Introduction of flexible monitoring equipment into the Greenlandic building sector

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Wireless Sensor Network (WSN) - Basics

• Sensors of any type
• Connected thought network
• Communication wireless
  – with a Synchronization node
  – with each other
  – through each other (hops)

• Strength
  – Sensors can be added and removed in the running network
  – Sensors can communicate through each other
  – ... a very flexible selv configuring platform
Development History

• 1st trial with SunSpots
  – Very good implementation of the WSN technology
  – Very bad implementation of the many sensors
    • E.g. Heat sensor was placed too near to the light diode
• 2nd trial with a development company
  – Lack of maturity
  – Lack of development infrastructure for programming the nodes
  – Very high price due to small production
• 3rd trial is the one presented here – Libelium Waspmote
Waspmites

- Extremely flexible development and demonstration platform
  - customizable
  - consisting of:
    - Sensor Board
    - Sensor Network modules (exchangeable)
    - Communication modules - plugins (GSM, Wifi, Zigbee etc.)
    - Battery packages
  - other characteristics
    - Open source
      - programming platform
      - policy
      - and community
Laboratory testing

- Range in the free: 50 meters
- Range in buildings (steel-concrete and brick stones): 30 meters
- Battery charging and usage
- Sensor precision
- ... and much more
The Building – Apisseq - Dormitory

- Dormitory, built 2010

- Aim: To save energy and keep the indoor environment
**HVAC optimization**

- **Before:**
  - On-off control which means on-all-the-time
- **After:**
  - Demand controlled on basis of CO2-measurements in every room
- **Requires:**
  - Sensors
  - Control strategy
    - If one sensor is above a threshold => ”On”
    - Else ”Off”
- **Expected savings = >70% ventilation energy**
HVAC optimization

- Installation of 18 sensors
- .. on half of the symmetrical building

- Enables comparison of the two buildings
  - to be corrected for the influence of solar gain through windows

Wireless controlled

On-off controlled
The Case Study Results – So fare ...

- Update software on any device to same state
  - Not the case by delivery
- Test sensors (until experiences are large)
- Configuring is straight forward
- Open source platform, Arduino with some changes
- Casing must be solved
- With a few sensors on can do the work as one goes
- With many sensors on has to build up procedures
- Configuration and programming may take a few days (not fulltime at all)

- Unfortunately no results on monitoring due to delays
Costs

Table 2. Price estimation for the wired solution

<table>
<thead>
<tr>
<th>Item</th>
<th>Price (incl.VAT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18x CO₂ sensors (Vaisala CARBOCAP® GMW 22)</td>
<td>6,000 €</td>
</tr>
<tr>
<td>Programmable logic controller with web server (Prolon PID 4000) including installation</td>
<td>4,000 €</td>
</tr>
<tr>
<td>Installation of the sensors</td>
<td>6,000 €</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>16,000 €</strong></td>
</tr>
</tbody>
</table>

Table 1. Price estimation for the wireless solution

<table>
<thead>
<tr>
<th>Item</th>
<th>Price (incl.VAT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>19x Wasp mote ZigBee PRO</td>
<td>3,800 €</td>
</tr>
<tr>
<td>18x Gases Sensor Board v2.0</td>
<td>2,160 €</td>
</tr>
<tr>
<td>18x Solid electrolyte CO₂ Sensor TGS 4161</td>
<td>880 €</td>
</tr>
<tr>
<td>Meshium ZigBee-PRO-AP</td>
<td>660 €</td>
</tr>
<tr>
<td>Installation of the sensors</td>
<td>500 €</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8,000 €</strong></td>
</tr>
</tbody>
</table>

• plus configuration & programming for both solutions

• STATUS
  – Due to paternity leave, the project is derailed
  – Not installed yet (to be installed in April 2014)
  – To be reported in October 2014
Expected results above the case study

- Simple coupling to
  - "Internet of Things"
  - "Big data"
  - Building Automation / "Smart Buildings"
  - "Smart Grid"

- Applicable for Positioning
Further work and Opportunities

• Battery lifetime
• Battery charging
• ... standardization on
  • Configuration
  • Programming
  • communication protocols
  • ...
• Flexible monitoring system developments
  – Commissioning
  – Debugging

• Positioning – on basis of the node RSSI measurements (~ 40 cm precise)
Any Greenlandic reflection

• Assumptions:
  - Limited access to automation professionals in Greenland
  - Skilled labour is expensive
  - Demanding to come around
  - => Hence expensive to use professionals
Any Greenlandic reflection

- Drawback for WSN
  - Hardware can be cheap and expensive
    - (many possibilities – choose one)
  - Battery charging is not solved – el-wired is recommended
    - (not really wireless, well?)
  - Sensor quality depends on the sensors applied (price-performance)
Any Greenlandic reflection

• Strength of WSN
  – Extremely easy installation, after prepared configuration
  – Very cheap installation (if el-wired)
  – Remote configuration and programming
  – Remote and automated calibration of sensors (esp. CO2-sensors)
  – Repurposing of hardware (a topic in itself)

![CO2 Measurement Comparison](chart.png)

**Figure 5.9:** CO\textsubscript{2} measurements from the burning procedure
Thanks to ...

- my colleagues
  - Christian Orthmann
  - Martin Kotol
- Bjarne Saxhof Foundation
Alternative platforms

- National Instruments
- Digital Instruments
- MakeThisWork
  - Danish produced
  - Communication: Bluetooth Low Energy – good battery conditions
  - rather expensive, 6000 DDK/node with a set of sensors)
- ... and many more