LOW-COMPLEX SYNCHRONIZATION ALGORITHMS FOR WIRELESS SENSOR NETWORKS

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ABSTRACT

In industrial applications of wireless sensor networks (WSNs), synchronized sampling of data on each sensor node is often required. Thus, the wireless communication protocol needs to support accurate timing synchronization. If due to a high sampling rate also high data throughput is required, WSNs based on the IEEE 802.15.4 physical layer often do not provide sufficient data rate. Wireless communications based on the well established IEEE 802.11 wireless local area network (WLAN) standard provides high data throughput but not an accurate timing synchronization unless the protocol stack is severely changed. We propose two low-complexity hybrid WSN introduced, which are executable at limited embedded computing capacity, e.g., on an 8 bit microcontroller. A time division multiple access-based synchronization packet broadcasting with three-step-controlled or proportional-integral (PI)-controlled clock adjustment enables 1 kHz sensor sampling rate with a sampling jitter <15 μs for the three-step-controlled synchronization algorithm and <1 μs for the PI-controlled algorithm.

Keywords: Hybrid WSN, TDMA, Data Rate and Data Throughput

I.INTRODUCTION

The WSN is built of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: 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. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. An increasing variety of radio communication systems and ultralow-power microcontrollers enable the application of battery-powered sensor nodes, which communicate their data wireless. Compared to wireless sensor networks (WSNs) in home automation or environmental monitoring, where small data traffic is expected, industrial sensing applications are often characterized by a high data throughput in a dynamical changing, harsh, and highly reflective environment. For data transmission in embedded low-power sensor networks, a common approach is the usage of established wireless standards, such as ZigBee- or other IEEE 802.15.4-based protocols (e.g., wirelessHART and ISA100.11a), Bluetooth low energy and other proprietary solutions, such as MiWi or SimpliciTI. Most of them operate in the unlicensed 2.4-GHz industrial, scientific and medical (ISM) band and are limited in their data transmission rate to between 250 kbps and 2 Mbps.

We introduced a measurement system, which features synchronized sampling of sensor data from up to two-independent wireless nodes that are within transmission range to the base station. The measurement system has to capture and deliver the sensor signals at a minimum of data loss, which requires a highly reliable communication link to the base station. The data samples must be received by the base station with a maximum latency of 2 s, required for a fluent visualization and open-loop data processing. In our application, we have to acquire sensor data from a three-axis acceleration sensor with 12 bit at 1-kHz sampling rate, which results in 6 kB/s data throughput, which have to be transmitted from each sensor node to the base station, which is the center of a star network. To establish this synchronized sampling with an applicable accuracy of maximum ±50 μs along with a highly reliable data transmission from the battery-powered sensor nodes to the base station, hybridWSN is proposed. The base station includes the data processing unit, which has to receive up to 24 kB/s sensor data in addition to the parts: 1) a data transmission and 2) synchronization system.

II.RELATED WORK

Many applications based on these WSNs consider local clocks at each sensor node that need to be synchronized to a common notion of time. In this context, the majority of previous researches were focused on the study of protocols, and algorithms that address these issues in order to resolve synchronization problems. Previous efforts and empirical studies in wireless sensor network (WSN) proposed several solutions (algorithms). The aim is to examine and evaluate the most important synchronization algorithms based on the positions of various quantitative and qualitative synchronization protocols for energy-efficient information processing and routing in WSNs.

Wireless Sensor Networks(WSN) are large scale networks of sensors running on wireless environment. For an application running on a WSN, gathered data by the sensors are time critical in most of the cases. However, almost all the nodes suffer from a problem named clock drift. This problem causes clock difference among nodes as time goes because the processors do not run exactly at the same speed. There are many proposed solutions to remedy this problem. TPSN (Timing-sync Protocol for Sensor Networks) is one of the effective protocols proposed to synchronize sensor networks. In the esisting system, the proposed enhancements over TPSN to synchronize nodes in a wireless sensor network more effectively with a lower message complexity and higher precision.

III.SYSTEM MODEL

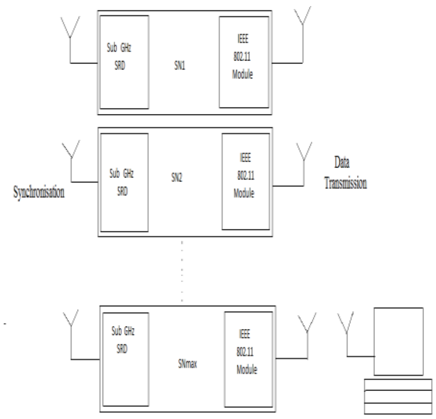

Figure 1. Block Diagram

From the above block diagram, the synchronization of data from various sensor nodes is made possible by using two synchronization algorithms they are 1) Coarse synchronization algorithm 2) Fine synchronization algorithm. Security to the data during the transmission, power consumption and energy efficiency of the each and every sensor node is obtained by using the ESRP protocol.

3.1 Coarse Synchronization

Here each sensor node uses the same timing based on milliseconds and node counts up 250 ms to one period and Nmax periods to one round. Within a round Nmax synchronization possibilities are offered. Sensor nodes start listening for a synchronization packet for a maximum duration.

Due to the broadcast nature of the packets, each packet can be received by all node participants.The transceiver starts listening at the beginning of the round, stops listening at the end of the round, and computes all received packets for synchronization.

3.2 Fine Synchronization

The fine synchronization algorithm has to deal with the limitations of system that the timer value cannot be set to an arbitrary value. This algorithm is used to adjust the skew rate of the clock to reduce the time difference between the clocks and find a common skew rate. This has the lowest computing complexity compared with all other synchronization algorithms.

The sensor node starts fine synchronization by comparing the measured time of actual packet reception with the expected time of reception. The simple three-step-controlled fine synchronization algorithm, performed in each period, consists of the following main points are:

1) Measuring time difference
2) Compare time difference
3) Adjust the time.

3.3 ESRP Proocol

ESRP- Energy Sensitive Routing Protocol .Node with highest energy in the radio range is assigned as CH 1.The node with farthest distance from CH1 and with highest energy will be selected as CH2. If any nodes are not falling within any of the clusters, those nodes transfer the sensed data to a nearby CH through its neighbors.

NODE 1

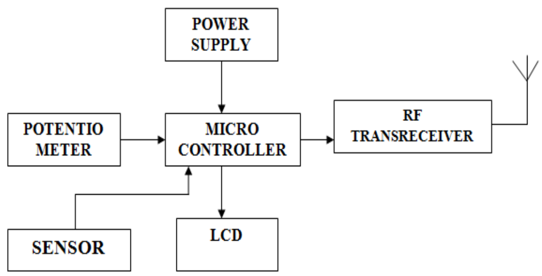

Figure 2. Block Diagram of Node 1

NODE 2

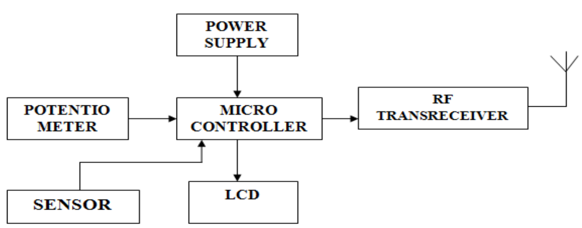

Figure 3.Block Diagram of Node 2

NODE 3

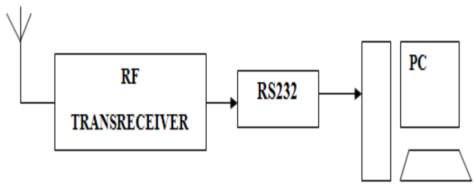

Figure 4. Block Diagram of Node 4

IV.RESULT

The energy efficiency of the nodes is identified with the help of the MATLAB program.

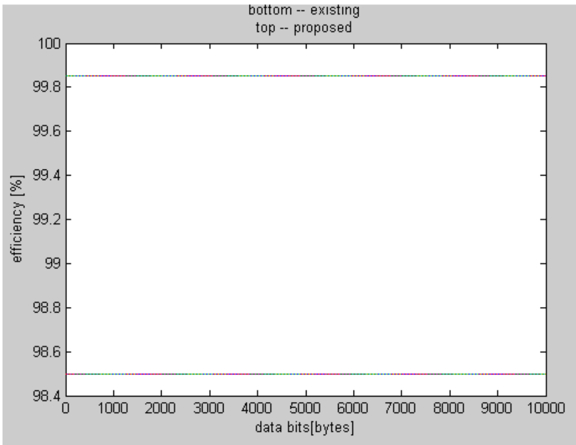

Figure 5.Energy Efficiency of the Nodes

V. CONCLUSION

In this project, the synchronization of data from various sensor nodes is done. Here the synchronization is done by increasing the sampling rate and the data throughput. The modulation and demodulation is done by using the TDMA technique. By using this algorithm, the synchronization of data in small WSN is also possible. ESRP protocol plays a major role in this project. It is used to give unique ID to each and every node in the network. Due to this efficiency of the communication is widely increased. The major advantage of this project is use of hybrid WSN; it is significantly different from the normal WSN. It has both the data transmission unit and the synchronization system. These parts are used to increase the data throughput and the sampling rate of the system. Thus by increasing sampling rate and data throughput, the synchronization of data is made possible.

REFERENCE

[1] Salim el khediri, Nejah Nasri, Mounir Samet, Anne Wei and Abdennaceur Kachouri, "Analysis study of time synchronization protocols in wireless sensor networks," International Journal of Distributed and Parallel Systems (IJDPS) Vol.3, No.3, May 2012.

[2] Gang Zhao," Wireless Sensor Networks for Industrial Process Monitoring and Control: A Survey", ISSN 1943-3581 2011, Vol. 3, No. 1

[3] Ali Burak Kulakli, Kayhan Erciyes, "Time Synchronization Algorithms based on Timing-Sync Protocol in Wireless Sensor Networks," International Computer Institute
Ege University Bornova, Izmir 35100, Turkey

[4] Sagar S. Joshi, D.S. Mantri, "Node Synchronization Algorithm in Wireless Sensor Networks," International Journal of Computer Applications (0975 – 8887) Volume 125 – No.4, September 2015

[5] Fikret Sivrikaya, Bulent Yener, "Time Synchronization in Sensor Networks: A Survey," 978-1-4673-2874-6/13/ 2013 IEEE

[6] T. Cooklev, J. C. Eidson, and A. Pakdaman, "An implementation of IEEE 1588 over IEEE 802.11b for synchronization of wireless local area network nodes," IEEE Trans. Instrum. Meas., vol. 56, no. 5, pp. 1632–1639, Oct. 2007.

[7] IEEE Standard for Local and Metropolitan Area Networks—Part 15.4:Low-Rate Wireless Personal Area Networks (LR-WPANs) Amendment 1:
MAC Sublayer, IEEE Standard 802.15.4e-2012, 2012.

[8] Y. R. Faizulkhakov, "Time synchronization methods for wireless sensor networks: A survey," Program. Comput. Softw., vol. 33, no. 4, pp. 214–226, 2007.

[9] S. M. Lasassmeh and J. M. Conrad, "Time synchronization in wireless sensor networks: A survey," in Proc. IEEE SoutheastCon, Mar. 2010, pp. 242–245.

[10] F. Sivrikaya and B. Yener, "Time synchronization in sensor networks: A survey," IEEE Netw., vol. 18, no. 4, pp. 45–50, Jul./Aug. 2004.

[11] M. K. Maggs, S. G. O'Keefe, and D. V. Thiel, "Consensus clock synchronization for wireless sensor networks," IEEE Sensors J., vol. 12, no. 6, pp. 2269–2277, Jun. 2012.