

# Failure history-based routing protocol for mobile ad hoc networks

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## Abstract

Mobile Ad-hoc NETWORKS (MANETs) are defined as a collection of mobile nodes that cooperate in order to operate. Nodes in MANETs should build and maintain routes in order to communicate. A routing algorithm is used to manage these routes. MANETs have dynamic topology because of node mobility. The probability of route failure increases when intermediate nodes have higher mobility. This study will propose a routing protocol that depends on the failure history of the nodes from which the route will be constructed. The proposed protocol will be implemented over the existing Ad hoc On-Demand Distance Vector (AODV) routing protocol. It is expected that the proposed protocol will improve the packet delivery ratio in the network.

**Keywords:** MANET; Routing; AODV.

## 1. Introduction

The main property of a MANET is that it does not need any type of infrastructure to operate (Bamrah, 2016), (Bouhorma, 2009). There are many limitations on MANET operations. The following are the main limitations (Toh, 2002):

a) Transmission Range.

Each node has a limited transmission range. Nodes can directly send and receive messages to and from other nodes that lie within the transmission range. If the destination node lies outside the transmission range, then the message should be sent through one or more intermediate nodes.

b) Physical Topology.

Nodes in a MANET are free to move in any direction, so that this causes continuous changes in network topology.

c) Energy.

The nodes are powered using batteries. Energy should be taken in account when designing a MANET because it can be consumed rapidly.

d) Infrastructure.

A MANET has no infrastructure, and there is no central administration. Each node in a MANET should be able to operate as a host and as a router.

Messages exchanged between far away nodes are sent using a routing algorithm that is used by each intermediate node to determine the path that the message should take to reach the destination node. The routing algorithm has one or more metrics to select the best routing path. There are mainly two types of routing algorithm used in MANETs (Jadeja, 2013).

e) Proactive Routing.

In this type of routing, each node has routing information stored in a routing table (Toh, 2002). Each node selects the next hop according to what is stored in the history table. This type of routing is used in many protocols such as Sequence Distance-Vector Routing (DSDV) (Perkins, 1994).

f) Reactive Routing.

In this type of routing, there is no need to store any routing information a priori, because the routes between nodes are discovered only when needed (Murthy, 1996). Any node that needs to send a message to another node first sends a request message to discover a route to the destination node. When a reply is received, the source uses the discovered route and starts sending messages. Reactive routing is used in many routing protocols, such as the Ad hoc On-Demand Distance Vector (AODV) routing protocol (Perkins, 1999).

## 2. Motivation and contribution

Most of existing routing algorithms in MANET concentrate on finding the shortest path between source and destination, without giving an importance to the routing reliability. Our proposed protocol uses history information to select the best route rather than the distance between source and destination.

Our contribution will be introducing a reliable routing protocol to address the routing problem in MANETs and improve the packet delivery ratio. We will implement our protocol by modifying existing AODV protocol and compare their performance using many simulation scenarios according to different mobility patterns. We will design and run our simulation using NS2 simulator.

### 3. Related work

Many algorithms were proposed to address the problem of finding stable routes in MANETs. Below, we will discuss some of these algorithms.

a) Associativity-Based Routing protocol (ABR) (Toh, 1997)

ABR was proposed to select the best route by studying the behavior of nodes in the MANET. It is a reactive protocol that finds that route only when needed. ABR uses an associativity scheme in which each node has an associativity state with its neighbors. In this scheme, the protocol selects the route with the least failures from all available routes.

b) Signal Stability-Based Adaptive routing protocol (SSA) (Dube, 1997)

SSA is a reactive protocol that selects the route according to the strength of the signal. It divides the links into two groups: strong and weak. The protocol always selects strong links to construct a route. When a source broadcasts a route request message to all neighbors, the intermediate node rebroadcasts it only when it is received over a strong channel. The destination always uses the route of the first arrived request because it is probably the most stable one.

c) Stable Weight-based On-demand Routing Protocol (SWORP) (Wang, 2007)

SWORP is another reactive protocol that searches for the most stable route between the source and destination. It uses a weight parameter to measure the stability level of a node. The weight factor depends on three factors. The first one is route expiration time, the second factor is the number of dropped packets, and the third one is number of hops.

d) History Based Routing Protocol for Opportunistic Networks (HIBOP) (Boldrini, 2007)

HIBOP is used for managing and using context-based routing framework for opportunistic networks for taking forwarding decisions. This model completely breaks the main assumptions on which MANET routing protocols are built.

Routing in opportunistic networks is usually based on some form of controlled flooding. But, often this results in very high resource consumption and network congestion. HIBOP is able to dramatically reduce resource consumption and reduce the message loss rate, and preserve the performance in terms of end to end delay.

e) A Centrality-based history prediction routing protocol for opportunistic networks (CHBPR) (Bamrah, 2016)

Due to high mobility, short radio range, intermittent links, unstable topology and sparse connectivity, routing in opportunistic networks is a very challenging task since it relies on cooperation between the nodes, using the concept of central nodes that are more likely to act as communication hubs to facilitate message forwarding and thereby routing. A node with the highest centrality value (so-called central node) is a node that has the capability to connect more often to other nodes in the network, and thereby is more likely to be a part of the constructed routing paths.

CHBPR inherits the same data structures and initialization settings utilized in HBPR. In addition, each node maintains a new data structure, called the centrality table, which records its home location, the number of neighbor nodes it has, and the centrality values of all nodes it has encountered so far. The CHBPR scheme is meant to reinforce the message forwarding part of HBPR.

CHBPR significantly outperforms HBPR and C-Epidemic (Epidemic protocol with the same centrality concept used in HBPR embedded in it) in terms of message delivered and overhead ratio under varying numbers of nodes, and time-to-live (TTL).

### 4. Proposed work

We propose a routing algorithm for MANETs that uses failure history as the main factor for selecting the best route between source and destination. When constructing routes, the protocol uses the intermediate nodes with the least failure history to achieve higher network reliability. The idea of the proposed protocol comes from the fact that a node that has periodic link failures will increase the probability of dropping packets if it participates in a route.

Each node in the network has a table called "Failure History Table" (FHT). Initially, FHT will be empty and start growing during operation. FHT contains four fields: route identification number, number of forwarded packet, number of dropped packets, and Failure History Factor (FHF).

Each valid route discovered in the network has a unique number (RID). A node that participates in a route will save RID for the route in its FHT. Each record in FHT will maintain two counters: the number of successful packets that were forwarded using this route through this node, and the number of packets that were dropped by this node. Using these two counters, the FHF will be calculated using Equation 1.

$$FHF = \frac{\text{Forwarded Pckets}}{\text{Forwarded Packets} + \text{Dropped Packets}}$$

FHF is between 0 and 1. A higher value of FHF indicates a more stable node. The proposed protocol aims to use intermediate nodes with high values of FHF to construct a route from source to destination.

The proposed protocol will be implemented over AODV. AODV has three main phases: the route discovery phase, the route reply phase, and the route maintenance phase. We will modify the first, and the second phases, while the third one will remain without any modification because it lies out of the scope of this study.

#### 4.1. Route request phase

In this phase, a source discovers a valid route to the destination. When a source needs a valid route to a destination, it broadcasts a route request packet to all neighbor nodes. When an intermediate node receives a request it either replies if it knows a valid route to the destination or calculate its FHF value, adds it to the request and rebroadcasts the request again.

## 4.2. Route reply phase

This phase is responsible for telling the source node that a valid route to the destination was found. A reply can be sent from the destination node itself or from any intermediate node that knows a valid route to the destination. When the destination or intermediate node sends a reply packet, it compares the failure value that comes with the request with the old failure value and selects the best route according to these values. If the new value is greater than the old, then it sends a reply packet to tell the sender that a new better route was found. Otherwise, it ignores the request and does not reply.

## 5. Materials and methods

We will make a comparison between our protocol and AODV to measure their performance according to the packet delivery ratio. Simulation experiments will be conducted using NS-2 simulator [13] [14]. The results from the simulator will be analyzed.

## 6. Results

Number of Nodes	Queue Length					
	25		50		100	
50	Pause Time	FHBR	AODV	Pause Time	FHBR	AODV
	0	86.61	76.84	0	88.23	78.55
	100	91.92	81.65	100	93.63	82.20
	300	93.48	86.12	300	95.45	88.20
	600	95.59	88.73	600	97.70	90.33
100	Pause Time	FHBR	AODV	Pause Time	FHBR	AODV
	0	85.40	74.70	0	87.19	79.23
	100	88.30	76.33	100	95.36	83.36
	300	91.35	84.47	300	96.65	89.54
	600	94.46	86.36	600	98.88	91.54

The results show that FHBR outperforms AODV more substantially in the high mobility networks, and outperforms less when networks are more static.

The results show that the packet delivery ratio was dropped for FHBR and AODV as we increase the congestion level.

## 7. Conclusion

In our study a new algorithm was designed and implemented to address the case of routing for MANETs called Failure History-Based (FHBR). FHBR chooses the path between source and destination by selecting the best intermediate nodes according to their failure history. A node that has a higher level of stability is selected rather than other nodes that have a bad history in frequent failures.

The idea of FHBR is that each node has a Failure History Factor (FHF) that express the history of a node. Each node adds its FHF to the route request packet. The destination selects the best route by selecting the route constructed from higher accumulated FHF of intermediate nodes.

FHBR was designed over the original AODV protocol by modifying route request and route reply phases. The maintenance phase in the original AODV was kept as it to maintain the network in case of link failures.

FHBR performance was evaluated against AODV by many scenarios conducted using Network Simulator (NS-2). The performance of FHBR and AODV was compared by two metrics: packets delivery ratio and average end-to-end delay. These two metrics were selected to ensure that FHBR handled the performance of a network with a minimum number of dropped packets and a minimum delay as possible.

We design many scenarios to evaluate the performance in different conditions according to nodes mobility, congestion level, ability of nodes to handle different number of packets and how network is dense.

The results of simulations show that FHBR outperforms AODV by a significant value in terms of packet delivery ratio because it selects the more stable intermediate nodes between source to destination and always avoid the shortest but congested paths.

The results always show that a higher buffer size made a higher packet delivery ratio in the network because of decreasing the packets that dropped in intermediate nodes. FHBR has a better average end to end delay than AODV but with a lower enhancement when compared with the enhancement measured by packet delivery ratio metric.

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