http://ansinet.com/itj

ITJ

ISSN 1812-5638

INFORMATION TECHNOLOGY JOURNAL

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 13 (7): 1356-1360, 2014
ISSN 1812-5638 / DOI: 10.3923/itj.2014.1356.1360

Study on the Effectiveness of Wireless *Ad hoc* Networks Routing Protocols

[1]Lin Zhang, [2]Jianming Liu, [1]Hongzhou Li and [1]Zhiyong Peng
[1]School of Electronic Engineering and Automation, Guilin University of Electronic Technology, Guilin Guangxi 541004, China
[2]School of Computer Science and Engineering, Guilin University of Electronic Technology, Guilin Guangxi 541004, China

Abstract: *Ad hoc* On-demand Distance Vector (AODV), Dynamic Source Routing (DSR) and Temporally Ordered Routing Algorithm (TORA) are three on-demand routing protocols for *ad hoc* networks. This study described the principles of the three protocols. The theoretical models of nodes distribution are then introduced. Finally, the effectiveness of routing protocols in wireless *ad hoc* networks is discussed based on the model of natural average distribution from a practical point of view. In this experiment, a comparison of performance tests of AODV, DSR and TORA is made by OPNET. From simulation results, it can be found that the performances of the three routing protocols are different and different protocols have different superiority in certain environment. These experimental results are provided as a basis for hardware implementation of wireless *ad hoc* networks.

Key words: Routing protocol, model, AODV, DSR, TORA

INTRODUCTION

Wireless *ad hoc* network is a dynamically reconfigurable wireless network with no fixed infrastructure or administration and communication between nodes rely on the radio link (Lee *et al*., 2000). With single-hop wireless network, the data exchange of *ad hoc* network nodes through multi-hop data forwarding mechanism, it requires the routing protocol to make packet forwarding decisions. Routing protocol role is to exchange the routing information, generate, maintain and choose the route, as well as provide the connectivity of network. It is a basis of communication between the nodes, therefore, the routing protocol becomes a research focus in *ad hoc* network architecture (Shi and Ying, 2001). So, far, it has many routing protocols in *ad hoc* network, for example, AODV, DSR, TORA and so on. These protocols have their own strengths, how to choose the routing protocols in a specific scene so as to achieve the best network configuration is a very important issue.

In this study, a series of simulation experiments are carried out and the characteristics of routing protocols under given conditions are studied. The superiority of different protocols in certain environment are found, in other words, it can be drawn the conclusion that what kind of the route can be realized optimum by which kind of model, rate and how many nodes in a given *ad hoc* network, this provides a theoretical basis for future hardware implementation.

PROTOCOL PROCESS DESCRIPTION

At present, it has two types of table-driven routing and on-demand routing in *ad hoc* network (Hao *et al*., 2009). On-demand routing has more wide range of applications. It refers to that while the source node needs to send packets to the destination node, the source node will initiate the process of routing lookup in the network, after find the appropriate route, they start sending messages (Liu *et al*., 2007). The advantage of on-demand routing protocol is that do not need to exchange routing information periodically, it can save a certain amount of network resources. This is vital in wireless communication, therefore, the majority of *ad hoc* routing protocols use demand routing at present, for example, AODV, DSR, TORA and so on.

AODV

AODV (*ad hoc* on-demand distance vector) is an on-demand routing protocol (Zahary and Ayesh, 2007), it uses packet mode hop by hop, the messages of routing request and answer are stored implicitly in each intermediate node. AODV protocol uses originator and destination sequence numbers to avoid "loops" (Yu *et al*., 2004). In addition, this protocol also sets the TTL (Time to live) value of IP header in routing requests and avoid broadcasting which route requests to bring in a whole network.

Corresponding Author: Lin Zhang, School of Electronic Engineering and Automation, Guilin University of Electronic Technology, Guilin Guangxi, 541004, China

DSR

DSR (dynamic source routing) is a reactive protocol that is based on two main mechanisms: route discovery and route maintenance. The main concept of this protocol is "source routing" (Adam *et al*., 2011), in which nodes place in the header of a packet contains routing information from a source to a destination, intermediate node do not need real-time maintenance network routing to forward packets. When a node does not know the route of reach destination node, the source node will initiate route discovery mechanism for dynamically this route, after route established; it will update stale routes by routing maintenance mechanism (Chen *et al*., 2009).

TORA

TORA (temporally ordered routing algorithm) is an on-demand routing protocol, it is based on a directed acyclic graph algorithms (Shi and Ying, 2001). It can provide multiple routes to destination node and transmit high-speed data by routing algorithm based on link reversal. The core concept of the protocol is control information is limited in the nodes which they are in the region of topology change (Zhao *et al*., 2007). TORA protocol is more suitable for high-speed mobile network environment.

THEORETICAL MODEL OF THE NODE UNIFORM DISTRIBUTION

In wireless *ad hoc* network, the choice of node distribution model has a significant effect on the performance of routing protocol. The distribution models of nodes are described briefly as follows.

The model of ideal average distribution: The model is based on the theoretical basis of swarm intelligence, describes that building the stable and movement status of wireless nodes within the specified range, identifying a suitable number of nodes and routing protocols under the uniform distribution of area.

The purpose of the model is that in accordance with specific distribution rule, to find the corresponding position of each node in a square region, the length and width of this square region and numbers of nodes in the square region are known.

The node coordinates of ideal average distribution model can be expressed as follows:

- When Cn is odd:

$$xn = Cn2\sqrt{\frac{XY}{6\sqrt{3}N}} - \frac{3}{2}\sqrt{\frac{XY}{6\sqrt{3}N}}$$

$$yn = (Rn-1)\sqrt{\frac{XY}{2\sqrt{3}N}} + \frac{1}{2}\sqrt{\frac{XY}{2\sqrt{3}N}}$$

- When Cn is even:

$$xn = Cn2\sqrt{\frac{XY}{6\sqrt{3}N}} - \frac{1}{2}\sqrt{\frac{XY}{6\sqrt{3}N}}$$

$$yn = (Rn-1)\sqrt{\frac{XY}{2\sqrt{3}N}} + \frac{1}{2}\sqrt{\frac{XY}{2\sqrt{3}N}}$$

Among them, X, Y each represents the width and length of the square region; N represents the total number of nodes; (Xn, Yn) represents the coordinates of the Nth node; Cn represents the nth column, Rn represents a n-th row.

In ideal average distribution model, the distance of two adjacent nodes are equal, this distribution is usually called positive Triangle distribution.

However, this model is only an ideal model; it is rare in the actual deployment of network. The simulation data of ideal model may be different from the actual application of network. So, another model of node distribution is introduced, it is called the model of natural average distribution.

The model of natural average distribution: In this model, node model is described by the distribution of probability density.

With N represents the number of nodes; S represents the region area; X, Y represents the horizontal length and vertical length of the region; N(x,y) represents the coordinates of an arbitrary node in the region.

Assume that the communication coverage range of a node is based on the N(x, y) as center, R is the radius of generating circle and the area is So<S, the probability density of a single node position is P.

The distribution of the node is $P = \pi R^2/S$.

This model is able to determine the distance from initial point of distribution of the node and the node can randomly deploy, simple and efficient. The simulation data of this model is closer to the actual; therefore, it has a wide range of applications.

From a practical point of view, the simulation experiments of routing protocols should be carry out, which it depends on the natural average distribution model to deploy network nodes.

SIMULATION OF ROUTING PROTOCOLS

Simulation tool is OPNET Modeler 14.5 and a medium-sized network with 30 nodes is simulation object. The purpose is to explore the superiority of different protocols in certain environment. There are AODV, DSR and TORA routing protocols are tested in the following experiments.

Here, is the configuration parameters of network simulation environment:

- The simulation scenario is randomly distributed 30 nodes within the range of 5000×5000 m^2. The first group experiments using fixed nodes. The second group experiment using mobile nodes and the movement of nodes according to pre-defined trajectory. Simulation time is set to 1 h
- MAC layer use mature 802.11 access protocol, wireless channel rate is 1Mbps and physical layer use spread spectrum frequency modulation
- In the first of experiment, the background service traffic is FTP service which packet size of 1000 bytes. The second experimental data packet inter-arrival according to exponential distribution and the mean value is 1. The size of data packets are exponentially distributed, mean is 1024 bits

In the following Fig. 1-3, the abscissa axis represents simulation time and the vertical axis represents parameter of network performance.

Simulation of fixed nodes *ad hoc* network: A comparison of three protocols when the nodes are fixed, the results of experiment as follows.

FTP upload, download response time: As can be seen from Fig. 1a and b, FTP service response time of AODV is greater than others. At the beginning of simulation, the upload response time of TORA is greater than the download but it decreases gradually and eventually stabilizes at close to the location of download response time. Performances of DSR protocol is the most stable, FTP upload and download response time are the shortest. So, in terms of FTP service response time, DSR is better than AODV and TORA.

Figure 2a shows that the throughput of AODV is significantly better than others, the descending order is AODV>TORA>DSR. Figure 2b shows that the end-to-end delay of AODV is smallest, followed by TORA, DSR is longest. Figure 2c shows that the packet loss rate of AODV is minimum, followed by DSR, TORA packet loss rate is obviously much greater, it proves that AODV has good adaptability of physical transmission.

In summary, in fixed-nodes network experiments, overall performance of AODV is better than others, DSR and TORA have their own strengths. For example, in occasions of high requirements to FTP service response time, the DSR protocol should be used. If a occasion is sensitive to network throughput and delay, in addition to AODV, TORA is also a good choice.

Simulation of mobile nodes *ad hoc* network: A comparison of three protocols when the nodes are moved at a moderate speed, the results of experiment as follows.

Figure 3a shows that in the case of network topology changes, the throughput has also many changes. And throughput of AODV is maximum, DSR has been relatively stable and it increased gradually, TORA is minimum.

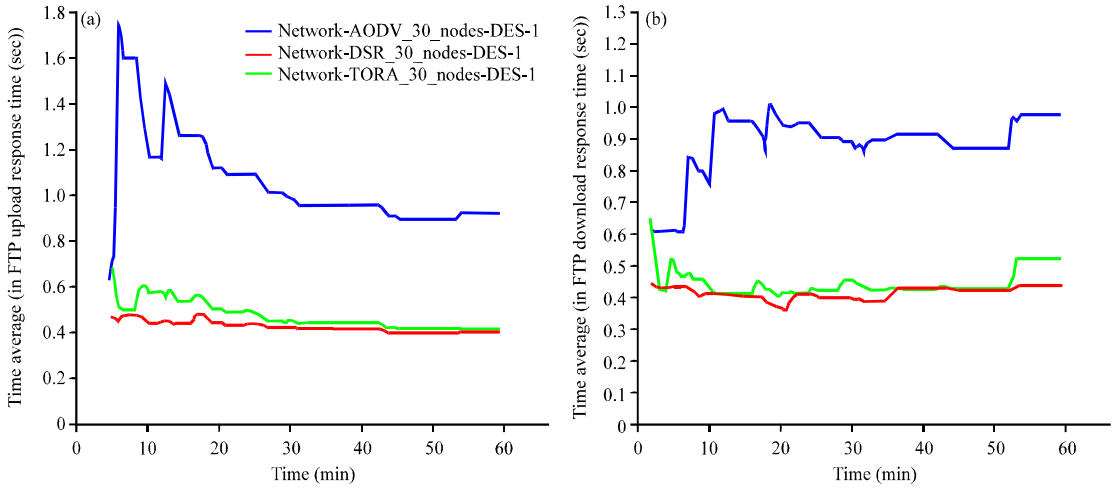
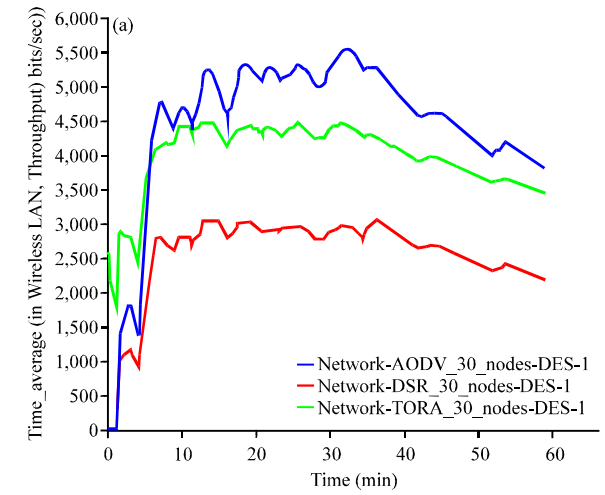
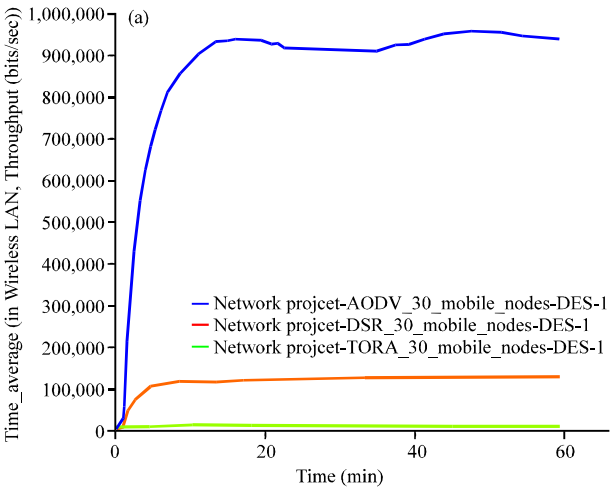
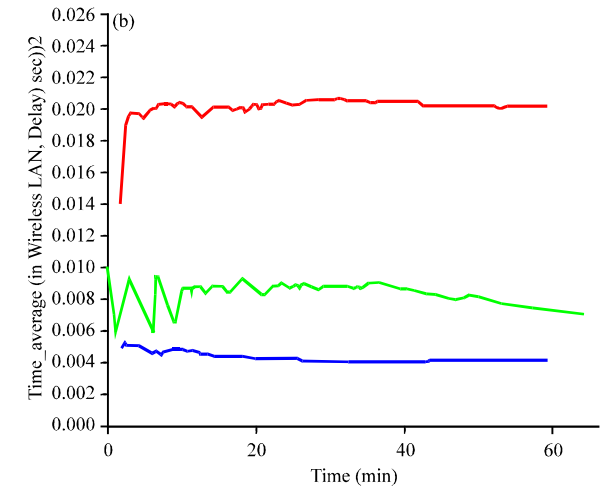
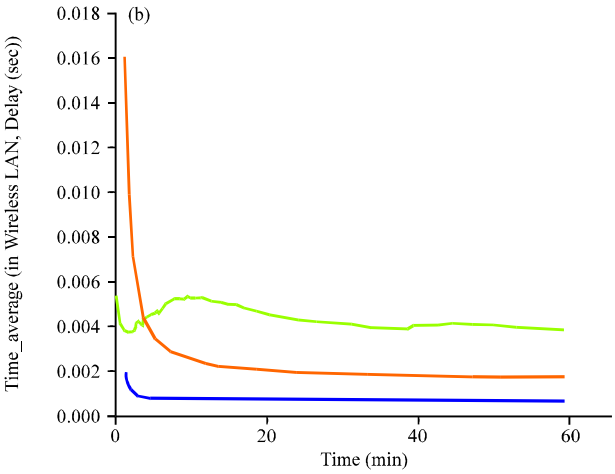


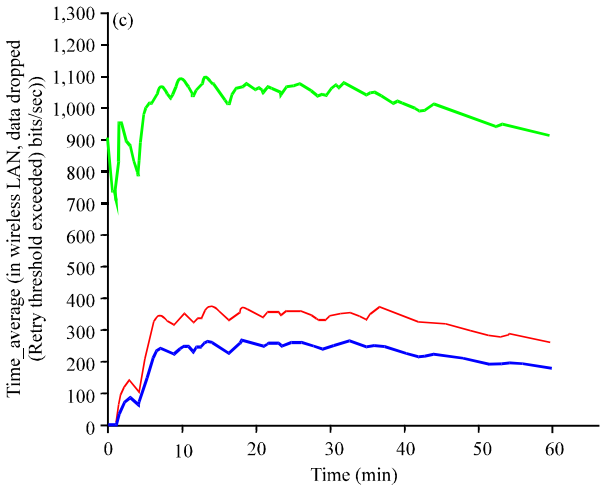
Fig. 1(a-b): FTP response time comparison for three routing protocols (a) Upload and (b) Download











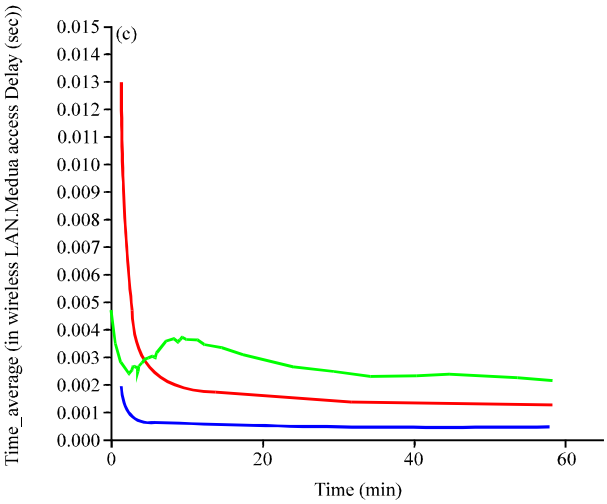


Fig. 2(a-c): Performance parameters comparison for three routing protocols (a) Throughput, (b) End-to-end delay and (c) Packet loss rate

Fig. 3(a-c): Performance parameters comparison for three routing protocols (a) Throughput, (b) End-to-end delay and (c) Media access delay

In Fig. 3b, compared with TORA, other two protocols are very clear advantages in end-to-end delay. Figure 3c shows that the media access delay of TORA is greater than AODV and DSR, it proves that TORA routing has not good adaptability in the case of nodes moving.

Thus, in the case of 30 nodes moving at medium speed, the overall performance of AODV and DSR are better than TORA, delay of TORA is greater and throughput is smaller. AODV and DSR can also maintain the good routing performance even if in mobile network.

CONCLUSION

In this study, from the practical point of view, there are AODV, DSR and TORA routing protocol are chosen and based on the model of natural average distribution, through principles analyze and simulation experiments, discovered their own superiority of different protocols in certain environment and a lot of practical experimental results are drawn. It provides a theoretical basis for the hardware implementation of wireless *ad hoc* networks.

ACKNOWLEDGMENT

The study has been sponsored by the National Natural Science Foundation of China (61262074, 61162008, 61163059), Foundation of Department of Education of Guangxi Province, China (201204LX126, 201101ZD006), Open Project of Key Laboratory of Trusted Software of Guangxi Province, China (kx201101), Subsidy Scheme of talents of university of Guangxi Province, China (201065), Natural Science Foundation for Returned Scholars of Guangxi Province, China (2012GXNSFCA053009).

REFERENCES

Adam, G., V. Kapoulas, C. Bouras, G. Kioumourtzis, A. Gkamas and N. Tavoularis, 2011. Performance evaluation of routing protocols for multimedia transmission over mobile *Ad hoc* networks. Proceedings of Conference on Wireless and Mobile Networking, October 26-28, 2011, Toulouse, pp: 1-6.

Chen, X.M., S.J. Li and H. Pu, 2009. Performance analysis and comparison between DSR and OLSR for *Ad hoc* network. J. Commun. Technol., 42: 199-203.

Hao, J.T., J.J. Zhao and M.L. Li, 2009. Energy level and link state-based AODV route request forwarding scheme study. J. Comput. Sci., 36: 68-70.

Lee, S.J., W. Su, J. Hsu, M. Gerla and R. Bagrodia, 2000. A performance comparison study of *Ad hoc* wireless multicast protocols. Proceedings of the 19th Annual Joint Conference on the IEEE Computer and Communications Societies March 26-30, 2000, Tel Aviv, pp: 565-574.

Liu, J., W. Guo, B.L. Xiao and F. Huang, 2007. Path holding probability based *Ad hoc* on-demand routing protocol. J. Software, 18: 693-701.

Shi, M.L. and C. Ying, 2001. Routing protocols for *ad hoc* networks: A survey. J. Commun., 22: 93-103.

Yu, X.T., G.G. Bi, X.J. Wang and Z.S. Zhang, 2004. An improvement to *Ad hoc* on-demand routing protocol. J. Comput., 27: 838-844.

Zahary, A. and A. Ayesh, 2007. Analytical study to detect threshold number of efficient routes in multipath AODV extensions. Proceedings of International Conference on Computer Engineering and Systems, November 27-29, 2007, Cairo, pp: 95-100.

Zhao, Y., H.T. Deng and Y. Xu, 2007. New layered routing protocol for *Ad hoc* network and performance evaluation J. Comput. Eng. Des., 28: 376-378.