European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - *EuNetAir*

COST Action TD1105

# Final Meeting at PRAGUE (CZ), 5-7 October 2016

## *New Sensing Technologies for Air Quality Monitoring*

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# IMPLEMENTATION OF COMPLEX GAS SENSOR SYSTEMS – IDEAS FOR A STRUCTURAL MODEL


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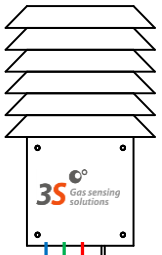
# Introduction: Background of 3S GmbH

- **Founded 10 years ago**
  by members of Prof. Andreas Schütze's lab for measurement technology at Saarland University (USAAR-LMT)
- Most developments based on **MOX sensor technology**, providing selectivity, sensitivity and stability while using **low-cost sensor elements**
- Main **commercial** fields of application:
  - **Leakage** detection
  - **Odour** assessment / air quality
- **Hardware systems for sensor research**
  - e.g. USAAR-LMT, LiU, acmit, FhG-ICT
  - IAQ projects: VOC-IDS, SENSIndoor

# AQ systems for indoor and outdoor air

**Weather station**
- Wind
- Temperature
- Humidity
- Pressure
- Precipitation type and volume

**Add-on sensor**
- Sensor combination
  - Extra MOX
  - EC
  - PM
- Sensor electronics



**OCO Ambient**
- MOX sensor combination
- r.H./T at the sensors
- System management
- Radio communication (GSM, GPRS)

**Solar power supply**
- Solar panel
- Battery
- Charge controller

Data→
← Energy

Data →
← Energy, Parameter

Parameters? →
← Energy, Information


cost
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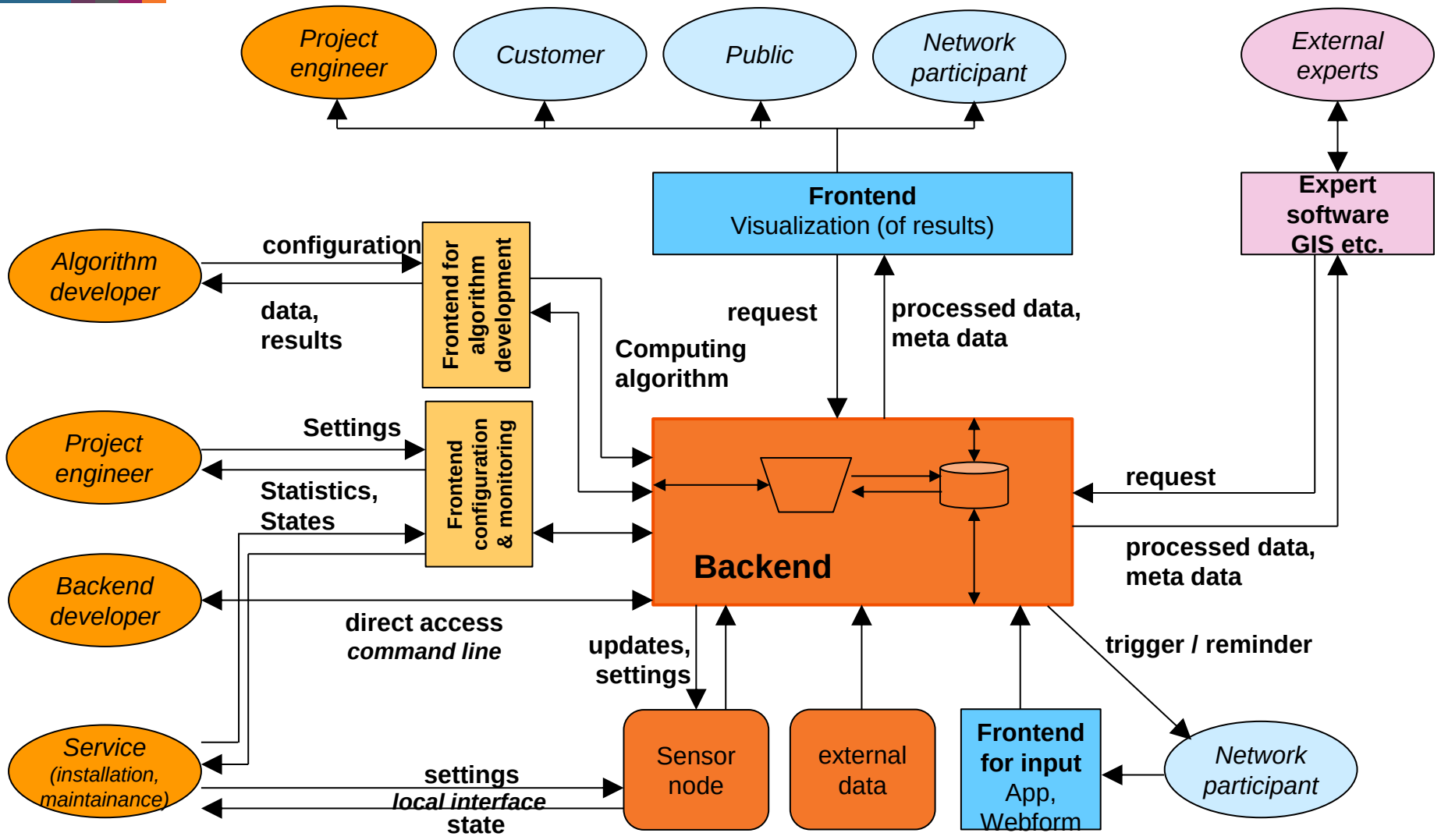
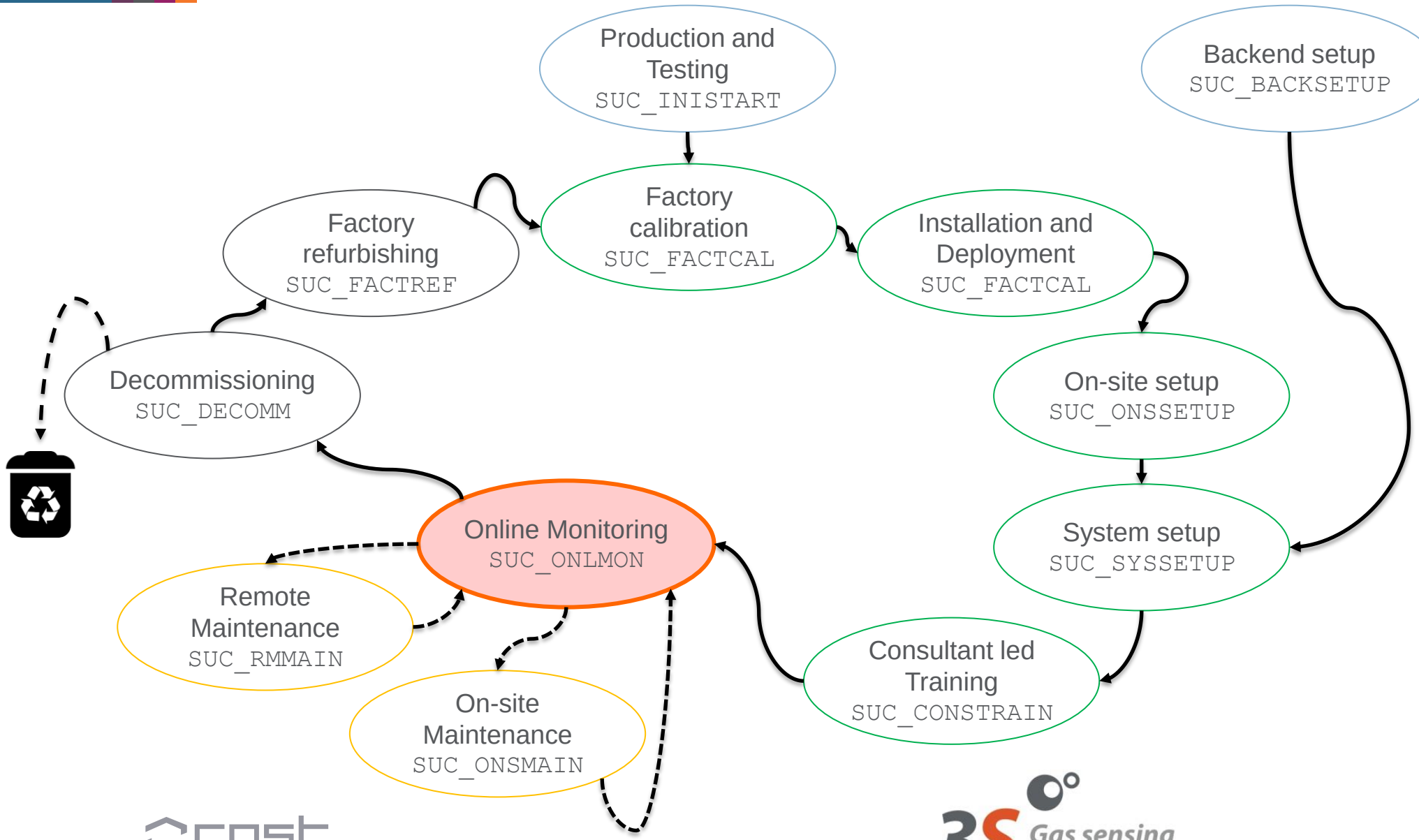
3S Gas sensing solutions

# Functions and actors in an AQ network

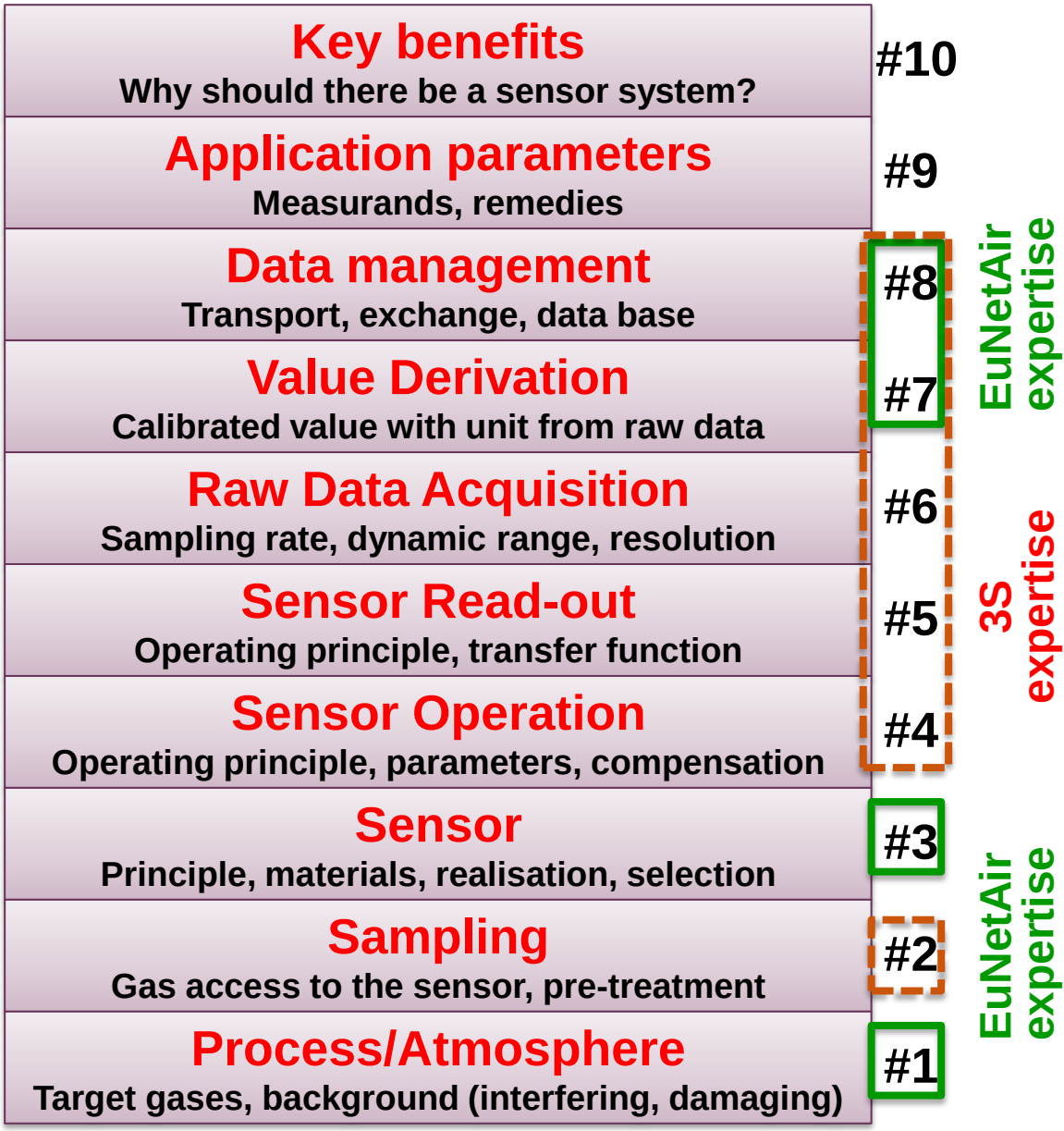


# Use Cases in a AQ product life cycle



# Sensor System Interchange Model

- Inspiration
  ISO-OSI reference model
- Motivation
  Complexity of application-ready (gas) sensor systems
- Current issue
  Sustainable and complete system implementation
- Example challenges
  - Calibration (lab-to-field, cross-device)
  - Data aggregation
- Aim within future consortia:
  → Efficient collaboration



# Example structures for AQ implementations I

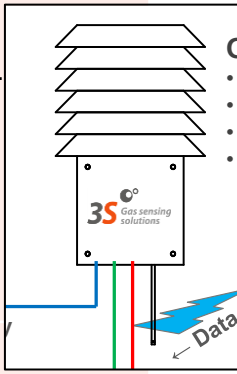
| Stand-alone device (Leak detection of packaged alcoholic solution) | | |
|---|---|---|
| #10 | Key benefits | Quality control for critical product package,<br>non-destructive 100% testing |
| #9 | Application parameters | Characteristics: Leakage rate as ethanol concentration with threshold<br>Remedy: Sort out and scrap leaky packages |
| #8 | Data Management | Caching raw data, logging test protocols and results,<br>output to operator + PLC |
| #7 | Value Computation | Peak detection and rel. amplitude evaluation |
| #6 | Raw Data Acquisition | 12bit ADC, 100Hz |
| #5 | Sensor Read-out | Linear electrometer type<br>constant voltage |
| #4 | Sensor Operation | Steady state,<br>temperature controlled |
| #3 | Sensor | MOS sensor, $SnO_2$ layer on ceramic substrate with Pt heater |
| #2 | Gas Access | Closed fluid circuit:<br>Pump, valves, test chamber |
| #1 | Process / Atmosphere | Clean air, ethanol |

# Example structures for AQ implementations II

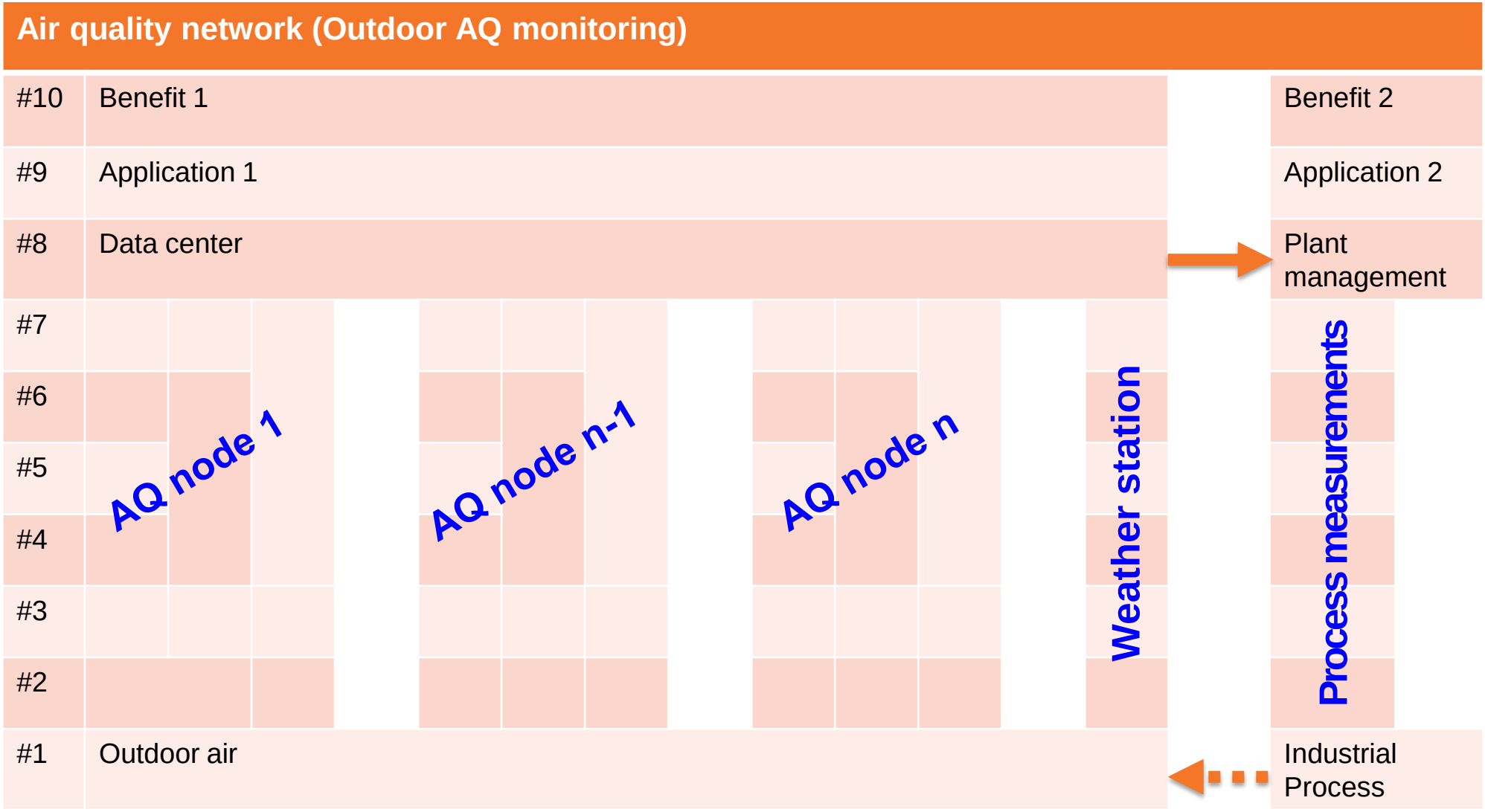

| Air quality node (SENSIndoor MOS field test device) | | | | |
|---|---|---|---|---|
| #10 | Key benefits | Comfortable and healthy indoor climate with minimal energy consumption | | |
| #9 | Application parameters | Characteristics: Pollutants (benzene, formaldehyde, toluene, TVOC), $CO_2$, temperature, humidity<br>Remedies: HVAC, windows, potted plants | | |
| #8 | Data Management | Caching raw data, caching computed data, output to UI/smartphone, interface to building automation/data aggregation | | |
| #7 | Value Computation | TCO based conversion algorithm with temperature / humidity compensation | | Proprietary with digital interface and calibrated output |
| #6 | Raw Data Acquisition | 12bit ADC, 1kHz | Proprietary with digital interface | |
| #5 | Sensor Read-out | Logarithmic current converter | | |
| #4 | Sensor Operation | Temperature control with cyclic operation | | |
| #3 | Sensor | Dual MOS sensor, $SnO_2$, $WO_3$ on micro hotplates | Integrated cap. humidity and temp. sensor | Dual beam NDIR |
| #2 | Gas Access | Diffusion based via limiting port | Diffusion based via dust protected hole | Diffusion based via lateral opening |
| #1 | Process / Atmosphere | Pollutants from #9 + other VOCs (ethanol, perfumes etc.) + CO + $H_2$ humidity, dust | | |

# Example structures for AQ implementations III

| Air quality network (Outdoor AQ monitoring) | | | | |
|---|---|---|---|---|
| #10 | Key benefits | 24/7 air quality monitoring in potentially polluted neighborhoods allowing for implementation of effective countermeasures | | |
| #9 | Application parameters | Characteristics: Regulated pollutants (e.g. benzene, $SO_2$, $NO_x$, CO, PM)<br>Remedy: traffic flow control, industrial exhaust air cleaning | | |
| #8 | Data Management | Data centre with backend (storage, computation) and frontend (access, visualisation, maintenance), transport via web protocol | | |
| #7 | Value Computation | TCO oriented data reduction | Conversion by mfg's specification | Proprietary with digital interface and calibrated output of PM10/PM2,5/PM1 |
| #6 | Raw Data Acquisition | 16bit ADC, up to 10kHz | Proprietary with digital interface | |
| #5 | Sensor Read-out | Logarithmic current converter | | |
| #4 | Sensor Operation | Temperature control with cyclic operation | | |
| #3 | Sensor | Dual MOS sensor, $SnO_2$, $WO_3$ on micro hotplates | Integrated cap. humidity and temp. sensor | Optical counter (laser scatter principle) |
| #2 | Gas Access | Diffusion access into ventilated housing with radiation screen | | Forced ventilation (fan) |
| #1 | Process / Atmosphere | Pollutants from #9 + other organic and inorganic compounds | | |



# Example structures for AQ implementations III



# Summary

- **Real world products are more than just a sensor**
  - Complete system integration necessary
  - Customer and application oriented design
- **General strategies to address problems exist**
  - Example: Use case analysis
- **Interchange model as a collaboration and planning tool**
  - Exchange of ideas
  - Application notes / whitepaper?
- Discussion and ideas

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