ISSN: 0975-766X
CODEN: IJPTFI
Available Online through ***Research Article***
www.ijptonline.com

MULTIPATH LIFE TIME PREDICTION OF NODE-TO-NODE COMMUNICATION USING MULTIPOINT RELAYS IN OLSR PROTOCOL FOR MOBILE AD-HOC NETWORKS

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Received on 25-10-2016 *Accepted on 02-11-2016*

Abstract:

Mobile *ad- hoc* networks (MANETs) are self organizing network, communication between nodes happens through single hope or multi hope. Topology structure of MANETs was highly dynamic, so designing an effective routing protocol is a crucial issue in MANET. The author proposes a hybrid protocol named MPLP-OLSR protocols, with less control overheads, by selecting MPRs. The nodes which cover maximum number of nodes in next level can act as Multipoint relays. If there is a tie in that value maxim-mum bandwidth node will be consider as MPRs. Multipath Dijikstra algorithm was used to generate multiple path between the source and destination. Link stability between each and every pair of nodes was calculated, among those values the minimum value was considered as path stability value. Path stability value was calculated for each and every path generated by Multipath Dijikstra algorithm, the path which was having high path stability value was considered for data transfer. Simulation was performed in network simulator 2, shows that MPLP-OLSR performs well when compare to any other protocols, even in highly dense network.

Key words: QoS; OLSR; MPLP-OLSR; MPRs

1. Introduction

Now-a-days any time anywhere connectivity was needed, which can be achieved by Mobile Ad hoc networks (MANET). Infrastructure less, self-organizing networks was called MANET. Nodes in a MANET can act as routers, able to transmit or receive packets from other nodes, within its transmission region. Designing a routing protocol for such a dynamic networks was a challenging task, due to frequent link failure, limited battery power, and mobility.

Huge number of routing protocols has been proposed for MANET [1] different Criteria were used to classify those protocols. Most important criteria's are,

1. Route discovery
2. Number of routes that are computed between source and destination.

1.1. Route discovery

Establishing the path between source and destination was called route discovery, as per this idea, routing protocols are classified into

1. Proactive or Table driven
2. Reactive or On demand
3. Hybrid Routing

Proactive protocols uses table to maintain the overview of the network topology, these table should be updated when ever there is a change in network topology (Ex: Optimized Link State Routing (OLSR) [2].

In reactive protocols route request is sent on demand i.e if a node want to sent data to another node, during that time route request was broadcast , once response came from destination data transfer will happen (Ex: Ad hoc On Demand Destination Vector Routing [3], Dynamic Source Routing (DSR) [4].

Hybrid protocols use the advantage of both proactive and reactive protocols (Ex: Zone Routing Protocols (ZRP) [5], Zone based Hierarchical Link state (ZHLS) [6].

1.2. Number of routes

Another important routing criterion was the number of routes that are computed between the source and destination. As per this criteria Routing Protocols was classified as,

1. Single path routing
2. Multipath routing

1.2.1. Single path routing

Single path Routing protocol will develop a single path between the source and destination. Link failure and node failure can happen frequently in Ad hoc network due to mobility, so there is a need for multiPath routing.

1.2.2. Multipath routing

More than one path will be established between the source and destination, if there is a failure in any one path, the network can able to survey with the help of the other path.

Many multiPath routing protocols were proposed for Ad hoc networks [7]. The main goal of these multipath routing protocols was to improve Quality of Service (QoS). Multiple Paths that are found by these protocols can be used as,

1. Backup Route in case of primary route failure.
2. Parallel data transmission through multiple paths.

These multipoint routing protocols was categorized as follows,

1. Disjoint
2. Inter-twisted
3. Hybrid

1.3. Disjoint

This can be further classified into,

1. Node disjoint
2. Link- disjoint
3. Hybrid

1.3.1. Node disjoint

It was clear that, the paths that are formed won't share any nodes. Most of the researcher prefers node disjoint, since if there was a failure in any one node it will affect the corresponding path alone, the remaining path can still un- affected.

1.3.2. Link-disjoint

In this multiPath type, some of the nodes were shared to form paths, but the link that connects these nodes should be different.

1.3.3. Hybrid: In hybrid multiPath, paths are formed by combining the advantages of both nodes disjoint and link-disjoint.

2. Related works: In the section, there was a discussion about OLSR and its versions, then the existing multipath routing protocols for MANET.

2.1. OLSR: OLSR was a table driven routing protocol, which uses effective flooding to reduce routing overheads. Effective flooding was achieved, by selecting the nodes which covers maximum number of nodes in next level as Multipoint Relays (MPRs). Some times this will avoid band width efficient paths, even though such paths exist.

2.1.1. OLSR versions

In OLSR versions [8], while selecting multipoint relays they consider the node which covers maximum number of nodes in next level as well as bandwidth and delay. It will select band width efficient path, but it does not reduces the number of loops that are formed during route establishment.

2.1.2. BEMPRs-OLSR

Bandwidth Efficient Multipoint Relays in Optimized Link State Routing (BEMPRs-OLSR) [9] it uses similar algorithm like OLSR version. But it maintains more number of MPRs when ever there was tie among the nodes to act as multipoint relays. Loop formation ratio was less when compare to the existing protocol.

2.2. Multipath routing Protocols

Many existing multipath routing protocols proposed in the littérateur are, modified versions of single path routing protocol: DSR and SMR [10], AODV and AOMDV [11], all these protocols are on-demand routing protocols. Most of the researchers are concentrating on-demand routing protocols, since the performance of the network was high, even though theses protocols are having some disadvantages.

2.2.1. Route request storm

These protocols generate number of route request to an intermediate node, to establish the path. Duplicate route request was discarding by an intermediate node which increases the redundancy [12].

2.2.2. In-efficient Route discovery

Some of the multipoint routing protocols, intermediate nodes are not allowed to send replay from its route cache information, so source has to wait until destination generates route replay. It increase the route discovery process of multipath routing protocols when compare to its single path version [13].

Version of OLSR [14], which uses IP-source routing. Node disjoint multipath route computation was done with the help of Dijkstra algorithm, calculated path was inserted in packet IP-header before sending. Load balancing was achieved, by finding the path congestion information. Congestion information was measured, as maximum size of the queue in the intermediate nodes of that particular path. This information's are encapsulated in HELLO packets and advertised in Topology Control (TC) message. Calculate multiple node disjoint path by differentiating used and unused nodes and considering only unused nodes for multipath [15]. QOLSR [16] uses shortest-widest path algorithm for calculating multiple paths for the protocol. QOLSR routing protocol was an extended version on OLSR routing protocol in which band width and delay metrics are used, but in practical maintaining bandwidth and delay was very difficult. Multipath dijkstra algorithm called MultiPath Optimized Link State Routing (MP-OLSR) [17] to calculate multiple paths between source and destination. MP-OLSR was a hybrid protocol; they mainly concentrate about loop detection and route recovery in source routing. Energy consumption and remaining battery power as a metric to increase the life of node-to node communication. Analysis was done by considering the network that supports Automatic Repeat Request (ARQ) and the network don't support ARQ [18]. Split Multi-path Routing (SMR) [19] proposed by the author, it was an on-demand routing scheme, which establishes multiple routes of maximally disjoint paths. A pure source routing strategy seems are not suitable for dense network. Route Error messages increases delay when compare to route recovery. LSLP protocol [20] in which Qos metric was used along with the lifetime prediction. The LSLP protocol was a single path protocol, for the selected path they found the life time. From the literature survey, author identified that most of the researchers are concentrating on various QoS service metric like bandwidth, shortest path, remaining battery power, size of congestion window while establishing the multiple paths. They never worry about mobility, since most of the time link breaks due to mobility. An effective mechanism should be introduced to predict the link break time, so that data can be efficiently transferred between the nodes. In this paper the author proposes a new Multipath Life-time Prediction (MPLP) algorithm, which provide either node-disjoint or link disjoint multiple paths.

3. System model

Notation used in the paper was given in Table 1.

Table 1 Notation table.

Notation	Meaning
V_i	Velocity of node N_i
θ_i	Direction of Node N_i
R_i	Transmission Range of Node N_i
d_i	Distance traveled by node N_i at time t
(X_i, Y_i)	Coordinate of node N_i
(PX_i, PY_i)	Predicted new Coordinates of node N_i
D_t	Distance between neighbors at time t
$LS_{(i,i+1)}$	Link stability between N_i and N_j
PS_i	i^{th} path stability

Multipath algorithm aims to build set P_K of N paths joining Source node S and destination node D, without any loops.

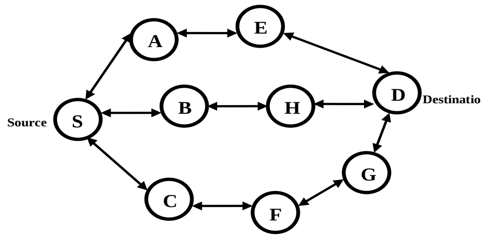

Fig.1 Mobile ad-hoc network.

MANET can be represented as a connected undirected graph G = (V, E, C) as shown in Fig. 1, where V is the set of Vertices, E 1 V × V the set of bidirectional edges and positive cost function C: V→E. The graph is a bi-directed graph, so (V_1, V2) 1 E & (V_2, V_1) 1 E and C (V_1, V_2) = C (V_2, V_1) and there is no loops i.e no edges join a node to itself. Any pair of vertices cannot be connected by more than one edge. A path between source and destination can be defined with the help of sequence of vertices (V_1, V_2, ……..,V_n), so that V_2,…, V_{n-1} 1 E, V_1= S and V_n=D Destination .The metrics used to evaluate the performance of a network can be classified as concave or multiplicative and convex metrics Asokan. R et al (2010).

3.1. Concave or multiplicative metric

If a metric value was calculated as minimum value of all the nodes or the links along the path P_K then it is called concave metric.

Ex:

Bandwidth, energy, Lifetime of a link

3.2 Additive metric

If a metric value was computed by considering the values caused by all the intermediate nodes within the path P_K then it was called additive metric.

Ex: End-to-end delay, Life time of a link

4. MPLP-OLSR

MPLP-OLSR was a hybrid protocol, which was the combination of proactive and reactive routing protocol. Its proactive nature was similar to OLSR, it doesn't use routing table to establish the path, and multiple routes were computed when there is a need to send data packets.

MPLP-OLSR core functionality can be divided into two pats

1. Topology sensing.
2. Multiple route computation.

4.1. Topology sensing

Topology sensing was done to identify the neighbors and it should be identified with fewer overheads, so while identifying the neighbor's effective flooding concept was used. In MPLP-OLSR Multi Point Relays (MPR's) are used to achieve the concept of effective flooding, MPRs are not special nodes; they are one among the nodes in the network. The node which act as multipoint relays are able to forward the packets, the node which covers maximum number of nodes in next level can act as MPR's. Through topology sensing it was possible to identify 1-Hop and 2-hop nodes, a 1-hop node which covers maximum number of nodes in 2-Hop act as MPRs, if there was any tie, it as been broken by considering maximum bandwidth. During this process nodes current coordinates was updated in the routing table. Topology sensing was explained with the help of Fig 2.

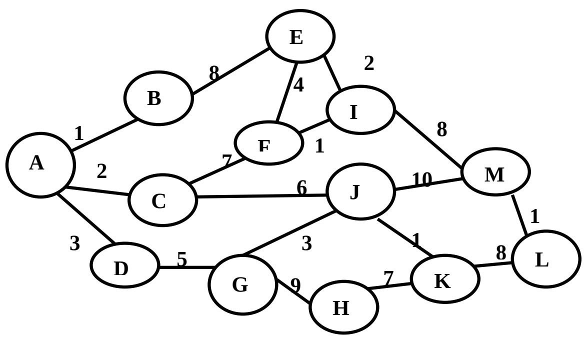

Fig 2 Weighted Mobile ad hoc network.

Fig 2 shows weighted mobile ad hoc networks, bandwidth was considered as weight. BEMPR's –OLSR has been modified such a way that each and every nodes coordinates as been sensed with the help of the Global Position System (GPS) and updated in the routing table. Updated routing table was shown in table 2.

Transmission region R_i for ad hoc nodes was assumed to be same and it is fixed, the direction of movement θ_i and Velocity V_i are constant. Once these values are known it was possible to detect the d_i for any node N_i and D_t between any neighbors, values of d_i was calculated by using (1).

$$\mathbf{d_i = V_i t \quad (1)}$$

Let us consider two nodes N_1 and N_2, the value of d_1 and d_2 was calculated using (2) and (3)

$$\mathbf{d_1 = V_1 t} \quad (2)$$

$$\mathbf{d_2 = V_2 t} \quad (3)$$

By using the following formula it was possible to predict the new coordinates (PX_1,PY_1) and (PX_2,PY_2) for the nodes N_1 and N_2 respectively, using old coordinates(X_1, Y_1) and (X_2, Y_2)

$$PX_1 = X_1 + PX_1 = X_1 + d_1 \cos i_1 = X_1 + tV_1 \cos i_1 \dashrightarrow (4)$$

$$PY_1 = Y_1 + PY_1 = Y_1 + d_1 \sin i_1 = Y_1 + tV_1 \sin i_1 \dashrightarrow (5)$$

$$PX_2 = X_2 + PX_2 = X_2 + d_2 \cos i_2 = X_2 + tV_2 \cos i_2 \dashrightarrow (6)$$

$$PY_2 = Y_2 + PY_2 = Y_2 + d_2 \sin i_2 = Y_2 + tV_2 \sin i_2 \dashrightarrow (7)$$

Once the values of new coordinates are known, it was possible to find the distance between two nodes at particular point of time; i.e the value of D_t

$$D_t = \sqrt{(X_1 - X_2)^2 + t(V_1 \cos i_i - V_2 \cos i_2)^2 + (Y_1 - Y_2)^2 + t(V_1 sin_i - V_2 sini_2)}$$

4.2. Transmission Region and distance

If the distances D_t between the two nodes are greater than the transmission region R_i, then there was a link break, since the nodes are not within the transmission region of others.

4.3. Link Stability (LS)

The value of LS between any two nodes at particular time t was calculated using (9)

$$LS_{(i,i+1)} = \frac{R_i}{D_t} \dashrightarrow 9$$

4.4. Path Stability

Path stability was defined as the minimum value of Link stability between any two nodes in that particular path.

$$PS_{(i)} = \text{Min}\{LS_{(i,i+1)}, LS_{(i+1,i+2)}, \ldots, LS_{(i+n-1,i+n)}\} \quad (10)$$

Input:

1. Routing Table: contains bandwidth and 1-hop node.
2. Neighbor Table: contains neighbor's information of all nodes.

Output:

1. Updated routing table:

1.1 1-Hop nodes, 2-Hop nodes, MPRs, coordinate.

Steps:

MPR set for node y was stored in MPR(y).

1. Multipoint Relay set was initialized as null set

   MPR(x)$\rightarrow\Phi$

2. For any node X

   a. If node Y is the only node to reach some nodes in next hop then

      MPRs = {Y}

   b. Update its coordinates.

3. While (node X! = MPRs set)

   3.1 Find the number of nodes it covers in next level.

   3.1.1 If a node Z covers maximum numbers of nodes in next then

   MPRs = {Z}.

   3.1.2 When more than one nodes covers same number of nodes in next level

   3.1.2.1 Copy all the nodes to MPRs, and tie was broken by considering a node with higher bandwidth

   3.1.2.2 Update the coordinates of the MPR node

4. Node repeat step 3 until it was covered by some MPRs.

5. If there was a loop in the selected path

   5.1 Try to form a path with different MPR, with updated cordinates

   Else

   GOTO step1

6. Call Multipath Dijikstra Algorithm to generate multiple paths.

7. Calculate the value of $D_{t\ and}$ LS $_{(i,i+1)}$ between the pair of nodes to find $PS_{i.}$

8. Select the path with p(i) for data transfer.

Fig 3 MPLP-OLSR Algorithm.

Table 2. MPR selection in MPLP –OLSR.

Nodes	1-Hop Nodes	2-Hop Nodes	MPR	Coordinates
A	B,C,D	E,F,J,G	C	a_1,a_2
B	A,E	C,D,F,I	E*/A	b_1,b_2
C	A,F,J	B,D,E,I,M,G,K	J	c_1,c_2
D	A,G	B,C,H,J	G*/A,	d_1,d_2
E	B,F,I	A,C,I,F,M	F*/I,b	e_1,e_2
F	C,E,I	A,J,B,I,E,M	C*/E/I	f_1,f_2
G	D,H,J	A,K,C,M	J	g_1,g_2
H	G,K	D,J,L	G	h_1,h_2
I	E,F,M	B,F,C,E,J,L	M*/E/F	i_1,i_2
J	C,G,K,M	A,F,DH,L,I	C*/G	j_1,j_2
K	H,J,L	G,C,M	J	k_1,k_2
L	K,M	H,J,I	K	l_1,l_2
M	I,J,L	E,F,C,G,K	J	m_1,m_2

5. Multiple route computation

Multiple routes was computed with the help of modified dijikstra algorithm called multipath dijikstra algorithm.

5.1. Multipath Dijikstra Algorithm

For each node in MPLP a path flag was used to decide whether any valid route was exist to the corresponding node. If the path flag was true the node will select a valid route to the destination from the multipath routing table. If the path flag value was false then it will evaluate multipath Dijikstra Algorithm to find multiple paths and store it in multipath routing table.

Input:

1. Neighbor information Table

It contains information about all the neighbors of a particular node.

2. Source (S) and Destination (D) nodes.

3. Cost Table

It contains all the nodes in the network and there corresponding cost initialized to Zero.

4. Number of routes K, needed between Source (S) and Destination (D).

Output:

1. Multipath routing Table:

It contains multiple paths or routes for the given source (S) and Destination (D) as input.

Algorithm:

/*calculating K Routes*/

1. Apply Dijikstra algorithm to find the shortest path P_i, store it in Multipath routing table.
2. For all the nodes in P_i

   2.1 Replace the old cost of the link and node value in P_i by new cost or add value one to older cost in cost table.

   /* To avoid reconsideration of node and link*/

3. Repeat step 1 until K routes is found.

Life time of a path was a Concave or multiplicative metric, i.e its value depends on all the nodes in that link. Multiple path Dijikstra algorithms will fetch multiple paths between the source and destination. For each and every path link stability value was calculated, from that calculated value select a path, with high link stability value.

$$P(i) = \mathrm{Max}\{PLS_{(1)}, PLS_{(2)}, \ldots\ldots\ldots, PLS_{(K)}\} \quad (12)$$

6. Performance Evaluation

The proposed MPLP-OLSR algorithm was compared with the protocols like OLSR, QOLSR-MPR2, BEMPRs-OLSR. Simulations are carried out in NS2 with the parameters shown in Table 3.

Table 3: **Simulation Parameters.**

Parameter	Values
Transmission Range	250m
MAC layer protocol	IEEE802.11
Traffic Pattern	CBR
Data Packet Size	1024 bytes
Simulation area	1000mX 1000m
Number of Nodes	100
Mobility	0-100 m/s

Mobility Model	Random way point model

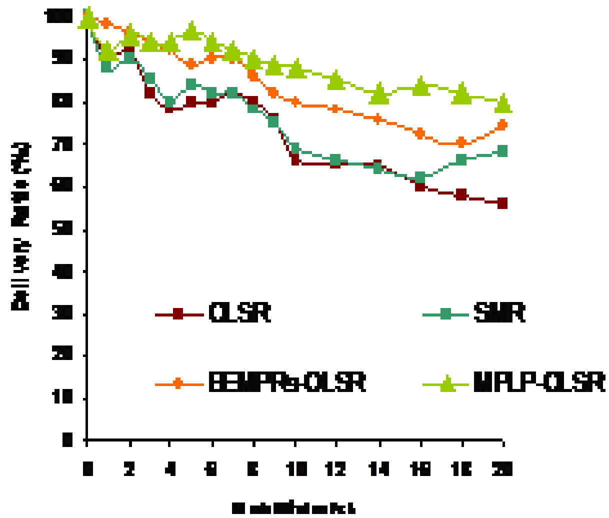

Fig 3 Comparison of packet delivery ratio.

Fig 3 shows the packet delivery ratio of four protocols. When ever mobility increases packet delivery ratio decreases, due to frequent link break. Packet delivery ratio for MPLP-OLSR was high when compare to any other protocol, since it was a multipath routing protocol, stable path was considered to transfer data through life time prediction. Just before a link breaks, packets are transferred through another stable path.

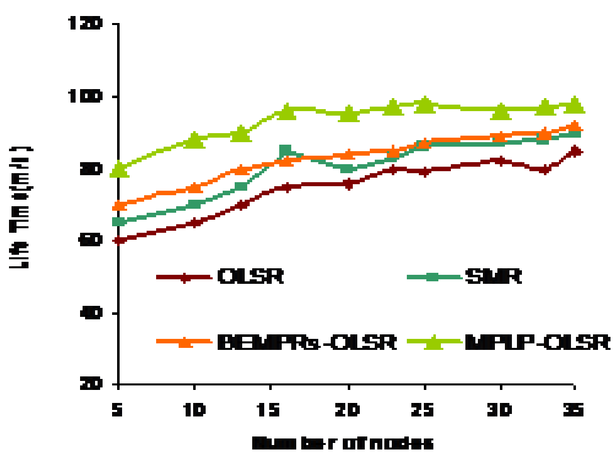

Fig 4. Life time of related protocols.

Life time of four protocols was shown in Fig4.Life time of MPLP-OLSR was high when compare to any other protocols, since link break prediction was done only in MPLP-OLSR. Even though SMR was a multipath routing they never discussed about path stability. Life time of a path increases, when ever the life time between the nodes increases. When ever node density increase, it will increase the life time between the nodes, which intern increases the packet delivery ratio between source and destination.

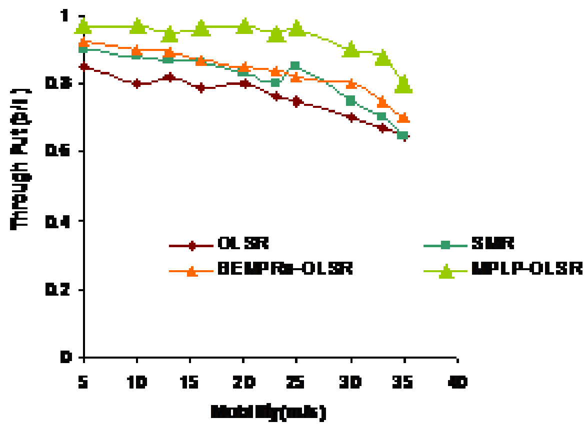

Fig 5 Through Put comparison.

Mobility increases throughput decreases, since the number of packets delivered is less. MPLP-OLSR through put was high when compare to any other protocol because of stable link selection.

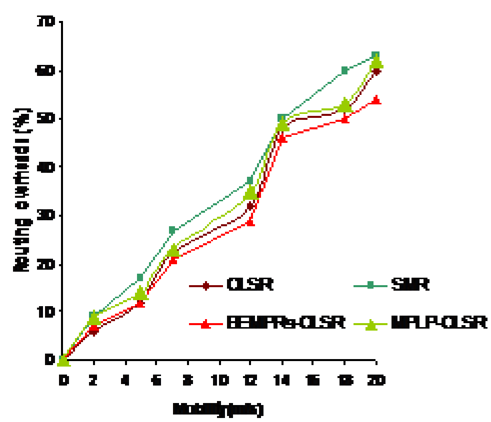

Fig 6 Control overheads comparison.

Fig 6 shows the variations in routing overheads due to mobility. Link breaks frequently when mobility increases, so new root as to be found frequently. Effective flooding was not used in SMR, so routing overheads are high when compare to any other protocol. MPLP-OLSR was a hybrid protocol control overheads increases when compare to OLSR and BEMPRs-OLSR.

7. Conclusion

Multipath routing protocols can improve the performance of Ad-hoc networks because of its nature of finding multiple paths. In this paper our proposed algorithm, MPLP-OLSR uses link prediction model to predict the link break, so that a stable path can be selected among the multiple paths generated by Dijikstra algorithm. Through simulations it was demonstrated that MPLP-OLSR perform well, when compare to any other protocols.

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