An Optimal Energy Allocation Scheme for WSN Based on Data Fusion In The Presence of Transfaulty Nodes

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Abstract: In this work, we proposed a data fusion technique to increase the network lifetime and energy efficiency. Sensing data is collected, processed, filtered and forwarded through cluster head to the base station contains the supported values refined from the data received and pre-processed with data fusion. In this paper, the approach for the data pre-processing is modified to involvement of data fusion along with the routing modified to makes the better utilization of the computing environment using data fusion and provide network a better life time and better energy efficiency. Also proposed a scheme OEAS (Optimal energy allocation scheme) for optimal energy allocation to nodes. Also used cluster head selection techniques. cluster head is selected on basis of its energy level, there are few addition essential factors which makes nodes an ideal candidate to be cluster head such as: Reliability of nearby nodes, Quality and Node reliability. As a result the simulation results come in favour of what it is designed for to increase in network's life time and data efficiency and reliability of the network data increases.

Keyword: Base Station (BS), Cluster Head (CH), OEAS Algorithm, Network lifetime, Transfaulty Nodes, Wireless Sensor Network (WSN).

1. Introduction

WSN is the network formed by the wireless sensor nodes having the limited resources and computational power. WSN can be defined as a network of devices, denoted as nodes. These nodes can sense the environment and communicate the information gathered from the monitored field (around environment, humidity or volume etc.) through wireless link. In the next section, the environment definition and its contents have been presented. The Wireless Body Area Networks (WBANs) application concerns the human body health only; the WSN may be utilized for public health environment monitoring. So, with the expected and complementary working the WBANs may be work as a branch of national WSN of public health saving within specific area or governor or complete country. In the WSNs, nodes are simple and low-complexity devices; the typical applications require few bytes sent periodically or upon request or according to some external event; every node can be either source or destination of information, not both; some nodes do not play the role of routers; energy efficiency is very relevant matter, while capacity is not for most application. Therefore, WSN are not a specific case of wireless ad-hoc networks. Thus, a lot of care must be used when considering protocols and algorithms which are good for ad hoc networks, and using them in the context of WSNs.

2. Routing Protocols in WSNs

Routing protocols are used for route the nodes to reach the source to destination. Routing protocols are very useful and important for the WSNs. Classification of routing protocols in WSNs are as follows:
Three main classifications of routing Processes are:
1) **Proactive**: Routes from each node to the base station are predefined.
2) **Reactive**: Routes from each node to the base station are defined when there is a demand for the route.
3) **Hybrid**: Some routes are predefined and some are defined after the demand is raised.

Other general classifications are:

- **a) Based on the structure of the network**
  - **Flat Routing**: In flat routing each node in networks are assigned the same task. To produce the final result different nodes with identical task collaborate & co-operate with each other because there are large number of nodes so global addressing not possible and the result is dispatched on the basis of some query. This technique of dispatching result according to query is known as date-centric approach because the date is dispatched according to some attributes E.g. [Temperature >60°F] only the node which sense the temperature >60°F sends the result to BS. There is number of protocols which come under this category.
  - **Hierarchical Routing Scheme**: Hierarchical routing is also known as cluster based routing. In this type of routing the nodes with higher energy are used for computational and communicational purpose, while the nodes with some low energy are used for sensing purpose only. It is more efficient technique as compared to flat routing. Data is aggregated and fused at cluster level which decreases the number of packets being sent from source to destination, which in turn decrease the consumption of energy. Use of cluster heads is an important feature of hierarchical routing.

- **b) Based on the operation of the protocols**
  - **Multipath Routing Protocols**: Multiple paths are created from sources to destination, all paths are sending sources message at regular intervals of time, the creation and maintenance of multiple paths from sources to destination will increase the fault tolerance capacity of network but energy use is increased. If the first path fails to transmit the message, other paths can be used alternatively.
  - **Query Based Routing**: The BS initiates the query and each node checks whether they have data related to query or not, if they have then the result is propagated back to the BS. A node first finds out the path after that it generates a query; the query can be forwarded in any direction. Each node after transmission of query waits for acknowledgement from the destination, in case if there is no response the query is flooded throughout the network.
  - **Negotiation Based Routing Protocols**: [SPIN family of protocols is an example of negotiation based protocols; these types of protocols minimize the transmission of redundant data with the help of negotiation. As in case of direct diffusion which floods the data to the network.]

- **QoS Based Routing**: In this type of routing the sensor nodes are known from their location. The signal strength is the measure of the distance between two nodes. The coordinates of the position of the node in x-y plane are exchanged with the help of messages. In these types of protocols it is assumed that nodes which are not sensing any event go to sleep or deactivated for a period of time.
Quality is a major issue of concern, the quality of data must be improved by consuming much less energy. There is a certain quality metric which may belong to delay in delivery of data, energy consumed in delivery of data is specified for each network, using QoS based routing and the network must satisfy the metric rules in order to transmit best quality data to the network. SAR (Sequential Assignment Routing) is declared as first algorithm which focuses on the quality of the service.

3. Related Work

Research efforts have been made to design optimal sensor placement policies under different performance metrics. In this optic, an algorithm is proposed to optimize the sensor placement. In [5] the problem of maximizing network lifetime while providing for coverage and connectivity in Wireless Sensor Networks. Static sensor nodes are deployed randomly in the region in order to provide sensing coverage to a set of points of interest in the region, called target points, and to provide for communication among the active sensors to propagate the data at all times in the network. Sensors have independent sensing and transmission ranges, with no specific relation between the two.

![Fig 3.1: Model of Wireless Sensor Networks.](image)

[9] Each cluster head broadcast the following parameters to other non cluster head nodes:-

**Attributes (A):** Attributes (A) defines the interest of the user. It may be a collection of a No. of attributes about which the user wants some information.

**Thresholds:** These are same threshold value as are used in TEEN, Hear threshold (HT) and soft threshold (ST).

**Schedule:** Schedule specifies TDMA mechanism on the basis of which different slots are assigned to different nodes.

**Count Time:** Time elapsed between two successive transmissions of a node.

**Bat Swarm Algorithm**

Bat Swarm Optimization Algorithm (BSO) was firstly presented by Yang 2010. It is a population-based optimization method that mimics the echolocation behaviour of bats. BSO applies both single and multi-objective optimization for the nonlinear global optimization problems. BSO is inspired naturally from bats’ social behaviour. Bats have an intelligent echo location system. It used for detecting the bat’s prey, avoiding obstacles and locating the bat’s roosting crevice in the dark based on sensing distances. Bats emit a very loud sound pulse (echolocation) and listen for the back bounced echo from the surrounding objects. Based on species, signal bandwidth varies and usually increases using harmonics. The $i^{th}$ bat randomly flies by velocity $v_i$ at position $x_i$ with a fixed frequency $f$. Bats usually have different wavelengths and loudness $A$ to search for food. The BSO pseudo code firstly initializes the variables of the bats’ echolocation system. Bats’ locations are set as initial solutions of BSO. The initial values of the pulse rate, loudness and frequency are previously initialized. BSO iteratively moves from the initial set of solutions to the best solution. The solutions are automatically updated in the sense of finding better ones. As bats get closer to its new better solutions, the pulse emission rate and loudness are updated gradually. Solutions are continuously updated based on the continuous flying iterations. This is repeated till the termination criteria are satisfied. Finally, when all criteria successfully met the best so far solution is reported.
some of the significant studies found in the literature pertaining to data fusion techniques. The prime motive was to present various challenges and issues that have been either addressed or found unsolved in the existing system.

Data Fusion Technique:
Reducing networks data transmission can effectively reduce the energy consumption of sensor networks, and the data fusion technology can be helpful to achieve the purpose of increase the network lifetime. In the process of transmission, data can be combined or relevant. The main method of data fusion is to remove redundancy and low credible data combining information from different node to reduce the amount of transmission in the network for the purpose of reducing energy consumption and prolonging the networks lifetime. Data fusion can be implemented in different protocol layers. The network layer is mainly used for routing and delivery, the application layer is mainly used for query, data fusion.

Data fusion in network layer: WSNs don't care about the specific sensor on a single data; pay more attention to the multi-node cooperative information collected such as temperature monitoring. Temperature distribution are concerned about the area in a specific information, but not limited to specific node value, more is how to transmit this information through the network to gather nodes which makes in the process of data transmission to speed up the convergence of redundant data, and to choose energy efficient routing in the form of multiple hops, reduce conflict of data transmission, improve collection efficiency.

Data fusion in the application layer: application layer data fusion technology research is mostly based on query mode of data fusion technology, based on the aggregation of distributed database operation, the user sends a query request to the network using descriptive language query request in the network in a distributed manner. The query results through multiple hops routing returned to the user, handle query requests and return the query result is essentially the process of the data fusion process. Data fusion technology using computer high-speed computing power and complementary of multi-source data to improve the quality is an integrated information process, which aims to eliminate the contradiction between the data collection of nodes in wireless sensor network, reduce redundancy and uncertainty.

4. Research Methodology

There are basically two types of algorithms in wireless sensor networks cluster based and non cluster based. In non-cluster based protocols every node is in direct communication with the base station. Each node sense its environment for which it is deployed, compute the result and send the result to base station based on the query which is broadcasted by the base station. On the other hand, in cluster based algorithms, the network is divided into clusters, and nodes elect the cluster heads, every non cluster head node is responsible for sensing and computation, after computation the result is send to the cluster head. Data fusion technique is used to process the data to get the information from the redundant information.

Data fusion in Clusters:
After each member node in the cluster send data to cluster head node, following the assigned slot interval, the cluster head node complete the data fusion work, then transport all the data to base station.
In this process of data fusion all the sensor nodes are sense the data and send it to the fusion nodes. Fusion nodes are collecting the data from sensor nodes and send

**Concept of Transfulty Nodes:**
Transfaulty nodes present in the network over the area. They behaves normal some time, sometime they are not working. In Fig 4.2 fusion node1 considered as the transfaulty nodes. If node is found transfaulty the path can be changed but after sometime it is working than it will be choose that path. A scheme named as ReDAST is represents the reliability of data. The data is received go through the process of data acquisition and the simulation is presented in the presence of transfaulty nodes sometimes these are they behave normally but in case some of the circumstances or the situation of the network is against the favouring nature these nodes stop responding, the respond of these nodes effect the size of the network. The network size decreases with unavailability of these nodes and then it increases with the respond of these nodes. The area coverage at a time is dependent on the nodes present in the network so the big difference arises in the routing requirements and the coverage with the increase and decrease in number of nodes in the network. To prevent the loss arising due to transfaulty nature of the nodes the dual mode of the nodes is used in the network.

**Fig 4.1: Data fusion process in WSNs**

**Fig 4.2: Data Fusion In the Presence Of Transfulty Nodes**

**PSEUDO CODE**
The basic and the core data fusion strategy lies in between the removal of unsupported data from the collected values. This phase-and error removal for the proposed work can be given as:

1. support(a,b) € [0,1]
2. support(a,b) = support(b,a)
3. If |a-b| < |x-y| => support (a, b) > support(x, y) provided that x, y are greater than 0.
4. On the basis of above
K |a-b|<=d, (K>0, d>0) support(a,b) =0 |a-b|> d

Pseudo code for the data fusion process:-
1. Size of Data- no. of sensing nodes responsible for the generation of sensing values.
2. Threshold – the sensing data get difference above which treated as an unsupportive value.
3. Sorting the (Data generated)
4. Refinement of Data may include deletion from most values.
5. Pre-processing of refined data.
6. Median and mean value for the data is generated.
7. Median value generation results in support value.
8. Mean value generate a separate support value.
9. Support value generated is compared.
10. Result is generated by the weighted result.
11. Step1 to 10 is repeated in each phase of the data communication so that the data which reach to the base station is completely processed.

Proposed Algorithm
OEAS Algo :
1) Initialize variables set the number of iterations from zero; each node calculates the distance of its location and saves up. Initializing every variable.
2) Update variables the variable of each node is coupled to the information of other node. Cluster heads node s must obtain the sensor information of other nodes by interaction. In the specific sensor network, this interaction can be obtained by sending an ACK packet Including information of other’s nodes, bringing about information of sensors by the small communication overhead.
3) Update sensor information each node s updates its stored value, source node sensed value and energy allocation ratio. Each node updates its information and it broadcasts them to the nodes which use nodes information. Note each node can update its variable by its local information.
4) Stop the iteration Check if node has the energy for communication or for actively participating in the communication, if not– the node is declared dead. Otherwise it continues to communicate. When each node of the network dies the network communication stops.

The following parameters are compared:
a. Network lifetime.
b. Number of nodes died vs. time.
c. Number of packets sent to base station.
d. Number of cluster heads selected.
e. Energy consumption per second.

Advantages
1.) The scenario replicates the communication pattern of actual wireless sensor network.
2) The authentication check step is done at the time of selection of cluster heads; if the nodes have the desired key only then it is allowed to be a cluster head.
3) Only cluster heads take the data to the base station which saves the energy of other nodes.
4) At a time, multiple nodes communicate through multiple paths.
5) The energies confirm the hardware standards set for the wireless sensor which helps to have the nearly same results of simulations as that of hardware.
6) Due to random election each node goes through the selection process.
7) No fix area or number of cluster heads
8) Network life is increased up to desired levels.

5. Results and Discussions
The proposed routing protocol is simulated using MATLAB tool. Experiments are performed on simulations with different numbers of sensor nodes uniformly distributed in a 100 m×100 m. Base station is located at position [50,50].

<table>
<thead>
<tr>
<th>Max Round</th>
<th>No of Max Round</th>
<th>4000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial energy of each node</td>
<td>0.5 nJ</td>
<td></td>
</tr>
<tr>
<td>Energy for transferring of each bit (ETX)</td>
<td>10pJ/bit/m²</td>
<td></td>
</tr>
<tr>
<td>Energy for receiving of each bit(ERX)</td>
<td>50 nJ/bit</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>Optimal election Probability of nodes</td>
<td>0.1</td>
</tr>
<tr>
<td>Energy of multi path model</td>
<td>0.0013pJ/bit/m²</td>
<td></td>
</tr>
<tr>
<td>Data aggregation energy</td>
<td>50nJ/bit</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.1: Simulation Parameters

5.1 Number of Cluster Heads Elected per Round
The process of cluster head election is randomized for each round. When the new round begins new cluster heads are elected. In this graph ReDAST schemes represent the many number of rounds at the 1000th round the cluster heads elected approximate 3 but in the OEAS scheme has capability at same round elected approximate 17 cluster heads values see in the fig 5.1(b) shown below.
5.1 Number of Cluster heads

5.1(a)                                      5.1(b)

Figure 5.1: Number of Cluster heads

5.2 Number of Survival Nodes per Round

When the nodes begin to transmit they start to consume their energy and their energy goes down after every transmission. In this graph the scheme ReDAST represents the at 1000th round approximate 10 survival nodes present rest of all are dead but in OEAS scheme at 1000th round approximate 98 nodes are survival nodes. It shows that the scheme OEAS has the capability to increase the lifetime of the network the values of this see in the fig 5.2(b) as shown below.

5.2(a)                                         5.2(b)

Figure 5.2: Number of dead nodes

5.3 Packets Send to Base Station per Round

After all non cluster head nodes have send their data to the cluster head nodes; each cluster head node aggregates the data to remove the redundancy and forwards this data to the BS. The graph shows that in scheme ReDAST at 1000th round approximate 3 packets send to the base station but in OEAS at same round approximate 15 packets send to the base station. Proposed scheme OEAS has maximum capability than ReDAST to send packets to BS values are see in the fig 5.3(a) and 5.3(b) as shown below.

5.3(a)                                         5.3(b)

Figure 5.3: Packets sent to base station
5.4 Packets to Cluster Head per Round
Each non cluster head nodes send data in the form of tiny packets. The graph shows that the scheme ReDAST represents at 1000 round packets send to the CH decreases continously but in OEAS at 1000 round it is stable and send maximum packets to CH. The comparison of packets transmitted to cluster head per round is done with the help of graph given below:

5.4(a)                                       5.4(b)  
Fig 5.4: Packets to cluster heads

5.5 Energy Dissipation per Round
The process of sending, receiving, forwarding and processing the data involves the consumption of energy which is calculated for each round and plotted for the comparison. In this graph ReDAST schemes represents 1 to 500 round the energy consumed maximum but in the OEAS scheme from 1 to 500 nodes consumed same energy less than ReDAST and it gives more lifetime to network so we can see this value in fig 5.5(b) shown below.

5.5(a)                                        5.5(b)  
Figure 5.5: Energy dissipation

Conclusion
Simulation and the experimentation results are plotted and the summarization of these results ensures to have the greater efficient and reliable network for the data reliability and energy efficiency. The data fusion task separates the unrelivant data from being on the base station. Sensing data so collected, processed, filtered and forwarded to the base station contains the supported values. Supported values can be generated through various support function, for the mean and median method and further the fuzzy mean median method can be utilized along with the method supporting minimum deviation and error in support value generation. The threshold holds a greater degree of control for the inclusion of the values arriving near to unsupportive. Removes the possibility of error or attack in the form of false data packets or modified data packet thus, increasing the reliability of the system. This approach is carried out in the presence of transfaulty nodes for the complete system implementation. The proposed algorithm has shown a significant improvement over the studied protocol and taken as the base for the work undertaken. The difference among existing protocols and proposed algorithm include proposed algorithm keep track of the Energy consumption and the coverage in the network and the selection is done to have the best results for the given scenario. As the network time increases the coverage and the
transmissions provided by the network are among the cases which cover the maximum space and area and provide the all direction network optimization.

Future work

Wireless sensor network is build with the nodes with limited energy, which limits the lifetime of the network, and a major constrain to WSN. To deal with such types of constraints researchers put many effort to design protocols for WSN which helps to increase the lifetime of the network and increase the stability period of the network but to some extent the field of data optimization and data processing for the wireless nodes is ignored. It is felt during the Corse of the study that very less work is done in maintaining the data uniqueness and avoiding the data replications from the values transmitted to the base station. The base station at the start of the processing is overloaded with the number of packets and the packets keep on decreasing as the time for the network processing passes. With the passage of time the number of nodes decreases resulting in the significant decrease in the data traffic on the base station. The base station seems to be over utilized in the initial phase of the network communication when all the nodes are alive while its computation resources are underutilized when the network nodes are remaining some percentage of the nodes that of total node initially present in the network.

References


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