Chapter 2
Challenges of Sensor Discovery

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ABSTRACT

This chapter addresses the challenges of sensor discovery on the background of the Sensor Web Enablement architecture of the Open Geospatial Consortium. In the first part of the chapter two kinds of sensor discovery are introduced: sensor instance discovery and sensor service discovery. After this, four key challenges are presented: the dynamic structure of sensor networks, the integration of sensor status information, the semantics of the observed phenomena and sensor metadata models as well as metadata harvesting mechanisms. Additionally, a practical solution for sensor discovery is introduced. This solution is integrated into the Sensor Web Enablement architecture and aims at addressing the challenges of sensor discovery.

INTRODUCTION

Sensor networks have become a very important means for gathering data about a broad range of physical, chemical, and biological characteristics and phenomena. The scenarios in which geosensor networks are used comprise use cases like weather station networks, environmental monitoring or crisis management systems (Stefanidis, 2006).

For achieving the aim of increased sustainability for mobility, sensor networks can play a significant role. For example sensor networks are used for measuring the traffic density, detecting traffic jams, monitoring real-time information about public transportation networks (e.g. train delays) or for measuring pollution caused by traffic. In addition mobile sensors (e.g. mounted on cars) may be able to deliver direct or indirect traffic data (e.g. deriving the traffic density from the speed of cars). This input delivered by sensor networks will make it possible to optimize traffic planning, avoid traffic congestion or to develop new applications for traffic management taking into account real time data.

However, for being able to use and flexibly integrate the information collected by sensors into

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applications, the availability of discovery mechanisms for sensors and sensor data is essential. Especially due to the usually distributed character of access points to sensors and sensor networks the user must be able to determine which source provides the data that is needed for a specific task or which components allow submitting certain tasks to specific sensors. This means that a user must be able to find the sensors that are available (e.g. searching for all traffic density sensors in an area), all sensor data that is available (e.g. all traffic density measurements performed on a certain street segment at a given time) and how the data can be accessed.

Compared to conventional data sources (e.g. maps, geometry information), sensor networks possess special characteristics that need to be taken into account when creating a catalogue or registry for sensors and sensor data. Especially the often highly dynamic structure of sensor networks must be considered as new sensors may be deployed, older sensors may disappear or mobile sensors may move to new areas (Dantu et al., 2005). Furthermore, additional information sources like sensor status data and specific sensor metadata formats have to be considered.

This chapter starts with a short overview of related work in the field of sensor discovery. After this, an introduction into the Sensor Web Enablement (SWE) architecture of the Open Geospatial Consortium (OGC) will be given. The SWE framework is currently the most important solution for integrating sensors into distributed applications and especially spatial data infrastructures by using the concepts of service oriented architectures. As this chapter will address the topic of sensor discovery on an application layer level, SWE will be an important technological foundation for illustrating how sensor discovery can be addressed in practice.

After this, challenges that have to be considered when enabling the discovery of sensors will be presented:

- Dynamic network structure.
- Integration of sensor status information.
- Exploitation of semantic relationships for describing the observed phenomena.
- Metadata models for sensor networks.

In addition, this chapter will describe an approach how the previously presented challenges can be handled in practice. For this section the SWE architecture will serve as a background. A SWE based approach for a sensor catalogue/registry framework will be shown that aims at tackling the challenges of sensor discovery. Thus, the practical impact of these challenges will be illustrated.

RELATED WORK

Although this chapter will focus on the OGC SWE framework, in this section several further activities dealing with sensor discovery outside the SWE context are shortly presented.

Whereas the SWE architecture concentrates on the sensor integration on an application layer level, other standards deal with sensors in a way that is closer to the sensor hardware. An important example for such a suite of standards is IEEE 1451 (http://ieee1451.nist.gov/). This set of standards allows describing sensors (and actuators) as well as their inputs and outputs. Although first approaches for mapping the IEEE 1451 world to the SWE framework are available (Hu, Robinson, & Indulska, 2007), future research will be necessary to integrate IEEE 1451 sensor networks into (SWE) discovery solutions.

Within this chapter, the SWE standard SensorML will be used as a metadata format as it is already applied in a broad range of applications. However, for future work also additional metadata formats will be considered. One example for such an additional metadata format is described by Nath, Lie, and Zhao (2006). The Sensor Description Markup Language (SDML) possesses a reduced