Rendezvous Based Techniques for Energy Conservation in Wireless Sensor Networks – A Survey

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Abstract - Energy conservation in Wireless Sensor Network (WSN) is an energetic research area in nowadays. Many research works have explained that energy can be protect significantly using mobile sinks data collection from the nodes via single or multi-hop communication. Mobility speed of the sink is turned down, since latency will be maximized in sensor network mainly in delay sensitive applications in order to overcome this issue, different rendezvous based techniques have been explained according to which group of sensor nodes from the area will be treated as Rendezvous Points (RPs).Remaining nodes will forwards the sensed data to its closest RP where data will be buffered. A path is then created using RPs through which mobile sink make a tour and collects the data buffered. This paper beautifully explains various Rendezvous based techniques and analysis of their merits and demerits with respect to energy conservation.

Index Terms: Wireless Sensor Network (WSN), Energy Conservation, Mobile Sink, Sensor nodes, Rendezvous Points (RP), Steiner minimum Tree, Data Sensing

1. INTRODUCTION

Wireless Sensor Networks (WSN) is composed of large number of sensor nodes which performs sensing, data processing and communication with other nodes. Every sensor node has the capability to process and collect data from the environment and forwards to the location center called base station (sink) through wireless communication. Nowadays so many consumer and industrial application such as smart homes, machine health monitoring, waste water detection etc…are using sensor networks. Battery life of sensor nodes which may not recharged or replaced is the major drawback of WSN, which leads to major research area in the field of sensor networks. Typically the data sensed will be changed to base station for processing using multi hop ad-hoc network created by the sensor nodes. It is very feasible method which creates a bottle neck in the network.

The nodes near the sink are congested due to data from the farthest node and battery of nodes will drain vastly which leads to non –uniform energy level. This results in network portioning [1].Several research works shown that mobile sink solves the problem by collecting the data directly from sensor nodes and transmits through single or multi hope communications. This can be formulated as TSP (Travelling Salesman Problem) which finds the shortest path by using the sink which visits the entire sensor node once and returns back to its original positions. When the number of nodes increases, this problem becomes not workable.[2].

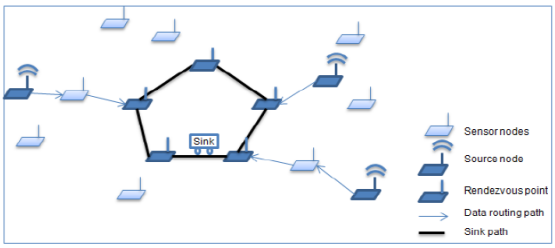

Fig 1: An example of rendezvous based technique.[1]

In a large network area, normally speed of mobile sink is low such that it takes long time to complete the tour. Due to this disadvantage of sink mobility, latency will get increase in delay sensitive applications such as fire detection systems. So, Researches have suggested Rendezvous based techniques in which mobile sink only visits a subset of sensor nodes called RPs (Rendezvous points) and non RPs forwards the sensed data to the neighboring RP where data will get buffered. For the selected RP, Source node forwards the data sensed to its closest RP. Mobile sink will make a tour and data collects will buffered the RP,which is shown in Fig:1.Through this paper, we discuss the several rendezvous based techniques to bind the tour length.RP-CP,RP-UG,RD-VT, and WRP are different techniques suggested in[2][3][4][5] follows several ways to solve the problem. Each method has its own advantage and disadvantages.

The remainder of this paper structured as follows. Section 2 reveals related works section 3 presents analysis of each technique. Finally in Section 4 we conclude the paper.

2. RELATED WORKS

Several existing methods uses mobile sink in sensor network have proved that the energy can be efficiently utilized and overall lifetime of the network can be stronger. Mobile sink in WSNs can be divided into two. a) Direct where data collects via single hop and mobile sink visits each sensor node. It aims to minimize data collection delays. To reduce the latency TSP based data collection methods were used which involves

finding the shortest travelling path that visits each sensor nodes.b) Rendezvous, where mobile sink visits nodes which is designated as RPs.It aims to find out the subset of RPs To reduce the latency TSP based data collection methods were used which involves finding the shortest travelling path that visits each sensor nodes which minimize the energy consumption. Rendezvous method further divided into three. a) Fixed b)Tree based c)Clustering. In fixed method, sink path is predefined and sensor nodes are randomly deployed. Nodes which exist within the communication range of mobile sink will act as Rendezvous Point. Here the length of the travelling path is independent on the buffer size. Hence, buffer of RPs may overflow or packets expire before they are collected by the sink.

In [5] propose a tree based algorithm known RD-VT to reduce the latency TSP based data collection methods were used which involves finding the shortest travelling path that visits each sensor nodes. (Rendezvous Design with a Variable BS Tracks) is to find the RP on SMT (Steiner Minimum Tree) where data will sufficiently buffered and minimize sink tour length A Steiner tree spans a given subset of vertices of a graph .Terminals and Non terminals are the two types of Steiner points. Terminal represents real sensor node and Non terminal represents virtual Steiner points.RD-VT works with SMT algorithm considering the sink as root.

In [3] two types of Rendezvous Planning Algorithm called RP-CP (Rendezvous planning with Constrained ME Path) deals with mobile sink path constrained, here all sensor node constructed as tree which connects the field with sink node as root. A weight is given to the edges in the tree in which number of nodes used to transfer the data to sink. For the construction, sorting the edges corresponds to their weight and highest weighted edge is selected and RP-UG (Rendezvous Planning with Utility based Greedy) which is a greedy algorithm effective than RP-CP.It deals with non-constrained mobile sink path. Here the tree is separated into different sections which operate in multiple iterations. For each iteration new RP set and tour of the sink node maximized. When tor is expanded the nodes updated which results in better selection of RP.

In Rendezvous method, to RP selection is the basic problem. To compute an optimal sink path tour such that the sink visits all the RP's and return to its starting position. This cause an NP-hard problem. In order to overcome Salarian [2] proposed Weighted Rendezvous Planning Algorithm (WRP) which is a novel method to approximate the optimal solution.

The notations are at follows: .Let model a WSN as $G(V,E)$,where V is the set of homogeneous sensor nodes and E is the set of edges between nodes in V. Let $M = m_0, m_1, ...m_n$, m_0 be set of sensor nodes where $m_i \in V$ such that it has the highest weight and considered as rendezvous points.

The main aim is to find the tour length by set of sensor nodes in M such that sink visits RP and tour M is no longer than largest allowed tour length $l_{\max}$ where

$$l_{\max} = D \times v \quad (1)$$

D is the maximum allowed packet delay
v is the mobile sink speed

RP forwards the sensed data to the closest RP.RP will buffer and collects the data which is send by the sensor and it forward to the sink when it comes to the RP.WRP will set a weight to each sensor nodes, which computes a tour by selecting the highest weighted node as RP.Weight of the sensor node can be calculated by,

$$W_i = NFD(i) \times H(i,M) \quad (2)$$

W_i is the weight of the sensor node

$NFD(i)$ is the number of packets that the node i will forwards

$H(i,M)$ is the hop distance of node i from the closest RP in M

From the equation the nodes that have more than one number of packets to be forwarded, it choose the highest priority and it will selected as RP.If sensor node is located in one hop distance from selected RP which have one data packet buffered will get minimized weight. So visiting highest node, multi hop transmissions will be minimized and load will balanced among the sensor nodes which dramatically results in energy efficiency.

3. ANALYSIS OF RD-VT,RP-CP,RP-UG,WRP

In this section provides the analysis part of the rendezvous techniques in terms of their merits and demerits towards energy conservation.

3.1 RD-VT

Steiner Minimum Tree (SMT) based approach Steiner point in the RD-VT may not be placed of sensor node. The algorithm replaces the virtual RPs with the sensor node which is close to them. In this approach the desired functioning undertake certain range of settings also it will balance the communication delay and it enables the sink to collect bulk of data from RP.SMT traverses in preorder until the shortest distance between visited node ad packet delivery time be equal. The major drawback of RD-VT is that route taken cross the SMT in preorder leads to selection of RP which results data forwarding path to sensor nodes in the various parts of SMT.So RD-VT causes nodes to have an imbalanced data forwarding load and energy consumption.[6]

3.2 RP-CP

It has the rendezvous planning with a constrained ME path. It has a fixed sink node and ME.RP-CP connects the entire sensor node and constructs routing tree which is rooted at sink node. It assigned weights and considered edges of the route tree. It sorts all edges according to their weight then it select edges with highest weight till selected edge length is less than or equal to required packet delivery time. This technique clearly decreases energy consumption of the sensor network. Due to the constrained sink mobility path on edges of routing tree, the sensor node on the edges will visited twice by the mobile sink.

3.3 RP-UG

RP-UG is an improved to RP-CP.RP-UG algorithm is a utility based greedy algorithm which will works on routed tree. It constructs all edges on the tree into different short intervals denoted as L_0.RP-UG uses Travelling Salesman Problem (TSP) solver to find out the tour length.RP-UG exchange virtual RPs with nearest sensor node and RPs.It unbalance the energy consumption rate of sensor nodes which effects network lifetime. Along with this complexity, algorithm uses TSP solver N times in each iterations, where N is the number of RPs.Hence RP-UG has a running complexity of $O(N^2 \times O(TSP))$.[5]

3.4 WRP

Weighted Rendezvous Planning is a heuristic method uses SMT algorithm and select the set of RPs.Compare with the RD-VT and RP-UG with WRP,WRP RP present in Steiner tree will no replace by any nodes whereas in previous algorithms exchange virtual RPs with the closest sensor node. Steiner positions contain in the tour will collect the data from the closest node and visited by sink node which leads to small number of RPs and uniform energy consumption. Hence WRP works better than RD-VT and RP-UG.WRP concentrates on hop count while selecting RP.It minimizes energy consumption when compared to other methods. Moreover, WRP minimizes the energy hole problem [7] in sensor networks because mobile sink visits the congestion points exits in dense area.[3]. Performance can be enhanced by using multiple mobile sinks. A sensor network divided into more than two groups, each contain sensor node with similar features. For each group mobile sink is assigned and WRP invoke for data collection.

4. CONCLUSION

Energy conservation is a challenging task in WSN which depends on several parameters. Through this paper, different rendezvous based algorithms and their analysis was discussed. All algorithms mainly focus on RP selection and well organized mobile sink path tour. Sink only visits the RPs and sensed reading collects within a delay bound. Among there are some e many advantages and disadvantages in each methods. WRP performs better than other methods in terms of energy consumption. It will prevent the formation of energy holes in sensor network and resulting overall network energy conservation

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