Realtime Publish/Subscribe for Cyber-Physical Systems
KSWS AVA / Projekt AVA / NEidl VHR

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What is Realtime (Echtzeit)?

Not necessarily fast, but predictable!

→ Do the right thing at the right time.
What is Publish/Subscribe?

- **publish** \((n)\)
  - Publisher produce data and offer them to everyone interested

- **subscribe** \((F_n)\)
  - Subscriber subscribe those data, in which they are interested
Scalable \( m:n \)-group communication

\[ \text{publish}(n) \]

\[ \text{subscribe}(F_n) \]
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

Time-critical communication when handing over work pieces.

Industry robots made by Kuka
Reconfigurable Production Cell

Flexible communication in case of task changes.

Industry robots made by Kuka
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)
  - TSN configuration (IEEE 802.1Qcc)
  - Time synchronization (IEEE 802.1AS)
  - Controlled timing (IEEE 802.1Qch)
  - Reliable communication (IEEE 802.1Qca, IEEE 802.1Qci)
  - Test/extension of the new TSN features of OMNeT++/INET

- TSN controller (CUC and CNC)
  - Implementation of TSN configuration option (IEEE 802.1Qcc)
  - Based on Ryu framework for SDN controller
  - Integration of a trivial planning component

- Development and test platform for prototypes
  - Scripts for configuring TSN switches
  - Generators for test data
  - Management tools for different purposes
Tasks: Autonomous Underwater Vehicles

> Cooperative navigation of several AUVs
  > Implementation of motion models
  > Implementation of localization algorithms

> Energy consumption caused by motion and activated sensors
  > Implementation of models for energy consumption for movement and activated sensors
  > Implementation of models for energy consumption for image processing algorithms

> Opportunistic communication via acoustic modems
  > Implementation of realistic underwater communication

> 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

> Enrollement in respective Stud.IP course

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

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