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Dynamic Lifetime Approximation Based Cluster Head Selection for Efficient Data Aggregation in Wireless Sensor Network

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Abstract: The Wireless Sensor Network (WSN) is used in many domains and data collection is one among them. The WSN can be deployed anywhere on the battlefield for data collection. To perform data collection, lot more methods has been recommended but suffers to achieve the performance in saturation. To improve the performance in data collection and to maximize the lifetime of the sensor network, a dynamic lifetime approximation algorithm is discussed in this study. The proposed method selects the cluster head each time based on energy, the frequency of data transmission, some neighbors and number of transmissions involved. The proposed method computes the Pertinent Lifetime Weight (PLW) and Pertinent Route Weight (PRW) using the factors mentioned above and the cluster head selection is performed. Based on a computed value of pertinent route weight the method selects a single route to perform data aggregation. This approach improves the lifetime and performance of aggregation of data in WSN.

Key words: Cluster based routing, data aggregation, lifetime estimation, pertinent route weight, WSN, collection

INTRODUCTION

The collection of sensor nodes located in the different geographic region makes the WSN. Each sensor node has fixed transmission range and can communicate with other nodes located within the transmission range so that the sensor nodes require the help of other nodes to complete the transmission. They involve in cooperative transmission and intermediate nodes forward the data packet towards the sink node. WSN used in the war field has various locations of the network information which must be collected from different locations. Each sensor node has built in radio which is used to perform data transmission and has built in battery. The nodes of a sensor network have fixed amount of energy and at each transmission, the sensor node loses a certain degree of energy. However, the transmission of data introduces energy depletion and reduces the lifetime of the network. As of the sensor nodes are bound to limited energy parameter, they can perform an only limited number of transmissions.

To improve the lifetime of the sensor network, it is necessary to utilize the energy of sensor nodes in an efficient manner. In some situation, there will be only one intermediate node for the data collection which connects different clusters. If the energy of the sensor node does not utilize properly then, it will lose its life in short time. Further, the data collection cannot be performed. This entirely affects the network and spoils the lifetime of the system.

To maximize the life of the sensor node and the network, the cluster head selection must be performed in an efficient manner. In the cluster head selection cycle, the method should consider various parameters of the sensor nodes. For example, there are algorithms like leach which selects the cluster head according to the energy parameter. The node with higher power will be selected as cluster head. This kind of cluster head selection will not be suitable where the density of sensor nodes is less. Hence, the cluster head selection approach should consider various other parameters. Instead of choosing the cluster head based on energy, it can be performed by adapting other parameters namely number of transmission involved, energy, location, the number of packets transmitted and so on. By including such parameters, the lifetime of the sensor node can be estimated in an efficient manner. Thus, the node capable of routing the data packets of others can be identified to improve the performance of data aggregation in WSN.

Literature review: Some methods have been discussed for the problem of data collection in WSN. By Caillouet *et al*. (2011), the researcher handles the issue of data collection based on mobile sinks in WSN. The

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researcher designed a framework to compute the relation between delay and energy consumption. This helps the decision makers in data collection. By Huang and Lin (2015), the researcher presented a data collection algorithm using the hop count approach. The use of multiple sinks creates higher data loss. To minimize the data loss, the data aggregation is performed with the help of multicasting technique. The researcher further presents a many to many data aggregation in distributed manner.

The problem of data collection with object tracking was performed by Placzek and Bernas (2013) to reduce the mobile sinks movement and tried to move the sink nodes in short time. The method focused on using the resources towards the target locations. A prediction-based approach was discussed in Samarah *et al.* (2011) using sequential patterns in data collection. The method focused on reducing the energy depletion with allowed missing rate.

By Yadav and Yadav (2016) the researcher reviews the design issues in structure and structure free network for data collection. The method evaluates the methods according to the energy dissipation and lifetime maximization. By Lee and Cheng (2012) a fuzzy logic based clustering mechanism was discussed, and the method used energy prediction to perform data aggregation. The method focused to improve the lifetime of the network and to perform higher data collection.

An unequal clustering based data collection was presented by Jiang *et al.* (2012) using energy parameters of the nodes. The method used multi-hop routing with inter-routing. The method had chosen the cluster head according to the energy and preserved the energy for all the nodes. Thus, a clustering approach based on transmission efficiency was presented by Xie and Jia (2014). The method organized the nodes in the cluster and presented an analytical model for the data transmission and analyzed the data transmission in a hybrid manner. By Orojloo and Haghighat (2016) a Tabu search algorithm for data aggregation in WSN was presented. This method exploited the routing in WSN and performed a neighborhood search at the move. This method utilized the property of ant colony optimization and reduced the energy depletion in other routing protocols. All the discussed methods suffered to provide higher performance in data aggregation and produced less time complexity.

MATERIALS AND METHODS

Dynamic lifetime approximation based cluster head selection technique: The dynamic lifetime approximation technique estimates the approximated lifetime for each sensor node which claims to become the cluster head. Unlike other methods of cluster head selection, the proposed method approximates the lifetime of each sensor based on energy, the number of transmissions involved, the number of neighbors and so on. Using all the parameters, the proposed method computes the PLW for each sensor node using various attributes. Based on the computed PLW measure, the method performs cluster head selection. Further, the method estimates the route weight for each route identified and selects a single route accordingly. Figure 1 shows the architecture of proposed multi-attribute lifetime based cluster head selection algorithm.

Packet handler: The sink node monitors the network and receives the incoming packet. At each time, the sink node discovers the available routes and computes PRW. Based on computed pertinent route weight, the sink node selects a route to perform data aggregation.

Pertinent lifetime weight computation: The pertinent lifetime weight is the measure to represent the concrete lifetime of the sensor node. The measure is computed using the network trace which is generated at the previous transmissions.

Using the identified trace, proposed method computes the number of Transmissions involved (TnT), the number of Neighbors (Nn), possible Residual energy (Re) and frequency in data Transmission (Tf). Based on computed measures, the proposed method computes the pertinent transmission weight for the sensor node.

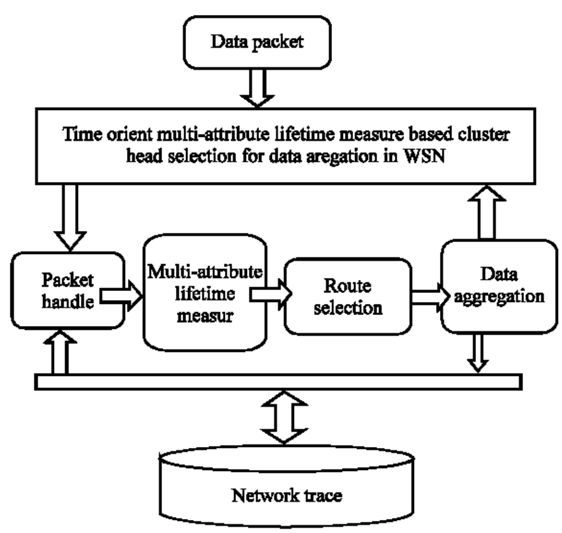

Fig. 1: Architecture of the multi-attribute lifetime measure based cluster head

Algorithm 1; Algorithm for PLW computation:
Input: Network Trace Nt, Sensor S
Output: Multi-Attribute lifetime Factor MALF
Start
Read network trace Nt
Identify list of traces belongs to the sensor S

$$\text{Trace set Ts} = \int_{i=1}^{size(Nt)} \sum Nt(i).\,Sensor{=}{=}S$$

Compute total number of transmission involved
Tnt = size (Ts)
Compute frequency of transmission

$$Tf = \frac{Tnt}{\text{Number of sessions}} \times 100$$

Compute number of neighbors:

$$Nn = \sum_{i=1}^{size(Ts)} Ts(i).\ \text{neighbour} \nexists Nn$$

Compute possible residual energy
Re = Initial Energy-(Tnt x μ)
μ-Energy Constant for single data transmission
Compute pertinent lifetime weight

$$PLW = \frac{Re}{Tf} \times \frac{Tnt}{Nn}$$

Stop

PLW Computation algorithm shown in Algorithm 1 computes the pertinent lifetime weight for the sensor node and computed value is used to perform cluster head selection.

Pertinent route weight estimation: PRW measure represents the trustworthy of the route for the data transmission and the efficiency. There is a possibility of dead nodes due to energy variations. This would introduce the retransmission of the data packet. To avoid this, the method computes the pertinent route weight measure which shows the trustworthy of the route. To compute the pertinent route weight, the method uses transmission and energy parameter of the sensor node.

Algorithm 2; Algorithm for PRW computation:
Input: Network Trace Nt, Route Ri
Output: Pertinent Route weight Prw
Start
Read network trace Nt
Compute list of intermediate nodes in Ri
Intermediate Nodes

$$Inodes = \int \sum Nodes \in RI < S, D >$$

//including source excludin g destination
For each node Ni from INodes
Split traces belong to node Ni.
Intermediate node trace

$$nT = \int \sum Traces(NeT).\,SensorID = Ni$$

Compute number of transmission involved NTI = size (InT)
Compute residual energy Re = Ni.Initial-Energy-(NTI×μ)
end
Compute pertinent route weight

$$PRW = \frac{\sum Ni(Re) > ETh}{size(INodes)}$$

Stop

PRW computation algorithm shown in algorithm 2 computes the trustworthy of the route for data transmission and computed weight is used to perform data transmission.

Pertinent route selection: The pertinent route selection algorithm identifies a single route from list of routes available according to the pertinent route weight measure of the identified routes. The method computes the pertinent route weight for each route using the pertinent route weight computation algorithm. Finally, a single route is selected according to the computed measure.

Route factor computation algorithm shown in Algorithm 3 computes the route factor for each route identified and based on computed value a single route is selected.

Algorithm 3; Algorithm for route factor computation:
Input: Trace set Ts, Route set Rs
Output: pertinent Route PR
Start
Read Trace set Ts
Read routes available Rs
Initialize pertinent route weight set Prws
For each route Ri from route set Rs

$$Prws = \int_{i=1}^{size(Rs)} \text{Pertinent RouteWeight}(Ri)$$

End
Choose the route PR for transmission

$$PR = \int_{i=1}^{size(Rs)} Max(Ri, Pws)$$

Stop

Data aggregation: The data collection in the sensor network is performed according to the routes and the conditions of the sensor nodes. Initially, the cluster head selection is performed by computing the pertinent lifetime weight for each node which is claimed for cluster head. Based on computed pertinent weight, the cluster head selection is performed.

Algorithm 4; Algorithm for data aggregation:

```
Input: Network Trace Nt
Output: Null
Start
        Read Network Trace Nt
        For each sensor S
              Compute pertinent lifetime weight PLW.
        End
        Perform Cluster Head Selection using PLW.
        Discover routes Rs
        Perform route selection
        Perform data aggregation
Stop
```

Data aggregation algorithm shown in Algorithm 4 performs data aggregation using various measures and based on computed PLW and PRW measures, the proposed method selects the routes to perform data aggregation.

RESULTS AND DISCUSSION

The dynamic lifetime approximation based cluster head selection algorithm for data aggregation in WSN has been implemented using java. Protocol's efficiency is evaluated under various circumstances. The proposed method resulted in efficient data aggregation with reduced retransmission frequency with increased network lifetime. Table 1 shows the parameters of simulation details to perform the data aggregation in WSN.

Figure 2 shows the comparable result on data aggregation performance produced by various methods and clearly exposed that the proposed method has resulted in higher performance. Figure 3 depicts the comparison of node clustering performance produced by various methods and it clearly illustrated that the proposed method has efficient clusters. Figure 4 shows the comparison on data aggregation latency produced by different methods and the proposed method. The comparison revealed that, the proposed method has less latency than other methods. Figure 5 shows the corresponding result on route selection efficiency produced by various methods and the proposed method. This comparison demonstrates that the proposed method has resulted in higher efficiency than other methods. Figure 6 illustrates the comparison on lifetime maximization by various methods and the proposed method. From the comparison chart, it is clear that the produced higher lifetime maximization than other methods.

Table 1: Simulation parameters

Parameters	Values
Language	Java
Protocol	DLA
No. of nodes	100
No. of sensors	10

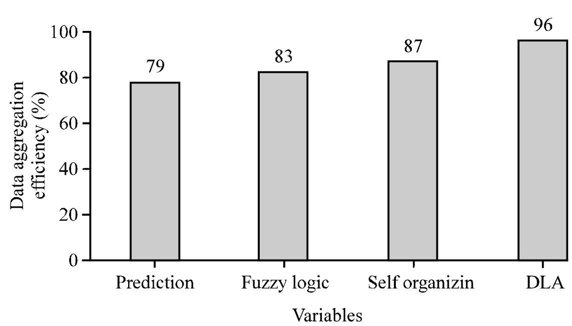

Fig. 2: Data aggregation performance comparison

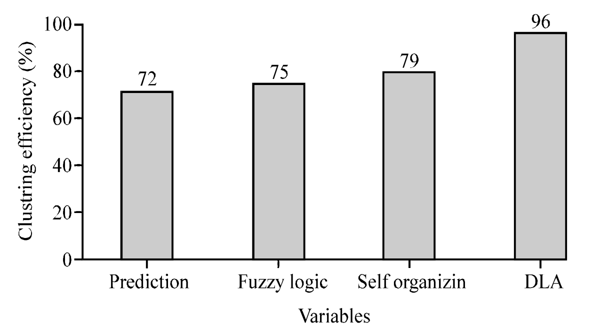

Fig. 3: Comparison of node clustering

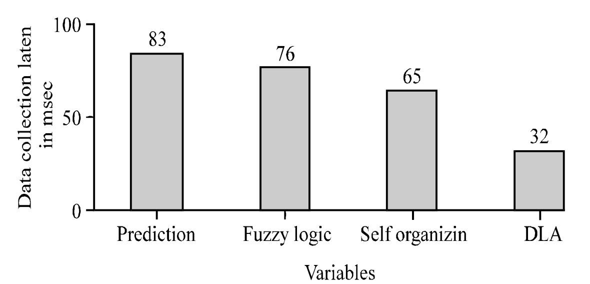

Fig. 4: Data aggregation latency comparison

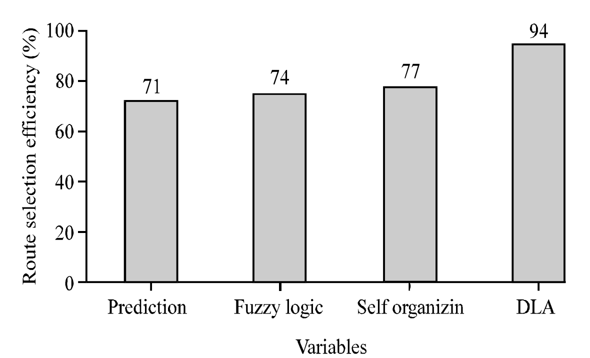

Fig. 5: Route selection efficiency comparison

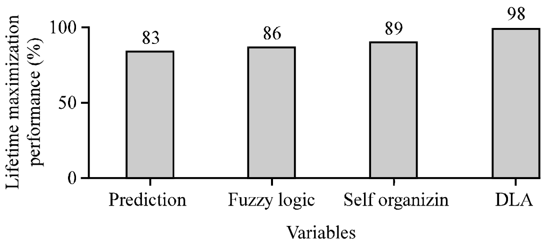

Fig. 6: Lifetime maximization comparison

CONCLUSION

In this study, a dynamic lifetime approximation based cluster head selection algorithm is discussed to improve the efficiency of data aggregation in WSN. The sink node computes pertinent lifetime weight for each sensor participates in the cluster head selection routine. Then based on the lifetime weight, a single sensor is selected as the cluster head for each cluster. Then, the sink discovers the list of routes available for each route and computes the pertinent route weight to choose an efficient route for data aggregation. The proposed method improves the cluster head selection performance up to 96% and increases the data aggregation by 98%. Similarly, the latency of the data aggregation has been reduced well.

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