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Lightweight Local Area Network Dynamic Routing Protocol for MANET

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Abstract. **A Mobile Ad Hoc Network (MANET) comprises mobile nodes, equipped with wireless communications devices; which form a temporary communication network without fixed network infrastructure or topology.**

The characteristics of MANET are: limited bandwidth; limited radio range; high mobility; and vulnerability to attacks that degrade the signal to noise ratio and bit error rates. These characteristics create challenges to MANET routing protocols. In addition, the mobility pattern of the mobile nodes (MNs) also has significant impact on the MANET routing protocols. The issue of routing and maintaining packets between MNs in the mobile ad hoc networks (MANETs) has always been a challenge; i.e. encountering broadcast storm under high node density, geographically constrained broadcasting of a service discovery message and local maximum problem under low node density. This requires an efficient design and development of a Lightweight routing algorithm which can be handled by those GPS equipped devices. Most proposed location based routing protocols however, rely on a single route for each data transmission. They also use a location based system to find the destination address of MNs which over time, will not be accurate and may result in routing loop or routing failure. Our proposed lightweight protocol, Local Area Network Dynamic routing (LANDY) uses a localized routing technique which combines an unique locomotion prediction method and velocity information of MNs to route packets. The protocol is capable of optimising routing performance in advanced mobility scenarios, by reducing the control overhead and improving the data packet delivery. In addition, the approach of using locomotion prediction has the advantage of fast and accurate routing over other position based routing algorithms in mobile scenarios. Recovery with LANDY is much faster than with other location protocols which use mainly greedy algorithms, (such as GPRS), no signaling or configuration of the intermediate nodes is required after a failure. The key difference is that it allows sharing of locomotion and velocity information among the nodes through locomotion table. Simulation results show that LANDY`s performance improves upon other position based routing protocols.

Keywords: *Ad hoc network, light-weight , Hybrid network, Wireless Network, Mobility predication.*

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1. Introduction

The needs of efficient routing mechanism over wireless communication have been increasing drastically over the last decade to address the rapid growth and demand in data-hungry applications and payloads. Two basic distinct approaches for enabling wireless communication between MNs are: i) ***Infrastructure based****:* where mobile networks rely on good infrastructure support, in which user equipment communicates with access points (base stations) connected to the fixed network infrastructure e.g. GSM, WLAN and 3G-UMTS [1]. ii) ***Ad-Hoc based*****:** the non-infrastructure platform based on collections

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of wireless MNs that are potentially capable of forming a provisional network to dynamically exchange data without relying on any pre-existing infrastructure. If the nodes are in locomotion, this scenario is commonly known as a mobile ad hoc network (MANET) [1, 2], which has completely different kind of traffic from the infrastructure based networks [1].

MANET is one of the potential upcoming technologies that can support advanced packet services and real-time applications, which also become one of the most innovative and challenging area of wireless networking. In MANETs, each node operates as a router and an end-system to forward packets. The nodes are able to move about, change location frequently and organize themselves into a network. Because of this, MANETs can offer a larger degree of freedom at a considerably lower cost than other networking solutions. MANETs can be used alone or as a hybrid together with other networks such as internet. Different MANET applications have different needs, and therefore the various MANET routing protocols can often be suitable in many different areas. Special routing algorithms are often needed to accommodate changing topology. In comparatively small networks, flat routing protocols may be sufficient. In larger networks, either geographic or hierarchical routing protocols are required [3, 8, 12].

One of the fundamental problems of MANETs is to determine whether it is better to route packets over many short or a few long hops [1]. Another important factor is whether or not the nodes of the network should keep track of the route to all of the possible destinations [1, 2, 7]. Since the network topology of MANETs is constantly changing, the issue of routing packets between any node becomes a challenging task [1, 2, 4, 7, 12,13,20].

The research objective is to design and develop an efficient 'light-weight' routing algorithm for MANET; that can be handled by GPS equipped devices. Most proposed location based routing protocols however, rely on a single route for each data transmission; and a location based system to find the destination address of MNs which will not be accurate over time, and this may result in routing loop or routing failure . Whenever there is a link disconnection (breakage) on the active path, the routing protocol must perform a route recovery process.

This study was devised to address the issues related to routing packets between the MNs in MANET. In this paper, we introduce an approach for predicting the mobility of the MNs in the near future which will aid in optimizing the communication and data delivery between nodes in MANET. The proposed method, Landy. addresses the major issues which position based routing algorithms encounter; There are i) broadcast storm under high node density, ii) local maximum problem under low node density, and iii) the geographically constrained broadcast of a service discovery message. LANDY`s unique locomotion prediction can improve routing performance in advanced mobility scenarios. LANDY being a localized routing protocol will reduce the control overhead. In addition, the approach of using locomotion prediction has the advantage of fast and accurate routing over other position based routing algorithms in mobile scenarios. Recovery with LANDY is much faster than with other location protocols which use mainly greedy algorithms, (such as GPRS), no signaling or configuration of the intermediate nodes is required after a failure. The key difference is that it allows sharing of locomotion and velocity information among the nodes through LT. A node may also be both an end node (Source or/ and destination) , in this case it will switch to recovery mode until it finds a neighbour, and after the connection is recovered, the configuration is fixed preventing possible reconfiguration and signal collision in the event of additional failures. The outcome of the simulation results illustrate that LANDY`s performance is better compared to other major position based routing protocols.

This paper is organized as follows. In section 2 a brief description of related works and approaches in this field. In section 3 the proposed routing algorithm is fully described. In section 4 details of the simulation and results are given. In section 5 the conclusion and future works are discussed.

2. Related Work

In this section existing approaches in MANET will be reviewed:

Proactive or table driven routing algorithms (connection oriented algorithm): in this type of algorithm the routing table is periodically updated via message broadcasting among all MNs. The advantage of this type of algorithm is that data packet broadcast is efficient because an end to end route is always available; and the disadvantage is the high overhead in maintaining routing table and waste of network bandwidth [1, 4, 10].

Reactive or on demand routing algorithms (connection oriented algorithm): in this type of algorithm the route is only established before data packet transmission. The advantage of this type of algorithm is message broadcast occurs only on route discovery to prevent broadcast storm; and the disadvantage is the end to end delay caused by the route maintenance which is higher than the proactive algorithm [1, 2, 4].

Hybrid schemes (connection oriented algorithm): this type of algorithm tries to include the advantages of the proactive and reactive algorithms; however it also includes the disadvantages of both algorithms, which is the control overhead and the end to end delay [1, 2, 7].

Position based algorithms (connectionless algorithm): this type of algorithm overcomes the problem related to the maintenance of the routing table in connection oriented algorithms [5, 6, 8], where the performance degrades quickly when there is an increase in the number of MNs or the speed (dynamic changing). Although a connectionless algorithm has no route manipulation for data transmission, it still encounters three problems. A) Broadcast storm under high node density. B) Local maximum problem under low node density. C) the geographically constrained broadcast of a service discovery message.

Location information is popularly used for forwarding data packet in connectionless algorithms. For example Location Aided Routing (LAR) algorithm proposed by Ko and Vaidya (1998). LAR only uses geographical information for route discovery. It is based on an on-demand protocol. LAR is based on two zones: expected and request zones [5]. Expected zone is the possible area that may include the destination MN. Request zone is the minimal rectangle containing the source MN and the expected zone. If within the requested zone, the data packet will be forwarded. The disadvantage of LAR protocol, is that it may behave in a similar way to flooding protocols (e.g., DSR and AODV) in high mobility networks.

DREAM (distance Routing Effect Algorithm for Mobility) proposed by Basagni et al. (1988) is a combination of position based routing algorithm and table driven. It improves the performance of LAR by changing the rectangular request zone as a cone from the source MN toward to the expected zone of the destination MN. The main disadvantages of such algorithms, are that this method induces a delay during each transmission.

GPSR (Greedy Perimeter Stateless Routing) proposed by Karp and Kung (2000) is also a position based routing algorithm. GPSR makes greedy forwarding decisions using only information about the position of immediate neighbours in the network topology. Packets are forwarded to the next-hop node which moves the packet the most “toward” the position of the destination. By keeping only local topology information, GPSR scales better than topology based routing as the number of network destinations increases. If the packet reaches a region where greedy forwarding is impossible, the algorithm enters into recovery mode by routing around the perimeter of the region [1,4,8,19]. The GPSR protocol is a routing protocol that is often used to establish routes in MANET or sensor networks. However, for it to operate effectively , it is a requirement that all MNs assist each other. However, such a process would be unlikely to perform efficiently in MANET. The disadvantages of GPSR is the control overhead and slow recovery process.

Greedy-Face-Greedy (GFG) proposed by Bose et al (2002). To handle situations where greedy forwarding fail. It routes packet around voids when concave nodes receive packets. GRG do not require nodes to memorize path/traffic and guarantee to find a path to the destination. The disadvantage is the increased overall complexity.

Also, CAM (Connectionless Approach for MANET) is a position based approach proposed by Ho et al (2004, 2006). CAM divides the network region into virtual cells. A virtual cells path can be generated easily according to the location of the source and the destination MNs. Each node uses the location information obtained by using technology such as the Global Positioning System (GPS). when a MN receives a data packet; it forwards the data packet if it is located within the virtual cells path of the data packet. Its disadvantage is the high overhead on maintaining routing table and the waste of bandwidth.

Geographic Routing protocol (GRP) is a proactive routing protocol [6, 11, 18]. Routing in GRP is based on the shortest geographical distance between source and destination. Each node within a geographical area uses GPS to identify its own position. GRP uses quadrants (neighbourhoods) to optimise flooding, it initiates network wide flooding to identify all nodes in the network [6, 12]. The disadvantage is heavy control overhead when there are RREP.

Geocast Ad hoc On-Demand Distance Vector (GeoAODV) is a modified version of ADOV. It uses GPS to keep track and distribute known node coordinates in the network. The RREQ message in GeoADOV carries additional information which contains the source, destination node coordinates and the flooding angle. The flooding angle identifies the search region, which the route discovery process takes place inside. [6, 9, 12]. Its disadvantage is that the packet header size grows in line with journey length, due to the flooding of message broadcasting from MNs in the Network.

Fang et al.[15] give a distributed algorithm to locate stuck nodes (local minimum). After locating stuck nodes, they present a distributed algorithm to find out holes in sensor networks, by memorizing the shape of the holes in the network. Fang et al. does not require planarisiation of the network topology and can achieve shorter path lengths. However , in large networks , the Control overhead and memory increase rapidly which make it not an effective routing protocol for MANET.

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Position and Neighborhood Based Routing (PNR) proposed by Hossein Ashtiani(2009), In PNR all MNs start a full flooding all over the network. Taking into consideration the network size, initial floods sent out by each node can be adjusted. A node maintains its list of neighbour nodes by periodically broadcasting Hello messages. By specifying a time period named as "Neighbour Expiry time", if a node does not receive Hello message from a neighbour node for a period exceeding "Neighbour Expiry time", it assumes the link is lost. Each node can determine its own position using a GPS.
Disadvantages, such as heavy control overhead and Local maximum problem under low number of MNs, make PNR not an efficient method for MANET.

3. Proposed Routing algorithm

3.1. Overview

The position based routing algorithm has two advantages over the topology based routing algorithm; first, the routing algorithm does not require route establishment or maintenance. Second, the geographical information is distributed only in the local region. While the position based routing protocols (e.g. GPSR) eliminate some of the limitations of the topology based routing protocols by using geographical information to make decisions about routing packets, they don't take into account the locomotion of the nodes. The mobility characteristic has an impact on MANETS routing performance.
LANDY will use locomotion information and the velocity of MNs, to route packets. It is assumed that nodes will have access to a position service. Obtaining location information from the position service, LANDY will employ a forwarding strategy to route packets between MNs. If routing problems occur with the forwarding strategy, the algorithm will include a recovery mode which will operate when the protocol recognizes that this problem has occurred. In the recovery mode, the protocol navigates the planar graph to the desired destination.

3.2. Network Initialization and Process Analysis

It is assumed that the routing area is a two dimensional plane. The entire network is divided into several non overlapping triangular cells, and each cell has CCID (Cell Code Identifier). The proposed algorithm allows each mobile node (MN) to determine the cell where it resides during the life of the network, based on the information provided by LT (Locomotion table) and the GPS device equipped with each node. Let n is the number of mobile nodes in the region and N i is the scale of the mobile node, Sj number of neighbuor mobile nodes to the source node S, where $Ni < n(CCID)$.
k is the existing number of mobile nodes in the request region (CCID) at time t0 and k' ($=k+\Delta k$) is the number of mobile nodes in that region at time t1, where $k<=n($ CCID), Δk can be either positive or negative. uv is the number of edges in the given network RNG (Relative Neighbour Graph), uv' ($<=uv$) is the number of edges in the request region, bp is the number of Backtrack Packets received by the node S and l is the length of the path (in hops) from the source node S to the destination node D. The network layer interacts with the MAC layer to estimate the bandwidth and taking consideration of the activities of neighbouring nodes, which makes LANDY more practical.

3.3. Locomotion predication of Mobile Nodes

Most MANET geographical protocols (position based) utilise the current position of the node, the neighbours and the destination to determine the packet's forwarding node. The position of the transmitting node is received from the position service. The positions of the neighbours are distributed by an intermodal mechanism such as HELLO message broadcasting. The destination position is learned by the location service, and may take time to update.
However, the position information of neighbours and destinations will not be accurate after some time, and this may result in routing loop or routing failure. With three samples of node position, it can estimate speed and direction and use this derived information to predict the locomotion in the near future of the mobile node. The forwarding decisions are made based upon the locomotion of the mobile node, the neighbour nodes and the destinations and it can be shown that mobility characteristics will affect MANETs.
On the other hand, the approach of using locomotion prediction has the advantage of fast and accurate routing over other position based routing algorithms in mobile scenarios. Figure 1 illustrates the locomotion prediction of the LANDY protocol. The source node (S) intends to send a data packet to the destination node (D). There are six one-hop neighbour

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nodes, a, b, c, d, e, f within the radio range of the source node. A HELLO message broadcasting mechanism makes all nodes aware of their neighbours' locomotion information. Each mobile node periodically broadcasts a HELLO message to its one-hop neighbours, with its Cell unique code Identifier (CCID), Mobile Node unique code Identifier (MCID) and locomotion component (LC). Each mobile node updates its locomotion table (LT) of neighbours when it receives a HELLO message. Based on the LT, the source is able to estimate the locomotion of the neighbours (the future position of its neighbours as a", b", c", d", e", f"). The source selects the neighbour as the next hop, such that the future position of the next hop is closer to the estimated future position of the destination (D"). In Figure 1, the next hop of the source node is node c" and backup route will be b".

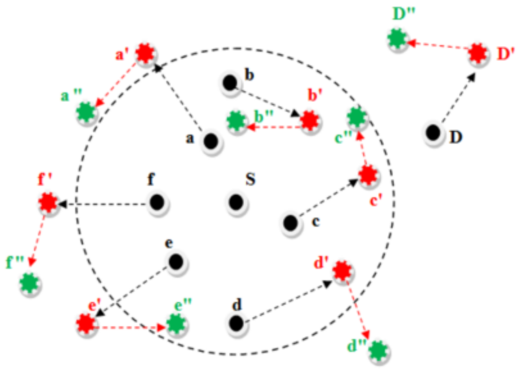

Figure 1. LANDY locomotion predication

3.4. Communication Process and Location calculation between two active Mobile Nodes

The MN at the route request stage will send at least query packets, but the backtrack packets process might have an impact which result in sending more than Q number of query packets. Therefore the communication packet overhead for the searching stage is Q(uv'+bp). This query number depends on the locomotion of mobile nodes. The route reply stage will send acknowledgements with the chosen path of length l. Therefore in normal circumstances, i.e. if there are no dynamic transformation in the network layout between route request and reply stages , the Packet overhead for the reply stage is Q(l) or Q(n). Therefore the packet overhead for LANDY algorithm is Q(uv'+n(CCID)+bp) = Q(uv'+bp).

Communication between two active nodes can be initiated as follows:

A) Two MNs moving in their particular self-directed modes come within the range of each other and start communication.

B) A mobile node becomes active at any given time at a random place and it happens to be in the range of communication of another mobile node .

These initial conditions of active communication, will have an impact on the calculation of the link/path metrics of the mobile ad hoc network. The key factor in the mobility model that is inherent for each mobile node of the MANET, plays the key role in controlling the performance metrics including link/path metrics. Two nodes are neighbours if their intermediate distance is less or equal to their transmission range. We assume that all nodes maintain the same radio range, and data rate is constant throughout the network. The distance between two nodes(x1, y1) and (x0, y0) can be derived from equation (1).

$$d = \sqrt{(x1 - x0)^2 + (y1 - y0)^2} \qquad (1)$$

In LANDY, it is important to know when the link is disconnected with surrounding nodes, for calculating node mobility. Each node can find its location information using GPS, so that it can calculate the node mobility using equations (2) and (3).

$$x1 = x0 + (v \times (\cos\theta)) \qquad (2)$$

$$y1 = y0 + (v \times (\sin\theta)) \qquad (3)$$

A node`s velocity is in sec unit, and its next location can be calculated. For calculating the next location, it uses current location p0(x0, y0), Velocity v, Direction Value θ, and circular functions formula to derive the next location p1(x1, y1).

After calculating the next location; its current location, next location and transmission range are added into LT and delivered to the surrounding nodes.

3.5. Node distribution and Neighbours discovery

LANDY localizes routing information distribution in the one-hop range. Thus LANDY will reduce the control overhead, simplify routing computation and save memory storage.

Each MN in the network needs to maintain the local status of its MNs neighbours only. For each connection a MN gets order of Ni query packets. The number of neighbour mobile nodes (Ni) may increase or decrease based on the movement of mobile nodes within the local region . Therefore the distribution of the Mobile nodes with in a region for the network state is S(n) in the worst case scenario.

In LANDY, the mobile node updates its LC through position service (e.g. GPS) periodically. The mobile node broadcasts its MCID, CCID and LC in a HELLO message periodically. Data packets are marked with the LC of the sender and the destination, so that the receiving nodes are able to update the neighbour's locomotion information upon receiving the data packet. The mobile node does not flood the HELLO message. Thus the LANDY routing protocol reduces the control overhead and simplifies the routing computation.

The HELLO message broadcasting mechanism makes all nodes aware of their neighbours' locomotion information. Each mobile node periodically broadcasts a HELLO message to its one-hop neighbours, with its MCID, CCID and LC. The HELLO message inter-arrival time is jittered with a uniform distribution to avoid synchronization of neighbours' HELLO messages that could result in conflict. Each mobile node updates its LT of neighbours when it receives a HELLO message. The LT associates an expiration value with each entry. If the node does not receive a HELLO message from a neighbour within the expiration time, it removes the neighbour from the table. Based on the LT, the source is able to estimate the future position of its neighbours. Figure 1 illustrates the one-hop broadcasting of the LANDY protocol. At time t, the mobile node a broadcasts a HELLO message, encapsulating the LC in the message. The mobile nodes S, a, c are b's one-hop neighbours. Upon receiving the HELLO message from node b, the receiving node updates LT of neighbour's locomotion information. Since the inter-arrival time of HELLO message t_i is jittered with a uniform distribution, each node has a different inter-arrival time of HELLO message. At time $t+t_i$, node a broadcasts a new HELLO message with updated LC. The mobile node S, c receive the new HELLO message and updates the LT. Upon not receiving a HELLO message from a neighbour for a long time (t2), the mobile node assumes that the link to the neighbour is broken and removes the neighbour form the LT. Besides the one-hop HELLO message broadcasting, the MNs will send out the LC in the data packets. The data packet LC transmission provides an alternative to the locomotion distribution. It is helpful in a dense mobile network with heavy traffic load. The mobility of the node at time t2 is calculated using equation (4).

$$M = \frac{1}{(t2 - t1)}\sqrt{(x1 - x0)^2 + (y1 - y0)^2} \qquad (4)$$

3.6. Forwarding protocol

The mobile node distributes the locomotion information through one-hop HELLO message broadcasting. Upon receiving the LT from the HELLO message and the data packet, the mobile node updates the LT. The node will be able to send out a data packet, receive a data packet and forward the packet, if it is not the destination. The node will choose a one-hop neighbour as the next hop, (forwarding node) such that the next hop is closer to the destination in the near future. The packet is forwarded to the next hop. Upon receiving the packet, the receiving node will establish the next hop, based on the same mechanism. This forwarding process is repeated until the destination is reached. In some situations the backup path will be utilised if the primary path is not available using the back track process, nodes can trackback for alternative routes just for three previous nodes. If the packet is in a local maximum problem, then the node will start a recovery process, to navigate the planar graph to the destination. There are three types of packet operations in LANDY:

- HELLO
- Packet sending - Figure 2
- Packet Receiving and Forwarding - Figure 3

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3.7. Locomotion components

There are two types of packets in LANDY: (1) HELLO message packet; (2) data packets. The content of the HELLO message is LC of the transmitting node. The MNs distribute the locomotion information through LC as shown on Table 1. Upon receiving the LC of the neighbours, the mobile node is able to construct the LT and route the packet.

Table 1. locomotion components format

	Description
CCID	Cell unique code Identifier
MCID	Mobile Node unique code Identifier
P1	Position of first sample
P2	Position of second sample
P3	Position of third sample
T1	Time stamp of first sample
T2	Time stamp of second sample
T3	Time stamp of third sample
Θ	Moving direction
V	velocity

```
Algorithm 1: Packet Sending (LC, LT, Future_dst)

Constant: Radio_Range
Data: LC, LT, Packet_Queue, Query Location Service Queue (QLSQ), Next_Hop, Distance,
CANDIDATE (CAND), Destination (dst).
Result: Future_dst
begin
  While (Packet_Queue! =Ø);
    If ((dst_LC = Look_up (dst, LT) ==Ø))
          Insert (dst, QLSQ);
      If ((d == distance <= Radio_Range)
          Insert (LC, MCID, CCID);
      Else
          Set mode to GREEDY; Set NEXT_HOP to self;
        Foreach Neighbour
          HOP_CAND = Look_up (LT);
          If (Future_dst (HOP_CAND) < Future_dst(NEXT_HOP))
            NEXT_HOP = HOP_CAND;
          end
          If (NEXT_HOP == self);
            Set mode to RECOVERY; Construct (RNG);
            NEXT_HOP = Traverse (RNG, RHR);
          end
        end
      end
    end
  end
end
```

Figure 2. The pseudo code of packet sending.

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```
Algorithm 2: Packet Receiving and Forwarding (LC, LT)

Constant: Radio_Range
Data: LC, LT, Packet_Queue, Query Location Service Queue (QLSQ) , Next_Hop, Distance, CANDIDATE (CAND),
Destination (dst).
Result: Future_dst
begin
  While (Packet_Forward_Queue != Ø) {
   If (mode == GREEDY) {
     If ((dst_LC = Look_up (dst, LT) == Ø))
          Insert (dst, QLSQ);
       If { ((d == distance <= Radio_Range)
              Insert (LC, MCID, CCID); }
       Else {
              Set NEXT_HOP to self;
           Foreach Neighbour {
                  HOP_ CAND = Look_up(LT);
              If (Future_dst (HOP_CAND) < Future_dst(NEXT_HOP))
                  NEXT_HOP = HOP_CAND;
              end
              If (NEXT_HOP == self){
                  Set mode to RECOVERY; Construct (RNG);
                  NEXT_HOP = Traverse (RNG, RHR);
              end
           end
       end
     end
     If (mode == RECOVERY) {
       If ((dst_LC = Look_up (dst, LT) == Ø))
            Insert (dst, QLSQ);
         If (RECOVER (packet) == TRUE){ Set mode to GREEDY;
            Foreach Neighbour {
                 HOP_ CAND = Look_up (LT);
               If (Future_dst (HOP_ CAND) < Future_dst(NEXT_HOP))
                 NEXT_HOP = HOP_ CAND;
               end
            end
         Else {
              Set mode to RECOVERY; Construct (RNG);
              NEXT_HOP = Traverse (RNG, RHR);
         end
       end
     end
   end
  end
end
```

Figure 3. pseudo code of packet receiving and forwarding.

3.8. The data packet header

The data packet consists of a data packet header and the data payload. LANDY data packet header is a modified version of the GPSR packet header. The data packet header provides:

(1) LC distribution.

(2) Information in the recovery mode.

Two types of packet mode are defined in LANDY: forwarding mode and recovery mode. The forwarding mode is the mode in which the packet is forwarded by LANDY forwarding algorithm. The recovery mode is the mode in which the packet enters into a local maximum problem and traverses the planar graph to the destination.

3.9. Backtracking Concept and Time intricacy

LANDY Backtracking Concept On blocked routes; packets can backtrack to the previous node (up to three previous nodes) to get rerouted along a different valid path. Nodes that receive the backtrack packet calculate the next closest neighbour node to the destination and send it along the new path. If no alternate route is available, then the packet is in a local maximum. Then the MN will start the inherent recovery mechanism, to navigate the planar graph to the destination.

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If a MN gets a query packet and this is checked against the queue packets stored in the LT, whose size is of order bp and LC (locomotion components) for a local region, to check whether the arrived query packet contains a loop or not. Each MN gets set of Ni query packets. Therefore the time intricacy of processing query packets is tq (LT.Ni). If a node gets a backtrack packet, then it will send another query on that link, if one exists. Therefore the time intricacy is tq (LT.Ni+LT), which is equal to tq (LT.Ni) in the local region which CCID is known.

3.10.Failure detection and recovery process

The failure detection recovery initiation process is simple: Active nodes monitor their signal quality and defined bandwidth threshold. For simplicity, it is assumed a bidirectional connection, which allows the node to initiate the recovery as soon as it detects a failure.

LANDY employs perimeter routing as a recovery mechanism, such as used in GPSR [3, 5]. The perimeter routing is a graph with no intersecting edges. The Relative Neighbour Graph (RNG) has been used in Landy`s recovery algorithm which can be defined as a graph in which an edge (u, v) exists between vertices u and v if the distance ||uv|| is less than or equal to the distance between every other vertex w.

There are two modes of packet forwarding in LANDY: forwarding mode and recovery mode. A packet enters the recovery mode when the protocol determines that it has arrived at a local maximum. It returns to greedy mode when it reaches a node with an estimated location closer to the destination, than the node where the packet entered the perimeter mode. To support both forwarding mode and recovery mode, a mobile node will construct the RNG of neighbours when it enters recovery mode, as well as update the LT when it receives HELLO packets.

Upon receiving a forwarding mode packet for forwarding, a mobile node searches its LT for the neighbour closest to the packet's destination in the near future. If this neighbour is closer to the destination than the mobile node itself, the node selects the neighbour as the next hop of the packet and forwards the packet to the next hop. When no neighbour is closer, the node marks the packet into the recovery mode. LANDY forwards the packet on progressively closer faces of the planar graph RNG to the destination, using the right-hand rule.

When a packet enters the recovery mode, LANDY records the position where the packet enters the recovery mode. It is used for the downstream hops to determine whether to recover from the recovery mode. At the first traverse of recovery mode, the mobile node forwards the packet to the adjacent edge based on the right-hand rule. When LANDY forwards a packet onto a new face, it records the position on line SD (S is the source where the packet enters the recovery mode and D is the destination) shared between the previous and new faces, and the first edge on the traversed face, in the packet header.

Upon receiving a recovery mode packet, LANDY first determines whether it is the packet's destination. If so, LANDY passes the Packet Data Payload (PDU) to the higher layer. If it is not the packet destination, LANDY then determines whether the packet can be recovered from the recovery mode.

LANDY compares its LC and the position where the packet entered into the recovery mode. If the distance from the node to the destination in the near future is less than the distance from the recovery entering position to the destination, LANDY returns the packet mode back to the forwarding mode. Otherwise, the node traverses the planar graph. LANDY forwards the packet along the face intersected by the line SD (S is the source where the packet enters the recovery mode, D is the destination node) using the right-hand rule. When the destination is not reachable (i.e., it is disconnected from the graph), LANDY will traverse the disconnected face entirely and enter the first edge of that face twice.

LANDY determines that it is a disconnected face, and drops the packet to the disconnected destination. This will prevent the packet routing loop.

The recovery process repeats at successively closer faces to the destination. Eventually, the face containing the destination is reached, as long as the planar graph is connected. Recovery with LANDY is much faster than with other location protocols which use mainly greedy algorithms , (such as GPRS), no signaling or configuration of the intermediate nodes is required after a failure.

The key difference is that it allows sharing of locomotion and velocity information among the nodes through LT. A node may also be both an end node (Source or/ and destination) , in this case it will switch to recovery mode until it finds a neighbour, and after the connection is recovered, the configuration is fixed preventing possible reconfiguration and signal collision in the event of additional failures.

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4. Simulation parameters, Setup and Results

There are different kinds of parameters for performance evaluation of routing protocols in MANET. These parameters have different impact on overall network performance. five important parameters will be evaluated in this research for overall network performance. These parameters are delay, control over head, throughput , average route length and delivery ratio, for protocol performance evaluation. When evaluating the performance of routing protocols in MANET, it is important to be checked against certain parameters for their performance.

➢ Delay

The end-to-end delay of packet is the time of generation of a packet by the source node up to the destination node. So this is the time that a packet takes to go across the network. This time is expressed in seconds. Therefore, all the delays in the network are called packet end-to-end delay, like buffer queues and transmission time.

The File transfer protocol (FTP) is tolerant to a certain level of delays. There are different kinds of activities, which increase network delay. Packet end-to-end delay is a measure of how well a routing protocol adapts to the various constraints in the network, to give reliability. There are several kinds of delays: processing delay , queuing delay , transmission delay and propagation delay. The queuing delay is not included. End-to-end delay can be represented mathematically in equation (5).

$$d_{end-end} = N[d_{trans} + d_{prop} + d_{proc}] \qquad (5)$$

Where

$d_{end-end}$ = end-to-end delay

d_{trans} = Transmission delay

d_{proc} = Propagating delay

d_{prop} = Processing delay

Assuming there are n number of nodes in the network, then the total delay can be calculated by taking the average of all the packets, source destination pairs and network configuration.

➢ Throughput

Throughput is defined as; the ratio of total data that reaches destination node from the source node. The time it takes the destination node to receive the last message, is called throughput [11]. Throughput is expressed as bytes or bits per sec (byte/sec or bit/sec). Some factors impact the throughput: if there are many topological changes in the network layout, unreliable communication between MNs, limited bandwidth availability and limited energy [11]. Throughput can be represented mathematically in equation (6).

$$Throughput = \frac{Number\ of\ deliverd\ packet * Packet\ size * 8}{Total\ duration\ of\ simulation} \qquad (6)$$

➢ Control overhead

The Control Overhead consists of HELLO messages and LC messages. due to the broadcast nature of the control message delivery, the packets are measured by summing up the size of all the control packets received by each mobile node during the whole simulation period. in addition, a large byte overhead would mean a larger wasted bandwidth. Many small control information packets, would mean that the radio medium on which packets are sent, is acquired more frequently. This would impact massively on the performance , power and network utilization.

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➢ Average route length

The average route length is the average route length of all successfully delivered data packet.

➢ Delivery ratio

The delivery ratio is the ratio of the number of successfully delivered data packets to the number of total data packets. It is the metric of the data transmission reliability.

The MAC layer protocol is IEEE 802.11 DCF CSMA/CA. The data rate is 2 mbps. The network protocol is IP, Figure 4. The transmission range is 300 m. The free -space- path -loss model is used in the simulations to determine the transmitter power. The path loss (in dB) can be determined via equation (7) [14].

$$FSPL = 20\log_{10}(d) + 20\log_{10}(f) + 32.45 \quad (7)$$

Where FSPL is the pathloss (in dB), d is the distance (in meters) and f is the frequency (in GHz).

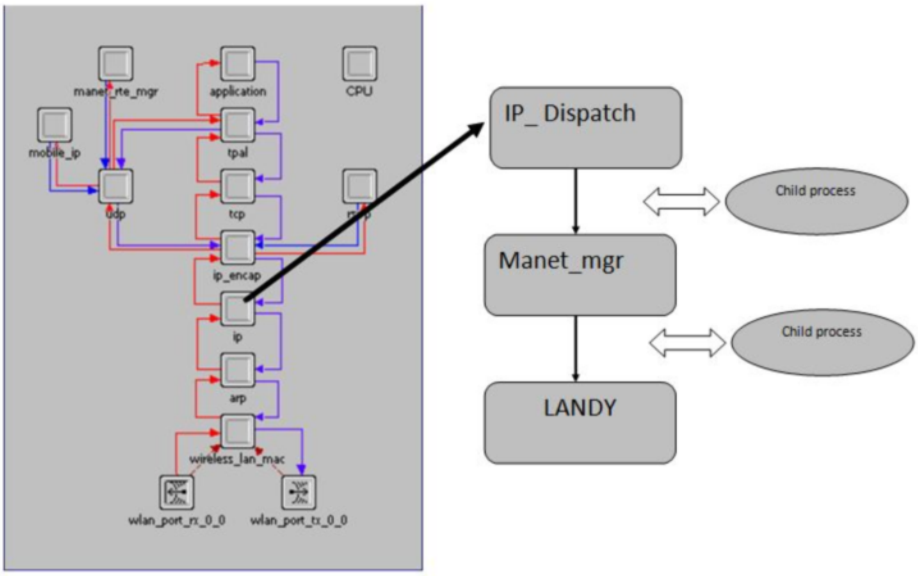

Figure 4. Model Architecture

The traffic destination is a random node. We randomly select 8 nodes to generate traffic packets in the simulations. The traffic application is a traffic generator. This traffic generator starts at 10 seconds during simulation. The packet inter-arrival time is exponentially distributed with mean value of 10 seconds.
Simulations were implemented using OPNET v14.5. Random Waypoint mobility model is used in running the simulations. The Random Waypoint mobility model is the most used mobility model in evaluating the performance of MANET protocols. The LANDY protocol is implemented in the OPNET as a process model in wireless mobile nodes. The LANDY process model can be represented in a State Transition Diagram (STD). Mobile node models were constructed that included OPNET standard IEEE 802.11 physical and MAC layers, as well as custom build process models to implement the LANDY protocol. Figure 5. The scenarios simulate the MANET nodes moving in a 2-D mobility region, and in this implementation the height dimension is omitted. The Random Waypoint mobility model is used to govern the movement of the nodes. In this model a mobile node will select a destination randomly and move towards it with a random velocity uniformly distributed in the interval [Vmin, Vmax]. Once the node has arrived at the destination it waits for a period (pause time) and then repeats the

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moving process. Two simulations were designed to evaluate the performance of LANDY. 50 nodes in the first ,and 100 nodes in the second scenario.

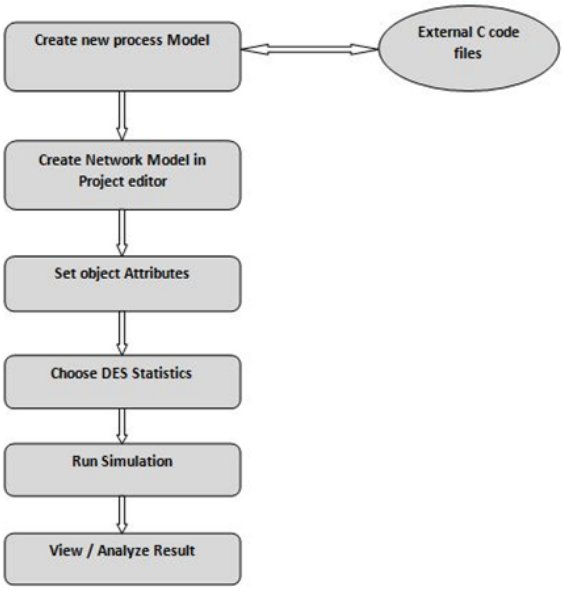

Figure 5. Process flow for simulations

Each mobile node has a nominal 300m radio transmission range with a free space path loss model. The nodes are initially distributed randomly in the simulation region. The maximum speed of the random waypoint model is set to 30 m/s. Each CBR flow sends traffic to a random destination. This dense network topology with a high mobility motion with a maximum speed of 30 m/s provides high mobility scenarios. Each scenario performs six simulation runs with different random seeds and the mean of the metrics are compared. In our simulation, we start MANET routing protocol after a specific random movement time, which is the simple solution to avoid the initialization problem. The common parameter setting of the simulation is shown in table 3 [23].

Table 3. Simulation Parameters

Parameters	Value	
Number of Nodes	50	100
Simulation Area	1500m X 300m	1800m X 300m
Nods Density	1 node / 9000 m2	1 node / 9000 m2
transmission range	300m	300m
simulation period in seconds	900 sec	900 sec
Maximum Speed	30 m/s	30 m/s
pause times	0, 30, 60, 90, 120	0, 30, 60, 90, 120
Traffic Flow	30 CBR flows	30 CBR flows

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- ## Simulation Results – End-to-end Delay

In end -to-end delay scenario, it should exhibit a lower performance when the number of nodes are under 50, because alternative longer routes might be selected instead of the shortest path. The end-to-end delay is lower in the case where more than two alternative routes can be selected or many alternative routes Figure 6 and Figure 7 show the end-to-end delay of LANDY and GPSR. The error bars indicate 95% confidence intervals. We do not compare LANDY and GPSR with DSR in this metric, because DSR has route request and route maintenance period; while the position based routing protocols LANDY and GPSR don't have the route request and route maintenance. Since LANDY searches the mobile node's future position instead of current position, it searches the path from the source to the destination faster than GPSR. Thus, the end-to-end delay of LANDY is lower than GPSR.

The end-to-end delay time is dramatically affected when network pace is at a slow rate. Because of little or no mobility of nodes, error occurs in the entire path and so there is a strong probability that it searches paths consisting of the same nodes. In this case, it cannot be effective even if it selects a path taking mobility in to consideration. Moreover, LANDY is most likely to have a larger number of nodes between source and destination node than GPSR. Therefore, more nodes can participate in communication.

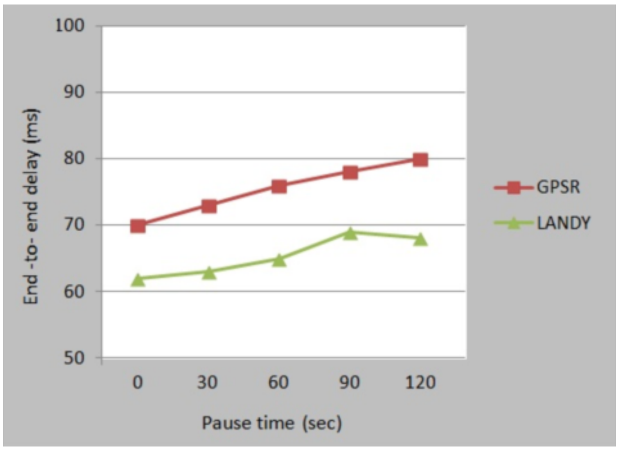

Figure 6. End-to-end delay for 50 nodes RW

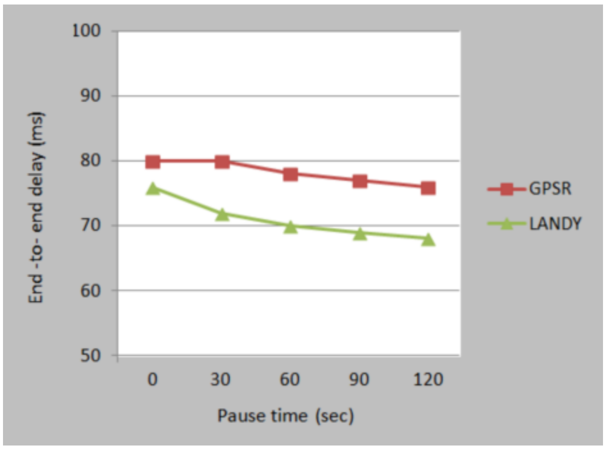

Figure 7. End-to-end delay for 100 nodes RW

- ## Simulation Results - Throughput

Throughput: the rate of packet throughput increases gradually according to the increasing number of nodes in all protocols (DSR, GPSR and LANDY). As shown in Figure 8, there are a few differences between LANDY and GPSR in section of pause time between 0 – 20 sec, but large differences in section 60 – 120 sec pause time. LANDY successfully increased the rate of packet throughput as high as 19%.

The reason why it is not a large performance improvement, is that the numbers of alternative routes are limited in the network which comprises of a few nodes. Because the numbers of nodes are small and nodes are of wide distribution, the numbers of routes are limited though a node searches for multiple routes. Also, the performance improvement is not large, but the performance improvement makes a distinct appearance when the pause time is more than 60 sec.

By observing the packet throughput , Figure 9. The more a node moves, the more nodes that consist of a link are changed, and link error can be generated frequently. Therefore, LANDY packet processing ratio improves upon DSR and GPSR, in setting the shortest path. DSR packet ratio is lower as due to link errors increasing as a result of faster node movement. But in LANDY, packet throughput is decreased little, when the Maximum velocity of nodes is 30 m/sec. The efficiency is 3%. This is logical, because large packet drops will of course produce lower throughput.

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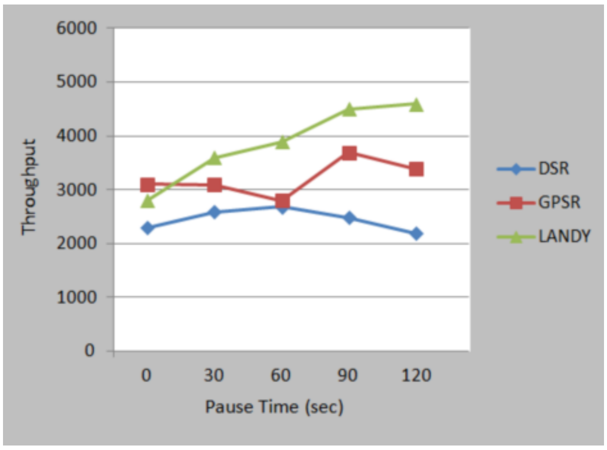

Figure 8. Throughput for 50 nodes RW

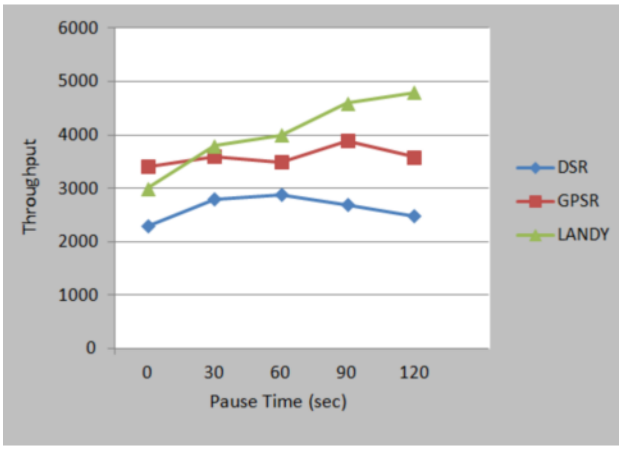

Figure 9. Throughput for 100 nodes RW

- ## Simulation Results - Control overhead

Control overhead can be determined by quantifying the effect per packet and number of path searches. Figure 10 and Figure 11 show the results for routing control overhead, in the 50- node and 100-node Random Waypoint scenarios, respectively. The error bars indicate 95% confidence intervals. Because LANDY and GPSR, broadcast routing protocol packets proactively in a nearly constant interval. The control overheads of LANDY and GPSR are nearly constant, and are very close in both 50-node and 100-node scenarios. DSR has a large number of routing control messages due to the topology changes. It is important to note that the location service will increase the routing control overhead. In contrast, LANDY has less overhead than DSR and GPSR.

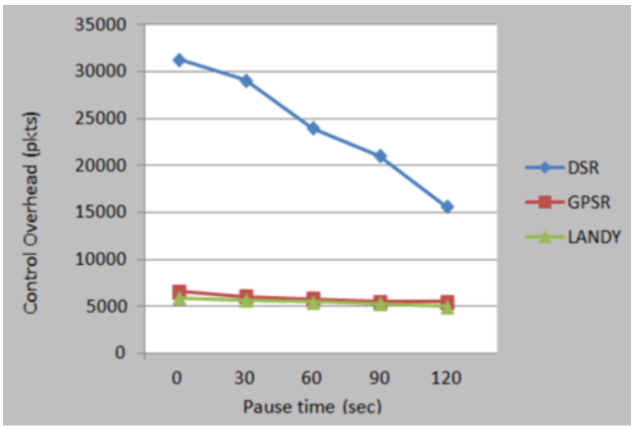

Figure 10. Control Overhead with 50-node RW

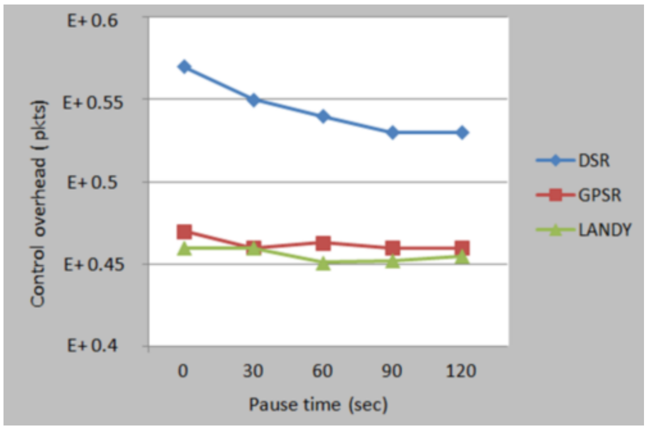

Figure 11. Control Overhead with 100-node RW

- ## Simulation Results - Average Route Length

The Average route length results are shown in Figure 12 and Figure 13 for LANDY, GPSR and DSR in 50-node and 100-node Random Waypoint scenarios. The error bars indicate 95% confidence intervals. The average route length of LANDY and GPSR are shorter than DSR. Since the packet delivery ratio of LANDY is higher than GPSR, the probability of longer route length is higher than GPSR. As a result, the average route length of LANDY is higher than GPSR .

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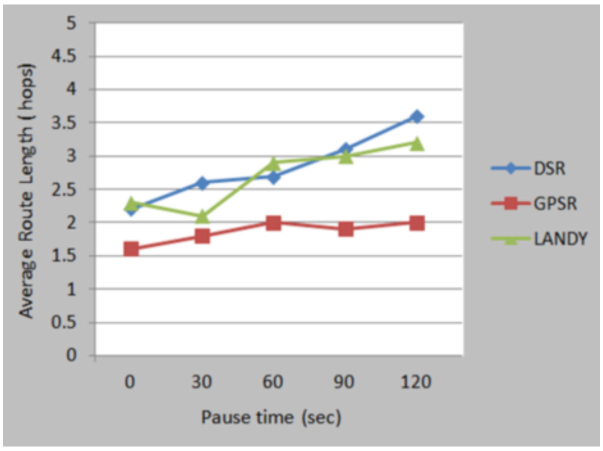

Figure 12. Average route length with 50-node RW

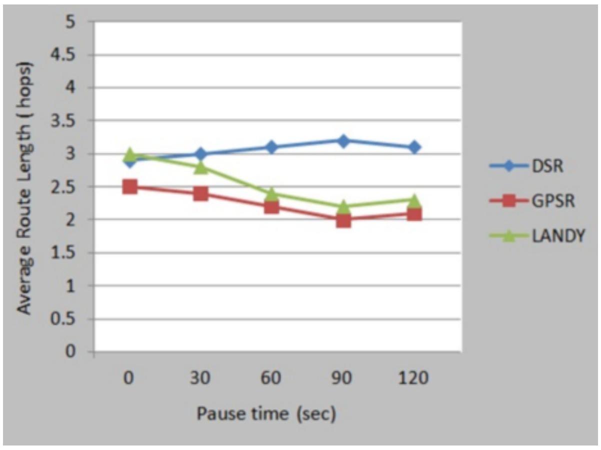

Figure 13. Average route length with 100-node RW

- ### Simulation Results - Delivery ratio

The Delivery ratio results are shown in Figure 14 and Figure 15 for LANDY, GPSR and DSR as a function of pause time in the 50-node and 100-node Random Waypoint scenarios, respectively. The error bars indicate 95% confidence intervals. We do not count the packets lost due to disconnected destinations, as a delivery failure. All three algorithms deliver over 97% packets successfully, in the 50-node scenario. The delivery ratio of LANDY and GPSR are over 96% in the 100-node scenario, while DSR delivers approximately 89% packets in the 100-node scenario. The delivery ratio of LANDY is higher than GPSR and DSR in both 50-node and 100-node network topologies. The delivery ratio of LANDY remains high at all pause times.

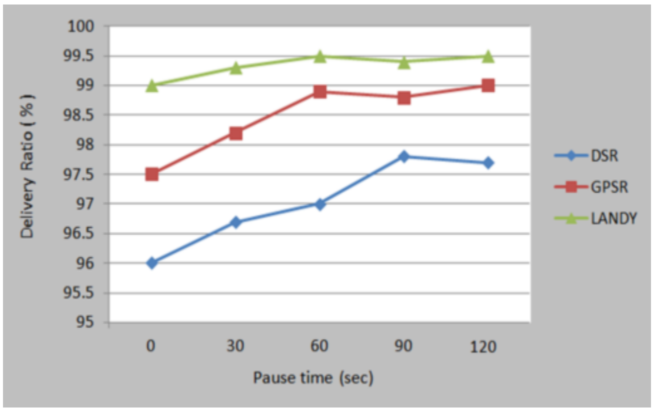

Figure 14. Delivery Ratio with 50-node RW

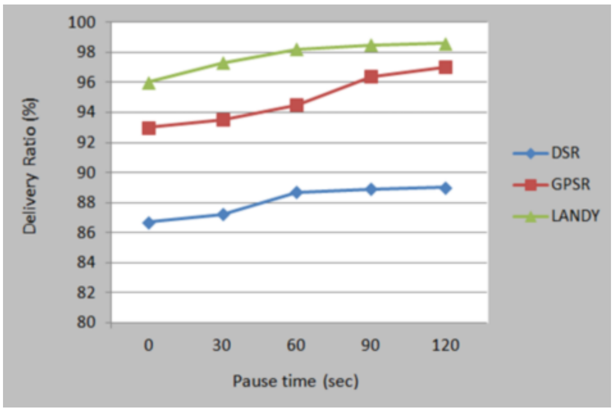

Figure 15. Delivery Ratio with 100-node RW

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5. Conclusion and Future work

Protocols that have link layer support for link breakage detection, are much more stable. The percentage of packets received using LANDY is almost constant at 82% even when mobility increases. This result indicates that these kinds of protocols will be desired for high mobility networks. DSR and GPSR are dependent on periodic broadcast which show a rather poor result, only 50 % of the packets are received when mobility is increased.

The performance of the protocols differs slightly during different network loads. The most apparent difference is the byte overhead. While LANDY has a rather unaffected overhead, it increases for DSR and GPSR during high loads. A higher sending rate causes the protocol to detect broken links faster, thus reacting faster; this leads to a slight increase in control packets, which affects the byte overhead. The increased send rate also sets demands on the send buffer of the routing protocol. Congestion occurs and packets are dropped. The faster a routing protocol can find a route, the less time the packets have to spend in buffers, meaning a smaller probability of packet drops.

In this paper, it is demonstrated through the simulations that the proposed lightweight routing protocol (LANDY) performed well under diverse situations and outperforms GPSR and DSR in both scenarios. One of the main advantages of LANDY is using Locomotion instead of current position to find the mobile node's Locomotion trajectory to predict the future position of mobile nodes. It reduces the impact of the inaccuracy of neighbours' positions on the routing performance, provides a shorter routing and avoids routing loop or routing failure. Another advantage is using only local Locomotion to determine a packet's next hop. This increases the scalability of the routing protocol.

While we have shown Landy protocol reduces the control overhead and improves routing performance in several types of sophisticated mobility scenarios, Landy can be enhanced with more features. In this research, we assume the position service is available. It is desired to integrate position service into Landy. Thus, Landy can be implemented in the live mobile node more easily. Landy can be extended to the 3D space in order to support seamless and real-time communications in military applications and data traffic in the wireless sensor networks. Landy can be extended to support more forwarding strategies. Some can perform better in high node density while others perform better in low node density. Landy will adjust the forwarding strategy adaptively to allow high throughput of data traffic. Additional work needs to be done on the adaptive location update mechanism and the area for location update.

A tremendous amount of research remains to be done in the area of mobility models in ad hoc networks. Group Pursuit Models are of special interest for FCS applications, and have to be included in a comprehensive simulation. It is important to investigate the application scenarios, to evaluate performance of MANET routing protocol. In other words, it is useful to simulate MANET routing protocols using the mobility model, which represents the application scenario more accurately. Also it is important to examine the movements of MNs in the real world, to develop a new model that combines the best characteristics of major MANET mobility models, which can be used for performance evaluation of routing protocols in MANET.

References

[1] Gupta P, Drag R (2006) An experimental scaling law for ad hoc networks, Bell Laboratories Technical report. Bell Laboratories, Murray Hill.

[2] Bandwidth-satisfied multicast trees in large-scale ad-hoc networks, Chia-Cheng HU (2010), Department of Information Management ,Naval Academy, Kaohsiung, China.

[3] L. Blazevic, J.-Y. L. Boudec, and S. Giordano, A location -based routing method for mobile ad hoc networks," IEEE Trans. Mobile Computing, vol. 4, no. 2, pp. 97{110, Mar. 2005

[4] Y. Ko and N. H. Vaidya, "Location-aided routing (LAR) in mobile ad hoc networks," Wireless Networks, 6(4), July 2000, pp. 307-321.

[5] Z. Haas, A new routing protocol for the recongurable wireless networks," in Proceedings of the IEEE Int. Conf. on Universal Personal Communications, pp. 12{16, Oct. 1997.

[6] G. J. Pottie and W. J. Kaiser, "Wireless Integrated Network Sensors", Communications of ACM, Vol.43, No.5, May 2000, pp. 51-58.

[7] F. Akyildiz, W. Su, et. al., "A Survey on Sensor Networks", IEEE Communication Magazine, August 2002, pp. 102-114.

[8] C. Perkins, E. Royer and S. Das, "Ad hoc On-Demand Distance Trajectory (AODV)routing"IETF,RFC3561: http://tools.ietf.org/html/rfc3561 (July 2003).

[9] H. Asenov and V. Hnatyshin, "GPS-Enhanced AODV routing", Proc. 2009 International Conference on Wireless Networks (ICWN'09), Las Vegas, NV, 2009
[10] Karp, B., Geographic Routing for Wireless Networks, Ph.D. Dissertation, Harvard University, Cambridge, MA, October, 2000.
[11] OPNET Modeler ver. 14.5. OPNET Technologies, Inc®, www.opnet.com .
[12] J. Hightower and G. Borriella. Location systems for ubiquitous computing. IEEE Computer, 34(8):57{66, 2001.
[13] S. Corson and J. Macker, "Mobile Ad hoc Networking (MANET) Routing Protocol Performance Issues and Evaluation Considerations", IETF RFC 2501, January1999.
[14] G. Comparetto, J. Schwartz, N. Schult, Marshall J., "A Communications Analysis Tool Set that accounts for the Attenuation due to Foliage, Buildings and Ground Effects", McLean, VA, MILCOM 2003.
[15] Q.Fang, J.Gao, L.J. Guibas. " Locationg and Bypassing Routing Holes in Sensor networks", IEEE INFOCOM`04, March 2004.
[16] H. Ashtiani, S. Alirezaee, S.Hosseini, H. Khosravi Proceedings of the World Congress on Engineering 2009 Vol I WCE 2009, July 1 - 3, 2009, London, U.K.
[17] S. Saeed Sadat Noori, S. Ali Sadat Noori, S. Morteza Lari Baghal"Optimization of Routes in Mobile Ad hoc Networks using Artificial Neural Networks", International Journal of Soft Computing and Software Engineering [JSCSE], Vol. 2, No. 4, pp. 36-50, 2012, Doi: 10.7321/jscse.v2.n4.4
[18] L.Darougaran , H.Shahinzadeh, M.Salavati "Simulated Annealing algorithm for Data Aggregation Trees in Wireless Sensor Networks", International Journal of Soft Computing and Software Engineering [JSCSE], Vol. 1, No. 1, pp. 1-8, 2011, Doi: 10.7321/jscse.v1.n1.6
[19] Y. Jiang, Z. Qiu, J. Zhang, J. Li"Integration of Unicast and Multicast Scheduling in Input-Queued Packet Switches with High Scalability", International Journal of Soft Computing and Software Engineering [JSCSE], Vol. 2, No. 4, pp. 14-34, 2012, Doi: 10.7321/jscse.v2.n4.2
[20] Sheikhan, M, Hemmati, E. " High reliable disjoint path set selection in mobile ad-hoc network using hopfield neural network", journal of Communications, IET, vol. 5, no. 11, pp. 1566 – 1576, 2012.
[21] Lal ,C, Laxmi, V. ; Gaur, M.S. "A Node-Disjoint Multipath Routing Method Based on AODV Protocol for MANETs" , In Proceeding(s) of (IEEE international conference) Advanced Information Networking and Applications (AINA), pp. 399-405, 2012.
[22] J. Broch, D. Maltz, D. Johnson, Y.-C. Hu and J. Jetcheva, "A Performance Comparison of Multi-Hop Wireless Ad Hoc Network Routing Protocols", in Proceedings of the fourth Annual ACM/EEE International Conference on Mobile Computing and Networking, 1998, pp.85-97.
[23] Xu Yi , Cui Mei ; Yang Wei ; Xan Yin , "A Node-Disjoin Multipath routing in Mobile Ad Hoc Networks" In Proceeding(s) of (international conference) Electric Information and Control Engineering (ICEICE), pp.1067-1070, 2011.

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