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Adaptive Sampling Approach for Energy Conservation in WSN Using Embedded System

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Abstract- Energy conservation methods for wireless sensor networks generally assume that data acquirement and processing have energy utilization that is significantly lower than transmission. An Adaptive Sampling Approach (ASA) that estimates the best possible sampling frequencies for sensors. This approach, which requires the design of adaptive measurement approaches, minimizes the energy utilization of the sensors and radio, while maintaining a very high accuracy of collected data. Since ASA recognizes on-line the minimal sampling frequency, guaranteeing reformation of the sampled signal and it reduces the power utilization of the measurement phase by adapting the sampling frequency to the real requirements of the physical phenomena under observation. By reducing the number of obtained samples ASA also decreases the amount of data to be transmitted and, as a consequence, the energy utilized by the radio.

Keywords: Adaptive Sampling Approach(ASA), ARM, Embedded System, Wireless Sensor Networks (WSN).

I. INTRODUCTION

The Wireless Sensor Networks (WSN) is built of "nodes" – from a few to several hundreds or even thousands, where each node is attached to one (or sometimes several) sensors. Each such sensor network node has typically several components: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. The concept of wireless sensor networks (WSNs) is build from a simple equation:

Sensor + CPU + Radio = Thousands of potential applications.

As soon as people appreciate the capabilities of a WSN, hundreds of applications spring to mind. It seems like a straight forward grouping of modern technology.

A sensor node might differ in size from that of a shoebox down to the size of a grain of dust, although functioning nodes of authentic microscopic dimensions have yet to be created. The cost of sensor nodes is similarly unpredictable, ranging from a few to hundreds of dollars, depending on the complexity of the utilization sensor nodes. Size and cost constraints on sensor nodes result in corresponding restriction on resources such as energy, memory,

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computational speed and transmissions bandwidth. In this paper it refers mainly to the sensor network model illustrated in Fig.1, which consisting of one sink node (or base station) and a (large) number of sensor nodes arranged over a large geographic area (sensing field). Information are transferred from sensor nodes to the target through a multi-hop transmission prototype [1], [2]. The main characteristics of a WSN comprises Power utilization constrains for nodes using batteries or energy harvesting. In recent years, the number of WSN employments for real-life appliances has rapidly increased, and this tendency is expected to even more enhance in the next years [3], [4]. However, energy utilization still remains a major blockage for the full diffusion and exploitation of this technology, although batteries can be recharged, e.g., through solar energy harvesting mechanisms [5]. To reduce the energy utilization of the sensor in this paper, an Adaptive Sampling Approach (ASA) is proposed, which measures the best possible sampling frequencies of sensor thus reducing the power utilization of the sensor. In recent years, many energy utilization methods have been proposed in the literature (a comprehensive survey can be found in [6]). Considering the acquirement times are typically longer than transmission ones, some sensors may even consume significantly more energy than the radio. As such, energy conservation schemes that aim at minimizing the radio activity need to be complemented with methods that implement a well-organized energy management of the sensors. D*uty cycling* (i.e., the sensor board is switched off between two successive samples) may corrupt the device performance [1].

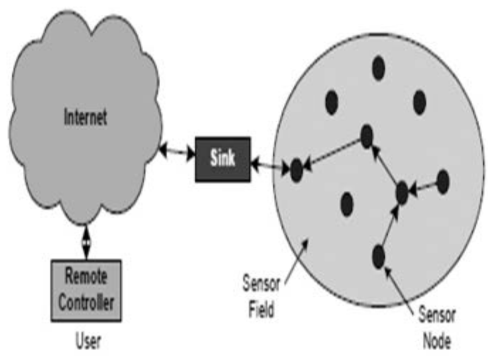

Figure 1: Sensor Network Architecture

In this paper, an Adaptive Sampling Approach (ASA) that adjust the sampling frequencies of the sensors to the changing dynamics of the process is suggested. In the instrumentation and measurement community, the adaptive sampling approach has been applied to focus on numerous problems. For instance, [7] has suggested an adaptive sampling method to measure the difference in phase between the fundamental components of two signals: one is the sampling rate is amplified until the phase is correctly evaluated and another one is the sampling rate achieves the maximum sampling rate of the system. The WSN has several applications including Area monitoring, Environmental Monitoring (e.g., Air pollution monitoring, Forest fires detection, Greenhouse monitoring, Landslide detection), Industrial monitoring (e.g., Machine health monitoring), Water/waste water monitoring (e.g., Agriculture), and Structural monitoring. Among these, many real-life applications need particular sensors whose power utilization cannot be ignored [8]. The main characteristics of a WSN includes, Power utilization restriction for nodes using batteries or energy harvesting. As sensor nodes are generally battery-powered devices, the critical aspects to face concern how to reduce the energy utilization of nodes, so that the network lifetime can be extended to reasonable times. The Adaptive Sampling Approach (ASA) is used for reduce the energy utilization of the sensor by decreasing the number of samples will be discusses in section II. The system requirement will be discusses in section III. Energy consumption of WSN will be presented in section IV and Simulation results are finally presented in Section V.

II. ADAPTIVE SAMPLING APPROACH

An Adaptive Sampling Approach (ASA) is employed for reducing the energy utilization of the wireless sensor networks. Wireless Sensor Networks (WSNs) units obtained information from the surrounding environment and, after (a possible) local processing, send measurements to one or more collection points or base stations for additional data aggregation and interpretation. In WSN most physical occurrences are widespread in time and space. Thus, they can be investigated in one or both these domains. For example a particular point in space can be considered and the time dependency of the signal at this point is analyzed. However, there also exists a space domain, which can only be observed with multiple sensors at various positions in space.

The ASA increases the sampling rate when the analog data from the sensor changes and decreases the sampling rate when there is no change in analog data. It decreases the energy utilization of the sensor and reduces the amount of information obtained by the sensor and the memory used is also reduced. Thus the sensor lifetime is increased. Among the set of potential enhancements, monitoring applications can predominantly benefit from this approach, because WSNs allow a long-term information collection at scales and resolutions that are complicated, if not impossible, to realize with conventional methods [3].

ASA is more general than the aforementioned solutions, because it does not assume any hypothesis with regard to the nature of the signal (e.g., stationarity); moreover, its computational load is acceptable for mid-complexity WSN entities. ASA identifies the minimal sampling frequency online, which guarantees the reconstruction of the sampled signal; thus, it reduces the power utilization of the measurement phase by adapting the sampling frequency to the real requirements of the physical occurrences under examination [12] & [15]. By decreasing the number of obtained samples, ASA also reduces the amount of data that will be transmitted and, as a consequence, the energy that the radio consumed. In addition, the proposed approach can be integrated with other methods for energy conservation by acting at different conceptual levels (e.g., data aggregation and/or compression).

In order to properly sample an analog signal the Nyquist-Shannon sampling theorem must be satisfied. In short, the sampling frequency must be greater than twice the highest frequency of the signal.

ASA runs at the base station, which notifies updates of the current sampling frequency to remote entities (the algorithm might be very complex to be executed on tiny devices). However, based on the conceptual point of view, there would be no objection in using a decentralized approach that executes ASA at the sensor-node level. The system requirement is discussed in the next chapter.

III. SYSTEM REQUIREMENTS

A. Embedded System

An embedded system is a special-purpose system in which the computer is completely encapsulated by or dedicated to the device or system it controls. Unlike a general-purpose computer, such as a personal computer, an embedded system performs one or a few pre-defined tasks, usually with very specific requirements. Since the system is dedicated to specific tasks, design engineers can optimize it, reducing the size and cost of the product. Embedded systems are electronic devices that incorporate microprocessors with in their implementations. Embedded system designers usually have a significant grasp of hardware technologies. The implementation is done by using specific programming languages and software to develop embedded system and manipulate the equipment. For this here embedded C language, keil cross compiler, MPLAB IDE software and ARM7 processor is used for simulation.

B. Block Diagram

The block diagram contains an input device, processor, output device and a transmission protocol for transmission and reception shown in Fig. 2. The sensor senses analog data and then send it to the data to the ARM7 processor. ARM is a 32-bitreduced instruction set computer (RISC) instruction set architecture (ISA) developed by ARM Holdings. It was named the Advanced RISC Machine, and before that, the Acorn RISC Machine. The Processor has rechargeable battery, keyboard and switches with itself. The ASA runs at the Processor. Depending upon ASA the sampling rate is increased when the analog data changed and decreased when there is no change in the analog data. For transmitting and receiving the processed data the Zigbee transmission protocol [13] is used.

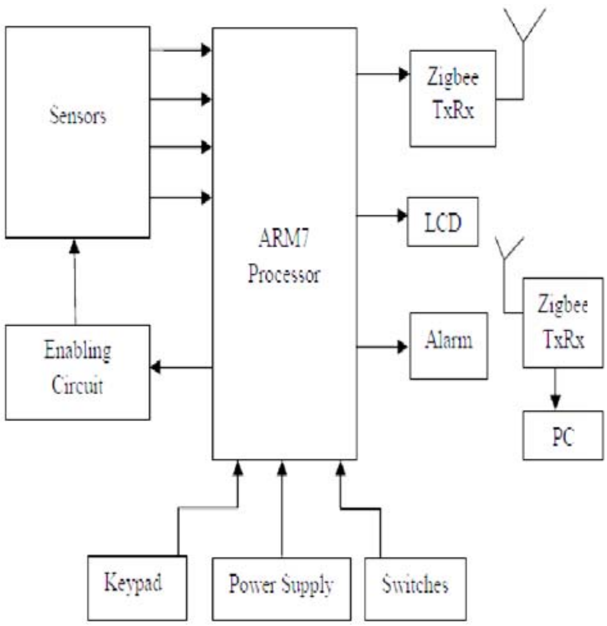

Figure 2: Block Diagram

C. Components of a Sensor Node

As sensor nodes are generally battery-powered devices, the critical aspects to face concern how to reduce the energy utilization of nodes, so that the network lifetime can be extended to reasonable times. ASA can be implemented in any sensor network architecture. However, for simulation, a collection based architecture (see Fig. 1) is considered. For each node, the sampling frequency is computed and dynamically updated at the base station and then notified to the node through special notification messages. A sensor node is made up of four basic components as shown in Fig. 3, a sensing unit, a processing unit, a transceiver unit and a power unit. They may also have application dependent additional components such as a location finding system, a power generator and a mobilizer.

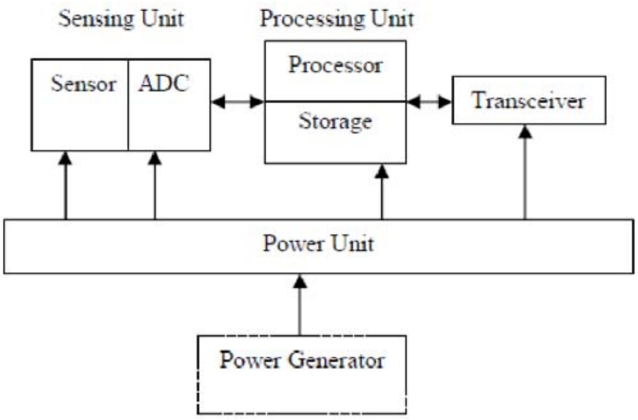

Figure:3 The components of a Sensor Node

Sensing units are usually composed of two subunits: sensors and analog to digital converters (ADCs). The analog signals produced by the sensors based on the observed phenomenon are converted to digital signals by the ADC, and then fed into the processing entity. *Processing unit*, which is generally associated with a small storage entity, manages the procedures that make the sensor node collaborate with the other nodes to carry out the assigned sensing tasks. *Transceiver unit* connects the node to the network using some transmission protocols. Here it uses zigbee communication protocol for collecting information from nodes to the base station and diffusing sampling frequency notifications in the back direction. The simulation of ASA is done by sing the KEIL simulation tool, which is a widely used simulator for WSN's.

IV. ENERGY CONSUMPTION

The wireless sensor node, being a micro-electronic device, can only be equipped with a limited power source (<0.5 Ah, 1.2 V). In some application scenarios, replenishment of power resources might be impossible. Sensor node lifetime, therefore, shows a strong dependence on battery lifetime. Power consumption can hence be divided into three domains:

1. Sensing Power

2. Communication Power

3. Data processing Power

Sensing power varies with the nature of applications.

A sensor node expends maximum energy in *data communication*. This involves both data transmission and reception. It can be shown that for short-range communication with low radiation power, transmission and reception energy costs are nearly the same. Energy expenditure in *data processing* is much less compared to data communication.

ASA reduces the amount of data that will be transmitted and, as a consequence, the energy that the radio consumed. Thus the data communication energy utilization is reduced.

V. SIMULATION RESULT

An Adaptive Sampling Approach (ASA) that measures the best possible sampling frequencies for sensors. This approach minimizes the energy utilization of the sensors and radio. The simulation result of the sampling rate variation (increase and decrease) obtained is shown in Fig. 4. which minimizes sensor energy consumption.

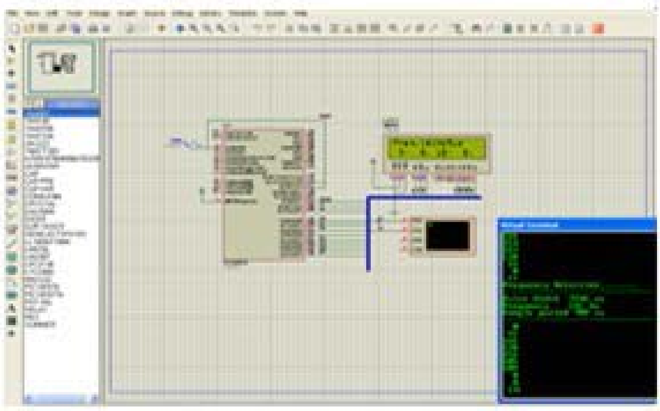

Figure 4: Simulation Result of an ASA.

VI. CONCLUSION

The proposed system (Adaptive Sampling Approach) has been recognized as best fitting method for sensor energy conservation. This approach results in a corresponding energy saving of both the sensor and the radio. We found that ASA can reduce the number of obtained samples with respect to the fixed sampling frequency while generally preserving the accuracy of the data sequence collected at the base station, thus the sampling rate reduction increases the energy conservation of the sensor.

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