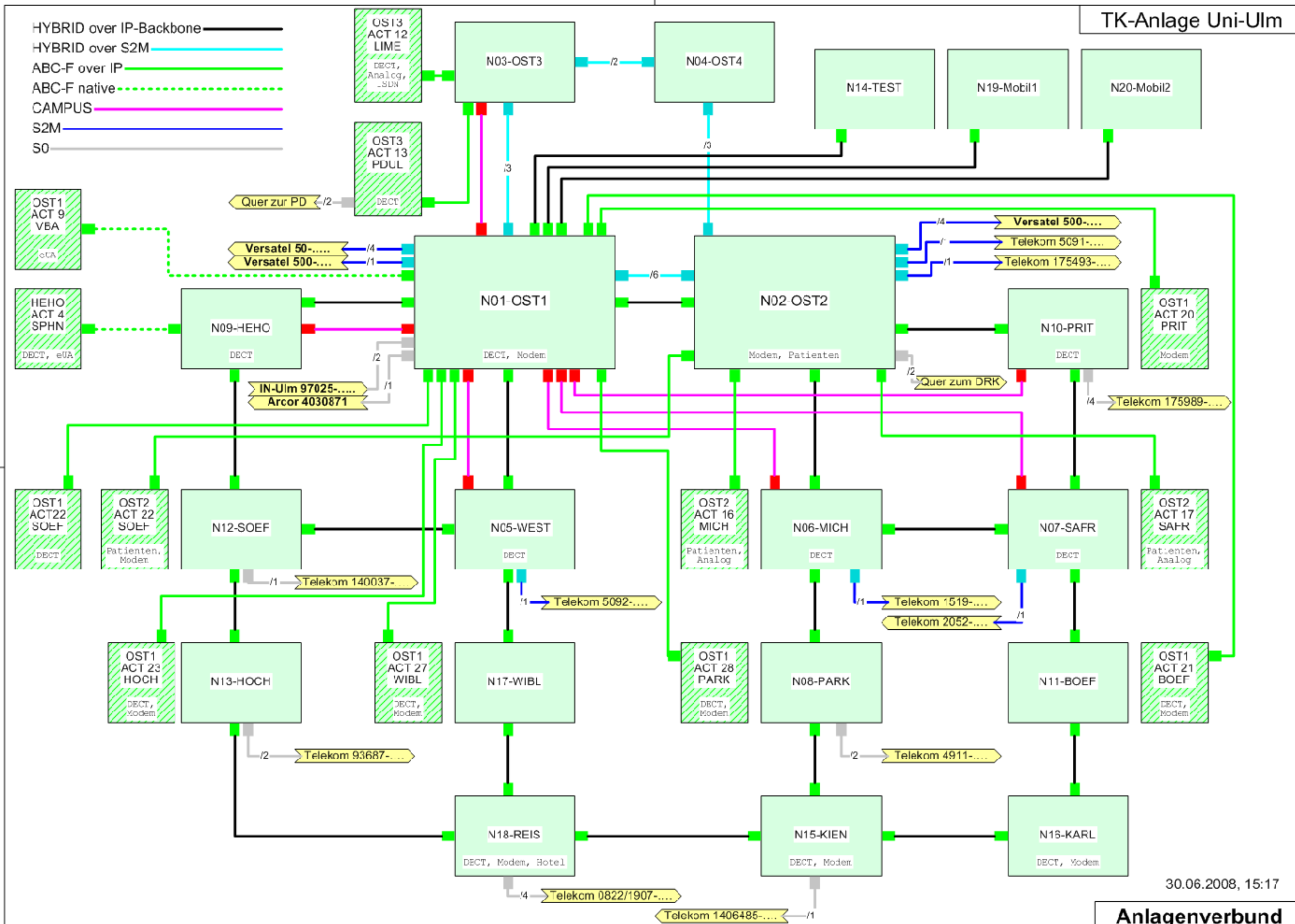
O27/O28 Gesamtzeichnung

Real-World Example: Data/Computer Network

- Uni Ulm Campus PBX (Private Branch Exchange) System

  Status as of the year 2008


TK-Anlage Uni-Ulm
HYBRID over IP-Backbone
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ABC-F over IP
ABC-F native
CAMPUS
S2M
S0
OST3 ACT 12 LIME
OST3 ACT 13 PDUL
OST1 ACT 9 VBA
HEHO ACT 4 SPHN
N03-OST3
N04-OST4
N14-TEST
N19-Mobil1
N20-Mobil2
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Versatel 50-....
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Telekom 175493-....
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OST2 ACT 22 SOEF
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N07-SAFR
DECT
OST2 ACT 17 SAFR
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DECT, Modem
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Telekom 1406485-....
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Anlagenverbund

Lecture Computer Networks

Introduction, Motivation II

Prof. Dr. H. P. Großmann and B. Wiegel and
A. Schmeiser and M. Rabel | Wintersemester 2010 / 2011 |
Institute for Information Resource Management

Content

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  - History
- Motivation: Real-World Network Implementations
  - Data/Computer Network
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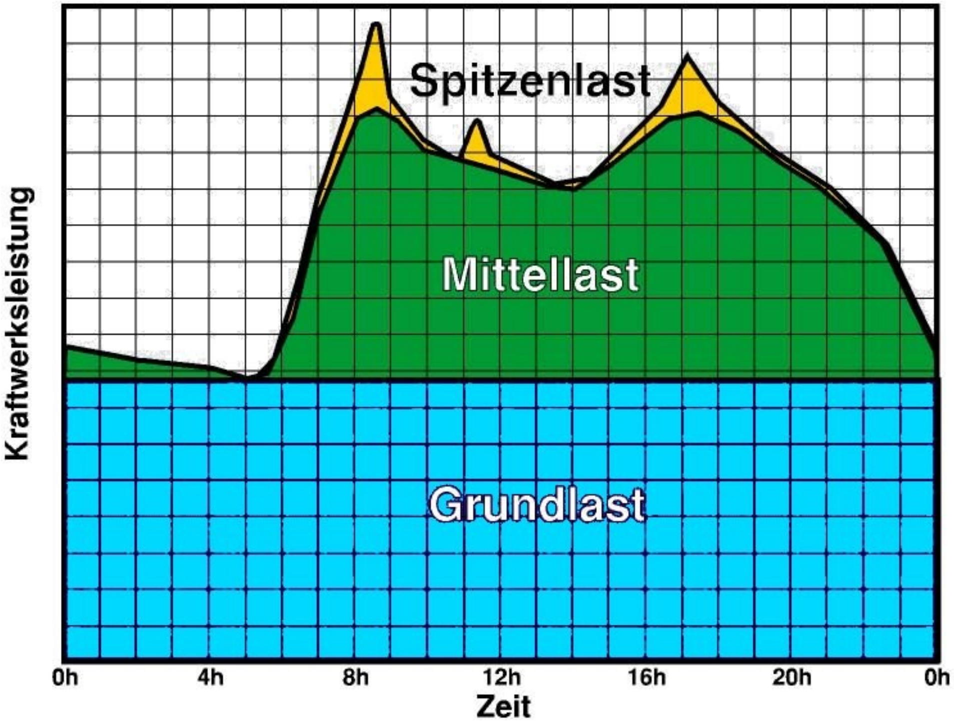
  - Networking in Automation
    - Pumped Storage Hydro Power Plant
    - Engine synchronization
  - In-Car Networks
  - Data Exchange between Mobile Systems
    - Example: VANET

Application: Pumped Storage Hydro Power Plant

Energy must be produced according to the current consumption:

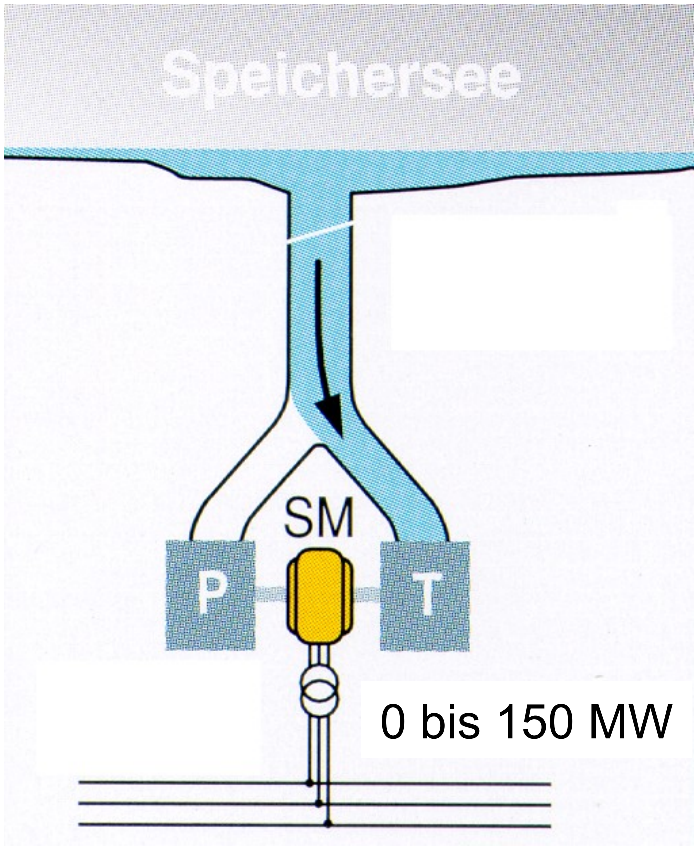
- Base Load Power Plants
  - Nuclear
  - Lignite (Brown Coal)
  - Run-of-the-river Hydro
- Mid-Load Power Plants
  - Black Coal (Anthrazite)
- Peak Load Power Plants
  - Natural Gas
  - Pumped Storage Hydro
- Feed-in Electricity
  - Combined Heat and Power
  - Renewable Energy Sources: Wind, Solar



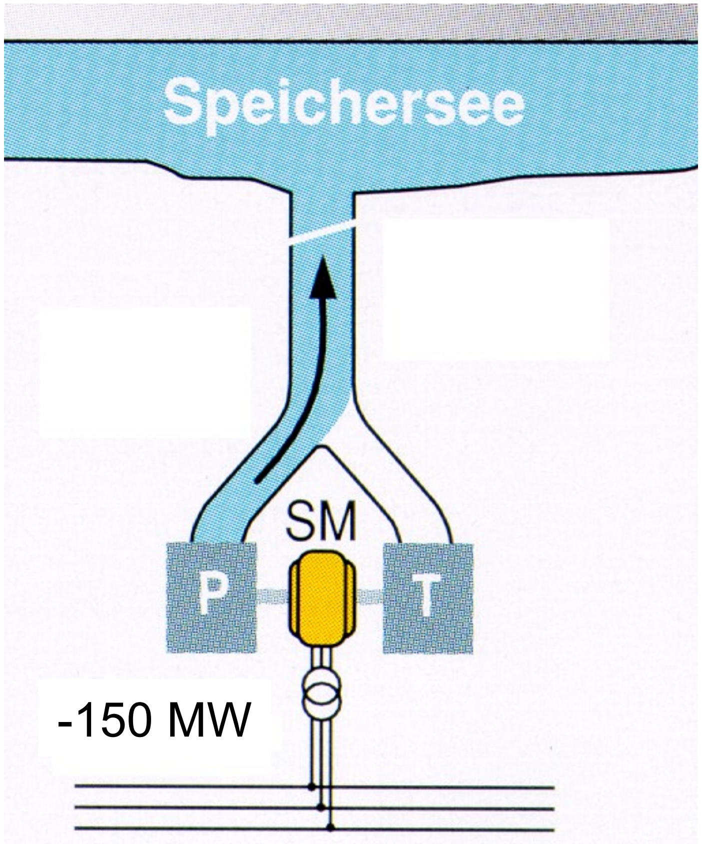
Source: http://de.wikipedia.org; Kraftwerksmanagement

Principle of a Pumped Storage Hydro Power Plant I

Turbine Operating Mode



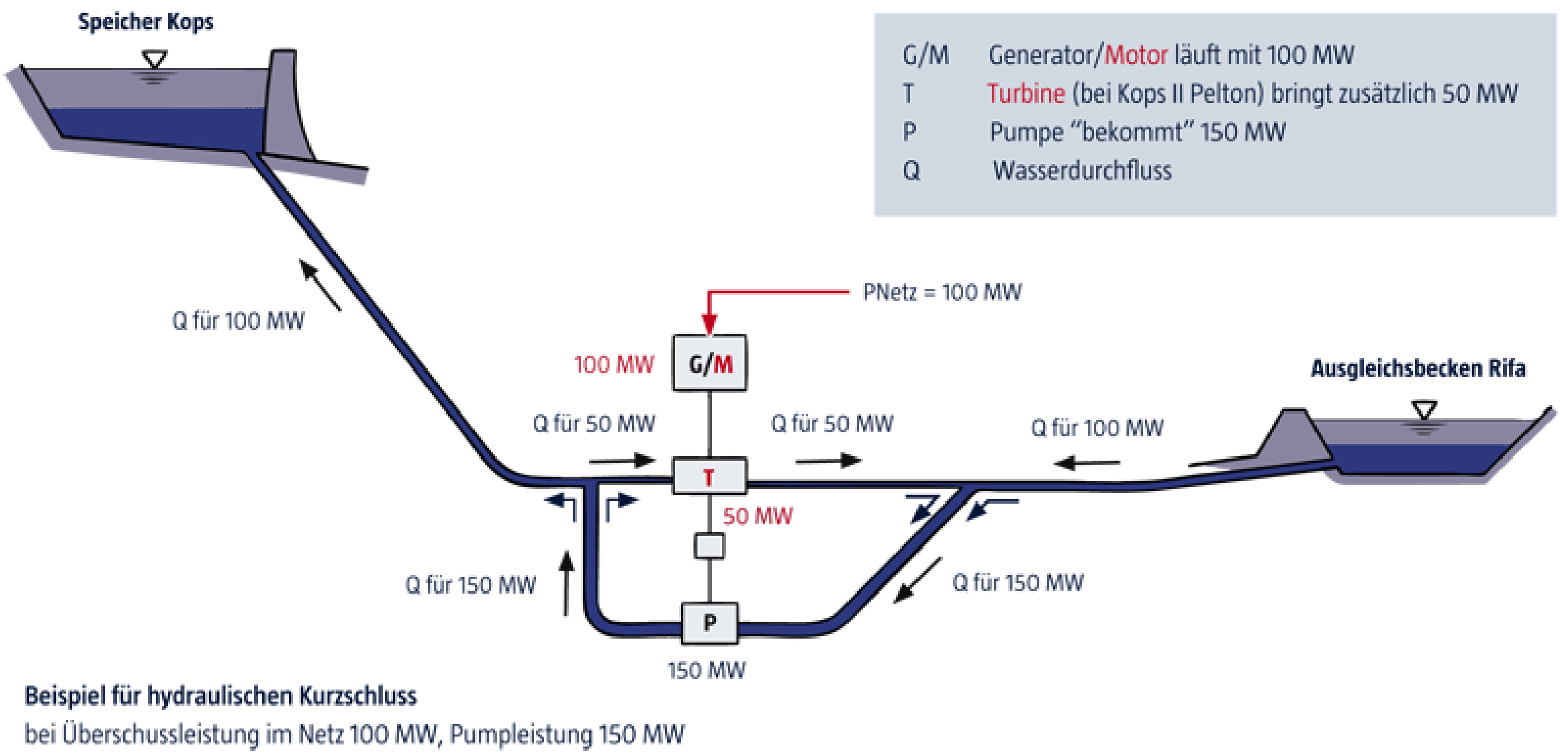
Pump Operating Mode



Source: Hamburgische Electricitäts-Werke AG, 40 Jahre Pumpspeicherwerk Geesthacht

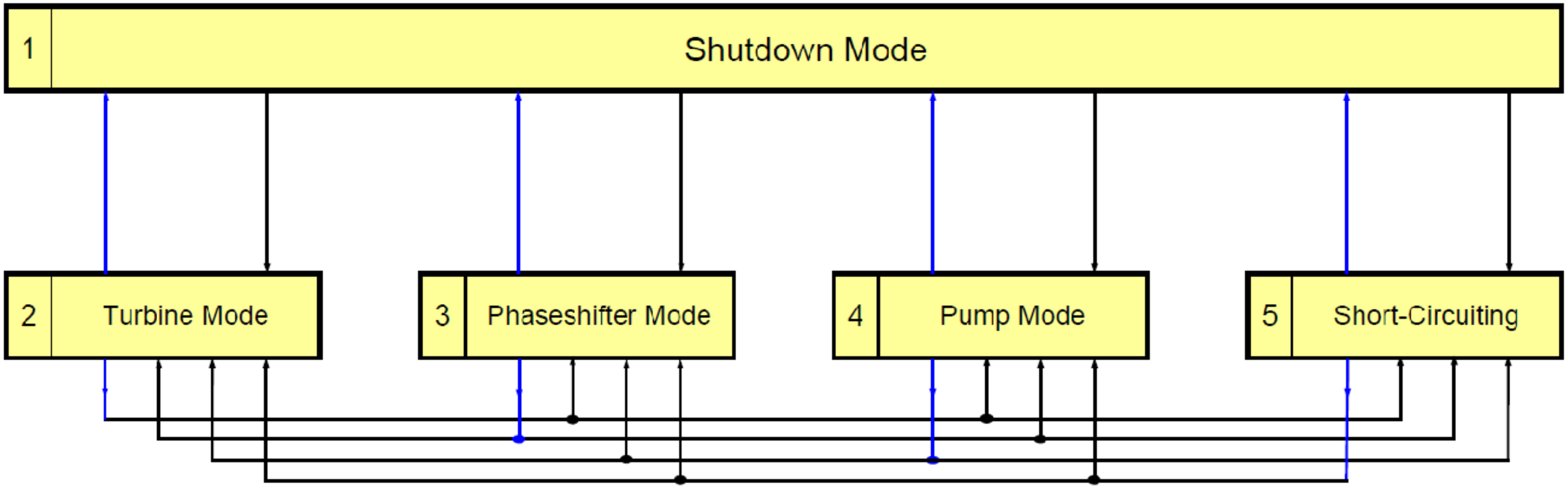
Principle of a Pumped Storage Hydro Power Plant II

Hydraulic Short-Circuiting using the example of
Kopswerk II, Montafon, Austria



Source: Vorarlberger Illwerke AG; http://www.kopswerk2.at/

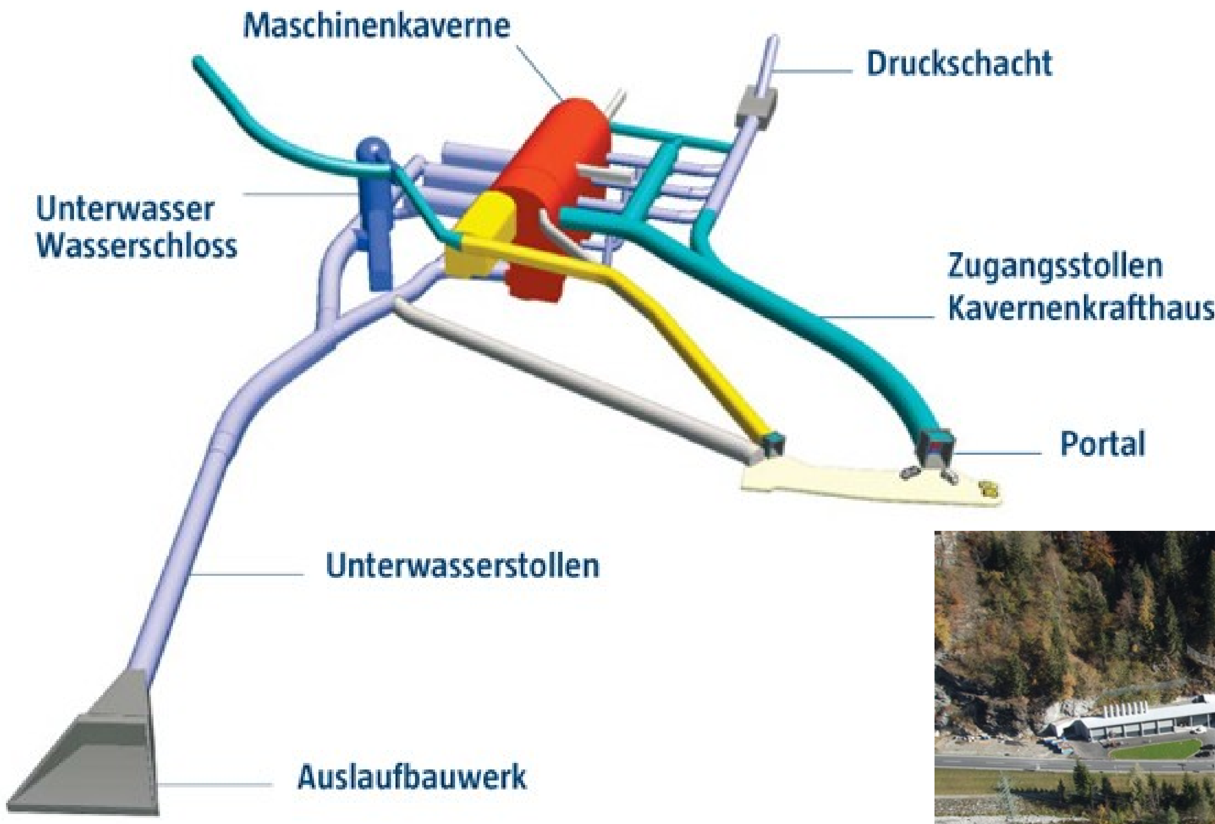
Overview Operating Modes and their Change Over



Source: Voith Hydro, Heidenheim

At any time (also during change over of operating mode) another mode can be addressed

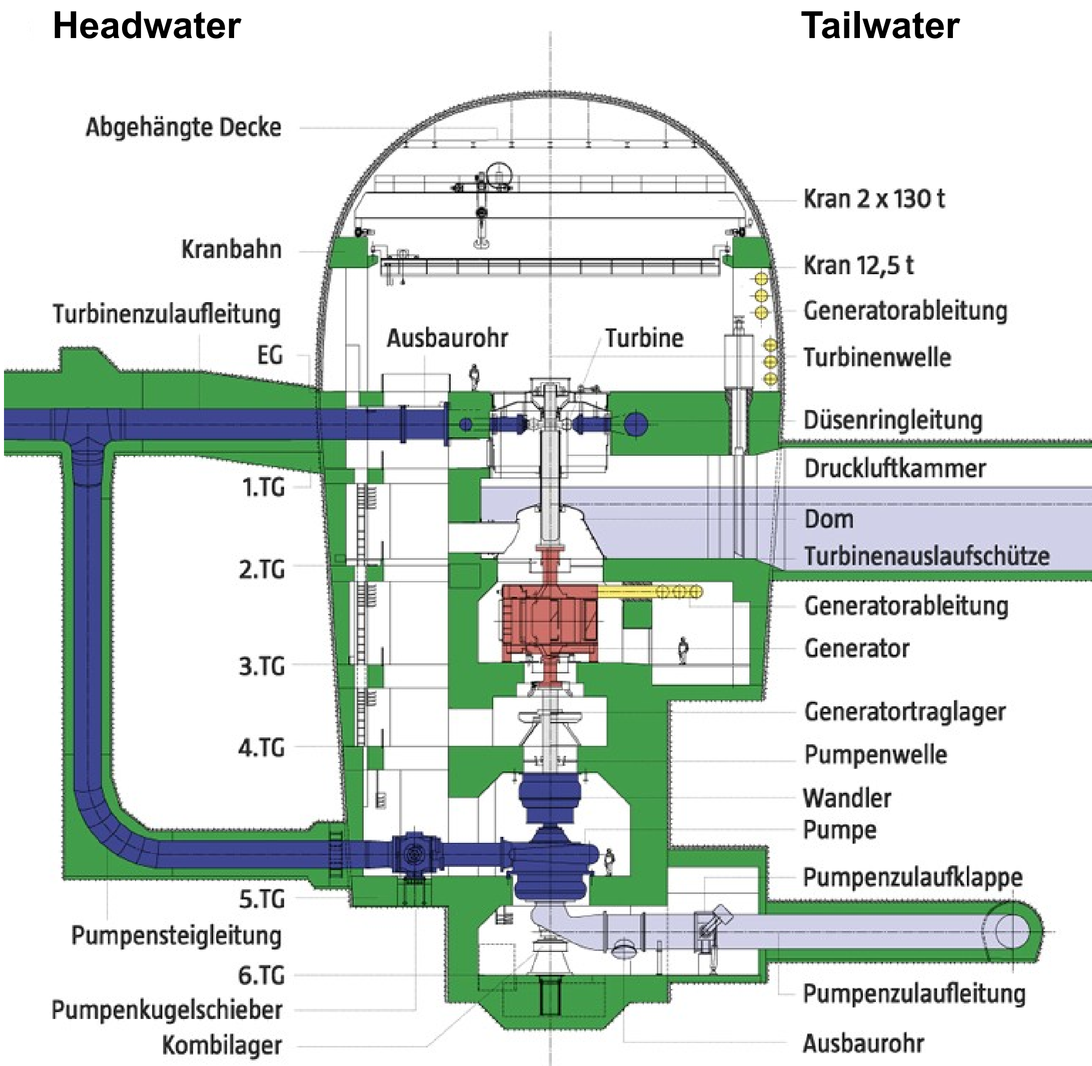
Underground Hydroelectric Power Station with 3 Units



Source: Vorarlberger Illwerke AG; http://www.kopswerk2.at/

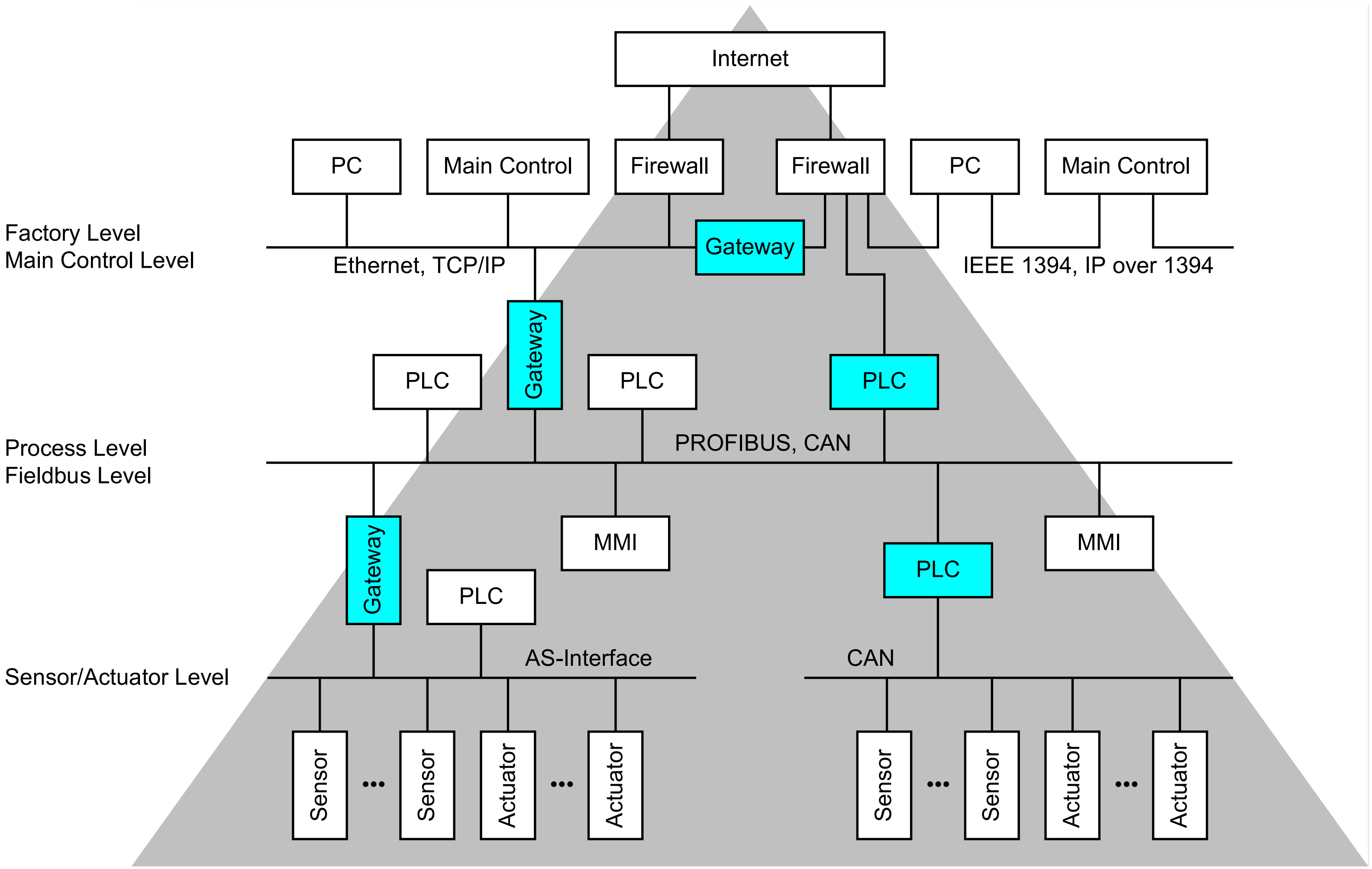
Section of Machinery Cavern

- Maschinery Cavern:
  - Length: ca. 88 m
  - Width: max. ca. 30.5 m
  - Hight: max. ca. 60.5 m
- Total Hight of a Maschine Unit: approx. 38 m
- Nominal Speed: 500 rpm
- Nominal Power per Turbine: 150 MW
- Input Power per Pump: 150 MW
- Head: approx. 800 m



Source: Vorarlberger Illwerke AG; http://www.kopswerk2.at/

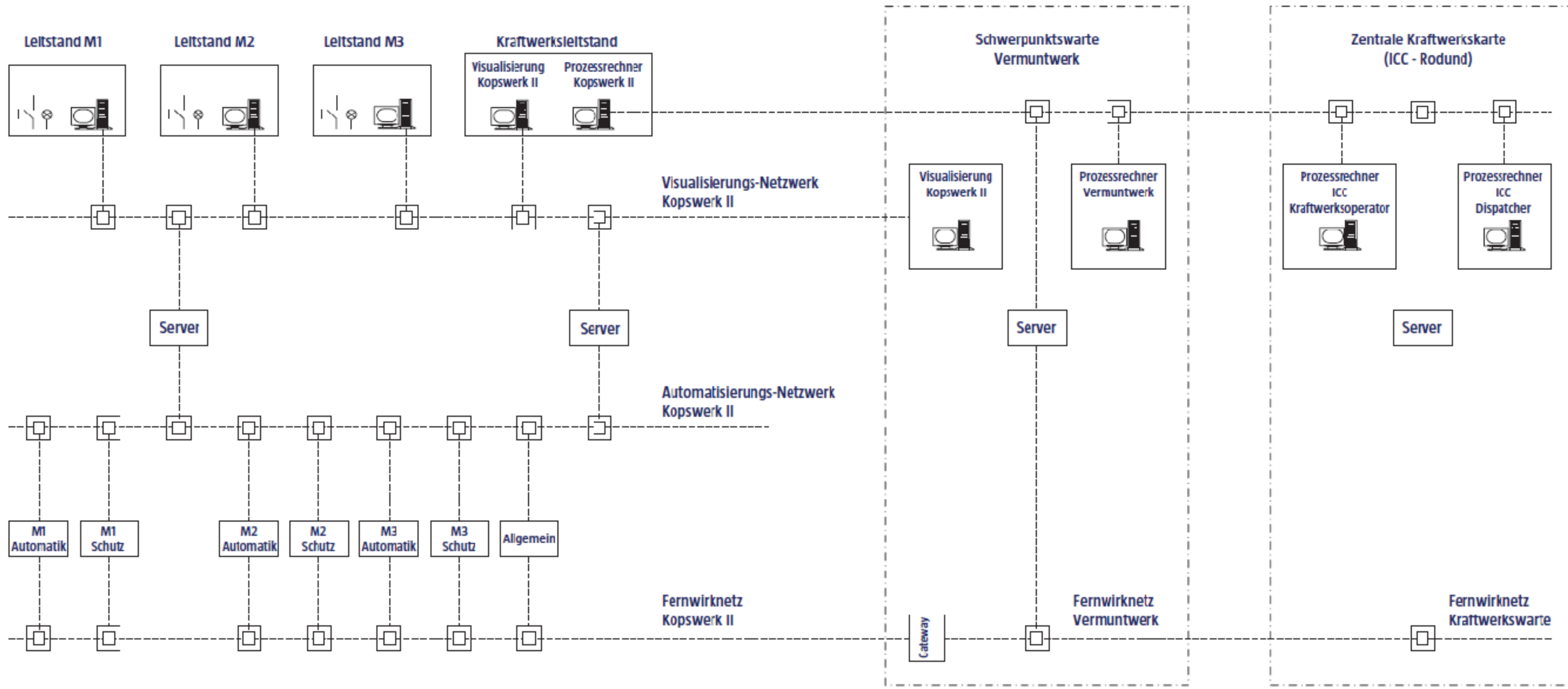
CAM Model



MMI – Men Machine Interface
PLC – Programmable Logic Controller

Plant Control System

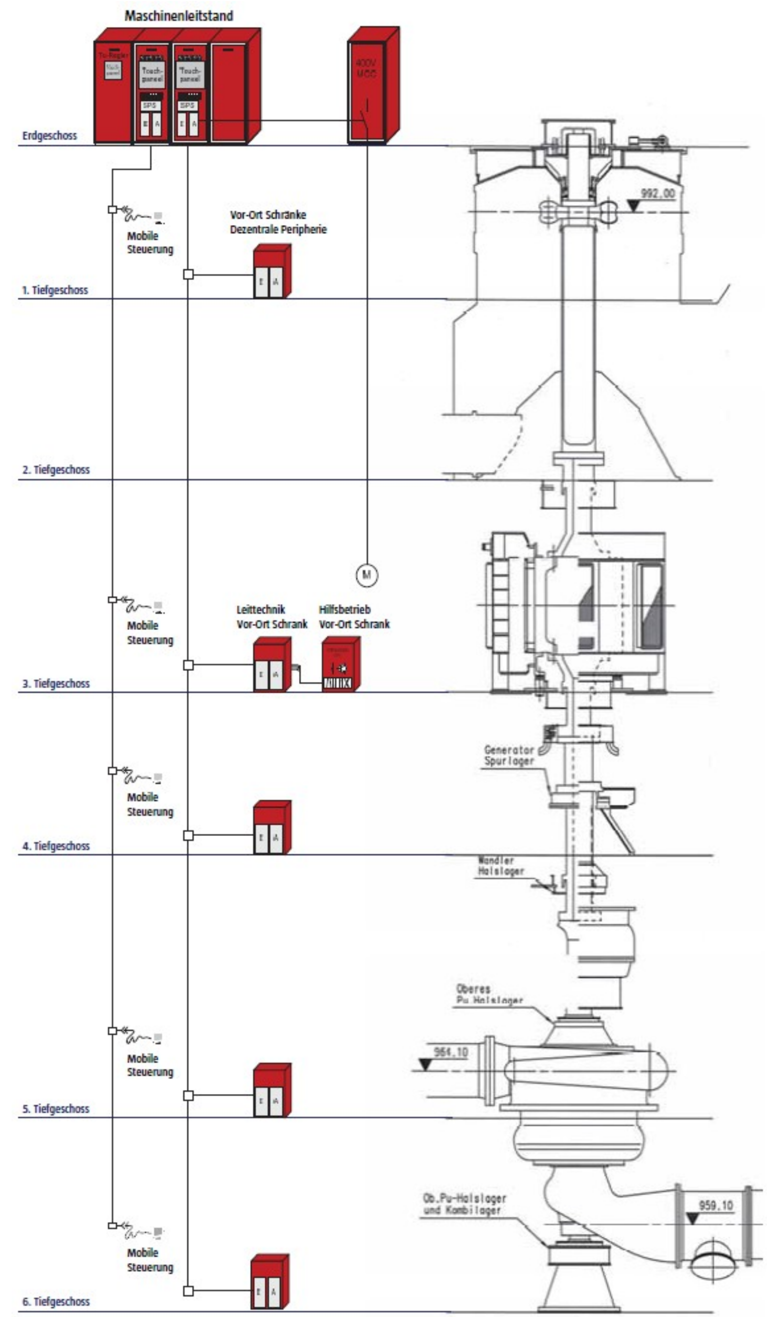
- General Power Plant Control System
- Machine Control System
- Visualization of the Control System Processes
- Remote Control via Connection to the Illwerke Control Center



Source: Vorarlberger Illwerke AG; http://www.kopswerk2.at/

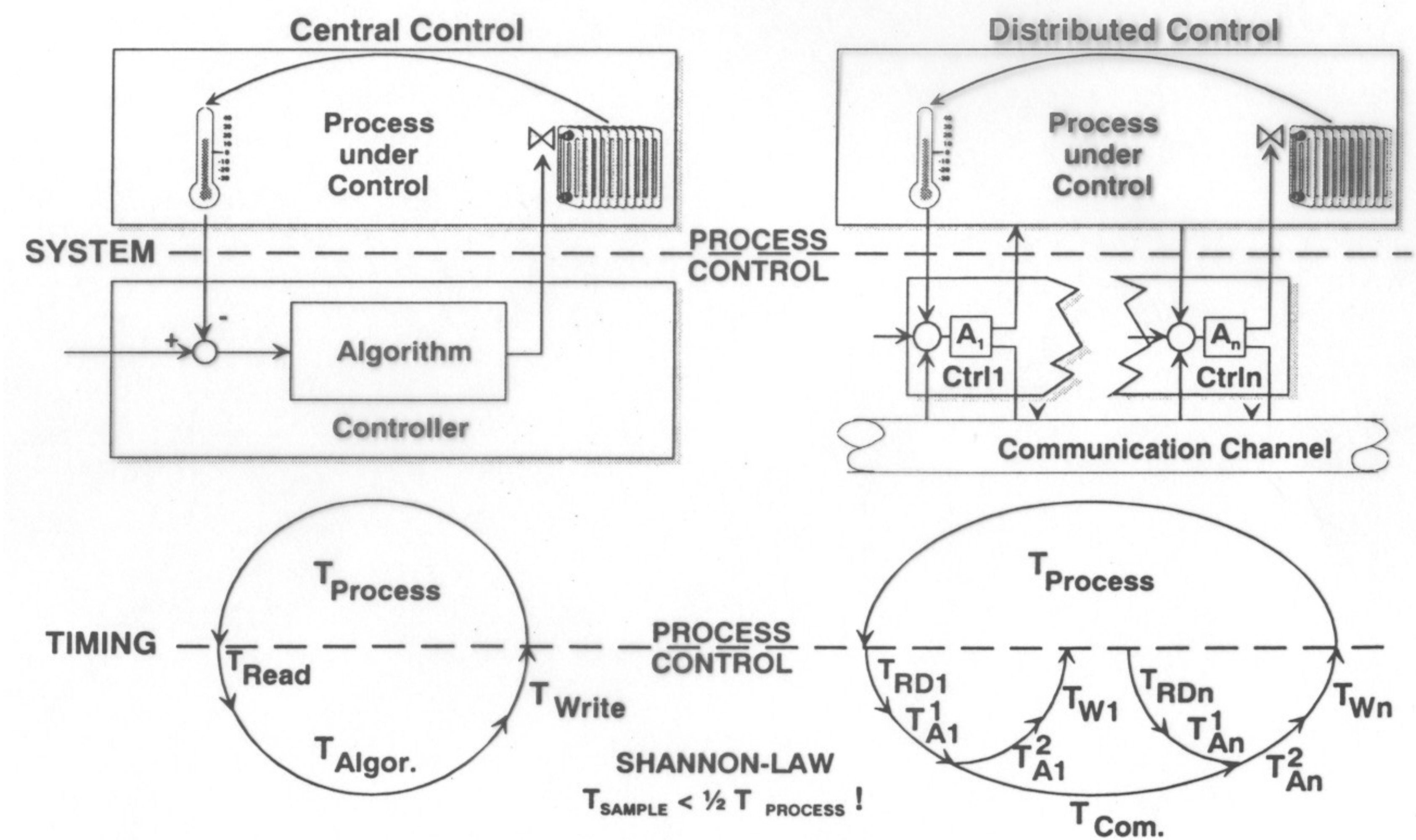
Machine Control System

- Control and Protection of each Unit
- Consists per Unit of „Islands of Hardware“ for:
  - Automatic (decentralized PLC)
  - Mechanical Protection (centralized PLC)
  - Mechanical Emergency Protection (relay control)
- Decentralized Peripheral Devices:
  Sensors (e.g. Pressure, Flow, Temperature) are wired on each floor to the corresponding field control cabinet
- At the Power Plant:
  - 176 Control Cabinets
  - 4.800 Cables; Total Length ca. 217 km
  - Overall approx. 8,500 Data Points



Source: Vorarlberger Illwerke AG; http://www.kopswerk2.at/

Time Response of a Distributed System



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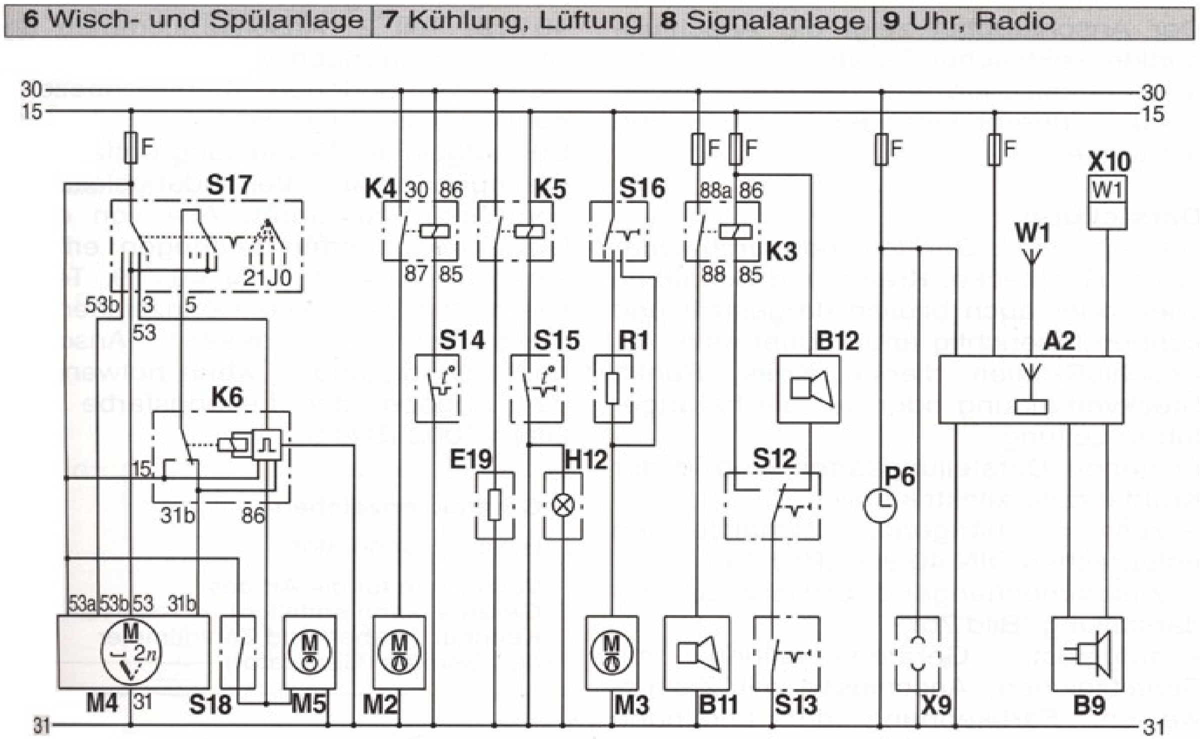
    - Example: VANET

Application: In-Car Networks

- Conventional Wiring System till the 1980s
  - Power Supply (Battery, Generator)
  - Starter
  - Ignition System
  - Lighting
  - Driver Assistance and Comfort Electronics

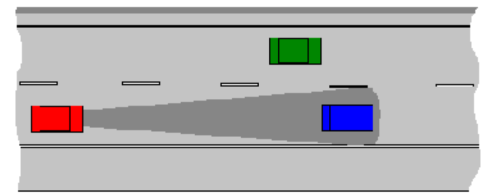
- Rising Functional Range demands more Cabeling



Source: Bosch; Autoelektrik Autoelektronik am Ottomotor

Complex Features in Modern Vehicles

- Power Train
  - Engine Management System, Exhaust After-treatment
  - Automatic Transmission
- Road Safety
  - Electronic Stability Program (ESP)
  - Adaptive Headlights, Cornering Lights
  - Adaptive Cruise Control (ACC)
  - Night Vision
- Comfort Electronics
  - Automatic Air Conditioning, Auxiliary Heating
  - Electric Window Lifts, Electric Sunroof
  - Electric Seat/Mirror Adjustment
- Infotainment
  - Radio, TV, CD, DVD, MP3
  - Navigation
  - Online Services
  - …

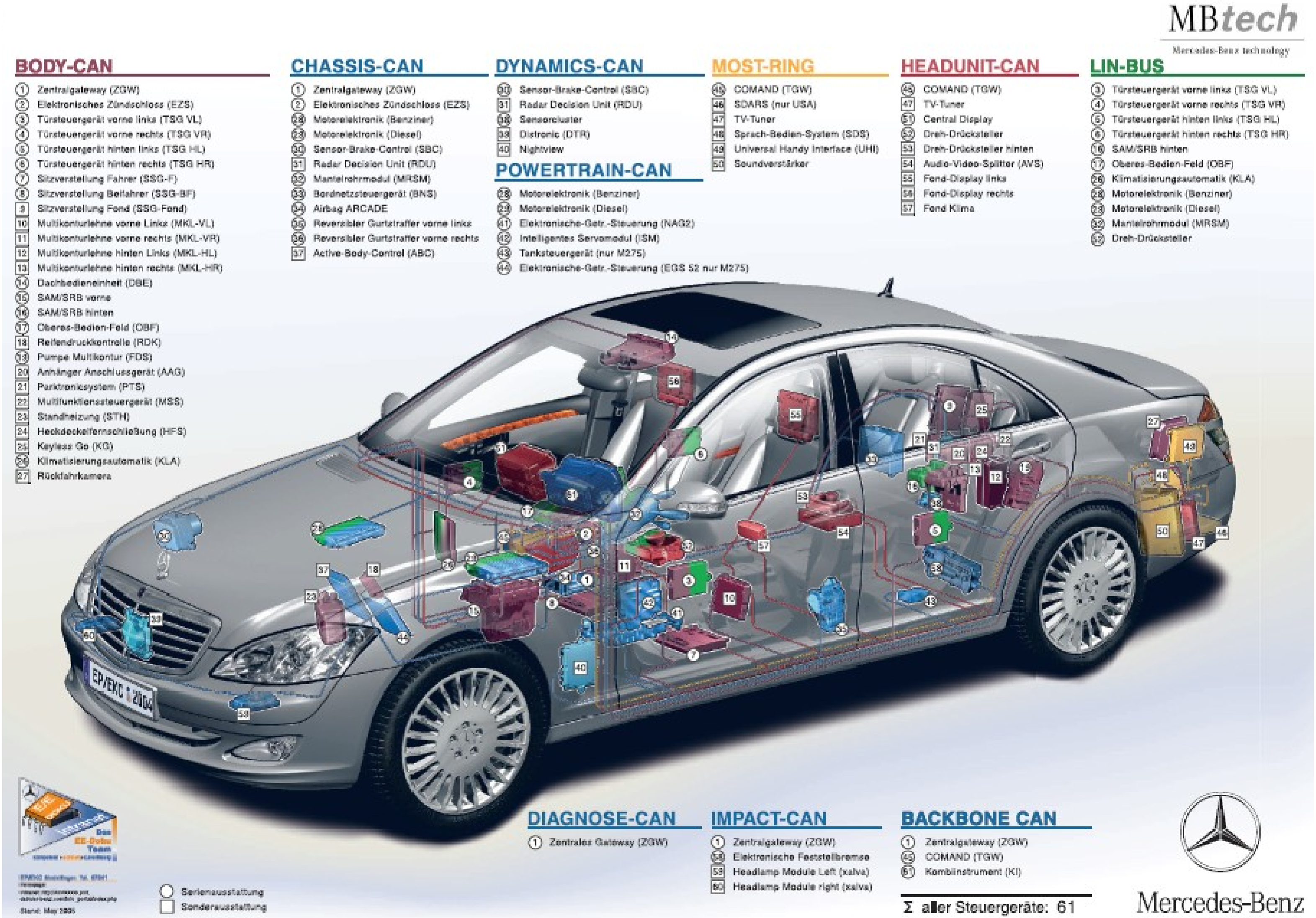


Source: http://de.wikipedia.org; Abstandsregeltempomat

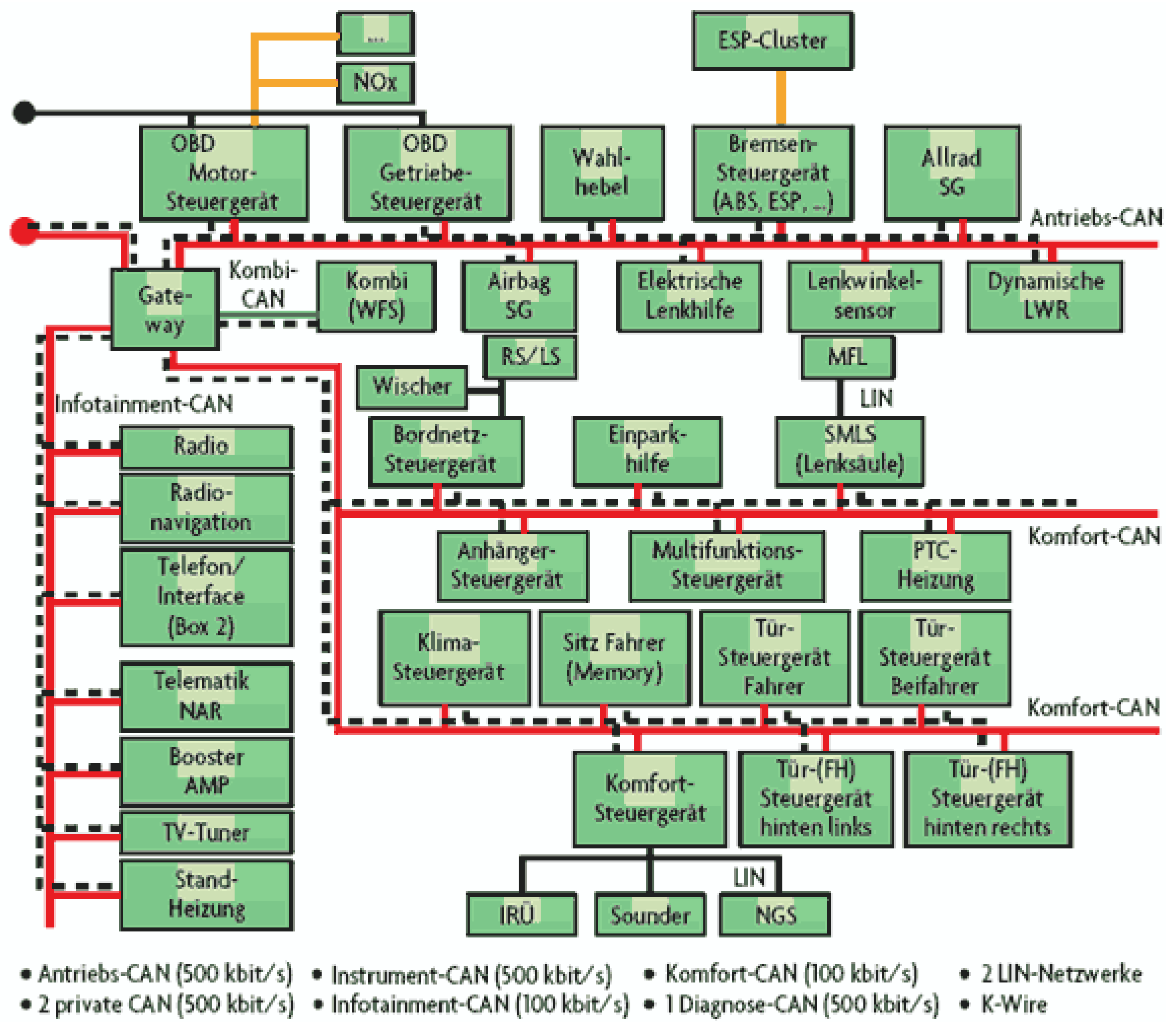
Source: http://www.mercedes-benz.de; Nachtsichtassistent

Source: http://www.bmw.de; Navigationssystem

Network Architecture of a S-Class (BR 221)



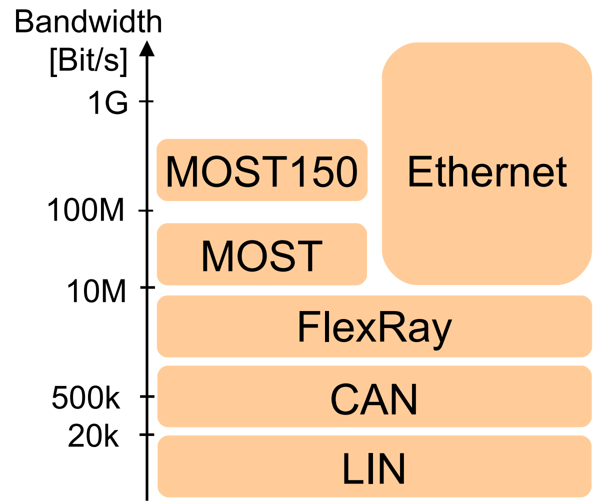
Network Architecture of a typical Medium-sized Vehicle



Source: http://www.tomshardware.com/de/bmw-x5-flexray-datenbus-neu,testberichte-1546-5.html

Automotive Fieldbus Systems

- Historically arised Demands
  - Driving relevant Features
  - Safety
  - Comfort
  - „Home/Office on Wheels“
- Specialised Networks
  - Control
  - Regulation
  - Automation
  - Audio/Video
- Embedded Systems Environment
  - Limited Resources



Latency? Jitter? Topology?

Cyclic or Event-driven Signals?

EMC?

Centralised or distributed Application?

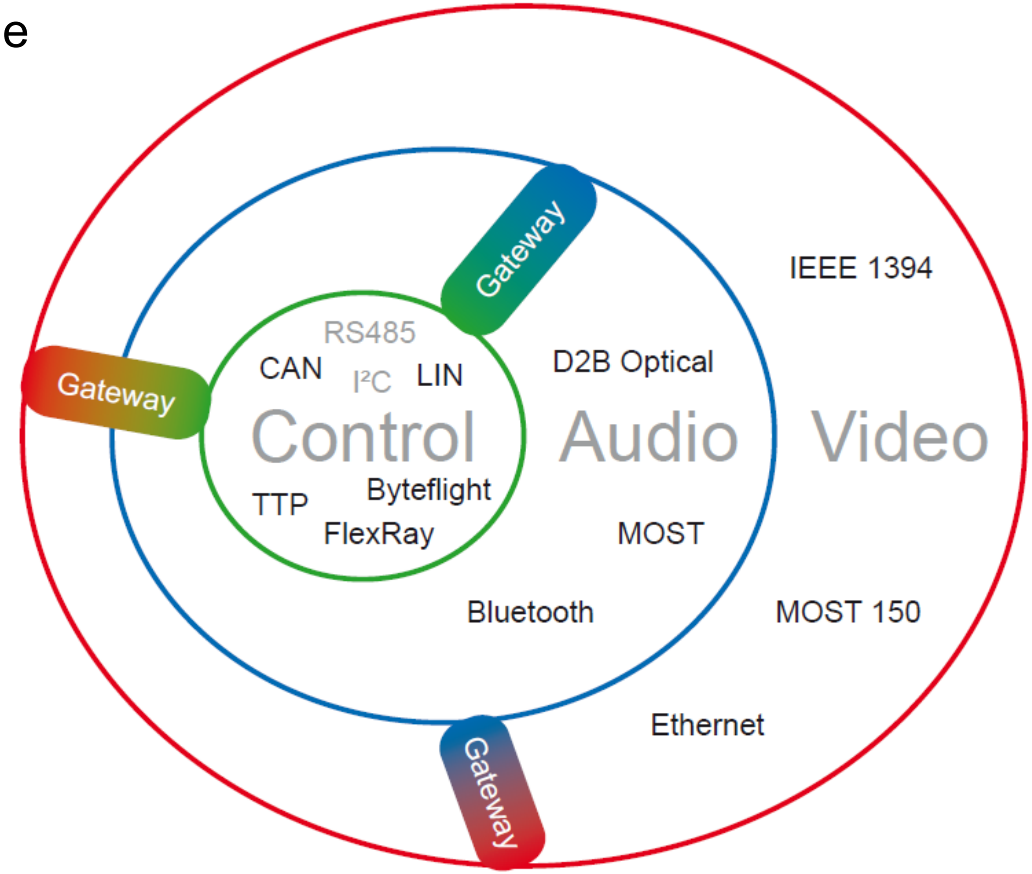
Redundancy? Safety? Payload Size?

LIN – Local Interconnect Network
CAN – Controller Area Network
MOST – Media Oriented Systems Transport

Heterogeneous Network Environment in Vehicles

- Consolidation not possible
  - Divergent QoS Requirements
  - Conservative Development Approach
  - Cost Pressure

Complex systems require costly application-specific gateways



LIN – Local Interconnect Network
CAN – Controller Area Network
TTP – Time Triggered Protocol
MOST – Media Oriented Systems Transport

Content

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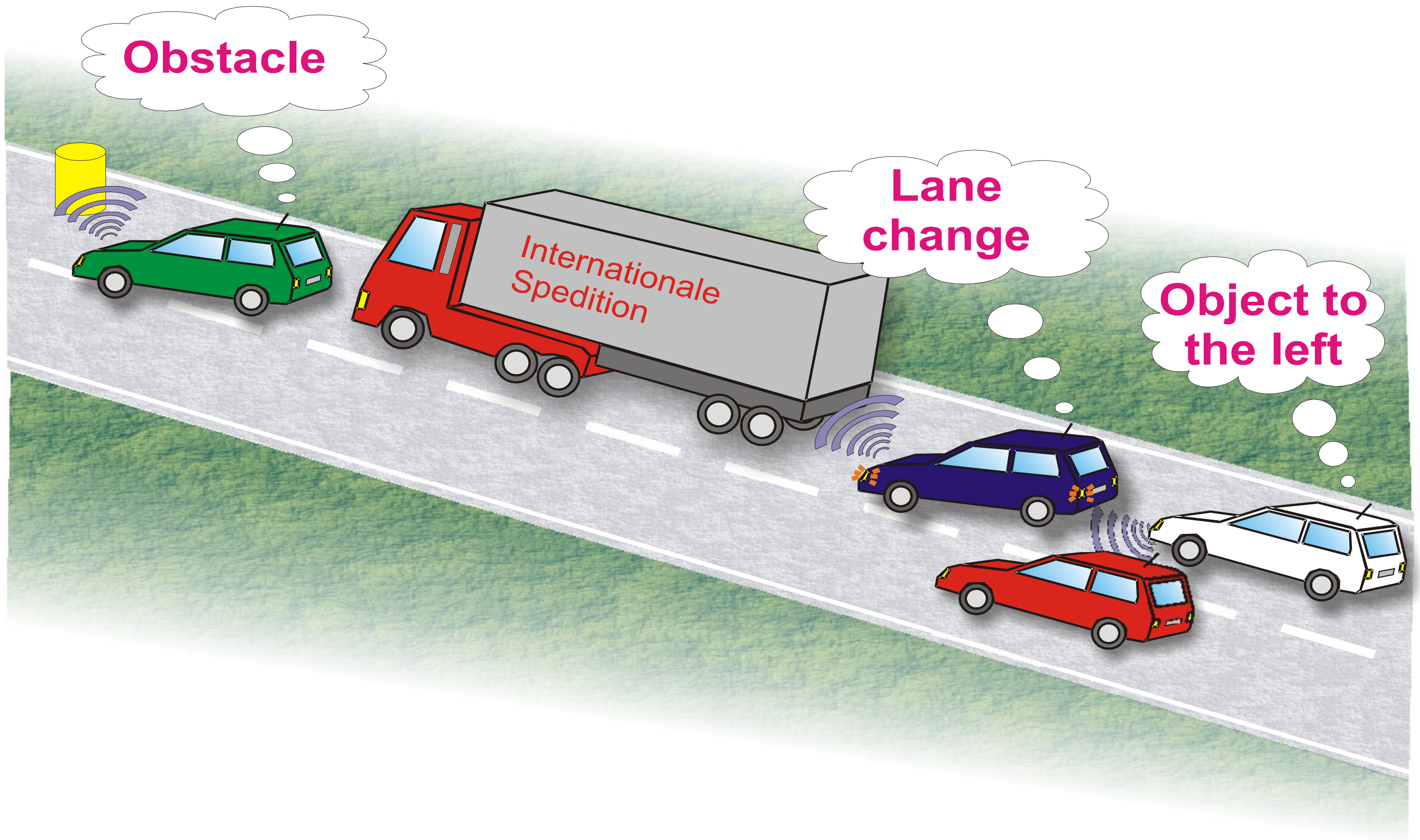
  - History
- Motivation: Real-World Network Implementations
  - Data/Computer Network
    - Uni Ulm Campus Network
  - Uni Ulm Campus PBX System
  - Networking in Automation
    - Pumped Storage Hydro Power Plant
    - Engine synchronization
  - In-Car Networks
  - Data Exchange between Mobile Systems
    - Example: VANET

Communication between mobile clients - Example: vehicles

- Vehicles are able to exchange information between each other
    - What information is worth to exchange ?
    - What applications can be deployed ?
    - How can information be disseminated ?
    - What sort of information is related to the different clients ?

- Wireless communication technology
    - What are the requirements ?
    - Is it possible to deploy existing technology ?
    - What are the challenges to overcome?

What information can be exchanged between vehicles ?

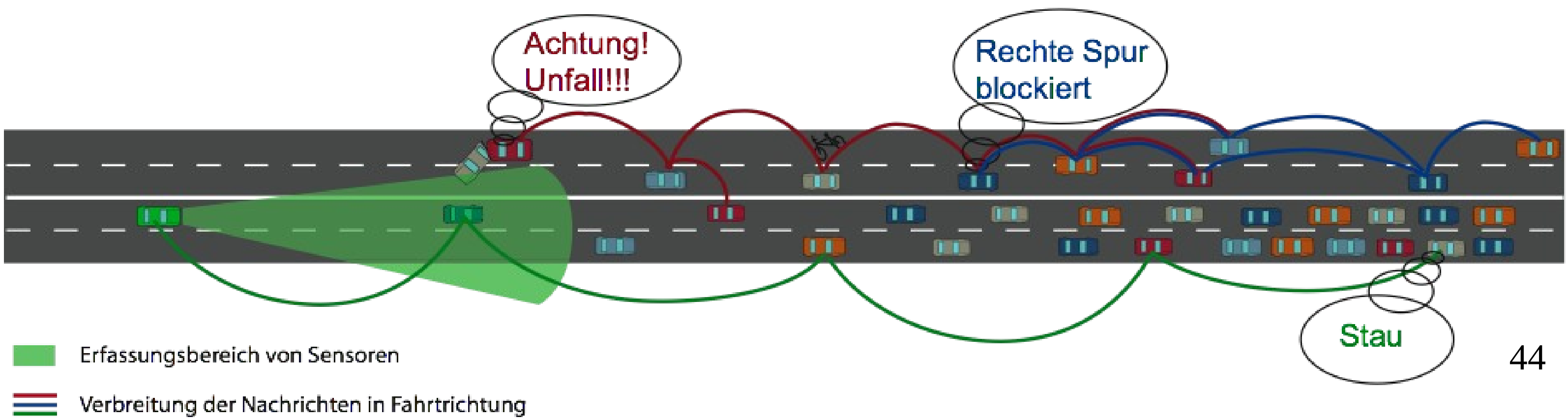


Possible Applications - Safety of Life

Safety of Life

- Local warnings in case of the following traffic situations
  - Accidents
  - Bad weather (like fog or icy roads)
  - Obstacles on the road
  - Slow or non moving vehicles (end of a traffic jam)

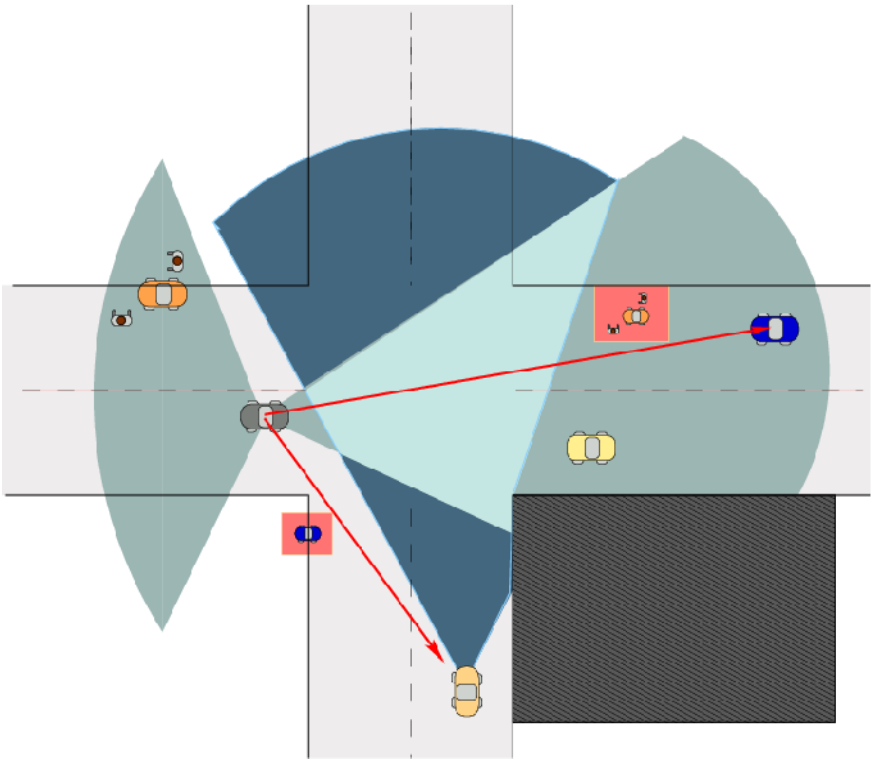
- Electronic break lights
  - Warning messages in case of an emergency break



Possible Applications - Co-operative Driving

Autonomous vehicles

- Exchange of driving maneuvers (overtaking, turn ...)
- co-operative fusion of sensor data
  - Exchange of information about objects detected by on-board sensors



Possible Applications - Decentralized Services

- Fast distribution of the local traffic information
  - Congested roads
  - Parking information
  - Traffic light information

Challenges for the technology

Aspect
- Reliability
- Delay and latency of the messages
- Real-time capability

Criteria	SAFETY OF LIFE	Co-operative Driving #1	Co-Operative Driving #2	Decentralized Services
Reliability	High	High	High	High
Delay	Low Delay	Low Delay	Low Delay	No relevance
Real-Time-Capability	No	No	Yes	No
Information destinations	Nodes in a dedicated area	Nodes in a dedicated area	Nodes in a dedicated area	Interested nodes in a dedicated area

Possible technologies - Infrastructure based network for mobile clients (GSM/GPRS/UMTS) ?

UMTS, GSM/GPRS

- support mobility of clients (+)
- already deployed in a wide area (+)
- infrastructure has to be added -> expensive (-)
- high overhead due to centralized structure (-)
- addressing of certain clients difficult (-)

Possible technologies - Ad-Hoc-Network ?

Ad-Hoc Network

- Nodes connect to each other spontaneously (+)
- Clients have to provide function of the active components (+)
- no infrastructure needed (+)

Bluetooth

- long inquiry process(--)

IEEE 802.11 (WLAN)

- no setup process (+)
- not for mobile environments (-)

VANET

Vehicular **A**d **H**oc **Net**work

- Similar to WiFi
- Broadcast network only
- High node mobility

Challenges / Tasks to get this going ...

- Medium Access Control (MAC)
- Message Forwarding, Routing, Data Dissemination
- Reliability
- Prioritization
- Resource Allocation