TECHNISCHE UNIVERSITÄT DRESDEN
**Faculty of Computer Science**, Software Technology Group

# PROtEUS++: A Self-managed IoT Workflow Engine with Dynamic Service Discovery

## Demo @ ZEUS 2017

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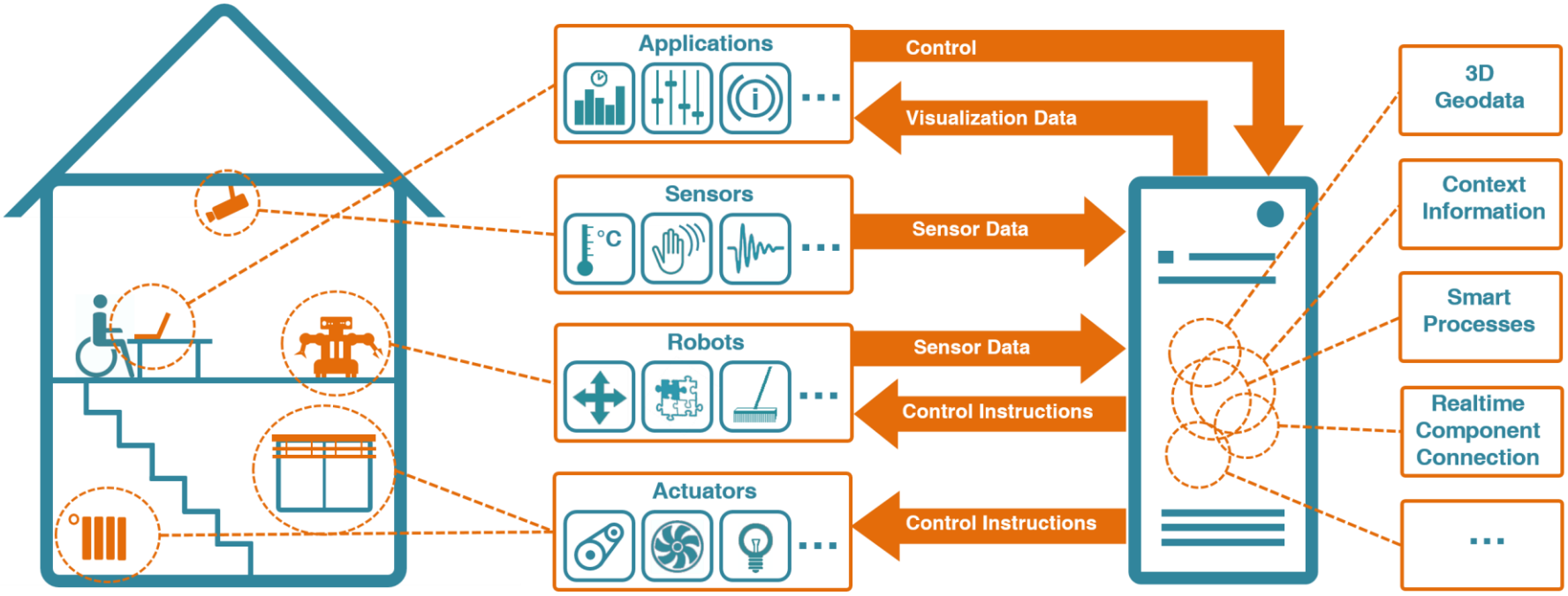
Lugano, 14.02.2017

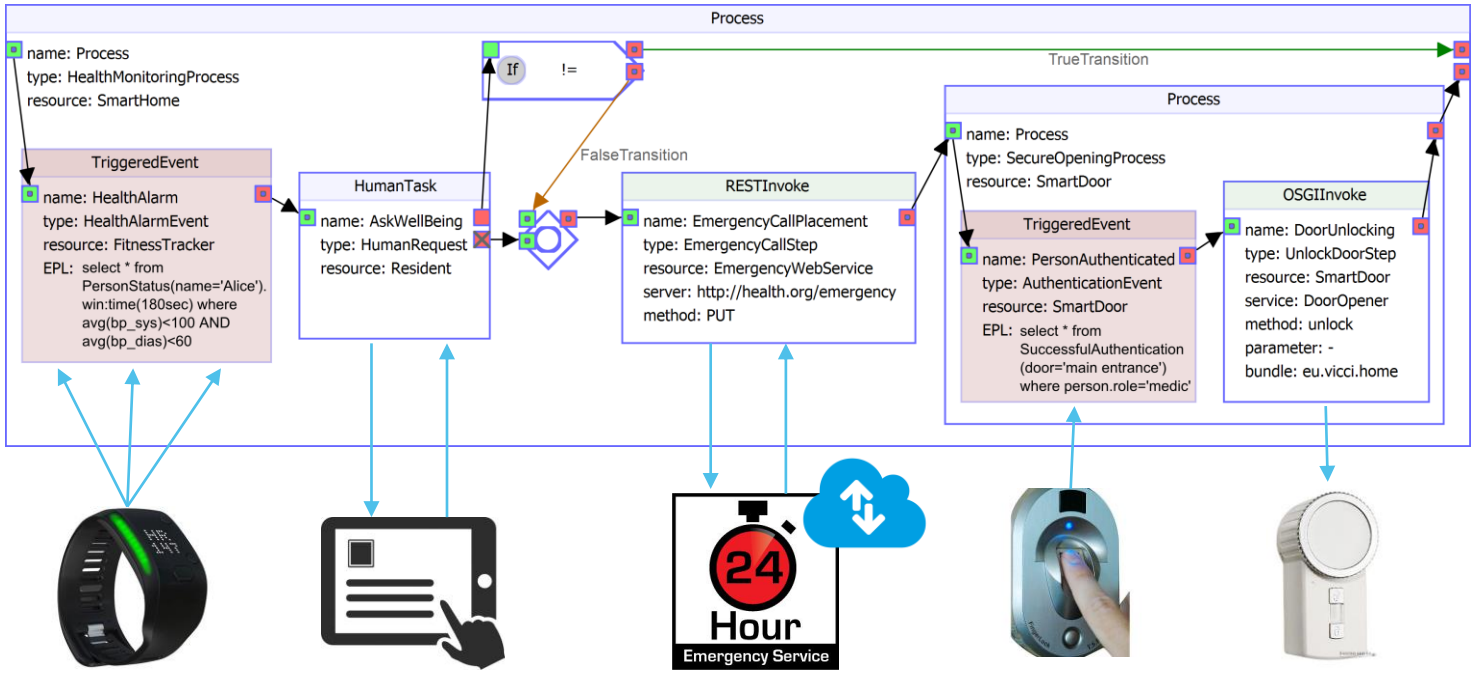
# Cyber-physical Systems and Internet of Things




from https://vicci.inf.tu-dresden.de/

# CPS/IoT and Workflows

- Automation of daily routines in Smart Home environments (AAL)
- Sensor events, dynamic services, human interactions

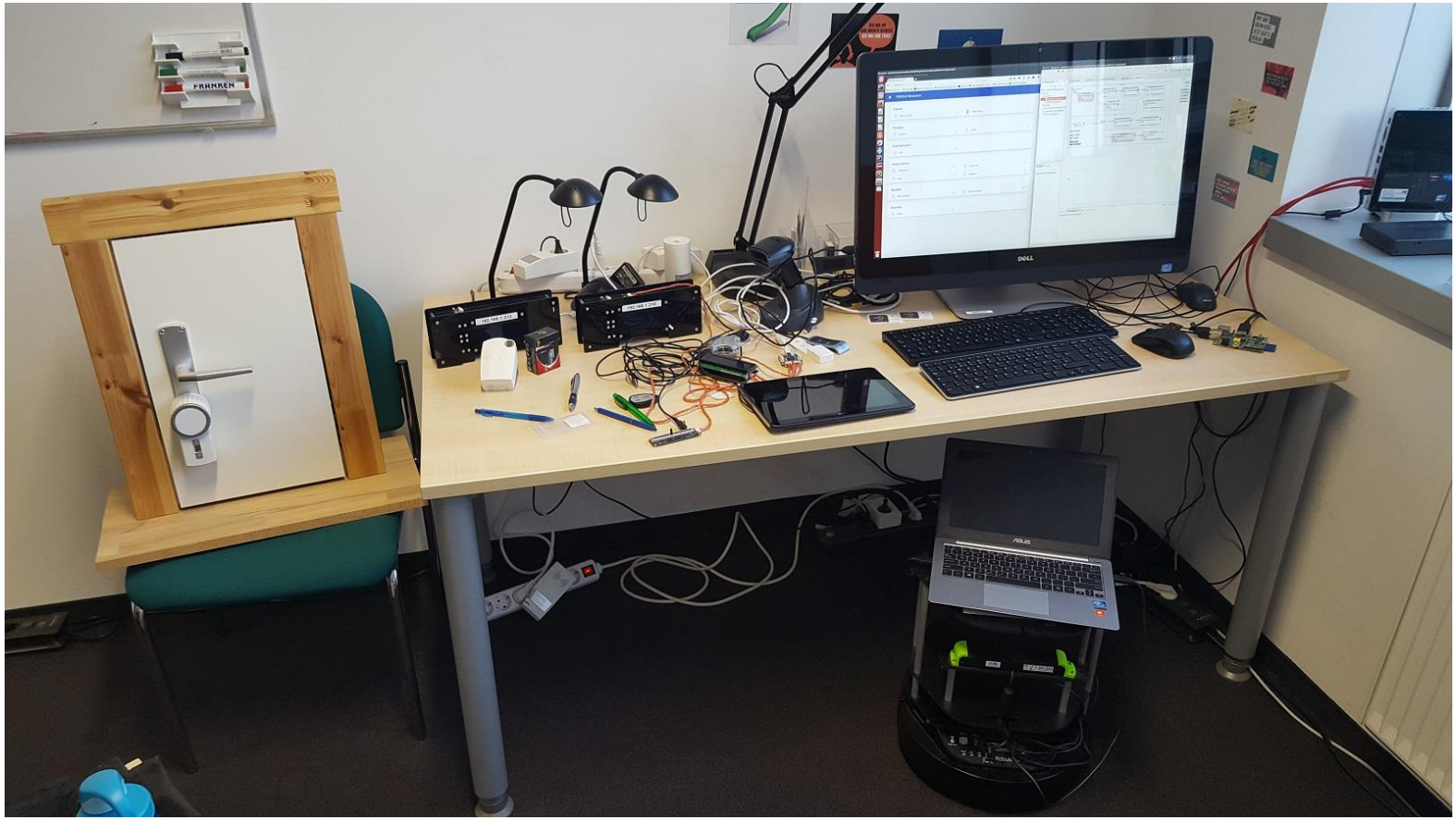


# Demo: PROtEUS++

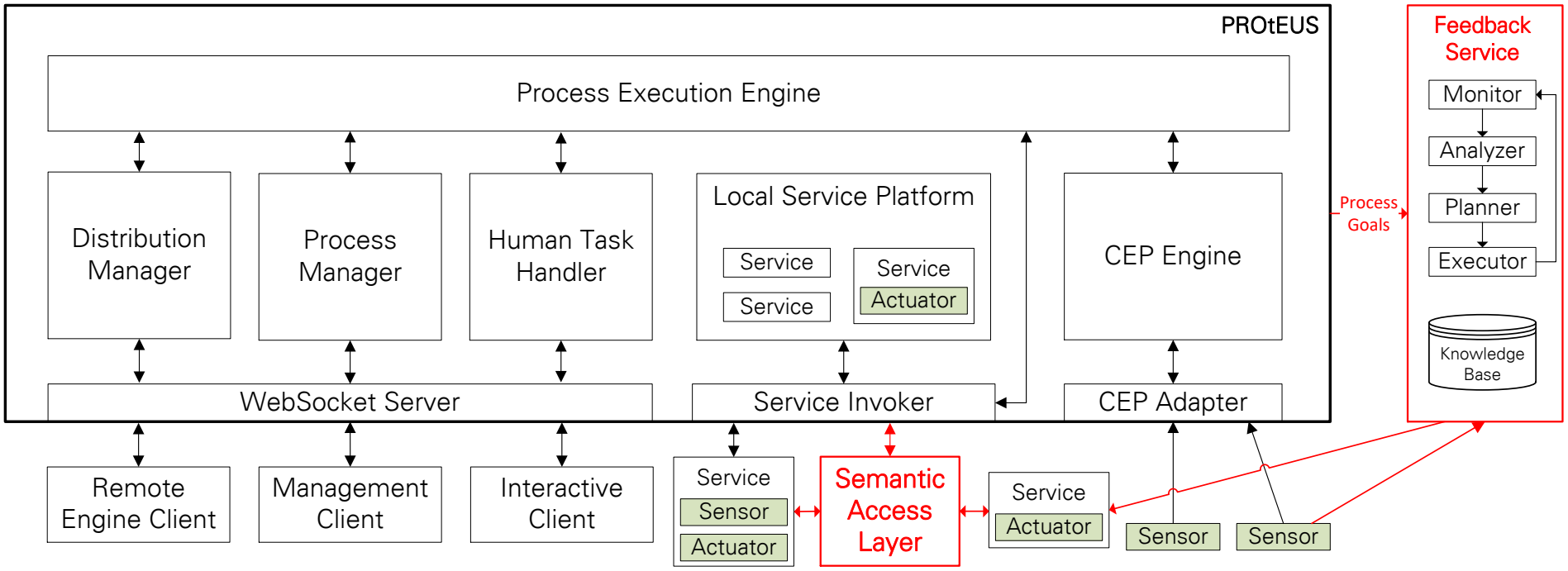
- Basic PROtEUS process engine -> Service-based IoT workflow engine
- Semantic Access Layer (SAL) -> Dynamic service selection
- MAPE-K Feedback Service -> Cyber-physical Feedback loop

- Demo processes:
  1) Emergency scenario (Ambient Assisted Living)
  2) Continuous light control (Home Automation)
  3) Distributed processes on service robots (Smart Home)

# The Setup

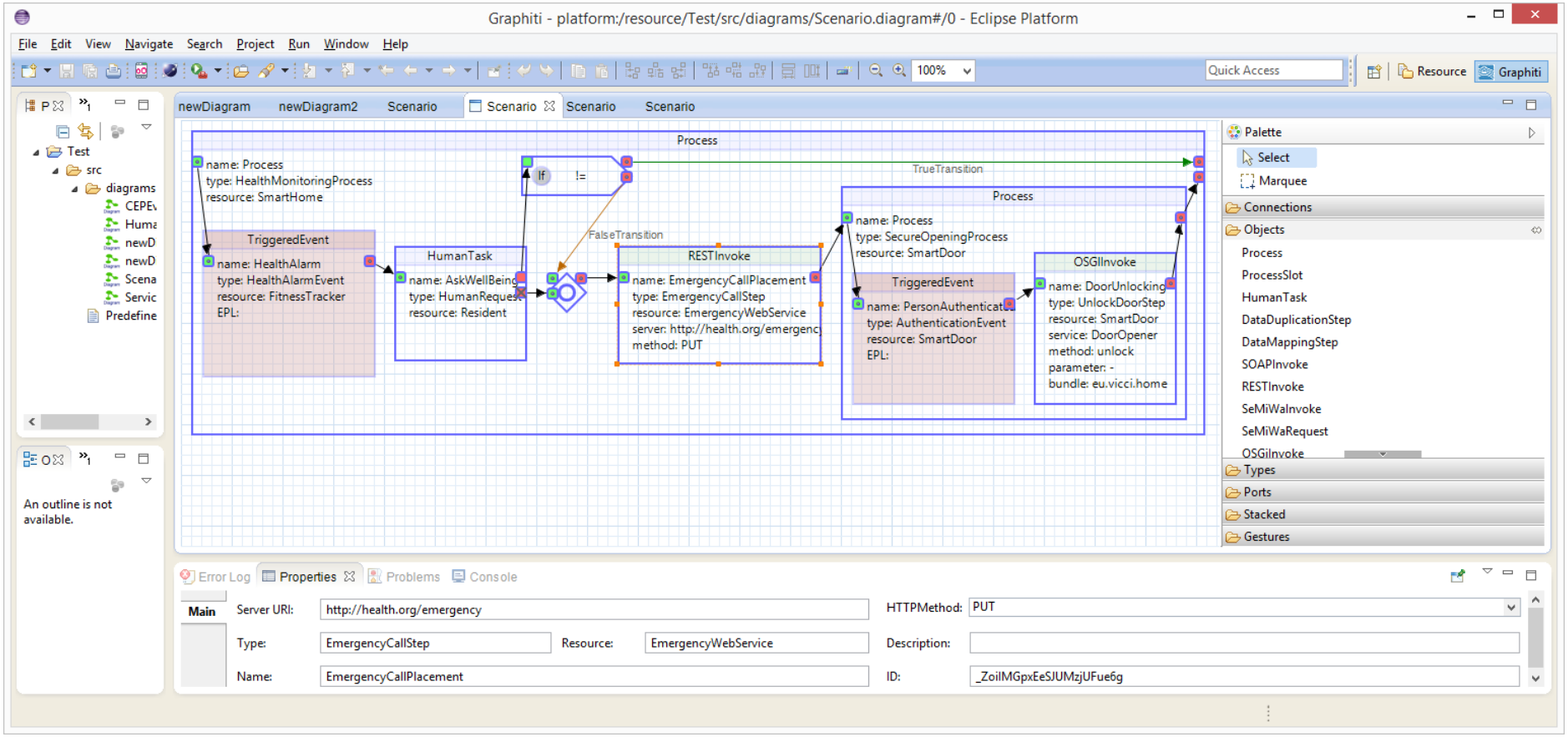


# PROtEUS++ [SHS15,SHS16,SHS17]

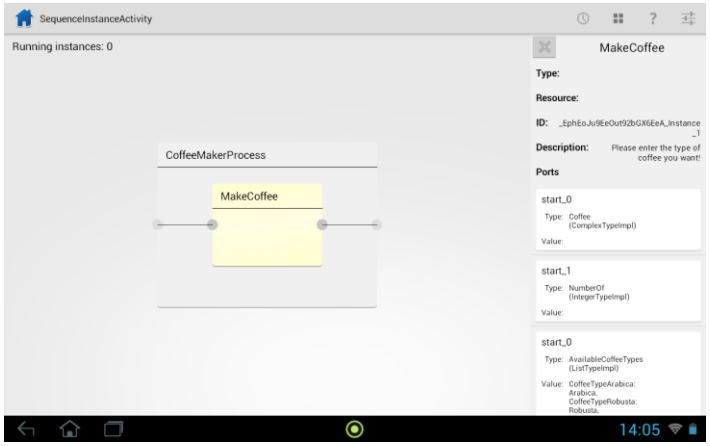


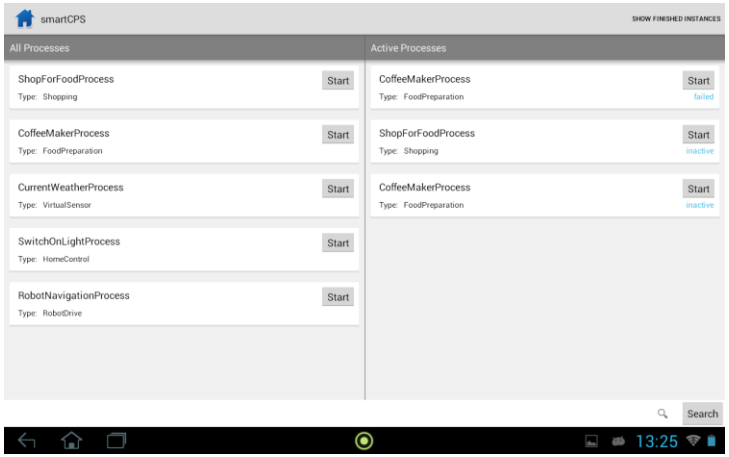

https://github.com/IoTUDresden/proteus

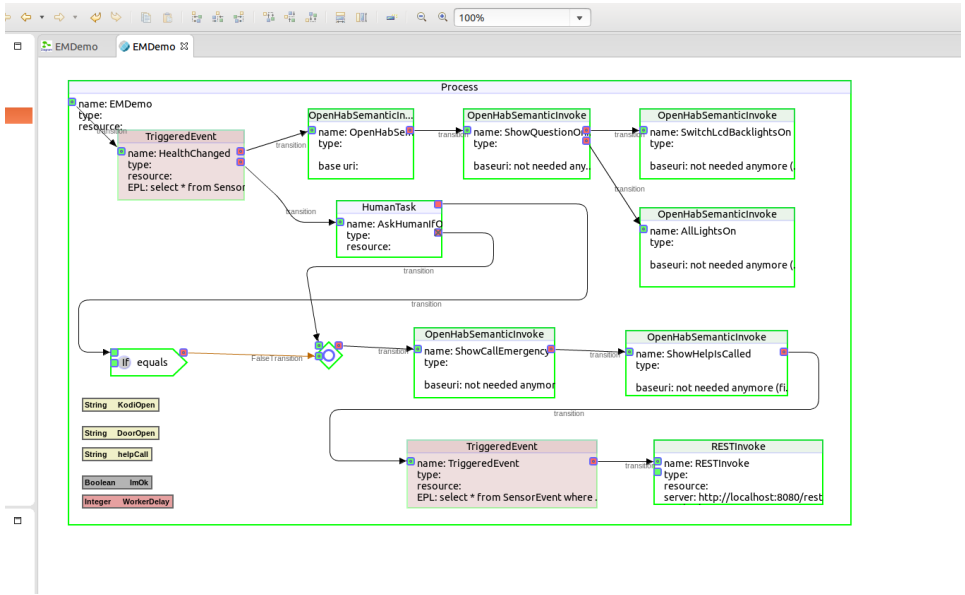
# The Modelling Tool [SKN+13,SKN+14]



# Process Visualization and Control [SHS16,SLS+16]



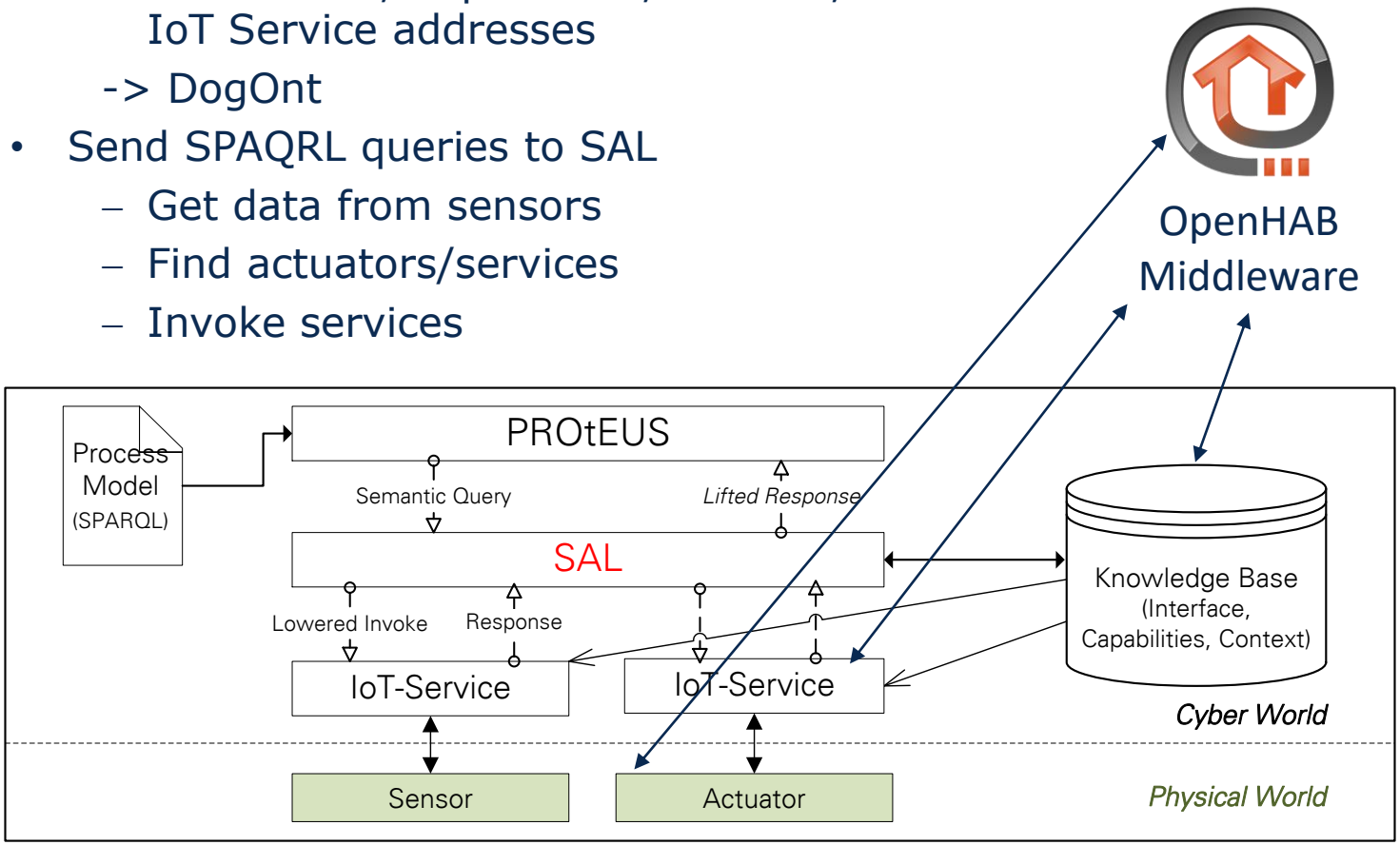



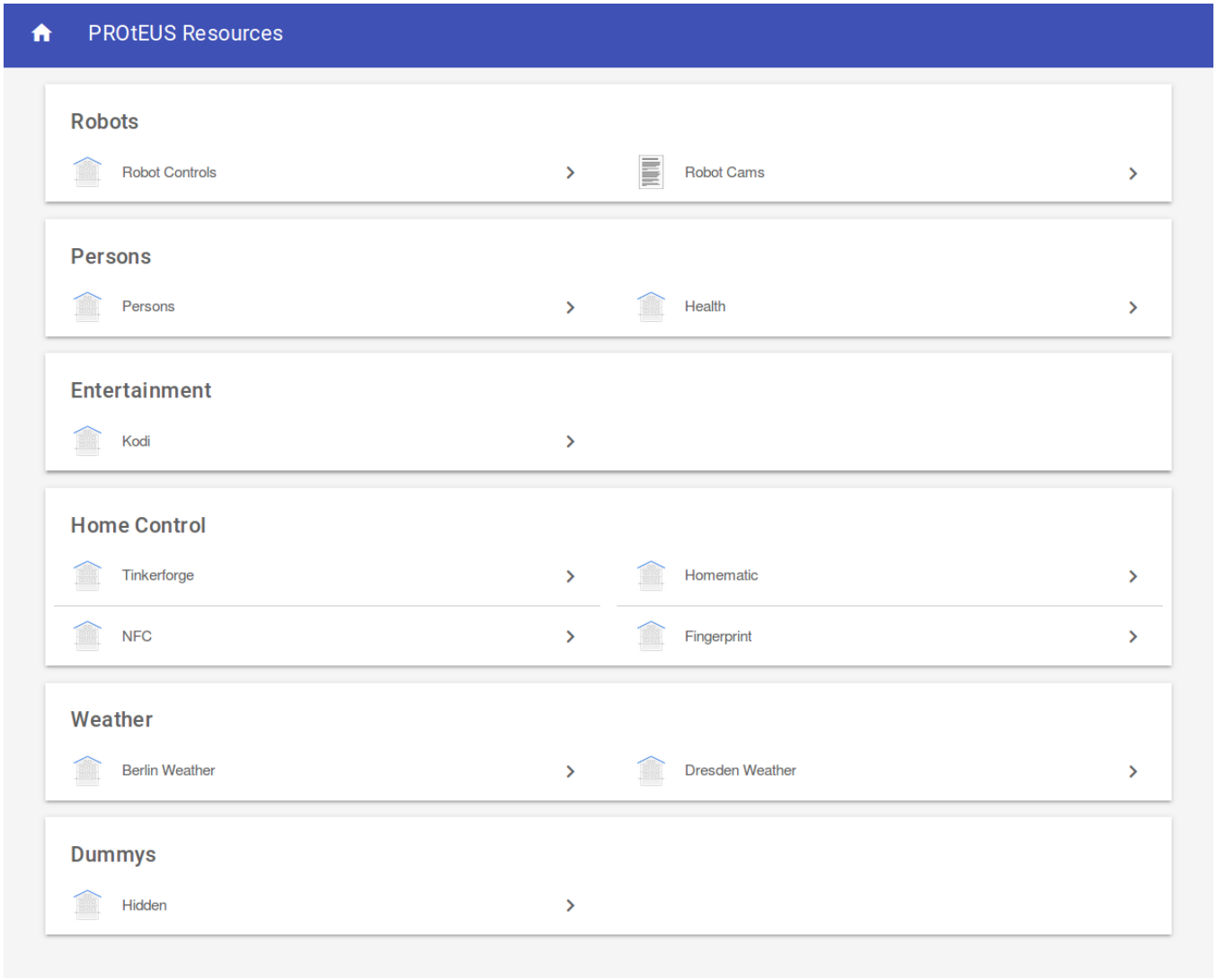
# Semantic Access Layer (SAL) [HSK+16a, HSK+16b]

- Find services at runtime
- Knowledge base contains
  - IoT devices, Capabilities, Context, IoT Service addresses

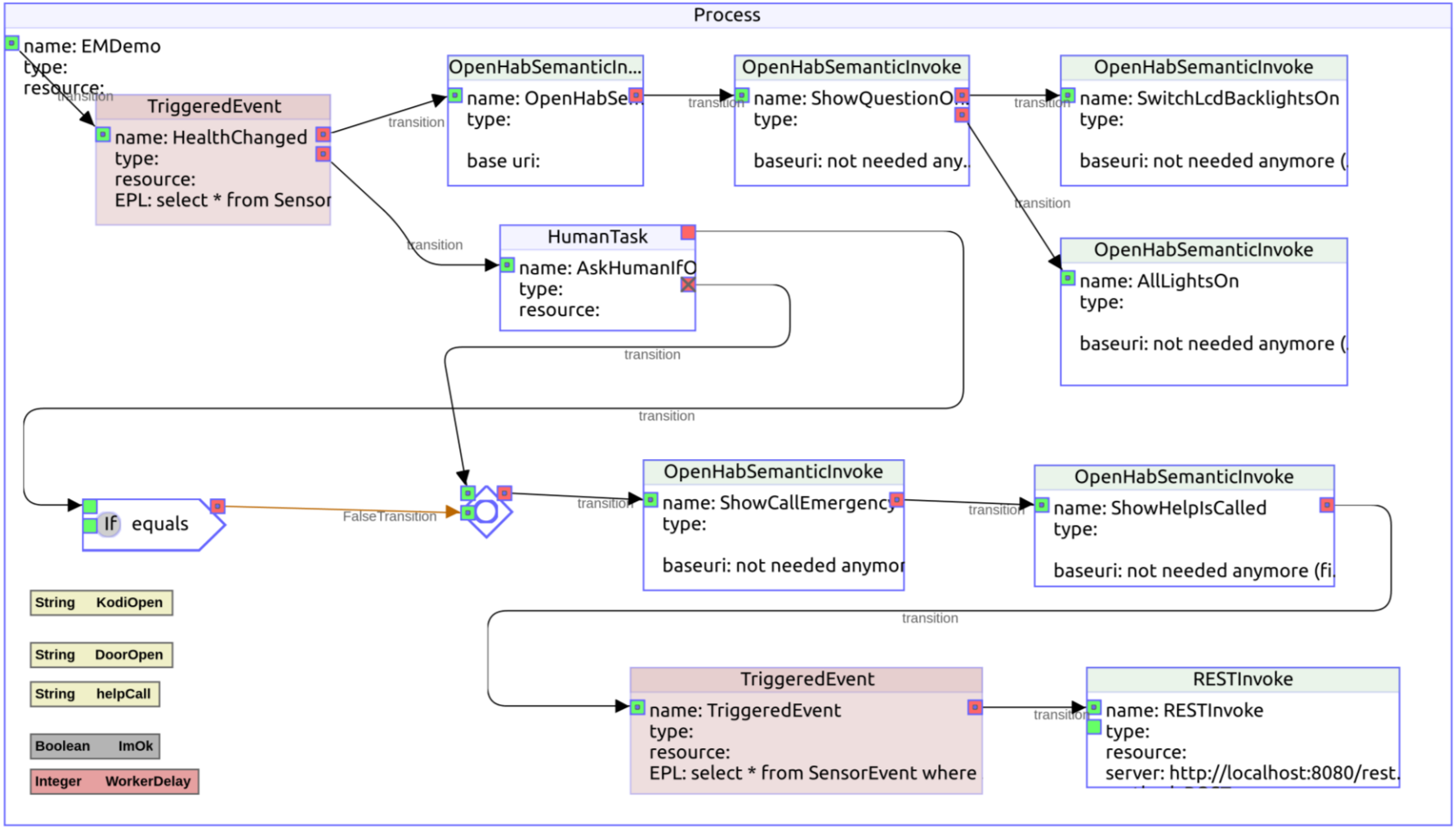
  -> DogOnt
- Send SPAQRL queries to SAL
  - Get data from sensors
  - Find actuators/services
  - Invoke services



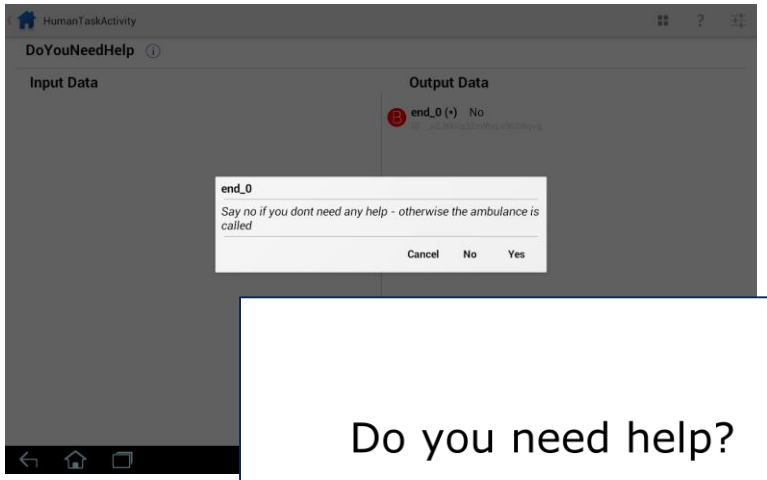
# OpenHAB Middleware with SAL



# Process 1: Emergency



# Process 1: Emergency

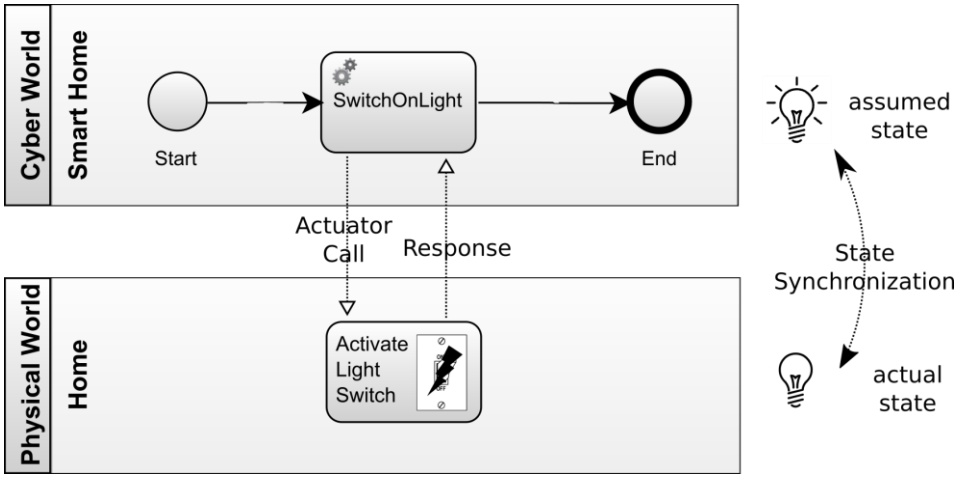

Do you need help?

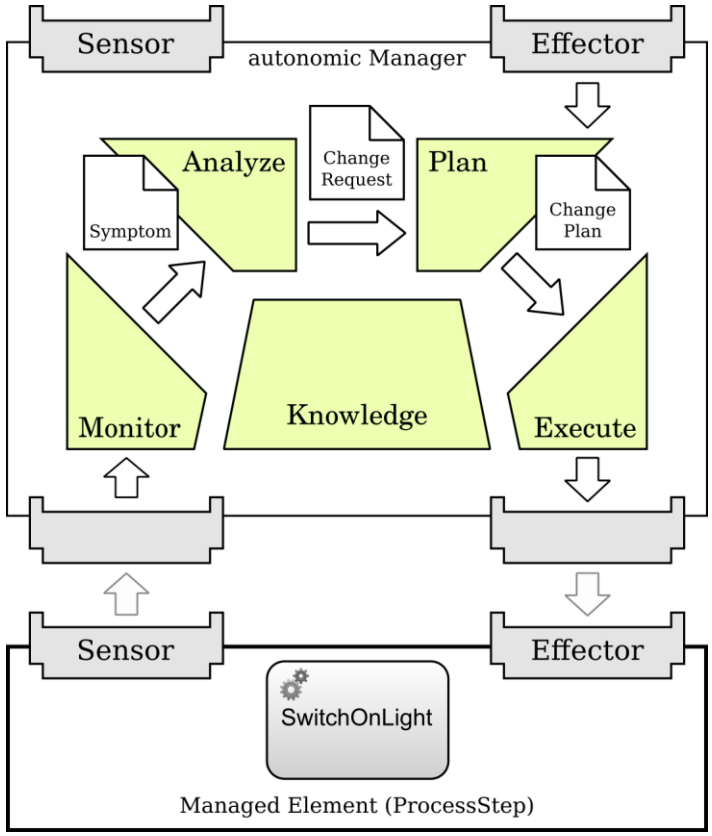


Automatic Emergency Call

# Process 1: Emergency - Video

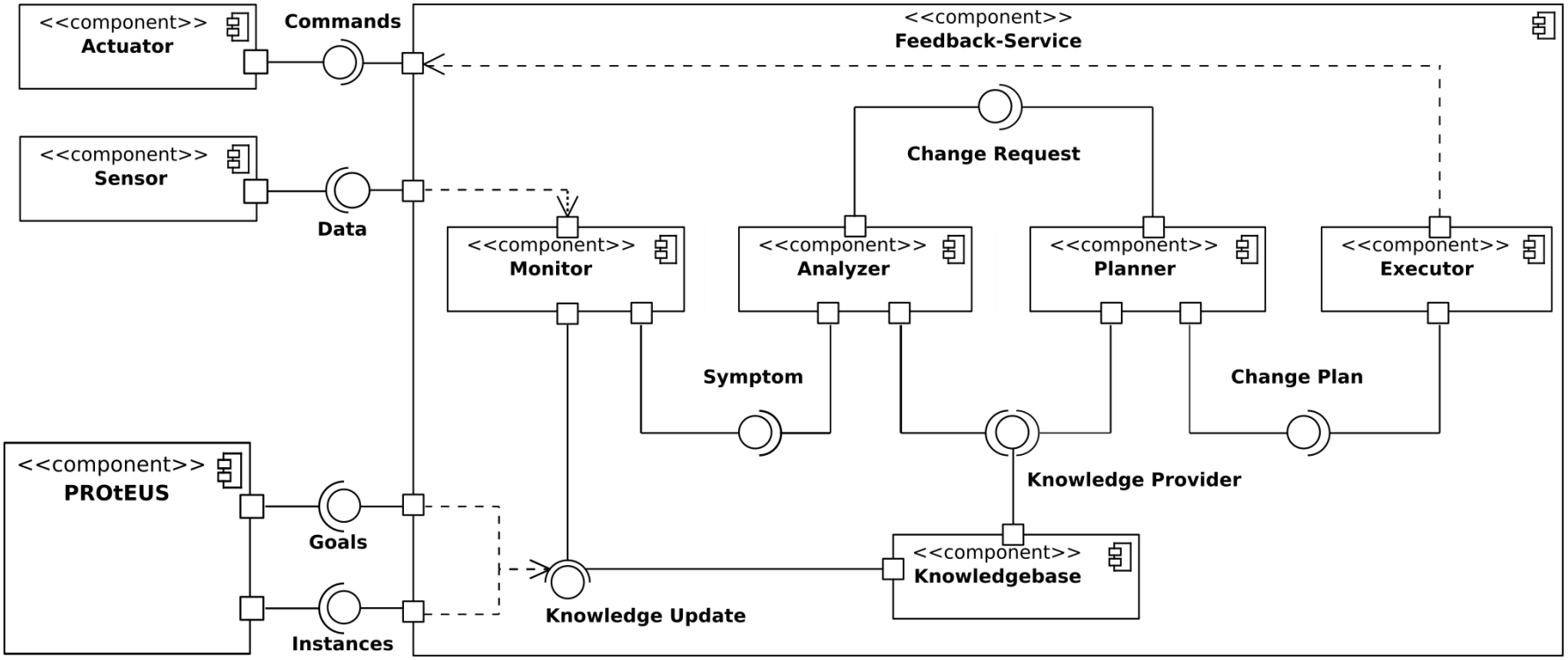
# CPS Feedback Loop [SHH+16,Sei15]




- Model: Goal with Subjectives
  - Context Path (Sensors)
  - Satisfied assertion
  - Compensate assertion
- **M**onitor: data from context path
- **A**naylze: check assertions
- **P**lan: find alternative resource
- **E**xecute: execute compensation
- **K**nowledge Base

# Feedback Service [SHH+16]




https://github.com/IoTUDresden/feedback-service

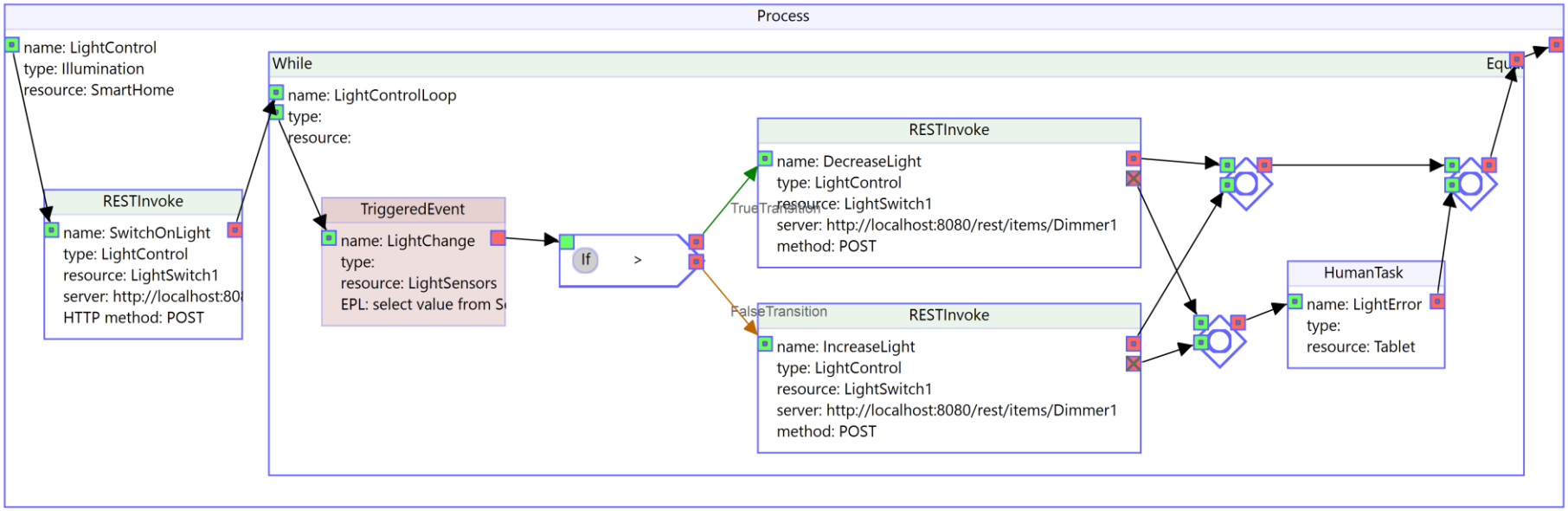
# Process 2: Light Control

- Goal with Objectives
- Context path: path to sensors
- Satisfied assertion: fulfillment of goal
- Compensate assertion: error

```
MATCH ( kitchen ) –[: instanceOf]–>(room)
MATCH ( light ) –[: instanceOf]–>(sensor )
MATCH ( light ) –[: isIn]–>(kitchen )
RETURN light . value AS lightIntensity
```

#lightIntensity > 865

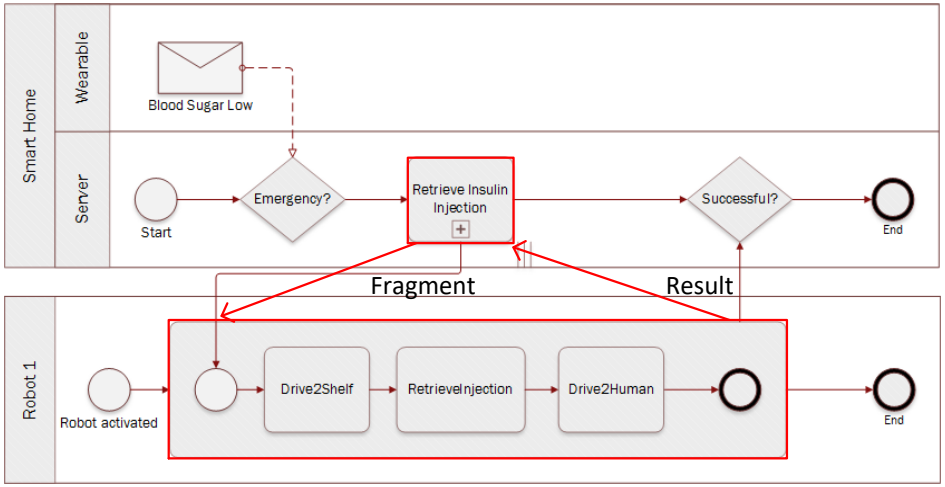
#objective . created . isBefore(#now. minusSeconds (5))

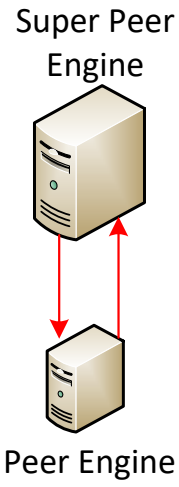


# Process 2: Light Control - Video

# Process 3: Service Robots

- Distributed process execution
- Deploy subprocess on service robot
- Use MAPE-K loop to monitor state of robot
  - Battery levels
  - Liveliness signals
  - Process states
- Redeploy subprocess on other roboter

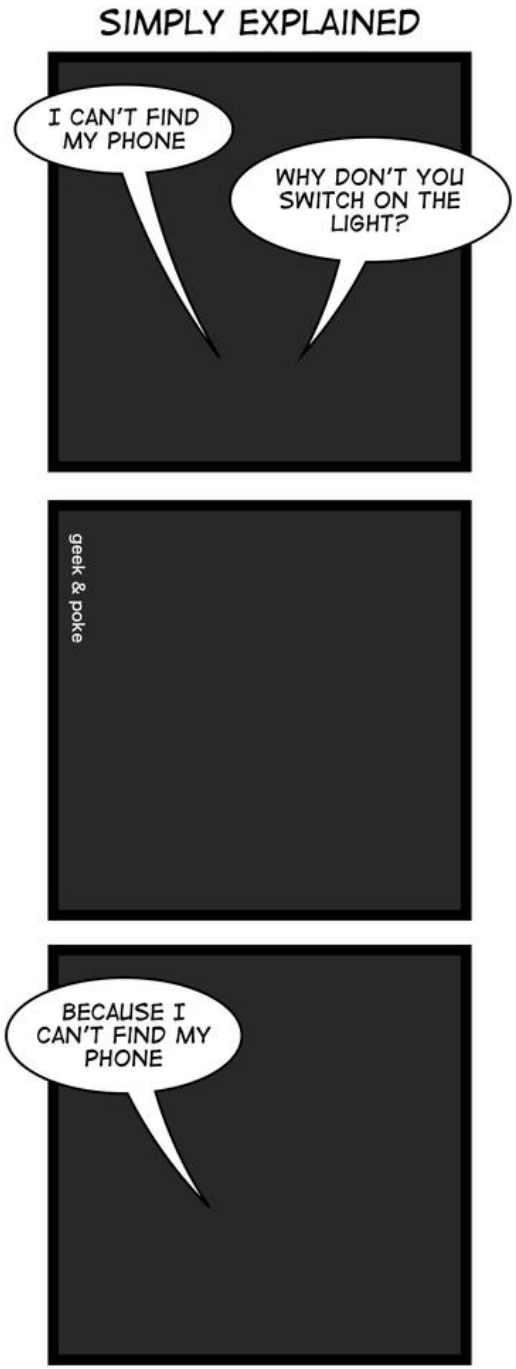



# Process 3: Service Robots - Video

- PROtEUS++: Workflow Engine for IoT/CPS
- Semantic Access Layer (SAL)
  - Dynamic service discovery (queries to Knowledge Base)
- MAPE-K Feedback Service
  - Correlate execution to physical effects
  - Find alternative resources in case of errors

  -> Self-healing / self-management for workflows

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# Publications (1)

**[SKN+13]** Modelling Complex and Flexible Processes for Smart Cyber-Physical Environments. Proceedings of 25th European Modeling and Simulation Symposium (EMSS). Athens, Greece, 25-27 Sept 2013, pp. 73 - 82.
Ronny Seiger, Christine Keller, Florian Niebling, Thomas Schlegel

**[SKN+14]** Modelling Complex and Flexible Processes for Smart Cyber-Physical Environments. Journal of Computational Science (JOCS), 2014. ISSN 1877-7503,
Ronny Seiger, Christine Keller, Florian Niebling, Thomas Schlegel

**[SHS15]** PROtEUS: An Integrated System for Process Execution in Cyber-physical Systems. 16th International Conference on Business Process Modeling, Development, and Support (BPMDS), 2015, Stockholm, Sweden, June 8-9, 2015.
Ronny Seiger, Steffen Huber, Thomas Schlegel

**[SHS16]** Towards an Execution System for Self-healing Workflows in Cyber-physical Systems. Journal on Software and Systems Modeling (SoSyM), Special Issue for BPMDS 2015.
Ronny Seiger, Steffen Huber, Thomas Schlegel

Steffen Huber, Ronny Seiger, André Kühnert, Thomas Schlegel

**[SLS+16]** An interactive mobile control center for cyber-physical systems. Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct.

Ronny Seiger, Diana Lemme, Susann Struwe, Thomas Schlegel

**[HSK+16a]** Using Semantic Queries to Enable Dynamic Service Invocation for Processes in the Internet of Things. 10th IEEE Conference on Semantic Computing (ICSC), Laguna Hills, USA, February 3-5, 2016.
Steffen Huber, Ronny Seiger, André Kühnert, Thomas Schlegel

# Publications (2)

**[HSK+16b]** Goal-based Semantic Queries for Dynamic Processes in the Internet of Things International Journal of Semantic Computing.
Steffen Huber, Ronny Seiger, André Kühnert, Vasileios Theodorou, Thomas Schlegel

**[HSK+16c]** A context-adaptive workflow engine for humans, things and services. UbiComp '16 Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct .

**[Sei15]** Modelling and Execution of Consistent and Distributed Workflows for Cyber-physical Systems. Doctoral Consortium of the 13th Conference on Business Process Management (BPM 2015), Innsbruck, Austria, August 30, 2015.
Ronny Seiger

**[SHH+16]** Enabling Self-adaptive Workflows for Cyber-physical Systems. 17th International Conference on Business Process Modeling, Development, and Support (BPMDS), 2016, Ljubljana, Slovenia.
Ronny Seiger, Steffen Huber, Peter Heisig, Uwe Aßmann

**[SNS14]** A Distributed Execution Environment Enabling Resilient Processes for Ubiquitous Systems. Pervasive Computing and Communications Workshops (PERCOM Workshops), 2014 IEEE International Conference on , pp. 220 - 223, 24-28 March 2014.
Ronny Seiger, Florian Niebling, Thomas Schlegel

**[SHS17]** An Execution System for Self-healing Workflows in Cyber-physical Systems. Proceedings of Software Engineering 2017. Lecture Notes in Informatics (GI). 2017
Ronny Seiger, Steffen Huber, Thomas Schlegel

**[SSM+14]** A Resilient Interaction Concept for Process Management on Tabletops for Cyber-Physical Systems. In International Conference on Human Interface and the Management of Information (pp. 347-358). Springer International Publishing. 2014

Ronny Seiger, Susann Struwe, Sandra Matthes, Thomas Schlegel