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A Reliable Routing Technique for Wireless Sensor Networks

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Abstract

Wireless Sensor Networks (WSNs) are composed of tiny and miniaturized electronic devices which are known as sensors. Sensors can sense, compute, store, transmit and receive data of interests from the environment in which they are deployed. Due to small size of sensors, a big size battery source cannot be embedded into them therefore sensors need efficient mechanism for energy utilization. Many of the existing hierarchical routing protocols do not guarantee the optimum choice of cluster heads because of the lack of comprehensive consideration of the remaining energy of the nodes, the distribution within a cluster and the distribution among the clusters in the process of choosing the cluster heads. In addition, the single-hop communication among clusters head to a serious imbalance in the energy of the cluster heads. This paper combines the improved particle swarm clustering algorithm and the inter-clustering algorithm to form an Adaptive Energy Efficient Clustering routing Protocol (AECRP).Simulations results show that this protocol not only balances the energy consumption of the overall network, delays death time of the nodes, but also provides more reliable data delivery.

Keywords: *WSN, routing, energy-efficient*

1. INTRODUCTION

Wireless sensor networks utilize large numbers of wireless sensor nodes to collect information from their sensing terrain, wireless sensor nodes are battery-powered devices, energy saving is always crucial to the lifetime of a wireless sensor network[2]. As the network deployment area is usually complex, the battery of the sensor is not always rechargeable after deployment, so the feasible methods of saving energy for WSN are to improve the network routing protocols and to optimize the network topology structure. The energy consumption model of the wireless communication shows that the energy consumption is related to the communication distance, so in order to reduce the energy consumption of the wireless communication we should shorten the communication distance and avoid long distance communication. Hierarchical routing protocols introduce the concept of cluster[2], which is conducive to the expansion of the network and network simplification, also needs not to build and maintain the routing information. Meanwhile, this will further reduce the energy consumption of the long distance communication.

However, some existing hierarchical routing protocols have some problems. Firstly, many of them don't consider the factor of energy in the process of choosing the cluster heads. Assume that the energy of each node is equal at the beginning, but as time goes on, the remaining energy of each node varies greatly. The nodes with very low energy may be still elected as the cluster heads. These nodes will die quickly resulting in a substantial decline in the network performance. Secondly, the lack of considering the geographical position could result in uneven distribution not only within a cluster but also among clusters. This condition can affect the balance of the network energy. Lastly, the adoption of single-hop between a cluster head and a sink node is not fit for long distance communication. When the cluster head is far from the sink node, it will spend a large amount of energy to transfer packets to the sink node. Obviously the cluster head would die soon.

This paper presents an energy-efficient routing protocol based on particle swarm clustering algorithmand inter-cluster routing algorithm for WSN, which makes improvements mainly in the following two aspects. First, network clustering is a kind of NP problem to optimize the network topology partitioning, particle swarm algorithm can effectively solve this problem. However, the convergence speed of the particle swarm algorithm is slow. To address the issue above, we introduce an adaptive inertia weight based on different dimensions to accelerate the convergence speed of the particles. Based on the improved particle swarm optimization (PSO) we present a particle swarm clustering algorithm which considers the remaining energy of nodes, the distribution within a cluster and the distribution among clusters. Second, an inter-cluster routing algorithm combining single-hop with multi-hop is designed to avoid long distancecommunication between the cluster head and the sink node, which at the same time adopts the "threshold detection" mechanism to relieve the load of the cluster heads near the sink node. Finally,we combine the improved particle swarm clustering algorithm with the inter-cluster routing algorithm to form an adaptive energy-efficient clustering routing protocol, referred to as AECRP.

2.LEACH

Low Energy Adaptive Clustering Hierarchy (LEACH) [3] is the first hierarchical cluster-based routing protocol for wireless sensor network which partitions the nodes into clusters, in each cluster a dedicated node with extra privileges called Cluster Head (CH) is responsible for creating and manipulating a TDMA (Time Division Multiple Access) schedule and sending aggregated data from nodes to the BS (Base Station) where these data is needed using CDMA (Code Division Multiple Access) as shown in figure 1. Remaining nodes are cluster members.This protocol is divided into rounds; each round consists of two phases:

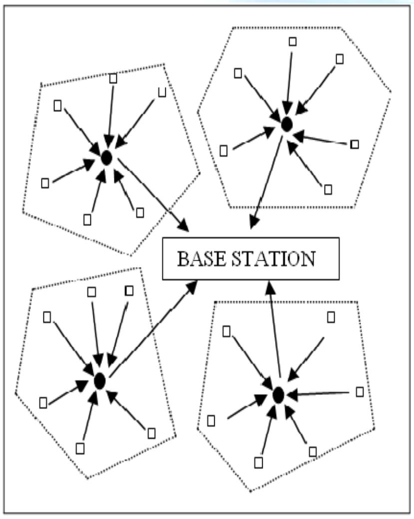

Figure 1 LEACH Protocol Architecture

2.1 Set-up Phase

Each node decides independent of other nodes if it will become a CH or not. This decision takes into account when the node served as a CH for the last time (the node that hasn't been a CH for long time is more likely to elect itself than nodes that have been a CH recently).In the following advertisement phase, the CHs inform their neighborhood with an advertisement packet that they become CHs. Non-CH nodes pick the advertisement packet with the strongest received signal strength.

In the next cluster setup phase, the member nodes inform the CH that they become a member to that cluster with "join packet" contains their IDs using CSMA. After the cluster-setup sub phase, the CH knows the number of member nodes and their IDs. Based on all messages received within the cluster, the CH creates a TDMA schedule, pick a CSMA code randomly, and broadcast the TDMA table to cluster members. After that steady-state phase begins.

2.2 Steady-State Phase

Data transmission begins. Nodes send their data during their allocated TDMA slot to the CH. This transmission uses a minimal amount of energy (chosen based on the received strength of the CH advertisement). The radio of each non-CH node can be turned off until the nodes allocated TDMA slot, thus minimizing energy dissipation in these nodes. When all the data has been received, the CH aggregate these data and send it to the BS. LEACH is able to perform local aggregation of data in each cluster to reduce the amount of data that transmitted to the base station.

Although LEACH protocol acts in a good manner, it suffers from many drawbacks such like;

• CH selection is random, that does not take into account energy consumption.

• It can't cover a large area.

• CHs are not uniformly distributed; where CHs can be located at the edges of the cluster.

Since LEACH has many drawbacks, there is a requirement to make this protocol perform better.

3. AECRP

This protocol process runs in accordance with the round, each round contains initial establishment stage and stable transmission stage. The initial establishment stage is just the stage of choosing the cluster heads and self-organizing clustering. The following is the stable transmission stage, namely the steady state stage.Usually the stable transmissionstage is longer than the initialization stage. The stable transmission stage is divided into multiple frames; each frame contains a plurality of time slots. Each frame is a data transmission process, a data transmission process contains data transmission within a cluster and data transmission from the cluster heads to the sink node. Each node can transfer data to its cluster head only in its own time slots;the last slot of each frame is the time for all the cluster heads to transfer the processed data to the sink node.

3.1 Particle Swarm Optimization (PSO)

PSO [8] is originally attributed to Kennedy, Eberhart and Shi and was first intended for simulating social behavior, as a stylized representation of the movement of organisms in a bird flock or school. Particle Swarm Optimization (PSO) is a computational method that optimizes a problem by iteratively trying to improve a candidate solution with regard to a given measure of quality. PSO optimizes a problem by having a population of candidate solution and moving these particles around in the search-space according to simple mathematical formulae over the particle's position and velocity. Each particle's movement is influenced by its local best known position and is also guided toward the best known positions in the search-space, which are updated as better positions are found by other particles. This is expected to move the swarm toward the best solutions. PSO is a meta-heuristic approach as it makes few or no assumptions about the problem being optimized and can search very large spaces of candidate solutions. Beside this, PSO do not guarantee an optimal solution always.

3.2 Particle Swarm Clustering Algorithm

Clustering algorithm can be divided into two steps,one is choosing the cluster heads, and the other is self-organizing clustering, choosing the cluster heads is the core of the clustering algorithm. Based on the improved PSO algorithm, we design an evaluation function whose independent variable is related to the remaining energy of nodes, the distribution within a cluster and the distribution among clusters. The particle whose evaluation function value is larger is better, so only the nodes whose energy is sufficient and position is appropriate can be selected as the cluster heads.

AECRP routing protocol adopts the central centralized control strategy for clustering. All the nodes send the information of their energy and position to the sink node, the sink node executes the clustering algorithm to choose the cluster heads and then broadcast the result to every node indistinguishably. When the nodes learn that they are elected as the cluster heads, they will broadcastannouncements. After other non-cluster head nodes receive the messages, they choose to join a cluster according to the size of the signal strength; strong signal often represents short propagation distance. In order to reduce the energy consumption of communication, the non-cluster head nodes choose the closest cluster to join.

4. Design of Inter-Clustering Algorithm

4.1 Single-hop and multi-hop

After clustering, the next is the stable transmissionstage which contains data transmission in a cluster and data transmission among clusters. The non-cluster head node will firstly transfer data to its own cluster head, and then the cluster head fuses these data and sends them to the sink node. A non-cluster head node only transfers data to its own cluster head, so the energy consumption of communication is less. A cluster head node not only receives data from all the non-cluster head nodes in the cluster but also transfers these data to the sink node, so the energy consumption of communication is more. Obviously, the energy consumption of the cluster head node is far higher than that of the non-cluster head node; to implement the energy saving of the cluster head nodes is particularly important. When a cluster head is far away from the sink node, the single-hop communication will increase the energy consumption of the cluster head and cause the cluster head to die prematurely. Since there are lots of uniform distribution cluster heads in the network, we can adopt multi-hop communication among these clusters.

Therefore, if the spacing between nodes is large, the multi-hop communication is more energy-efficient than the single-hop communication, if not, the single-hop communication is better. In the wireless communication energy consumption model, when the propagation distance is less than the threshold d_0(Free Space Model), the energy consumption has a linear relationship with the square of the propagation distance, when the propagation distance is not less than the threshold d_0(Multipath Fading Model), the energy consumption has a linear relationship with the biquadrate of the propagation distance. As shown in formula.

4.2 Inter-cluster routing algorithm

Inter-cluster routing algorithm uses the greedy algorithm to select the next hop node; a cluster head always selects the neighbor cluster head with the largest weight as its next hop relay node.

When the cluster head ineed to send data to thesink node, it will firstly calculate the distance to the sink node. If the distance value is less than the critical value R, the data will be sent to the sink node directly. Otherwise, the cluster head i will pick out the relay node j which has the largest weight in its routing table, and then the cluster head j will forward the data according to the same principle. If there is no appropriate routing information in the routing table, the data will be also sent to the sink node.

5. Results and Simulations

5.1 Energy Analysis of LEACH And AECRP Protocol

LEACH uses the Random Inertia Weight Strategy (RIW). In this scheme the cluster heads are selected in a random manner without considering the remaining energy of the nodes. In this process the nodes with low energy are also chosen as the cluster head, thus the network fails to communicate when the energy of the cluster head node is drained out completely. This is overcome in the AECRP protocol where the cluster heads are selected according to the DIW strategy.

In this process the nodes with low energy is given high priority and these high priority nodes are chosen as cluster heads first in the network. Since the high priority nodes are chosen first, the network performance is increased and hence the energy of the network is balance throughout the lifetime of the network. The simulations are carried out using NS-2 simulator. The number of nodes taken is 100. The initial energy of the network is taken as 2J. The protocols analyzed are LEACH and AECRP.

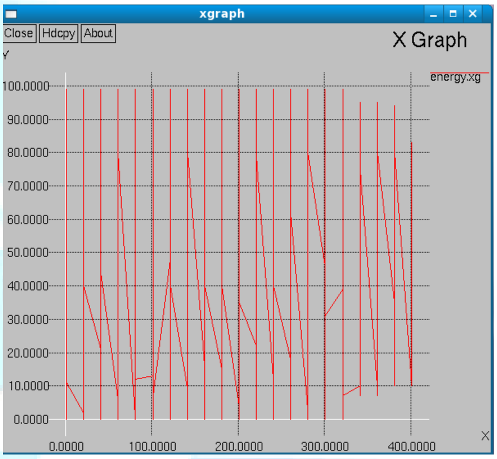

Figure 2Energy Analysis of LEACH Protocol

In figure2 the energy of LEACH protocol is analyzed with time in milliseconds in X-axis and Energy in Joules in Y-axis. The energy is not balanced throughout the lifetime of the network because of the RIW strategy.

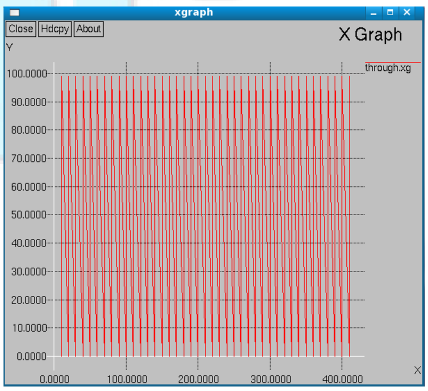

Figure 3Throughput Analysis of LEACH Protocol

In figure 3 the throughput of LEACH protocol is analyzed. Time in milliseconds is taken in the X-axis and throughput in percentage is taken in the Y-axis. The throughput is less because of the random selection of cluster head in the network.

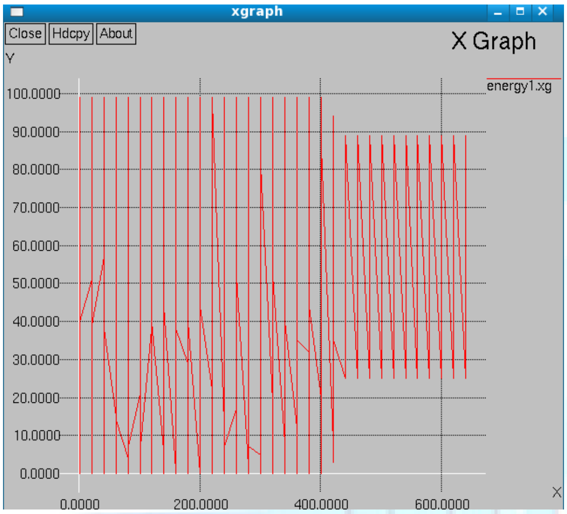

Figure 4 Energy Analysis of AECRP Protocol

Figure 4 shows the energy analysis of AECRP protocol. This is plotted against time in milliseconds X-axis and energy in Joules in Y-axis. This plot shows that the energy is balanced throughout the lifetime of the network. Thus increases the network performance.

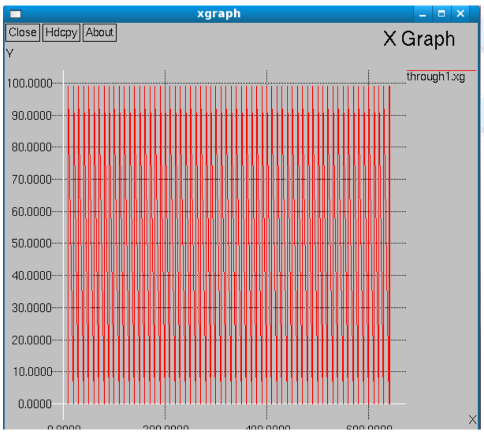

Figure 4 Throughput analysis of AECRP Protocol

Figure 4 shows the throughput analysis of AECRP protocol. The graph is plotted with time in milliseconds in X-axis and throughput in percentage in Y-axis. The throughput of the system is increased due to the DIW which increases the performance of the network by selecting the cluster head according to priority in terms of remaining energy of the nodes.

5.2 Comparison of LEACH and AECRP

AECRP and LEACH protocols are compared in terms of end-end delay, packet delivery ratio, throughput and energy.

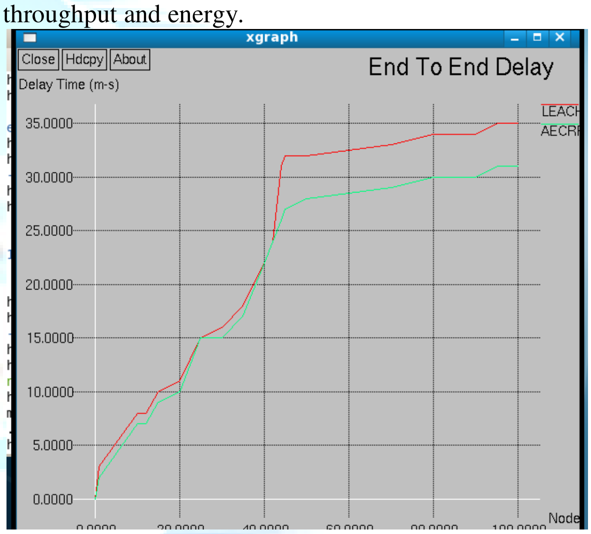

Figure 6End to End Delay comparisons of LEACH and AECRP

Figure 6 shows the end to end delay comparisons of LEACH and AECRP. This shows that for LEACH the delay is more than that of AECRP. End to end delay is the time taken for the packets to get transmitted from the source node to destination. The graph is plotted against node in X-axis and delay time in milliseconds in Y-axis.

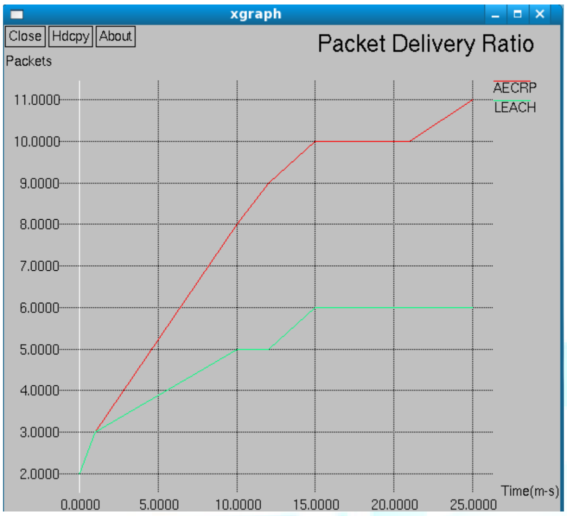

Figure 7Packet Delivery Ratios of LEACH and AECRP

In figure 7 the packet delivery ratio of LEACH and AECRP is compared. The packets are delivered at more increased speed in AECRP than LEACH. The graph is plotted against time in X-axis and no. of packets in Y-axis.

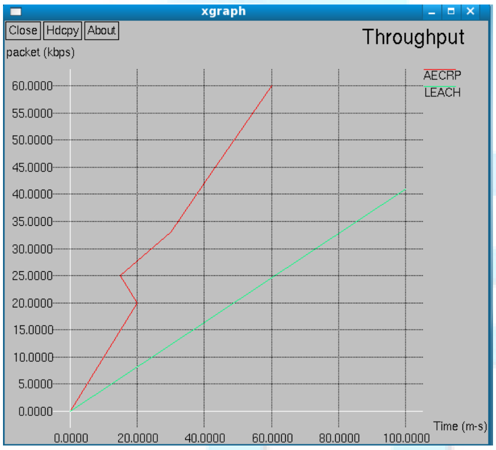

Figure 8Throughput comparisons of LEACH and AECRP

Figure 8 shows the throughput comparison of LEACH and AECRP. In AECRP the throughput is high compared to LEACH. The graph is plotted against time in milliseconds in X-axis and packet in kbps in Y-axis. This shows that apart from saving the energy of the network. The AECRP protocol provides better throughput, packet delivery ratio and end to end delay.

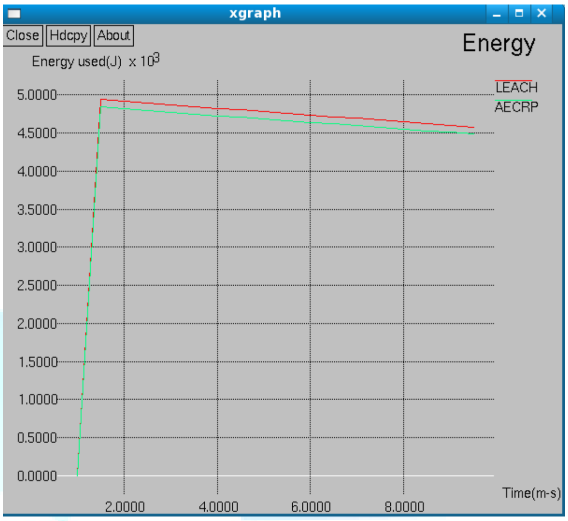

Figure 9 Comparison of Energy used in LEACH and AECRP protocol

In figure 9the energy used in LEACH and AECRP is compared. AECRP uses the Decreased Inertia Weight Strategy (DIW), which makes the energy consumed to be less than LEACH.

Algorithm (RIW) in which the cluster heads are chosen in a random manner. The graph is plotted against time in milliseconds in X-axis and Energy used in Joules in Y-axis.

6. Conclusion

In this paper the energy consumption of the network is reduced by making use of AECRP protocol which uses the DIW strategy. The parameters such as end to end delay, packet delivery ratio, energy, and throughput are compared and plotted. Thus it is shown that AECRP is better than LEACH for routing in a WSN. Future work is concentrated on the data reliability of AECRP and to compare it with LEACH to show that data is reliably sent in the network using AECRP protocol.

References

[1] Chi-Tsun Cheng, C.K. Tse, F.C.M. Lau. "A Delay-Aware Data Collection Network Structure for Wireless Sensor Networks", IEEE Sensors Journal, Vol.11, No.3, 699-710, 2011.

[2] Al-Karaki, A. Kamal, “Routing Techniques in Wireless Sensor networks: A Survey,” Security and Networks, 2004, Vol. 11, Issue 6, pp. 6-28.

[3] M. J. Handy, M. Haase, D. Timmermann, “Low Energy Adaptive Clustering Hierarchy with Deterministic Cluster-Head Selection,” In Proc. 4th International Workshop on Mobile and Wireless Communications Network, USA, 2002, Vol. 1, pp. 368-372.

[4] D. A. Vidhate, A. K. Patil, S. S. Pophale, “Performance Evaluation of Low Energy Adaptive Clustering Hierarchy Protocol for Wireless Sensor Networks,” In Proc. International Conference and Workshop on Emerging Trends in Technology (ICWET 2010)TCET, Mumbai, India, 2010, pp. 59-63.

[5] C. Karlof and D. Wagner, “Secure routing in wireless sensor networks: attacks and countermeasures,” in Proc. of IEEE SNPA 2003, 2003.

[6] NS-2 Network Simulator. http://www.isi.edu/nsnam/ns/.

[7] K. Latif, M. Jaffar, N. Javaid, M.N. Saqib, U. Qasim, Z.A. Khan. “Performance Analysis of Hierarchical Routing Protocols in Wireless Sensor Networks”, 2012 Seventh International Conference on Broadband, Wireless Computing, Communication and Applications (BWCCA), 620-625, 2012.

[8] J. Kennedy, R. Eberhart. “Particle swarm optimization”, IEEE International Conference on Neural Networks, Vol.4, 1942-1948, 1995.

[9] B. Naik, S. Swetanisha, D.K. Behera, S. Mahapatra, B.K. Padhi. “Cooperative swarm based clustering algorithm based on PSO and k-means to 6find optimal cluster centroids”, 2012 National Conference on Computing and Communication Systems (NCCCS), 1-5, 2012.

[10] R.V. Kulkarni, G.K. Venayagamoorthy. “Particle Swarm Optimization in Wireless-Sensor Networks: A Brief Survey”, IEEE Transactions on Systems, Man, and Cybernetics, Part C: Applications and Reviews, Vol.41, No.2, 262-267, 2011.

[11] Y. Shi, R.C. Eberhart. Empirical study of particle swarm optimization, 1999. CEC 99. Proceedings of the 1999 Congress on Evolutionary Computation, Vol.3, 1999.

[12] Shi Yuhui, R.C. Eberhart. “Fuzzy adaptive particle swarm optimization”, Proceedings of the 2001 Congress on Evolutionary Computation, Vol.1, 101-106, 2001.

[13] R.C. Eberhart, Shi Yuhui. “Tracking and optimizing dynamic systems with particle swarms”, Proceedings of the 2001 Congress on Evolutionary Computation, Vol.1, 94-100, 2001.

[14] D.H. Smithgall.”Toward the 60 gm wireless phone”, Radio and Wireless Conference, 157-159, 1998.

[15] L. Qing, Q. Zhu, M. Wang, "Design of adistributed energy-efficient clustering algorithmfor heterogeneous wireless sensor networks".ELSEVIER,Computer Communications 29, pp2230-2237, 2006.