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Optimizing the Power Use of Parking-Related Sensor Nodes

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Abstract— ***Since WSNs bring together cutting-edge sensor technology with cutting-edge network algorithms, they are an important area for future study. A wide range of environmental monitoring and information collecting applications may benefit from wireless sensor networks (WSNs). An important point will be made in this article. Using WSN, construct a parking management structure. A number of sensor nodes are installed in the parking field as part of the parking management system to indicate whether or not a parking spot is occupied. A base station at the parking entrance receives information on the status of the parking spots and uses it to direct cars. Nodes have built-in batteries that provide power for the sensors. Sensor nodes rely on this energy source heavily, and it has a direct impact on the nodes' lifespans and, by extension, the health of the whole WSN. Hybrid communication method is proposed in this work in order to reduce energy usage. The suggested parking management architecture is compared to the three ways of communication; a multi-hop, a single hop, and a hybrid.***

Key words: Wireless sensor networks, sensor nodes, and energy consumption

I. INTRODUCTION

Because they address such pressing concerns as safety, health, prevention, and production, wireless sensor networks (WSNs) are one of the most promising study fields today. [1]. Sensors in these networks are linked to each other by a tiny CPU, memory, battery, antenna, and sensor itself, which collects data from a particular media and sends it to a system that saves it for the appropriate application [2]. Despite the wide range of applications for WSNs, there is still much room for improvement, which necessitates tailoring technological solutions such as protocols, algorithms, and the like to the specific needs of each application in order to track the WSN's behaviour and draw meaningful conclusions about things like energy consumption, data delivery to the intended recipient, and delay, to name just a few. [3]. Data processing and storage modules, wireless transmission units and batteries form the core of sensor nodes. [4]. These nodes, organised in a chain, are tasked with gathering and transmitting data to the network's central nodes despite the system's computational, storage, and energy resource restrictions. [5]. The following four components are required for every sensor. The sensor: A seize device and an analog-to-digital converter called an ADC are two of the components of this system [6]. The sensor gives an analog/digital signal, and the latter turns it into digital signals that the processing stage unit can understand. [7]. The processing unit Processors and decreasing memory units are grouped together. Saving and performing the perceptual task given to it are both permissible functions [8]. All data transmissions and receptions are handled by the transceiver device. Power supply: [9] The sensor has access to electricity (battery). [10] There is a limit on this power source. Often, sensor nodes rely heavily on energy since it directly influences their lifespan and consequently the network as a whole. [11].

As a power source, each sensor relies on a small battery, which has a limited lifespan. Recharging or replacing these batteries is difficult or impossible in certain WSN applications (military, seismic, and so on), which leads us to believe that the service life of a sensor is mostly dependent on the battery's lifespan [13]. So the way of reducing the network's energy usage is a big limitation. Parking lot management is a WSN-enabled application [15]. It's a designated area or structure for parking automobiles.

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In order to accommodate customers, it is often situated in front of or next to public facilities (such as train stations and airports), offices, and retail malls [16]. Using a WSN, a parking control architecture is presented for the 81,835 vehicles parked in the centre of Mansour, Baghdad, 35 percent of which is spent searching for a parking spot. Because one in three cars are seeking for a parking place, this suggested solution may greatly improve traffic flow by precisely displaying the number of free parking spaces in the park. For power consumption evaluation, sensors communicate their data directly to the main station, or in multi-hop mode, if necessary. Including an energy-saving hybrid mode. A WSN included into the system can tell whether a parking spot is occupied or not, which is a useful feature. Each parking place has a sensor that is either fastened to the floor or the ceiling of the parking area.. It's powered by a battery that only lasts so long before it has to be recharged.

A variety of protocols already exist, all of which aim to find more efficient ways of using bandwidth, reducing power consumption and other such factors. Because nodes must be powered by batteries, their life expectancy relies on their power source, putting them to sleep while they are not in use reduces energy usage, which is perhaps the most crucial concern. Each of the communication ideas in the WSN is tailored to satisfy the needs of a specific application or set of related applications, hence there is no universally approved standard in the WSN yet.

It is organised in the following manner: System architecture, power usage, and current WSN energy consumption are discussed in Section 3. The simulation results are summarised in Section 4. Section 5 wraps off the project.

II. APPLICATIONS OF SENSOR NODES

Due to unit growth and advancements in low power radio technology, WSNs have expanded during the last several years. As the cost of sensors and communication networks has reduced, a wide range of possible applications for civic and environmental goals have developed. As seen in figure 1 [19], we'll go into further depth about the many uses for this technology going forward.

Fig. 1. Sensor networks applications

1. Condition monitoring:

Condition monitoring includes detection of human presence, vibration of objects, sound, stress, acceleration, power, etc. [20].

2. Environmental monitoring:

This domain covers the largest scope of WSNs today. It includes the monitoring of the state of the ambient air, the quality of the water (for example the control of its degree of pollution, etc.), the control of dangerous environments, especially those that are vulnerable to fire, flood or landslide. In addition, this area of application includes weather forecasts [21].

3. Health Surveillance:

Embedding sensors for health is an interdisciplinary field that revolutionized telemedicine systems by enabling cheap and continual health observation through the real-time updates of medical recordings over Internet. In fact, WSN is integrated into hospital buildings to trace and monitor patients and the medical resources [22].

4. Control the Traffic:

The sensor networks used the traffic lights and monitor vehicle movement. Cameras are also often applied to monitor high-traffic road segmentations [23].

III. MODELS OF NETWORKS AND ENERGY

This section explains the network's design and the energy consumption model. The sensor's lifespan is heavily influenced by the battery's life expectancy. Detecting parking spot occupancy, developing data processing, and transmitting the results to the main station behind parking are only some of the key functions of this sensor's use. Capture, processing, and connection make up this portion of the sensor's

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energy use. Because of the enormous number of electrical components in the circuit, the data connection step consumes the most energy. There are two phases in this stage: transmitting data and receiving it. Utilizing the sensor node simulation model, calculate the energy use. A single-hop or hybrid hop sensor network is used to communicate with the base station. Each node in a hybrid hop network serves as both a data source and a router. When using a hybrid hop, each sensor transmits its data to its neighbouring nodes, which then pass it on to their neighbours, and so on, until it reaches the central node. Sensors are designed to last for a few months or a few years. Consequently, the sensor's energy capacity should be used to the fullest extent possible in order to optimise network life. If a sensor loses power, it is rated defective and must be replaced. As a result, the risk of losing network connectivity increases. The radio model is shown in Figure 2.

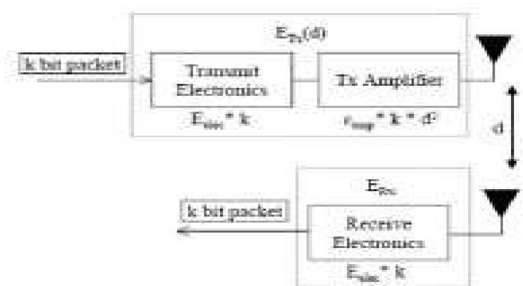

Fig. 2. Radio model

For a transmission of a k-bit message over a distance d, the sensor node consumes given by Equation (1) and (2). And for receiving a k-bit message, the sensor node consumes given by Equation (3).

$$E_{Tx}(k,d) = k \times E_{elec} + k \times \varepsilon_{fs} \times d^2 \qquad d < d_0 \qquad (1)$$
$$E_{Tx}(k,d) = k \times E_{elec} + k \times \varepsilon_{amp} \times d^4 \qquad d \geq d_0 \qquad (2)$$
$$E_{Rx}(k) = k \times E_{elec} \qquad (3)$$

Where is the amount of energy consumed for a bit. elec E is the amplification of the signal in a distance less than the threshold distance .If the emission distance is greater than , amplification is used. 0 d 0 d amp

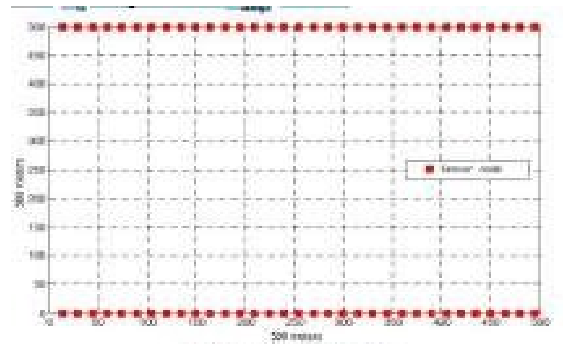

Fig. 3. Parking with WSN

Figure 3 models the parking the distance between one sensor node and another is 15 meters. In region of 500 meters' x 500 meters, we will need 66 sensor nodes.

IV. SIMULATION

Compared to conventional networks, energy is a major issue with WSNs. To extend the life of WSNs, it is important to reduce the power consumption of sensor nodes. The parking sensor nodes are simulated in the Matlab environment and the energy usage is calculated. An alternative channel access mechanism is the non-persistent carrier sense multiple access (CSMA). There are a number of simulation parameters listed in Table 1.

TABLE I. THE SIMULTION PARAMETERS.

Parameter	Value
Region	500 m x 500 m
Package Size	1000 bits
Distance d_0	87 m
Number of sensor nodes	66
E_{elec}	50 nJ/bit
ε_{fs}	10 pJ/bit/m^2
ε_{amp}	0,0013 pJ/bit/m^4

In order to reduce power consumption, we suggest a hybrid connection between a single-hop mode and a multi-hop mode inside the sensor and the main station. According to this definition, the hybrid mode is: Using a single-hop mode, a sensor node may convey its data about the parking space's status to the base station through direct connection. The sensor node delivers its multi-hop information to the sensor node nearest to the main station if it is not configured this way. Each sensor's quickest route to the main station is examined. The intermediate sensors are selected in order to meet the following criteria:

$$E_{Tx}(k, d = \text{distace between } S_i \text{ and } S_j) + E_{Tx}(k, d = \text{distace between } S_j \text{ and } SB) < E_{Tx}(k, d = \text{distace between } S_i \text{ and } SB)$$

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Figure 4 shows the transmission power consumption for the single and multi-hop communication modes, and the hybrid mode proposed for each sensor to reach the main station. The proposed hybrid mode consumes less power than the other two modes because the distance in the hybrid mode is minimized.

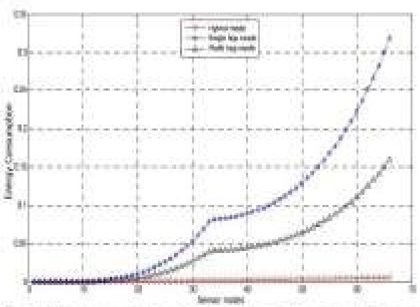

Fig. 4. Power consumption with single-hop, multi-hop and hybrid mode.

V. CONCLUSIONS

For every system that relies on input from the outside world, sensors are now a need. Parking management might benefit from the use of a sensor network. An essential WSN parameter, sensor node energy consumption, was also evaluated in this design, and we suggested a hybrid communication technique to reduce sensor node energy consumption. Car park management and other applications may benefit greatly from WSNs, according to our opinion. As part of a larger national research effort, we plan to test this hypothesis in the near future.

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