A Mobile Agent Approach to Opportunistic Harvesting in Wireless Sensor Networks

(Demo Paper)

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ABSTRACT

This demonstration illustrates the feasibility of harvesting data from a WSN by interested parties, either in the WSN coverage area or in a remote location. Embedded and mobile agents are harnessed for the data capture process. Individual nodes communicate with gateways to which, user devices connect. Users can query and view the local data in an ad-hoc manner, and possibly remotely configure and manipulate the data capture process. It is envisaged that the combination of embedded and mobile agents offer a dynamic method of sensor data viewing and processing, either in situ, or in a central repository.

Categories and Subject Descriptors

C.2.1 [**Computer-Communication Networks**]: Network Architecture and Design—*Wireless communication*

General Terms

Design

Keywords

Wireless Sensor Networks, BDI Agents, Embedded Agents

1. INTRODUCTION

For a Wireless Sensor Network (WSN), harvesting data can pose significant challenges. The objective is to realize a configuration that can deliver appropriately sensed data elements to the right user at the right time. An initial solution requires not only the deployment of WSN nodes, but also an infrastructure to deliver data to roaming users for immediate consultation as well as to central repositories for post-processing, analysis and visualisation. Should the network be configured statically, a situation may develop where the number of messages being transmitted is excessive or perhaps insufficient for an adequate Quality of Service (QoS). In the former case, the operational lifespan of the network may be reduced; in the later case, the actual usefulness of the WSN is compromised. Thus a solution is called for that enables the WSN be accessed, queried and configured while in the field, as well as centrally.

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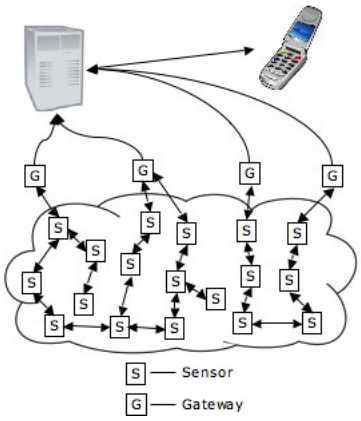

Figure 1: Infrastructure-based data harvesting.

One solution to this problem is to employ an ad-hoc configuration, whereby users can interact with data that is produced in their proximity. As users navigate a particular area coinciding with a WSN, they can communicate with the WSN gateways using a wireless connectivity technology supported by their mobile device. Under this regime, localised, real-time or historic sensed information, concerning air quality for example, can be delivered to their device for immediate study. Based on this information, users will be better informed about the state of their environment and thus make more informed decisions, or certain authorised users may dynamically configure individual network parameters so as to optimise performance.

2. ARCHITECTURE

A traditional architecture for querying WSNs is depicted in figure 1. As can be seen, the mobile device does not interact with any component of the WSN; rather it establishes a connection with a central server that serves the WSN. Such an approach is functional but somewhat static in nature. Augmenting it with a mechanism for data access while the

user is in immediate proximity offers a flexible solution for opportunistic data harvesting and WSN configuration.

An architecture for mobile data harvesting is depicted in figure 2. Sensors interact with each other and the gateway in order to perform the sensing function. Gateways link the WSN with the user devices and in addition store a limited amount of historic data locally. This is to ensure that a user can be presented with historical data should they require it. In a similar fashion to the server based technique, this approach can incorporate data from nodes that are not directly connected with the appropriate gateway. This is only the case if the network of sensors remains connected. Both requests and data can be multi-hopped directly on the WSN; under the centralised approach the server has all the data and can therefore deliver as much or as little data as required by the user.

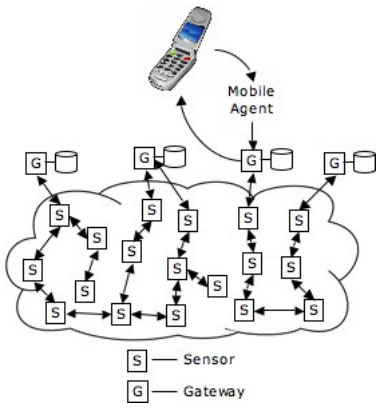

Figure 2: Mobile agent harvester for WSNs.

An interesting consequence of using the ad-hoc based approach is that it can be adopted as a centralised solution without placing the burden of deploying the infrastructure on the WSN provider. Typically, mobile devices are connected to a telecommunications network. In providing the sensing service to users, the cost of receiving readings may be partially or completely offset by the user's willingness to upload data using their GPRS connection, for example. In this way, a hybrid system can be created which meets the requirements of a diverse user base. Indeed, one could envisage a market economy whereby telecommunications operators entice data hunting by providing free SMS messages as an incentive.

3. AGENT INFRASTRUCTURE

To facilitate dynamic ad-hoc querying of WSNs, an approach based upon embedded intelligent agents [5] has been adopted - an approach adopted by others in this area [6] [1]. Such agents offer an intuitive construct for modelling the constituent processes as well as ensuring, at least from a designer's perspective, that scalability and extensibility are not compromised. Recalling that the topologies of WSNs are dynamic to varying degrees, and that the requirements of an arbitrary user base vary according to the needs of the individual users themselves, as well as to the context prevailing at the time a query is initiated, it can be seen that the classic agent attributes of reactivity, proactivity and autonomy would be attractive to those engineering such a solution. Ongoing developments in agent and sensor technologies are enabling the harnessing of these apparently disparate solutions for innovative applications and services.

For the purposes of this demonstration, we adopted Agent Factory Micro Edition (AFME). AFME [3] is the result a number of years research on embedded agents [4] [2]. In summary: AFME is designed for computationally small footprint devices such as PDAs and mobile phones. As the sophistication of sensor technology has increased, it has been successfully ported to the Crossbow Stargate platform and porting to the IMote2 is ongoing. From an agent architecture perspective, AFME supports Belief Desire Intention (BDI) type agents that follow a sense-deliberate-act cycle. The platform itself comprises a scheduler, a number of platform services and individual application-specific agents.

4. ADVANTAGES OF THE MOBILE AGENT APPROACH

Using mobile agents for data harvesting, as outlined, provides a number of distinct advantages over a client-server model, for example. Firstly, mobile agents allow the processing or fusion of large quantities of data in situ rather than the transmission of the raw data to the users device. Secondly, mobile agents offer a method of multiplexing multiple overlays on the same sensing infrastructure for given users and applications. New or custom techniques can allow the existing nodes to provide functionality that was not specifically built into the network. A third advantage is an increasing possibility as more powerful sensor nodes emerge, namely that sensor nodes themselves could host mobile agents, enabling agents to traverse the precise set of sensors required by the user.

5. ACKNOWLEDGEMENTS

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