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A taxonomy of robustness in sensor service networks

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Abstract: We consider which aspects of a sensor service network are important in achieving robustness, i.e. the ability to adapt or react to changes and external influences. The sensor service network is viewed as a collection of functional domains ranging from the Sensor Domain up to the Application and User Domains. The characteristics of robustness relate not only to resilience to communication problems, but also to dynamic sensors and services and to the overall system architectural design.

Keywords: Robustness, sensor, service network

1 INTRODUCTION

The word *robust* stems from the Latin *robustus* meaning oaken (like oak wood) or hardy and strong. A widespread oak tree is the *Quercus robur*, commonly called English oak. *Robustness* implies resilience and the ability to adapt to changes and external influences. The degree of robustness is determined by the types of changes and influences which can be coped with. The attribute robust is broadly applicable to practically all entities, including living beings, natural and man-made objects, processes and technical systems.

Ideally, a robust object or system has its own inherent ability to react and / or adapt to changes and external influences, even to those for which no explicit reaction has been foreseen.

The workshop contribution will propose a classification of factors characterizing robustness in a sensor service network. The essential issues of what should be made robust to which changes and influences are summarized in the sections below.

2 FUNCTIONAL SCOPE OR WHAT MUST BE ROBUST

The complete functionality of a sensor service network can be structured into domains as shown in Figure 1. Layer-like interfaces are not implied between the domains, instead the domains should be considered as a loose functional structure.

The Sensor Domain covers the actual sensor or transducer technology, and the communication within the sensor network (wired or wireless such as ZigBee) and to gateway nodes with access to higher level networks, which are typically IP based. The sensor nodes may be mobile and belong to varying sub-networks. Information sources such as a database of archived data or a model-based algorithm can both be considered as sensors as defined in the Observation & Measurement Model of OGC, cf. Cox [2007].

The overlying functional domains serve to find, integrate, generate and present information originating in the Sensor Domain. The overall goal is of course to achieve robustness in the User

Domain where decisions are made. Robustness must be built in to each functional layer for the overall system to be robust. This is illustrated below for several aspects of the lower layers.

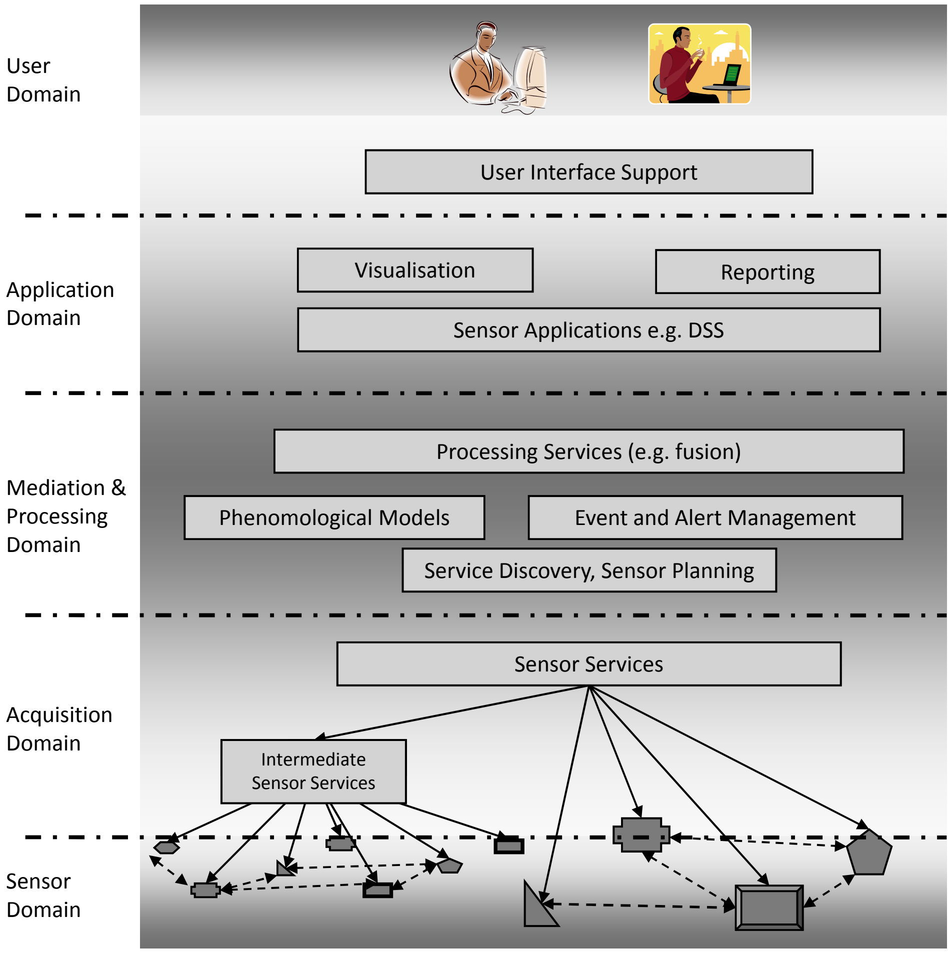

Figure 1: Functional Structure of a Sensor Service Network as defined in the project SANY

3 CHARACTERISTICS OF ROBUSTNESS

3.1 Architectural Robustness

The architecture shall make use of proven concepts and standards in order to decrease the dependence on vendor-specific solutions, to ensure openness of the service network and to support the evolutionary development of the system. The main architectural characteristics in this respect are (cf. Usländer [2007]):

- The system components shall be *loosely coupled*, implying the use of mediation to allow components to be interconnected without changes.
- The architecture shall be *independent of technologies* such as sensor communication protocols, middleware and programming languages as far as possible, and also *independent of the structure or format of existing information sources.*

- The architecture shall be *designed for evolution* in order that new user requirements and deployment forms can be handled easily.
- The service infrastructure shall be *generic* in the sense that it is independent of a particular application domain.
- The architecture shall follow *recognized standards* (such as from ISO, OGC, OASIS, W3C) and *strategic initiatives* such as GMES, GEOSS and INSPIRE.

3.2 Robustness in the Sensor domain

A wireless ad-hoc sensor network, probably with energy autarkic or battery powered nodes, is susceptible to disturbances and must be able to dynamically reconfigure itself when a communication link or sensor fails. Sensors can be mobile and belong to changing network configurations.

3.3 Robustness in the Acquisition Domain and Mediation and Processing Domain

Resilience to uncertain data: Data uncertainty in the Sensor Domain is caused not only by measurement inaccuracy, but also by missing sensor values which have to be replaced by other sensor values or approximated using a spatial-temporal fusion of available data and, possibly, models of the phenomenon of interest. In the latter case the system reaction is in the Mediation and Processing Domain. A sensor planning service can help to deploy sensors where most needed. For critical applications, redundancy in the Sensor Domain is required, too.

Resilience to changing sensors and sensor services: The system must be able to cope with changing, possibly very voluminous sources of information (sensors, models) and services. These sources need to be discovered by registration or harvesting and integrated into the system. The ideal is *plug & measure*, implying a minimum of manual adaptation to new sources.

Resilience to heterogeneous data formats and property names: This refers to the ability of services to map data provided with different names for the same physical concepts and in different languages or formats. Semantic and ontological techniques are required here.

4 CONCLUSIONS AND RECOMMENDATIONS

Robustness of a sensor service network can only be achieved by exercising a bundle of measures across the functional domains of the overall system. The reward for this work is expressed in terms of longer system life, lower life cycle costs and greater user benefit.

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