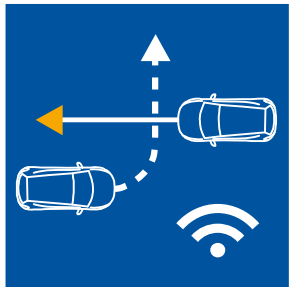


EECI-IGSC Course

Networked Model Predictive Control for Multi-Vehicle Decision-Making

Dr.-Ing. Bassam Alrifaee | Patrick Scheffe, M. Sc.

2021

Part 1

Introduction

Your instructors

Bassam Alrifaee
alrifaee@embedded.rwth-aachen.de
Lectures

Patrick Scheffe
scheffe@embedded.rwth-aachen.de
Lab, Organization

RWTH Aachen University

RWTH Aachen University

- Founded 1870
- Largest technical university in Germany
- 45.000 students, 6.500 graduates per year
- >20% international students, from 128 countries
- 9500 staff, 540 professors
- 900 million € expenditure
- >400 million € third party funding (biggest amount in Germany, in total and per professor)
- Highest number of alumni as CEOs in DAX companies

RWTH Aachen University

Nine schools (”Fakultäten”):

1 **Natural Sciences, Computer Science, and Mathematics**

2 Architecture

3 Civil Engineering

4 Mechanical Engineering

5 Mining and Materials

6 Electrical Engineering

7 Philosophy

8 Economics

10 Medicine

RWTH Aachen University

1 Natural Sciences, Computer Science, and Mathematics

- Biology
- Chemistry
- **Computer Science**
  - ~ 3500 students
  - > 450 graduates
  - ~ 30 Professors
- Mathematics
- Physics

4 Mechanical Engineering

- ~ 10.000 students
- ~ 2.000 graduates, 200 PhDs in 2014
- ~ 60 Professors

Computer Science

Computer Science

1 Algorithms
2 Software Theory
3 Software Engineering
4 Distributed Systems
5 Information Systems
6 Speech Recognition
7 Logics and Automata
8 Computer Graphics
9 Data Mining
10 Human Computer Interaction
11 Embedded Software
12 High Performance Computing
13 Computer Vision

Informatik 11 - Embedded Software (i11)

https://embedded.rwth-aachen.de

Informatik 11 - Embedded Software (i11)

- Head: Prof. Stefan Kowalewski (since 2003)
- Ca. 20 researchers, 4 non-academic employees, 5 apprentices
- > 1.600 students per year in our courses
- Ca. 40 graduates per year (15 Bachelor and 25 Master)
- 3 spin-off companies in the last five years

Informatik 11 - Embedded Software (i11)

Biomedical Systems (5 researchers)

- Head: Dr. André Stollenwerk
- Supervision of medical devices
- Data analysis

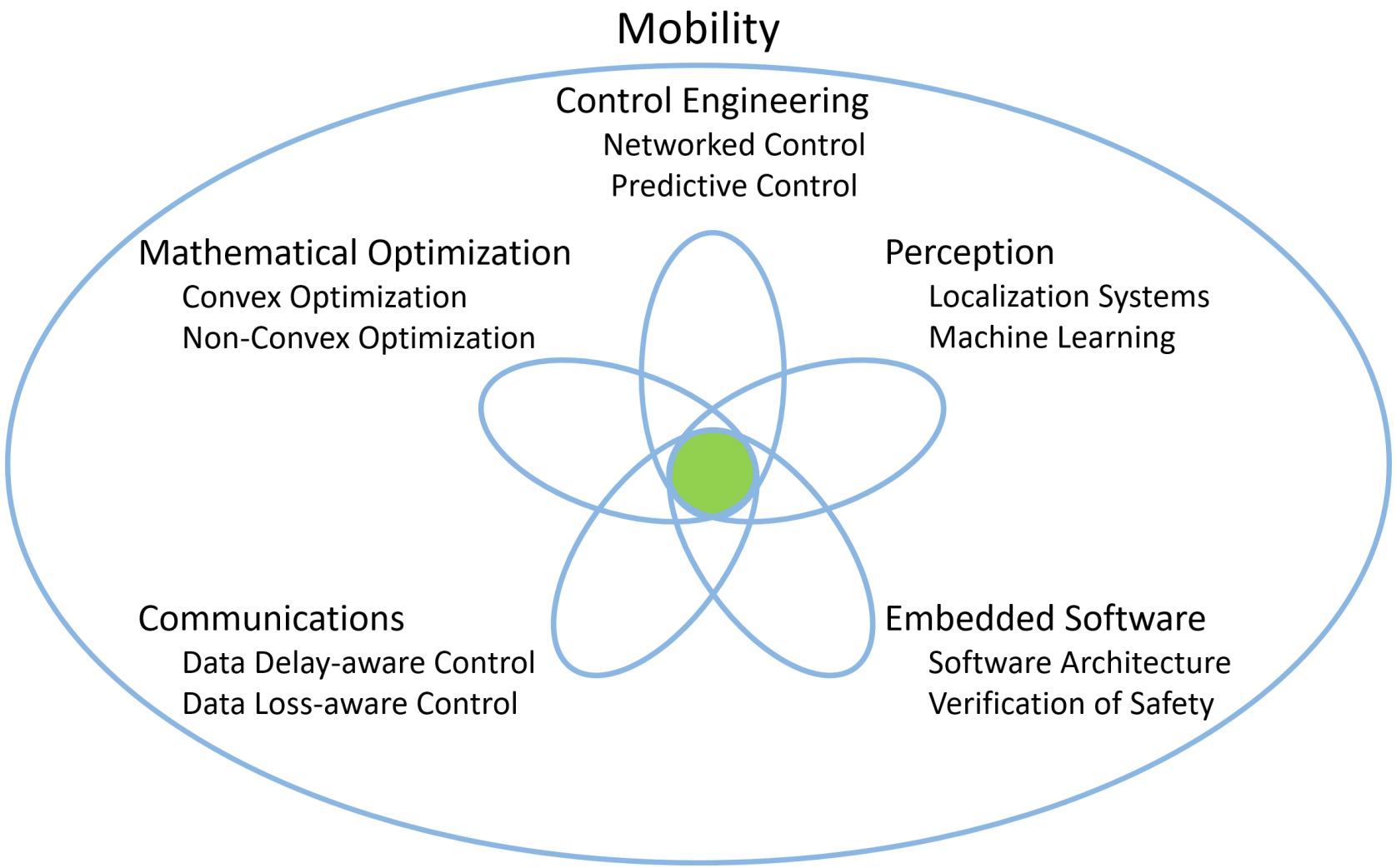
Cyber-Physical Mobility (7 researchers)

- Head: Dr. Bassam Alrifaee
- Networked control systems
- Service-oriented architectures

Formal Methods (4 researchers)

- Head: Marcus Völker, M. Sc.
- Verification of CPS
- Application: industry automation

Profile of Cyber-Physical Mobility Group



Members of Cyber-Physical Mobility Group

Dr. B. Alrifaee
Head of Group

A. Kampmann
M.Sc.

M. Kloock
M.Sc.

A. Mokhtarian
M.Sc.

P. Scheffe
M.Sc.

B. Schraml
M.Sc.

S. Rakel
M.Sc.

- 23 Master's and Bachelor's students
- 6 students in Team GalaXIs (our student team participating at Carolo-Cup)

Participants

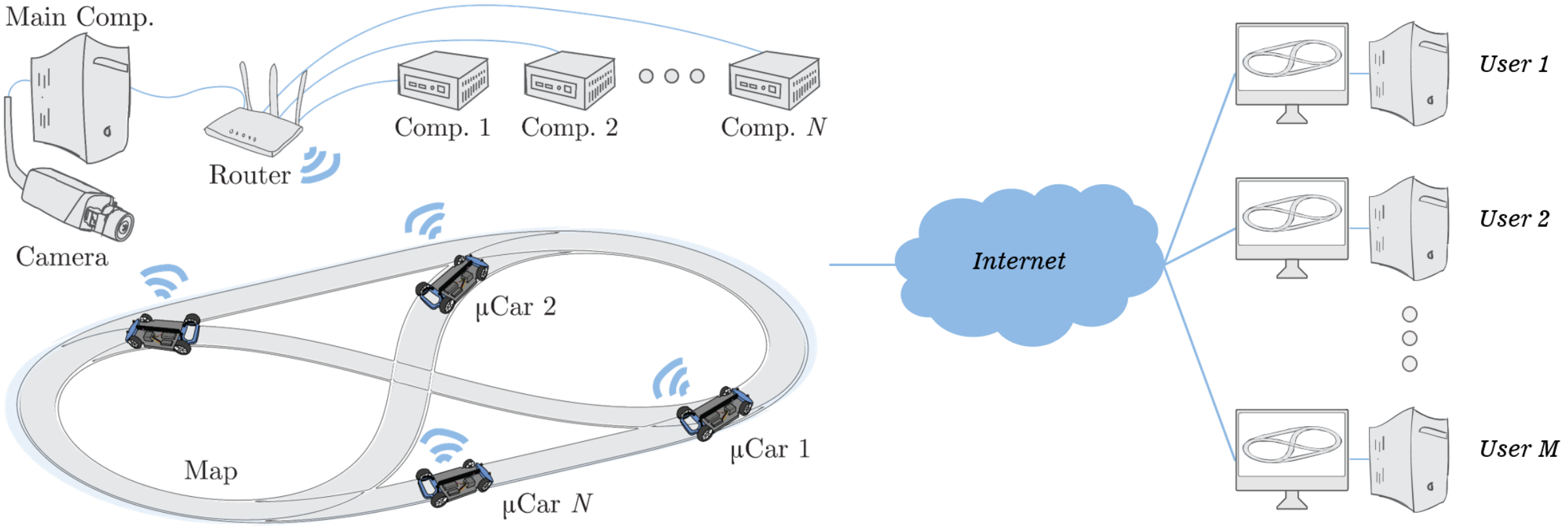
Participants

Shortly introduce yourself, e. g., with your …

- Name
- Topic
- Progress
- Motivation/Expectation

CPM Lab Visit

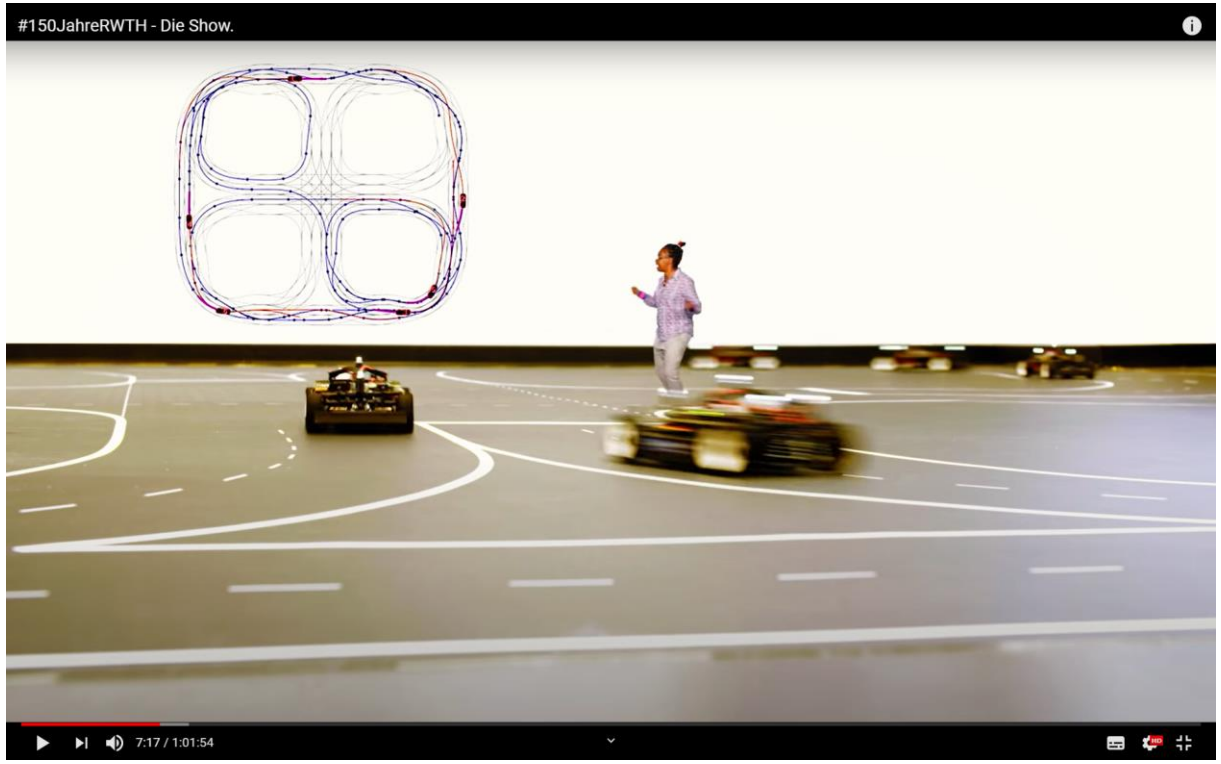
CPM Lab virtual visit



https://cpm.embedded.rwth-aachen.de/

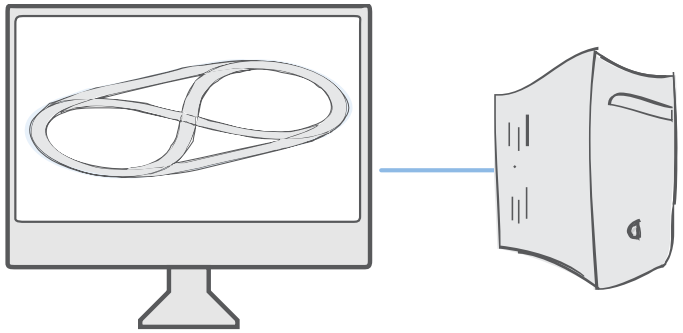
Movie of 150 years of RWTH

- https://youtu.be/RBuqHPCQPGo?t=428

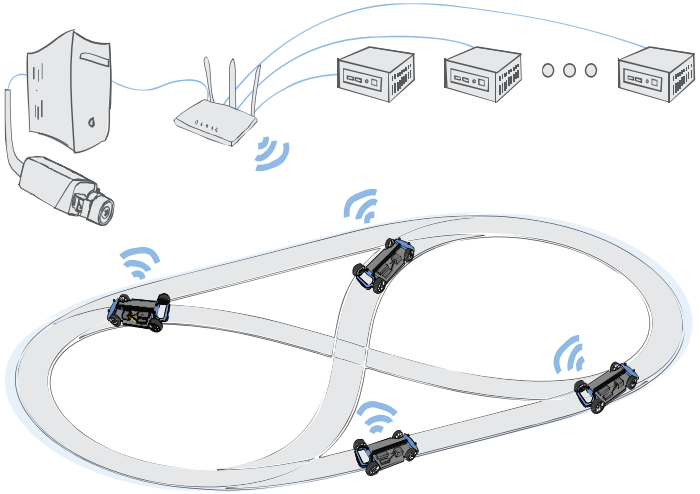


CPM Lab motivation

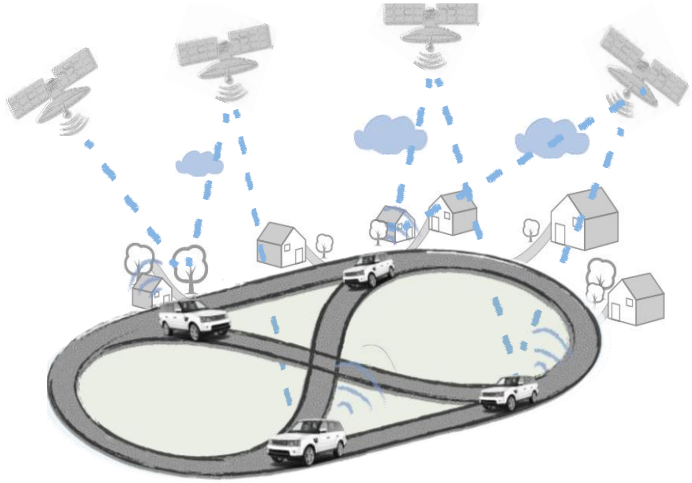
Lab-Vision: See your ideas develop into reality!



Simulation
Test your ideas in a simulation environment



CPM Lab
See your ideas work in a model-scale testing platform



Real World
Apply your ideas to real world scenarios

https://cpm.embedded.rwth-aachen.de

CPM Lab main features

Open source, remotely accessible platform

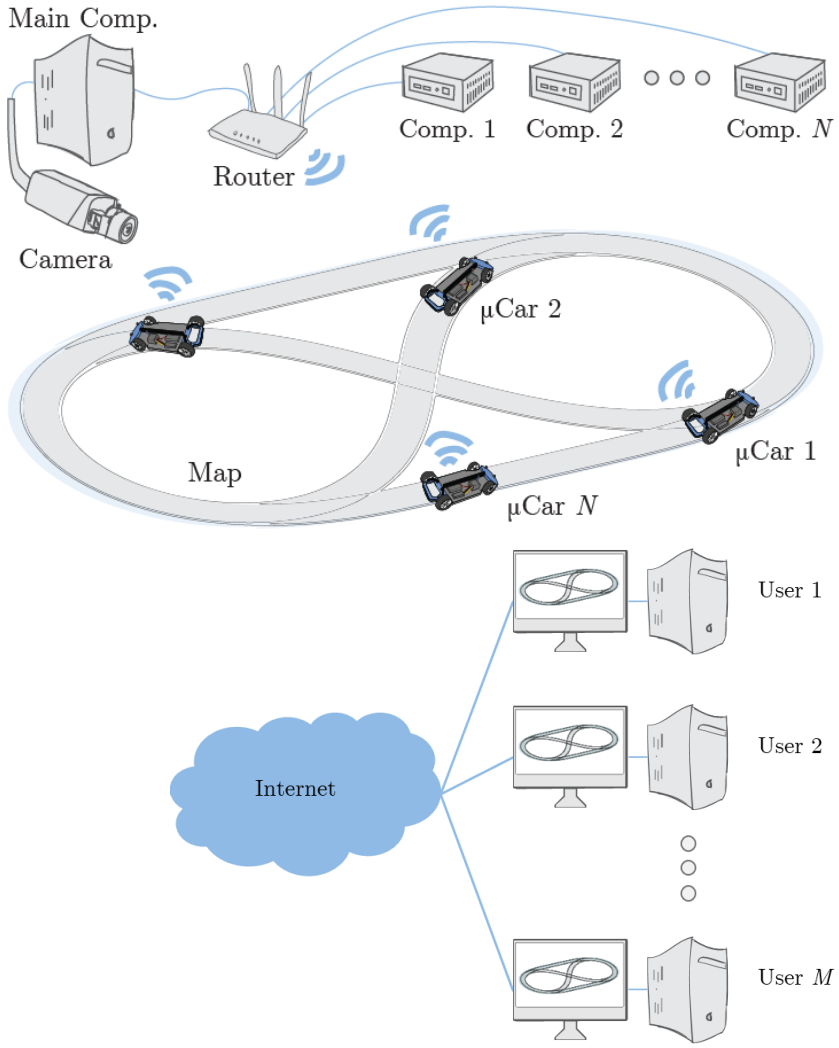
- Open code, plans, and documentation
- Remote access via web

Rapid algorithm prototyping

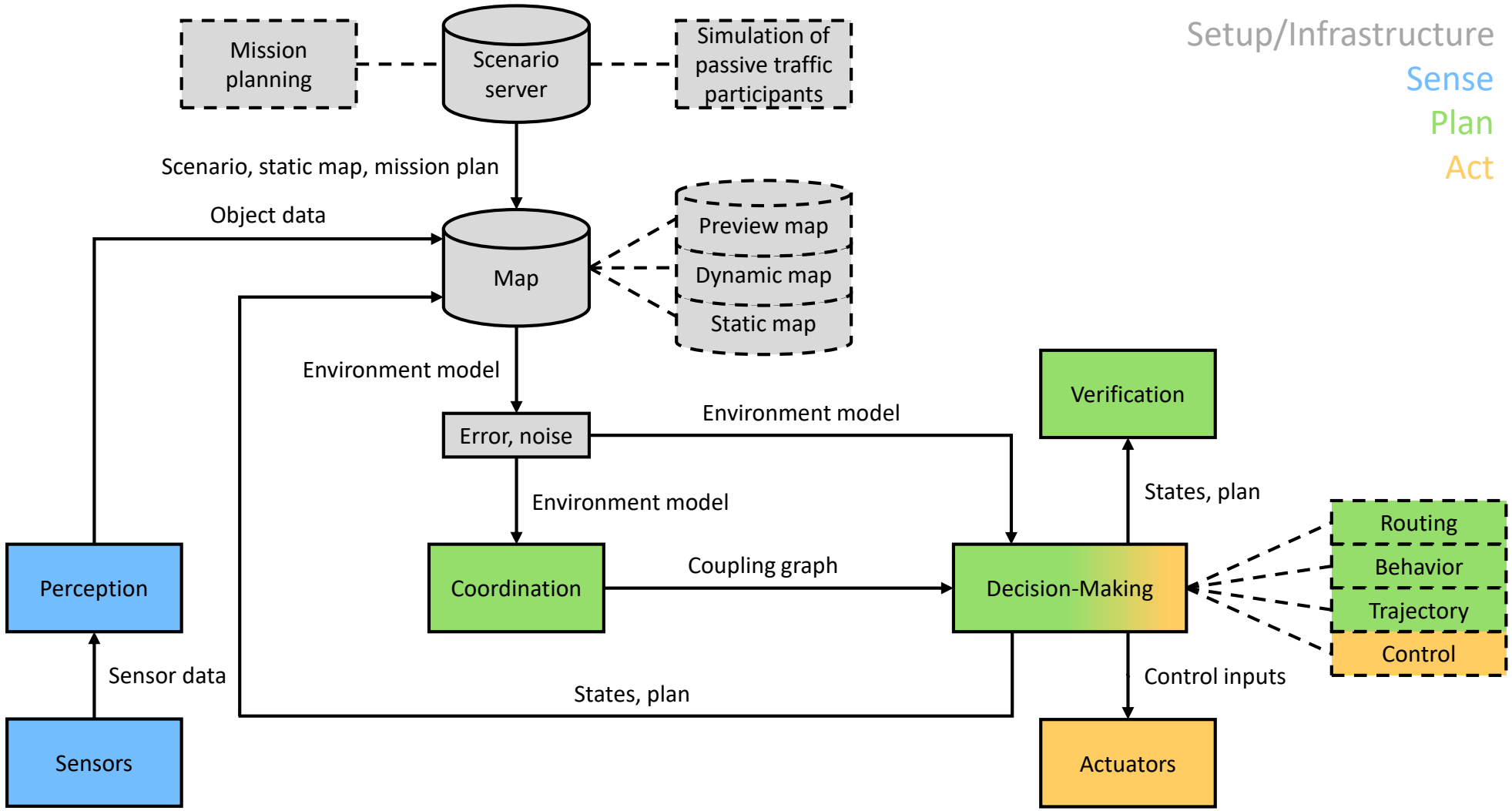
- 20 networked model-scale vehicles (µCars)
- Centralized and distributed computations

Hierarchical service-oriented architecture

- High- for complex computations, mid- and low-level
- Middleware for data exchange and synchronization



CPM Lab architecture



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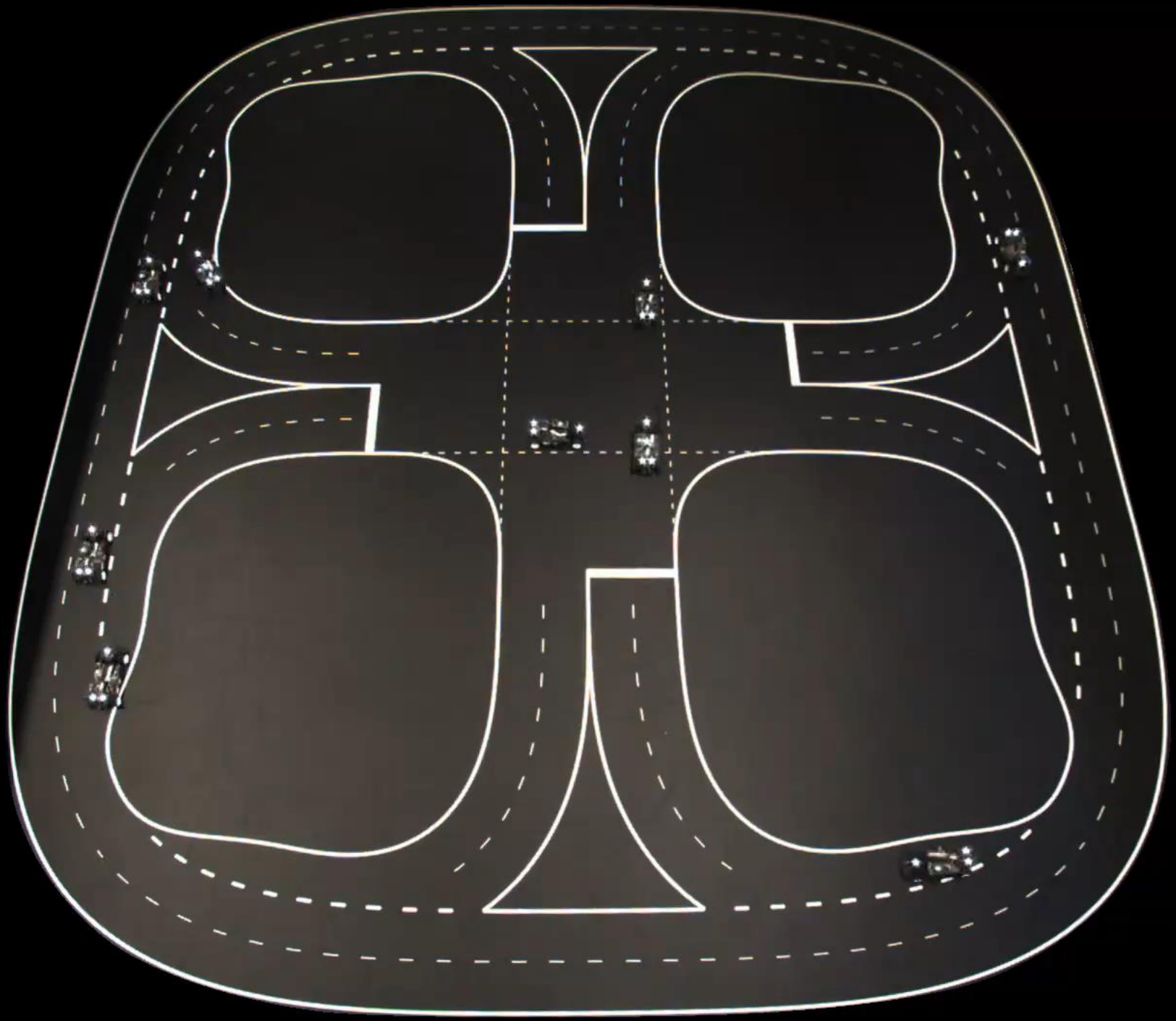
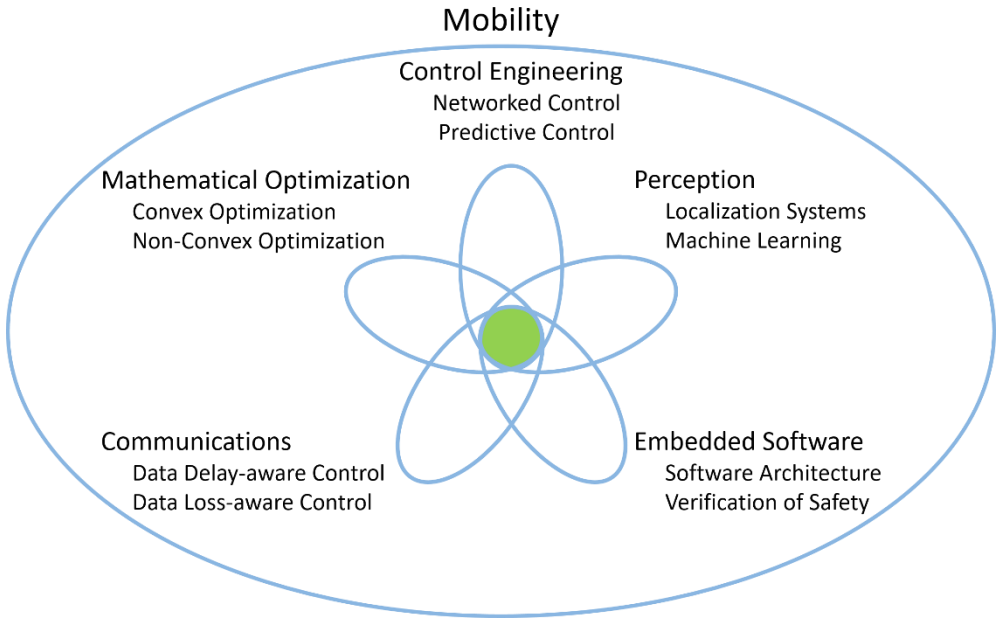


Course Logistics

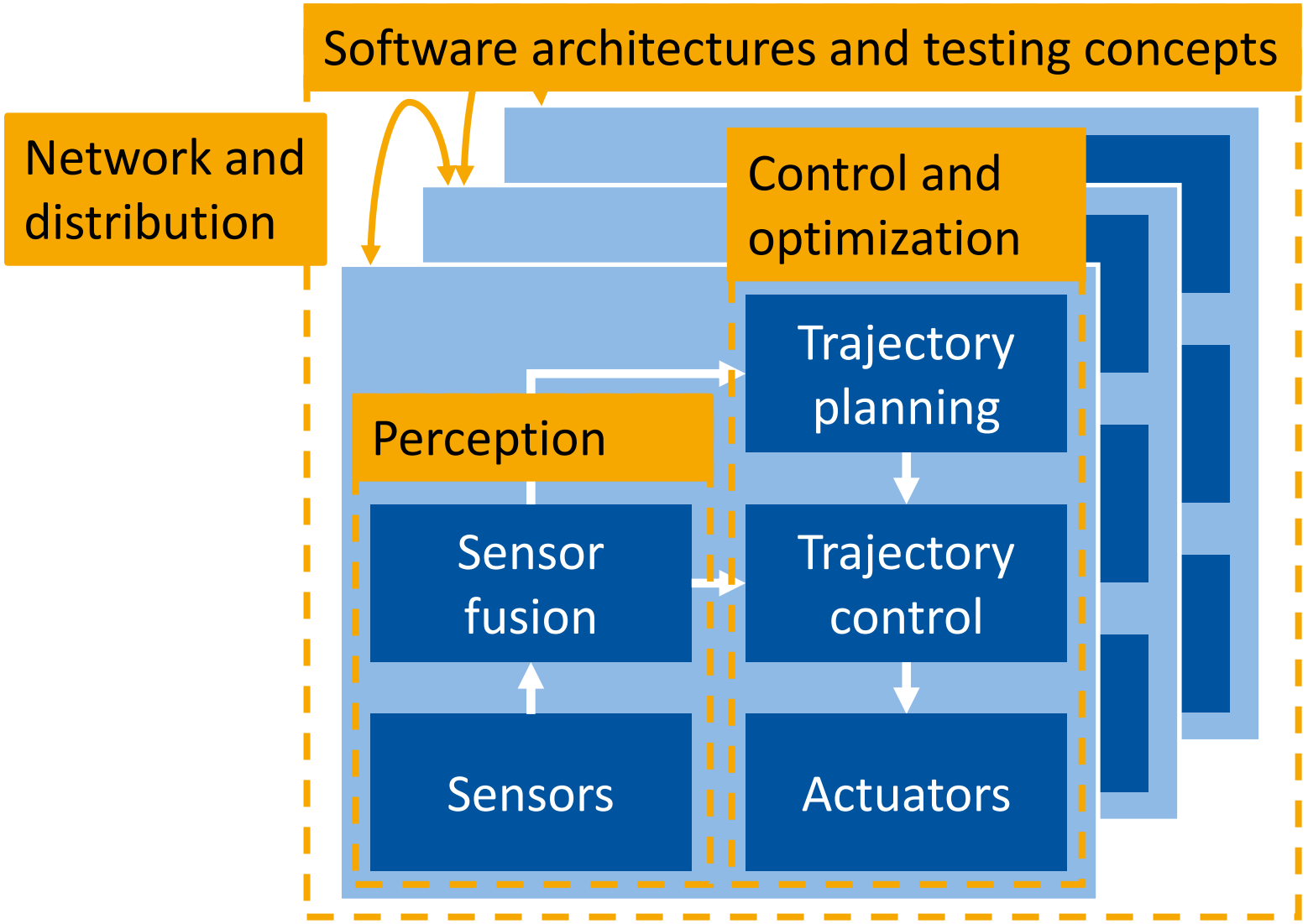
Course contents

- Vehicle models
- Control and optimization
- Network and distribution
- Software architectures and testing concepts



- Course materials will be posted on Sciebo
- Lab will allow you to apply techniques on real model-scale vehicles

Lab – apply techniques from lectures



Logistics

- Lecture style
  - Presentation
  - Group discussions
- Participation
  - Attendance list
- Prize for lab work
  - Donation of 15€ per working solution for a good cause
  - Invitation of best solution for a week
- Diagnostic test results

Schedule

EECI IGSC 2021 Online				Module M05	
15.03.2021-19.03.2021			Bassam Alrifaee & Patrick Scheffe		
UTC+01:00	Monday	Tuesday	Wednesday	Thursday	Friday
09:00-9:30	Introduction	Control	Network	Lab: DMPC	Control
9:30-10:00					
10:00-10:30	Models				
10:30-11:00	Break	Break	Break	Break	Break
11:00-11:30	Models	Lab: Basics	Lab: CMPC	Lab: DMPC	Presentation
11:30-12:00					
12:00-12:30					Wrap-up
12:30-13:00	Break	Break	Lab: Team Work	Lab: Team Work	Assessment
13:00-13:30					Certificates
13:30-14:00					
14:00-14:30	Architectures	Network			
14:30-15:00					
15:00-15:30					
15:30-16:00	Break	Break			
16:00-16:30	Lab: Basics	Lab: CMPC			
16:30-17:00					
17:00-17:30					
19:00-21:00			Social Event		

Lecture CPM Lab

Some Terms

Levels of automation

- SAE J3016 from Society of Automotive Engineers (SAE)
  - Level 0
  - Level 1 ("hands on")
  - Level 2 ("hands off")
  - Level 3 ("eyes off")
  - Level 4 ("mind off")
  - Level 5 ("steering wheel optional")
- US National Highway Traffic Safety Administration (NHTSA)
- German Federal Highway Research Institute (BASt)

Definition of networked vehicles

- Also called connected
- Vehicle-to-X communications
- Consists of interacting vehicles
- Contribution to better
  - Perception
  - Decision-making
- Many challenges arising from computation time and communications
  - Feasibility
  - Quality

Next Part

Vehicle models

- Longitudinal models
- Lateral models