Universität Rostock

Traditio et Innovatio

Realtime Publish/Subscribe for Cyber-Physical Systems

KSWS AVA / Projekt AVA / NEidI VHR

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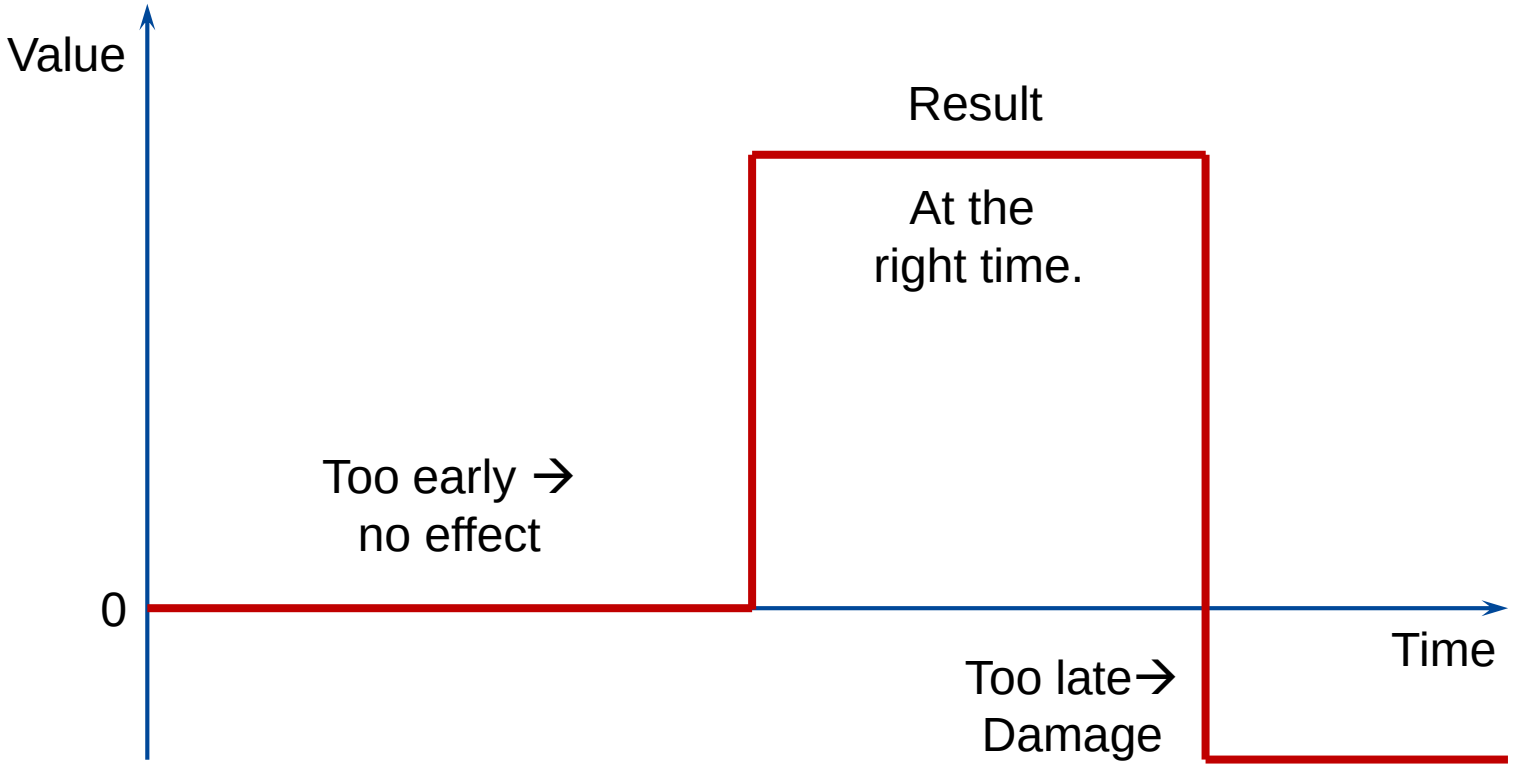
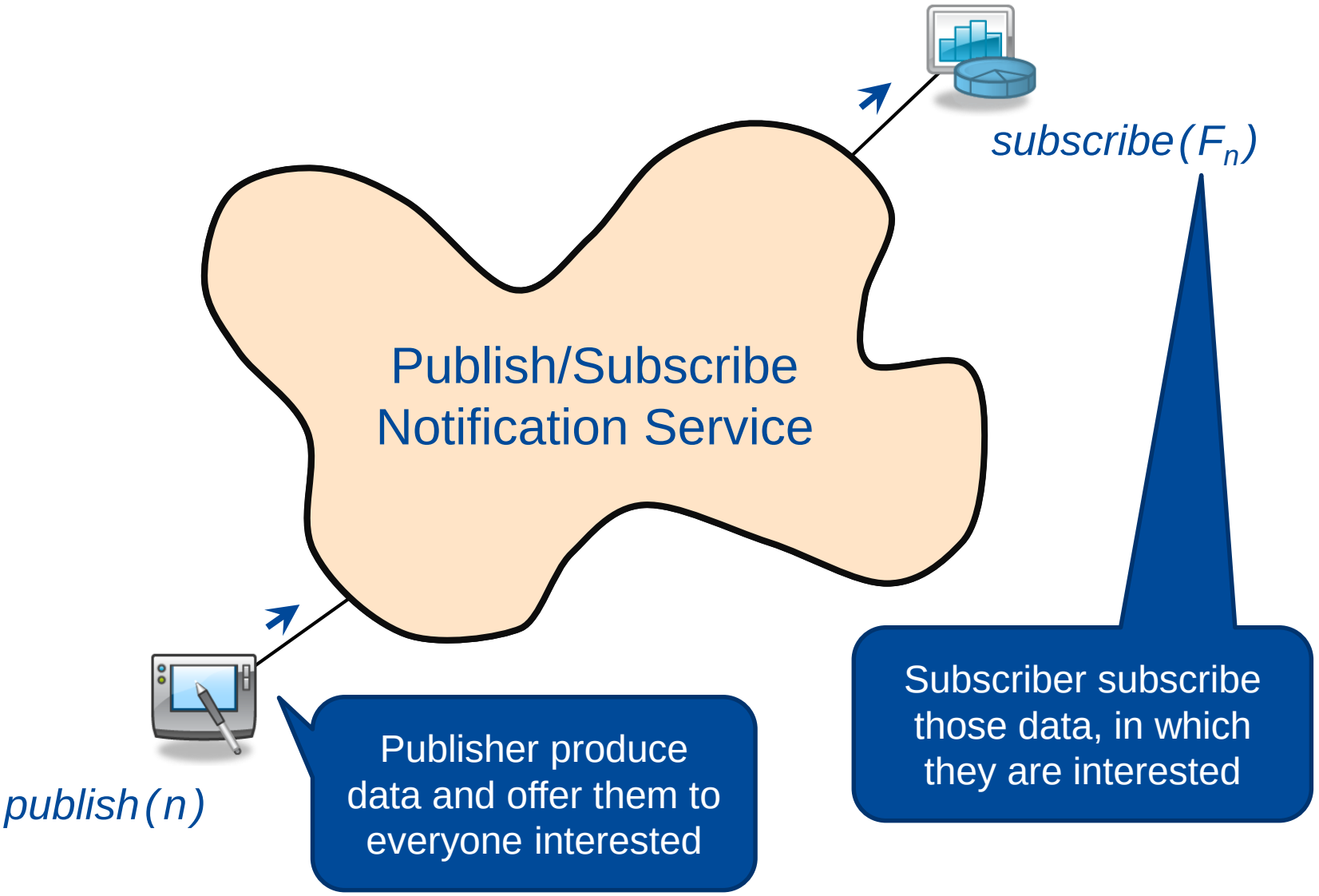
What is Realtime (Echtzeit)?

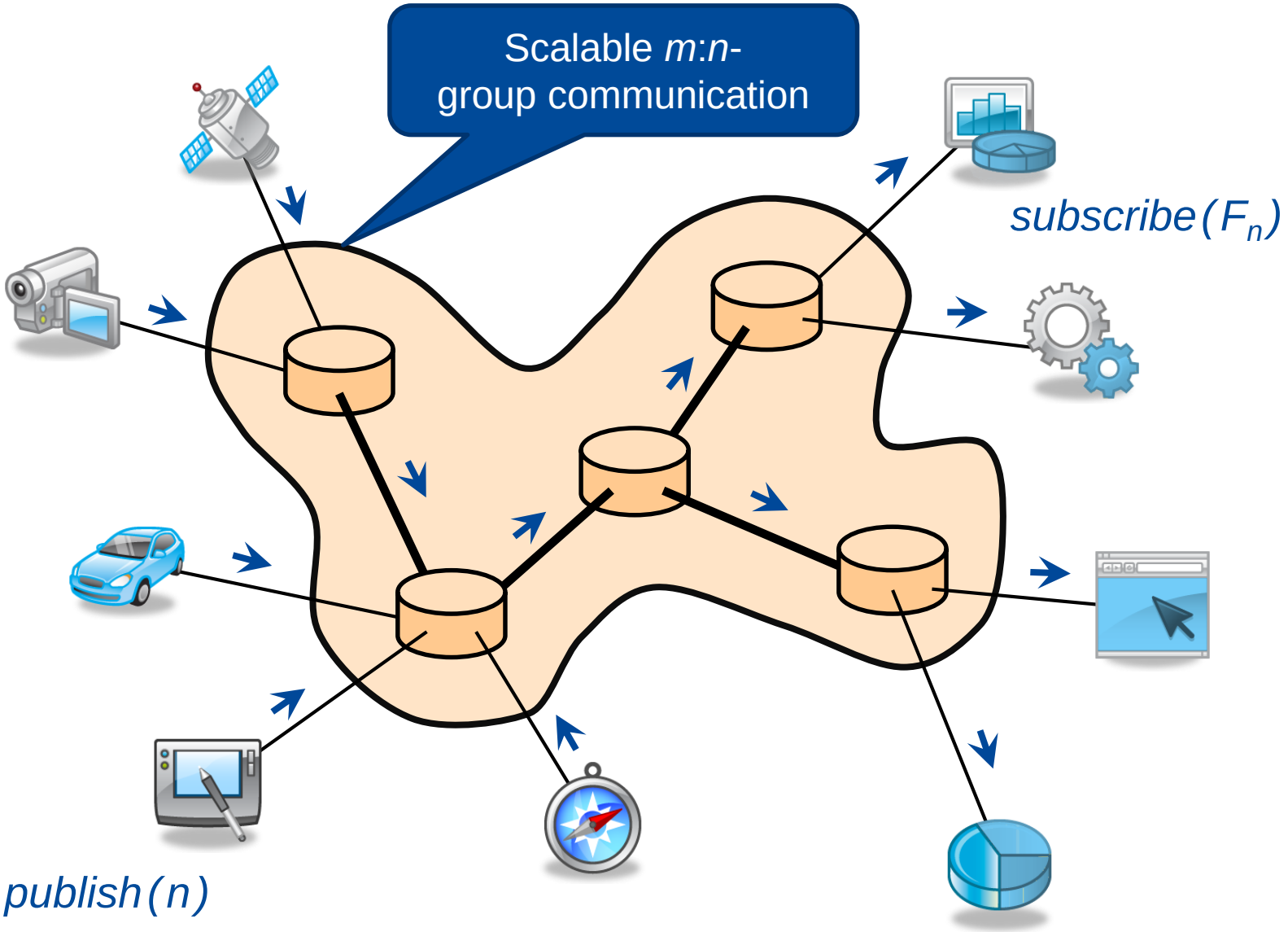


Not neccessarily fast, but predictable!

→ Do the right thing at the right time.

What is Publish/Subscribe?




Scalable m:n-
group communication
subscribe(F_n)
publish(n)

What are Cyber-Physical Systems?

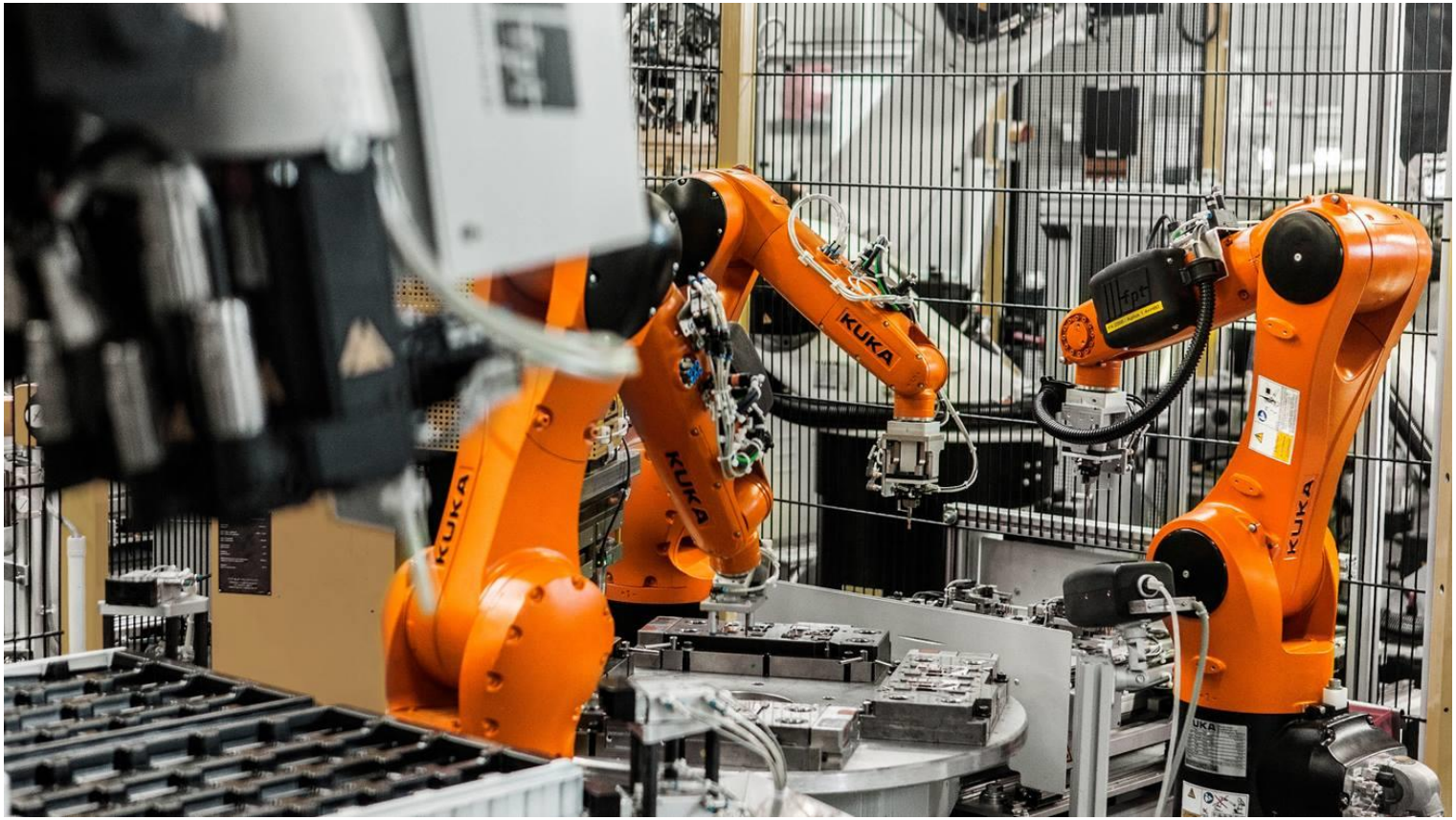
- Systems containing software components and mechanical or electronic parts that are interconnected via network
- Interact with the real, physical world
  → are subject to physical laws
  → have requirements w.r.t (real) time
- Examples
  - Industry robots
    - Production line in the smart factory
    - Reconfigurable production cell of a smart factory
  - Modern (autonomous) vehicles
    - Steer/fly by wire
    - Autopilots of any kind

Industry Robots in a Smart Factory

Industry robots made by Kuka

Time-critical communication when handing over work pieces.

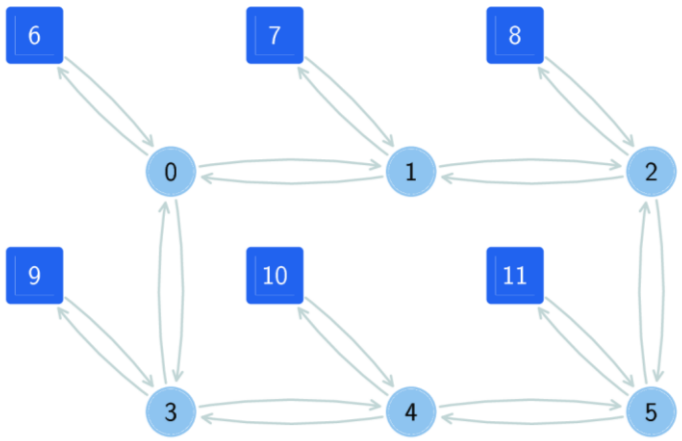
Reconfigurable Production Cell

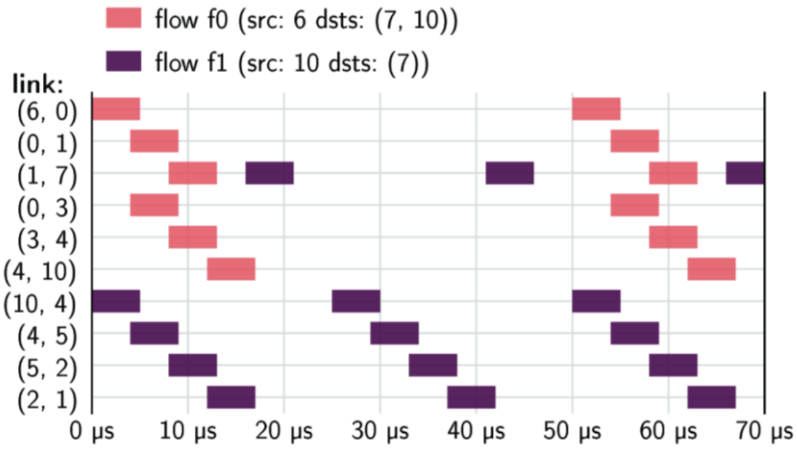


Industry robots made by Kuka

Flexible communication in case of task changes.

Communication Schedule





- Streams
  - From node 6 to nodes 7 and 10 (multicast)
  - From node 10 to node 7
- Schedule
  - Determines exactly when which packet is sent over which link
  - Has to be always without conflicts → provable correct
  - Needs to be adapted whenever communication pattern changes
  - Additional traffic of lesser importance is possible

Projects and Collaborations

- Realtime publish/subscribe communication
  - Part of a DFG project (VHR, AVA und IMD)
  - Planning of flexible communication patterns and reservation of required time slots on communication links
  - Formal models and methods for scheduling
  - Estimation of the worst case runtime for publishing and filtering (content-based if necessary) a notification
  - Application scenario within a smart factory
- Autonomous Underwater Vehicles (AUVs)
  - Cooperation with the Institute for the Protection of Maritime Infrastructures, Resilience Department of Maritime Systems, German Aerospace Center (DLR) Bremerhaven

Tasks: Realtime Publish/Subscribe

- Data models and filter models
  - Design of suitable data models
  - Design of corresponding filter models
  - Prototypical implementation (probably) in C
- Realtime properties
  - Estimation of Worst Case Execution Time (WCET)
  - Scalability analysis (#Filter, #Daten, #Subscriber)
  - Test/measurement of implementation
- Development and test platform for prototyping
  - Scripts for configuring TSN switches
  - Traffic generators for test traffic
  - Management platform/tools of any kind

Tasks: Realtime Communication Schedule

- Integer Linear Programming (ILP) model
  - Familiarize with formal modeling of optimization problems
  - Familiarize with programming an ILP solver (→ Python)
- Porting existing ILP model from Gurobi to CPLEX and PuLP
  - Document the steps for porting models
  - Evaluation of model complexity and solver runtime
- ILP models for flow migration
  - Development of new models to reschedule a part of an existing schedule
  - Migration of flows/streams to different time slots and/or different paths

Optional: Autonomous Underwater Vehicles

- Cooperative navigation of several AUVs
  - Battery capacity limits motion and sensors
  - Opportunistic communication via acoustic modems
- Limited number of advanced tasks available
  - Implementations using Simulator OMNeT++ and C++
  - Improving motion models and 3D visualization
  - Simulation of sensors (energy consumption, coupling with other systems)
  - Modelling/simulation of underwater media and communication

Organizational Matters

- Up to three teams
  - Team A: Realtime publish/subscribe
  - Team B: Realtime Communication Schedule
  - Optional team C: Autonomous Underwater Vehicles (AUVs)

- Design methodology
  - Agile development
  - Three milestones w.r.t. design, implementation, documentation

Type and size/scale of tasks depends on number and interests of participants!

Registration and Contact

- Enrolement in respective Stud.IP course

1. 23846 (Vorlesung) KSWS: AVA
2. 23848 (Vorlesung) Neueste Entwicklungen der Informatik (Verteiltes Hochleistungsrechnen
3. 23847 (Projekt) Projekt: AVA

- Questions via email to Peter Danielis and Helge Parzyjegla
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  - helge.parzyjegla@uni-rostock.de