An Improved Routing Mechanism for Secure Ad-hoc Network

Yogendra kumar Jain, Geetika S. Pandey, Deshraj Ahirwar

Abstract- An ad-hoc network is a multi-hop wireless network where all nodes cooperatively maintain network connectivity without a centralized infrastructure. If these nodes change their positions dynamically, it is called a mobile ad-hoc network (MANET). The security of ad hoc networks is becoming an increasingly complex issue. Security requirements such as authentication, non-repudiation, data integrity and confidentiality, which would otherwise be provided by a central server, must be enabled and provided by all nodes. In this paper we proposed enhance based direction routing protocol. The zone direction is reduced until the node can select the strongest and most stable link and so increase availability in the network. Each node in the network has a counter for the stability of link (SL) to its neighboring nodes, which indicates which nodes are active in the network, improving the performance of the network and increasing the likelihood of selecting the optimal path. We also propose a novel secure routing protocol to improve the security level in ad hoc networks, based on key management and a secure node-to-node path, which protects data to satisfy our security requirements.

Keywords- Ad-hoc Network, Routing Protocol, Security Mechanism.

I. INTRODUCTION

An ad-hoc network is often characterized by rapidly changing and unpredictable wireless topology. Because the multiple nodes in such a system can enter and leave the system at any time, this system requires some sensing of the location and hence offers a very attractive environment to support context aware applications. The ad-hoc network provides limited automation needed in the position calculation and is an ideal and cheap alternative in the environment where the infrastructure is not developed yet. Bluetooth is one such emerging technology that provides ad-hoc networking [2]. The major challenges to *ad hoc* networks concern their design and operation, and result mainly from the lack of a centralized entity and infrastructural elements such as base stations, communication towers and access points. The possibility exists of fast node movement and all communications are conducted through a wireless medium. These unique characteristics present nontrivial challenges for *ad hoc* networks [1] and [3]. This paper proposes a new routing protocol: the Enhanced -direction Routing Protocol based on an on-demand routing scheme.

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We have added important features to overcome its disadvantages and improve its performance, providing the stability and availability required to guarantee the selection of the best path. This paper also proposes a novel secure routing protocol for *ad hoc* networks: the Secure Enhanced Direction Routing Protocol. This is designed to improve the security level in *ad hoc* networks, based on key management and a secure node-to-node path, which protects data to satisfy our security requirements: the detection of malicious nodes, authentication, authorization, confidentiality, availability, data integrity and a guarantee of secure correct route discovery.

II. BACKGROUND

The routing protocol has two main functions: the first is to find a feasible data packet path from a source node to a destination node; the second is to identify and exchange the routing information as a routing table, required for establishing the routing path, discovering path breaks, re-establishing or repairing broken paths and reducing bandwidth utilization. The nodes in an *ad hoc* network function as routers which discover and maintain routes to other nodes in the network. This absence of dedicated routers makes the provision of security a challenging task in *ad hoc* wireless networks, where the task of ensuring secure communication is also made difficult by factors including the mobility of nodes, limited processing power and limited availability of resources such as battery power and bandwidth [2].

Directional Angle Routing Protocol- The core of the proposed schemes is the direction Routing Protocol, so called because it utilizes directional information on nodes in the network. Such information can be obtained from the node‘s own instruments and sensors, such as a compass, which delivers the -direction angle (HDA) of the mobile device relative to magnetic north. This protocol is used to reduce routing overhead and to increase the lifetime of links between nodes. It has been assumed that every node can exchange information frequently with its neighbours. Under HARP, every node classifies its neighbouring nodes into eight different zones according to their direction. In theory, the nodes are categorized within at least one of the eight zone ranges, regardless of their location. This protocol is based on an on-demand routing technique. The RREQ packet is transmitted from a node to one of the neighbouring nodes that has an angular direction similar or near to the HDA of neighbouring nodes, where D is a value used for increasing the search around ND. When a source node S sends a request for a route to destination node D, it will look into its cache for D and if it is found,

Node S will start broadcasting the data packets to node D. If D is not found, a time Td will be initiated by source node S, where Td is the time required to find the destination. Then, node S starts searching in its cache for a neighbour that has a reference or near reference angle matching with or close to the HDA of S. This protocol reduces the overheads and minimizes bandwidth usage, since not all neighbouring nodes need to reply to a RREQ. Its main advantage is that it increases the lifetime of links between nodes. A disadvantage is that when the source node receives an error message, it will resend the request packet; the limited amount of sending avoids the formation of a loop without taking into account whether it knows the accurate path. Another drawback of HARP is the classification of different zones that are not suitable for the network if it is of high or low density. This protocol does not seem useful as an axis mapping technique, despite its use [5] and [6].

Hybrid Routing Protocols- Hybrid routing protocols are designed to be both reactive and proactive in order to classify and offer different routing solutions. They increase the network‘s scalability, which allows nearby nodes to define a local zone, while determining routes to distant nodes using a reactive approach. In order to reduce route discovery overheads, neighbouring nodes work together by proactively maintaining routes to nearby nodes. Most proposed hybrid protocols are based on zones, which mean that the network is partitioned. Each given node partitions a zone of the network into two distinct regions. The routing zone for a particular node can be defined in terms of distance from that node or as lying inside a particular geographical region. This routing uses a proactive (table-driven) approach; a reactive routing approach uses nodes located in the area beyond the routing zone. The most typical hybrid types are the Zone Routing Protocol (ZRP) and the Core Extraction Distributed *Ad hoc* Routing (CEDAR) algorithm. The latter selects a minimum set of nodes as a core to perform quality of service route computations [7].

Authenticated Routing Protocol-The Authenticated Routing *Ad hoc* Network (ARAN) protocol provides secure routing for *ad hoc* wireless networks by means of cryptographic certificates that successfully defeat all identified attacks in the network layer. It takes care of authentication, message integrity and non-repudiation, but expects a small amount of prior security coordination among nodes. In general, the main requirements it attempts to fulfill are first preventing things such as the spoofing of routing signals, the fabrication of routing packets, the shaping by adversaries of routing loops and the exposure by routing packets of the network topology; and secondly ensuring that such routing packets are not altered during transmission and that the shortest routing path is utilized. The major drawback of the protocol is that it needs a trusted certification server to issue the initial certificates. It offers security at two levels. The first, which is not fully secure, is an end-to-end authentication that is effective and requires low CPU power; however, it does not guarantee the shortest path usage. The second is stronger in security and guarantees to provide the shortest path, but requires more CPU power and resources. The ARAN protocol prevents compromised nodes from disrupting the network by providing route maintenance mechanisms and key revocation schemes [1] and [9].

III. RELATED WORK

Due to the inherited form of MANET, most of the operational phases of VANET are derived as well as adapted from the previous type of network in one way or the other. Not completely relying, there are some characteristics and distinctiveness differences from its classical beginnings. According to the explicit discussion, the infeasible routing criteria of well-known MANET protocols not fully compatible within VANET‟s scenario, could be due to its mobility differences. In fact, adaptability approach remains there for some achievable results. Before discussing the routing contemplation (the core scheme of this proposition), there are many other interrelated areas (actually subareas) with their issues and proposed solutions are explored during the phase of literature surveying. The major differentiation of these sub areas are identified according to the study of mobility patterns and their associated models, and reliability concerns with traffic flow and congestion controls. This will then leads toward the actual progression of routing scope from network layer. Recently proposed the architectural model for carrying reliable vehicle-to-vehicle services in an unreliable VANET environment has a range of factors. These variable factors of VANET are due to its multi-hop delivery mechanism with different network involvements The proposed model named STRAW (STreet RAndom Waypoint) also evaluated the routing performance in the ad-hoc networks. In comparison of two main routing protocols DSR and AODV with respect to packet delivery ratio gives the clear picture of vehicular diversification of on the road networks. There is also a comparative study available in Djenouri (2008) discussing different VANET mobility models like: Freeway, Manhattan, City Section Model (CSM), Stop Sign Model (SSM), and STRAW for some positive mobility considerations with different tools. In previous proposed, much of the focus was made on safety related problems faced by vehicular ad hoc network (VANETs) with certain limitations observed within and general traffic monitoring. In addition, another vehicular mobility model is proposed that reflects real world vehicle movement on road and performance of present network. The networking performance of VANET is directly affected by traffic rules (physical) road layouts and traffic regulations. Keeping this fact in mind, process of VANETs requires careful investigations. The observation leads to the drawbacks of the MANET protocols which modified with certain changes and an investigation made to large scale VANETs phases of routing protocols with the incorporations of map information and overlay road graphs [2] and [8] and [10]. With the help of all these major interrelated sections of mobility and routing explored in this background,

A formal methodology be derived to consider the overall aspects of mobility and reliability with different routing schemes in a pragmatic simulation environment with the help of NS2. In this paper, we implemented enhance based direction routing protocol.

IV. PROPOSED ROUTING PROTOCOL MECHANISM

The mobility of mobile nodes and the stability of links to establish a robust and long-lived route between sources and destinations, in addition to reducing the flooding and overhead effects and minimizing the rate of breakage of links in the established paths. In the proposed approach, selecting nodes to forward packets between the source and the destination nodes is based on the Head Direction Angle (HAD) of these nodes and the stability of links between them. It should be borne in mind that the proposed approach could be used as a stand-alone routing protocol under the limits and environmental conditions.

Now we presents the operation of the proposed enhancement of direction Angle Routing Protocol based on an on-demand routing scheme. We have added important features to overcome its disadvantages and improve its performance, providing the stability and availability required to guarantee the selection of the best path and to reduce the occurrence of broken links and dropped packets.

➔ Each node in the network is able to classify its neighboring nodes according to their directions into four different zone-direction groups. The zone direction is reduced until the node can select the strongest link stability and so increase availability in the network.

➔ Each node in the network has a counter for the stability of link (SL) to its neighboring nodes. The SL counter indicates which nodes are active in the network and this will improve the performance of the network and increase the likelihood of selecting the best or optimal path. The counter has an initial value of zero, which is increased by 1 after every successful sending or receiving and reduced by 1 after every failure in sending or receiving. The strongest stability of link is based on the greatest value in the counter.

➔ This protocol is based on the time and acknowledgement message in order to guarantee the selection of the path and link stability.

➔ Each node will send an acknowledgement message after receiving an RREQ and forwarding it, so the acknowledgement message should provide information on which nodes have problems or have been unable to forward the RREQ.

➔ The source node should resend the RREQ whenever the time elapses before receiving the error message, in order to make use of the full lifetime of the links.

EHARP is an on-demand routing protocol which can be considered as comprising two parts: the mobility and classification of nodes and the discovery and maintenance of routes.

Enhance based Direction Routing Protocol Architecture-
Under enhance based direction routing protocol each mobile node in the network sends its mobility information to its neighboring nodes periodically and each classifies its neighboring nodes into four different zone-direction groups (Z1, Z2, Z3, Z4). As can be seen in Figure 1, according to their directions, each mobile node in the *ad hoc* wireless network divides the directions into different sectors. The directions between 0° and 90° comprise zone-direction 1 (Z1); those between 90° and 180° comprise zone-direction 2 (Z2) and so on. After the source node *S* has classified its cache table, as shown in Figure 1, and wants to send a request packet to its neighbour, *S* then selects that neighbour. This selection depends on two factors; the first being that it has an angular direction of one of the four axis angular values (0°, 90°, 180°, 270°) $\pm\delta$, where δ is an angular value that represents the range of angles that are considered near to the axis. The second factor is the value of the link stability of its neighbours. The neighbouring nodes of a mobile node are categorized within at least one of the four zone ranges, regardless of their actual positions relative to the mobile node itself.

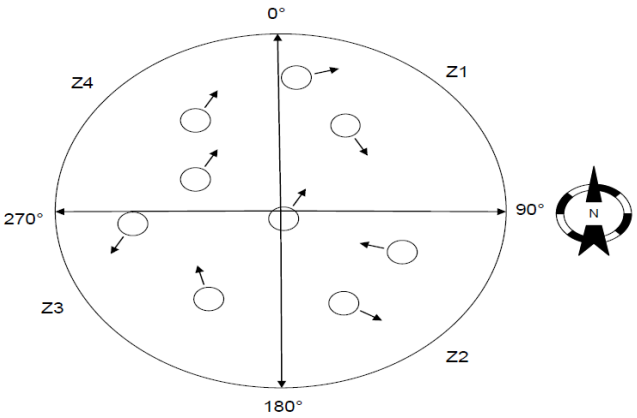

Figure1: The four basic direction ranges and neighbours classified in these ranges

- **Route Discovery**

The route discovery process initiated at the source node and the intermediate nodes (all nodes except the source and destination). It also covers the route maintenance and local repair mechanisms that are executed when a link is broken.

➔ Route Discovery at the Source Node

At the source node, when a source *S* requests route to a destination *D*, it will look in its cache for the destination node *D* and if it is found as a neighbour, *S* will start forwarding the data packets to *D*. If *D* is not found in the source cache, *S* will set a determined time *Td* within which the destination node must be found. *S* then searches its cache for a neighbour that has a reference or near reference angle, matching with or close to the direction angle of *S*, and the greatest value of SL, in order to extend the lifetime of the route. Therefore, for the best matching and finding a neighbour with nearly similar direction to the node itself and the greatest value of SL, this protocol performs well in a network where nodes form groups and where each group moves together in one direction, such as in military vehicles on a road. This protocol performs better than other existing routing protocols that use the technique of flooding the route request across the network to reach the target destination, by controlling the flooding by those nodes that let the link last longer. Here, after searching for a neighbour in the cache memory of *S*, there are two possibilities:

1) If *S* does not find a neighbour in its cache by axis mapping or the only neighbour has a negative SL value, it will apply an increment of $\pm\delta$ around the angle of *S*, to widen the search for another neighbour in a new direction.
If no neighbour is found in the time *Td*, a route request will be triggered again (*S* will repeat the RREQ for a limited number of times, to avoid the search-to-infinity, while excluding neighbours that have been selected in previous tries at finding D.
2) If *S* finds a neighbour in its cache, then where more than one neighbour is found, the greatest value of SL will be selected. *S* will initiate an RRL and add its information record to that list. Each record has the following fields: node IP, node angle, zone range area, *Td*, SL. The route request packet will then be broadcast along a selected angle of a neighbouring node. The steps followed at a source that has data packets to send to node *D*. The *Max RREQ Count* is the maximum number of RREQs allowed to be sent to search for a particular destination. *S_Dir* is the direction angle of *S* and *S_Zone* is the zone of *S* (Zone 1 between 0° and 90°, Zone 2 between 90° and 180°, and so on). *Nb_Dir* is the direction angle of the neighbour *Nb*, *Nb_SL* is the stability of the corresponding link and *Max acceptable HDA* is the maximum accepted angle around its HDA axis that the node uses to search for a neighbour.
The source node will again trigger a route request:
→If it does not find a neighbour in the time *Td* (*S* will repeat the RREQ a limited number of times, to avoid the risk of search-to-infinity). Each time, it will apply an increment of $\pm\delta$ around the angle of *S*.

→ If it does not receive a route reply from *D* in *Td*.

→ If it receives an RREP from *D* before *Td* has elapsed.

- **Route Discovery at Intermediate/ Relay Nodes**

At intermediate nodes, all the nodes that receive the route request message update their route cache entries by updating the information of the neighbouring node from which the message was received; only the intermediate node to which the RREQ message is addressed will accept it, while other nodes will silently drop it. The intermediate node to which the message is addressed will search in its cache of neighbours for *D*, then:
1) If the intermediate node is found, *D* in the cache table will be updated in the RRL by adding the record containing the information about the node itself, then it will broadcast a reply message along the nodes that have records in their RRLs backtracked to the initiating source node.
2) If the intermediate node does not find *D* in the cache table, axis mapping will apply, increasing the angle of *S* by $\pm\delta$ to extend the search for another neighbour with the greatest value of SL in a new direction. Before forwarding the route request message, the intermediate node will add a record to the RRL containing information about the node itself. It will then set up a determined time *Tn* within which a neighbour must be discovered. After the intermediate node forwards the RREQ, an acknowledgement message will be sent to *S*.
3) Each intermediate node identified again triggers an RREQ, which will be checked in the cache memory to see whether it has received an acknowledgement message from its nearest neighbour. This will be propagated to the same neighbour. If it has not received an acknowledgement message from its nearest neighbour, then an increment of $\pm\delta$ will be applied around the angle of S to extend the search for another neighbour in a new direction. Figure 5.3 shows the actions performed at the intermediate node.

- **Route Reply**

A route reply message is triggered in two cases:
1) When it receives the route request packet, *D* will piggyback the RRL that is included in the route request in the reply message, which it will send along the reverse path determined by the nodes recorded in the RRL.
2) When the intermediate node has received the route request message and has information about the destination stored in its cache (a valid path to *D*), the intermediate node will update the RRL by adding its information and piggyback the RRL in the reply message, then send it along the reverse path determined by the nodes recorded in the RRL.
Secure Enhanced Direction Routing Protocol- Our main focuses are to introduce Secure Enhanced Direction Routing Protocol to protect data transmission and to construct a secure routing protocol. The network consists of a group of mutually trusting nodes. There are two types of node, which are:
➔User Node (UN): Normal ground nodes, typically soldiers.

➔ Network Backbone Node (NBBN): Usually units or master nodes located within the network, for example tanks. NBBNs can establish direct wireless links for communication amid themselves

Secure Enhanced Direction Routing Protocol works as a group and has three stages, examined in turn in the remainder of this section:

➔Distribution of keys and certificate stage.

➔Secure path stage.

➔Secure routing protocol stage.

- **Distribution of Keys and Certificate Stage**

Our scheme adopts the NBBN approach because of its superiority in distributing keys and achieving integrity and non-repudiation. The system uses private and public keys. The private key is used to sign the certificate and the public key of all the nodes, while the public key is used to renew certificates that are issued by another NBBN. All nodes must have a copy of the NBBN‘s own public key to verify signatures. The public keys and the corresponding private keys of all nodes are created by the NBBNs, which also issue the public-key certificates of all nodes. Each node has its own public/private key pair. Public keys can be distributed to another node in the secure path stage, while private keys should be kept confidential to individual nodes.
The NBBN signs the public key certificate for all nodes, so that these signings take place offline before the nodes can enter the network.

Each node in our approach receives exactly one certificate after securely authenticating its identity to the NBBN. Each node will hold its digital certificate in the Node Databases (NDB). The main structure of node digital certificates, it contains the identifier of the node, its public key, the name of the NBBN issuing this certificate, the certificate issue and expiry dates, and the public key of the NBBN. Finally, the contents of the certificate will be attached to the digital signature of the NBBN. All nodes in a network should maintain fresh certificates with the NBBN. At the secure path stage, nodes use their certificates to authenticate themselves to other nodes in the network.

- **Secure (node-to-node) Path Stage**

Our approach is to use a public-key algorithm to establish secure paths between nodes. The Secure Path Stage (SPS) is based on the requirement for all nodes to have a secure path with other nodes before sending any route request packet. Any node receiving an RREQ from the source node or another node without a secure path should discard the request. In our approach, each node is given the system public key in order for any node to be able to send a Secure Path Request (SPR) to another node the first time the certified public keys are exchanged. The authenticity of the certificate can be confirmed as the nodes have the system public key. The first objective of the SPS is the exchange of the certified public keys and their confirmation, while its second objective is to ensure the identity of the sender before acceptance of the RREQ. The SPS considers secure authentication node by node.

- **Secure Routing Protocol Stage**

At this stage, our Secure Enhanced Direction Routing Protocol approach uses a hybrid of security mechanisms so that it satisfies the main security requirement and guarantees the discovery of a correct and secure route. The security mechanisms that the protocol uses are the hash function, digital signature, time synchronization and route discovery request.

Hash Function- The hash function is used to encrypt and update the data necessary for the routing process in order to secure the mutable data, which in this case is the head direction and time to find a destination, whose information uses hash chains. Secure Enhanced Direction Routing Protocol uses hash chains in order to secure the mutable data of the head direction and Td, the maximum time to find a destination node, for any node in the network, including an intermediate node and the destination node, which when it receives the message can verify that the mutable data has not been decremented by any attacker. Secure Enhanced Direction Routing Protocol forms a hash chain by applying it one way. A hash function is the operation whereby a node creates an RREQ or RREP and a hash function repeatedly to begin. The setting of the hash function is as follows:

→Assign a random number to the Hash field as the beginning value, so that Hash = beginning.

→ Set the MaxHashCount field to the time to find destination value from the IP header, i.e. MaxHashCount = *Td*.

→ The Hash_Function field is set to indicate which hash function is employed: Hash_Function = h.

→ Calculate Top_Hash by hashing beginning value as hash_Count.

- *Top_Hash = h* MaxHashCount – *h hash_Count*
- *Hash Count = time to find neighbour*

- Where *h* is a hash function and *h j (y)* is the result of applying the function *h* to *y j* times.

When a node is retransmitted an RREQ or an RREP packet is used to verify the hash count. The node performs the following operations: 1. It applies the hash function indicated by the *Hash_Function* field MaxHashCount minus Hash Count to the beginning value in the Hash field and verifies that the value is equal to the value contained in the Top_Hash field. *Top_Hash =(h* MaxHashCount – *h Hash_Count)*. 2. Before rebroadcasting an RREQ or forwarding a RREP, a node uses the hash function from the Hash value for the new node: *Hash = h (Hash).*

Digital Signature- A digital signature is used to protect the non-mutable data, which is data not required or changed in the routing process. Digital signatures provide authentication and data integrity and ensure non-repudiation. Proposed Secure Enhanced Direction Routing Protocol has two digital signatures. The first is the source signature used to protect the integrity of the non-mutable data in RREQ and RREP messages, which means that the source signs everything. The second is the node-by-node signature, based on who obtained a secure path, and every intermediate node afterwards verifies the hash function, updates information and provides a signature for the updating. When a node receives an RREQ, it first verifies the signature of the sender and of the secure path before creating or updating a route to that neighbour. Only if the signature is verified will it update a route and set *Td* to find the neighbour. After it is updated, it will sign all new updating and fields node by node from the RREQ. In the event of a failure, it will discard the RREQ. The destination node, when it receives an RREQ, first verifies the signature of the source and the signature of the intermediate node that has a secure path by field signature node-to-node. In the event of a failure, the RREQ will be discarded.

Time Synchronization- A timestamp is used to protect the route path from specific attacks. The Enhanced Direction Routing Protocol protocol is based on the time to find the destination and neighbouring nodes. When a node has a request packet, it calculates the time to find a neighbour and destination, and after creating the packet uses the timestamp; then the node that has received the packet must verify it from the timestamp.

We presented a secure routing protocol based on key management, a secure path and protecting data to satisfy our security requirements. After understanding security requirements and identifying the types of attack the network might face, we proposed the security mechanism most able to satisfy these security requirements, having the following elements:

→ asymmetric encryption (used to protect non-mutable data)

→hash function (used to protect mutable data)

→Time synchronization.

All these mechanisms when applied to routing protocols should prevent external attacks, including black holes and routing holes, while providing viability, confidentiality and authentication. Time synchronization is used to provide the protocol with the ability to find the route and to ensure that the selected route is the correct path. The digital signature mechanism, when applied to routing protocols, should prevent internal attacks, including impersonation, and should provide non-reputation and integrity.

V. SIMULATION ENVIRONMENT

Our proposed Secure Enhanced Direction Routing Protocol algorithm was successfully implemented using NS2 simulator, in which I have implemented the algorithm in existing techniques by making necessary changes in the existing system. The following choices are made for simulation considering accuracy of result and available resources. Then, we carry out quantitative and comprehensive evaluation of performance in terms of time, overall performance ratio, and traffic sensitivity. The simulation parameters of our thesis work as follows:

Length of WMN	1000 (M)
No. of mobile nodes	30-300
Packet rate of normal connection	1
Movement Model	Random Waypoint
Traffic type	CBR, HTTP, FTP
Max. mode speed	5 m/s – 30 m/s
No. of connections between nodes	5 – 30
Pause time	10 s
Rate (packet per sec)	2 packets/s
Data payload (packet size)	28 – 512 bytes

Table 1 Simulation parameters

VI. RESULT ANALYSIS

Comparative Overview and Analysis

This section highlights the performance parameters used for comparing our proposed algorithms with the HDRP protocol.

Route Discovery Packets (overhead)

Figure 2 is a chart of route discovery packets throughout the simulation period with the information captured at 50 sec and interval. The number of route discovery packets needed to find the path under Secure Enhanced HDRP and HDRP increase and is shown in the chart.

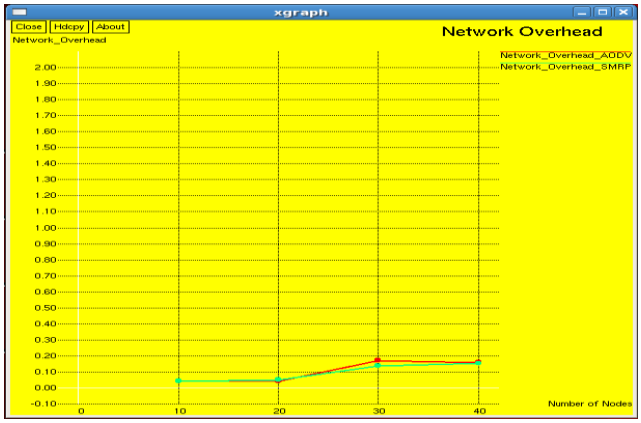

Figure 1: Route discovery vs. mobility (elapsed time)

It can be seen that the number of route discovery packets needed to find the path is much lower in Secure Enhanced HDRP than in the HDRP protocols, because the node under Secure Enhanced HDRP selects only that one node which has the greatest value of link stability to transmit the request packet. The impact of node speeds on the route discovery packets for our scheme is shown in Figure 6.2, which plots route discovery against speed of node movement. As speed increases, the number of route discovery packets generated by Secure Enhanced HDRP and HDRP increases, because the locations of source and destination are changed; thus the number of attempts to reach the destination will be the maximum. Route discovery packets in our scheme are significantly fewer than this generated by HDRP because when establishing routes, in all situations, the source and intermediate nodes under Secure Enhanced HDRP select a limited number of nodes to contribute to finding these routes.

- **Efficiency of Data Packet Delivery**

Figures 3 compare the efficiency of our proposed scheme with HDRP a by plotting ERDP against mobility for elapsed times, node speeds and network size. In general, these figures show that the ERDP in our scheme is higher than for HDRP in terms of elapsed time, speed and number of nodes. This means that fewer of the number of route discovery packets are needed to deliver data packets from source to destination, because long-lived routes are established.

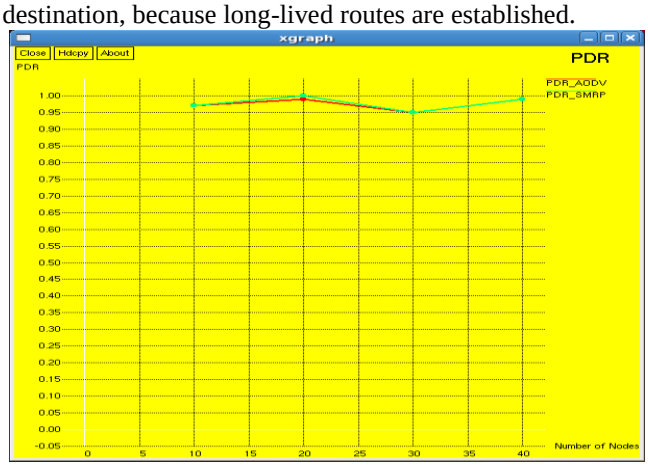

Figure 2: Efficiency of data packet delivery vs. mobility (elapsed time)

- **Average end-to-end Delay**

The comparison of Secure Enhanced HDRP with HDRP in terms of the average end-to-end delay of transferred data packets against mobility for elapsed times, node speeds and numbers of mobile nodes is depicted in Figure 4.

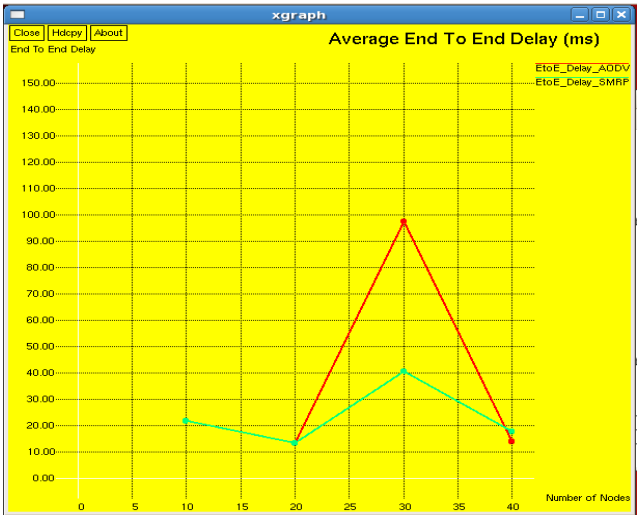

Figure 3: Average end-to-end delay vs. mobility (elapsed time)

It can be seen that Secure Enhanced HDRP has an increased delay compared to HDRP, because it forwards route request packets to the nodes which are nearest heading direction and have the strongest stability links. Therefore, additional delays will occur during establishment of the path to the destination. When the speed of mobile nodes is increased, the average end-to-end delay is decreased in Secure Enhanced HDRP.

- **Throughput**

Figure 4: Throughput vs. mobility (elapsed time)

Comparative Analysis of Results for HDRP and Secure Enhanced HDRP

The metrics mentioned above are important determinants of network performance. We have used them to compare the network performance of our scheme with that achieved using the original protocol. The results of this study show that our scheme enhances the security of the routing protocol without causing substantial degradation in network performance.

- **Efficiency of Data Packet delivery**

In our results analysis compare the efficiency of the proposed Secure Enhanced HDRP scheme with HDRP by plotting ERDP against mobility with elapsed times, node speeds and network sizes. In general, it can be seen that the ERDP is lower in HDRP than in Secure Enhanced HDRP and better than in HDRP in terms of elapsed time, speed and number of nodes. Because the throughput of the network decreases after incorporating Secure Enhanced HDRP, the ERDP is low in many cases. When elapsed times increases, a number of data packets waiting for route discovery are dropped, hence fewer data packets reach the destination, but the decrease in throughput is only about 3%. As the number of routing packets increases, this can again be attributed to the authentication overhead.

In terms of the scalability of the network by increasing the number of nodes, Secure Enhanced HDRP performs better than HDRP, because it selects the only nodes have the secure path with strongest link as the next hop towards the destination.

VII. CONCLUSION AND FUTURE WORK

In this paper we proposed enhance based direction routing protocol. The zone direction is reduced until the node can select the strongest and most stable link and so increase availability in the network. Our scheme adopts the network backbone node system because of its superiority in distributing keys and achieving integrity and non-repudiation. The system uses private and public keys. The former are used to sign certificates and the public key of all the nodes, while the latter is used to renew certificates. Our approach is to use a public-key algorithm to establish secure paths between nodes. The secure path stage requires all nodes to have an SP (Secure Path) with other nodes before sending any route request packet. Any node receiving an RREQ from the source node or another node without an SP should discard the request. At this stage our approach uses a hybrid of security mechanisms to introduce the proposed techniques so that it satisfies the main security requirement and guarantees the discovery of a correct and secure route. The security mechanisms that the protocol uses are the hash function, digital signature and time synchronization. The performance of these two protocols was tested in simulation and their communication costs were measured using the NS-2 simulator, which was suitable for the present purpose. The evaluation metrics used in this study were success ratio, delay, average number of retries and overhead. There are interesting challenges facing in our implementation of ad hoc networks, in addition to security, which are worth investigating in future works. These include: The design of multicast routing protocols, the development of MAC layer protocols, approaches to efficient load balancing, provision of end-to-end quality of service, and the design of power-efficient protocols.

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