

The Design of an Open and Integrated Sensor Network Management Platform

Michalis Kalochristianakis¹, Vasileios Gkamas¹, Georgios Mylonas¹,
Sotiris Nikolettseas¹, Jose Rolim², and Emmanouel Varvarigos¹

¹Department of Computer Engineering and Informatics, University of Patras, Greece

²Department of Computer Science, University of Geneva, Switzerland

{kalohr,vgkamas,mylonasg,nikole,manos}cti.gr, rolim@cui.unige.ch

Abstract. We present the conceptual basis and the initial planning for an open source management architecture for wireless sensor networks (WSN). Although there is an abundance of open source tools serving the administrative needs of WSN deployments, there is a lack of tools or platforms for high level integrated WSN management. The current work is, to our knowledge, the first effort to conceptualize and design a remote, integrated management platform for the support of WSN research laboratories. The platform is based on the integration and extension of two innovative platforms: jWebDust, a WSN operation and management platform, and OpenRSM, an open source integrated remote systems and network management platform. The proposed system architecture can support several levels of integration in order to cover to multiple, qualitatively differentiated use-cases.

Keywords: Remote management, wireless sensor networks, pervasive communications, open source.

1 Introduction

The effective and flexible integration of sensory systems with interconnection networks and grid technologies is a critical step towards developing pervasive computing and communication services and applications. Because of sensor network inherent characteristics such as heterogeneity, limited bandwidth and energy constraints, WSN management and monitoring architectures need to: (i) provide a wide range of services so as to cover the whole spectrum of supported WSN architectures, (ii) minimize the overall WSN management effort and make it uniform to the degree possible, (iii) reduce the needs for network administration and sensor node software management and (iv) expose web interfaces for WSNs management. A number of administrative and management tasks that are typically supported by standard management tools for workstations would be also valuable to WSNs operators and administrators. Such tasks are: multiple WSNs management and monitoring, web-based control, remote command execution or remote configuration, software / firmware upgrade, reporting and grouping.

This paper presents an architecture that is capable of delivering remote management functionality to wireless sensor networks. The idea is based on the combination of

jWebDust [5], a software environment that allows the implementation of customized applications for wireless sensor networks, and OpenRSM [8]. In order to bring management to WSN, it is essential to automate routine WSN practice. jWebDust provides all standard WSN management functionality, including querying, monitoring, data logging and visualization. jWebDust employs an extendable architecture and provides easy interfacing and API. OpenRSM provides the implemented distributed logic suitable to deliver services, such as inventory and asset management, software delivery, remote control and network monitoring, all integrated in one environment.

The paper is organized as follows. Section 2 describes the related state of the art on monitoring and administration tools for wireless sensor networks. Section 3 presents the proposed integrated architecture and section 4 presents the integration methodology. Conclusions and future work are discussed in Section 5.

2 Related Work

Software environments that provide the necessary tools and operations to allow the monitoring and administration of a wide range of WSN's applications are relatively few, and to our best knowledge, none of them integrates all the desired management functionality in a single environment.

TinyDB [2] is an example of an application that allows multiple concurrent queries, event-based queries and time synchronization through an extensible framework that supports adding new sensor types and event types. MoteWorks [6] is a commercial WSN management product. It is based on an n-tier architecture model and offers standard management functionality and it supports a significant number of sensor node hardware platforms. MoteWorks also offers visualization tools and login services [1]. ArchRock [7] is a commercial product that offers WSN management capabilities. It offers sensing functionalities and APIs to interface with, and integration with IP networks, using a 6LoWPAN network stack inside the sensor network. TWIST [3] and MoteLab [4] are examples of testbed deployment management environments, targeted toward research teams. They provide capabilities such as job scheduling and network sniffing designed for special-purpose environments that focus on WSN applications testing.

The above platforms and tools provide administrative functionality, mostly in terms of development. Their goal is not to deliver an integrated remote management WSN environment capable to convey detail and mass administration and monitoring commands to the wireless sensor network.

3 The Concept of Integrated WSN Management

jWebDust and OpenRSM can complement each other in order to deliver integrated management to WSNs. With respect to the level of integration we distinguish the following management layers: (i) WSN server / gateway infrastructure management, (ii) WSN server functionality support, application programming interface (API) integration and (ii) firmware management.

OpenRSM can be primarily used to deliver infrastructure management to WSN servers that is, bring inventory and assets management, network monitoring, software delivery, and remote desktop control to laboratory servers. This level of integration is achieved by incorporating the OpenRSM agent within a jWebDust installation.

OpenRSM can be further integrated with jWebDust. In particular, current work focuses on extending OpenRSM to support jWebDust services, APIs and tools and to expose them as special-purpose remote management services. The result of the integration will be that OpenRSM will be capable to schedule and synchronize the execution of jWebDust-specific jobs. Users will then be capable to define custom jWebDust-specific jobs corresponding to distinct administrative task manageable within the jWebDust platform. OpenRSM will embody standard jWebDust template jobs. Users will be capable to utilize the template jobs to create custom ones. Jobs can also be correlated with machines and then be submitted to the OpenRSM integration server; the server will forward them to the agent running at WSN's server/gateway where jobs will be executed as jWebDust procedures.

In order to cover advanced needs for WSN management, such as firmware development and deployment, a higher level of integration is required. Firmware construction, deployment and discovery of individual sensor nodes require firmware level integration that will enable the management platform to deliver identifiable sensor nodes, capable to dynamically change their state and runtime environment. It is therefore necessary for the management platform to support the underlying development environment and to include a firmware construction framework. The underlying development environment for sensor node firmware, TinyOS [9], offers development tools that can be integrated into custom OpenRSM jobs. TinyOS functionality can be used by OpenRSM via TinyOS job templates, disposable to users for customization or immediate usage. The compilation and deployment tasks can be formalized to produce accurate and safe results, disallowing the creation of modules that may result to WSN malfunction. For example, incompatibilities in the discovery or firmware update services must be eliminated via the formalization of TinyOS jobs. The output of the TinyOS jobs will be registered and stored.

4 Integration Methodology

The integration of the two platforms is currently in progress. An early milestone is setting jWebDust under OpenRSM management by producing a custom agent module for WSN gateways. The agent module can be integrated into the codebase of the jWebDust platform or it can be deployed as an external module. The next milestone is integrating the base of high level system management functionality for the specific needs of WSN gateways, into the agent module. Integration will produce agent connectors for the jWebDust API interface. After this point the integration will proceed to all OpenRSM levels and eventually to the management console where the user will be presented with visual representations of the managed boards and even sensors. At this point, the integration of jWebDust and OpenRSM may even consider branching from OpenRSM and jWebDust, since it will have the potential needed for building end-user services for WSN management.

5 Conclusions and Future Work

This paper presents the conceptual design of an integrated management environment enhanced with WSN management functionality. The design is based on the integration of the WSN monitoring platform jWebDust with the OpenRSM systems and network management system. The derived platform is an integrated remote management WSN environment, under which the overall administration and monitoring of the wireless sensor network can be performed both in low and high level. Current work includes the gradual integration of the two platforms in accordance with the integration levels, as mentioned in section 4, and the evaluation of its feasibility and performance (implementation overhead, evaluation of performance metrics).

Acknowledgements

This work has been partially supported by the IST Programme of the European Union under contract number IST-2005-15964 (AEOLUS), the Programme under the European Social Fund (ESF) and Operational Program for Educational and Vocational Training II (EPEAEK II) and the Programme PENED of GSRT under contract number 03ED568.

References

1. Mote-VIEW monitoring software, Crossbow Technology Inc., <http://www.xbow.com/>
2. TinyDB: A declarative database for sensor networks, <http://telegraph.cs.berkeley.edu/tinydb/>
3. TWIST Community Web Site, <http://www.twist.tu-berlin.de/wiki>
4. MoteLab, Harvard Experimental Wireless Sensor Network Testbed, <http://motelab.eecs.harvard.edu/>
5. Chatzigiannakis, Mylonas, G., Nikolettseas, S.: jWebDust: A java-based generic application environment for wireless sensor networks. In: The proceedings of the 1st International Conference on Distributed Computing in Sensor Systems (DCOSS), 2005, pp. 376–386 (2005); Also, in the International Journal of Distributed Sensor Networks (IJDSN) (to appear, 2008)
6. Mote-Works monitoring software, Crossbow Technology Inc., <http://www.xbow.com/>
7. ArchRock, <http://www.archrock.com/>
8. Karalis, Y., Kalochristianakis, M., Kokkinos, P., Varvarigos, E.: OpenRSM: An Open Source Lightweight Integrated Remote Network and Systems Management Solution, under publication in International Journal of Network Management
9. TinyOS, <http://www.tinyos.net/>