Asian Journal of Information Technology 15 (2): 255-262, 2016
ISSN: 1682-3915


# A Link State Based Route Discovery for Probabilistic Broadcast Approach to Reduce Broadcast Storm Problem in Manet

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**Abstract:** Broadcast is a basic operation for communication by forwarding a message from a node to all other nodes in a Mobile Ad-Hoc network. A broadcast storm occurs while a network is saturated with a huge amount of broadcast traffic. The broadcast storm results in a contention and collision in a high dense network. Hence, this study proposes a link state based route discovery approach to reduce the number of broadcast chain. A probability value is assigned to each link according to the information tracked at unit time interval and based on that value the link can be selected for further broadcast. Hence, the number of broadcasts is minimized by checking the link state information to reconnect the previous nodes. The proposed approach is compared with the existing broadcast strategy approaches and the performance is measured in terms of broadcast ratio, rebroadcast, success rate and number of forwarding nodes. The experimental results show that the proposed approach performs better than the previous approaches.

**Key words:** MANET, broadcast, link state based probabilistic route discovery, broadcast storm, node

## INTRODUCTION

Mobile Ad-Hoc Networks (MANET) comprise of mobile nodes that are self-organizing network establishing connected via multihop wireless links. Due to depletion of energy resources and behavior of users in MANETs, link breakages can occur frequently that lead to path failures which make to discover the routes regularly (Belghith *et al*., 2012). The main issue during the route discovery processis to determine the effective route which is stable for long periods. The traditional on demand routing protocols like adhoc on demand distance vector and dynamic source routing uses the flooding method for route discovery (Zhang *et al*., 2013). These protocols utilize less bandwidth for routing in light of the fact that the connection is created just on the premise of the necessities of a specific node.

In the flooding schemes, a source node forwards the RREQ packet to all of its neighboring nodes which cause the redundant RREQ packet and this problem is termed as a broadcast storm problem and it lead to a significant number of packet collision and traffic problems. The broadcast storm problem is notified and few methods like distance based methods, probability based methods, counter based methods and neighbor knowledge has been proposed and these methods reduce the problem in a least possible level.

Thus, in this study, a link state based route discovery approach has been proposed to reduce the number of broadcast chain. The link state information contains link tolerant capacity, the delay value and the probability of the link and it has been maintained by all the nodes from its one hop neighbors. During the route discovery, the link state information alone can be checked to reconnect the previous nodes and it will eventuallyreduce the number of the broadcasts when compared to the previous methods.

**Literature review:** (Jang and Hung, 2010) proposes a Directive Location-Aided Routing (DLAR) protocol to select the neighbor nodes based on the mobility direction of the source node to prevent the broadcast storm. Furthermore, the route discovery process is achieved by employing the AODV for location aided routing and uses the local repair procedure to initiate path discovery at the local disconnected location in order to fast up the path discovery process. The performance of the protocol is measured in terms of RREQ packet capacity, packet delivery ratio and so on and it is compared with the existing protocols like AODV, DSR and LAR. The simulation results show that the DLAR protocol achieves a better performance than the existing protocols.

Kalani *et al.* (2014) proposed a 2-hop neighbor based protocol in order to reduce a broadcast storm in MANET by selecting the minimum number of hops using self-pruning and dominant-pruning. The network coding idea (COPE) is used in order to overcome the number of transmissions by victimization using logical operation. A

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new effort has been made in the process by introducing an ant colony optimization to the COPE protocol with pruning algorithm. The pheromone value is used to decide the packet combination and this value is estimated based on the intersection of the forward node packet list by pruning algorithm and the sender packet list. The experimental results show that the protocol has the best capability to reduce the broadcast storm.

Zhang *et al*. (2013) proposed a neighbor coverage based probabilistic approach for broadcast problem. A rebroadcast delay has been proposed to find the rebroadcast order and then the additional coverage ratio has been accurately obtained by sensing coverage knowledge. A connectivity factor has been defined to offer the node density adaptation. A rebroadcast probability has been set by combining the connectivity factor and additional coverage ratio. Thus the approach takes the advantage of the probabilistic technique and neighbor coverage ratio and the results shows that the approach can reduce the retransmission significantly by enhancing the routing performances.

Khalaf *et al*. (2010) proposed a dynamic probabilistic broadcasting algorithm for the Broadcast storm problem in MANET. The approach improves by including the well-known Ad hoc On demand Distance Vector protocol (AODV). The simulation results show that the proposed approach outperforms better than the existing approaches.

Zhou *et al*. (2011) proposed lightweight, reliable service discovery approach which uses the basis as a Service Magnetic Field (SMF) concept and a cross layer is implemented to integrate the SMF and AODV routing protocol. The SMF determines the more efficient service providers to the consuming node andadditionally it provides information about the direction for the service discovery and it ultimately reduces the number of broadcast packets. The experimental results show that the approach is more effective than the previous approaches.

Mohammed *et al*. (2007) proposed a broadcasting scheme by integrating the advantages of traditional probabilistic and counter-based schemes to minimize the broadcast storm in MANET network. The simulation result shows that the system achieves a significant performance in terms of reachability, rebroadcast and latency.

Yassein *et al*. (2013) proposes an adaptive algorithm to reduce the overall network overhead with minimizing the broadcast storm problem. In additionally, the performance of the different traffic types such as traffic GEN and Constant Bit Rate (CBR) has been evaluated. The simulation results show that the algorithm enhanced the overall network performance. The evaluation of the traffic type concludes that the traffic GEN outperforms CBR traffic in terms of throughput and delay values.

Belghith *et al*. (2012) proposes a proactive routing framework based on a generic model and probabilistic decisions to evaluate the existence probabilities of links and nodes. In addition, a distributed algorithm has been presented to gather the cartography of the network. This cartography is utilized to instantiate the presence probabilities. The simulation results show that the scheme performs better than the conventional routing protocols.

Kaur and Garg (2014) proposed a scheme to reduce the broadcast storm problem and the scheme takes the advantage of techniques such as neighbor knowledge, particle swarm optimization and probabilistic rebroadcast. The order of forwarding is decided by calculating the rebroadcast delay. The rebroadcast probability is determined by the neighborhoods covered set. The probability of rebroadcast is determined by comparing the rebroadcast probability with the value of the particle swarm optimization function. The simulation results show that the scheme has the capability to reduce the broadcast storm better than the existing approaches.

Khalaf *et al*. (2012) proposed velocity aware route discovery approach to mitigate the broadcast storm problem. The approach excludes the unstable nodes during the route discovery process. The simulation results show that the approach performs better than the existing approaches in terms of link stability and RREQ packet overhead.

Yang and Wu (2010) proposed a scheme using a directional antenna for efficient broadcasting in MANET. The network coding is used to reduce the number of transmissions. The forwarding nodes are selected using the directional antenna for transmitting the coded messages to the predefined sectors. The simulation results show that the scheme reduces the number of transmissions in the broadcast application.

## MATERIALS AND METHODS

**System model and problem statement:** The MANET is modeled as uni-directed graph:

$$G = (V, E)$$

Where:

V = A finite set of nodes in the network
E = The set of link between the nodes

The network is a complete graph where each node consists of at least one incoming and one outgoing link. The nodes in the network support the bidirectional abstraction. The link's broadcast time is fixed to be constant (despite of node mobility).

While during the route discovery phases, the source node flood the RREQ packets to its neighbors. These neighbor nodes flood the control message to all of its neighbors and this process is repeated until the destination node D is reached. Then D sends theroute reply control packets to the source, hence the path is discovered. Some of the nodes which cannot able find the path also takes part in the route discovery process and unnecessary RREQ messages are flooded and it leads to collision, channel contention and congestion in the network. If the network overhead increases then battery power, node energy and bandwidth are wasted and it will result in link failure (Sakhaee *et al*., 2007). The failure can be reported to the source node by sending the RERR message by the intermediate nodes. Again, the source node starts the route discovery process and these processes result in a broadcast storm problem. Hence, the study proposes the link state based route discovery Approach where every node maintains the one hop link state information to rebroadcast the message that resolves the above mentioned problem.

**Link state based route discovery approach:** The outcome of the broadcast storms is the heavy traffic contention and therefore collisions of packets because of huge flooding of broadcasts between neighboring nodes where huge control overhead will be the result. In this study, a link state based route discovery approach is proposed which is a probabilistic approach and aims to reduce the broadcast chain in order to reduce the broadcast storm problem. In this approach, the number of broadcast is reduced after the initial transmission with a pre-determined link state so that every node maintains the one hop link state information to rebroadcast the message in spite of its number of neighbors. Limiting the flooding of RREQ and selecting effective link will reduce the control overhead which ultimately reduce the broadcast storm in the proposed approach.

**Link state information:** After the initial transmission, the link state information is generated for each uni-directed link connected between the pair of nodes. When a source node initiates a broadcast with one RREQ message then the delay value of each link has been calculated based on the time difference between the received RREP message and the forwarded RREQ message and it has been given in the following equation:

$$\text{DelayTime}(\text{DT}) = T_{\text{RREP}} - T_{\text{RREQ}} \quad (1)$$

The link's delay time is fixed to be constant despite of its node mobility. The link usage is the number of times the link is repeated for further broadcasts (i.e., number of requests and replies passing at unit time interval t of a link between the nodes) from the other nodes that has been maintained to know the stabilityof the link and it has been given as follows:

$$\text{LU} = \sum_{i=1}^{t} l_i \quad (2)$$

A Link tolerant Capacity (LC) is considered as one metric in link state information to avoid the link failure while during the data transmission check the number of rebroadcasts. Let X is the total number of packets transmittedfrom node $n_i$ to the node$_j$ via a link$_{ij}$ and Y be the number of packet received by node$_j$ from node$_i$ then the packet drop can be calculated as follows:

$$\text{Packet drop} = x - y \quad (3)$$

Then, the link tolerant capacity is evaluated as follows:

$$\text{LC} = \sum_{i=1}^{t} x - \text{packet drop} \quad (4)$$

where, t is the time period for the total packet transmission of the link in the network broadcast storm problem leads to resource wastage which is to be limited in the network. So, this method considers the probability to select the node as a forwarding node. The probability is based on the earlier behavior of the links between two nodes. To compute this probability, a forwarding index ($\mu_k$) is used as probability of selecting the neighbour to initiate a route request. A forwarding index is calculated based on the link state information to find the efficiency of the link during the route discovery process and it has been given as follows:

$$\mu_k(l_i) = \frac{\text{LC} \times \text{LU}}{\text{DT} \times 1000} \quad (5)$$

For every attempt each node updates the fi for every outgoing link using:

$$\mu_k \leftarrow \mu_k \times \alpha + (1-\alpha)\mu_{k-1}$$

Here, $\alpha$ is a constant $0<\alpha<1$. At initial attempt each node forwarding index on every outgoing link is considered as 1. After the initial $\mu_k$

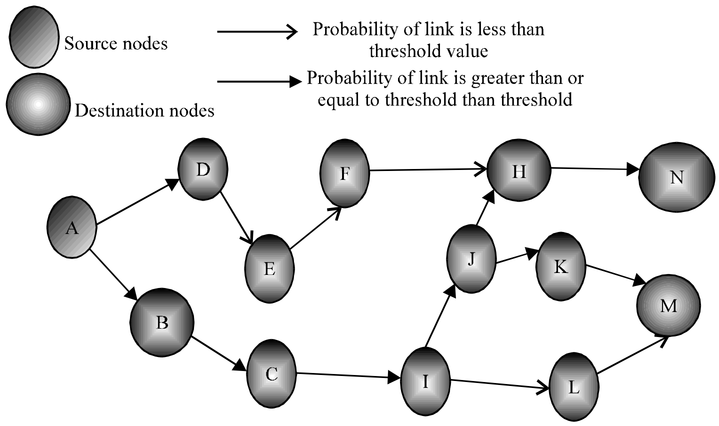


Fig. 1: Example of path discovery using the proposed approach

attempt is computed in every attempt. A threshold level for $\mu_k$ is given as 0.55. Any $\mu_k$>0.55 is deliberated as eligible link to be explored for connectivity.

**Route discovery:** The working of the proposed approach is explained through the following example. Consider a MANET topology as shown in Fig. 1. During the initial data transmission the nodes obtain the link state information and the probability of the link using the Eq. 3 of its one hop neighbors. Let the source node, A initiate a broadcast by sending RREQ message to its one hop neighbors in the network, respectively. The node D does not forward the RREQ to the node E due to the probability of the link being less than the threshold value. In the similar manner, the link between F and H, I and L does not take part in the route discovery process. So, the forwarding nodes are B, C, D and F, I, J, K and N. When, it reaches the destination the RREP packet is forwarded through the shortest path found through the proposed approach. And the shortest path determined by the proposed approach is A-B-C-I-J-K-M. The algorithm of the proposed approach has been given in algorithim. The number of broadcasts is minimized at the second transmission (lesser when compared to the previous methods). This reduces the broadcast chain.

### Algorithm of the link state based route discovery approach

Begin
Step 1: Initial Data Transmission
Step 2: Nodes in the network collects the link state information of its one hop neighbors
Route Discovery Phase during second transmission
Step 3: Check a source node initiates for the route discovery
Step 4: Then
Check the link state of its one hop neighbors
Step 5: Then
Check if ($\mu_k$(li)≥threshold value)
Step 6: Then
Connect to the previous node via link$_i$ by broadcasting RREQ message
Step 7: Else
Switched to the next possible link
Step 8: End Condition Step
9: End Condition
Step 10: Check if Destination Reached
Step 11: Then
Step 12: RREP packet is send to the shortest path from
Step 13: Else
Step 14: Repeat step 4 to step 10
Step 15: End condition
Step 16: End Condition
End

**Route maintenance:** The algorithm for route maintenance phase of the proposed approach. This phase checks the link state at regular interval of time to know the link is stable or broken. When a link provides P_ACK then check the number of times P_ACK provided by that link and if it is less than the threshold level,then the link can remove the corresponding request path and accept a new communication. As the number of P_ACK increases, the link will be flooded before which the link must be erased by the Routing Process (when P_ACK>Threshold). When a link failure occurs, then all the communications must be removed from the routing and re-broadcast occurs.

### Route maintenance algorithms:

Begin
Step 1: Check If link provides P_Ack
Step 2: Then
Check If N(P_Ack)< threshold
Step 3: Then
Remove the link and accept the new communication
Step 4: Else
Remove the link completely from the routing process for next sequential process
Step 5: End Condition
Step 6: End Condition
Step 7: Check If link failure occurs
Step 8: Then
Step 9: Erase the communication and rebroadcast occurs
Step 10: End Condition
End

## RESULTS AND DISCUSSION

The proposed Link State Based route discovery approach (LSB) attempted to minimize broadcast storm problem improves the network performance. The NS2 simulation has been used to assess the performance of the proposed approach and the simulation setup is shown in the Table 1. The performance of the proposed approach is compared with other existing approaches such as Bouble Covered Broadcast (DCB), Efficient Broadcast based on network Coding and Directional antennas (EBCD). The performance of the protocol is measured in terms of forward success rate, broadcast ratio, rebroadcast counts and number of forwarding nodes.

### Performance metrics

**Success rate:** Success rate is the ratio of packets received at each node by the total number of packets broadcast in the network.

**Broadcast forwarding ratio:** Broadcast forwarding ratio is the ratio of broadcast packets retransmitted by the network nodes for one broadcast operation.

**Rebroadcast counts:**: A rebroadcast count is the number of times the rebroadcast occurs in the network due to the data packet does not reaching successfully to the destination.

**Mobility:** The mobility of node impacts badly on the performance during the broadcast operation. Since, the node moves fast there is higher chance to lose the broadcast packet.

The proposed approach increases the broadcast success rate by excluding the link which does not have the ability to reach the destination. Figure 2 shows the broadcast success rate with respect to network size. The broadcast success ratio increases as the network size increases. The proposed approach attains maximum broadcast ratio when compared to the existing approaches.The proposed LSB achieves 86% broadcast ratio for 30 nodes while the EBCD and DCB incurred 79 and 63%, respectively.

Figure 3 shows the number of forwarding nodes with respect to the network size. In the proposed approach, the total number of the forwarding nodes is comparatively stable for various sizes of the network. The DCB selects the forwarding nodes which arecovered by 2-hop neighbors of the sender and covering at least two forwarding 1-hop neighbors.

Hence, it is unstable for the smaller network. The EBCD selects the forwarding nodes locally using directional antenna and it is unstable with respect to the network size increases. The forwarding set selected by the proposed LSB using the link state information will be stable until there is no link breakage or link fading in the network.

The source node waits for a time to overhear the rebroadcasting from its forward nodes. If it fails to identify all its forward nodes while forwarding the packets during this duration, it assumes that a transmission has been failed for this broadcast due to the missed forward nodes are out of its communication range. Afterwards, the sender rebroadcast the packets in the network till all the forwarding set has been retransmitted successfully. The proposed approach considers the stable link in the route

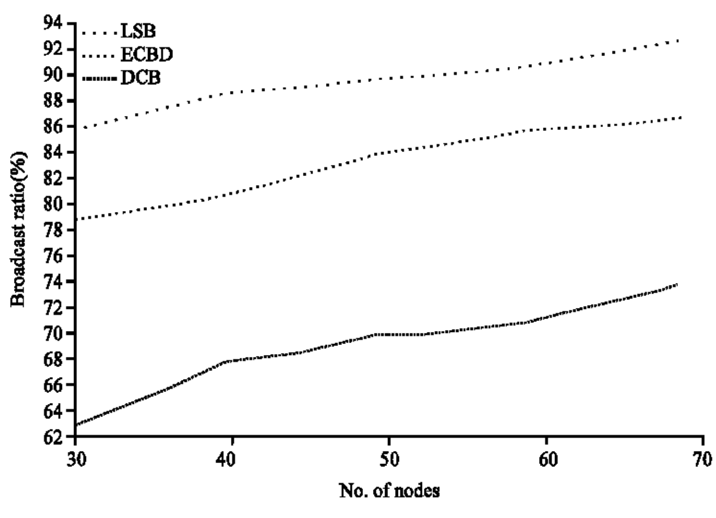


Fig. 2: Broadcast successes

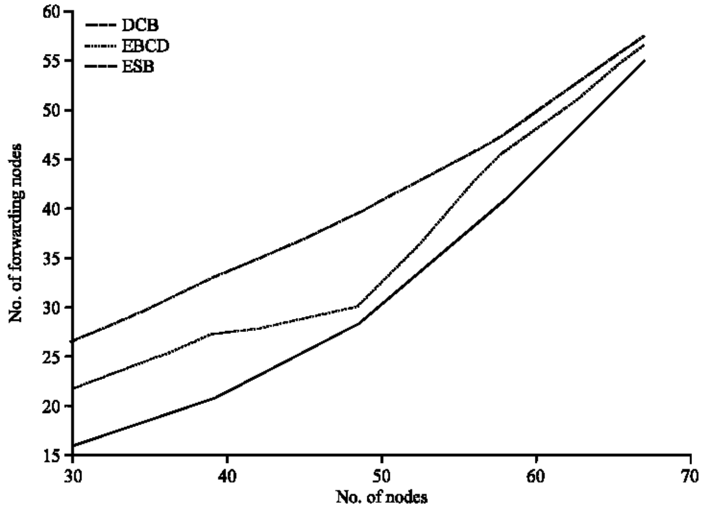


Fig. 3: Broadcast forward

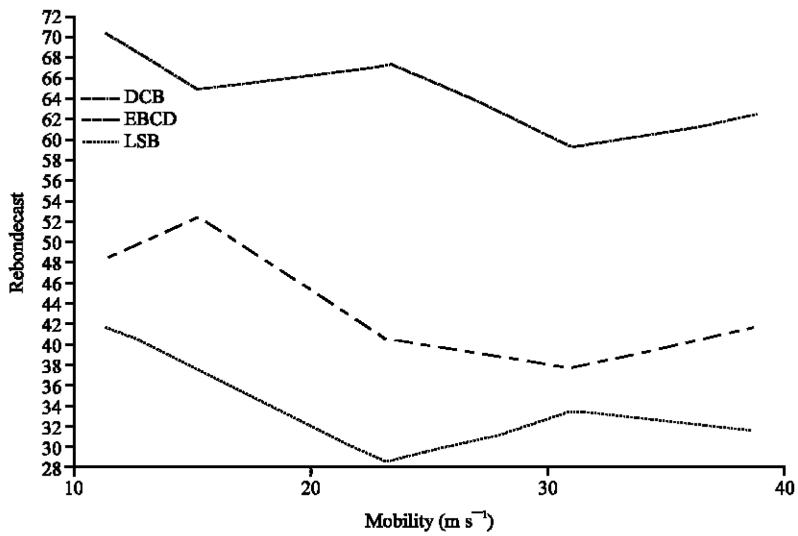


Fig. 4: Rebroadcast

discovery process so, the rebroadcast will be less when compared to the existing approaches. Figure 4 shows the rebroadcast count with respect to the mobility where the proposed approach is attained minimum rebroadcast when compared to the existing approaches. The rebroadcast count of LSB is 37 for the 10 $sec^{-1}$ mobility while the EBCD, DCB incurred 53, 66 rebroadcast count.

The forwarding nodes correctly forwards the broadcast packet successfully. The broadcast packets have been successfully forwarded in the proposed approach by considering the link capacity in the link state information. Figure 5 shows the success rate with respect to mobility where the proposed LSB attains a maximum success rate when compared to the existing approaches. The LSB achieves 91.8% success rate for 10 $m s^{-1}$ mobility while the EBCD, LSB incurred 81.7, 76% success rate.

Table 1: Simulation setup

| Simulation parameters | Values |
|---|---|
| Simulator | NS-2 |
| Topology size | 500×500 |
| Number of nodes | 30, 40, 50, 60, 70 |
| Transmission range | 250 m |
| Traffic type | CBR |
| Packet size | 512 bytes |
| Pause time | 0s |
| Min speed | 1 $m s^{-1}$ |
| Max speed | 5 $m s^{-1}$ |
| MAC protocol | IEEE 802.11 |
| Routing protocol | AODV |
| Simulation time | 100s |

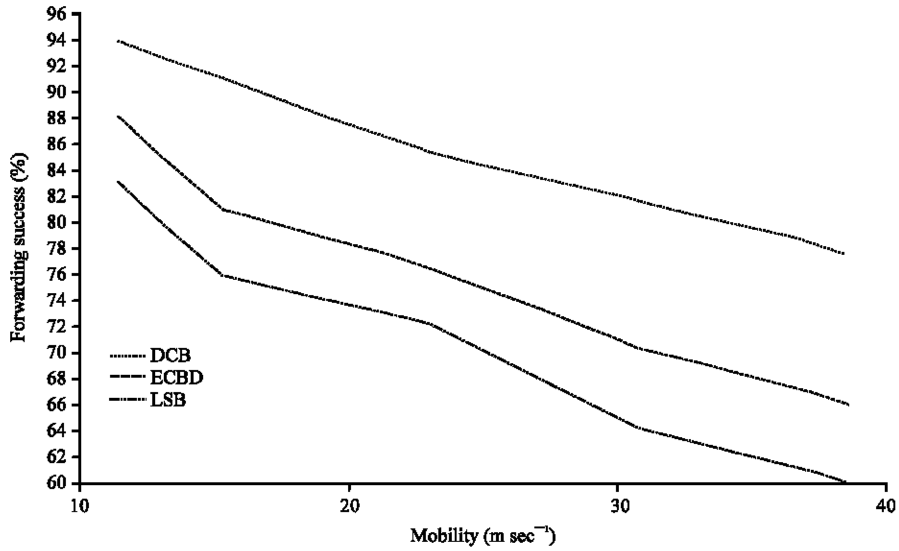


Fig. 5: Success rate

## CONCLUSION

The link breakages may make the source node to initiate the route discovery process regularly by broadcasting RREQ message. Hence, there is a need to find an efficient path while during the route discovery phase with minimum number of broadcast to reduce the broadcast storm problem. Thus, this study identifies important issue in MANET, the broadcast storm problem and proposed a link state based route discovery approach for reducing the number of broadcast chain. The number of requests and replies passing at unit time interval of a link between the nodes is tracked for the next sequential process.

Every node maintains the link state information of its one hop neighbors to know the efficiency of the link that it is capable to take part in the Route discovery process. Hence, the number of broadcast is minimized by checking the link state information only. The simulation results show that the system performs better than the existing approaches in terms of broadcast ratio, rebroadcast, success rate and number of forwarding nodes.

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