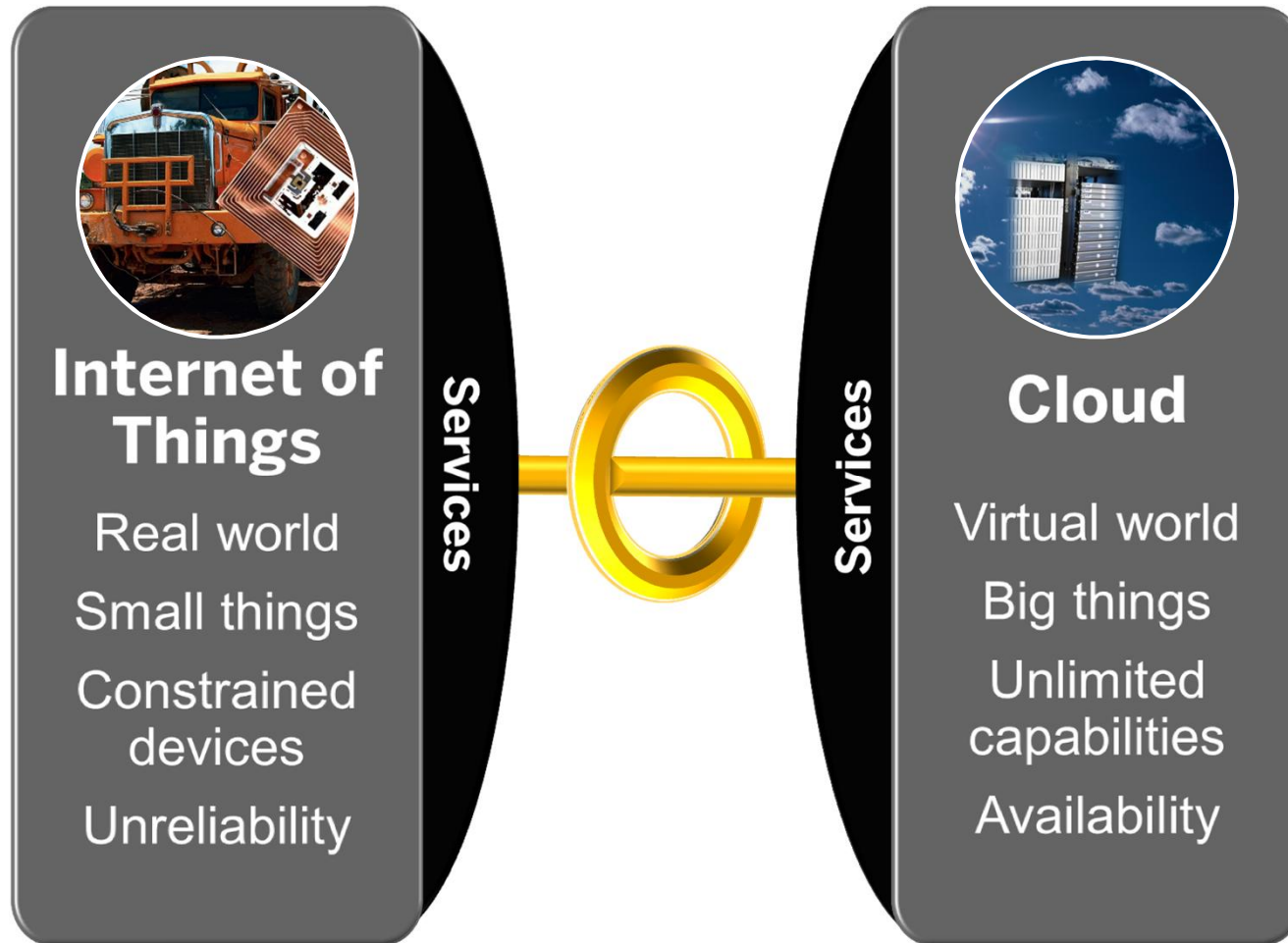


# Internet of Things & Cloud: A Happy Marriage?

Stephan Haller, SAP Research  
January 19, 2012

# Internet of Things vs. Cloud Properties



# Internet of Things, Cloud and Services

## Internet of Things enables

- High-resolution management
- Real-world control
- Adaptive processes

IoT Issue	Possible Solution
Heterogeneity	Services as abstraction layer
Application Development	Mash-up of services
Solution Deployment	Support through XaaS models
Producing a lot of data	Processing of large data quantities in the cloud

*IoT, Cloud, and Services are **complementary aspects** of a Real World Internet*



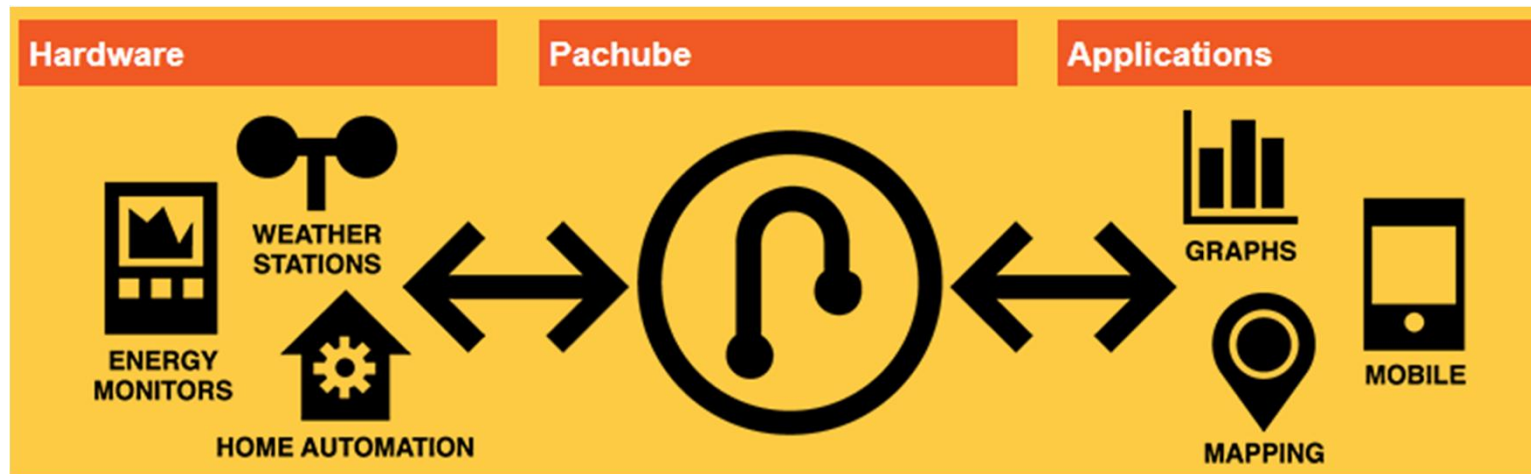
# 2 Examples

- For the public and the society
- For business and enterprises

## Example 1: Pachube

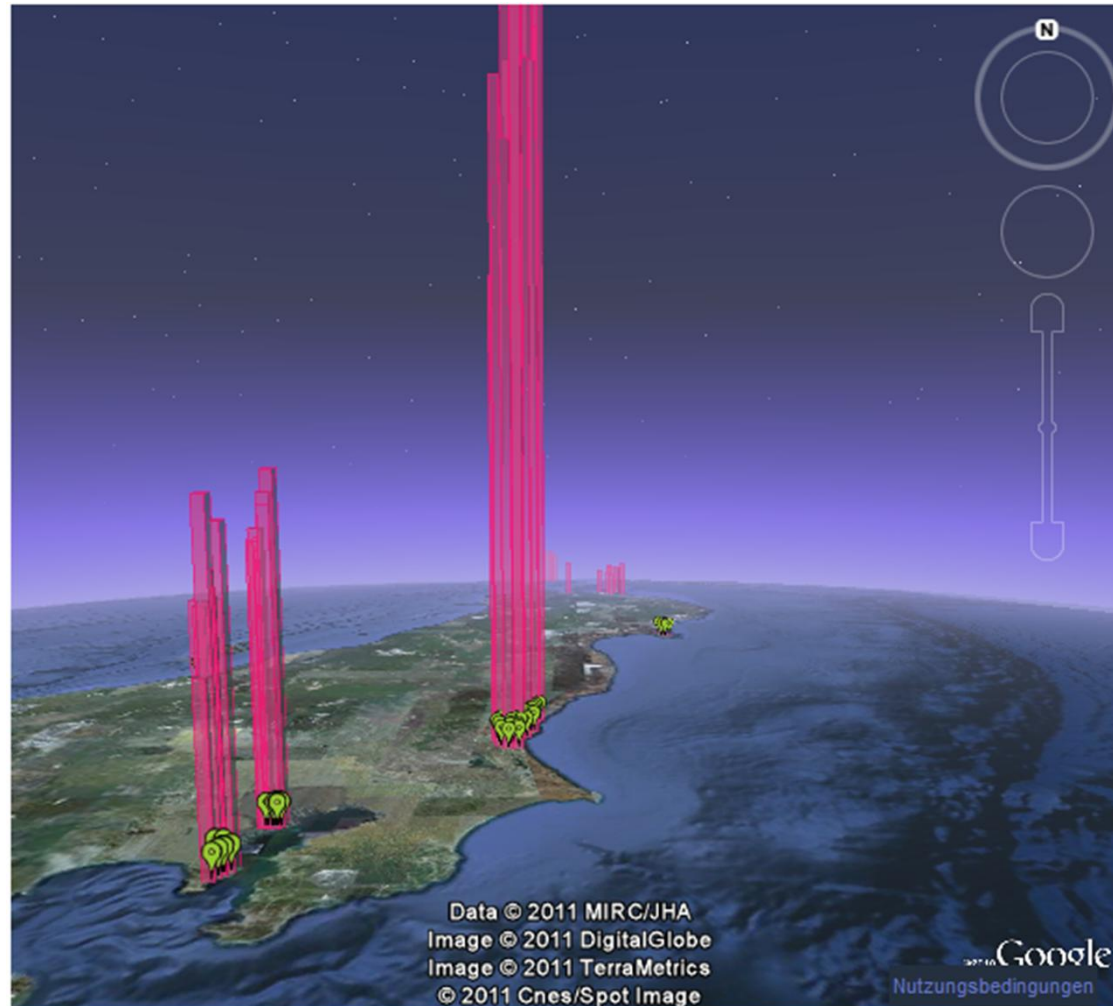
### "The Internet of Things Real-Time Web Service and Applications"

- Platform to connect sensors and other hardware
- Platform to build IoT services and applications
- RESTful APIs



Source: <https://pachube.com/>

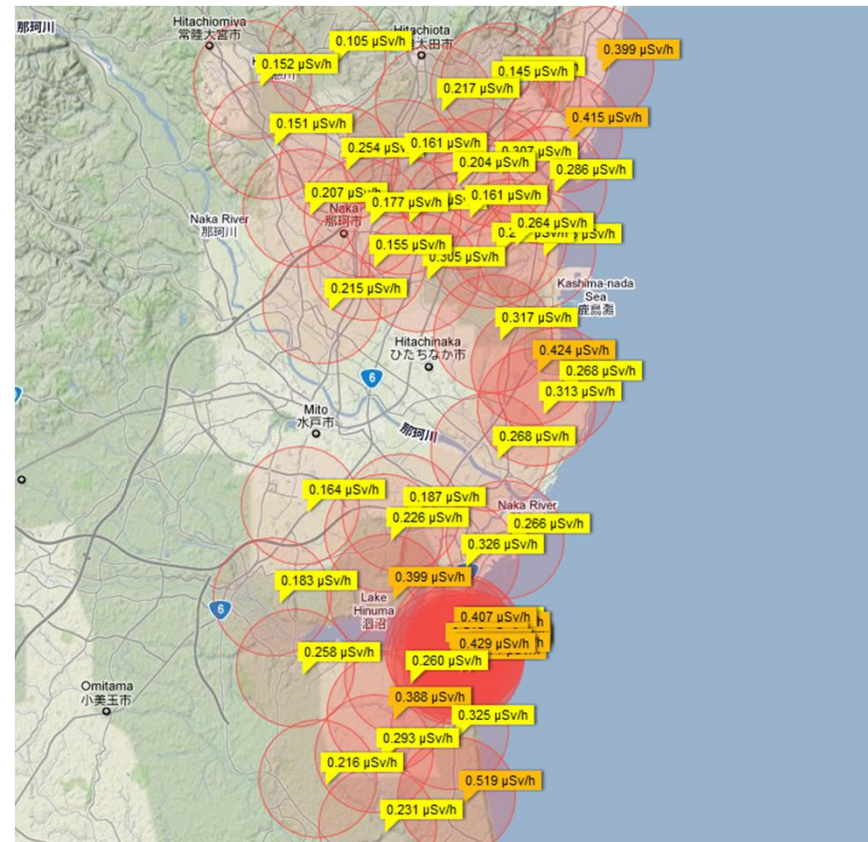
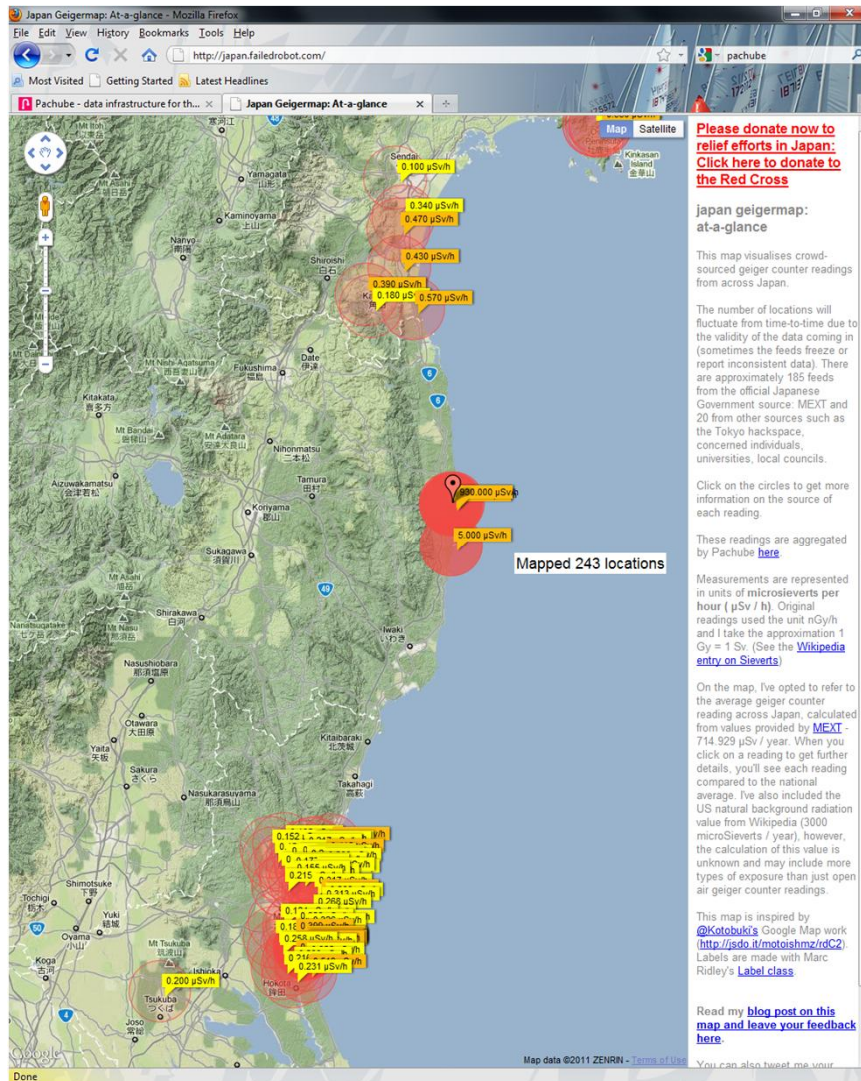
# After the Fukushima Disaster on Pachube



<http://community.pachube.com/node/611#3d>, 31.3.2011

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# Many people connected radiation sensors...



<http://japan.failedrobot.com/>, 31.3.2011

# Cool, but ...

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## Data quality of various sources

- Accuracy of each data point
- Sensor reliability and availability
- Time of measurement
- Important for trust!

## Unit jungle:

- nGy/s, mSv/h,  $\mu$ Sv/h, Bq/kg, cpm ...
- Sometimes misleading, sometimes just hard to compare...

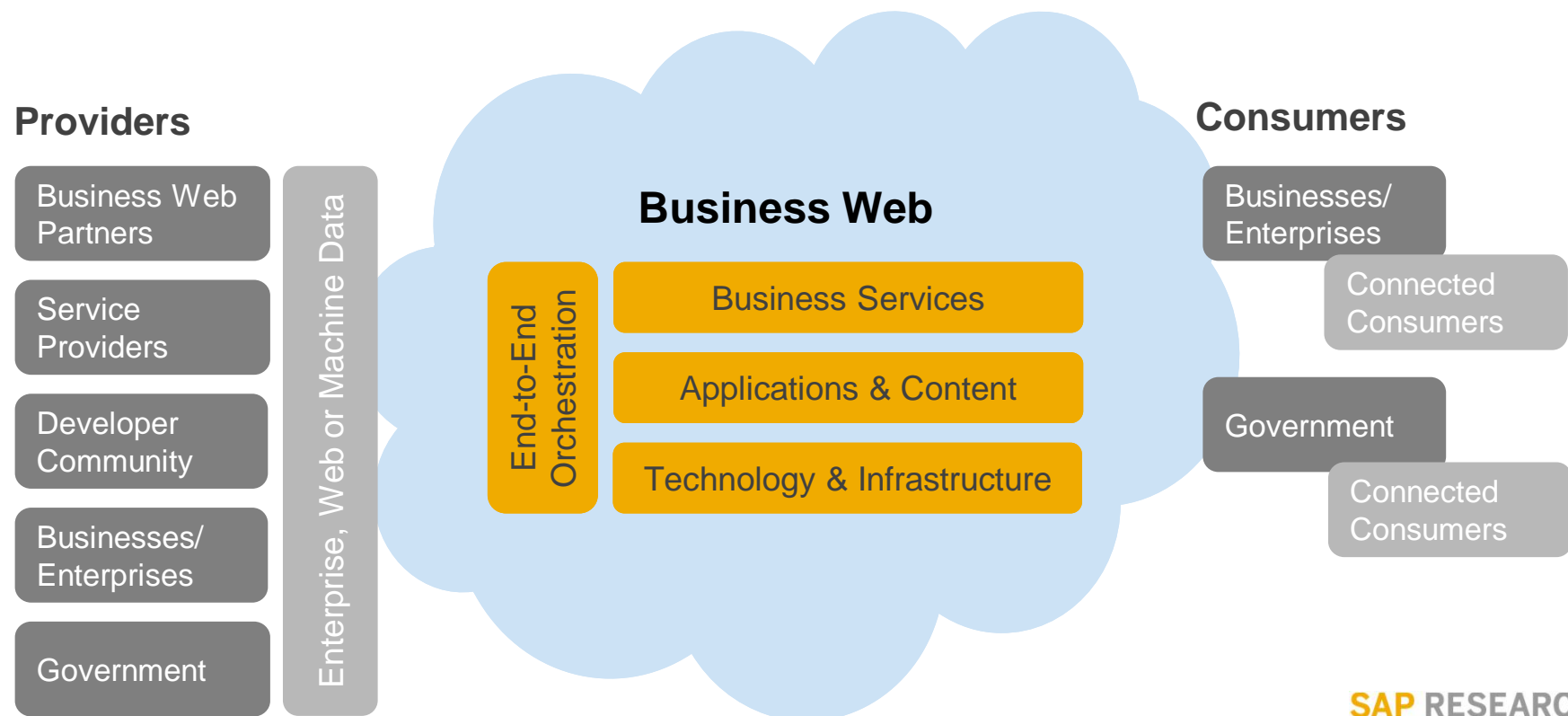
## Mix of data sources

- Real sensors
- Virtual sensors (data scraping from web pages, e.g., <http://www.houshasen-pref-ibaraki.jp/present/result01.html>)

# Business Web

## A Platform and Marketplace for Business Services

The Business Web is a **cloud-based business environment** that provides access to the necessary infrastructure, applications, content, and connectivity to deliver **end-to-end business services** optimized for **mobility** and ease of participation.



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# Business Web: First-class Internet of Things Integration



Configuration & Actuation  Business relevant events & information 



## M2M Scenario – Ice Cream Cabinets

- The application provides consumer products companies with detailed information about the location and status of its ice cream cabinets.
- This information can be used to find these cabinets, supply them with new ice cream in time, and monitor their temperature in order to avoid ice cream becoming bad due to a defective ice cream cabinet.
- The ice cream cabinets become smart items that monitor their energy consumption, send alarms, and become an active part in the companies operation processes as well as sustainability efforts.



# IoT Configuration

## 2.5 million ice cream cabinets

- Worldwide distributed
- Biggest growth markets: China and India

## Sensing

- Need to refill
  - Avoid stock-outs
- Location
  - Reliably find and refill
- Temperature / power outage
  - Detect failures and avoid product loss
- Behavioral statistics
  - Conclude conversion rate

Estimated business value: >5% increased sales



# IoT Integration into Business Processes

## Roles and processes

### CPG Backend

- Operational BI on supply chain efficiency
- User behavior monitoring and campaign efficiency

### 3<sup>rd</sup> Party Supplier

- Dispatcher: Improved planning of daily logistics processes
  - Get refill priorities and alarms on power outage and temperatures
- Truck Driver: Guidance and real-time integration into process

### Store Owner

- Push alarms to store owners for immediate actions
  - Resolve power outage / close lid to save energy

### Consumer

- Guidance to next ice cream cabinet (source of happiness)

## 3rd Party Supplier



Consumer  
Augmented  
Reality App:  
Guide me to the  
next ice cream  
opportunity



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# Business Value

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## Ice Cream Business is a 60+ billion market

Highest margin business in food CPG

- 10.5%

### Unilever

- 10+ billion in ice cream sales
- Market leader in out-of-home ice cream business
  - 30% market share
  - 2/3 is out-of-home business
- ICC scenario estimated benefit is 45 million additional profit per year

### Phase 1: Pilot

- 500 ICCs in Germany, 50 mobile users

### Phase 2:

- 10.000 ICCs in Germany, 1.000 users

### Phase 3:







- Replacing 200.000 ICCs yearly world wide.





# Some Challenges

# Not all services are created equal...

	Category	Subcategory	Properties	Cloud-deployable	Examples
Non-IT Services			<ul style="list-style-type: none"> <li>Provisioned by humans physically</li> </ul>	 (but can be ordered through cloud-based IT services)	<ul style="list-style-type: none"> <li>Home Care</li> <li>Hardware installation / maintenance</li> </ul>
	IT-based Services	Standard Web Services	Public	<ul style="list-style-type: none"> <li>Direct device access</li> <li>Heterogeneous protocols</li> </ul>	
Enterprise Services			<ul style="list-style-type: none"> <li>Direct device access</li> <li>Heterogeneous protocols</li> </ul>		<ul style="list-style-type: none"> <li>Create sales order</li> </ul>
IoT Services		On-Device / On-Resource low level service	<ul style="list-style-type: none"> <li>Direct device access</li> <li>Heterogeneous protocols</li> </ul>		<ul style="list-style-type: none"> <li>getTemperature</li> </ul>
		„Entity“-Service	<ul style="list-style-type: none"> <li>Information about a physical entity</li> <li>Composition of low-level services</li> </ul>		<ul style="list-style-type: none"> <li>getLocation</li> </ul>
		Value added service	<ul style="list-style-type: none"> <li>Services that work with „Entities“,</li> <li>Composition with non IoT services.</li> </ul>		<ul style="list-style-type: none"> <li>EPCIS</li> </ul>

Categorization of IoT services based on work of the IoT-A Project

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# Not all services are created equal...

**IoT Services have different characteristics (in particular on-device services)**

- Granularity
- Geo-location
- Streaming data
- Resource constraints & performance requirements
- Reliability, Quality of Information, Quality of Service

Non-IT Services	Cat				les
	Stand				Care ware ation / enance
IT-based Services	Web				ge ss
	Service				e order
	IoT Services	On-Device / On-Resource low level service	<ul style="list-style-type: none"> <li>• Direct device access</li> <li>• Heterogeneous protocols</li> </ul>		• getTemperature
	„Entity“-Service	<ul style="list-style-type: none"> <li>• Information about a physical entity</li> <li>• Composition of low-level services</li> </ul>		• getLocation	
	Value added service	<ul style="list-style-type: none"> <li>• Services that work with „Entities“,</li> <li>• Composition with non IoT services.</li> </ul>		• EPCIS	

Categorization of IoT services based on work of the IoT-A Project  
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# What Cloud Models are relevant for IoT?

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## IaaS – Infrastructure as a Service

- Sensor & Actuator "Cloud"?
- Business Model?
- Resource Access Control?

## PaaS – Platform as a Service

- Most realistic model today
- The platform offers access to IoT data and control services, but not directly to the hardware resources
- Applications can be built on top

## SaaS – Software as a Service

- Can be offered on top of PaaS solutions
- For specific application domains, e.g., monitoring of energy consumption

# Where to process data?

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On the **Device**?

In the **Service Enablement Layer**?

In the **Application Layer**?



➔ **The right trade-offs need to be found**

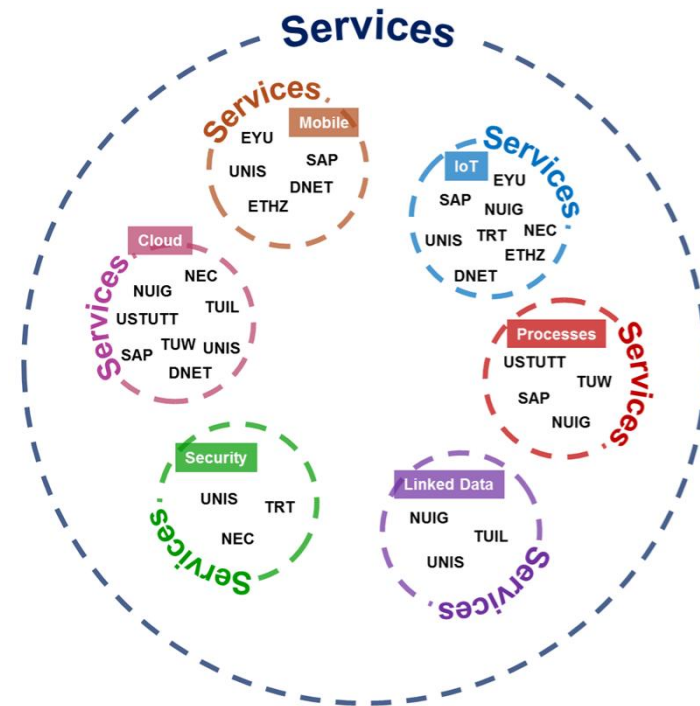
- No general answer
- Depends on application domain

# Proposed Research Project SOLIST



SOLIST will design a **Platform-as-a-Service (PaaS)** solution for the convergence of the Internets of Services and Things

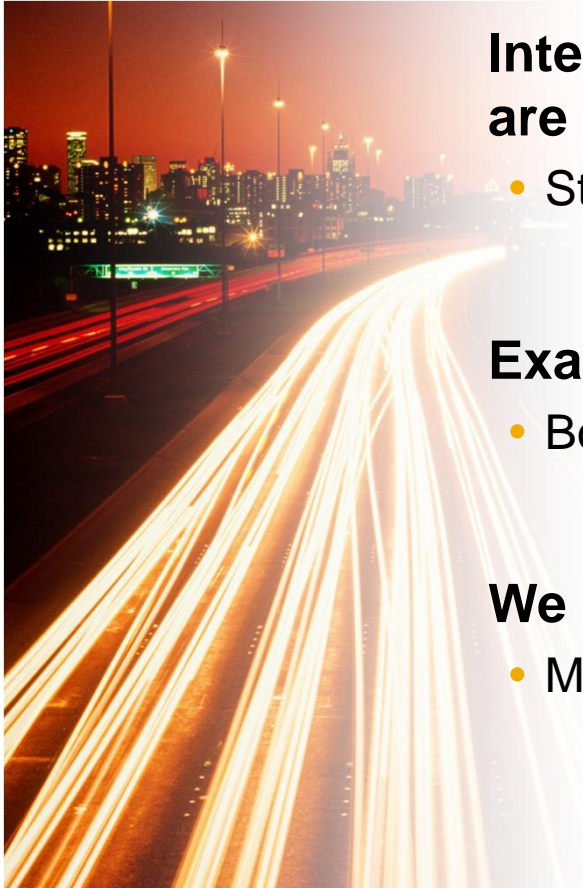
- Encompassing **heterogeneous devices** (mobiles, embedded devices)
- Native access to **Cloud processing**, storage and analytical infrastructures
- Enable **service-oriented**, flexible systems
- Produce and consume information according to **Linked Open Data** standards
- Composition into higher-level services and **processes**
- Including **security, privacy and trust**
- Suitable for **real-world applications**



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# Summary

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## **Internet of Things, Cloud Computing and Services are all aspects of a (Future) Internet**

- Strengths of each can and should be combined

## **Examples of successful combinations exist**

- Both in the public and the business domain

## **We are at the beginning of an interesting journey**

- Many challenges still lie ahead



# Thank You!

Danke    ありがとう    Merci    आभारी    Grazie    Gracias    謝謝    Obrigado  
Ευχαριστώ    Tack    감사합니다    Dankie    شكرا    Xin cảm ơn    благодаря  
Köszö    Terima kasih    спасибо    Mahalo    ขอบคุณ    Ngiyabona    நன்றி    תודה  
Teşekkürler    Mulțumesc    مرسي    Ndiyabulela    Dzięk    Grazcha

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