WEBDUST: A PLATFORM FOR SUPPORTING DEVELOPMENT OF LARGE WIRELESS SENSOR & ACTOR NETWORKS APPLICATIONS

Christos Koninis
Research Academic Computer Technology Institute and University of Patras, Greece
koninis@ceid.upatras.gr

Georgios Mylonas
Research Academic Computer Technology Institute and University of Patras, Greece
mylonasg@cti.gr

Ioannis Chatzigiannakis
Research Academic Computer Technology Institute and University of Patras, Greece
ichatz@cti.gr

Abstract We present the basic concepts behind the design and implementation of WebDust, a peer-to-peer platform for organizing, monitoring and controlling wireless sensor networks, along with a discussion of its application regarding an actual testbed. Our software architecture provides a range of services that allow to create *customized* applications with relatively low implementation overhead. WebDust aims to allow heterogeneous components to operate in the same sensor network, and give the ability to manage and control large numbers of such networks, possibly on a global scale. We also give insight to several applications that can be implemented using our platform, and a description of our current testbed.

1. Introduction – Motivation

Recent research in WSN strongly relates to Internet-scale sensing applications. Unlike the applications that were proposed or implemented in the previous years, interfacing between/with different networks and applications is gaining importance. Such applications are related to what is refered to as “the Internet of things”. To realize such a vision, software for WSN applications must adapt to the new requirements posed. The seeming integration of the Internet and sensor domains and its benefits can be better described e.g., by the concept of a Sensor-oogle or a Google Earth Sense. One can imagine a version of Google offering search capabilities for sensing services or a Google Earth with live sensing data coverage per square mile.

WebDust is a software platform for monitoring and controling a multitude of disparate wireless sensor networks, using a peer-to-peer infrastructure for the communication between the different networks comprising the system, in order to achieve great scalability. The system’s overall goals, apart from scalability, are to greatly simplify sensor network deployment, maintenance, and application development by offering a set of implemented services to the user and an extendable architecture to the developer, and also to offer heterogeneity by supporting a number of hardware platforms.

WebDust differs from other similar WSN software by using a peer-to-peer notion to unify multiple WSNs, providing great ease in the integration of different testbeds, while at the same time having advanced end-user interface capabilities. We chose to offer a user interface related to the concepts described above, by using software like Google Earth and Google Maps. Furthermore, we are working on integrating control functionality extensions to our system, thus making actor networks a part of the system as well. WebDust is currently under development.

2. Overview of WebDust's Architecture

In general, we make the following distinction into three sub-domains: (i) the *Peer-to-Peer network*, where peers are applications executing on a relatively powerful device that has the ability to communicate with other peers via the internet, (ii) the *Nano Peers* (sensor devices), that form various wireless sensor networks, (iii) the *Gateway Peers*, that consist of nodes that have access to the wireless sensor network and allow interaction between the Peer-to-Peer network peers and the nano peers.

The structure of the peers of our system follows a modular architecture of essentially two layers: the *inner layer* that is comprised of a minimum set of core functionalities and an *outer layer* that hosts a variety of services. We use JXTA, a Java-based technology, as a substrate in order to implement the peer-to-peer part of the system. The rest of the system is written in Java as well.

Due to the heterogeneity of the devices but also to the very nature of such global sensing systems, each peer may provide a different subset of the available services, and different versions of a particular service. Gateway peers appear on the global network as participants that have certain sensing and monitoring capabilities. The existence of the wireless sensor network is abstracted from the top layers, and similarly the the lowest layer ignores the top layers.

2.1 Technologies Supported – Current Testbed

One of the prime goals of WebDust was to support heterogeneity, i.e., different kinds of hardware and software platforms coexisting on the sensor network level. At this point, the system is supporting the use of the following sensor node platforms: mica2, micaZ, telosB (or the equivalent Tmote Sky from Sentilla) from CrossBow, Sun SPOTs (offered by SUN), and iSense (offered by Coalesenses Gmbh). Regarding the sensor boards supported for these platforms, we are currently using most of the sensor boards offered by CrossBow (temperature, humidity, light, GPS, barometric pressure, accelerometer, magnetometer), the integrated TelosB (temperature, light, humidity) and Sun SPOT (temperature, light) sensors, and iSense sensor boards (temperature, light, accelerometer, magnetometer, PIR camera). Regarding the software used on the software level, we use an extended version of Octopus and Crossbow's MoteWorks for mica2, micaZ and TelosB, and custom software for the Sun SPOTs and the iSense nodes.

Our current testbed consists of a total of 8 peers, all of which host a wireless sensor network and residing in different geographical areas, 4 located at the University of Patras, 1 at the University of Ioannina, 1 at the University of Rome de La Sapienza, 1 at the University of Geneva and 1 at the INRIA, Sophia Antipolis. All of these discrete sensor networks will sum up to well over 150 sensor network nodes.

Regarding future extensions to the system, we are planning to add support for 1-wire sensors (IEEE 1451), a feature which we believe will enhance the application scope of our system. Specifically, we are planning to use such sensors for measuring weather data, as a low-cost alternative to expensive weather stations. Furthermore, as mentioned previously, we are planning to extensively investigate the use of actuators within the network.

3. Application Scope

WebDust was designed with large-scale applications in mind. We give some examples here.

Building Management: Wireless sensor and actuator networks can potentially serve as a relatively low-cost alternative to traditional wired building management systems. It is a well-known fact that building energy consumption accounts for a large part of the total energy spent (close to 40%), and there are potential savings in energy consumption by employing the right technology. The problem is that current building management systems are rather on the expensive side and generally rely on wired networks, making post-installation in older buildings difficult. The use of a wireless sensor network to monitor conditions inside buildings and actuators in order to accordingly control HVAC systems and save energy seems to be a viable alternative. We plan to use our current testbed in the building of CTI in Patras, using over 100 nodes, as a means to continuously monitor conditions inside the building and control lighting and airconditioning, as a first step towards a WSN-based building management system.

We also plan to use it as a way to control the temperature and humidity inside CTI's data center – the idea is to use external air to cool the data center instead of an air-conditioning system whenever possible (depending on outdoors temperature and humidity levels).

Urban Pollution Monitoring: Another large-scale possible application is to use WSN to monitor pollution and air quality in urban scale. Imagine sensor nodes deployed throughout a city, measuring CO_2 and other gas levels, as well as sound pollution and thermal/humidity distribution. With WebDust, such an application is feasible, providing scientists with precise data of unforeseen detail over the conditions inside a city, while civilians are able to watch online measurements through the use of Google Earth and be informed about the real conditions in their area.

Acknowledgments

This work has been partially supported by the IST Programme of the European Union under contract number IST-2005-15964 (AEOLUS) and the ICT Programme of the European Union under contract number IST-2008-215270 (FRONTS).