Semantic Technologies in a Continuous Information Process Engineering Cycle for Internet of Things Applications

IPE, Knowledge Management Research Group

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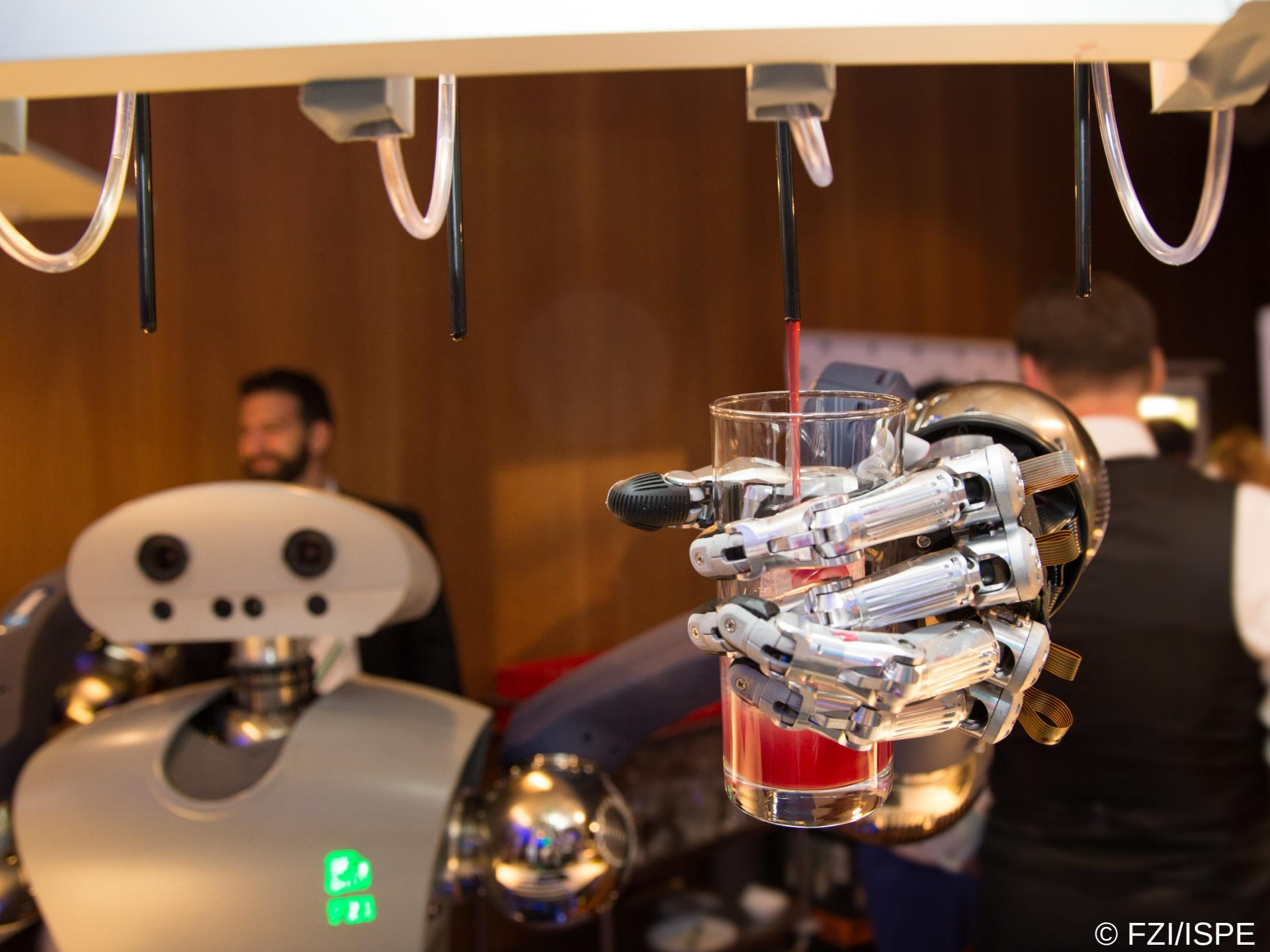
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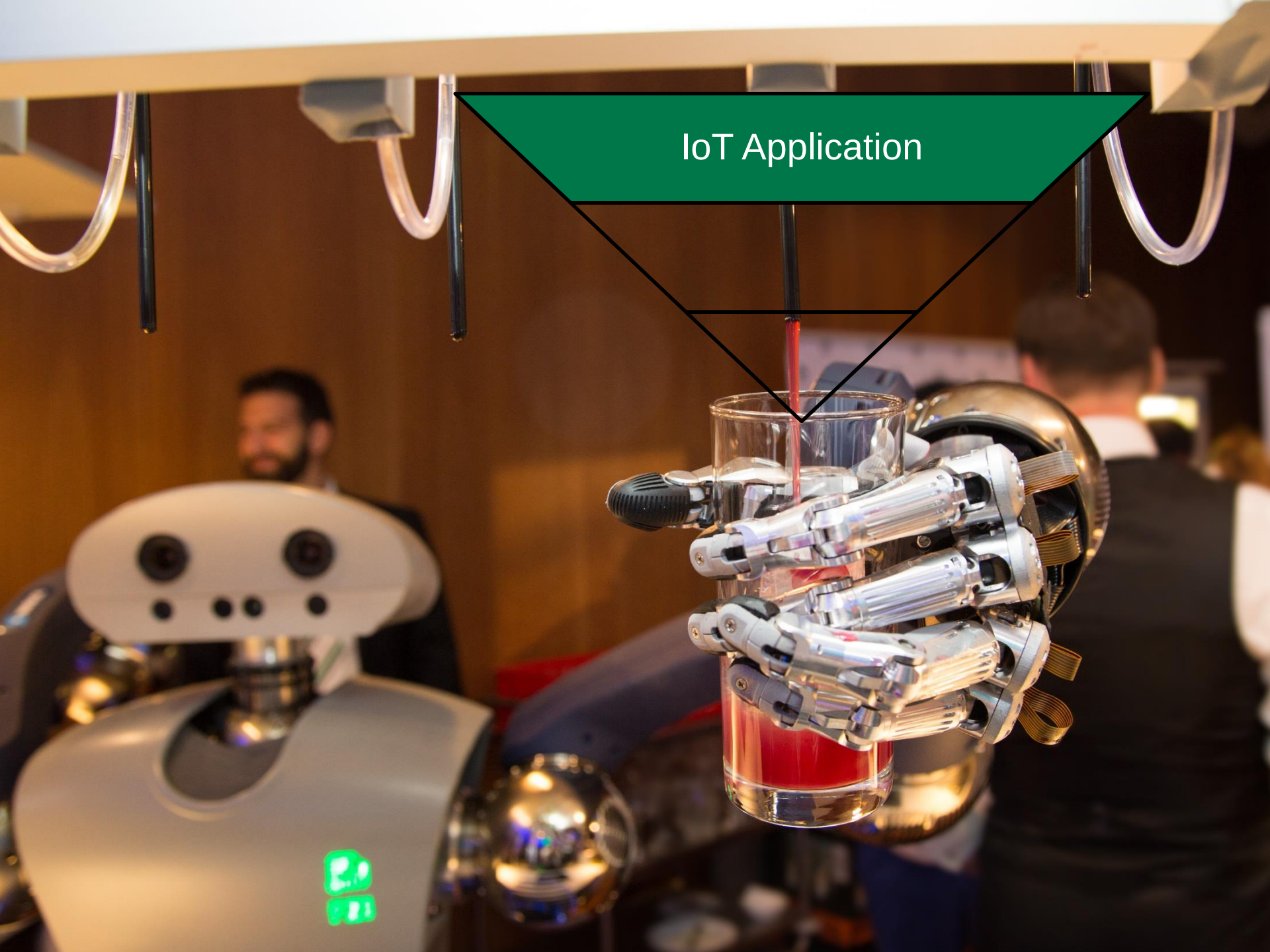
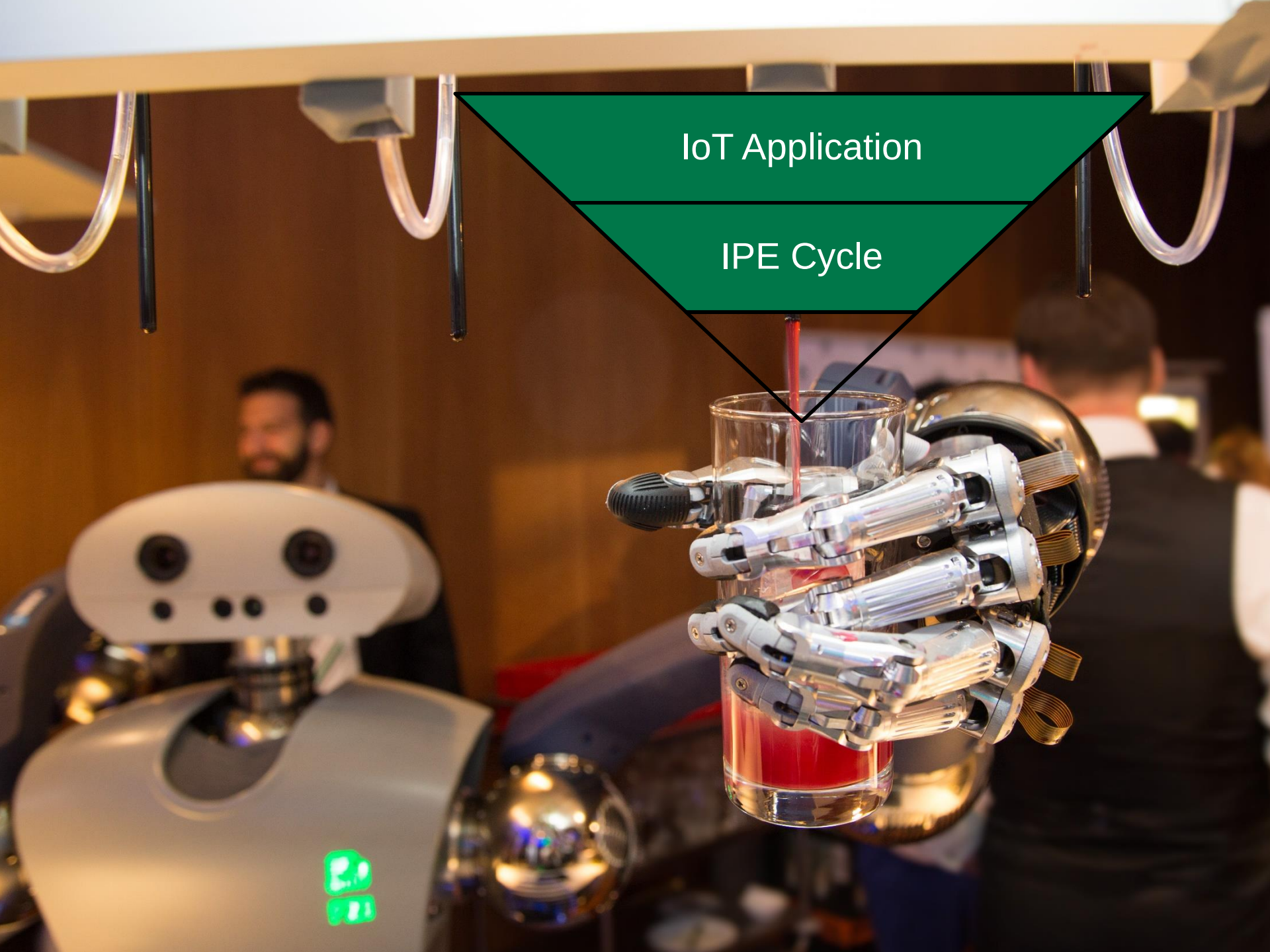
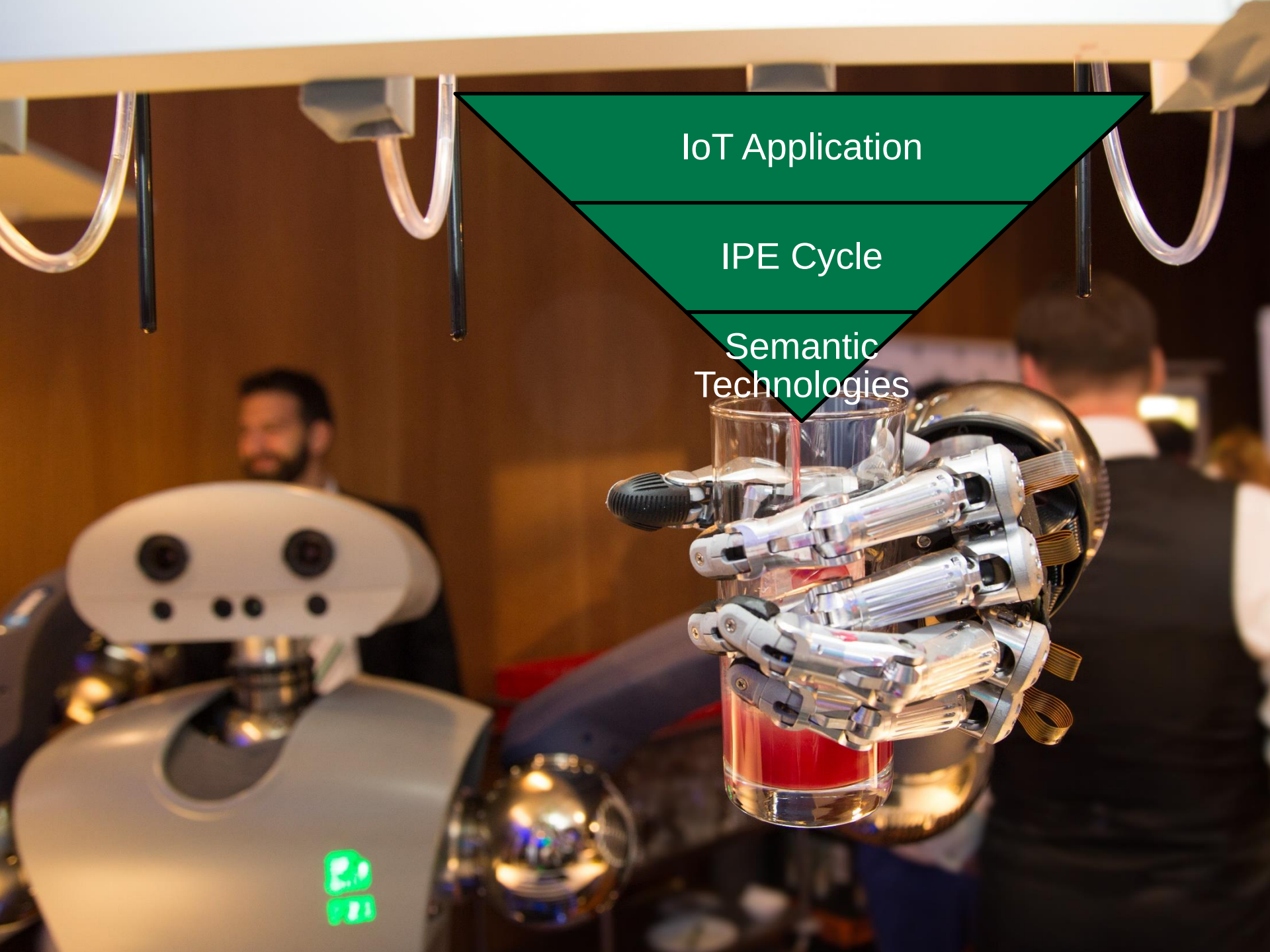

IoT Application


IoT Application
IPE Cycle


IoT Application
IPE Cycle
Semantic Technologies

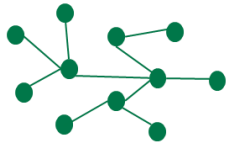
Outline

- **Why are there still challenges to develop IoT applications?**
- Information Process Engineering Cycle of IoT Applications
- Semantic Technologies for Interoperability
- Example Solutions
- Conclusions

Why are there still challenges to develop IoT applications?

- There is not "the single perfect" IoT

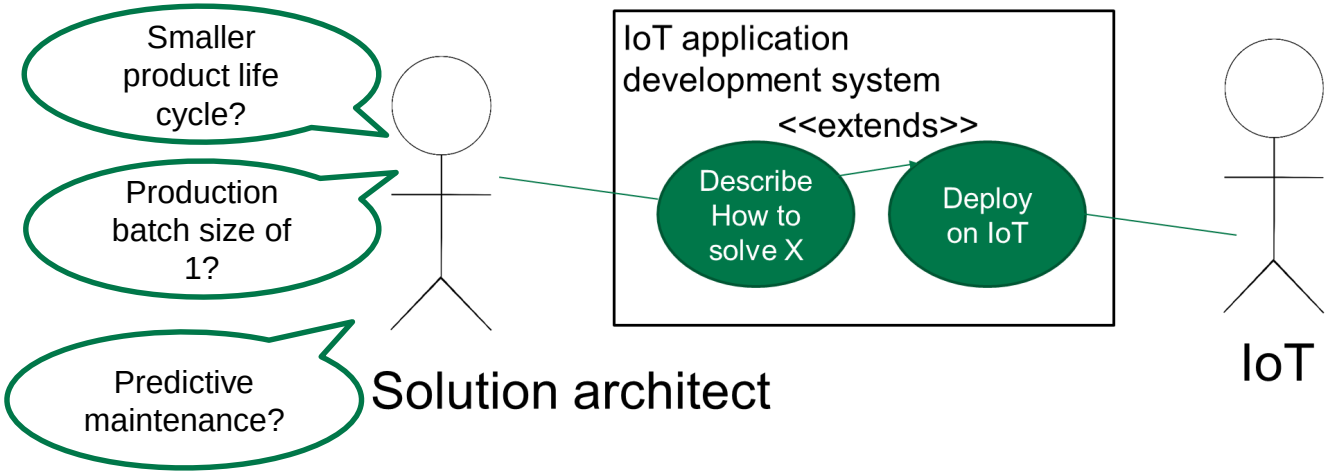
vs.



Centralised intelligence (agent)

Decentralised intelligence (swarm)

- IoT is an "uncontrollable environment"



- Non-IT end users
- Unknown devices
- Data quality issues
- Dynamic changes

Outline

- Why are there still challenges to develop IoT applications?
- **Information Process Engineering Cycle of IoT Applications**
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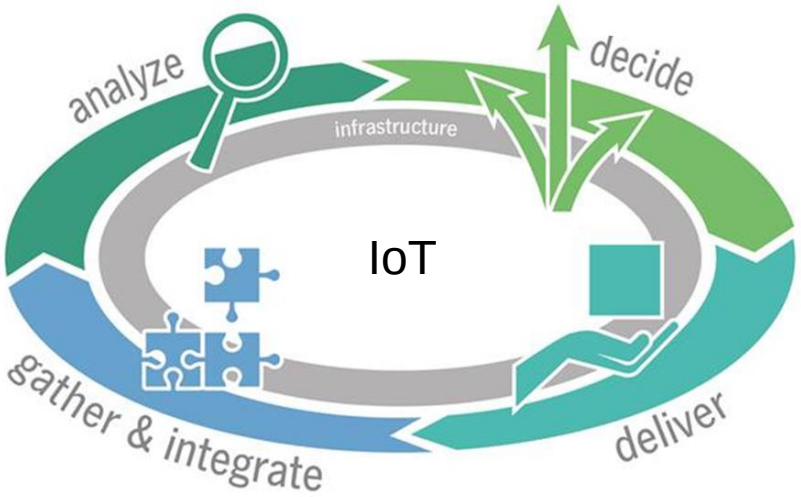
Information Process Engineering (IPE) Cycle of IoT Applications

How to analyze the data to get a useful interpretation of the current world?

How to make a reliable and context-aware decision to solve the problem?



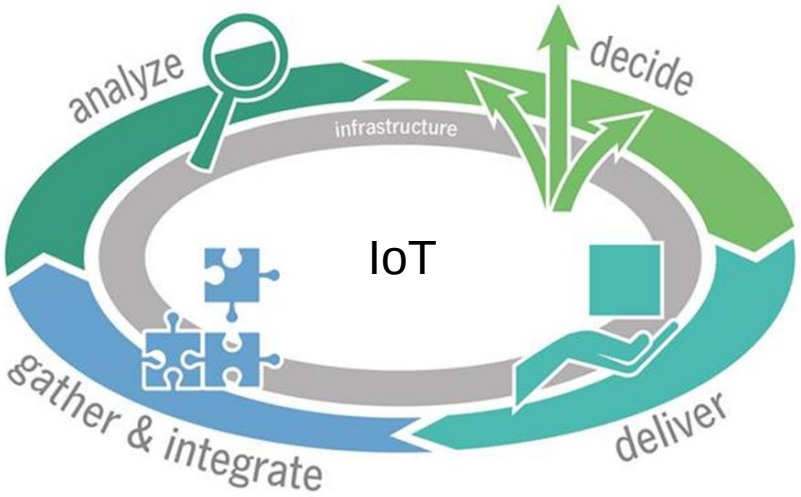
How to select, gather and integrate all relevant data about the problem at hand?

How to communicate the decision and learn from the outcomes?

Information Process Engineering (IPE) Cycle of IoT Applications

How to analyze the data to get a useful interpretation of the current world?

Heterogeneous data models



How to make a reliable and context-aware decision to solve the problem?

Heterogeneous contexts, profiles

How to select, gather and integrate all relevant data about the problem at hand?

Heterogeneous sensors, services, protocols

How to communicate the decision and learn from the outcomes?

Heterogeneous actuators, external systems, protocols

Outline

- Why are there still challenges to develop IoT applications?
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Semantic Technologies for Interoperability

Heterogeneous contexts, profiles

Heterogeneous data models

Heterogeneous actuators, external systems, protocols

Heterogeneous sensors, services, protocols

- Semantic interoperability [1]
  - structured representation of identified IoT concepts
  - machine-interpretable descriptions
  - reasoning mechanisms
  - homogeneous access mechanism to heterogeneous objects with diverse capabilities
  - automated interactions and horizontal integration with existing applications

[1] Martín Serrano et al. Internet of Things IoT Semantic Interoperability: Research Challenges, Best Practices, Recommendations and Next Steps, EUROPEAN RESEARCH CLUSTER ON THE INTERNET OF THINGS, 2015.

Semantic Technologies for Interoperability

Heterogeneous contexts, profiles

Heterogeneous data models

Heterogeneous actuators, external systems, protocols

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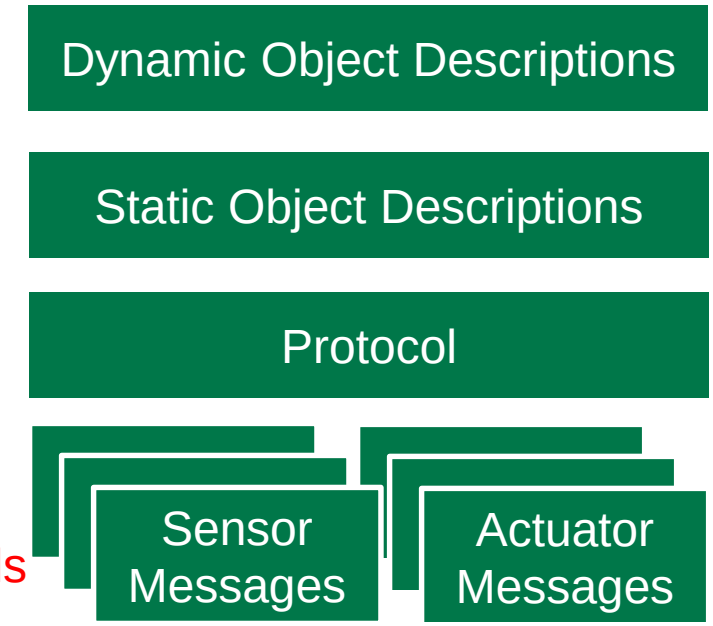


RAML, AutomationML, Hydra, …

Key-Value Pairs, JSON, XML, binary, …

HTTP, CoAP, KNX, ZigBee, XMPP, …

RWE, CIBEK, Martin Elektrotechnik, Escos, Wunderbar, KUKA…

IoT data stack

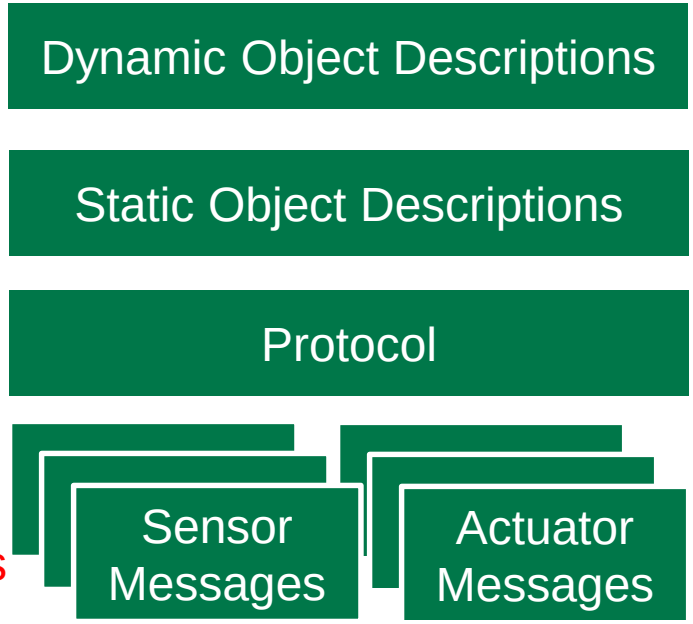
Semantic Technologies for Interoperability

Heterogeneous contexts, profiles

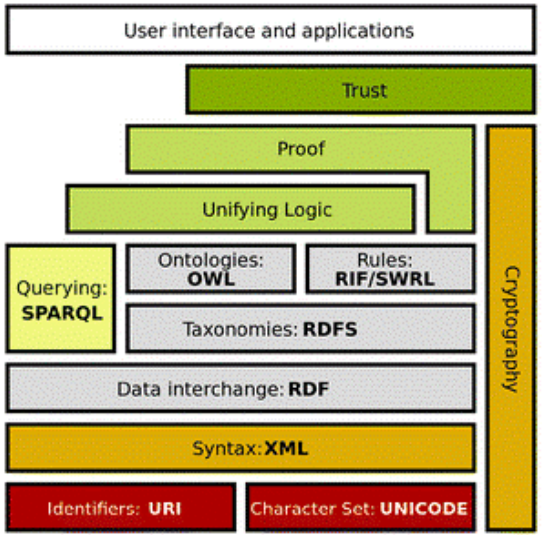
Heterogeneous data models

Heterogeneous actuators, external systems, protocols

Heterogeneous sensors, services, protocols



IoT data stack



The Semantic Web “layer cake” presented by Tim Berners-Lee at the XML 2000 conference.

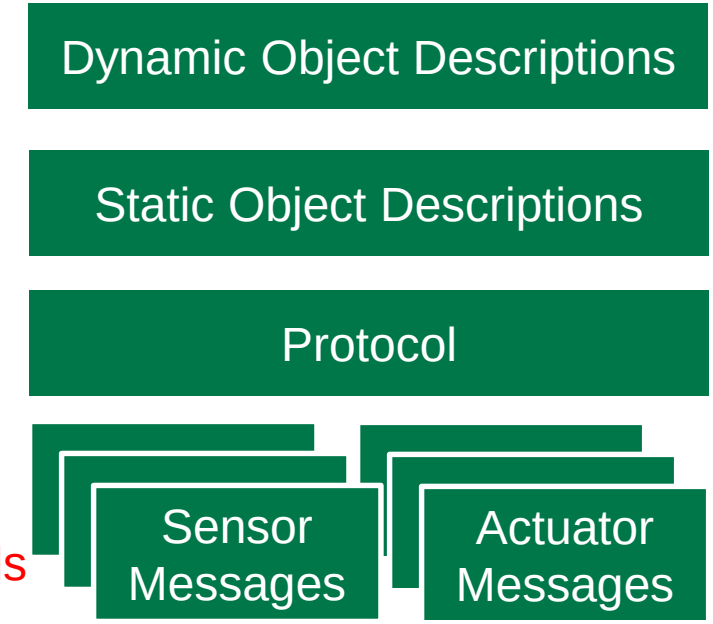
Semantic Technologies for Interoperability

Heterogeneous contexts, profiles

Heterogeneous data models

Heterogeneous actuators, external systems, protocols

Heterogeneous sensors, services, protocols



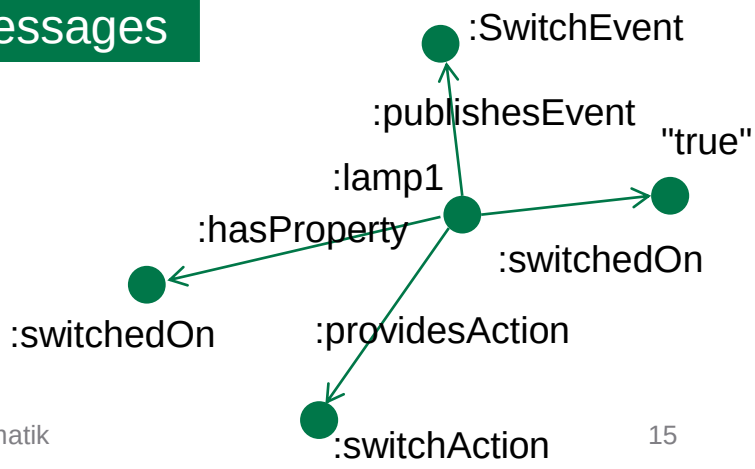
IoT data stack

Linked APIs, SPARQL, LD-Fu

RDF(S), OWL, SSN, QB

HTTP

URI



Outline

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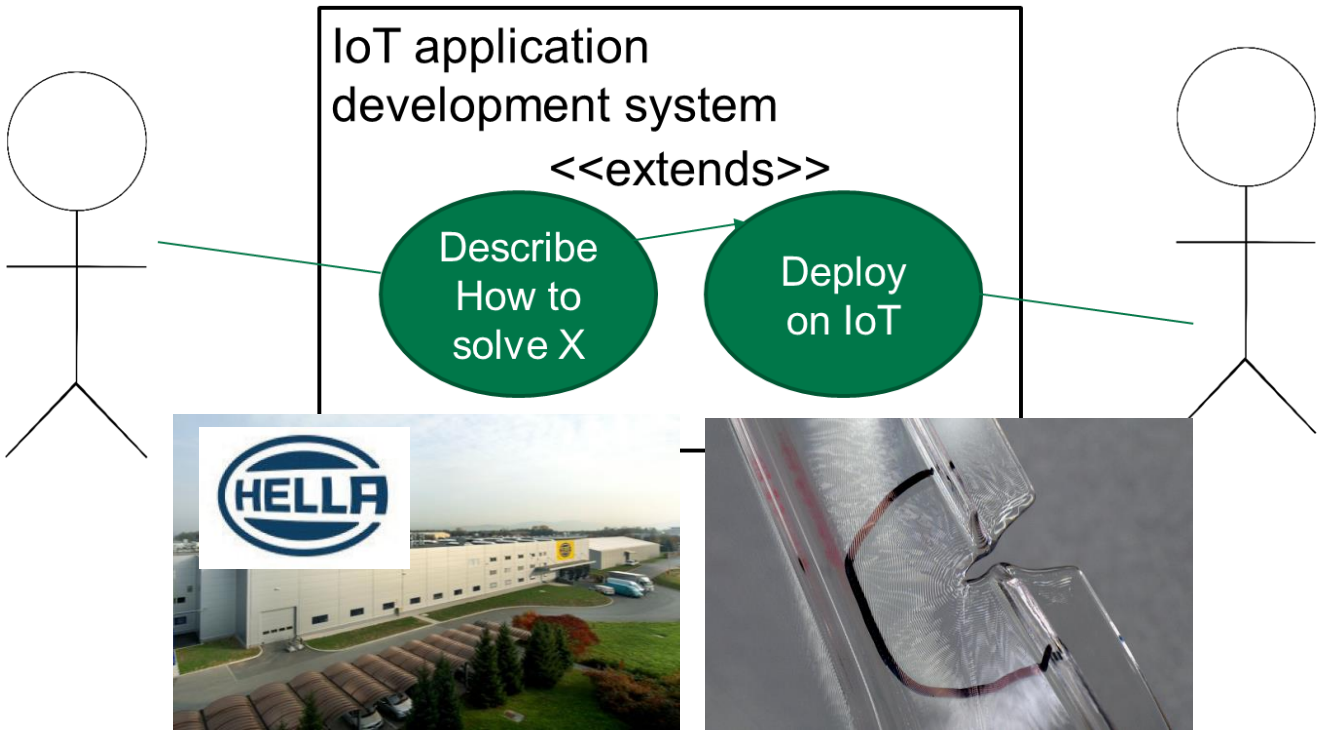
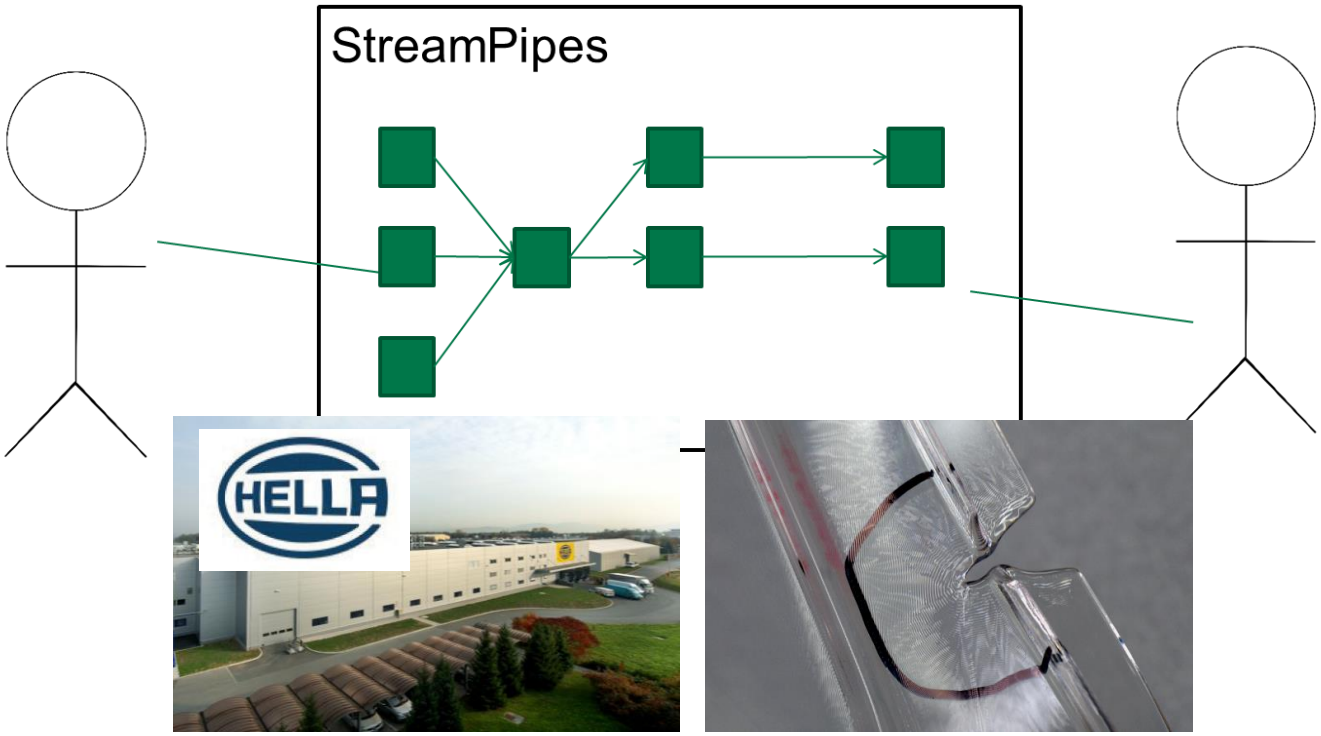
Example Solution 1:
Self-Service Real-Time Big Data Platform



Self-Service Real-Time Big Data Platform

prosense
The Proactive Sensing Enterprise



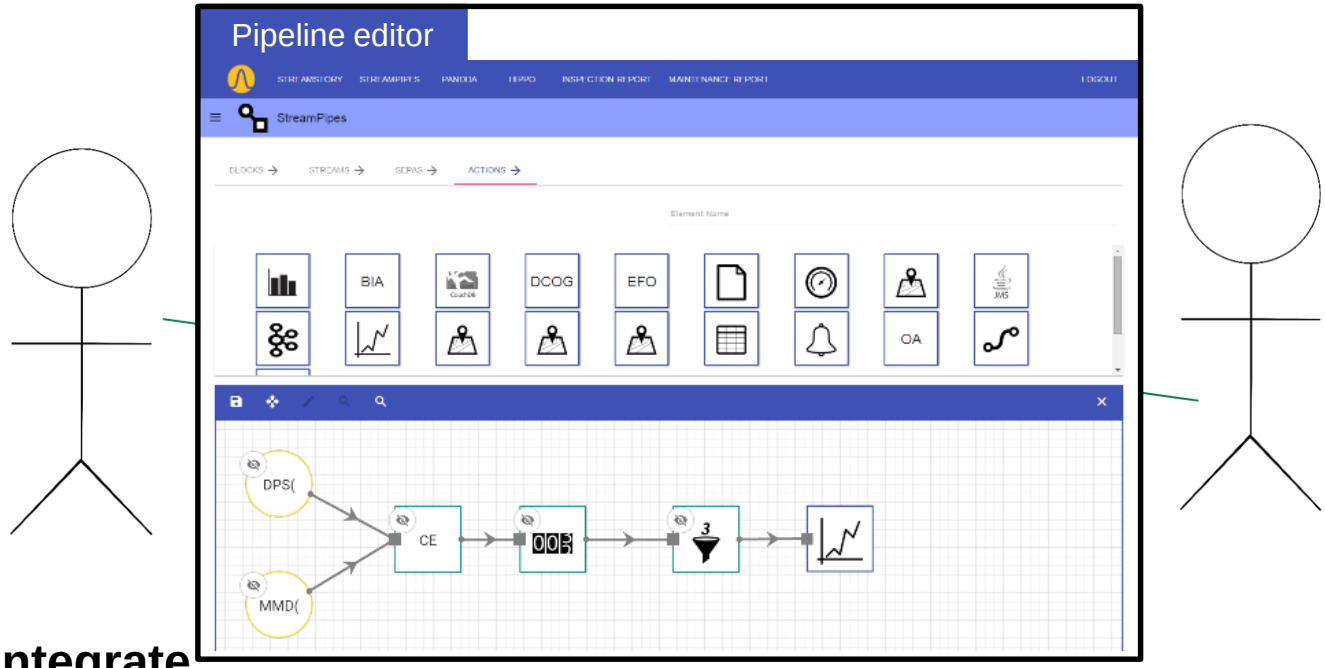
Self-Service Real-Time Big Data Platform: StreamPipes

Analyze

Description of enrichment/analysis algorithms

Decide

Abstraction from technologies



streambase
APAMA
APACHE STORM
EsperTech
Spark Streaming
Flink

Gather & Integrate

Description of sources (OPC UA, sensors…)

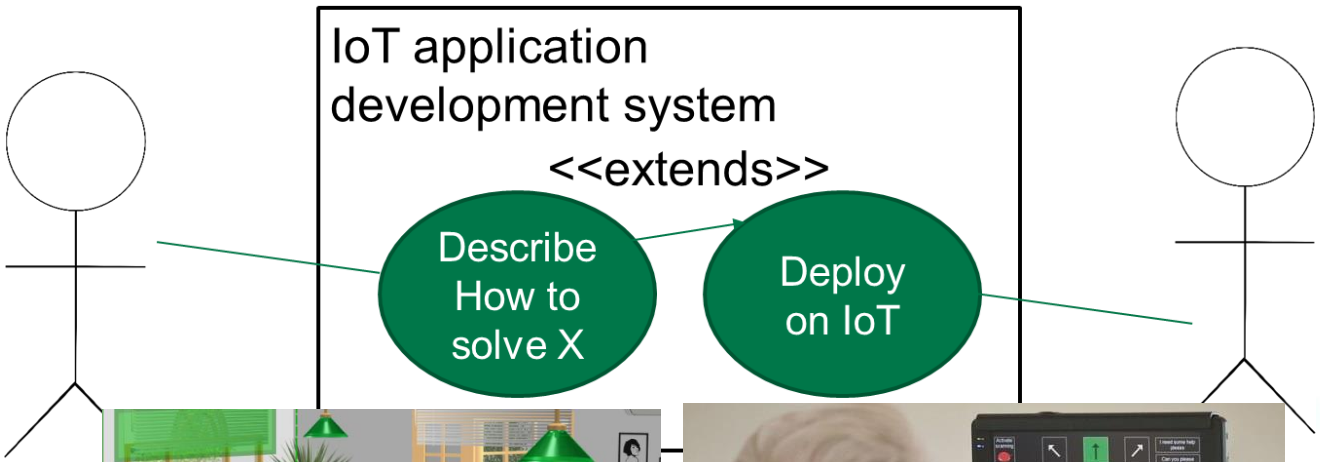
http://streampipes.fzi.de

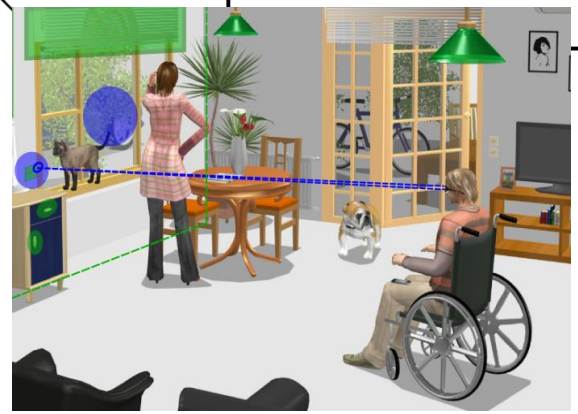
Deliver

Description of external systems

Dominik Riemer, Florian Kaulfersch, Robin Hutmacher, Ljiljana Stojanovic: StreamPipes: solving the challenge with semantic stream processing pipelines. DEBS 2015

Example Solution 2: Language and an Interpreter for Agents in the Web of Things



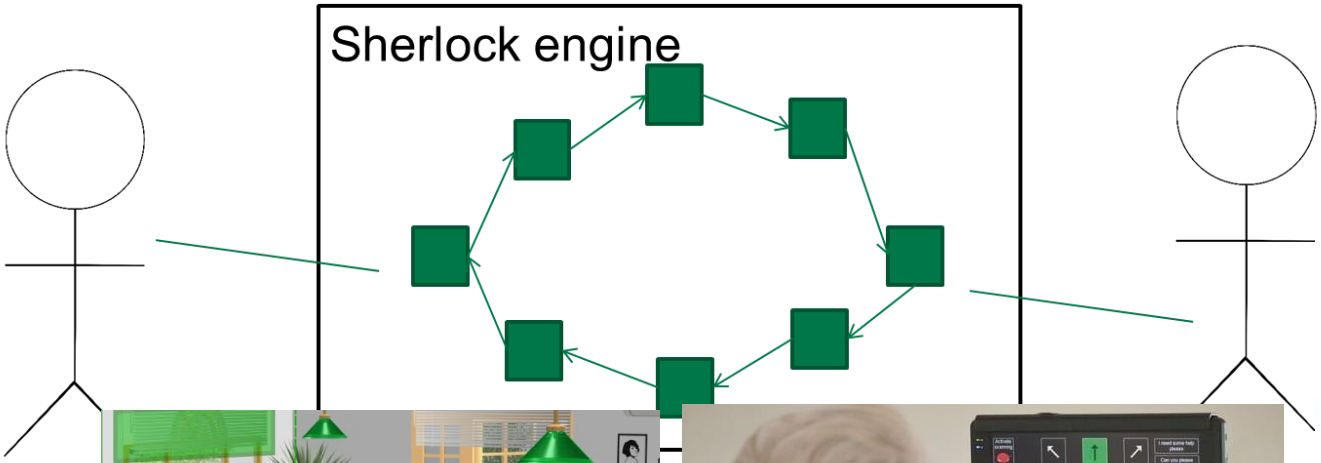


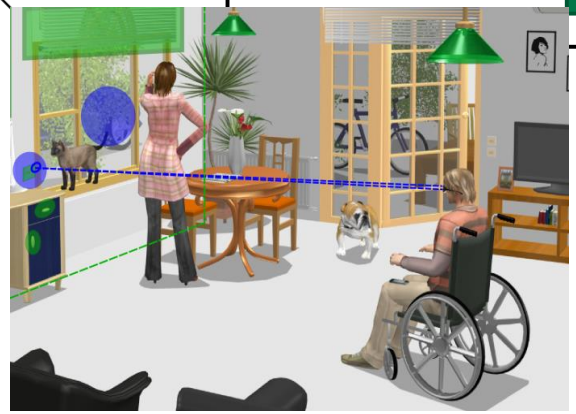
Smart Home

RollTalk Nova

Language and an Interpreter for Agents in the Web of Things

AICA SYS





Smart Home

RollTalk
Nova

Language and an Interpreter for Agents in the Web of Things: Sherlock engine

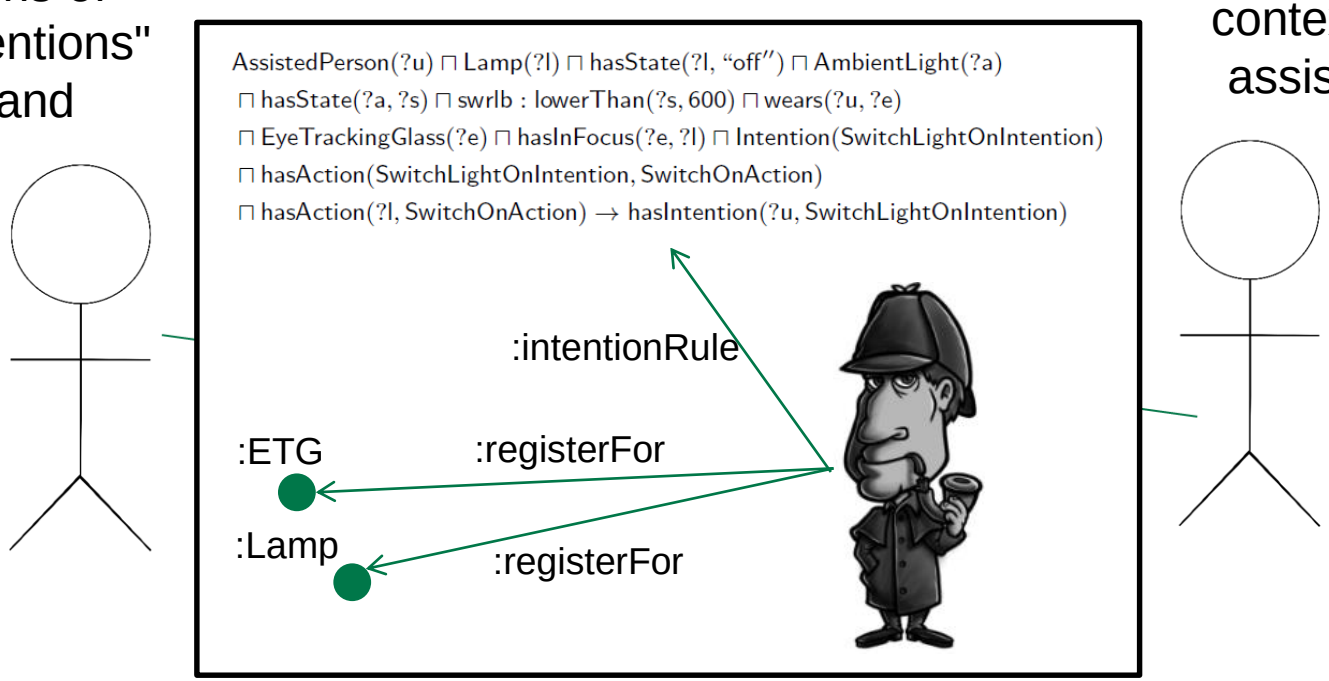
Analyze

Declarative descriptions of what "intentions" to detect and what info required

Nicole Merkle, Benedikt Kämpgen, Stefan Zander: Self-Service Ambient Intelligence Using Web of Things Technologies. SEMPER@ESWC 2016

Decide

Consider context/profile of assisted person



Gather & Integrate

https://koralle27.fzi.de/aicasys/ontology#id

Web of Things server wraps devices/protocols/platforms to URI/HTTP + simple schema (property, event, action)

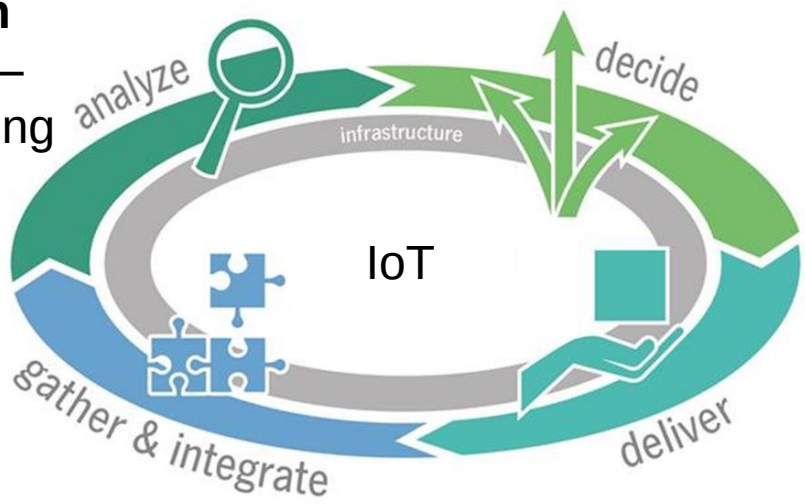
Deliver

Direct execution of action if confidence high, otherwise double-check with user

Conclusions

- "uncontrollable" IoT environment key challenge to IoT applications
- IPE cycle using semantic technologies over IoT data stack necessary
- Various interesting ways to support solution architects:

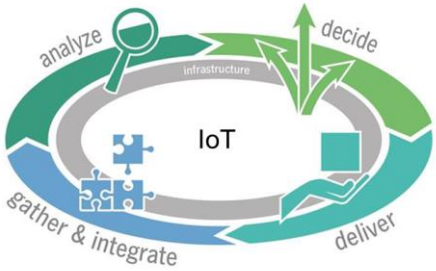
Machine Learning in Knowledge Graphs – Learn new from existing semi-structured information

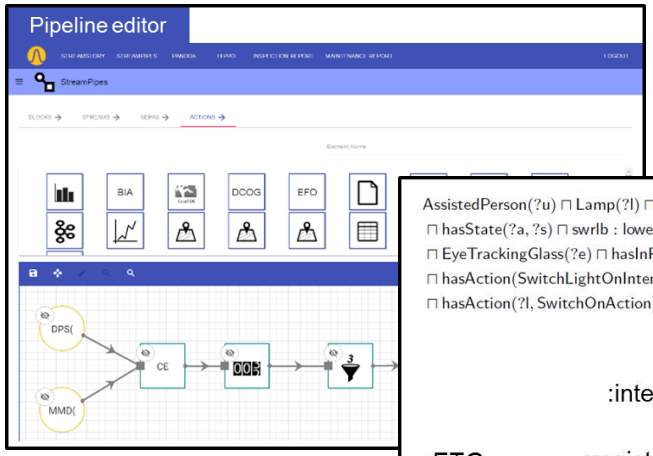


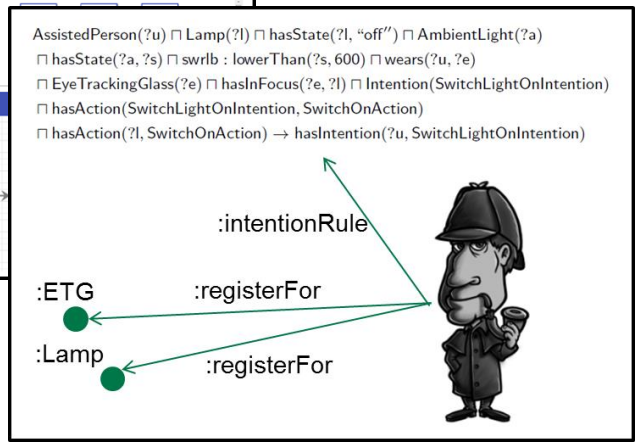
iCEP – Detect relevant situations from streaming data in real-time

Semantic Data Management – Semi-automatically resolve heterogeneity in messages, protocols and data models

Smart Services – Self-monitoring, self-diagnosis, and self-actuating







Thank you!

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How to reach semantic interoperability?

- Semantic interoperability [1]
  - structured representation of identified IoT concepts
  - machine-interpretable descriptions
  - reasoning mechanisms
  - homogeneous access mechanism to heterogeneous objects with diverse capabilities
  - automated interactions and horizontal integration with existing applications
- Standardisation
  - Larger companies heavily invest in standardisation efforts.
  - For SMEs, there is little chance to use other hardware/software than provided by larger companies.
  - Risk of vendor lock-in (Amazon WS, Microsoft Azure, ...)

[1] Martín Serrano et al. Internet of Things IoT Semantic Interoperability: Research Challenges, Best Practices, Recommendations and Next Steps, EUROPEAN RESEARCH CLUSTER ON THE INTERNET OF THINGS, 2015.