An Energy-aware Technique to Improve the Lifetime of Cell Phone Based WSNs Using ISA100.11a

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ABSTRACT

Ubiquitous nature of Cell phone and the recent advances in wireless communication technologies have made the concept of Cell Phone based Wireless Sensor Networks. This cell phone based wireless sensor networks supervise some of the surroundings distinctiveness, such as noise, trembling, temperature, and strain. Sensor nodes can be deployed over different geographic regions for a variety of applications. These sensor nodes consume the energy mainly for sensing, processing and transmitting operations. The energy constraint working condition of these sensor nodes necessitate the development of more energy efficient routing protocol. In this paper we propose a new energy efficient routing protocol called Improved Lifetime Wireless Protocol based on ISA100.11a (ILWP-ISA100.11a) for Cell phone based WSNs. The key objective is to enhance the working potential of the wireless sensor network by minimizing the energy consumption at different levels of operation while not compromising reliable data delivery.

Keywords- Cell phone based WSNs, ISA100.11a, Distributed data aggregation, Improved Lifetime Wireless Protocol (ILWP) etc.

1. INTRODUCTION

Wireless Sensor Networks (WSNs) consist of small nodes also termed as sensors with sensing, computation, and wireless communication capabilities [1]. These sensors are generally equipped with data processing and communication capabilities and are battery powered. The sensing circuitry measures ambient conditions related to the environment surrounding the sensor and transform them into electric signal. These WSNs have got wide range of applications in every day human life ranging from Battle field survey, habitat monitoring, remote data collection, and fire detection systems and so on and becoming integral part of human life. Already these networks have shown their need for presence even in common man life as well through their capabilities. Such networks have a got various kinds of applications leading to many open questions to be addressed and resolved. So there is a great room for students, researchers, scientists to address the problems so to gain most out of this battery powered devices by increasing their lifetime to collect the data. The Wireless Sensor Networks are measured as influential sensing network to the present day world due to their agreeable support to a diversity of real-world applications. The elasticity in its use is also the cause for it to be a demanding research and engineering problem. Wireless Sensor nodes are constrained in energy provide and bandwidth [3]. Thus, inventive techniques that eradicate energy inefficiencies that would abbreviate the lifetime of the network are extremely required. Several new algorithms have been proposed for the routing problem in Wireless Sensor Networks [4], [5]. These routing mechanisms have taken into consideration the inherent features of WSNs along with the application and architecture requirements [25]. The task of finding and maintaining routes in WSNs is nontrivial since energy restrictions and sudden changes in node status (e.g., failure) cause frequent and unpredictable topological changes. Routing techniques proposed here employ some well-known routing tactics to minimize latency and energy consumption e.g., data aggregation and clustering. Innovative techniques to eliminate energy inefficiencies that shorten the lifetime of the network and efficiently use the limited bandwidth are highly required. Such constraints combined with a typical deployment of large number of sensor nodes pose many challenges to the design and management of WSNs and necessitate energy-awareness at all layers of the networking protocol stack. For example, at the network layer, it is highly desirable to find methods for energy-
efficient route discovery [26] and relaying of data from the sensor nodes to the BS so that the lifetime of the network is maximized.

All the collected statistics, models and surveys shows that there’s a greater need in WSNs for addressing issues on energy consumption to extend their life time. Routing and data collection are the main activities of a WSN and which consumes most of the energy of a node during their lifetime. In literature many routing protocols have been introduced to address the problem of energy consumption to an extent and still there’s a need for Energy efficient routing protocols which tries to optimize the overall energy consumption.

2. RELATED WORK

Despite the innumerable applications of WSNs, these networks have several restrictions [27]. The design of routing protocols in WSNs is influenced by many challenging factors which must be overcome before efficient communication is achieved in WSNs. Routing in WSNs is very challenging due to the inherent characteristics that distinguish these networks from other wireless networks [7] like mobile ad hoc networks or cellular networks. First, due to the relatively large number of sensor nodes, it is not possible to build a global addressing scheme for the deployment of a large number of sensor nodes as the overhead of ID maintenance is high. Thus, traditional IP-based protocols may not be applied to WSNs. Furthermore, sensor nodes that are deployed in an ad hoc manner need to be self-organizing as the ad hoc deployment of these nodes requires the system to form connections and cope with the resultant nodal distribution, especially as the operation of sensor networks is unattended.

In WSNs, sometimes getting the data is more important than knowing the IDs of which nodes sent the data. Second, in contrast to typical communication networks, almost all applications of sensor networks require the flow of sensed data from multiple sources to a particular BS. This, however, does not prevent the flow of data to be in other forms (e.g., multicast or peer to peer). Third, sensor nodes are tightly constrained in terms of energy, processing, and storage capacities. Thus, they require careful resource management. Fourth, in most application scenarios, nodes in WSNs are generally stationary after deployment except for maybe a few mobile nodes. Nodes in other traditional wireless networks are free to move, which results in unpredictable and frequent topological changes. However, in some applications, some sensor nodes may be allowed to move and change their location (although with very low mobility). Fifth, sensor networks are application-specific (i.e., design requirements of a sensor network change with application).

For example, the challenging problem of low-latency precision tactical surveillance is different from that of a periodic weather monitoring task. Sixth, position awareness of sensor nodes is important since data collection is normally based on the location.

In general, routing in WSNs can be classified into flat-based routing, hierarchical-based routing and location-based routing depending on the network structure. The first category of routing protocols like SPIN, CADR, ACQUIRE [8] are the multi-hop flat routing protocols also known as data centric routing protocols. In flat networks, each sensor node collaborates together to perform the sensing task so it is not feasible to assign a global identifier to each node. The second kind of routing protocols are the hierarchical routing protocols also known as cluster-based routing, LEACH, TEEN and APTEEN, PEGASIS [9] proposed in wireless networks. They are well known techniques having special advantages related to scalability and efficient communication. The third category is the location based protocols in which sensor nodes are addressed by means of their locations, GEAR, SAR and SPEED [10]. The incoming signal strengths can estimate the distance between neighboring nodes. Relative coordinates of neighboring nodes can be obtained by exchanging such information between neighbors.

In common, routing in WSNs can be divided into three main categories such as data-centric routing, hierarchical based (cluster based) routing, and location based routing, depending on the network structure. In flat based routing all nodes plays the same role and it is not feasible to assign a global identifier to them. Base Stations sends queries and waits for data from the sensors. Well known protocols proposed are the Sensor Protocol for Information via Negotiation [9],[10], Directed Diffusion [11], Rumor Routing [7], Minimum Cost Forwarding Algorithm [13], Gradient based Routing [14], Information driven sensor Querying [15] etc. In a hierarchical architecture, sensor nodes are grouped and the one with the greatest residual energy is usually chosen as the cluster head. Higher energy nodes can be used to process and send the information, while low energy nodes can be used to perform the sensing task of the environment. This routing also called cluster based routing method. Some of the proposed cluster based protocols are the Low-Energy Adaptive Clustering Hierarchy [8], [12], Power-Efficient Gathering in Sensor Information Systems [16], Threshold sensitive Energy Efficient sensor Network protocol [17]. The location information of the sensor nodes is elegantly utilized in order to determine energy efficient routing paths. The distance can be estimated according to the level of signal strength. To save energy, some location based schemes demand that nodes should go to sleep if there is no activity. Well known protocols in this category are the Minimum Energy Communication Network [6], Geographic Adaptive Fidelity, Geographic and Energy Aware Routing, Most Forward within Radius etc.

ISA100.11a [24] is the “wireless system for industrial automation”. It is an open standard wireless networking technology developed by ISA (International Society of Automation). ISA100.11a was released in September 2009 and it defines the protocol suite, system management, gateway, and security specifications. It supports for low-data-rate

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wireless connectivity with fixed, portable, and moving devices with very limited power consumption requirements. This standard is intended to provide reliable and secure wireless operation for non-critical monitoring, alerting, supervisory control, open loop control, and closed loop control applications. ISA100.11a addresses low energy consumption devices with the ability to scale up and provides robustness in the case of interference found in harsh industrial environments. It also helps anyone to implement and deploy and also ensure multi vendor interoperability. The ISA100.11a is specifically designed for wireless sensor networks and can be used in factory automation.

3. PROPOSED ILWP-ISA100.11A PROTOCOL

We present an improved protocol for the Energy efficient data communication in cell phone based wireless sensor networks - The Improved Lifetime Wireless Protocol based on ISA100.11a (ILWP-ISA100.11a). This protocol covers networks of wireless devices connected to an application. To accomplish this, a full specification from the physical layer to the application layer is required. In this paper, we focus on the implementation of the network layer and the transport layer of the ISA100.11a. The network layer is responsible for inter-network routing and the transport layer provides the transparent transfer of data between end systems and also supports error recovery. The OSI stack of ISA100.11a is implemented and ported to OMNeT++ for simulation to check for its performance and the comparison is made with respect to the existing wireless protocol-Zigbee. The simulation results show the dominance of ISA100.11a in terms of energy consumption over Zigbee.

The Network Layer (NL) receives the requests from the transport layer and provides services to it. It also makes requests to the data link layer and receives service from it. Network layer functionalities are: Address translation, fragmentation and reassembly and routing. The Transport Layer (TL) is responsible for end-to-end communication and operates in the communication endpoints (as opposed to the routing devices). The TL provides connectionless services with optional security. The connectionless service extends UDP over IP version 4 (IPv4). UDP is a does not provide virtual circuits, nor reliable communication, delegating these functions to the application program. UDP packets are called datagrams rather than segments.

The ILWP-ISA100.11a (network layer module) is implemented in C++ using OMNeT++ simulator. The INETMANET framework is used for the implementation of Network layer and transport layer of ISA100.11a.

Packet Transmission in ILWP_ISA100.11

The simulation part of the ILWP_ISA100.11a as shown in the above figure is expanded to show the individual modules (Network layer and Transport layer). The modules are as follows:

- **End to end transmission**: The end to end transmission includes the socket establishment and release operations. At the sender side (1.1) the socket bind operation takes place and after the data transfer is complete the unbind operation takes place at the receiver side (1.10).

- **Encapsulation**: The encapsulation operations at the transport layer attaches the transport layer header with data received and send it to the network layer (1.2). Similarly encapsulation operations at network layer attach the network layer header with the TPDU (Transport Protocol Data Unit) and send the NPDU (Network Protocol Data Unit) down to the data link layer (1.5). These operations are done at the sender side.
Decapsulation: The decapsulation operations at the network layer removes the header from the PDU received from the transport layer and send the data to the transport layer (1.6). This operation is done at the receiver side. Similarly the decapsulation operation at the receiver side of transport layer removes the header of the PDU received from the network layer and sends them to the upper layer (1.9).

Address translation: The network layer uses 128 bit addresses. When PDUs (Protocol Data Units) are transmitted over a DL (Data Link) subnet 128 bit addresses can consume more energy and bandwidth, hence we use alias 16 bit addresses. When a packet moves from the network layer to the data link layer the 128 bit address is converted to 16 bit address (1.3) at the sender side and when the packet moves from the data link layer to the network layer at the receiver side the 16 bit address is converted back to 128 bit address (1.8).

Fragmentation: The fragmentation module at the sender side (1.4) is responsible for fragmenting the packet into smaller frames if the size of the packet exceeds a certain threshold.

Reassembly: The reassembly module (1.7) is responsible for reassembling the fragments of a packet at the destination side.

Steps involved in simulation using OMNeT++
- An OMNeT++ model is build from components (modules) which communicate by exchanging messages.
- Define the model structure in the NED language. NED can be edited in a text editor or in the graphical editor of the Eclipse-based OMNeT++ Simulation IDE.
- The active components of the model (simple modules) have to be programmed in C++, using the simulation kernel and class library.
- Provide a suitable omnetpp.ini to hold OMNeT++ configuration and parameters to the model. A configuration file can describe several simulation runs with different parameters.
- Build the simulation program and run it. We can link the code with the OMNeT++ simulation kernel and one of the user interfaces OMNeT++ provides. There is command line (batch) and interactive, graphical user interfaces.

Figure 1 shows the network topology in case of wired network. The simulation results are written into output vector and output scalar files. We can use the Analysis Tool in the Simulation IDE to visualize them. Result files are text-based, so it can be processed with Matlab. The following shows the comparison of simulation results of Zigbee and ISA100.11a in case of mobile nodes. Figure 2 and 3 shows how the relationship between the signal Bit Error Rate (BER) and Signal to Noise Ratio (SNR) is effected when varying the data rate and power.

Simulation of Zigbee: Simulation was run using the 2.4 GHZ signal frequency. The noise power in the AWGN channel was fixed at 0.168 watts per symbol, while the data rate was varied between 64, 128 and 250 Kbps. The results are shown in Fig. 6. Looking at the results where the SNR was 5 db the value of the BER is 10^-4 for a data rate (DR) =64 Kbps. While for both DR=128 and 250 Kbps the BER value is approximately 10^-2.3. This shows that the higher the data rate, the higher the probability of error for a desired SNR.
Figure 2: BER versus SNR for different data rate values in Zigbee.

SIMULATION OF ILWP_IsA100.11a: The same experiment was performed in case of ILWP_IsA100.11a. The simulation result is shown in figure 7. Using IsA100.11a where SNR was 5 db the value of BER is 10^-4 for a data rate (DR) =64 Kbps. While for both DR=128 and 250 Kbps the BER value is approximately 10^-3.6. This shows that for higher data rate the error probability is less in IsA100.11a.

Figure 3: BER versus SNR for different data rate values in ILWP_IsA100.11a.

Since there are more number of devices operating in the 2.4GHz band the WLAN and Zigbee devices are likely to be in close proximity to one another with possible interference. But the IsA100.11a provides coexistence with other wireless standards.

The simulation results show that compared to Zigbee, using IsA100.11a: (1) for higher data rate the BER is less. Hence the performance of the network is high. (3) Network is less disturbed by interferences. (4) IsA100.11a based protocol can be implemented for large network.

4. CONCLUSION AND FUTURE WORKS

In this research we propose a new energy efficient routing algorithm which is related with distance factors and energy. Characteristic routing techniques have major purpose of boosting the lifetime of the sensor network while not compromising the data delivery. For the future work ,we propose sensor mediators going to use to sense, monitor and verify the concerned data. All of the cleverness, mediators are going to be managed from a supervision center which is associated to descend, by the satellite communication.
REFERENCE


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