Optimized FZ-LEACH Using Exponential Weighted Moving Average for Wireless Sensor Network

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Abstract. Wireless Sensor Network (WSN), fundamentally opportunistic communication system, where communication links only exist temporally rendering. It is impossible to establish end to end connection for data delivery. In such network, routing is largely based on nodal contact probability. The basic idea of this WSN is to distribute the group mobile node with similar mobility pattern into a cluster. A new energy efficient clustering protocol OFZ-LEACH, which eliminates the above problem by forming Far-Zone. Far-Zone is a group of sensor nodes which are placed at locations where their energies are less than a threshold an Exponentially Weighted Moving Average (EWMA) scheme is employed for on-line updating nodal contact. Based on this, nodal contact probabilities, the set of functions are used. This function is used for clustering formation and gateway selection.

Keywords: Wireless Sensor Network (WSN), Exponential weighted Moving Average (EWMA).

1 Introduction

Wireless Sensor Network (WSN) is an approach to computer network architecture that seeks to address the technical issues in heterogeneous networks that may lack continuous network connectivity. Examples of such networks are those operating in mobile or extreme terrestrial environments, or planned networks in space. WSNs span very challenging application scenarios where nodes (e.g., people and wild animals) move around in environments where infrastructures cannot be installed (e.g., emergency operations, military grounds, and protected environments).

Some solutions to routing have been presented for these cases, starting from the basic epidemic routing, where messages are blindly stored and forwarded to all neighboring nodes, generating a flood of messages. Existing routing protocols (AODV, DSR) are must take to a "store and forward" approach, where data is incrementally moved and stored throughout the network in hopes that it will eventually reach its destination. A common technique used to maximize the probability of a message being successfully transferred is to replicate many copies of the message in the hope that one will succeed in reaching its destination. This is feasible only on networks with large amounts of local storage and internodes

N. Meghanathan et al. (Eds.): CCSIT 2012, Part III, LNICST 86, pp. 473–481, 2012.

bandwidth relative to the expected traffic. The drawbacks that are encountered in Wireless sensor Networks are,

- ✓ Lack of Connectivity.
- ✓ Lack of Instantaneous End-To-End Paths
- ✓ Very High Number of Messages that are needed to obtain a successful delivery to the right recipient.

2 Problem Definitions

Due to the Lack of continuous communication among mobile nodes and possible errors in the estimation of nodal contact probability, convergence and stability becomes a major problem in the Wireless Sensor Network. In non clustered Wireless sensor network any node in the network may not able to get contact with the other neighboring node this is because of the nodes will not be having a correct updating in their nodal contact probability and the gateway information, therefore they lacks in communication. Low-Energy Adaptive Clustering Hierarchy (LEACH) [8] is the most popular cluster-based routing protocols in wireless sensor networks. In LEACH the cluster heads are randomly selected and when the cluster head die then another node will be selected as cluster head. Therefore, the cluster head role keeps on rotating to balance the energy dissipation of the sensor nodes in the networks. The function of cluster head nodes are to fuse and collect data arriving from cluster members and forward the aggregated data to the sink in order to reduce the amount of data and transmission of the duplicated data. The data collection is performed periodically. As a result, the nodes cannot provide end to end delivery of the information. At the same time nodes break up their communication if they move out of the coverage area.

3 FZ-LEACH Clustering Algorithm

The Fair Zone Low-Energy Adaptive Clustering Hierarchy (FZ-LEACH) clustering algorithm used to form a cluster in wireless sensor network. FZ-LEACH is generally divided into two phases the set-up phase and the steady-state phase. In the set-up phase, cluster heads are selected and clusters are organized. In the steady-state phase, the actual data transmissions to the sink take place. In the proposed FZ-LEACH algorithm, few nodes are randomly selected as Cluster Heads (CH). This role is rotated to all nodes to balance the energy dissipation of the sensor nodes in the network. The algorithm is event-driven, where the key part lies on the meeting event between any pair of nodes. The set of functions in the algorithm including Sync, Leave, and Join is outlined below. The Methodology will give an idea about, how the algorithm performs its function

3.1 Methodology

1. The base station (i.e. sink node) is located inside the sensing field.
2. Nodes are location-unaware, i.e. not equipped with GPS capable antennae.

3. Communication within the square area is not subjected to multipath fading.
4. The communication channel is symmetric.
5. Data gathered can be aggregated into single packet by Cluster Heads (CH).
6. Nodes are left unattended after deployment. Therefore battery re-charge is not possible.
7. An Exponentially Weighted Moving Average (EWMA) scheme is employed for on-line updating nodal contact probability.
8. Weighting factors which decrease exponentially. The weighting for each older data point decreases exponentially, giving much more importance to recent observations while still not discarding older observations entirely.
9. True contact probability. Subsequently, a set of functions including *Sync()*, *Leave()*, and *Join()* are devised to form clusters and select gateway nodes based on nodal contact probabilities.
10. The cluster table consists of four fields: Node ID, Contact Probability, Cluster ID, and Time Stamp.
11. Each entry in the table is inserted/ updated upon meeting with another node, by using the aforementioned online updating scheme.
12. The gateway table, used for routing, consists of four fields: Cluster ID, Gateway, Contact Probability, and Time Stamp.

3.2 Nodal Delivery Probability

The delivery probability indicates the likelihood that can deliver data messages to the sink. The delivery probability of a power *i,* is updated as follows,

$$\xi_i = \begin{cases} (1-\alpha)[\xi_i] + \alpha\xi_k & Transmission \\ (1-\alpha)[\xi_i] & Timeout \end{cases} \tag{1}$$

where ξ_i is the delivery probability of power i before it is updated, ξ_k is the delivery probability of node k (a neighbor of node i), and α is a constant employed to keep partial memory of historic status.

Sync()

The *Sync()* process is invoked when two cluster members meet and both pass the membership check. It is designed to exchange and synchronize two local tables. The synchronization process is necessary because each node separately learns network parameters, which may differ from nodes to nodes. The Time Stamp field is used for the "better" knowledge of the network to deal with any conflict.

Leave

The node with lower stability must leave the cluster. The stability of a node is defined to be its minimum contact probability with cluster members. It indicates the likelihood that the node will be excluded from the cluster due to low contact probability. The leaving node then empties its gateway table and reset its Cluster ID.

Join ()

The *Join ()* procedure is employed for a node to join a "better" cluster or to merge two separate clusters. A node will join the other's cluster if

1. It passes membership check of all current members.
2. Its stability is going to be improved with the new cluster. By joining new cluster, it will copy the gateway table from the other node and update its cluster ID accordingly.
3. Thus the distributed clustering algorithm is used to form a cluster in DTMN [7] (Disruption-Tolerant Mobile Networks).

3.3 Cluster Based Routing

The cluster based routing protocol used to perform a routing in delay tolerant mobile network. We assume that Node i has a data message to Node j then, the types of cluster based routing protocol is given below.

Intra-cluster Routing

If Nodes i and j are in the same cluster, they have high chance to meet each other, thus Node i will transmit the data message to Node j directly upon their meeting. No relay node is necessarily involved, because we considering here the case of intra-cluster communication. Let MinPwri denote the minimum power level required by a node vi, $1 \leq i \leq N$ to communicate with a cluster head u, where N is the number of nodes within the cluster range All cluster members send their *MinPwri* to the CH. CH now computes A*verage Minimum Reachability Power* (AMRP) with *MinPwri* values of all sensor nodes. AMRP can be defined as the mean of the minimum power levels required by all *N* nodes within the cluster range to reach

One-Hop Inter-cluster Routing

If they are not in the same cluster, Node i look up gateway information to Node j's cluster in its gateway table. If an entry is found, Node i send the data message to that gateway. Upon receiving the data message, the gateway will forward it to *any* node. e.g. Node *k,* in node j's clusters. Node *k,* which in sum delivers the data message to node j via Intra-cluster Routing. If no gateway entry is found, node i precede the Multi-hop Inter-cluster Routing as to be discussed next.

Multi-hop Intra Cluster Routing

If node i does not have any information about node j, the data transmission needs a multi-cluster routing scheme. Given the low connectivity environment, on-demand routing protocols, with extremely high packet dropping probability, will not work effectively here. However, any table-driven routing algorithm such as the following link-state-like protocol can be employed. In the protocol, every gateway node builds a *Cluster Connectivity Packet (CCP),* and distributes it to other gateways in the network. The CCP of a Gateway comprises its cluster ID and a list of clusters to which it serves as gateway along with corresponding contact probabilities. Such information can be readily obtained from the gateway table.

1. Once a gateway node accumulates a sufficient set of CCP's, it constructs a network graph. Each vertex in the graph stands for a cluster. A link connects two vertices if there are gateways between these two clusters.
2. The weight of the link is the contact probability of the corresponding gateway nodes. Based on the network graph, the shortest path algorithm is employed to establish the routing table. Each entry in the routing table consists of the ID of a destination cluster and the next-hop cluster ID.
3. Once the routing table is obtained, the routing is performed from a cluster to another cluster via one-hop Inter-cluster Routing and Intra cluster Routing. The diagram shows the cluster based routing protocols.

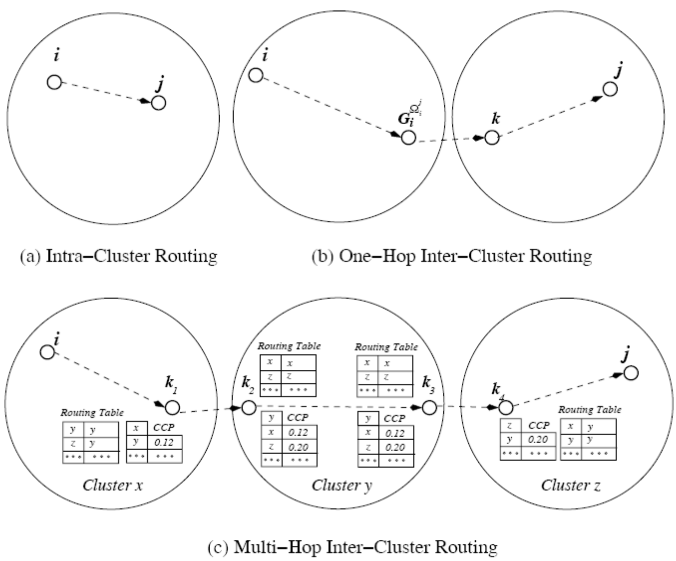

Fig. 1. Cluster based routing protocol

By using the above mentioned[7] concepts with the block diagram in Fig 1 and the flow control the construction of Exponential Weighted Moving Average become simple. Thus the distributed clustering algorithm used to form a cluster in delay tolerant mobile networks and the cluster based routing protocol used to perform routing in delay tolerant mobile networks. We use the AMRP to estimate the communication cost. The AMRP of a node is a measure of the expected intra cluster communication energy consumption for communication to the cluster head. Using AMRP as communication cost, we can find out Far-Zone members. The nodes power levels below the AMRP are considered in Far-Zone. When Far-Zone is formed, any member of the zone is selected as ZH (Zone Head) in pure random basis only for that round may be one with the highest energy. The ZH create TDMA (Time Division

Multiple Access) schedule as LEACH and assign time slots to zone members to transmit the sense data to the ZH. ZH then transmit data to the BS (Base Station). In this way one round is completed.

4 Experimental Setup

The performance of power balanced communication scheme is evaluated using Network simulator-2, which simulate node mobility, realistic physical layer radio network interface and AODV protocol. Evaluation is based on the simulation of 50 nodes located in the area of 1500 x 300 m^2. The traffic simulator is constant bit rate (CBR). The three different scheme non cluster method, EWMA, and power balanced communication are used for comparison.

4.1 Performance Metrics

The performance metric used in this research is throughput packet delivery ratio, bandwidth end to end delay, energy construction and routing overhead. The various measures and details of the all parameters are given below.

Packet Delivery Ratio

It is defined to be the percentage of the ratio of number of packets received to the number of packets sent.

$$PDR = \frac{Number\ of\ packets\ received}{Number\ of\ packet\ sent} x100\ \% \qquad (2)$$

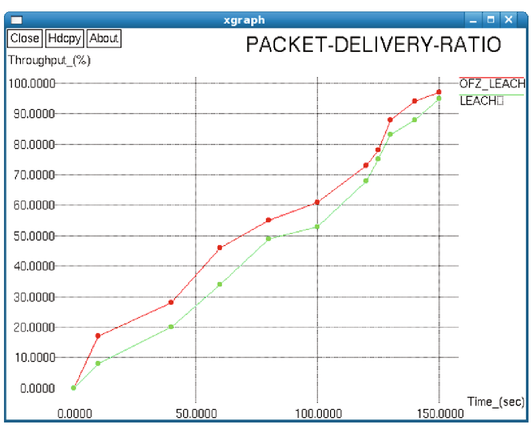

Fig. 2. Performance comparison using Packet delivery ratio

The graph shows in Fig 2 the variation of Packets (bytes) received based on the time when two different routing schemes are implemented.

End to End Delay

The time interval between the first packet and second packet is called End to End Delay. Here the total delay takes 1.3 in non-cluster method and 0.9 in EWMA and power balanced communication have 0.4.

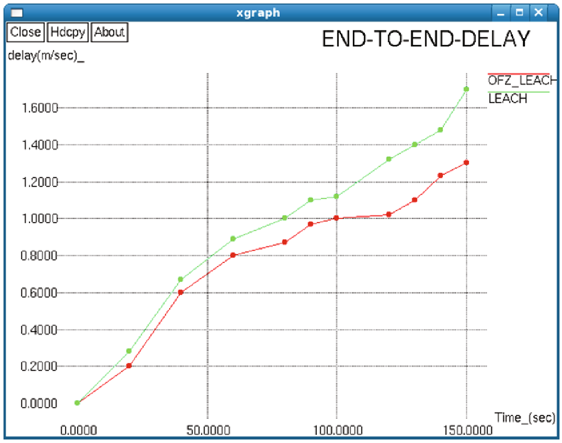

Fig. 3. Performance comparison using end to end latency

From the graph shows in Fig 3 power balance communication system achieves low end to end delay.

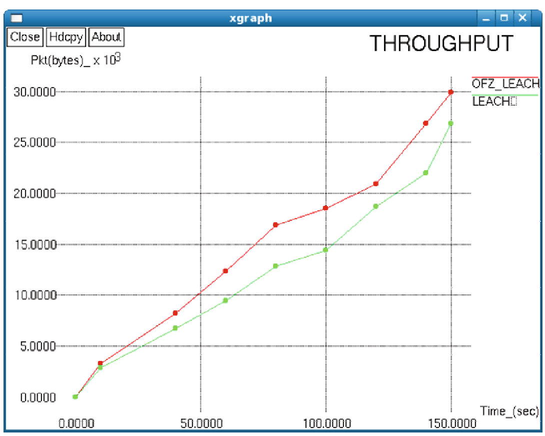

Fig. 4. Performance comparison using Throughput

Throughput

Throughput is the ratio of number of packets received to the time seconds.

$$Throughput = \frac{Number\ of\ packets\ received}{Time(sec)} \tag{3}$$

From the graph shows in Fig 4 throughput high value to the Power balanced communication when compare to other existing methods.

Energy- Consumption

Average energy consumed by node is decreased in our proposed method due to the creation of Fair- Zone Optimization. Fig 5 shows that remaining energy in LEACH & OFZ-LEACH.

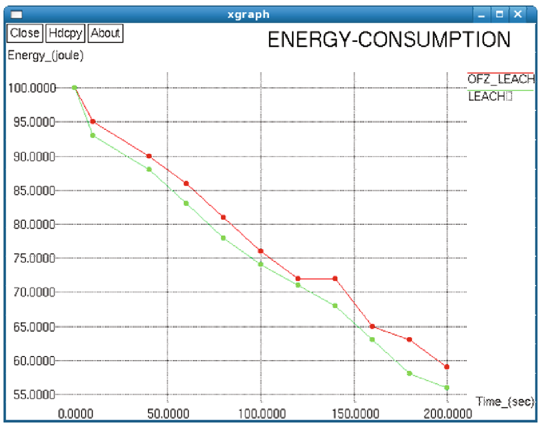

Fig. 5. Performance comparison using Energy- Consumption

5 Conclusions

Establishing end-to-end connections for data delivery among wireless sensor Networks becomes impossible as communication links only exist temporarily. In such networks, routing is largely based on nodal contact probabilities. To solve this problem, an exponentially weighted moving average (EWMA) scheme is employed for on-line updating nodal contact probability. In proposed OFZ-LEACH algorithm, which is based on the original protocol and considers a Far-Zone inside a large cluster. The results proves the improvement in the performance in the original LEACH protocol in terms of energy dissipation rate and network lifetime A set of functions including sync(), leave(), and join() are devised for cluster formation and gateway selection. Finally the gateway nodes exchange network information and perform routing. The results have shown that it achieves higher delivery ratio and significantly lower overhead and end-to-end delay, compared with its non-EWMA.

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