Universität Rostock

Traditio et Innovatio

Realtime Publish/Subscribe for Cyber-Physical Systems

KSWS / Projekt / NEidI / Projekt CSI

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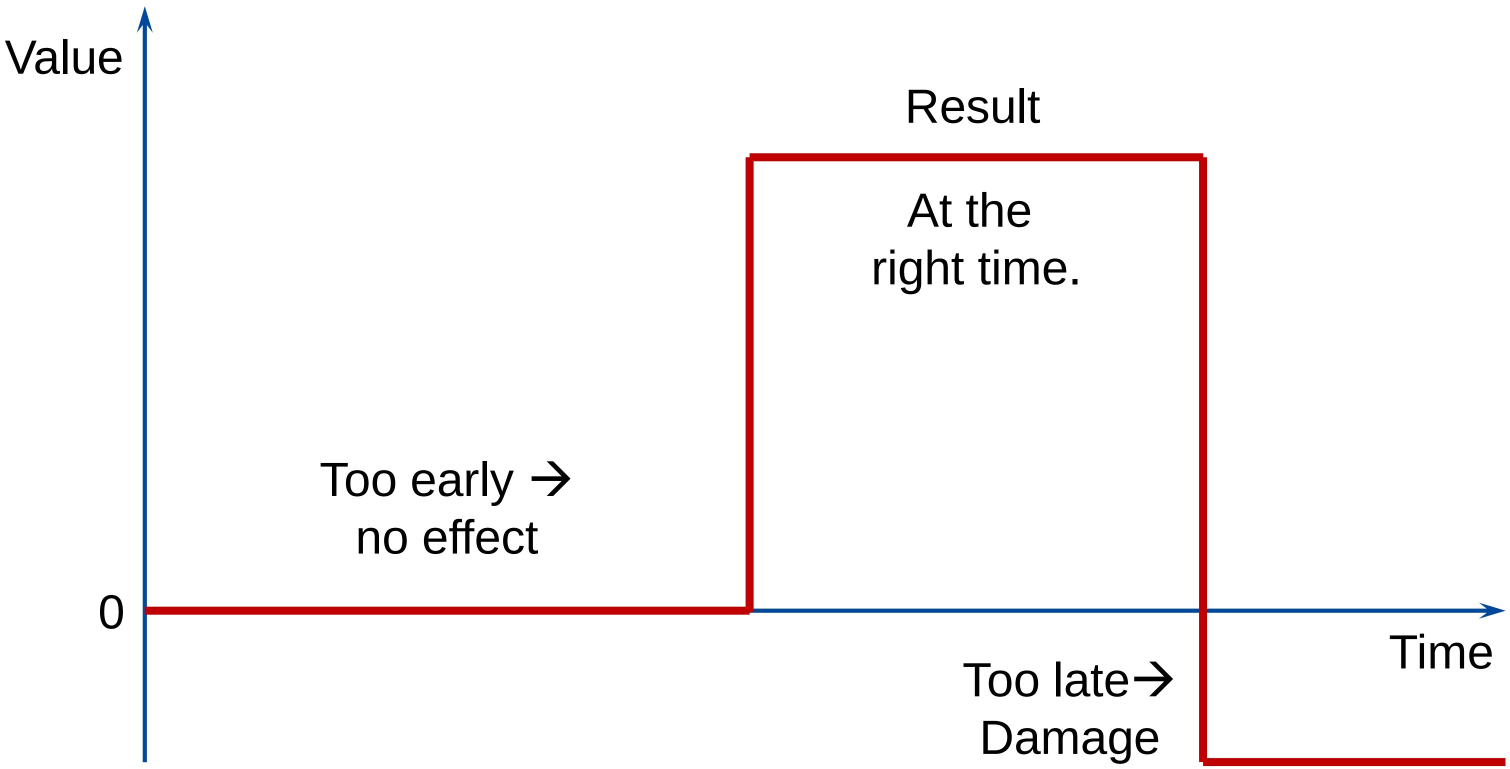
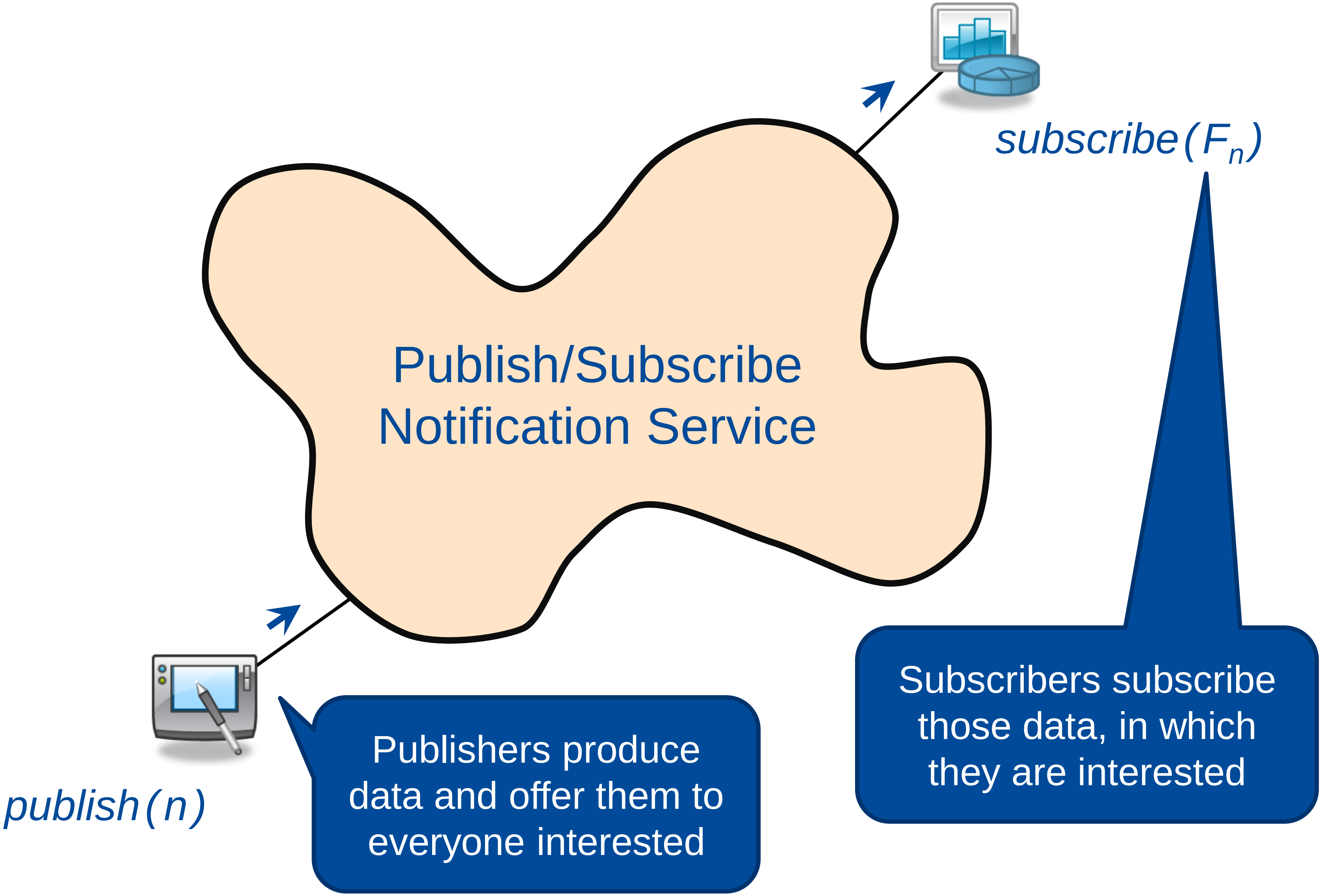
What is Realtime (Echtzeit)?



Not neccessarily fast, but predictable!

→ Do the right thing at the right time.

What is Publish/Subscribe?



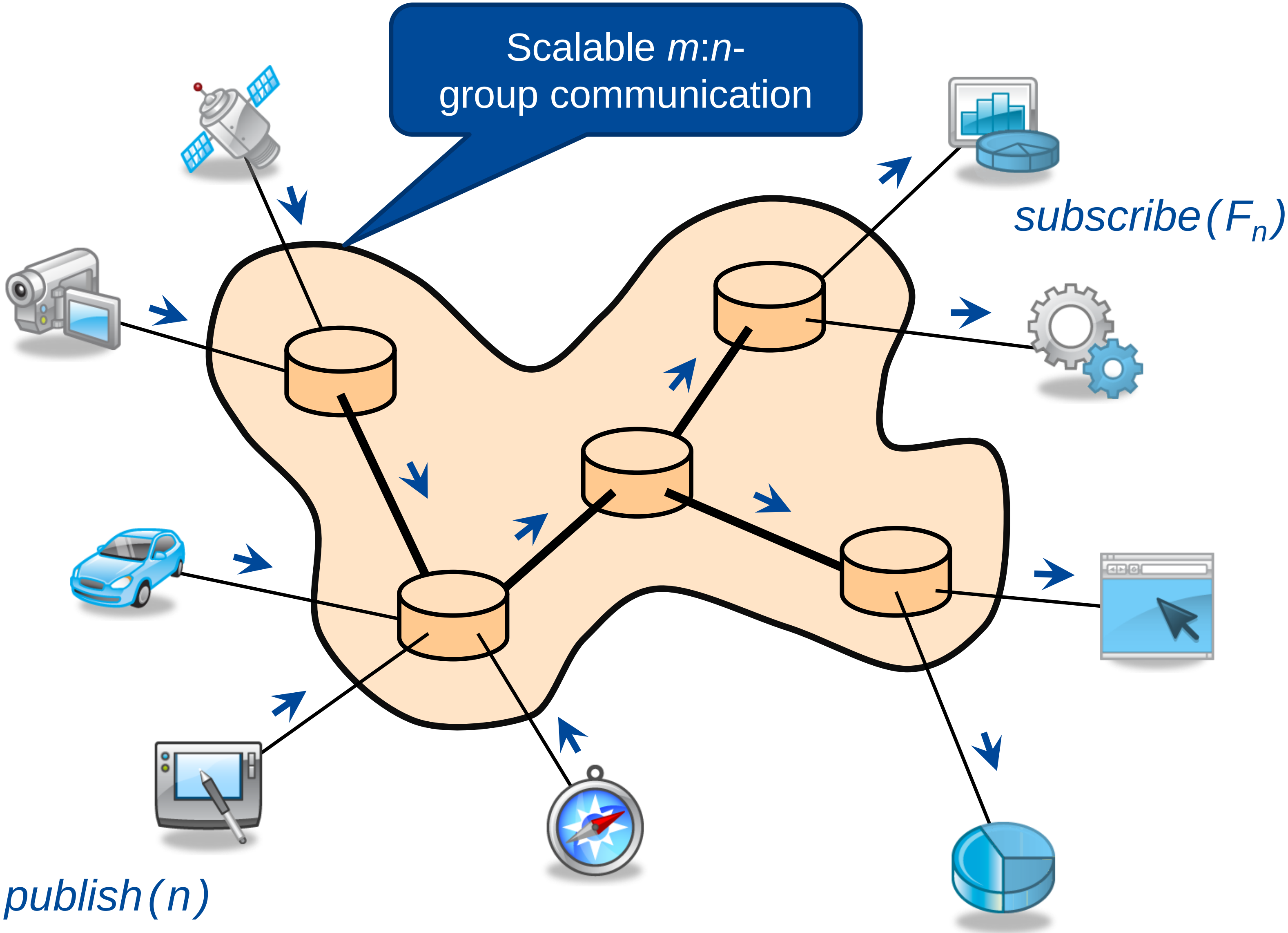
Publish/Subscribe Notification Service

subscribe(F_n)

publish(n)

Publishers produce data and offer them to everyone interested

Subscribers subscribe those data, in which they are interested



Scalable *m*:*n*-group communication

subscribe(F_n)

publish(n)

What are Cyber-Physical Systems?

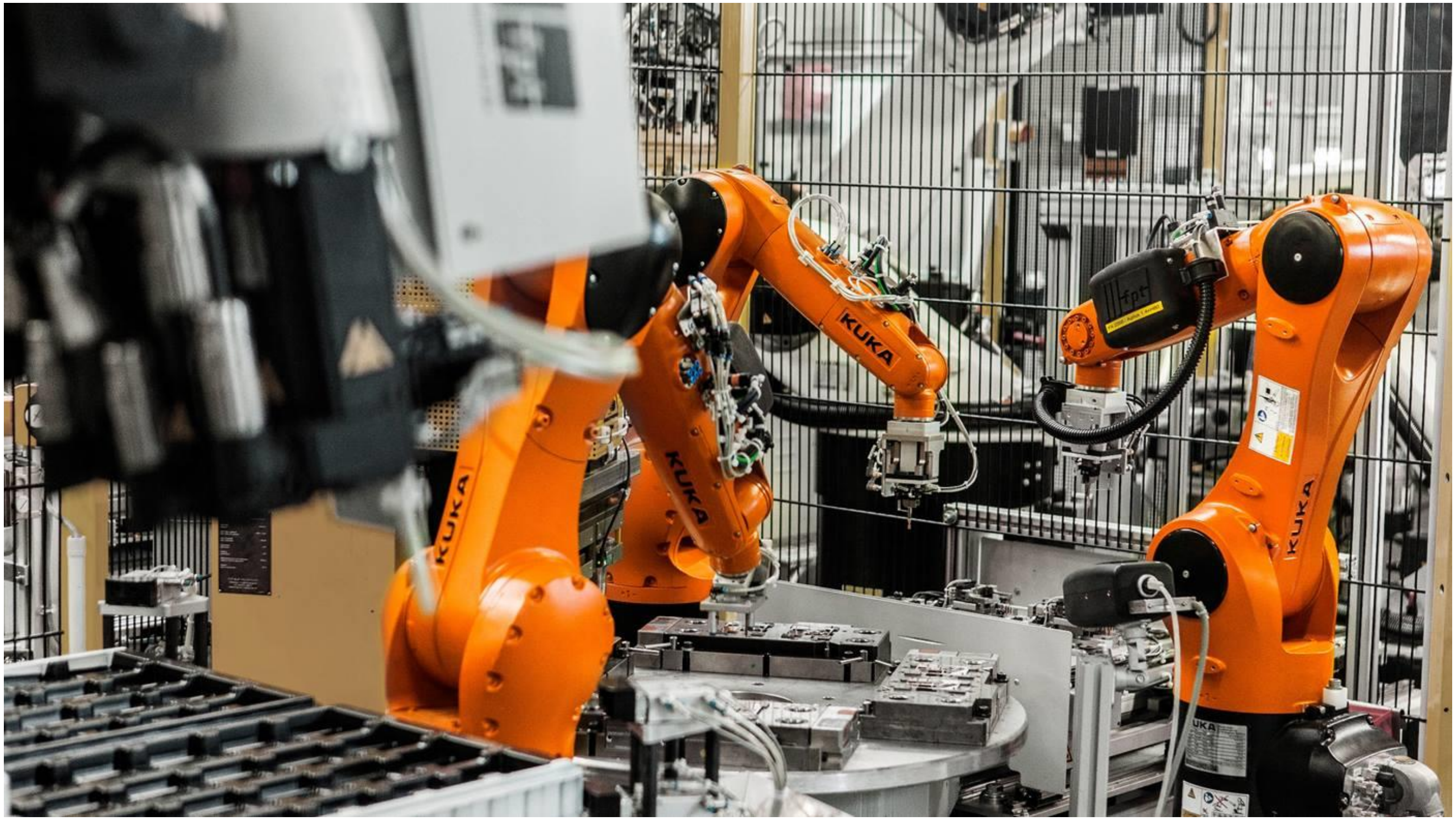
- Systems containing software components and mechanical or electronic parts that are interconnected via network
- Interact with the real, physical world
  → are subject to physical laws
  → have requirements w.r.t (real) time
- Examples
  - Industry robots
    - Production line in the smart factory
    - 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.

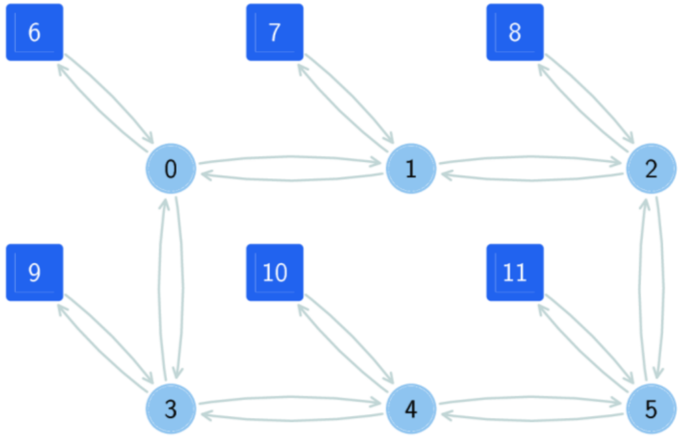
Reconfigurable Production Cell

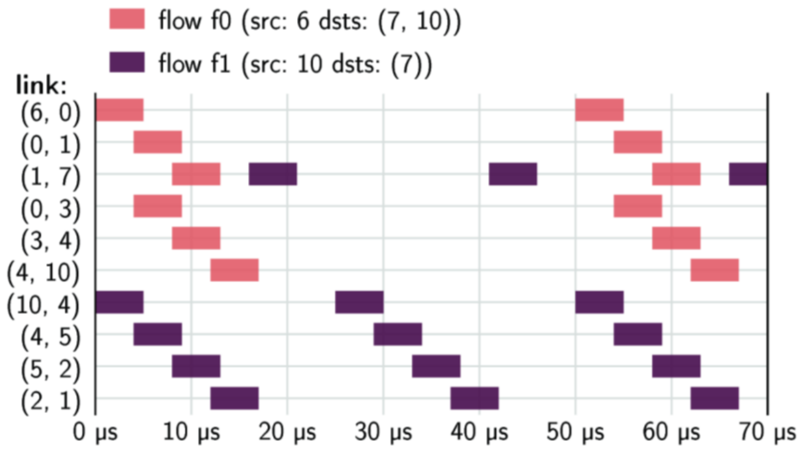


Industry robots made by Kuka

Flexible communication in case of task changes.

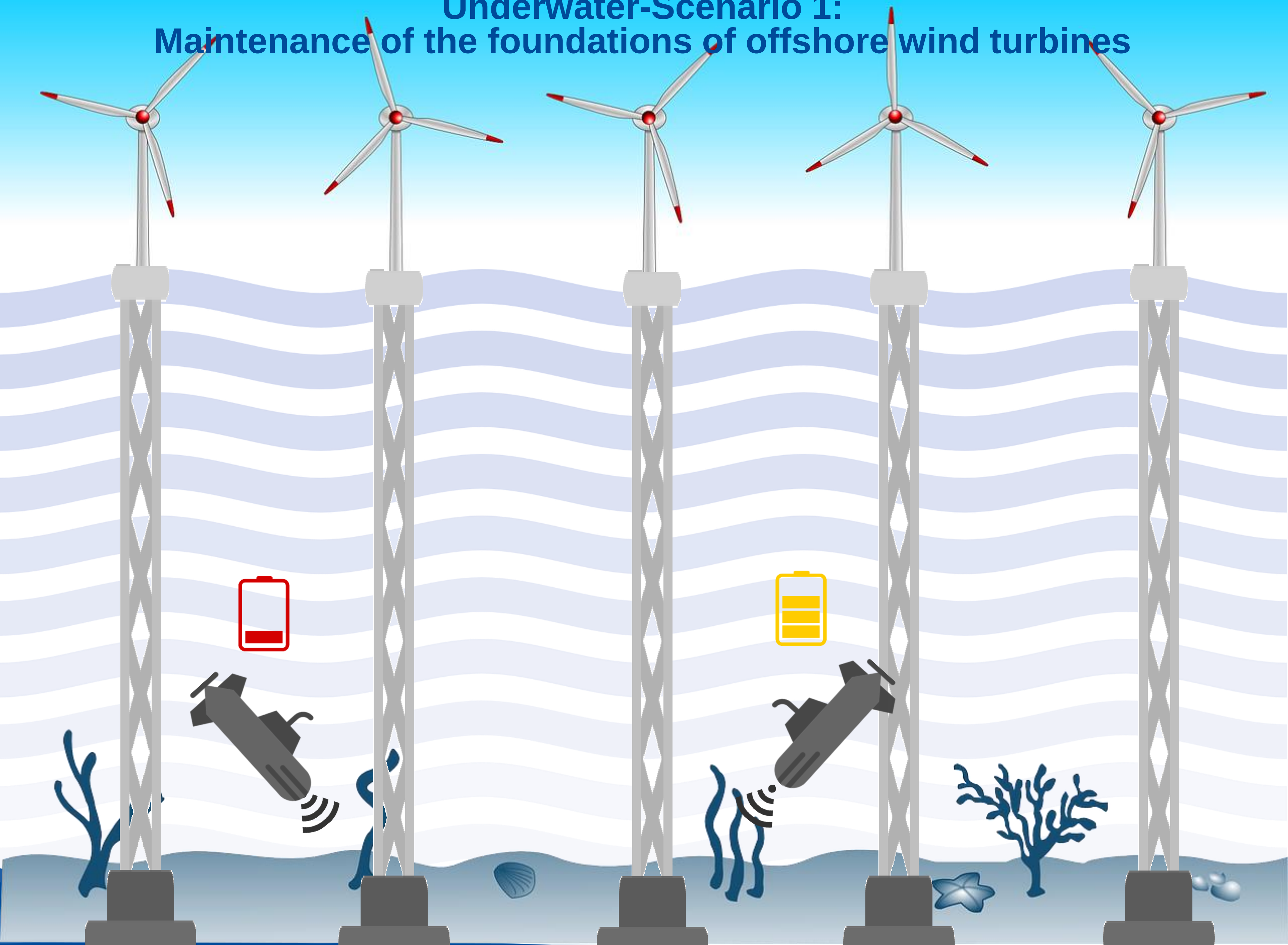
Communication Schedule



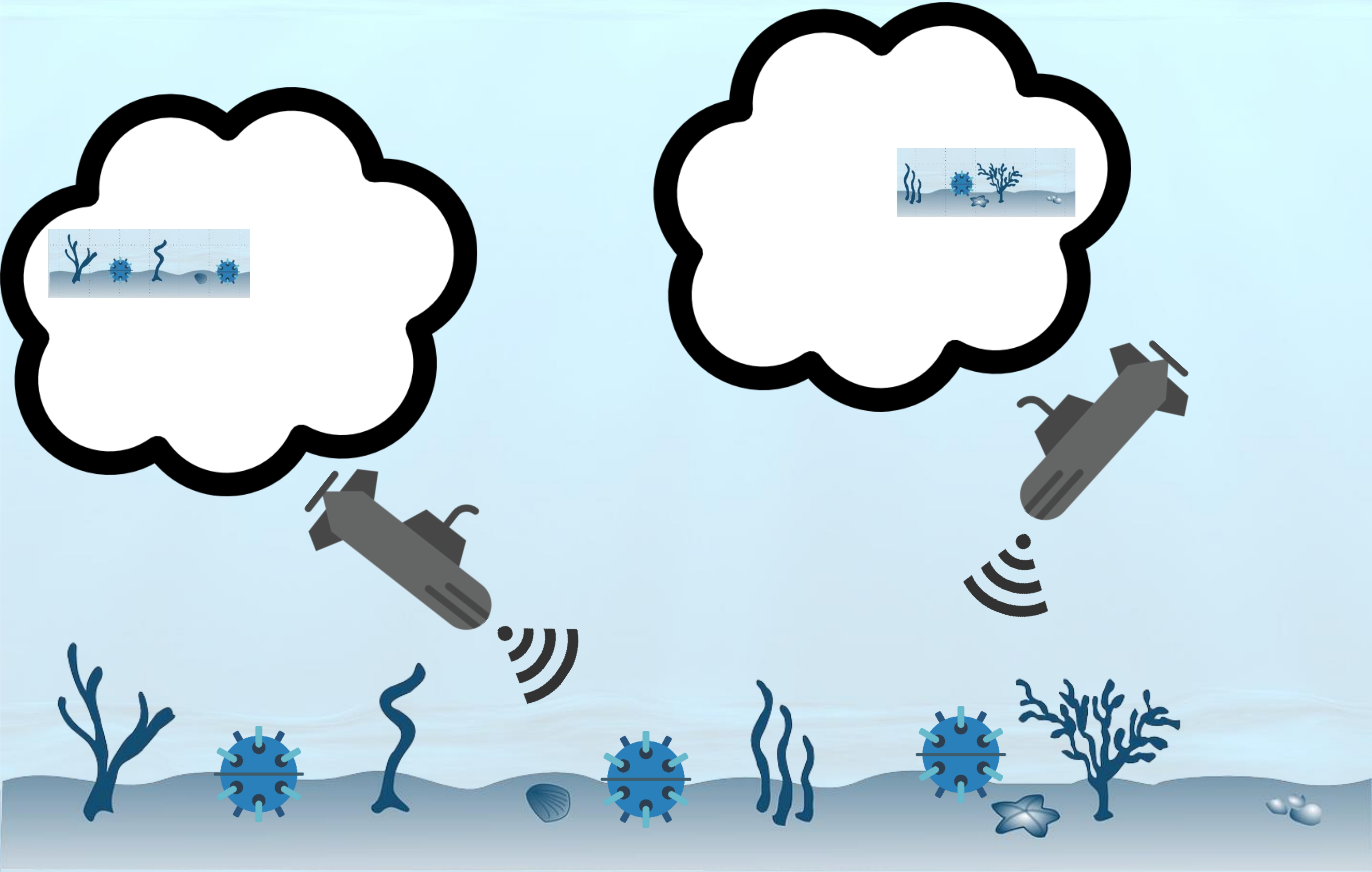


- Streams
  - From node 6 to nodes 7 and 10 (multicast)
  - From node 10 to node 7
- Schedule
  - Determines exactly when which packet is sent over which link
  - Has to be always without conflicts → provable correct
  - Needs to be adapted whenever communication pattern changes
  - Additional traffic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

Underwater-Scenario 1:
Maintenance of the foundations of offshore wind turbines



Underwater-Scenario 2:
Clearance of Unexploded Ordnance (UXO) from World War II



Projects and Collaborations

- Realtime publish/subscribe communication
  - Part of a DFG project
  - 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
  - Cooperative navigation of several AUVs
  - Limited Energy restricts movement and usage of sensors
  - Opportunistic communication via acoustic modems

Tasks: Realtime Publish/Subscribe

- Simulation models for realtime communication (TSN standards)
  - Simulation of mixed-critical data traffic
  - Configuration of time-critical networks with mixed-critical traffic
  - Simulation model for per-stream filtering and policing
  - Test and extension of new TSN features of OMNeT++/INET

- TSN-Scheduler
  - ILP-Models for Gurobi or CPLEX (→ Python)
  - Own heuristics in different programming lanuages (C++, Java, Go, Rust, …)
  - Input/Output of constraints and configurations, respectively
  - Checking of computed solutions (→ Python)
  - Benchmarking (→ Docker container)

Tasks: Autonomous Underwater Vehicles

- Further development of motion models for AUVs
  - Reaction to obstacles
  - Autonomous adaptation
- Integration of simulation models for AUVs
  - Energy consumption
  - Communication with acoustic modems
  - Motion
- Simulation of cooperative missions
  - Formation of multiple AUVs
  - Mapping of the seafloor
  - Cooperative hunting

- Implementations using Simulator OMNeT++ and C++
  - Python for scripting and evaluation of simulation results

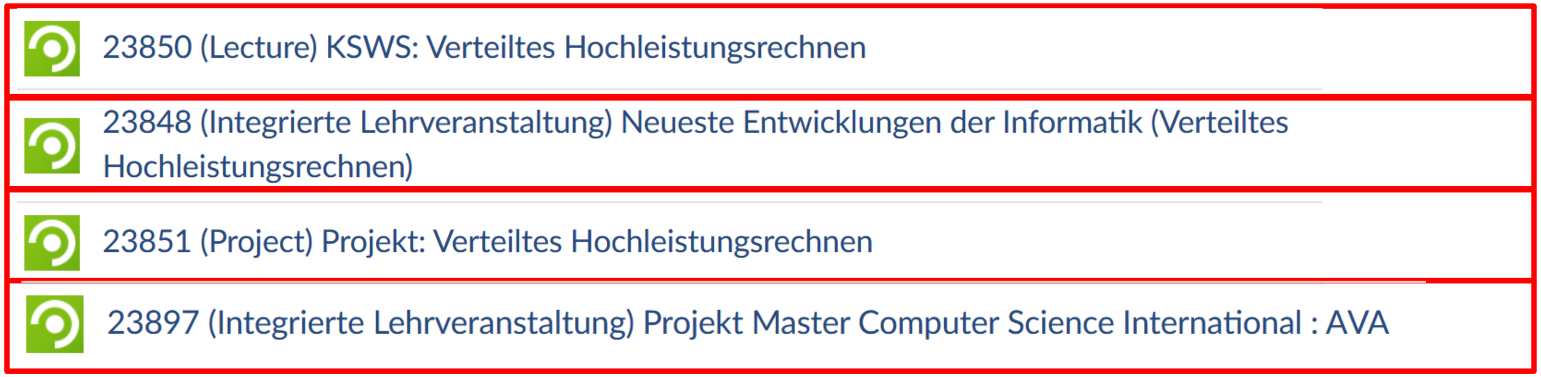
Organizational Matters

- Up to two teams
  - Team A: Realtime publish/subscribe
    (probably more fine-grained distribution of tasks)
  - Team B: 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. 23850 (Lecture) KSWS: Verteiltes Hochleistungsrechnen
2. 23848 (Integrierte Lehrveranstaltung) Neueste Entwicklungen der Informatik (Verteiltes Hochleistungsrechnen)
3. 23851 (Project) Projekt: Verteiltes Hochleistungsrechnen
4. 23897 (Integrierte Lehrveranstaltung) Projekt Master Computer Science International : AVA

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