Power Optimization in Wireless Sensor Networks

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Abstract—
Wireless Sensor Networks (WSNs) consist of a network of wireless nodes that have the capability to sense a parameter of interest. Sensors of various types are deployed ubiquitously and pervasively in varied environments such as office buildings, wildlife reserves, battle fields, mobile networks, etc The sensed parameter is relayed to a base station through the network formed amongst these nodes. The devices used are typically characterized by low cost, low power and are rugged in operation. The node integrates programming, computation, communication, and sensing onto a single system and provides an easy user interface for operating and deploying it. The paper presents such a design which minimizes cost and power consumption, thus enhancing the life time of the node.

Keywords: node, Wireless Sensor network, ZigBee

I. INTRODUCTION

The advances in the hardware and wireless technologies have resulted in inexpensive low power communication devices that can be deployed throughout a physical space, providing dense sensing close to physical phenomena, processing and communicating this information, and coordinating actions with other nodes. Such a deployment can be termed as a Wireless Sensor Network (WSN). To realize such a network, we must address a new collection of challenges. The individual devices in a WSN are inherently resource constrained: they have limited processing speed, storage capacity, battery capacity, and communication bandwidth. These devices have substantial processing capability in the aggregate, but not individually. These devices are called as nodes.

A “node” in a wireless sensor network is capable of gathering information, processing and communicating with other connected nodes in the network. Typically the node may contain one or more sensors that can monitor the surroundings for specific parameters. Some of these sensors commonly used are to sense temperature, light, sound, position, acceleration, vibration, stress, weight, pressure, humidity, etc. The microcontroller performs all the data processing tasks and controls the functionality of other components in the sensor node. The sensors measure data of the area to be monitored. The continual analog signal sensed by the sensors is digitized by an Analog-to-digital converter and sent to controllers for further processing. The nodes also contain the communication module which provides communication over wireless medium using transceivers. The nodes can be powered by using batteries. A large number of nodes hence communicate over wireless channel form an ad-hoc network. All the information can eventually be transmitted to a gateway node.
By forming an ad-hoc network they can function for a long time without any human intervention since they consume limited power.

The paper is organized as follows: Section 2 deals with the architectural issues in wireless sensor network. Section 3, presents the overview of Wireless Sensor Network. Section 4 deals with power constraints in WSN. Section 5 deals with the various aspects of ZigBee. The paper is concluded in section 6.

II.ARCHITECTURAL ISSUES IN WSN

Wireless Sensor Networks (WSNs) are an important new class of networked system. Simultaneously presenting intellectually deep CISE research challenges and promising tremendous societal impact through scientific progress, better engineering, improved productivity, and enhanced security, research in this area has progressed substantially. Dealing with both scale and density is hard enough in ideal environments. Unfortunately, we don’t have the luxury of ideal environments with sensor networks. Because sensor networks are intended to monitor the physical world, they must often be deployed in natural and uncontrolled environments. No longer can we assume the carefully controlled temperature, abundant power, and human monitoring of server rooms and data centers. Instead, wireless sensor networks must be designed to operate while unthread (no external power), unattended (no manual configuration or management), intermittently connected (radios may be turned off for substantial periods of time to conserve power), and uncontrolled environment.[1]. The following architectural issues must be considered while designing power optimized WSN.

A. Implications on WSN

1. Network Dynamics

There are three main components in a sensor network. These are the sensor nodes, sink and monitored events. Supporting the mobility of sink nodes is an important issue in WSN design. Routing plays important role as routing messages from or to moving nodes is more challenging since route stability becomes an important optimization factor, in addition to energy, bandwidth etc [2].

2. Node Deployment:

Another consideration is the topological deployment of nodes. This is application dependent and affects the performance of the routing protocol. The deployment is either deterministic or self-organizing

3. Energy Considerations:

During the creation of an infrastructure, the process of setting up the routes is greatly influenced by energy considerations. Since the transmission power of a wireless radio is proportional to distance squared or even higher order in the presence of obstacles, multi hop routing will consume less energy than direct communication.

4. Node Capabilities:

In a WSN, different functionalities can be associated with the sensor nodes. According to previous studies, all sensor nodes are assumed to be homogenous, having equal capacity in terms of computation, communication and power. However, depending on the application a node can be dedicated to a particular special function such as relaying, sensing and aggregation since engaging the three functionalities at the same time on a node might quickly drain the energy of that node. Inclusion of heterogeneous set of sensors raises multiple technical issues related to data routing. The results generated from these sensors can be at different rates, subject to diverse quality of service constraints and following multiple data delivery models. Therefore, such a heterogeneous environment makes data routing more challenging.

III. OVERVIEW OF WIRELESS SENSOR NETWORK

Sensor networks are applied to various fields ranging from special application fields such as wild environment monitoring, industrial machine measurement and military purpose measurement to daily application fields such as fire monitoring and pollution monitoring.[3]. A wireless sensor network is a wire and wireless network, which consists of several sensor nodes deployed in a certain field. A sensor node should have computation, sensing and wireless communication functions.

The numerous sensors are used for delivering crucial information in real-time from environments and processes, where data collection is impossible previously with wired sensors [4]. Typically, wireless sensor networks are composed of low power sensor nodes and integrate general-purpose computing with heterogeneous sensing and wireless communication. Their emergence has enabled observation of the physical world at an unprecedented level of granularity. One of the most important components of a sensor node is the power unit [5].A wireless sensor network limits the radio frequency channel, due to, that is to say, unstable links, limit of physical protection of each sensor node, actual of each nodes connection, variation topology in addition dangerousness about routing security is high by activity spite nodes. In addition, restrictions of the hardware of the sensor node itself makes it difficult guarantee the maintenance of security because of vulnerability.[6][7].A wireless sensor network consists of spatially distributed autonomous sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants.

A sensor network normally constitutes a wireless ad-hoc network, meaning that each sensor supports a multi-hop routing algorithm. The network does not rely on a pre-existing infrastructure, such as routers in wired networks or access points in managed (infrastructure) wireless networks. Instead, each node participates in routing by forwarding data for other nodes, and so the determination of which nodes forward data is made dynamically based on the network connectivity.

The sensor nodes must

(i) Consume extremely low power
(ii) Operate in high volumetric densities
(iii) Have low production cost and be dispensable and
(iv) Be adaptive to the environment.

The base stations are one or more distinguished components of the WSN with much more computational, energy and communication resources. They act as a gateway between sensor nodes and the end user. Fig1 shows the basic components of a sensor node.

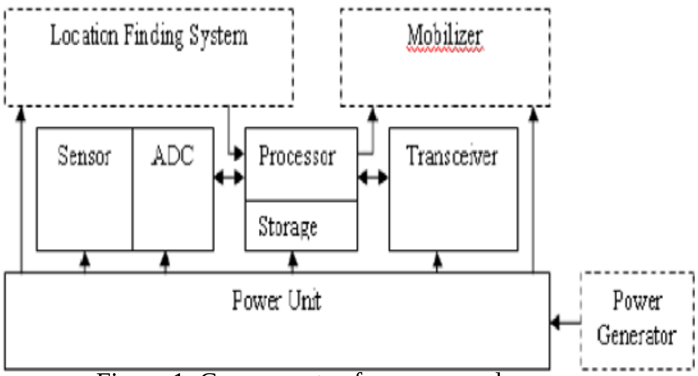

Figure 1: Components of a sensor node

IV. POWER CONSTRAINTS IN WSN

Wireless sensor networks typically have power constraints. The absence of wires implies the lack of an external power supply such as battery packs. Although photovoltaic's or other passive energy gathering techniques are possible, these approaches typically provide only a modest amount of operating pow-- Therefore it is necessary to extend the battery life individual sensors so that the network can remain functional as long as possible. Moreover, for biomedical sensors, power usage results in heat dissipation that may further require minimizing the total power consumed by the wireless sensor network.[9].

The handling of the wireless transceiver contributes significantly to the node's overall energy consumption [10]. In order to extend the working time of individual devices, it is frequent practice that some node elements are deactivated, including the radio transceiver. They remain inactive for most time and are activated only to transmit or receive messages from other nodes. Radio transceiver in WSN network node can operate in one out of four modes, which differ in the consumption of power necessary for proper operation: transmission – signal is transmitted to other nodes (greatest power consumption), receiving – message from other node is received (medium power consumption), stand-by (idle) – transceiver inactive, turned on and ready to change to data transmission or receiving (low power consumption), sleep – radio transceiver off [11].

A typical wireless sensor network consists of sensors powered by small batteries that are difficult to replace if not impossible. Hence, the sensor nodes can only transmit a finite number of bits before they run out of energy. Thus, reducing the energy consumption per bit for end-to-end data transmission is an important design consideration for such networks. We assume that each information bit collected by a sensor is useful for a finite amount of time; after this time the information may become irrelevant. Hence all the bits collected by the sensors need to be communicated to a hub node before a certain deadline. Therefore, the maximum end to-end transmission delay for each bit must be controlled to meet a given deadline under the hard energy constraint. Since all layers of the protocol stack affect the energy consumption and delay for the end-to-end transmission of each bit, an efficient system requires a joint design across all these layers as well as the underlying hardware where the energy is actually expended. [12].

For many applications, wireless sensor networks (WSNs) are required to be unobtrusive, with numerous nodes that are dependent on a battery power source. These nodes are typically very simple, small, and inexpensive modules that are equipped with a sensor to measure a phenomenon. A simple transceiver is used to transmit and receive the measured observations to and from neighboring nodes.

Figure 2: A typical sensor node

Figure 2 depicts a typical sensor node with these simple components. Ultimately, the sensor nodes cooperate in transmitting their observations to a data sink where they can be processed as shown in Figure 3. Since nodes must be as small, inexpensive, and as efficient as possible, there are stringent constraints on their computational and energy resources. On the other hand, the data sink is assumed to have access to substantial energy and computational resources, within the limits of reasonable expense and contemporary technology. Therefore one of the main challenges of designing a successful WSN is in minimizing the probability of error in transmitting data, subject to constraints in available power and computational resources [13].

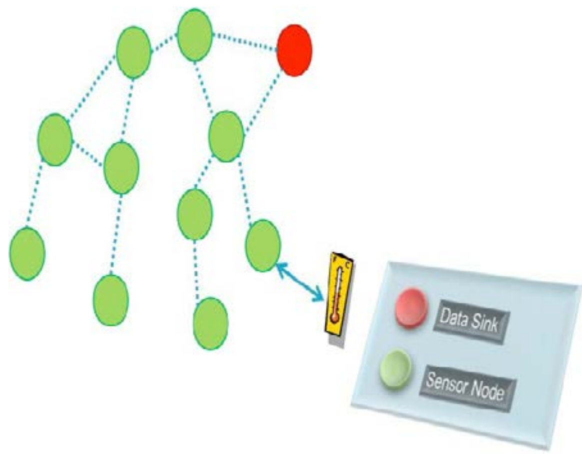

Figure 3: A Typical Sensor Network

V. WHY ZIGBEE FOR WIRELESS SENSOR NETWORK?

The name "ZigBee" is derived from the erratic zigzag patterns many bees make between flowers when collecting pollen. This is suggestive of the invisible webs of connections existing in a fully wireless environment, similar to the way packets would move through a mesh network.

During the last few years, the ZigBee Alliance has made significant modification and improvement on the ZigBee standard IEEE 804.15.4, making it more applicable to the increasing demand on Personal Area Network (PAN) service. However, the ZigBee standard specified that the maximum data rate of a ZigBee link be 250kbps. This data rate faces many difficulties dealing with the increasing data transmission pressure in many applications [14]. ZigBee is a low-cost, low-power wireless mesh networking proprietary standard. The low cost allows the technology to be widely deployed in wireless control and monitoring applications, the low power-usage allows longer life with smaller batteries and the mesh networking provides high reliability and larger range. The technology defined by the ZigBee is intended to be simpler and less expensive than other WPANs, such as Bluetooth. ZigBee wireless sensor network has great advantages in terms of low power consumption, high fault tolerance, flexibility, and autonomy.

ZigBee operates in the industrial, scientific and medical (ISM) radio bands; 868 MHz in Europe, 915 MHz in the USA and Australia, and 2.4 GHz in most jurisdictions worldwide. The ZigBee specifications are available free of cost for all non-commercial purposes. ZigBee can go from sleep to active mode in 15 msec or less, thus the latency can be very low and devices can be very responsive particularly compared to Bluetooth wake-up delays, which are typically around three seconds. Because ZigBee can sleep most of the time, average power consumption can be very low, resulting in long battery life. It is a typical wireless communication technology, which is widely used in wireless sensor network. ZigBee wireless sensor network has great advantages in terms of low power consumption, high fault tolerance, flexibility, and autonomy [15]. Using Zigbee techniques as a back bone to develop ubiquitous applications has been warming up while current information technology evolution moving from electrification to mobilization. However, most successful business cases still rely on mobile tools, such as PDA, WIFI, RFID, and GPS, to realize the concept of ubiquitous. The main challenges ahead for making real U-applications on the market are not only the definitions of ZigBee specifications and protocols, but the related optimal database build-up and interface design methods [16].

The block diagram of a node is shown in the fig4 [17].

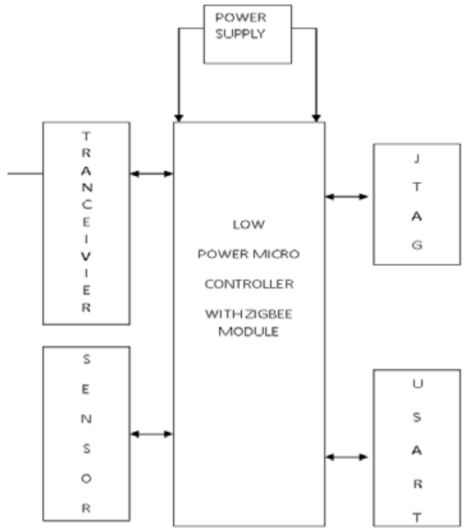

Figure4. Block Diagram of node

As the main controller of the whole system, the microcontroller's major responsibilities are initializing the system, receiving and executing the orders and memorizing these. The flow of the main programs is illustrated in figure 4. [Q].

VI. CONCLUSION

In this paper we have presented the power related issues of WSN and the role of ZigBee in designing the node. In a wireless sensor node, the radio consumes a vast majority of the system energy. This power consumption can be reduced through decreasing the transmission output power or through decreasing the radio duty cycle. Both of these alternatives involve sacrificing other system metrics.

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