iCAAS: An Interoperable and Configurable Architecture for Accessing Sensor Networks

Catello Di Martino, Università di Napoli Federico II, Italy
Gabriele D’Avino, STRAGO Spa, Italy
Alessandro Testa, Università di Napoli Federico II, Italy

ABSTRACT

Wireless sensor networks (WSN) are spreading as a common mean for mitigating installation and management cost in environment monitoring applications. The increasing complexity ad heterogeneity of such WSN and the differentiated users needs calls for innovative solutions for managing and accessing produced data. This paper presents an architecture, named iCAAS, designed to collect, store, manage and make available to users data received from heterogeneous WSNs. The objective of the architecture is to adaptively deliver data to users depending on their specific interests and transparently to adopted terminals and of networks details. The contribution of the paper is twofold. First the authors detail the requirements that these types of architectures should meet to fill the gap between sensors, details, and users needs. Second, the authors describe the structural organization of the proposed architecture, designed by taking into account the defined requirements. Implementation details and case studies are also provided, showing the effectiveness of the architecture when used in real world application scenarios. Finally, iCAAS architecture’s scalability is tested against the number of concurrent client querying the same time.

Keywords: Adaptive, iCAAS Architecture, Interoperability, Wireless Sensor Networks, WSN

INTRODUCTION

Nowadays, WSN (Akyildiz et al., 2002) are being more and more envisioned as the key to reduce installation and management cost of environment monitoring applications (Mainwaring et al., 2002). Instrumenting natural areas with wireless sensors enables long-term data collection with high resolution in the measurements due to the huge number of cost-effective nodes that typically compose such networks. WSN nodes can be equipped with a number of different sensing devices such as temperature, sound, vibration, pressure, motion or pollutants sensors. Examples of applications are target tracking and environmental monitoring (e.g.}

DOI: 10.4018/jaras.2010040103
detection of fires in forests and structural monitoring of civil engineering structures, Akyildiz et al., 2002).

Typically, WSN act as follows. Sensor nodes gather measurements from the environment that is sent to a specific node in a multi-hop fashion. The node in charge of collecting and storing the data is called sink node.

The real challenge for WSN users is to navigate the huge amount of collected data, that often must be accessed through tiny devices in mobility (e.g., on the construction site of a building). Also, complex monitoring systems require different WSN to collect data concurrently, each of them with a special purpose. Examples of solution for managing and accessing WSN are TinyDB (Madden et al., 2005) and Mate (Levis & Culler, 2002). Hence, the availability of different solutions for WSNs management increases the overall heterogeneity level. Finally, different end-users of the same system may have different needs regarding the way data have to be perceived (e.g., a user may be not interested in a certain area, or two users may set different alarm thresholds on the same data set). In this paper we present iCAAS, an interoperable and Configurable Architecture for Accessing Sensor networks. The architecture is conceived to provide a set of facilities tailored to manage heterogeneous WSNs, and to make accessible the collected data. The idea is to provide a user friendly Web-based toolset to monitor only user-specified data (e.g., only temperature from room X, and not for all the floors), providing a presentation layer accessible also from tiny mobile devices, such as PDAs and smartphones. To this aim, we propose to abstract sensors data as Web resources, by using the REpresentational State Transfer (REST) (Fielding, 2000) paradigm. To the best of our knowledge, iCAAS is the first architecture proposing the REST paradigm for accessing WSN data. In addition, iCAAS also defines Web services to make its facilities accessible by third party systems.

In order to provide such a level of flexibility and interoperability, the following requirements need to be taken into account: i) ubiquitous access and management of sensor networks, ii) interoperability among sensor networks and heterogeneous client applications, and iii) configuration of the process of data acquisition, data processing and data use. Interoperability and configuration make the architecture adaptive: WSNs are simply used to collect raw measurements and forward them to iCAAS; the logic for data management is provided by iCAAS. Shifting the data aggregation/filtering/masking effort from the nodes to a user friendly toolset makes it possible to simplify the application run by sensor devices.

In order to provide flexibility to user choices, regarding the specification of data to be accessed and presented, we define the concept of senselets, tailored to abstract physical sensor devices and to adapt them to user needs.

The rest of the paper is organized as follows. First we present and discuss iCAAS requirements, and describe iCAAS structure in detail, illustrating its internals. Then details on the implementation and, briefly, a set of preliminary case studies are presented. Further, we present result of a test of responsiveness of the system. The related work is also presented.

**REQUIREMENTS**

The design of iCAAS started from the definition of several functional requirements: data processing, WSN setup, configuration, user management, and non-functional requirements: interoperability, adaptability, responsiveness, as detailed in the following.

**Data Acquisition and Processing**

Data acquisition is central task to be performed by a WSN for environmental monitoring. In every sensor network data have to be acquired and permanently stored in the first place, typically by means of a special node called data-sink...
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