Gang WANG[1,2], Shigang WANG[3], Cai LIU[1], xiaorong ZHANG[4]

College of Geo-Exploration science and Technology,Jilin University (1), College of Electric and Information Engineering, Beihua University (2), College of Communication Engineering, Jilin University(3), TangShan House Fund Management Center (4)

Research for Improved AODV Algorithm Based on Probability Broadcasting with Percolation Theory

***Abstract**. As the MANET topology send so excessive RREQ packets, we propose an improved AODV algorithm based on probability broadcasting with percolation theory, and select the critical threshold of network connectivity as the forwarding probability in the processing in routing discovery of AODV. We retain historical routing information and record the numbers of the remaining hops into the hop counter, making RREQ groups forwarding along to the node of the minimum remaining hops, reducing the overlap coverage of the sending signals among the neighboring nodes.*

***Streszczenie.** Zaproponowano ulepszony algorytm AODFV (ad hoc on demand distance vector routing) do topologii MANET. Algorytm uwzględnia prawdopodobieństwo transmisji, teorię perkolacji (teorię przecieku) oraz historię połączeń. (**Badania ulepszonego algorytmu AODV uwzględniającego prawdopodobieństwo transmisji i teorię perkolacji**)*

Keywords: AODV; Percolation Theory; RREQ.
Słowa kluczowe: algorytm AODV, sieci MANET

Introduction

MANET (Mobile Ad hoc network) is a dynamic topology and multi-hops wireless network [1], considering MANET node mobility, transmission range, cost and energy, and transmission bandwidth, traditional routing protocols are unsuitable for MANET. Therefore, the study of MANET routing protocol is one of the hot spots and major difficulty of MANET. So far, many protocols establish network routing by broadcast or multicast, core of them is to reduce a broadcast storm.

In general, routing protocols of MANET are classified into three categories, the first is the Proactive routing protocols, also called the Table driven routing protocols. The second is the Reactive routing protocols, also called on demand routing protocols [2]. The third is a Hybrid routing protocols.

Table driven routing protocols require each node maintains one or more the routing tables contained the latest and consistent network routing information. In order to maintain such a routing table, one node periodically need to broadcast network topology information, and adopt different broadcasting strategies, different quantities and contents of routing table to keep a consistent view of the network but it will spend a large overhead required to adapt to the topology changes. The AODV (Ad Hoc on Demand Distance Vector Routing) is an important protocol of table driven routing protocols. It is improved and forward based on DSDV protocols and combined with DSR on-demand routing mechanism. On-demand routing protocols is an important feature different from the conventional MANET routing protocol. In AODV, only when in the source nodes need necessary routing table, they will generate routing information. Only nodes involved in the communication process need to maintain routing tables, which those not on the path does not need to save the routing information and data packets need not included all the routing information from the source node to the destination node. Namely, it adopts hop-by-hop forwarding, and in the routing table there is only one path to reach the destination node, only supports two-way channels [3]. The AODV protocol has three basic messages: RREQ message, RREP message and RRER message, which are divided into routing discovery and routing maintenance process:

Firstly, source nodes broadcast a routing request packet (RREQ). When it find a suitable routing or all of the possible routing protocols has been checked, the process is terminated. Secondly, starting the routing maintenance process until the passages of any path are unable to access the target node or the routing is no need.

However, in the existing routing discovery process of AODV, source node send RREQ packets to all the neighbors node by flood broadcast, and node received the packets at the first time will again forwarding them to all of neighbor nodes, which will transmit many enough RREQ, lend to consume more MANET source and Reduce network efficiency.

AODV algorithm based on probability broadcasting with percolation theory

Percolation concept [4, 5] once is known as physics mechanics theory, fluid motion in porous media law, which was the flow of fluid through a porous medium. We distributed randomly MANET nodes on the two-dimensional space, and the two-dimensional space were mapped into the porous medium[6], as the same time the nodes were mapped into the solid porous skeleton, and the rest space were mapping into the pores in porous media, packets forwarding between the nodes, which is mapped that the fluid flows between porous media. When the forwarding probability was reach to the critical probability threshold, the network connected instantly, forming infinite order components with nodes connected each other, so that components were mapping into the effective pore space [7].

In mathematical model of percolation theory, global states in the side percolation state keeps invariant when the broadcast probability is less than the critical probability threshold, global states keeps invariant, but is more than critical value, mutations must occur. Therefore, percolation theory is applied on analysis of the reasons for network state mutations.

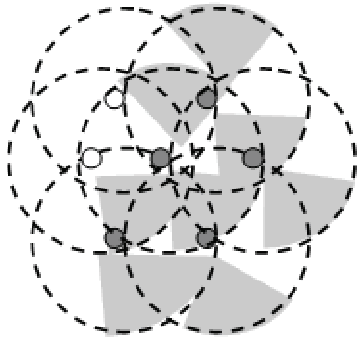

Fig.1. Directional broadcast

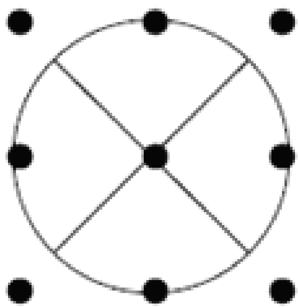

Fig.2. Four sector forward

MANET probabilistic broadcasting algorithms based on percolation theory[8, 9]adopt to topology control theory of the directional antenna, and each node is built with a directional antenna including the N sectors without overlapping each other, and each sector covered a 2π / N radian range, a node can simultaneously transmit and receive signals, on k (1 ≤k ≤N) specific directions, and each node independent send a broadcast message at all angles. Meanwhile, in a square model, the fixed radius model set the same node degree, that is 4, probabilistic broadcasting algorithms of MANET based on percolation theory only send messages in the specific four directions of four neighboring nodes, so that it could reduce energy cost in the procession of MANET broadcast.

Fig.1shows that MANET probability broadcasting is mapped into percolation model with directional broadcast .Fig.2 shows that probability broadcasting based on percolation theory transmit broadcasting message only in 4 directions.

Realization on Improved AODV algorithms based on percolation theory

Firstly, mathematical model of percolation theory is mapping to the MANET probability broadcasting, find out the critical threshold as RREQ forwarding probability, which it is directional RREQ broadcasting. But critical threshold has not definitive mathematic expression; it is an experimental determination value. Secondly, according to the numbers of RREQ packets in the hop counter, it will send RREQ packets to the node which is closest distance from destination, reducing redundancy of RREQ in the maximal degree, improving the node of the effective power. Simultaneously, AODV routing protocols based on percolation theory are all the same with in the other aspects of the traditional AODV agreement, it also makes that improved AODV routing protocol is not difficult to achieve with the most simple mathematic method, solving the key problems on the Influence of AODV.

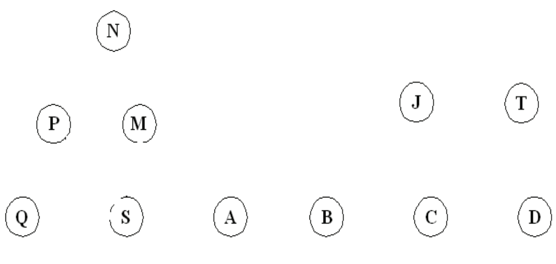

Fig.3. Distribute nodes at random

In improved AODV protocols based on the percolation theory, RREQ packets still forwarding in fixed radius model. The following illustrate that is the operation of the RREQ packet of the improved AODV routing protocol. As shown figure 3, distribute randomly 11 nodes, S is for the source node, D is for the destination node, A, B, C, J, T, G, M, N, P, Q as the middle nodes. When S source node want to send packet to D destination node, but find unavailable path in the routing table in the routing discovery process, it will initiate to send RREQ packets to adjacent nodes.

Figure 3. shows that the source node S is according to the probability of broadcasting algorithm based on percolation theory, setting node S initial emission power of P (U) = e, S transmission range is divided into 4 sectors with select directional antenna as initial empty sectors, the node S is gradually increasing transmit power, sending RREQ message as the critical probability threshold to empty sector of its antenna, and collecting RREQ messages sent from other nodes, when S find a new node, such as A, the node S will save A into the adjacent set of nodes, and then mark a non-empty sector nodes in S node antenna covered, until there is no empty sector or the node transmission power has reached the maximum power, therefore the source node S found its neighbor nodes of P, Q, M. In this paper, the research is still in scenes of the large-scale sparse network. Through this process, it has also completed a reverse path.

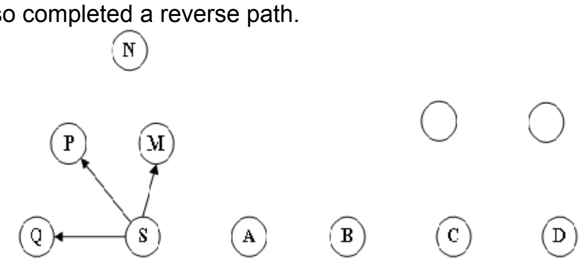

Fig.4. Source nodes S find neighbour in routing discovey

As shown in Figure 5, other intermediate nodes apply this same approach , achieving network connectivity, looking for the path from the source S node to the destination D node , in the meanwhile it has completed a reverse path.

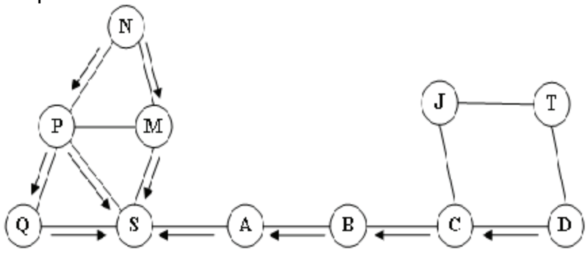

Fig.5. Source nodes S complete a reverse path

As shown in Figure 6, all the nodes are identified the shortest remaining numbers of the hops from the destination node. Obviously, we find the best path for S-A-B-C-D.

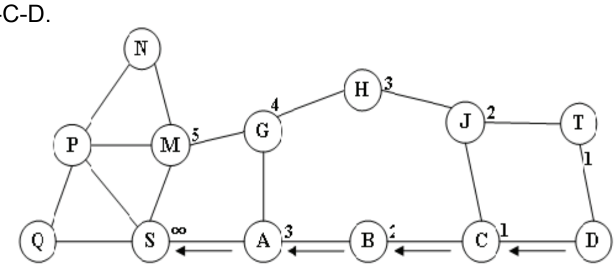

Fig.6. Completion of final path

Algorithm Simulation and Performance Analysis

Simulate improved algorithm by NS2[10,11]: within the 250 x 250 regions, distribute 100 nodes at random, link layer is based on 802.11 standard MAC protocol, MAC protocol use CSMA/CD multiple access mode, maximum node transmission range is 125m, maximum speed for 10m/s. Considering the multi-hop CBR business flow, random build 10 communication links, CBR business flow transmission rate were 2 packets per second, 4 packets, 6 packets per second, 8 packets per second, 10 packets per second. The simulation time is 20 seconds. The traditional AODV routing protocol and AODV routing protocol based on percolation theory is analyzed and compared. Evaluation index is packet delivery rate and average delivery delay.

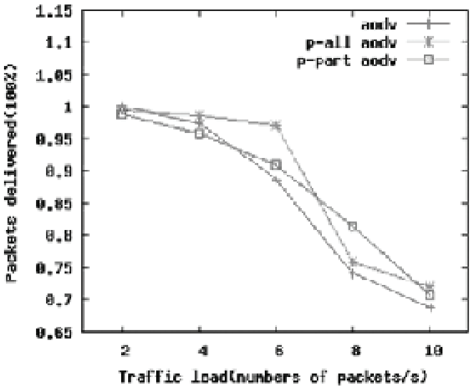

Fig.7. Packet delivery rate

As shown in Figure 7, it is packet delivery rate comparison chart for the different business flow, AODV is traditional AODV routing protocol packet delivery rate, p-all AODV is packet delivery rate of forwarding RREQ of AODV based on the percolation theory to all directions, p-part AODV is packet delivery rate of forwarding RREQ of AODV based on the percolation theory to some directions. As you can see from Figure 7, along with the business flow increasing, AODV algorithm based on probability broadcasting with percolation theory is better than traditional AODV packet delivery rate. For the main reason, with the service load increasing, it reduce average forwarding RREQ packet numbers in AODV algorithm, which makes probability of the message competition in channel smaller at some point. On the contrary, probability of the message competition in channel in the traditional AODV gets larger, and leads to discard a large number of data packets, thereby increasing the data packet delivery rate.

As shown in Figure 8, it is average delivery delay for the different business flow, AODV is average delivery delay of traditional AODV, p-all AODV is average delivery delay of forwarding RREQ of AODV to all directions based on the percolation theory, p-part AODV is average delivery delay of forwarding RREQ of AODV to some direction based on the percolation theory. As you can see from Figure 8, along with the business flow increasing, average delivery delay of improved AODV algorithm is less than traditional AODV. It is also that reducing average forwarding RREQ packet number in AODV algorithm makes end to end delay less.

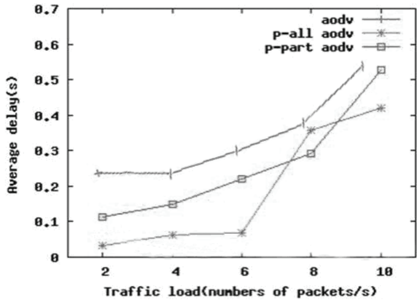

Fig.8. Average delivery delay

Conclusion

We apply percolation theory with RREQ broadcasting in AODV, design directional broadcasting for RREQ packet, reduce neighbor node coverage overlap, increase the effective transmitting rate and reduce the transmitted power, set up the relatively sparse networks.

REFERENCE

[1] Zheng Shaoren, Wang Haitao, Zhao Zhifeng, Mickey Zhichao, Li Ning, The Ad Hoc network technology. *People's post and Telecommunications Publishing House*, 2005.1,78-98

[2] Geetha Jayakumar, G Gopinath. Performance comparison of two on-demand routing protocols for ad - hoc networks based on random way point mobility model, *American Journal of Applied Sciences*, 5 (2008), 659-664

[3] Nidhi S Kulkarm, Balasubramanian Raman, Indra Gupta.On Demand Routing Protocols for Mobile Ad Hoc Networks: A Review. *IEEE International Advance Computing Conference IAC*, (2009), 586-591

[4] Broadbent S R, Hammersley J M. Percolation processes, I and II. *London: Cambridge Philo s Soc*, (1957), 629- 645

[5] Dengyinger,Advance Percolation Theory and method, *Scinece Press*,(2004), 32-85

[6] G R Grimmett, Percolation,New York, *USA Spring*, (1999), 20-180

[7] Chien-Chung Shen, Zhuochuan Huang, Chaiporn Jaikaeo. Directional Broadcast for Mobile Ad Hoc Networks with Percolation Theory. *IEEE Transactions on Mobile Compution* 5(4)(2006), 317-322

[8] Wang Gang, Zhang Xiaorong. Research on the probabilistic broadcasting algorithms of Mobile ad hoc network based on percolation theory. Proceedings 2011 International Conference on Mechatronic Science, *Electric Engineering and Computer*, MEC 4(2011), 31-334

[9] HE Peng, LI Jian-Dong, CHEN Yan-Hui, and CHEN Liang, Distributed Topology Control Algorithm for Ad Hoc Networks Using Directional Antennas, *Journal of Software*, 32(2007), 1308-1318

[10] Xiaorong Zhang, Research on the Method of Data Transmission in MANET Based on Percolation Theory,*JIuniversity Master Paper* , (2010), 28-50

[11] Tuteja, Asma, Gujral,Rajneesh,Thalia.Comparative Performance Analysis of DSDV, AODV and DSR Routing Protocols in MANET Using NS2.,*Advancesing Computer Engineering ACE*, (2010), 330-33

***Authors**: dr Wang Gang, Xinshan street No.1 Jilin City China, E-mail: jluwg@yahoo.com.cn; pro. dr WangshiGang, E-mail: wangshigang@vip.sina.com.cn; pro. dr LiuCai, E-mail: liucai@jlu.edu.cn; ZhangxiaoRong, E-mail: zhangxr931@163.com*