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Fakultät Informatik Institut Software- und Multimediatechnik, Lehrstuhl Softwaretechnologie

Big Data in Cyber-Physical Systems (CPS)

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Courtesy to Christian Piechnick, Sebastian Richly, Max Leuthäuser,
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5G Lab Germany

Software Engineering Group

<http://st.inf.tu-dresden.de>

Oct 8, 2015



1) Cyber-Physical Systems (CPS)



http://commons.wikimedia.org/wiki/File:Traffic_seen_from_top_of_Arc_de_Triomphe.JPG

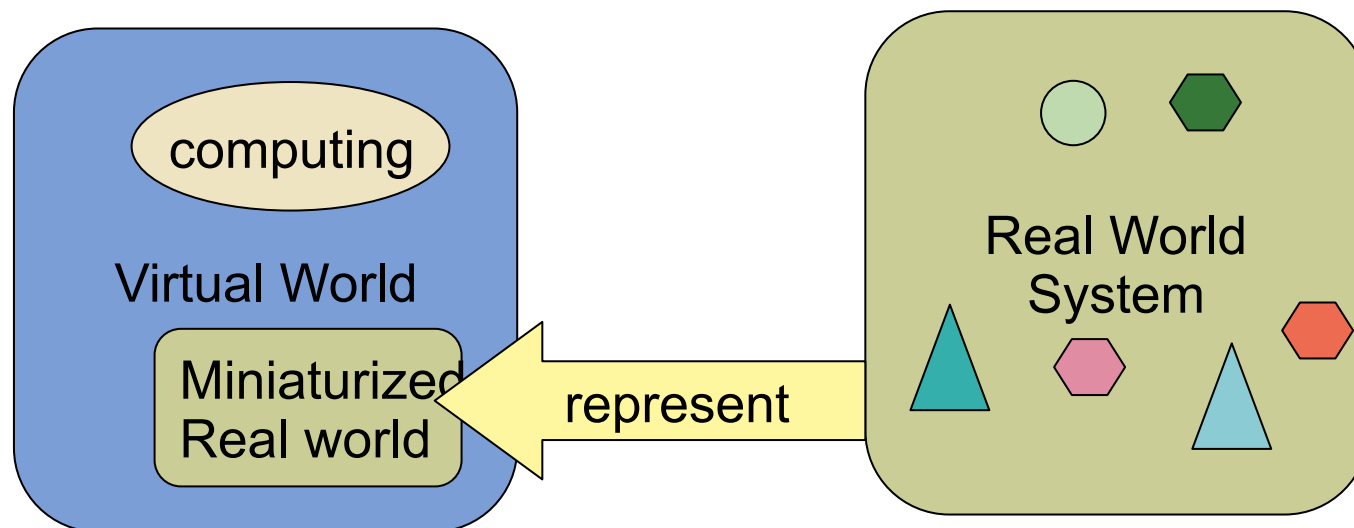


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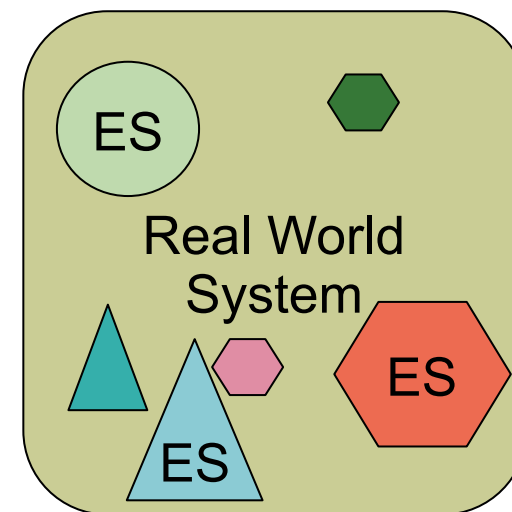
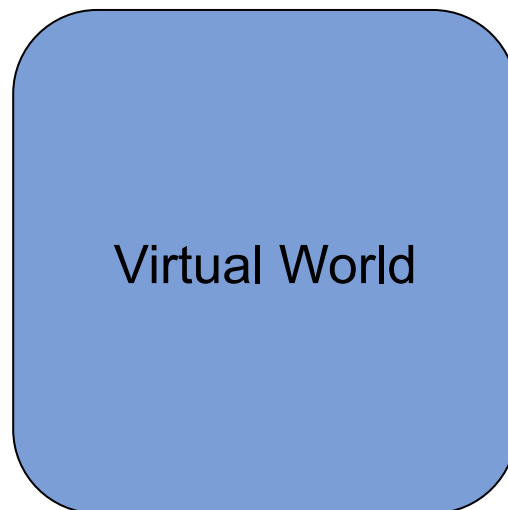
http://commons.wikimedia.org/wiki/File:Bundesarchiv_Bild_183-H0605-0007-001,_Rostock,_Ernst-Th%C3%A4lmann-Platz,_Parkplatz,_Marienkirche.jpg#mediaviewer/File:Bundesarchiv_Bild_183-H0605-0007-001,_Rostock,_Ernst-Th%C3%A4lmann-Platz,_Parkplatz,_Marienkirche.jpg

- Just search on YouTube for Kiva Systems
- <https://www.youtube.com/watch?v=8gy5tYVR-28>
- <https://www.youtube.com/watch?v=6KRjuuEVEZs>

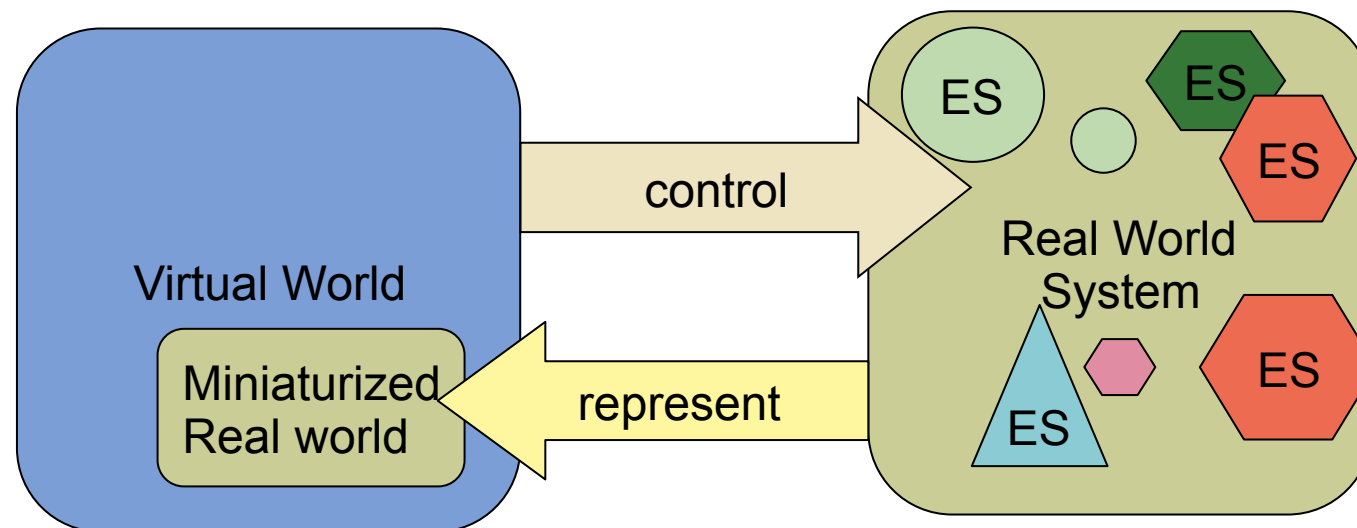
- „Standard“ Computing maps the real world into the computer and computes about it by simulation



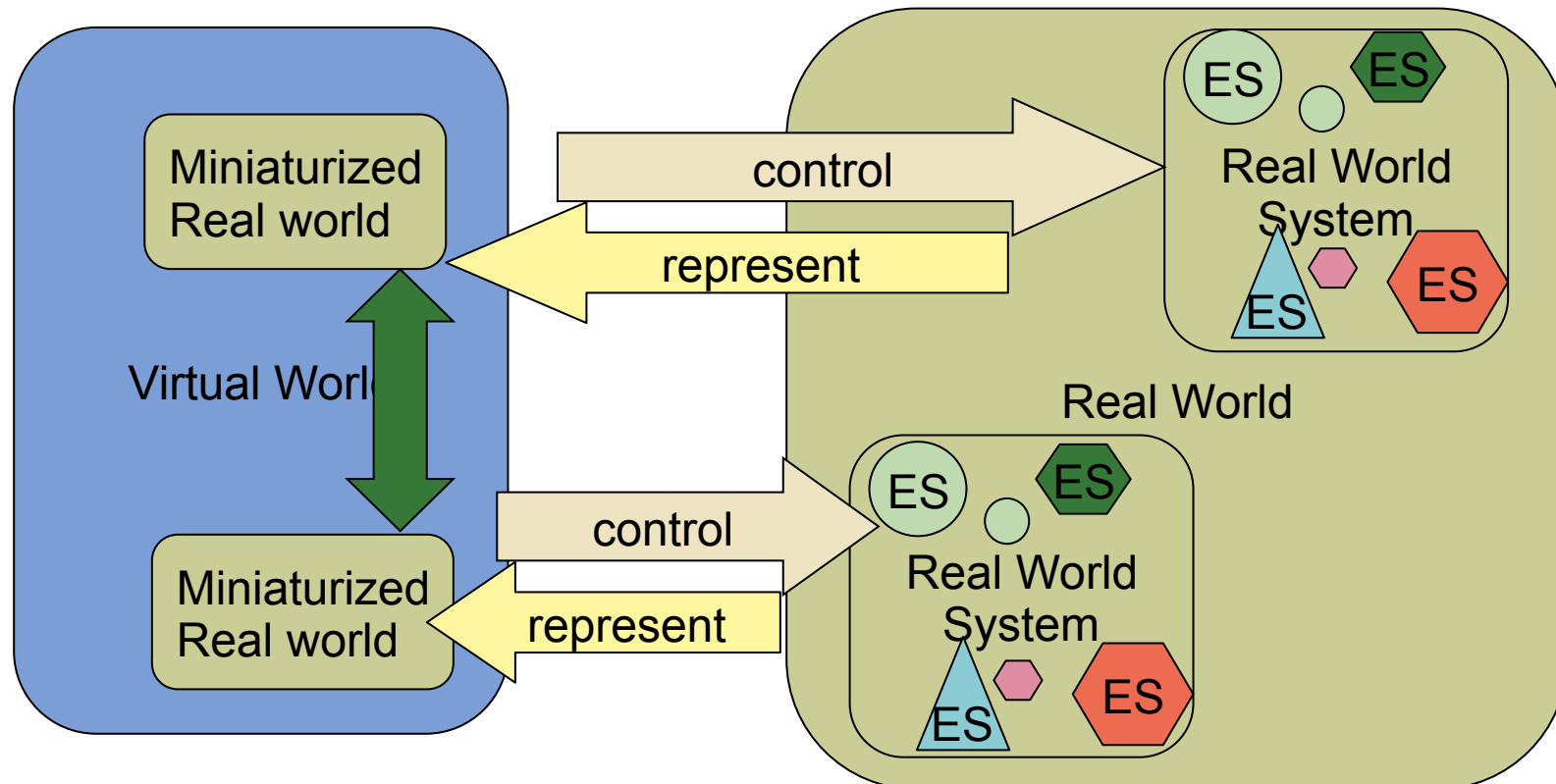
- The computer is integrated into the real-life object



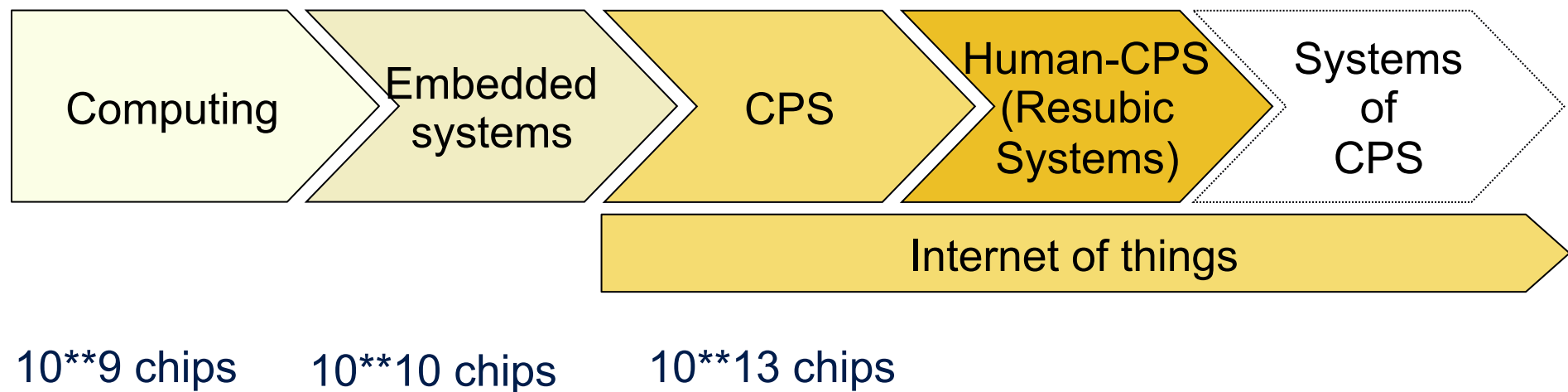
- Dual reality
- Control of space and time of all things



- The Internet of Things consists of *systems of Cyber-Physical Systems*
- Potential for a 4th industrial revolution (Industrie-4.0)

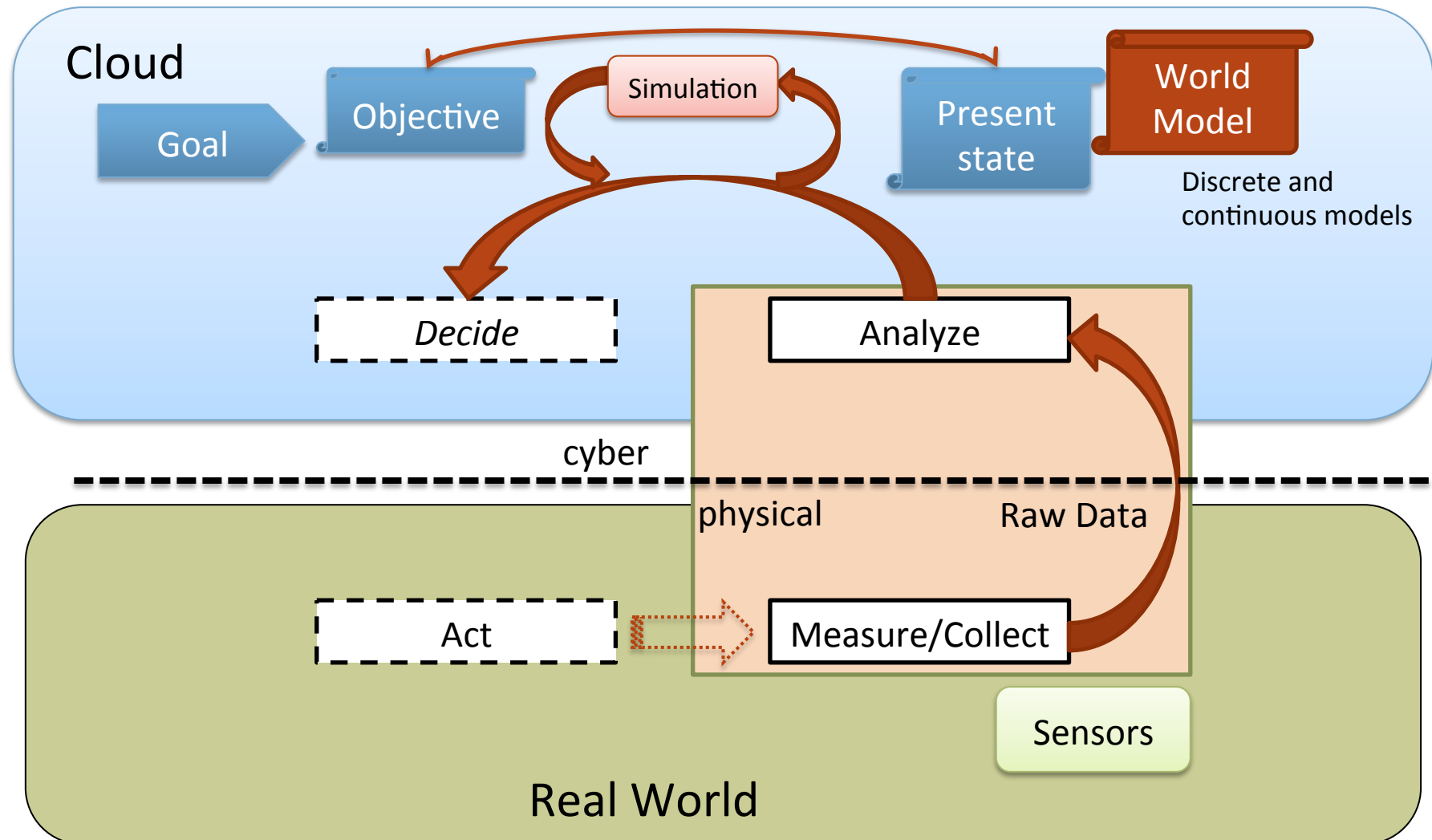


- Cyber-physical systems are the first step in the internet of things

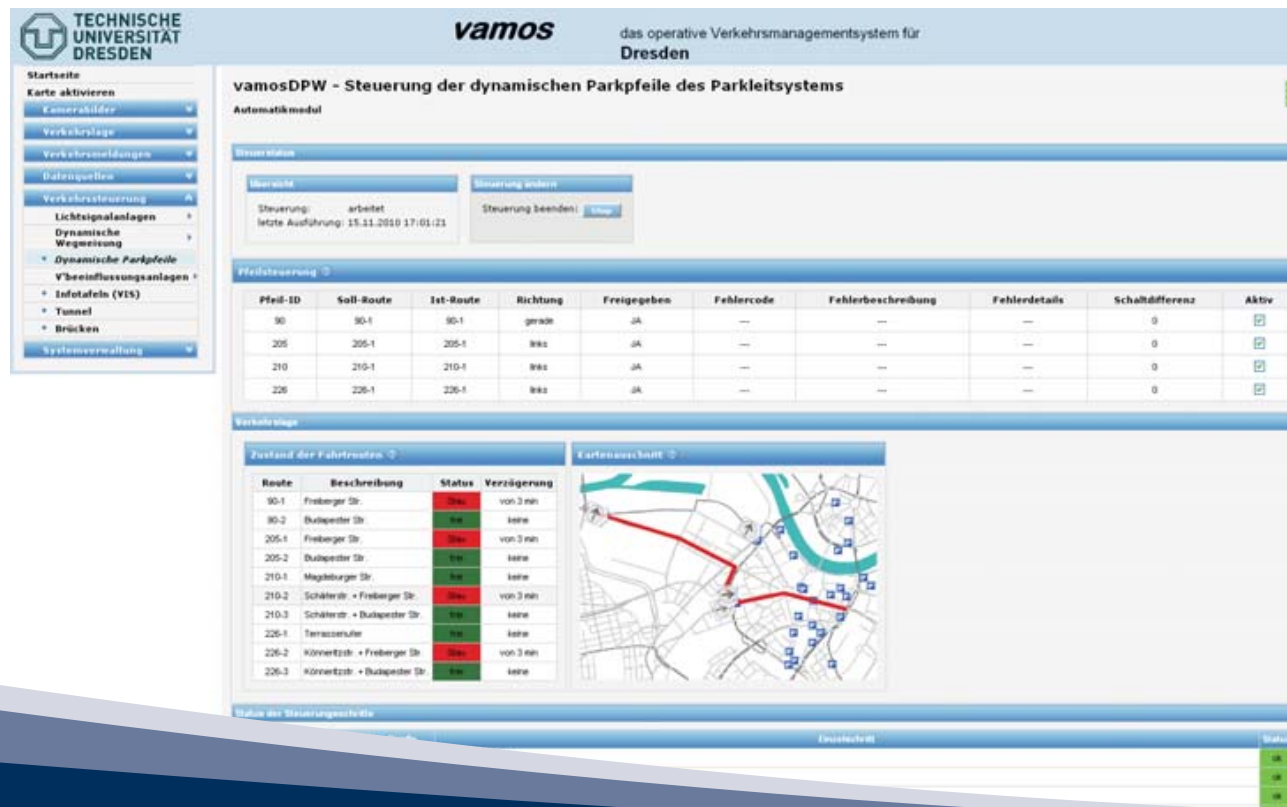


2. Two Basic Forms of CPS

- World Databases
- Cloud Robots



- Realtime data from the city's traffic
- <http://www.vamosportal.de/>
- http://wwwpub.zih.tu-dresden.de/~vamos/flyer/vamos_web.pdf



Freistatistik

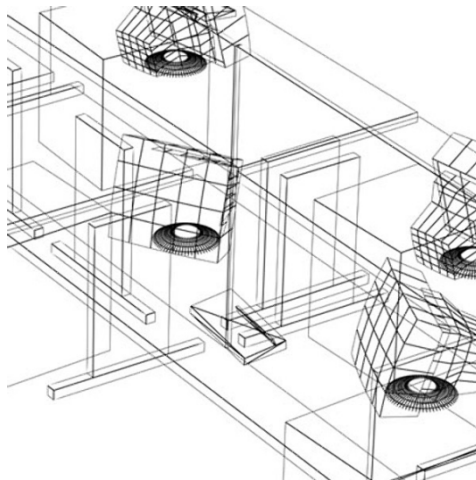
Pfad-ID	Soll-Route	Ist-Route	Richtung	Freigegeben	Fehlercode	Fehlerbeschreibung	Fehlerdetails	Schalttdifferenz	Aktiv
90	90-1	90-1	grade	JA	---	---	---	0	<input type="checkbox"/>
205	205-1	205-1	links	JA	---	---	---	0	<input type="checkbox"/>
210	210-1	210-1	rechts	JA	---	---	---	0	<input type="checkbox"/>
226	226-1	226-1	links	JA	---	---	---	0	<input type="checkbox"/>

Zustand der Fahrtrouten

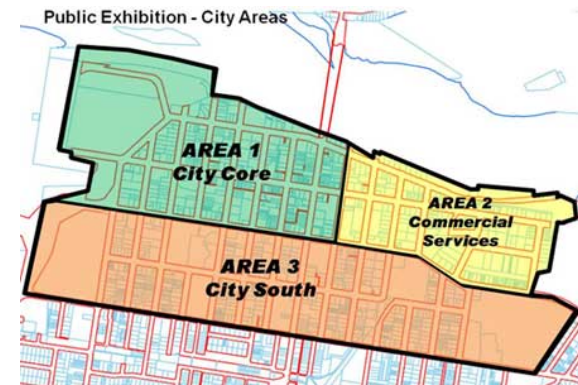
Route	Beschreibung	Status	Verzögerung
90-1	Freiberger Str.	rot	von 3 min
90-2	Dubopeter Str.	rot	keine
205-1	Freiberger Str.	rot	von 3 min
205-2	Dubopeter Str.	rot	keine
210-1	Mageburger Str.	rot	keine
210-2	Schäferstr. + Freiberger Str.	rot	von 3 min
210-3	Schäferstr. + Dubopeter Str.	rot	keine
226-1	Terrassenrute	rot	keine
226-2	Könneritzstr. + Freiberger Str.	rot	von 3 min
226-3	Könneritzstr. + Dubopeter Str.	rot	keine

2.1.1 Important World Models of World Databases

- Where is my thing in space?
 - Model of Physical Environment required
 - spatial, real-timed
 - magnetic, heat, humidity, user-defined

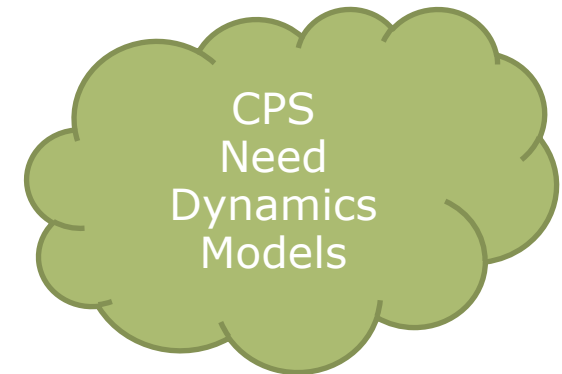


3D office model
<http://www.turbosquid.com>

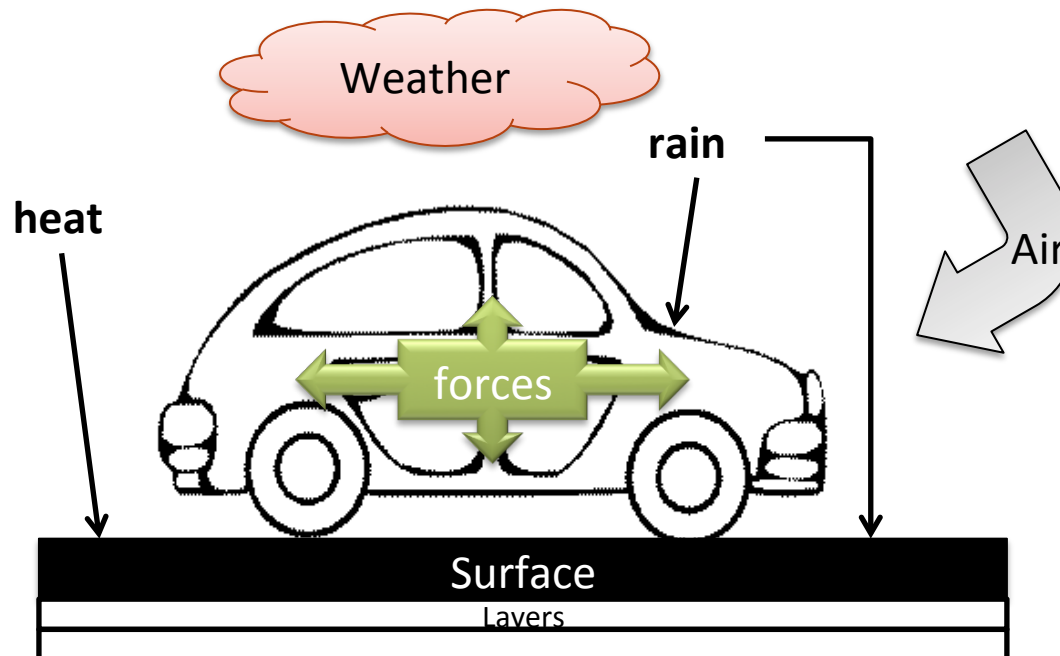


Areas of Mackay City
<http://www.mackay.qld.gov.au>

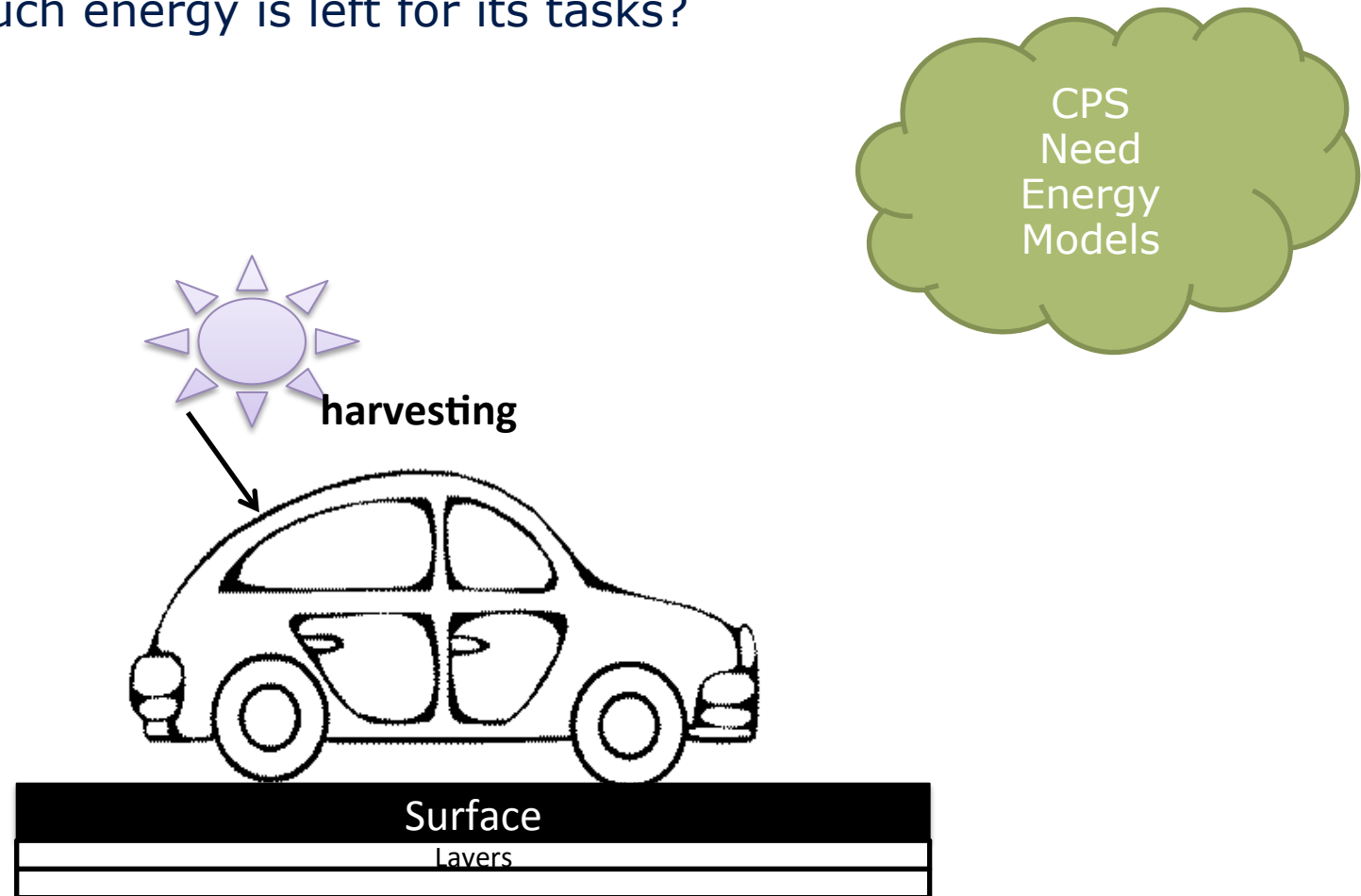
- How does it move in space?
 - Continuous modeling languages (Modelica)



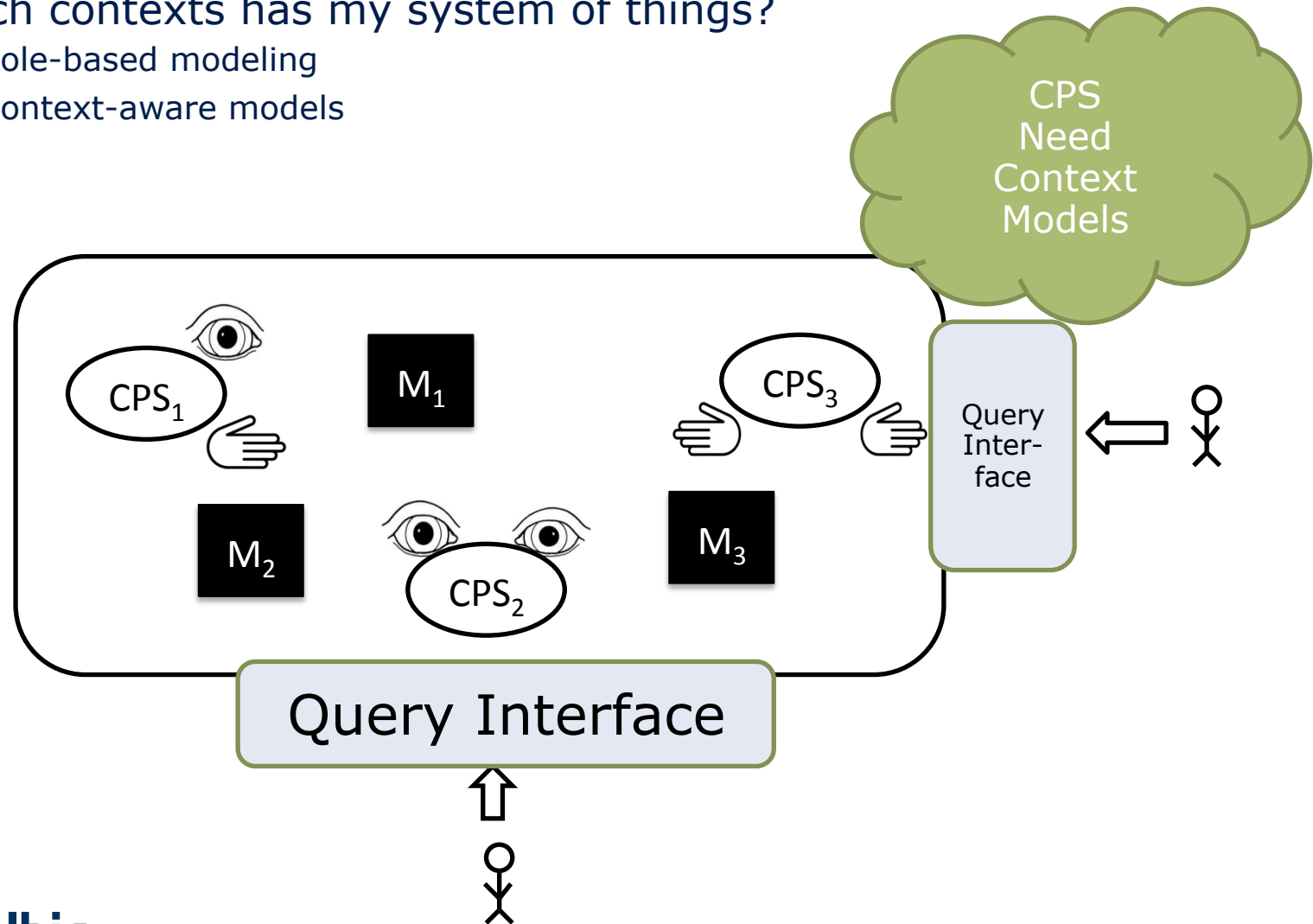
complex interplay of
-surface props
-weather: wind, rain, heat



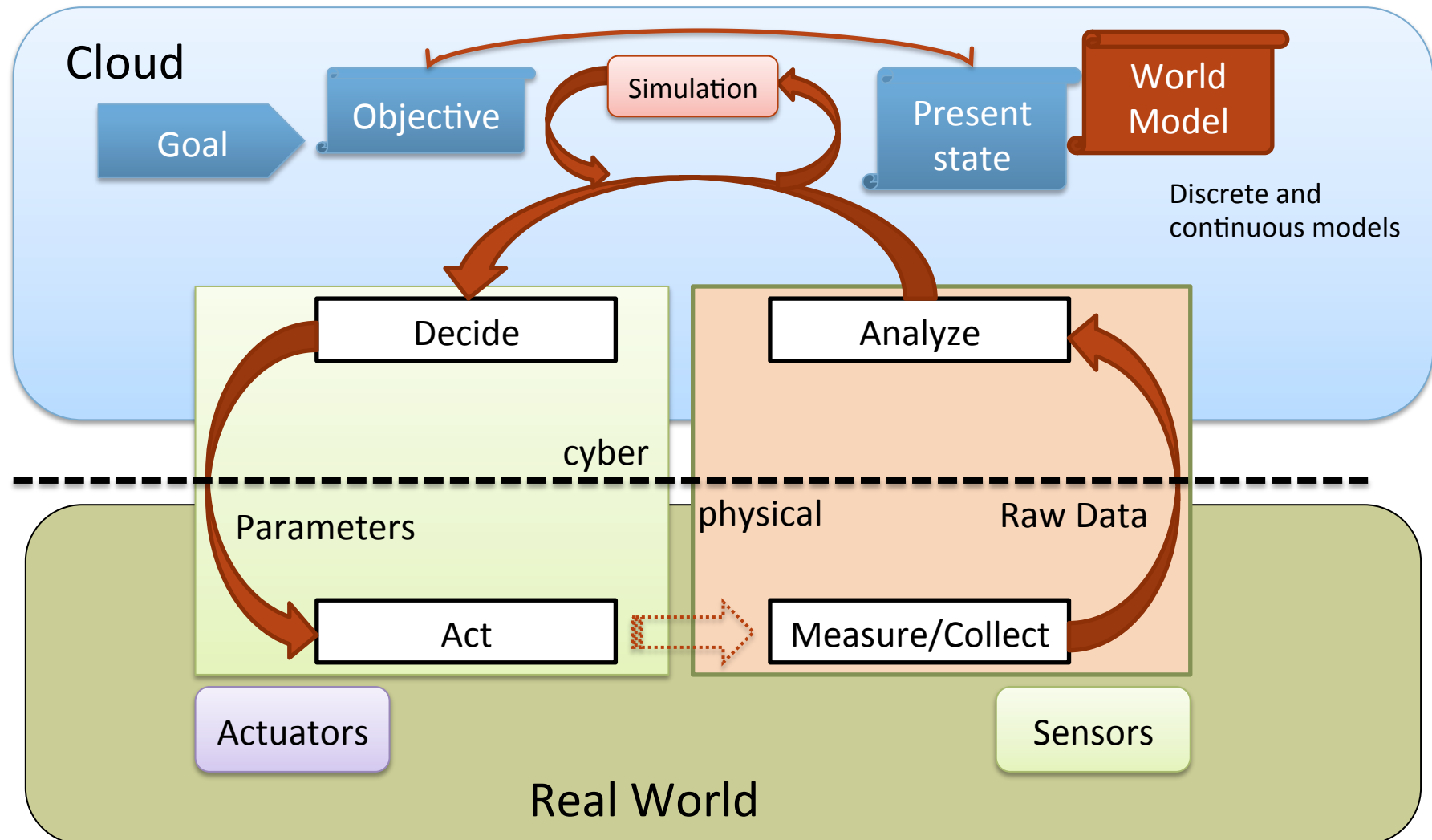
- How much energy is left for its tasks?



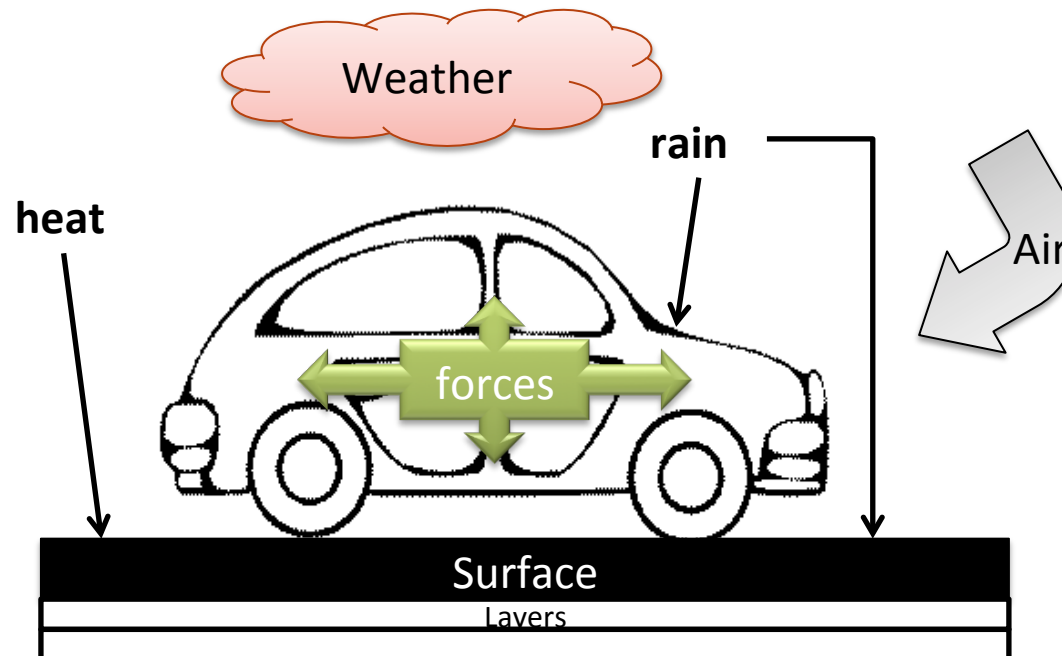
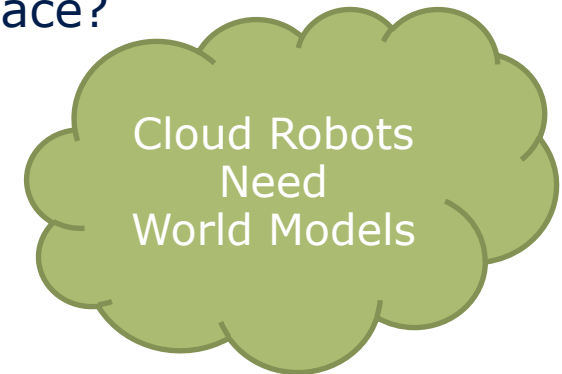
- Which contexts has my system of things?
 - Role-based modeling
 - Context-aware models



2.2. What is a Cloud Robot?



- How can I **control** a cloud robot move in space?



- <https://www.youtube.com/watch?v=8gy5tYVR-28>
- <https://www.youtube.com/watch?v=6KRjuuEVEZs>

Real-time data (smart city, smart factory smart home)

- 10000 things in the world model
 - with 50 sensors
- 500 000 sensors in the world model
 - 1kB message, 50Hz per second (50kB/sec)
- 50 000MB/sec (50 GB/sec)

Historical data

- 3TB/min „who drove more than 50km on a street?“
- 180TB/hr „which street has a starting jam?“
- 4PB/day „in which part of town should Ozone shrink tomorrow?“

- Relational data is **flat – what to do with 5PByte?**
- Help: **Hierarchically structured world model** with things
- We need tree-shaped data models allowing for abstraction (such as XML)

3. Experiments with Cloud Robots

Made by

-  ALDEBARAN Paris, Frankreich

[<http://www.aldebaran-robotics.com/>]

Application fields

- Teaching (Robot programming)
- Research
 - Robotics, AI
 - RoboCup
 - **Software Engineering**

Price

- 9.000 – 12.000 €



Length: 58cm

Weight: 5kg

Hardware:

- x86 AMD GEODE 500MHz
- 256MB RAM
- 21 motors
- Battery 55Wh

OS:

Embedded
Linux 32bit

Speakers

Cameras

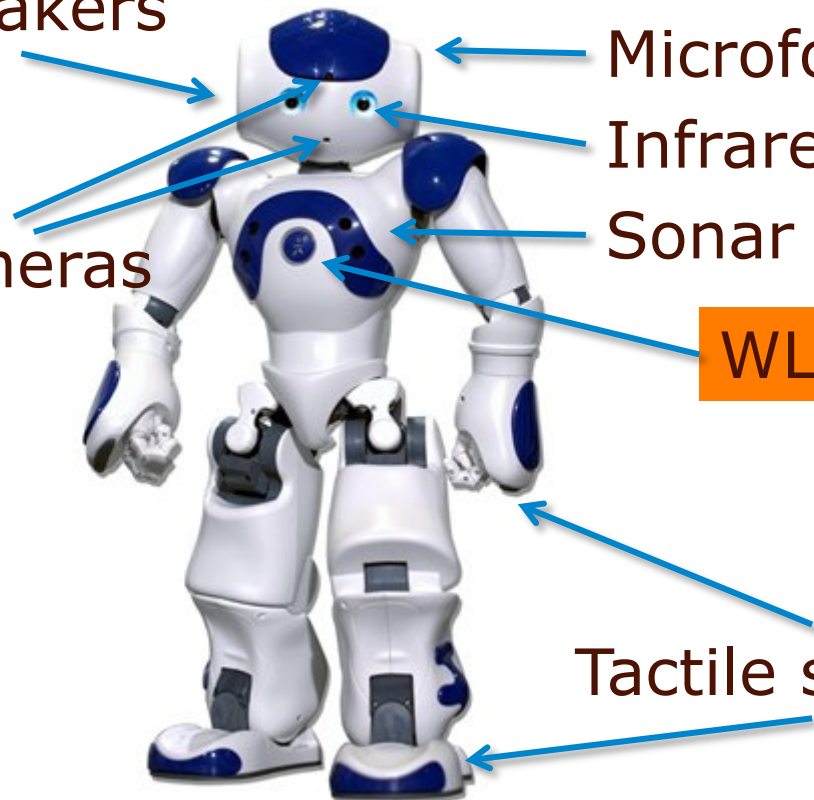
Microfone

Infrared

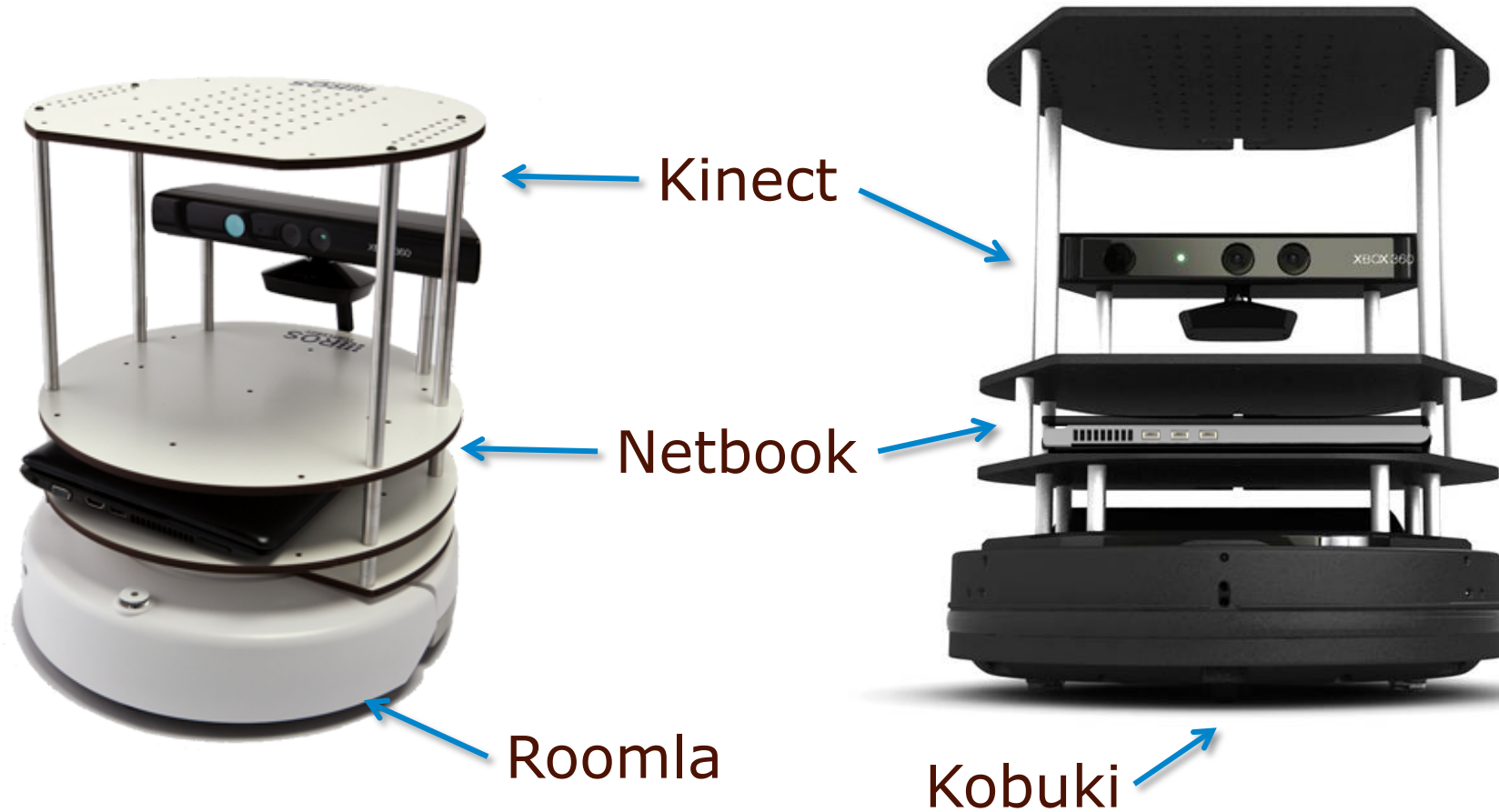
Sonar

WLAN

Tactile sensors



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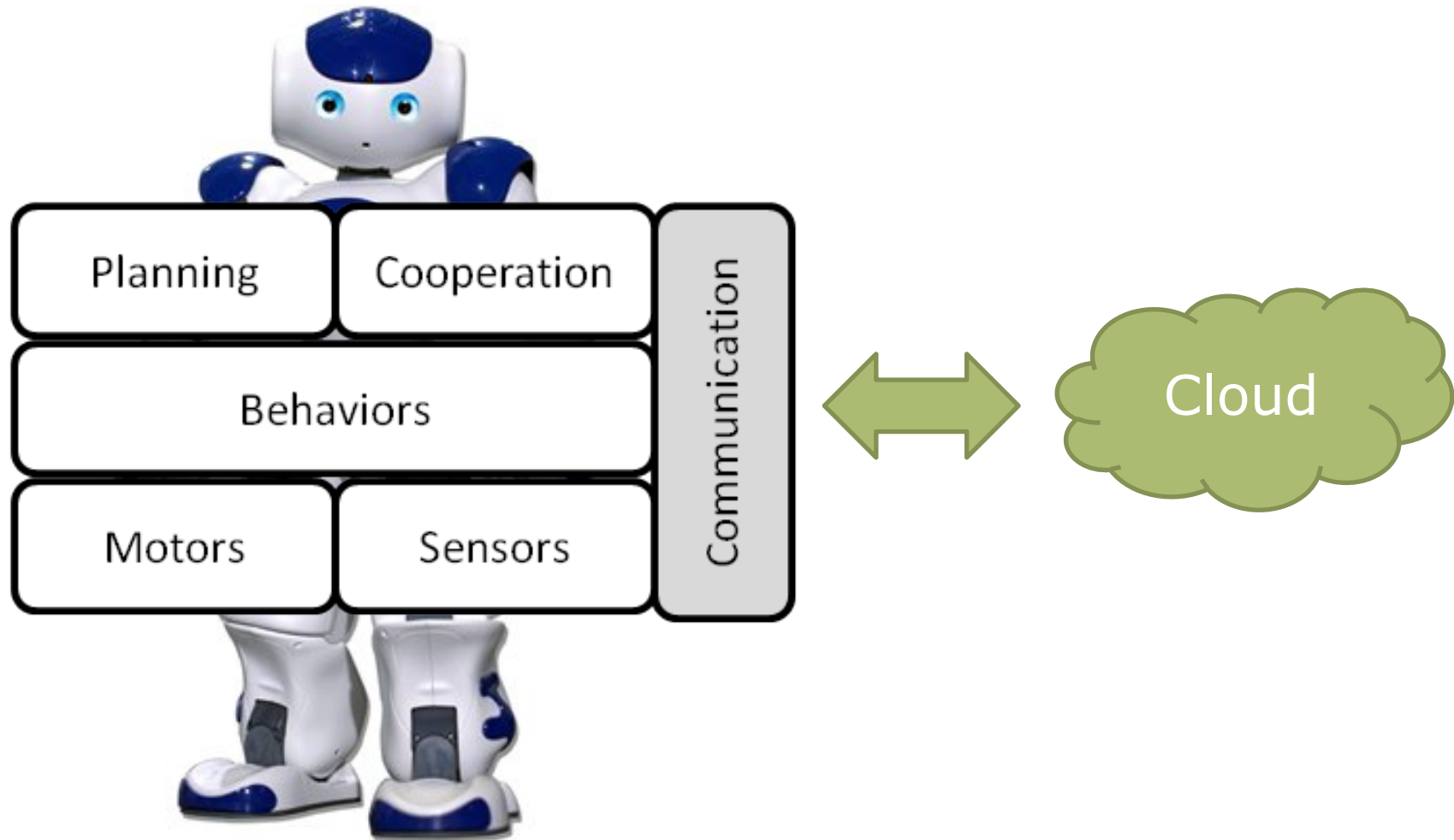


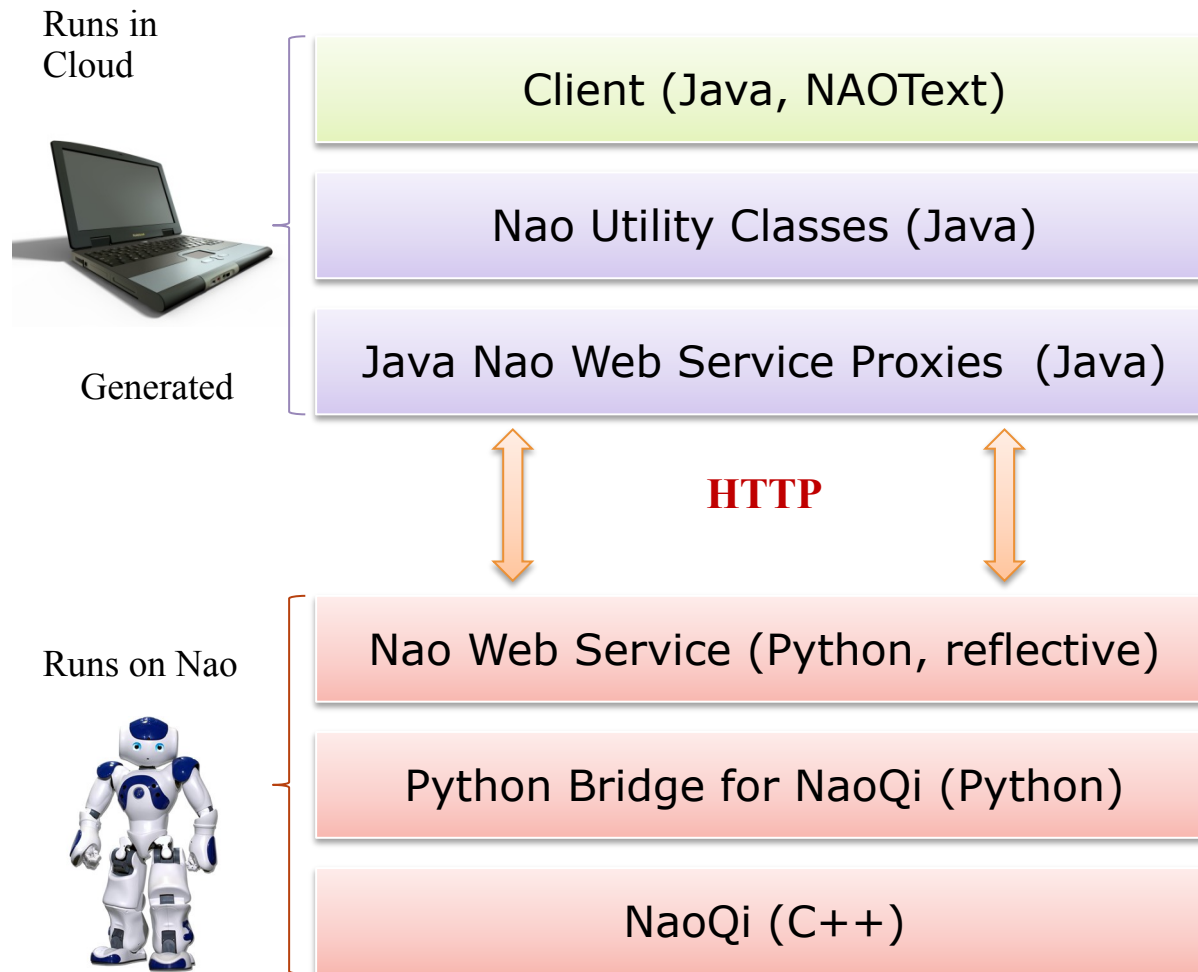
50kHz Sensor data rate

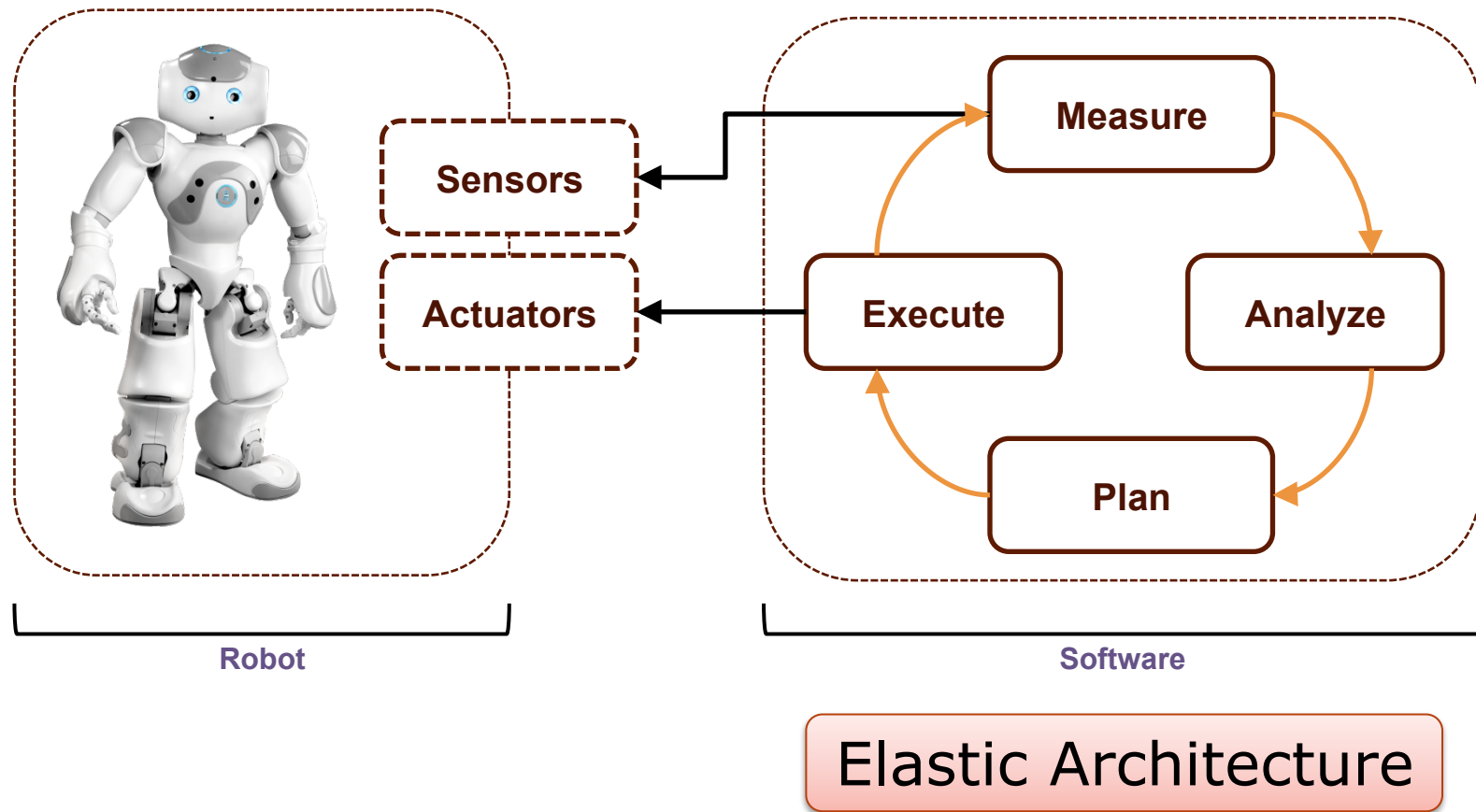
<http://wiki.ros.org/Robots/TurtleBot>

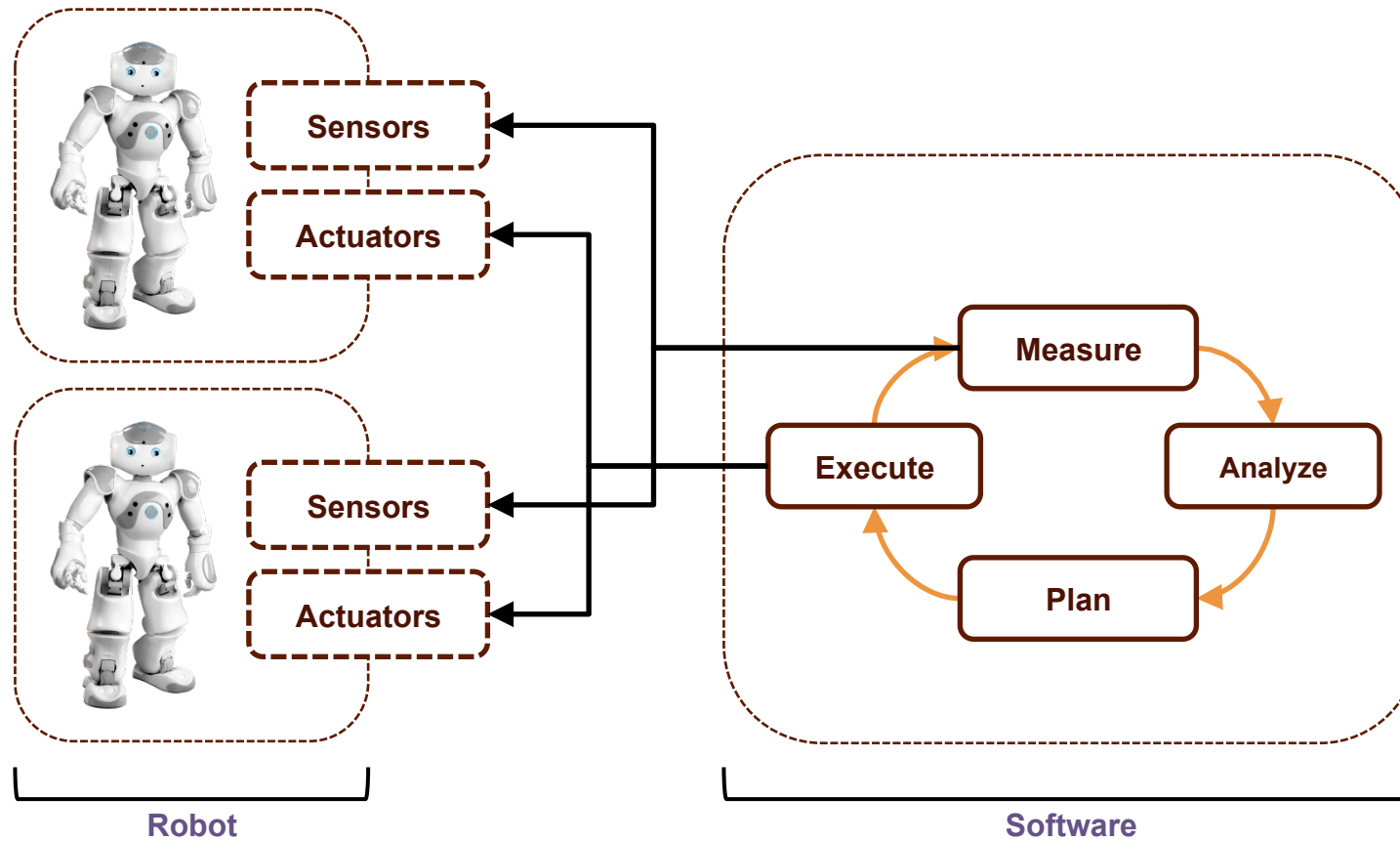
<http://www.turtlebot.com>

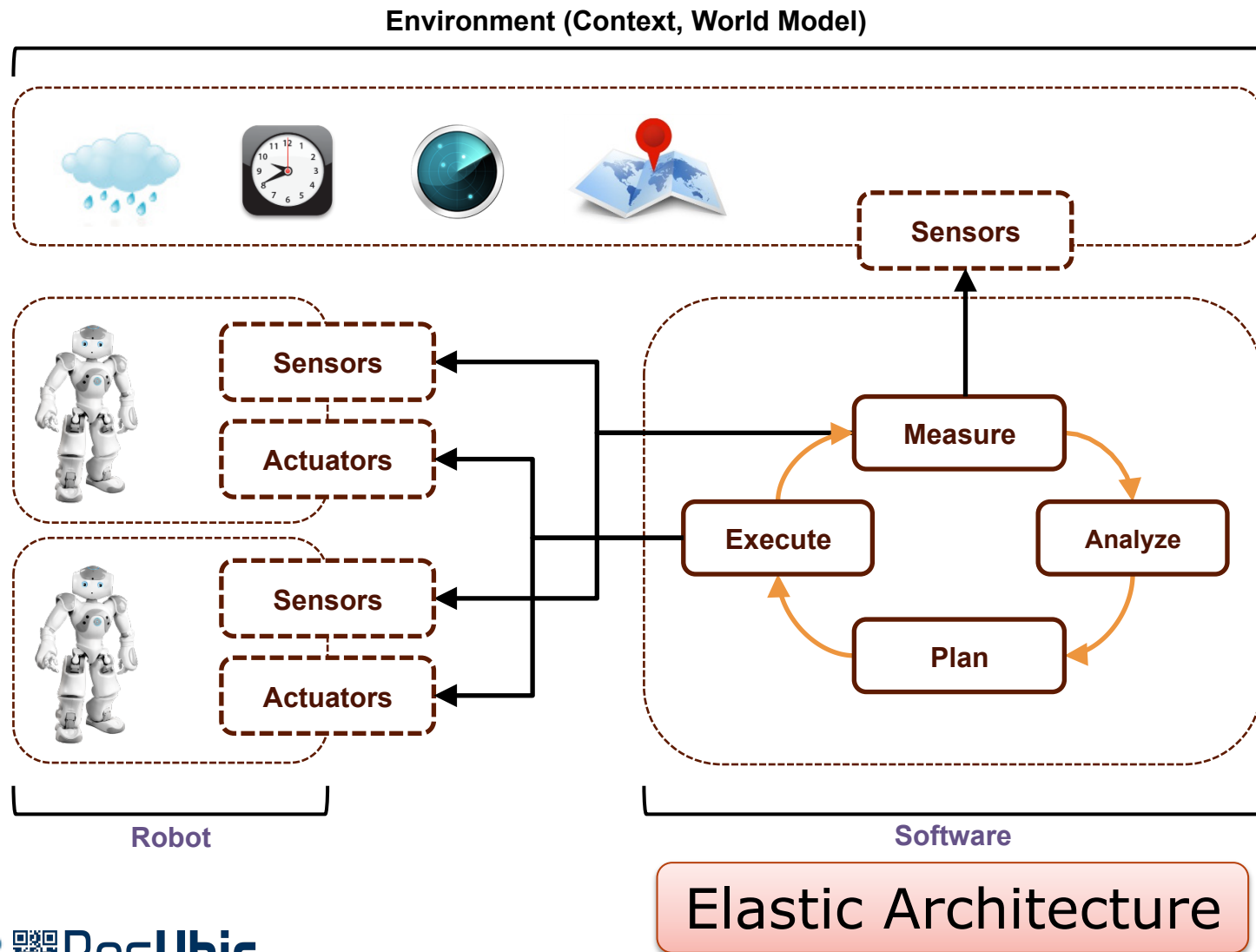


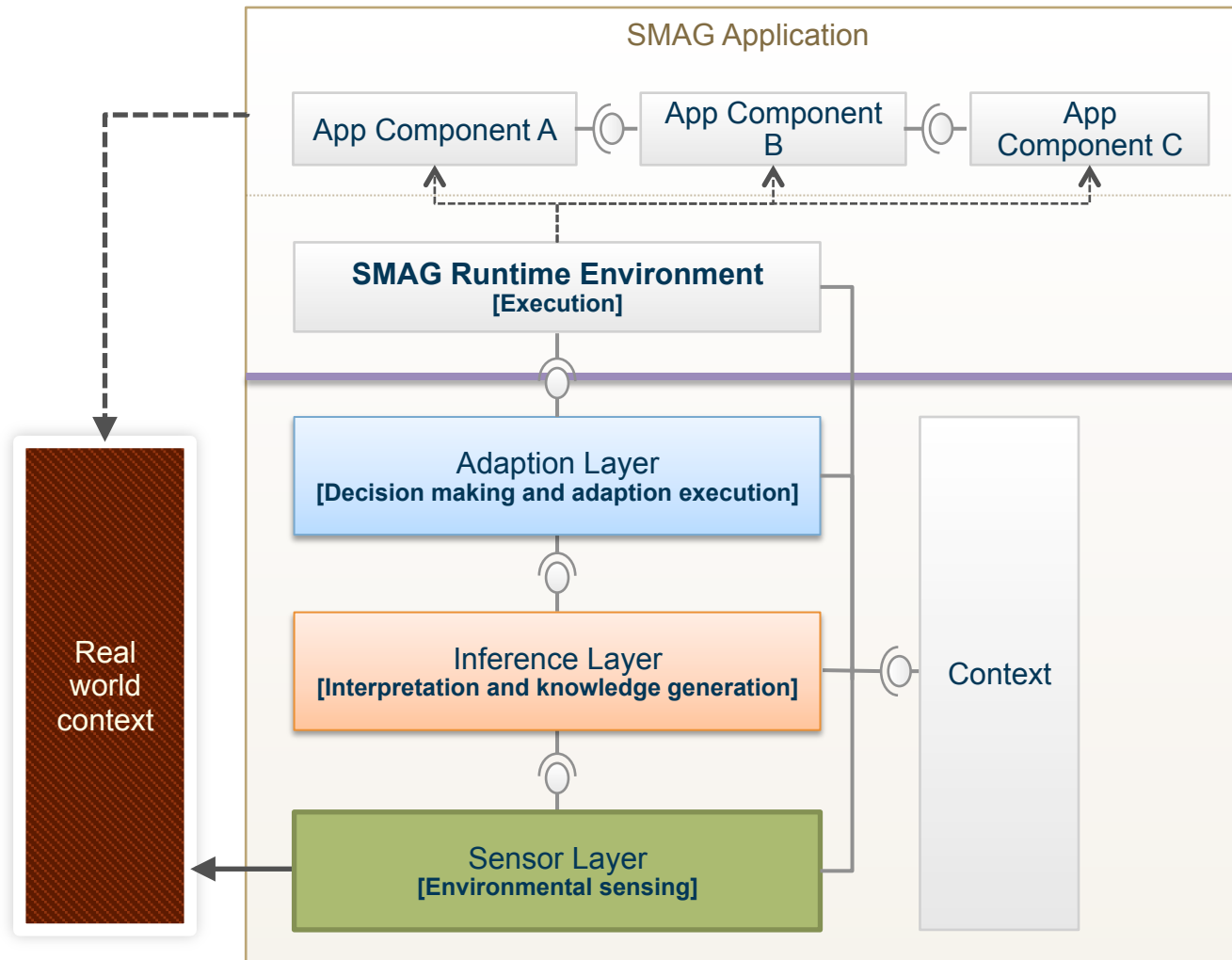












4. A Killer App for Cloud Robots: Donut Production in „Nachtsprung“

And the Topping
Makes the
Difference





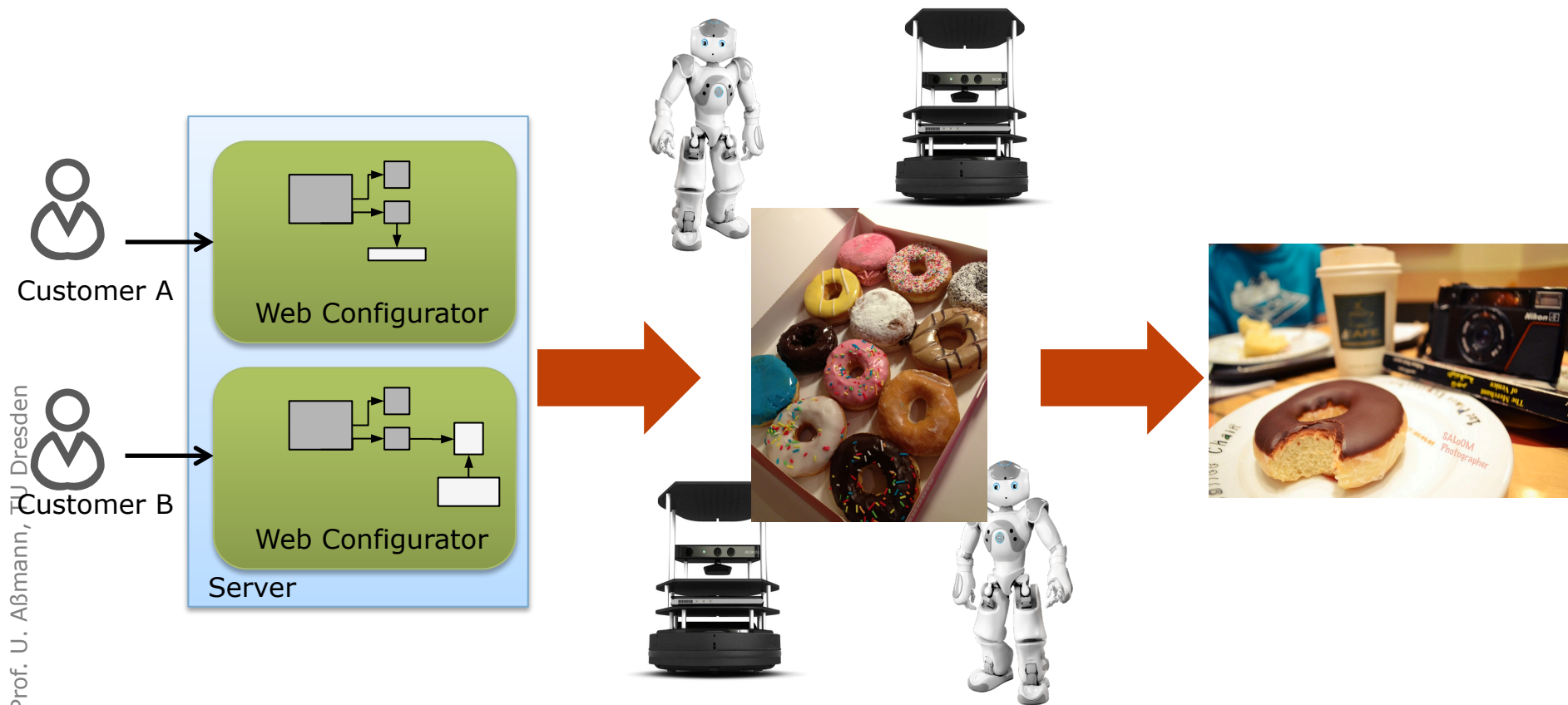
<https://www.flickr.com/photos/jeades/2383525381/>

- Mass production
- No individual configuration
- No fast, individualized production
- No „Nachtsprung“

Donut Industry-4.0: Pulling Individual Donuts out in Nachtsprung

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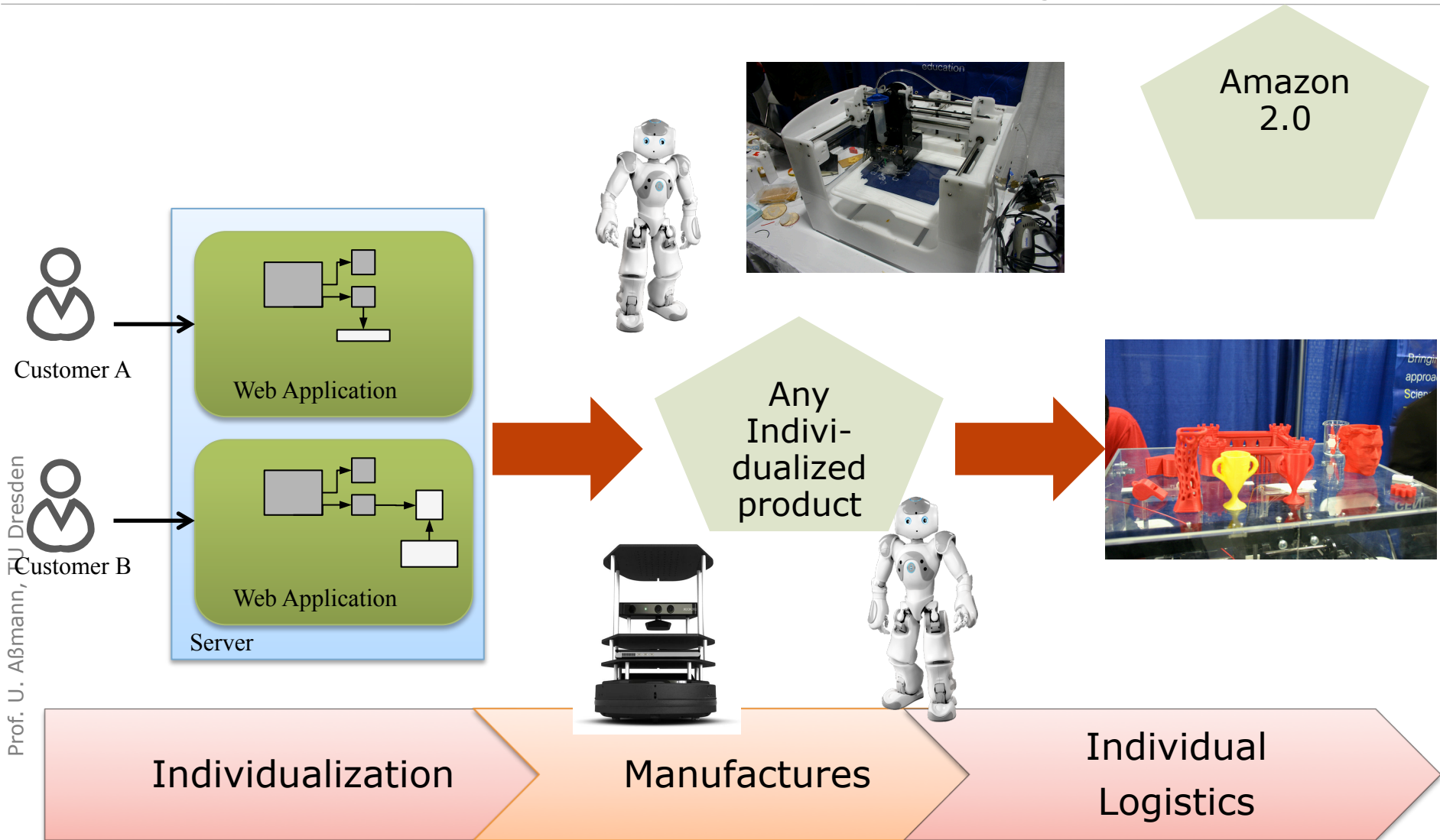
SALoOM CCB-2.0 https://www.flickr.com/photos/soso__1991/7179199134/



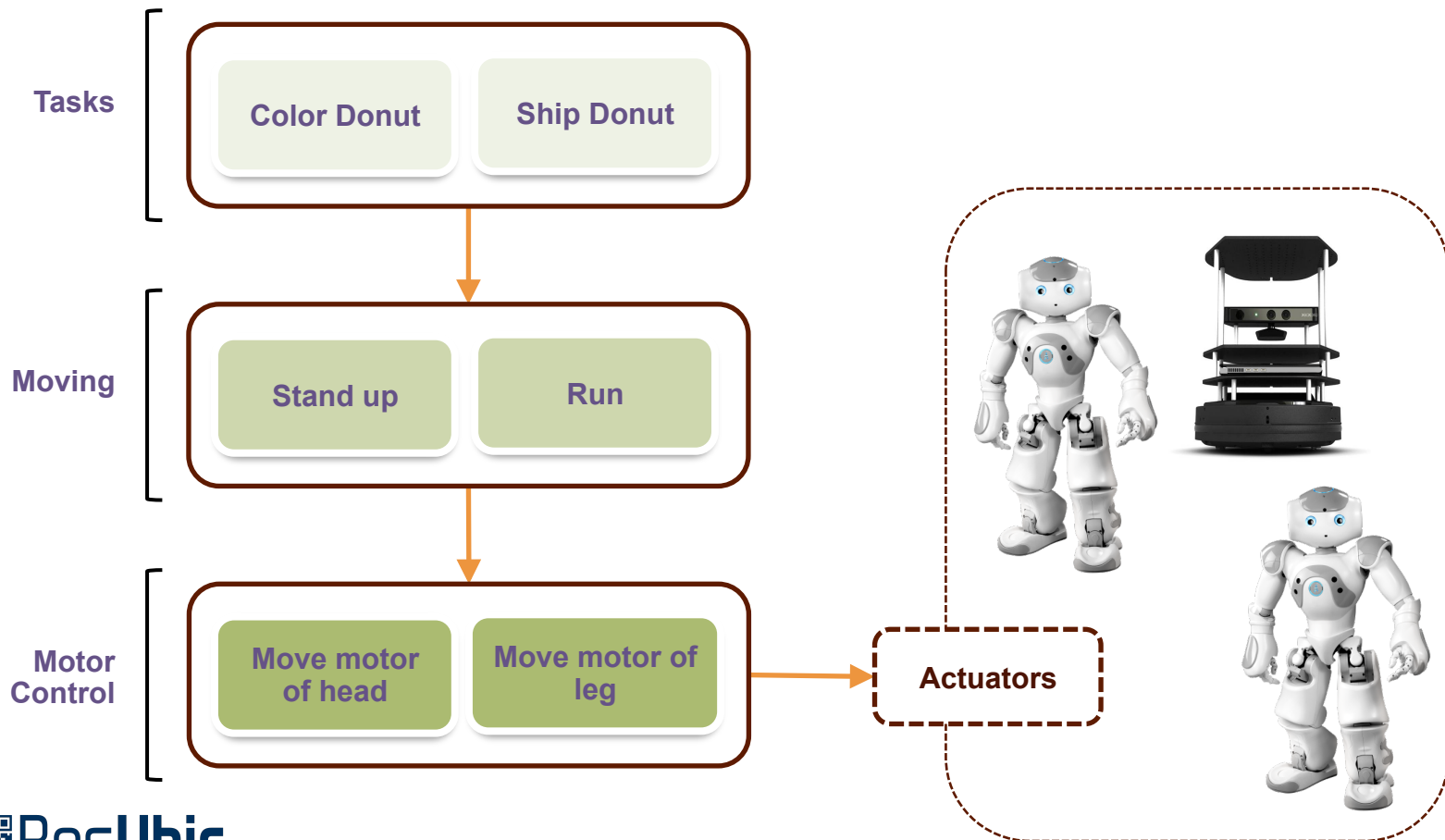
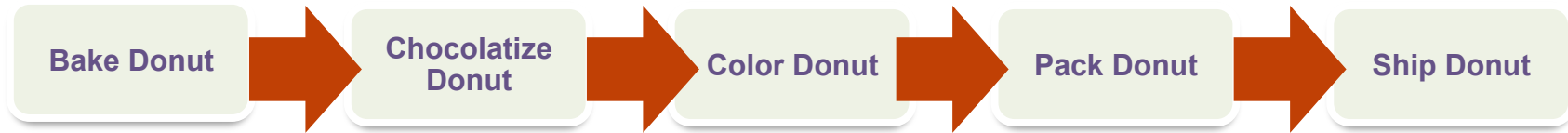
Configuring in the evening

Producing in the night

Shipping in the early morning



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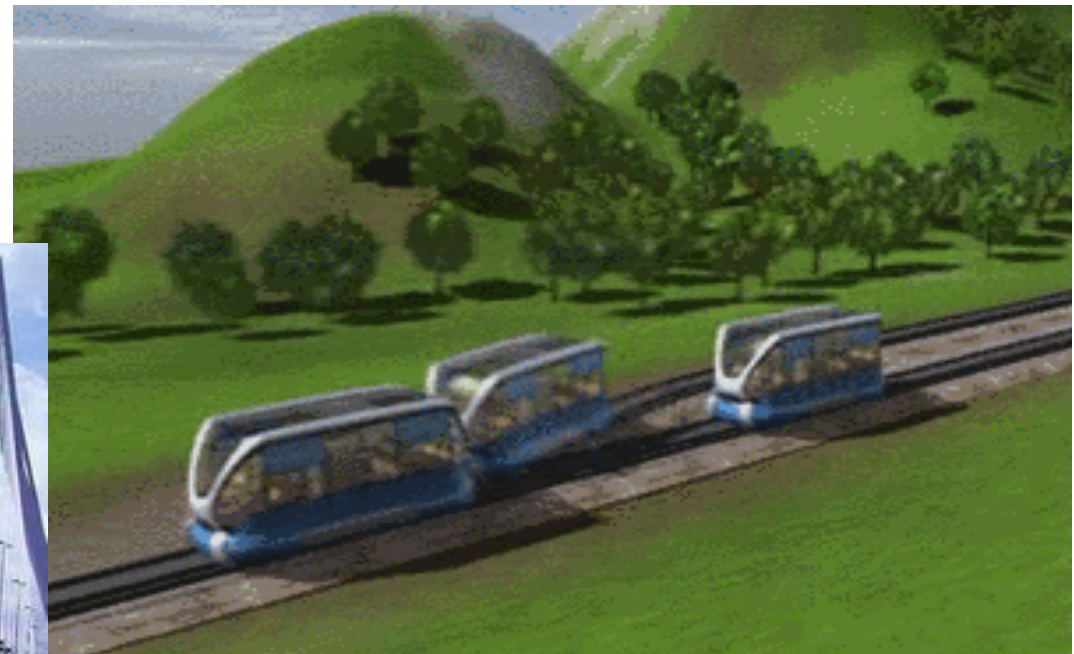
- Embedded System: machines, robots, presses, transport systems
- CPS: Autonomous control of the factory
 - Self assembly of the products
 - Autonomous control of logistics
 - Pull of products instead of push



PD: http://commons.wikimedia.org/wiki/File:Mail_sorting_assembly_line.jpg

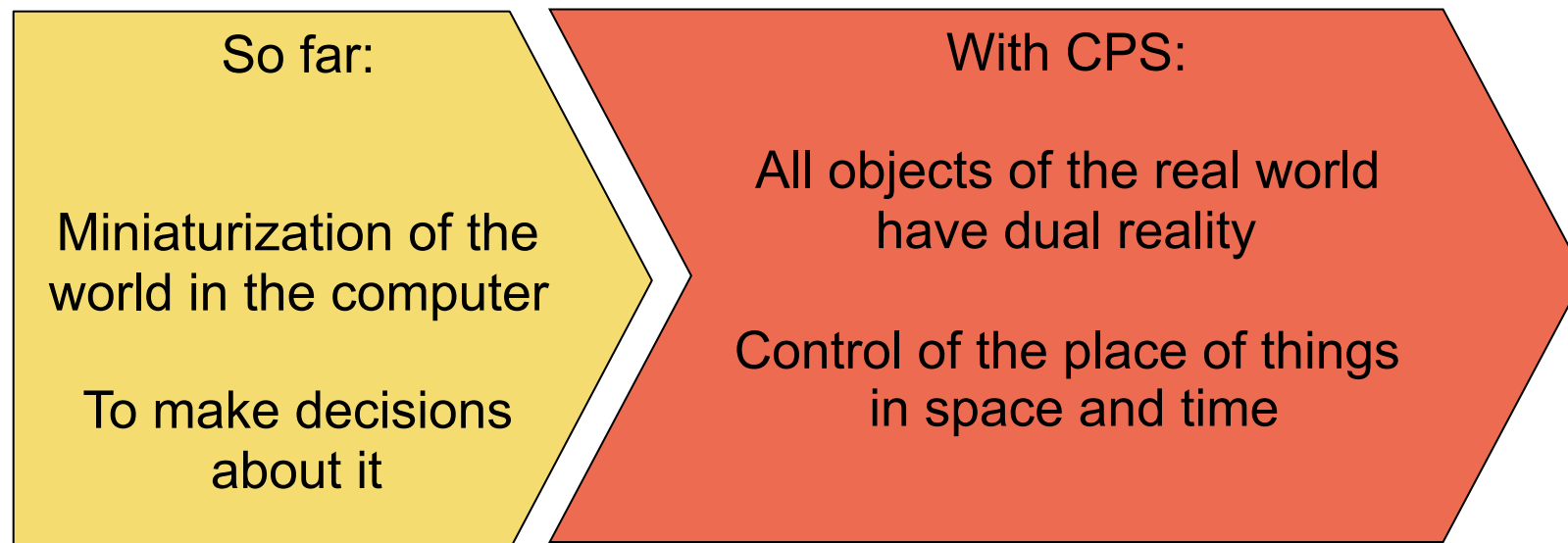
Kozuch CCBYSA-2.0 http://commons.wikimedia.org/wiki/File:Factory_Automation_Robotics_Palettizing_Bread.jpg?uselang=de

- Embedded System: Railcabs are autonomous train cars (Paderborn)
- CPS: Optimization of the German logistics



<http://www.railcab.de>

- All domains in transport, logistics, assembly, housing, cities will change
- Nothing will stay as it is
- All engineering disciplines will change until 2020



7. Big Data, CPS and the 5G Lab Germany

Smart Apps are important for CPS

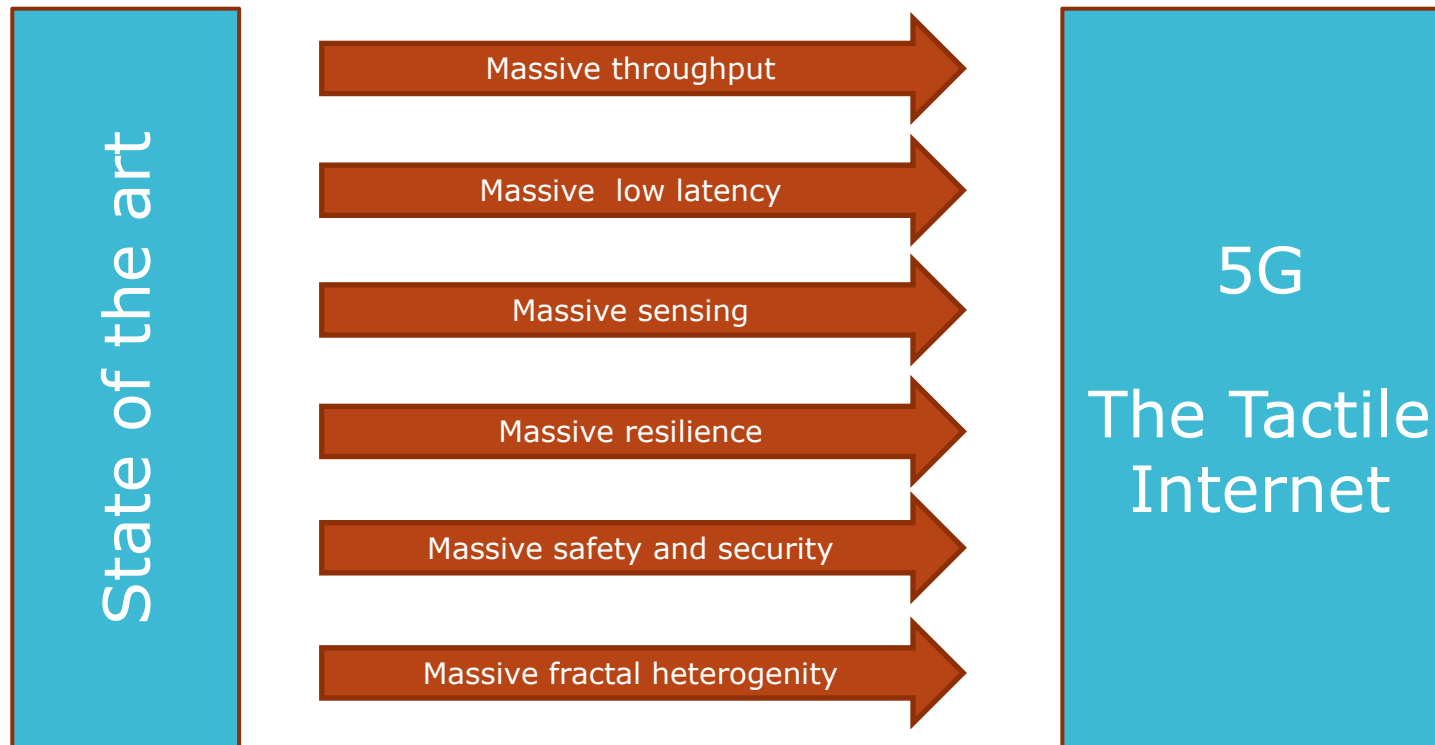
- Otherwise no adaptive behavior

Smart Apps rely on real-time big data

- World models with real-time data analytics required
- Latency requirements $< 1\text{ms}$

Smart Apps adapt to real-time big data

- New software languages with roles and contexts





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5G Research on four Tracks



Dresden
5G Lab

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Dresden 5G Lab

Tactile Internet applications

Mobile edge cloud

**Second Conference
Sept-24 2015
in Dresden**



5G Lab
GERMANY



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5G Lab Members



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Wireless
Communication



F. Ellinger
RFIC Design



R. Schüffny
SoC Integration



D. Plettemeier
RF Engineering



M. Schröter
Electronic Devices &
Integrated Circuits



E. Jorswieck
Information
Theory



C. Baier
Formal
Methods



K. Janschek
Automation



U. Aßmann
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Engineering



F. Fitzek
Communication
and Storage



S. Santini
Wireless Sensor
Networks



W. Lehner
Databases



W. Nagel
Big Data
and HPC



C. Fetzer
Resilience
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T. Strufe
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L. Urbas
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Interfaces



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Engineering



H. Härtig
Operating
Systems



ResU**bi**c



Roy Niswanger CCBY2.0 <https://www.flickr.com/photos/motleypixel/4784478824>

Have Fun with CPS

- NAOText, a domain-specific role-based language for robots
- http://www.qualitune.org/?page_id=453
- Götz, S., Leuthäuser, M., Reimann, J., Schroeter, J., Wende, C., Wilke, C., Aßmann, U.: A Role-based Language for Collaborative Robot Applications. In: Proceedings of 1st ISoLA Workshop on Software Aspects of Robotic Systems (ISoLA SARS'11).
- Smart Apps (SMAPPs) and Smart Application Grids (SMAGs)
- Under development by Christian Piechnick
- C. Piechinick, S. Richly, S. Götz, C. Wilke, U. Aßmann. Using Role-Based Composition to Support Unanticipated, Dynamic Adaptation – Smart Application Grids. Adaptive and Self-adaptive Systems and Applications (Adaptive 2012)

- Martin Franke, Christoph Seidl, and Thomas Schlegel. A Seamless Integration, Semantic Middleware for Cyber-Physical Systems. In Proceedings of the 10th International Conference on Networking, Sensing and Control, ICNSC'13, 2013.
- Christoph Seidl and Uwe Aßmann. Towards Modeling and Analyzing Variability in Evolving Software Ecosystems. In Proceedings of the 7th International Workshop on Variability Modelling of Software-intensive Systems (VaMoS), VaMoS'13, 2013.
- Georg Püschel, Sebastian Götz, Claas Wilke, and Uwe Aßmann. Towards systematic model-based testing of self-adaptive systems. In Proceedings of The Fifth International Conference on Adaptive and Self-Adaptive Systems and Applications (ADAPTIVE), 2013.

Thank You!

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