Plug&Manage Heterogeneous Sensing Devices

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ABSTRACT

With the emergence of sensors in applications in which the quality of service requirements are high (e.g., industrial, medical, domotic), management of these sensing devices gains an increasing importance. However, management issues are still little explored in this context. This demonstration presents our solution for dynamically managing networked heterogeneous sensing devices. The solution is based on a service oriented middleware that provides generic management operations for configuration, software management and performance monitoring of sensing devices.

1. CONTEXT AND OBJECTIVES

Sensing devices are becoming pervasive and changing the way of information processing in many application domains. Extensive research has been done on networked sensing systems covering a vast array of topics. However, management issues in this context are still little explored, e.g., configuration, software management, performance monitoring. Nonetheless, initially used by experimental applications, sensors (e.g., temperature sensors, audio-visual devices, chemical sensors, GPS devices, RFID readers) have now started to be used in more critical applications requiring properties such as quality of service, reliability, security and integrity; in application domains such as industrial, military, medical and domotic. These properties can only be obtained with efficient management mechanisms.

This demonstration presents our integrated management solution for networked heterogeneous sensing devices. The solution is based on a service oriented middleware that provides generic management operations to be performed on a common data model. The contributions of the middleware can be summarized along three axes:

Heterogeneity. Different types of sensors from many manufacturers and service providers are being deployed. They are managed by specific software. In our middleware the heterogeneity of sensors and their specific software are hidden behind generic management services and a common data model. The solution is built on top of our sensor data querying middleware, SStreaMWare [3]. The objective of SStreaMWare has been to be able to query any type of sensors of any provider via a common platform. Following the same philosophy, with a management extension to SStreaMWare, we aim to be able to manage sensors of different types and from different providers. Our middleware eXtended with the management support is called XSStreaMWare.

Dynamicity. Computing environments have recently been highly dynamic containing many devices that come and go continuously. More and more systems try to include plug&play features in order to facilitate the dynamic integration and use of new devices. Having the same plug&play philosophy, XSStreaMWare aims to introduce a "plug&manage" facility thanks to its service-oriented approach. Arrival and departure of services, as well as their modification, are intercepted, thus the adequate measures are taken immediately. For instance, data of newly arriving sensors are taken into account by ongoing continuous queries.

Integrated management. Management is a very general term and refers to several domains such as *network*, *systems* or *application management*. There are no clear boundaries between these domains and their functional areas mostly overlap. In fact, more and more integrated solutions are being developed: "network & systems management" (e.g., SNMP), "systems & application management" (e.g., JMX) and most recently, "device management" solutions integrating network, system and application management domains [1]. This work aims to answer the question "what about device management for sensing devices?" and proposes an integrated management solution.

The overall objective of this demonstration is to show the feasibility of an integrated management solution for heterogeneous sensing devices. We implemented our approach and validated by integrating different types of sensors to be managed by the middleware. We showed via experimental results that our solution brings little latency comparing to the sensor specific management tools [2].

2. OVERVIEW OF XSSTREAMWARE

Based on a hierarchical architecture, XSStreaMWare allows a simple set of management operations to be performed on a generic data model.

Architecture. We adopt a simple multi-level hierarchical architecture composed of managers, sub-managers, agents and managed entities (see figure 1(a)). *Manager* is the entity at the top level providing an overall view of the managed environment. Management operations are initiated by the manager and then distributed to the *sub-managers*. Each sub-manager is responsible for a given region. They interrogate, control and manipulate sensing devices via their agents and return results back to their managers. *Agents* are software entities that collect data from managed entities and perform operations on them as requested by sub-managers. They maintain management information bases (MIB). Finally, *managed entities* are abstract views of physical and

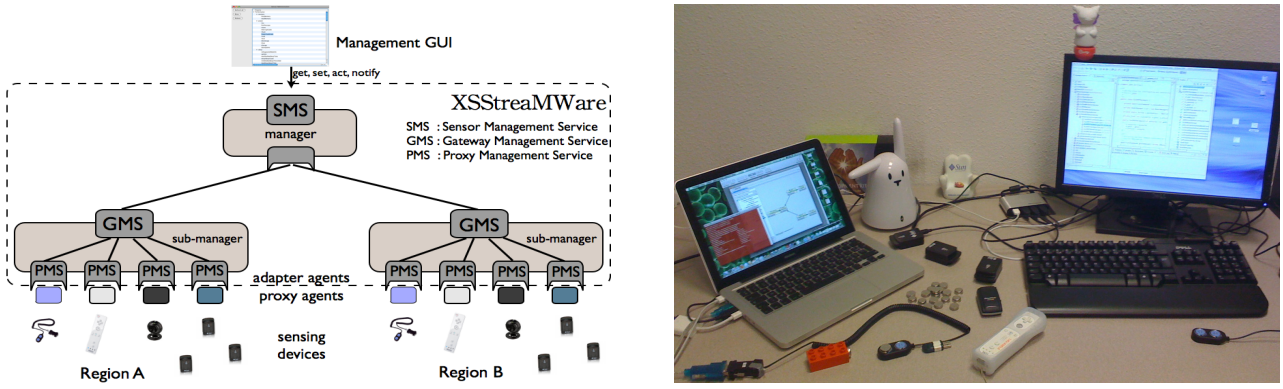

Figure 1: Software architecture and real world deployment with heterogeneous sensing devices

logical resources of sensing devices to be managed.

Data model. For its simplicity and extensibility, XSStreaMWare specifies a hierarchical model for representation of management information. The model defines the structure of the management data, identify some common parameters and define their names and attributes. We classify four parameter families according to the functional area they belong to. i) Some *general information* on sensors such as device name, manufacturer, model, type, location and description. ii) *Configuration* parameters, including network, system, application or physical device parameters such as neighbor table, logical address, alarm threshold, supported protocols and/or algorithms, sampling rate. iii) *Software* information of sensors such as operating system name, virtual machine version, or installed application modules. iv) And finally, *performance* related parameters to be continuously monitored, such as communication delay, energy level, CPU and memory usage.

Management operations. XSStreaMWare offers a simple set of common operations to be performed on the managed devices. i) `get` operation is used to retrieve values of sensor parameters. ii) `set` operation updates the values of parameters. iii) `act` operation executes common operations such as install, reboot, reset or ping, as well as device specific operations such as radio tests, calibration or application deployment. A management client can gather the list of supported operations from the data model and execute them without any prior knowledge. iv) `notify` operation is used to subscribe for modification events of parameters such as uptime, location, sampling rate, firmware version or state.

3. DEMONSTRATION SCENARIO

Adapters for two types of sensors are already implemented and integrated to the middleware, namely for Sun SPOT sensors and i-Button temperature sensors. More adapters (for webcams, GPS devices, RFID readers) are being implemented and will also be integrated in very short time. After the presentation of the sensing devices and the management GUI, management actions on these devices via the GUI will be demonstrated. The participants will observe the detection of the newly arriving devices and visualization of their data models. They will formulate management operations such as getting various device parameter values, modifying them or performing actions such as ping, application deployment and provisioning, time synchronization or other sensor specific actions. We will also show how these operations can have an impact on ongoing continuous queries that are being evaluated on the data of sensors that are being concurrently manipulated by management operations.

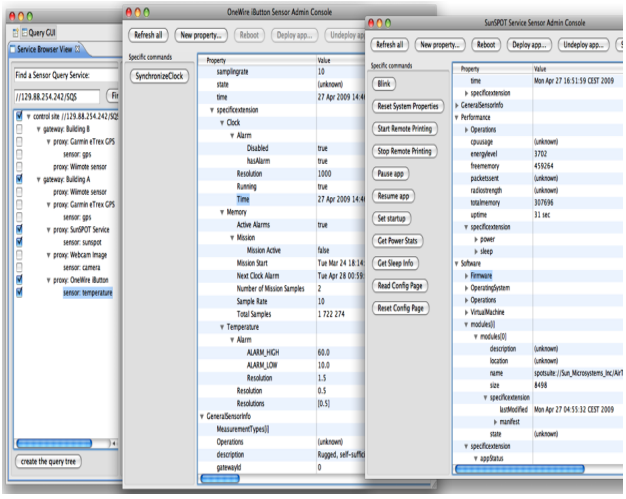

Figure 2: A screenshot of the management GUI

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