

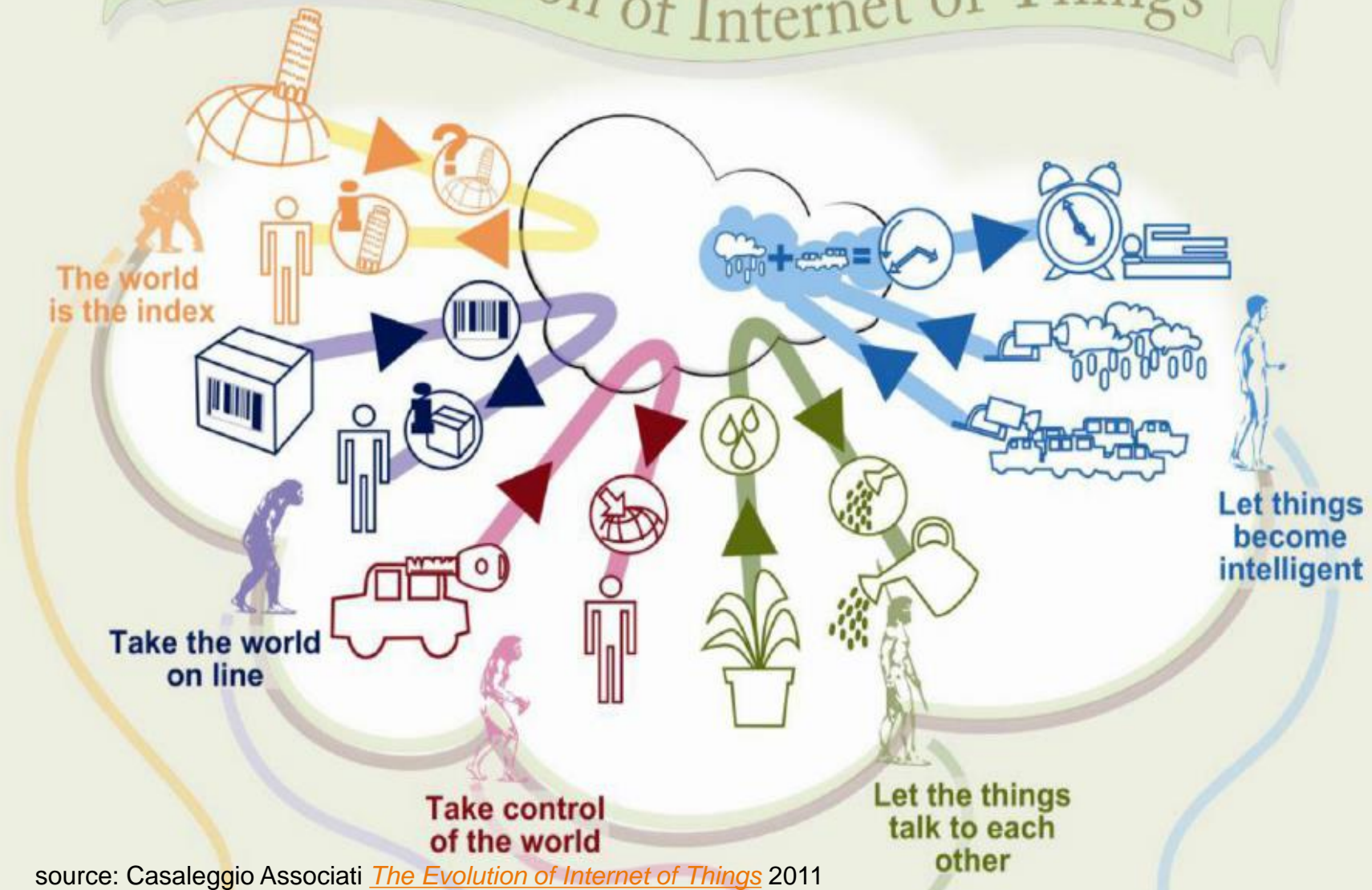
ICSI, March 2015, Berkeley

From the Internet of Things to a Web of Systems

Florian Michahelles

CASALEGGIO ASSOCIATI
STRATEGIE DI RETE

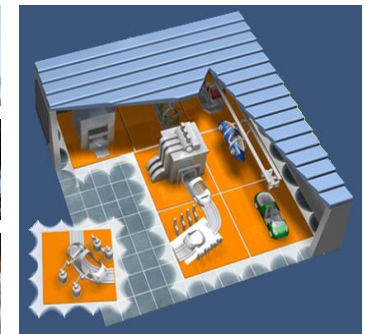
The Evolution of Internet of Things



source: Casaleggio Associati [The Evolution of Internet of Things](#) 2011

WoS is the combination of the ubiquitous internet and decentralized intelligence in industrial domains

WoS is the combination of internet of things with smart networked devices and domain know how



- Internet protocol
- Web technologies

- Local intelligence
- Local analytics
- Interacting
- "Apps"

- Domain-specific tasks
- Domain-specific properties
- Domain Know How
- Semantic

Internet of Things

+

Smart Networked Devices

+

Domain Context

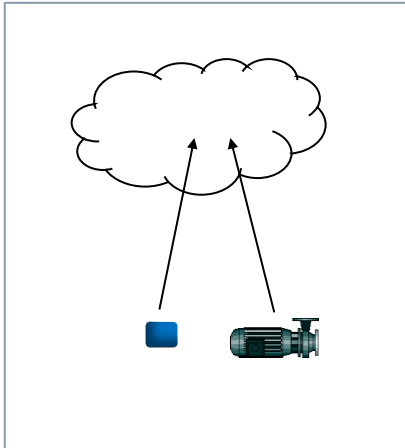
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Web of Systems

Different types of Web of Systems

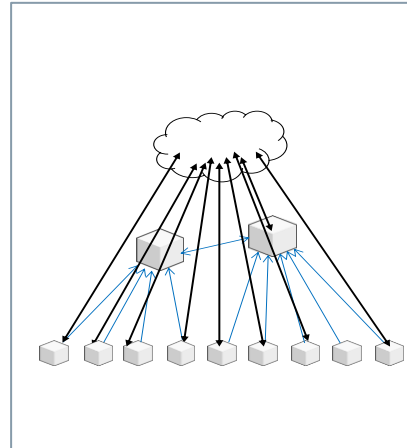
Enabler for brown field and green field approaches

Web of Systems - From Connectivity to a Web of Smart Networked Systems and Devices



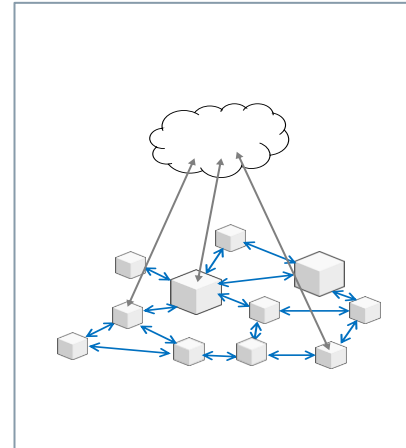
1) 'Connected Systems'

IP-connected devices (sensors, actuators...), supplying "big data" to a central IT system.



2) 'Smart Systems'

Intelligence in the micro controllers of Smart Networked Devices communicating via web-services with a common semantic.
Create added value through local intelligence.



3) 'Interacting Systems'

A mesh of interacting Smart Networked Devices creating self-aware Smart Networked Systems, potentially a "digital twin".
Decentralized, distributed intelligence



4) 'App-powered Systems'

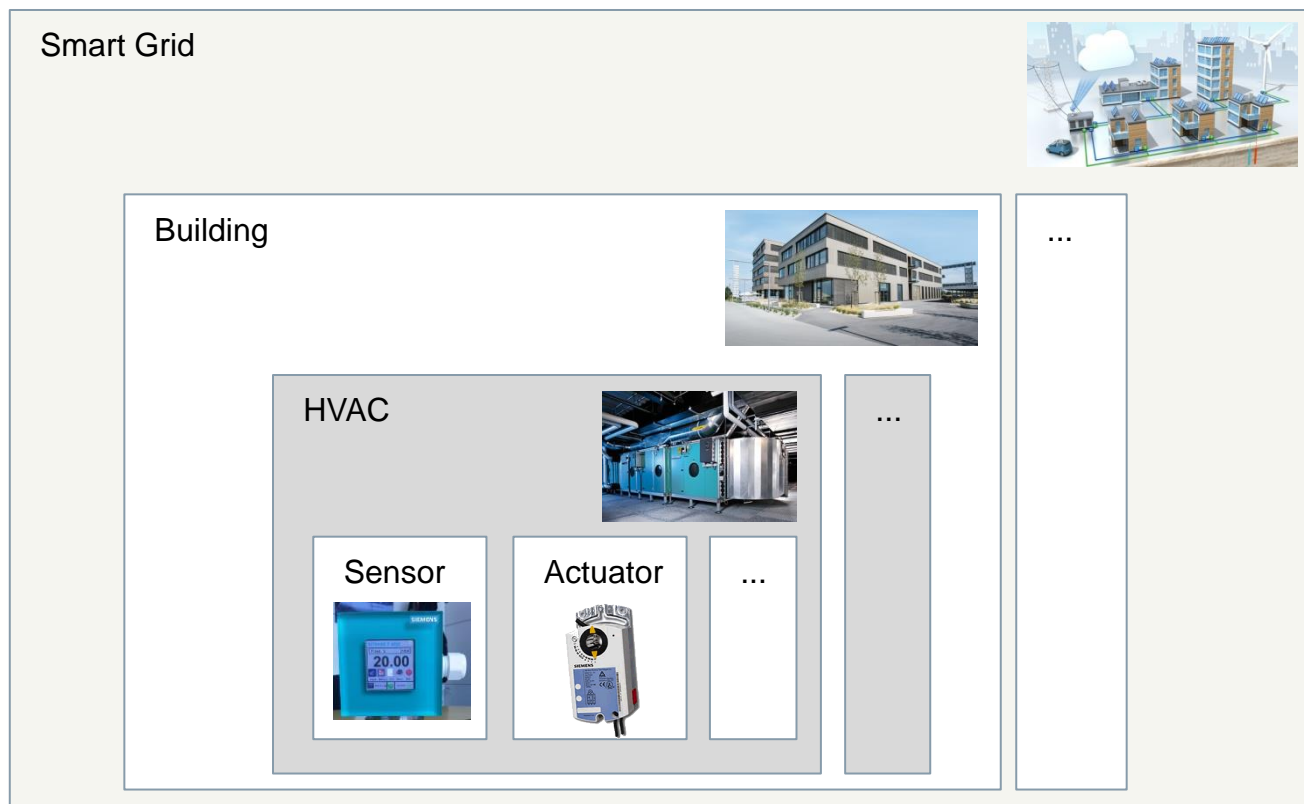
Enhance products by offering Services for e.g. extended features
Additional opportunities along the Life Cycle.

Internet of Things

Web of Systems

What exactly are the "things" in the Web of Systems?

"Fractal" view on Things – an example



Is every product/system a "thing"?

- A thing can be a small sensor or a large building, depending on the viewpoint and task
- Not every small sensor needs to be a "thing" (i.e. act in the WoS)

WoT: Web of Systems

Agenda

Introduction

About us

Projects

conclusions

Research Team Web of Things

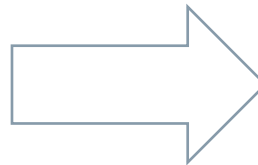
Research Silicon Valley

- Internet Technologies
 - Consumerization
 - App ecosystems
 - OpenFlow
- Web Technologies
 - Web Services
 - Web Architecture
 - Semantic Web
- Central Programs and Industry Initiatives

Emerging Technologies

- Human-robot modelling
- Wearable Sensing
- Activity Streams

Share your ideas with us



Let's grow together

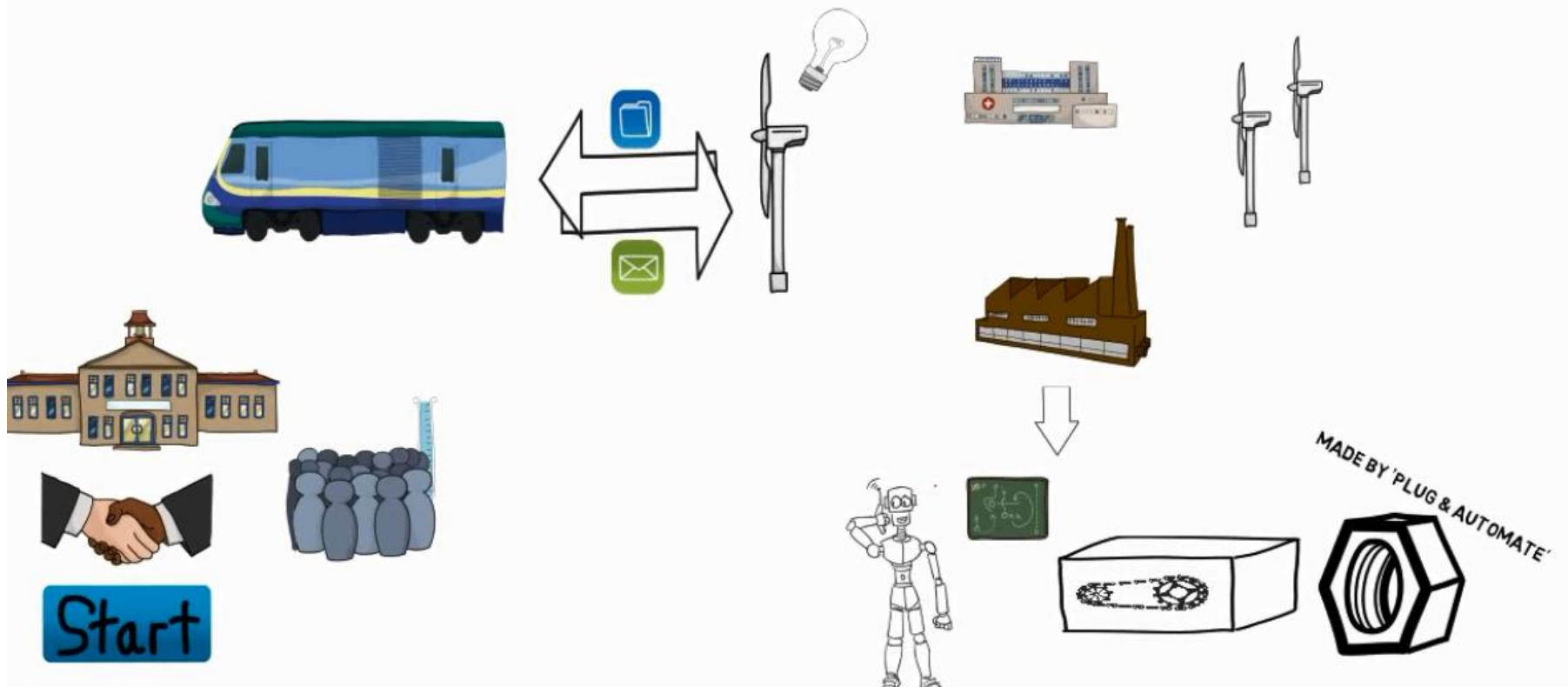


Web of Things (WoT) Research Group
Leveraging emerging data sources of web-connected devices



Together with academic partners, startups and corporate research groups we explore the application of web technologies to Siemens business fields.

WOT'S UP@SIEMENS?



The Internet of Things should leverage web technologies for...

Digital World



1. ...embedding **sensing/acting, connectivity, and processing** into objects.
2. ...designing objects with the **characteristics and paradigms of the web**.
3. ...incorporating **applications/control** - also from **third parties**.



Agenda

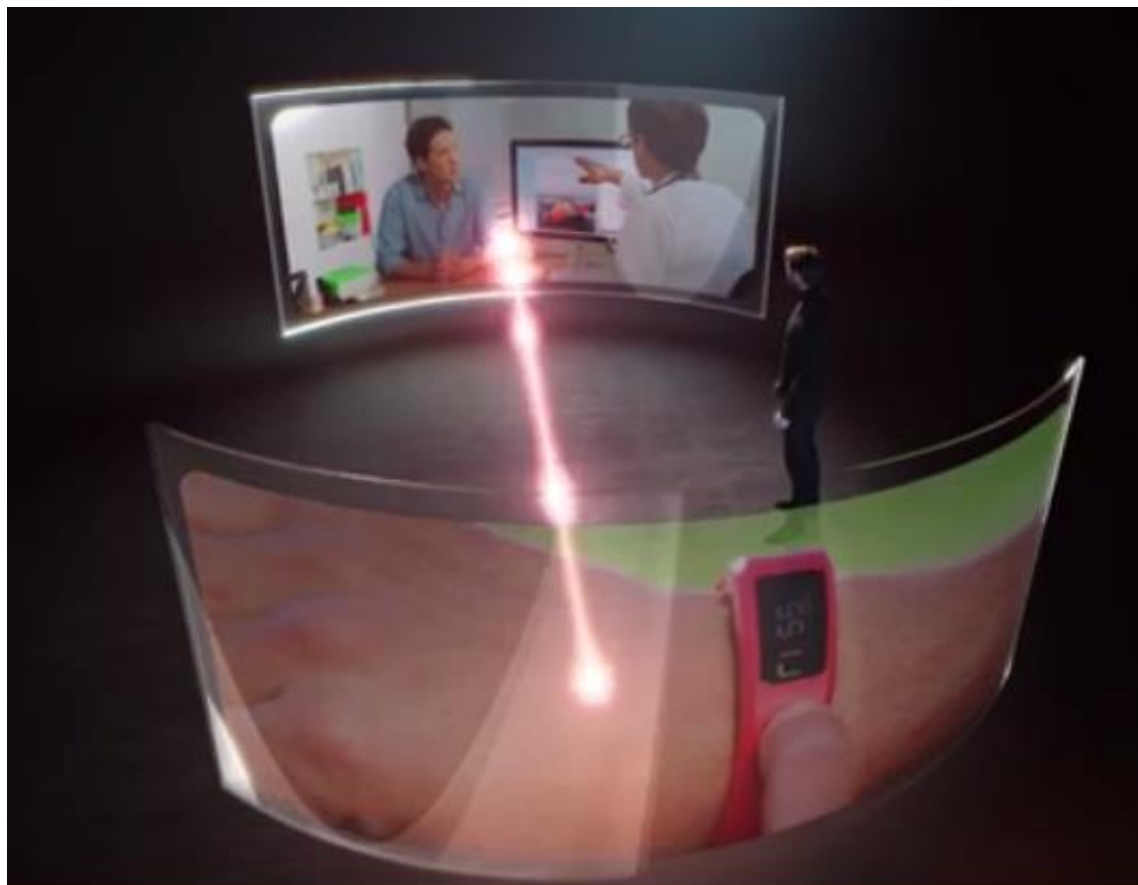
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About us

Projects

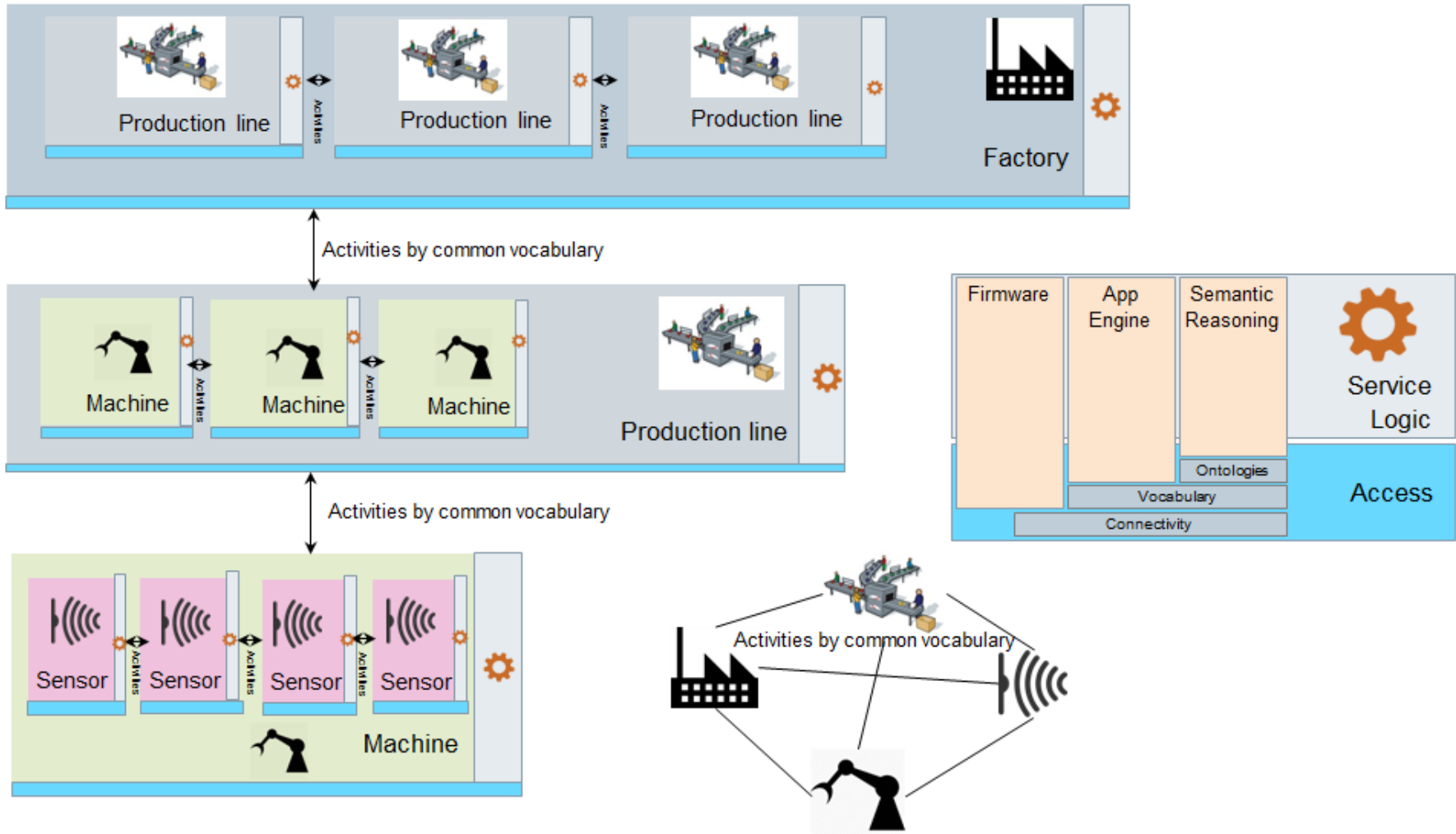
Conclusions

The missing link (movie)



<https://www.youtube.com/watch?v=qx8YAzZwWGU>

In order to make machines responsive they have to be able to communicate across device levels.

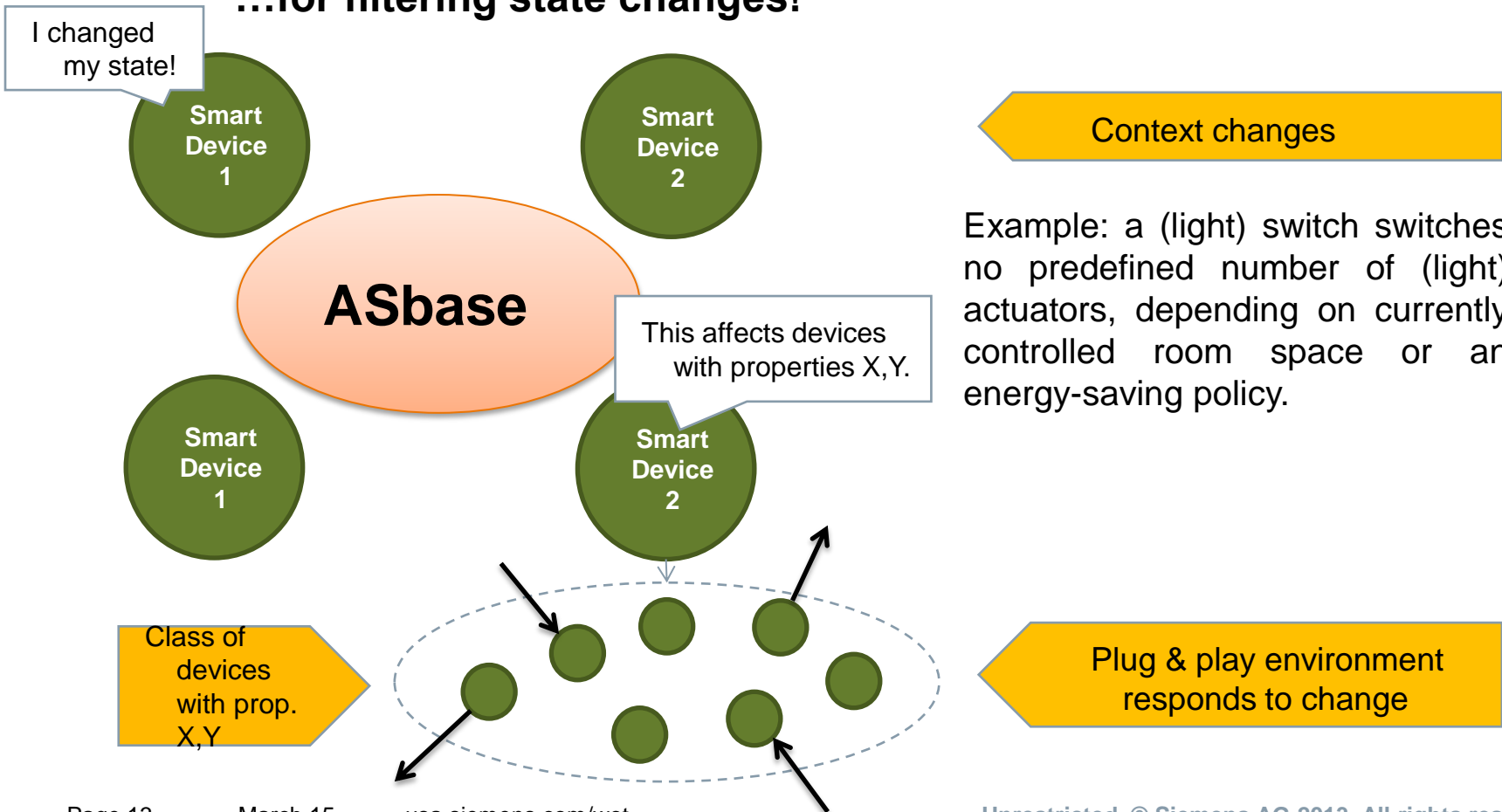


Semantically Enriched Events Brokerage

Slide credits: Darko ;-)

Brokering events in semantically enriched Web of Things environments

...for filtering state changes!



ASbase: An AS-based Event Broker

Activity Streams (AS)

- Origins in social media platforms, adopted in other fields (e.g., software project management)
- We use them for **more general events** by defining extension properties
 - “New health data has become available!”
 - “The robot has picked up object X!”

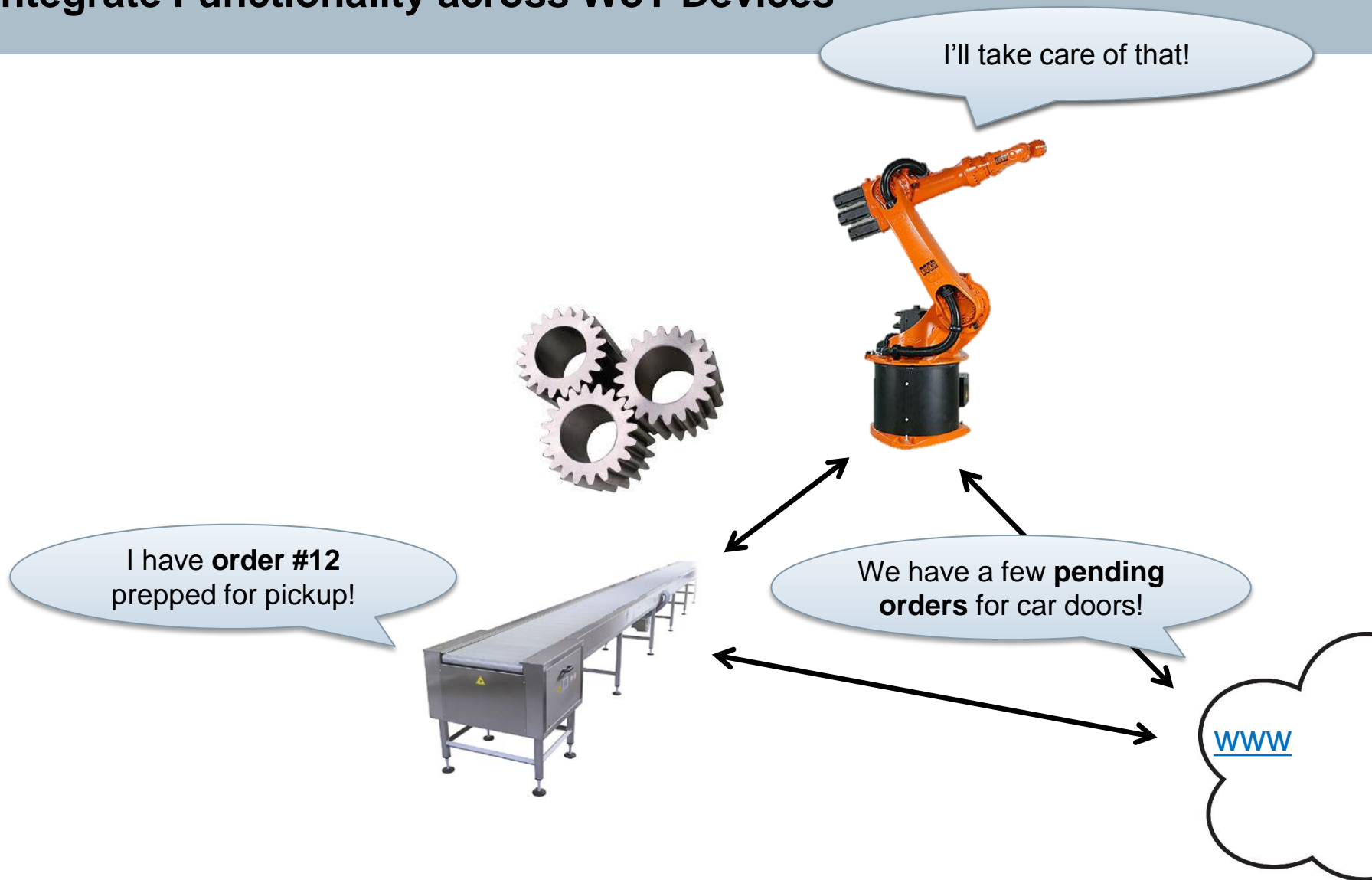
ASbase

- Consumes events in the Activity Streams format
- Supports both **request/response** and **publish/subscribe** patterns
- Clients can query and subscribe using a **filtering mechanism** (based on MongoDB querying)
- Prototype online, first client interactions <http://russet.ischool.berkeley.edu:8080>

Goal: Applicability to a broad range of Siemens businesses

- Make it **flexible, sturdy, and (re)usable**: Many different use cases and lots of testing!

Integrate Functionality across WoT Devices



Embed semantic functional service descriptions in smart things representations



What?

Describe what a service does

How?

Describe service API

Given **coordinates** in my workspace, I can **pick up an object** at that location!



Object Coordinates

Object picked up

Send HTTP PUT to robot.net

Precondition → *Postcondition* ∧ *Service Request*

What?

Describe what a service does

How?

Describe service API

Given **coordinates** in my workspace, I can **pick up an object** at that location!

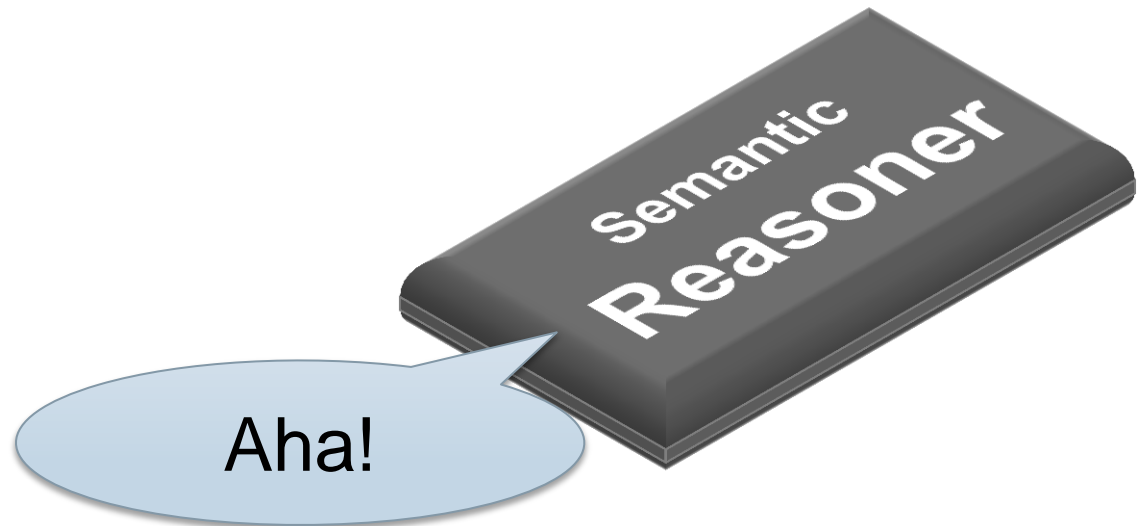


Precondition → *Postcondition* \wedge *Service Request*

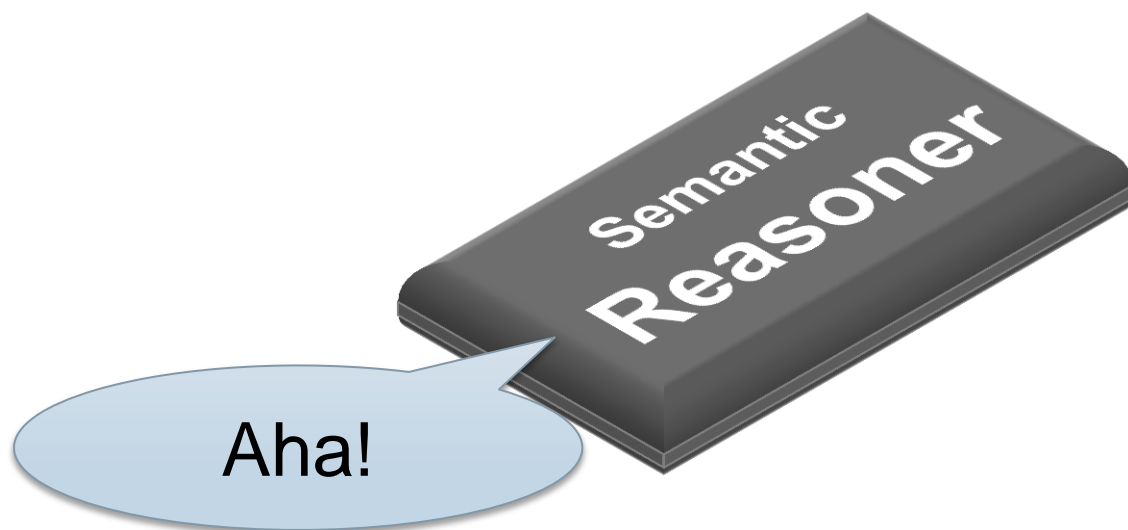
Semantic **reasoning engines** can process these descriptions and **automatically combine services** to achieve a user goal



Semantic Metadata



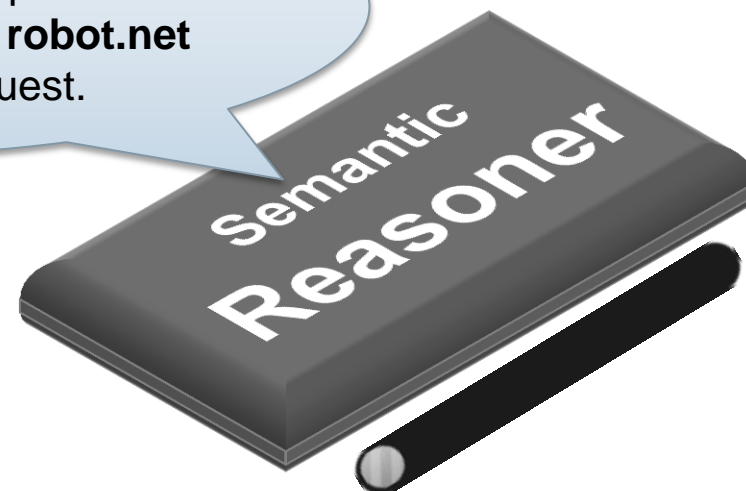
This enables the **goal-driven configuration** of smart environments!



I want the robot to
hold the car door.



Send an **HTTP GET** request to
carDoor.net to obtain its position.
Next, send this position to **robot.net**
in an **HTTP PUT** request.



Responsive Machines: Teaching Collaboration

Universal Robotics UR5

Environment Representation

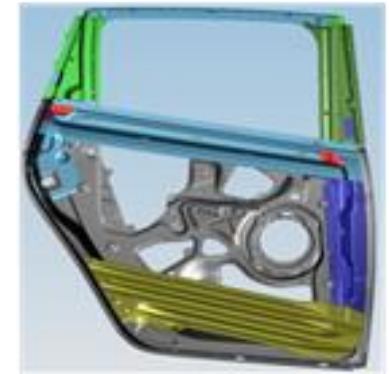
- Modeling as **semantic facts**
- Robot **reacts** to environmental cha

Human-Robot Collaboration

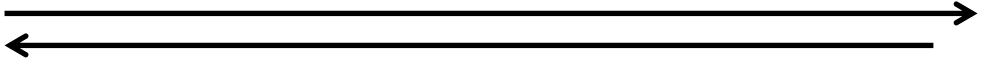
- Human kinematic model



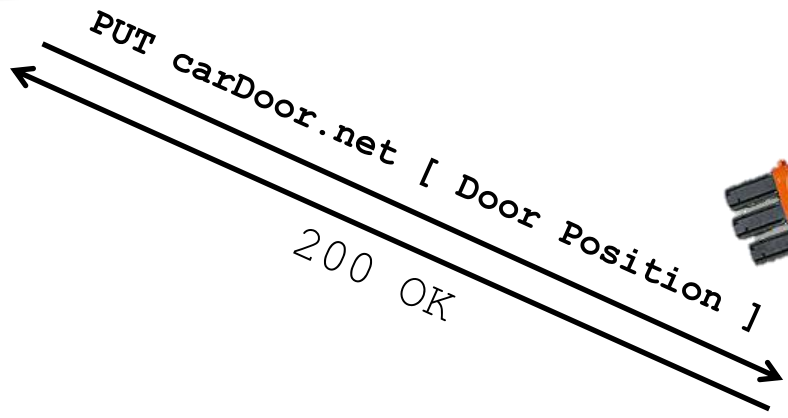
I want the robot to hold the car door.



GET carDoor.net



200 OK [Door Position]



PUT carDoor.net [Door Position]

200 OK

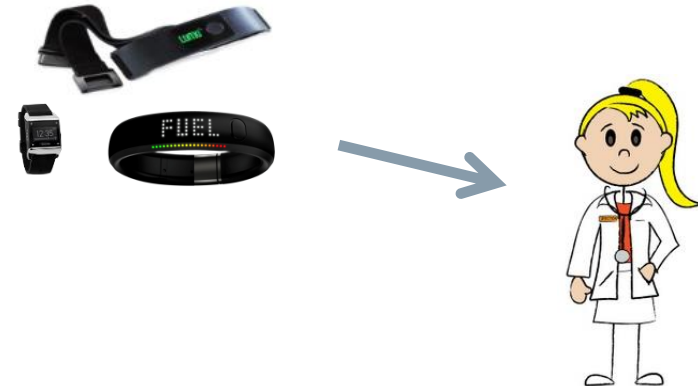


The ASbase Project

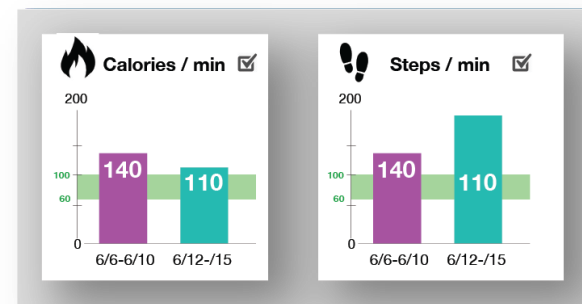
Goal: Facilitate **integration of heterogeneous data sources, algorithms, and consumers**

Example: Personal Healthcare

- Wearables supply health/wellness data about patients
- Doctors can use this data in the diagnosis process
- Need for **selecting relevant** bits of the data
 - Dependent on the patient's condition!



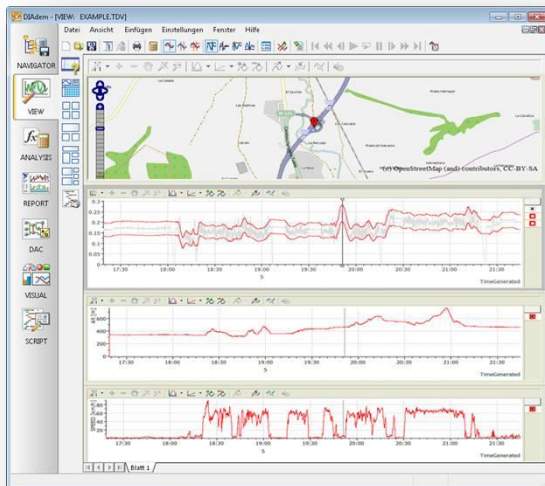
Select relevant data



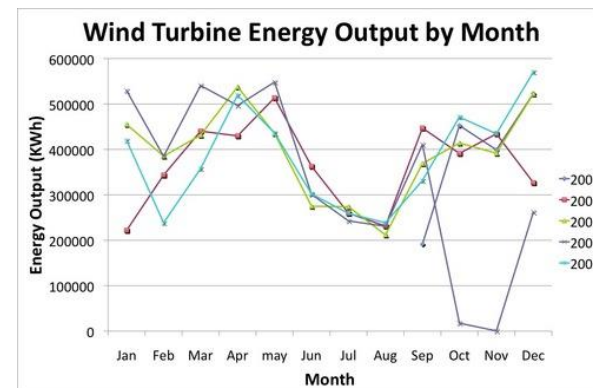
Goal: Facilitate **integration of heterogeneous data sources, algorithms, and consumers**

Example: Industrial Maintenance

- Sensors provide data streams
- Maintenance personnel can make use of this data
- Need for **selecting relevant** bits of the data
 - Dependent on the problem at hand!



Select relevant data



Agenda

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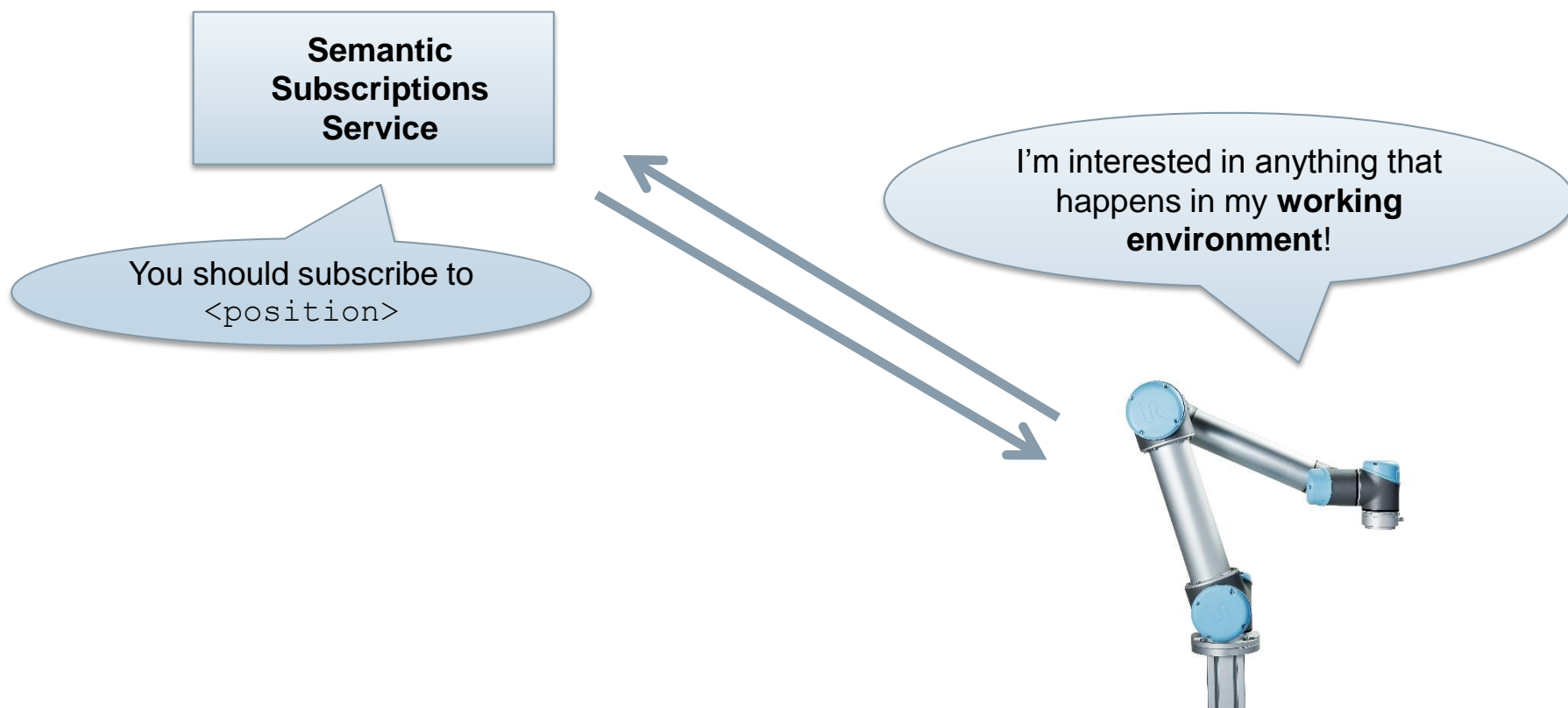
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Projects

Conclusions

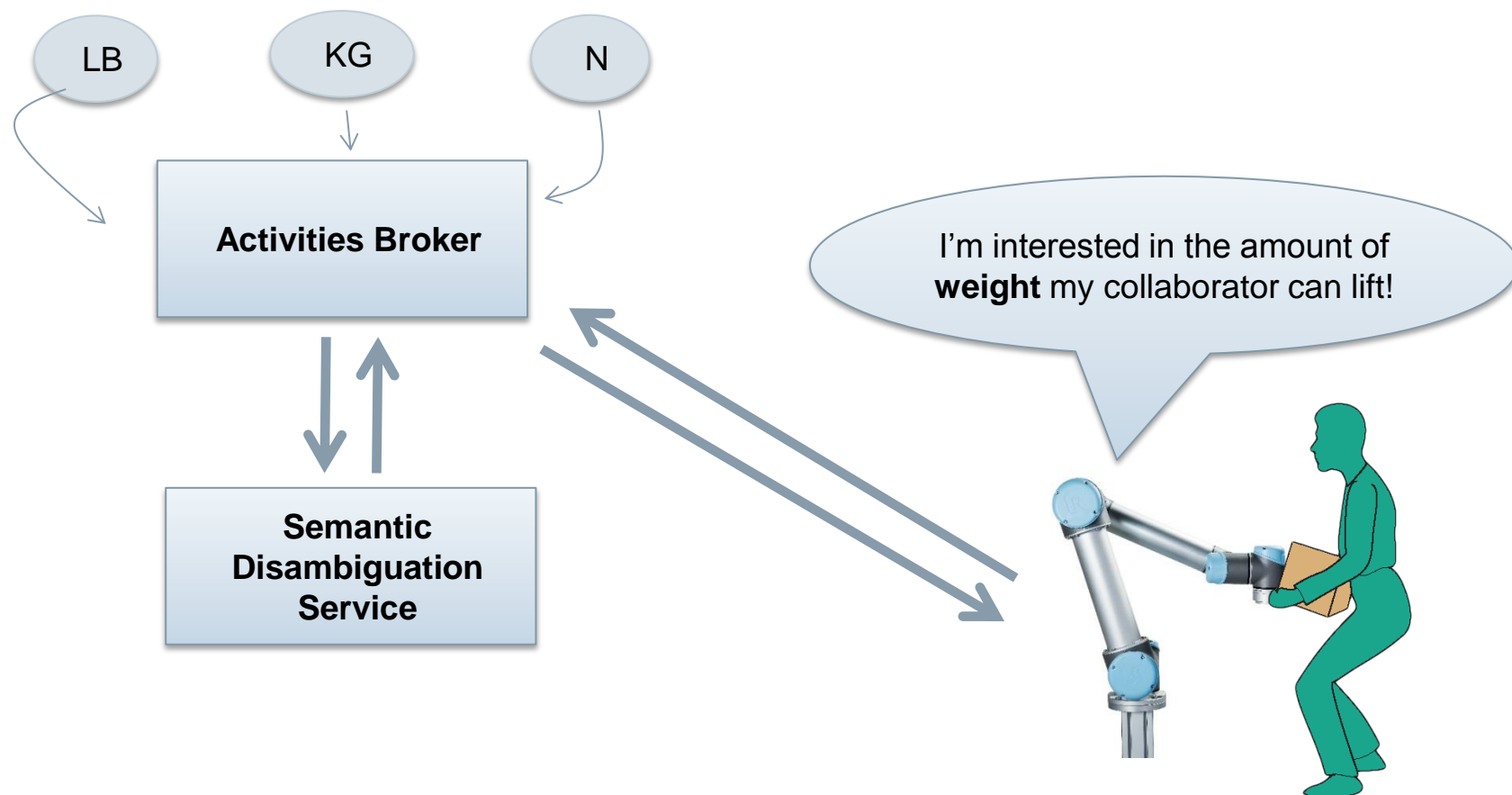
Semantically Enriched Events Brokerage

How do these “interested parties” know what to subscribe to?

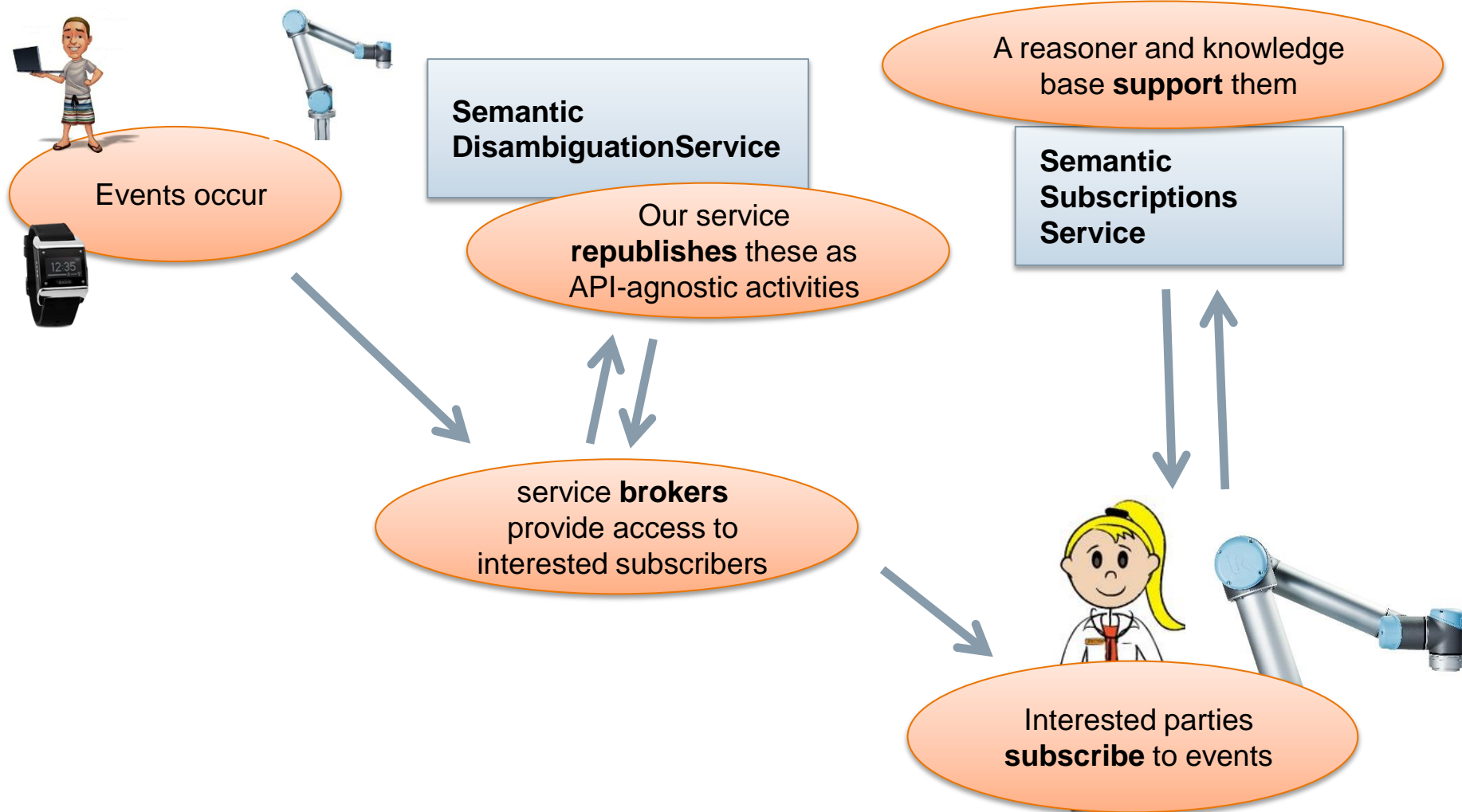


Semantically disambiguated events

How do “interested parties” work with APIs using different models or terminology?



Semantically Enriched Events Brokerage

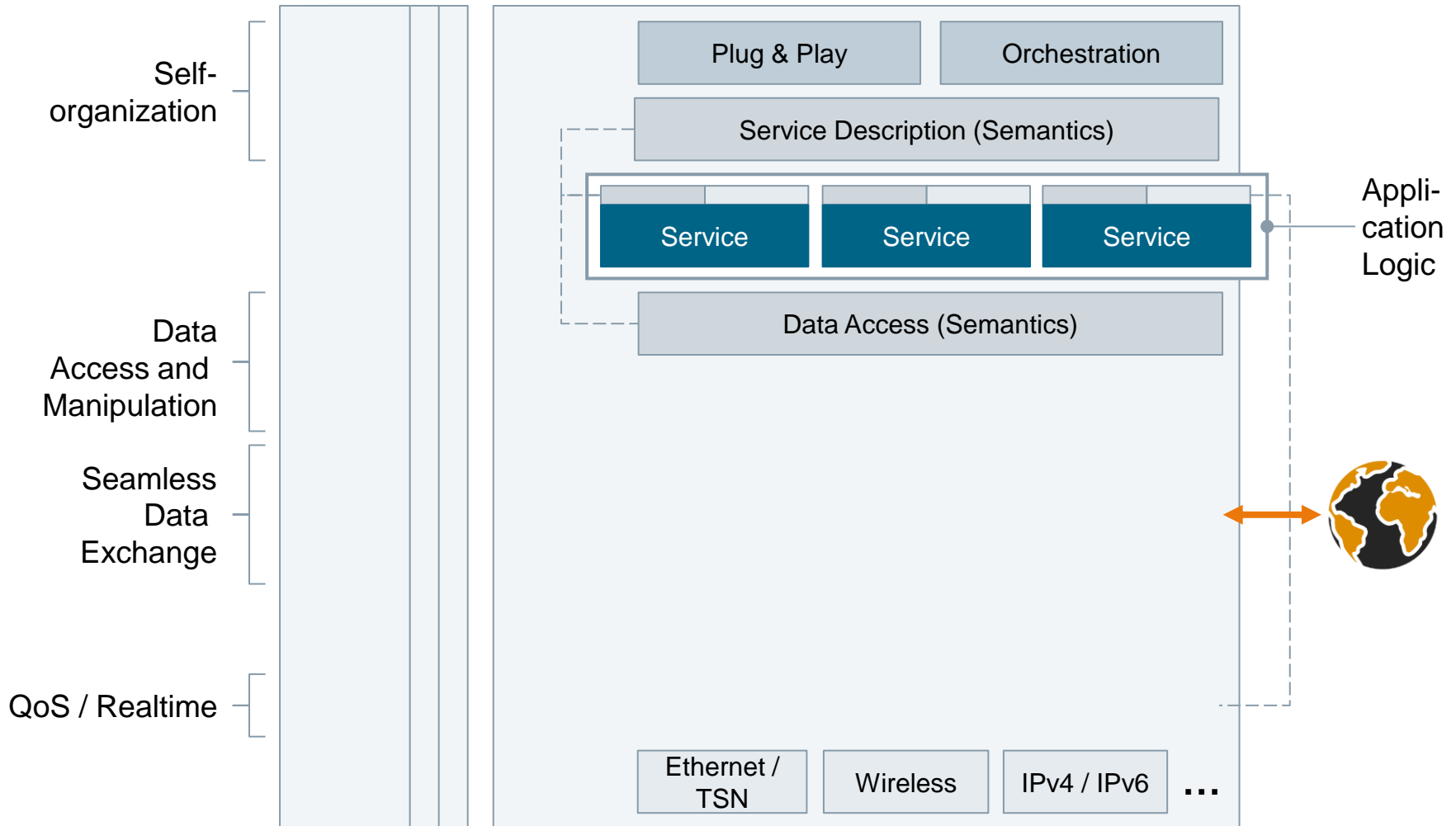


Next, the world!

- Lightweight event tracking scales nicely
- Semantic integration mediates information-heavy tasks such as disambiguation or filling in the gaps
- Neither of these is domain specific
 - Tools such as browsing would apply in any domain
 - Tools such as inferencing would apply to any model
- Future demonstrations
 - Greater complexity in semantic relationships
 - Event chaining such as task planning and execution
 - Vertical integration where agents view and use the same information in different ways

Web of Things requires a stack of technologies for smart things and applications

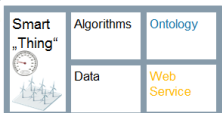
Technology: Communication Stack for Smart Things



Questions to be answered

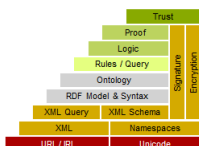
How to manage smart things with regards to...

- ...describing needs, characteristics, service offerings?
- ...establishing collaboration among devices?
- ...balancing performance, reliability and security?



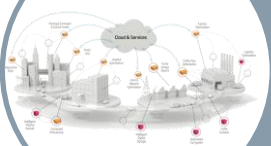
How to describe data and control in order to...

- ...enable “Plug and Automate Functionality”?
- ...mediate between data models of embedded devices?
- ...integrate vertical standards into the semantic web technology stack (e.g. RDF, OWL)?



How to leverage smart things and big data processing by...

- ...moving run-time procedures between cloud and edge?
- ...harvesting domain knowledge and context information?
- ...keeping control of determined and well defined process?



Thank you very much!

Questions?

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