Industrial Ethernet

- Generic term for using the Ethernet standard in automation / industrial applications
- Specific Quality of Service requirements
  - Real-time
    - Cycle time (e.g. < 1 ms for motion control applications)
    - Latency, Jitter
  - Safety
    - Consistency of time and content
    - Prevention of fatal injuries / economic loss
- Devices suit industrial needs
  - DC power supply (typically 24 V DC)
  - Enhanced EMC
  - Extended temperature / humidity range
  - Protection against ingress of objects and water (Better IP rating)
  - …

IP – International Protection

How to make Ethernet real-time capable?

- Overrule stochastic medium access of CSMA/CD
  - Prevention of collisions
  - Deterministic timing
  - → Polling scheme
  - → Intermediate layer superimposes TDMA scheme

Disadvantages

- Minimum transmission period of Ethernet frame given by
  - 7 Byte Preambel
  - 1 Byte Start Frame Delimiter (SFD)
  - 64 Bytes Header, Data, Checksum
  - Inter frame gap

- Waste of bandwidth
  - Payload typically some Bit ... Bytes

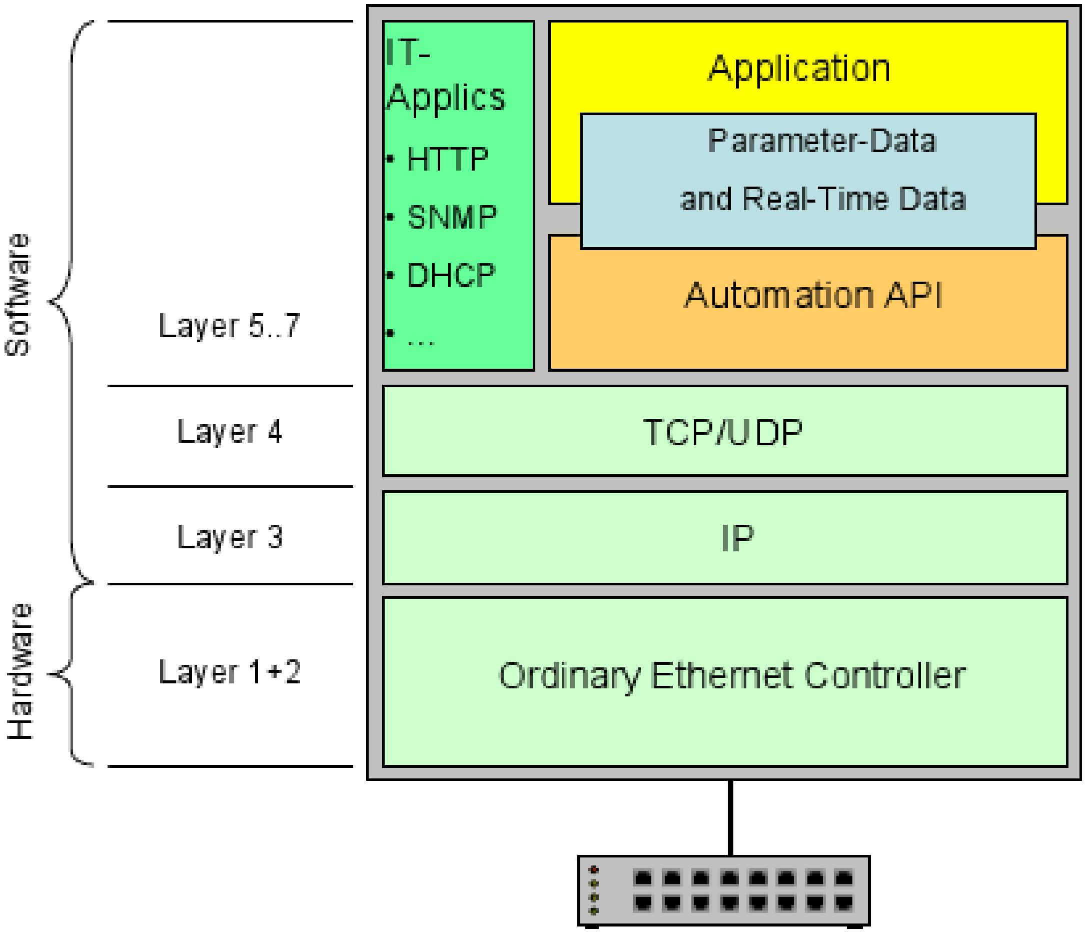
Examples of Industrial Ethernet Standards

Ethernet	Protocol	Standards
Modbus TCP	TCP/IP	IEC 61158, IEC 61784
PROFINET IO	Isochronous real time protocol (IRT), Real time protocol (RT), Real time over UDP protocol (RTU)	IEC 61158, IEC 61784
EtherNet/IP (CIP)	TCP/IP; UDP/IP	IEC 61158, IEC 61784, ODVA EtherNet/IP standard
Ethernet Powerlink		By EPSG
EtherCAT	EtherCAT, EtherCAT/UDP	IEC 61158, IEC/PAS 62407, IEC 61784-3, ISO 15745-4
SERCOS III		IEC 61491, merged into IEC 61158
TTEthernet		By TTTech
AFDX		ARINC 664

AFDX – Avionics Full-DupleX, switched Ethernet
ARINC – Aeronautical Radio, Inc.
CIP – Common Industrial Protocol
EPSG – Ethernet Powerlink Standardization Group
IEC 61158: Industrial communication networks - Fieldbus specifications
IEC 61784: Industrial communication networks - Profiles
ODVA – Open DeviceNet Vendors Association

Device Architecture I

- Completely TCP/UDP/IP based
- Ordinary Ethernet Controllers and Switches
- Applied by
  - Modbus TCP
  - EtherNet/IP
  - PROFINET (CBA)

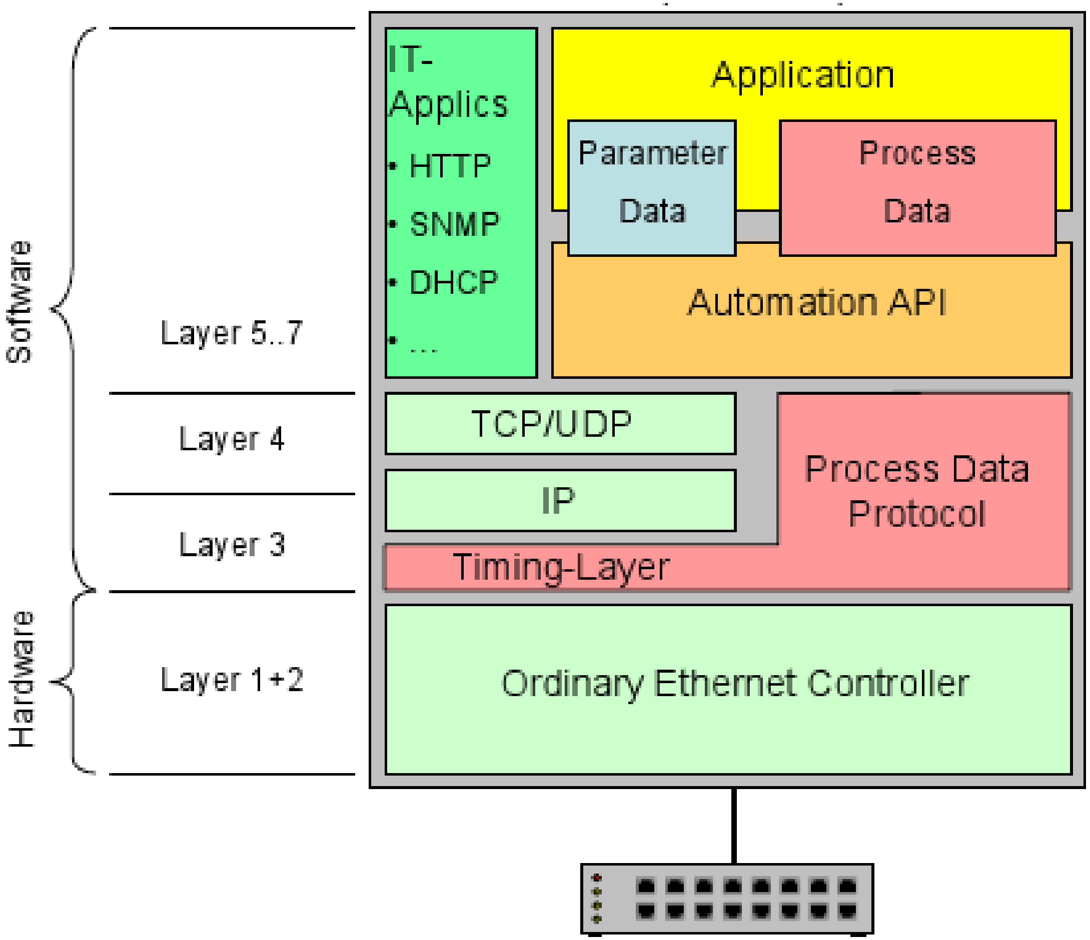


CBA – Component Based Automation

Source: EtherCAT Technology Group, http://www.ethercat.org/

Device Architecture II

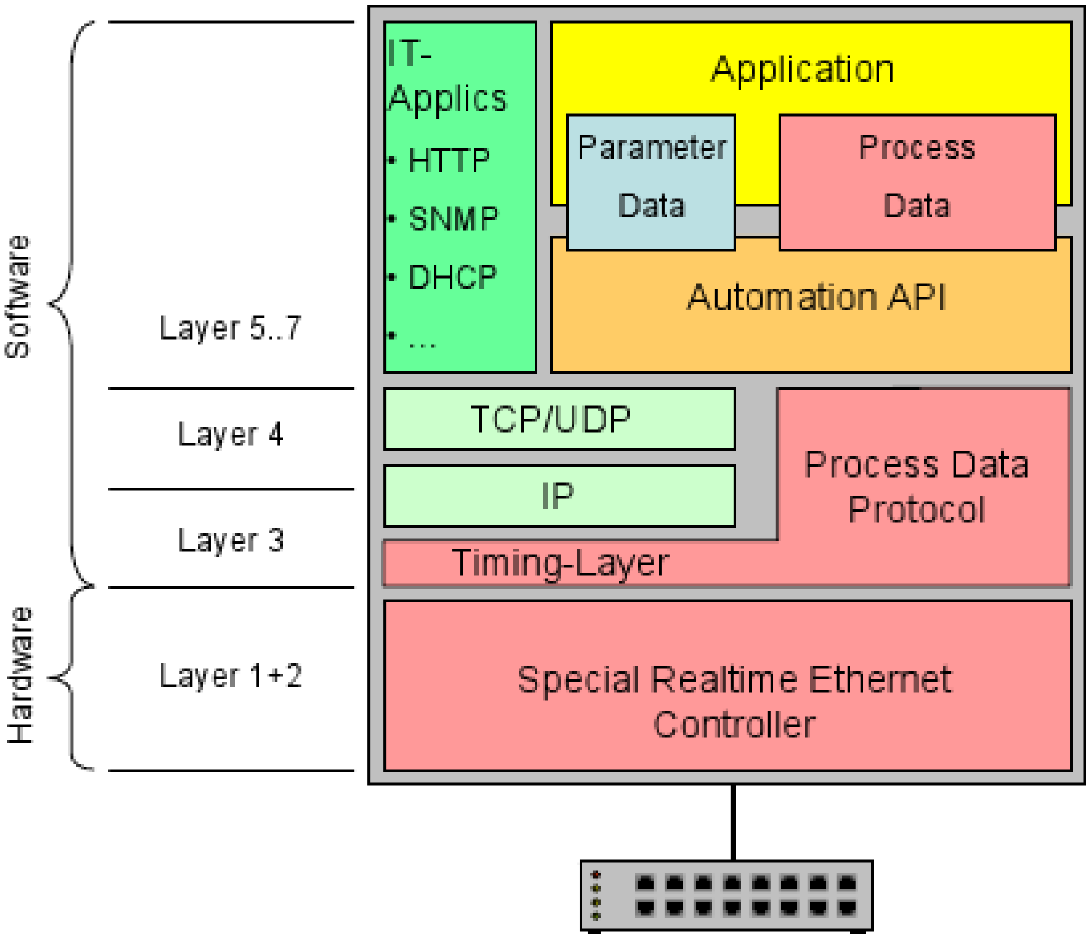
- Separate Process Data Channel
- IP communication controlled by intermediate timing layer
- Ordinary Ethernet Controllers and Switches
- Applied by
  - Ethernet Powerlink
  - PROFINET (RT)



Source: EtherCAT Technology Group, http://www.ethercat.org/

Device Architecture III

- Separate Process Data Channel
- IP communication controlled by intermediate timing layer
- Special Realtime Ethernet Controllers
- Applied by
  - PROFINET (IRT)
  - SERCOS III
  - EtherCAT



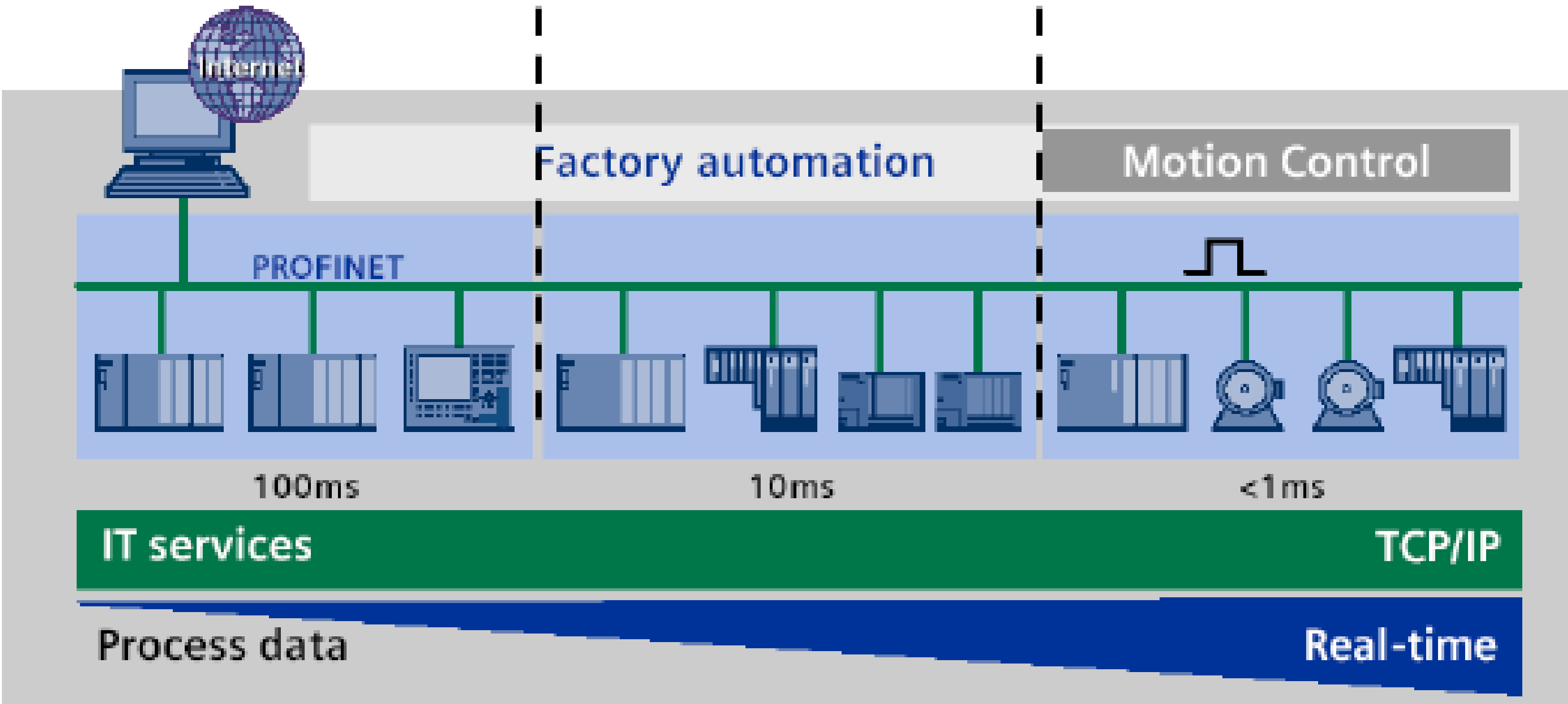
Source: EtherCAT Technology Group, http://www.ethercat.org/

PROFINET IO

PROFINET CBR
- Architecture I

PROFINET RT
- Software based
- Architecture II

PROFINET IRT
- Hardware based
- Architecture III

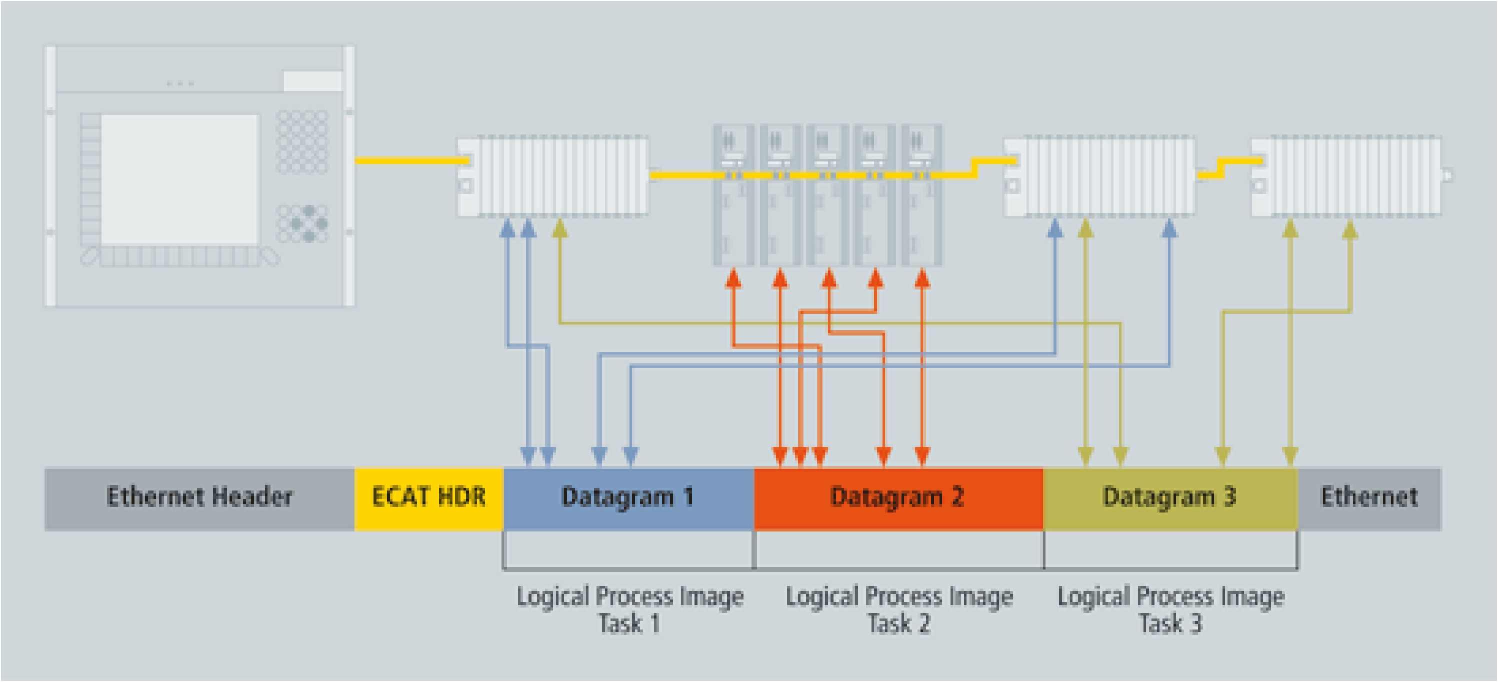


CBA – Component Based Automation
RT – Soft Real-Time
IRT – Isochronous Real-Time

Sources:
EtherCAT Technology Group, http://www.ethercat.org/
Siemens AG

EtherCAT – Frame Processing on the fly

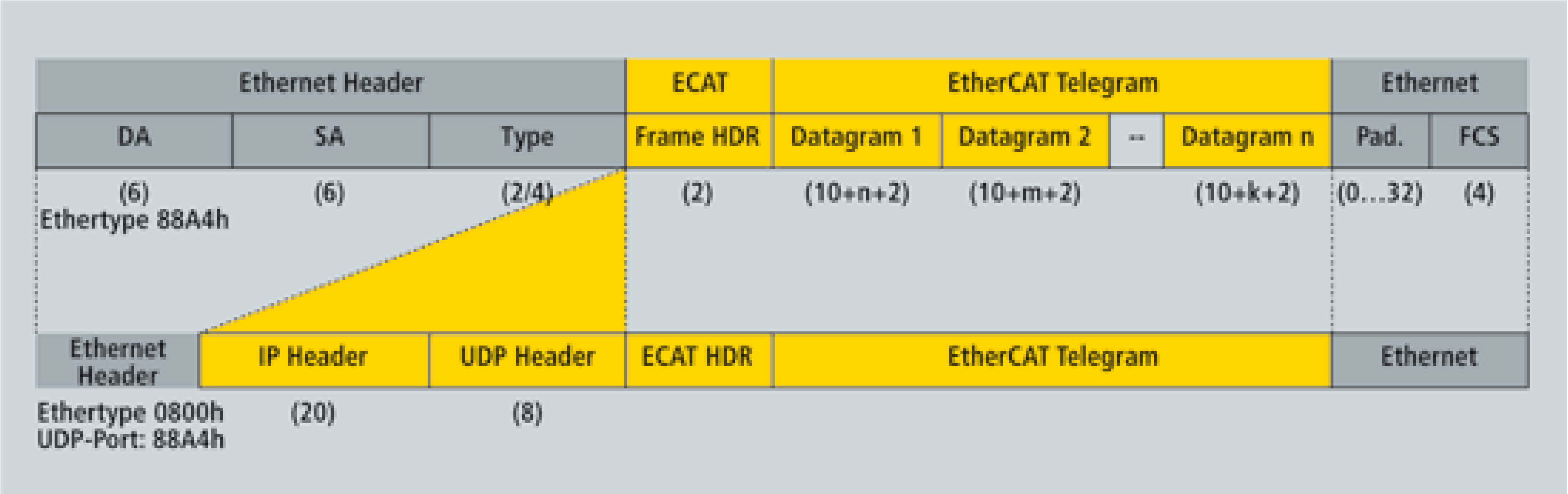
- Master device transmits standard frame (Architecture I)
- Slave devices (Architecture III)
  - Read the data while the frame passes through the node
  - Input data is inserted while the telegram passes through
  - The frames are delayed by a few nanoseconds



Source: EtherCAT Technology Group, http://www.ethercat.org/

EtherCAT – Frames

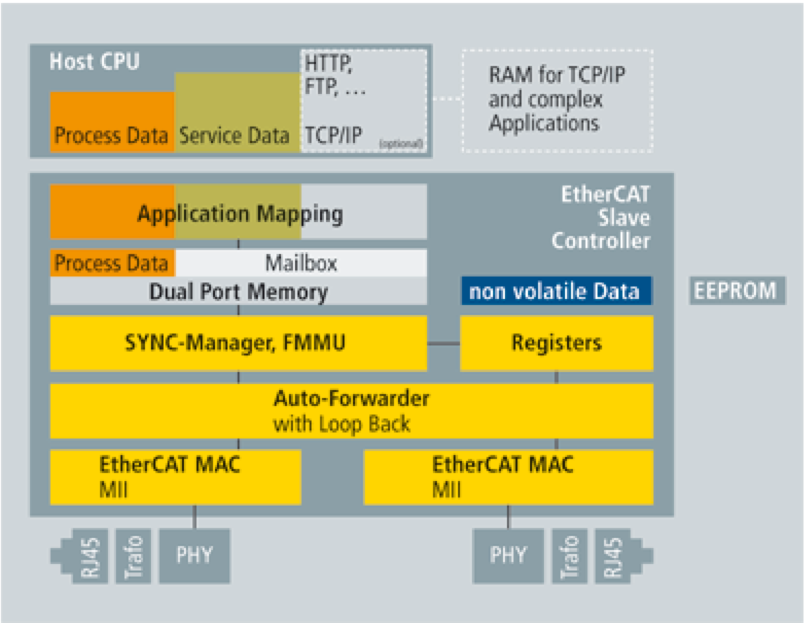
- EtherCAT
  - Optimised for decentralised I/O
  - Transported within standard Ethernet frame
- EtherCAT/UDP
  - If IP routing required, EtherCAT frame is inserted in UDP/IP datagramm

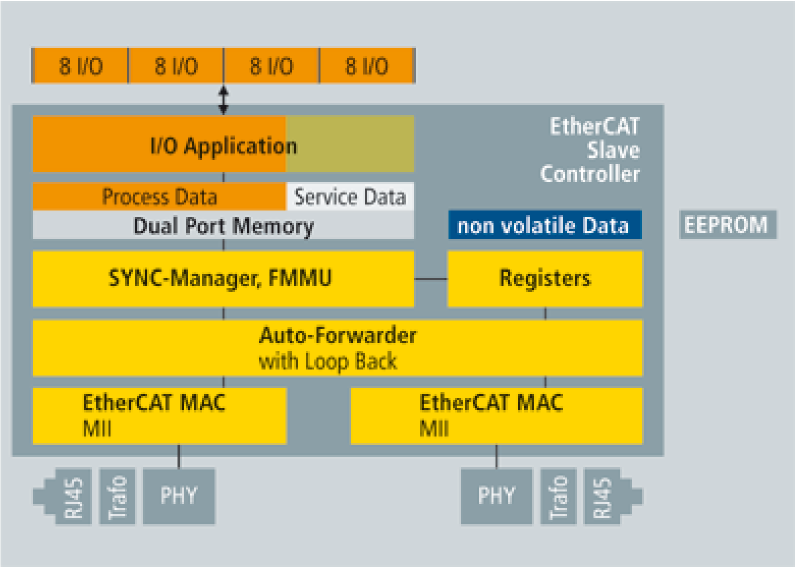


Source: EtherCAT Technology Group, http://www.ethercat.org/

EtherCAT – Slave Controllers

- Slave Hardware: FPGA with Host CPU
- Slave Hardware: FPGA with direct I/O





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