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Vorlesung Kommunikationsnetze

Research Topics: Protocol Family for Control Data Communication in Heterogeneous Network Environments

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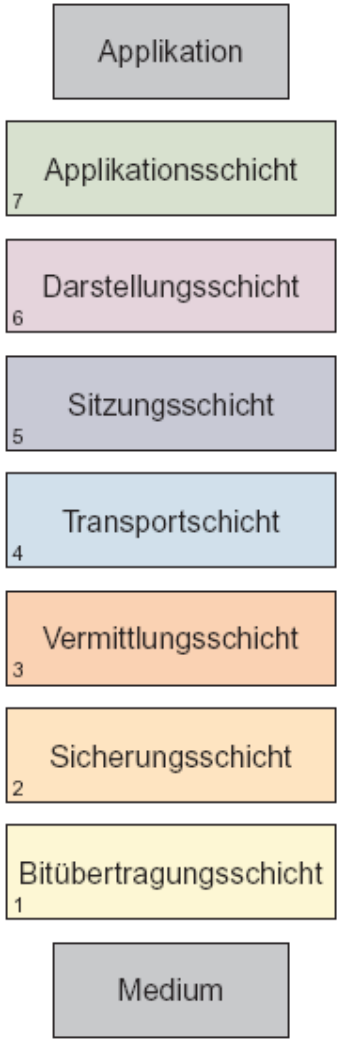
Institut für Organisation und Management von Informationssystemen

Fieldbus Systems

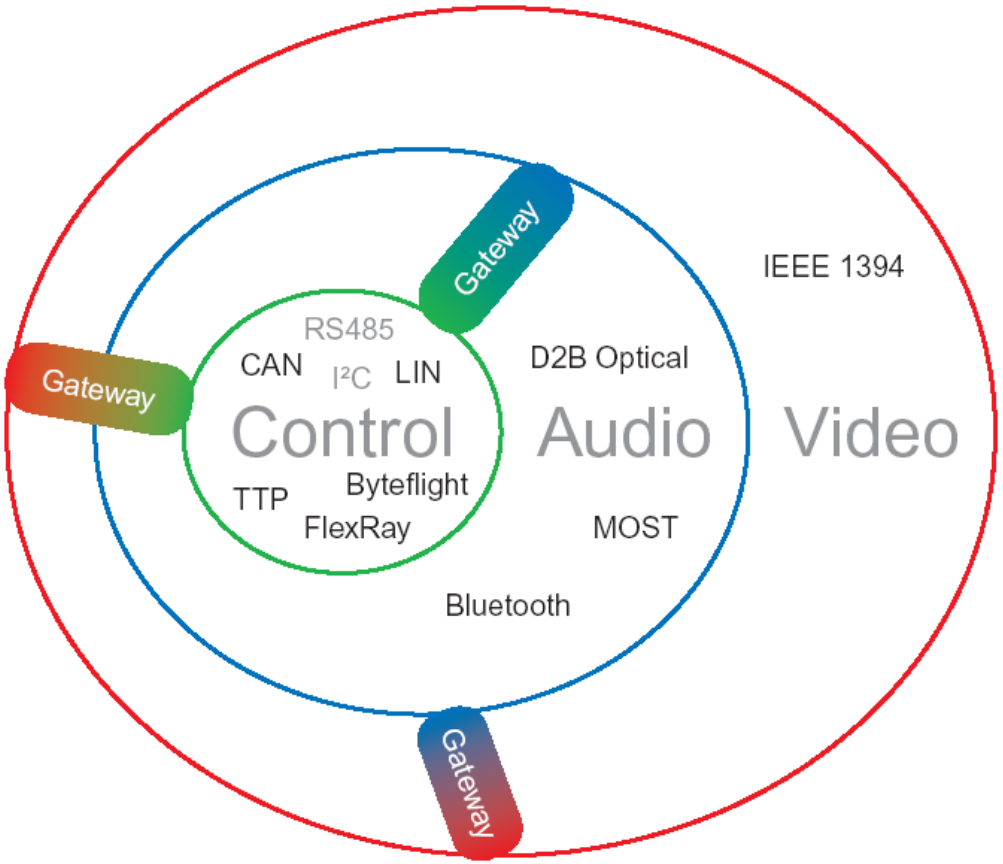
- Specialized networks
  - Governing
  - Closed-loop control
  - Automation
- Evolved historically
  - Automotive engineering
  - Industrial communication
  - Building services engineering
- Embedded system environment
  - Limited resources
- Variety of interfaces
  - Network technology
  - Application specific higher layer protocols



Heterogeneous Network Environment in Cars

- No consolidation
  - Divergent requirements to QoS
  - Conservative approach
  - Cost pressure

➔ Complex Systems need elaborate, application specific gateways

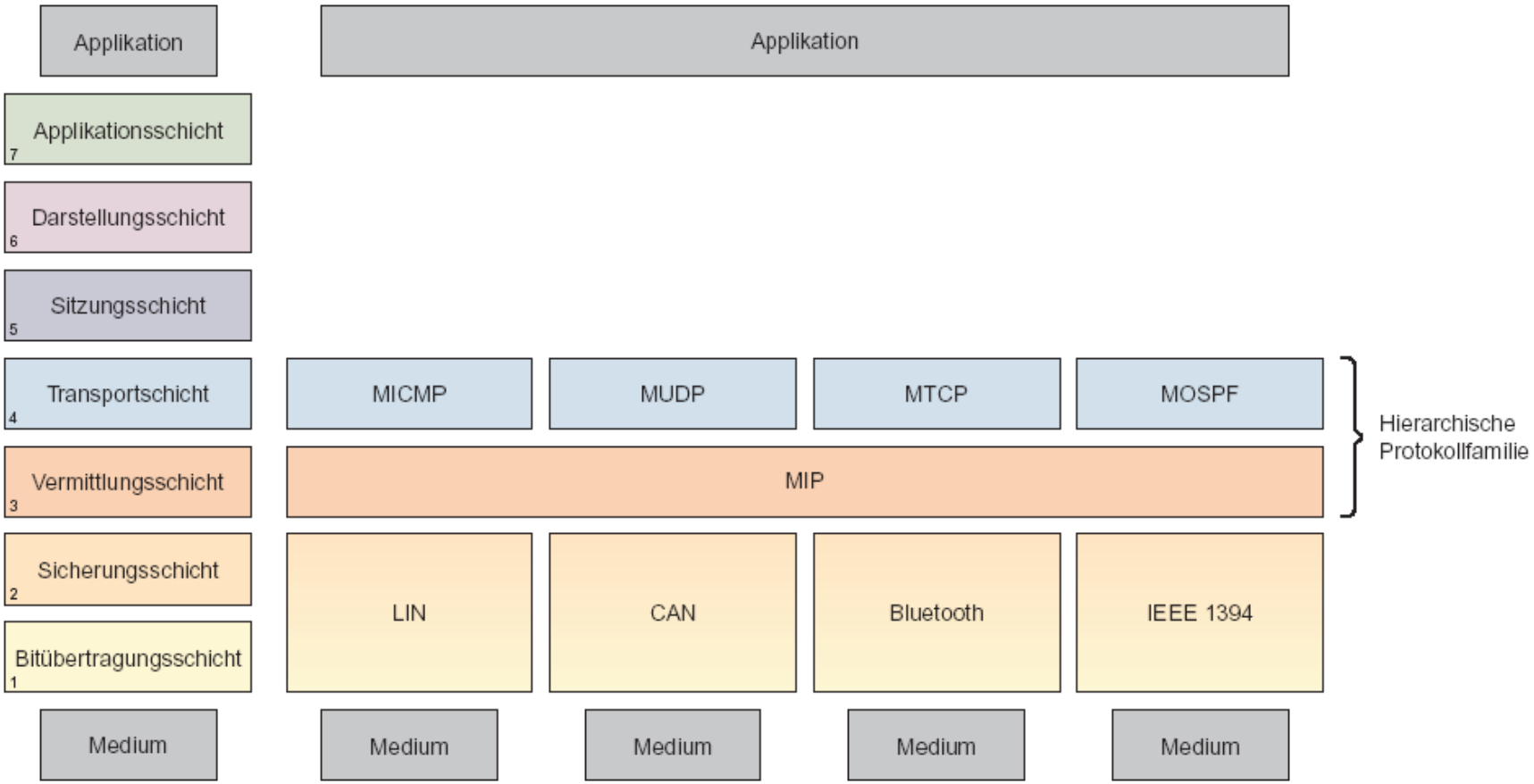


LIN – Local Interconnect Network
CAN – Controller Area Network
TTP – Time Triggered Protocol
MOST – Media Oriented Systems Transport

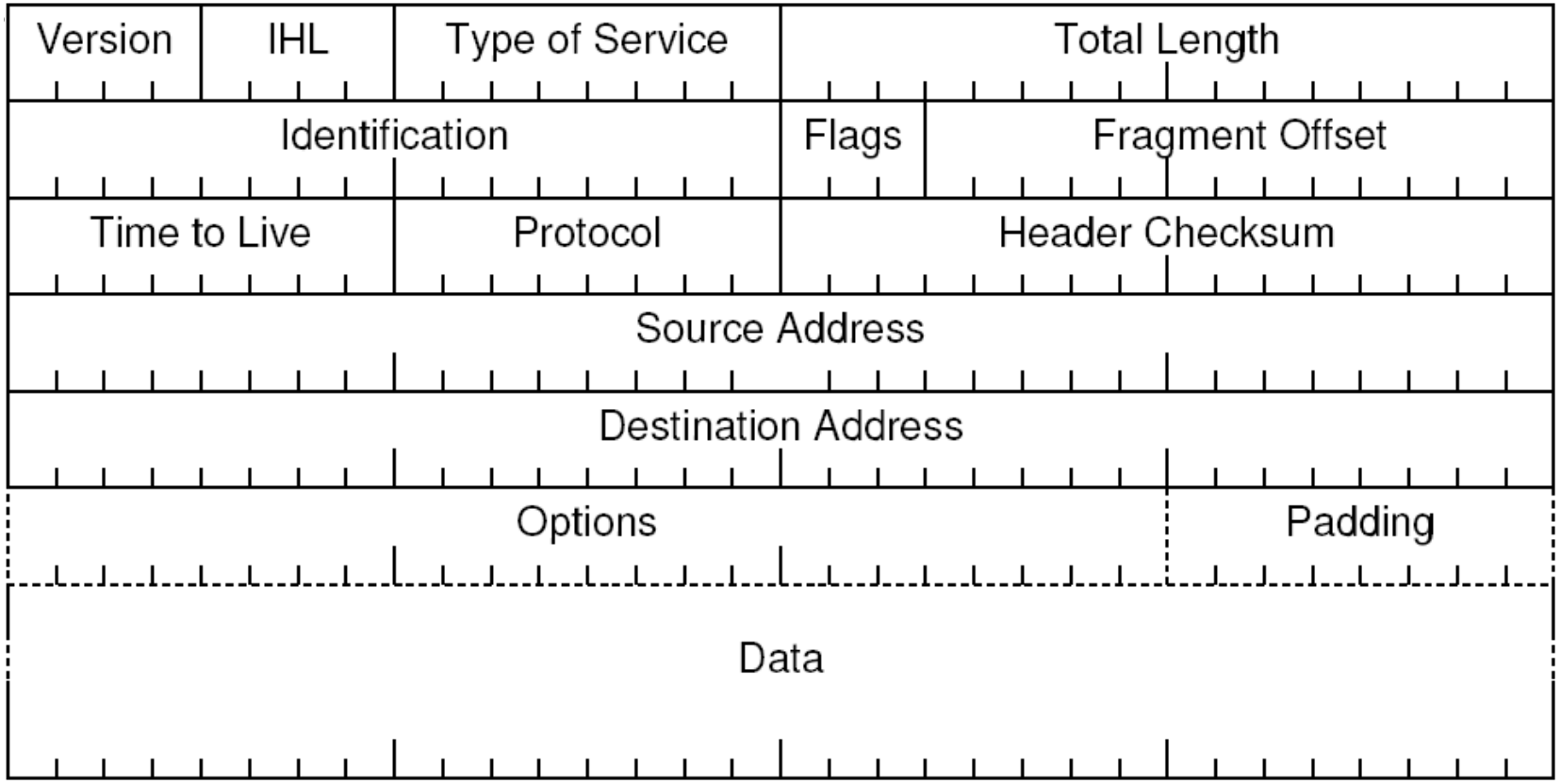
Goals

- Data communication with standardised gateways
  - Using redundant paths
  - Routing under consideration of QoS
- Common interface for future-proof applications
  - Normal operation mode
    - Control data communication
    - Data packet with small amount of payload
    - Overhead as little as possible
  - Temporary operation mode
    - Software updates of automation devices
    - Transfer of larger amount of data
- Transfer of data from/to Internet
  - Remote diagnosis and maintenance

Concept: Hierarchical Protocol Family



Excursus: IPv4 Datagram

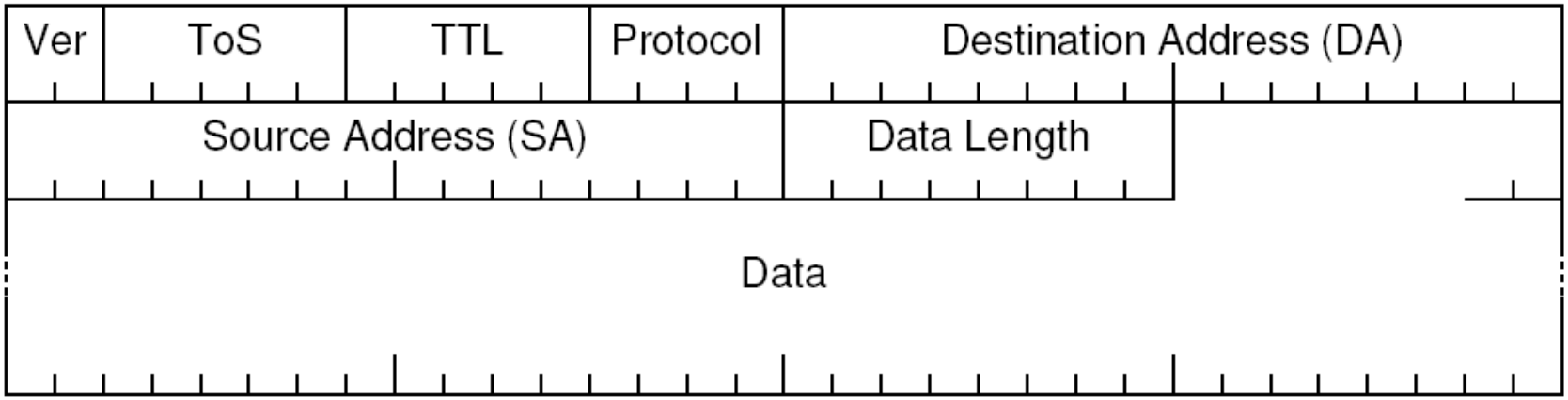


Hierarchical Protocol Family: Layer 3

Micro Internet Protocol (MIP) as the convergence layer

- Transparent communication using different network technologies
- Consistent addressing scheme: 16 bit node address
  - 8 bit network, 8 bit host
- Interfaces to fieldbuses
  - Adaptation of addressing schemes
  - Fragmentation
  - Exemplary defined for LIN, CAN, Bluetooth, IEEE 1394
- Unacknowledged datagrams
  - Optimised header for control data
    7 byte (IP: min. 20 byte)
  - Indication of desired QoS by applications

MIP Datagram



MIP Protocol ▸

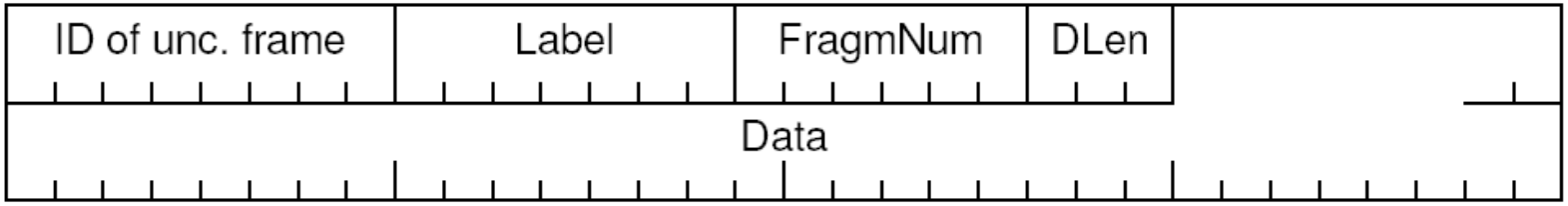
0x1	Micro Internet Control Message Protocol (MICMP)
0x2	Micro User Datagram Protocol (MUDP)
0x3	Micro Transmission Control Protocol (MTCP)
0x4	Micro Open Shortest Path First (MOSPF)

Interface to LIN

- LIN Identifier

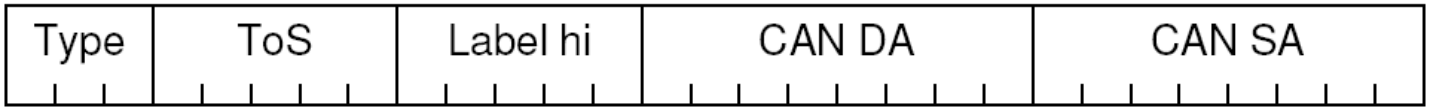
- LIN Data (unconditional frame)

- LIN Data (event-triggered frame)



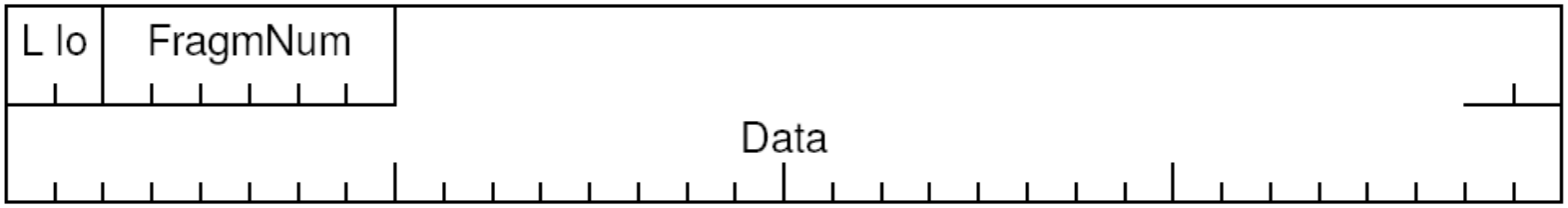
Interface to CAN

- CAN Identifier



- CAN Data Length Code

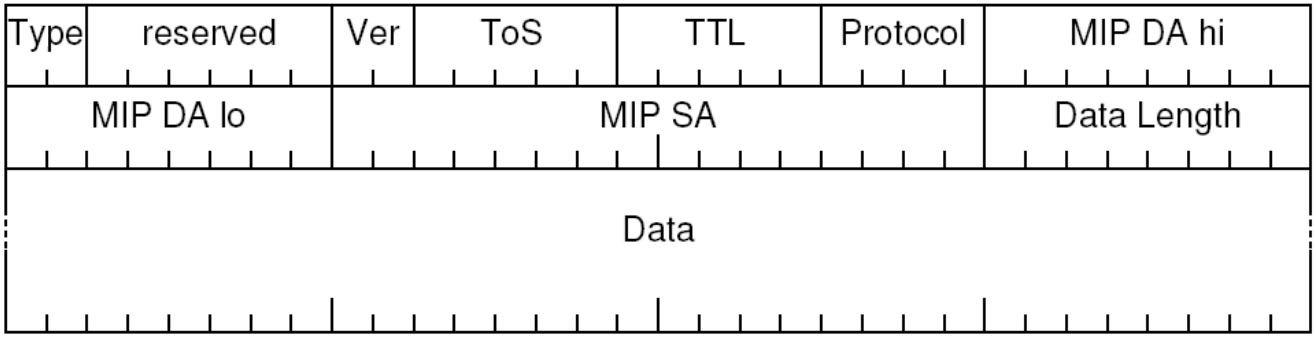
- CAN Data



Interface to Bluetooth

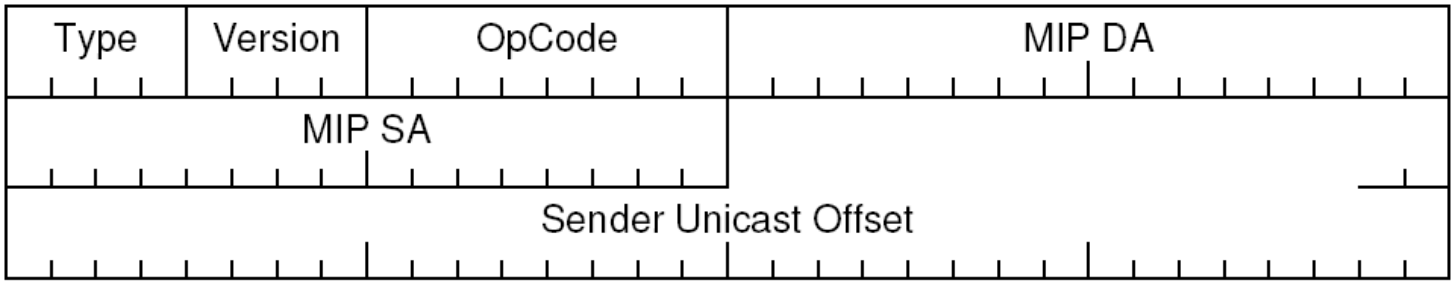
- Based on Bluetooth Network Encapsulation Protocol (BNEP) over Logical Link Control and Adaption Protocol (L2CAP)
  - MARP-BT Datagram
    Type = $0x0_{Hex}$

  - MIP Datagram
    Type = $0x1_{Hex}$

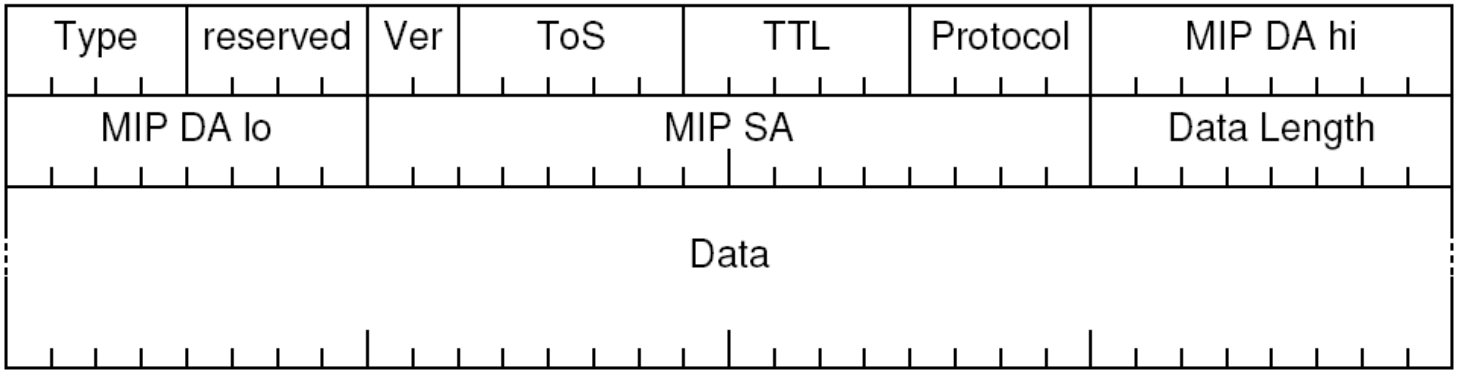


Interface to IEEE 1394

- Unicast: Write Request for Data Block (WRDB)
- Broadcast: Global Asynchronous Stream Packet (GASP)
  - MARP-1394 Datagram
    Type = $0x0_{Hex}$

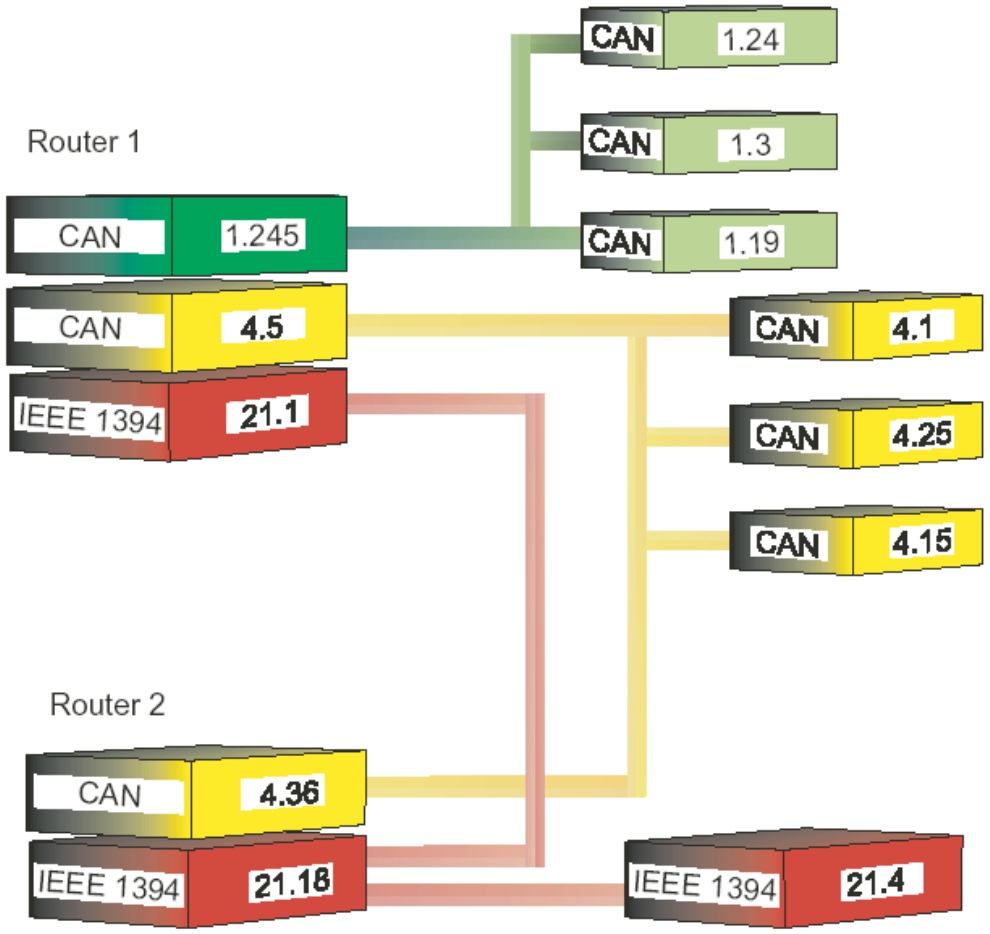


  - MIP Datagram
    Type = $0x1_{Hex}$



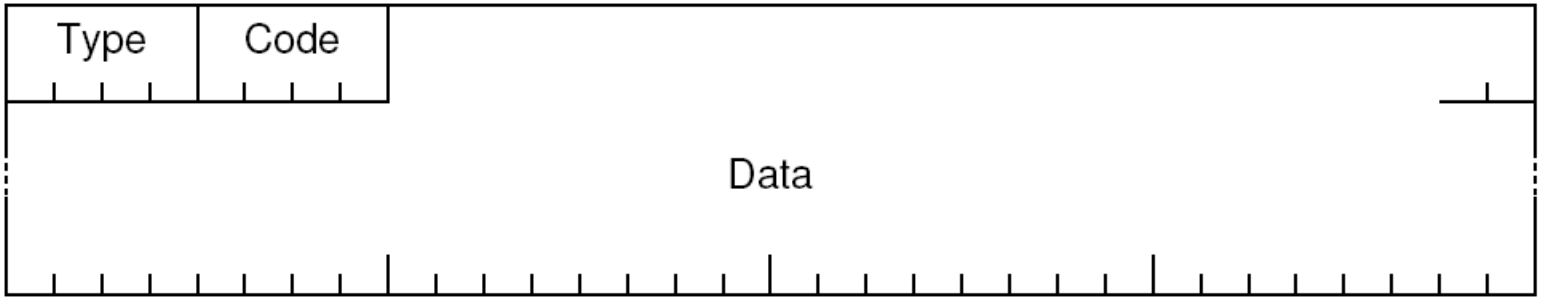
Routers in place of Gateways

- Consider heterogeneous networks as subnets
- Routing is independent of the used fieldbus
- Using redundancy if a network segment fails
- Basis for QoS dependent routing



Hierarchical Protocol Family: Layer 4 (I)

- Micro Internet Control Message Protocol (MICMP)
  - Signalling of errors due to processing of MIP datagrams
  - Network diagnosis
  - Header: 1 byte (ICMP: 8 byte)

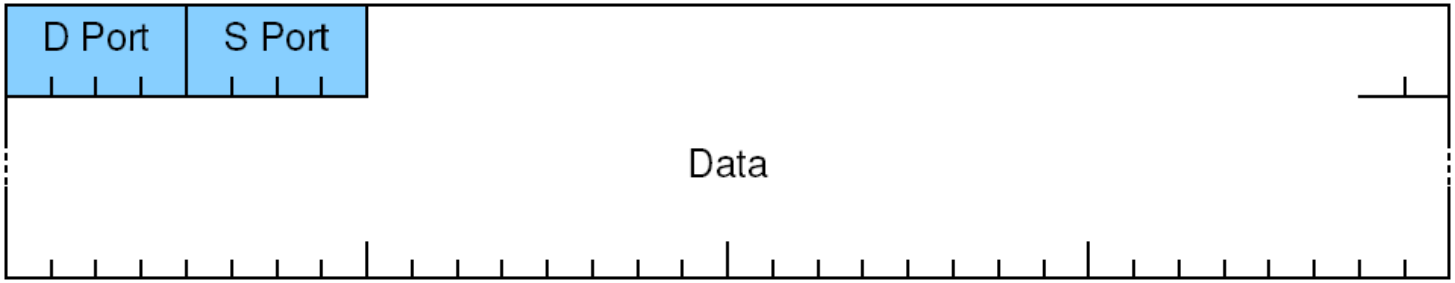


MICMP Type

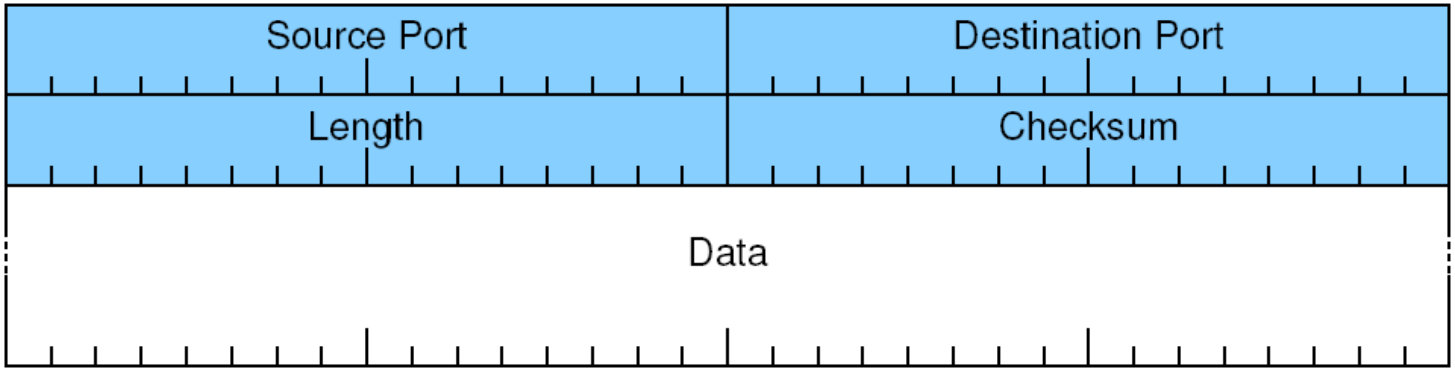
0x0	Echo Test
...	...
0x3	TTL Exceeded
0x4	Destination Unreachable
0x5	Parameter Problem

Hierarchical Protocol Family: Layer 4 (II)

- Micro User Datagram Protocol (MUDP)
  - Connectionless unreliable transport service for applications
  - Header: 1 byte

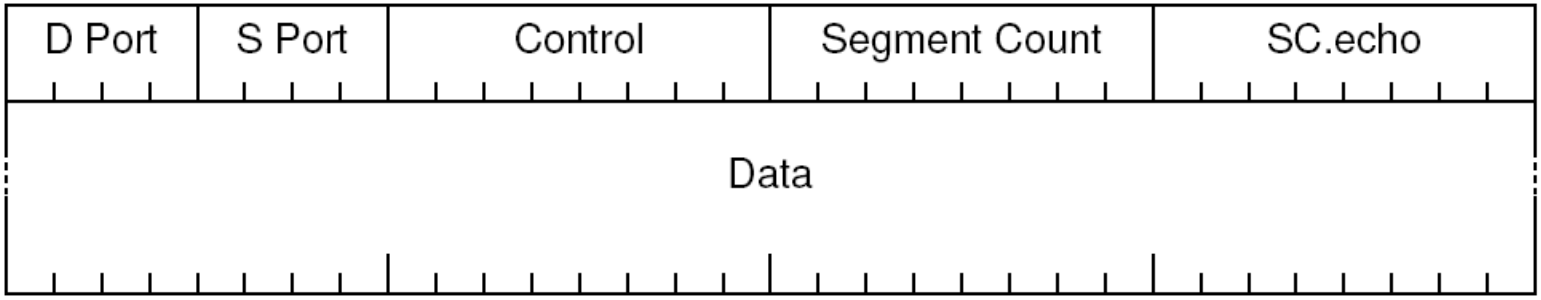


- Comparison: User Datagram Protocol (UDP)
  - Header: 8 byte



Hierarchical Protocol Family: Layer 4 (III)

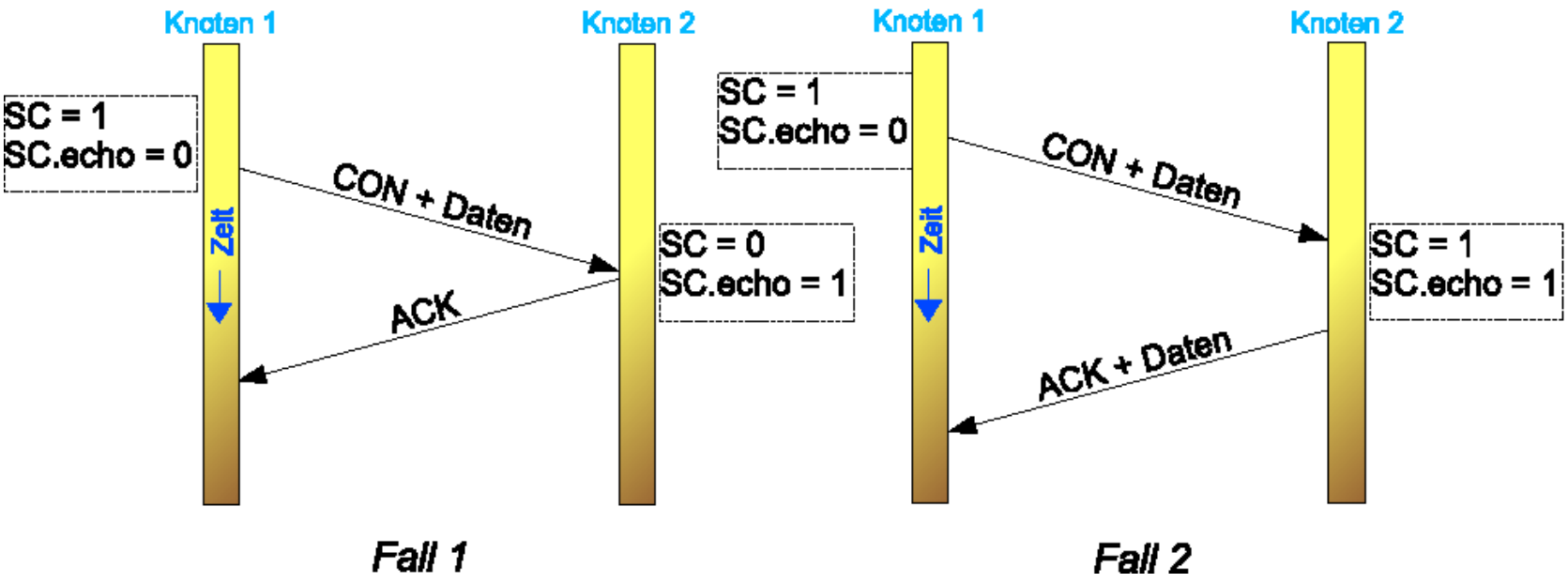
- Micro Transmission Control Protocol (MTCP)
  - Transport service for applications
    - Connection-oriented, reliable
    - Transactions
  - Header: 4 byte (TCP: min. 20 byte)



MTCP Control

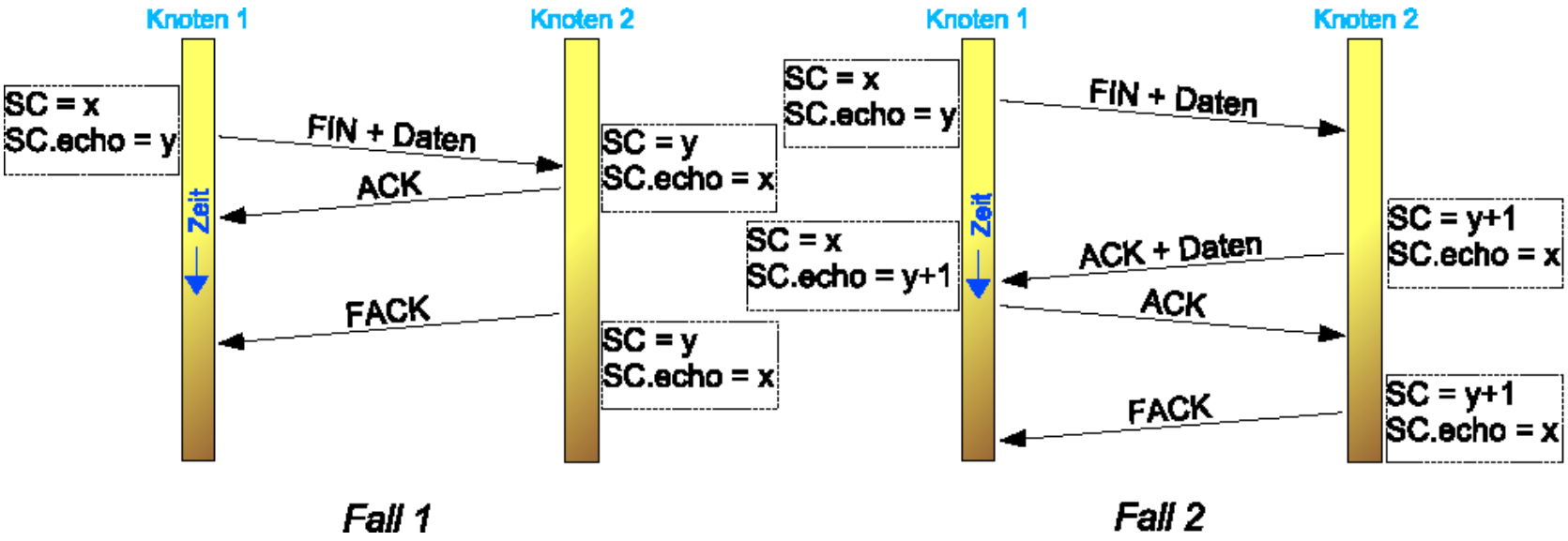
Bit	7	6	5	4	3	2	1	0
Signal	unused	unused	FACK	ACK	FIN	CON	WND	RST

MTCP – Connection Establishment



- Case 1: Node 2 answers connection request from node 1 with ACK flag solely.
- Case 2: Node 2 sends ACK flag together with the first data package.

MTCP – Connection Termination

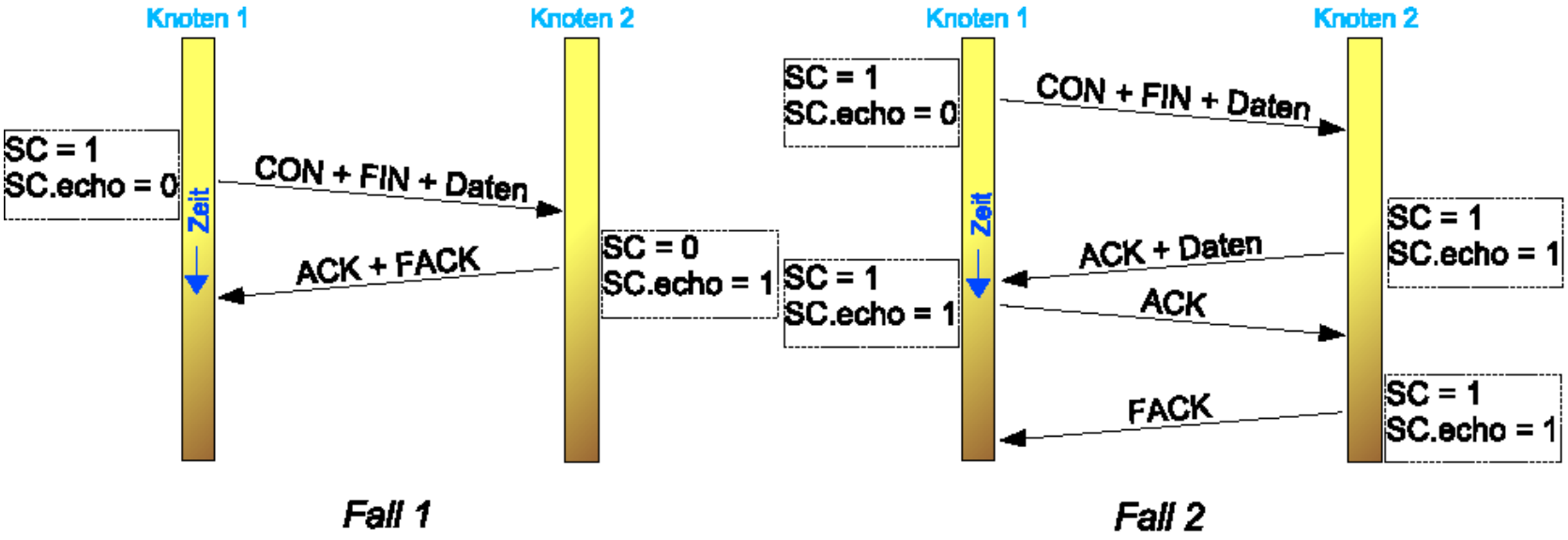


- Case 1: Node 2 has no further data. The received segment from node 1 is acknowledged by ACK flag, the connection is terminated by FACK flag. ACK and FACK flag can be combined.

- Case 2: Node 2 has further data. The FACK flag can be sent when all data segments of node 2 are acknowledged from node 1.

MTCP – Transaction

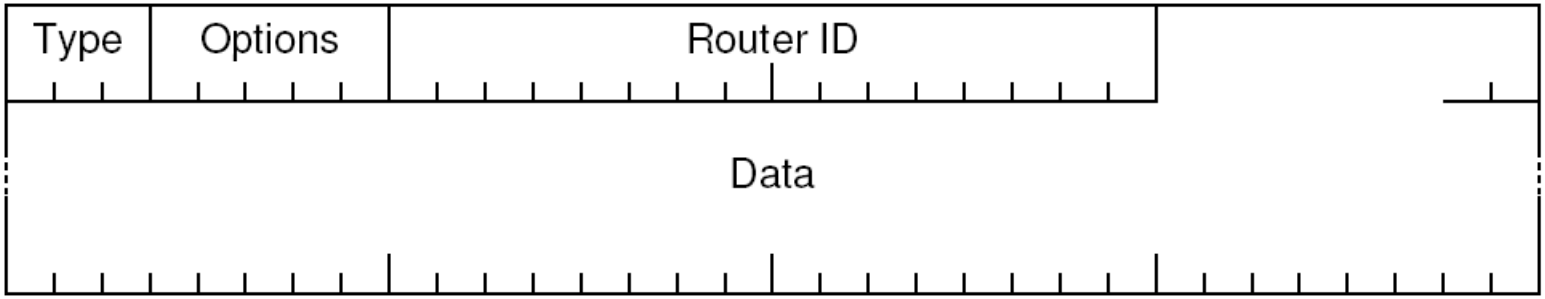
Special case of connection termination, the CON flag is set in the first segment



- Case 1: Status message from node 1 to node 2.
- Case 2: Transaction, consisting of request and reply.

Hierarchical Protocol Family: Layer 4 (IV)

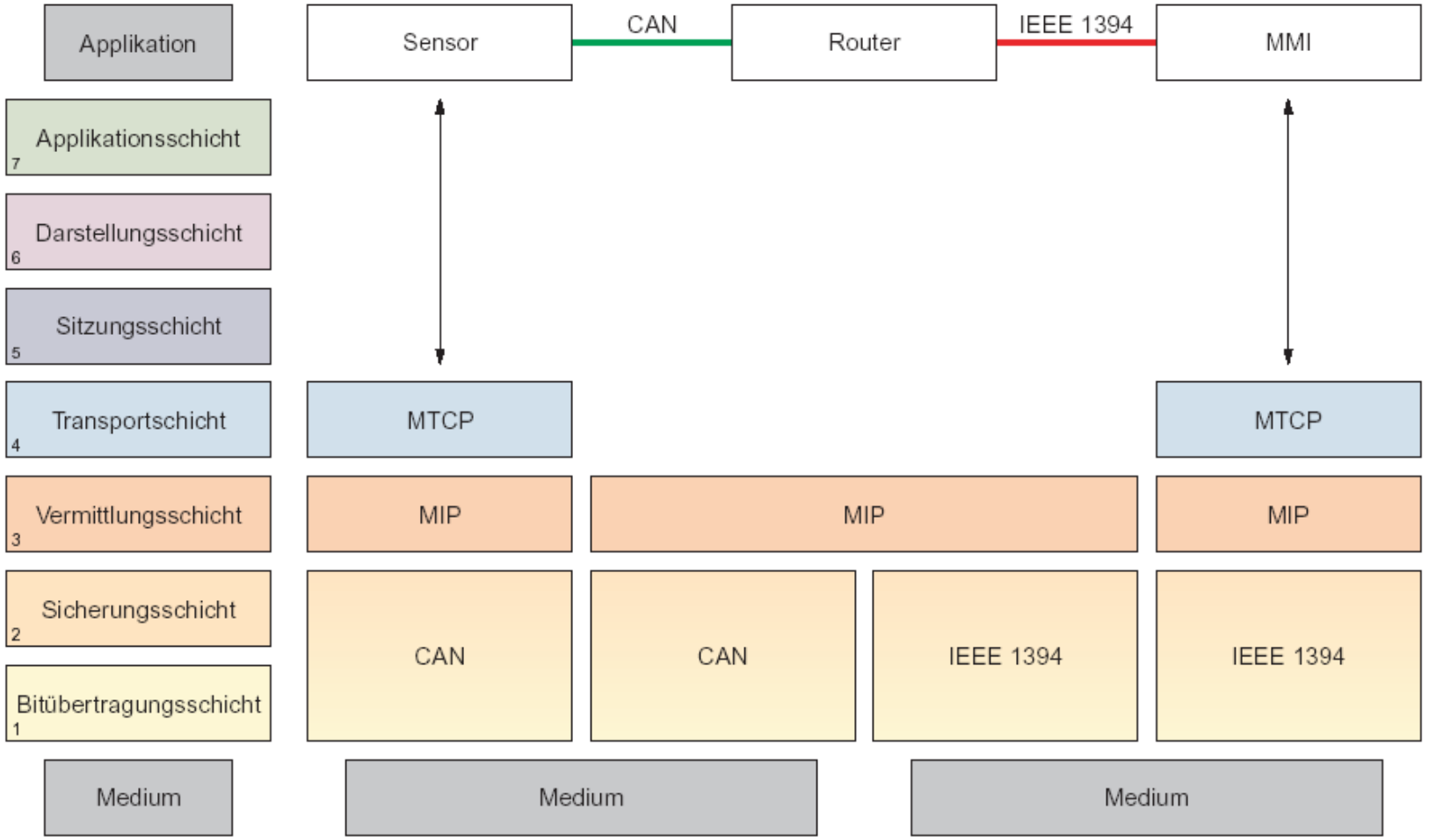
- Micro Open Shortest Path First (MOSPF)
  - Link-state routing protocol for QoS dependent routing
  - Exchange of topology informationen between routers
  - Header: 3 byte (OSPF: 24 byte)



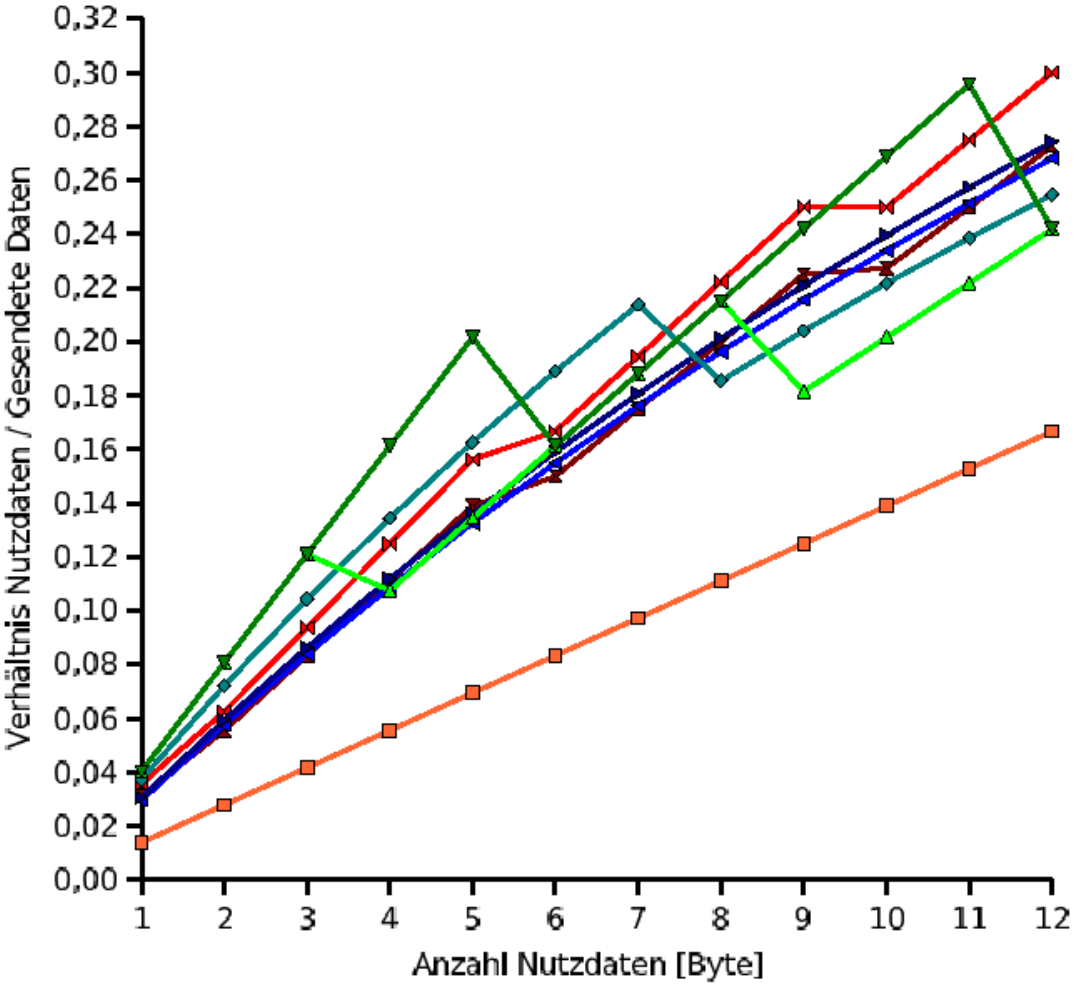
MOSPF Type

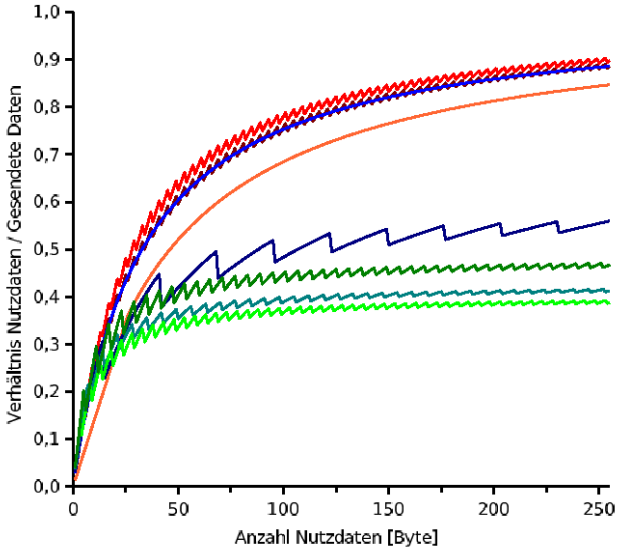
0x1	Hello
0x2	Database Description
0x3	Link State Request
0x4	Link State Update
0x5	Link State Acknowledgement

Application Example



MIP vs. IP





- LIN unconditional
- LIN event-triggered
- CAN
- Bluetooth DH1
- Bluetooth DH5
- IEEE 1394 WRDB
- IEEE 1394 GASP
- IP via Ethernet

Comparison of Transfer Time and Latency

- Using MTCP packets with 8 bytes payload

Field bus and operation mode	Transfer time	Latency
LIN unconditional (20 kbit/s)	24,8 ms	396,8 ms
CAN (1Mbit/s)	377 µs	393 µs
Bluetooth DH1	625 µs	8,125 ms
IEEE 1394 GASP	12,95 µs	3,5 ms
Worst case		32 ms

Summary

- Idea of Internet protocol family reused
- Lean protocol for embedded systems
- Routers in place of gateways
- Defined interfaces for applications