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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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

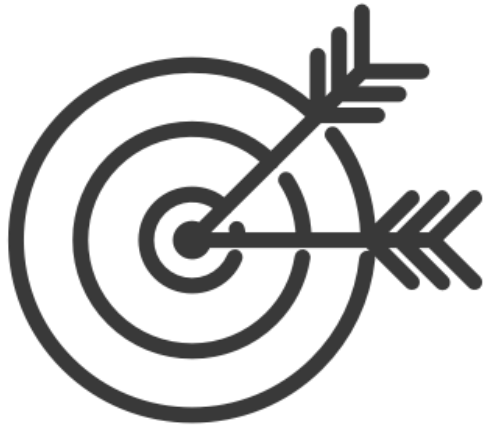
Open EtherCAT Society

Simple Open Source EtherCAT Master & Slave Society

Main goal

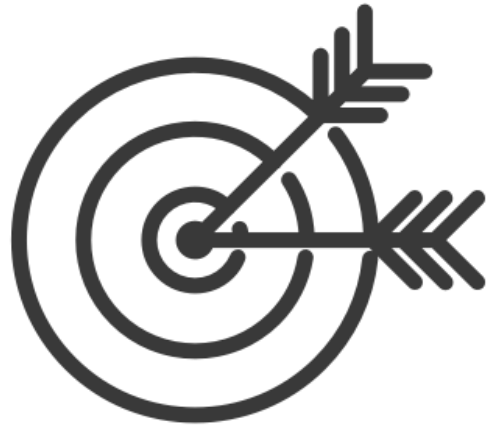
"Develop a device using open-source tools to read out sensor data from a robot axis that can be interfaced with an RTE Network.

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."



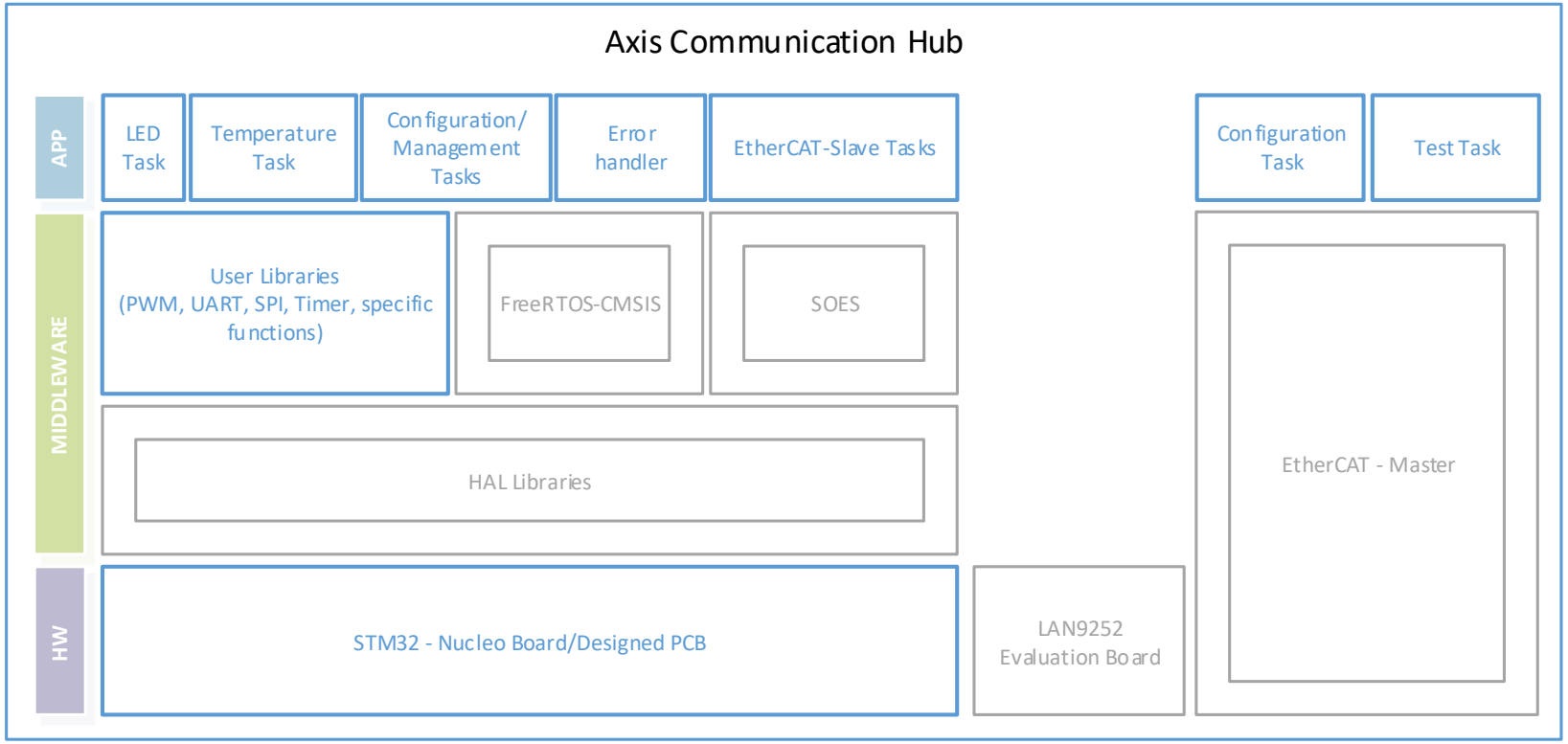
Specific goals

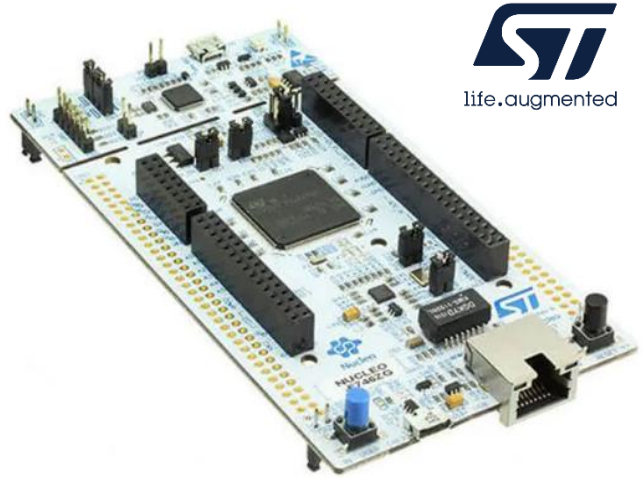
- To specify the requirements of the system
  - Comparison considering the state of the art
- To develop the embedded system as a functional EtherCAT Slave Device
  - Integrating FreeRTOS-CMSIS with SOES (Open-source tools)
  - Integrating the LAN9252 (SoC over SPI)
  - Reading out of axis temperature 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

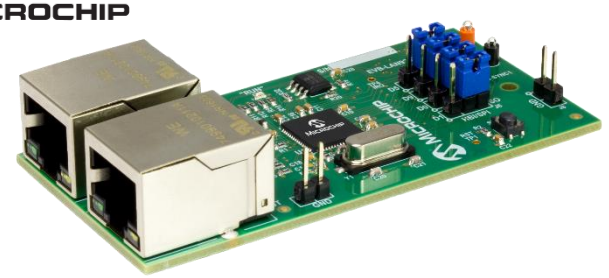


Solution proposal

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

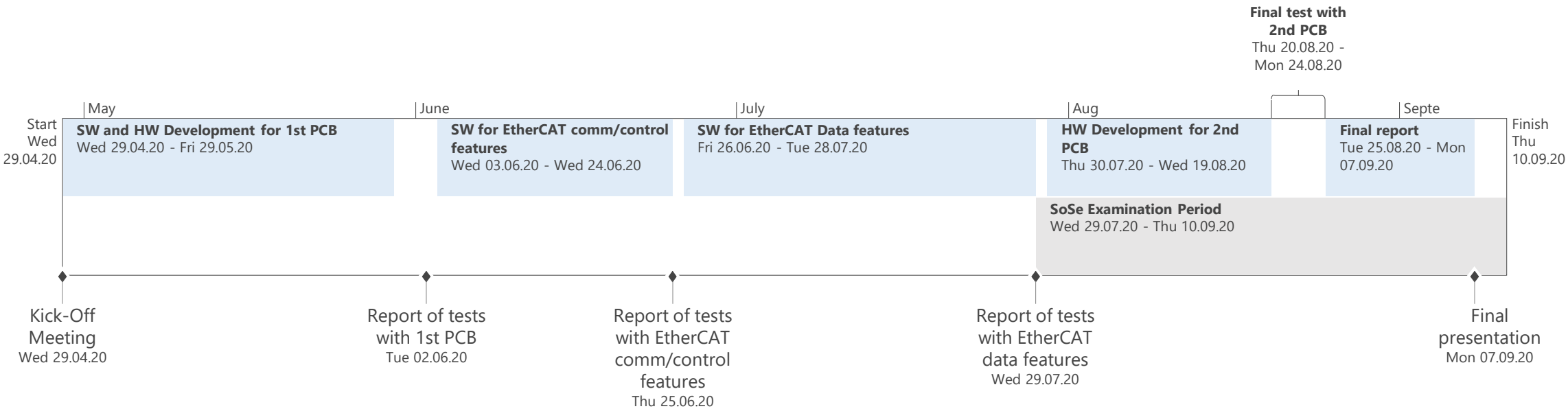






Timeline

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



Questions

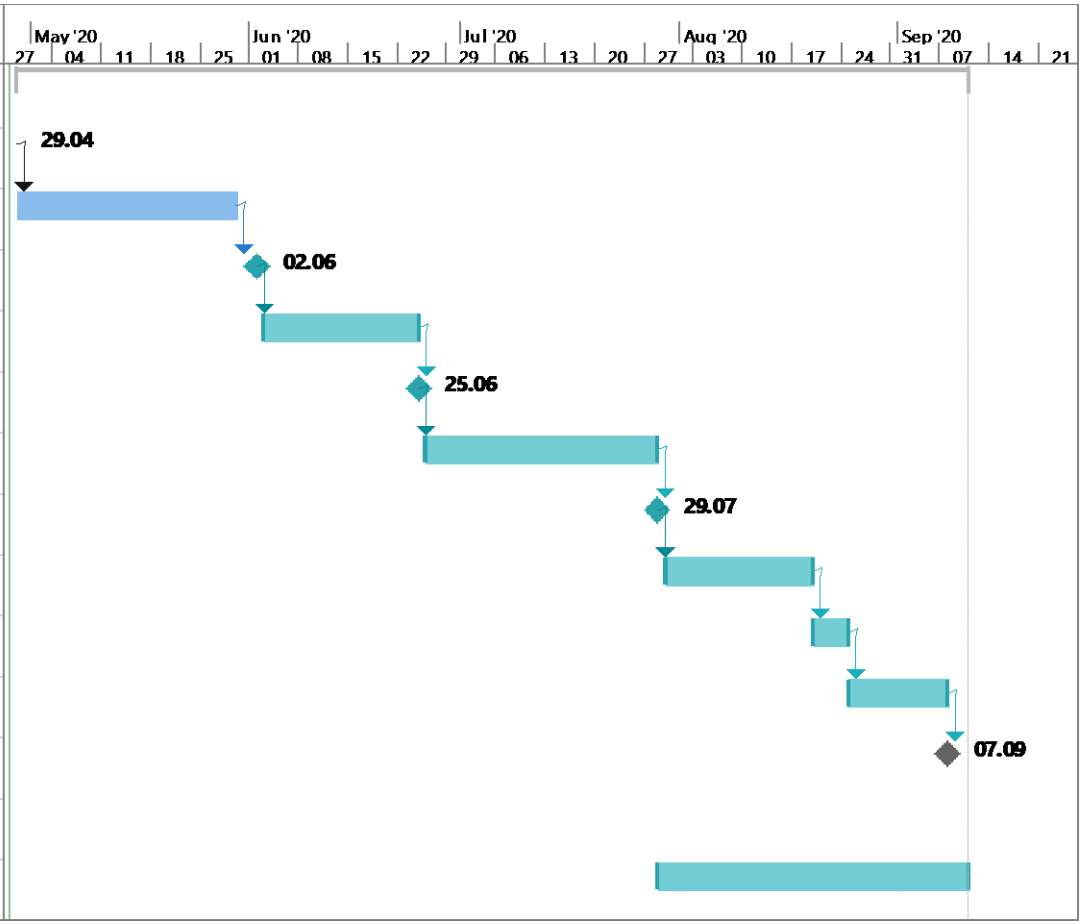
Dankeschön für Ihre Aufmerksamkeit!

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



Technical notes

- NUCLEO-F446ZE
  - ARM®32-bit Cortex®-M4 + FPU + Chrom-ART™ Accelerator
  - Up to 180MHz CPU frequency
  - 512 kB of Flash memory
  - 128 KB of SRAM
  - General-purpose DMA
  - Up to 17 timers
  - Up to 4 × I2 C interfaces (SMBus/PMBus)
  - Up to 4 USARTs/2 UARTs
  - Up to 4 SPIs
  - 2 × CAN (2.0B Active)
  - USB 2.0 full-speed device/host/OTG controller with on-chip PHY

- SOES is an EtherCAT slave stack
  - Address offset based HAL for easy ESC read/write access via any interface
  - Polling for interrupts

  - EtherCAT State Machine
  - Mailbox Interfaces
  - Protocols
  - CoE
  - FoE + bootstrap template

- Build up the SII-EEPROM Data-Layout
- ESI-file
- Port the Libraries to the STM32 using HAL
- FreeRTOS: Hardware Requirements >64KB RAM

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