KUKA

Ontology-based knowledge representation in robotics

Potentials and challenges from the KUKA point of view

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- European Robotics Forum – Workshop „Robot Ontologies“
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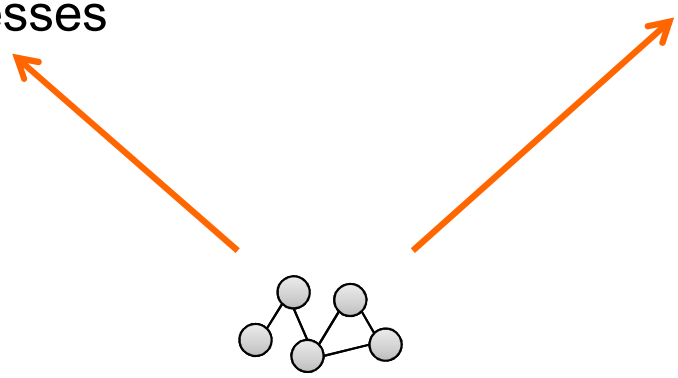
Ontologies

- An ontology is a formal, explicit specification of a shared conceptualization. (Studer et al. 1998)
  - Formal, explicit: machine-understandable, logical underpinning, no “hidden assumptions”
  - Shared: ability to communicate knowledge, incorporating “hidden assumptions” after all by using shared vocabularies

utilize knowledge to realize knowledge-based processes

communicate knowledge



Knowledge-based processes

- Operating the robot based on formalized knowledge
- Utilization of formal knowledge representation, i.e. logical underpinning to allow for automatic inferencing
- (Expressive) semantic representation of processes, tasks, states, objects, environment, constraints, …
- Challenge:
  - Finding a suitable abstraction level that allows for reuse / transferability
  - Problem of physical embodiment

Knowledge sharing

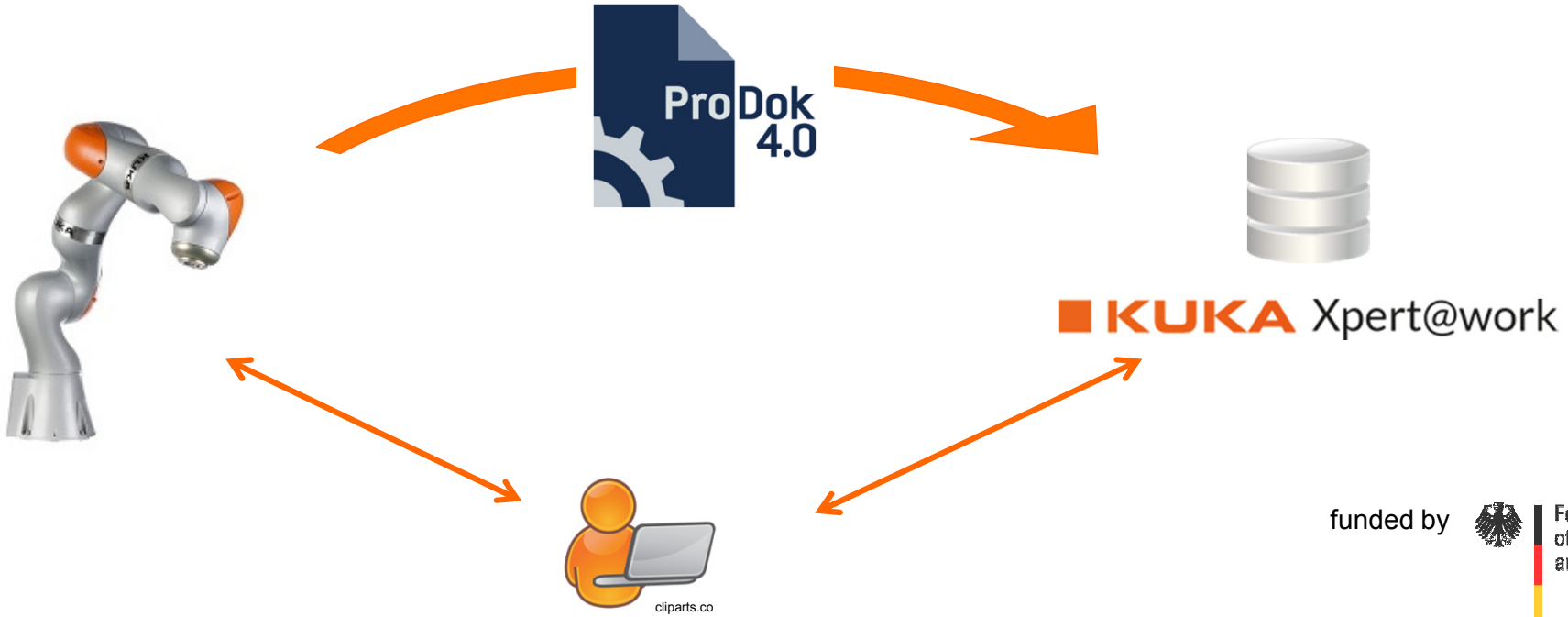
- Robot as component in cyber-physical production systems (Industry 4.0)
- Allowing for Industry 4.0 components to communicate with each other (without manual configuration)
- Enabling Self-X characteristics (self-description, self-configuration, self-optimization, self-healing, …)
- Challenges:
  - Agreement on the reuse of existing vocabularies / ontologies

    eCl@ss® ProSTEP iViP <AutomationML/> OPC UA Companion Specifications OWL-S

  - Sharing own, specialized ontologies
  - Ontology mapping

Sharing knowledge to communicate with external components

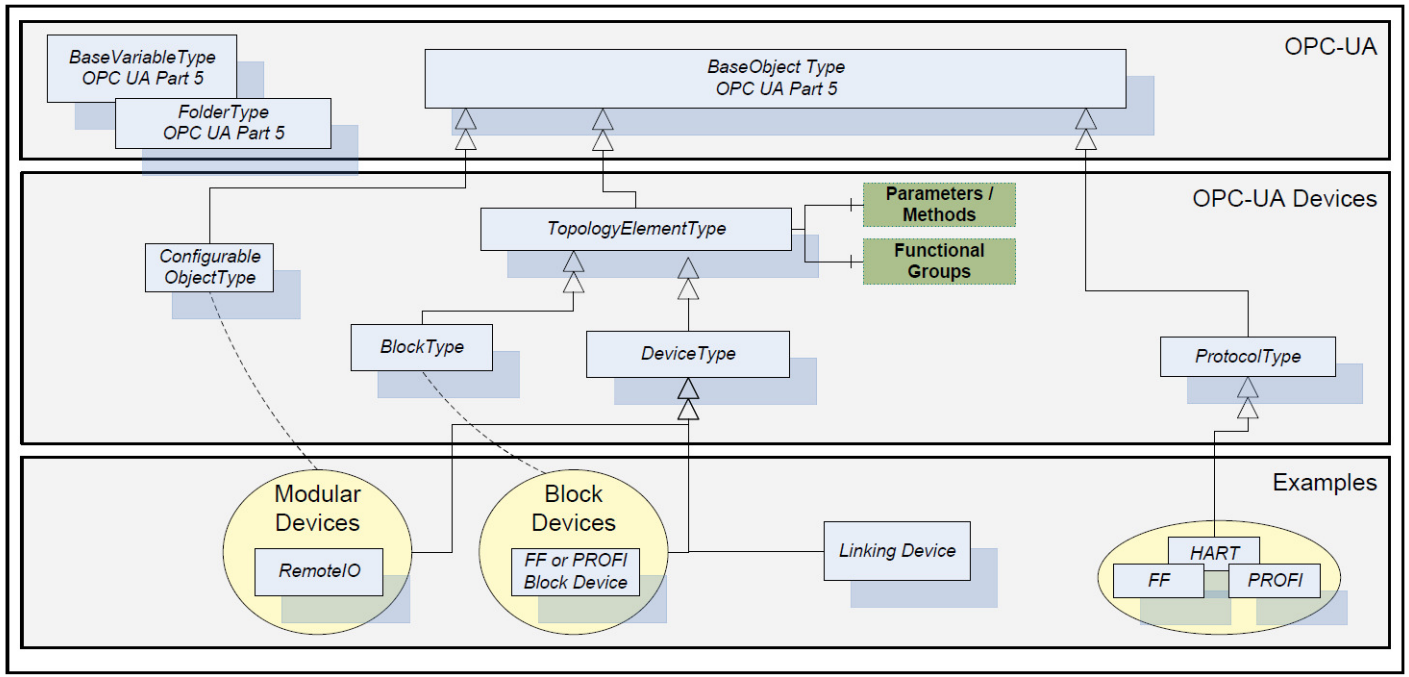
- Use Case: Knowledge sharing of the robot with an external documentation system
  - States, messages, logs, errors, … represented in a semantic formalism
  - Linked to semantically annotated documentation
  - Providing situation-related information
  - Project ProDok 4.0 (funded by the German Ministry of Education and Research)



funded by Federal Ministry of Education and Research

OPC UA

- OPC UA as the upcoming Industry 4.0 communication standard
- Knowledge representation in terms of OPC UA Information Models
- OPC UA Address Space allows for modelling knowledge formally, but not logically
- Challenges:
  - Can there be a mapping to well-known semantic representation formalisms, such as OWL

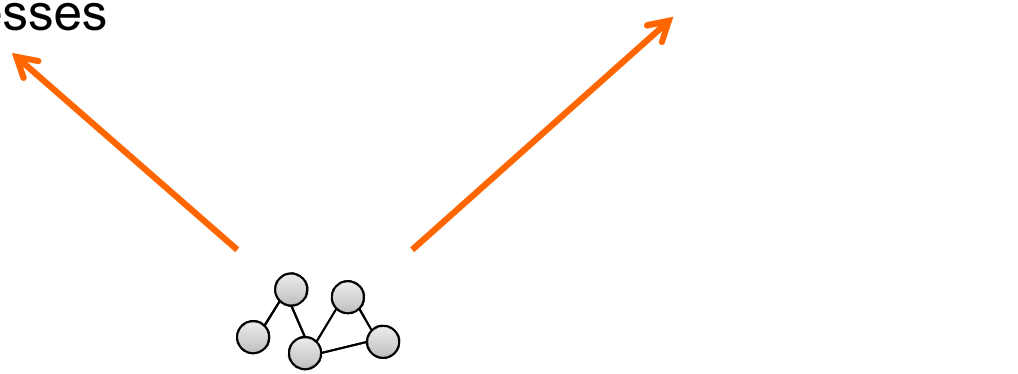


Source: OPC UA for Devices (Companion Specification)

Summary / Requirements

utilize knowledge to realize knowledge-based processes

communicate knowledge



- Find a solution that addresses both goals in a consistent way
- Modular design
  - Information hiding
  - Different levels of expressivity / formality

Thank you!