An Intelligent Mesh Based Multicast Routing Algorithm for MANETs using Particle Swarm Optimization

E. Baburaj[1], and V. Vasudevan[2]

1. Research Scholar, Anna University
2. Professor, Department of IT, A.K. College of Engineering

Abstract
Multicast routing protocols in Mobile Ad-hoc Networks (MANETs) are emerging for wireless group communication which includes application such as multipoint data dissemination and multiparty conferencing which made the analytical design and development of the MANETs in a very efficient manner. For MANETs there are several multicast routing protocols are available, but they perform well under specific scenarios only. The topology of a MANET changes adequately due to the random mobility of network nodes, unlike the wired network which is static. Due to the lack of redundancy in multipath and multicast structures, the multicast routing protocols are vulnerable to the component failure in ad-hoc networks. Due to this fact, route selection becomes a tragedy in MANETs. So it is the dire need to optimize the route selection. PSO is an optimizing tool and its key factors that determine the performance of PSO is by the well designed architecture of particles and procedures in the intelligent algorithm. In this paper we attempt to propose a new PSO based On Demand Multicast Routing Protocol (PSO-ODMRP), which improves the performance in the routing messages. PSO-ODMRP is well suited for mobile ad hoc networks where the topology changes frequently and power is constrained. We evaluate PSO-ODMRP performance under various realistic scenarios.

Keywords:
multicasting, routing protocols, MANETs, ODMRP, PSO, reliability, transmission rate, overheads

1. Introduction

A mobile ad-hoc network [8] is a wireless network in which nodes can communicate the packets without any pre installed infrastructure. This is most suitable for applications such as military communications, search and rescue operations, and multiparty conferencing. If two nodes want to communicate with each other, but the nodes are not in direct communication range, then the data packets are forwarded through other nodes. Due to the limited radio propagation range of the wireless devices, routers are most often multi-hopped. That is every node in a mobile ad-hoc network is capable to function as a router which forwards the data packets to the other nodes [10].

Mobile ad-hoc networks have a dynamic topology due to node mobility, limited channel bandwidth, and limited battery power of nodes. In a typical ad-hoc environment, group-oriented communication is much popular than one-to-one communication. Multicast protocols deployed in static networks do not perform well in ad-hoc networks due to the random node mobility and limited channel bandwidth.

The strength of the received signal depends on the following factors: power of the transmitted signal, the antenna gain at the sender and receiver, the distance between the two nodes, the obstacles between them, and the number of different paths the signals travel due to reflection.

The each and every node in a multihop mobile ad-hoc network must continuously monitor the radio signals it receives in order to determine the neighbors which composes a localized view of the network topology that uses the routing protocols [2].

A number of MANET multicast routing protocols have been proposed to enable group oriented communication in mobile ad-hoc network environment [3]. The multicast routing protocols are of two types. The first type has to do with maintaining routing states. The second type classifies protocols according to the global data structure used for forward multicast packets.

The routing mechanisms used in the first type are of two types named proactive protocols and reactive protocols. Proactive protocols maintain routing state and reactive protocol reduce the impact of frequent topological changes by acquiring routes on demand.

Manuscript received May 5, 2008
Manuscript revised May 20, 2008

The rest of the paper is organized as follows. Section 2 describes the ODMRP routing protocol. Section 3 proposes the PSO optimization approach. The PSO based mesh based routing is discussed in section 4.The simulation environment is described in section 5. The experimental results are shown in section 6 and conclusion and future scope is given in section 7.

2. Multicast routing protocols

Instead of sending through multiple unicast, multicasting minimizes the network parameters like bandwidth consumption, sender and router processing, and delivery delay. It also reduces the communication costs for applications that send the same data to multiple recipients.

2.1 ODMRP

On Demand Multicast Routing Protocol (ODMRP) [4] [14] is a mesh–based demand driven multicast protocol, where a mesh is formed by a set of nodes called forwarding nodes which are responsible for forwarding data packets between a source and receiver. A source periodically builds a multicast tree for a group by flooding a control packet throughout the network. Nodes that are members of the group respond to the flood and join to the tree.

When a node has information to send but no route to the destination, a Join Query message is broadcasted. The next node that receives the Join Query updates its routing table with the appropriate node ID from which the message was received for the reverse path back to the sender. Then the node checks the value of the time to live and if this value is greater that zero it rebroadcasts the Join Query [6].

When a multicast group member node receives a Join Query, it broadcasts a Join Reply message. A neighbor node that receives a Join Reply consults the join reply table to see if its node ID is the same with any next hope node ID. If it is the same then the node understands that it is on the path to the source and sets the forwarding group flag [3].

3. Particle Swarm Optimization

Particle swarm optimization (PSO) is a population-based stochastic optimization technique, which simulates the social behavior of organisms, such as bird flocking and fish schooling, to describe an automatically evolving system. In PSO, each single candidate solution is "an individual bird of the flock", that is, a particle in the search space. Each particle makes use of its individual memory and knowledge gained by the swarm as a whole to find the best solution [13].

All of the particles have fitness values, which are evaluated by fitness function to be optimized, and have velocities which direct the movement of the particles. During movement, each particle adjusts its position according to its own experience, as well as according to the experience of a neighboring particle, and makes use of the best position encountered by itself and its neighbor.

The particles move through the problem space by following a current of optimum particles. The initial swarm is generally created in such a way that the population of the particles is distributed randomly over the search space. In each iteration, each particle is updated by following two "best" values, called pbest_route and gbest_route.

Each particle keeps track of its coordinates in the problem space, which are associated with the best solution (fitness) the particle has achieved so far. This fitness value is stored, and called pbest_route. When a particle takes the whole population as its topological neighbor, the best value is a global “best” value and is called gbest_route. The pseudo code of the PSO procedure is given above.

4. PSO based Multicast Routing

Particle Swarm Optimization (PSO) is a population based swarm intelligent algorithm to find solution for an optimization problem in a search space. In PSO, each single candidate solution is an individual bird of the folk, i.e. a particle in the search space. Each particle makes use of its individual memory and knowledge gained by the swarm as a whole to find the best solution [11].

This class of algorithms is designed based on the natural principle exists in the form of a fitness function. In a mobile ad-hoc network links can go up and down depending on a variety of physical and social behavior such as movement of hosts, terrain, weather, interference, or battery power.

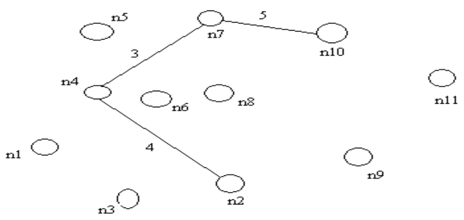

Figure 1 A sample Ad hoc network with initial random route

The optimal agent population composition can be derived theoretically and a search based technique should be used to find acceptable suboptimal solutions rather than guaranteed optimal ones. The system is initialized with a population of random solutions and searches for optima by updating generations. In PSO, the potential solutions, called particles, fly through the problem space by following the current optimum particles [12]. Figure 1 and 2 show sample network in which after each generation a new route is obtained. So at the end of the entire simulation the route obtained will be an optimum one.

Particle velocities of each dimension are tried to a maximum velocity V_{max}. If the sum of the velocities obtained by the total velocity of that dimension is exceeding V_{max}, then the velocity of that dimension is limited to V_{max}. V_{max} is a user-specified parameter.

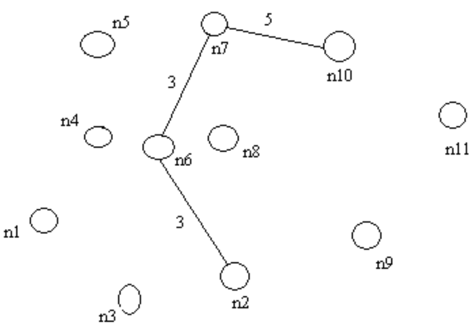

Figure 2 After first generation

The updated velocity and position can be obtained by the following equation

$$V_{t+1} = w * V_t + C_1 * \text{rand}\ (\text{pbest} - X_t) + C_2 * \text{rand}\ (\text{gbest} - X_t) \quad (1)$$

and

$$X_{t+1}=X_t+V_{t+1} \quad (2)$$

where

V_{t+1} = updated velocity

w = inertia weight

V_t = old velocity

C_1 & C_2 = learning or acceleration factors = 2

X_{t+1} = updated position

X_t = old position

rand = random numbers between 0 and 1

For simulation we set the required particle number first, and then the initial coding alphabetic string for each particle is randomly produced [13]. At the end of the simulation, the route found is to an optimized one. The pseudo code for the PSO based Multicast routing is given below.

Initial Population (all possible routes)

While (no. of generations, or the stopping criterion is not met)

For p=1 to no. of routes

If fitness of (X_p > $pbest_{p\_route}$)

Update $pbest_{p\_route} = X_p$

Update route

For k ε Neighborhood of X_p

If fitness of (X_k > gbest_route)

Update gbest_route = X_k

Update route

Next k

For d

$V_{t+1} = w * V_t + C_1 *rand (pbest\_route – X_t) +$

$C_2 * rand * (gbest\_route_d – X_t)$

If V_{t+1} *ε* (V_{min}, V_{max}) *then*

$V_{t+1} = max (min (V_{max}, V_{t+1}), V_{min})$

$X_{t+1} = X_t + V_{t+1}$

Next d

Next p

Next generation until stopping criterion

5. Simulation Scenario

The goal of our simulation is to analyze the behavior of ODMRP and PSO-ODMRP. The simulation environment is created in NS-2, a network simulator that provides support for simulating multihop wireless networks. The simulations were carried out using a MANET environment consisting of 50 wireless mobile nodes roaming over a simulation area of 1000 meters x 1000 meters flat space operating for 900 seconds of simulation time.

The radio and IEEE 802.11 MAC layer models were used. Nodes in our simulation move according to Random Waypoint mobility model, which is in random direction with maximum speed from 0 m/s to 20 m/s. A free space propagation channel is assumed for the simulation. Multicast sources start and stop sending packets; each packet has a constant size of 512 bytes.

Each mobile node in the network starts its journey from a random location to a random destination with a randomly chosen speed. Once the destination is reached, another random destination is targeted after a pause by the mobile node. Once the node reaches the boundary area mentioned in the network, it chooses a period of time to remain stationary.

After the end of this pause time, the node chooses a new direction, this time between 0 an 180 degrees, adjusted relative to the wall of the area on which the node is located. By varying the pause time, the relative speeds of the mobiles are affected.

6. Experimental Results

The following metrics were used in comparing the protocol performances. The metric were derived from ones suggested by the IETF MANET working group for routing and multicast protocol evaluation [5].

Packet Delivery Ratio

Packet Delivery Ratio is defined as the number of multicast data packets delivered to all multicast receivers and the number of multicast data packets supposed to be delivered to multicast receivers. This ratio represents the routing effectiveness of the multicast protocol. Figure 3 shows the performance analysis of packet delivery ratio for the ODMRP and PSO-ODMRP.

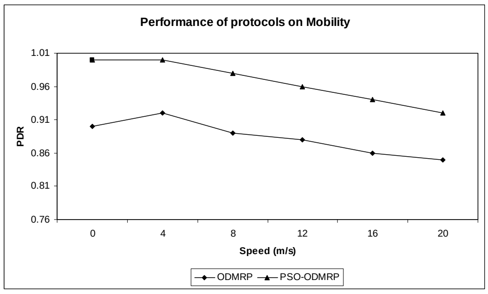

Figure 3 Analysis of Packet Delivery Ratio

Control Overheads

Control packet overhead is the ratio of the number of control packets originated or forwarded related to the route creation process that are received by a node per multicast data delivery. Figure 3 shows the performance analysis of Packet delivery ratio for the ODMRP and PSO-ODMRP. Figure 4 shows the analysis of control overheads with two and five senders and of different receivers 10, 20, 30, 40, and 50.

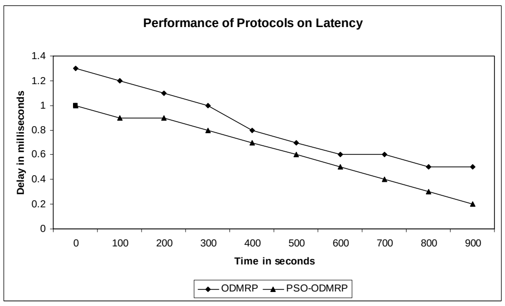

Figure 4 Control Overheads with 2 & 5 Senders

7. Conclusion

In this paper, we present a PSO-ODMRP model to support the multicast routing optimization algorithm in mobile ad-hoc networks. The simulation results make obvious that the proposed approach and parameters provide an accurate and efficient method in realistic scenarios. Our approach for optimizing the route selection in PSO-ODMRP shows good performance in the low mobility speed. However, if there is high mobility speed and high mobile density, the protocol does not find a good optimal solution. This has been left as a future work and we are currently working on the solution.

References

[1] Royer E Perkins C, "Ad-hoc on-demand distance vector routing", ACM, March 2000.

[2] B. Chen, K. Jamieson, H. Balakrishnan, and R. Morris, "SPAN: An Energy-Efficient Co-ordination Algorithm for Topology Maintenance in Ad-hoc Wireless Networks", Proceedings of ACM MOBICOM, pp. 85-96, 2001.

[3] W. Rabiner, H. Balakrishnan, "Energy Efficient Communication Protocol for Wireless Micro-sensor Networks", Proceedings of 33rd Annual Hawaii International Conference on Systems Science, pp. 3005-3014, 2000.

[4] Inn Inn ER, and Winston K. G Seah, "Distributed Steiner-Like Multicast Path Setup for Mesh-based Multicast Routing in Ad-hoc Networks", Proceedings of the IEEE International Conference on Sensors Networks and Trustworthy Computing (SUTC'06), IEEE Computer Society, 2006.

[5] C. Ho, K. Obraczka, G. Tsudik, K. Viswanath, "Flooding for Reliable multicast in Multi-hop Ad-hoc Networks", Proceedings of the 3rd International workshop on Discrete Algorithms and Methods for Mobile Computing and Communications, pp. 64-71,1999.

[6] L. Ji, M. S. Corson, "Differential Destination Mulicast : A MANAT Multicast Routing Protocol of Small Groups", Proceedings of IEEE Infocomm, pp. 1192-1202, 2001.

[7] S. J. Lee, M. Gerla, and C. C. Chiang, "On Demand Multicast Routing Protocol", Proceedings of IEEE WCNC, pp. 1298-1302, Sep. 1999.

[8] Gerla. M, and Lee S. J, "On-Demand Multicast Routing Protocol for Mobile Ad-hoc Networks", 2005.

[9] D. Lundberg, "Ad-hoc Protocol Evaluation and Experiences of real world Ad-hoc networking", Uppsala University, Department of Information Technology, technical report, June 2004.

[10] Thomas Kunz and Ed Cheng, "Multicasting in Ad-hoc Networks: Comparing MAODV and ODMP", Proceedings of the Workshop on Ad-hoc Communications, Bonn, German, Sep. 2001.

[11] G. Venter, and J. Sobieszczanski-Sobieski, "Particle Swarm Optimization", Proceedings of the 43rd AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, Denver, Co. 2002.

[12] M. Clerc, and J. Kennedy, "The Particle Swarm-Explosion, Stability and Convergence in a Multidimensional Complex Space, IEEE Transactions on Evolutionary Computation, pp. 58-73, 2002.

[13] Chung-Jui Tu, Li-Yeh Chuang, Jun-Yang Chang, and Cheng-Hong Yang, "Feature Selection using PSO-SVM", IAENG International Journal of Computer Science, Feb.2007.

[14] E. Baburaj, V. Vasudevan, "Performance evaluation of multicast routing protocols in MANETs with Realistic Scenarios", IETECH Journal of Advanced Computations, Vol. 2, No. 1, pp. 15-20, 2008.

[15] E. Baburaj, V. Vasudevan, "Genetic Algorithm based On Demand Multicast Routing Protocol for MANETs", International Conference on Soft Computing and Intelligent Systems", ICSCIS-07, pp. 220-225, Dec. 2007.

[16] E. Baburaj, V. Vasudevan, "An Intelligent Multicast Routing Protocol for MANETs", ICETET-08, International Conference on Emerging Trends in Engineering and Technology, Nagpur.