PSA-MP: Path Selection Algorithm for MANET depends on Mobility Prediction to Enhance Link Stability

Nismon Rio Robert¹ and Calduwel Newton Pitchai²

¹Department of Computer Science, CHRIST (Deemed to be University), Bangalore, India
²Department of Computer Science, Government Arts College, Tiruchirappalli, Tamil Nadu, India

Corresponding author and e-mail: nismon.rio@christuniversity.in

Abstract. Link failure is a much crucial issue to be addressed for improving the stability of the routing. Selection of a stable path is an important task since nodes are mobile. The instability of a link leads to frequent link failure, which further causes to link re-establishment. In this paper, a Path Selection Algorithm based on Mobility Prediction (PSA-MP) is proposed that uses Mobility, Direction and Link Expiration Time (LET) as metrics to evaluate the link stability. In the existing algorithm, if any link gets fails during the link-establishment phase, it informs the previous node for selecting alternate link. But, in PSA-MP the alternate link is selected before a link fails by predicting Mobility, Direction and LET of nodes. As a result, it reduces link re-establishment delay. Ultimately, PSA-MP reduces E2E delay, which in turn boosts Packet Delivery Ratio (PDR). Eventually, link stability is enhanced in MANETs, which is the focus of this paper.

1. Introduction

The selection of a stable path in ad-hoc environment is based on minimum hops, low mobility with high energy from source to destination. Besides, the links may have bad signal quality due to wireless links changing dynamically. Link stability is used to stabilize the links for transmitting the real-time applications. Link stability can be defined as how long the link connection is going to be alive between neighboring nodes. In other words, link permanence demotes to the capacity of repairing the link(s) locally through selection of alternate connection(s) in lesser time. In PSA-MP, the link stability is estimated based on Mobility, Direction and LET of nodes to avoid instability link of nodes. In Figure 1, the slashed line in the 45 degree of the circle is where the value of signal is bigger than local Threshold. All nodes are considered as constant contentions. Maximum communication (outer path) range of v1 be slashed by vertically. Nodes inside the small ovals are considered as stable links. The link1→2 when v2 is on path (1), (2), (5), (6) and (7) are very much good situations. The main reason is the value signal strength which obtained from v1 is a lesser amount of than Thr. The link 1→2 is deemed as a constant link when v2 on path (3) and (4) and the signal strength collected is larger than Thr. Link 1→3 is forever believed as unhinged as the signal power obtained by v3 is a reduced amount of than the Thr right through the network. The stable path is selected based on stable forwarding links which has high stability of link connectivity. Without identifying the stable links, the established path leads to frequent link collapse in elevated mobility.
situation. So, there is a need to select the path which provides stable connection in order to achieve towering PDR and smallest E2EDelay.

Figure 1: Mobility Prediction [1]

2. Related Works

This section describes the link stability, path stability and other mobility prediction methods for stable link selection. Moreover, this section presents the different ways of stable link selection for achieving better PDR and minimum E2E delay. Also, the discussion is made on various issues in existing mobility protocols and LET estimation method. Two metrics are used to know about the node lifetime and link lifetime along with energy-depletion and mobility-evaluation rate [2]. Moreover, two processes depend on normal routing to recover the competence of DSR. The two imperative mobility constraints are neighbour mobility nodes and link for loss path mobility [3]. The link loss is calculated by using Signal-to-Noise-Ratio. Node is computed based on BEB; trustworthy nodes were used to build a stable path between source and destination. Stability judgment was showed for multicast routing which depends on relative and local stability values [4]. Two decision factors play an important role in estimating the node strength. Stable path supplies best steps to prefer more resourceful multicast tree with spontaneous method. QoS routing protocol is created by Link Stability by adding the mobility degree of various nodes [5].

Long Life Time Multicast Routing Protocol is developed to locate a constant road map during link failure by modifying the mechanism of route discovery [6]. They extended route lifetime, reduce the delay and control overhead. [7]. It chew over the energy consumption for packet transmission and the time for enhancing the stability of a link.

Prediction of link stability helps to enhance the reliability of the communication between source and destination [8]. Individual link stability is computed between neighboring nodes to extend the link connectivity with minimum updation time. SERiES is implemented to enhance stability and security for MANETs. A stable path is exposed with learning agent. Learning agent used the link-state database to recognize the exact path that contains the complete information about the paths bandwidth, queue length and energy [9]. Once the path is recognized the data transfer is done between the corresponding nodes.

LSPMAODV is developed to select reliable neighboring nodes. The predicted information of nodes diminished the stoppage and augmented the competence. In LSPMAODV, three clusters were created and one node from each cluster is accepted as main node depends on the packet priority [10]. Finally, a link with higher probability for long time was selected. The QoS values example delay, energy consumption, E2E delay, packet loss and overhead are minimized. A novel method is explained for the nodes’ mobility prediction to avoid link failures [11].
The best link is chosen with maximum path available time. The concept of stability noted at fixed link from the available links in E2E route. For assessing the stable path periodic packets is utilized in the case of successful transmission. The connectivity of the network depends on packets acknowledgment [12]. The probability of success denoted that the particular link is continual for a big time. The lesser mobile node is developed by Mobility Factor of neighbor links with last link set [13]. Finally Link Stability Factor is evaluated form QoS metric value. The new process is extended [14] for LLFR with create improvement from link destroyed at the point of node breakage. Fuzzy Logic based Ad-hoc On Demand Distance Vector (FLAODV) rules were applied to increase the durability of path in term of high battery level, high bandwidth and rate of mobility Eventually, FLAODV eliminates unstable paths from the route discovery process by applying fuzzy rules to get optimum path. The drawbacks of the given process were that they predicted the mobility of nodes based on low mobility and high LET after link failure. They did not predict the mobility of nodes before link failure. Instead, they just looked at the low mobility and high LET as a stable path. For this reason, PSA-MP is proposed for stability of MANETs.

3. PSA-MP: Path Selection Algorithm based on Mobility Prediction
The objective of the proposed PSA-MP is used to predict and select a stable path from set of available links during mobility condition before the link meets with failure. In this research, the PSA-MP is evaluated to the breathing Local Link Failure Recovery (LLFR) algorithm. PSA-MP estimates mobility, direction and LET of each nodes and links to select a stable path for enhancing the link stability. The source node finds a link that is highly stable. The proposed PSA-MP algorithm consists of four phases as given below.

- Link Discovery
- Link Updation
- Neighbor Link Selection
- Link Establishment

The following algorithm explains the process of identifying a stable link as shown below.

**Input:** Consider a wireless network graph that contains $U_g = (U_v, U_E)$ where $U_v$ is the vertices and $U_E$ is the edges of links.

**Initialization:**

- $V_S = \emptyset$;
- $V_D = \emptyset$;
- $M = \emptyset$;
- $d = \emptyset$;
- $n = \emptyset$;
- $n_i+1 = \emptyset$;
- $LET = \emptyset$;
- $link(i) = \emptyset$;
- $link(j) = \emptyset$;
- $P_{V_i+1} \rightarrow V_D = \emptyset$;

In PSA-MP algorithm, nodes collect information such as $M$, $d$ and $LET$ in order to predict stable links during mobility to construct a stable path before link failure. These metrics are deployed to enhance the link stability in MANETs.

**Proc PSA_MP** ($M$, $d$, $LET$) /* This procedure is used to predict a stable path among link $V_{i+1}$ to $V_D$.

$V_S$ computes $Min(M)$ on $n_i$, $n_{i+1}$ where $i=1$ to $n$ and $j=1$ to $m$

Begin

**Continuous for** $i :: 1$ to $n$ do

**Continuous for** $j :: 1$ to $m$ do

**If** ($n_i^{Min(M)} > n_{i+1}^{Min(M)}$) *then*

/*This procedure invokes when mobility is high

$(n_{i+1}) \leftarrow Min(M)$ /*Computes the value of $m$, $d$ and $LET$*/

Select an alternate link locally from routing table before node moves out of the range

**Else**

$(n_i) \leftarrow Min(M)$ /*Check whether the selection of next node mobility is high*/

if $(n_i(max(link)[j]=1....m)])$ *then*

Select an alternate link locally from routing table before link failure

**CALL Max_(LET)** /* This procedure invokes when mobility is low*/
End if
End for
Alternate path is selected from $V_{i+1} \rightarrow V_D$*/
End

Proc Max_(LET)
Begin
If $n_i^{\text{link}(j)} > n_{i+1}^{\text{link}(j)}$


\[ n_i^{\text{link}(j)} \leftarrow \text{Max}(\text{LET}) \]

Else

\[ n_{i+1}^{\text{link}(j)} \leftarrow \text{Max}(\text{LET}) \]

End if
End

Where,
$V_S$ = Source Node
$V_D$ = Destination Node
$V_{i+1}$ = index for Intermediate Node representation
$M$= Nodes mobility representation 1 to M (i.e., ‘M’ nodes mobility speed
$d$= Nodes direction 1 to d (i.e. ‘d’ direction of nodes in a network)
$n_i, n_{i+1}$ = index for $n$ represents 1 to n (i.e. ‘n’ total number of nodes)
LET = Link Expiration Time
$\text{link}_i$ = index for links representation 1 to L (i.e. ‘L’ total number of links)
$\text{link}_k$ = index for paths representation 1 to P (i.e. ‘P’ total number of links)

3.1 Link Discovery

When a link is established between two nodes, source node has the responsibility to discover the path to destination using control packets such as RREQ and RREP. Initially, mobile link overflows the RREQ to all of its neighbors to establish a link. Each and every nodes flood this RREQ by appending its address in the header of packet. For this reason, at least two nodes must be connected within the range of each other.

3.2 Link Updation

In MANETs, node links can be updated periodically by sending periodic “Hello” messages.
Link Updation Timeout ($t_{lu}$) is depends on the mobile nodes new mobility. The advanced mobility leads to frequent link failure, $t_{lu}$. Equation (1) denotes $T_{lu}$ at time $t$.

\[ T_{lu} = T \min \left[ \text{ubound} \left( T_{lu} \right), \phi \right] \]

\[ \text{s.t.} \]

\[ \phi = \max \left[ \text{lbound} \left( t_{lu} \right), \frac{\hat{m}}{m_t}, \frac{\hat{t}_{lu}}{t_{lu}} \right] \]

Where, $t_{lu}$ is defaulting value of $T_{lu}$ ubound ($T_{lu}$) and lboun (T_) denotes bigger and smaller levels of $T_{lu}$. $m_t$ is mobility of node with $t$. $\hat{m}$ with $m^\sim$, are the default and average values of node mobility. Next for updating, link of mobile nodes, weighted average mobility and directions are computed for the link updating procedure every $t_{lu}$
time as follows. A mobile node weighted average mobility \( m_t^- \) and flow \( d_t^- \) with respect to \( t \) are calculated to predict a stable link. In equation (2) and equation (3), \( m_t^- \) and \( d_t^- \), with respect to \( t \) are evaluated by \( m \) and \( d \) for earlier periods.

\[
m_t^- = (1-\alpha) \sum_{i=1}^{t} \alpha^{-i} m_{t-i+1}^{-}
\]

(3)

Where, \( d_t^- \) and \( d_t^- \), are route and average path of mobile node. \( \alpha \) is an exponential parameter. A node continuously checks the \( m_t^- \), \( d_t^- \), and above equations can be described as follows:

\[
m_t^- = (1-\alpha) \int \alpha^{-i} m_{t-i+1}^{-} di
\]

(4)

\[
d_t^- = (1-\alpha) \int \alpha^{-i} d_{t-i+1}^{-} di
\]

(5)

After that the calculation of mobility, That means \( m_t^- \), all process can be accessed. The start value is

\[
m^0 = \lim_{\Delta t \to 0} \frac{\Delta_x}{\Delta_t}
\]

(6)

Where, \( \Delta_x \) and \( \Delta_t \) represent dissimilarity of path value and time period. Next process which depends the combination assessment of hastening (\( \alpha^- \)) under

\[
\frac{d}{dt} m_t^- = \alpha^-
\]

(7)

Hence,

\[
m_t^- = \int_{0}^{t} \alpha^- dt = \alpha^- t
\]

(8)

For notifying mobile node mobility, the comparison between \( d_{t,-1}^- \) at fixed time \( t \) with \( d_{t,-1}^- \) at any time \( t_{i} \). In equation (9), equation (10) and equation (11), if any modified value over 90 degrees that means, \( \frac{\pi}{2} \) value between \( d_{t}^- \) and \( d_{t-1}^- \). So that flag \( f \) is fixed for 1 as probability of mobile node mobility is big. The flag weighted average (\( f_i \)) be fixed to partisan regular of \( f_i \) so that mobility flag \( f^- \) remains a value of 1 during several subsequent periods after \( f_i = 1 \) and nearby nodes mobility.

\[
f_i = \begin{cases} 
1, & d_i \geq d_{i-1} + \frac{\pi}{2} \\
0, & \text{Otherwiswe}
\end{cases}
\]

(9)

\[
WAvg (f_i) = \sum_{i=1}^{t} \alpha (1-\alpha) f_{t-i+1}^{-}
\]

(10)
\[ f^\sim_t = \begin{cases} 1, & \text{W.Avg}\left(f^\sim_t\right) > 0 \\ 0, & \text{Otherwise} \end{cases} \quad (11) \]

### 3.3 Neighbor Link Selection

Neighbor link provides maximum information among detected links. After receiving neighbors’ information from each links, the information of links is calculated using source node in terms of such as mobility, direction and LET. Equation (12), Represent \( LS_{i,j} \), which is satisfied the degree of S node of path for link stability parameter denoted i,

\[
LS_{i,j} = \min \left( LS_{i,j}, \frac{AL_{ji}}{RREQ_{ji}} \right) \quad (12)
\]

Where, \( RREQ_{ji} \) and \( AL_{ji} \) are the available link information in S and link stability. Thus, the stability information \( LS_{j} \) is calculated with weight \( W_i \) as given below:

\[
LS_{j} = 1/n \sum_{i=1}^{n} W_i \times LS_{j,i} \quad (13)
\]

\[ 0 \leq LS_{j} \leq 1 \quad (14) \]

### 3.4 Link Establishment

Although, the alternate link provides the maximum information than the current serving link, the link establishment to the new link becomes unsuccessful if the predicted link expiration time in the new link is smaller LET or if mobility is high. Thus, the decision has to be taken into account in both the current link and the new link. LET in the alternative link can be calculated by using the nodes’ direction and mobility. Link re-establishment process is invoked.

\[ n_i \text{Min}(M) > (n_{i+1} \text{Min}(M)) \]

\[ n_i \text{Min}(\text{link}[j]) < n_{i+1} \text{Min}(\text{link}[j]) \]

PSA-MP can predict the mobility, LET of \( n_i \) and the next available \( n_{i+1} \). If the information of \( n_{i+1} \) is better than the node \( n_{i+1} \), or if mobility and direction is irregular, then the alternate node is selected as a stable link. In consideration of irregular mobility Equation (15) represent for timer is given below:

\[ t_d = \min \left[ \text{ubound}(t_d), \delta \right] \quad (15) \quad \text{s.t.} \]

\[ \delta = \max( \text{lbound}(t_d), (1 + l^\sim f_t^\sim), \frac{C_{\text{link}}}{N_{\text{link}}} t^\sim_d ) \]

Where, \( l^\sim f_t^\sim \) is link failure at time t(0 or 1), \( l^\sim f_t^\sim \) is an average link failure until time t(0 or 1), \( \text{ubound}(t_d) \) and \( \text{ubound}(t_d) \) are the greater bound and minor bounds of timer \( (t_d) \) default value of timer.

### 4. Explanation and Discussions

PSA-MP is used to find a stable path when the communication ranges accept from one node to another node. Thus, stable links be able to predicate according to their link mobility, direction and LET calculation between \( V_S \) and \( V_D \). Node \( V_{i+1} \) is changing position from one place to the node \( V_i \) for statement range with mobility (M). The total travel time is calculated by, it requires total distance (d) of \( V_{i+1} \) is ephemeral throughout
communication range of $V_i$. Equation (6) shows total travel time of $V_{i+1}$. Nodes and available paths are identified as shown in Table 1.

**Table 1.** Node’s and Available Paths

| Node ID(s) | Neighboring Nodes | Available Paths |
|------------|-------------------|-----------------|
| Vs         | 1,4,8             | Vs→1→2→3→VD    |
| 1          | 2,12              | Vs→1→2→8→7→6→VD |
| 2          | 3,7,8             | Vs→1→2→8→7→3→VD |
| 3          | 6,7,D             | Vs→1→2→8→7→3→6→VD |
| 4          | 5                 | Vs→1→2→8→7→5→10→6→VD |
| 5          | 7,10,11           | Vs→1→2→8→7→5→10→6→3→VD |
| 6          | 3,9,10,D          | Vs→1→2→8→7→5→10→9→VD |
| 7          | 2,3,5,6,8         | Vs→8→2→3→VD    |
| 8          | 2,7               | Vs→8→2→7→6→VD |
| 9          | 6,10,13,D         | Vs→8→2→7→6→3→VD |
| 10         | 5,6,9             | Vs→8→2→7→5→10→6→3→VD |
| 11         | 5                 | Vs→8→2→7→5→10→6→VD |
| 12         | 1                 | Vs→8→2→7→5→10→9→6→3→VD |
| 13         | 9                 | Vs→8→2→7→5→10→9→6→3→VD |
| D          | 3, 6,9            | Vs→8→2→7→5→10→9→VD |

4.1 PSA – MP Scenario

The PSA-MP is suggested to choose a stable path for the multiple paths. This is represented by accepting the new network topology which is shown in Figure 2. It consist 20 nodes for network scenario. It is, Vs, 1,2,…,VD. The edges number represent the mobility speed in m/s. Disconnection of links between source and destination may happen due to low LET or high mobility.

![Figure 2: Node’s and their Mobility (in m/s)](image)

The prediction of link in terms of LET and mobility provides the link stability. The value of Mobility is calculated for all the links and stored in routing table. Here, the link stability is referred as total time taken to re-establish the link between source and destination after or before the link failure occurrence. Here, ‘Vs’ denotes source node and ‘VD’ denotes final node. Rest part is considered as transitional nodes. As per the PSA-MP, if any link is likely to be disconnected due to mobility, it re-establishes a
link before the link breaks. If any node moves away from the selected path, a low mobility node value is found. It informs neighbors about the disconnection of links. Then, it checks for the link availability in its routing table to reach the destination.

If a link is available, it selects the alternate link which has low mobility. Otherwise, it resumes with the current link. Assume that as per existing link, the path \(V_i \rightarrow 1 \rightarrow 2 \rightarrow 3 \rightarrow V_j\) is chosen for sending packets. Due to moving of nodes or low LET, a link meets with failure between any two nodes as per this scenario.

Assume that the link between \(2 \rightarrow 3\) is likely to break soon due to mobility, the node 2 informs about its mobility of its neighboring nodes to avoid link failure. So, node 2 establishes link with high LET and low mobility nodes among the multiple links. Table 2 shows the mobility of nodes min \((v_i, v_j)\), \(X_i, X_j, Y_i,\) and \(Y_j\) denotes the coordinates values of \(v_i, v_j\) and LET values of all the links.

| Links | \(V_i\) | \(V_j\) | \(X_i\) | \(X_j\) | \(Y_i\) | \(Y_j\) | LET (in ms) |
|-------|--------|--------|--------|--------|--------|--------|------------|
| S\(\rightarrow\)1 | 2.1 | 2.4 | 0.0366 | 0.9993 | 0.0418 | 0.9991 | 11.08 |
| S\(\rightarrow\)4 | 2.1 | 5.3 | 0.0366 | 0.9993 | 0.0923 | 0.9957 | 9.93 |
| S\(\rightarrow\)8 | 2.1 | 1.7 | 0.0366 | 0.9993 | 0.0331 | 0.9994 | 11.10 |
| 1\(\rightarrow\)2 | 2.4 | 2.7 | 0.0418 | 0.9991 | 0.0471 | 0.9988 | 11.08 |
| 1\(\rightarrow\)12 | 2.4 | 6.3 | 0.0418 | 0.9991 | 0.1097 | 0.9939 | 9.44 |
| 2\(\rightarrow\)3 | 2.7 | 2.3 | 0.0471 | 0.9988 | 0.0401 | 0.9991 | 11.10 |
| 2\(\rightarrow\)7 | 2.7 | 1.7 | 0.0471 | 0.9988 | 0.0296 | 0.9995 | 11.04 |
| 2\(\rightarrow\)8 | 2.7 | 1.9 | 0.0471 | 0.9988 | 0.0331 | 0.9994 | 11.06 |
| 3\(\rightarrow\)6 | 2.3 | 2.1 | 0.0401 | 0.9991 | 0.0366 | 0.9993 | 11.10 |
| 3\(\rightarrow\)7 | 2.3 | 1.7 | 0.0401 | 0.9991 | 0.0296 | 0.9995 | 11.08 |
| 3\(\rightarrow\)8 | 2.3 | 1.9 | 0.0401 | 0.9991 | 0.0331 | 0.9994 | 11.10 |
| 3\(\rightarrow\)D | 2.3 | 1.7 | 0.0401 | 0.9991 | 0.0366 | 0.9993 | 11.08 |
| 4\(\rightarrow\)5 | 5.3 | 7.4 | 0.0923 | 0.9957 | 0.1287 | 0.9916 | 10.37 |
| 5\(\rightarrow\)7 | 7.4 | 1.7 | 0.1287 | 0.9916 | 0.0296 | 0.9995 | 8.90 |
| 5\(\rightarrow\)10 | 7.4 | 4.2 | 0.1287 | 0.9916 | 0.0732 | 0.0073 | 10.41 |
| 5\(\rightarrow\)11 | 7.4 | 8.7 | 0.1287 | 0.9916 | 0.1512 | 0.9884 | 10.20 |
| 6\(\rightarrow\)3 | 2.1 | 2.3 | 0.0366 | 0.9993 | 0.0401 | 0.9991 | 11.09 |
| 6\(\rightarrow\)9 | 2.1 | 8.2 | 0.0366 | 0.9993 | 0.1426 | 0.9897 | 7.81 |
| 6\(\rightarrow\)10 | 2.1 | 4.2 | 0.0366 | 0.9993 | 0.0732 | 0.9973 | 10.54 |
| 6\(\rightarrow\)D | 2.1 | 2.1 | 0.0366 | 0.9993 | 0.0366 | 0.9993 | 11.10 |
| 7\(\rightarrow\)2 | 1.7 | 2.7 | 0.0296 | 0.9995 | 0.0471 | 0.9988 | 10.96 |
| 7\(\rightarrow\)3 | 1.7 | 2.3 | 0.0296 | 0.9995 | 0.0401 | 0.9991 | 11.04 |
| 7\(\rightarrow\)5 | 1.7 | 7.4 | 0.0296 | 0.9995 | 0.1287 | 0.9916 | 8.16 |
| 7\(\rightarrow\)6 | 1.7 | 2.1 | 0.0296 | 0.9995 | 0.0366 | 0.9993 | 11.07 |
| 7\(\rightarrow\)8 | 1.7 | 1.9 | 0.0296 | 0.9995 | 0.0471 | 0.9988 | 10.96 |
| 8\(\rightarrow\)2 | 1.9 | 2.7 | 0.0401 | 0.9991 | 0.0471 | 0.9988 | 11.06 |
| 8\(\rightarrow\)7 | 1.9 | 1.7 | 0.0401 | 0.9991 | 0.0296 | 0.0296 | 2.30 |
| 9\(\rightarrow\)6 | 8.2 | 2.1 | 0.0366 | 0.9993 | 0.0366 | 0.9993 | 11.10 |
| 9\(\rightarrow\)10 | 8.2 | 4.2 | 0.0366 | 0.9993 | 0.0732 | 0.9973 | 10.54 |
| Source | Dest | Delay 1 | Delay 2 | Delay 3 | Delay 4 | Delay 5 |
|--------|------|---------|---------|---------|---------|---------|
| 9→13   | 3.2  | 0.0366  | 0.9984  | 0.0558  | 0.9984  | 10.92   |
| 9→D    | 2.1  | 0.0366  | 0.9993  | 0.0366  | 0.9993  | 11.10   |
| 10→5   | 4.2  | 0.0732  | 0.9973  | 0.1287  | 0.9916  | 8.43    |
| 10→9   | 4.2  | 0.0732  | 0.9973  | 0.0366  | 0.9993  | 11.10   |
| 11→5   | 8.7  | 0.1287  | 0.9916  | 0.1287  | 0.9916  | 11.01   |
| 12→1   | 6.3  | 0.1097  | 0.9939  | 0.0418  | 0.9991  | 9.99    |
| 13→9   | 3.2  | 0.0558  | 0.9984  | 0.1426  | 0.9897  | 8.56    |
| D→3    | 2.1  | 0.0366  | 0.9993  | 0.0401  | 0.9991  | 11.09   |
| D→6    | 2.1  | 0.0366  | 0.9993  | 0.0366  | 0.9993  | 11.10   |
| D→9    | 2.1  | 0.0366  | 0.9993  | 0.1426  | 0.9897  | 11.10   |

Here, node 2 has three links 2→1, 2→7 and 2→8. The stable link is chosen as 2→7 as it has low mobility and high LET as depicted in Figure 3.

![Figure 3: PSA-MP MANETs Scenario with LET](image)

**4.2 Link Establishment Delay Calculation between LLFR and PSA-MP**

As per existing algorithm, the path V_S→1→2→3→V_D is chosen for sending packets. The delays taken to reach V_S→1, 1→2,...,V_D are t_1, t_2, t_3,...,t_22 respectively as represented in Fig.4.

![Figure 4: Link Re-establishment Delay Calculation](image)
The link between 2→3 is likely to break soon due to mobility the node 2 informs about its LET and mobility of its neighboring nodes to avoid link failure. So, node 2 establishes an alternate path with high LET and low mobility links among the multiple links. Here, node 2 has three links, 2→1, 2→7 and 2→8. The stable link is chosen as 2→7 as it has low mobility and high LET. In existing algorithm, the stable path is chosen as \( V_S \rightarrow 1 \rightarrow 2 \rightarrow 3 \rightarrow V_D \). It leads to link establishment delay as it chooses a stable link after link failure. But, in PSA-MP, the path is chosen as \( (i.e. V_S \rightarrow 1 \rightarrow 2 \rightarrow 7 \rightarrow 6 \rightarrow D) \) before link failure. Consider the following equations:

Total Time taken to re-establish the links after link failure

\[
LLFR = T_{lf} + t_{10} + t_{11} + t_{12}
\]

Let \( t_4 = 6\text{ms}, t_{10} = 7\text{ms}, t_{11} = 3\text{ms} t_{12} = 2\text{ms} \)

Total Time taken \((6+7+3+2) = 18\text{ms}\)

Where, \( T_{lf} \) - Time taken for link failure

Total Time taken to re-establish the links before link failure

\[
PSA-MP = t_{10} + t_{11} + t_{12}
\]

Let \( t_{10} = 7\text{ms}, t_{11} = 3\text{ms} t_{12} = 2\text{ms} \)

Total Time taken \((7+3+2) = 12\text{ms}\)

Figure 5 depicts that the proposed PSA-MP outperforms than existing algorithm with respect to link re-establishment delay. The ‘X’ axis represents algorithms which have been compared, and ‘Y’ axis represents the link(s) re-establishment delay in milliseconds.

Figure 5: Comparison between LLFR and PSA-MP

5. Result Analysis

The presentation of the result of PSA-MP algorithms are calculated using NS – 2.34. A network topology size in an area of 1000 * 1000m\(^2\) is considered. Initially 20 nodes are placed in the square grid area, where the Source and Destination are assumed to be in a stable position, and there are other nodes having mobility in different directions in the given network topology as shown in Figure 3. The link capacity is set to 256kbps. The traffic agent is set as Constant Bit Rate (CBR) and application agent as File Transfer Protocol (FTP). The mobility of nodes varies from 1.7, 2.7, 3.2, 4.2 and 5.3 m/s. Each mobility simulation runs for 100ms of simulation time as listed in Table 3.

| Parameters          | Values                        |
|---------------------|-------------------------------|
| Number of Nodes     | 20                            |
| Topology Size       | 1000 * 1000 m\(^2\)          |
| Transmission Range  | 250m                          |
| MAC Layer Protocol  | IEEE 802.11                   |
| Link Capacity       | 256kbps                       |
| Packet Size         | 512 Bytes                     |
| Mobility Model      | Random-Way Point              |
| Mobility Speed      | 1.7, 2.7, 3.2, 4.2 and 5.3 m/s |
| Pause Time          | 10ms                          |
Traffic Agent  Constant Bit Rate (CBR)
Application Agent  File Transfer Protocol (FTP)
Routing Protocols  LLFR and PSA-MP

As a result E2E delay of PSA-MP be reduced for respect to LLFR. This is because this link prediction algorithm is carried out by PSA-MP. It chooses the alternate link before link failure based on prediction of nodes mobility and LET of links. The exiting protocols select an alternate link after link failure with respect to maximum bandwidth, maximum energy and minimum count. It again leads to disconnection of links during mobility condition. The Packet Delivery Ratio of PSA-MP is increased with respect to LLFR. This is due to the reduction in link re-establishment delay. As a result, PSA-MP predicts the most stable path before link failure occurrence. Obviously, it minimizes the link failure occurrence for link re-establishment.

**Evaluation Metrics**

The presentation of the PSA-MP is calculated depends on main part of the QoS parameters.

**Packet Delivery Ratio (PDR):** This calculation between the data packets obtained and sending packets. This can be calculated as:

\[
PDR = \frac{\text{Total Number of data packets received}}{\text{Total Number of data packets sent}} \times 100
\]

**Standard E2E Delay:** It denotes time which is calculated for a packet to the broadcasted through a network follow the road Source point to Destination point.

### 5.1 Experimental Results and Discussions

In LLFR, if any link failure occurs between two nodes, it tries to revamp the link locally; or else, node selects the path which has low mobility in mobility condition. The proposed PSA-MP predicts the link before meets with link failure. As a result, PSA-MP incurs less E2E stoppage than existing LLFR protocol as revealed in Fig.6. In existing, the average E2E delay increases regularly as speed of the nodes increase in link failure condition. Graphical illustration explains the suggested PSA-MP plays LLFR with deference to mobility scenario.

![Figure 6: E2E Delay with varying Mobility Speed](image)

The presentation of existing steering algorithm is corrupted. In that time the mobility speed enlarges gradually beginning 1.7, 2.7, 3.2, 4.2, 5.3, 6.3, 7.4 and 8.7 m/s link failure also increases, resulting in more link re-establishment delay and less PDR. Figure 7 shows, the average PDR of LLFR is 94.45%, whereas the average of PDR of PSA-MP is 96.14%. The proposed PSA-MP outperforms LLFR by 1.69%
6. Conclusion

In this paper, PSA-MP is proposed to enhance the link stability in MANETs. It finds multiple paths and provides a stable link with the help of routing information such as low mobility, high LET and direction among the nodes. PSA-MP predicts the high mobility node before link failure occurs. The results with mathematical explanation that the PSA-MP momentously condenses Delay of E2E. This evaluation precisely shows that PSA-MP gives better results than LLFR. The significance of the proposed PSA-MP algorithm PDR is outperforms LLFR by 1.69%. Hence, it ensures better stability of links, minimizes the link failures and re-establishment delay.

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