International Journal of Soft Computing 10 (2): 169-174, 2015
ISSN: 1816-9503

Energy Efficient Cluster Based Transmission Protocol in Wireless Sensor Networks

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Abstract: Wireless Sensor Networks (WSNs) consists of distributed autonomous sensors without central base controller to monitor environmental conditions. Scalability, energy efficiency, network lifetime and load balancing are important issues in sensor network applications. Clustering and energy efficient routing is an effective technique for achieving above cited issues. This study proposed an Energy Efficient Cluster based Transmission Protocol (ECTP) which uses the report sensing mechanism through the sink with the help of link aware sensory network to improve network lifetime and energy saving. The report generation can be done with the subsidiary analysis of efficient scaling and dynamic Clustering algorithm. In this study, Broadcast Incremental Power algorithm (BIP) is used to find the minimum power tree from the source node for achieving energy efficient broadcasting in the network. It is a sensible methodology to predict the energy efficient and modulated routing path. The transmitted packet delivery ratio and latency outrages the sequential analysis of the cluster path and route navigations. The qualification of cluster head election predominate the route discovery mechanism. The ECTP protocol determines the optimal path for determining the cluster head and route navigation with best path approaches. The ECTP significantly outperforms the energy aware cluster and LEACH. This approach also compared of various network parameters is done with various clustering protocols. Simulation results have shown that ECTP give better performance than other protocols like LEACH and EC in terms of prolong network lifetime and energy efficiency.

Key words: Broadcast Incremental Power algorithm, cluster, energy efficiency, route discovery, wireless sensor networks

INTRODUCTION

The most challenges of WSNs are the use of limited energy resources and to monitor the route navigation. The WSNS energy aware predicting mechanism are largely utilized in various energy predicting areas which includes Object Tracking System, environmental, Temperature Monitory System and Surveillance Monitoring System. Energy efficient Routing (Pantazis *et al*., 2013; Li *et al*., 2011) is one of the great challenges in WSNs. The resources are mostly constrained in terms of energy, processing capability and frequency band width. It is difficult for routing to cope with unpredictable and dynamic topology changes in WSNs. Data communications by sensor nodes must be considered by routing protocols. In some applications, energy conservation is more important than quality of service where all sensor nodes are constrained in terms of energy which is related in prolong the network lifetime.

In general, nodes are battery powered modules. The sink nodes act as the central control unit for processing the route delivery paths. When the nodes in the network increases the transmission delay and routing parameters contrives more in making the path delivery to the sink, the farthest node assumed to be the leader head for making the control unit. The tree nodes with multiple levels cause transmission delay and delayed multi hop communication. The root node is elected as the head node for making the routing efficiently in WSNs (Zhang and Shen, 2010; Jiang and Jin, 2008; Tulone and Madden, 2006). In cluster mechanism, each node perpetuates with neighboring communication nodes and option based system is nominated to elect the cluster head, finally the active clustering involves and fix the cluster head. The cluster head was proposed with gateway to determine the network data packet current state position. The passive cluster head mechanism is predominantly supported to provoke the external node with reduced battery power

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consumption. The packet delivery ratio has been associated with frequent retransmission which leads to poor energy loss and worst case quality aware clustering.

The proposed ECTP has energy aware clustering mechanism and reliable routing with minimized delay in routing path with flexible gateway. A gateway candidate and a cluster head is selected based on the metrics includes energy, link quality and Packet Transmission Count (PTC). The algorithm specifies that a candidate with highest priority is sketched as the nominal cluster head candidate. The simulation pattern pre limits with a high level of cluster head selection using the PTC. The wireless sensor nodes have strictly restricted sensing, computation, battery life and communication capabilities. Due to resource limitations for the sensor nodes, it is important to use energy efficiently for each sensor node.

Kumar *et al*. (2011) presented taxonomy of energy Efficient Clustering algorithms in WSNs and also present timeline and description of LEACH and its descendant in WSNs.

Ishmanov *et al*. (2011) described overview of Energy Consumption Balancing (ECB) issues and mechanisms in WSNs that ensures that the average energy dissipation per sensor is equal for all sensors in the network. ECB consider the energy efficiency property for managing energy consumption of sensors optimally to prolong network lifetime. They are not focusing on routing overhead that leads degrade the network performance.

The passive cluster approaches by Lee *et al*. (2010) and Mammu *et al*. (2013) reduce the overhead faced with the elaborate cluster maintenance with data packets being delivered. The passive approach proposes two mechanisms called First Declaration Wins Mechanism (FDWM) and Gateway Selection Heuristic Mechanism (GSHM) that helps to determine the CH and Cluster Head Gateway (CHG) nodes effectively. In the First Declaration Wins Mechanism, the CH candidate uses a contention energy reabsorbing nodes and express wish to become a CH node. That is the CH candidate first claiming to become a CH node within the communication range will successfully become a CH node. The GSHM mechanism determines the minimal number of CHG nodes to aware of the fact that a single cluster has at least two CHG nodes to maintain network connectivity. A CH and CHG node uses the utmost energy parameters as it being the important candidates. The passive approach deals with a random selection principle to use CH and CHG nodes. It would not bother about data range transmission mechanism and link routing schemes.

In the cluster based routing approach, nodes are partitioned into clusters, a cluster head node collects, processes and forwards the data from all its members which greatly improve bandwidth reusability, enhanced resource allocation and improved power control. LEACH (Malik *et al*., 2013) incorporates randomized rotation of the high energy cluster head position such that it rotates among the sensors in order to avoid draining the battery of any one sensor in the network. In this way, the energy load associated with being a cluster head is evenly distributed among the nodes. Since, the cluster head and its members use TDMA mechanism to transmit its data to other. It also prevents intra cluster collisions among all the nodes. The LEACH's function has divided into rounds. Each round begins with a set up phase when the clusters are organized and then it followed by a steady state phase where various frames of data are transferred from nodes to the cluster head and base station. LEACH guarantees not only the equal probability of each node as cluster head and also the relatively balanced energy consumption of the network nodes.

The energy efficiencies and load balancing are evaluated with the metrics of clustering schemes illustrated as energy of sensory node. Each node in the networks is maintained with a level of degree of survivable environment. Energy Equalization and Conservation algorithm (EC) (Zhang and Shen, 2010; Wei *et al*., 2011) is applied for multi-hop data delivery scenarios in clustered WSNs. EC determines the density of CH nodes in the network based on the hop distance to sink for improving energy conservation. This approach is achieved load balancing by uniform distribution of CH in the sensor network.

Lee and Cheng (2012) proposed, a fuzzy logic-based clustering approach based on LEACH architecture with an extension to the energy predication has been proposed for WSNs (LEACH-ERE). LEACH-ERE selects the CHs considering expected residual energy of the sensor nodes to achieve proper CHs considering expected residual energy of the sensor nodes from existent sensor nodes.

Anno *et al*. (2008) proposed two Fuzzy-Based Systems for cluster head selection in sensor networks. It considered 3 input linguistic parameters such as remaining battery power of sensor, degree of number of neighbor nodes and distance from cluster centroid to found that the remained energy of the sensor and the number of neighbor nodes. Energy efficient routing protocols described by Barfunga (2012) and Farazandeh *et al*. (2013).

The ECTP specifies a probabilistic approach which obtains a node that has more residual energy to successfully become a cluster head with the following probabilistic approach:

$$P_{CH} = IP_{CH} \times \frac{NR_E}{NI_E} \tag{1}$$

Where:

- P_{CH} = The probability of total cluster head in the network
- IP_{CH} = The initial percentage of cluster head
- NR_E = The total probability residual energy
- NI_E = The node preliminary energy which has been supposed to be a maximum energy node

In this proposed metrics, the more residual energy has been successfully become a cluster head for active participation in networks.

MATERIALS AND METHODS

WSNs is assumed an unconventional bidirectional graph G (N, L) where N denotes the group of sensory nodes, L specifies the communication link between the specification with $L \subseteq N \times N$. N_{so} is the source linkage and N_{si} is the sink linkage within the clusters. The N_s is the set of neighbor nodes having the node ID's that allows proposing the number of elements. When the node gets connected with the state of approval with the current status, the state transition and clustering will be formed with mutual neighboring nodes. The state transition in the cluster formed can specify the new threshold level with anticipated frequency.

The multimodal nodes may establish the state transition to be congruent with the residual energy ratio upgraded with the radio electronics parameter metrics. The ultimate transmission packet count established with the metrics parameters. The sensor nodes are stationary towards the Global Positioning System to retrieve the stored actual transmission count metrics. The radio frequency estimation is elaborated with the source frequency as N_{rf}. The same amount of energy is consumed through out all the nodes with the residual pact analysis.

The random selection using PC techniques is nevertheless a efficient approach rather a model while communication with neighbors. It must specify the approximate selection of link condition and range coverage with the input packet data. The cluster and gateway node uses a rational factor with novel approach proposes the channel allocation for nodes, compared to the previous researches justified that the ECTP suggest a bidirectional frequencies data packet count. The transmitted packet count elaborates the specification which is calculated from Eq. 2:

$$PTC_{sosi} = \frac{1}{F_{sosi}} R_{sosi} \tag{2}$$

Where:

- F_{sosi} = The forward ratio of the source node corresponding to the sensory cluster
- R_{sosi} = The reverse ratio sink node
- PTC_{sosi} = The estimated packet transformation counts

The proposed methods estimates the ratio of energy modules using Eq. 3:

$$RE_{sosi} = \frac{E_i^{res}}{PTC_{sosi}} E(k, d_{sosi}) \tag{3}$$

Where:

- RE = The ratio of energy modules
- E_i^{res} = The residual energy of nodes
- $E(k, d_{sosi})$ = The energy consumption for source node to transmit a k bit message over a distance d_{sosi}
- d_{sosi} = The distance between sources and sink node

The distance assumes the energy ratio to be off between the same diagnostic parameters. The estimated nodes to be the cluster based on the gateway cluster broadcasting meter. The total energy can be calculated from Eq. 4:

$$E_{tx}(k, d_{sosi}) E_{ideal} + E_{tx}(RE, d_{sosi}) \tag{4}$$

E_{ideal} is the ideal energy of nodes. The energy is calculated with the total energy icons analyzed with the radio electronics with amplification energy in each node. The zero level degree is estimated with the above energy level predictions. Then, higher order level the energy parameters are also estimated for considering forming a cluster.

Cluster head election based on prioritization: The ECTP algorithmic approach evaluates the candidate node of CH and CHG for data forwarding based on the prioritization. CH candidate and CHG candidate performs the following steps to determine its priority:

Level 1: Calculate the PTC and RE of each neighboring node where $N_{sj} \in N_{rel}$.

Level 2: Divide N_{rel} into two sub clusters, N_{rel} (i) and N_{rel} (j) where the PTC of all elements in N_{rel} (i) are greater than or equal to F_{req} and the PTC of all elements in N_{rel} (j) are smaller than F_{req}.

Level 3: The minimum level of degree nodes are taken for consideration in the N_{rel} with the node specification and elected as cluster head.

Algorithm: Cluster Head Election
Input: F_{req}, N_{rel}
Output: Re_i
Calculate RE where $N_{rel} \in N_{sosi}$ has to be estimated
N_{rel} (i)$\leftarrow \phi$;
N_{rel} (j)$\leftarrow \phi$;
For j = 1 to 0, N_{sosi} d0
  if $RE \geq N_{req}$
   $N_{rel}(i) \leftarrow N_{rel}(i) \cup \{N_{rel}(j)\}$;
  else
   $N_{rel}(j) \leftarrow N_{rel}(i) \cup \{N_{rel}(j)\}$;
  if N_{rel} (i) = ϕ
   RE_i = min RE, $sosi \in N_{rel}(i)$;
  else
   RE_i = max RE, $sosi \in N_{rel}(i)$;

The priority node specifies a random approach to defer the transmission nodes of data packets. The waiting period (T^w) of the candidate node is calculated based on the time slot frequency:

$$T^{w} = t_{slot}\frac{1}{F_i} \qquad (5)$$

The time slot has been estimated with the above mentioned illustration of node parameters.

Broadcast Incremental Power algorithm (BIP): BIP is used to find the minimum power tree from the source node to all of the other nodes in the network. And also it adapt multicast as well. BIP is based on Prim's algorithm.

BIP algorithm:

Input
S_n, N
Initialize:
$N_{new} = \{n_1, n_2, ..., n_i\}$,
$T_{new} = \{\phi\}$
Repeat until $N_{new} = \phi$:
Choose a node u with minimal weight from S_n
$MST_{new} = u$
Output:
MST_{new} // minimum spanning tree
Evaluate transmitted power.
$MP_{ij} = P_{ij} - P(i)$
// P_{ij} is the link cost of a transmission between Node i and j
// P(i) is the power level already transmitting

Figure 1 shows a five node network in which node 'A' is the source node. This approach initially begins by determining the node with minimum transmission of power which is Node 'B' and then it is added to the tree. And then determine which other node can be added to the tree with next minimum cost. Node 'B' can transmit to its nearest neighbor that is not already in the tree. Now two nodes in the tree include node 'A' and 'B'. This step is continued until all nodes are included in the tree as shown in step 4 of Fig. 1. The total transmission power required to maintain this tree is the sum of the transmitted powers at each of the transmitting nodes in the network. This prolong the network life time.

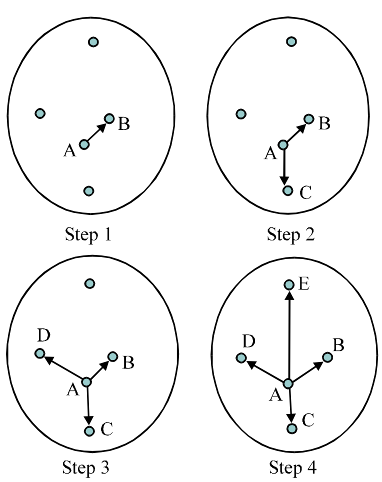

Fig. 1: Tree construction using BIP

RESULTS AND DISCUSSION

This research used ns-2 as the network simulator and conducted numerous simulations to evaluate the ECTP performance. All sensor nodes are randomly scattered with a uniform distribution. The random selection of nodes is evenly distributed throughout the metrics including data packets delivery ratio, maximal energy and packet transmission latency are analyzed and compared to other protocols like LEACH and HEED. The simulations were established in the following table of network parameters simulation setup is described in Table 1.

Data packets delivery ratio: Packet delivery ratio is the ratio of the number of report messages the sink receives the total number of report messages the source node sends. The analysis was predicted using the simulation setup in Fig. 2 which presents the packet transmission

Table 1: Simulation parameters

Parameters	Values
Network size	250×250 m
Nodes	50, 100, 150, 200, 250, 300, 350, 400
Range	25 m
Packet size	1500 bits
Initial energy of nodes	2.0 J
Transmission energy	50 nJ bit^{-1}
Transmit amplifier energy	100 pJ bit^{-1}
Energy of elected node	46 J bit^{-1}
Time slotn (tslot)	75 msec
Simulation time	100 msec

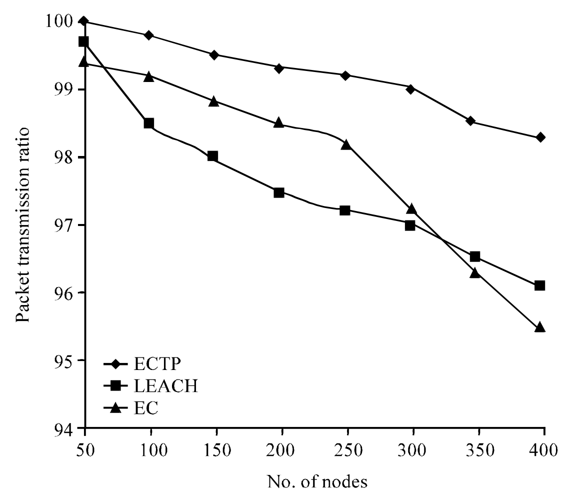

Fig. 2: Data transmission packet ratio for ECTP

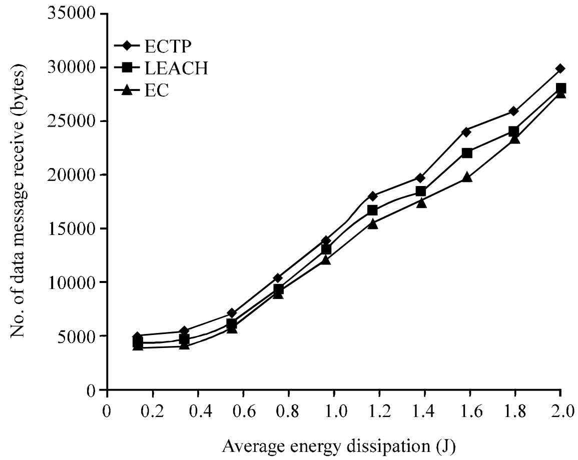

Fig. 3: Average energy dissipation metrics analyzed using ECTP

ratio of the three clustering mechanisms. Decreasing the packet transmission ratio make the causes includes discovered broken routing path and reconstruction of cluster which leads additional energy dissipation of sensor nodes. The simulation result notices that ECTP improve packet transmission ratio by 4.2% than other two protocols.

Average energy dissipation: Average energy dissipation measures the mean value of the residual energy of all active sensor nodes when simulation terminates. The analysis was predicted using the simulation setup in Fig. 3 which provides a comparison of the energy dissipation results of three clustering mechanisms. In general, sensor nodes consume more energy in clustering, thereby decreasing the residual energy. The result notice that the increasing number of nodes which reduce the residual energy of the nodes. Figure 3 showed that the proposed ECTP consumes less energy than the LEACH and EC. Because the ECTP approach is selecting the CH node efficiently to save more battery power than other two protocols.

Packet transmission latency: Packet transmission latency is the time delay experienced by the source node while Fig. 4 presents the average latency of the three clustering mechanisms. More clusters is generated and the length of routing path increases provide long delivery latency. Increasing the delivery latency based on poor link quality and retransmission of messages result in cluster reconstruction and to determine a new routing path. The proposed ECTP can efficiently reduce the retransmissions which provide better delivery latency than other two protocols. Based on the observation,

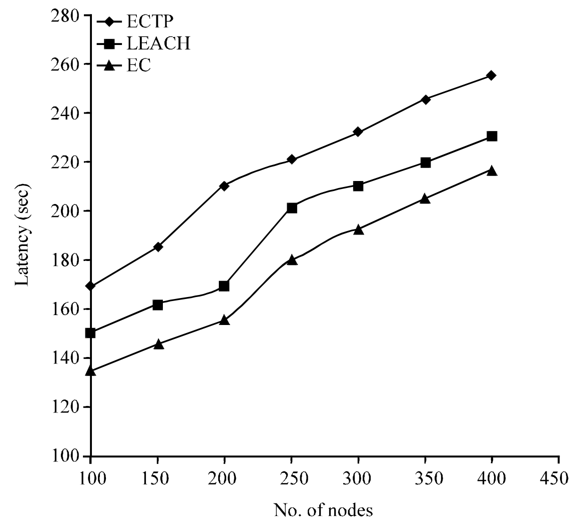

Fig. 4: Latency vs. network size

ECTP shows improvement of 5% in system lifetime over LEACH and EC. And also this improvement is expected to be more significant for sensor networks with larger dimensions.

CONCLUSION

The ECTP protocol proposes the energy efficient cluster mechanisms which highlights the nominal transmission range provoking the priority for the cluster head and gateway candidates. The report generation to the nodes has achieved a higher compatibility to the proposed methodology. The packet transmission count and the delivery ratio of the packet decide the highest priority node to be the cluster head and the gateway candidate. The proposed methodology utilizes minimized energy level to nominate the cluster head with the good link level of transmission.

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