Seven Pitfalls in the Internet of Things

Hello, how are you?

fine, and you?
Captain Jean-Luc Picard, Star Trek, in front of the „Replicator“
Seven Pitfalls in the Internet of Things

1. Not understanding the Paradigm Change
2. Lack of Interoperability
3. Lack of Intelligence
4. Lack of Security
5. Lack of User Centered Design
6. Not understanding the real Driver
7. Not understanding the Impacts on Development
Smart Objects connect Digital and Real World

- The digital revolution of the 21st century will be much, much larger than previous two digital revolutions of personal computers and the internet.

- We are now facing the digital revolution of the 21st century: Smart objects in the Internet of Things, that interconnect the digital world with the physical world.

- A smart object is a small microelectronic device that consists of a communication device, typically low power radio, a small microprocessor and a sensor and/or actuator.

Credits: Jean Philippe Vasseur, Adam Dunkels
Internet of Things changing Automation Paradigm

- The "Internet of Things" (IoT) is describing billions of embedded devices that are communicating with each other through internet technology without involving human beings directly.

- In the automation context, the IoT means the shift from centralized and hierarchical control towards cooperative, distributed networks and control structures.

- Formerly passive sensors (simple objects) become active players (smart objects) in networks and are enhanced with the capability for computation and decision making.
Enabling Technologies

- **IPv6**

- **Low Power Wireless** (6LoWPAN, ZigBee IP, BLE, Thread)

- **New Protocols for constrained Embedded Devices**

- **Mobile Multiagent Systems**
Wireless Sensors
Wireless Sensor Networks
Why Wireless?

- Electrical wall socket + installation = 60 €
- CAT 5 socket + installation = 110 €
- 1 billion nodes?

Credits: Carsten Bormann
# Wireless Networking Technologies

<table>
<thead>
<tr>
<th></th>
<th>Bluetooth 4.1</th>
<th>Wifi</th>
<th>ZigBee 3.0</th>
<th>ZigBee Green</th>
<th>EnOcean</th>
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<tbody>
<tr>
<td><strong>Standard</strong></td>
<td>IEEE 802.15.1</td>
<td>IEEE 802.11</td>
<td>IEEE 802.15.4</td>
<td>IEEE 802.15.4</td>
<td>IEC 14543-3-10</td>
</tr>
<tr>
<td><strong>Topology</strong></td>
<td>Piconet, Scatternet</td>
<td>Star</td>
<td>Mesh, Star, Tree</td>
<td>Mesh, Star, Tree</td>
<td>P2P, Star</td>
</tr>
<tr>
<td><strong>IPv6</strong></td>
<td>Coming 4.2</td>
<td>Yes</td>
<td>ZigBee IP</td>
<td>./</td>
<td>./</td>
</tr>
<tr>
<td><strong>RF frequency</strong></td>
<td>2.4 GHz</td>
<td>2.4 GHz, 5.8 GHz, 3.65 and 3.7 GHz</td>
<td>868/915 MHz, 2.4 GHz</td>
<td>868/915 MHz, 2.4 GHz</td>
<td>868 MHz/315 MHz</td>
</tr>
<tr>
<td><strong>Data rate</strong></td>
<td>&lt;= 305 Kbit/s</td>
<td>&lt;= 600 Mbit/s [n]</td>
<td>&lt;= 250 Kbit/s</td>
<td>&lt;= 250 Kbit/s</td>
<td>&lt;= 125 Kbit/s</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>&lt;= 50 m</td>
<td>&lt;= 100 m (depending on frequency)</td>
<td>&lt;= 300 m (depending on frequency)</td>
<td>&lt;= 50 m (depending on frequency)</td>
<td>&lt;= 300 m</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>Very low</td>
<td>High</td>
<td>Very low</td>
<td>Harvesting</td>
<td>Harvesting</td>
</tr>
<tr>
<td><strong>Wakeup time</strong></td>
<td>&lt;= 6 ms</td>
<td>&lt;= 3 s</td>
<td>&lt; 30 ms</td>
<td>&lt; 30 ms</td>
<td>&lt; 10 ms</td>
</tr>
<tr>
<td><strong>Battery lifetime</strong></td>
<td>Weeks to month (rechargeable)</td>
<td>Hours (rechargeable)</td>
<td>Month to years</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Security</strong></td>
<td>AES 128 + + application layer</td>
<td>SSID</td>
<td>AES 128 + application layer</td>
<td>AES 128 + application layer</td>
<td>Option</td>
</tr>
<tr>
<td><strong>Nodes</strong></td>
<td>Depending on implementation</td>
<td>32</td>
<td>$2^{16}$</td>
<td>$2^{16}$</td>
<td>$2^{32}$</td>
</tr>
</tbody>
</table>
Benefits of Wireless Lighting Controls

- Cost savings
- Demand management
- Flexibility
- Scalability
- Simplicity of use
- Energy management
- Other add on.
Why IPv6?

- IPv4 is limited to 4.294.967.295 addresses
- IPv6 provides $3.4 \times 10^{38}$ addresses
- There are only $10^{25}$ grains of sand on earth
- Let’s settle for $10^{10}$ objects on the IoT
- IPv6 is an enabling technology for the IoT
IPv6 in ZigBee and 6LoWPAN

ZigBee SE 2.0

IPv6

TCP

UDP

Network Management (ND, RPL)

6LoWPAN adaption

802.15.4 MAC

802.15.4 PHY

Application Security

Stack Security

TLS

EAP-TTLSv0

EAP

PANA
Protocols for constrained Embedded Devices

100s - 1000s of bytes

- XML
- HTTP
- TCP
- IP

10s of bytes

- EXI, JSON
- CoAP
- UDP
- 6LoWPAN

Credits: Zach Shelby
Multi Agent Systems

- Autonomous software agents collaborating in one system
- Decentral concept with distributed intelligence, no mandatory central control, no need of designated controlling agent
- Not necessarily determined, can be self-organizing and self-learning
- Enables loose couplings
- More flexible and reliable.
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Dimensions of Interoperability

- **Technical Interoperability**
- **Semantic Interoperability**
- **Process Interoperability**
Unified Communication & Protocol Abstraction

Applications

Nogs Super-Protocol (JSON based)

HTTP  CoAP  ArtNet

TCP  UDP  UDP

IP  6LoWPAN  IP

IEEE 802.3  IEEE 802.15.4  IEEE 802.11

Internet over LAN  IoT over WPAN  DMX over WLAN

Nogs Protocol Abstraction Layer wrapping & unwrapping
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Artificial Intelligence
“Smart Objects are Objects which with the embedding of Information Technologies possess capabilities over and above their primary applications.”
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Security in Building Automation System & IT

<table>
<thead>
<tr>
<th>Feature</th>
<th>BAS standards</th>
<th>IT mechanisms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BACnet</td>
<td>LonWorks</td>
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<tr>
<td>Entity authentication</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Authorization</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Data integrity</td>
<td>+</td>
<td>~</td>
</tr>
<tr>
<td>Data freshness</td>
<td>+</td>
<td>~</td>
</tr>
<tr>
<td>Data confidentiality</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Data availability</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Embedded devices</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Communication models</td>
<td>-</td>
<td>~</td>
</tr>
<tr>
<td>Scalability</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Non IP networks</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>QoS features</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Credits: Wolfgang Kastner
Security by Design
Security

- Security is not only a question of the communication protocol
- Security has to start with hardware (e.g. hardware encryption, hardware based communication)
- Security as to be included in the application level (e.g. authentication, sandboxes)
- Special mechanisms e.g. for man in the middle & overload attacks & APT-infection
- Open Source.
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User Centered Design
UCD Standards

What is User Centered Design (UCD) Approach?

- User-Centered Design process for interactive systems
  
  EN ISO 9241-210 (replaces EN ISO 13407)
  ISO PAS 18152

- Ergonomics of Human Machine Interfaces (HMI)
  
  EN ISO 9241-110
  ISO TR 16982

- Software Usability
  
  EN ISO 9241-11
  EN ISO 14915

- Design for All.
UCD Process

Plan
Define user requirement & analyze competition

Design
Design wireframes, interaction sequences & navigation

Proto type
Develop & test dynamic prototypes for usability

Review
Review wireframe designs with customer
DYI - Maker Culture
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Elements of disruptive Innovation

1. Sophisticated technology that simplifies

2. Low-cost innovative business models

3. Economically coherent value network

Credits: Clayton Christensen
Business Model

Who are the customers?

What is being sold?

How is it produced?

How is the revenue earned?
How IT transforms the Business Model

Credits: Oliver Gassmann
Keep on moving - reinvent your Business Model
Business Model Canvas

The Business Model Canvas

Key Partners

- Record Companies
- OEMs

Key Activities

- Hardware Design
- Marketing
- Apple Brand

Key Resources

- Content & Agreements
- iPod Hardware
- iTunes Software

Cost Structure

- Manufacturing
- Marketing & Sales
- People

Value Propositions

- Seamless Music Experience
- Switching Costs
- Lovemark

Customer Relationships

- Mass Market
- Retail Stores
- apple.com

Customer Segments

- Mass Market
- Apple Stores
- iTunes Store

Revenue Streams

- Large Hardware Revenues
- Some Music Revenues

Credits: Alexander Osterwalder
Internet driven Business Models

**Web 1.0**
Web as a Business Structure

- E-Commerce
- Freemium
- Leverage Customer Data
- Open Source (Software)
- Digitalization

**Web 2.0**
Web as Social Media „When users add value“

- User designed
- Crowdsourcing
- Crowdfunding
- Long Tail
- Open Source (Content)

**Web 3.0**
Internet of Things „When sensors add value“

- ?
- Digitally charged Products
- Sensor as a Service
IoT Business Models - Grades of Maturity

- **Maker**
  - Experimental
  - Hardware sales model complemented by cloud service
  - Hardware capex

- **Hardware**
  - Bring your own thing
  - Unified service across sold things
  - Hardware capex & service opex

- **Service funded thing**
  - Connected thing is part of service contract
  - Service opex

- **Commodity IoT service**
  - Commodity service assumes ubiquitously available things
  - Service opex

Credits: Forester Research
New Quality of IoT Data

- Location based
- Realtime
- High resolution
- Ubiquitous
Data based Services

- ThingSpeak
- If this then that (IFTTT)
- Wolfram Alpha

...
Services powered by Embedded Devices
Smart Building
Real Time Location Services

**LED luminaire with VLC enabled driver**

**Phone plugin for decoding VLC positioning information & 1-time download of loyalty app with fixture and merchandise map**

**1-time commissioning of fixture map**

**Database** with fixture coordinates and merchandise map + Analytics

**Technologies:**
- Qualcomm Lumicast
- Bytelight
Heat-map of Occupancy Activity
Augmented Reality

- AR is a live view (direct or indirect) of a real world environment whose elements are augmented by computer generated sensory input such as graphics, video, sound or GPS-data

- Augmentation is conventionally in real time an in semantic context with the environmental elements

- With the help of technologies like computer vision and object recognition the surrounding real world of user becomes interactive and digitally manipulable.
physio sense
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What’s new for many Industries?

- Intelligent Sensors
- Microcontroller
- Software
- Distributed Intelligence
- Data
- Analytics
- Services
Agile Development
BENEFITS OF AGILE DEVELOPMENT

- **Visibility**
- **Business Value**
- **Adaptability**
- **Risk**

**Agile Development** vs. **Traditional Development**
Wrap-up - Impacts

- Future-proof products have to adopt to IoT technologies
- IoT is non domain-specific (e.g. lighting controls)
- Developing IoT based solutions requires a deep understanding of embedded systems
- Intelligent software concepts will be the key factor to generate USP in the industry
- Connecting products with the IoT opens complete new business models in several industries
- Industries have to rethink it’s development approach and consider open source
- Solely hardware based business models gonna have though times.
Thank you - Questions?