Route Discovery Using Hybrid Approach for Disaster Management in MANET

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Abstract**—**A disaster situation is an event that alters in the normal execution of activities. A mobile ad-hoc network (MANET) is a self-controlled, autonomous wireless network used in an uncertain environment with decentralized control. In disaster, when communication between nodes is not performed properly, MANET can impart an important role of communication between nodes in uncertain situations. In MANET, routing is considered one of the most salient aspects of data transfer in a disaster situation. Proactive and reactive protocols are used as standard in various applications of MANET owing to the simplicity in their design and performance. Combining three routing protocols makes a hybrid approach to get better performance inefficient route discovery and maintenance. This is because reactive routing protocols, sometimes, do not provide better performance in heavy traffic and load, especially in a disaster. This is because the hybrid approach is very useful for fast convergence with low memory and power management. This paper introduces an improved hybrid routing protocol (IHRP) approach that combines two reactive and one proactive routing protocol to provide efficient route discovery and maintenance mechanisms. The simulation environment is used for the proposed approach. Results after simulation illustrate that it provides better performance in data packet delivery, routing load, throughput, and end-to-end delay data packet delivery, routing load, throughput, and end-to-end delay than the Ad-hoc On-demand Distance Vector (AODV) and Zone-based Routing Protocol (ZRP). The contrasting results between the IHRP and existing protocol indicate that the IHRP outperforms and increases the performance from 9% to 12%.

Index Terms**—**MANET, hybrid approach, AODV, ZRP

I. Introduction

Mobile Ad-hoc Networks (MANET) are networks without any infrastructure. The networks with no fixed access station and every node can act as a router. All nodes can move freely without any restriction and are connected dynamically arbitrarily. The terminals are responsible for controlling, managing, and organizing the whole network themselves. The whole network has a mobile nature, and the movement of each terminal is free. Fig. 1 displays a similar type of network [1]. Technology has progressed very rapidly in the past years. This authenticates the current achievements in different fields such as information processing systems, information security, information technology, and Computer Science. Current achievements of information technology, especially in wireless and Ad-Hoc Technology, are more than the attainments in other fields. The survival of wireless networks started in the 1980s. It was the emergence of wireless systems. After that, it started unlatching new doors in all aspects of human life and still making its way towards progress [2]. In the past 14 years, Ad-hoc network technology has rendered a lot of appreciable activities and remarkable achievements in research. This is mainly because its ease of configuration and on the fly usability in meetings and other environments especially by means of the smart devices and IoTs. Many researchers investigated this area for further advanced research and learning purposes [3].

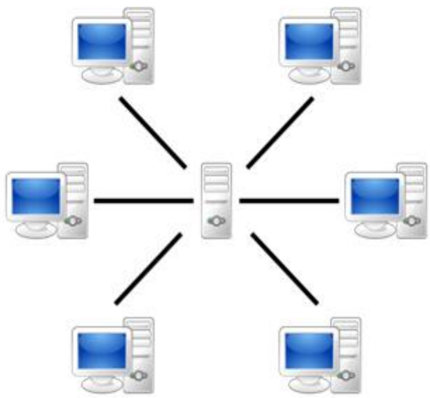

Fig. 1. Without infrastructure network

As already discussed, a disaster is an event that disturbs the normal execution of things. During this situation, communication between nodes is highly disturbed. Therefore, it required a mechanism or ad-hoc network to handle an emergency. Many disaster situations caused due to floods, and artificial chemical and industrial slides, are the common natural disasters in the world. The role of information technology is very important during disaster management [4]. A reliable system and a mechanism are needed for information sharing, integration, analysis, and rescue operations to accommodate available information

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during a disaster situation. The routing is set up maintained by routing protocol that is the main performance indicator in the MANET. The protocols routes indicate the route direction among the nodes and disseminate information in a choice of the route between any two nodes of a network [5]. Routing confers an essential role in MANETs. Routing gives direction to route discovery routing protocols in MANETs. The routing protocol initiates the data and information flow in networks and makes the path efficient enough to reach the destination. The routing protocols in mobile ad-hoc networks are mainly categorized into two major forms: Topology and position-based. Therefore, situations where the nature of nodes is highly dynamic, create many complications of route discovery and link breakage. These problems are especially in disaster situations that have become a highly emotional motivation for research. The network performance is degraded by the frequent breakage of the path during disaster situations. So, the main objective of the paper is to propose an improved hybrid approach concerning criteria in, integrate the link breakage, and find improved route discovery mechanisms based on reactive and proactive routing protocols. Routing protocols can be divided into three types of protocols: proactive routing protocols, reactive routing protocols, and hybrid routing protocols [6]. Principally, proactive is considered the table-driven route of the protocol, reactive as on-demand routing of protocols and hybrid holds the benefits of both proactive and reactive routing protocols. In this paper, a hybrid approach is suggested for rapid convergence, low memory, and energy utilization to provide an efficient route toward the destination in disaster, to less link breakage and increment in average packet delivery ratio, end-to-end delay, and network overhead and throughput. This paper presented a hybrid approach that discovers an efficient route with the help of distance value and MPR nodes selection as intermediate nodes [7]. After that, there is a discussion on the proposed hybrid approach design and methodology. At last, simulation results and the discussion on results with future research direction is debated [8].

II. Existing Techniques

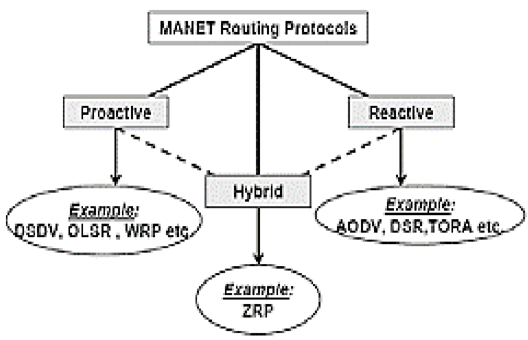

Fig. 2. Demonstrating the types of routing protocol

In MANET, routing protocols can be classified into three protocols: proactive table-driven routing protocols, reactive on-demand routing protocols, and hybrid routing protocols combination. Fig. 2 demonstrates the types of MANET protocol being used in the literature [9].

A. (RRP) Reactive Routing Protocol

In reactive routing protocol (RRP), the development of a route to achieving a goal is just possible when it is required. The distance-vector routing algorithm administers the route to a particular destination station. This eventuates only when a node requires and demands it. Such protocols are based on a demanding nature. So, it is also known as the On-demand nature routing protocol. The main idea about these protocols is to minimize routing overhead that is also the main challenge of the proactive routing protocol (PRP). Destination sequence routing (DSR), AODV, AOMDV, OLSR, ZRP, Destination Sequence distance vector (DSDV) are proactive and reactive routing protocols. Proposed approach combined AODV, AMODV, and OLSR.

An Ad- hoc On-Demand Distance Vector (AODV) is a reactive routing protocol (RRP). This protocol is specially designed for mobile ad-hoc networks where the working environment is wireless [10]. On-demand establishment of routes from source to destination is its major possession. This possession provides support in, either unicast routing protocols or multicast routing protocols. On the source node request, the AODV protocol develops routes between nodes. Due to this reason, it is called an on-demand nature procedure [11].

It does not create extra traffic along with link communication purposes. According to the source's requirement to sustain the routes lifetime, they develop a tree-style architecture to connect multicast representative groups. The AODV uses the chronological numbers preserving the table for route freshness. The maximum benefit of AODV is its only on-demanding nature. It will perform all operations like discovering and maintaining routes between two nodes. The shortcoming of this protocol is its highly time-consuming nature (latency) in route finding [12]. AOMDV routing protocol is an on-demand routing protocol for MANETs. It performs the discovery procedure of a route when a source node transmits data to communicate with a destination node with the help of an intermediate node [13]. AOMDV routing protocol locates multiple paths during the route discovery process. The multiple paths choice mechanism is used for load sharing purposes or the backup procedure of routes on the shortfall of primary routes [14].

B. Proactive Routing Protocol (PRP)

In these types of routing protocols, routing algorithms transfer its related information consistently to its neighboring nodes. In proactive routing protocol (PRP), every node has a table that preserves continuous change [15]. This table has all kinds of information about the routing of the network. The network performs the management of routes with the help of this table. Therefore, it is also called a table-based routing protocol where every node has network topology data in the form of tables. The administration of these tables is done by sending and receiving data in the form of sending and receiving data in the period to capture the current data picture. Examples of proactive routing protocols (PRP) are DSDV, WRP OLSR. The discussion of OLSR here perceives the concept of being well known table-driven and the most popular routing protocol used in MANET. There are mainly three functions of OLSR: forwarding of packets, sensing of neighbors, and topology controlling (TC). The first two provide neighbors information to the router and offer flooding messages through MPR (multipoint relays) [16]. The topology controlling function imparts information about the entire network topology. OLSR stores information about routing tables to provide the route if required. Any ad-hoc network is suitable for OLSR routing protocol implementation. Due to the table-driven nature of OLSR, it is also known as a proactive routing protocol. MPR Multipoint relay MPR selectors transmit a major role in OLSR path selection [17].

In this routing protocol, not all nodes are responsible for broadcasting of data packet. Only MPR nodes are responsible for the procedure of broadcasting. The selection criteria of MPR are the main aspect of selecting key neighbor nodes. Broadcasting nodes tend to occur in the neighborhood of the source node. In the network, each node has an information list of MPR. HELLO, packets delivery selects the MPR from the neighbor nodes. Routes are stored first in this protocol, and then the source node sent towards the destination [18]. In OLSR, each node in the network has information about the routing table. Due to this reason, the overhead for OLSR is less than other proactive routing protocols in terms of the short route towards the destination. There is no need for new routes if the existing routes are used. Considering this, there is not enough routing overhead. As a result, there is a reduction in route discovery delay. Available nodes broadcast HELLO messages to the neighbors [19]. In OLSR, a predetermined interval is responsible for the link status. If there is a neighborhood between node a, and node b, a node broadcasts a HELLO message towards node b. The link will be asymmetric when node b receives this message. Now b node broadcasts the same HELLO message towards node a. It is also called an asymmetric link. If there is two-way communication between nodes, it is called asymmetric communication link. All the neighboring information is kept in the HELLO message [20]. This procedure makes it possible for the mobile node to keep a table with its entire multiple hop neighbor's information. After an asymmetric connection is built, a node chooses a minimal number of MPR nodes. Topology control (TC) messages will be broadcasted with link status information at the predetermined TC interval. TC messages not only calculate the routing tables but also include information about MPR [21].

C. (HRP) Hybrid Routing Protocol

The hybrid routing protocol (HRP) is a routing protocol carrying the benefits of both proactive routing protocol (PRP) and reactive routing protocol (RRP). The major benefit of hybrid routing is that it first maintains some proactive routes and then presents its demand from an extraordinary, activated node through reactive routing techniques like ZRP. Proactive and reactive routing protocols also have some of their constraints. These constraints include the slow processing of restructuring (proactive) and a high ratio of latency in reactive. Therefore, the following are the protocols from which some proactive and reactive protocols choose to make a hybrid approach for better network convergence.

III. Proposed Method

Reactive and proactive routing protocols are hybridized to discover an effective route discovery and maintenance using the following routing algorithm. Fundamentally, this thesis selects the protocols to better approach normally towards disaster situations instead of individually checking these protocols with performance parameters. These parameters are like normal and disaster scenarios in performance metrics: throughput, average packet delivery ratio, end-to-end delay, and network overhead during the route discovery and maintenance process. The optimized link state routing (OLSR) proactive protocol finds the best route through the proposed algorithm uses MPR nodes with distance values to find the best route. After that, ad-hoc on-demand distance vector (AODV) and ad-hoc on-demand multi-path distance vector (AOMDV) follow route reply to procedures for efficient route discovery and further communication. At first, the source node originates broadcasting route request (RREQ) to all its neighbors using the AODV routing protocol. Therefore, the OLSR protocol is applied within the same network to select and find the best route using multi point relay (MPR). Every node is loaded with a distance-value: 0 as hop value at the initial node and infinity for all other nodes. Each node M with 1-hop and 2-hop neighbors is stored in the route maintenance table with a hop count of 1. It is stored on the neighbors using the OLSR routing protocol.

Therefore, M indicates the number of nodes. Every added node N in the routing table is added with hop-count n=2. The new entries are added with a hop- count of n+1. It is also added from the TC set and is stored in N. The current value is compared to the newly calculated distance of that node. Set the smallest distance or long-life value in terms of the hop count of the TC set. That has TC = N. OLSR selects the best efficient route for communication and is given to the AODV and AOMDV protocols. Next, the AODV protocol continues the further communication from source to destination. All intermediate nodes update the RREQ and broadcast route requests to their neighbors until reaching the destination. The destination receives the RREQ, creates an RREP packet, and transmits it to the source with multipath using the AOMDV routing protocol. Otherwise, create the RERR message to all its predecessors and send it to the source. The source then launches the route using the New Broadcast- ID. The proposed algorithm is depicted in Fig. 3.

Algorithm for the route discovery in the hybrid approach

1 IF (current node is destination node) then
   1. Initiate route RREQ
   2. Select MPR nodes of all feasible routes.
   3. Computes the distance value in hop values for each feasible route.
   4. Set value as 0 at the initial node and 1 for all other nodes.
   5. 5: Select one with the smallest distance.
   6. Sends an RREP packet using multipath to that selected route.

7. End IF
   8. Source node receives the RREP packet from destination node using multipath
   9. Source node sending data to the destination with maximum hop count

Fig. 3. Proposed algorithm

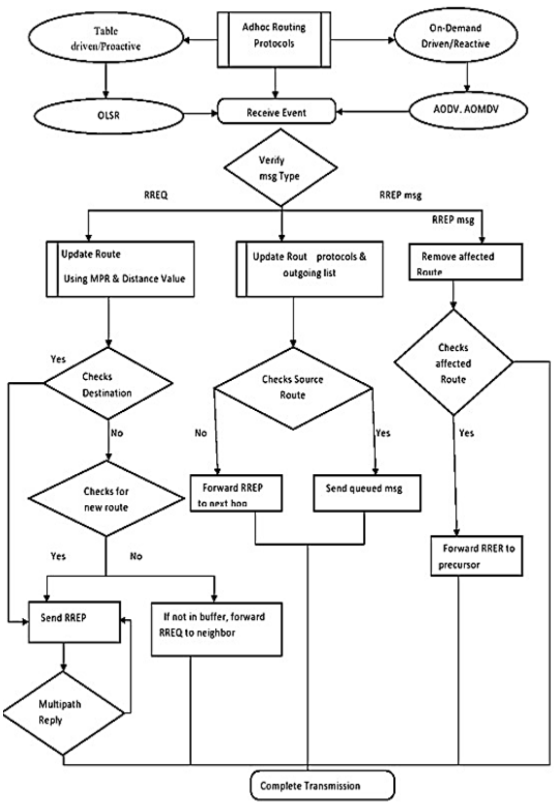

Fig. 4. Flowchart for the criteria of proposed approach

IV. Performance Evaluation

In the proposed hybrid approach, the performance is evaluated through the simulations carried out using the network simulator tool NS-2 [22]. In the simulation, conditions varying from normal to disaster are analyzed through a hybrid model [23]-[26]. The hybrid approach combines three routing protocols: Two from on-demand routing and one from table-driven form. This approach is used to evaluate results and compare hybrid approach results with the AODV routing protocol. In this model, every node makes route selection through the OLSR routing technique where route replies through AODV or AOMDV [27]. Performance metrics are given below.

TABLE I. Parameters for Simulation

Simulation-Parameters	**Value/ description**
Number- of- nodes	5,10,15,20,25,30,35,40,45,50
Traffic- pattern	Constant Bitrate (CBR)
Network -Size	1000 X 1000
Simulation- time	100s to 1000s
Routing protocol	Hybrid -Approach

A. End-to-End Delay Versus Max Speed

The average delay between sending the data packet from the source towards its receiver (destination) includes the delays due to route buffering and processing at intermediate nodes or relying on nodes [28]. If the value of an end-to-end delay is higher, the protocol performance is not good due to the network congestion. This relates to the following performance formula in Eq. 1.

P: Performance
AT: Arrival time
ST: Sent time
n: Number of connections

$$P = \frac{AT-ST}{n} \tag{1}$$

Fig. 5 represents the total sending time taken for data packets. It indicates the time taken by the data packet for receiving. Subtracting sending time from the receiving time equals the end-to-end delay. The average end-to-end delay is calculated by dividing the sum of delay packets by the number of received packets. The simulation environment was created seven times for each node with varying speed values. This figure summarizes the average result of simulations. The comparison of end-to-end delay of a hybrid approach with AODV and ZRP represents that both protocols have the same delay results.

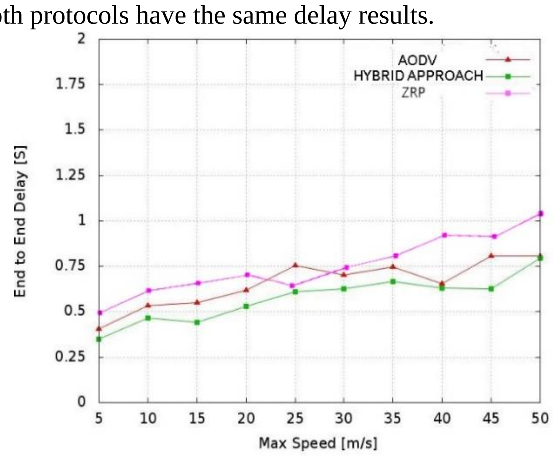

Fig. 5. End to end delay versus max speed

B. Throughput Versus Maximum Speed

The ratio between the total data received and simulation time is calculated in bit/sec and byte/sec. It can be expressed mathematically as [30] in Eq. 2.

T: Throughput (bits/sec)
N: Number of deliver packets
S: Packet size
t: Total duration of simulation

$$T = \frac{N*S*8}{t} \quad (2)$$

Throughput is the total data received at the destination in unit time of the network. Fig. 6 represents the total number of bits received at the destination point. To evaluate throughput, perform the summation of all bits reached to the destination divided by the total time taken for it. The simulation environment was performed on each node at least seven times with varying speed values. The figure shows different kinds of results of all simulations.

Fig. 6 represents throughput due to the different effects of the speed of nodes on the network. The results of the simulation environment show a decrement in throughput if there is an increment in the speed of nodes in both cases. Fig. 4 shows minimum reliability due to the fast motion of nodes. A hybrid approach chooses an efficient route for the transmission of data. So, from the graph as a whole, it is clear that at all kinds of speeds, the throughput of hybrid is much better than AODV and ZRP.

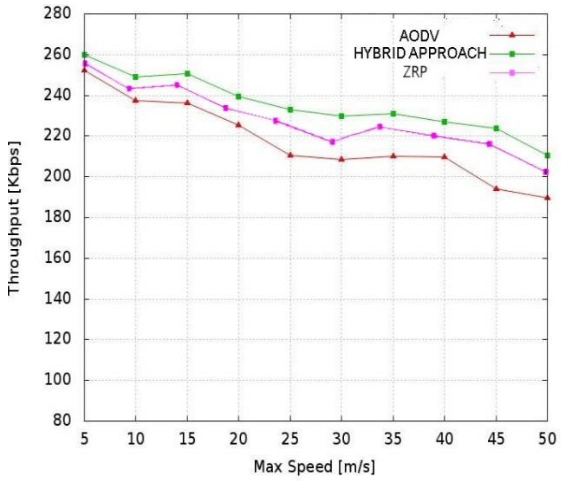

Fig. 6. Throughput versus Maximum speed

C. Network Routing Load Versus Max Speed

It is the total number of packets transmitted in a simulation environment. Bytes transferred to each hop through a multi-hop route are counted as a single transmission [29]. Load of the network represents the total number of packets needed per data packet delivery. Figure 5 provides a clear picture of the total number of packets received on each node with a maximum speed range of 25ms^{-1} in the simulation environment. It is a clear picture of packets on each node. Total network load can be attained by dividing the total number of packets by the number of received packets. The simulation was performed on each node with a different range of speed values. All results of simulations are illustrated in the Fig. 7. The figure indicates that the hybrid approach's network load is minimum compared to AODV and ZRP. The minimum result of the hybrid approach is due to a reliable route from the source towards the destination. This result is the failure of route reduction and reduces maintenances and route rediscovery mechanism. Due to this reason, the routing load of the hybrid approach is less as compared to AODV. The performance of the hybrid approach is much better than AODV and ZRP. It reduces overhead by at least 25 to 30 percent compared to AODV and ZRP.

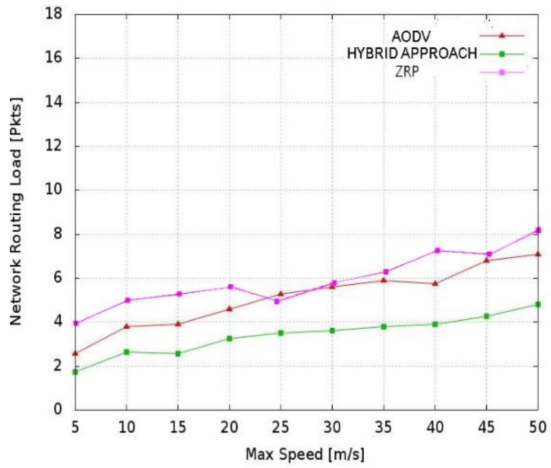

Fig. 7. Network load verses maximum speed

D. Packet Delivery Fraction versus Maximum Speed

It is the ratio of the successful delivery of packets towards the destination by the total number of packets delivered. The highest value of this metric indicates the better performance of the proposed approach. A general formula for calculating packet delivery ratio as a percentage as given in [31]-[45]. Packet delivery ratio represents data packet sent by source nodes and received by destination nodes. The total packet delivery ratio can be obtained by dividing received packets and sender packets. The simulation experiment was performed for each node 6 to 7 times for a range of different speed values.

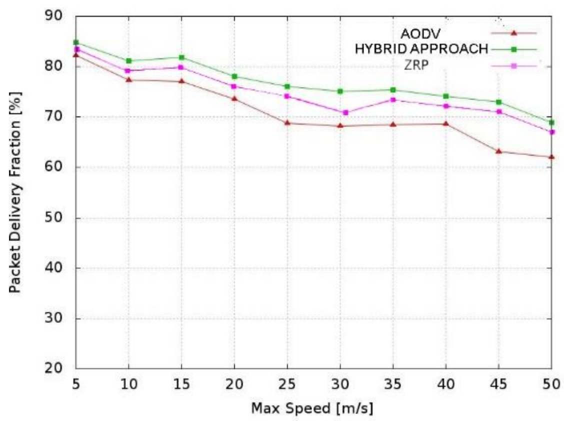

Fig. 8. Packet delivery ratio versus Maximum Speed

Fig. 8 indicates all ranges of simulation results. It also indicates that in both cases, when there is a decrement in PDF, there is an increment in the node's speed. This causes easier breakage on route due to the increment in node speed. In Fig. 8, the graph also indicates more packet delivery in the hybrid approach than AODV and ZRP. The preeminence of the hybrid approach delivery ratio is due to its criterion of root selection, through which routes that are more reliable are selected due to MPR nodes. That selection of route reduces breakage of the route. Fig. 8 indicates the increment in the ratio of packet delivery.

In comparison, AODV only selects the shortest path from the source towards the destination. In AODV, time constraint in the selection of route is not important because more breakage of route and data occur during the discovery of route. The graph shows that at minimum speed, the PDF of the hybrid approach is increased from 2 to 3 percent compared with the AODV and ZRP routing protocols. Therefore, less breakage of route occurs on less speed. Nevertheless, on the high speed of nodes, PDF of hybrid approach increased 5 to 8 percent compared to AODV and ZRP.

V. Conclusion

In the paper, a hybrid approach for route discovery mechanism and minimum link breakage has been presented that decides the efficient route for communication in a normal to the disaster situation in terms of variations in speed. This occurs based on the distance value of MPR nodes. In the proposed approach, the distance value of MPR nodes is the main metric for selecting routes that minimize the failure of routes and link breakage.

The proposed IHRP approach through the graph indicates a reduction in route discovery requests and the significant improvement in work overhead, end-to-end delay, and average packet delivery of every node involved in the route discovery process. Consequently, the overall performance of the routing protocol improves. The considerable contribution of this paper is to design a criterion using a hybrid approach for route discovery in disaster management. Future contributions focus on more minimization of the proposed approach and compare with other routing protocols of MANET.

Conflict of Interest

The authors declare no conflict of interest.

Author Contribution

Abdul Majid Soomro considering the research framework, writing scraper bots for data collection, data cleaning, performing analysis, conducting tests, preparing final manuscript.

Dr. Farhan contributing to research thinking, learning related activities, which contribute to the preparation of the final manuscript.

Hafiz Muhammad Saim contributing to conceptualize the research, studying related works, contributing to prepare the final manuscript.

Dr. Gohar Zaman proofread the paper and revised in the light of reviewer's comments and prepared the final version of the paper.

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