SIEMENS

TUM & Siemens Corporate Technology

The "Internet of Things" for industrial applications

IoT Technologies: Semantics

Challenges in the Future of Embedded Networks

Growing number of interconnected heterogeneous devices in different kind of application domains such as home/building and industry automation, smart grid, and automotive industry.

Questions

How to identify particular devices in a network?

How to identify particular data in a network?

What is the meaning of the data?

How can machines make inferences?

Approaches

- Web Semantic technologies provide mechanisms for self-description of data which are also machine interpretable
- These technologies have to be made feasible to devices which have constrained resources such as memory or processing capabilities.

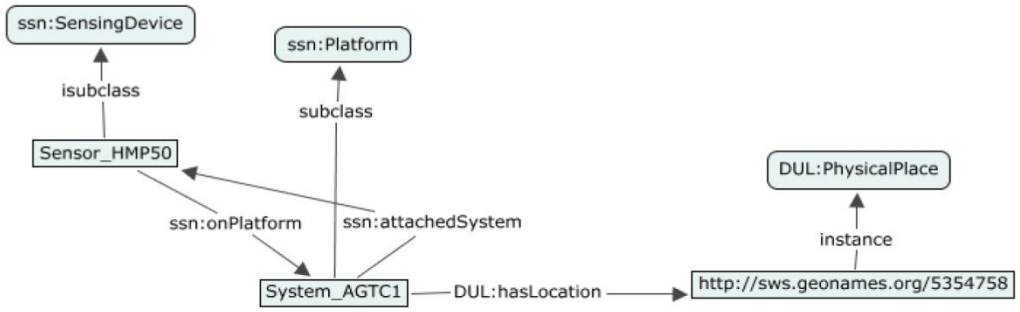
IoT Technologies: Semantics

Presentation Ideas

- Overview about known Web Semantic technologies relevant for devices
- Semantic for devices approaches presentation such as from SPITFIRE, DIEM, and MIoTE projects
- Comparison of semantic reasoners which are relevant for embedded environment

Possible Resources

- W3C:
  - Binary RDF
  - OMM
  - Semantic Sensor Networks
  - RDF/OWL 2/ SPARQL



- Papers:
  - “Enabling Semantic Technology Empowered Smart Spaces”, Kiljander et. al, 2012
  - "SPITFIRE: Towards a Semantic Web of Things“, Pfisterer et al, 2011
  - “Embedded EL+ Reasoning on Programmable Logic Controllers”, Grimm et al,

IoT Technologies: Data Processing

Data Processing in Embedded Networks

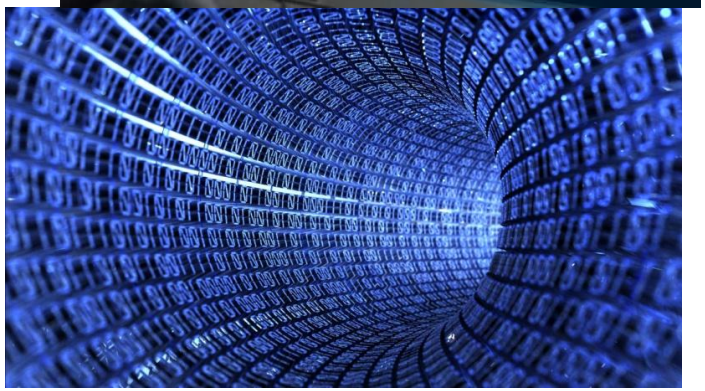
A multitude of devices and a bulk of measurements of sensors have to be monitored and processed. Typically, a measurement is provided to the network (streamed) and can not requested again (send & forget).

Questions

How to identify important data events?

How to detect malfunctions of a system?

Who has access to particular data?



Approaches

- Data stream management systems (DSMS), publish-subscribe mechanism, and complex event processors provide opportunities to identify requested data events and optimize data usage in networks
- Direct adaptations in industry ‘s embedded environment is in most cases not feasible due to the system requirements

IoT Technologies: Data Processing

Presentation Ideas

- Overview about filtering approaches known form publish-subscribe systems (e.g., YFilter)
- Data processing approaches for constrained devices such as TinyDB ,Cougar, Binary XML Filtering
- How to realize data policy (data ownership) in stream-based networks?
- Overview about stream-based approaches such as from DSMS or semantic environment (e.g., EP-SPARQL)

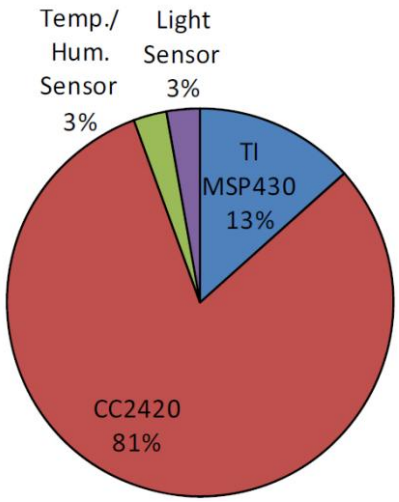
Possible Resources

- Madden et. al., TinyDB: An Acqusitional Query Processing System for Sensor Networks
- Diao et al, High-Performance XML Filtering: An Overview of YFilter
- Käbisch et al, Efficient Filtering of Binary XML in Resource Restricted Embedded Networks
- Darko et al, EP-SPARQL: a unified language for event processing and stream reasoning

IoT Technologies: Low Energy Communication

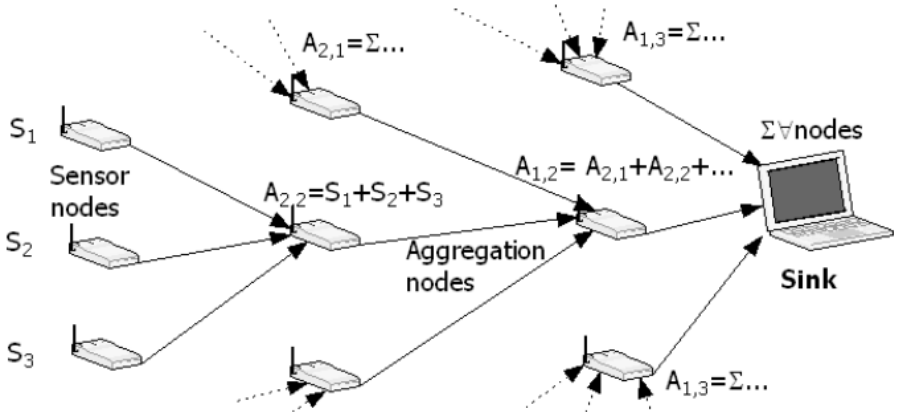
Challenges

- Devices should operate for months or years, powered by batteries or by harvested power
- Wireless communication has one of the biggest or THE biggest energy costs in the device's lifetime



Approaches

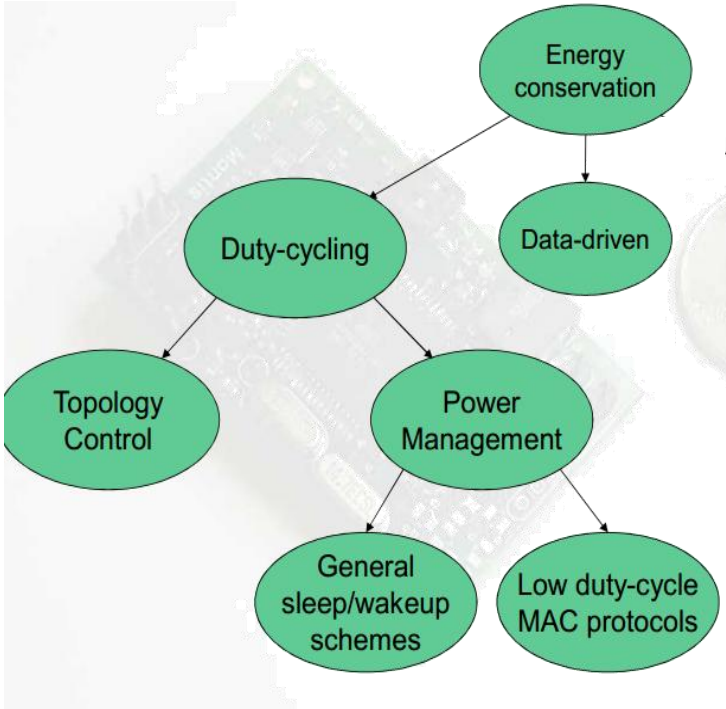
- Low-energy communication protocols
  - Physical (IEEE 802.15.14, Bluetooth low energy, …)
  - Medium Access (TDMA-based, backoff-based, …)
  - Routing
- Reduce communication (Data-driven)
  - In-network aggregation (TAG, SIA, …)
  - Model-driven Data Prediction
- Duty-cycling



IoT Technologies: Low Energy Communication

Possible Topics

- Communication protocols / low energy stacks
  - E.g. ZigBee vs. Bluetooth low energy
- Comparison of different physical/MAC/routing protocols
- Overview data-driven approaches to energy saving
- Any sensible sub- or superset of the above topics



Literature

- Anastasi, Giuseppe, et al. "Energy conservation in wireless sensor networks: A survey." Ad Hoc Networks 7.3 (2009): 537-568
- Ozdemir, Suat, and Yang Xiao. "Secure data aggregation in wireless sensor networks: A comprehensive overview." Computer Networks 53.12 (2009): 2022-2037
- Boukerche, Azzedine, et al. "Routing protocols in ad hoc networks: A survey." Computer Networks 55.13 (2011): 3032-3080

Advisor

- Thomas Kothmayr, kothmayr@in.tum.de

IoT Technologies: Constrained Devices

Smart Objects

- are nodes with constrained computational and memory resources
- are expected to integrate and interface with existing Internet and Web-technology in an interoperable manner

Hardware Platform

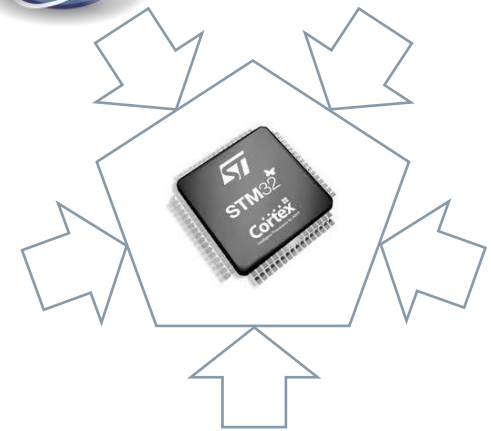
- Daily growing number of (evaluation) boards
- ARM Cortex M3 seems dominant
- Typical configuration 128/256k Flash / 8/16k RAM (Harvard)

Approaches towards Resource Efficient Protocols

- Some protocols can be implemented efficiently (e.g. embedded IP stacks) but often with different API (e.g. no BSD sockets)
- Some protocols use extensions / add-ons to decrease overhead (e.g. IP header compression)
- Some protocols user different encoding / representation (e.g. EXI & XML)
- Newly defined protocols with well-defined mapping to existing Internet protocols (e.g. CoAP & HTTP)

HTTP / CoAP

IPv6 / 6LoWPAN



XML / EXI

IoT Technologies: Constrained Devices

Presentation Ideas

- Overview of the whole picture in both worlds (the Internet stack vs. the constrained stack)
- Comparison of protocol / solution on a specific layer
- ? (open for suggestions)

Possible Resources

- Specs / docs / examples for eval boards
- Standards
  - W3C Efficient XML Interchange (EXI)
  - IETF Constrained Application Protocol (CoAP)
  - IETF IPv6 over Low power WPAN (6LoWPAN)
- Working Group mailing lists
  - To browse discussions for specific design decissions
- Open source projects / implementations
- IoT startups

IoT Applications: Smart Grid

Smart Grid

- **Past:** centralized generation, predictable consumption
  Control paradigm: generation follows load
- **Today:** fluctuating decentralized generation, local optimization of consumption
  Control paradigm: generation follows weather conditions
- **Tomorrow:** smart prosumers managing their own energy production and consumption, electricity, heat and mobility closely interconnected
  Control paradigm: internet of energy

- **Don’t forget the physics!**
  - In every second you have to produce and consume ***exactly*** the same amount of energy
  - Control loops at various timescales (from milliseconds to months) and extent (from single device to trans-european grid) have to interoperate
  - System stability is essential!

IoT Applications: Smart Grid

Presentation Ideas

- System stability and robustness in a massively distributed system: problem scope and approaches
- Timescales in the electric grid: from millisecond control loops to long-term planning
- Smart Grid communication protocols and their application areas
- Economic aspects of Smart Grids (virtual power plants, dynamic prizes, trading)

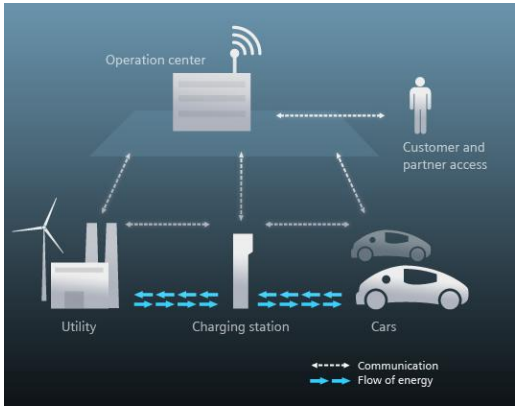
Possible Resources

- Research projects (e.g. E-Energy)
- Communication standards
  - IEC 61850, IEC 61968, IEC 61870
  - OpenADR
  - Homeplug / ZigBee Smart Energy Profile 2
- Government institutions, organizations (Bundesnetzagentur, ENTSO-E, …)

IoT Applications: Electro Mobility

Charging Technologies

- Different technologies with different benefits available
- Various challenges, e.g. charging speed, ease of use, Ecar weight, costs, complexity

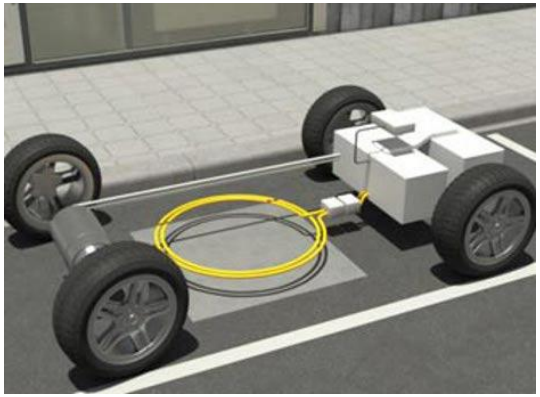


Communication between Ecars and Charge Spots

- “Dump” charging will cause problems for grid stability
- Charging parameters should be negotiable
- Fast and efficient control of the charging process
- Strong interest for value-add/other applications (telemetry, software update, etc)

End Users

- What are acceptable charging approaches (what flexibility is the user willing to provide)
- HMIs, how can the user monitor the charging process, how can the user configure and influence the charging process
- Fleet management



IoT Applications: Electro Mobility

Presentation Ideas

- Mechanisms / solutions for the identification of Ecars users at charging spots
- Charging technologies, their differences, common and unique challenges
- Charging control from the user perspective (applications)
- Ecar to charging station communication protocols and their functionalities

Possible Resources

- Google search
- Communication standards
  - ISO/IEC 15118
  - IEC 61841-1
  - Siemens presentation V2G ISO/IEC 15118 standardization - A key for electromobility
- Final report of the project Harz.ErneuerbareEnergien-Mobility

IoT Applications: Home /Building Automation

Trends in Home Automation

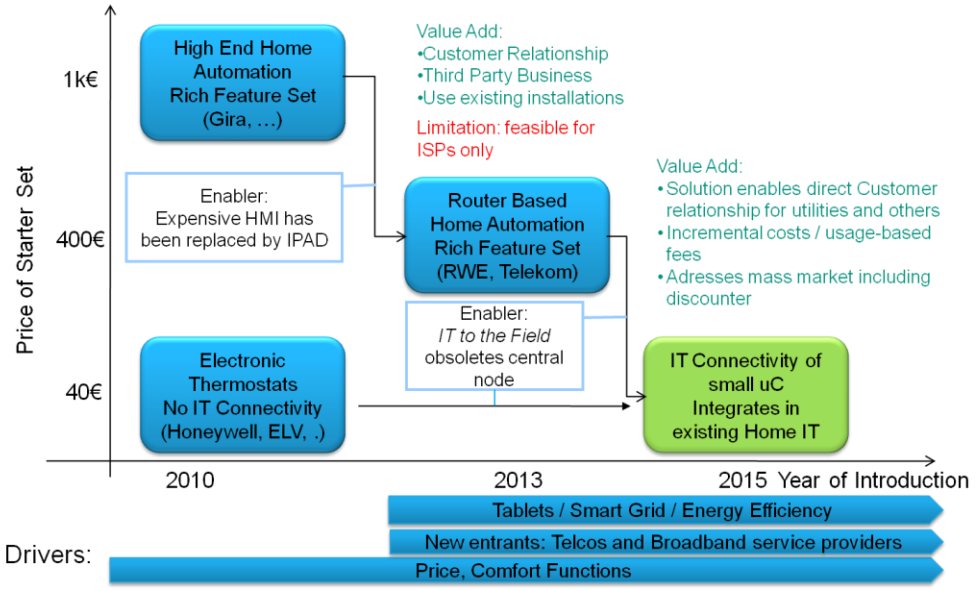
- IT integration, at least for smart phone
- Smart automation coming from high end
- Nerd solutions coming from the electronic distributors

Technology enabler

- Affordable 32bit uC including the wireless interface
- Powerfull open source router plattforms
- uIP stacks for embedded networks
- Affordable development boards and IDEs

Architectures driven by stakeholder interests

- Decentralized, networked devices vs
- Router based star networks vs
- Online hosted direct connectivity



IoT Technologies: Home /Building Automation

Presentation Ideas

- Architectures, Openess and Motivation of the different solutions / stakeholders on the market
- Protocol technologies and IT integration
- ? (open for suggestions)

Possible Resources

Solutions

- Telecom / QIVICON
  www.qivicon.com
- RWE
  http://www.rwe-smarthome.de
- ELV
- Belkin WEMO
  http://www.belkin.com/de/PRODUKTE/home-au
- Philips hue
  https://www.meethue.com/
- OGEMA
  http://www.ogema.org

Discussion Boards

- Elektronik Foren