HAN'S ROBOT GERMANY

Development of an Embedded Communication Hub for the Acquisition of Sensor Data in a Robotic System

Project Thesis

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V2 (2020.04.28)

Contents

Background

- Robotic applications increasing their multi-connectivity
  - Collaborative robots
  - Peripherals
    - 2D/3D vision systems
    - HMIs
    - Sensors/Actuators

- Industrial shift into the Real Time Connectivity

Background: RT Ethernet Networks

- Fieldbuses were included within IEC 61158 (CPFs) 1988-1999
  - RTEN referenced to IEC61784 part II 2008
- Two strategies to ensure RT communication:
  - TDMA and CIP (Common Industrial Protocol)
- TSN Group improves the Data Link and MAC Layer (IEEE802.1Qbv) 2012-2019

- Open-source tools offer compatibility → Further development

Licensed RTE Solutions:

PROFINET®

ETHERNET POWERLINK

hilscher COMPETENCE IN COMMUNICATION

EtherCAT®

Open source tools:

freeRTOS

CMSIS COMPLIANT ARM® Cortex™ Microcontroller Software Interface Standard

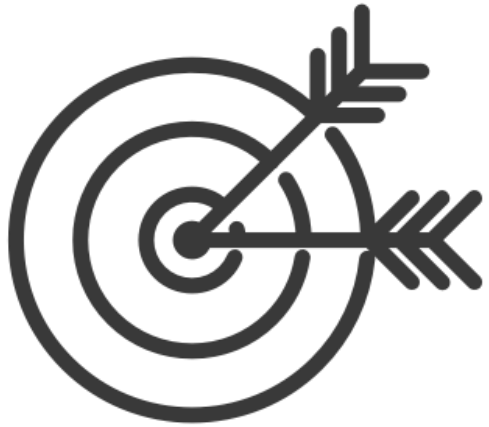
Open EtherCAT Society

Simple Open Source EtherCAT Master & Slave Society

Main goal

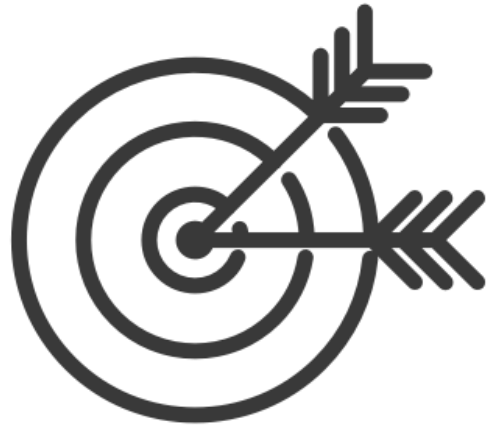
“Develop a device using open-source tools to read out sensor data from a robot axis that can be interfaced with a RTE Network.

The device could be used afterwards as a test platform within an industrial environment to characterize its compatibility with the ongoing IEC/IEEE 60802 TSN Profile for Industrial Automation.”



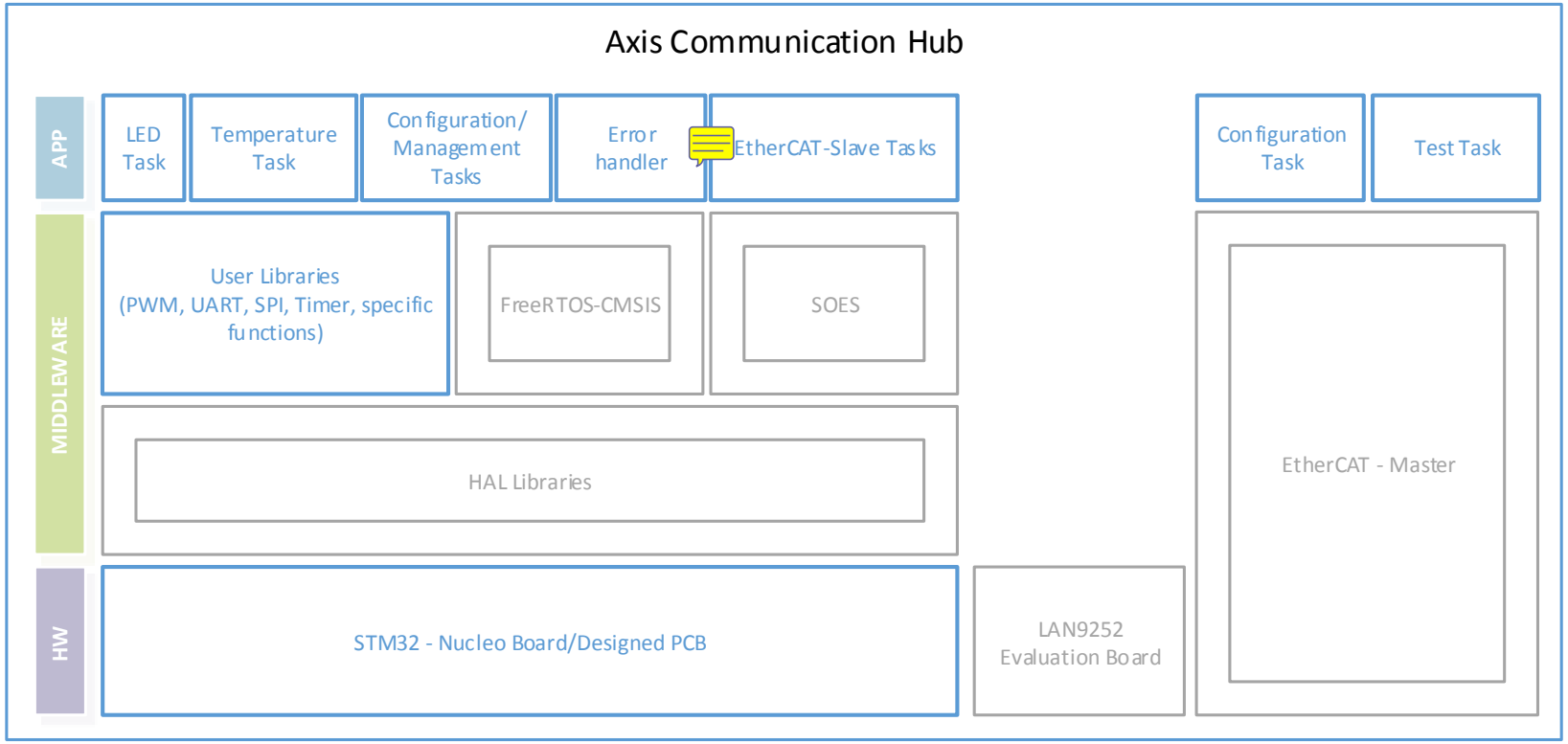
Specific goals

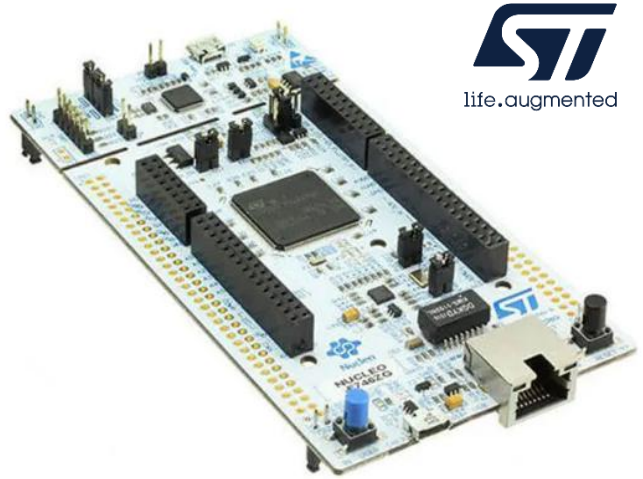
- To specify the requirements of the system
  - Comparison taking into account the state of the art
- To develop the embedded system as a functional EtherCAT Slave Device
  - Integrating FreeRTOS-CMSIS with SOES (Open-source tools)
  - Integrating the LAN9252 (SoC over SPI)
  - Reading out of axis temperature sensors
  - Controlling the axis LED Ring (WS2812b)
  - Designing the required user application libraries
- To design and manufacture a PCB prototype using Altium Designer
- To test and report the system functionality

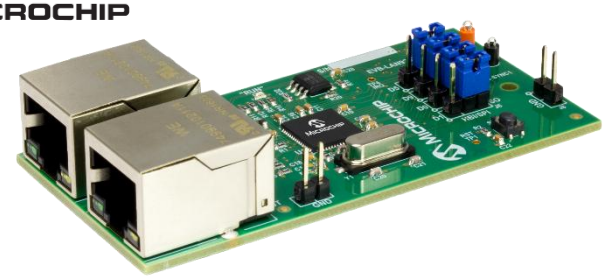


Solution proposal

- Layered structure of functional blocks
  - Main HW: STM32Nucleo Board, Microchip LAN9252 SPI Eval Board

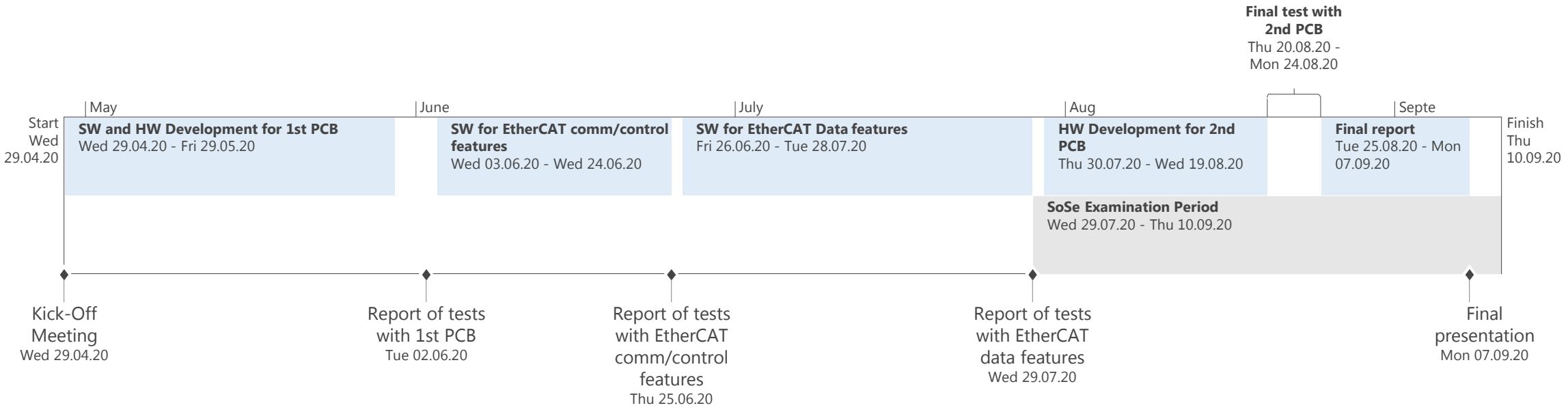






Timeline

- Duration: ~4 Months
- Official start: 29.04 Final Presentation: 07.09 (Proposal)



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Dankeschön für Ihre Aufmerksamkeit!

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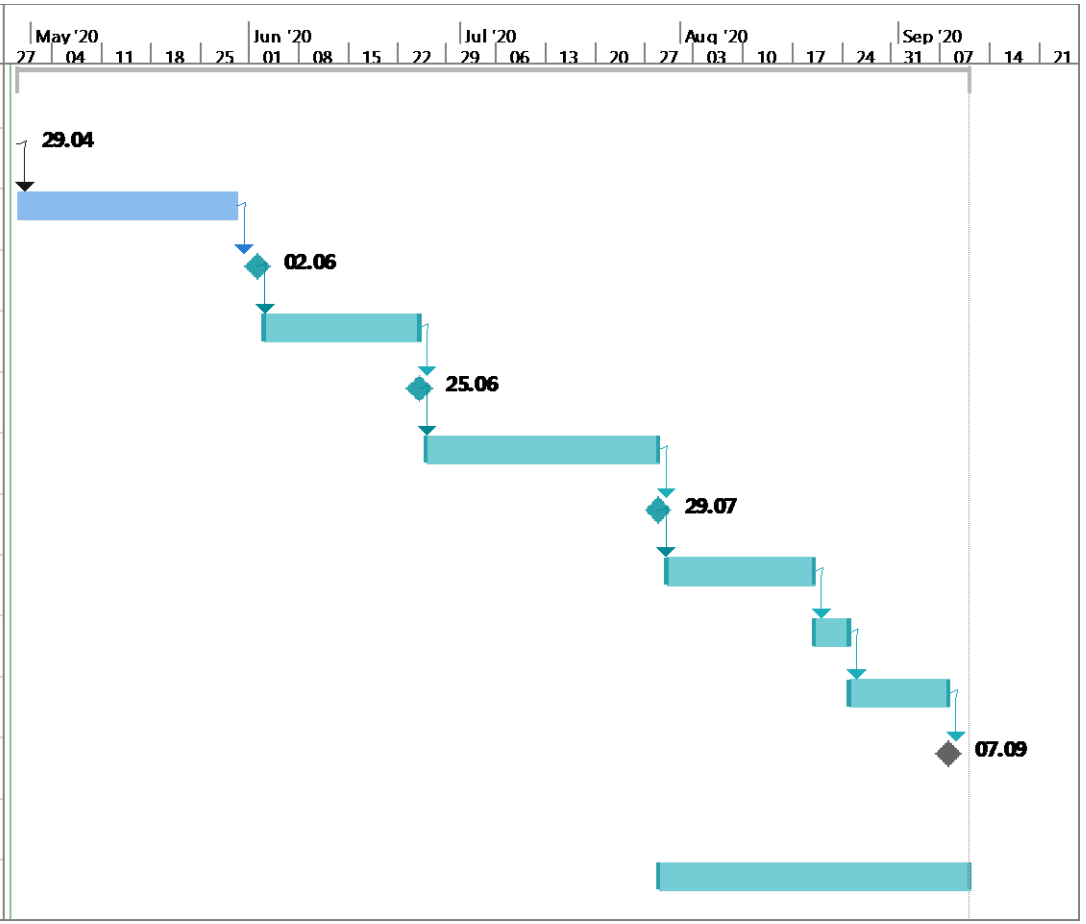
Extra information

Gantt Chart

- Duration: ~4 Months
- Official start: 29.04 Final Presentation: 07.09 (Proposal)

ID	Task Name	Duration	Start	Finish
0	**Axis Communication Hub Development**	**97 days**	**Wed 29.04.20**	**Thu 10.09.20**
1	Kick-Off Meeting	0 days	Wed 29.04.20	Wed 29.04.20
2	SW and HW Development for 1st PCB	23 days	Wed 29.04.20	Fri 29.05.20
3	Report of tests with 1st PCB	0 days	Tue 02.06.20	Tue 02.06.20
4	SW for EtherCAT comm/control features	16 days	Wed 03.06.20	Wed 24.06.20
5	Report of tests with EtherCAT comm/control features	0 days	Thu 25.06.20	Thu 25.06.20
6	SW for EtherCAT Data features	23 days	Fri 26.06.20	Tue 28.07.20
7	Report of tests with EtherCAT data features	0 days	Wed 29.07.20	Wed 29.07.20
8	HW Development for 2nd PCB	15 days	Thu 30.07.20	Wed 19.08.20
9	Final test with 2nd PCB	3 days	Thu 20.08.20	Mon 24.08.20
10	Final report	10 days	Tue 25.08.20	Mon 07.09.20
11	Final presentation	0 days	Mon 07.09.20	Mon 07.09.20
12				
13	SoSe Examination Period	32 days	Wed 29.07.20	Thu 10.09.20



Main topics

- Programming of software for embedded systems
  - STM32 MCUs with ARM architecture
  - Communication Interfaces (UART, I2C, BiSS, SPI)
  - Real Time tools (FreeRTOS - CMSIS)
- Programming with industrial tools
  - Integration of an industrial protocol software stack into RTOS (SOES)
  - RT Ethernet Industrial Protocols (EtherCAT)
- External configurations
  - EtherCAT Host (Beckhoff)
- External documentations
  - TSN Industrial profile specification 2019

- [05.29] First PCB will be able to measure the temperature, interface over Uart to any serial host, control the LEDs and will only have the pinouts for SPI and BiSS connections. Tasks will be handled with a basic FreeRTOS approach. PCB will connect directly to the Nucleo and the LAN9252 Eval Board (firmly assambled, no-MCU on the manufactured board, 2X SPI Ports, 4X Temperature sensor connectors and X-Ports to LEDs).

- [06.24] First EtherCAT Slave Test - This will have at least a running framework for SPI communication, initial configuration of the LAN9252 Eval Board and a test data flow coming from the temperature sensor to the Master. It will run over the Nucleo Board.

- [07.24] Second EtherCAT Slave Test - This should exchange the data coming from sensors and saving/updating the control data coming from the Master. All the data should be structured according to the Robot application. Important to notice , the BiSS Encoder is not included in this version.

- [08.21] Second PCB - This PCB will improve the first version having the MCU considered to replace the attached Nucleo Board and adding any component that might be needed for signal instrumentation. Any code improvement could be also added to adjust the several ports considered in the PCB design.

- [08.26-28] Final Presentation - Mainly it would be focused on the integration of SOES with the RTOS to create a device that will be the base for a future performance analysis within TSNs for industrial applications. Also the current status of the TSN initiative and any discussion that might appear due to the employment of open-source tools.