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Details about Industrial Network use cases

Industrial Networks

IEEE 802.3 Interim Session – Norfolk

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Intention of this Slide Deck

Some industrial use cases where presented during previous IEEE Meetings and the usage of the shown methods was unclear to the IEEE group.

This presentation tries to provide some detailed information about industrial network.

General Background

Industrial Automation Applications

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The same Industrial Automation devices (actuators, sensors, …) **are used for a wide range of different Applications** (e.g. control applications)

This leads to configurable, scalable and flexible devices:

- industrial automation components are programmable
  (e.g. PLC – programmable logic controller)
- Control applications are designed (offline) by an engineering tool
- Each single control application is completely engineered
  (e.g. control-data-traffic communication sensor -> PLC -> actuator)
- Communication Parameters can be Control application dependent
  (e.g. end-2-end connectivity, payload size, max latency, availability, …)

Streams for measurement or HMI systems and also legacy communication are not engineered within the same industrial network – *plug & play*

Bandwidth and end-to-end connectivity for this applications is required
(e.g. end user uses web services to configure applicable parameter in end station)

General Background

Existing Systems for Industrial Automation Applications

Within industrial we have two different Systems:

- **Closed Systems for highest Performance**
  Typical used for **“**Closed-Loop-Applications” like motion control systems

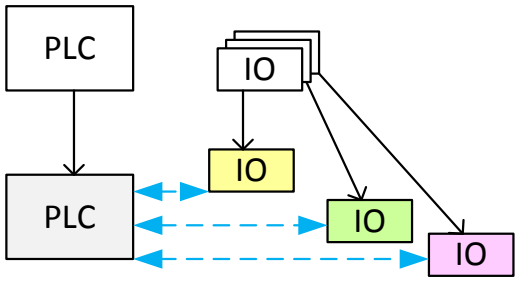
- **Open systems for flexible applications**
  Typical used for “Control-Applications” like assembly lines

TSN provides mechanisms for both kinds of systems.

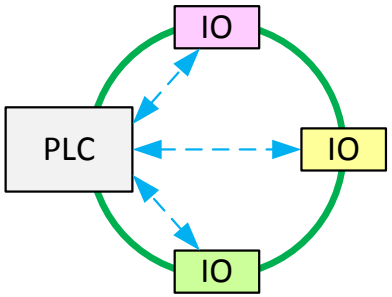
Details about the Closed Systems

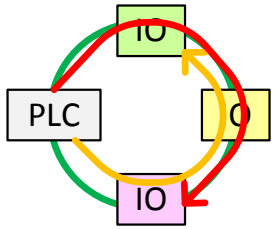
- **Closed Systems**
  - One network for one application – this application is fixed
  - Fix topology – adapted to application
  - Highly optimized scheduling
  - Harmonized transmission period
  - Coordinated windows (using time based forwarding - Qbv Shaper)

Engineered Applications

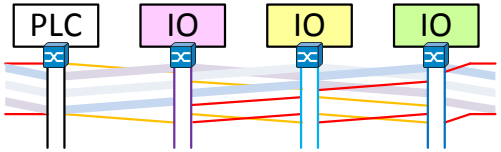


Engineered Network





Topology dependent
Communication Scheduling

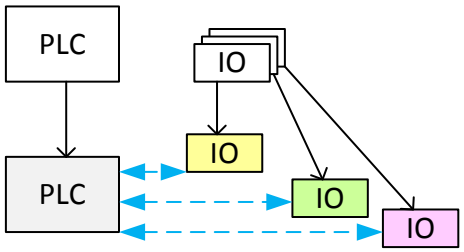


Details about the Open Systems

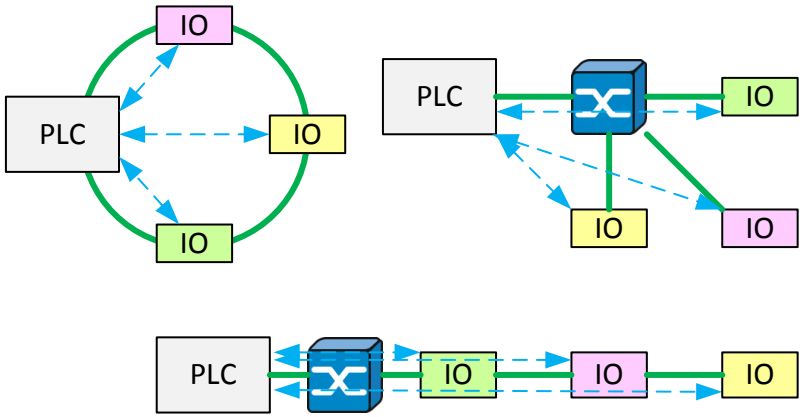
- **Open systems**
  - *Multiple applications share one network*
  - *Topology can change when applications are added , changed or removed at runtime*
  - *Multiple different transmission periods*
  - *Guaranteed QoS & guaranteed low latency*

➢ ***Requires hot network reconfiguration of a flexible traffic class***
➢ ***Undesired side effects on already established control-data-traffic must avoided***

Engineered Applications



Dynamic Network Setting



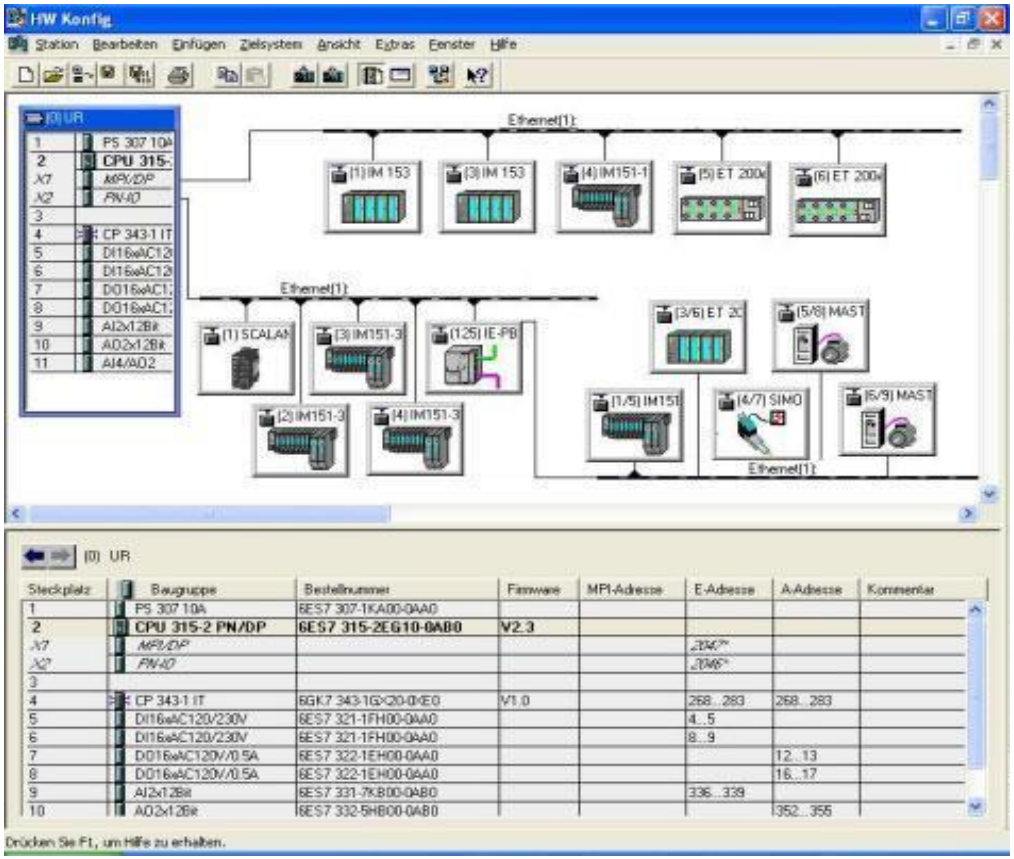
General Proceeding in Engineering Industrial Automation Applications

Applicable communication parameter set from control application engineering tool for Control-Data-Streams (CD-Streams):

- application cycle
- end-2-end connectivity
- payload size
- max latency
- availability
- …

Communication parameter set from network design tool for CD-Streams:

- VLAN / VID
- Control-Data-Traffic-Class (CD-TC)
  - transmission period
  - scheduled and/or coordinated
  - priority for CD-TC
  - preemtive
  - …
- Synchronization
  - Working clock
- …



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Proceeding in Engineering of Closed Systems

- **Control application is engineered offline - talker–listener relationship is known** (e.g. sensor -> plc -> actuator control-data-traffic communication)
- **ONE physical network infrastructure for ONE control- or closed-loop-application system**
- **Application dependent Network topology** (e.g. daisy chain or ring for assembly line)
- **Control application dependent communication parameter**
  - to determine traffic classes for control-data-streams
  - to determine transmission period
  - allocate bandwidth for control-data-traffic class on each egress port
  - to determine if seamless redundancy is required
  - ...
- **Centralized path computation and scheduling for coordinate transmission of CD-Streams** (Online or offline – based on planned or discovered network topology)

Less flexibility by adding and removing CD-Streams within a "Closed System"
but allows optimization of control-data to cover the performance requirements on communication *for time critical applications*

➢ **Requirements for industrial TSN:**
  - *network components with static configuration (path, bandwidth, schedule)*
  - *No / less functionality for network reconfiguration at runtime is required*

Proceeding in Engineering of Open Systems

- **Each application (control- or closed-loop) is engineered offline**
- **Each single control application talker – listener relationship is known**
  (e.g. plc <-> actuator <-> sensor control-data-traffic communication)
- **More than one control application share one common physical network**
- **At runtime control- and closed-loop application will be added or removed**
  (without any side effects control applications which are in operation mode)
- **While multiple control applications share the same plant network a network design tool is used for dimensioning the network**
  - to determine traffic classes for control-data-streams
  - to determine transmission period
  - to determine bandwidth limit for each control-data-traffic class
  - to determine for which streams high availability (.1CB “Seamless Redundancy”) is required
  - **…**

- **In plant networks path computation, path reservation and bandwidth reservation for control-data-streams at runtime will be done by PCE’s or BLCE’s based active topology**

Proceeding in Engineering of Open Systems

➢ Requirements for industrial TSN:

- **Configuration of time sensitive industrial networks at runtime**
- **Protocols for**
  - topology discovery (active topology for CD-Streams, AV-Streams, …)
  - path computation and path reservation
  - bandwidth reservation

  has to make sure a consistent network configuration
- **Automatic or user triggered path re-computation, path re-configuration and also bandwidth re-reservation for control-data-streams shall also be possible**