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Quality of Service in Industrial Ethernet Networks

Can we provide appropriate Quality of Service for industrial applications using an all-Ethernet network?

Outline

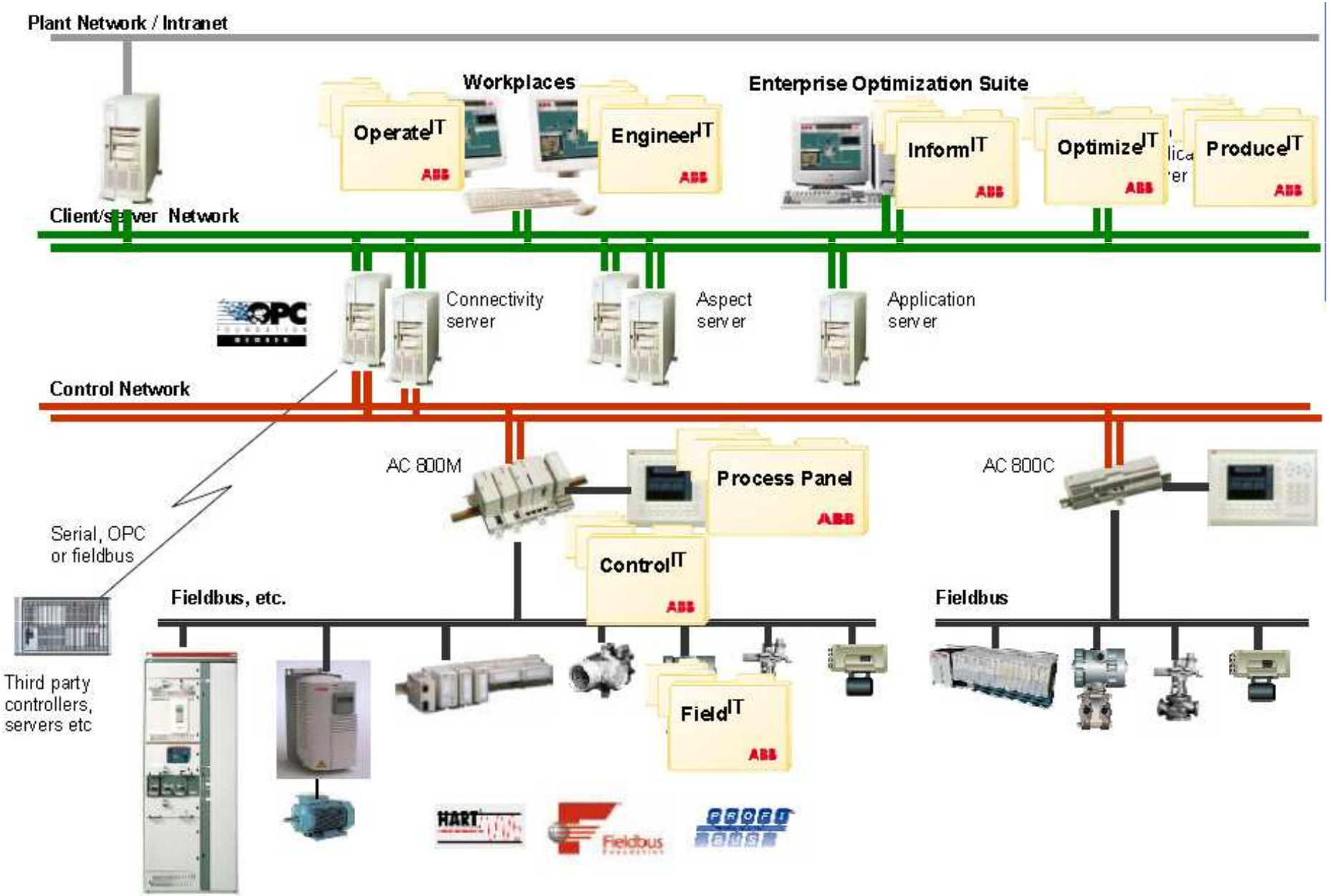
- Meaning of QoS in industrial environments
- Background
  - Industrial network evolution
  - Scenarios
  - Topology
- Technologies
  - Standard Ethernet
  - Industrial Ethernet
  - Special hardware-enabled Ethernet
- Quality of Service
  - L2 and L3
  - Connection with VoIP and AV Bridging
- Conclusion

Disclaimer: the following presentation does reflect my opinion which might not necessarily conincide with ABB's view or opinion in the given area.

Industrial Network Evolution

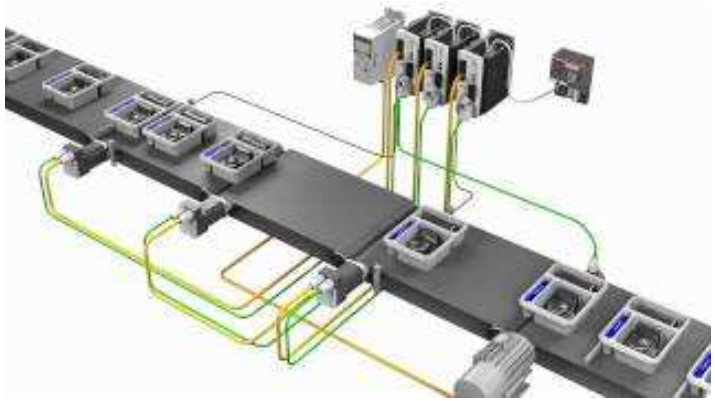
- Connectivity
  - Direct wiring
  - Low speed serial buses
  - Ethernet
- Requirements
  - Centralised control
  - SCADA
  - Safety integrated systems
  - Security supervision
  - Communication
  - Remote assistance

An Example Architecture – ABB 800xA



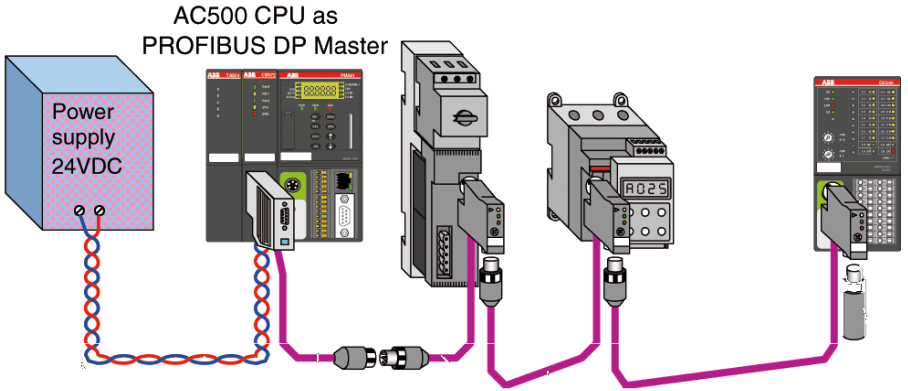
Scenarios

- Very fast reaction times
  - Motion control
  - Robotics
  - Substation automation
- Fast reaction times
  - Factory automation
- Slow reaction times
  - Process automation

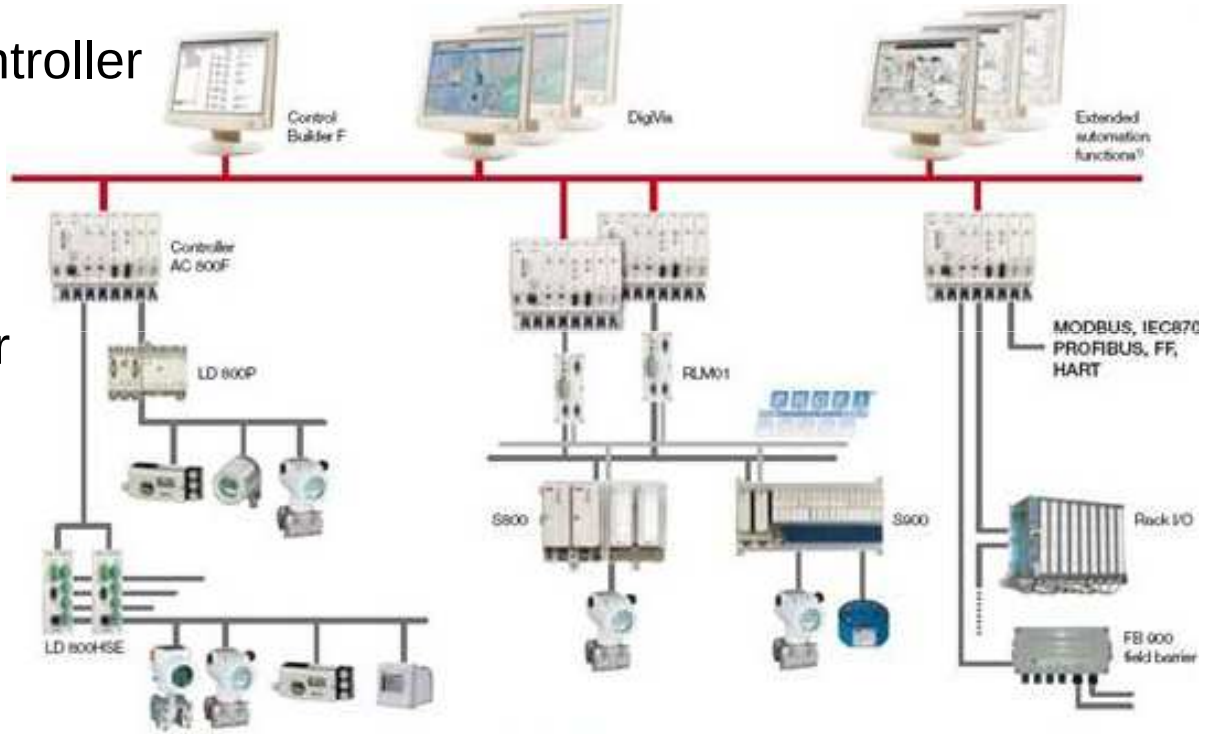


Topology

- Serial Fieldbuses
  - Daisy-chaining



- Composite
  - Ethernet from the Controller
  - Fieldbus after the Controller
- Ethernet-based
  - Ethernet to the sensor



Technologies

- Ethernet solutions
  - Industrial modifications
- Telecommunication solutions
  - SDH to carrier Ethernet or IP
- Embedded communication
  - Chain length
  - Limited feature set

Standard Ethernet

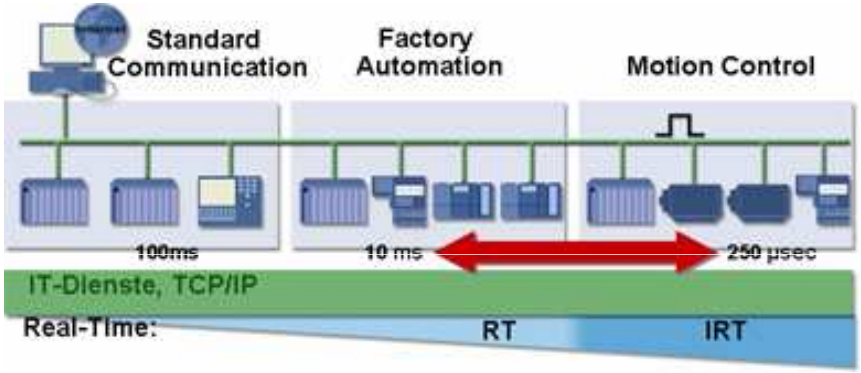
- Determinism
- Bandwidth and compatibility
- Loop-avoidance
- High port count, high branching factor
- Cheap, efficient implementation
- De facto standard in LANs
- Moves towards both the telco and industrial area

Industrial Ethernet

- Determinism
- Speed difference compared to fieldbuses
- Cyclic traffic
- Cost reduction
- Uplink connectivity
- Low branching
- Safety Integrated Systems

Industrial Ethernet with special hardware

- Profinet IRT
  - Special embedded switches



- EtherCAT
  - Intrinsic QoS

SCADA and telecommunication

- Relaxed QoS:
  - Supervisory Control and Data Aquisition
  - Remote management

- High QoS
  - Electric grid
  - Electrified production platforms

Quality of Service

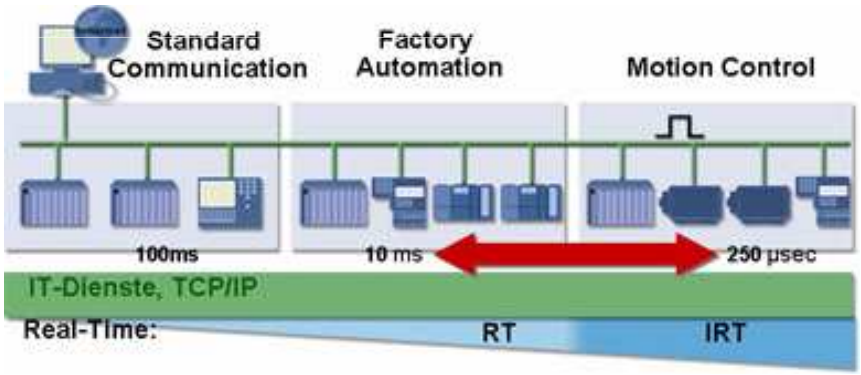
- Jitter and delay
- Resiliency
- Bandwidth
- Time sync (SNTP 1 ms, IEEE 1588 10s of ns)

- Ethernet:
  - Rapid Spanning Tree
  - E.g. Parallel Redundancy Protocol
- Telecom
  - Per Service Level Agreement
  - MPLS over SDH fast reroute
  - Move to Carrier Ethernet

Intrinsic QoS

- Traffic engineering
  - Source->Backbone->Destination
  - 100M/1G
- EtherCAT
- Cyclic solutions e.g. Profinet IRT
- Synchronous Ethernet (ITU)

- 100 ms: ping to a remote website (19 hops)
- 10 ms: ping to LAN (1-2 ms typ.)



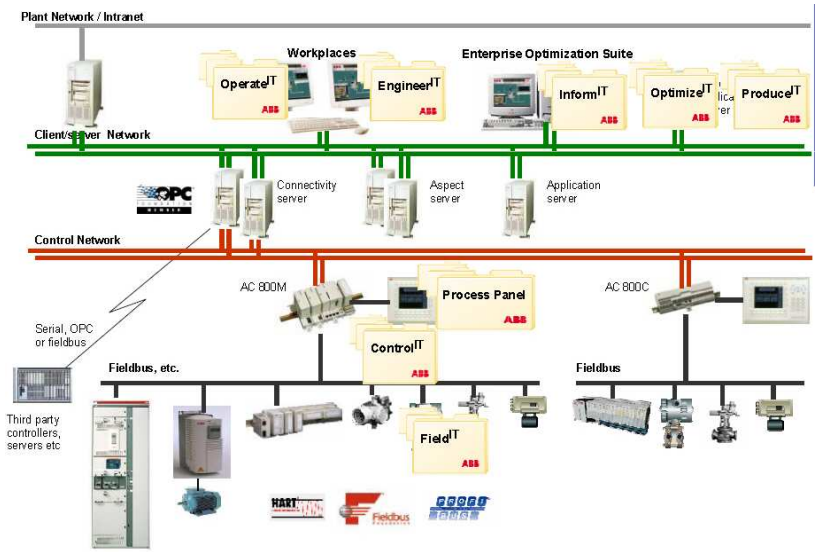
Layer 2 QoS with Standard Ethernet

- Time sync to approx. 1 ms without GPS clock in units
- Redundancy and parallel sending of data
- Branching and planned traffic aggregation
- Transmission and queuing delay gives a lower bound
- Key question only on the control network
- Sensitivity differs depending on the area e.g. several seconds of tolerance in a slow process
- Secondary use for supervision

- Typical area: factory automation and process automation

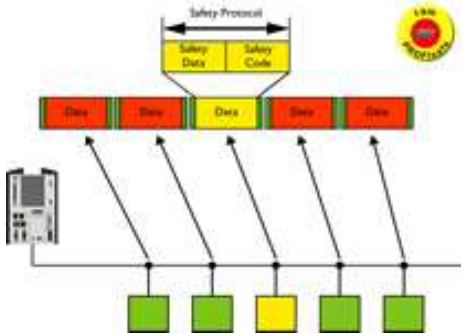
Layer 3 QoS on IP

- Similar to VoIP
- After the control loop, on the client/server network
- Resource Reservation Protocol
- Redundant transport
- Virtual Private Network



Safety Integrated Systems

- Imagine as yellow envelopes mixed into the traffic
- Requires software and might require hardware extensions
- The safety function is not depending on QoS!
- Safety levels: SIL 2, 3 and 4
- Until approx. SIL 3, a normal, RSTP-redundant LAN is sufficient



Redundancy

- Rapid Spanning Tree
- Media Redundancy Protocol: only rings, two-way sending
- Redundant Network Routing Protocol: switchover to reserve network

- Multicast on IP (FF-HSE)

AV Bridging and VoIP

- IEEE 802 Audio Video Bridging Task Force
  - Time sync
  - Stream reservation
  - Forwarding and Queuing

Conclusion and Challenges

- Requirements depend on the actual field
- Intrinsic QoS for the most demanding applications
- AV efforts may lead to better solutions also for industry
- Historical problems still limit the wider adaptation of Ethernet

- Challenges
  - Shifting the border between control and client/server network (beside physical limits e.g. signal propagation)
  - Cost of QoS in long haul
  - Embedded switches

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