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Improving the Network Life Time of a Wireless Sensor Network using the Integration of Progressive Sleep Scheduling Algorithm with Opportunistic Routing Protocol

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Abstract

Energy consumption is one of the major issues to be considered in wireless sensor network (WSN). The energy consumption problem is usually persistent in every sensor node, which occurs due to the communication overhead between the nodes and other environmental factors that keep on changing throughout the network lifetime. **Objective:** To improve the energy efficiency of a WSN integrating Progressive Sleep Scheduling (PSS) Algorithm with Opportunistic Routing Protocol. **Analysis:** The sensor nodes we use are generally battery operated which in most cases uses replaceable batteries instead of rechargeable batteries. The network lifetime will be effected due to the energy consumption of the sensor nodes. To improve this energy consumption, different routing methods are available, which are constantly under research and improvisation. **Methods/Statistical Analysis:** In this paper we propose opportunistic routing algorithm, where the selection of neighbouring nodes plays a very crucial role. Selection of neighbouring nodes in the network is one of the factors that improve the Energy consumption and network lifetime. To improvise this opportunistic routing algorithm to work even more efficiently, we introduce a sleep algorithm called, PSS algorithm for the sensor nodes integrating with Opportunistic Routing Protocol. **Applications/Improvements:** We implement our proposed system in NS-2. By integrating the PSS algorithm to the Opportunistic Routing Protocol in an energy constrained WSN, we've achieved the Optimal energy consumption with less energy overhead, which eventually increases the quality of routing in the sensor network.

Keywords: Energy Conservation, Neighbour Node Selection, Network Lifetime, Opportunistic Routing Algorithm, Progressive Sleep Algorithm, Routing, Wireless Sensor Networks

1. Introduction

The recent trends in wireless communication and wireless sensor networks are developed for most of the hardware platforms in use and they play a vital role in integrating the upcoming hardware and software technologies with ease. Such integrated wireless platforms employ tiny and low power wireless devices which have huge constraints on their resources. Wireless Sensor Networks (WSN) typically employs such sensors to monitor the physical environmental conditions such as Heat, sound, pressure etc. WSN find their applications in lot of industrial fields such as Medical, Industrial, Military and Agriculture, etc.

Sensor nodes in WSN will perform trivial tasks such as data processing, data gathering, communicating with

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other nodes. Each sensor node contains a sensing unit, processing unit, transmission unit and power unit. The sensing unit have Analog to Digital Convertor (ADC), Processing unit contains processor. The transceiver will be used in transmission unit. In WSN , the intermediate nodes are also called Relay nodes, these will be placed in between source and destination nodes. These sensors are placed particularly near the boundaries, this boundary area is called sensor field.

WSN faces lot of problems such as fading and interfacing in the communication scenario. In this paper we concentrate on communication scenario, where Routing technique will be our utmost concern. The importance of this emphasis on routing concept is minimising the routing power and improving the network life time[1]. Recent trends in research fields include Power Control, Security, Data Aggregation, Path Quality and Routing Techniques etc[2–5].

In recent years, the emphasis is on techniques related to routing[6,7]. We will have a brief look over several popular existing routing techniques such as Extremely Opportunistic Routing (EXOR), Energy Efficient Opportunistic Routing (EEOR), Coding Aware Opportunistic Routing (CAOR), Most Forward within Range (MFR) Routing, Geographical Random Forwarding (GeRaF), Qos aware Geographical Opportunistic Routing protocol etc[8–10].

1.1 EX-OR

The EX-OR (Extremely Opportunistic Routing) protocol is combination of routing protocol and MAC protocol. In this Routing protocol the data is sent from source node to destination node in the form of a packet which will traverse through all the nodes before reaching the destination. The path leading to the destination with the minimal number of node traversals is shortest path and finally the MAC protocol decides the shortest path. By employing this routing protocol we can achieve 35% of efficiency in the output and increase the network life time. This protocol will not support multicast routing. The implementation scenario is illustrated in Figure 1.

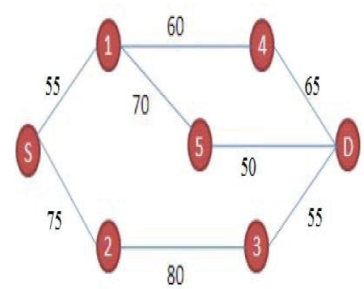

Figure 1. EX-OR Implementation scenario.

1.2 CAOR

In CAOR (Coding Aware Opportunistic Routing) protocol, coding plays a major role; the number of transmissions and duplicate transmissions are avoided in this protocol. Here the forwarding is done as that of EXOR protocol, but we calculate the ETX (number of expected transmissions), it will be calculated as

$$ETX = 1/\text{delivery ratio}$$

1.3 QoS Aware G-OR

This QoS Aware Geographical-Opportunistic Routing (G-OR) protocol improves the Quality of service than the previous existing Geographical-Opportunistic Routing (G-OR) protocol. In this protocol, forwarding path will achieve the network life and Quality of Service.

1.4 MFR

The MFR (Most Forwarded within Range) protocol will be mostly used on 1-D networks, the best and forwarding path is selected based on the Most Forwarded paths with in the range of the network. Here best forwarding can be achieved by the parameter, Probability Mass Function (PMF).

This routing scheme finds its usage in industrial and civilian applications such as Pipeline Monitoring, Electrical Power Monitoring, Intelligent Traffic etc., and the above mentioned applications are one-dimensional (1-D).

1.5 Opportunistic Routing Mechanism

In this routing approach we mainly concentrate on energy consumption. In many cases of WSN, direct communication is not possible in such cases we employ this technique. For this we have to select the best route between source and destination. The best route will be working on minimizing the energy consumption. For this process we use different types of forwarding methods namely Time Based Forwarding (TiBF), Token Based Forwarding (ToBF), Path Based Forwarding (PBF)[11].

Time Based Forwarding:

In this Forwarding method we use the Relay nodes in sensor network. The Relay node having the highest priority node will respond in the first time slot, next priority will respond in next time slot and in this way at Mth priority node will responds in Mth time slot. This forwarding method is having the major drawback of duplicate packets if weighting time of each node is high.

1.5.1 Token Based Forwarding

To improve the time based forwarding, we introduce a method called Token based forwarding. In this method Tokens are generated at the high priority nodes and particular nodes in a sensor network, in this scheme, data will be processed based on priority levels.

1.5.2 Path Based Forwarding

Present systems use this type of Forwarding method, because it gives best path than the above Forwarding methods. In this the best path is achieved by calculating the delivery ratio and average probability delivery ratio, this value will be calculated by source node, it will sends the packets and analyse requirements than selected the path.

2. Proposed Method

2.1 Network Model

We consider a 1-D multi hop queue model, in this queue model, Relay nodes are considered, those nodes having more number of neighbour nodes, each and every node having information about source node, destination node and neighbour nodes. Each node having maximum transmission range (Tr-max) and minimum transmission range (Tr-min), the 1-D queue model represents through a graph G = (V,E), where E is the set of direct link between communication nodes, that is the edges of the graph and V is set of sensor nodes aligned in one particular direction, that is the vertices of the graph. We set the nodes in a particular order of (0,1,2,3,..................,z-1,z), here starting node is assumed as the source node and final node is assumed as the destination node. N(i) represents the set of neighbour nodes, the link between nodes is represented by (a,z) and weight of link is given by W(a,z).

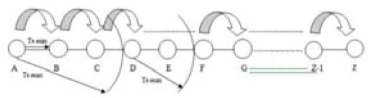

Figure 2. Network Model.

Here we've taken a 1-D industrial pipe line that is shown in the Figure 2. These pipelines have nodes that are arranged in Uniform manner. Here each and every node will be source, relay, sleep, and destination node simultaneously.

The node will be represented in alphabet. The node transmission range is bounded by maximum and minimum values. The maximum transmission range will represent in Tr-max and minimum transmission range will represent in Tr-min. Here all the nodes will play the role of source or destination or relay/sleep role.

2.2 Energy Calculation

Our main concern is reducing the power or energy cost, will explained in this section. In WSN network life time mainly depends on energy constraints. Because of this, more research work is going on energy reduction and improvising the routing efficiency. In WSN the energy calculation will be in two stages: 1. Transmission stage and 2. Receiving stage. Here we mainly concentrate on transmission stage,

The energy calculation is given by

$$ET = Eelec + ODP \quad (1)$$

Where ET is the total transmission energy, Eelec is sensor board electric energy and ODP (Optimal Distance Path).

In transmission power calculation, environmental factors and noise also considered. This transmitter energy calculation, ODP will calculate by the Theorem 1, which gives the Optimal Distance Path (ODP). We consider a large sensor network, in which each node having the position that will be N(i),it will also be considered in calculation, this will be given by

$$ODP = ZN(i)/N+W(a,z) \quad (2)$$

Where Z is the destination node, N is the number of nodes and W(a,z) is Link weightage of communication nodes. This Link weightage will calculated by

$$W(a,z) = E(a,z)Ld \quad (3)$$

Where E(a,z) is energy consumption of only transmission of data and Ld is the Length of Transmitting data from source to destination. From Equations 2 and 3 we calculate the energy consumption at Transmission stage.

2.3 PSS (Progressive Sleep Scheduling) Algorithm

This calculation will be helpful in selecting the best Relay nodes in network by Opportunistic Routing protocol, when the working part of this Relay node is completed, it will change the mode to Sleep. The changing of mode is achieved by applying PSS (Progressive Sleep Scheduling) algorithm. In this algorithm some nodes are working and the remaining nodes are in sleep mode, the working nodes are selected by the protocol mechanism is the best path selection of the nodes. This algorithm will support static networks and does not support dynamic networks because this algorithm will be used only in 1-D networks. These networks were fixed and they cannot change their locations. The PSS algorithm flow is illustrated in the Figure 3.

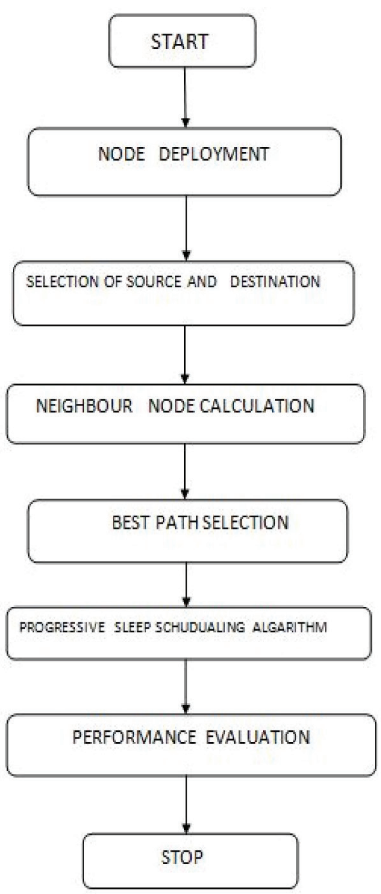

Figure 3. PSS algorithm flow process.

3. Performance Evaluation

We conduct the simulation of our proposed system in Network Simulator(NS) 2,Here we've taken some nodes and arranged in a fixed 1-D pattern.

To perform simulation, we've taken 10 nodes under our test case. Eelec value is taken as 50×10^{-9} J/bit at a sending rate of one packet per second, Packet transmission range of 25 m and finally testing time of 10 ms. Here, all the nodes are arranged in a Uniform manner. All the parameters we've taken to perform the simulation are defined in the Table. The major parameters are tabulated as shown in the tables 1 and 2. The simulation is carried out in NS2 simulator.

Figure 4 shows the cluster head or source node having number of bits at initial stage and the increase in the performance time and the difference between initial and the improved values are shown in Figure 4, the cluster head comprises of more number of bits and encompasses the extended lifetime as compared to the previous method, this nodes lifetime will enhance the overall network lifetime.

Figure 5 shows the live nodes in the network, in any network live nodes are very high in the initial stages of the operation. The nodes after performing for some time become dead. We can observe from the Figure 6 that the

Table 1. Parameters

Parameters	Parameter's value
Deployment area	50m x 50m
Node arrangement	Uniform
Number of nodes	10
Packet Transmission Range	25m
Sending rate	1 packet/sec
Testing time	10 ms

Table 2. Abbreviations

Abbreviation	Full Name
ODP	Optimal Distanse Path
Tr-max	MaximumTransmission range
Tr-min	MinimuTransmission range
TiBF	Time Based Forwarding
ToBF	Token Based Forwarding
PBF	Path Based Forwarding
PSS	Prograssive Sleep Schuduling algorithm

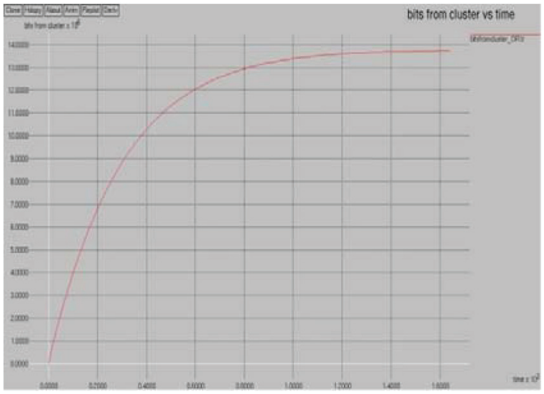

Figure 4. Number of bits at initial stage vs. Time plot.

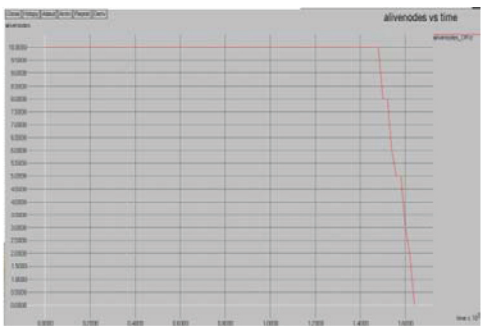

Figure 5. Live node representation vs. Time plot.

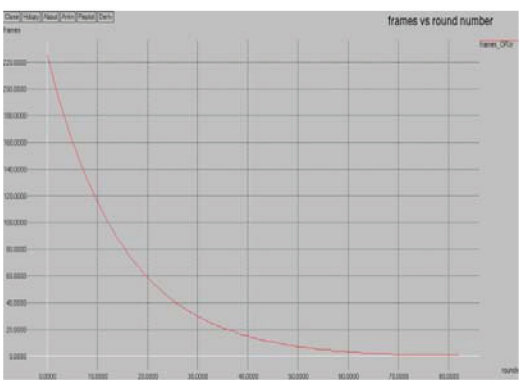

Figure 6. Frames vs. Round Number plot.

live nodes are more in number than the dead ones .The frames over the nodes are also shown.

4. Conclusion

WSN finds their use in wide variety of applications in monitoring and controlling in our day to day life with their reliable and flexible features such as low cost, minimal power consumption, implementation simplicity and maintainability. The only concern her is the limited life of the non re chargeable battery life of the individual sensor nodes. Hence this battery power conservation is one of the primary aspects of designing a routing protocol for a WSN.

Our work in this paper emphasizes on lowering the power and energy consumption and extending the lifetime of 1-D queue networks, where sensors are deployed to predetermined areas. Our developed system optimizes the energy efficiency of the network by employing the opportunistic routing methods by evaluating the distinctions among the individual sensor node distances to the energy sink and energy of each other. Our concern in this paper is to implement this opportunistic routing methodology to the relay nodes to improvise the optimal transmission distance, which will greatly extend the network lifetime. Therefore, we developed an energy efficient opportunistic routing methodology combined with progressive sleep scheduling algorithm which facilitates the network in consuming minimal amounts of power and also ensures a protective method for individual sensor nodes with relatively low energy. Our system test cases demonstrate that developed system employing Opportunistic Routing technology integrated with Progressive sleep scheduling algorithm makes practical and vital improvements in energy conservation compared to the conventional methods.

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