Introduction to Embedded Systems Design

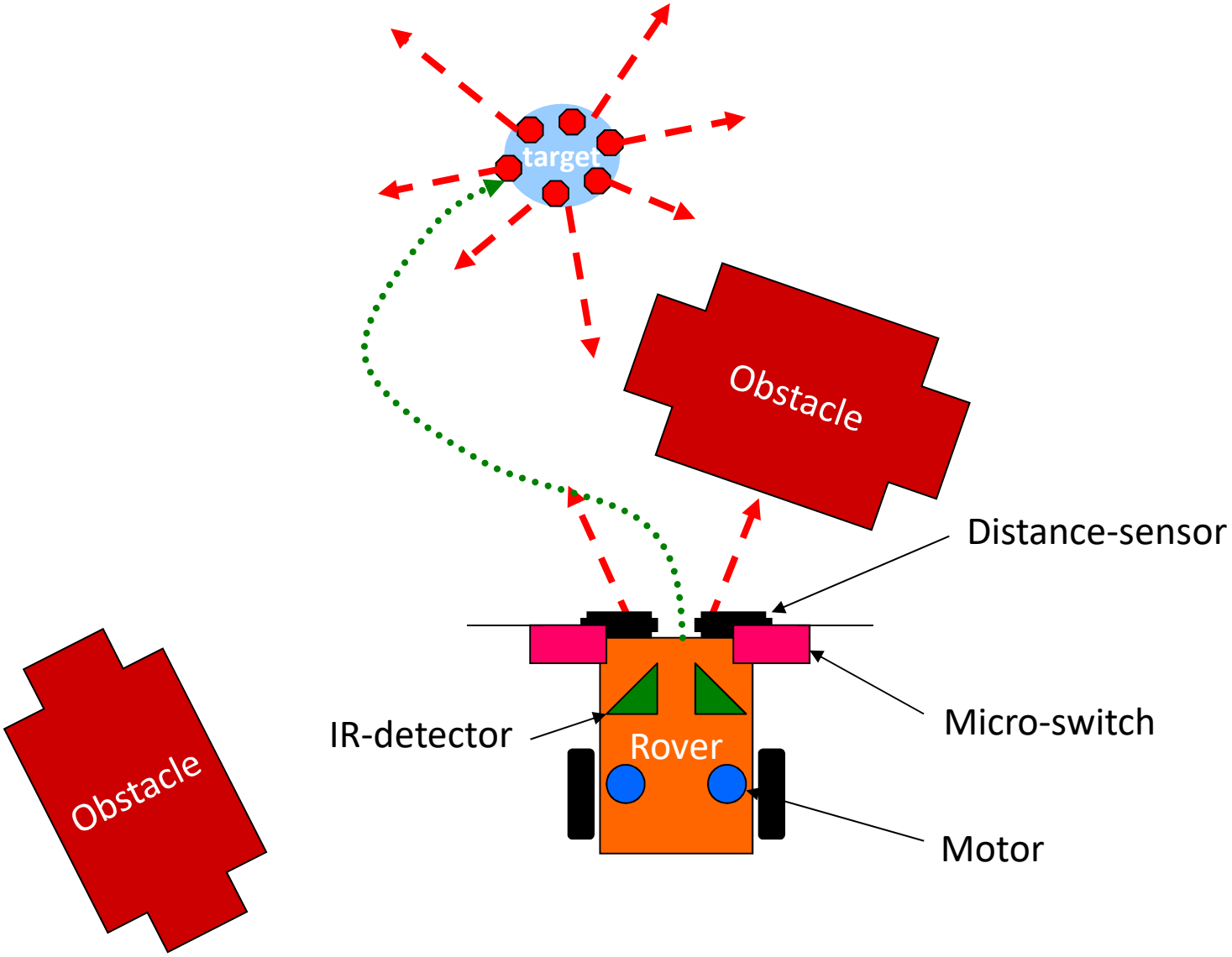
Embedded Systems Lab Project

Prof. Dr. Rolf Schuster

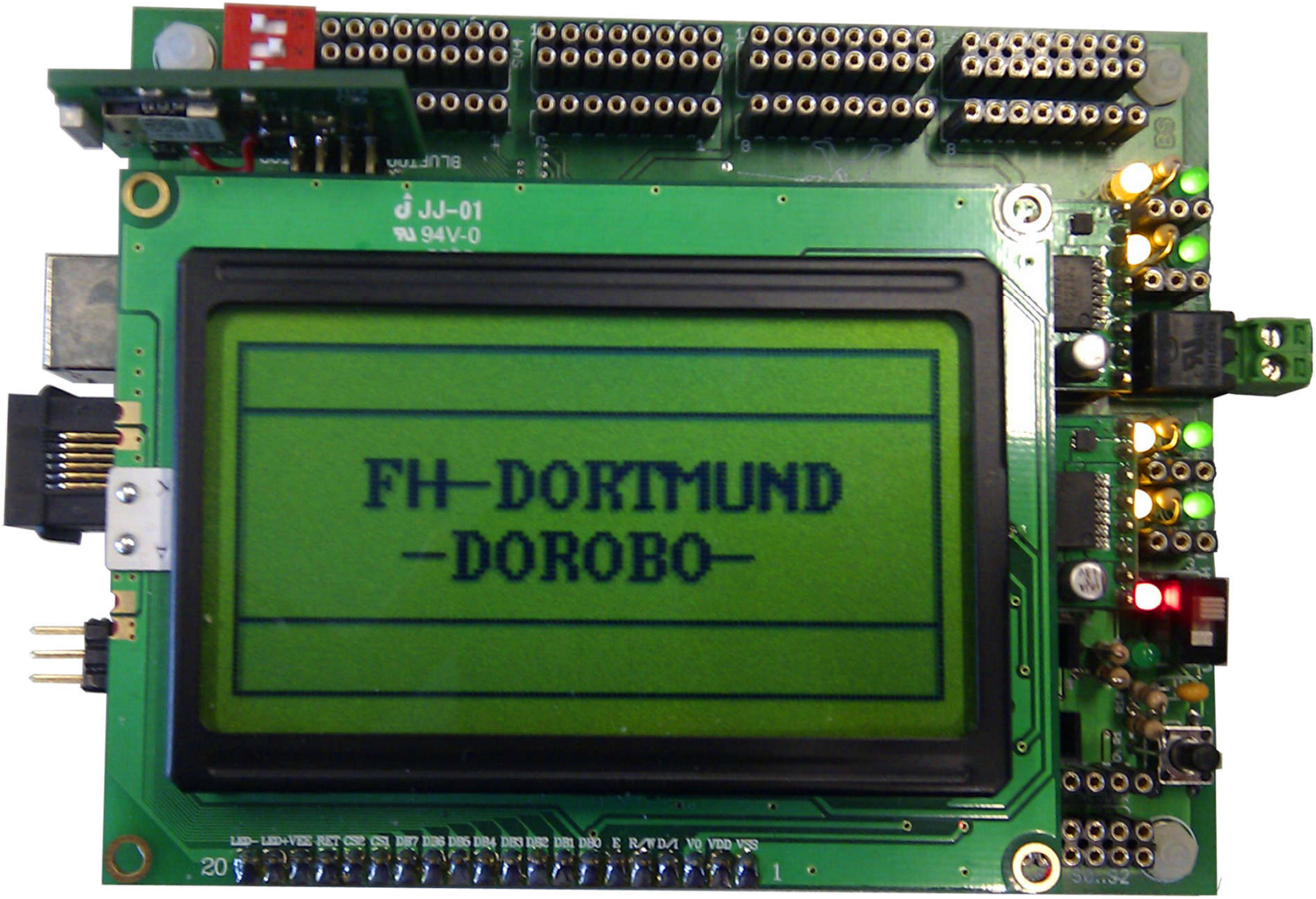
The task

- Develop a robot for a specific task within 5 weeks
- Build the robot with LEGO
- You can use
  - 2x Sharp ir-distance sensors,
  - 2x micro switches,
  - 2x remote control receiver sensors and
  - 1x chassis with three motors
- Program and optimise the robots behavior
- Work in teams with 2 students. Find fellow-workers!
- Use the material provided on ILIAS to get started
- After 5 weeks you present your approach and compete with the other teams
- Finally, you upload your complete project on ILIAS. The folder shall contain the team members last names

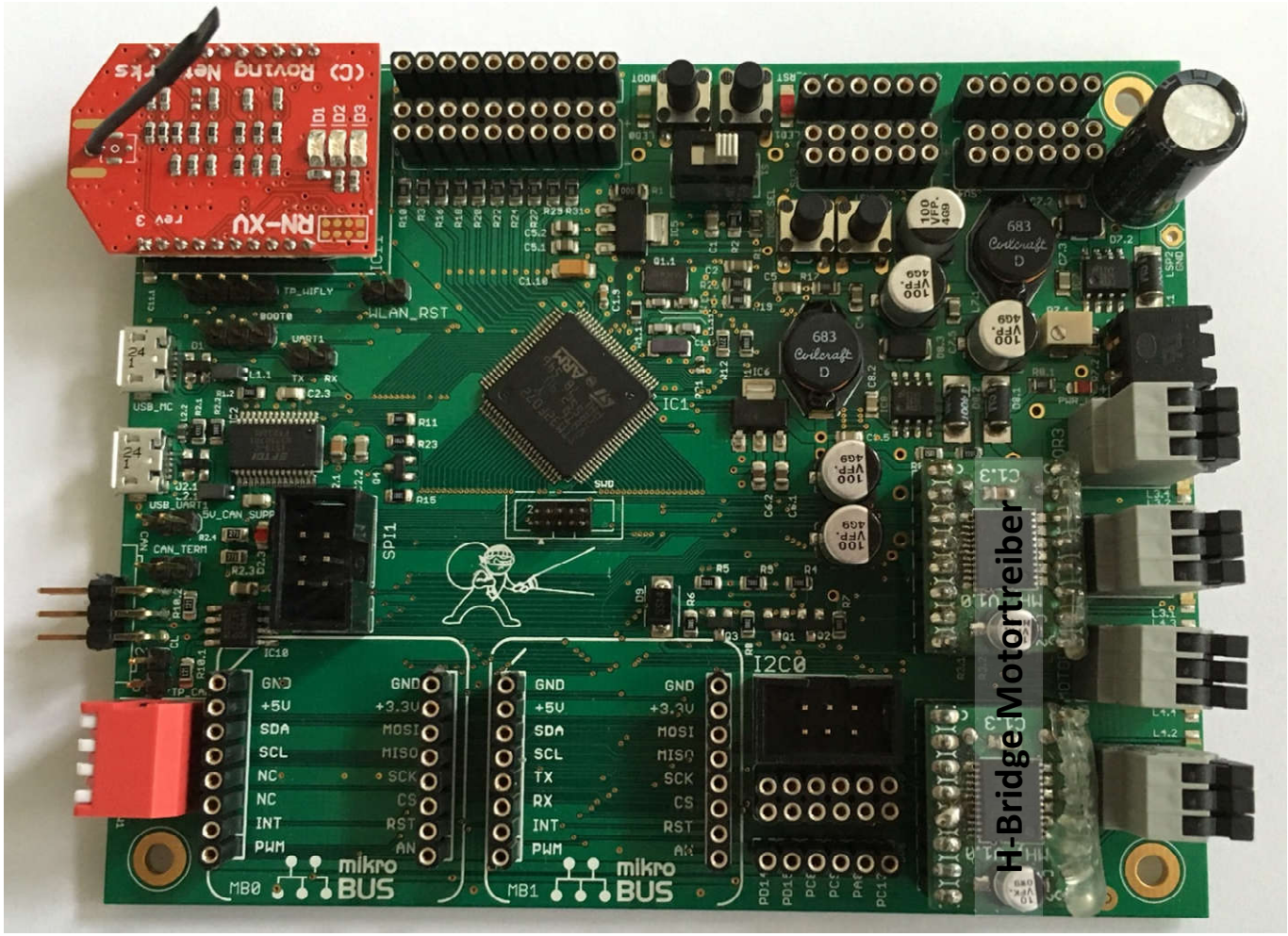
The task


target
Obstacle
Obstacle
Distance-sensor
IR-detector
Rover
Micro-switch
Motor

Dorobo-Board



Dorobo32-Board



DoRoBo32-Board

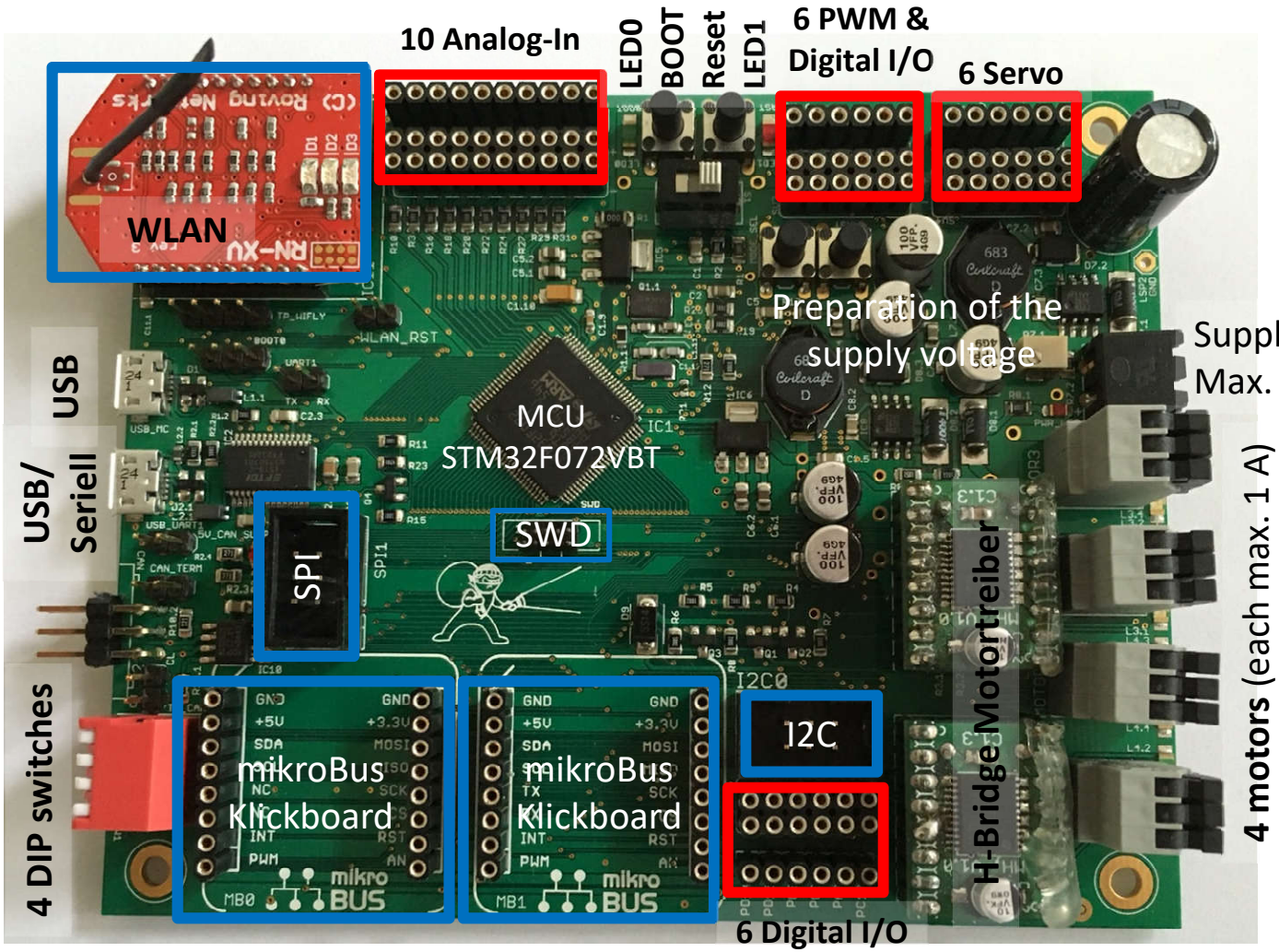
connections for sensors and actuators

- 10 analog inputs (sensor for light, distance, battery voltage u.a.)
- 6 digital in-/outputs (configurable as in- or output)
- 4 motor driver (in speed of rotation and direction)
- 6 servo-outputs
- 6 pwm-outputs for generation of pulsing signals;
  additional useable as encode-inputs (such as odometry)
- 4 DIP-switches
- state-LEDs

interfaces

- 1x USB over RS232 seriell
- 1x USB free programmable
- I²C (such as TWI), SPI, CAN bus and additional serial interfaces
- WLAN, ZigBee via extra mounted boards
- 2 extensions slots for mikroBUS Klickboards

Dorobo32-Board



DoRoBo32-Board (sensors)

micro switches

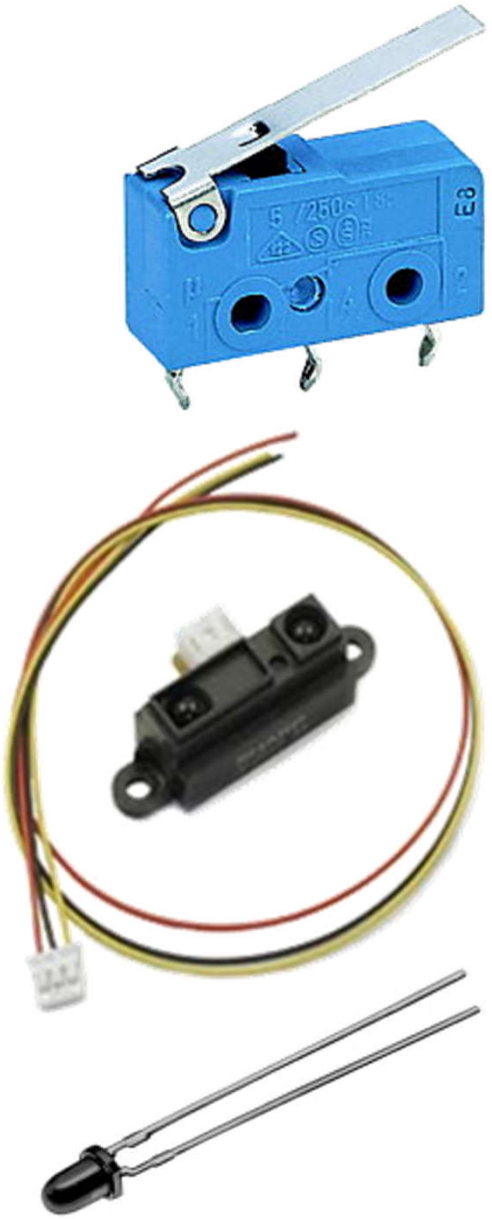
- detection of collisions
- reading via digital IO ports

IR distance sensor

- distance measurement through triangulation
- output voltage depends on distance
- reading via analog ports

IR remote control sensor

- detection and location of an IR transmitter
- detection of 38 kHz modulated IR light
- Reading via digital IO ports. Preprocessing of the signal with FFT (*libdorobo32*)



DoRoBo32-Board (actuators)

drive motors

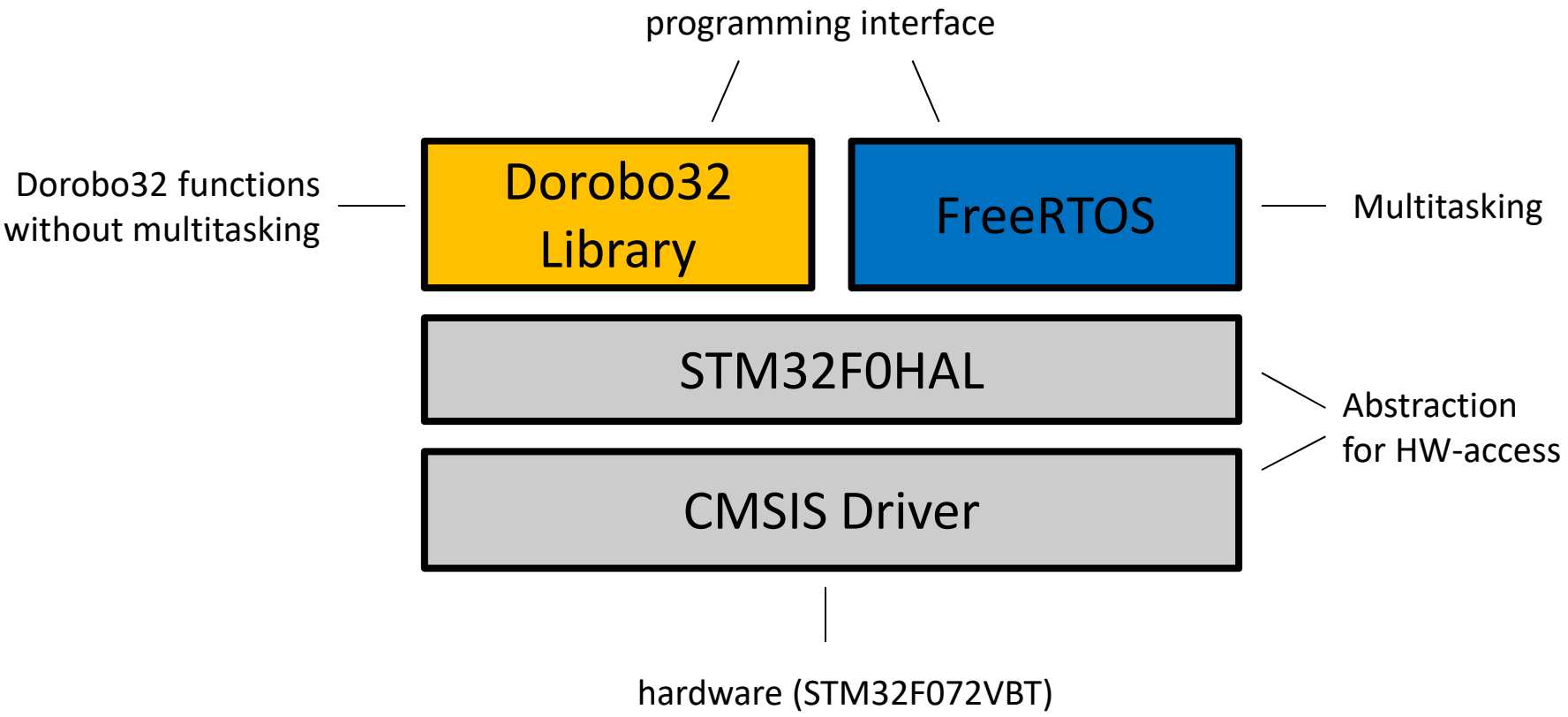
- brush motors with gearbox
- connection to motor outputs of the board
- engine control via PWM
- speed and direction controllable via software

3x 

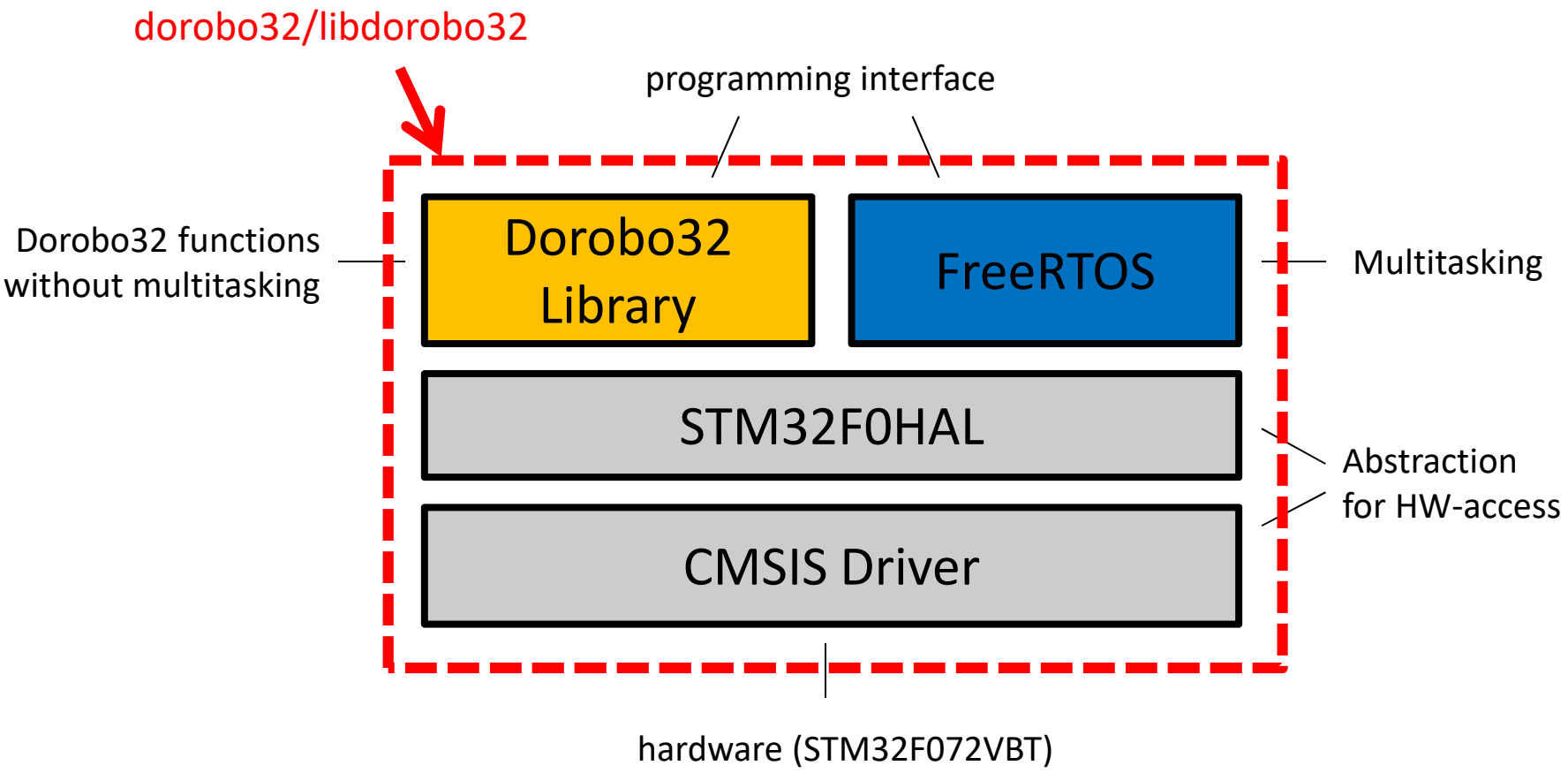
WIFI

- debugging, telemetry, telecontrol, ...
- no display available!

DoRoBo32 (software architecture)



DoRoBo32 (software architecture)



Embedded Systems Lab Project: Target Learnings

- Revisit embedded system technology:
  I/O, CPU, storage, processing etc.
- Revisit real-time processing & scheduling
- Learn how to work with sensors and sensor analysis
- Use sensor input to program the behaviour of a system
- Design an embedded system for a given task
- Implement and test an E2E system that delivers a given task

- Plan & structure your work in a team until a fixed deadline

The Schedule (Weekly steps)

- Week 1 + 2:
  - „Play“ with the sensor and actors to learn about them
  - Build the robot mechanically
- Week 2 + 3 + 4:
  - Program the robots behavior
- Week 5:
  - Presentation
  - Competition

Embedded Systems Lab – Grading

- You can earn a maximum of ***100 points*** from the Embedded Systems Lab Project
- The bonus points can be earned in four areas
  - Getting sensors to work (***30 points***)
  - Find the target (***30 points***)
  - Presentation on system concept ***(20 points***)
  - Quality of the source code (***20 points***)

You need at least 50 points to pass the course (grade 4.0)!

Embedded Systems Lab – Bonus Points

- Getting sensors to work (***30 points***):
  - For each type of sensor, you will get 10 bonus point (micro-switches, Sharp distance sensor, ir remote control sensor)
  - For the sharp sensor a calibration curve is required
  - In a short oral test with the lecturer each group must show that you are reading values from each sensor and understand the functionality

- Find the targets (***30 points***):
  - You`ve three attempts to find the target
  - For every target, found by the robot you will get 10 points
  - The start position and direction are unknown. Also the position of the obstacles are unknown
  - If the target is not found within 90 seconds the you will not get a point for the try
  - The team that reaches the target in the shortest time gets all thirty points

Embedded Systems Lab – Bonus Points

- Presentation on system concept ***(20 points***):
  - Present your solution in a short presentation of 5 minutes
  - The assessment is based on the quality of the presentation

- Quality of the source code (***20 points***):
  - The assessment is based on the quality of the source code
  - This contains e.g. the quantity of comments, coding style and usage of the programming language C

Overall Time Plan

Old Schedule

Calendar Week	Date	Special days	Course Week	Lecture and Lab Works
41	11. October 2017	n Week		
42	18. October 2017		1	Lecture - Embedded Systems Overview
43	25. October 2017			Groups A, Week 1
44	1. November 2017	Public Holiday		
45	8. November 2017			Week 2
46	15. November 2017		4	
47	22. November 2017	Block Week - No Master Lecture		
48	29. November 2017		5	ion and Race
49	6. December 2017	Travel - No Lecture		
50	13. December 2017		6	Groups B, Week 1
51	20. December 2017		7	Groups B, Week 2
52	27. December 2017	Christmas Break		
1	3. January 2018	Christmas Break		
2	10. January 2018		8	Groups B, Week 3
3	17. January 2018		9	Groups B, Week 4
4	24. January 2018		10	Groups B, Week 5, Final Presentation and Race
5	31. January 2018			

Final Time Plan

Calendar Week	Date	Special days	Course Week	Lecture and Lab Works
41	11. October 2017	Introduction Week		
42	18. October 2017		1	Lecture - Embedded Systems Overview
43	25. October 2017		2	Groups A, Week 1
44	1. November 2017	Public Holiday		
45	8. November 2017		3	Groups A, Week 3
46	15. November 2017		4	Groups A, Week 4
47	22. November 2017	Block Week - No Master Lecture		
48	29. November 2017		5	Groups A, Week 6
49	6. December 2017	Travel - No Lecture		
49	8. December	Friday!	6	Groups A, Week 8, Final Presentation and Race
50	13. December 2017		7	Groups B, Week 1
51	20. December 2017		8	Groups B, Week 2
52	27. December 2017	Christmas Break		
1	3. January 2018	Christmas Break		
2	10. January 2018		9	Groups B, Week 5
3	17. January 2018		10	Groups B, Week 6
4	24. January 2018		11	Groups B, Week 7
5	31. January 2018		12	Groups B, Week 8, Final Presentation and Race

Project Steps (1st week)

- Steps to get it to run?
  - Find fellow-worker.
  - Choose a PC, which you should always use for work in the next weeks.
  - Download the .zip file from ILIAS
  - Create a new project. Preferably use C:/Users/<User>/…
    for your project. Additional infos how to create a project you will find in project-creation-manual.pdf.
  - Connect the DoRoBo-board with the PC and flash the created project which contains a simple example.
  - Work with the sensors.
  - When you reach the targets for 'Getting sensors to work', you can start building the robot with the LEGO. Otherwise build the robot in the first half of the practicum next week.

Project Steps (2nd week)

- Finish the work with the sensors from last week
- Finish the build of the robot
- Present the result of the work with the sensors to the tutor
- Start with the development of the robots behavior

Project Steps (3rd and 4th week)

- Finish the development of the robots behavior
- Test and optimize the behavior of your robot

Project Steps (5th week)

Brief Project Presentation (max 5 minutes) covering

- Your robot behaviour concept to reach the target
- Your system design
- Your system implementation

Final Robot Race: Find the target

- You`ve three attempts to find the target
- For every target, found by the robot you will get 10 points
- The start position and direction are unknown. Also the position of the obstacles are unknown
- If the target is not found within 90 seconds the you will not get a bonus point for the try
- The team that reaches the target in the shortest time gets all three bonus points

→ **Please upload your presentation and your project code in ILIAS latest on the day of the robot race (Ilias… Embedded Systems Lab Project / Results GroupsA/B…)!**

Important Remarks

- You can work in the Embedded Systems lab any time
  - When it is open
  - When there is no other class
- Always work at the same lab PC!
- Do backups of your work (at least) after every session!
- Caution with Motor Control:
  Write functions to control the motors, which limit the acceleration so that a changeover from "full force ahead" to "full force back" takes at least 0.5 s. The deceleration to zero may be instantaneous, then increase the speed linearly (moderate slope).
- Make sure that the DoRoBo board is not damaged (always fix to rack etc.)
- Always hand in your robot batteries to get charged! Otherwise sensor behavior different!
- Make sure that the reset-button is accessible!
- Always report damages of sensors, boards, actuators to the lab staff!

Good luck and a successful competition!