Academic Journal of Nawroz University (AJNU), Vol.12, No.1, 2023
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https://doi.org/10.25007/ajnu.v12n1a1375

Analyzing Multi-Channel and Single-Channel on Multi independent Paths of Ad-Hoc Sensor Network

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ABSTRACT

The Ad Hoc routing protocols include the route rediscover algorithms. Thus, a desirable aim for any routing protocol is to design an effective and rapid route recovery technique to rebuild the broken link. This study presents Multiple Node Index in Multi-Channel (MNIMC) and Multiple Node Index in Single-Channel (MNISC) as two novel route discovery techniques. MNIMC integrates multiple pathways and channels to create an alternate path. MNIMC reroutes the data packet via a different route in previously detected channels. Furthermore, it works with numerous link failures. MNIMC nodes are considered multi-transceiver enabled, in contrast to MNISC, which enables several routes and a single channel. Using the Network Simulator 2 (NS2), the MNIMC and MNISC schemes are developed and thoroughly tested. Simulation results demonstrate that the suggested approach improves packet delivery ratio, throughput, and end-to-end latency.

Keywords: Mobile Ad-hoc network, Routing Protocol, Many hops, MIMC, Routes, MNIMC, MNISC

1. INTRODUCTION

Wireless Ad Hoc network research has expanded as a result of mobile wireless devices such as smartphones, Wi-Fi, and automobiles (Van Hoang and Ogawa 2014; Kongsiriwattana and Gardner-Stephen 2017; Mane, Mane, and Khairnar 2015). The Mobile Ad-hoc networks (MANETs) are self-organizing, infrastructure-free networks (Zhang and Sun 2016). MANETs are used in many functions in different industries, such as manufacturing, education, and medical devices using standards like IEEE 802.11g, which includes 2.4 GHz (Committee and Compatibility 2014; Santi et al. 2021; Zuo et al. 2020) and IEEE 802.11n frequencies, where data rates range from 54 Mbit/s to 600 Mbit/s (Daldoul, Meddour, and Ksentini 2018), both using the same frequency band. Many interfaces/radios are available on IEEE 802.11-based devices (Al-Hazmi and De Meer 2011). The number of interfaces utilized is the same as or less than the number of node channels. As an example, at IEEE 802.11g frequency is around 11 channels at 2.4 GHz, and providing a wireless node with the same number of device interfaces is costly as a result, in Multi-Interface and Multi-Channel (MIMC) mobile ad-hoc networks, the efficiency of channel assignment based routing protocols is critical (Xie et al. 2021). When the number of available channels and accessible interfaces is equal, each interface may be assigned to a given channel, reducing assigning channel failure to assigning interface which is the topic of our study (Aodv, Wsans, and Chaichana 2015; Mandape and Theng 2015). Reactive routing protocols include the Ad hoc on-demand multipath distance vector (AOMDV) routing protocol. The AOMDV routing protocol for distributing route request packets (RREQ) from source to destination provides a number of pathways at both the intermediary and destination nodes. This path is used by a lot of route reply packets (RREP) that are returning to the source from middle and destination nodes. AOMDV establishes a formula based on the principles that each node on the network should adhere to in order to ensure the flexibility to repeat and diverge from the path (Alamsyah et al. 2019). An intrusion from a malicious node is another issue that MANET faces. A malicious node may take advantage of node cooperation to impede network performance. Selfish nodes are another name for malicious nodes (Akram 2020). The malicious node's goal is to prevent the routing protocol from functioning normally and to reject as many network services as possible. Other issues with MANET include dynamic topology changes, low energy usage, and lack of infrastructure support. Hence, a Quality of Service (QoS) is required. The aggregate impact of service performance, which affects the degree of service users' happiness, is another definition of QoS (Masruroh et al. 2020).

This paper includes the following: MIMC's related work is described in Section 2. In section 3, the implementation of MNISC and MNIMC on ad hoc networks using NS-2 is described and explains multi-channel for interface assignment in depth, as well as the adjustments that must be made to the NS-2 C++ code as a result. Simulation scenarios given in Section 4 and performance analyses are presented in Section 5. Finally, section 6 brings the study to a close and suggests research areas for the future.

2. RELATED WORK

The efficiency of wireless mesh networks can be improved by extending the protocol for multi-interfaces and multi-channels (Ling et al. 2011). Several scenarios explained the essential concepts of Multi Interface Multi Channel (MIMC) expansion by using NS-2 for Static, dynamic, and hybrid interface and channel techniques can be used. For the research study, static assignment using a common channel strategy is being investigated by assigning an interface to a certain channel regularly or over a lengthy period of time (Bhagwat, Bedekar, and Naik 2017). Furthermore, there is no official release of NS-2.35 that supports multiple interfaces in a multi-channel setup (Hui and Yuan 2017). The adjustments necessary in NS-2 at several layers to accommodate the Multi Interface Multi Channel (MIMC) paradigm has been frequently cited (Lavén and Kassler 2010). To solve the issue of single interface single channel communication, (Boutalline et al. 2021) proposed to build and simulate an interface assignment routing mechanism of MIMC mobile ad-hoc networks. Where each node has numerous network interfaces. However the Open Systems Interconnection model (OSI) has a cross-layer solution that the authors have incorporated to enable communication across the physical and network layers.

The Medium Access Control (MAC) protocol uses a communication channel to solve the collision problem. This protocol employs the single-channel and multi-channel MAC protocols to utilize the channel. This protocol, which is specified by IEEE 802.11, works in single channels to strengthen the channel by providing a shared common route for a number of mobile hosts. The network's performance may be hampered by common paths because of increased collisions. Furthermore, multiple channels is used to lessen the network's collision issue. As a result access to mobile hosts is made more powerful by the multi-channel. There are various benefits of this protocol, including less propagation delay and greater throughput. This transceiver feature made it simpler to maintain higher QoS and prevent collisions (Ranjani and Kanmani 2022).

A source-initiated node disjoint multipath protocol used to improve the Ad hoc on-demand distance vector routing protocol. In the typical route discovery procedure, a higher number of disjointed paths are calculated between the source and destination. This node disjoint loop free protocol offers a reliable node failure path recovery technique. In this scenario, the source node broadcasts Route Request (RREQ) packets to every nearby node inside its coverage area. When a valid path has been found, a route reply (RREP) message will be sent from the destination node to the source node. The intermediate node broadcasts a route error (RERR) message to all member nodes linked to it in the data forwarding path as a result of an unanticipated path failure. The source node starts a fresh route discovery procedure to continue sending data to the destination after receiving the RERR message. The destination has the right to deliver RREP packets to the source node in power-aware node disjoint multipath source routing, and additional RREP messages received from intermediate nodes will be ignored. In order to choose the shortest path, the destination sends the RREP message to the source node (Harold Robinson et al. 2019) .

An appropriate path is found using an energy-efficient reactive routing protocol based on an on-demand basis. Any node in this network has the potential to be a source node or a destination node. This multiple route discovery approach makes use of more control messages. Introduced source-initiated Low Interference Energy-efficient Multipath Routing to transfer the data via several channels. This method distributes the full load across the several pathways that are built between the source and the destination (Sampoornam et al. 2020).

3. THE IMPLEMENTATION OF MNISC AND MNIMC

The first part focuses on the implementation of Multiple Node Index in Single-Channel (MNISC), while the later part describes Multiple Node Index in Multi-Channel (MNIMC) implementation by using NS-2.

3.1 MNISC Implementation

Multiple aspects specified in NS allinone-2.35 are used in the simulator to simulate the MNISC routing protocol. Route discovery and maintenance are performed using control packet of Route Request (RREQ), control packet of Route Reply (RREP), Route Error (RERR), and Hello packets. The broadcast packets RREQ, RERR, and Hello are broadcast, whereas the RREP packet is unicast to every Path. For network congestion management or load balancing, MNISC finds a minimal hop. The next section focuses into the MNISC protocol's implementation and the services that it employs. The source node starts route discovery by broadcasting of RREQ control packet across all available interfaces. Every node received RREQ will save the RREQ's sender's reverse route as well as the number of which interface the RREQ packet was received. If the node's routing table has an active route to the destination, or if the node is destination node, the RREP packet is transmitted to the source node; alternatively, the RREQ is sent to all available interfaces by forward RREQ, and the process will be repeated for each node gets RREQ. RREP is will be send and forward to the source using interface that was placed in the backward route of the routing table. Multiple aspects specified in NS allinone-2.35 are used in the simulator to simulate the MNISC routing protocol. Route discovery and maintenance are performed using control packet of Route Request (RREQ), control packet of Route Reply (RREP), Route Error (RERR), and Hello packets. The broadcast packets RREQ, RERR, and Hello are broadcast, whereas the RREP packet is unicast to every path. For network congestion management or load balancing, MNISC finds a minimal hop. The next section focuses on the MNISC protocol's implementation and the services that it employs.

3.2 . MNIMC Implementation

As illustrated in Fig. 1, the interface allocation is based on the premise that two neighboring nodes connect with their next hops on the same channel/interface. As a result, when node 1 sends a packet like RREQ to node 2 via interface call A, node 2 will get a RREQ from node 1 on the same interface call A and send a RREQ to node 3 on a different interface call B. During the process of route finding, the source node sends RREQ over all available interfaces in the routes table, and any node on the path gets the initial RREQ control packet changes the route database for the backward route, and uses the interface number on the location of the received RREQ to rebroadcast RREQ over interfaces, while the source node sends RREQ over interfaces. If the new route exists to the destination node in the routing table of any intermediate node on the path, then the node uses the same interface that received RREQ to send RREP. Accordingly, the destination node and intermediate node set the rp_rt_miface content of the RREP control packet and send it to the next hop on the path to the source node. Furthermore, update the routing database with the same information. Consequently, the node gets the interface number in rp_rt_miface of RREP from the previous node. The node will pick a different interface to forward RREP, as illustrated in Fig. 1. Consequently, each node selects an interface using the route, and each pair of nodes uses a different interface.

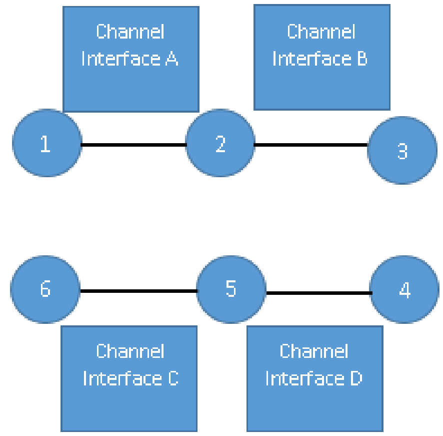

Fig. 1 Example of MNIMC

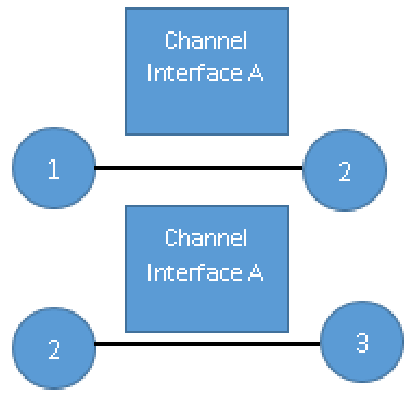

Fig. 2 Example of MNISC

The rt_miface variables are specified in the routing table of each node in the MNIMC protocol to accommodate multiple interfaces. The scenario script initializes rt_miface, which holds a number of the interfaces used by the node. The rt_miface variable defines the interface that will be used to transmit data to the next hop on the path. When any node has several interfaces, broadcast packets must be routed across all interfaces, whereas unicast packets must be sent over a single interface. RREQ, Hello, and RREP will now be broadcast over all interfaces, whereas RREP will be unicast. A new control packet of the RREP structure is utilized, which includes all of the received RREP contents as well as an additional field named rp_rt_miface. The numeric variable rp_rt_miface is specified in the MNIMC control packet and is used to inform the neighbour about the node's transmission interface. The interface employed for the route and the next hop is also saved inside the node in the routing table using the rp_rt_miface location, and the node will process received packets to append the new route in routing table. Throughout route discovery, the routing protocol needs to update rp_rt_miface. Alternatively, the nodes will broadcast on the random interface. The following pseudo code is used for processing RREQ and RREP control packets:

Receive RREQ:

```
If RREQ_Source ≠ lookup Routing_Table_ Source; then
  If (RREQ_Destination ≠ Index) && ((RREQ_Destination ≠ lookup Routing_ Destination) && (Path_Interface (RREQ_nodes_ID≠ RT_ nodes_ID); then
      Insert RT_Path_Interface (RREQ_nodes_ID,rt_miface);
      Broadcast RREQ();
  End If
     Insert Path_Interface ((RREP_nodes_ID,rt_miface);
        Send RREP(RP_rt_miface);
  End If
     Drop RREP();
```

Algorthim. 1 RREQ packet

Receive RREP:

```
Insert RT_Path_Interface (RREP_nodes_ID,RP_rt_miface);
  Insert RREP _Path_Interface(RP_rt_miface);
    If RREP_Source ≠Index;
      Send RREP(rp_rt_miface);
End If
```

Algorthim. 2 RREP packet

4. SIMULATION

The performance of MNISC and MNIMC is examined at 512 bytes of packet size with a changing topology area including 20, 40, and 80 mobile nodes with a 200 second simulation time. The source node sends CBR packets to the destination node. Table 1 contains the simulation parameters.

TABLE.1
NS2 Simulation Parameters

Parameters	Value
Simulator	NS2
Channel Type Wireless Channel	Wireless Channel
MAC Layer Protocol	IEEE 802.11
Number of Nodes	20,40,80 Nodes
Simulation Time	200 Second
Data Packet Size	512 Bytes
Traffic Type	Constant Bit Rate (CBR)
Simulation Area	1000*1000
Routing Protocols	MNISC, MNIMC

5. PERFORMANCE ANALYSIS

End-to-End delay, Packet delivery Ratio, Packet Loss, and throughput are measured during simulation and compared to MNISC to assess MNIMC's performance. The End-to-End delay is known as the time of a packet to reach its destination and is measured in seconds. However, the number of bits received in a unit of time, measured in bits per second. According to the results given in Fig. 3, the end-to-end delay in MNIMC is a little bit similar to MNISC at low data rates. In MNIMC, any node that receives an RREQ packet transmits it to all interfaces. As a result, a huge number of RREQ packets are created and received on numerous interfaces at each node, increasing not only the path setup time but also network power consumption. However, when increasing the data ratio, the number of control packets to be transferred rises, and the End-to-End latency overtakes the route discovery time. As a result, MNIMC will have less End-to-End delay across greater packet rates, as well as a higher packet delivery ratio than MNISC Fig.4, higher packet loss than MNISC Fig. 5, and higher throughput at MNIMC Fig. 6. The number of packets received at the destination is divided by the number of packets transmitted by the source. Broadcast control packets (RREQ and RREP) are issued on all interfaces in MNIMC, and single-hop neighbors will result in more duplicate control packets, causing network routing inefficiency. As a result, more control packets are created for the neighbors to avoid this issue.

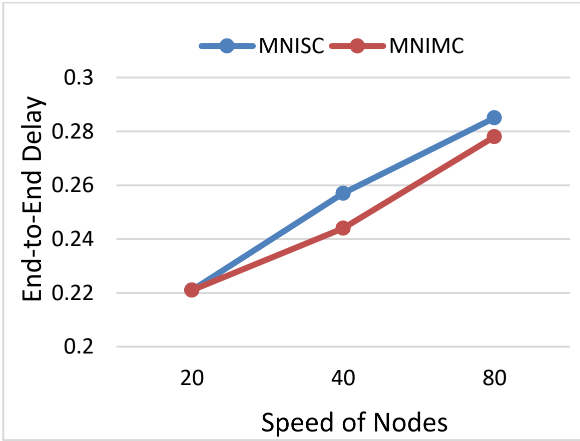

Fig 3. End-to-End Delay

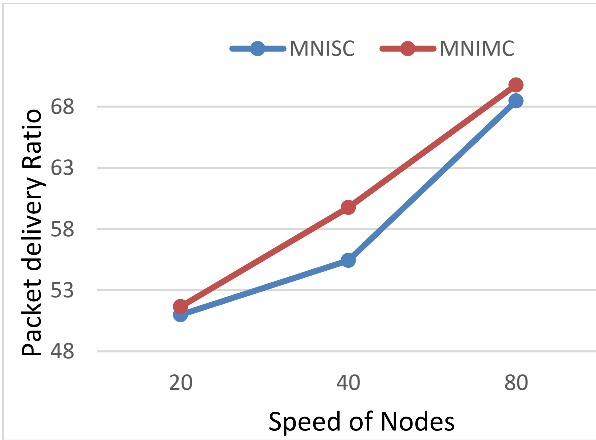

Fig 4. Packet delivery Ratio

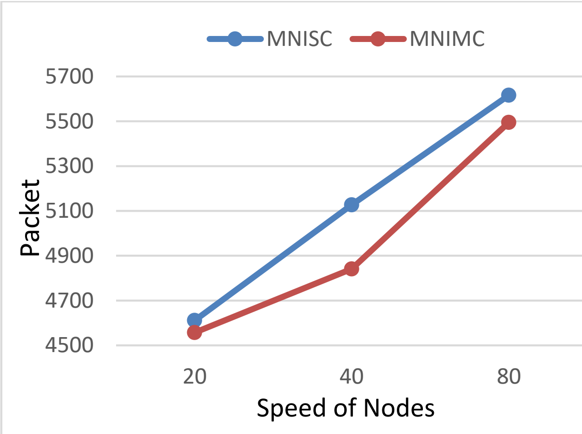

Fig. 5. Packet Loss

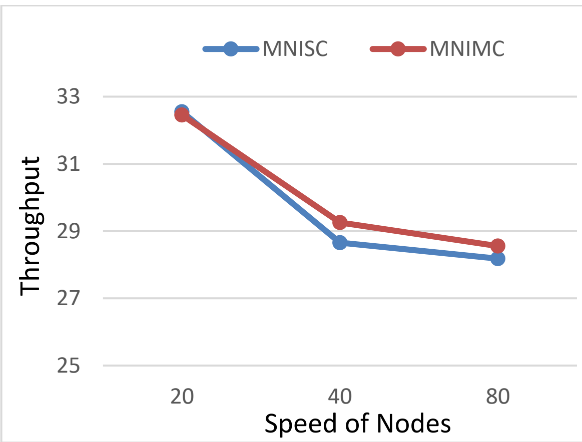

Fig 6. Throughput

6. CONCLUSION AND FUTURE WORK

MNIMC's route performance was found to be superior over single interface single channel performance. Consequently, adding a network interface to a wireless node at the physical layer can increase performance if the upper layer protocols are adjusted to make optimal use of it. This study described step-by-step processes for simulating interface assignment in MNIMC and MNISC to optimize network performance. The work may be expanded further in the scenario when the number of interfaces accessible is smaller than the number of available channels. Furthermore, the work may be applied to cognitive radio networks, mobile ad-hoc networks, and other types of ad-hoc networks.

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