Demo Abstract: GSN, Quick and Simple Sensor Network Deployment

Ali Salehi
School of Computer and Communication Sciences
Ecole Polytechnique Fédérale de Lausanne
Switzerland
firstname.lastname@epfl.ch

Karl Aberer
School of Computer and Communication Sciences
Ecole Polytechnique Fédérale de Lausanne
Switzerland
firstname.lastname@epfl.ch

***Abstract*— Wireless sensor and actuator networks are an emerging computer class based on a new platform, networking structure, and interface that enable novel, low cost and high volume applications. One of the main obstacles in adaption of the sensor networks is the lack of standardization and the continuous inflow of novel sensor network technologies which have made the sensor network deployment the main factor of manpower consumption. To address these problems we developed the Global Sensor Networks (GSN) middleware with the aims of rapid and simple deployment of a wide range of sensor network technologies, providing flexible integration and discovery of sensor networks, enabling addition of new platforms quickly, and dynamically adaption of the system configuration during operation. In this paper we provide a brief overview of GSN with the focus on automated wireless sensor network deployment. GSN is available for download at http://gsn.sourceforge.net.**

I. Introduction and Motivation

The emergence of wireless sensor networks as one of the dominant technology in the coming decades has posed numerous unique challenges to researchers. These networks are designed to be composed of hundreds, and potentially thousands of small smart sensor nodes (called motes), functioning autonomously, and in many cases, without access to renewable energy resources.

While the set of defined research problems in the wireless sensor networks are diverse, we focus on practical aspects of sensor network deployment. As organizations have begun working with the wireless sensor networks, two significant obstacles have emerged: deploying wireless sensor networks is extremely time-consuming not only because of the complexity of creating the software that manages the networks and their components but also the heterogeneity introduced due to different (an sometimes conflicting) application requirements. These challenges are so significant that they have slowed deployment plans to a crawl, and have considerably tempered initial excitement about wireless sensor network technology.

To address these problems we developed the Global Sensor Networks (GSN) middleware which supports rapid and simple deployment of a wide range of wireless sensor network technologies, provides flexible integration and discovery of sensor networks in addition to the common data stream processing requirements off the shelf. GSN offers virtual sensors as a simple and powerful abstraction, which enables the user to declaratively specify XML-based deployment descriptors in combination with the possibility to integrate sensor network data through plain SQL queries over local and remote sensor data sources.

In the GSN we follow the standard model of sensor network deployment in which a sensor network can have one or more base computers, which are dedicated to perform expensive data mining operations in addition to disseminating the outputs (processed or raw) to the interested users. GSN is designed to be used on the base computer. GSN looks at the sensor network as a black-box which can produce sensor data and optionally consume control messages. Depending on hardware and software restrictions on the sensor networks, the connection between the base computer and the sensor network can be either unidirectional or bidirectional. For instance, a sensor network of RFID readers only produces a stream of string values representing the TagID and their contents (hence unidirectional) while a sensor network programmed to use TinyDB not only can produce the aggregated sensor readings but also can consume TinySQL queries (hence bidirectional). The reason for this separation is to use the in-network processing capabilities of sensor networks as much as possible.

II. GSN and Virtual Sensors

The key abstraction in GSN is the *virtual sensor*. Virtual sensors abstract from implementation details of access to the sensor network and correspond either to data streams received directly from sensors or derived from other virtual sensors accessible through the network (thus a chain of virtual sensors). A virtual sensor can be any kind of data producer and/or consumer, for example, a real sensor, a wireless camera, a desktop computer, a cell phone, or any combination of virtual sensors. A virtual sensor may have any number of input streams (called sources) and produces exactly one output data stream based on the input data streams and arbitrary local processing. The virtual sensor descriptor (VSD), which is a XML file, provides all the necessary information required for deploying and using the virtual sensors, such as the meta-data used for identification and discovery, the structure and properties of the produced data streams, a declarative SQL-based specification of the data stream processing and filtering and finally the functional properties related to stream

```
...
 <output-structure>
  <field name="temp"  type="double" />
 </output-structure>
 <storage permanent="true" history-size="10h" />
 <streams>
  <stream name="temperature">
    <source alias="temp"  storage-size="10min">
      <address wrapper="tinyos-2.x">
        <predicate key="host">pc15-epfl</predicate>
        <predicate key="port">22001</predicate>
       </address>
       <query>SELECT avg(temperature) as AVERAGE
              FROM WRAPPER</query>
    </source>
    <source alias="rfid"  storage-size="1">
      <address wrapper="rfid">
        <predicate key="host">pc16-epfl</predicate>
        <predicate key="port">22001</predicate>
      </address>
      <query>SELECT rfid FROM WRAPPER</query>
     </source>
     <query>SELECT temp.average FROM
            temp,rfid WHERE rfid.id = 587499
     </query>
    </stream>
   </streams>
...
```

Fig. 1. A typical virtual sensor definition.

quality management, persistence, error handling, life-cycle management, and physical deployment. Figure 1 defines a virtual sensor that reads the RFID Tag from a reader and the temperature sensors from a TinyOS-2.x network and in case the TagID equals to 58749 (representing the personnel identifier number) outputs the latest temperature average over that last 10 minutes.

For detailed description and analysis of all aspects of GSN we refer the reader to [1].

III. Demonstration

The main benefits of using GSN are its modularity, extensibility, the low effort and experience required for deploying, and the integrating new sensor networks and the flexibility in reconfiguring all the aspects of the system while it is running. In the demonstration, our primary focus will be on deploying and integrating heterogeneous sensor networks to show the simplicity and expressiveness we offer. The deployment and integration of sensor networks is the major cost factor by far in the software industry. In the demonstration we shall setup four heterogeneous sensor networks: BTNodes using the NutOS operating system, Mica2 nodes using TinyOS-2.x, a RFID reader and wireless cameras. We intend to use several base computers to show the peer-to-peer nature of the GSN.

During demonstration, the audience is first invited to examine the system using the web interface. The deployment is done such that the audience can issue arbitrary queries to the sensor networks and integrate the output of the sensor networks based on the desired application requirement. This experiment gives some initial hands-on experience of the sensor Internet. After the initial familiarization with GSN, we invite the audience to interactively change the setup of the system on-the-fly while the system is running. The audience will be able to monitor the status of all components of the system and the reactions to dynamic changes in configuration using the web interface and various network and system plots.

IV. Related Work

Till now, the focus in the research community was on providing energy efficient routing and data propagation algorithms inside one sensor network. In GSN we extended the idea to support interconnection and collaboration between sensor networks independent of the algorithms used for internal routing and data transmission inside each network. One of the close systems to GSN is [3], which suggests basic abstractions, a standard set of services and an API to free application developers from the details of the underlying sensor networks. However, the focus is on systematic definition and classification of abstractions and services, while GSN takes more general view and provides not only APIs but also a complete query processing and management infrastructure with fully declarative language. Other similar projects, such as the Hourglass[4] provide connection between sensor networks and applications by providing topic-based discovery and data processing services with the primary focus of maintaining quality of service of data streams in the presence of disconnections. GSN however, targets at general abstraction, flexible configurations and distributed query support. The HiFi[5] project's aim is to provide efficient, hierarchical static data stream query processing to acquire, filter, and aggregate data from multiple sources (with the homogeneous sensor networks), while GSN takes the peer-to-peer perspective assuming a dynamic environment (peers can join and leave) with heterogeneous sensor networks and allowing any node to be data source, data sink or data aggregator.

V. Conclusion

GSN provides a flexible software infrastructure for rapid deployment and integration of sensor networks with the existing technologies and the outside world. GSN is designed to meet the challenges that arise in real-world environments. GSN can hide any data source under its virtual sensor abstraction and provides a simple and uniform API to use and interact with sensor networks. Due to space constraints we only provide an overview of the GSN. A detailed description of various aspects of GSN is given in [1], [2]. The GSN implementation, evaluation and the up-to-date documentations are available at http://gsn.sourceforge.net.

References

[1] K. Aberer el al., "The Global Sensor Networks, middleware for efficient and flexible deployment and interconnection of sensor networks", Tech. Rep. LSIR-REPORT-2006-006, Ecole Polytechnique Fédérale de Lausanne, 2006.

[2] K. Aberer el al., "A middleware for fast and flexible sensor network deployment" , VLDB, 2006.

[3] M.Sgroi et al., "A service-based universal application interface for ad hoc wireless sensor and actuator networks", in Ambient Intelligence, Springer Verlag, 2005.

[4] J. Shneidman et al., "Hourglass: An Infrastructure for Connecting Sensor Networks and Applications", Tech. Rep. TR-21-04. Harvard University, 2004.

[5] M. Franklin, el al. "Design Considerations for High Fan-in Systems" , CIDR, 2005.