



# Closing the Gap between Sensor Networks and the Sensor Web

INPE / IfGI Research Workshop 2009

*GIScience for Dynamic Environmental Sensors*

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# Motivation

- **Sensor Networks** are used for:

- Precision agriculture
- Wildlife tracking
- Early warning systems
- Hazard management
- ...

- *Important:*

Integration of **sensors** and **spatio-temporal resources**



# Motivation

- **Sensor Web Enablement (SWE)** can be used
- Integration on **application level**
- Building blocks for a **Sensor Web**



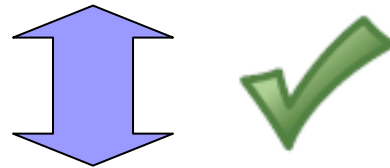
# Motivation

- Service interfaces & communication protocols
- Integration of sensors and **SOA**
- Core functionalities:
  - Sensor discovery (Catalogue / Registry)
  - Sensor data access (SOS)
  - Sensor tasking (SPS)
  - Alerting & Notification (SAS / WNS)

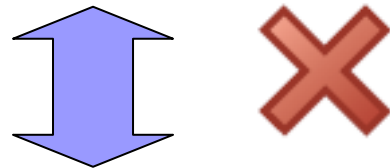
see Botts et al. (2006)

# Problem

Application Level



Sensor Web Level (SWE)



Sensor Network Level

# OSIRIS - Industrial Fire Scenario

( [www.osiris-fp6.eu](http://www.osiris-fp6.eu) )

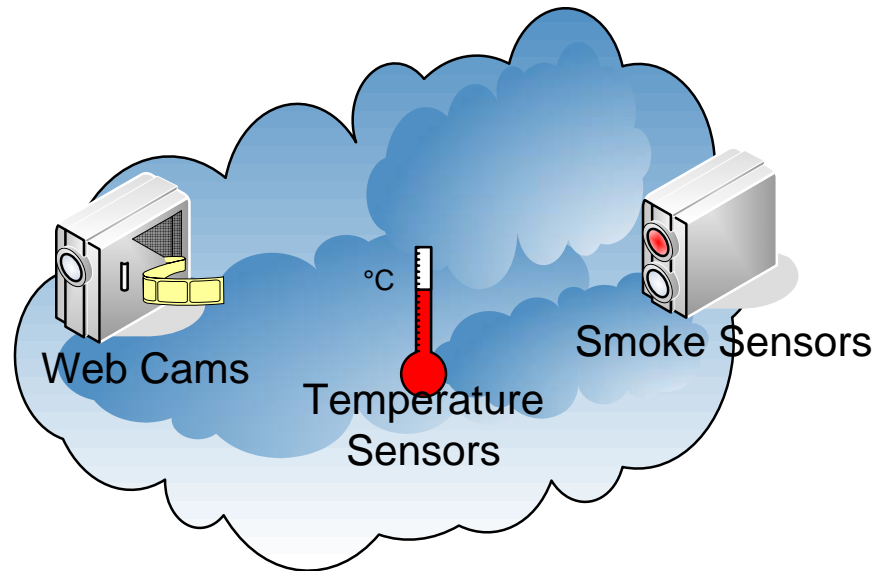
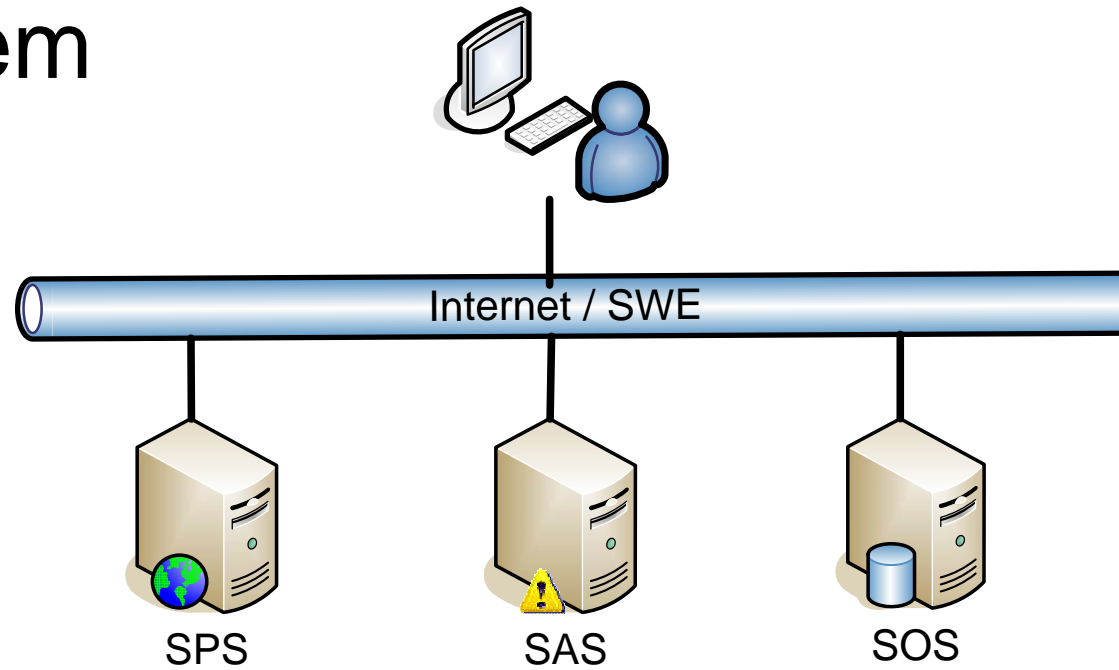


Hot fire training lab

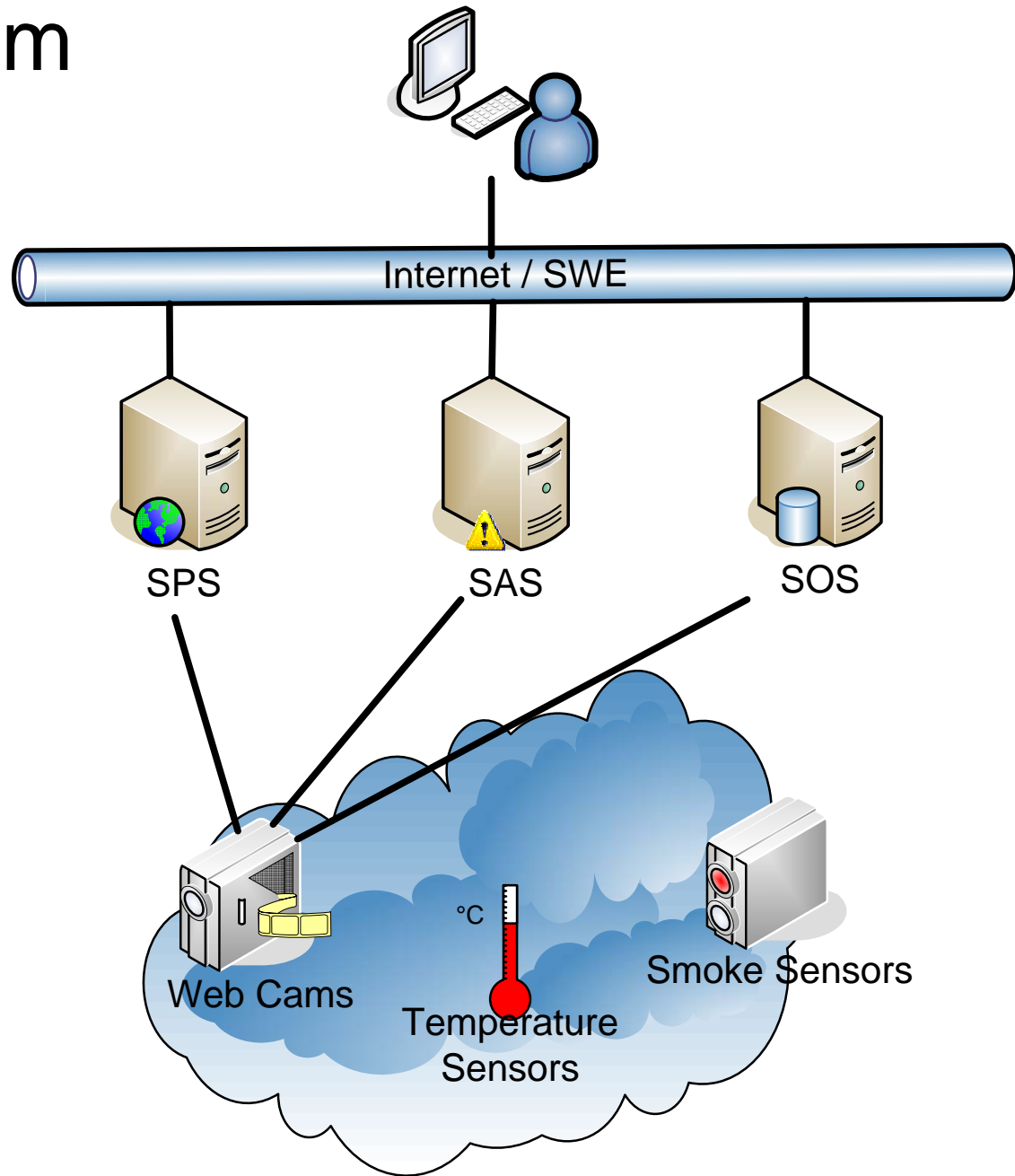


photos: APS

# Problem

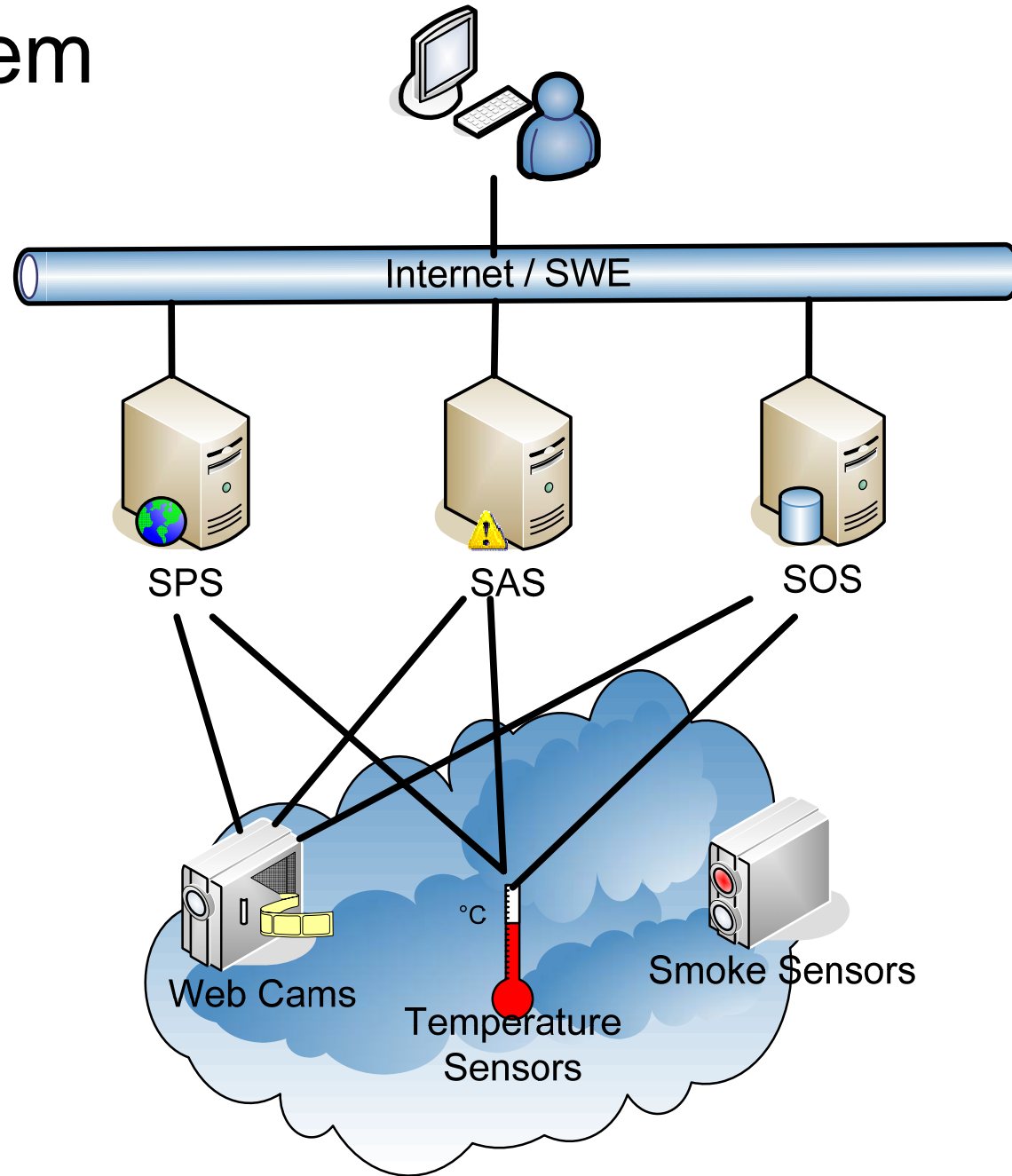


# Problem

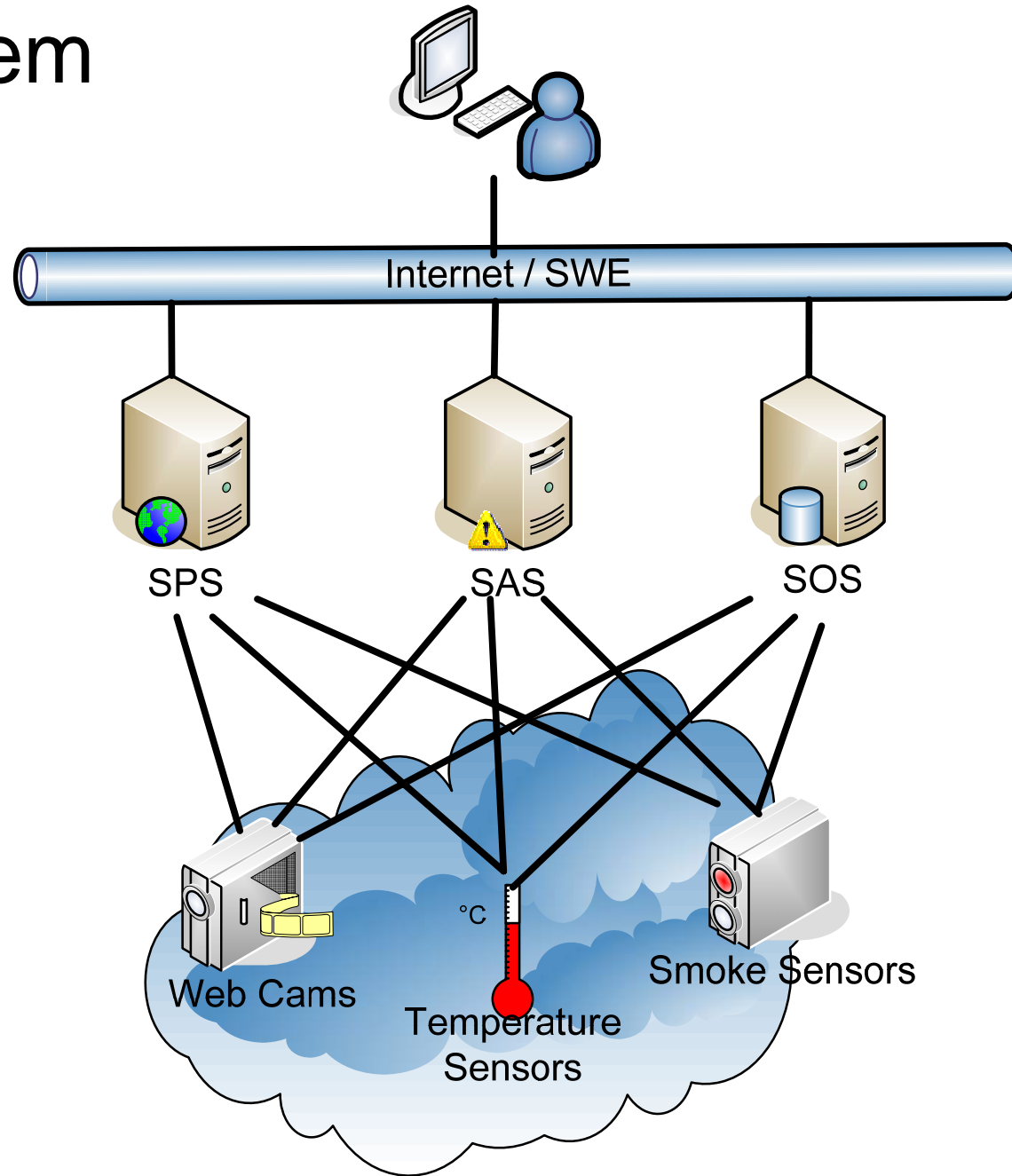




# Problem



# Problem





# Problem

- **Proprietary bridges**
- Contrary to our aim: **Interoperability**
- Cumbersome and inefficient
- Extensive amount of **adaption effort**
- → **Key cost-factor** in large-scale systems

see Aberer et al. (2006)



# Problem

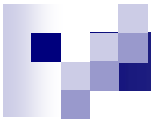
- **Gap:** Sensor Network - Sensor Web
  - Different protocols
  - Low-level **data** - high-Level **information** models
- *Missing:*
  - Concepts & methods for **sensor - service interaction**
- → Deficits hinder the Sensor Web to emerge



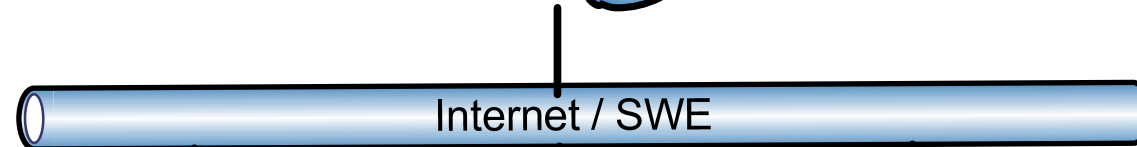
# Solution

- **Aim:**

*Elaborate methods to close the gap between  
Sensor Networks and Sensor Web*



Application



Sensor Web



SPS

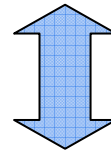


SAS

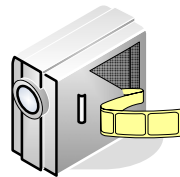


SOS

Intermediary Layer



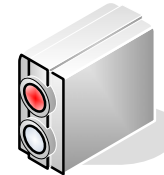
Sensor Networks



Web Cams



Temperature  
Sensors



Smoke Sensors



# Solution

1. Identifying general interaction patterns
2. Analysis of infrastructure topologies
3. Integrate *Event Processing* methods



# Solution

## 1. Identifying general interaction patterns

### ■ Building blocks for:

*Event-driven, publish/subscribe systems*

### ■ **Interactions:**

- Sensor Registration
- Service Registration
- Asset Discovery
- Data Publication
- Sensor Tasking
- ...





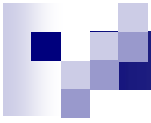
# Solution

## 2. Analysis of infrastructure topologies

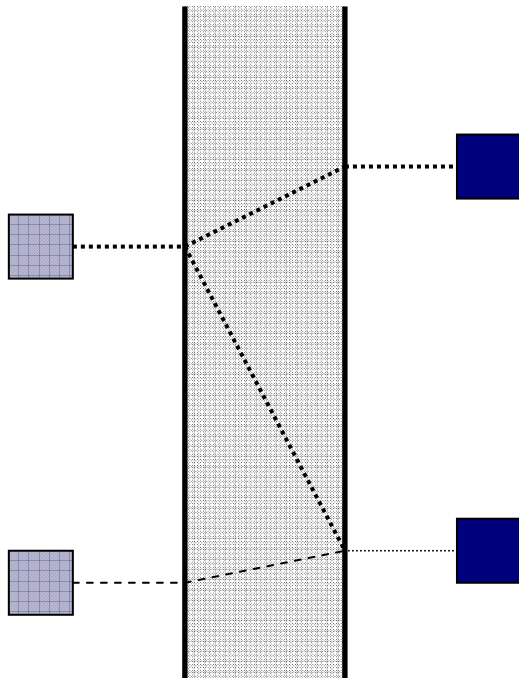
- Examples: *Bus, P2P, Hub-and-Spoke, ...?*

### → Evaluation:

- Technical functionalities*
- Performance*
- Scalability*



## Fat Sensor Bus

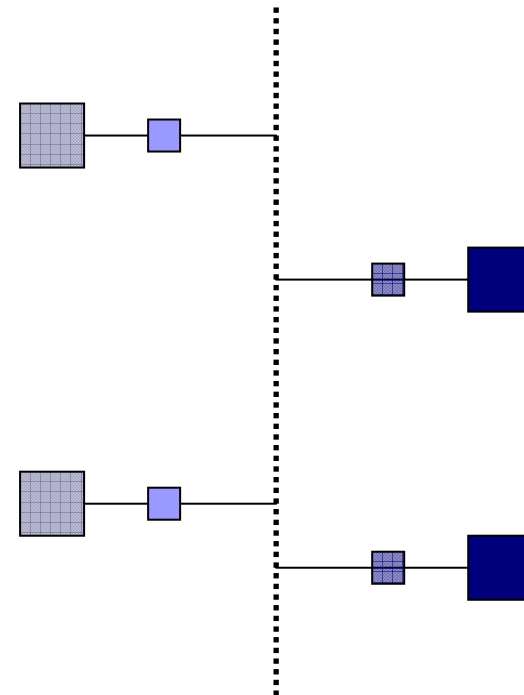


Sensor



Service

## Thin Sensor Bus



Sensor Adapter



Service Adapter



# Solution

## 3. Integrate *Event Processing* methods

- (Multi-) Sensor Fusion
- Combine multiple sources
- Improve information  
(greater relevance, greater quality,...)
  
- Transform: low-level data → high-level information

see Luckham “The power of Events” (2005)  
or Wu et al. (2008)



# Solution

## ■ Example Event:

### □ **Trigger:**

*temperature* > 50°C

from Sensor  $S_{temp}$  in Room  $R$

**AND**

*PM10* > 0,001 mg/m<sup>3</sup> (> 5 min)

from Sensor  $S_{smoke}$  in Room  $R$

### □ **Output:**

Fire Event

### □ **Actions:**

→ Trigger **SPS** to start fire sprinkler

→ Send alert via **SAS**

→ Insert Observation in **SOS**



# Research Questions (preliminary state)

- **How to close the gap between SN - SW?**
  
- Which interaction patterns exist on the intermediary level between sensors and sensor web services?
  
- Where to do what kind of event processing?  
(In-network, intermediary layer, service level, application level)



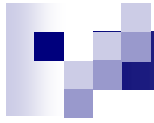
# References

ABERER K., M. HAUSWIRTH, A. SALEHI (2006): Middleware support for the Internet of Things. 5. GI/ITG KuVS Fachgespräch "Drahtlose Sensornetze", Universität Stuttgart, 2006.

BOTTS, M., G. PERCIVALL, C. REED & J. DAVIDSON (2006): OGC® Sensor Web Enablement: Overview And High Level Architecture. OGC White Paper. Open Geospatial Consortium: 06-046r2, Version: 2.0.

LUCKHAM, D. (2005): The Power of Events. Addison-Wesley, Boston, USA.

WU E., Y. DIAO, S. RIZVI (2006): High-Performance Complex Event Processing over Streams. SIGMOD 2006, June 27-29, 2006, Chicago, Illinois, USA



Thanks for your Attention!

Questions?

Comments?



# Increasing Information Content

Sensor Networks

Middleware

Sensor Web

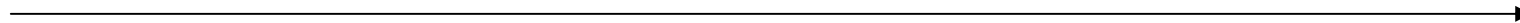
Applications

Ontologies

SWE  
Encodings

Middleware  
Protocol

(Proprietary)  
Sensor Protocols



Information Content