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Enhancement of Energy Control Routing Protocol for Mobile Ad Hoc Network Based on Hybrid Particle Swarm Optimization with Ant Colony-based Energy Control Routing

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Abstract

MANET is an autonomous collection of distributed mobile nodes. Every node in a MANET works as a source and a sink and that relays packets for other nodes. The key features of a MANET include dynamic network topology, distributed network nature, multi-hop communication, limited bandwidth, and limited energy constraints. Given that the battery of the nodes is limited, the energy of the nodes and the lifetime of network is a critical problem in MANETs. Moreover, nodes maintain static or less movement after being deployed. The energy of the MANET nodes cannot be recharged, which leads to dead nodes. This study improves the energy cost for the ACECR and boosts advancement through its contributions. Areas in the ad hoc network where much work is needed are discussed. This study only explored the impact of PSO on ACECR. Results indicate that ACECR- PSO performed better than the other protocols in terms of balanced energy consumption and extended network lifetime.

Keywords: *ACECR, PSO, ACO MANET*

1. Introduction

Wireless networks are utilized in various technology fields, such as in the military, in the industrial setting and in personal area networks[1]. Wireless networks possess valuable attributes, such as easy installation, cost-efficiency, and reliability, leading to their wide range of applications[2]. These networks are also independent of fixed infrastructure compared with wired networks[3]. Common examples of the usage of these networks are in cellular phone networks, Wi-Fi, satellite communication, and other applications [4, 5] as shown in Figure 1.

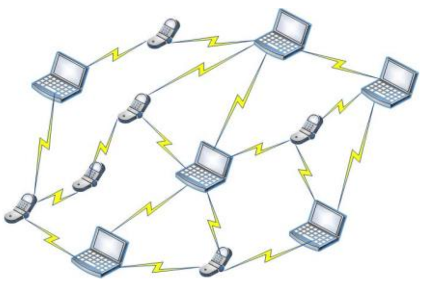

Figure 1: MANET structure

However, in recent years, wireless networks has become a major concern in the communications field [6]. In particular, the power problem in MANETs has been receiving significant attention. The problem of energy efficiency in mobile ad hoc networks (MANETs) can be addressed at various layers[7] and research work has focused on optimizing the energy consumption of mobile nodes from different viewpoints[8]. In recent years, power management schemes have two objectives, which are to minimize the total power consumption in the network

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and to minimize the power consumption per node. A method to reduce the energy costs among the different nodes, called the ant colony-based energy control routing (ACECR) protocol, has been suggested [9]; however, two major issues were found regarding their work, namely, pheromone evaporation and leak of routing efficacy protocol[10]. Therefore, a hybrid particle swarm optimization (PSO)–ACECR protocol is proposed to address the work of Zhou et al. (2016), in which the route decision does not depend on the QoS between the routing and the MANET energy[11]. Therefore, this present study aims to develop a PSO for ACECR in terms of the best and nearest path and the minimal node power consumption, which focuses on each node that is consistently available and reduces the dead node numbers in the work of Zhou.

2. Proposed Approaches

There are two important characteristics in the proposed PSO-ACECR protocol. First, PSO uses a population of particles. Second, PSO has the “traditional” topologies, namely, gbest and pbest, to describe the interconnections among particles[12]. The gbest topology is considered the fully interconnected population because each member of the population can be influenced by any other member. Specifically, the particles can be affected by the individual who found the best solution so far. Therefore, gbest is ultimately responsible for tracking the best solution found. The pbest topology is considered as a partially interconnected population, in which every particle is connected to the neighboring particles in the population array[13]. Third, every particle changes its position according to the change rule. The interaction rule (or the velocity equation) determines the next point of the particle, which will be tested in the search space, where the previous success of the particle in the search space with the previous success of the other particles is considered. When a particle discovers a pattern that is better than any of the patterns that the particle had previously found, the particle stores the coordinates in the pbest(t). The difference between the pbest (the best point found so far) and the current position of the individual is stochastically added to the current velocity, causing the trajectory to oscillate around that point. Furthermore, each particle is defined within the context of a topological neighborhood. The PSO process is illustrated in Figure 2.

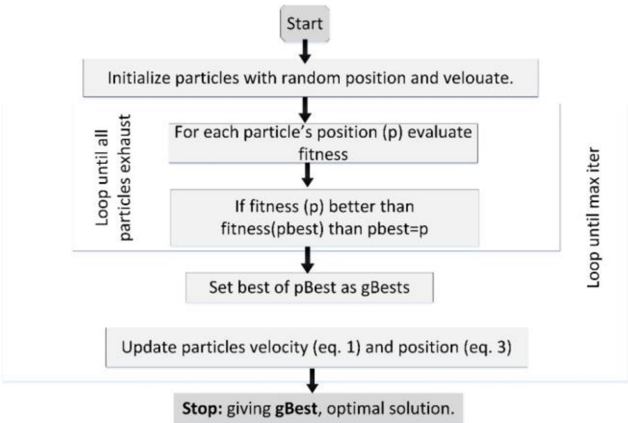

Figure 2: PSO structure

Several hybrid conventional algorithms, such as the genetic and the PSO algorithms, were used to resolve the route difficulty in MANETs[14]. The ACECR Protocol suggested by Zhou et al 2016 has different difficulties. The information gained by using PSO [15]. Therefore, the hybrid between PSO and ACECR Protocol is proposed in this study for the optimization strategy outlined in the subsequent sections.

The hybrid algorithm has advantages of particle swarm Optimization which is Global search but in the ACECR is Local search. The major disadvantage in the ACECR protocol is that while trying to solve the combinational optimization problems the search should performed much faster[16], but in ACECR the movement through the path where the chemical substance called pheromone has been deposited. Hence local search will be performing at the faster rate than in the ACECR. In order to overcome the above drawback. However, PSO works based on direct communication between particles. But A ACECR mechanism highly depends on indirect communication among Particle. For that reason it need to hybrid PSO with ACECR to optimize protocol energy.

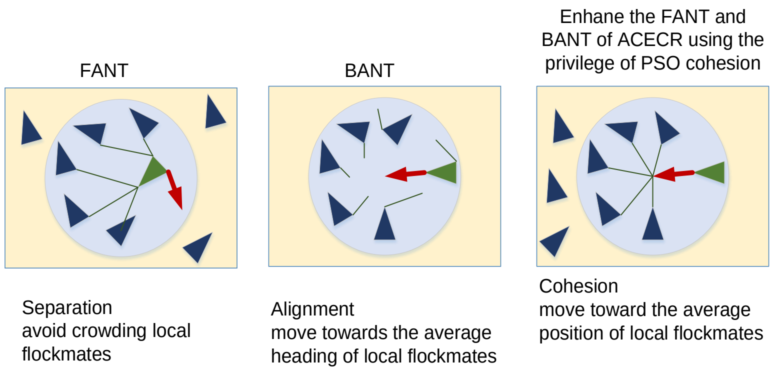

Figure 3: Enhance FANT and BANT of (Andry Pinto & eles. 2010)

In order to feed the weakness of BANT and FANT of ACECR the cohesion aspect of Particle Swarm Optimization is put to use in order to perform optimization by iteratively attempting to enhance a solution with regard to a certain measure of quality. Figure 3 describes hybrid that stands for the PSO-ACECR. For the reason that Particle Swarm Optimization uses velocity procedure to reclassify any random vectors, the Particle Swarm Optimization will feed the pheromone vectors for ACECR.

However, the particle rules show that

$$p = p + v, \qquad (1)$$

$$v = v + c1 * rand * (pBest - p) + c2 * rand * (gBest - p), \qquad (2)$$

Where

- p: position of the particle
- v: direction path
- c1: local information of weight
- c2: global information of weight
- pBest: particle best position
- gBest: best position of the swarm
- rand: randomly variable

However, the number of particles is typically between 10 and 50.

1. C1 is the personal best value.
2. C2 is the best value neighborhood.
3. In general, C1 + C2 = 4 (empirically chosen value).
4. If the algorithm is too slow mean that it cause from velocity is too low.
5. If algorithm is too unstable, it cause from velocity is too high

The best path is selected using Particle Swarm Optimization algorithm while the multi-paths are gotten using ACECR algorithm. Pheromones can be deposited by the particle agents and every pattern is sensed by local attributes. The pattern agent executes dynamics of pheromones evaporation, dispersion and aggregation. Attribute pheromone inside the pattern and pattern pheromone are the two levels of pheromones. Particle Swarm Optimization algorithm is responsible for updating the pattern pheromone to compare the path's fitness as well as their related attributes. This fitness is re done for a certain number of iteration and the pattern with large fitness is reciprocated as a solution that meets all the difficulties.

Particle Swarm Optimization deals with the strange position of ACECR order of routing and an appropriate fitness function to find the most advantageous parameters of sorting function resulting into energy reliability matters that might later lead to inefficiency, for instance as seen in Zhou paper in the figure 4 below, the node 1-2, 2-3, 3-5 having pheromone misconnection problem resulting to a position that is not known.

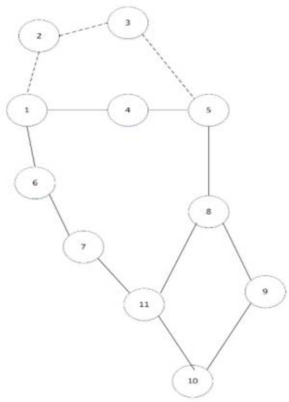

Figure 4: the main aim of PSO will feeds the pheromone on ACECR

3. Implementation Setup

Simulation was done in MATLAB [17], and the results were evaluated and compared with standard ACECR routing protocols and recent approaches. We used different simulation parameters, such as varying the number of nodes and the node speed, to evaluate the performance using Zhou parameters as summarized in Table1.

Table 1: Simulation parameters Zhou et al. (2016)

Parameter	Value
Simulate	MATLAB
Channel type	Wireless
Area	1000 m
Nodes	25 nodes
Routing protocol	ACECR
Simulation time	100 ms
Node speed	5 m/s
Traffic type	CBR
Initial energy	200 J
Packet size	64 byte
Simulation model	IEEE 802.15.4a

However, we compare the performance of our proposed protocol ACECR-PSO to the other three protocols: ACECR, EAAR[18], and AOMDA protocols. These protocols extend the single path AODV protocol to compute multiple paths, which always offers a superior overall routing performance than ADOV in a variety of mobility and traffic conditions[19]. EAAR is an ACO-based energy-aware routing protocol, which does not only incorporate the effect of power consumption in routing a packet, but also exploits the multi-path transmission properties of ant swarms and use min-max energy to calculate pheromone value; hence, it increases the battery life of a node. Mobility is a natural characteristic of ad hoc networks. It is imperative to use a mobility model that accurately represents the mobile nodes that will eventually utilize the given protocol. The choice of a mobility model can have a significant effect on the performance of an ad hoc network routing protocol.

There are 100 nodes in a network, which move over a 1000 m ∗ 1000 m flat space. For the RPGM model[20], we divided all nodes into four groups, with 25 nodes in each group. The node's MAC layer uses IEEE-802.11 DCF media access control protocol, the radio transmission range and the interference range of nodes are all set to be 200 m [21]. Each node has a total energy of 100J.Mobile nodes, and are assumed to move randomly according to the random walk, random waypoint, and RPGM mobility models. The speeds of nodes are set to be 1.5, 5, 10, 15, and 20 per second, each node starts moving from a randomly selected initial position to a target position, which is also selected randomly in the simulation. Each pocketsize is 512-bytes, and 10 Constant-Bit-Rate (CBR) flows are generated randomly at a rate of 10 packets per second for 1000s to test the performance of protocols[22].

4. Results and Discussion

The percentage of the number of data packets correctly delivered to the number of data packets sent by source nodes is presented. Figure 5 shows the packet delivery ratio of AOMDV, EAAR, ACECR and ACECR-PSO protocols at different speeds in different mobility models, where the packet delivery ratio for four routing protocols decreases when the speeds of the nodes increase. We observe that the packet delivery ratio for ACECR-PSO is better than all the other protocols. ACECR-PSO and EAAR protocols can balance the energy use of the network and reduce the link break caused by dead nodes because they are energy control routing protocols. Since both average energy and the minimum energy of a path is considered in ACECR-PSO, it can select a path with more residual energy on global view. ACECT and EAAR only consider the residual energy of nodes instead of paths, and the packet delivery ratio for ACECR protocols is higher than that for AOMDV protocol.

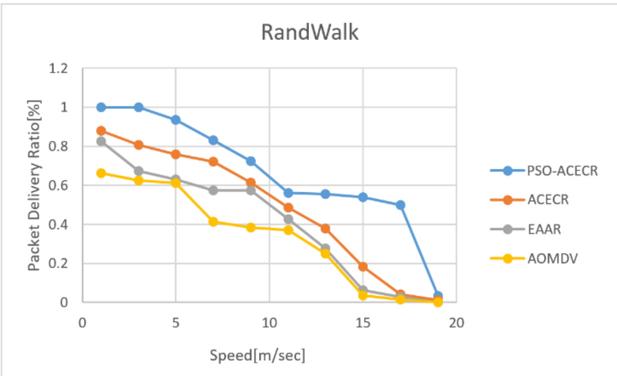

Figure 5 Packet Delivery Ratio

The average time between transmission of data packets at sources and successful reception at receivers is presented in Figure 6. Figure 6 shows the average end-to-end delay of data packets from source nodes to their destination nodes for AOMDV, EAAR, ACECR and ACECR-PSO in different mobility models. The end-to-end delays decrease with increase of node mobile speeds, because the increase of node mobile speeds will make network topology change, which in turn will cause data buffer and route rediscovery. The average end to-end delay for ACECR-PSO is less than ACECR and other protocol, because ACECR-PSO is enhanced energy control routing protocol. Moreover, since ant colony-based energy control routing protocol is multi-path routing protocols, they can balance the energy use of the network, and reduce the route rediscovery.

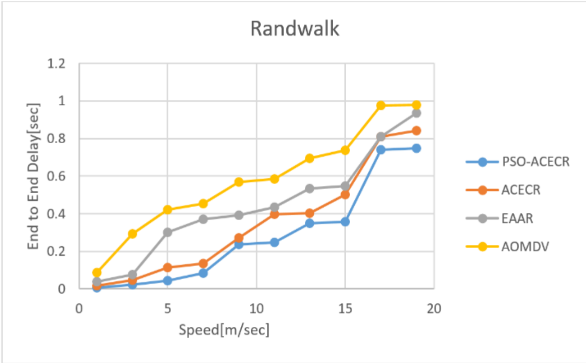

Figure 6 End to End Delay

The communication overhead of dead-node has a profound effect on the performance of routing protocols. It represents the total size of exchanging packets in the network. The control packets increase the communication overhead and reduce the throughput of the network. Figure 7 shows that the routing overhead that caused from dead node of ACECR-PSO is less than ACECR protocol, since ACECR-PSO is multi-path routing protocols, they use pheromone updating to maintain the route selection with best fitness function of PSO.

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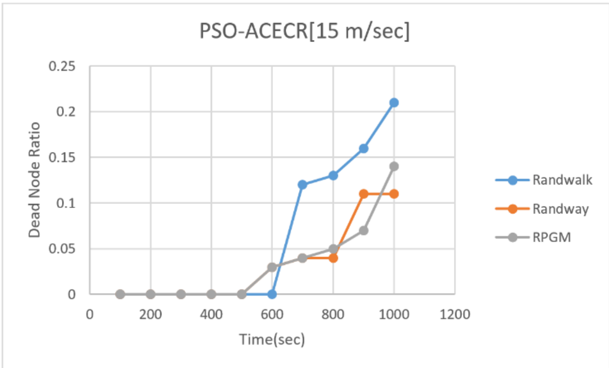

Figure 7. Dead Node Ratio

4. Conclusion

In this paper, we proposed an ant colony-based energy control routing protocol PSO-ACECR and evaluated the affect of different mobility models to the performance of PSO-ACECR in MANETs. In PSO-ACECR, the routing protocol will find the better route which has more energy than other routes through the analysis of average energy and the minimum energy of paths. Simulation results show that PSO-ACECR has a better performance than existing routing protocols, such as ACECR, EAAR and AOMDV, in terms of the number of dead nodes and the packet loss rate, which means that PSO-ACECR can extend the network’s lifetime. In addition, the simulations investigated the movement characteristics of different mobility models and the effect on routing protocols. Furthermore, results show that PSO-ACECR has a better performance than the other three protocols in balanced energy consumption and extended network lifetime.

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