ISSN: 2277–3061 (online)

International Journal of Computers & Technology
Volume 2 No. 3, June, 2012

# A Novel Approach of Stability Awareness Routing in MANETs

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## ABSTRACT
In this paper, we introduce a novel approach of stability awareness routing for efficient utilization of Bandwidth by use of Bandwidth Threshold. Earlier work on routing in MANETs had resulted in several routing protocols which targets at finding a viable route from source to destination without taking into consideration battery backup or Bandwidth availability for data transfer & they frequently fails to discover stable routes between source and destination, resulting in network overloading & discarding of data packets. In Novel stability awareness routing protocol, selects only the route which can provides minimum required Bandwidth and uptime to support the data transfer for the expected duration. The Novel stability awareness routing (NSAR) resolves the problem of SADSR protocol & provide better results in terms of route discovery success rate with multiple route establishment, maintenance overheads and enhancing QOS.

## Keywords
Mobile Ad Hoc Networks, Dynamic Source Routing (DSR), Dynamic Power Management (DPM), Stability Aware Routing, Threshold & Bandwidth.

## 1. INTRODUCTION
A MANET is a group of two or more devices or mobile nodes (such as laptops, notebooks) forming an arbitrary network without the help of any permanent infrastructure such as base station or access point. In MANET, every node functions as a router and forwards packets for other peer nodes. There is no fixed topology due to the node mobility, which results in interference, multipath propagation and path loss. Mobile nodes are restricted in battery power, computation capacity, bandwidth, and wireless channel leading to number of challenges while designing routing procedures. Determining viable routing paths and delivering messages in a decentralized environment where network topology fluctuates has always attracted the attention of researchers to design new and new mechanism to solve these problems. While the shortest path (based on a given cost function) from a source to a destination in a static network is usually the optimal route, this idea is not easily extended to MANET.

MANETs Routing protocols are classified into three categories: table-driven, on-demand and hybrid routing protocols. The table-driven routing protocols (DSDV, FSR, CGSR, WRP, and GSR) determine the path to destination before it is needed. On-demand routing protocol (AODV, DSR, TORA, ABR) determines the route to destination when required. Hybrid routing protocols uses both approaches [6] [8] .The table-driven routing protocols attempts to maintain consistent, up-to-date routing information from each node to every other node in the network. [10] [13]. On-demand routing creates routes only when desired by the source node.

In a mobile ad hoc network, nodes are often powered by batteries. The power level of a battery is finite and limits the lifetime of a node. Every message sent and every computation performed drains the battery. One solution for power conservation in mobile ad hoc network is power awareness routing. This means that routing decisions made by the routing protocol should be based on the power-status of the nodes [7]. Nodes with low batteries will be less preferably for forwarding packets than nodes with full batteries, thus increasing the life of the nodes. A routing protocol should try to minimize control traffic, such as periodic update messages to improve the lifetime of the nodes and network. However, not every routing protocol is suitable for implementing power awareness routing and different approaches on power awareness routing can be followed [11] [12].

The extremely dynamic character of a mobile ad-hoc network (MANET) poses significant challenges on constraints such as minimum hop/distance or low energy. Current routing protocols frequently fails to discover stable routes between source and sink when route availability is transient, e.g. due to mobile devices switching their network cards into low-power sleep modes whenever no communication is taking place [5]. In most MANETs, wireless traffic is infrequent and recent work [1] shows that wireless network cards should be turned inactive for 50% or less of the entire lifetime to obtain a balance between optimal power-saving and sustained network connectivity.

In this paper, we have proposed a Novel stability awareness routing protocol (NSAR) which is capable of calculating the Bandwidth & stability of multiple routes. Firstly, the proposed protocol selects the route which provides minimum required Bandwidth to support the data transfer for the expected duration of packet transmission. Proposed protocol then selects the route which minimizes hop count while staying available for the expected duration of packet transmission. The objective of this paper is to extend the network lifetime by overcoming some of the drawbacks of the existing power & stability problem of nodes in MANETS & also improving packet delivery ratio. We strive to properly utilize the ability of wireless devices to read the remaining battery energy which the device uses to determine how to route packets and their available Bandwidth. As Bandwidth is one of the essential components for efficient network resource management and seamless mobile service provisioning of Quality of service (QOS) guarantee for real time media application.

## 2. RELATED WORK

We have many numbers of algorithms which takes into consideration of routing decisions for Bandwidth estimation & power saving in MANETs.

**2.1 Multiple Parameter Approach to estimate Bandwidth in MANETs:** This paper addresses the problem of estimation of Bandwidth in MANETs[14] by considering channel busy time, channel idle time, packet transmission time & packet retransmission time under the collision conditions and handshaking time. By the observation of channel utility of the node, we can measure the activities of the node as well as its surrounding neighbors & thus obtain good approximation of bandwidth usage. The channel utilization ratio is defined as the fraction of the time within which a node sensing the channel as being utilized.

**2.2 Bandwidth Estimation in MANET:** In this paper bandwidth estimation scheme [15] is proposed which uses some components of the two methods for the bandwidth estimation i.e. "Hello Bandwidth Estimation & Listen Bandwidth Estimation". It estimates the Bandwidth by counting the used bandwidth as in the case of Listen Bandwidth estimation method. If there is a route Break then it uses the update scheme used in Hello bandwidth estimation.

**2.3 Dynamic Power Management:** MANETs has gained huge popularity over the last decade. Mobile nodes in wireless ad-hoc networks often put their wireless network cards to sleep when they are not transmitting or receiving data. In most MANETs, wireless traffic is infrequent and recent work [1] shows that wireless network cards should be turned inactive for 50% or less of the entire lifetime to obtain a balance between optimal power-saving and sustained network connectivity. But sleep modes can lead to loss of network connectivity and hence lower the packet delivery ratio. This paper focuses on routing in MANETs with transient route availabilities, i.e., route establishment takes into consideration the expiration time and therefore the stability of a potential route. This new approach is based on the prediction of future sleep times of mobile nodes (i.e., the times when mobile nodes' DPM techniques will turn off their network cards). The goal of this approach is to introduce DPM-awareness in routing decisions and thereby to increase the number of successful packet transmissions. The concept of stability awareness can be added to any routing protocol.

**2.4 Network Sleep Time:** Chia et al .[2] proposes that devices which are not currently active in any data communication may enter a sleep state, but can be powered up remotely through a signal using a simple circuit based on RF technology. Radio devices select different time-out values (sleep patterns), to enter various sleep states depending on their battery status and quality of service. In [3], Singh et al. employ a MAC layer protocol for PAMAS (Power Aware Multiple Access protocol with Signaling) in which nodes overhearing transmissions between two other nodes turn themselves off and wake up after an interval of time equal to the total transmission time as indicated in the RTS/CTS message exchange between the sender-receiver pairs. They deploy metrics such as minimize energy consumed per packet or minimize time to network partition, and verify these metrics with their proposed MAC layer protocol. In proposed protocol, the sleep and awake schedule is determined from prediction of link expiration based on the queue contents of the packet scheduler and the network interface device timeout value. The DPM schedule is somewhat conservative since it ignores the possibility of more packets being added before the timeout expires.

## 3. PROBLEM FORMULATION

Firstly, the proposed protocol selects the route which provides minimum Bandwidth to support the data transfer for the expected duration of packet transmission. We can apply any of the Bandwidth estimation technique in order to calculate the bandwidth.

We will calculate the Bandwidth by considering channel busy time, channel idle time, packet transmission time & packet retransmission time under the collision conditions and handshaking [14].

$$\mathrm{BW} = \frac{T_{\mathrm{idle}}}{T_{\mathrm{idle}} + \mathrm{T_{tx}} + \mathrm{T_{rtx}} + \mathrm{T_{hs}}} \times \mathrm{C}$$

Where $T_{idle}$ - Idle time in a Interval $T_{interval}$
C - Channel Capacity
$T_{interval}$ comprise following time periods.
$T_{tx}$ -Time taken for actual transmission of the data
$T_{rtx}$ - Time taken for retransmission of packets
$T_{hs}$ - Time taken for four-way handshaking

At any instance, there are a number of end to end flows and each flow has its own required bandwidth. Each node must determine the Bandwidth to allocate to each flow. If the neighboring nodes provides bandwidth equal or greater than the Bandwidth threshold then only link can be established otherwise new route is discovered.

If the neighboring node provides desired bandwidth, the proposed protocol then selects the route that minimizes hop count while staying available for the expected duration of packet transmission.

DPM supports energy conservation by making mobile nodes put their wireless network cards to sleep when no data communication is taking place. A consequence of this technique is that mobile nodes will be unreachable for large periods of time. Therefore, we need to know the accurate network `up' and `down' times (DPM schedule) in order to introduce DPM awareness in routing decisions. Currently the protocol predicts the DPM schedule for mobile nodes from the queue contents of the packet scheduler and the network device timeout value. Toward that end, the protocol computes the minimum time to transmit all packets currently residing in the packet scheduling queue and adds the device-specific timeout value, each data packet's transmission time is calculated as follows[4]:

$$\mathrm{T_{data}} = \mathrm{T_{rts}} + \mathrm{T_{cts}} + \mathrm{T_{ack}} + \mathrm{T_{difs}} + 3\mathrm{T_{sifs}} + \frac{(\mathrm{P} + \mathrm{Q})}{\mathrm{BW_{channel}}}$$

Where $T_{data}$ - transmission time of each data packet
$T_{rts}$ : Time for transmitting RTS
$T_{cts}$ : Time for transmitting CTS
$T_{ack}$ : Time for transmitting ACK
$T_{difs}$ : DCF inter frame space defined in the IEEE 802.11 protocol standard

$3T_{sifs}$ : Short inter frame space defined in the IEEE 802.11 protocol standard
P : Size of the data packet
Q : IP and MAC packet header length
$BW_{channel}$ : Channel capacity

The route uptime factor (RUF) is described as a metric which indicates the earliest up time when the link between any pair of adjacent nodes on a route is going to be interrupted due to one (or both) of the nodes being put to sleep. Now we derive RUF as follows: If we assume nodes as vertices and the links between the nodes as edges connecting them, then let G(V,E) be the graph representing the network topology where V is the set of vertices and E is the set of edges. Let

$$Rij = (V_i, V_{i+1}, V_{i+2}, \ldots\ldots\ldots V_k, V_{k+1}, \ldots.. V_{j-1}, V_j) \quad (1)$$

be the route from source node Vi to Vj through intermediate nodes Vk,Vk+1, etc. Let Ωij be the set of all possible alive routes between Vi and Vj . The DPM sleeping schedule Sij for the route Rij is defined as

$$Sij = (t_i^{up}, t_{i+1}^{up}, t_{i+2}^{up}, \ldots.., t_k^{up}, t_{k+1}^{up}, \ldots.., t_{j-1}^{up}, t_j^{up}) \quad (2)$$

Where $t_i^{up}$ is the earliest up time for node Vi. We define the link uptime vector or Lij for the route Rij as

$$Lij = \left(t_i^{uptime}, t_{i+1}^{uptime}, t_{i+2}^{uptime} \ldots, t_k^{uptime}, t_{k+1}^{uptime}, \ldots, t_{j-1}^{uptime}\right) \quad (3)$$

Where $t_i^{uptime}$ is the uptime of the link $Ei, i+1$ connecting nodes Vi and Vi+1 and is defined by $\text{minimum}(t_i^{up}, t_{i+1}^{up})$, since uptime of a link is determined by how long the

$$t_i^{uptime} = \text{minimum}(t_i^{up}, t_{i+1}^{up}) \quad (4)$$

link will be alive before breaking down due to one of its end nodes going to sleep and thus essentially is expressed by the minimum of the DPM sleeping schedule of the end nodes. The route uptime factor RUFij for route Rij can be expressed as the minimum of the link uptime vector Lij along the route since it will indicate how long the route will be alive before breaking down due to the break in any of its constituent links:

$$RUFi = \min t_i^{uptime}, V_i \in V, t_i^{uptime} \in Li) \quad (5)$$

Given the next earliest time to sleep ti off for each node $V_i \in V$, in the graph G(V,E), accumulate the set of all possible routes Ωij between nodes Vi and Vj with the corresponding route uptime factors RUF ij for each Rij ∈ Ωij and find the min-hop route Rij from the set of all stable routes Ωij . If there are more than one route with the same min-hop length, then the one with the minimum route uptime factor value is selected since it has the highest predicted lifetime. The route uptime factor contains the all link uptime value between two node which is satisfied the transmission threshold value. The each node stores the link uptime vector which contains the all stable link between two nodes from source to destination.

## 4. PROPOSED WORK

In this we offer to introduce a Novel Approach of Stability Awareness routing in MANETs & proposed work is divided into following sections.

**4.1 The proposed work will follow the following steps in order to identify the stable path.**

1. Firstly, Source Node initiates the Data Transmission Request.
2. Check for the destination node in route cache. If found then forward the data packet to Destination.
3. If destination node is node found in route cache then broadcast the route request Packet (RREQ) to their neighbor node
4. If Tb ≥ BTH
   Then Calculate the Link Uptime Vector.
5. Calculate the link uptime value between the nodes
   $t_i^{uptime} = \text{minimum}(t_i^{up}, t_{i+1}^{up})$
6. If $t_i^{uptime} >$ th (Threshold) then add in to the link uptime vector
   $Lij = \left(t_i^{uptime}, t_{i+1}^{uptime}, t_{i+2}^{uptime} \ldots, t_k^{uptime}, t_{k+1}^{uptime}, \ldots, t_{j-1}^{uptime}\right)$
   and forward the packet to the next node.
7. If the intermediate node receive more than two RREQ packet then
   If $t_i^{uptime}$ .previous RREQ > latest RREQ then forward previous RREQ and discard latest RREQ otherwise forward latest RREQ
8. Repeat step 3 to step 6 till destination is found.
9. If destination found then store all route in to the routing table in increasing order of Route
   Uptime Factor, RUFij = $\min t_i^{uptime}, V_i \in V, t_i^{uptime} \in$ Li) and send RREP to the first entry of routing table.

**4.2. Algorithms:** The proposed work will utilize the following algorithm in order to find out the stable path.

**4.2.1. Algorithm for forwarding the data packet from source to destination is as follows:**

```
#Algorithm NSAR (DA Destination Address, DP Data Packet, Route_Cache)
// TTL=16
{
n = Count(Address)

For(i=0; i<Route_cache_size; i++)
{
If (Route_Cache[i]==DA)
{
forward DP;
break;
}
Else

{
X = Find_Route(Tkup,Tb,DA,Threshold,LUV,BTH);
If X=RREP
{
RUF=min(LUV);
add X of min(RUF) in Route_Cache;
}
Else
{
Drop DP;
Forward RERR;
```

```
Break;
}
}
}
}
```

**4.2.2 Algorithm for find stable routes between source to destination:**

```
# Algo Find_Route(T kup,Tb,DA,Threshold,LUV,BTH)
{
If(DA==NA)
{
Return 0;
}
Else If (TTL<=n)
{
If (Tb>BTH)
{
Tkuptime=min(Tkup,Tk+1up);
Prev.Tkuptime=Tkup;

If (Tkuptime>Threshold)
{
addTkuptime to LUV;
forward RREQ;
if (Node_Visited==0)
{
if(Prev.Tkuptime>Tkuptime)
Forward (Tkuptime=min(Prev.Tkuptime,Tkuptime));
else Forward (Tkuptime=min(Tkuptime,Tk+1uptime));
}
Find_route (Tkuptime,DA,Threshold,LUV);

}
else drop the DP;
}
else drop the DP;
}
}
```

**4.2.3 Algorithm for the Node already visited**

```
#Algorithm Node_Visited(NA Node Address)
{
n = Count(Add)
For(j=0;j<n;j++)
{
if (NA == Add[j]);
return 0;
}
return 1;
}
```

**4.3 Route discovery phase in Novel Stability Awareness Routing**

When a source node needs to send a data packet to a target node, it first searches its routing cache for any entry using the target node address as the key [5]. An entry in the routing cache contains a list of stable routes to the target node. If a routing cache entry is found, then the source node picks a route. If no entry is found for the target node, then the source node initiates a route discovery for the target. The proposed protocol adds five new entry types to the RREQ packet format of standard DSR [9] which are:

1. Link Uptime Vector = $(t_i^{uptime};\ i \in (1, \dots \dots, N-1))$ for the route.
2. Partial route
   Rij = $V_i, V_{i+1}, V_{i+2}, \dots \dots \dots \dots V_k, V_{k+1}, \dots . . V_{j-1}, V_j)$
3. Earliest Up-time of Last-upstream node $(t_i^{up})$
4. Bandwidth Threshold ($B_{TH}$)
5. Threshold value ( Th =$T_{data}$ transmission time of each data packet )

The protocol allows intermediate nodes to forward many RREQ packets with the same <source address, request id> pair if the packets contain distinct source routes. During the RREQ lookup at intermediate nodes, the 4-tuple <source address, request id, last upstream node address, partial route length> is checked with each entry in the recently seen requests list for possible match. If no match is found, then the RREQ contains a distinct source route and is eligible to be forwarded if the contained source route is predicted to be stable. If the intermediate node receives the more than two RREQ packets. It does not forward these all RREQ packet to their neighbor node. The intermediate node performs the comparison between the received RREQ and the previous RREQ packet. If uptime of previous RREQ is greater than to the Received RREQ then discard the received RREQ and forward the previous RREQ uptime.

<table>
<tr><td>Source Address</td><td colspan="2">Source Sequence</td><td>Destination Address</td></tr>
<tr><td colspan="2">Partial Route</td><td colspan="2">Link Uptime Vector</td></tr>
<tr><td colspan="3">Earliest Up-time of Last Upstream Node</td><td>Threshold value</td></tr>
</table>

**Fig.4.1 Route Request (RREQ) packet in NSAR**

RREQ packet header of NASAR has the four new entries in the standard RREQ packet header of DSR.

NSAR predicts the route stability using a link by link stability prediction. Each intermediate node receives RREQ and predicts the stability of the link between itself and the last upstream node. All previous links in the source route are assumed to be stable; otherwise the previous upstream nodes would not have forwarded the RREQ packet. Thus the stability of the current link ensures the stability of the entire source route. For each received RREQ, intermediate node VK+1 calculate the uptime of the link between itself and the last upstream node recorded in the RREQ and appends it to the Link Uptime Vector in the RREQ. If the uptime is less than Threshold, then the link will not be stable for the entire period of exchanges of the RREQ, the following RREP and then the data packet. Hence the intermediate node discards the RREQ.

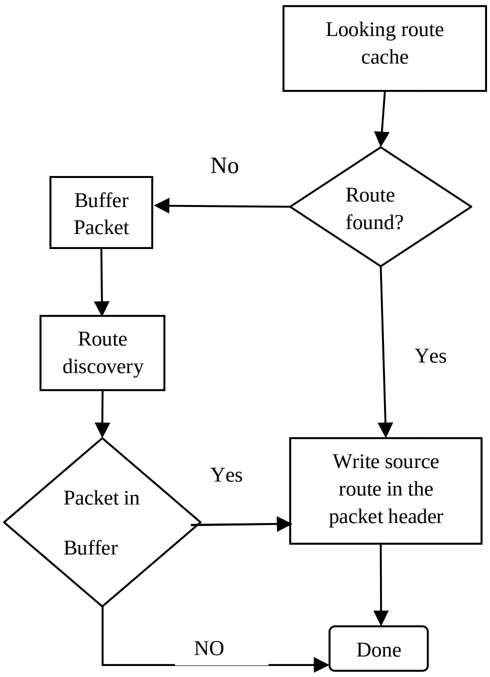


**Fig.4.2 Flow chart of route discovery at source node**

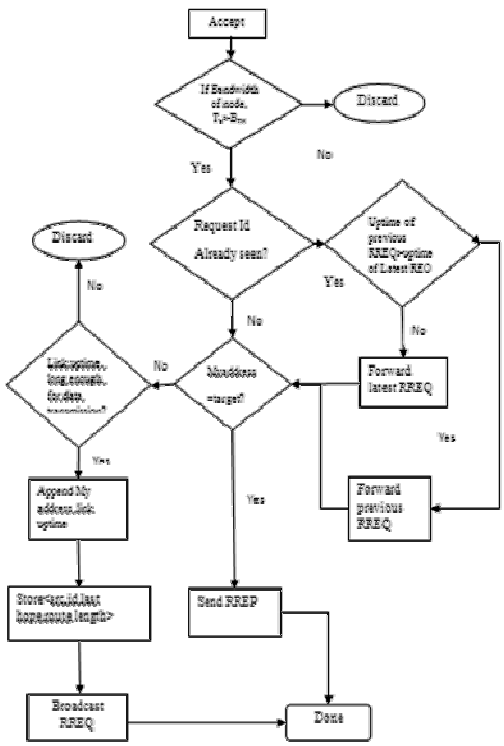


**Fig.4.3 Flow chart of route discovery at Intermediate node**

### 4.4 Route reply phase in NSAR

When the RREQ reaches the target, the route is predicted to be stable; the target node sends an RREP packet back to the source along the reverse path recorded in the RREQ. In this proposed protocol the routing table is maintained at the destination node. At the destination node all the stable route is stored in the routing table in increasing order of the Route uptime factor. In the route reply phase the destination node simply sends the one RREP packet which contains the first entry of the routing table. Thus it leads to reduce the total transmission time between source to destination. The proposed protocol adds four new entry types to the standard DSR [9] RREP packet format:

1. source route
   Rij =
2. Link uptime vector (
3. Earliest up time. The minimum of all the Link Uptime Vector elements.
4. Estimated Transmission Time

| | |
|---|---|
| Source Route | Link Uptime Vector |
| Earliest Up Time | Estimated Transmission Time |

**Fig. 4.4 Route Reply (RREP) packet Format in NSAR**

### 4.5 Route selection phase at the destination node

At the destination node all the stable route is stored in the routing table in increasing order of the Route uptime factor. In the route reply phase the destination node only send the one RREP packet which contains the first entry of the routing table. Hence it leads to reduce the total transmission time between source and destination.

| | | |
|---|---|---|
| Destination Address | Source Route | Earliest up Time |

**Fig. 4.5. Routing table Entry in NSAR**

## 5. EXPERIMENTAL RESULTS

In order to validate the proposed protocol and to show its competence we present simulations using MATLAB.

### 5.1. Setup

- The simulated network area is 25pixelX25pixel with 10 to 25 nodes.
- Network simulates a random interval constantly for each transmitting node. Each node stays up for the input Uptime percentage of the simulated random interval and notifies the routing module about its next earliest time to sleep each time when it is up.
- Every simulation was run for 10 trials, with a full range of uptime percentages from 0% to 100% with an interval of 10%. Each trial was run for 120seconds. Each transmitting source node attempts to send one data packet to the sink node.
- Nodes intermediately turn off their network cards for power-saving in absence of important communication,

which leads to link failures and low network connectivity.

- Simulated network uses the uptime threshold value of 0.1 & Bandwidth Threshold value of 0.24 for each link stability in the case of Bandwidth measurement.
- Simulated network uses the uptime threshold value of 0.3 & Bandwidth Threshold value of 0.24 for each link stability in the case of Uptime measurement.

### 5.2. Results

We assess the performance of NSAR in terms metric as following:

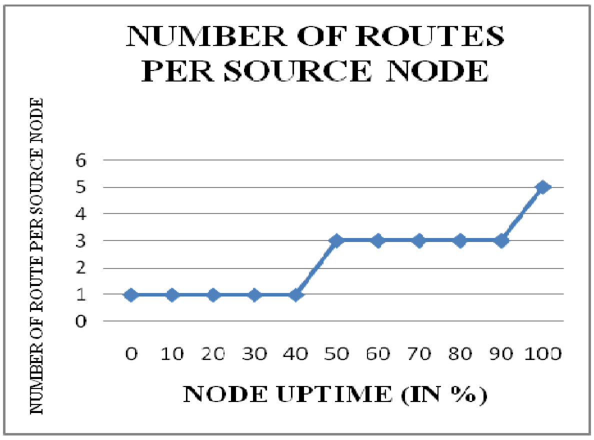


**Fig. 5.1. Number of routes per source node w.r.t. Uptime Value of each Node**

In fig 5.1, we measure the number of routes per source node while considering the uptime value of each node which is varying from 0 to 100%. The graph firstly shows only one route & remains constant till 40%. But then it drastically increases to 3 routes at 50 % & remains constant till 90 %. At 100 % increment of RUF, we are able to achieve 5 routes per source node which is a notable performance & ahead of standard DSR.

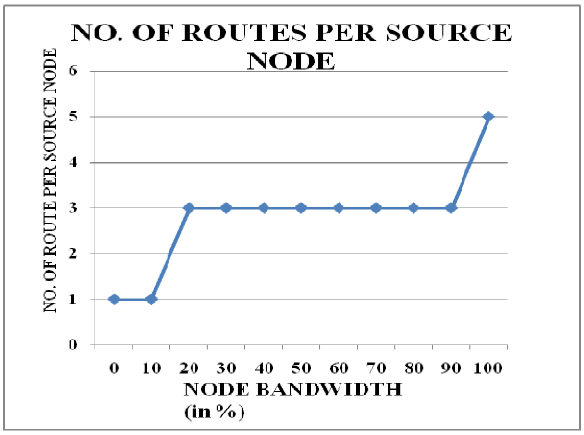


**Fig 5.2. Number of routes per source node w.r.t. Bandwidth Threshold**

In fig 5.2., we measure the number of routes per source node while considering the Bandwidth Threshold which is varying from 0 to 100%. The graph firstly shows only one route till 10 % & after increment we get 3 routes & it provides a stable path constantly till 90 %. `Afterward it increases to 5 routes per source nodes. Its performance is better in comparison to the previous graph of uptime value.

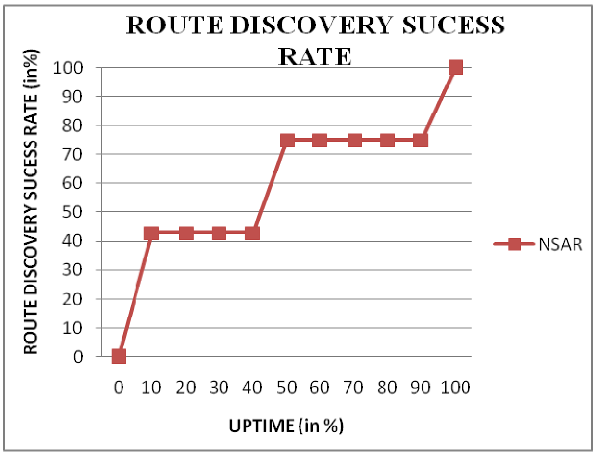


**Fig. 5.3. Route Discovery Success Rate**

In fig 5.3., we measure the route discovery success rate in NSAR. Route discovery success rate is measured as the ratio of number of successful source nodes getting RREP packets back to the number of source nodes sending a RREQ packet. This graph gives a remarkable performance improvement over previous routing protocols as it uses both the Bandwidth threshold and stability metrics in route discovery and thus finds more routes. A 100% success rate is achieved at uptime percentage of 100%.

## 6. CONCLUSION

The proposed protocol *"Novel Stability Awareness Routing"* introduce Bandwidth estimation & DPM awareness into the routing decisions and finds numerous stable routes to the target node. The proposed protocol provides a considerable enhancement in successful packet transmissions with comparable route establishment and maintenance overheads. NSAR solves the problem of SADSR routing problems and decreases the packet overhead on each node and minimizes the traffic of packet transmission. NSAR is based on the prediction of available Bandwidth & future sleep times of mobile nodes. NSAR is hard in sense that it may discard any RREQ which it considers to be non-stable and as a result may lead to a situation where the source node fails to discover any stable path to the sink node. But it can provide a user-specified data rate & enhanced end-to-end transport performance.

## 7. ACKNOWLEDGMENT

We are extremely thankful to Mr. Aniket Mathuria, Assistant Professor, SRMIET, Ambala for his valuable guidance and continuous support in making this paper.

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