Energy-saving Intelligent Street Lighting System
Problem Statement

- Goal of public lighting systems
  - Keeping public space of settlements safe at dark times of day
    - Street lighting
    - Lighting of parking lots
    - Lighted highways

- Problem of the “conventional” street lighting:
  - High financial burden to the public administrations
  - At the edges of the city and in settlements almost off use
  - Unnecessary light pollution of the environment
Possible Solutions

1) Switching off lights after 24:00
   - Eliminates the main goal of public lighting systems – keeping a pedestrian in a “safe” lighting zone

2) Switching off each second lamp
   - Also reduces the security and convenience factor significantly

3) Equip each lamp with a motion sensor and switch it on/off upon detected motion
   - Limited range of detection
   - Inertia of the lamps - effect of switching on behind the pedestrians
   - Very limited area of illumination
More intelligent way - communication among the lamps

- Motion sensor in each street lamp
- Pedestrian movement estimation
- Control lamps' operation:
  - brightness
  - timing
More intelligent way – communication among the lamps

- Spanning of illuminated area along pedestrians’ paths, e.g.:
  - 250 m ahead / behind
  - Hold-on time 5 min
Operation example (1)

Step 0. Idle, all lamps are off. Motion detection is on
Operation example (2)

Step 1. Person detected at the edge lamp. 3 lamps span an illuminated area
Step 2. Person detected at the second lamp. Illuminated area is now ahead and behind the person
Step 3. At a crossing, each possible path must be illuminated.
Step 4. After passing the crossroad the left part can be switched off
System concept

- Linux SoC-based system for communication and management
- Switching on/off, dimming the lamps
- Message exchange with neighboring lamps
- Communication with the central management system
SmartLighting - the communication concept

- Mesh network over all lamps
  - Using IPv6
  - Auto-configuration of the network
    - IPv6 addresses as position index
  - Application-specific IP routing protocol for message delivery
- GPS-based auto-recognition of street topology
- Diversity of network technologies
  - 2.4 GHz (IEEE 802.11x, 802.15.4)
  - PLC
  - UHF technology (868 MHz)
SmartLighting – the communication concept

- Linux OS on a SoC platform
  - Re-use of open source stacks, libraries and drivers
  - Easy to extend
    - Just extend the software application with new features
      - e.g. dimming instead of simple on/off
  - Easy to maintain
    - Remote access via VPN
    - Integration into a central (communal) lighting management system possible

- A lighting point becomes a powerful network node
  - Advanced applications possible
    - WiFi access point
    - Public security announcements
    - Route information
Development status (1)

- 2-nd generation of lamp prototypes
  - ~ 50 lamps in total
  - Field tests are possible
- Mesh routing protocol for seamless IP-based connectivity
- SmartLighting API for central system monitoring / management purposes
Development status (2)

- Work on object detection
  - PIR sensor
  - Ultrasonic sensor
  - X-band detector
- Other options of object recognition and motion detection
  - IR-camera
  - Hybrid sensors
Development status (3)

- First field test with real lamps on a street with 20 lamps under development
- Integration of SmartLighting circuitry into the lamps of an Austrian manufacturer is ongoing
- Patent on routing means for SmartLighting granted by the German Patent Office (DPMA) granted 2014
- Additional patent applications in preparation
Power savings impact

- Usage plans
  - Energy saving:
    - Expected savings of 80-90% energy within dark period

- Evaluation of energy savings:
  - Using measurements of real pedestrians’ traffic profile
## Power savings impact

<table>
<thead>
<tr>
<th>Input Data</th>
<th>Auxiliary data</th>
</tr>
</thead>
<tbody>
<tr>
<td>price, kWh, €</td>
<td>minutes per hour</td>
</tr>
<tr>
<td>0,25</td>
<td>60</td>
</tr>
<tr>
<td>hold on Time, min</td>
<td>days per month</td>
</tr>
<tr>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>power of lamp, W</td>
<td>days per anno</td>
</tr>
<tr>
<td>150</td>
<td>365</td>
</tr>
<tr>
<td>dark time, night, h</td>
<td>W/kW</td>
</tr>
<tr>
<td>9</td>
<td>1000</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>number of events per night</th>
<th>duration of on-time, h</th>
<th>energy consumption per night, kWh</th>
<th>costs per night</th>
<th>energy consumption per month, kWh</th>
<th>costs per month, €</th>
<th>energy consumption per year</th>
<th>costs per year, €</th>
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</thead>
<tbody>
<tr>
<td><strong>SmartLighting</strong></td>
<td>6</td>
<td>1</td>
<td>0,1</td>
<td>0,0225</td>
<td>2,7</td>
<td>0,68</td>
<td>32,85</td>
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<td><strong>Conventional</strong></td>
<td>20</td>
<td>1,35</td>
<td>0,3375</td>
<td>40,5</td>
<td>10</td>
<td>492,75</td>
<td>123,19</td>
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<tr>
<td><strong>Cost saving</strong></td>
<td>19</td>
<td>1,3</td>
<td>0,3</td>
<td>37,8</td>
<td>9</td>
<td>459,9</td>
<td>115,0</td>
</tr>
</tbody>
</table>
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