

Equipping LED-based public lighting with wireless sensor network

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AgroSense

Outline

SensorLab

LED lighting background

Miren-Kostanjevica municipality

Wireless sensor network & control application



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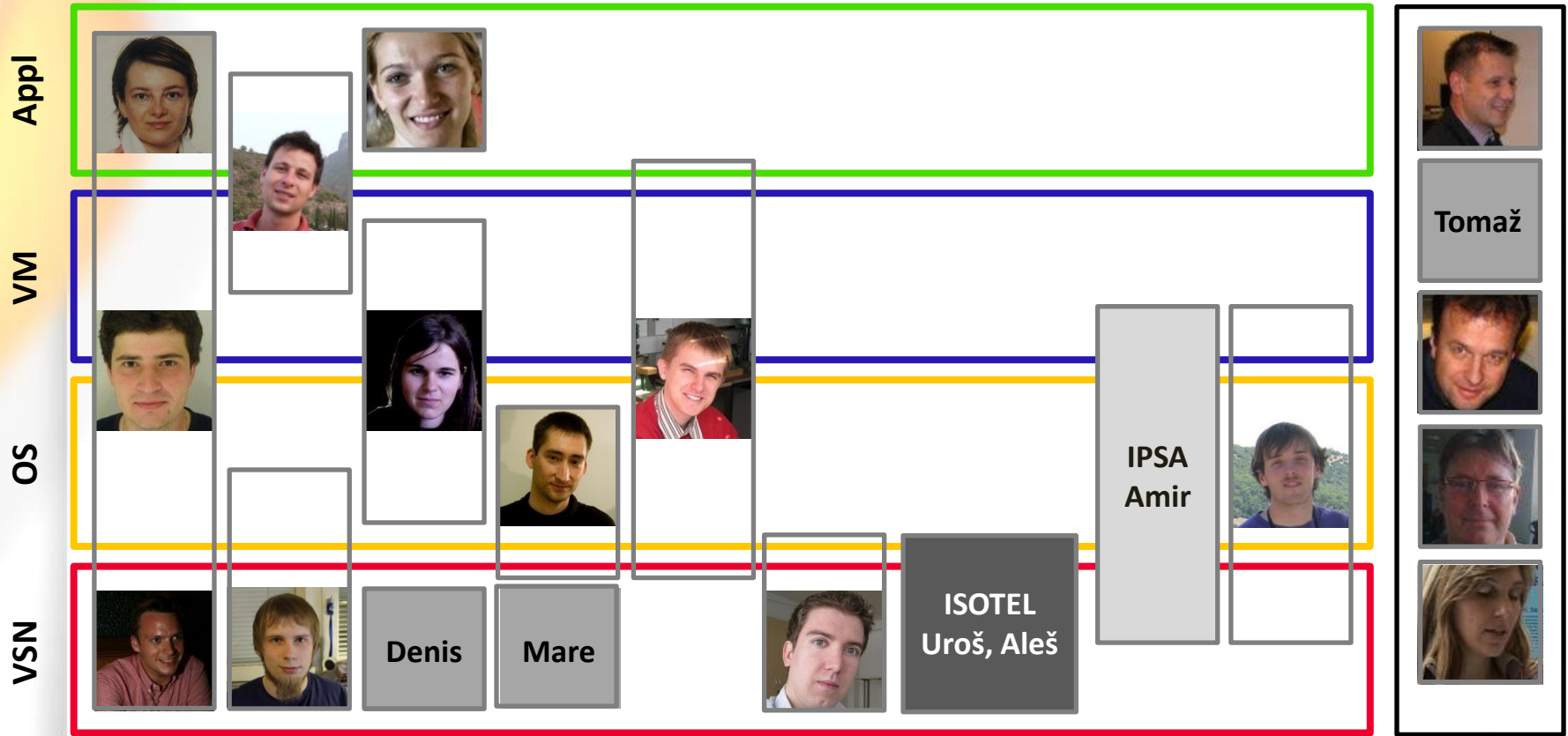
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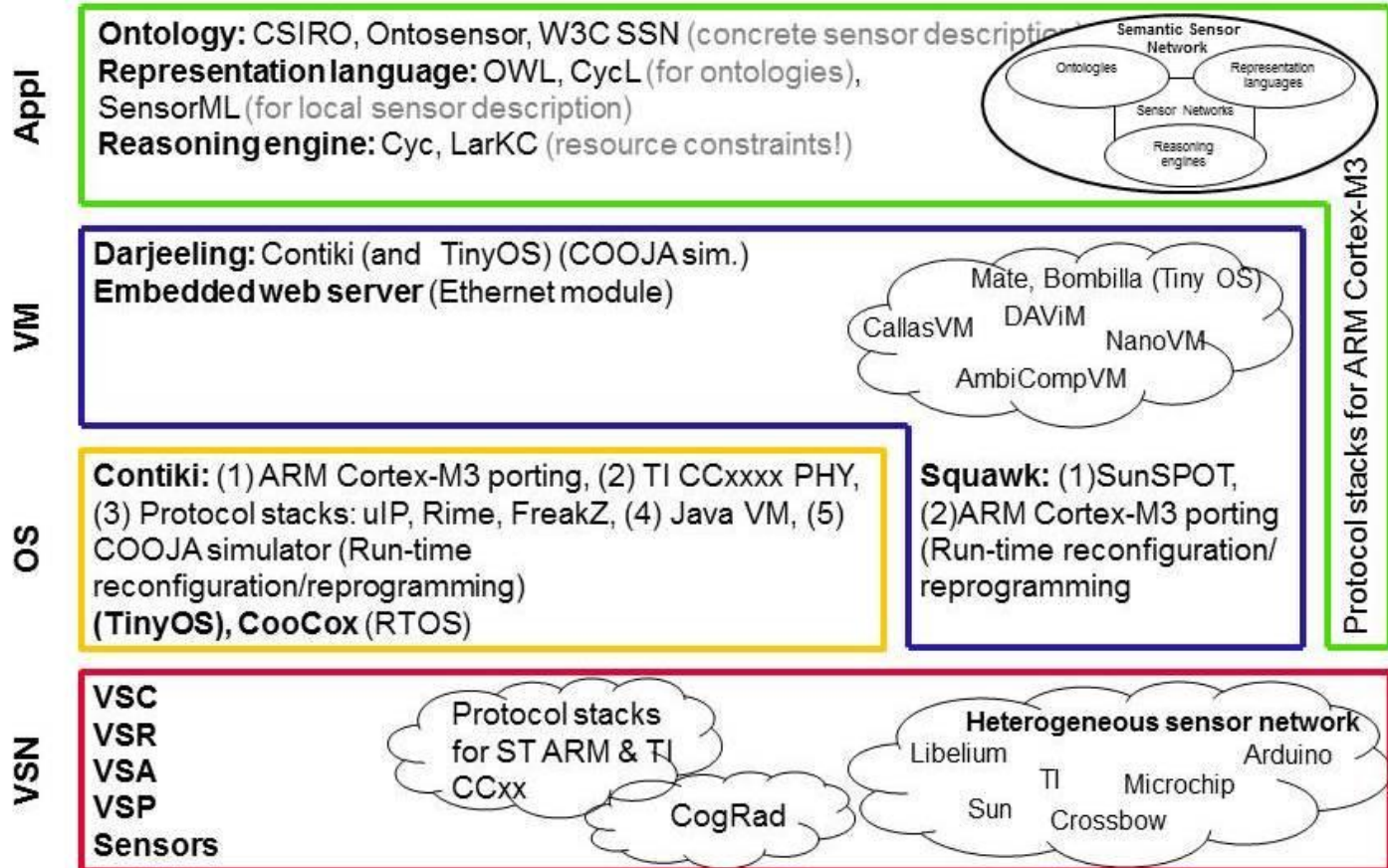
SensorLab

- Department of Communication Systems @ JSI
Department of Knowledge Technologies @ JSI
ISOtel d.o.o.
- Coordinated activities on the development of custom WSN solution started in May 2009
- Key words: Versatile Sensor Node, Vertical Integration, Sensor as a Service (IP connectivity, WEB access), Deliberate/Participatory Sensing, Semantics

SensorLab – The team

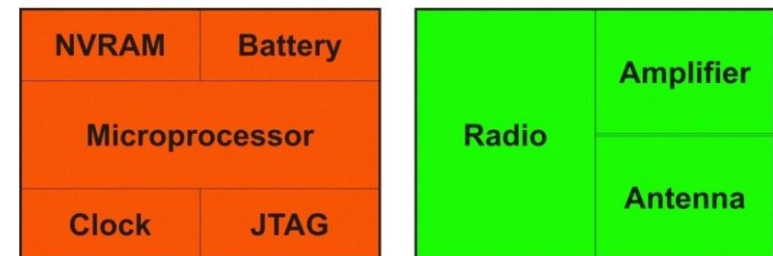
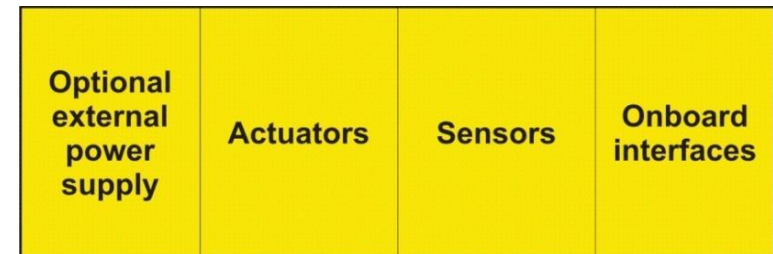


SensorLab - Activities

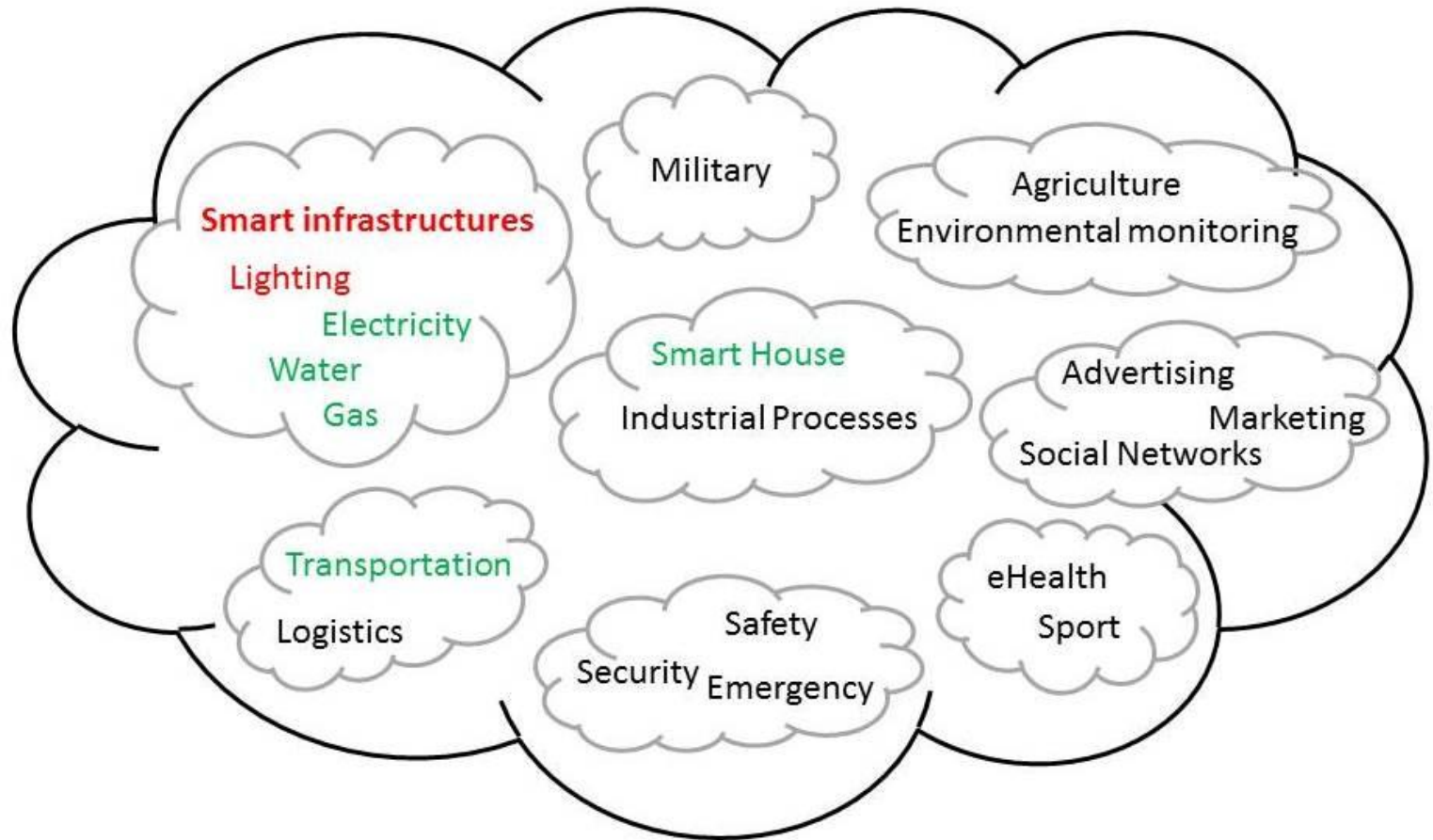


Versatile Sensor Node

- VSC
 - Analog and digital sensor/actuator interfaces
 - Possibility to use operating system (real-time, event-driven)
 - Multiple expansion options
 - Open C/C++ code libraries
 - Onboard memory
- VSR
 - 300-900 MHz, 2.4 GHz radiointerface (all ISM bands)
 - ZigBee, 6LoWPAN and other IEEE 802.15.4 based solutions
- VSE
 - Bluetooth, Wi-Fi, Ethernet, GSM/GPRS
 - Sensors/actuators
 - PoE



WSN application areas



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LED lighting background

- Worldwide policy begins to outlaw inefficient incandescent lights
 - Lighting represents roughly 20% of world electricity consumption
 - EU phase out period: until 2012 (2015)
- Light pollution (dark sky initiative)
 - Focused light beam
- Optimization of external public lighting
 - Uredba o mejnih vrednostih svetlobnega onesnaževanja okolja (Uradni list RS 81/07, 109/07, 62/2010)
 - EN 13201: European standard for Road Lighting



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LED lighting background

- LED-based lights are 90% more efficient than incandescent lights (5% light, 95% of the heat) and 50% more efficient than high pressure mercury lamps
 - About 40% savings in electricity consumption can be achieved just by replacing old lamps with LED technology
 - Additional 25% savings can be achieved with intelligent dimming
- Mutual energy, environmental and economic benefits
 - Reduced energy consumption and CO₂ emissions
 - Emitted light / dissipated heat = efficiency
 - Lifetime + reliability = economy
 - Reduced light pollution

LED characteristics

- LED output of 100 lumen/watt is a crucial factor for breakthrough and mass market
- Advantages:
 - High energy efficiency (operation costs)
 - Long life cycle - 50.000 hours \approx 15 years (maintenance costs)
 - Reliability (mortality curve)
 - No pollutants (mercury)
 - Robustness (resilient to shock and vibration)
 - High degree of directionality
 - Low system complexity
 - Dimming
 - Inherent solar/battery power support
 - Compact form factor
 - Wide range of colors (color temperatures)
 - Lack of UV – do not attract insects

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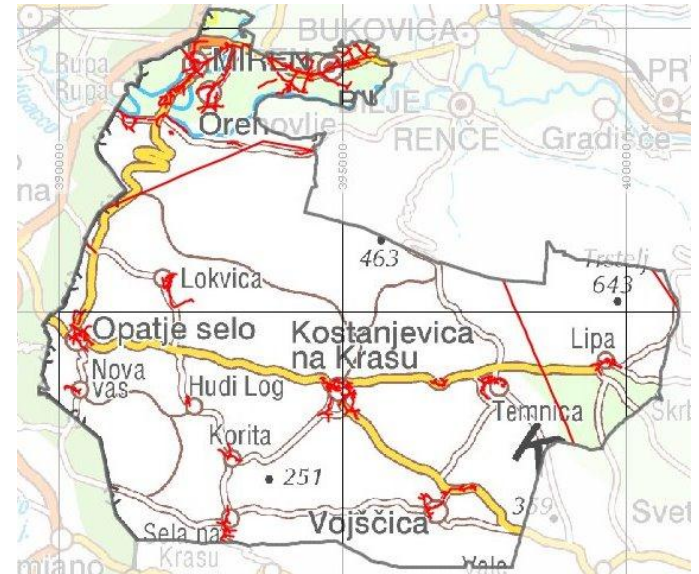
LED lighting background

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Wireless sensor network & control application

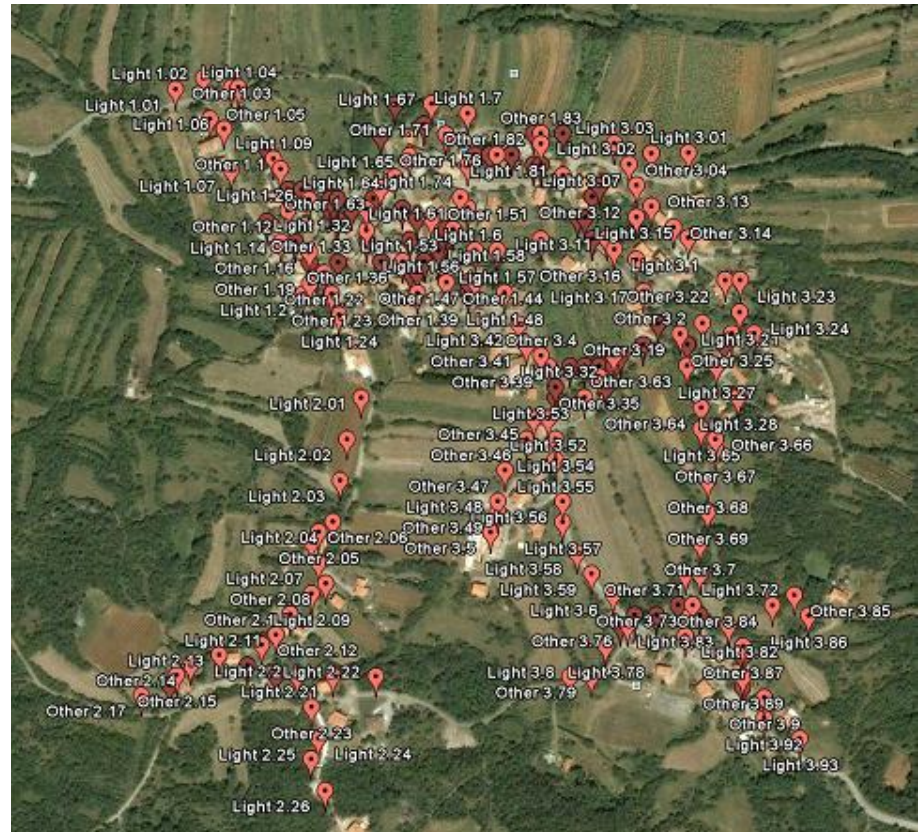
Motivation

- LED technology represents one of the biggest opportunities in lighting. Coupling infrastructure with communication networks provides additional energy savings and opens a portfolio of new applications.
- Replace 850 existing lamps with LEDs
- Equip 25 lamps with WSN
 - Individual lamp dimming
 - Micro level environmental monitoring
 - Real time control of infrastructure over Internet
- 10 years test-bed
- Collaboration: MI4, JSI, municipality, lamps producer, lighting operator, electricity distributor, telecom provider



Kostanjevica

- 53 light poles
- 5 equipped with sensor nodes



SGA LED lamps



- voltage 100-250 V
- low consumption
- full electronics working control (also LED light sources)
- dimming range from 1-100% with control signal from 1 to 10V
- protection class I
- life time minimum 60.000 hours



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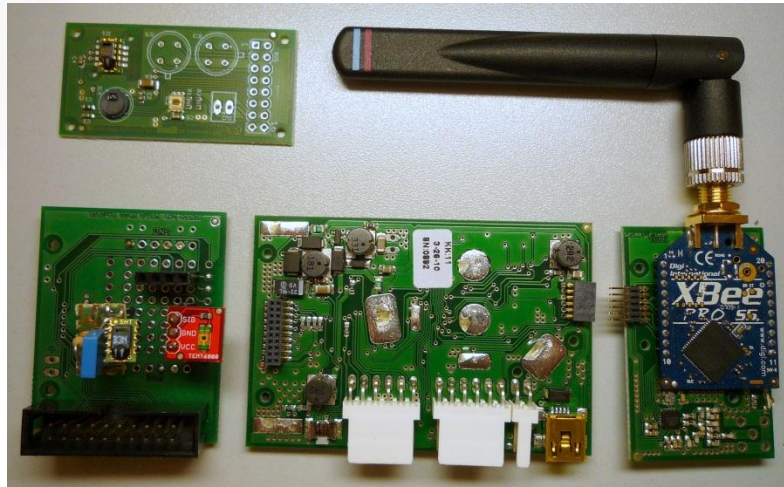


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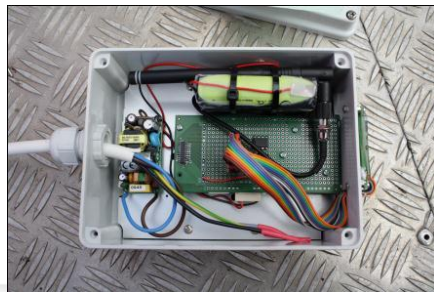
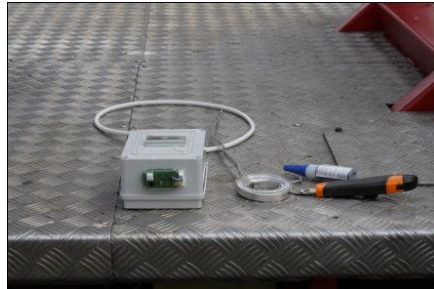
Sensor/Gateway Node

- VSN + Xbee + Power supply + sensor board



Setup

- 1st phase: up & running 25 nodes
- 2nd phase: up & running 100 nodes (by end of 2010)
- 3rd phase: up and running 830 nodes (2011)



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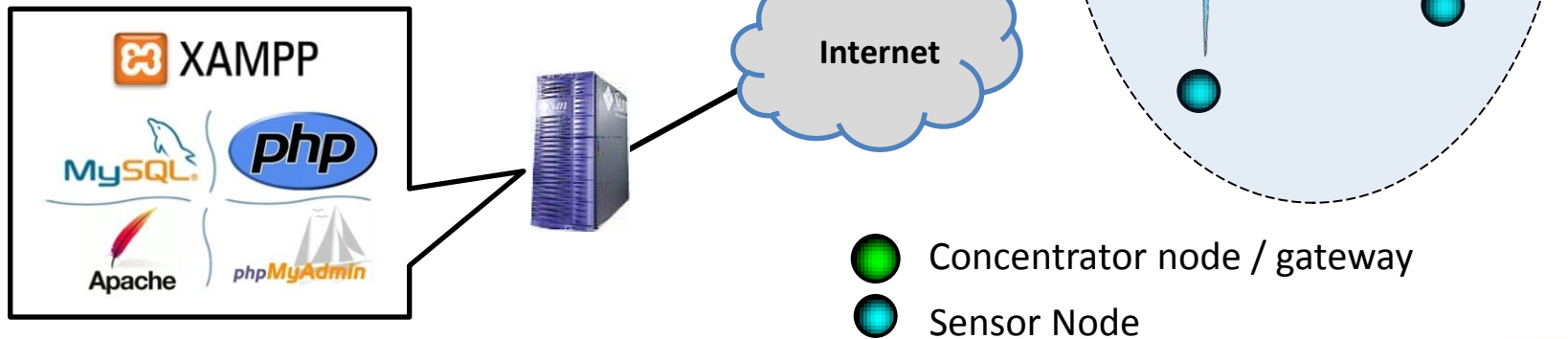


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Wireless Sensor Network

- VSN-based nodes
 - 4+2 sensors
 - 868 MHz
 - Ethernet gateway
 - Battery / external power
- Star network topology
- Web server & application



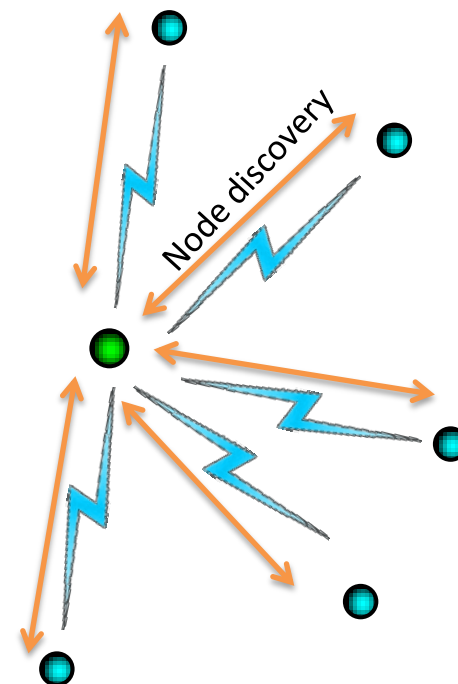
Sensor/Concentrator node tasks

- Sensor node tasks
 - Measuring sensor data
 - Sending data on request
 - Battery charging
 - Light control
- Concentrator node / gateway tasks
 - Sensor node discovery
 - Requesting data
 - Network monitoring
 - Communication with web server



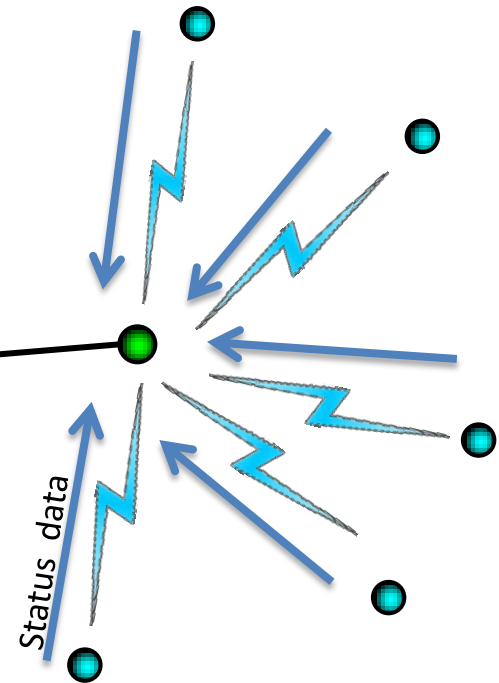
Sensor network protocol

- Node discovery
 - Gateway sends broadcast message with its address
 - After power-on, reset and periodically every 30 sec



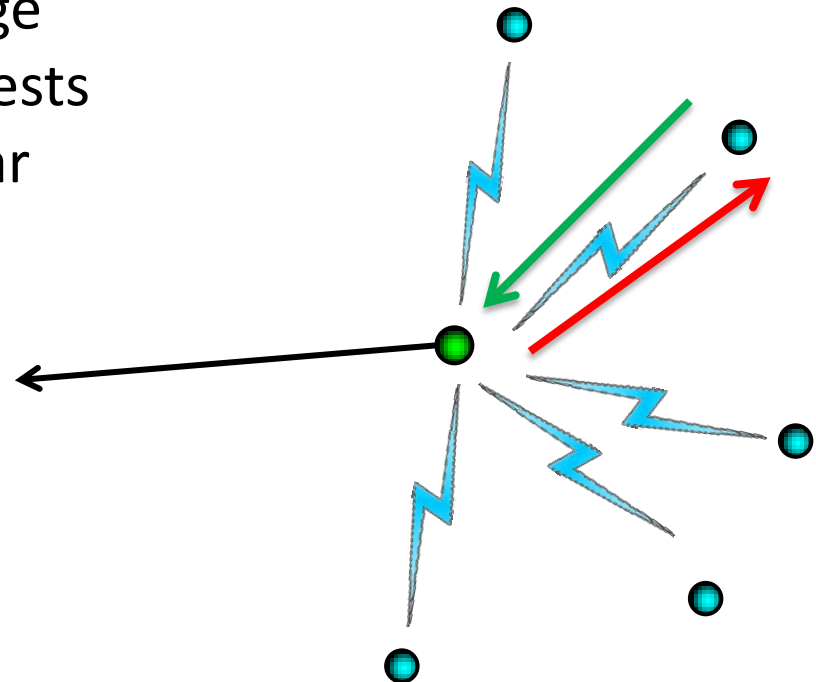
Sensor network protocol

- Binding
 - Nodes respond with special status message, containing their
 - Address
 - Status
 - Power supply state: battery / external / battery+external (node failure detection)
 - Settings
 - Device type (light): ON/OFF, dimming 0-100%
 - Gateway builds a network table



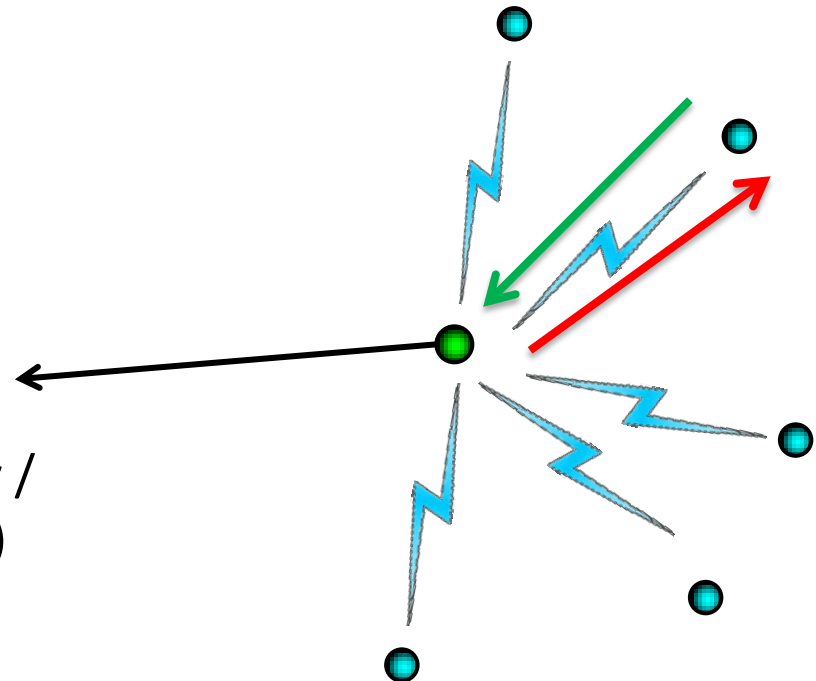
Sensor network protocol

- Pooling
 - By sending unicast message gateway periodically requests sensor data from particular sensor node
 - Period can be set using web control application
 - Sensor node performs measurements
 - Up to 0.5 s response time



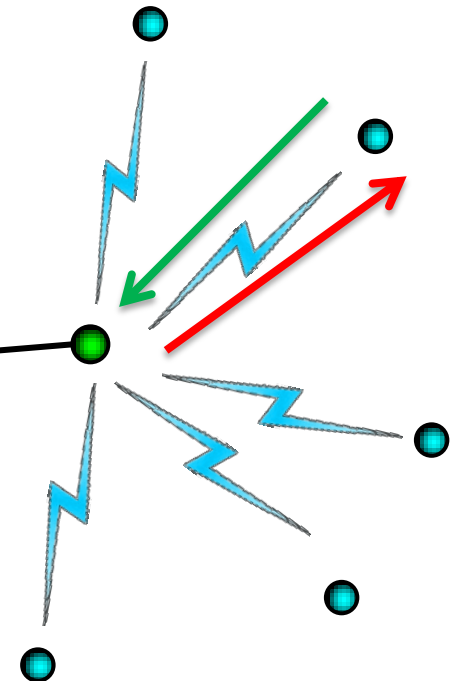
Sensor network protocol

- Pooling
 - Sensor node replies with
 - Temperature
 - Humidity
 - Atmospheric pressure
 - Luminance
 - Battery voltage
 - Power supply state (battery / external / battery+external)



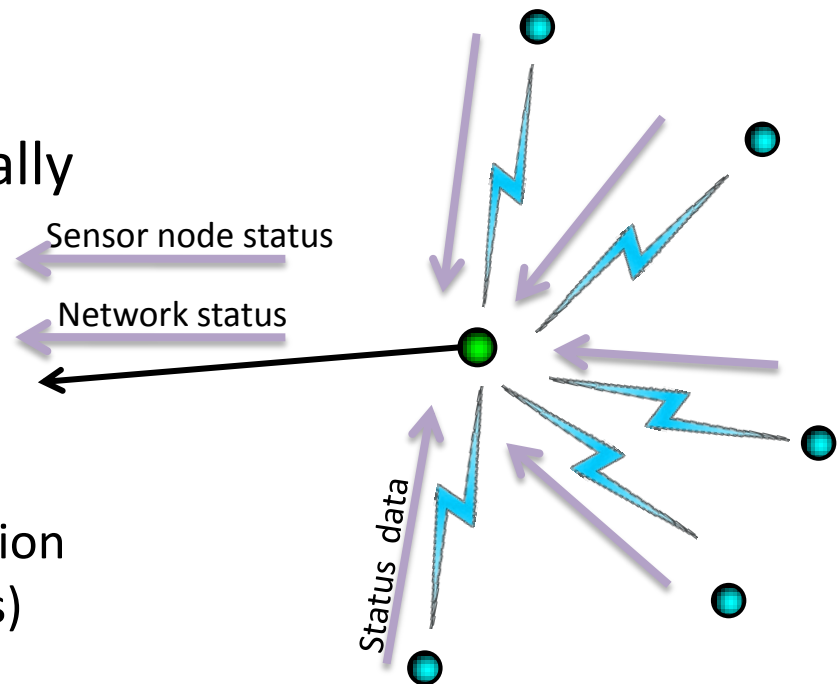
Sensor network protocol

- Pooling
 - Sensor node replies with
 - Temperature
 - Humidity
 - Atmospheric pressure
 - Luminance
 - Battery voltage
 - Power supply state (battery / external / battery+external)
 - Gateway receives data, appends time information and forwards data to server



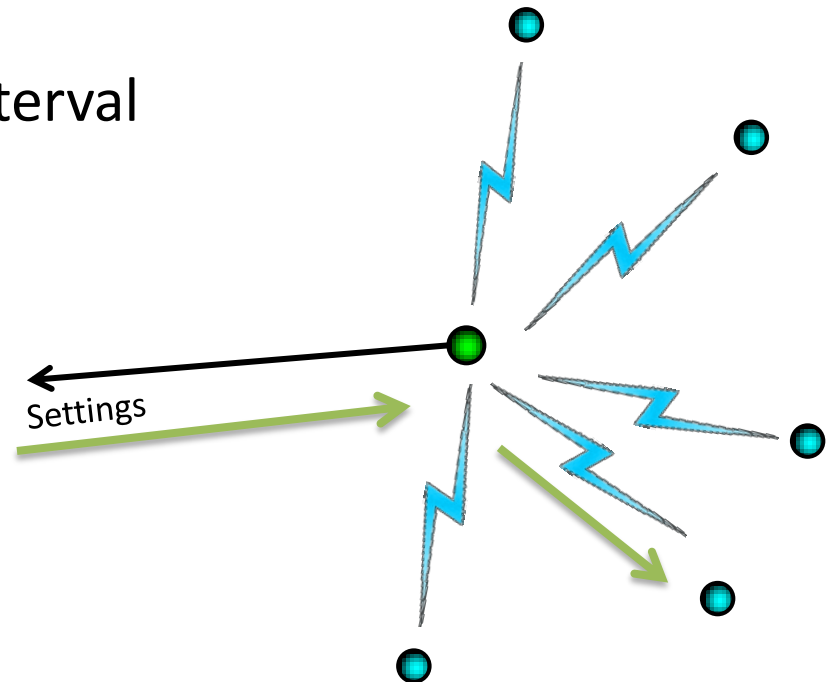
Sensor network protocol

- Network status
 - After Ethernet gateway obtains IP and builds a network table it periodically (5 min interval) reports to status to web control application
 - This info is necessary for back control from application to sensor nodes (actuators)



Sensor network protocol

- Settings for gateway
 - Pooling interval
 - Network status refresh interval
 - Clock refresh interval
- Settings for sensor node
 - Light ON/OFF
 - Dimming 0-100%

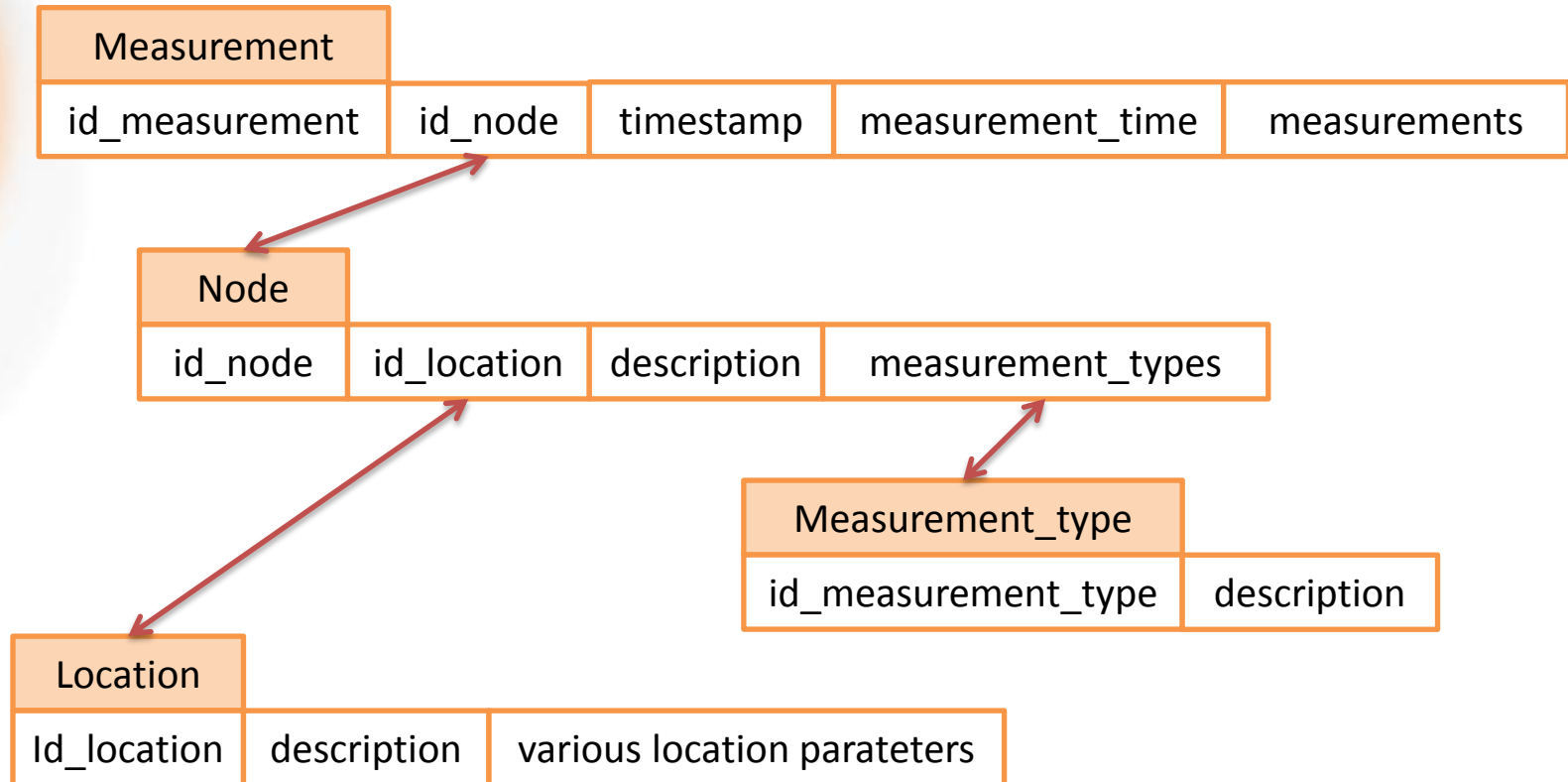


Web server and control application

- *Windows OS*
- *Apache* web server
- *MySQL* Database
- *phpMyAdmin* for database editing
- Communication with the database is performed with *PHP* scripts



Database structure



Thanks for your attention!

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