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LOW ENERGY CONSUMPTION RATEINHOME SENSORS USING PRIME NODES

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ABSTRACT

Many of conventional home and industrial automation systems have substantially spurred the appearance of the embedded devices with wireless sensors in order to execute their functionality in the wireless sensor networks or to build inter-device wireless communication. To facilitate the adaptation of wireless sensor networks (WSN) to industrial applications, concerns about problems of battery power and energy resources must be addressed to fulfill real-time requirements. In fact, the network has many wireless nodes that depend on their batteries as power supply to stay connected and operate well. The main reason of spending the nodes power is the data transmission and reception operations via the wireless signals. Many researchers have been conducted to enhance the remaining energy of the home devices that are based on sensors and to increase these home sensors lifetime. A novel method has been presented in this paper to optimize consuming power in these home sensors. This issue can be done by, enhancing the functionality of some home devices by making them as central nodes (prime nodes) for the other home sensors by reducing their consumption rate. This will lead to eliminate some transactions of transmissions and receptions of the home sensors. Hence, powerful home sensors are employed to have the capability to live longer and have more power supply to be used in various home application. Large scale of home sensors are used in the simulation conducted in this research in order to make it accurate. The simulation results clarify the efficiency of the proposed mechanism in term of low power consumption rate of the home devices with the availability of the prime home sensor nodes that have the capability to live longer.

Keywords: home devices, home Sensors, transmission power, reception power, prime nodes, network reliability and lifetime.

1. INTRODUCTION

The high spread of implementing the WSNs in various applications such as industry and home automation systems is because of the low cost of small size, powerful multifunctional sensor nodes[1, 2].The famous applications that use WSNs are: patients' health monitoring systems, weather and environment measurement factors, traffic monitoring and control systems, tracking and localization systems, and military applications. Many sensor devices are implemented in home automation systems to transfer small amount of data and guarantee the delivery of data such as monitoring and controlling machines at home, temperature and the humidity, opening and closing doors and windows, and tracking objects and alerting about some events. However, these home devices have limited sensors features in computation, memory capacity and battery power supply [3].

Figure-1. Home sensors in various applications [3].

Many researchers have worked on many fields of using the home sensors applications such as reducing the power consumption, increasing the wireless range, enhancing security protocols, and routing protocols. Some of these researches has also studied the effect of the coverage problem because its affection on the networks lifetime and the sensor power. Distributing the responsibility of the transmission and reception of the data among of the home sensors was one of our researches before in order to achieve better lifetime and enhance the delivery ratio in the WSN [4].

The home sensor nodes can be arranged in the sensor field systemically or can be thrown randomly as in the previous Figure-1.

These Home sensors start sending and receiving data when an event is detected in the surrounded environment or when a command comes to that home sensor. This transmission may be indirect through other devices. Therefore, the home device will forward that to the destination device. Repeating this operation of sending and receiving data packets from home devices is the main reason of power consumption for these sensors that more often depend on installed batteries as power supply. However, other power consumption, happens in the sleep mode of these sensors, can be ignored, because it is small amount compared with the transmission and reception operations.

These home sensors, that are based on ZigBee communication standard, used the Ad hoc on-demand distance vector (AODV) for transmitting and receiving the data among these devices[5]. This protocol is used to transfer the alert notifications or the sensed data packets from the sensor node. Subsequently, the sensor node initiates this request to sink nodes or base station (BS) through path of intermediate sensor nodes which may only

waked up for this purpose. Thus, let routing as transmitting and receiving packets to be the main source of losing the energy of the sensor nodes. In other words, the sensor node may die in the network only by being intermediate node in the network for the whole lifetime. Therefore there are many routing protocol that have been proposed for distributing the power consumption among the sensor nodes in order to increase the lifetime of the wireless sensor networks such as our proposed protocol introduced in [6]. Furthermore, there are different categories of routing protocols that are based on the functionality of the routing protocols that are transferring the data in the WSN such as the location-based or the Geographical routing protocols, Quality of Service (QoS) routing protocols, and energy-aware routing protocols[7].
Due to the high restraints of limited power supply that are based on battery for the most home application devices the research on reducing the consuming energy in these home devices is main issue in installing a network of these home sensors [8]. This concern can be protected by three main researches categories; increasing the number of batteries, or increasing the energy capacity of each batteries, or enhancing the algorithms used for routing the data among these home devices [9]. The basic idea is grouping the home sensor nodes into various types of nodes that have different roles in the network. Number of active nodes were reduced and the power consumption for these nodes is improved by reducing the number of the transmission among the other sensors that are not active.

The objective of the prime nodes in this paper is to introduce novel method which considers the power efficiency of the WSN and improve it. In addition, this new technique will control the transmission range of wireless sensor nodes by formed a group of connected prime nodes as seen on Figure-2 the transmission node of the nodes can be different among each other. These nodes manage the traffic of transmitted packets between sensor nodes and reduced the network load. In contrast to the classical WSN, the proposed technique raises up the network lifetime.

The rest of the paper is organized as the follows. In Section 2, we describe the related works from the literature. Section 3, the proposed method is introduced. The simulation results are conducted and discussed in Section 4. Conclusion and future works are provided in Section 5.

2. RELATED WORK

Many researchers have studied the relation between the range of the wireless signal of the sensor nodes and the power consumption of the sensor nodes and the network lifetime[10]. Some of them adopted the PEAS routing protocol. PEAS used sleeping technique to decrease the total number of the active nodes in the network [11]. Other researchers tried to send the packet to some of the sensor nodes in the WSN by sending directional packets to certain geographical area using Geographic routing protocol and activate the sensor nodes in that area of the WSN such as the Greedy Distributed Spanning Tree Routing (GDSTR) and the Greedy Embedding Spring Coordinates (GSpring) [12]and[13].Other researchers also suggested choosing minimum candidates of nodes to cover all the WSN. This leads the power consumption among wireless nodes in the network more balanced[14]. Finding the optimal bath to transfer the packets using the search algorithms and generating diagrams was other researchers works to raise up the lifetime of the WSN[15].

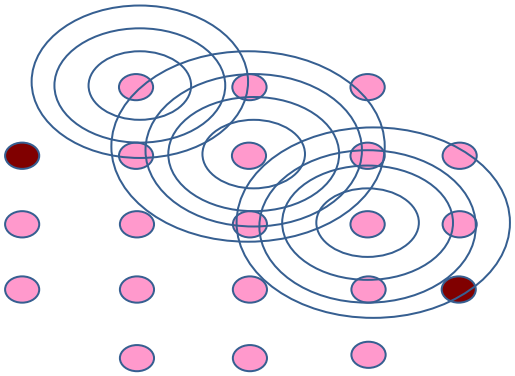

Figure-2. The range of the wireless signal of the wireless sensor nodes.

Using hand shake protocols and negotiation messages to activate the interested node and the nodes which have large amount of surrounded neighborhoods in the network and turning off the nodes was also studied by other researchers.[16]and [17] proposed distributed sensor integration methods based on mobile agent for energy efficient and scalable data integration. Hence, network conditions are changed using mobile agent to assure successful performance. Researchers in [18]used changeable WSN to find the good variable that are enough for the transmission range to reach the other end. In[19], stationary wireless sensor nodes were developed to deliver the transmitted packet to its destination.

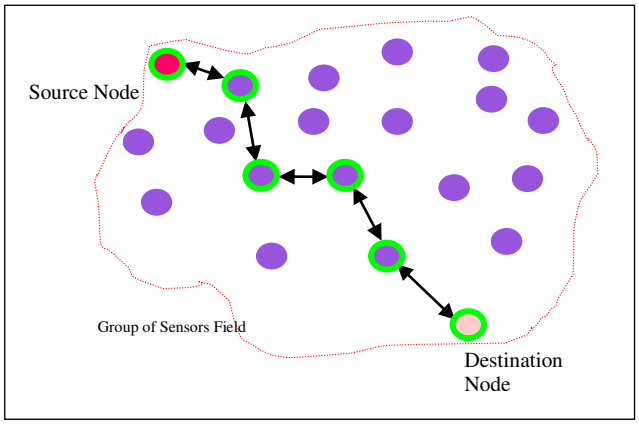

Figure-3. Connection path between nodes in WSN.

3. IMPLEMENTATION AND DESIGN

The main aim of the home sensors network is to measure the quantity of the paradigm of distributed networks that consists of large amount of small and prime wireless sensors. The digital signals sent among the home

devices are used to carry data through the network. Figure-3shows a simple data path from a source home device to a destination device via connection path where sensor nodes perform some diverse assignment operations such as neighbor node discovery, data storage and processing, information connection, node localization, synchronization and efficient routing between base stations and their nodes. One of the WSN problems is transmitting packets via wireless sensor nodes efficiently. This problem becomes a challenging issue due to various constraints that makes it hard to discriminate this type of network from others. These constraints could be complex routing algorithm used with simple resources, and the variation of applications which use these sensor devices at home[20].

Some of the constraints were regarded to design an efficient routing protocol in WSNs. They can be introduced in [21] as follows:

a) Home sensors network routing protocol aimed to minimize power consumption by eliminating communications, which have nodes in sleep mode. Furthermore, it tries to reduce the power consumption rate. In other networks, improving Quality of Service (QoS) in WSN during packet transmission is achieved by some routing protocols utilizing multiple frequencies or increasing transmission power etc.

b) Wireless sensor nodes are highly constrained on power supply, memory buffer, data rate, computational capacity, and available bandwidth. Hence, limited resources of such wireless required to be exploited efficiently.

c) WSN is an automated environment to have thousands of nodes that working in parallel to accomplish specific tasks such as sensing, processing and distributing sensed packets to other nodes, as a result, these nodes may not have global identification addresses to access each other.

d) It is crucial to design any algorithm or protocol for WSN topology in an optimal manner. To solve this issue, resource constraints need to be evaluated and compared to select the best topology under a specific application. Each topology has its own advantages and disadvantages under a specific WSN. Hence, the main challenge is to design routing protocol that has the ability to work in various network topologies.

e) Failure on WSN could happen due to several nodes redundantly receive multiple patches of the same data packets. Moreover, these nodes do not regard their resources to limit their functionalities. Redundant data consumes processing as well as energy and bandwidth of the wireless network.

f) Different types of failure could happen in WSN such as crash failure, fail-stop, omission, timing and hardware failure etc. these failures could make implosion of entire functionality of WSN. Fault tolerant management is mandatory to maintain and achieve reliability of WSN.

Two main classes of routing protocols in WSN: network based structure and protocol based operations. Based on network structure topology, routing protocols are classified [22]into: Hierarchical, Flat and Location-based protocols. According to protocol operations topology, routing protocols are categorized into: Quality of Service (QoS)-based, Negotiation-based, Multipath-based, Query-based and Coherent-based routing [23].

The proposed method shows the strategy for creating routing path between nodes and base station. Hierarchical routing algorithm is used in our method which is based on Ad hoc On-demand Distance Vector (AODV)as described in [6]. Here, the proposed method considers the following WSN topologies to design the routing protocol in a good manner:

a) The lifetime of the sensor nodes and the entire WSN will be increased by keeping most of the nodes in sleeping mode and wake them up after detecting an event in the surrounded environment.

b) The location of the sensors themselves and their neighbor's nodes should be available for the nodes.

We have implemented for this paper two simulations environment parameters the first one is initially divided into seven clusters as shown in Figure-4 in order to solve the coverage problem between the far nodes and the base station by selection prime node in each cluster. These prime nodes should have certain capability to cover the range of wireless of its cluster with optimum energy consumption with the fact that these primes must have energy unit that have more capacity than the traditional nodes in the cluster. They also have transceivers with larger range of transmission.

4. SIMULATION AND RESULTS

As pointed out in [3], the result of simulation of the proposed method shows the identified prime nodes appeared in each cluster and how they have the large cover of neighbor nodes in the same cluster. Network Simulator NS-2 (USC-NS2, 1989) is applied to design the routing protocol. The simulation employs the AODV as a routing protocol to discover and maintain the routes between the sink and destination nodes. Furthermore, this simulation uses IEEE802.15.4 as a Medium Access Control (MAC) and Physical layer (PHY) protocols (IEEE802.15.4, 2003). The first simulation model as in [4]had at 100 wireless sensor nodes distributed in network grid of distance 100 meter square. This simulation has used the Two Ray Ground radio model to transmit the radio frequency in

donate shape with same amount of transmission power and reception power while the prime nodes must have more transmission and reception power to reach far nodes.

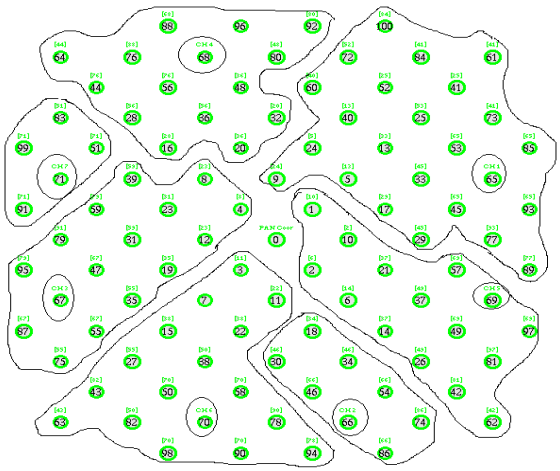

Figure-4. The first simulation to implement the proposed technique.

In the first simulation, we assigned fixed transmission powers for regular sensor to cover 20-meter square grid size. Prime nodes can cover 60 meters square grid size. These sensor nodes are distributed systematically in clusters as the previous figure 4. A cluster head and prime node at least are required for each cluster in the proposed technique of prime nodes. These cluster heads and prime nodes can reach the network coordinator or the base station directly or through other sensor nodes. This systematic distributed grid guarantees 10 meters among the neighbor nodes.

The simulation used the NS-2 energy model with the following parameters: the sensor node initial energy (InitEng), the transmission power (rxPower_), and the reception power, (txPower_) of sending and receiving each packet. This energy model will calculate the energy of each node after sending or receiving packets based on the following equations that represent the relation between the node energy, the transmission power (txPower), reception power (rxPower), and how many times the node transmit or receive (txTime) and (rxTime) [12].

$$Node\_Eng = Node\_Eng - (txPower * txTimes) \quad (1)$$

$$Node\_Eng = Node\_Eng - (rxPower * rxTimes) \quad (2)$$

The simulation parameters are explained in the following Table-1. In addition, the full energy of each node was 4 joules and the full energy of the prime node was 12 joules.

Figure-5 shows that, the energy consumption rate of the proposed sensor nodes with the prime nodes has been much less the traditional network because most of the sensor nodes in the new network were in the sleep mode.

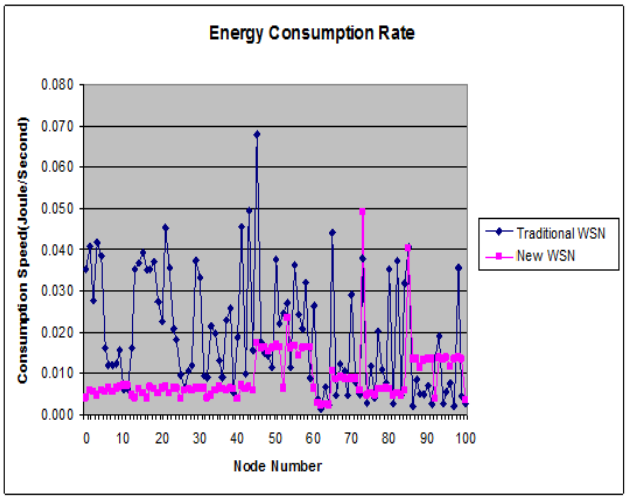

Figure-5. Energy consumption rate of the wireless sensor nodes.

To measure the delivery ratio in these two home networks, number of packets generated during all the time of the simulation. These packets were sent from different home devices to the destination server or the base station. As shown in Figure-6, almost all the packets were delivered correctly to the destination node in the new network with delivery ratio more that 98%. While the delivery ratio in the traditional network was around 60%.

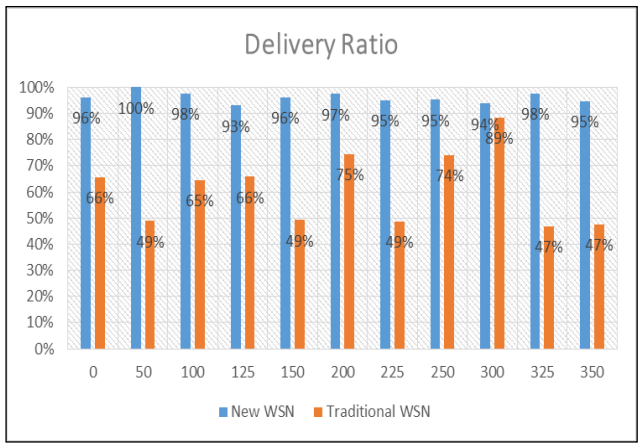

Figure-6. The delivery ratio during the simulation time.

As shown in Figure-7, all these results proof that the lifetime of the home sensor device in the new WSN is increased for most of the sensor devices to more than the double.

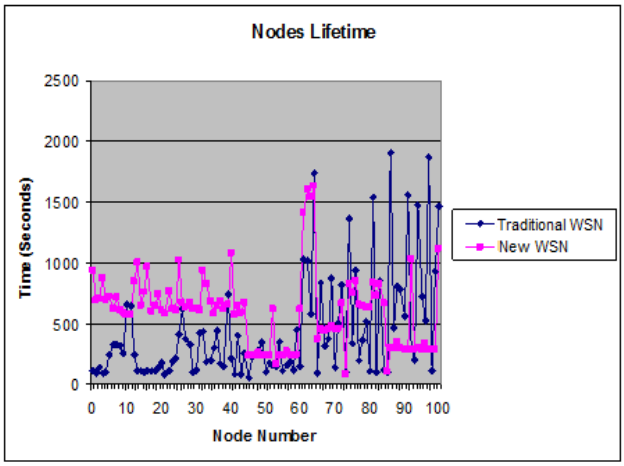

Figure-7. The network lifetime of the wireless sensor nodes.

Furthermore, in this paper we applied our routing protocol simulation with increased number of sensor nodes up to 1000 nodes to be more accurate as all the WSNs are density networks. The sensor nodes are distributed systematically in grid of size 500 x 500 meters presented in Figure-8.

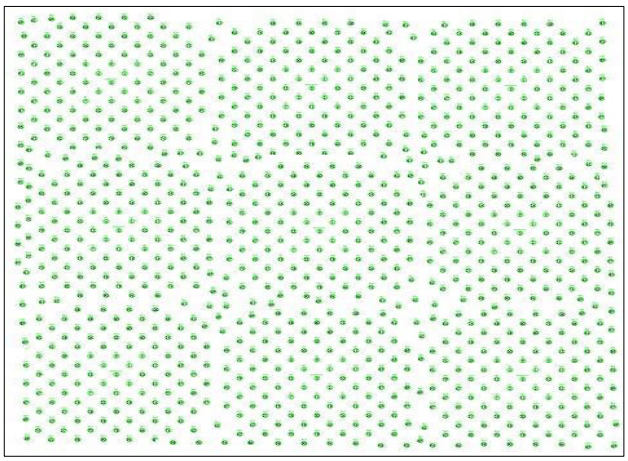

Figure-8. The density simulation grid using NS2.

The other simulation parameters were the same as the previous simulation parameters and the same energy model is used in the previous simulation of the 100 nodes but the simulation has been run for 15000 seconds rather than 500 seconds in that simulation. The WSN has been loaded by generating random events in both the tradition network and the new network with the prime nodes. These random events have been generating in all of the existing clusters.

In this simulation, the power consumption speed was also measure based on the prime nodes approach where only 160 nodes out of the 1000 nodes was active if nothing happened around them the result of these 1000 nodes simulation as shown in the following Figures 9 and 10.

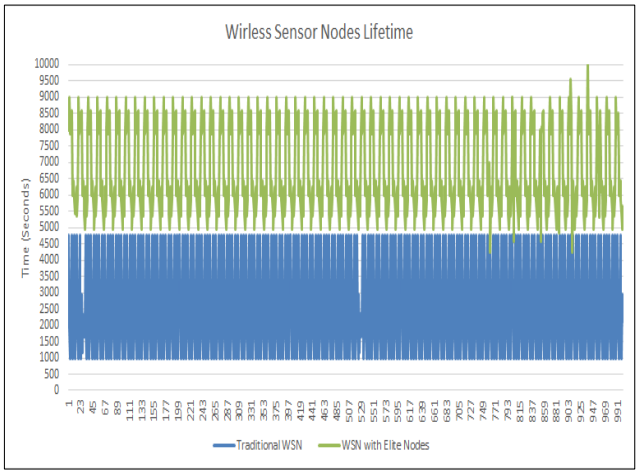

Figure-9. The density WSN lifetime of the wireless sensor nodes.

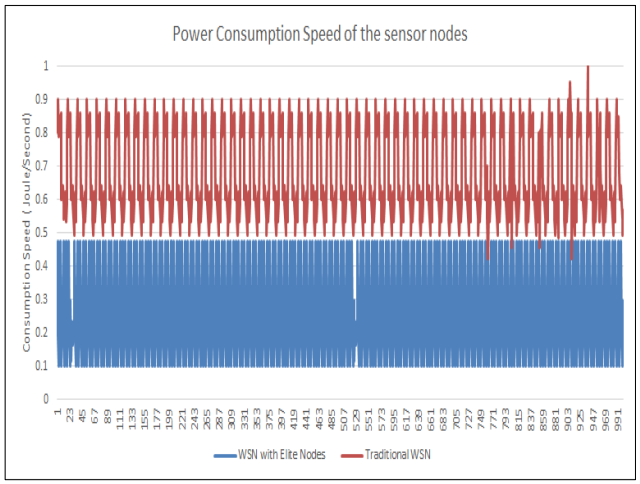

Figure-10. The power consumption of the density wireless sensor nodes.

5. CONCLUSIONS

Home automation systems are based in multi sensors functionality used in different application. In this paper, the coverage problem in the home sensors network with energy consumption of the sensor node is considered. The proposed method analyzed the sensor nodes to collect information about these nodes and group them to solve the coverage issue. One prime node is selected in each group which has the capability to reach any home sensor devices including the base station or the server device. The proposed model of the new home WSN with the prime nodes showed better results and let the nodes live longer that the original network in term of power consumption, nodes lifetime and delivery ratio of the new WSN with the prime nodes. Therefore, the proposed WSN has more than 98% delivery ratio of the sent packet to the base station compared with 60 % of them in the home systems with the traditional WSN.

DATA AVAILABLITY

No data were used to support this study.

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