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Authors	Angove, Philip;O'Grady, Michael J.;Hayes, Jer;O'Flynn, Brendan;O'Hare, Gregory M.P.;Diamond, Dermot
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# A Mobile Gateway for Remote Interaction with Wireless Sensor Networks

Philip Angove, *Member, IEEE*, Michael O'Grady, *Senior Member, IEEE*, Jer Hayes, *Member, IEEE*,  
Brendan O'Flynn, *Senior Member, IEEE*, Gregory O'Hare, *Member, IEEE*,  
and Dermot Diamond, *Life Fellow, IEEE*

**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. Fundamental to remote O&M is a means for interaction with the WSN through individual nodes. The issue of incompatible protocols is one key barrier to enabling remote access via conventional mobile phones. To remedy this situation, a mobile gateway has been implemented, that, when placed in a WSN field, enables communications between mobile devices and individual 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

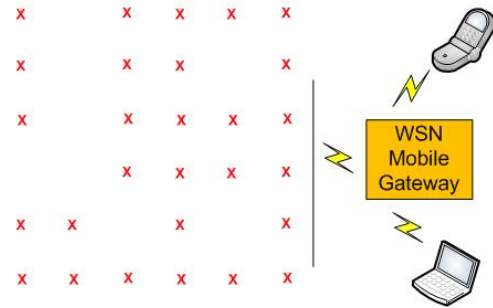


Fig. 1. Using the Mobile Gateway to access a WSN subnet.

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 in this paper is a generic solution, supporting Zigbee, the most common protocol supported by WSNs, and Bluetooth, which is available on practically all mobile devices.

## 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] thereby enabling interchangeability (for example, an alternative 433MHz RF layer) was envisaged. The standard Bluetooth module 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. 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 device can

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Philip Angove and Brendan O'Flynn are with the Tyndall National Institute, "Lee Maltings" Dyke Parade, Cork Ireland. e-mail: {philip.angove, brendan.offlynn} @tyndall.ie.

Michael O'Grady and Gregory O'Hare are with University College Dublin. Jer Hayes is with IBM,.....

Dermot Diamond is with Dublin City University.....

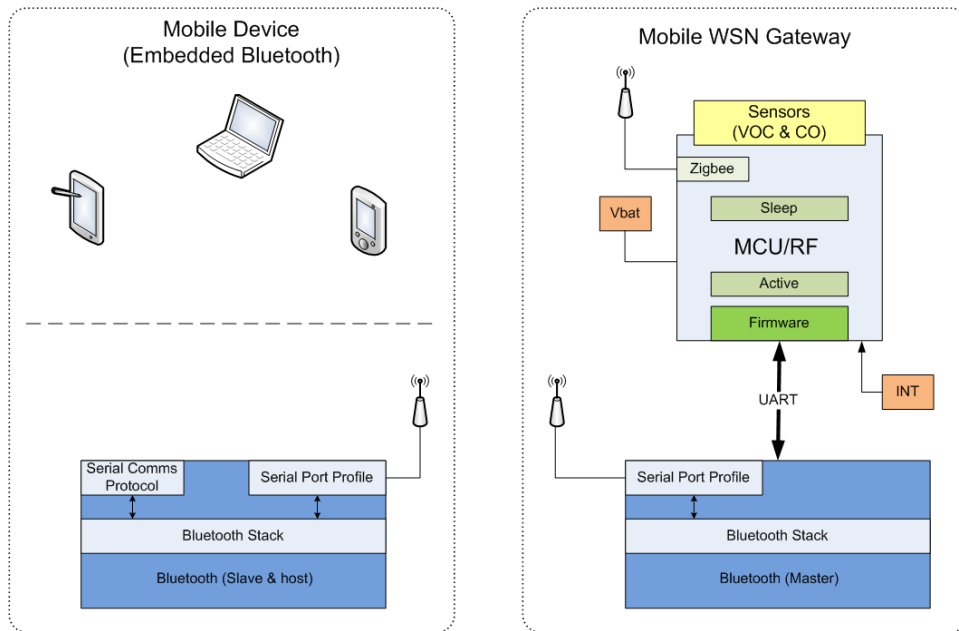


Fig. 2. Schematic of the Mobile Gateway.

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 (QoS) with minimum power by utilising a handshaking command set, including, in addition to RTS, CTS, pause, start of frame and EOF eliminators. Wasp mote [8], 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 [9] discuss a BT module approach with simple modifications to a TelosB gateway involving direct data forwarding to both the 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 Pluggable Bluetooth 2.0/EDR Class1 Module, incorporating sensors for CO and VOC's 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 only with limited support for pluggable low-power gateways. The solution described here represents a more realistic approach for remotely deployed networks where mains-powered gateways are not an option. Moreover, 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.

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