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# Platform-independent interface for the management of sensor-generated power and data flows in an automotive data-centric architecture

**Jakob Stoeck**, B.Sc., **Ljubo Mercep**, M.Sc., Fakultät für Informatik, TU München, Garching;
Prof. Dr.-Ing. **Gernot Spiegelberg**, Institute for Advanced Study, TU München/Siemens AG, München;
Prof. Dr.-Ing.habil. **Alois Knoll**, Institut für Informatik VI, TU München, Garching

**Abstract**

This research paper's outcome is a 2-dimensional visualization of sensor interaction. You can see sensor information in real-time or simulate them by steering a model of the Innotruck through different scenarios. As the spectator of sensor information you subscribe and learn more about those. In one simulation scenario you drive to ecars, charge them from your battery and receive money. The energy, data and cost flows are visualized at the same time making the interdependency easy to understand.

## 1. State of the Art for Storing and Publishing Sensor (Meta-)Data

With the semantic web and web 2.0 movements, much data like maps, social graphs and government data is now easily retrieved, filtered, often standardized and can be used in mashups to base new services on it. While there are sensors everywhere, their information is not yet publicly accessible most of the time. To open up this big resource of publicly available sensor data, standards were established and are promoted by the Sensor Web (a term first coined by the NASA in 1997 [1]). In the same way that HTML and standardized transport protocols helped to establish the World Wide Web, those standards try to let the Sensor Web become reality.

The two main standards in this field are from the Open Geospatial Consortium (OGC) and the Institute of Electrical and Electronics Engineers (IEEE). The OGC has a higher-level approach standardizing sensor (meta-)data, while the IEEE standard goes deeper into the hardware specification and microprocessor implementation. Both support a plug-and- play approach, allowing new sensors to self-publish their presence.

### 1.1 OGC SWE Information and Service Model

The Sensor Web Enablement (SWE) aims to discover sensors by needs, obtain sensor information, access sensor observations, task sensors and subscribe and receive alerts to a specified phenomenon. [2] It is being developed by the OGC. It specifies a number of standards that define formats for sensor data and metadata as well as sensor service inter- faces. It is divided between information and service model.

The key aspect of the OGC SWE is a dynamic Sensor Web, such that sensors can be added and reconfigured any time. They are web-enabled and self-describing to humans and other sensors so that multiple Sensor Web nodes may discover each other's capabilities and may connect to one another automatically forming a distributed analysis system. [1, p. 53]

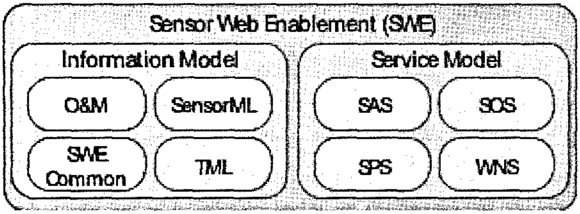


Fig. 1: Overview of the Sensor Web Enablement architecture. [3, p. 3]

### 2. Realization

The implementation consists of a real-time mode showing actual emitted sensor signals and a simulation mode that showcases some of the more specialized modes in which the Innotruck may be used.

The basic architecture is a publish and subscribe pattern with an intermediate message broker. The data flow is coming from sensors, getting converted to a standardized protocol and stored in a message broker which is subscribed to by front end elements we call features similar to the definition of the OGC in paragraph 1.

**Sensors + Converter (Publisher)** Most sensors today have implemented diverse proprietary protocols. They also have a very different frequency and amount of data they send. To convert the data they send to a standardized protocol we need to add a converter being able to process those messages or streams and output standardized Observation & Measurements. They should also host a sensor description in SensorML giving the possibility to discover sensors and sensor capabilities in a standardized way. Since many new sensors will be installed in the Innotruck in the future it should be easy to add them.

**SOS Server + Client (Message Broker)** As mentioned, sensors talk at a very different frequency and differ in the amount and quality of their observations. A message broker needs to store those messages and forward transformed ones according to quality rules for the output. That may be interpolation for too many or too few values depending on bandwidth and processing power of the requesting client.

**Features (Subscriber)** In our visualization, features are real-world objects we are interested in visualizing. They are not necessarily sensors but usually a system of sensors and other components. An eCar charging station for example has a watt meter, sensors for authentication via a magnet chip and other means for interaction like a display. This granularity is too high for an informational display. The sensor system is abstracted as one feature in our visualization which receives and transmits energy and information. It there- fore subscribes to the data of multiple sensors. Features may subscribe to different observations. By default they subscribe to every observation which includes this feature as an O&M feature of interest.

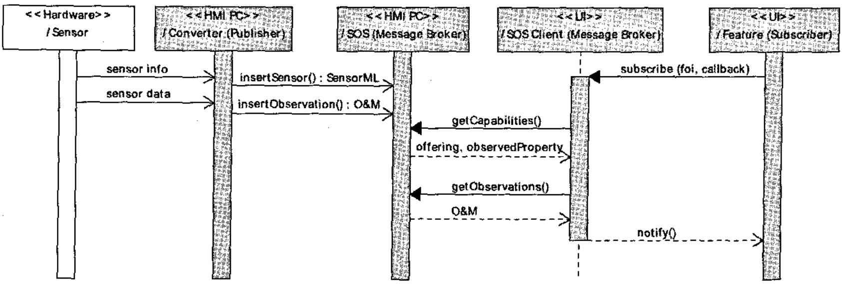


Fig. 1: Sequence diagram of sensor information flow in the implemented system

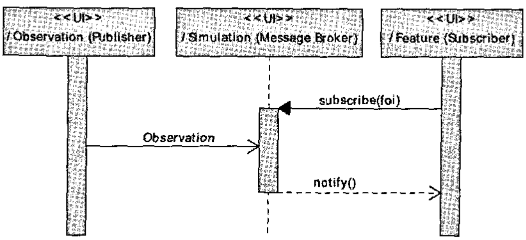


Fig. 2: Sequence diagram of sensor information flow in the simulated system

### 2.2 Visualization

The visualization is split between observation and scenario view. Together they form a full screen visualization. The larger observation view uses the upper 80 percent of the screen estate while the scenario view fills out the rest.

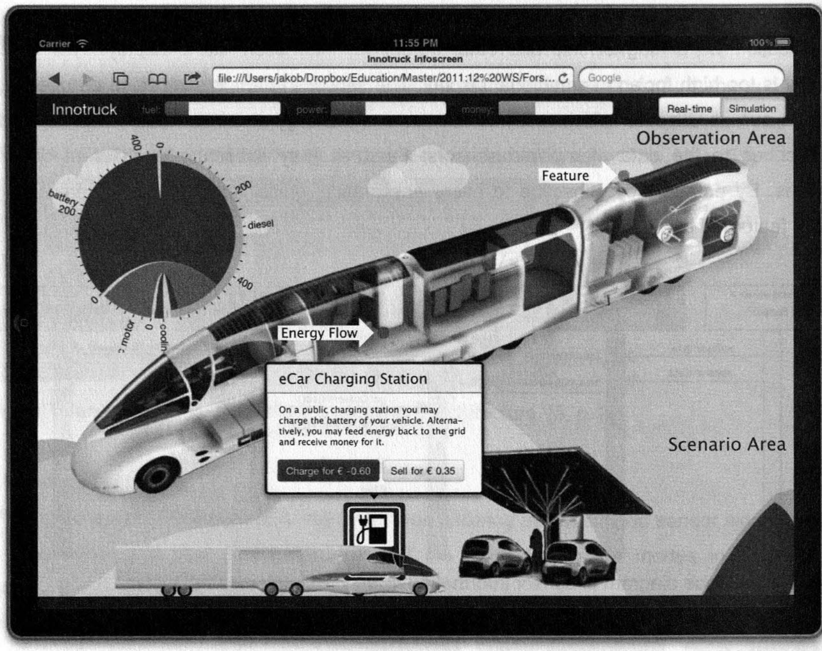


Fig. 3: Annotated example of the visualization on a small screen size

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[1] M. Botts and A. Robin. Bringing the sensor web together. http://www.brgm.fr/dcenewsFile?ID=473, October 2007.

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[3] S.J irka, A. Bröring, and C. Stasch. Discovery mechanisms for the sensor web. Sensors, 9(4):2661–2681, 2009.