



Synchronous Multisink Self Organized Routing Protocol for Wireless Sensor Networks

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Abstract:

Wireless sensor network is a network that is used to collect and send various kinds of data in a region where wired medium cannot be used. The simplest approach is to directly transmit the data to the base station. The problem here is if the base station is located far away from the target area more energy is consumed to transmit the data. Since the nodes have limited battery power and if more energy is consumed battery gets down quickly. Replacing the battery in WSN is a critical task. Therefore the greatest challenge in WSN is improving the lifetime of the network. Many protocols have been introduced to consume the energy and use it efficiently. In this paper, we propose a protocol namely time synchronous multisink self organized routing protocol. The nodes involved in this protocol can build its own tree and they transmit the data based on time slots allocated to them. Each time data is transmitted based on the time slot and if any node fails, further the data of that is transmitted by the neighbour node automatically. The simulation results prove that the performance of our protocol is better when compared with the other protocols in network lifetime improvement.

Index Terms:

Network Lifetime; Sensor Nodes; Time Slot; Self-Organized; Wireless Sensor Networks

1 INTRODUCTION

Advancement in various technical fields produced variety of sensor nodes with low cost. These sensor nodes are not powerful as the expensive one; also they have limited

battery power. The main purpose of wireless sensor nodes is to collect and send the information to the base station by the cooperation of the sensor nodes. WSN has become one of the major research area in current scenario and has a variety of application in military, surveillance, monitoring the environment, disaster prevention etc. The applications of WSN are in very critical areas where data loss cannot be compromised.

These sensor nodes are deployed densely in a region where wired medium cannot reach and where data changes often. Once if it is deployed, it must monitor all the changes and send the data to the base station. So to perform this work properly the battery power of the sensor node is an important parameter. Another challenge in a sensor network is data collision due to data overhead. Many protocols have been introduced to avoid these shortcomings. Protocols such HEED, PEGASIS are self organized routing protocols. CSMA protocol is mainly designed to avoid data collision. Among the above said routing protocols and data aggregation, that reduce sensor energy consumption and data transmission delay, packet scheduling (interchangeably use as task scheduling) at sensor nodes is highly important since it ensures delivery of different types of data packets based on their priority and fairness with a minimum latency. Indeed, most existing Wireless Sensor Network operating systems use First Come First Serve schedulers that process data packets in the order of their arrival time and, thus, require a lot of time to



be delivered to a relevant base station. However, to be meaningful, sensed data have to reach the BS within a specific time period or before the expiration of a deadline. Additionally, real-time emergency data should be delivered to BS with the shortest possible end-to-end delay. Hence, intermediate nodes require changing the delivery order of data packets in their ready queue based on their importance and delivery priority.

In this paper, the proposed protocol namely synchronous multisink self organized protocol data is transmitted in time slots. The nodes can transmit data in their time slot and also it can transmit in others time slot based on the priority of the data it holds. On transmitting the data the sensor node moves to active state if not it remains in sleep/idle state. This can save energy in the sensor network.

Further the paper is organized as section II related work, section III system model, section IV about the protocol, section V the results are analysed finally the conclusion and references.

II RELATED WORK

Power Efficient Gathering in Sensor Information Sensor is an improvement over Leach, HEED protocols. The overview is [2] each node communicates only with a close neighbour and takes turn transmitting to the base station, thus the amount of energy spent per round is reduced. All the nodes are placed in the field. The nodes are organized to form a chain; this can be accomplished using the greedy algorithm. This chain is broadcasted to all the sensor nodes. Chain formation is done from the farthest node as the starting node. When a node dies, the chain is reconstructed again in the same manner. In each round the node receives data from one node, fuses the received data with its own data and transmits to other neighbour on the chain. Nodes take turn to transmit data to the BS. The nodes are selected based on the formula $i \bmod N$. Once the leader node has been selected for each round, a simple control token initiated by the leader is send to the other nodes, indicating to

start data transmission. The improvement over leach is that most of the nodes transmit are much less compared in Leach. The amount of data for the leader to receive is at most two messages instead of 20. Finally only one node transmits to the BS in each round of communication.

Another energy efficient protocol is the HEED protocol. There is no assumption about the presence of infrastructure or node capabilities. In this protocol cluster heads are selected periodically based on the residual energy and secondary parameter. This secondary parameter may be node proximity to its neighbour or node degree. The overall goal is to increase the lifetime of the network. Clustering the approach used here. The purpose of the parameters mentioned above is to select an initial set of cluster heads probabilistically and to break ties among them. In each round the cluster head is changed based on the coverage area. The advantage of HEED protocol is the nodes automatically update their neighbour sets in multihop networks by periodically sending and receiving heartbeat messages. HEED prolongs network lifetime, resource usage is optimized according to network density.

A General Self Organized Tree Based Energy Balance routing protocol is a tree based self organized protocol. The overview of this [1] protocol is for each round BS assigns a root node and broadcasts this selection to all sensor nodes. GSTEB is a dynamic protocol. The main is to achieve longer lifetime. The operation is divided into five phases. The first phase, the initial phase the network parameters are initialized and has three steps. When the initial phase begins, BS broadcasts a packet to all the nodes to inform about the beginning time, the length of time slot and the number of nodes N . Each node sends its packet in a circle with a certain radius. Each node sends a packet which contains its entire neighbour's information. After this phase the protocol operates in rounds. Tree constructing phase, the second phase constructs the routing tree. For this



process the BS assigns a node as root and broadcasts root ID and root coordinates to all sensor nodes. To avoid network overhead in each round the node with largest residual energy is chosen as root. After the routing tree is constructed the next phase data collecting and transmitting phase starts. Each sensor nodes selects information to generate a data packet which needs to be transmitted to BS. This round is divided into three segments. In the first segment, the parent node is checked for any communication inference. In the second segment, the leaf nodes for data transmission are confirmed. In the third segment, the permitted leaf nodes send their data to their parent nodes. The last phase information exchange phase transmits the collected information. The nodes that are going to die will inform the other nodes. This phase is divided into various time slots. In each time slot the nodes that are going to die will compute a random delay. GSTEB outperforms HEED, PEGASIS. Since it is self organizing tree based protocol it only consumes a small amount of energy in each round. It prolongs more lifetime when compared with PEGASIS.

Low-cost non-intrusive wireless sensor network is ideal for high-fidelity data center monitoring and helping improve energy efficiency. However, the stringent quality of service (QoS) requirements such as real-time data delivery together with the dynamic nature of low-power wireless communication render traditional MAC protocols inapplicable to high-fidelity data center sensing networks. In this paper, we present RoMac, a localized QoS-aware TDMA MAC protocol for high-fidelity data center sensing networks. The key contributions of RoMac include: (1) it provides collision-free communication and persistent QoS guarantee such as constant packet jitter and bounded latency; (2) it is resilient to topology dynamics and truly traffic adaptive in dynamic environments. This is the first TDMA MAC protocol that can achieve the resilience to dynamic topologies; (3) its localized design eases the need of scheduling message exchange beyond the initialization

phase. The protocol is implemented using Tiny OS operating system running on the iMote2 sensor mote platform. The experiment result shows that RoMac can achieve the adaptability to dynamic changes in data collection sensor networks and provide persistent QoS support in terms of timeliness, packet jitter and fairness.

Wireless Sensor Networks have been evolved and applied to industrial, commercial, defense and civil applications. Energy is the main constraint in sensor networks. Energy management techniques increases the life cycle of sensor network and enhances the performance of throughput. Multi-hop communication and clustering approaches are used to save the node energy in sensor networks. Energy aware protocols minimize the participation of sensor nodes with less threshold energy and selects optimal energy path. In sensor networks, Cluster Heads (CHs) collect data from the sensor nodes and forward it to the neighbouring CHs and finally to the Base Station (BS). CHs contribute to save the node energy. Cluster management techniques aim to minimize the number of clusters, density of clusters and energy consumption per cluster. In this article, we propose Self-organized Energy Conscious Clustering protocol (SECC) for WSNs to group the sensor network into clusters based on node energy and node distance. If the node energy is below the threshold value, SECC forms self-organized clusters and re-organizes the sensor network. Nodes with energy attributes less than the threshold value are eliminated from the clusters to maintain energy efficient sensor network. Energy aware cluster management in SECC is based on node parameters (like node distance, node energy, node density) and cluster parameters (like cluster density, sensor nodes per cluster). Performance analysis and simulation results are given with variations in number of clusters, energy levels and node distance.

Synchronization of tiny sensor nodes forming Wireless Sensor Networks (WSNs) is a challenging problem due to frequent

topological changes, node failures and power, memory and computation constraints. These difficulties promote a self-organizing solution for the problem of time synchronization in WSNs to be quite desirable. Current self-organizing time synchronization protocols in WSNs have drawbacks: They either provide synchronicity but not a common notion of time for the nodes in the network or they demand keeping track of the time information of the neighbouring nodes. The latter drawback becomes quite crucial especially on dense WSNs, which makes available self-organizing time synchronization protocols impractical. This paper provides a novel self-organizing time synchronization protocol for WSNs which does not require keeping track of the neighbouring nodes. The main component of our protocol is a computationally light "adaptive-value tracking" algorithm which synchronizes the rate of each sensor node to that of all its neighbouring nodes through successive feedbacks. We show by simulations that the proposed protocol achieves a tight synchronization which results in the desired property of global time notion after a finite amount of time on dense networks. Although there is no formal proof yet of the protocol's convergence, we anticipate this protocol could be used as a practical time synchronization approach.

III SYSTEM MODEL

The system is designed as follows:

- (i) A group of sensor nodes deployed randomly.
- (ii) Sink node covers maximum range of sensor nodes.
- (iii) Sink node is a static one which consumes less energy.
- (iv) Sensor nodes form a tree structure and

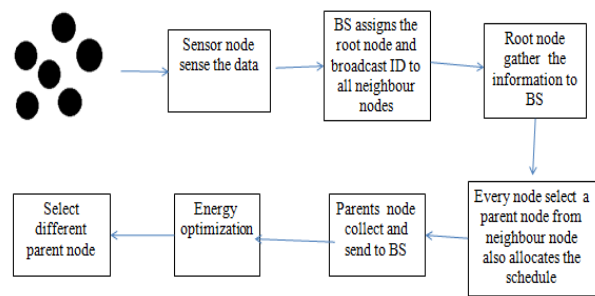


Fig.1. System Architecture

can act as parent and child.

The above provided is the system architecture. It works as described below. Once the sensor nodes sense the data they are ready to transmit the data. Initially the base station assigns the root node and broadcast the ID of the root node. Other nodes can select their own parent node based on the energy level. All the data is given to the root node and the root node transmits the data to the common sink thus reducing the energy consumption. Also each node is assigned a time slot during which it can transmit the data.

Transmitting = (No. of packets transmitted) * (Transmission Power)

Receiving = (No. of packets received) * (Receiving Power).

Energy is given in the form of joules per second.

We compare our system with the existing system that transmits data only during the time slot assigned to it in which the delay is more. We compare our results based on the data overhead, delay packet rate, energy used.

IV SYNCHRONOUS MULTISINK SELF ORGANIZING PROTOCOL

The protocol operates in various phases. The operation of the protocol is given below.

A. Network formation

Initially the sensor nodes are formed having their sink nodes placed based on the



coverage area. The network is formed based on a tree structure that is with parent node and child node. The nodes have the capability to select the sink node based on geographical position of the sensor nodes. All nodes can act both as parent node as well as child node. Also any node can select its own parent to forward the data. The responsibility of the parent node is to collect the data from its entire child node and aggregate the data and forward it to the sink node. Since our system consists of multisink the nodes create different topologies based on the direction of the sink node.

B.Route Maintenance

In our system we use improved TDMA method for forwarding the packet. It is very important in WSN to forward the packets properly according to its priority and soon on. Therefore the nodes are given some time slots to transmit the data. In our system all the nodes can move to sleep state and active state at the same time interval. If any node holds some data to be transmitted both the sender and receiver node should first move to active state and then transmit and receive the data respectively. During this transmission other nodes can either be in sleep state or idle state. To provide synchronization between the sender and the receiver node RTS/CTS is used. Each node is provided with time slots. Initially the total time slot is assigned further this time is divided into sub-slots. Every node have the capability to synchronize the timer therefore the nodes know the beginning and ending of the time slot. At the beginning of each time slot the nodes will be in idle listen mode. If any nodes have data to be forwarded they initially check the availability of the time slot then the sub-slot. If any node fails the neighbour node takes the responsibility of the failed node and stores the data and forwards it from the point of failure. Based on the priority level slots are allocated to the nodes.

C.Synchronous based routing

The type of transmission used in our system is synchronous transmission where the data of the failed node can be further

transmitted by the neighbour from the point of failure. In sensor network, while transmitting and receiving the packets results in energy loss in the battery level of the nodes. Further decrease in battery level may result in failure of the node. Once the node fails transmission gets halted and data may be lost. In our system, if any parent node fails the child selects an alternate parent to transmit the data. The main idea here is the new parent will resume or start transmitting the data only from the point of failure. This results in consumption of energy and avoids repetition of data to the sink which may reduce data overhead. Only the data that is not transmitted already is transmitted by the new node. The algorithm used on our system is as follows: Initially the nodes are given its time slot based on the priority of the data. Then the nodes are synchronized with timer.

Algorithm

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If synchronization is completed
if data generated
set the mode (priority or non-priority)
a.checks the pkt priority
i ) if prio-pkt
    then set the pkt sending in next slot as
    starting pkt
ii)if non-prio-pkt
    then add into buffer
I ) if data recv
    continue the same process as I-b
II ) if current time is for next slot
    count the current slot number
a.if slot number matching with own slot
    i)set the timer for own slot access
b.if slot number is others
    i)set the timer for other slot access
c.schedule next slot
III ) if current time is to access own slot
a.check the mac
    i)if free
        send the data
    ii)if not
        re-buffer the pkt
IV)if current time to access other slot
(continue the process of (II-a))
V)if current time is to emergency pkt

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forward the packet immediately

The algorithm works as follows initially the network is formed. The child node selects its own parent based on the energy level. The node with higher energy level is selected as the parent node. The parent node forwards the data to the sink node. Once the network is formed the time slots are allocated to every node. This total time slot is divided into three slots namely priority slot, own slot and other slot. Each time before transmitting data the node checks for the slot then the sub slots. After the time slot is allocated then the nodes are synchronized with the timer by which it can know about the beginning and ending of every time slot. After synchronization gets completed then if data is generated the mode of the packet is set. If the packet is a priority packet then the corresponding packet is send in the coming slot as the starting packet. If the packet is a non-priority packet then add the packet into the buffer. Now in the receiving side, if data is received the route is proper and the process can be continued further. Now the current time slot is checked. If the current time is for the next slot to be started then the slot number is counted to know the packet size. If the current time matches with the own time slot number then set the timer to the own slot access. If the time slot equals other time slot set the timer as such. Finally schedule the next slot. Other than these entire if the time slot is to access the own slot then check the Mac. If the Mac is free forward the data if not re-buffer the data. If the current time is to access the other slot the follow the procedure performed already. If suppose the current time indicates an emergency packet forward the packet immediately. Thus the packets are forwarded to the sink node. Thus the algorithm for transmitting the data to the sink node is energy efficient when compared with the other algorithms for data transmission in WSN.

V COMPARISON AND SIMULATION RESULTS

The simulation is performed using NS2 simulator where a NAM and Xgraph is generated. The proposed is compared with the

normal TDMA based system with a tree structure consisting of single sink. In the existing system all the nodes are organized and they are allocated a time slot. Every node can transmit data only during its time slot even if the data is an emergency data. This is the normal topology of the existing system with 17 sensor types and single sink. In the normal TDMA model each node has the slot to transfer the data. The fig below shows the result of time slot allocation. First figure shows the confirmation message sharing for allotted slot information and the next one depicts the requesting message to own slot allocation.

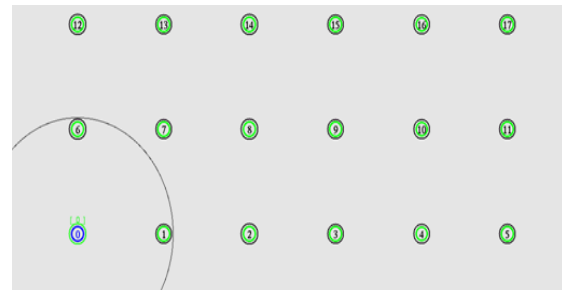


Fig.2 Node 0 shares the confirmation message.

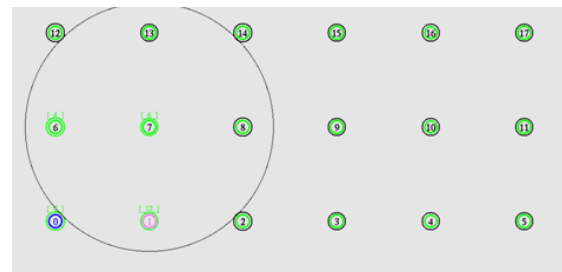


Fig.3 Node 0 shares the slot request message

Here the nodes can transmit data only during their time slot therefore nodes must be aware about the time slots. If a slot is allocated to some node the same cannot be accessed by any other nodes. Therefore nodes must be aware about the previous and next two slots. Also data can be transmitted only in the own time slot in the existing system. In our proposed system, initially the base station shares the originating message once the time slot allocation has been completed. The originating message consists of the routing information in which the packets are to be forwarded. Once the nodes receive this

message they forward to the other nodes and also update themselves about the routing information. The route to destination will be selected based on less hop count. Once synchronization of the timer gets completed data can be transmitted. In our system total time is divided into slots then sub-slots. But the difference is in our system data can be transmitted in own slot as well as in other slot. The total time slot is divided into three slots that is priority slot, own slot, other slot. If there is any priority data present in the node, then the node can transmit the data at the beginning of the time slot whether it may be other or own slot. If there is no priority data the node checks the current slot whether it is own or others. If the slot is own slot means the node can send the data in the coming slot. If suppose the current slot is other slot then it wait for the next slot to begin. The figure depicts the data transmission in the next slot since the current slot is the other slot.

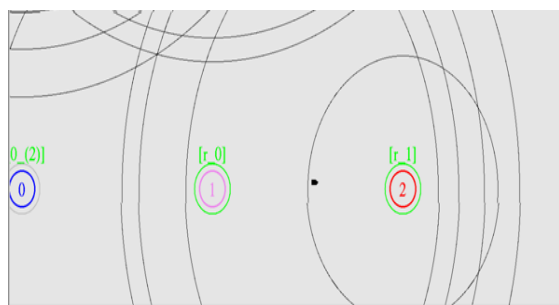


Fig.4 Data transmission in other slot

If there occurs any node failure the first neighbour or the second neighbour transmits the data from the point of failure. It is the responsibility of the neighbour to check for the active participation of the nodes. Since the node transmits data only from the point of failure energy can be saved more thus reducing data overhead. In fig.4 our system is compared with existing system based on the packet rate. The packets transmitted for the total time is higher in our system than the existing one. The packets delivered are acknowledged by the receiver side. Since the nodes in our system can transmit data both in own slot and also other slot the packet rate is increased. Also emergency data is given

higher priority in our system therefore this proposed system is considered best among the other protocols. By using xgraph we can see the performance of different technique. We did our project in progressive manner. First we have implemented the model of Basic Smac method. In basic SMAC each node has the independent timer to make on and off the node. In basic smac each node will announce it status by the synch message. Here we have implemented the basic SMAC mode in AODV protocol (AODV protocol is simple and easy to access and modify that's why we have selected aodv protocol to manage sleep). Then we have implemented Time slot allocation like basic TDMA method with sleep mode control, and then we have added the priority model with TDMA model. To make IHMAC we have implemented other slot access by dividing time slot into three small slots, and then we have applied the power control technique. We tested our implementation with various parameters like connection throughput, packet delivery fraction, end to end delay, energy and overhead. Connection throughput is defined as ration b/w total received packet size from a node and duration of the communication. And packet delivery function is nothing but the ratio b/w received packet and sent packet. And end to end delay is defined as difference of received time and sent time. Overhead is nothing but the number of extra packet used to synchronize and find the route.

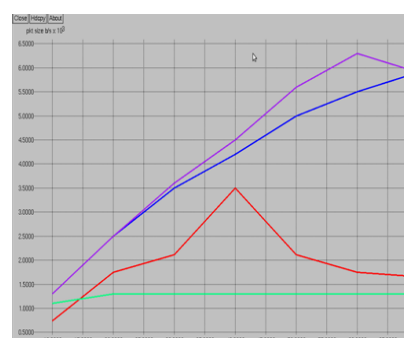


Fig.5 Throughput comparison with various implementations

Fig.5 shows the comparison result of throughput variation. In basic TDMA method,

node can send the data always in own slot. Throughput level is limited to some fixed threshold level of time slot (fig. 5). For Basic TDMA model, the PDF is very low due to fixed time slot, pkt generation will be more but limited packet can only be received in destination.(fig.6), due to fixed time slot delay is increased further more (fig 7).

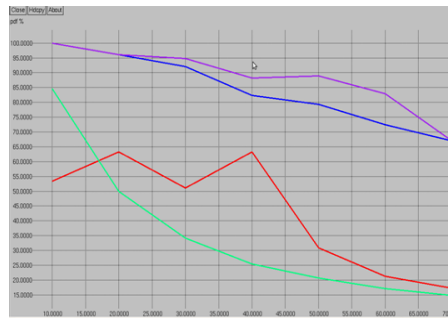


Fig.6 Comparison of PDF

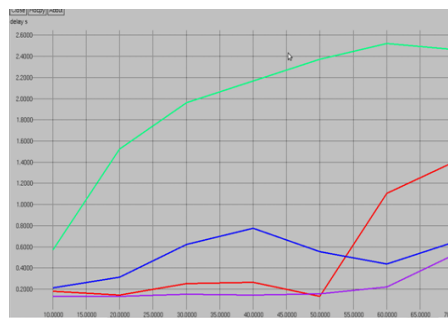


Fig.7 Comparison of Delay

But in Basic SMAC there is no fixed slot to transfer the data, so each node can send the data in any time by using CSMA method. The throughput depends on only the congestion level. If number of nodes tries to send the data at the same time then collision will occur then no communication can be initialized. If there is less number of nodes for communication at a time there may be less collision then communication will be initialized.

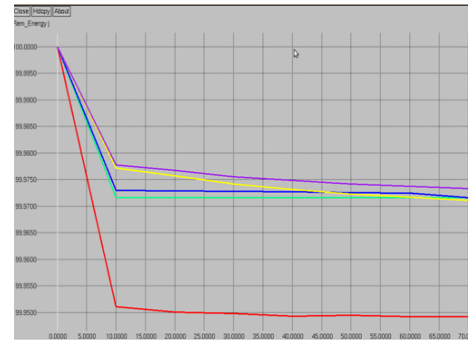


Fig.8 Comparison of energy level

In fig.8 there is peek throughput with data rate 40kb, and remaining places less throughput. In CSMA method each node has its own random back off time to make communication. Due to independent random exponential back off time, node retrying time will vary; here at 40kb data rate collision is less so throughput is increased (fig.5) and PDF also increased (fig.6) and delay reduced (fig.7).

For TDMA with priority method, the node can use the others time slot if it has priority data. And it checking with CSMA method to detect the collision, so almost we can remove the collision and we can improve the throughput further compared to Basic SMAC method (fig.5) and in priority model we can reduce the delay further compared to Basic TDMA method. But if the data missed one slot means it should wait for another slot but in SMAC there is no time slot so priority based transmission has some extra delay compared to basic smac (fig.7)

Synchronous multisink self organizing model with power control and without power control has same performance at all the parameter other than energy remaining (fig8). In this model we have divided time slot into three parts so the performance is increased further. Therefore our system provides good performance in all the parameters. Since the transmission is done in synchronous manner no data is repeated again and again therefore data overhead is reduced and energy can be consumed further. The Xgraph results show that our system outperforms the existing



system in improving the lifetime of the network.

VI CONCLUSION

In this work we have introduced multisink synchronous self organizing protocol that transmits data in a synchronous manner based on time slots. The use of multisink eliminates data overhead, traffic and failure of the sink node. Synchronous transmission can also increase the lifetime of the network by not repeating the same data to be transmitted again and again. Using improved TDMA method reduces delay in delivery of data to the sink node. In comparing with the system with single sink and asynchronous mode of transmission our protocol outperforms by improving the lifetime of the network and reducing delay.

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