Networks & Technologies for Autonomous Manufacturing in Industry 4.0 Industrial Use Case

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Industrial Achievements and new Research Perspectives

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Agenda

- Brief Introduction of Deterministic Ethernet
- Using Virtualization in TT NWs
- Removing the Conveyor Belt
- Open Workshop Approach
- Potential Network
- TAPPS Platform
- Industrial Demonstrator Overview
- Building Blocks
- Industrial Demonstrator Implementation
- Achievements so far

Deterministic Ethernet (1/2)

Goal of Deterministic Ethernet: make Ethernet better suitable for real-time and fault-tolerant applications

Time-Triggered

Real-Time & Determinism

- IEEE 1588 PTP clock sync.
- Real-time control, ultra-low latency
- Safety systems

Rate-Constrained

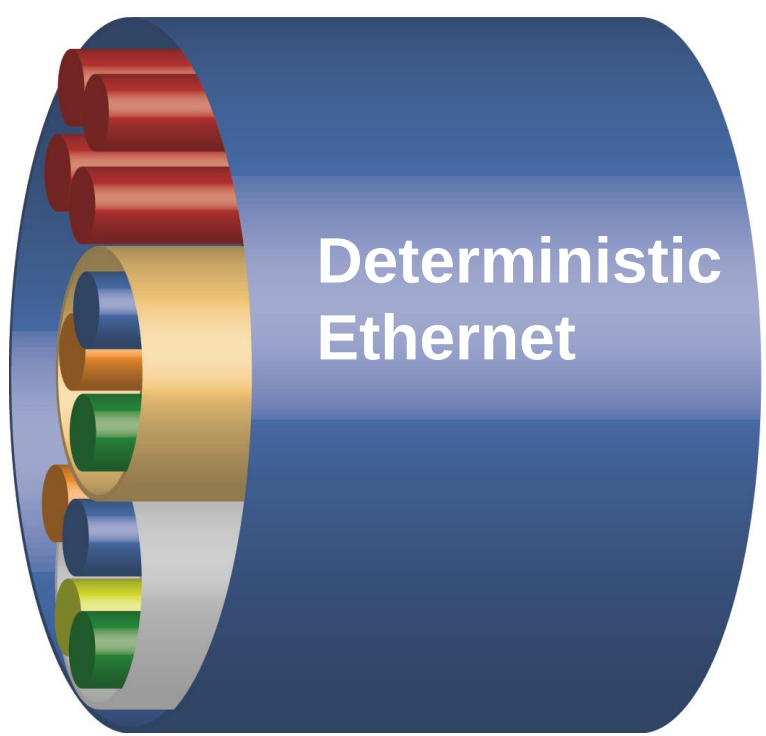
Streaming

- AVB / ARINC 664
- Audio/video
- Sensor fusion

Best Effort

Ethernet (IP)

- IEEE 802.3
- compatible with standard traffic



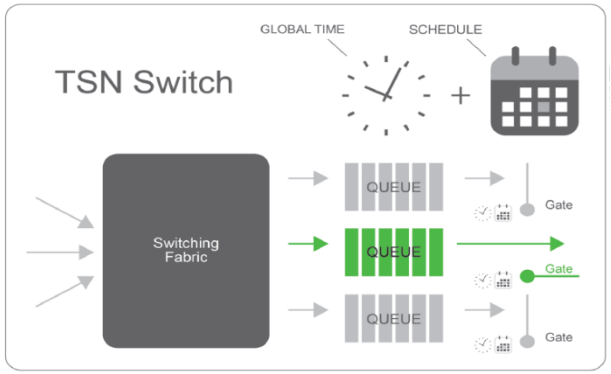
Deterministic Ethernet (2/2)

Time Sensitive Networking (TSN)

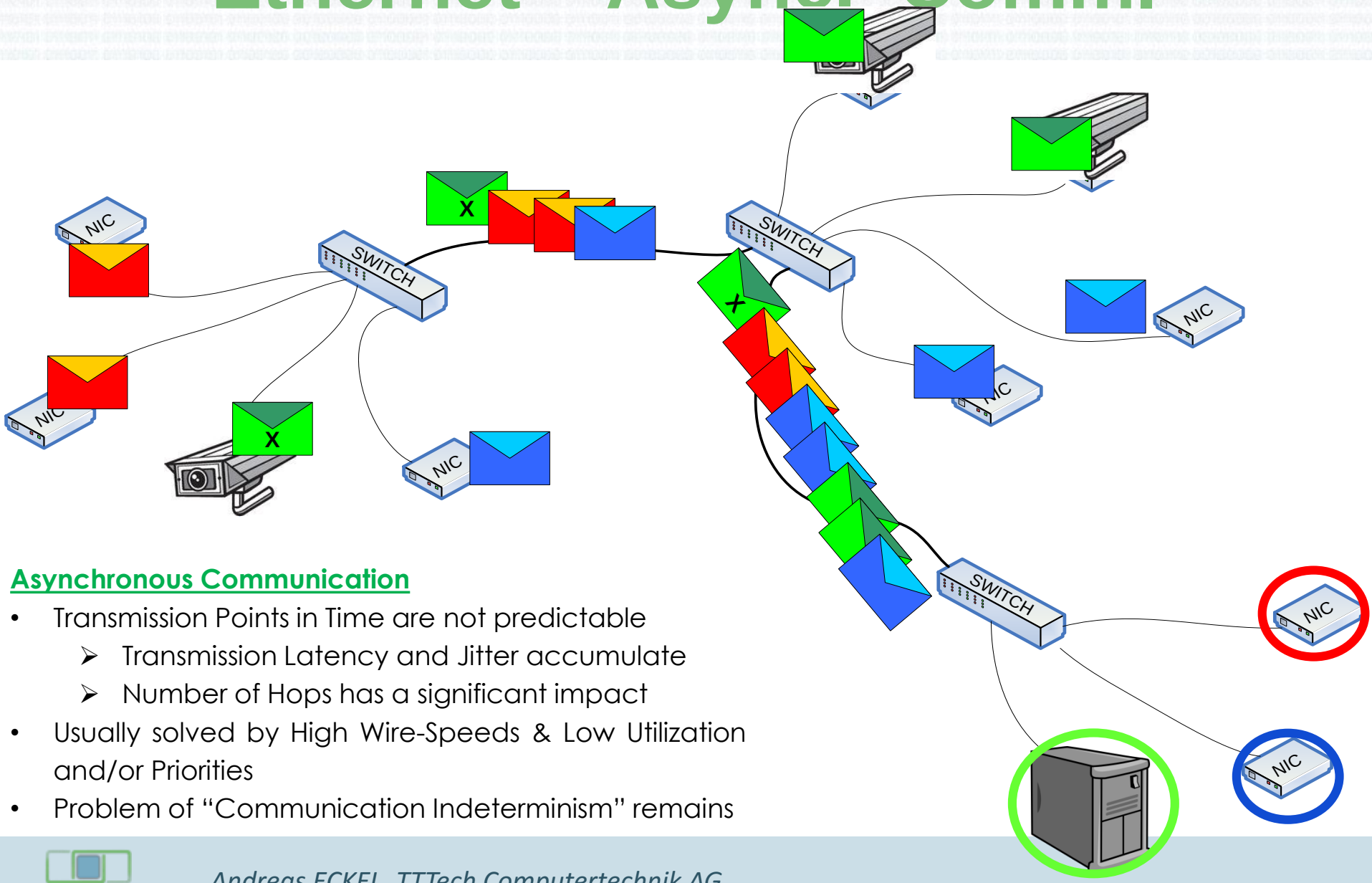
- TSN covers a set of Ethernet standards currently being defined in the IEEE 802.1 TSN task group.
- mechanisms provide **time synchronization** for networked devices
- **scheduled** forwarding of defined traffic flows through the network.

Time synchronization & scheduling:

TSN delivers deterministic communication over standard Ethernet, enabling the **convergence** of critical control traffic with data traffic over one infrastructure without the need for gate-ways or proprietary solutions.



Ethernet = Async. Comm.

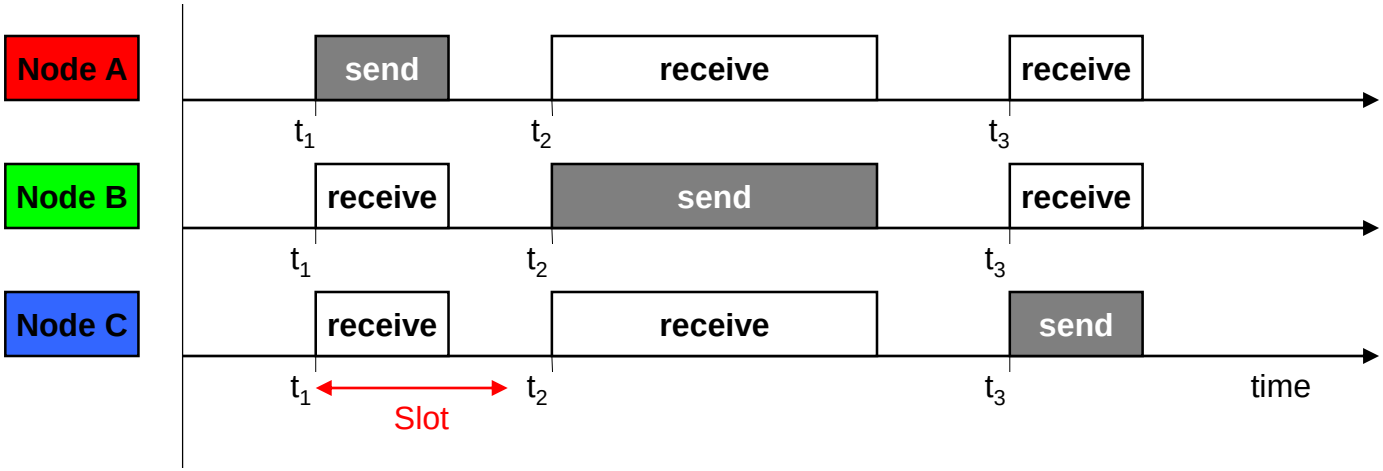


Asynchronous Communication

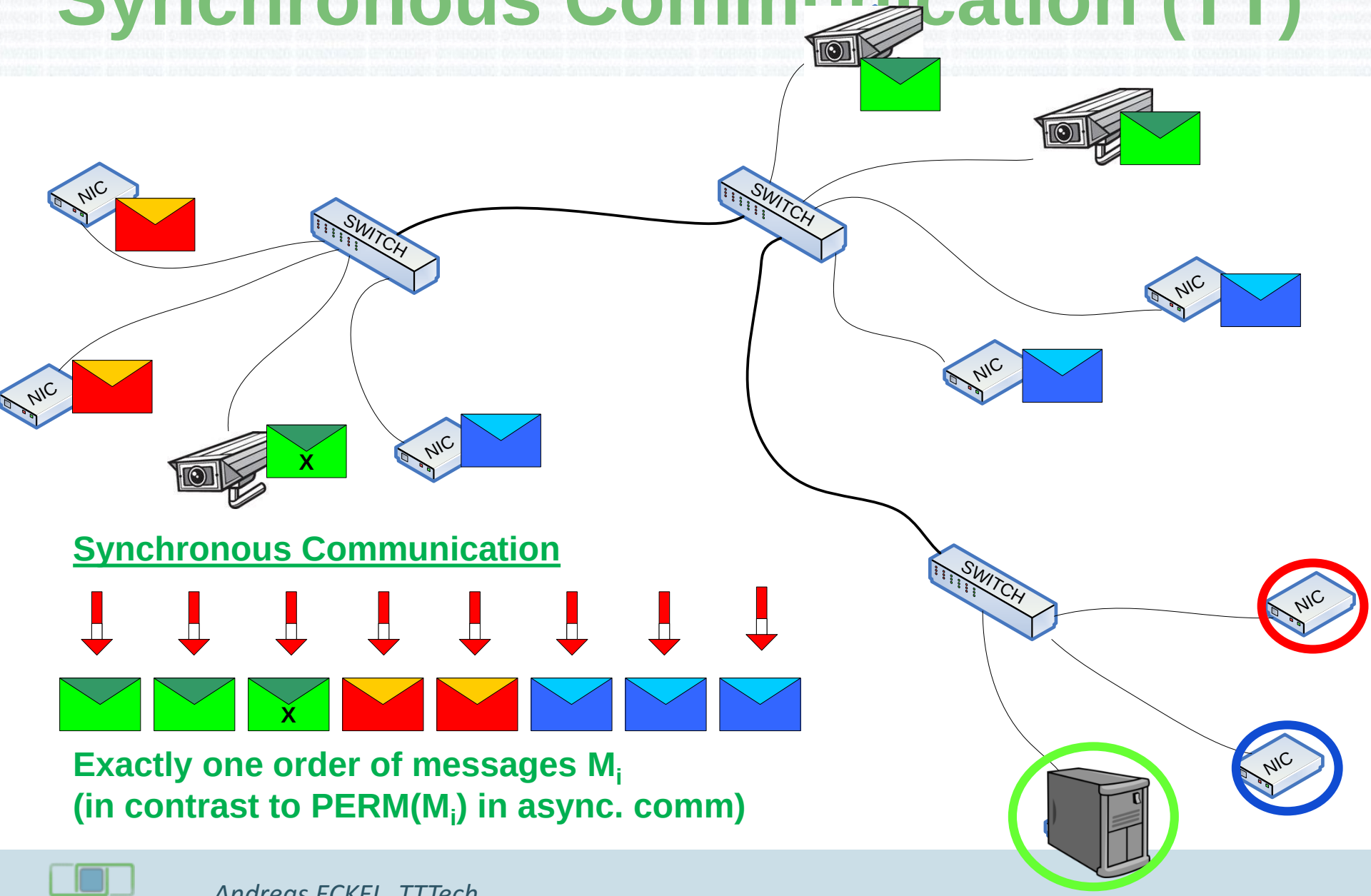
- Transmission Points in Time are not predictable
  - Transmission Latency and Jitter accumulate
  - Number of Hops has a significant impact
- Usually solved by High Wire-Speeds & Low Utilization and/or Priorities
- Problem of "Communication Indeterminism" remains

Time-Triggered Operation

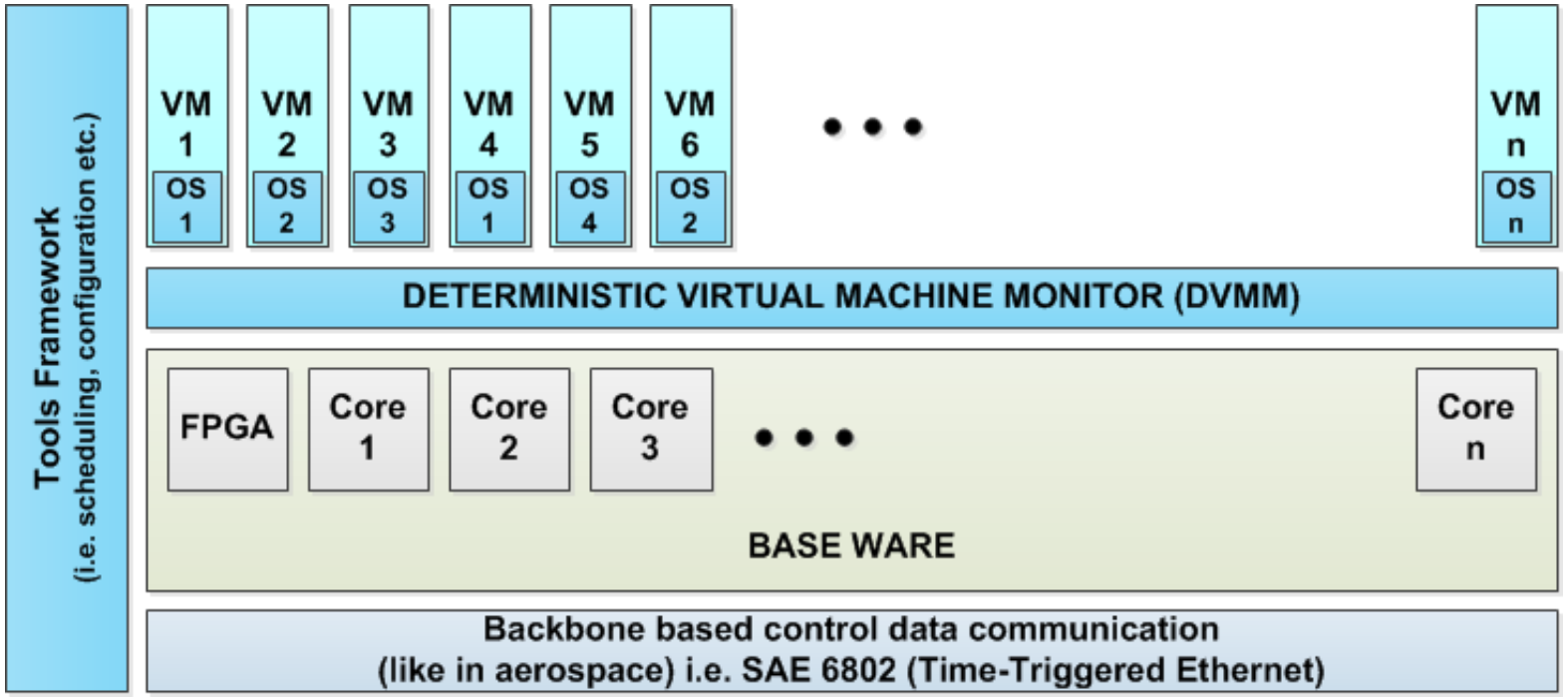
Synchronized time and a **communication schedule** allows to realize the time-triggered communication paradigm



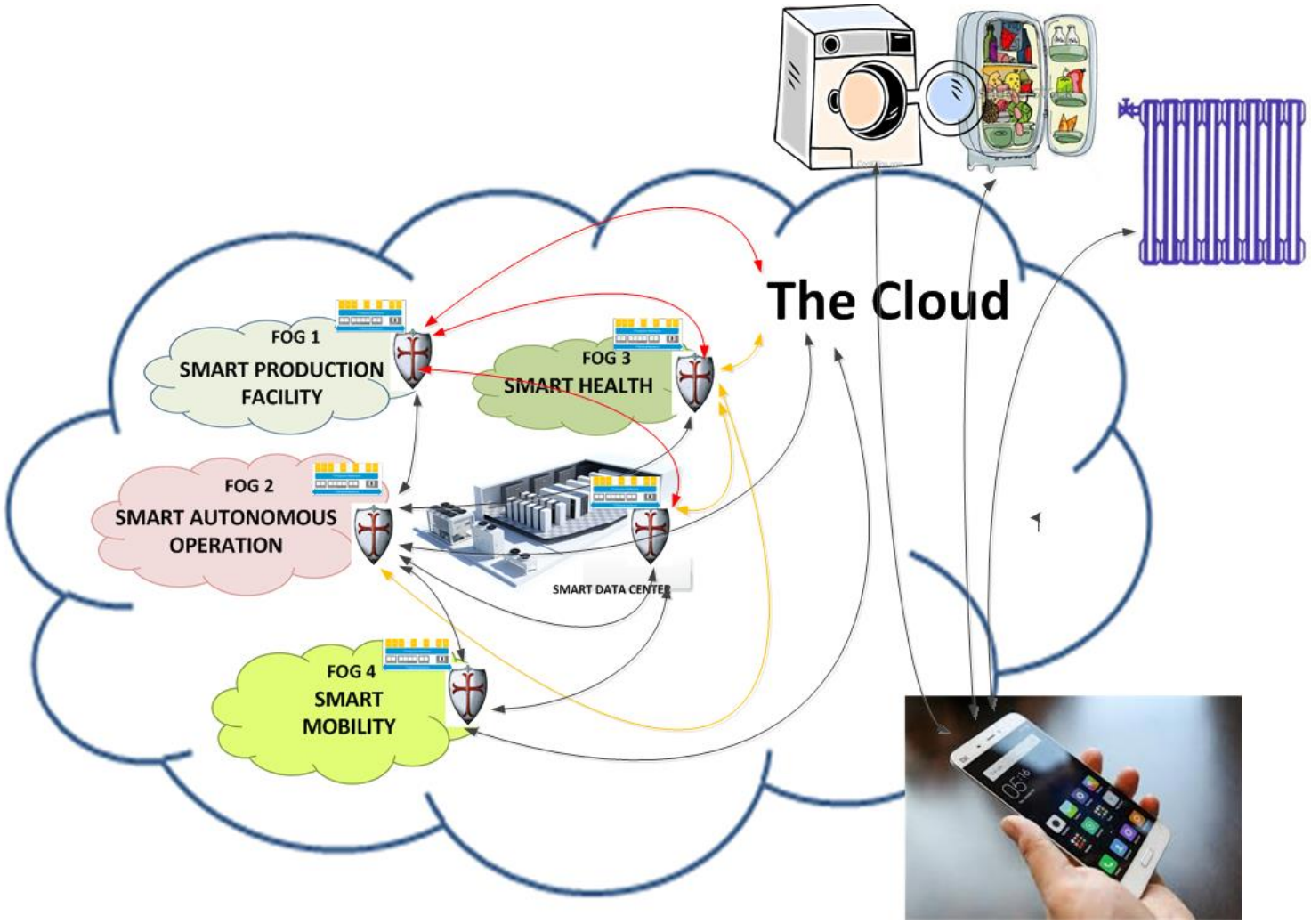
Synchronous Communication (TT)



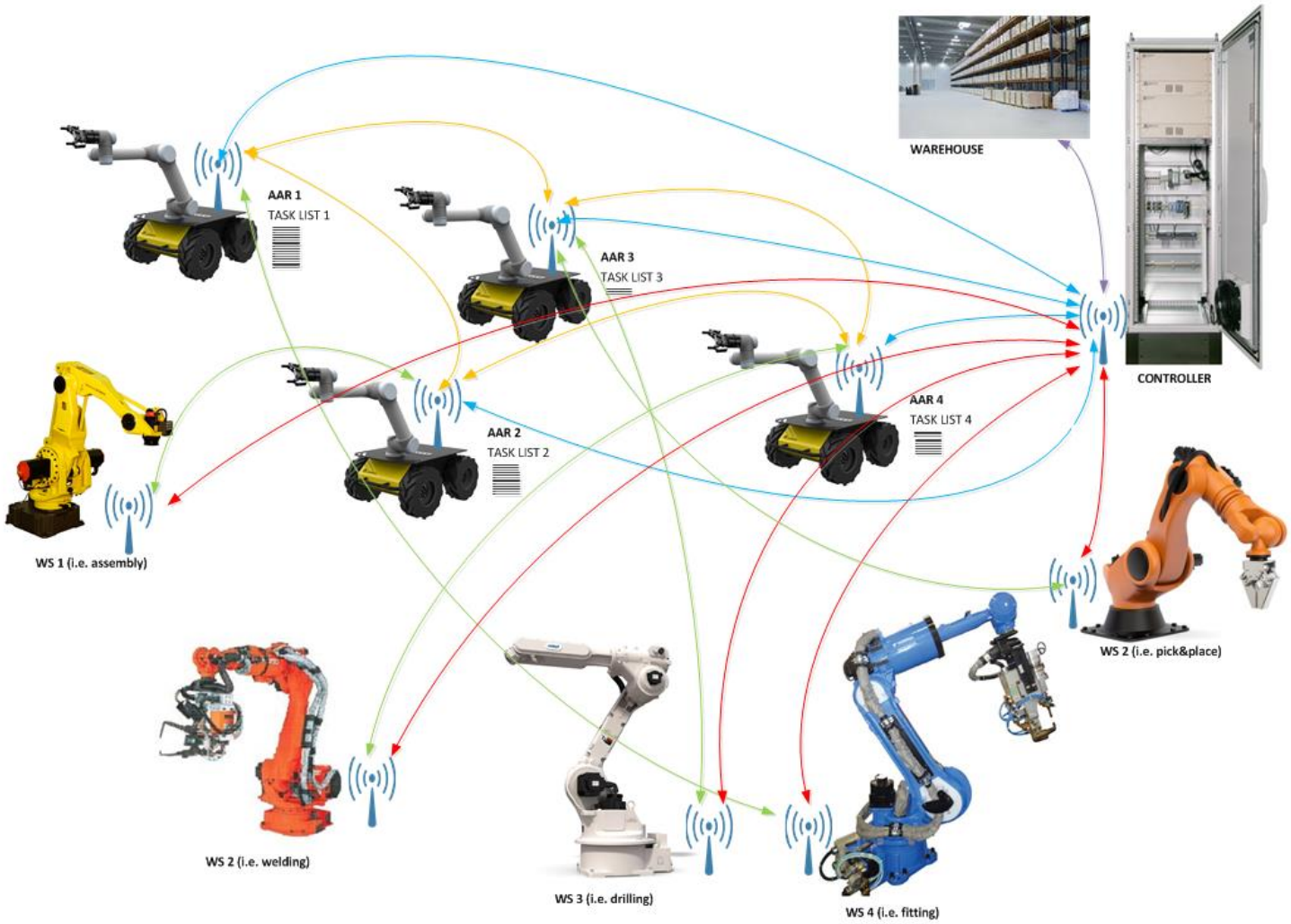
Using Virtualization in TT NWs



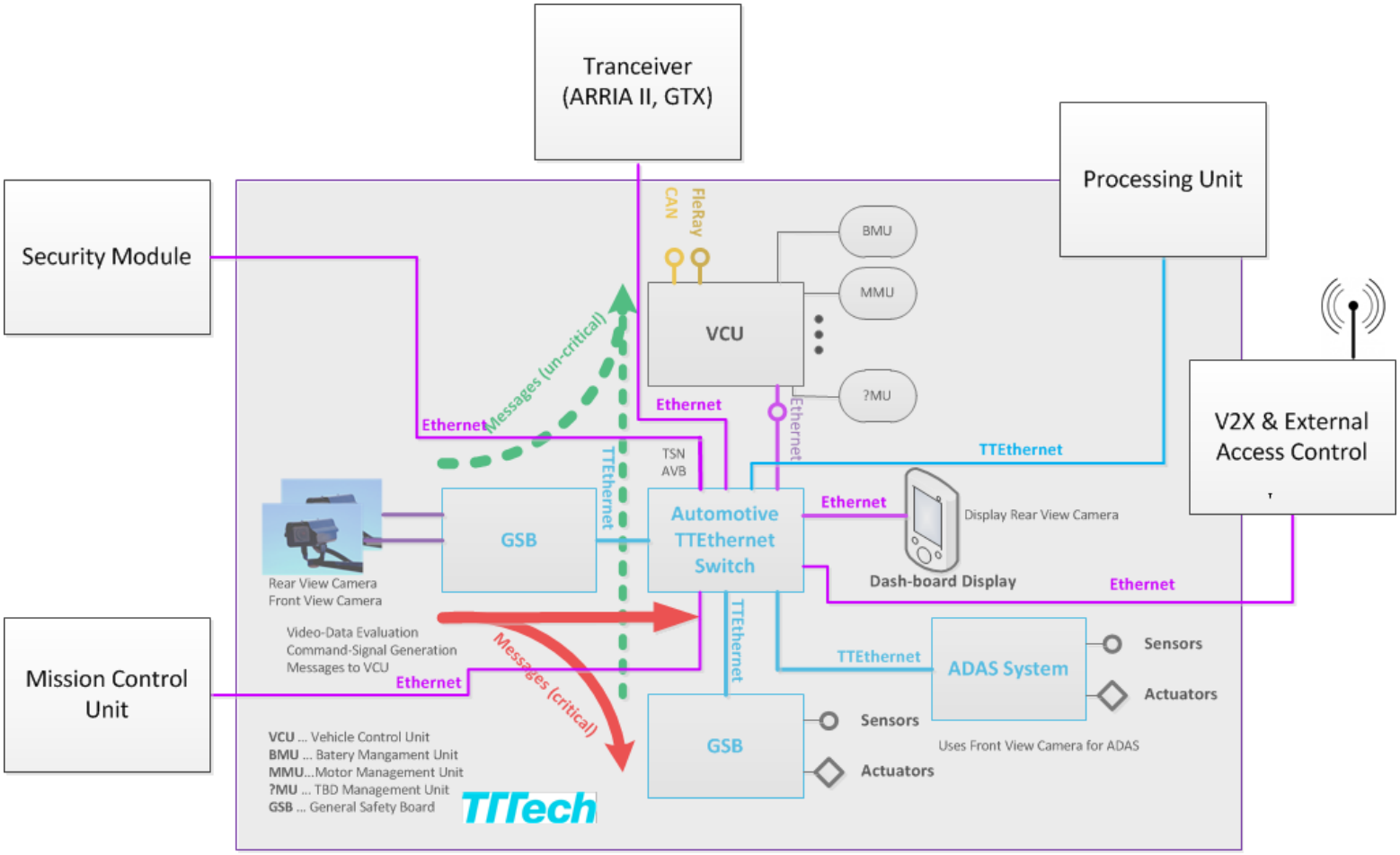
Removing the Conveyor Belts



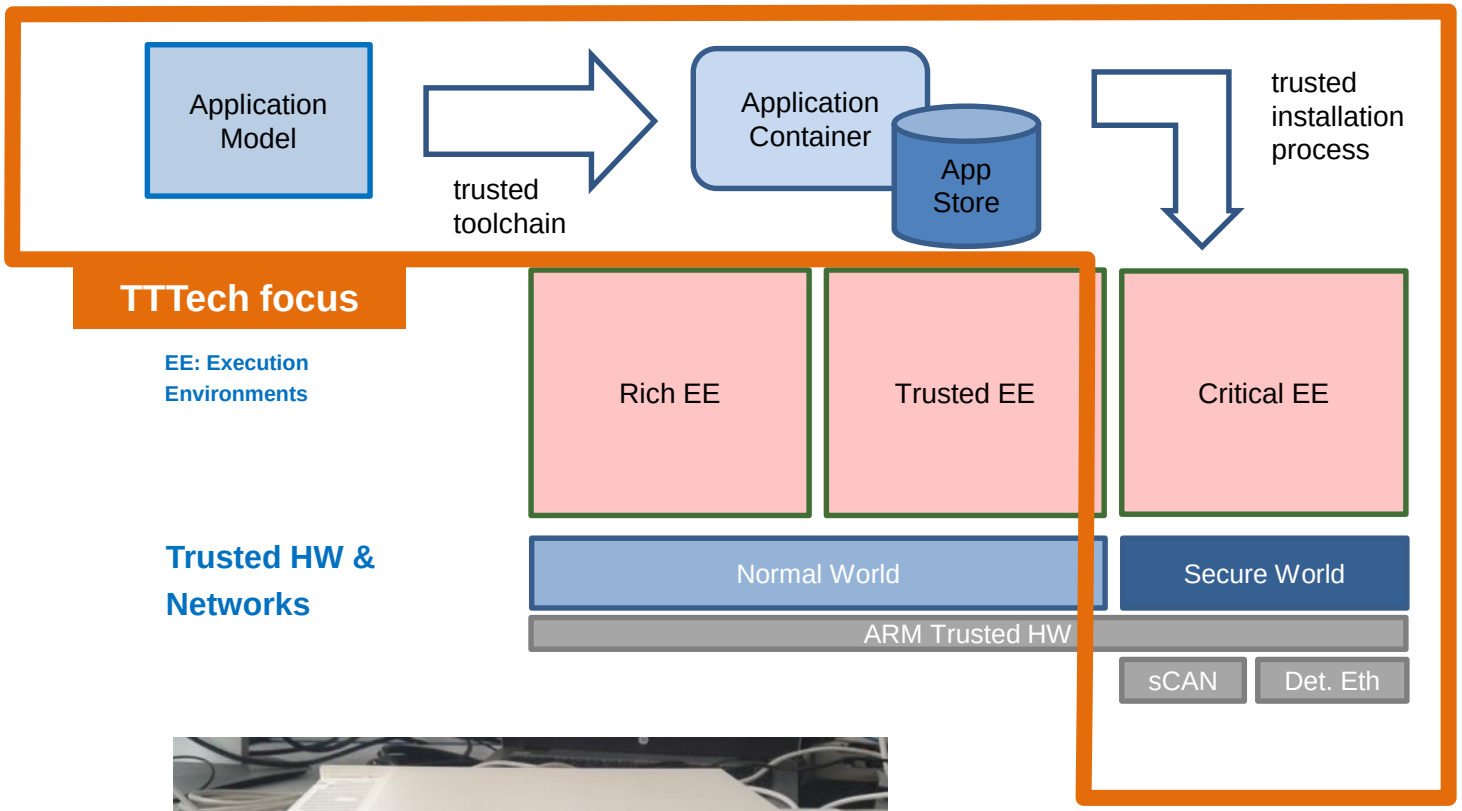
Open Workshop Approach



Potential Network



TAPPS Platform



Ind. Demonstrator overview (1/2)

- **Industrial Equipment**
  - Controlled by **TAPPS Control Platform** with several apps
  - Control application written and deployed with **TAPPS toolchain**
  - Data visualization, maintenance application(s) deployed on **TEE** or **REE** (Trusted/Rich Execution Environment)

Data aggregation platform

TAPPS Control Platform

TTTech Communication

Example: Festo 1&2 electric processing

Ind. Demonstrator overview (2/2)

Overview of Demonstrator

Function of Festo1: Pick & Place

‘distributed application‘, using 4DIAC on Juno and BB connected via TSN

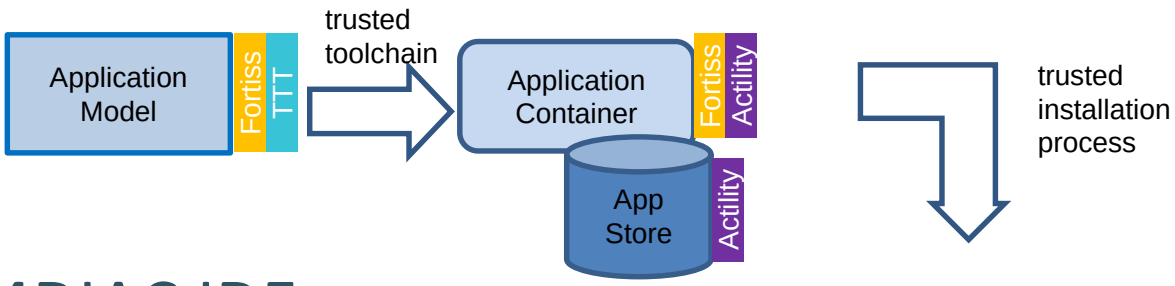
Function of Festo2: Drilling

‘non-distributed application‘, using 4DIAC RTE on Juno

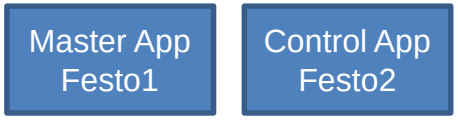
Installation process of Festo2 („installing an update“)

Building Blocks

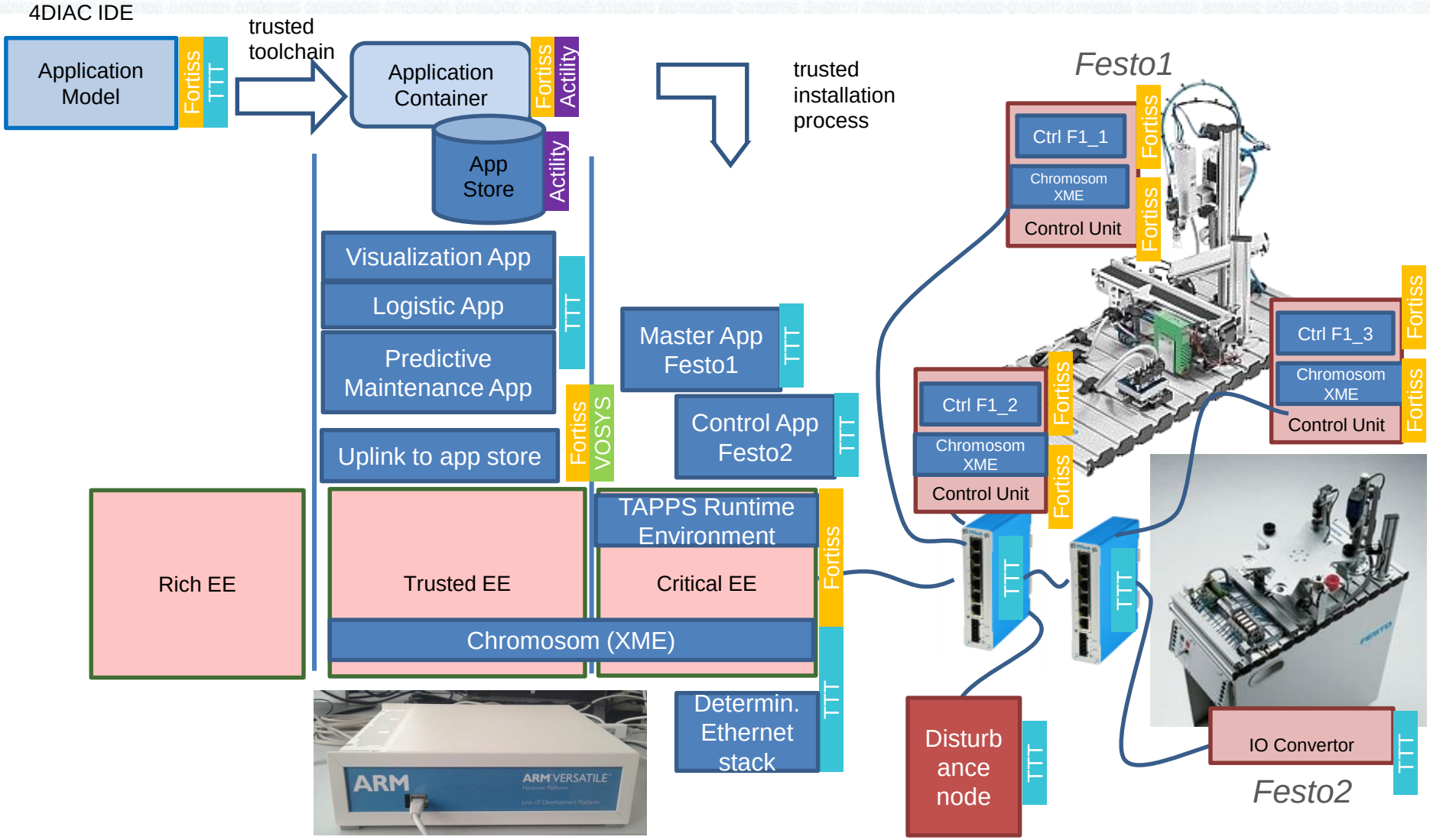
- **Toolchain to develop Critical Apps**



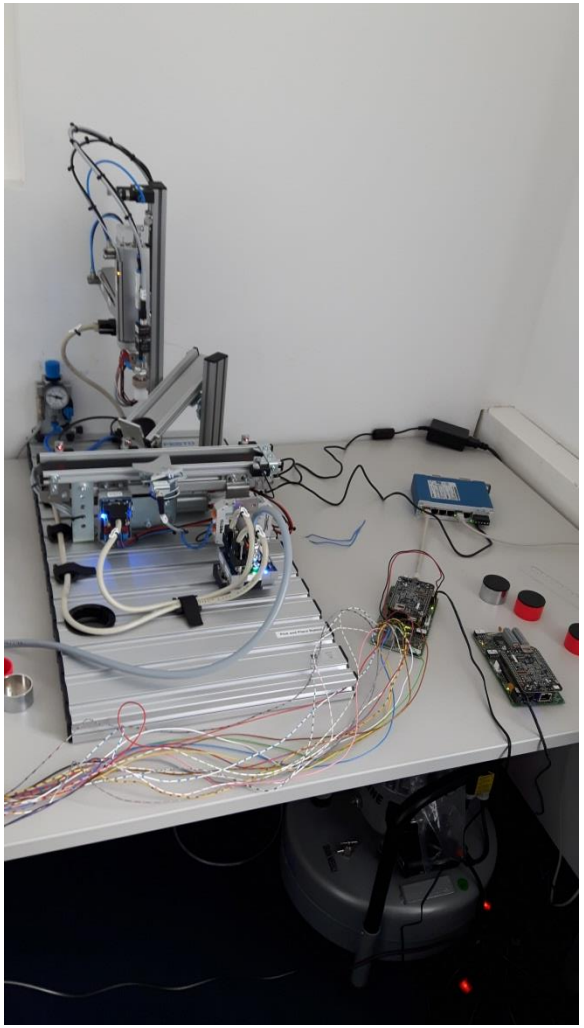
  - 4DIAC IDE
  - NuSMV Checker
  - TAPPS Marketplace
- **Critical Apps**

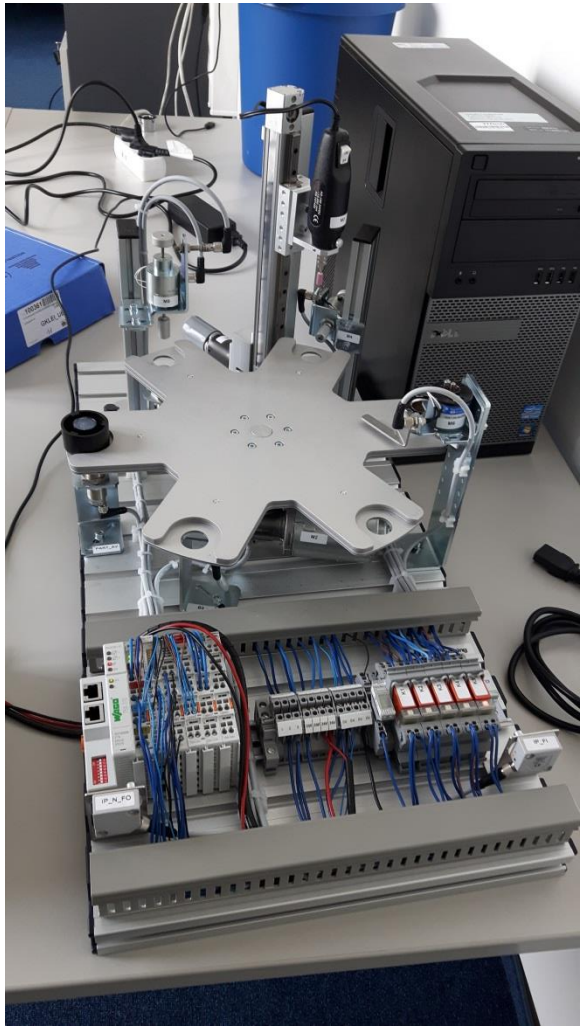


Ind. Demonstrator Implementation



Status of Ind. Demonstrator





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Third parties

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TAPPS

Trusted **Apps** for open CPSs

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