Open wireless sensor network telemetry platform for mobile phones

C. K. Harnett, *Member, IEEE*

***Abstract*—Mobile phones are an underutilized resource for connecting low-power wireless sensor networks (WSNs) to the internet. WSNs typically expend most of their battery power on data transmission. Mobile phones carried by the public could enable a hybrid approach where data makes a low-power short distance hop to phones in the vicinity using Bluetooth or a similar short range protocol, then uses the phones' long distance connectivity to upload to the internet. Because a large fraction of mobile phones have Bluetooth short-distance radio, this paper describes low-cost hardware for a generic WSN-to-Bluetooth gateway and open-source software that allows a wide subset of mobile phones to download and save WSN data.**

***Index Terms*—telemetry, mobile communication, multisensory systems, distributed computing.**

I. Introduction

Wireless sensor networks (WSNs) are the subject of intense research for structural health monitoring, agricultural monitoring, and environmental research [1-3]. These systems can identify previously unobservable patterns thanks to their large spatial extent. Wireless sensors are popular because of simplified installation requirements for physically independent sensor nodes, but this advantage is offset by the need for local power at each node—a constraint that drives nearly all aspects of wireless sensor design [4]. Typically, the radio link is the largest consumer of power.

This paper makes available an open-source "opportunistic telemetry" system that creates the long-distance data link using mobile phones carried near the sensor network, reducing the power burden on the WSN. The overall system is illustrated in Fig.1. WSN researchers will appreciate the practical aspects of wireless data pickup on mobile phones, which are less bulky and expensive than laptops. Reduced expense makes it possible to equip larger groups of students, and data can be collected without making bystanders aware that a valuable data logger or sensor network is nearby.

II. Sensor Network – Bluetooth Gateway

In a typical wireless sensor network setup, one wireless sensor board is programmed to receive data from others distributed throughout the environment. In this report, a Bluetooth module (RN-41, Roving Networks) is connected to the receiver (TelosB, Crossbow Technology, Inc) through a direct connection to the receiver's serial transmission (TX) line as shown in Fig. 2. This method would work with most other WSN hardware that uses a serial port to upload data to a computer. The Bluetooth module handles pairing of mobile phones and other devices as they enter the area. With an 18 Ah battery the gateway will run 4 weeks; lifetime can be extended to 7 weeks by putting the Bluetooth module in "sniff mode," and further by using a Class 2 (10 m range) Bluetooth module instead of the Class 1 (100 m) module above. Software on the TelosB is the open-source TOSBase receiver application [5] compiled to run at 9600 bps. This data rate was more than enough for sampling 10x per hour [6], but higher speeds can be configured. A similar gateway was briefly mentioned in [7], but a schematic and software were not available and a smartphone was required. Software provided below extends such gateways to low-cost mobile phones.

Manuscript received September 10, 2009. This work was supported by the National Science Foundation under grant 0644511.

C. K. Harnett is with the University of Louisville, Louisville, KY 40208 USA (phone: 502-852-0689; fax: 502-852-8128; e-mail: c0harn01@louisville.edu).

III. Cellular Handset Software

To connect with a mobile phone over Bluetooth, a dedicated JavaME application or "midlet" was written. The compiled application (DataGetter.jar) and source code are available in an online archive [8]. The free Mobile Processing environment provides a user-friendly platform for modifying the application [9] and also a list of phones that can run midlets.

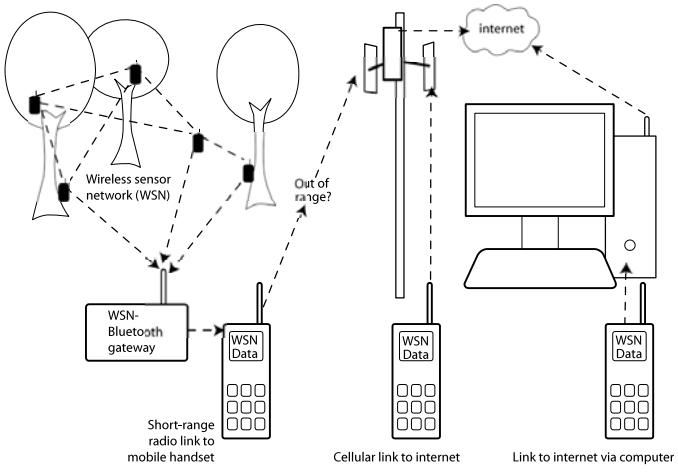

Figure 1: Wireless sensor network gateway for transmitting data to nearby mobile phones over a short-range radio link. Phones can upload stored data when in range of a cellular tower or internet-connected computer.

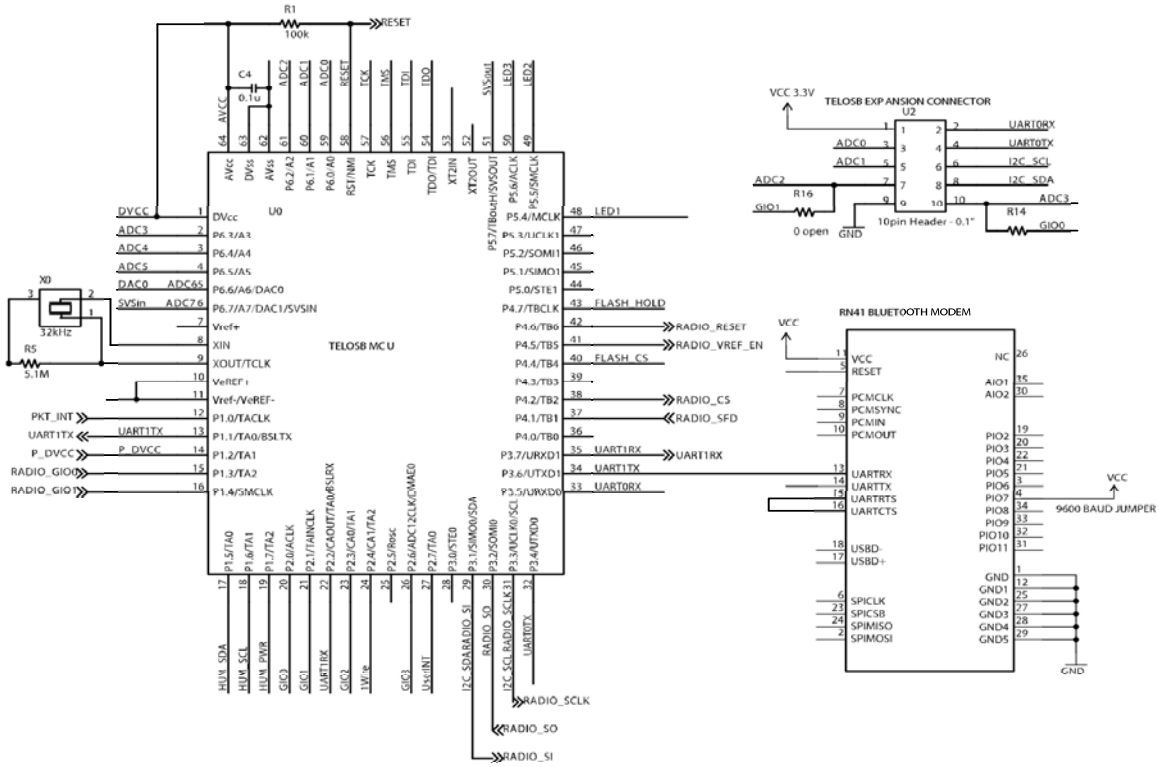

Figure 2: Wireless sensor network-Bluetooth gateway schematic.

After pairing the phone with the Bluetooth module (default passkey "1234" for RN-41), the user runs the application and selects the RN-41 from a list of discovered Bluetooth devices. Then the application enters a toggle mode to start and stop data acquisition. Bytes are saved to a Record Management System (.rms) text file in the application directory, which is overwritten with new data each time the application runs. The user sends the rms file from the phone for further processing.

IV. Conclusions

The software and hardware described here is a low-cost entry point for experiments in "opportunistic telemetry," enabling researchers to join the emerging mobile-phone-as-distributed sensor movement [10,11] even if their projects use specialized sensors that are not included in consumer handsets. The system is currently used by a small group, but can expand to a much larger group—where data upload rates and verification will depend greatly upon the motivation of participants. Positive motivation includes incentive programs or an interest in contributing to a collaborative project. Negatives include locating and stealing network hardware, spreading mobile phone viruses [12], or misleading the public about an environmental condition. Mobile participants and wireless sensors form a combined system of interest to researchers in environmental, social, and computer science.

References

[1] N. Xu, S. Rangwala, K. K. Chintalapudi, D. Ganesan, A. Broad, R. Govindan, and D. Estrin, "A wireless sensor network for structural monitoring," *Proc. SenSys*, Baltimore, MD., Nov. 3-5, 2004, pp. 13-24.

[2] K. Langendoen, A. Baggio, and O. Visser, "Murphy loves potatoes: experiences from a pilot sensor network deployment in precision agriculture," in *Proc. Parallel and Distributed Processing Symposium*, Rhodes Island, Greece, April 25-29, 2006, 8 pp, DOI: 10.1109/IPDPS.2006.1639412.

[3] J. K. Hart and K. Martinez, "Environmental sensor networks: a revolution in earth system science?" *Earth-Science Reviews* vol. 78, pp. 177-191, 2006.

[4] M. Siegel, "Scaling issues for energy and communication in large networks of small sensors," in *Proc. Inst. Meas. Tech. Conference*, Warsaw, Poland, May 1-3, 2007, pp 1-4, DOI: 10.1109/IMTC.2007.378975.

[5] Online: http://www.tinyos.net/tinyos-1.x/apps/TOSBase/

[6] C. K. Harnett, S. M. Courtney, and C. J. Kimmer, "SALAMANDER: A distributed sensor system for aquatic environmental measurements," *Proc. Inst. Meas. Tech. Conference*, Victoria, BC, Canada, May 12-15, 2008, pp. 1787-1792, DOI: 10.1109/IMTC.2008.4547334.

[7] S. B. Eisenman, E. Miluzzo, N. D. Lane, R. A. Peterson, G.-S. Ahn, and A. T. Campbell, "The BikeNet mobile sensing system for cyclist experience mapping," SenSys 07, DOI:10.1145/1322263.1322273

[8] Online: DataGetter.jar and source at http://salamander.sourceforge.net

[9] Online: http://mobile.processing.org

[10] R. Kwok, "Phoning in data," *Nature* vol. 458, pp. 959-961, 2009.

[11] P. Aoki, R. J. Honicky, A. Mainwaring, C. Myers, E. Paulos, S. Subramanian, and A. Woodruff, "Common Sense: mobile environmental sensing platforms to support community action and citizen science," UbiComp 2008, http://www.paulaoki.com/papers/ubicomp08-demo.pdf

[12] P. Wang, M.C. Gonzales, C. A. Hidalgo, and A. –L. Barabasi, "Understanding the spreading patterns of mobile phone viruses," *Science* vol. 324, pp. 1071-1076, May 2009.