Research Journal of Applied Sciences, Engineering and Technology 4(8): 981-986, 2012
ISSN: 2040-7467

Submitted: December 20, 2011 Accepted: January 16, 2012 Published: April 15, 2012

A Review of Routing in Ad Hoc Networks

[1]V. Anand, [1]N. Sairam and [2]M. Thiyagarajan
[1]School of Computing, SASTRA University, Thanjavur, Tamil Nadu, 613401, India
[2]Adjunct Professor, School of Engineering, Amrita Vishwa VidyaPeetham, Coimbatore, Tamil Nadu, 641105, India

Abstract: Routing in ad hoc networks is a major criteria, which always plays a key role. A study of routing in ad hoc networks should not focus only on finding a shortest path to the destination. So, we have done a study of routing in ad hoc networks which takes into account the important factors which revolves around routing, like routing the packets through a shortest path, identifying the neighbors by broadcasting messages, using different parameters to reduce the overhead because of flooding, route discovery to find an appropriate route to the destination, using location-based information for route discovery, retrieving the information about destination using Hint-Based Probabilistic protocol and a protocol WARP (Wormhole-Avoidance Routing Protocol) to detect and quarantine the wormhole nodes, when routing the packets to the destination.

Key words: Broadcasting, link-state routing, route discovery, routing overhead, topology sensing

INTRODUCTION

Ad hoc networks are defined as a type of wireless networks, which can operate without the support of any fixed infrastructure. In ad hoc networks, the location-based information is essential, because of the frequent changes in network topology. This type of networks has problems like link failures because of changes in network topology, identifying the neighbors when the network topology changes, and overhead resulting from broadcasting of messages to identify the neighbors. When broadcasting the messages between nodes, transmission delays occur based on the network density and node mobility. The performance of the routing also degrades when the transmission delay exceeds the threshold value.

In this study, different algorithms and approaches are studied for comparing as well as arriving at a solution, which increases the performance of the routing in ad hoc networks in an efficient manner. We have reviewed the works that has been done on routing of packets in ad hoc networks, based on finding the shortest path, broadcasting of messages, location-based information, route discovery and avoiding the wormhole attacks during routing.

Zhuang *et al*. (2010) has proposed an adaptive algorithm for connecting mobile ad hoc network to Internet. This adaptive algorithm improves the available gateway discovery approaches by sending and receiving route broadcasting messages with local topology information. A protocol, MCLSR (Multi-Channel Link-State Routing) proposed by Cheolgi *et al*. (2010) is for multi channel mesh networks. This protocol aims at reducing the overhead because of broadcast messages, by making the all nodes keep the link state information of a network.

Jiazi *et al*. (2010) has proposed MP-OLSR (MultiPath OLSR), which is a multipath routing protocol based on optimized link state routing. This protocol is a hybrid routing protocol that mixes both proactive and reactive. To improve the quality of service in OLSR, route recovery and loop detection are implemented in multipath OLSR. A counter-based broadcasting scheme proposed by Muneer *et al*. (2011), avoids the ‘‘brute force” attitude of flooding which leads to a very high overhead, specifically at large dense networks. The ultimate aim of the scheme is to minimize the overhead and delay due to flooding and maximize the packet delivery ratio.

An algorithm, which is proposed by Wahabou *et al*., (2011) is evolutionary in nature and has an optimization engine, network simulator and a log analyzer. The proposed method regulates the broadcasting of messages using a new set of parameters. A position-based routing protocol, BLR (Beacon-Less Routing protocol) uses location-based information to minimize routing overhead. The approach proposed by Torsten *et al*. (2010) presents the behavior and performance of BLR, especially in irregular transmission ranges. BLR does not require the periodic updates, as required by other position-based routing protocols.

The work presented by Beatrice *et al*. (2011) is a blend of research on dynamic routing for wireless and mobile networks. This work is based on adaptation, power, transmission quality, traffic and topology. Natarajan, (2011) proposed the design of a Location Prediction Based Routing Protocol (LPBR) that reduces both the number of route discoveries and the hop count for path between a source and a destination. This work focuses only on the reactive on-demand routing protocols.

Corresponding Author: V. Anand, School of Computing, SASTRA University, Thanjavur, Tamil Nadu, 613401, India

An approach, that makes routing efficient using link costs as a routing metric instead of hop counts, has been proposed by Mary and ChongGun, (2010). All nodes in a network maintain the information on the minimum-cost matrix. An enhanced Hint-Based Probabilistic routing protocol (HBP), proposed by (Keyvan *et al*. (2010) introduces a new information retrieval method. The HBP can work efficiently, for networks with different node-density, coverage area size and node-mobility.

A wormhole attack is an attack formed by some of the malicious nodes. Two malicious nodes at different locations exchange routing messages through a secret channel. When routing the packets from source to destination, security issues like sniffing, dropping a packet are to be addressed. Ming-Yang, (2010) proposed a routing protocol called WARP (Wormhole-Avoidance Routing Protocol). Based on AODV (Ad hoc On-demand Distance Vector), WARP has been developed to defend against wormhole attacks.

LITERATURE REVIEW

We have studied and presented the work that focuses on different protocols and approaches for finding the shortest path, reducing overhead due to broadcasting of messages, optimal route discovery and defending wormhole attacks. The issues mentioned are interrelated: To find a shortest path, route and gateway discovery should be performed and when discovering a route or gateway, messages need to be broadcasted.

Finding the shortest path and topology sensing: Routing the packets from source to destination, involves finding the shortest path to the destination. Shortest path is computed by taking the routing metrics like hop count and link cost. Gateway discovery and route discovery approaches can be used for finding the shortest path. When using these approaches, number of retransmissions and time interval between retransmissions. is an issue that has been addressed. Zhuang *et al*. (2010) proposed an adaptive algorithm, in which gateways can regularly search the active source list to obtain list of source nodes around it and modify time of gateway advertisement messages. A protocol, MCLSR (Multi-Channel Link-State Routing) proposed by Cheolgi *et al*. (2010) shows the performance results resulting from a path, which offers a transitory route discovery and lower packet, drop rate. Jiazi *et al*. (2010) has proposed a protocol, called MultiPath OLSR (MP-OLSR), is a multipath routing protocol based on optimized link state routing The core function of MP-OLSR is topology sensing, in which each node in the network can get sufficient information of the topology to enable routing.

An approach, proposed by Mary and ChongGun, (2010) that makes routing efficient using link costs as a routing metric instead of hop counts finds the shortest path. All nodes in a network maintain the information on the minimum-cost matrix.

Reducing overhead due to broadcasting: The overhead because of broadcasting the messages for gateway discovery approaches has to be reduced by using only the local topology information. An algorithm proposed by zhuang *et al*. (2010) is an adaptive algorithm that improves the available gateway discovery approaches by exchanging the route broadcasting messages with local topology information.

The flooding introduces some overhead, which has been reduced by a counter-based broadcasting scheme. The scheme has been proposed by Muneer *et al*. (2011), specifically for large dense networks, to minimize the overhead and delay due to flooding. The evolutionary algorithm proposed by Wahabou *et al*. (2011) has an optimization engine, network simulator and a log analyzer. The proposed method regulates the broadcasting of messages using a new set of parameters.

The approach proposed by Torsten *et al*. (2010) presents the behavior and performance of BLR, especially in irregular transmission ranges. It reduces the routing overhead using location information.

Route discovery and wormhole avoidance: Route discovery will be much more complicated due to the change of the topology and the instability of the wireless medium. The performance of a protocol, which enables routing, depends on route discovery also. Jiazi *et al*. (2010) has proposed a protocol, called MultiPath OLSR (MP-OLSR), in which route computation makes it possible to find multiple paths from source to destination. Route computation done by selecting a source node in the network, MP-OLSR keeps an updated flag for every possible node in the network to identify the validity of the routes to the corresponding node. Hint-Based Probabilistic routing protocol (HBP), proposed by Keyvan *et al*. (2010) uses a new information retrieval method, in which each node has a hint table that contains hints towards any possible destination. This helps in route discovery with a minimum delay. A routing protocol proposed by Ming-Yang (2010) called WARP (Wormhole-Avoidance Routing Protocol), is to defend against wormhole attacks.

STUDY OF PROPOSED SOLUTIONS

In this section, we present the solutions proposed for improving the efficiency in the cases mentioned in the previous section.

To find the shortest path and sensing the topology: Finding a shortest path needs to implement the gateway discovery approaches also. Zhuang *et al*., (2010) proposed an adaptive algorithm, in which gateways can regularly search the active source list to obtain list of source nodes around it and modify time of gateway advertisement messages. To remove the unidirectional links, route computations and repeated retransmissions of the broadcast packets are reserved. To overcome the problem of unidirectional links, alter the local route broadcasting messages RREQ (RREQ_I) with appended neighbors' information got from neighbor node list. The nodes maintain a NNL (Neighbor Node List) by periodically sending hello messages to record its set of neighbors.

Adaptively adjusting time to live (TTL) of GWADV is proposed in terms of the distribution of source mobile nodes. Each gateway keeps an active sources list ASL to record the information of every active source around it. To implement the adaptive broadcasting, gateways periodically search the ASL to obtain the distribution of source nodes around it and dynamically modify the TTL of GWADV message. Based on the activity of source nodes, interval of sending GWADV messages is adjusted. The control overhead is further reduced according to the scheme.

The performance results shown by MCLSR (Multi-Channel Link-State Routing), a protocol proposed by (Cheolgi *et al*., 2010) results in a path, which offers a transitory route discovery and lower packet drop rate. The protocol, Multi-Channel Link-State Routing (MCLSR) protocol is designed for multichannel mesh networks. MCLSR is an altered link-state routing protocol for multi-channel mesh networks, designed to reduce the broadcast overhead due to link-state propagation. Here, all nodes keep the link state information of a network.

In MCLSR, nodes are of two categories: cluster-heads and dependents A cluster-head is the sole authority for collecting and distributing the link-state information to its dependents. A cluster-head along with its dependents form a cluster. Once a node is selected as a cluster-head, some of the other nodes that are within one hop of this node become its dependents. Each dependent can have multiple neighboring cluster-heads. The restriction is, one and only one of them is designated as its master cluster-head. A cluster-head cannot have another cluster-head as its tight neighbor (Nt), as a rule. The advantage is, it has only two control messages, Hello messages and inter-cluster head messages.

An efficient approach for routing has been proposed by Mary and ChongGun (2010) uses link costs as a routing metric instead of hop counts to find the shortest path. All nodes in a network maintain the similar information on the minimum-cost matrix. A routing algorithm, which uses the minimum-cost matrix and the next-node matrices. Both are calculated from the adjacency-cost matrix, to yield the link costs of the network. When a node has some data to be transmitted to a destination, the path can be swiftly calculated using only the maintained minimum-cost and the next-node matrices.

A leader node that is designated as agent calculates the minimum-cost matrix and the next-node matrices and distributes them to all the other nodes in a network. To minimize the communication cost of distributing the matrices, along the spanning tree they are distributed to other nodes, which is rooted from the agent. This approach shows good performance in lessening transmission delay and routing delay. It is efficient than other table-driven and on demand routing methods for dynamic wireless ad hoc networks.

A Multipath OLSR protocol proposed by (Jiazi *et al*., (2010) is based on optimized link state routing The main function of MP-OLSR is topology sensing, in which each node in the network can get enough information of the topology to enable routing. The nodes use topology sensing which includes link sensing, neighbor detection and topology discovery. The topology sensing makes it possible to find multiple paths from source to destination.

The situation gets more complicated when topology changes frequently and because of the instability of the wireless medium. In this algorithm, loop-free paths will be available. To improve the performance of the protocol, route recovery and loop detection are proposed also as functionalities. The results depict that MP-OLSR is suitable for mobile, large and dense networks with high traffic.

To reduce the overhead due to broadcasting: The adaptive algorithm proposed by Zhuang *et al*. (2010), is that each mobile node maintains an NNL (Neighbor Node List) by regularly sending hello messages to record its set of neighbors. To avoid unidirectional links, the GWADV messages are appended with neighbors' information, which is retrieved from NNL. An effective adaptive gateway discovery scheme is adapted to offer best coverage of gateway advertisement by dynamically adjusting broadcast range. The broadcast range is dynamically adjusted by changing the time to live of GWADV messages.

A counter-based broadcasting scheme proposed by Muneer *et al*. (2011), specifically for large dense networks, to minimize the overhead and delay due to flooding. The first phase starts with the new counter-based algorithm using three dynamic thresholds to present a more efficient broadcast solution in sparse and dense networks by initiating the counter c that will count the number of times, which the node receives, the same packet and increment this c for each same broadcast packet.

To determine whether the node is within dense, medium distribution or sparse regions and assigned Cmin, Cmid, and Cmax thresholds, respectively. Then RAD (random assessment delay) is calculated. RAD is calculated as follows:

RAD, which is randomly chosen between 0 and Tmax seconds by dividing random number between 0 and 1 and Random Factor (RF) such as (RAD = X/RF)).

If the total number of neighbors n is less than the average number of neighbors then the node may exist in sparse area and it will take the smallest threshold Cmax, but if the number of neighbors n is within the average number of neighbors, then the node exist in medium area, so it will take the medium threshold Cmid, or if the number of neighbors n is more than the average number of neighbors, then the node exist in dense area, so it will take the dense threshold Cmin; or else, the rebroadcast is stopped The main aim of the proposed approach is to reduce the overhead and delay because of flooding. By comparing this approach with the other approaches, this has a very low overhead.

An evolutionary algorithm proposed by Wahabou *et al*. (2011) has an optimization engine, network simulator and a log analyzer. The proposed method regulates the broadcasting of messages using a new set of parameters.

The proposed new parameters, which includes the number of retransmissions of the same message and the time between successive transmissions by a single node. It has been verified that in a very low node density environment, these parameters are important. First, the EA generates a set of possible parameters that are passed to the network simulator. The network simulator integrates the received parameters to the simulation scripts. Then, the simulations are run and some log files are generated. These log files describe the network behavior. But, the nodes should be able to determine the density of their neighborhood. The aim is to do so by sending the least possible number of control messages. Then, based on the density changes, the nodes must be able to switch from a communication strategy to another, each time choosing the most appropriate one.

This context-aware flooding protocol is based on a probabilistic broadcasting strategy. Each node is a smart repeater. To adapt its behavior to the current environment, each node when receiving a message, decides whether to forward or discard the message, using four parameters:

- **P:** the probability to accept repeating a packet when receiving it for the first time
- **Nr:** the total number of repeats
- **Dr:** the delay between repeats
- **TTL:** the time to live of a packet

expressed as a number of hops the packet is allowed to do. The given values of parameters enable to use the network efficiently without saturating the wireless channel.

Torsten *et al*. (2010) presents the behavior and performance of BLR, especially in irregular transmission ranges. This paper examined the impact of irregular transmission ranges on the Beacon-Less Routing protocol (BLR). The results of simulation reveals that irregular transmission ranges suffers with some performance penalty compared to scenarios with isotropic transmission ranges. But, still this performance penalty proves the worth of the proposed method.

The implementation of BLR has been made with simulation models, which takes an out-door test-bed with GNU/Linux laptops, wireless LAN network interfaces and GPS receivers. The results show that the implementation of BLR is feasible even though there are some problems like the limited timer resolution on Linux have to be overcome. BLR does not require the periodic broadcast of hello packets, as required by other position-based routing protocols,

Route discovery and wormhole avoidance: Performing a route discovery using appropriate protocols identifies a route properly with minimum route discovery messages. MultiPath OLSR (MP-OLSR), proposed by Jiazi *et al*. (2010), is a protocol, which finds multiple paths from source to destination. A source node in the network is selected, and then MP-OLSR keeps an updated flag for every possible node in the network to identify the validity of the routes to the corresponding node. The algorithm proposed for finding multiple paths is the multipath dijkstra Algorithm, which employs different link metrics and cost functions.

MP-OLSR is a hybrid multipath routing protocol, which blends the proactive and reactive features for route discovery. HELLO and TC messages are sent periodically to detect the network topology, as like OLSR. But, MP-OLSR does not always maintain a routing table. When data packets are to be sent only, it calculates routes. An on-demand scheme is used to overcome the problem of heavy computation of multiple routes for every possible destination.

The method is: before an intermediate node tries to forward a packet to the next hop according to the source route, the node first checks whether the next hop in the source route is one of its neighbors. If yes, the packet is forwarded. If not, then there is a chance that the ‘‘next hop” is not available. The node will re-discover the route and forward the packet using the new route. Since the route discovery checks only the local topology information, there will not be any additional delay. This will improve the packet delivery ratio of the network. Qualnet simulator is used to perform simulations. The results show that MP-OLSR can be used for complex multimedia applications with time constraints.

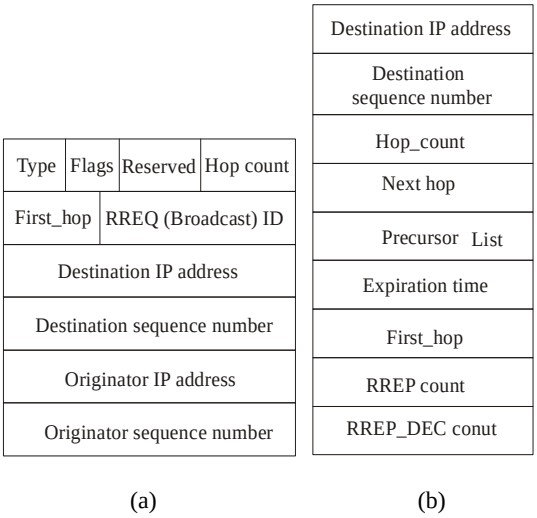

Fig. 1: (a) Format of RREQ message in WARP, (b) Routing table entry in WARP

A probabilistic routing protocol called HBP (Hint-Based Probabilistic Protocol), proposed by Keyvan *et al*. (2010) uses a method, in which each node has a hint table that contains hints towards any possible destination. This helps in route discovery with a minimum delay.

The method is: each node i keeps a hint table that has hints towards any possible destination. The hints are created by other nodes, not far away from a specific hop distance, referred as LookAhead from i. Node i is responsible for computing the hint for any possible destination d, and distributing the hints into its locality. When choosing the next hop node among its neighbor nodes to forward the packets, node i uses the hints in its hint table

This study presents an enhanced hint-based probabilistic routing protocol, introducing a new information retrieval method. By using this method, the new protocol could work efficiently in networks with different node-density, coverage area and node-mobility. To compare this method with the existing methods, the information about destinations at a long distance can be fetched without additional overhead.

The simulations performed has proved that the scheme can be used for any network setting, but an improvement of routing process is needed based on delivery probability, route length, and latency with respect to the nodes-mobility.

A wormhole attack is a type of attack from two or more malicious nodes. Two malicious nodes at remote locations exchange routing messages through a secret channel. Wormhole nodes can snatch the route from the source node to the destination node. Then they can sniff, drop, or selectively drop the data packets passing through the route. Even if authentication and confidentiality are provided, wormhole nodes can make the attack.

Based on the Ad hoc On-demand Distance Vector (AODV) routing protocol, a secure routing protocol has been proposed to protect the data from wormhole attacks, referred as WARP (Wormhole-Avoidance Routing Protocol). When discovering a path, WARP considers link-disjoint multiple paths. Eventually, it chooses only one path to transmit data packets.

WARP does not allow intermediate nodes to reply to the RREQ with an RREP, and only the destination node can send RREPs to the originator. If an intermediate node replies to the RREQ with an RREP, none of the following nodes on the path can accumulate the anomaly value of its next neighboring node along the route.

WARP makes the neighbors of a wormhole node to identify that it has abnormal route acquisitions. Its neighboring nodes gradually isolate the wormhole node. Then, the whole network quarantines the node. If a normal node is quarantined due some acquisitions, it will not be quarantined for a long time. After being observed by its neighbors, the normal node would be recovered from the quarantine by its neighbors. Figure 1a, shows the format of RREQ messages, which are sent by originator to the nodes in the network. The Fig. 1b, shown above gives an idea of the information like destination IP address, sequence number of the destination, hop count, next hop and expiration time that are stored in the routing table maintained by WARP.

The simulation has been performed with ns2 and according to the results, WARP improves the packet loss rate in a better way when compared with the original AODV. The important merit is that it WARP achieves degradation in packet loss rates.

CONCLUSION

In this study, a study of routing in ad hoc networks is done, which proves that the main issues like finding shortest path to the destination, reducing the broadcast overhead, route discovery, topology sensing and wormhole avoidance has been taken. Different solutions, which are proposed by using different approaches and protocols are presented. This review of different issues and the solutions gives an exploration into routing in ad hoc networks and opens ideas for further research in this area.

REFERENCES

Beatrice, P., Y. Cholatip and D. Riadh, 2011. Network awareness and dynamic routing: The ad hoc network case. Comput. Netw., 55: 2315-2328.

Cheolgi, K., K. Young-Bae and H.V. Nitin, 2010. Link-state routing without broadcast storming for multichannel mesh networks. Comput. Netw., 54: 330-340.

Jiazi, Y., A. Asmaa, D. Sylvain and P. Benoit, 2010. Multipath optimized link state routing for mobile ad hoc networks. Ad. Hoc. Networks, 9: 28-47.

Keyvan, K.N., A. Shawish, J. Xiohong and H. Susumu, 2010. Probabilistic proactive routing with active route trace-back for MANETs. Ad Hoc Netw., 8: 640-653.

Mary, W. and K. ChongGun, 2010. A cost matrix agent for shortest path routing in ad hoc networks. J. Netw. Comput. Appl., 33: 646-652.

Ming-Yang, S., 2010. WARP: A wormhole-avoidance routing protocol by anomaly detection in mobile ad hoc networks. Comput. Secur., 29: 208-224.

Muneer, B.Y., F.N. Sanabel and A.Y. Al-Dubai, 2011. A new dynamic counter-based broadcasting scheme for Mobile Ad hoc Networks. Simul. Model. Pract. Th., 19: 553-563.

Natarajan, M., 2011. A location prediction based routing protocol and its extensions for multicast and multi-path routing in mobile ad hoc networks. Ad Hoc Netw., 9: 1104-1126.

Torsten, B., H. Marc and R. Tobias, 2010. Performance of the beacon-less routing protocol in realistic scenarios. Ad Hoc Netw., 8: 96-107.

Wahabou, A., H. drien, B. Christelle, D. Dominique, C. Damien and S. Francois, 2011. Using an evolutionary algorithm to optimize the broadcasting methods in mobile ad hoc networks. J. Netw. Comput. Appl., 34: 1794-1804.

Zhuang, L., Y.A. Liu, K.M. Liu, L.B. Zhai and M. Yang, 2010. An adaptive algorithm for connecting mobile ad hoc network to Internet with unidirectional links supported. J. China Univ. Posts Telecomm., 17: 44-49.