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WIRELESS SENSOR NETWORK OPTIMIZATION AND HIGH ACCURACY IN NETWORKING TESTBED

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ABSTRACT

The most important applications for wireless sensor networks (WSNs) is Data Collection, where sensing data are collected at sensor nodes and forwarded to a central base station for further processing and optimizing. The battery powers and wireless communications, sensor nodes can be very small & easily attached at specified locations without disturbing surrounding networks and environments. In this paper, we review recent advances in this research area. We highlight the special features of data collection for Wireless Sensor Networks, by comparing with wired data collection network and other Wireless Sensor Networks. Sensor deployment is one of the major issues in wireless sensor networks. An optimal placement of sensors is propitious to the maximum possible utilization of the available sensors and balancing sensor node energy consumption, and prolonging the wireless network lifetime. Simulation results show that some mobile sensors in the disk-based mobility can realize the k-coverage, which reduces the cost of the sensor networks and moving distance of mobile sensors.

KEYWORDS

WSN, Sensor, Mobility

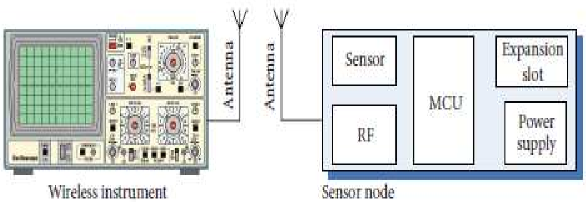
INTRODUCTION

The advancement in wireless sensor and communication technologies have made it possible to manufacture sensors with simple sensing, processing, and wireless communication capabilities in a cost-effective manner. A wireless sensor network (WSN) basically formed by deploying specialized sensors in the region of interest to perform certain given tasks, such as surroundings and target tracking. Wireless sensor networks have been applied to many applications since emergence. A large number of wireless sensors can be deployed randomly in hostile areas without human involved, e.g., by air-dropping from an aircraft for remote monitoring and surveillance purposes. Once the sensors are deployed on the ground, their data are transmitted back to the base station to provide the necessary situational information. Sensor networks or sensing data are continuously collected at each sensor node on network wherever employed and forwarded through wireless communication to a central base station via authorized node for further processing. In Wireless Sensor Network, each sensor node is powered by a battery and uses wireless communications smoothly.

The key features of Wireless Sensor Networks, however, also bring many new challenges. The lifetime of a wireless sensor node is constrained by their battery attached on it, and the wireless network lifetime in turn depends on the lifetime of wireless sensor nodes, thus, to further reduce the costs of wireless and sensor networks maintenance, redeployment and further communications, the consideration of energy efficiency is often preferred in a WSN design. Moreover, these challenges are complicated by the wireless losses and collisions when sensor nodes communicate with each other.

The deployment of sensors in the region of interest is one of the key issues in WSNs, which reflects how well the field is monitored by sensors. An optimal placement of sensors is propitious to the maximum possible utilization of the available sensors, and balancing the sensor energy consumption. The proper choice for sensor locations based on application requirements is difficult. The deployment of a sensor network is often either human monitored or random. Though many scenarios adopt random deployment for practical reasons such as deployment cost and time, random deployment may not provide a uniform sensor distribution over the region, which may introduce uncertainty in the final sensor positions and pose coverage holes and vacancies. Recently, mobile sensors have been considered for coverage improvement. The key objective is to detect holes in the network and to ensure that they are covered by at least one sensor. Sensors locally detect holes, estimate their new positions, and move to the new positions to cover detected holes. The authors proposed the idea of constructing potential fields for sensor movements. The fields are constructed such that each node

FIGURE 1: WIRELESS TEST DATA WITH INSTRUMENTS



REVIEW OF LITERATURE

The awareness of the network behavior is important for the studies on wireless sensor networks. There are basically two kinds of methods, that is, simulation and experiment, to gather the runtime data of wireless sensor networks. The experimental test method to use some additional test instruments is shown in Figure 1. The wireless instruments will probe the wireless network packets on the air without any influence on the wireless sensor network itself. But the wireless devices have none of knowledge about the internal status of autonomous wireless sensor nodes. Users cannot judge whether the wireless sensor node received the data packets which is observed by the instruments and vice versa. The practically experimental methods for the present test environment and platforms can be further divided into two categories according to the mechanisms of gathering data.

The former category is to obtain test data by microcontroller of wireless sensor nodes and transfer their test data over the sensor links of the wireless sensor network. The sensor microcontroller unit sends test data to radio frequency transceiver and afterwards these data are transferred in the sensor network node-by-node towards the test server which gathers all test basic information to sensor node process for further analysis. However, the computing network resource of the wireless sensor node and the network bandwidth of the sensor network must be consumed for the purpose of collecting test data. In other words, it will interfere with spontaneous network behavior. Such interference will be quite serious because the resource of wireless sensor network is very limited.

DATA GATHERING APPROACHES AND COVERAGE ANALYSIS IN SENSOR NETWORKS

In the Sensor network the data gathering approaches consider the main issues that how to deliver networks sensing data from each sensor node to the network base station and moving/migrating node. To achieve high efficiency, a cross-layer design is often involved, where the MAC, network, and transport layers are considered together to achieve multiple goals such as energy efficiency as well as reliability. Figure 1 shows that a generic architecture for data gathering approaches over wireless sensor networks. To collect data from sensor nodes the topology maintenance component constructs a connected topology; often a tree rooted at the base station, and maintains the connectivity during network dynamics and link quality variations. The network transmission scheduler schedules node data packet transmissions based on information from other components so as to reduce collisions and energy costs.

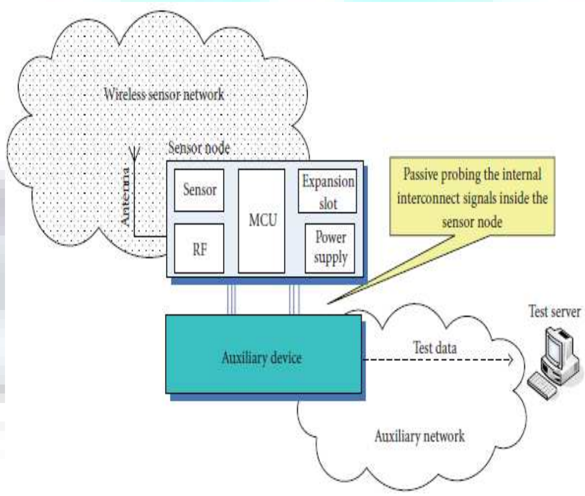
TABLE 1: LIST OF TYPICAL SENSOR NODES

Name	MCU	Transceiver
Btnode	Atmel ATmega 128L	T1 CC1000
Eyes	T1 MSP430 F149	TR1001
EyesIFX V1-2	T1 MSP430 F149	TDA 5250
IMote2	Marvel PXA271	T1 CC2420
Iris	Atmel ATmega 128L	Atmel AT86 RF230
Mica	Atmel ATmega 103	RFM TR1000
Mica2	Atmel ATmega 128L	T1CC1000
MicaZ	Atmel ATmega 128L	T1CC2420
TelosB	T1MSP430	T1CC2420

DESIGN OF HINT

We proposed a novel testbed HINT. The core idea of HINT consists of three parts. First, auxiliary devices passively probe the internal chip-level signals to obtain the test data in a nonintrusive manner, which does not consume any computing and storage resource of the sensor node. Second, the test data, which represent the runtime behavior inside sensor nodes, are transferred over additional networks so that they do not consume any wireless bandwidth of the sensor networks. Finally, the entire test data are collected by the testbed server and then the network behavior are reconstructed to execute a full network-scale testing. The mechanisms of HINT are shown in Figure 5. The system architecture of HINT is shown in Figure HINT consists of a testbed server and a number of test units. The testbed server and all test units are connected with additional network, usually with Ethernet. Each test unit consists of a sensor node and a test board. All sensor nodes form a wireless sensor network while all test board form another wired or wireless network for the purpose of transferring test data. Each test board is linked to the corresponding sensor node in order to probe the internal chip-level signals inside the sensor node. The testbed server is used to collect test data from all test boards and perform future analysis.

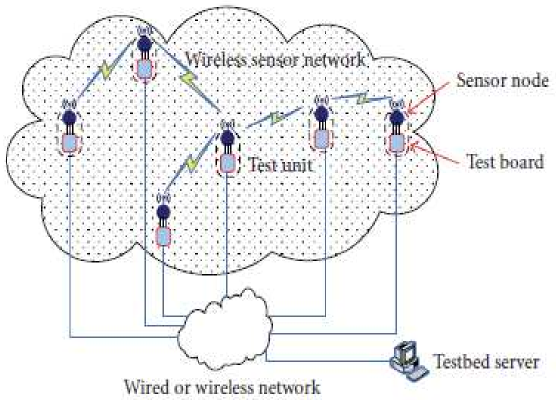
FIGURE: 2 MECHANISM OF HINT



CHIP-LEVEL SIGNAL CAPTURING

In the wireless Sensor nodes essential to decide which signals inside the sensor nodes should be captured? The useful signals inside the sensor node are divided into 5 groups. The first group is the wires between the RF transceiver and the MCU inside sensor nodes, which provide information on the radio packet. The second group is those from the MCU to the sensor, which provide information on the sensing operation. The third group is the Joint Test Action Group (JTAG) pins of the MCU, which provide functions to reprogram and debug. The forth group is external communication pins of the MCU, such as RS-232, which provide information about external data sent by MCU. The last group is the power supply lines for the sensor node, which help us to turn on or off the sensor node and measure its power consumption. The test board is linked to the corresponding sensor node via one or more groups of wires carefully chosen. Among all the five groups, the first group, that is, the signal group between the RF transceiver and the MCU inside sensor nodes, is most important for the networking test.

FIGURE: 3 SYSTEM ARCHITECTURE OF HINT



COLLECTING AND TRANSFERRING TEST DATA

The captured data of raw signals are too huge to be transferred. In HINT, such raw captured data are encoded and compacted inside the SARC module of the test board. The compacted test data are then transferred to the testbed server. The raw signals are mainly divided into two classes, that is, analog or digital. Different encoding methods are adopted for different signals.

EXECUTION AND IMPLEMENTATION

HINT is quite a complex system with mixed software and hardware. The detailed implementation is introduced as follows.

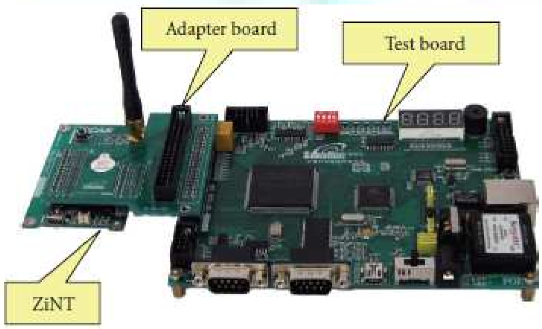
SENSOR NODE & TEST BOARD

The chip-level signals to be captured depend on the chips inside the wireless sensor nodes. For instance, inside the wireless sensor nodes like TelosB, IMote-2 and MicaZ, the RF transceiver chip CC2420 is used and hence the signals to be captured between the RF transceiver and the MCU for wireless sensor nodes are CS, SCK, MOSI, MISO, SFD, INT, FIFOP and CCA. But inside the wireless sensor nodes likeMica2 and Btnode, the RF transceiver chip CC1000 is used and hence the signals to be captured are DIO, DCLK, PCLK, PDATA and PALE. All these signals are explained in the CC2420 and CC1100 datasheets in detail. The test board is the kernel component of HINT.

FIGURE: 4 ACTUAL PICTURE OF TEST BOARD

Such types of test board mainly consist of two main parts. One part is particularly for data processing and transferring including CPU and Ethernet Card, whereas the other for data acquisition and remote control, that is, SARC module.

FIGURE: 5 MECHANICAL STRUCTURE OF TEST UNIT



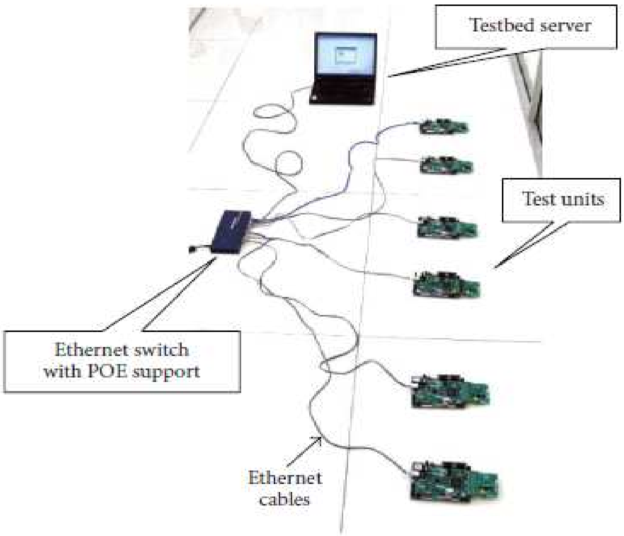
PRACTICAL EXPOSURE (EXPERIMENTS)

It is fundamental for HINT to acquire the internal signals accurately inside a sensor node. Hence two experiments are carried out to verify the analog and digital signals acquisition by comparing with the outputs of oscilloscope and logic analyzer.

Digital Signals: The digital signals between the microcontroller and the RF transceiver consist of Start of Frame Delimiter (SFD), interrupt (INT), SPI bus and so on, which are critical for HINT to obtain the network packet information. Thus the correct acquisition of these signals will be proved in this experiment. All the sensor nodes send packets periodically. We use HINT to acquire these internal digital signals of sensor nodes and demonstrate the result in the graphics user interface. At the meantime, these signals are observed by a logic analyzer LA1016. Both HINT and the logic analyzer support SPI protocol parsing. Comparing the output of HINT with those of the logic analyzer, we conclude that HINT can correctly gather the internal digital logic signals (including SPI communication protocol) inside sensor nodes.

Analog Signals: The energy consumption is a key parameter for wireless sensor networks. In HINT, the energy consumption parameter is deduced from the measurement of the electric current at power supply wire of the sensor node. The electric current is a typical analog signal. The correct acquisition of this signal will be proved in this experiment. All the sensor nodes change their status periodically. The sensor nodes firstly stay at idle state with radio transceiver and all LEDs turned off and therefore the power consumption is very low. After 100 ms, the sensor nodes turn on radio transceiver and the power consumption increases. Then after another 100 ms, the sensor nodes turn on all LEDs and the power consumption increases more. Finally the sensor nodes enter the first idle state after 100 ms. therefore the supply current will also change periodically.

FIGURE: 6 AN EXPERIMENT SCENARIO OF HINT



FUTURE SCOPE AND CONCLUSION

Mobile Sensor and Ah hoc networks node becomes increasingly important to obtain the accurate and spontaneous runtime data which represent the network behavior for further studies on the wireless network. However the test mechanisms nowadays cannot appropriately match such requirements. We proposed a novel test mechanism that the internal chip-level signals inside sensor nodes are passively probed in order to access the network data in a non-intrusive way. Subsequently we implemented the testbed HINT. In this paper we introduced the implementation and the experiment studies of HINT.

In this paper we showed that, with the help of HINT, users can collect information of internal signals on the remote wireless sensor nodes, measure the energy consumption of wireless sensor nodes, parse the interconnect signal for the radio packets, obtain precise timestamps of events for fine-grained phases, evaluate and calculate the network performance parameters, program and debug the sensor nodes remotely, store the runtime data to trace files, and so forth. Most of these features are disturb-free and transparent to the sensor applications. HINT provides users real and accurate information on the runtime data to represent the spontaneous network behavior of wireless sensor networks. HINT is a nonintrusive testbed. HINT provides users high-accuracy information on the network behavior. HINT also supports the test mechanisms of the existing testbeds.

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With sincere regards

Thanking you profoundly

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