A Mobile Gateway for Remote Interaction with Wireless Sensor Networks

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***Abstract*—Wireless Sensor Networks (WSNs) almost invariably support a centralised network management model. Though the data gathering function is conducted remotely, such data is usually routed via data sinks to central servers for processing, storage, visualisation and interpretation. However, the issue of supporting remote access to WSNs and individual sensor nodes whilst in their physical environment has not been viewed as a priority. It is envisaged that this situation will change as WSNs proliferate in a range of domains, and the potential for supporting innovative revenue-generating services manifest themselves. As a step towards realising such access, a mobile gateway has been designed and implemented. This gateway supports Zigbee as this is the predominant protocol supported by WSNs. Furthermore, it also supports Bluetooth, thereby facilitating interaction with conventional mobile devices. The gateway is programmable according to the needs of arbitrary services and applications.**

***Index Terms*—Wireless Sensor Networks, remote access**

I. Introduction

CONVENTIONAL perceptions of Wireless Sensor Network (WSN) configurations are inherently centralised, ensuring all key activities including processing and storage, take place at a centralised location. However, there are situations where interactions with individual sensor nodes may be essential. An exemplar case is that of WSN Operations and Maintenance (O&M). When deployed in a physical environment, the performance of a WSN will inevitably deteriorate over time. Eventually, situations will emerge that demand operatives visit the network in the field (Figure 1). Fundamental to remote O&M is a means for interaction with the WSN through individual nodes. The issue of incompatible protocols is a key barrier to enabling remote access via conventional mobile phones. To remedy this, a mobile gateway has been implemented, that, when placed in a WSN field, enables communications between mobile phones and WSN nodes.

A. Related Research

Mobile WSN nodes are not a new concept, and have been proposed for remedying a number of inherent problems with WSNs including data collection [1], network operational lifetime [2] and connectivity [3]. The potential of mobile phones as a means of connecting WSNs to the internet has been explored by Harnett [4] amongst others. Likewise, the issue of interaction between phones and sensor nodes has been explored by Lifton [5] and Ringwald [6], though in each case, the solution is closely tied to individual technologies. The mobile gateway described here is a generic solution, supporting Zigbee, the most common protocol supported by WSNs, and Bluetooth, which is available on practically all mobile devices.

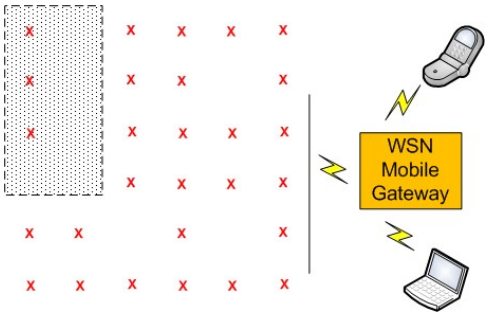

Fig. 1. Using the Mobile Gateway to access a WSN. In this case, part of the network has become isolated, requiring physical intervention.

II. A Mobile Gateway

To enable practical remote sensor node connectivity, a mobile Bluetooth (BT) gateway resident on a WSN backbone, for example Zigbee, and utilizing a stackable modular connector system [7] [8] thereby enabling interchangeability (for example, an alternative 433MHz RF layer) was envisaged (Figure 2). The standard Bluetooth module Universal Asynchronous Receiver/Transmitter (UART) connection to an onboard device micro-controller and the use of the Serial Port Profile (SPP) does not meet the low-power sleep requirements in long term WSN deployments. To overcome these power issues, an architecture with sensor RF (ZigBee) acting as Master, and thereby being in control of data transfer, was proposed. An application deployed on a smart phone (slave) can be configured for continuously polling or sniffing for any available sensor data whilst on the move. To enable reliable power-efficient communications, a serial protocol, with hand shaking, residing on top of the standard Bluetooth protocol stack, was proposed. The Virtual COM port connection to the within-range discoverable sensor devices can subsequently be relinquished following successful data transfer. Thus a Master role for WSN nodes is seen as the most power-efficient method on battery-constrained sensor node devices, whereby mobile

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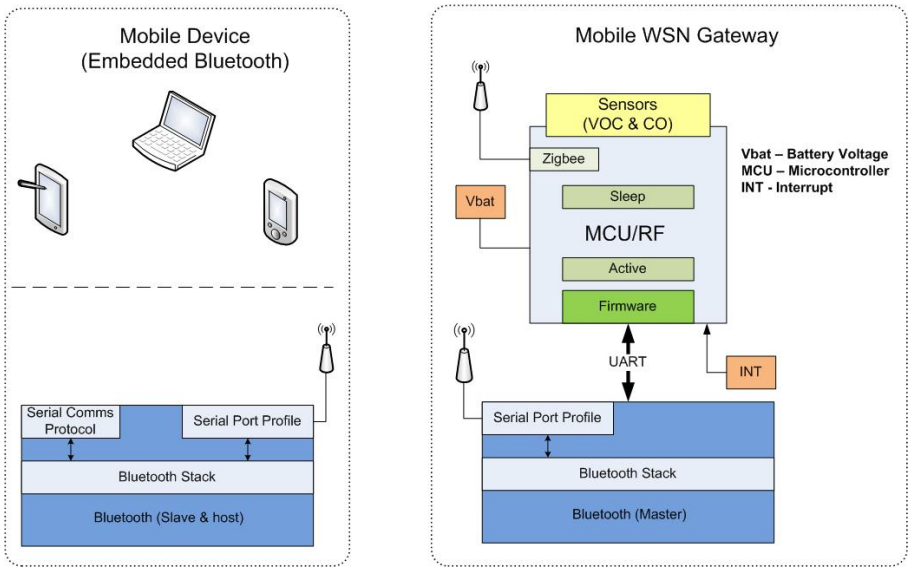

Fig. 2. Schemetic of the Mobile Gateway illustrating both the mobile device and mobile WSN gateway components.

device can remain in sniff mode (as a discoverable slave), scanning for nearby nodes. This is of particular importance in the case of low duty cycle nodes that remove BT power to save energy. Serial communications protocol ensures successful BT transmission, that is, Quality of Service (QoS), with minimum power by utilising a handshaking command set, including, in addition to Request To Send (RTS), Clear To Send (CTS), pause, start of frame and End of File (EOF) eliminators. Waspmote [9], recently released from Libelium, has a similar hybrid RF architecture, with a radio power-off feature; however it remains unclear how practical resource-constrained communications can be implemented, for example by using a serial protocol on top of the BT stack. Similarly [10] discuss a BT module approach with simple modifications to a TelosB gateway involving direct data forwarding to both the Universal Serial Bus (USB) port and the BT module. While the BT module can be placed in sniff mode, a possible limitation may be the considerable gateway power usage. Utilising the discussed BT power minimization and serial protocol, BT can be used for WSN sensor data or firmware upgrades. The solution described here involves a Roving Networks (RN-21) Bluetooth 2.0/EDR Class1 Module, combined with sensors for Carbon Monoxide (CO) and Volatile Organic Compounds (VOCs) amongst others. A sample GUI application was developed to display sensor data and to poll periodically for any available in-range discoverable connection requests from sensor networks. Consequently, Over-the-air upgrades of nodes is possible. Hybrid BT / ZigBee networks have been implemented albeit with limited support for pluggable low-power gateways. This solution represents a more realistic approach for remotely deployed networks where mains-powered gateways are not an option. Also, the pluggable nature allows optimal positioning of gateways for best mobile RF connectivity.

III. Conclusion

In this paper, the design and implementation of a mobile gateway for supporting remote interaction with WSN nodes has been described. Such a facility is essential for O&M operations in geographically disperse WSNs, and opens opportunities for new WSN-based services.

Acknowledgment

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