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Research paper

Improved DCFR protocol for path recovery in mobile ad-hoc networks

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Abstract

The mobile ad-hoc network is the decentralized type of network in which mobile nodes can move from one location to another. Due to random mobility of the mobile nodes route establishment, route maintenance is the major issues of mobile ad-hoc networks. This research paper, focus on the route establishment and route maintenance properties of mobile ad-hoc network. The DCFR protocol is the route establishment and route maintenance protocol in which broker route will be recovered on the basis of node connectivity. The node, which has maximum connectivity, is selected as the best node for route recovery in DCFR Protocol. In this research work, the DCFR protocol is further improved by adding buffer size parameter for route recovery which also maintains quality of service in the network. The proposed DCFR protocol simulation results perform well as compared to existing DCFR protocol in terms of certain parameters

Keywords: *DCFR; NCPR; MANETS; AODV.*

1. Introduction

The infrastructure-less type of network in which the wireless mobile hosts are gathered is known as a mobile ad-hoc network. Through multi-hop paths, communication is performed within MANETs. These networks are mainly utilized within various applications due to their higher flexibility as well as scalability. However, these networks face numerous challenges since they do not have any central administrator within them. There are several resources present within these networks and a very ambiguous line of defense if available [1]. Within the shared wireless mediums, operations are performed by the nodes and since they are dynamic is nature, the topology of these networks also keeps changing. Another issue that arises within these networks is the reliability of radio link in several cases there is a link breakage found. Within various applications, there is variation in the number of nodes present, their density and the hosts' mobility. In order to forward the data packets to other nodes, each node acts as a router within MANETs. There is a need of higher security within these networks due to the self-organization of nodes within these networks. However, security within these networks is difficult to be provided because of the limited communication and communication resources available. Due to the rapid change in topology, the links broke as well as re-establish within these networks. It is to be ensured that the rapid change within the topology is responded by the routing protocol [2]. Each node acts are a router within these networks. The source and destination might communicate through the intermediate nodes due to the limited bandwidth available within the nodes. Asymmetric links, routing overhead, interference as well as dynamic topology are the major issues arising within routing. There are various advances being made within the routing techniques provided within MANETs and many new routing protocols have been introduced. The two broader classifications of various routing protocols of MANETs are proactive and reactive types of protocols. On the basis of requirement of user, the routes are generated within the reactive or on-demand types of routing protocols [3]. The Dynamic Source Routing Protocol (DSR) and the Ad-hoc on-demand Distance Vector Routing Protocol (AODV) are the two reactive routing protocols. Up-to-date information of routes is maintained for each node to every other node present in the network within the proactive types of routing protocols. Through the exchange of topological information amongst the nodes of network, the topology of the network is continuously learnt by these protocols. An immediate availability of the route information is provided when route is to be established towards the destination [4]. By making some enhancements within the classical Bellman-Ford Routing algorithm, the Destination-Sequenced Distance-Vector (DSDV) Routing protocol is developed. Because of the issues such as count to infinity and bouncing effect, the distance vector routing is less robust in comparison to link state routing. Entries from all devices present within the network are maintained within the routing table for every device through this protocol. A point-to-point proactive type of routing protocol in which multipoint relaying is performed is known as OLSR the Optimized Link State Protocol. Multipoint relaying is an efficient link state packet forwarding mechanism. OLSR is a pure link state routing protocol in which there are two methods in which the optimizations are performed. The size of control packets is either minimized or the numbers of links that are utilized for forwarding the link state packets are minimized. Through exchange of link-state messages amongst other nodes periodically, the topology information for each node is maintained [5]. On the basis of flooding algorithms which is similar as in DSR, the Location-Aided Routing (LAR) protocol is developed. The minimization of routing overhead on the basis of location information is the prior objective of LAR protocol. By restricting the flooding to specific regions, the information of location will be utilized by LAR. The protocols in which the various properties of both proactive and reactive types of routing protocols are included are known as hybrid routing protocols. There is either flat or hierarchical type of routing possible amongst which hierarchical routing is provided by hybrid types of routing protocols. The organization of networks as per the parameters involved is impossible within these routing protocols. The nodes in which high level of topological information is present are responsible for maintaining higher amount of routing information. Due to this, the memory as well as power consumption is higher, which is a major drawback of these routing protocols. The localization of nodes into sub-networks or zones is done by applying ZRP protocol which is a hybrid type of protocol [6]. The advantages of on-demand and proactive routing protocols are combined within this protocol. In order to increase the speed of communication amongst the neighbors, proactive routing is applied within each zone. In order to minimize the unnecessary communication, on-demand routing is utilized by inter-zone communication. On the basis of distances amongst the mobile nodes, the network is partitioned into routing zones. The combination of routing with QoS is provided by a partitioning protocol named as Core Extraction Distributed Ad hoc Routing (CEDAR). A dominator node which is a core node is present within each partition made through this protocol [7]. So, all such types of protocols have their own advantages and disadvantages on the basis of which they can be applied to certain applications.

2. Related work

Chanda Dhakad, et.al proposed a novel technique for minimizing association, node crash, packet loss and other issues arising within MANETs [10]. A novel LFAODV technique is proposed here in order to provide a reliable and stable route for communication. Comparisons are made against SEAODV in order to identify the shortest path. It is seen that the proposed protocol provides the shortest path for communication and ensures better connectivity degree amongst the nodes. Further, the issues related to node failure are also eliminated by applying the proposed technique and the results achieved have been enhanced in terms of accuracy and path failure has also been minimized. Deepika Vodnala, et.al proposed an Efficient Backbone Based Quick Link Failure Recovery Multicast Routing Protocol for avoiding any kinds of link failures within the MANETs [9]. The multicast groups are generated in order to create virtual backbone within the proposed mechanism. An alternate path is provided due to link failure on the basis of localization due to which the efficiency and reliability of MANET can be enhanced. In order to attain minimum control overhead, higher packet delivery ratio and throughput, less jitter and packet loss ratio, this network model is proposed. It is seen as per the simulation results and comparisons that the proposed protocol provides enhancement in results. M. Malathi, et.al presented in this paper the need of introducing reliable route within the dynamic MANETs. Within these networks which are highly dynamic in nature, reliable communication is required. So, Power Proficient Reliable Routing protocol is a novel protocol proposed in this paper [11]. Route failure occurs within these networks due to mainly three reasons. Channel Quality, Link Residual Life and Residual Energy are these three reasons. The route failure which occurs during transmission can be minimized due to link residual life during the path discovery. The overall throughput of the system is enhanced due to the channel quality involved during the route discovery process. The node failure during data transmission can be minimized because of residual energy involved during the routing process. As per the simulation results, the performance of proposed protocol is enhanced for several mobility speeds by applying the proposed protocol. Sedrati Maamar, et.al proposed a novel protocol on the basis of AODV which is named as (PF_AODV) [12]. The QoS of the MANETs is enhanced with the application of this protocol. The prediction of future disconnection of road that is being used and providing new segment before the disconnection occurs is done by utilizing signal strength. Various simulation experiments are performed by applying this novel protocol and the results are evaluated. It is seen that in terms of parameters like throughput, loss and delay, the proposed PF_AODV provides better results.

Sachi Brahmbhatt, et.al [20] presented the multimedia communication that is widely used nowadays in the wireless networks. Network performance can be increased using multicast networks that transmit data to various receivers. They are transmitted on the basis of their node energy, network congestion and bandwidth consumption. Link failure is caused due to the availability of high mobility in the application of the MANETs. Author mainly focused on the issues and their solution that occurred in the multicast network. This can be done by selecting stable links in route construction process. When the data is transmitted the maximum signal strength has been utilized that lead to the availability of higher rate of node in the process of communication flow. In order to solve the issue of the route and link failure author enhanced the existing On demand Multicast routing protocol (ODMRP) that was utilized for the communication of multi-media. These existing protocols follow the first come first serve (FCFS) method that lead to route failure.

Abedal Motaleb Zadin et.al presented a node protection protocol through which stable connections have been established within MANETs which face several node failures [8]. There is higher network stability as well as packet delivery ratio provided by proposed protocol as per the simulations performed. In the simulations, it is also seen that the communication reliability of MANETs is affected due to the time various locations and velocities of the mobile users as per this model. Against the link protection protocol, the protocol is validated and compared through which enhancements have been seen in terms of number of packets delivered and there is occasional failure of the nodes which affects the delivery rate. The graphs that have less nodes can notice the advantages of GBR-NP.

S.A. Jain, et.al., in this paper [17], they presented the ad hoc connections, which opens many opportunities for MANET applications. In ad hoc network, nodes are movable and there is no centralized management. Routing is an important factor in mobile ad hoc network that not only works well with a small network, but also it can also work well if network get expanded dynamically. Routing in Manet is a main factor considered among all the issues. Mobile nodes in Manet have limited transmission capacity; they intercommunicate by multi hop relay. Multi hop routing have many challenges such as limited wireless bandwidth, low device power, dynamically changing network topology, and high vulnerability to Failure. To answer those challenges, many routing algorithms in Manets were proposed. But one of the problems in routing algorithm is congestion which decreases the overall performance of the network so in this paper we are trying to identify the best routing algorithm which will improve the congestion control mechanism among the entire Multipath routing protocols.

Sreenivas B.C G.C., et.al, in this paper [18], they introduced about congestion control is a key problem in mobile ad-hoc networks. Congestion has a severe impact on the throughput, routing and performance. Identifying the occurrence of congestion in a Mobile Ad-hoc Network (MANET) is a challenging task. The congestion control techniques provided by Transmission Control Protocol (TCP) is specially designed for wired networks. There are several approaches designed over TCP for detecting and overcoming the congestion. This paper considers design of Link-Layer congestion control for ad hoc wireless networks, where the bandwidth and delay measured at each node along the path. Based on the cumulated values, the receiver calculates the new window size and transmits this information to the sender as feedback. The sender behavior is altered appropriately. The proposed technique is also compatible with standard TCP.

Sunita Nandgave-Usturge [19] discussed about the challenges faced by the MANET in which major challenge is Routing with its mobility feature. There are various reasons that hamper the functioning of MANETs that is interference, congestion and mobility that cause link failure in a network. The occurrence of interference is due to hidden node and collision. When the two nodes far from each other's radio range and transmit data to the intermediate node within the range of the sending nodes is known as hidden node. Nodes are free to move within its transmission range is known as mobility. The collision occurs at the intermediate node as the sending node is not aware of the presence of other node while transmission that cause collision in a network. The RTSCTS handshake method of 802.11 MAC has been utilized as the solution to overcome the issue of interference problem at the hidden node. The parameter of the cross layer interaction is signal strength where it is analyzed when received from the physical layer and evaluated at the MAC layer whether it is above certain threshold. Link is weak if it is less than threshold and vice-versa. Due to weak signal strength a route cause link failure therefore an alternate path is found. Author concluded that proposed protocol AODV has better mechanism to avoid congestion and it is useful signal strength based congestion control.

Mohammad Amin, et.al introduced [16] standard congestion control cannot detect link failure losses which occur due to mobility and power scarcity in multi-hop Ad-Hoc network (MANET). Moreover, successive executions of Back-off algorithm deficiently grow Retransmission Timeout (RTO) exponentially for new route. The importance of detecting and responding link failure losses is to prevent sender from remaining idle unnecessarily and manage number of packet retransmission overhead. In contrast to Cross-layer approaches which require feedback information from lower layers, this paper operates purely in Transport layer. This paper explores an end-to-end threshold-based algorithm which enhances congestion control to address link failure loss in MANET. It consists of two phases. First, threshold-based loss classification algorithm distinguishes losses due to link failure by estimating queue usage based on Relative One-way Trip Time (ROTT). Second phase adjusts RTO for new route by comparing capabilities of new route to the broken route using available information in Transport layer such as ROTT and number of hops.

Problem formulation

The mobile ad-hoc network is the decentralized type of network in which mobile nodes join or leave the network when they want. Due to which quality of service is the major issues of the network. The DCFR is the improved version of AODV protocol for path recovery in mobile ad-hoc networks. In the DCFR protocol, when the mobile node change its location then link failure occurred in the network. The DCFR protocols works on the node connectivity factor for the link recovery. When any node detects link failure in the network, then the code with which maximum number of nodes is connected is selected as the best node for link recovery. The DCFR protocol performs well in terms of certain parameters but for the link recovery it does not include quality of service parameters. In this research work, improvement in the DCFR protocol will be proposed by applying quality of service parameters for path recovery in mobile ad-hoc networks.

3. Proposed methodology

The Improved Dynamic Connectivity Factor routing Protocol (DCFR) includes the several components in it which are discussed further. The major objective of this proposed protocol is to replace the variables used within the network parameters by utilizing a novel connectivity and buffer size estimation metric. Further, a novel dynamic connectivity factor is utilized in order to drop the extra RREQ packets. Due to this, the routing overhead of the network is minimized. In order to work within the three major stages which are route discovery, route reply as well as route maintenance, the AODV, the NCPR, and the proposed improved DCFR protocol are introduced. The routing table for the destination needs to be checked when there is a need to transmit the data from one node to another within the network. The transmission of data from source node is initiated once the destination is identified. If the destination is not found, a route to the sink node is identified by RREQ [13]. The flooding mechanism however is the only mechanism through which the nodes that have path towards the destination can be identified. In this mechanism, each node that receives RREQ for the first time rebroadcasts RREQ in the network. Further, a Route REPLY message (RREP) is sent back as a reply from the sink node or any node that needs to establish route. However, there is link breakage within the nodes as they move frequently. A Route ERROR message (RERR) is generated if any such event is identified by any node to the neighbors so that this breakage can be notified With the minimization of redundant RREQ packets, the flooding issue is addressed by DCFR at initial stage. However, routing overhead still occurs due to the presence of these messages that are relevant to the flooding mechanism. The performance of the DCFR degrades the performance when the link failure occurred in the network. The performance of system is enhanced by recovering the path in the least amount of time. There are numerous disadvantages of various protocols presented in this research. The performance of network is degraded due to the extra routing overhead caused by protocols. In order to resolve all such issues occurring within the route discovery and link recovery process, a novel protocol is proposed here [13]. The various parameters utilized within the experiments are explained further. The major issue for various routing protocols like AODV and NCPR is the aggregated routing overhead and link recovery. As shown in Equation (1), in these protocols, the route discovery overhead and route maintenance overhead are caused.

$$\mathrm{RO_{aggregated}} = \mathrm{RO_{discovery}} + \mathrm{RO_{maintenance}} \tag{1}$$

In this research however, the routing overhead is only discussed in the initial part of route discovery. This is defined as the RREQ overhead and is shown in Equation (2) below.

$$\mathrm{RO_{discovery}} = \mathrm{RO_{RREQ}} + \mathrm{RO_{RREP}} \tag{2}$$

Here, the route reply overhead is denoted by$\mathrm{RO_{RREP}}$. Further, for all nodes present within the network, the sum of all RREQ overhead is defined by$\mathrm{T_{RO-RREQ}}$. These nodes involved here are all searching for a path such that the data can be transmitted at particular time (t). This is explained in Equation (3) below:

$$\mathrm{T_{RO-RREQ}} = \sum_{i=1}^{n} \mathrm{RO_{RREQ}}(P_i) \tag{3}$$

Here, for packet (P_i) the total number of RREQ is represented by n. On the basis ofDCF, $\mathrm{DCF}(P_i)$, a new connectivity metric is utilized by DCFP for each of the received RREQ packet (P_i). The forwarding decision of the received RREQ message is affected due to this metric. The preset variable present in NDPR are replaced by DCF. On the basis of average number of neighbors present within a network, this formula is proposed [13]. Thus, while making forwarding decision related to whether the RREQ packets are to be forwarded or dropped is made on the basis of average number of neighbors present in the network From an extensive run of thirty different environments for every point, the novel formula for DCF is proposed. Here, the nodes are diverse up to the range of 50 to 300. For all nodes present in the network, the total numbers of neighbors are computed here after which the experiments are performed. After computing all these values, the average number of neighbors is calculated. On the basis of number of nodes and the information collected from the experiments, a curve is drawn. In order to identify the best formula through which the similar relation amongst the average number of neighbor send the total number of nodes can be represented, this curve can be evaluated.

Further, in Equation (4), a new variable known as is calculated.

$$\mathrm{NB}_{(ni)} = 1 + \left(\frac{N_{(n_i)}}{c}\right)^{b} \tag{4}$$

Here, the total number of neighbors that receive RREQ for any node which are represented by $N_{(n_i)}$. The variables 'b' and 'c' are fixed.

By using DCF as shown in Equation (5), the total number of nodes can be computed.

$$\mathrm{DCF}_{(n_i)} = \mathrm{d} + \frac{\mathrm{a-d}}{[\mathrm{NB}(n_i)]^m} \quad (5)$$

Here, the fixed variables involved are 'a','d' and 'm'. a novel connectivity factor known as Dynamic connectivity-Aware Factor (DAF) is thus proposed here. Through this, the RREQ redundant packets found in NCPR and AODV protocols are minimized. Equation (6) shows this evaluation.

$$\mathrm{DAF}(n_i) = \frac{\mathrm{DCF}(n_i)}{\mathrm{N}(n_i)} \quad (6)$$

The current node located either within the sparse area or the dense area is reflected by the dynamic connectivity factor. The ratio of average number of neighbors to the number of current neighbors for a given node is computed for this. The node which has maximum connectivity factor which is calculated by the equation 6 is selected as the node which can recover the path from source to destination. The buffer size will be allocated to each node in the network by DCF the basis of equation (7)

$$\text{Buffer allocated to each node}=\frac{\text{total buffer space}}{\text{number of nodes}} \quad (7)$$

The total buffer space is the space which is available for the allocation and number of nodes are the nodes which are available in the network.
The DCF has the component which can estimate the vacant buffer size on each node for the path recovery. To estimate the vacant buffer space on each node the equation 8 is given

$$E_{\text{vacant buffer}}= [\frac{\text{buffer of nodes}(n-1)}{\text{total buffer allocated}}]*\text{nn} \quad (8)$$

The vacant buffer size is calculated, when the neighbor node buffer size will be divided from the total buffer size. This process will be repeated until vacant buffer size of each node will be calculated. The node which has maximum Estimate $_{\text{vacant buffer}}$ which is calculated with equation 8 and maximum connectivity which is calculated with equation 7 is selected as best link recovery node from source to destination. Algorithm 1: Improved DCFR Protocol for Link Recovery

1) Initialization :

NN=Number of Nodes in the network

2) Establish path from source to destination If path exits from source to destination Else Source send route request packets

When node receive route request message Path established from source to destination If source receive route error message

Calculate $NB_{(ni)} = 1 + (\frac{N_{(n_i)}}{c})^b$

Calculate $DCF_{(n_i)} = d + \frac{a-d}{[NB(n_i)]^m}$

Calculate E $_{\text{vacant buffer}}$ = $[\frac{buffer\ of\ nodes(n-1)}{total\ buffer\ allocated}]$*nn

If ($DCF_{(n_i)} > DCF_{(n_i+1)}$ &&Evacantbuffer (ni)>Evacant buffer (ni+1) Recovery node=Ni
Else
Recovery node=N_{i+1}
End;
End;
End;

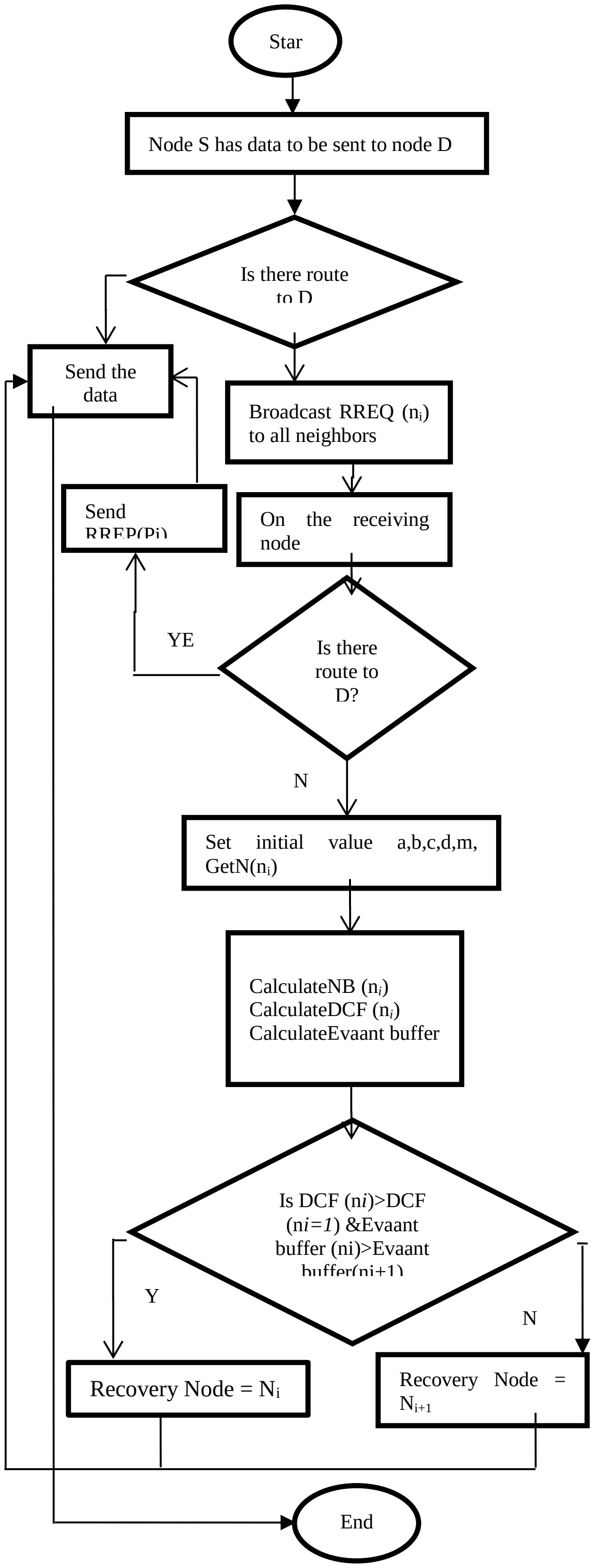

Fig. 1: Proposed Flowchart.

4. Implementation

By using the latest version of NS2, which is version 2.35, the improved DCFR protocol is implemented. The connectivity factor and buffer size is modified in order to enhance the source code of NCPR protocol such that the improved DCFR protocol can be implemented. A hello message is used in order to update the neighbor table. The Improved DCFR Evaluation: Comparisons are made amongst the DCFR protocol [14] and the improved DCFR Protocol within MANETs in order to evaluate the performance.

There is a need to preset the value of total number of nodes present in the network as well as to minimize the number of redundant packets. However, the major objective of this improved DCFR protocol is to avoid link failure. Thus, there will be minimization of routing overhead, end-to-end delay, energy consumption as well as MAC collision rate in the network. Furthermore, by handling the packet delivery ratio, there will be increment in the network connectivity. The scenario in which such enhancements are made is a high-or low-density network and high or low traffic loads. Within the simulation scenario, for each node, the transmission range taken is 18 meters and in order to create the mobility as well as node position, the random waypoint model is utilized. The setdest command version 2 from NS-2 is utilized in order to include the usage of tools. The uniform distribution is followed and amongst 1300 trails present in the created mobility models, 2scenarios are selected. From range of (1) to (5), the speed of node can vary. The pause time involved here is (0), across the region of 1,000 meters X 1,000 meters the nodes are deployed in random manner, 512 bytes of packet size and 2Mbps of bandwidth is used. The value of Constant Bit Rate (CBR) can vary up to 10, 12, and20 which are applied during the connection of nodes. Table 1 shows simulation parameters involved within the simulation.

Table 1: Performance Parameters

No.	Simulation Parameters	Value(s)
1	Simulator	NS-2 version (2.35)
2	Number of Nodes	25, 40, 60, 100
3	Topology Size	1000 m X 1000 m
4	Node Transmission Range	18 m
5	Connection Type	CBR
6	The Packet Size	512 bytes
7	Min Speed of the Node	1 m/s
8	Max Speed of the Node	5 m/s
9	Pause Time	0 s
10	The Number of CBR Connection	10, 12, 14, 16, 18, 20
11	Packet Rate	4 packets/Sec
12	Route Bandwidth	2 Mbps
13	Interface Queue length	50

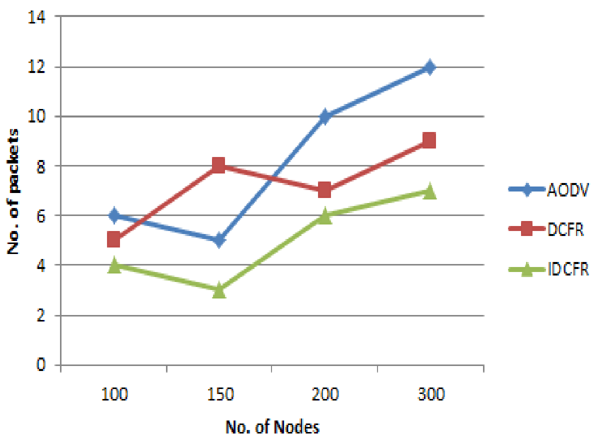

Fig. 2: Packet Loss Comparison.

As shown in figure 2, the packet loss of the AODV, DCFR and IDCFR protocol is compared for the performance analysis. The Packet loss of the IDCFR protocol is least as compared to AODV and DCFR protocols

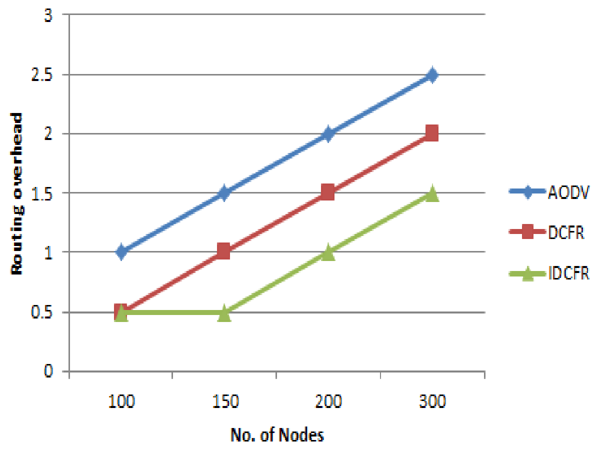

Fig. 3: Overhead Comparison.

As shown in figure 3, the routing overhead of improved DCFR protocol is compared with existing DCFR protocol. In the improved DCFR Protocol, the routing overhead is reduced as compared to DCFR Protocol. The routing overhead of AODV protocol is also compared with other two protocols and performance analysis is done versus number of nodes.

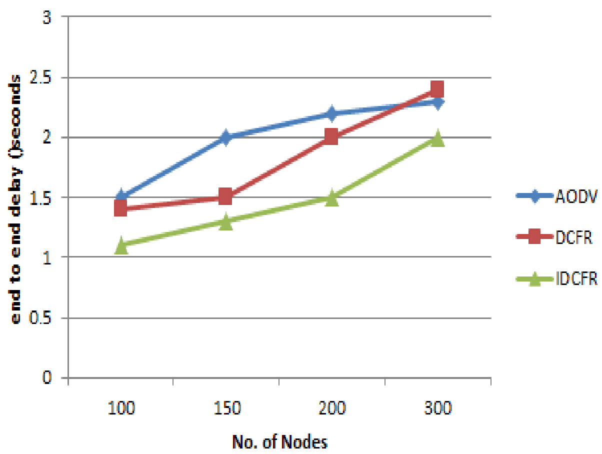

Fig. 4: Delay Comparisons.

As shown in figure 4, the delay of improved DCFR Protocol and existing DCFR Protocol is compared and due to route maintaining property of improved DCFR Protocol delay is less as compared to existing DCFR Protocol. The graphs are drawn versus number of nodes.

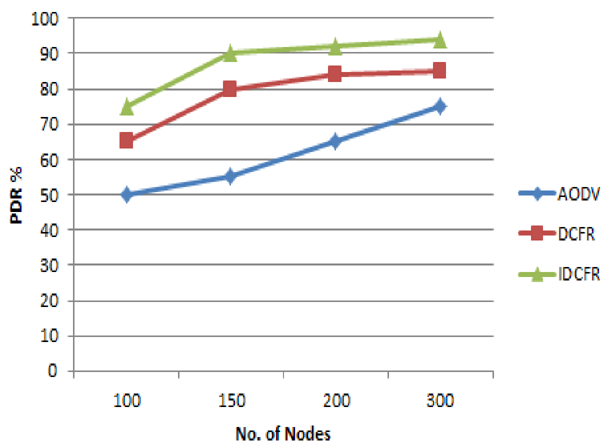

Fig. 5: Packet Delivery Ratio.

As shown in figure 5, the PDR values of AODV,DCFR and IDCFR protocol is compared and it is analyzed that IDCFR protocol performs well as compared to other two protocols. It is analyzed that graphs are drawn versus number of nodes.

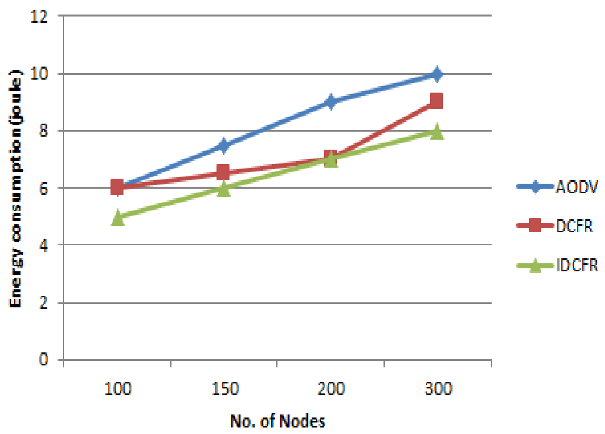

Fig. 6: Energy Consumption.

As shown in figure 6, the energy consumption of AODV, DCFR and IDCFR is compared for the performance analysis. The IDCFR protocol has least energy consumption as compared to DFCP and AODV

5. Conclusion and future scope

In this work, it is concluded that mobile ad-hoc network is the self configuring type of network in which mobile nodes join or leave the network any time. The DCFR protocol is the routing protocol which helps in route establishment and route maintenance on the basis of node connectivity. In this research work, the buffer size parameter is further added for the route recovery. The node which has maximum connectivity factor and also has maximum buffer size is selected as the best node for path recovery from source to destination. The simulation of proposed DCFR protocol and existing DCFR and AODV protocol are compared in terms of packet loss, routing overhead, delay and energy consumption. The simulation results shows up to 10 to 15 percent improvement in improved DCFR protocol as compared to existing DCFR Protocol. In future, the technique will be design which improves security of MANET using light weight cryptography.

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