Enhancement of Wireless Sensor Network Technology For Environmental Monitoring And Its Implementation

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Abstract- *This project is concerned with the application of wireless sensor network (WSN) technology to long-duration and large-scale environmental monitoring. The holy grail is a system that can be deployed and operated by domain specialists not engineers, but this remains some distance into the future. We present our views as to why this field has progressed less quickly than many envisaged it would over a decade ago. We use real examples taken from our own work in this field to illustrate the technological difficulties and challenges that are entailed in meeting end-user requirements for information gathering systems. Reliability and productivity are key concerns and influence the design choices for system hardware and software. We conclude with a discussion of long-term challenges for WSN technology in environmental monitoring and outline our vision of the future.*

Keywords- System integration, Collinearity, Simulation, Environmental sensing, Sensor networks ,

I. INTRODUCTION

to years, other features envisaged at the outset such as event detection, sensing and actuation, or the integration of robots and sensor networks have not become commonplace. It seems that the technology is still emerging

WSN technology has followed a hype cycle [2] triggered by the availability of low-cost low-power feature-rich microcontrollers and single-chip radio transceivers. This led to excitement, expectation, the founding of startups, and the establishment of new conferences and journals. Early adopters embraced the technology as end users, willing to suffer the inconveniences of bleeding-edge technology in order to gain an advantage. Activity peaked and the trough of disillusionment followed. The early adopters became frustrated, the researchers felt that the early adopters were too needy, and the expected markets did not materialize. Then follows the slope of enlightenment when expectations are moderated all round, the bugs are ironed out, the real rather than supposed applications become clear, and the field grows steadily.

An early claim was that WSNs are a new instrument for gathering data about the natural world [3] and our collaborators who are primarily scientists have high, and not unreasonable, expectations of something that purports to be an instrument. In particular, they expect a high level of system integration, performance, and productivity. system integration means creating an end-to-end system that delivers data to an interested user. This meant that our mind set had to change from a narrow focus on just the WSN component to creating an information sys-tem. The WSN is just one small part of a complex system that includes internet links from the WSN to a server, databases, and web presentation tools. Each of these components was critical for success and we underestimated each of them. For example, the internet link from a sensor network to the server presupposes that an internet endpoint exists and this was not always the case 3G modems are ideal in principle but problematic in practice. We naively assumed that servers within our organization were always up, but did not know that network infrastructure upgrades happen late at night and on weekends, making those servers inaccessible from the outside world.

Performance has many aspects. One is reliability of the node itself: its power source, radio links and overlying protocols, and reliability of the application and operating system software. Lack of performance leads to gaps in the data record, negating the claim about high temporal precision, and incorrect data (due to all manner of root causes) lead to a lack of trust and confidence in the system. Accuracy and calibration are critically important it is not enough that the network returns numbers to a central database which is the engineers concern; the numbers must accurately reflect the state of the environment [4]. Sensor calibration and detecting stuck values from broken transducers are very important

Productivity has two aspects. Most important is how well it assists the end user to do their science or business, and is largely related to human interface design and the performance of the underlying database and presentation software. Databases and web presentation tools are simple student projects when they have to deal with trivial amounts of data, but as the data volume grows performance falls dramatically and will frustrate the end user and lower their productivity. For developers and maintainers of WSNs, productivity is about reducing the total cost involved in a sensor network over its lifetime analogous to total cost of ownership (TCO) for a computer system. Costs that must be accounted for include planning, node hardware, deployment, troubleshooting, and maintenance. Only semiconductors follow Moore's law; the other costs follow a learning curve and are already mature.

Applications of sensor networks are very diverse but we use as case studies some of the many applications that we have tackled which are outdoor, and concerned in some way.

II. LITERATURE SURVEY

In the localization scheme presented by Sichitiu and Ramadurai[5], the sensor nodes determine their locations based on the beacon messages transmitted by a single mobile anchor. However, in this case, the sensor nodes estimate their positions by applying the Received signal strength Indicator (RSSI) technique to the beacon messages.

Galstyan et al.[6] proposed a distributed localization scheme based on a single mobile anchor, in which radio connectivity constraints were imposed in order to minimize the uncertainty in the localization results.

Sun and Guo[7] proposed various probabilistic localization schemes based on a single mobile beacon, and showed that non-parametric probabilistic estimation techniques yield more robust and accurate localization results than parametric estimation methods.

Koutsonikolas[8] et al. proposed three path planning schemes for the mobile anchor node in the localization scheme presented by Sichitiu and Ramadurai, namely SCAN, DOUBLE SCAN and HILBERT. In SCAN, the mobile anchor node travels along a single dimension (e.g. the x-axis or y-axis direction), and the distance between two neighbouring segments of the node trajectory defines the resolution of the trajectory. SCAN is simple and provides uniform coverage to the entire network. However, the collinearity of the beacons degrades the accuracy of the localization results. In DOUBLE SCAN, the collinearity problem is resolved by driving the anchor in both the x- and the y-directions. However, whilst this strategy improves the localization performance of the sensor nodes, the path length is doubled compared to that of SCAN, and thus the energy overhead increases accordingly. In HILBERT, the mobile anchor node is driven along a curved trajectory such that the sensor nodes can construct non-collinear beacon points and the total path length is reduced.

Huang and Zaruba[9] presented two further path planning schemes designated as CIRCLES and S-CURVES, respectively, for avoiding the collinearity problem inherent in the localization method. In CIRCLES, the mobile anchor follows a sequence of concentric circular trajectories centered at the center point of the deployment area, while in S-CURVES, the anchor follows an S-shaped curve rather than a simple straight line as in the SCAN method.

Han et al. introduced a path planning scheme for a mobile anchor node based on the trilateration localization scheme[10]. The anchor node moves according to an equilateral triangle trajectory and broadcasts its current position information in the sensing area. After receiving three position information, each sensor node can estimate itself location based on trilateration calculation. The distance between the sensor node and the anchor node can be measured based on Received Signal Strength (RSS).

Kim et al. presented an adaptive path planning for the mobile anchor node[11]. The anchor node moving according to a regular triangle with the length of its radio range first broadcasts three beacon messages. The sensor nodes that do not know their own positions then request the anchor node to deliver more beacon messages. The anchor node thus decides its trajectory on the basis of the received request messages.
M.Patil et.al [12] has proposed a distributed localization scheme based on Received signal strength Indicator (RSSI) by the three masters. The distance from three masters is determined and the unknown nodes can compute its location by using circular triangulation concept. Based on the simulation results, with regard to the localization error and power consumption, they have proposed and verified that the three master approach performs relatively much better than two master and one master approaches

Frankie K.W.Chan, H.C.So et.al [13] has proposed a novel subspace approach of deterministic type for positioning the nodes in a WSN with the use of the node-to-node distance estimates, deduced from Received Signal Strength **(**RSS) or Time of Arrival (ToA) measurements. They have developed three versions of subspace algorithm for positioning the nodes in a WSN. They are full-set subspace algorithm, minimum-set subspace algorithm and distributed subspace algorithm.

Ji zeng Wang et.al [14] has proposed an improved Approximate Point-in-Triangulation Test(APIT) algorithm for location estimation in WSN. The improved APIT algorithm that is proposed in this work performs best when compared to the original APIT algorithm, based on the metrics such as high Node Packet Loss Rate and Node Density etc.

III. PROBLEM DEFINITION

More than a decade on from this original vision however, we are far from seeing widespread use of large-scale sensor networks becoming a reality. Networks are typically relatively small in size (G 30 nodes) and/or only deployed over short periods (days to months) of time. Network nodes are almost exclusively programmed by experienced software engineers and maintenance costs required to sustain continuous operation of networks are usually significant and usually borne by the sensor network researchers.

Based on learnings from our own design, development, and deployment experiences, we identify some of the key technical challenges of this field which remain to be solved. We also consider some of the future challenges around value-proposition and alternative technologies.

3.1 Ongoing Technical Challenges

The field of sensor networks has become very popular in many ways due to the breadth and depth of its technical challenges. In moving to an environment free of fixed communications infrastructure, and introducing significant constraints around energy and computational resources, much of the standard thinking around communications, networking, operating systems, hardware plat-forms, and sensing has had the opportunity to be rethought from first principles

In the majority of sensor-network applications, radio clearly dominates the energy consumption. As such, much of the community has focussed on ways to reduce the radio duty cycle to save energy. As it stands, duty cycling at the communications link layer has plateaued at around 1%–5% [8] for most practical deployment scenarios and is unlikely to improve significantly with current radio technology. Reliability of data communications is also an important problem for WSN. As a number of our deployments showed, the variability in conditions in many environ-mental areas (e.g., foliage, rain, humidity) means that communication LQ between nodes is highly dynamic and unpredictable. Given the constraints around radio output power and fixed antennas used with most nodes, guaranteeing the delivery of data over multiple node hops is extremely difficult, with low data throughputs expected for nodes with long hop counts to a sink.

Energy has been and remains a challenge for sensor network deployments. The energy state of a node places a constraint on the performance that a node can deliver. A node’s energy state reflects its stored battery energy, actual and predicted harvested energy (through solar and other sources), and its energy load. Progress in battery technology has been much slower than increases in processing and communication rates, which emphasizes the importance of energy-efficient operation.

The lack of resources for building and deploying net-works in the order of thousands of nodes means that practical issues around scale are yet to be fully explored. In the case of typical collection tree protocols back to a single gateway, it is clear that these protocols cannot scale by orders of magnitude given the current capacity of network links. Whereas a sample-and-send paradigm may be suit-able in some applications.

3.2. Cost Benefit

For any emerging technology, economic drivers and cost benefit are pivotal issues which could have a dramatic effect on its market growth. Sensor networks face a number of challenges in this regard. The field arguably emerged due to the commoditization of cheap, low-power, single-chip microcontrollers and radios. These components emerged due to the rapid growth of global industries such as cell phones, wireless remotes, and car locks.

While these components form the core of the typical platform for environmental sensing, the value proposition is greatly reduced by the remaining cost components: transducers, housing, and deployment. Compared with cell phones or television remotes, environmental sensing is a miniscule market. As a result, the current cost of transducers and the housing usually dwarfs the cost of the computational and communications elements of a WSN node.

IV. PROPOSED SYSTEM

In this chapter the system we chose for this project is presented. Also the reasons behind the selection of these methodologies are discussed. We have used mixed method approach for this dissertation. According to, a mixed method methodology is a research methodology that includes both qualitative and quantitative approaches.

Requirement Analysis:

In this project we require both hardware and software.

Hardware requirements are as follows:

Processor: Intel(R) Pentium(R) CPU N3530 @2.16 GHz @2.16GHz
Installed RAM: Min 2.00 GB
System type: 32/64-bit operating system, X64 –based processor.
Windows Edition: Windows XP /Windows 8.1 Single Language

Software requirements are as follows:- Docklight
Driver – C P 2102 1C Supports communication between software and hardware.

V. APPLICATIONS OF WIRELESS SENSOR NETWORKS

In this section, we discuss the major sensor network applications that we created over the past six years, the unique technical challenges they posed, and the lessons we learned from them. The applications all share a common theme: understanding the natural and agricultural environments in response to major challenges faced by Australia. The applications include microclimate monitoring for farms and rain forests, water-quality monitoring, and cattle monitoring and control. Two applications involve actuation in addition to sensing: cattle are actuated by applied stimuli, and a robotic boat is actuated to perform sampling.

Each application presented different challenges which included mobility, actuation, energy, and intermittent connectivity. Our design choices and technologies were responses to these challenges and have evolved over time but the rate of change is slowing and, after six years, we are now at a stage where the core technology is reliable and configurable enough that it is has been deployed, unaided, by domain scientists.

5.1. Cattle Monitoring

We developed a network at a research farm over 500 km from our laboratory. The project has had several phases and technology generations, and it has been the primary driver of our technology development. The first phase involved recording the positions of cattle over time, and also soil moisture at various points in a paddock. Soil moisture is an important indicator of how quickly pasture will grow and therefore important for planning stocking rates (number of animals per unit area).

Challenges: Information from static and mobile nodes was to be relayed to a base station and then over the internet to a remote server. We later added nodes with cam-eras that periodically transmitted images of key locations such as water troughs. This was our first deployment that included both mobile and static nodes and this raised new challenges for routing and network topology maintenance.

5.2. Virtual Fencing

A new group of large-scale and remotely operated deployments was looming that included cattle control. The lessons learned so far stressed the need for better foundational technology. This led us to develop our own operating system and a new node with a better radio but which was incompatible with the Fleck-1 and Fleck-2. Deployment D, at our laboratory, was a testbed to shakedown this new technology.

Challenges: Key requirements included the ability for access to status and control of remote nodes, and this was particularly important to meet the ethics requirements for the virtual fencing [10] experiments.

5.3. Environmental Monitoring

Environmental monitoring has become a necessity in the current course of time. To regularly check the amount of poisonous gases, increasing temperature and amount of humidity in the nearby surroundings, the wieless sensor networks are implemented. Different sensors are used to keep a check on temperature to avoid green house effect, humidity, carbon monoxide and methane.

Challenges: Key requirements included the ability to access the remote areas, reliability of the sensors, and giving the accurate results.

Applications

AVR controllers come with a wide range of applications where automation is required. Following are the main applications of Atmega16.

- Medical equipment
- Home automation
- Embedded systems
- Used in automobiles and industrial automation
- Home appliances and security systems
- Temperature and pressure control devices

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VI. RESULTS AND DISCUSSION

Air Quality Measurements

Gas Emissions

The gases that are to be monitored in the environment are

(i) carbon monoxide (CO),
(ii) methane (CH4),

Carbon monoxide is a poisonous, colorless, odorless, insipid, and very toxic gas. It is usually emitted because of incomplete combustion processes, and it is very dangerous since it replaces the oxygen in the hemoglobin causing what is commonly called the "sweet death." The limit value to comply with regulation in the factory is 500 ppm.

All of them are electrochemical sensors. Those sensors consist in three different electrodes with a thin screen of electrolyte between them.

The first one, the working electrode or sensing electrode, is the one in contact with the outside gas, so that it is the real surface where the reduction or the oxidation occurs. In this way, a current which is linearly proportional to the volume of the toxic gas is generated. The second electrode is called the counter electrode, and it is in charge of balancing the reactions on the working electrode generating the same current but in the opposite sense.

The last one is the reference electrode. This one is to ensure that the working electrode is always working in the correct region of the current-voltage curve. By keeping the potential of the working electrode as stable as possible, the spoilage of the sensor can be dramatically reduced when at the same time both linearity and sensitivity are increased.

The project is portable and can be carried to remote areas where electric supply is not available . It can be done using an adapter which may involve solar panel . The solar panel use solar energy which is a positive aspect for our environment.The model uses three 3.3V battery which consumes less power and is cost efficient as compared to the traditional 5V battery. The comparison between the traditional 5V battery and the installed 3.3 V battery description is shown below:

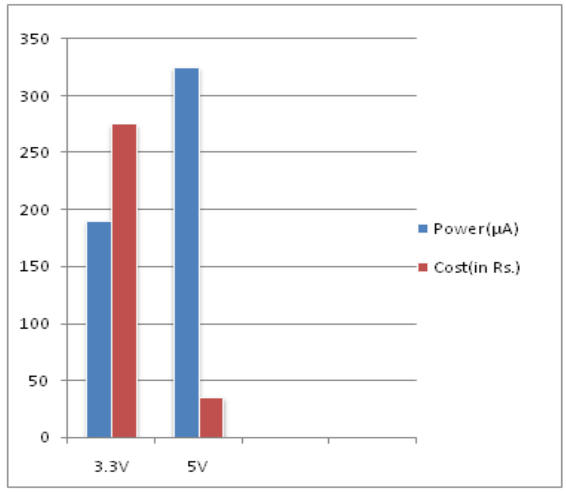

Figure : Comparison of output of different batteries

VII. CONCLUSION AND FUTURE SCOPE

This project has shown a real application of a WSN. Many contributions are presented about the use of a custom platform, such as the adaptation to a heterogeneous network, the study of an interesting industrial field which is applicable worldwide in many installations, the integration of management and control tools with WSNs, and so forth.

This project may serve as a starting point for many replicas of environmental control applications. A closed loop has been presented where three different partners have joined efforts to achieve a complete monitoring system based on a nonintrusive and unattended technology. Thanks both to the chemical nature of the measurements and to this very specific industrial application, this project has been very didactic for the team since it was necessary to learn about very different topics to face all the requirements. Apart from that, the application has served as well in the monitoring processes which is now capable of facing very demanding applications in terms of reliability and adaptation to the measurement of new parameters. Besides, deploying the network in a very hard place in terms of communication reliability has been very important in order to know more about the limitations of the platform and, in this way, being able to improve or change some aspects.

This application opens a wide opportunity in the environmental control which is one of the strongest industries while it continues with a very interesting research line in the WSN field.

Power is always been a challenge for WSNs designs. One of the ways to prolong the network lifetime is to design the energy efficient algorithms and hardware that uses power intelligently.

Security is one of the major challenges in WSNs. Most of the attacks that are performed on WSN are insertion of false information by compromised nodes within the networks. Development of security schemes for WSN also faces challenges related to constrained environment.

Protocols need to be developed for real world problems considering the theoretical concepts and synthesizing novel solutions into a complete system wide protocol for real world application.

REFERENCES

[1] D. Estrin, R. Govindan, J. Heidemann, and S. Kumar, BNext century challenges: Scalable coordination in sensor networks,[in Proc. 5th Annu. ACM/IEEE Int. Conf. Mobile Comput. Netw., 1999, pp. 263–270.

[2] Gartner Group, Understanding Hype Cycles. [Online]. Available: http://www.gartner.com/ pages/story.php.id.8795.s.8.jsp

[3] D. Estrin, D. Culler, K. Pister, and G. Sukhatme, BInstrumenting the physical world with pervasive networks,[IEEE Pervasive Comput., vol. 1, no. 1, pp. 59–69, Jan.–Mar. 2002.

[4] J. Beutel, S. Gruber, A. Hasler, R. Lim, Meier, C. Plessl, I. Talzi, L. Thiele, C. Tschudin, M. Woehrle, and M. Yuecel, BPermadaq: A scientific instrument for T. Wark, P. Corke, J. Liu, and D. Moore, BDesign and evaluation of an image analysis platform for low-power, low-bandwidth camera networks,[in Proc. ImageSense08 Workshop/ACM Sensys08, 2008, pp. 7–11. [Online]. Available: http://research. microsoft.com/en-us/um/redmond/events/imagesense08/CameraReady/ imagesense2008-wark.pdf

[5] J. W. Hui and D. Culler, BThe dynamic behavior of a data dissemination protocol for network programming at scale,[in Proc. 2nd Int. Conf. Embedded Netw. Sensor Syst., 2004, pp. 81–94.

[6] J. Polastre, J. Hill, and D. Culler, BVersatile low power media access for 2nd Int. Conf. Embedded Netw. Sensor Syst., 2004, pp. 95–107.

[7] T. L. Dinh, W. Hu, P. Sikka, P. I. Corke, Overs, and S. Brosnan, BDesign and deployment of a remote robust sensor n/w: Experiences from an outdoor water quality monitoring network,[in Proc. 2nd IEEE Int. Workshop Practical Issues in Building Sensor Netw. Appl., Dublin, Ireland, 2007, pp. 799–806.

[8] T. Wark, D. Swain, C. Crossman, P. Valencia, Bishop-Hurley, and R. Handcock, BSensor and actuator networks for protection of environmentally sensitive areas,[IEEE Pervasive Comput., vol. 8, no. 1, pp. 30–36, Mar. 2009.

[9] P. Levis, S. Madden, J. Polastre, R. Szewczyk, K. Whitehouse, A. Woo, D. Gay, J. Hill,Welsh, E. Brewer, and D. Culler, BTinyos: An operating system for sensor networks,[Ambient Intell., pp. 115–148, 2005.

[10] A. Dunkels and O. Schmidt, BProtothreads lightweight, stackless threads in C O. Kasten and K. Ro¨mer, BBeyond event Programming wireless sensors with attributed state machines,[in Proc. 4th Int. Symp. Inf. Process. Sensor Netw., 2005, pp. 45–52.

[11] P. Levis, S. Madden, D. Gay, J. Polastre, Szewczyk, A. Woo, E. Brewer, and Culler, BThe emergence of networking abstractions and techniques in TinyOS,[in 1st Conf. Symp. Netw. Syst. Design Implement., Berkeley, CA, 2004, pp. 1–1.

[12] A. Adya, J. Howell, M. Theimer, Bolosky, and J. Douceur, BCooperativemanagement without manual stack management,[in Proc. Usenix ATC, Jun. 2002, pp. 289–302.

[13] S. Bhatti, J. Carlson, H. Dai, J. Deng, J. Rose, Sheth, B. Shucker, C. Gruenwald, Torgerson, and R. Han, BMANTIS OS: An embedded multithreaded operating system for wireless micro sensor platforms,[Mobile Netw. Appl., vol. 10, no. 4, pp. 563–579, 2005.

[14] A. Dunkels, O. Schmidt, T. Voigt, and Ali,BProtothreads: Simplifying event-driven programming of embedded systems,[in Proc. 4th Int. Conf. Embedded Netw. Sensor Syst., 2006, pp. 29–42.

[15] K. Klues, C.-J. M. Liang, J. Paek, Musa˘loiu-E, P. Levis, A. Terzis, and Govindan, BTosthreads: Thread-safe and non-invasive preemption in tinyos,Proc. 7th ACM Conf. Embedded Netw. Sensor Syst., 2009, pp. 127–140.

[16] P. I. Corke, BA remote procedure call system for FOS,[CSIRO ICT Centre.