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Reconfigurable Industrial Process Monitoring using the CHROMOSOME Middleware

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DAS MIKROSYSTEMHAUS

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Outline

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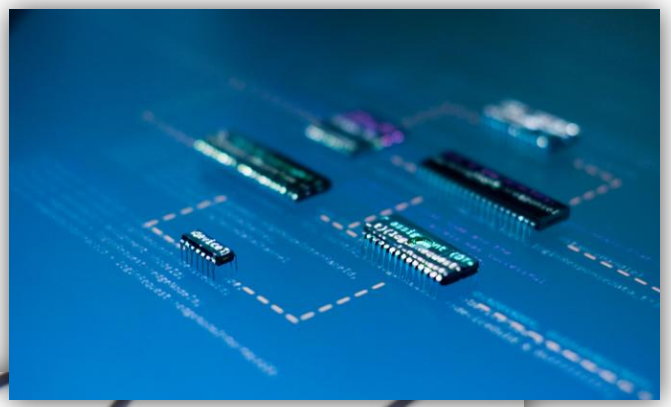
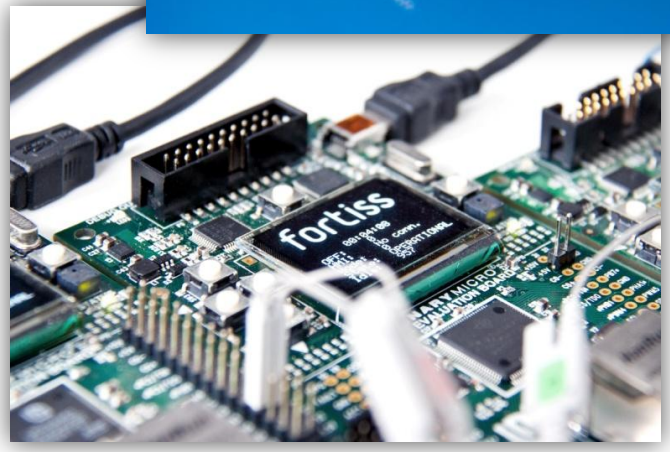




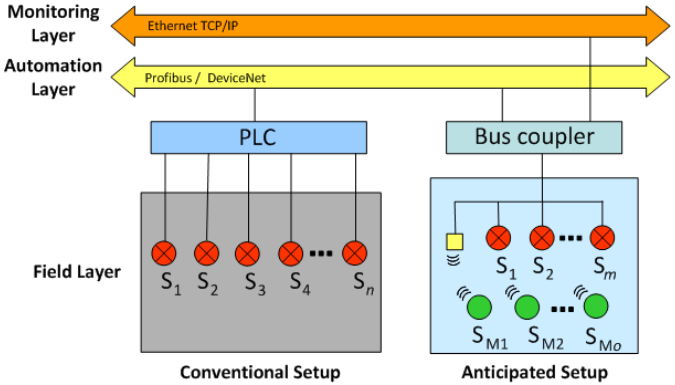
Project Overview

Goals of Project "Multifunk":

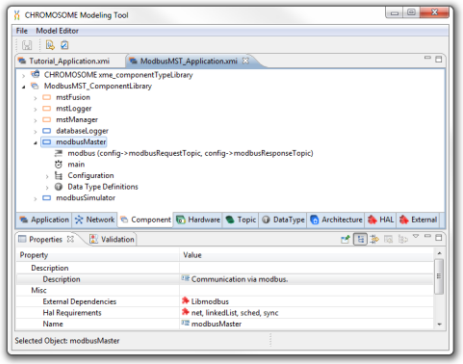
- Wireless sensor network-based monitoring of industrial production processes for quality assessment
- Model-driven design tools
- Code generation
- Network self-organization

Showcases:

- Development of redundant sensor system "MST2012" for monitoring of temperature and pressure data
- Development of a generic automation line monitoring sensor network



Sample Multifunk Network Topology



Modeling Tool

Demonstration Platform

Motivating Application Example

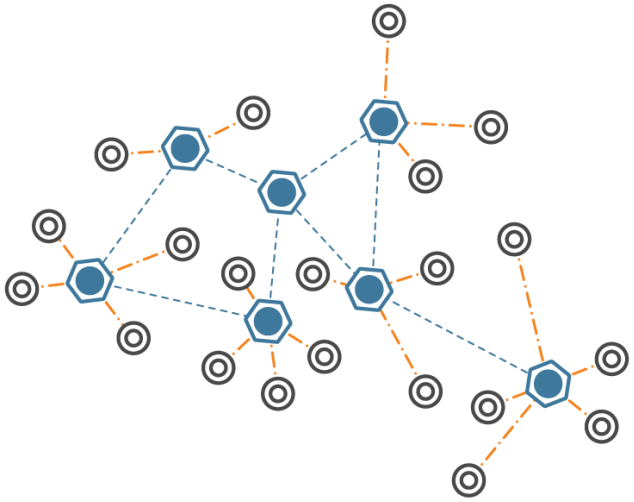
Tire Production:

- Certain temperature and pressure profiles have to be asserted during vulcanization
- **Rough environment, industrial sensors**

Goals:

- Acquisition of temperature and pressure data for later reference and quality assurance
- Optimization of heating and hence energy consumption
- **Acquisition of quality assurance data should be isolated from physical process**

Idea



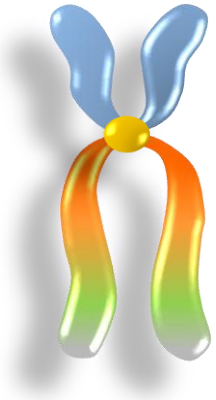
Observation:

- Process monitoring for quality assurance...
  - Is often added or extended after installation of the automation system
  - Needs to be easy to set up and reconfigurable
  - **Needs to be adaptable during runtime**
  - **Needs to be isolated from the production process**

Idea:

- Introduce a flexible sensor network that is based on a middleware with dynamic reconfiguration during runtime
- Reliability aspects such as health monitoring need to be considered

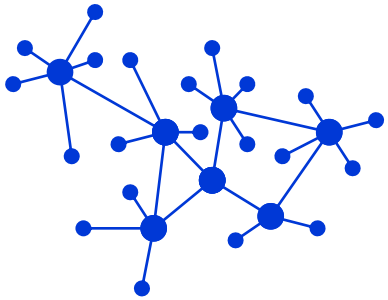
→ **CHROMOSOME Middleware**



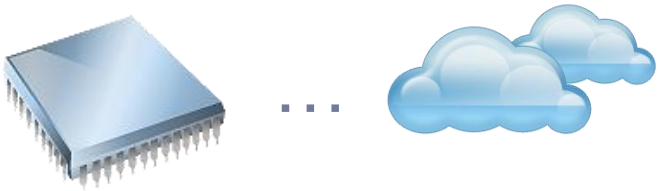
The CHROMOSOME Platform

- **Adaptive Runtime System:**
  - → Execution
  - → Plug & Play

- **Communication:**
  - → Middleware
  - → Real-time capability



- **Multi-domain and Multi-platform:**
  - → Support “from 8 bit controllers to the cloud”



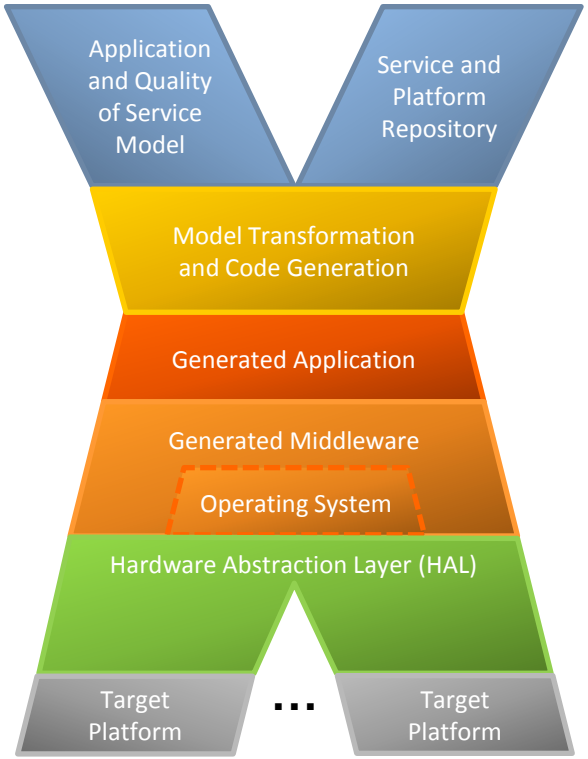
CHROMOSOME Architecture

Scalable Middleware Architecture:

- On resource constrained systems,
  the middleware is configured statically
  and only contains core functions
  → **Suitable for small embedded controllers**
- On more elaborate systems, aspects like
  PnP allow dynamic reconfiguration at runtime
  → **Flexibility**

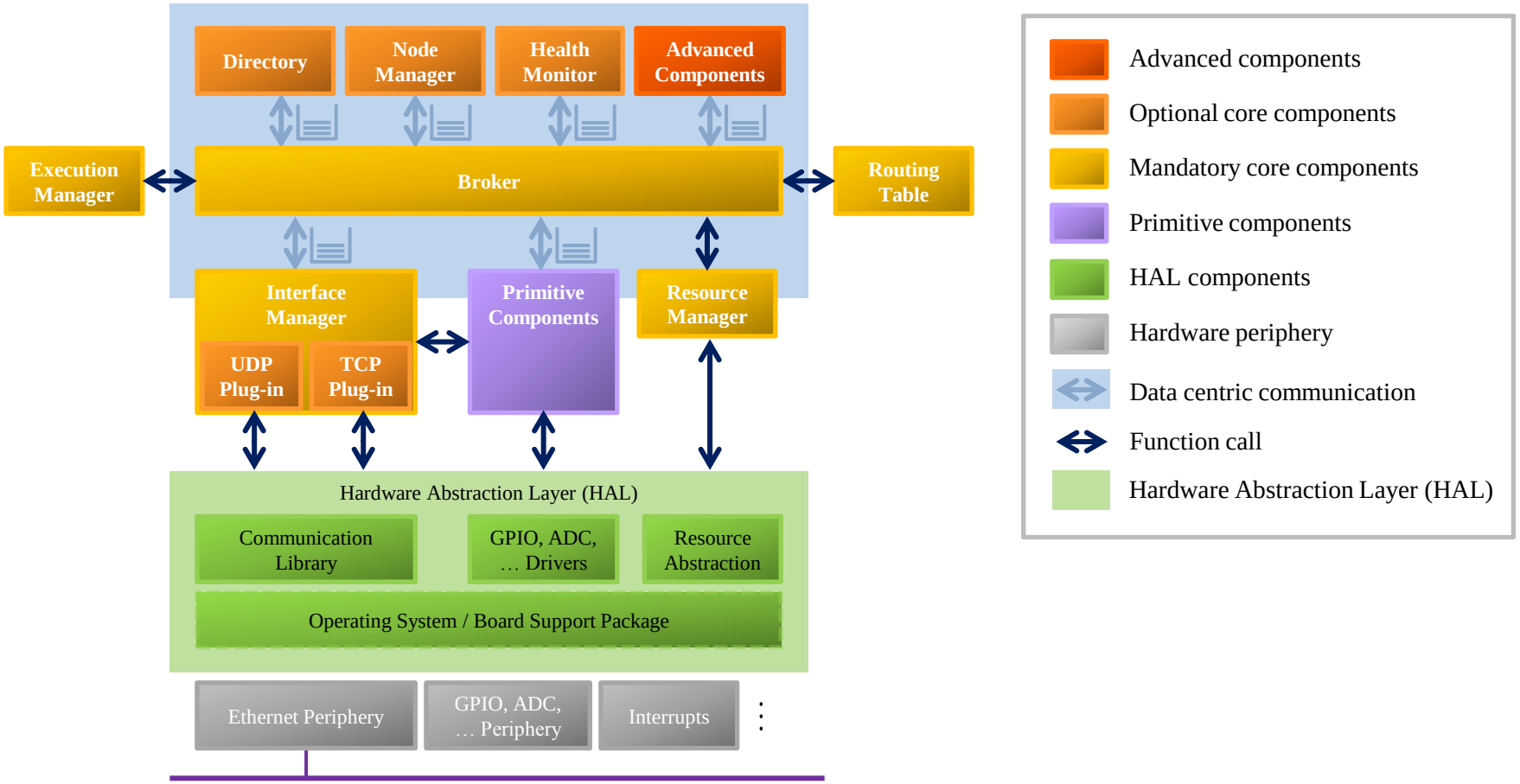
Model-driven Tooling:

- Allows to select the appropriate implementation variant and to configure the middleware

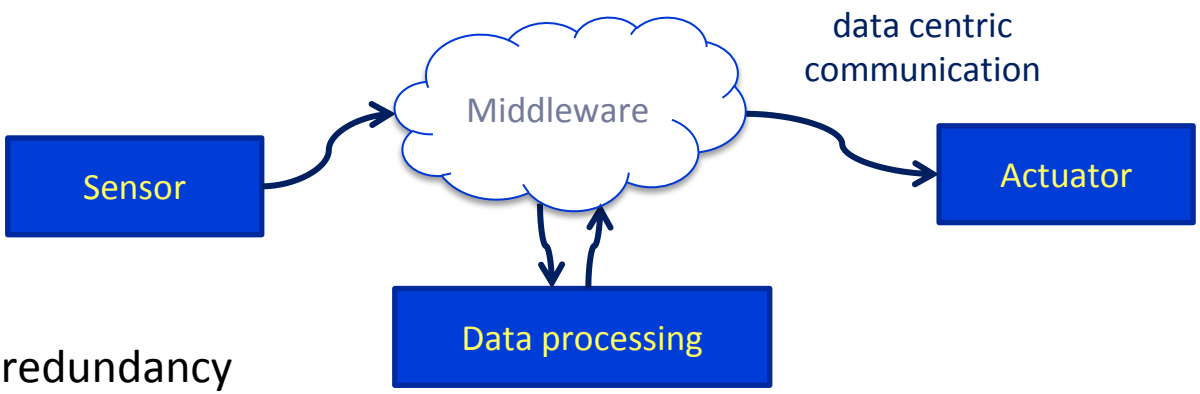


Middleware Components

Basic Structure of a single Node:



Data Centric Communication



Goal:

- Make all data available to all processing units

Rationale:

- Avoid costs by unneeded redundancy

Realization:

- Decoupling of sender and receiver → *Data centric communication*
- **Route resolution during runtime is performed by *Directory*, which updates local and remote *Routing Tables* accordingly**

Concepts:

- *Topic:* Data type with assigned semantics and fixed structure (e.g., temperature, pressure)
- *Publication:* Intent to send data of a given *topic*
- *Subscription:* Request to receive data of a given *topic*

Health Monitoring

Goal:

- Increase reliability by detecting hardware and software faults as well as the absence of a node

Realization:

- Health Monitor component on every node
- Suite of hardware and software tests on every node
- Health Manager component on a dedicated node (collects information)

Concepts:

- *Periodic hardware tests:* Hardware tests that are performed at a specific interval
- *Periodic software tests:* Algorithmic tests that are performed at a specific interval
- *Node-level proof of life:* Monitor data exchange and force explicit signaling between nodes where no data is exchanged at a regular basis

Multifunk Application Scenario

Image: efm-systems GmbH

Purpose:

- Experimental setup with temperature and pressure sensors before implementing the concept in the plant

Functionality:

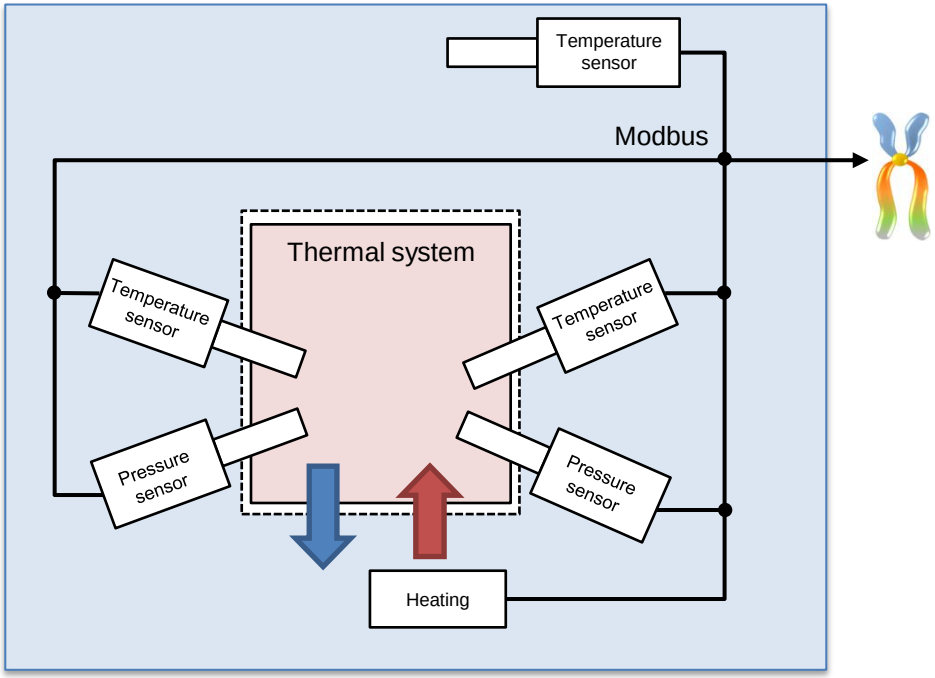
- Logging and fusion of industrial sensor data (e.g., temperature) for product quality assessment
- Sensor life cycle management

Target Platform:

- PC with Windows, ARM

Middleware Configuration:

- Dynamic login and logoff of sensors
- *Topics*: Temperature, pressure, error, fusion data, …



MST2012 Sensor System

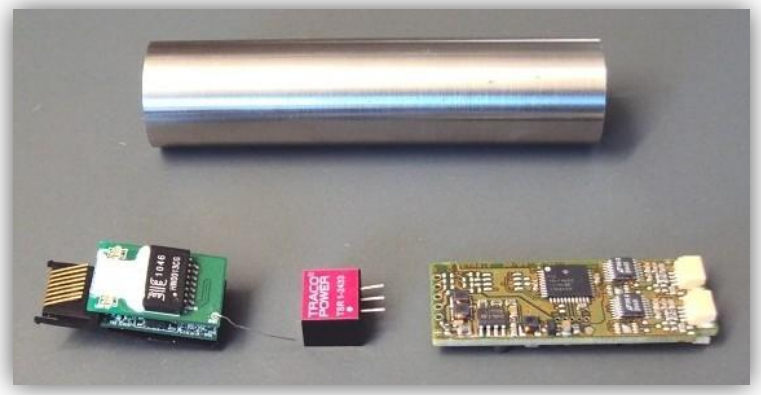


Image: efm-systems GmbH

Prototypic implementation of one channel

Purpose:

- Industry compliant sensor system implementing the stated requirements

Basic Concept:

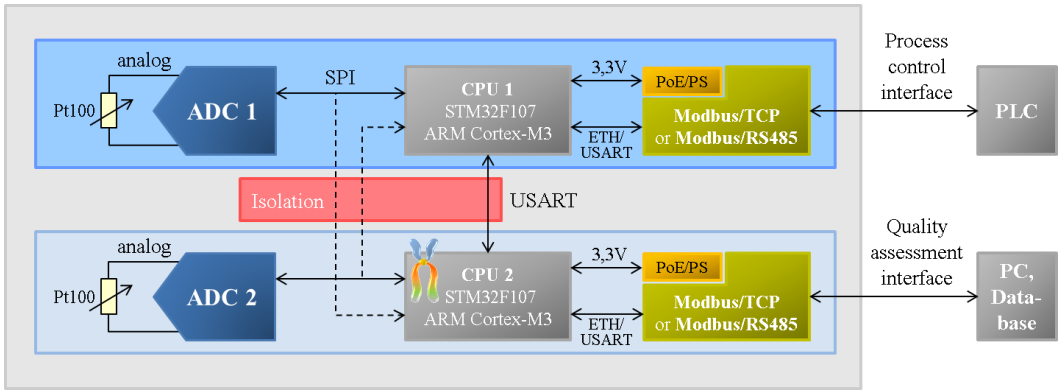
- **Dual-channel: process control channel (industry compliant Modbus/RS485) and quality assessment channel (CHROMOSOME communication protocol)**
- Health cross-check and health monitoring

Realization:

- ARM-Cortex M3 controller
- Ethernet (Modbus/TCP)

Benefits:

- Data pre-processing
- In-system drift detection of sensor and ADC



Block diagram of MST2012

Summary and Contribution

Industrial Application Scenario:

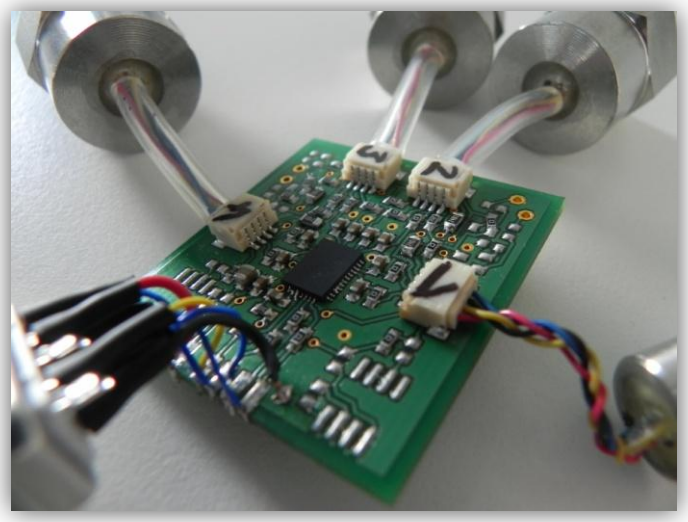
- Thermal processes: temperature and pressure
- Redundant data acquisition for quality assurance

CHROMOSOME Middleware:

- Open source
- Data centric communication
- Portability

Redundant Sensor System:

- Small size
- Connectivity
- Simple deployment



Four-channel Temperature Probe Prototype with ADC

Thank you
for your attention!

Questions?

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