Journal of Mobile Communication 4 (2): 38-42, 2010
ISSN: 1990-794X

Weighted Election Protocol for Clustered Heterogeneous Wireless Sensor Networks

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Abstract: We propose a new protocol named WEP (Weighted Election Protocol) to improve the stable region of the clustering hierarchy process using the characteristic parameters of heterogeneity, namely the fraction of advanced nodes and the additional energy factor between advanced and normal nodes. WEP attempts to maintain the constraint of well balanced energy consumption. Intuitively, advanced nodes have to become cluster heads more often than normal nodes. The performance of the WEP via computer simulation is evaluated and compared with other clustering algorithms. It has been found that WEP always prolongs the stability period compared to other current clustering protocols (LEACH, HEARP and SEP) for higher values of extra energy.

Key words: Sensors, stability, clustering, lifetimes, algorithms, performance

INTRODUCTION

Wireless communication technologies are growing firstly. It can be expected that Wireless Sensor Network (WSN) will be utilized everywhere in future life. It is a one kind of wireless ad-hoc networks, composed of a collection of thousands or millions of sensor nodes which are deployed randomly and widely. WSN is identified as one of the promising technologies in the field of wireless communication. It becomes more popular for enormous applications such as the military, medical service, environment and business. Sensors are battery powered tiny devices fixed up in the remote place to collect information for a specific task. Therefore, we can use WSN as a powerful tool to gather information from the real world (Jian-Wu *et al*., 2008). If it is required to collect information continuously from remote places where people are usually not allowed or maintenance is very difficult, WSN can be the perfect network for that case (Sung and Tong, 2005).

The battery of sensor has limited power, deployed randomly in remote place and handle data for a relatively long time (Wang and Yang, 2007). It is not possible to recharge or replace the battery when the batteries of sensors are powerless. So, sensor nodes are died frequently and network becomes obsolete very quickly. It should be required to ensure greater stability period of the wireless sensor network with those sensor nodes to collect information over the sensing fields where they are deployed. Here, stability period means the number of rounds to which all the nodes become alive to collect meaningful information from every part of the sensing fields. Therefore, ensuring greater stability of the WSNs becomes critical importance. As the member of Sensor network community we have been put a significant focus on increasing stability period of the network.

MATERIALS AND METHODS

LEACH: In wireless sensor networks, one of the crucial methods for increasing network lifetime is clustering (Zadeh *at el*., 2010). The concept of clustering protocol is first proposed by Heinzelman *et al.* (2000) for periodical data gathering applications. This protocol disperses the energy load between sensor nodes to prolong the network life time. The whole network is divided into some clusters and each cluster contains a number of nodes. One sensor node in the cluster acts as a cluster head. It controls the cluster i.e., collect information from neighbor nodes, accumulates them and then sends the accumulated data directly to sink. As a result, cluster head consumes more energy than other ordinary sensor nodes. Cluster heads are randomly rotate to distribute energy consumption of over all nodes in the network. LEACH is homogenous i.e., it assumes that all nodes have same energy. Therefore, some time later, it has a probability to become a cluster head which has low energy. This is the main limitation of LEACH. Several energy-efficient

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(hierarchical) clustering algorithms have been reported to prolong the network lifetime (Heinzelman *et al*., 2002; Rashed *et al*., 2010; Handy *et al*., 2002; Xiangning and Yulin, 2007).

HEARP: Parvin (2007) is proposed a new clustering protocol called HEARP, a hierarchical energy-efficient routing protocol. She has proposed this protocol based on both LEACH and PEGASIS (Lindsey and Raghavendra, 2002). The operation of HEARP is broken up into rounds where each round begins with a set-up phase, followed by data transmission phase. The duration of the transmission phase is longer than the duration of the setup phase. In HEARP, network establishment begins with the formation of clusters. Several clusters are formed including a Cluster Head (CH) in each cluster like LEACH. A chain is established among all the CHs using a greedy algorithm. The chain is started with a furthest CH from the base station followed by immediate nearest CH neighbor. A CH is chosen as leader node from this chain for sending data to the BS.

SEP: Smaragdakis *et al.* (2004) have proposed a clustering protocol named SEP, one of the elegant improvement of LEACH. SEP is a heterogeneous-aware protocol. It means that all nodes do not have same energy i.e., some nodes acquire more energy than that of others. This protocol increases the time interval before the death of first node which is called as stability period. Due to high energy in some sensors, the probability of these sensors to become a cluster head is high. SEP protocol successfully extends the stable region than LEACH. But in SEP and LEACH, cluster heads aren't choose base of energy level and their position. This is main problem of these methods, so their operations are static. However, the stability period provided by SEP is no longer which is crucial for many applications. It may possible to increase the stability period than SEP. In order to ensure the longer stability of the WSNs we proposed the WEP.

Architecture of WEP: Weighted Election Protocol (WEP) is a clustered heterogeneous routing protocol for wireless sensor networks. Actually, WEP is designed to improve the stable region of the network by the combination of both HEARP and SEP. It is based on the clustering hierarchy process using the characteristic parameters of heterogeneity, namely the fraction of advanced nodes and the additional energy factor between advanced and normal nodes as used in SEP. We have considered similar radio energy dissipation model as describe by Smaragdakis *at el*. (2004). In order to prolong the stable region, advanced nodes have to become cluster heads more often than that of normal nodes which is equivalent to a fairness constraint on energy consumption. Figure 1 shows a typical WSNs network using novel routing protocol (WEP). Figure 1 shows the formation of chain among the cluster heads. The steps of novel protocol are as follows:

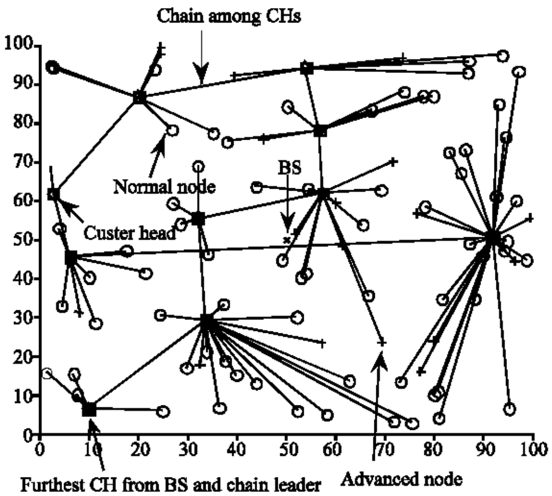

Fig. 1: A snapshot of cluster-head chain formation in the proposed WEP

- Cluster heads are randomly selected from both advance and normal nodes in the sensor network. But the probability is high for advance nodes to elect as a cluster head which is weighted by their additional energy
- Each cluster head broadcast a massage indicating its position and energy level
- Normal nodes are received the broadcast massage and sends the acknowledgement massage to their chosen cluster heads and belong in that cluster
- All cluster heads make a chain between themselves using Greedy algorithm
- A chain leader is selected randomly among the cluster heads within the chain
- According to TDMA schedule, non cluster head nodes send data to their corresponding cluster head. These data received by cluster heads and fuse them. Finally all cluster heads send the aggregated data to the chain leader cluster head. It aggregates all data and send to the base station
- After a certain period of time, the network reforms the cluster head selection process for a new round

Simulation setup: In this research, the randomly distributed 100 nodes are considered in the network. The network size is 100×100 m. Both normal and advanced nodes are randomly (uniformly) distributed over the field.

Cartesian coordinates are used to locate the sensors. The base station is located at the center (x = 50, y = 50). So, the maximum distance of sink from any node is approximately 70 m. The initial energy of a normal node is set to E_0 = 0.1. However, it can be possible to consider larger value of energy. The size of transmitted message from nodes to cluster heads and the size of aggregated message from chain leader to the BS is set to 4000 bits. The energy required for data aggregation is 5 nj/bit/signal. The data processing time per node is taken as 5-10 milli sec. The radio speed is considered as 1 Mbps.

RESULTS AND DISCUSSION

In order to evaluate the performance, we simulate the existing protocols using MATLAB software (Hanselman and Littlefield, 2005). The result of LEACH and HEARP are shown in Fig. 2 for m = 0 and α = 0. It is a comparison between LEACH and HEARP in homogeneous environment. We to make a cluster head chain and select a cluster have observed that HEARP performs slightly better than LEACH regarding network lifetime where first node die at round 139 and 158 for LEACH and HEARP, respectively. Head leader is responsible for this improvement. A detail behavior view

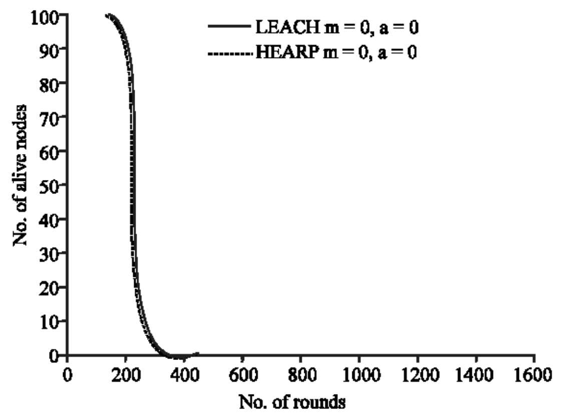

Fig. 2: Number of alive nodes for both LEACH and HEARP to their homogeneous case (m = 0.0 and α = 0)

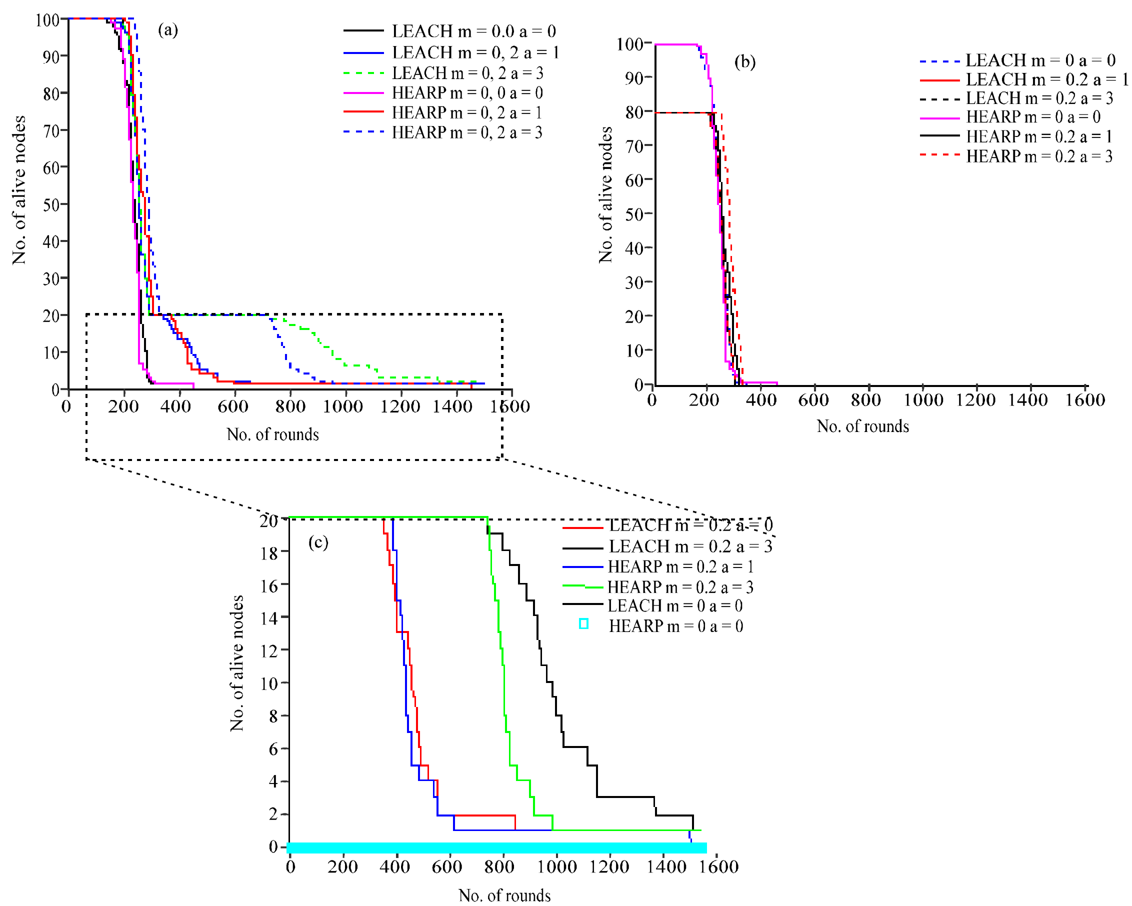

Fig. 3: Behavior of LEACH and HEARP in the presence of heterogeneity: a) Alive nodes per round; b) Alive normal nodes per rounds and c) Alive advanced nodes per round

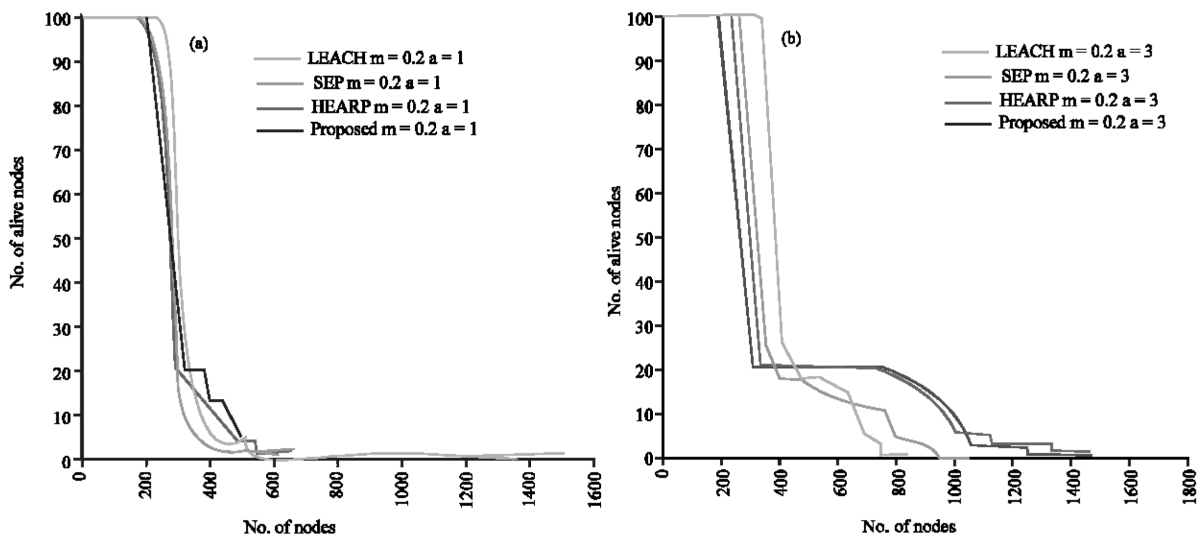

Fig.4: Comparison among LEACH, SEP, HEARP and WEP in the presence of heterogeneity; a) m = 0.2 and α = 1; b) m = 0.2 and α = 3

of LEACH and HEARP is shown in Fig. 3 for different distributions of heterogeneity. Figure 3a for LEACH and HEARP where the number of alive nodes is shown for the scenarios (m = 0.2, α = 1; m = 0.2 and α = 3) where $\alpha \times m$ remains constant. To make a cluster head chain and select a cluster have observed that HEARP performs slightly better than LEACH regarding network lifetime where first node die at round 139 and 158 for LEACH and HEARP, respectively. Head leader is responsible for this improvement.

A detail behavior view of LEACH and HEARP is shown in Fig. 3 for different distributions of heterogeneity. Figure 3a for LEACH and HEARP where the number of alive nodes is shown for the scenarios (m = 0.2, α = 1) and (m = 0.2 and α = 3) where $\alpha \times m$ remains constant. Although, HEARP shows better performance than that of LEACH but do not able to take full superiority of heterogeneity in both scenarios. The numbers of rounds are very close for both heterogeneous setting. Considering the normal nodes, it is found that these nodes die very sharply in both cases as shown in Fig. 3b. As a result, the sensing field turns into sparse quite faster.

A closer view of Fig. 3a for alive advance, nodes is shown in Fig. 3c. It can be seen, on the other hand, from Fig. 3 that the advanced nodes gradually expire because they are not frequently elected as cluster heads after the death of normal nodes. Hence, these nodes are not able to transmit any data most of the time. That's why, the method of election for cluster heads turns into unbalanced. In addition that the numbers of elected cluster heads do not reach to the optimal number.

Results for WEP: In this section, we simulate the proposed WEP protocol and compare the performances with LEACH, HEARP and SEP in the same heterogeneous setting. Figure 4a shows the simulated results for the condition of m = 0.2 and α = 1. It is obvious that the stable region does not moderately change in SEP and HEARP than that of LEACH.

However, the unstable region of Fig. 4 is remarkable; it shows that HEARP and SEP are more and less than LEACH, respectively. It can be noted, the interesting feature of this figure in the stable region for WEP which is extended in comparison with LEACH (by 7%), SEP (3.5%) and HEARP (by 3%). Moreover, the unstable region of WEP is shorted than that of LEACH, HEARP while that of slightly larger than that of SEP. Figure 4b shows results for the case of m = 0.2 and α = 3. The stable region of proposed protocol is increased significantly by 13% (LEACH), 6% (SEP), 8% (HEARP). WEP shows better performance (stable region) by increasing only the value of α.

Here, WEP shows smaller unstable region like LEACH, HEARP and SEP. This is because the dying process of advanced nodes goes away into similar trained as normal ones. Where, the weighted probability of electing cluster heads is proportional to initial energy of the nodes.

CONCLUSION

Researcher propose a new cluster based hierarchical routing protocol, Weighted Election Protocol (WEP) for sensor networks in heterogeneous environments. The proposed protocol overcomes the instability problem of LEACH and HEARP. The ultimate improvement of WEP from LEACH, SEP and HEARP is that the stable region is greatly maximized by reducing the unstable region of the networks. The simulated results show that WEP always prolong the network lifetime compared to other clustering protocols (LEACH, SEP, HEARP). Therefore, it can be concluded that WEP provides energy efficient routing protocols that ensures longer stability region with reasonable amount of delay in data delivery.

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