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Enhance the Efficiency Routing between Mobile Nodes in MANET Networks

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ABSTRACT

This paper evaluates the performance of the OLSR pro-active protocol with and without backup routes under varying node densities and with different speed movements in the network. Additionally, this paper assists in ascertaining the effect of varying node densities on the connectivity's life between mobile nodes in the network. Hence, it showed the affect of a local recovery mechanism resulted in achieving a significant improvement in network performance by seeking a long life backup path between source and destination for low/high density nodes. Real time applications are required to be supported by mobile ad hoc networks. This is because of the free movement for the mobile nodes from one area to another without any notification via frequent paths. The real time applications traffics are considered a sensitive application, and it is the most affected by failure through the occurrence of delay and loss of packets. It is, therefore, not suitable for use by players. In mobile ad hoc networks, routing protocol functions are based on many factors, such as, node mobility and density and broken paths

Keywords

Link state; ART (Alternative Routing Table; Mitigation Fault

1. INTRODUCTION

Network communication continues to increase and thus the system is required to tolerate large volumes of traffic with respect to huge capacity of links. Network communication is affected by frequent failures and this leads to find an efficientrecovery mechanism. In current networks, failures occur frequently, which will affect the stability of the network. When there is a link or a node failure, the node that is connected to that failure needs to re-compute its routing table and propagate the up- dates to all nodes concerned with this failure. The work in this paper provides a new study based upon node density with varying speed movements from low to high in the network's topology. The aim of this study is to analyse the network's performance in high and low density nodes when they move from low to high speed in order to optimise the best number of nodes in the same range. The challenge, however, in ad hoc mobile networks, is that the flexibility of node movements results in an increase in overheads and delays during route maintenance. There is a need to mitigate this effect. Flooding control packets can be harmful due to sharing wireless media. When this occurs, the loss of packets is both high and difficult to avoid [16]. Increasing the number of nodes inside the terrain area will result in them taking less time to find an alternative backup path but it will also produce a higher overhead. Hence, a high density of nodes leads to a better retention of connections compared to nodes in low density. In low density, the frequent movements of nodes can form an instantaneous disconnected graph between source and destination and then packets that have been already sent will be dropped.

OLSR is a traditionally driven routing protocol based upon a link state algorithm. It a pro-active (table-driven) protocol, which employs the periodic exchange of control packets to maintain topological information about a network's topology but at the same time it combines the amount of information sent in the packets to reduce the number that are re-transmitted over the entire network. OLSR was developed in order to address and provide protection against frequent failures when nodes keep moving during the simulation time by computing an alternative path and using it in case of loss of connection. This work considers how to support video traffic across a different number of nodes in a network's topology. In this paper, the researcher proposes a Backup Route-OLSR (BR-OLSR), which aims to create a backup path with fewer overheads. Moreover, BR-OLSR can work with any network environment including high or low-density ones.

The main contribution of this paper is to optimise the number of nodes in the terrain area and provide a reliable backup path to the destination together with a high QoS for players. This paper evaluates the overall proposed solution (backup path), that is, the ability of the OLSR routing protocol to react to changes in the network's topology while at the same time it the endeavours to send successfully packets from source to destination. This evaluation is based on the simulation of 25, 50 and 100 nodes that form an ad hoc mobile network topology. These nodes move and change their positions over a rectangular terrain area. An extension code was implemented and configured by using an OLSR protocol to compute a backup path during the convergence of the network's topology. This technique will lead to high QoS for video traffic in live streaming networks and reduce the impact of frequent failures.

2. NODE DENSITY IN MOBILE AD-HOC ROUTING PROTOCOL

2.1 Network with Varying Node Density

In MANET ad hoc networks, each environment has a different number of node densities. As a realistic environment, low node density can be concentrated in small area, such as, parks or roadways. High-density mobile nodes are found in urban city buildings within a specific area. In low density, the movement of mobile nodes can lead to the formation of a disconnected graph when any node in the propagation range starts to move to an area with fewer mobile nodes. In high density, the availability of adjacent nodes maintains the connection for a long time, (even if the mobile nodes move far from the source node), because the number of adjacent nodes surrounding the source node in the model's space area can achieve a more efficient route with better fault-resilience.

2.2 Mobile Node Movement

Our mobility model employs the Random Way-point model, which allows the nodes to move randomly within a predefined area. Hence, each node can chose a destination and then move directly towards it at different speeds uniformly distributed over 1 to 20m/s. A source node starts to determine the final destination where to forward the data packets via the primary path in its routing table. Hence, the nodes are travelling at variable speeds (from low to high), which causes continuity changes in the topology and routing table. With regard to movement, the number of neighbours can be increased or decreased for each node in the network based upon their direction. They is more efficient when their density is high. Figure 1 shows the direction for each node that moves within the area. Each node moves randomly by selecting a new direction with a different speed.

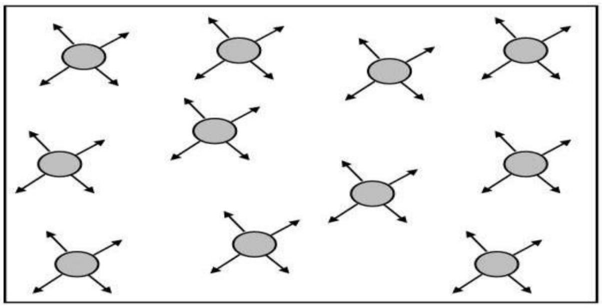


Fig 1: Simulated Movement in the Random Mobility Model

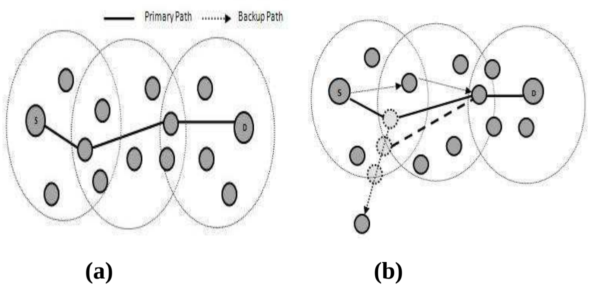
2.3 Backup Route Discovery

In route discovery, high density can offer a number of multiple disjointed paths unlike low density where fewer alternative paths are available. In network communications, using pre-computed second paths provide a solution when failure or loss of connectivity occurs. Pre-computed paths demonstrated good performances in high-density conditions in some cases. With ad-hoc mobile networks, mobile nodes in the same range can exchange messages with their neighbours to create a full view for the whole network. Through these messages, the routing protocol will begin to construct the routing table between source and destination. Neighbourhood is represented by a set of nodes that have at least two nominated as neighbours. The BR-OLSR protocol computes a backup path after checking that, these nodes are on the primary one. The protocol then excludes them to ensure that the alternative path will be disjointed from the primary one and that it has different nodes to be able to maintain this path even if the nodes move. In high density, the BR-OLSR protocol estimates the best adjacent node based on the shortest distance from the source node to find a long lifetime path. This is because when this adjacent node starts moving it may need more time to be out of the source's range. This is applicable to all nodes in the network. Each node, however, on the primary path marks an adjacent one that has a disjointed path to the destination hop-by-hop with guaranteed freedom from local loops in the network. A high-density network with a recovery mechanism is less likely to create local loops in the network compared to a low-density one because of the number of multi-path routes available for each mobile node in the network's topology. Hence, loops can be avoided and packets do not return to nodes that have already previously passed the same packets.

3. MOBILITY AND DENSITY IMPACT ON BACKUP ROUTE

The motivation is to evaluate the computed backup path between source and destination when the primary path breaks down with respect to the mobility and node density, and to gain a better understanding of the optimum number of mobile nodes with different speeds that is required within the space area during transmission. When nodes begin moving, the nodes are connected directly with failure will detect a link break by receiving a link layer feedback signal, which takes a few milliseconds. The BR-OLSR protocol, via the backup path, will pass traffic to its destination without waiting to re-compute a new routing table and any other procedures that the routing protocol may perform. Due to the node movements, failure can occur suddenly. Thus, the reaction by nodes once notified about failure (having received a notification) is to re-route the traffic via the adjacent node, which has previously been selected as a first hop in the backup path. Each adjacent node replies with an acknowledgement in the form of a packet field containing ”0” or ”1”. When the acknowledgement packets contain ”1”, it means that the adjacent node has a different route and it can provide a backup node in case of failure. If the acknowledgement packets contain ”0”, it means this node cannot act as a backup adjacent to the destination. When the source node extracts the packets and checks if they contain ”1,” it will insert the node that responds with a ”1” into its backup route as a first hop. If a ”0” packet is received, the source node will then check the answers from other adjacent nodes. Thereafter, if all acknowledgement headers from all adjacent nodes contain ”0”, all these will signal that the traffic cannot be passed. Hence, the second step of the BR-OLSR protocol is to find an alternative path from their adjacent node to another. We performed high and low density topologies, which acted as good examples, giving each node at least two neighbours that can re-route data packets through either of them when failure occurs. The BR-OLSR with high density performed better with less recovery time than low density because of the availability of multiple disjointed paths that can be easily found.

Figure 2 shows the primary and backup path. When the BR-OLSR protocol determines the primary path, it will discover how many adjacent nodes located within the same area range are not connected to the primary path. The primary path from source to destination is computed by a routing protocol. Any nodes connected to the primary path will be excluded from the next hop in the backup route. Each node randomly takes a position (X , Y) in the radio propagation range for the area (1000 X 1000 m2). All nodes are considered as a source and destination, so each node will check the arrived acknowledgements from adjacent nodes to see if there is any available route to the destination. If more than one alternative path exists, then the node will select the best one based upon distance and the number of hops.



(a) **(b)**

Fig 2: Finding Backup Path

4. RELATED RESEARCH

Different routing protocols have been published for different environments to improve network performance when connectivity is lost by nodes moving or failing [22, 6, 15, 7]. In [8], the authors indicated some of MANET's features and environments, such as, BW, resources and limited energy. Some proactive routing protocols (such as DSDV, OLSR, CGSR and WRP) trigger messages that can detect links when they fail [12, 10]. Based on these messages, the routing protocol can construct and maintain routes to its destination. In reactive protocols, such as, DSR, AODV (On-demand Distance Vector) and TORA, overheads will be reduced because new paths between two nodes will only be created when a failure occurs. In [11, 5], it was found that the OLSR had Multi Point Relay (MPR) nodes, which were used to send link state messages to construct a routing table. In OLSR, two kinds of broadcasts are sent: Hello and Topology Control (TC) messages. Each node will send a Hello message to its neighbours every two seconds to check if connectivity is up or down as a waiting time of six seconds is considered too long.

The TC message is thus based on the information collected by the Hello messages [2]. The interval time is five seconds. The holding time is fifteen seconds to allow for the detection of failures. The OLSR routing protocol allows the nodes to start transmitting data packets only after re-computing a new routing table and updating the information for all the nodes on the topology. Depending upon Hello message interval times, the re-routed traffic will take longer, which leads to an increased loss of data packets and reduced throughput [3]. With respect to node density, in [4], 60 nodes were created and distributed in a 1200m X 800m terrain area. The Random Waypoint Mobility Model with varying node speed from a low of 2.5m/s to a high of 15 m/s was configured by the network [20]. This research, however, showed that high node density did not have a significant affect because of node mobility. This is because radio connection cannot be lost quickly to the surrounding nodes. The paper showed the advantages of Multiple Path Tree Algorithms for the traffic. In contrast with [21], the authors proved that providing multi-disjoint paths at the same time can improve network performance. In [13],the authors mentioned how recovery in a network can be achieved within a short time when failure occurs by computing an alternative backup path. In a QoS routing schema, the Core Extraction Distributed Ad Hoc Routing (CEDAR) an algorithm was introduced for a medium size ad hoc network. CEDAR is an on demand routing protocol [17]. It advertises to all core nodes with high link bandwidths to compute the path. The philosophy behind the multiple paths QoS routing schema is to try to find a number of paths between source and destination based on high capacity bandwidth requirements. Service providers can offer a reliable service via a set of measurements, such as, delay, jitter and loss of data packets. These parameters are the part of QoS that can optimise the network by investing in the provisioning of resources in cases of increased traffic or node failures [9, 14]. In [18], the authors discussed how to enhance service discovery in terms of service discovery and energy consumption. In addition, the paper mentioned the effects of node speed and density on the duration of discovered services. In [19],the authors presented the problems that arise in the MANET routing protocol's design, such as, broadcast storms, stale routes and faulty nodes or the frequency of node movements from one area to another. The authors introduced a new routing protocol called the Density-First Ad Hoc Routing Protocol. This protocol considered node density and route length in order to choose paths with longer lifetimes and better throughput. The current researcher evaluated the performance of nodes under different conditions of density where a backup route existed (having been computed in advance) to improve the performance of the network [1].

5. SIMULATION EXPERIMENT

5.1 Simulation Environment

A network simulation (NS2) was performed to evaluate the performance of the proposed enhanced protocol in high/low density nodes with the free movement nodes in the network. A comparison of the simulation results of the OLSR protocol with and without our extension code was made. The evidence gathered by the NS2 simulation offered good support for node mobility in ad hoc mobile networks. A radio propagation range with a transmission power of 0.28 watt was used. It allowed each node to send or receive a packet to or from its neighbours for a distance up to 250m. At the physical and data-link layers, the researcher used the IEEE 802.11b protocol to allow the multimedia wireless to be shared. The random WayPoint mobility model was employed with a roaming area of 1000 X 1000 m2 in the network simulator. During the simulation, each node's speed changed from low to high (in meters/second). The initial speed was 1m/s (low mobility). Subsequently, the nodes started to move to 5, 10 and 20 m/s respectively. The duration of each simulation was 250 seconds. All results were repeated 10 times and an average calculated. The packet size was 512 bytes and the bit rate was set to 2Mb/s. As is known, the wireless channel can be shared in an ad hoc configuration network. In relation to density, the first simulated scenario included 25 nodes moving on in a field terrain of 1000m by 1000m. These nodes followed the random WayPoint model with variations in speed from 1 to 20 m/s (minimum speed remained 1m/s). The second and the third scenarios (the high-density scenarios) were identical to the first but included 100, 50 nodes. Both scenarios lasted 250 seconds. Traffic rate of 200Kb/s was generated from the source node to destination during the simulation. Based on the parameters in table 1, we have shown the simulation results in the form of line graphs in the following section. Each graph illustrates a comparison between the OLSR protocol operating with and without computing a backup path while varying the node's density and their speeds.

Table 1. Simulation Parameter for High/low Density Mobile Node

Parameter	**Value**
Wireless technology	IEEE 802.11
Max. range	250 m
Roaming area	1000 X 1000 m^2
No. of Nodes	25,50,100
Pause Time	No pause time
Min. Speed	1 m/s
Max. Speed	20 m/s
Mobility model	Random WayPoint
Routing protocol	OLSR

Before evaluating the performance issues of network topologies with respect to computing a backup path over MANET, it is important to determine the network's parameters that could affect the QoS of streamed video traffic. Here the research focuses on three parameters, which may better reveal the affect of video traffic techniques:

- Packet loss ratio: the packet ratio between dropped and sending data packets.
- Average end-to-end delay: the average time between transmission and arrival data packets.
- Throughput: the number of packets arrived successfully during the simulation time without any disturbs.

In order to evaluate the effect of the density of mobile nodes, it is necessary to recognise that high density is longer lived compared to low/medium densities. This is because the latter is less able to discover and maintain new paths when the nodes start to move further from each other, increasing the possibility to form a disconnected topology. High-speed movements lead to an increase in the probability of paths breaking compared to when nodes move at a slower speed. This means that nodes are more stable when they move slowly and thus the slower movement maintains services for longer. We measured the packet delay for different cases: high/low density with high/low speeds.

5.2 Performance and Analyses Evaluation

Figure 3 shows the results for the average end-to-end delay as a function of node movement from low to high speed with varying numbers of mobile node densities. The delay in low density performed better for 1-10 m/s movement speed compared to high density, but in high density the delay was reduced when the mobile nodes moved in high speed. This is because of the availability of more adjacent mobile nodes around the source that can pass the packets directly between them, which reduces the waiting time for the packets inside the node's buffers. In addition, when the nodes move in a random direction the possibility of making the source node move towards its destination and vice-versa is increased, therefore, packets arrive at the destination in a shorter time. On the other hand, when the destination node is further from the source node each node will retain its data packets in its buffer until it can find an available path to forward them to their destination. If a node receives packets that exceed the size of the buffer then it will start to drop them. In low density, when the node is moving at high speed a disconnected network can result in which the nodes cannot send or receive data packets until they join another space area that has mobile nodes within the same range. The BR-OLSR protocol reduces the delay when a loss of connection occurs along the pre-computed backup path (that can pass the traffic directly to its destination) when the nodes are informed about the failure. In high node mobility, the delay time will be greater than for low density if based on the length of the path between source and destination when the nodes move at low speed.

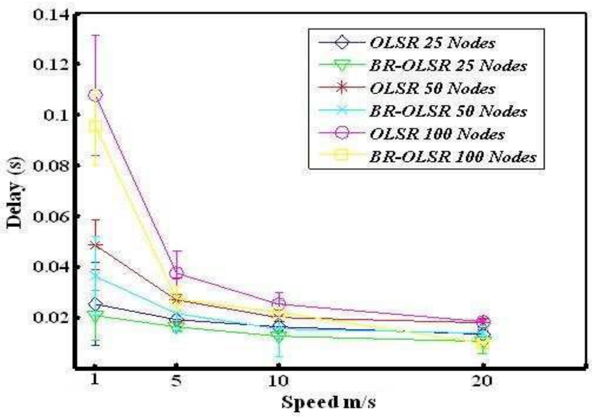


Fig 3: End to End Delay

The low density has an advantage by sending fewer control packets transferring between nodes, and fewer next-hops are needed to pass the packets to their destination. In contrast with high density offers the advantage of its inherent availability to form many backup routes, which reduces computation times for the recovery mechanism to find an alternative path compared to low density nodes. Hence, more alternative routes can be found because each node has many neighbours. As the speed of the nodes increase they will start to change their positions more frequently, which will lead to the packets being retained in their buffers longer with an increased drop of packets. The availability for computing an alternative path, however, can be used to pass data packets to their destination during the process to compute a new primary path. When the alternative path is still available to each node on the primary, mobile nodes will try to dispose of the packets in their buffers by sending them to the backup next hop before losing the connection. By changing the speed from low to high, node movement directions can play an important role by reducing the delay time while the destination and source are moving around each other. When the number of nodes is increased, the time for updating the new routing table is increased. Reducing the number of nodes will affect network performance. From the results against speed movements in figure 4, it is obvious that increasing the node density by one-half, the service duration distributions follow the same pattern. The fact is that routing messages marginally increased in order to update the information for each topology. This means that very good scaling properties were found when the density increased. The lengths of routing messages play a significant role in high-density cases where congestion is present. Hence, when the frequency of control messages increase, the loss of packets becomes higher due to congestion in the network, therefore, a lower number of services would be discovered. In high density, it was found that the delivery packet ratio increased compared to low density when the nodes moved at high speed. When the speed becomes high (10 to 20m/s), the loss of packets will increase because of the increased frequency of losing the connection between the nodes. Hence, the loss of packets will increase in relation to the frequent changes in the routing table. In this case, the nodes need to re-broadcast messages for updating the routing table. In case of the recovery mechanism (BR-OLSR), the computed second route can alleviate the loss of packets when loss of connectivity occurs. In low density, however, the recovery mechanism can become insignificant if the network becomes a disconnected graph or the destination node is in an isolated area with no backup route available between source and destination, therefore, high density can be more efficient than low density.

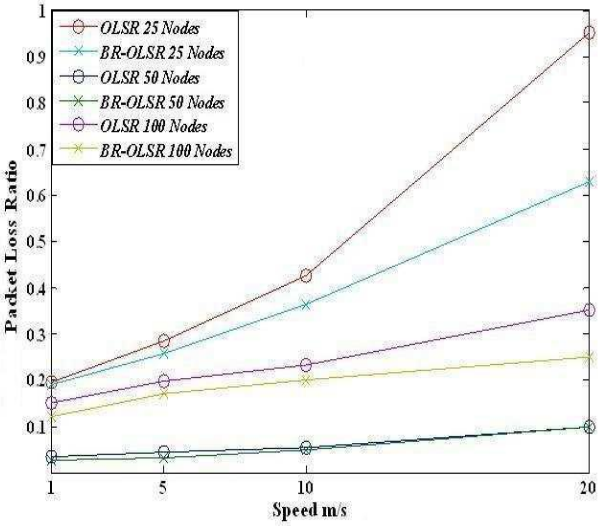


Fig 4: Packet Loss Ratio

Loss of packets was lower for the 50 node compared to the 100-node scenario. In low density, packet loss does not show much improvement compared to high density, because connectivity is not that efficient that it can save the service. This is because there are a smaller number of nodes in the same field. This is especially true when the nodes start to move in the opposite direction to the source. Therefore, the loss of packets between low and high speed increases because the source may not find any nodes within its range. The variation of speed from low to high will lead to loss of stability between the nodes in the network, which will increase the loss of packets. The advantage of low density is that successful transmission for a small portion of the network can be achieved via a short path to the destination. Therefore, services experience a little improvement at low density. The way a node moves is an important factor in the case of delay and loss of packets, because the destination nodes can move far from the source, which means that a large number of hops are required for the packets to arrive at their destination. Compared to low density, high density can connect the source with its destination via a long path length that can be formed. In the case of local recovery, many alternative disjointed paths associated with a primary one can be found. Hence, recovery starts to reflect network enhancement by reducing delay times and loss of packets. The OLSR protocol generates messages to maintain the routes that offer the greatest probability of collisions occurring in the network. In addition, it takes up to 15 seconds to compute a new routing table in medium and high-density conditions. When there are collisions, there is an increase in the loss of packets even if a recovery mechanism is present. The IEEE 802.11, which can send RTS packets, can reduce collisions in the network but the length of time to achieve it remains

Figure 5 measures the continuity index for each scenario. Live video streaming can be divided into blocks of similar size. In the case of a live streaming system, all the nodes play back similar content for the same part. Therefore, the continuity index can be defined as follows :

$$ContinuityIndex \;=\; Np/Ns \qquad (1)$$

where Np is the number of blocks which arrive before playback deadlines and Ns is the total number of blocks in one content.

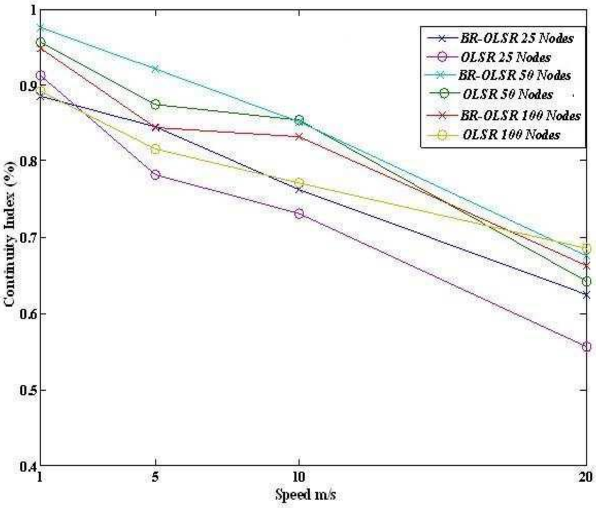


Fig 5: Continuity Index

Each scenario shows the continuity index per second for packets arriving in high and low density conditions. The packets arriving after one second (including buffering time) will be eliminated. This figure indicates that high-density nodes perform better compared to low density ones for case movements. The large number of connections in high density makes the data packet service longer even when the nodes start to move at different speeds. The success of local recovery is improved, because it helps salvage the data packets by using the backup route. This means that the backup route has improved the continuity index for live streaming packets in all cases as expected. In high density, comfortable viewing is experienced for video traffic.

The continuity index is reduced when the nodes move from low to high speed. Bearing in mind the time the packets spend in the buffer and in updating the routing table this figure 5 shows that broadcasting messages will increase overheads, which will affect the continuity index in the case of live streaming. Recovery, however, shows a high continuity index compared to the OLSR protocol in relation to congestion in the network and the ability of the existing backup path to pass the packets when a loss of connection has occurred.

Based on figure 6, we compared the throughput with and without backup route for the OLSR protocol for different number of nodes. All comparisons used the same traffic as that used in the previous sections. In high density, the OLSR-BR performed better when failure occurred. Additionally, OLSR-BR performs better in low speed than in high speed movements. A better throughput was achieved in 50 nodes than in 25 and 100 nodes. This is because there are less sending control packets than 100 nodes, and more availability of adjacent nodes that can keep the graph continuity. The throughput may be high in low density based upon different cases. First, less extra messages are broadcast between the nodes. Second, less time is required to compute the routing table and less traffic can be sent between the nodes in the network. On the other hand, the throughput in low density can be lower than high density nodes if the nodes start to move more further from each other that will lead to form a disconnected graph and then losing of connections will be occurred between each other, but the possibility of such occurrences is low regarding the number of adjacent nodes around each node on the topology. The recovery mechanism with OLSR, as is obvious from figure 6, was little improved in almost all cases because the OLSR protocol had to retain all its backup routes in a static routing table, keeping one route per destination. When any node on the primary path moved out of range or failed the OLSR, the routing protocol needed to re-compute a new routing table as new nodes joined the network or old ones departed.

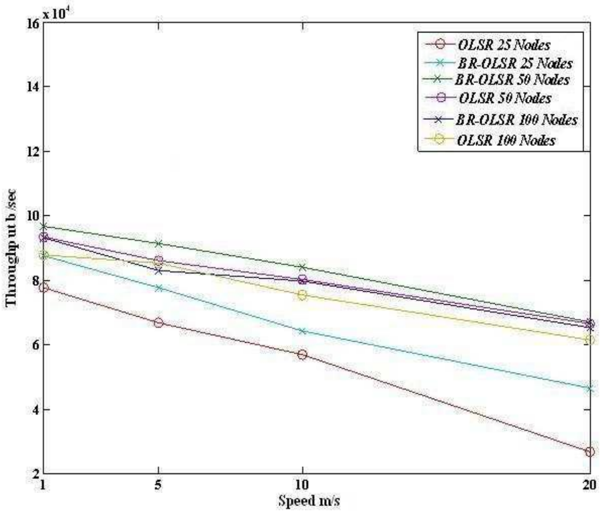


Fig 6: Throughput Network

6. CONCLUSION

This paper has evaluated the local recovery mechanism with low and high density mobile nodes in ad hoc networks. We observed that two main factors can affect the network's performance: node density and the frequent movement of nodes in the network. Therefore, three scenarios (25, 50 and 100) have been evaluated through simulation to examine the relationship between high/low speeds with high/low density that can affect the transfer of data packets. In node density, high density has certain drawbacks, such as increasing congestion and overheads of the network. The OLSR performs quite predictably, delivering virtually all data packets when node mobility rates and movement speeds are low, and failing to converge as node mobility increases in less time. In scenarios with 100 or 50 sources, the network was unable to handle all of the traffic generated by the routing protocol and a significant fraction of data packets were dropped when the nodes kept moving. In cases of high speed, the nodes move in different ways that can make the destination move toward the source in a short time, hence the delay will become very small. On the other hand, the higher density gives a marginally better result than lower density. This is because in low density the network can be a disconnected graph wherein all nodes move far from the source. This leads to an increase in the loss of packets. Short connections between nodes are caused by the instability of the network owing to frequent changes due to joining and departing nodes within a short time before the routing protocol has computed a new routing table. Additionally, the increase in broadcasting control packets will raise congestion in the network. At this time, low speeds bring about an improvement in the delivery packet ratio with increasing delay time. Based on the path length between source and destination, low density nodes perform well at low speeds because the primary path has less numbers of hops to the destination and less control packets are sent. The performance of local recovery has been very good for all mobility rates and movement speeds as well as its use of source routing to increase the continuity index for live streaming video traffic.

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