International Journal of Future Generation Communication and Networking
Vol. 13, No. 1, (2020), pp.716 -731

Mobility Prediction based Energy Efficient QoS Routing

Mamatha C R[1], Dr M Ramakrishna[2]
Research scholar[1], Professor and Head of CSE[2]
Vemana Institute of technology

Abstract

Many Real time applications which include rescue operations, disaster management, and safety critical systems make use of infrastructure less network called as MANETs. Mobile Ad Hoc Networks(MANETS) is a wireless Ad-Hoc network that is designed to alter its location and design by itself on the fly. These networks are dynamic in nature. The self-organising nature of these nodes causes the link failures and loss of packets while transmitting the data from one node to the other in the network. These causes the degradation in the overall network performance hence requires an efficient routing mechanism to overcome this. The efficient use of networking equipment is crucial in designing an efficient routing protocol. In this paper we intend to design a protocol that predicts the mobility in the network. The accurate prediction of the network traffic will reduce the power consumption and enable efficient use of network resources and ensures good quality of service.

***Keywords**: Mobility Prediction, MANET, Routing, Energy Efficient*

1. Introduction

A wireless mobile ad-hoc network (MANET) is a self-organizing network without a fixed infrastructure and consists of self-organising mobile nodes that can exchange data among themselves. The network can be easily scalable and positioned which makes them usable in several application scenarios like disaster management, rescue operations, setting of conference, vehicle networks, and personal networking. Because of the frequent mobility of the nodes and limited range of transmission, the nodes in the network has to discover the new routes and exchange the messages among them. The frequent topology changes in the network degrades its performance and it has to be addressed [1, 2]. Due to the topology changes, the path from sender node to the receiver node might be broken unexpectedly and new paths need to be established for the data to be transmitted among them.

The protocols used for the purpose of routing in MANET's can be grouped into two types such as proactive and reactive routing protocols. Examples include AODV, OLSR, DSR, and DSDV which are used for transmitting data among the nodes in the network. The aim of these protocols is to ensure reliable data transmission and enhance the overall network performance which is challenging due to wandering nodes.

The reactive routing protocol such as ad-hoc on-demand distance vector routing algorithm (AODV) has been proposed which resists the nodes from topology changes as well as path breakages and helps them to adapt to the necessary network changes. AODV uses the flooding mechanism to identify the possible routes to the destination from source. The route discovery process in AODV make use of the shortest path principle. The longer the routes are maintained for the data transmission, the more is the overhead placed on these nodes.

An example for transmitting data among the set of nodes in a military ad-hoc network is shown in the figure 1 and 2.

ISSN: 2233-7857 IJFGCN

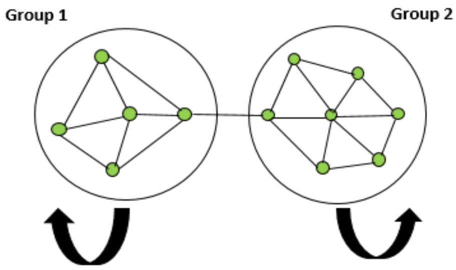

Figure 1: Instance of an ad-hoc military network before node groups transfer.

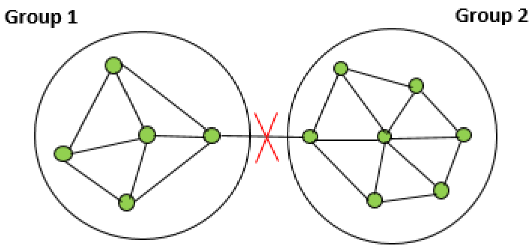

Figure 2: Instance of an ad-hoc military network after node groups transfer.

Due to the mobility nature of nodes, the link breakages and data loss are incurred frequently. But in critical networks like military applications exchange of data among the nodes in time is very much necessary. The mobile ad-hoc networks also suffer from other network resources like bandwidth, battery life of nodes, transmission range which causes route breakages and data loss, hence causing inconsistency in the network and degradation in overall network performance. The MANET protocols fail in adapting to the frequent topology changes. The major challenging issue in the research field is to develop mechanisms that will ensure a reliable network and efficient communication among the set of nodes in the dynamic environment.

Majority of the studies carried out so far have concentrated on regulating the transmission range of the mobile nodes and hence is controlling the topology changes. The level of transmission range is to set up to certain levels and cannot be modified further. This limits the applicability of these existing algorithms. Furthermore, most of the researchers concentrated on reduction of power consumption of the nodes and decreasing the meddling between the networks as well as minimising the link failures.

The nodes mobility affects the transmission delay, throughput, and PDR considerably and the state-of-the-art topology. In environment that involves frequent movement of nodes, existing mobility control mechanisms do not provide consistent end-to-end transmission with good network performance. These open challenges have lot of potential are to further develop a consistent and research work The shortcomings of the existing research works gives us a lot of scope in developing a consistent and energy efficient mobility control techniques for MANET's. These techniques should improve the performance of network even during mobility.

To overcome the above limitations, we propose an algorithm for predicting mobility of nodes and controlling these mobility nodes with an improved consistent performance of the network. In a highly dynamic environment our proposed method is a cross layer solution that improves the performance of network as well to predict and control the mobility of nodes. The 3-D Cartesian coordinate system is

ISSN: 2233-7857 IJFGCN

used to model the network and the same is evaluated in real world environment for predicting the mobility of nodes. This paper's main contribution are as follows:

1. Firstly, to predict the out of range mobile nodes in an infrastructure-less, wireless, scattered network. To predict mobility of out of range mobile node we use weighted clustering algorithm (WCA) that divides the network into various clusters. The WCA selects one of the designated node as the cluster head and it is called as predictor node in our paper. This helps us to avoid unexpected link failures in the network.
2. Secondly, the one-hop prediction function of extreme learning machine is executed iteratively by the predictor node to predict and find the nodes that may possibly move from the range other nodes. The selected predictor node updates its routing table with values of the nodes which possibly move out of its transmitting range with a flag label.
3. Next, the predictor node detects the out of range nodes and it executes the mobility control function for maintaining end-to-end communication. The predictor node will send the control packets which includes information about future mobility state. The predictor nodes routing table's control packet has Cartesian coordinate, velocity has future mobility information of the nodes and same is updated.
4. Lastly, the route breakages and data loss are avoided by efficiently using the routing function in the mobility control algorithm. This mechanism performs better compared to the other mechanisms and is shown in the simulation reports.

Further contents of the paper are organised as follows: Firstly, in section 2 the extensive literature review of related work has been carried out and analysed the research gap. In section 3, our proposed mobility prediction and control protocol in MANET are discussed in detail. The proposed results are tabulated and compared with existing protocol for the evaluation of performance of new system is carried out in section 4. Also, the simulation setup for our proposed protocol is also listed. Finally, the proposed algorithm is concluded in section 5.

2. Related Work

Many schemes for the mobility control have been contributed towards providing uninterrupted network connectivity within the available transmission range for efficient bandwidth utilization and conservation of the battery power. Many Centralized algorithms [3–4] provide solutions which are inclusive and may not be the feasible solutions for Mobile Ad-Hoc networks. Many existing Probabilistic algorithms [5,6,7] does not guarantee seamless connectivity among nodes present in the network.

Many other techniques designed for topology control are based on the use of radio ranges which are not uniform and predicted using one-hop geographical information. Some general topology control protocols [8,9], find each nodes nearest neighbour set based on the its immediate one-hop position to its neighbors.

The authors Rodoplu et al. [10] formulated technique to maximize the number of edges where ≥ node connectivity in the network is uninterrupted while preserving the minimum energy routes. Later the approach was improved by Li and Halpern [11] using k-hop (k 2) paths to minimize edge counts and reducing the overhead estimations. In either of these techniques the nodes collect the information about other nodes within their conveying spectrum to reduce the load on control messages, and hence not choosing the logical neighbours from the 1-hop neighbour set.

ISSN: 2233-7857 IJFGCN

Li et al. [12] proposes a work in which a local minimal spanning tree (LMST) is constructed at every node which uses one-hop location information choosing the neighbours in the tree as logical neighbours. An adaptive LMST-based local topology control protocol was proposed by Abiuzi et al. [13] that is capable of self-configuring based on the variation in the nodes mobility pattern.

Williams and Camp [14] conducted various simulation studies on localized broadcast protocols and observed that due to high congestion in the network and nodes mobility packet delivery ratio is lower. Future observations made by, Dai and Wu [15] stated that low packet delivery ratio is caused due to factors like nodes mobility and various network conflicts. To reduce such conflicts arising in the network, only few nodes are selected for forwarding the packets which also reduces the redundancy.

A mobility-sensitive topology control algorithm proposed by Wu and Dai [16] makes use of the local views that are consistent in nature which help in avoiding the obsolete information and reducing the delay caused due to the mobility management.

In 2007, Mousavi et al. [17] introduces a protocol mechanism called an adaptive mobility prediction-based distributed topology control mechanism. The intention of such control mechanism is reduction in amount of power consumed by mobility nodes. Further they [18] suggested a pattern matching based method for mobility prediction where every node in the network find identical patterns that is present in its mobility history and predicts its future position. The result is better prediction accuracy and improved energy conservation in MANET.

The genetic algorithms (GAs) [19] based approach is used to regulate the pace and course of the knowledge-sharing agents which results in uniform distribution of the mobile nodes geographically.

Hunjet et al's. [20] simplified particle swarm optimization technique, places the extra nodes at keys points which reduces the energy consumption and interference between nodes . A mobility control framework is a security compliance presented by Patrick Tague in 2010 [21] used in mobile network helps in reconfiguring the set of nodes. The result is improvised attack impact and greater efficiency of the protocol.

In 2011, Hosek, J.et al [22] presented a solution on Map-based direct position control system for wireless ad-hoc networks and they developed the simulation model where mobile stations were able to be controlled based on the position. The process model was fully automated and provides a convincing solution for mobile stations.

Stankovic et al. [23] proposed an adaptive and distributed algorithms for controlling the position and power in an non cooperative environment. The algorithms use the mobile agents cost function and pricing function calculated using only the local available information. Later Hee-Tae Roh and Jang-Won Lee[24] improvised the above work by considering the nodes that are mission critical and good communication among the neighbour nodes depend on the locations . An Nash equilibrium converging distributed algorithm was formulated to provide the solution for joint mission and communication aware mobility control problem.

The authors Gundry, S.; Zou, et al [25] introduce a topological control protocol (TCM-Y) which is fault tolerant and based on the network connectivity. Each mobile node maintains a user defined minimum connection between the nearest neighbouring nodes. The mechanism is the decision making process for the mobiles nodes that are adaptive in nature and are capable of spatially configuring in MANETS. In 2013, these researchers [26] analyse a differential evolution based topology control methods to prove that TCM-Y node distribution mechanism is fault tolerant because every node present in the network will have a minimum of k neighbours at all times.

ISSN: 2233-7857 IJFGCN

The authors Li, J.; Gong, et al . [27] propose a new type of MANET called aeronautical ad hoc network (AANET) in which the airborne nodes move freely which result in rapid topological changes. The relay nodes in such type of network are necessary for construction of a fault tolerant system since the AANET has fixed transmission range. Hence this online algorithm was proposed for the placement and controlling of the relay nodes that guard against node failures in an aeronautical ad hoc network that is used for security needs in military.

Interference based topology control algorithm for delay-constrained mobile ad hoc networks by Zhang, et al [28] propose an algorithm that considers both the delay and interference. The cross layer distributed algorithm considers delay occurred during the transmission, contention and queuing. The authors Namdev.A.et al [29] propose an algorithm that efficiently utilizes the nodes energy and improves the reliability of the network. The minimum mobility and maximum route selection algorithm with AODV protocol concentrates in avoiding the link breakdowns occurring due to insufficient node energy and enhances link stability to ensure reliable network transmission.

A new distributed topology control algorithm which is based on optimization of delay in ad hoc networks by Hu, Y et al [30] develop a simulation model that considers the link delay while reducing the energy consumed. Link delay function is calculated by considering the signal to noise ratio that is present in the destination nodes link, the packet forwarding time.

Sheu et al.[31] propose a two phase distributed protocol known as location-free topology control (LFTC) protocol. The protocol address the issues in network layer like topology control and Hidden Terminal problem that is prevalent in the MAC layer. The nodes determine the power during the transmission of data and control packet without the knowledge of location of nodes. An improvement to the above work was done by Yamini et al. [32] LFTC –RP protocol which consumed less battery power by using the nodes that are not active during the transmission.

Energy Efficient Topology Control for QoS of ad hoc wireless network proposed by Li [33] concentrate on optimizing the network lifetime by using the QoS routing techniques. The protocol satisfies several QoS requirements like bandwidth, traffic, Number of hops for which enhances the network lifetime.

The authors Y. Hayashi and M. Harayama [34] address the issues of unstable communication and energy consumption the is prevalent in MANETs. The develop a topology control mechanism that subdues the interference occurring due to electric waves and stabilizes the communication while reducing the power consumption in the nodes.

The authors [35] propose methods to enhance the routing in a dynamic network of nodes, by determining the shape of the request zone. This allows us to use a directional antenna to route packets after determining the shortest distance between source and destination using Dijkstra’s algorithm. If route discovery fails in the first attempt, a multi-step approach is used to build the request zone.

The work of authors in [36] concentrates in the development of a Smartphone Ad Hoc Network that automatically decides the network topology for multi-hop, based on the control information received from the control centre which is based on the developer’s desired topology relationship.

In [37] A. Konak et al proposes hybrid recovering algorithms like cascade movement based on (1) nearest node (2) connected dominating set (3) critical nodes are used to adjust the node movement and maintain robustness in an Ad Hoc network. Using the Kalman filter, identification and connectivity to all the nodes is always ensured along with immediate recovery of lost nodes. Conclusively it’s found that CMCN is optimal out of them all.

ISSN: 2233-7857 IJFGCN

In 2017, the proposed work by Stephan et al. [38] aims to develop a hybrid system for a team of robots, having a 2-layer feedback loop, one outer loop for infrequent global co-ordination and one inner loop to determine motion and communication variables. This helps the team complete a task in a complex environment while maintaining end-to-end data rates.

In [39] the authors Tang, Z et al propose a protocol which concentrates on the frequent link breakages and data losses which is caused by unmonitored node mobility. A new mobility control mechanism has been introduced which reduces frequent link breakages. Nodes Coordinator executes mobility control functions regularly and send control packets to those nodes that may leave its transmitting range. These packets are used to modify their future trajectories.

The authors Kitagawa et al. [40] and extension of this work, by the authors [41] aim at implementing a flexible Information Centric Networks, Flying Routers (FR) . It is important to realize a collaborative movement strategy in case of multiple FR's hence these paper proposes a communication control system that controls FR's by sending explicit Interests. It was also found that the RMICN method can retrieve content faster than the Message Ferry method.

From the Literature survey, we learn that the mobile nature of the nodes has higher impact on the routing while affecting the routing protocol performance. Most of the previous work on the areas like topology and mobility control concentrated on conserving the energy present in the batteries and nodes transmission range. But due to the mobile nodal structure, nodes suffered from frequent link breakages which affected the throughput, delay, PDR. Although some algorithms suggest use of the intermediate nodes which help in maintaining the connectivity, in many situations like mission critical systems the solution is unfeasible. In this article, we develop a protocol called adaptive mobility control protocol for MANET in which the performance is improved at various levels of mobility.

3. Proposed Mobility Prediction and Control Protocol

The proposed mobility prediction and control mechanism algorithm is presented in the below section which improves the total network performance and also ensures reliable transfer of data from one node to another. The proposed mobility prediction and control mechanism is presented in a detailed view as shown in figure 3.

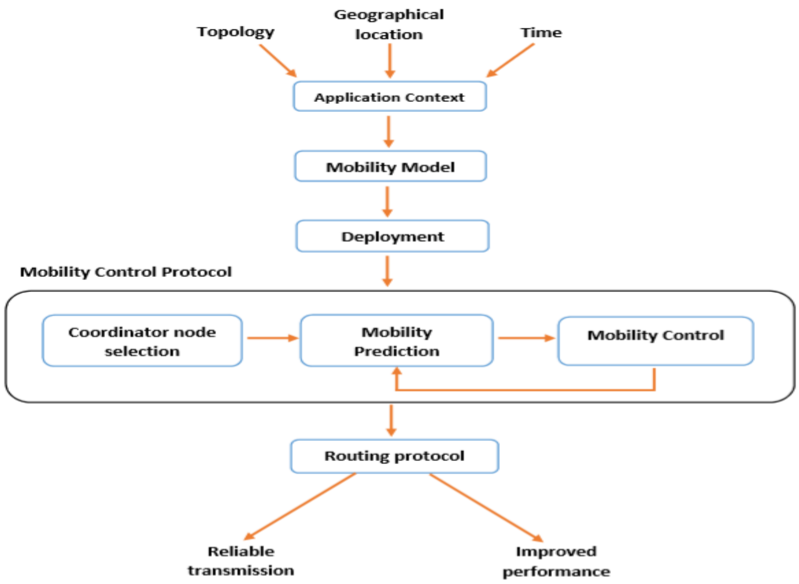

Figure 3: Proposed framework for mobility control in MANET

ISSN: 2233-7857 IJFGCN

The proposed protocol is based on the implementation on above the existing routing protocols and implementation details is presented in the rest of this paper. The proposed mobility prediction and control mechanism algorithm consist of three steps and are described in the following steps.

Step 1: *Select a predictor node* - To predict the out of range mobile nodes in an infrastructure-less, wireless, scattered network we use weighted clustering algorithm (WCA) that divides the network in to various clusters. The WCA selects one of the designated node as the cluster head and it is named as predictor node in our paper.

Step 2: *Mobility prediction* – In this step the extreme learning machine based one-hop prediction function is executed iteratively and the paths of those nodes that may possibly out of range are predicted. The selected predictor node puts this predicted information in its route decision table with those values of the nodes, which may possibly transmit out of its spectrum.

Step 3: *Mobility control* – During this process, the predictor node detects the nodes that move out of its transmitting range and then executes the mobility control function. It sends the control packets to make sure that communication between sender and receiving nodes are unaffected during the transmission of critical information. The predictor nodes control packet includes information about next mobility state (Cartesian coordinate, velocity) of the nodes by setting the flags in the predictor node's routing table.

The description of the above steps is done in the below subsections.

3.1.1 Predictor Node Selection

The implementation of the mobility control protocol for MANETs requires the boosting the process of prediction and control process by reduction in the overhead of the network nodes. The process requires the ad-Hoc network to be partitioned into various cluster groups using an algorithm called weighted clustering algorithm (WCA).

This algorithm divides the network based on number of clusters in MANETS that can be enhanced. The WCA make use of accurate system parameters and its non-rigid tuning of measuring factors makes it suitable to be used in frequent changing network conditions as compared to the other clustering algorithms.

In our proposed work, the nodes in the network is organized as a 3-D Cartesian coordinate system which is very much important and relevant for the adhoc network applications. The cluster head selected by WCA is called as predictor node in our work which iteratively executes the prediction and control function till convergence. The process of clustering and coordinator node selection is explained as follows:

The mobile ad-hoc network is represented as an undirected graph G= (V, E), where V represents a set of Nodes and E represents a set of links. In this network setup the number of nodes are constant but the number of links are varying due to creation of link or deletion of links based on mobility. The optimal network partitioning is a major issue since MANET does not exhibit any regular network patterns. The collection of cluster head neighbours contains the nodes who are within its transmitting spectrum. A dominating set C is either a vertex of G is in C or its neighbor is in C. The dominating set is a collection of all cluster heads in the network. The vertices set C $\subseteq$ V (G) is determined as, $\bigcup_{v \in C} N[v] = V(G)$, where N[v] is a set of neighbors of node v.

Deciding the appropriateness of a node to be a cluster head depends on several network parameters like degree of the node, battery efficiency, node mobility, and transmission range. The WCA considers all of these parameters while deciding on choosing the cluster head. Based on different perspectives and the application domain these metrics are used in the computing and the cluster head is selected that deals with the trade-off among several cluster heads with different cluster size, latency, power

ISSN: 2233-7857 IJFGCN

consumption and data processing capability of each node. Only few minimum number of the cluster heads are selected by the WCA algorithm among the networking nodes and the number of nodes in each cluster is constrained to some predefined threshold δ. In our clustering algorithm the following characteristics are considered.

- Decreasing the number of computations and transmission overhead by reduction in system updates through non periodic executions.
- Effective medium access control implementation through Optimized threshold of number of nodes present in each cluster.
- Effective battery power usage within limited range of transmission.
- Lower mobility nodes being chosen as the cluster head.

The network constraints along with the weights which have been chosen as per the specification are efficiently combined by WCA so that overall network efficiency is managed. The amount of battery consumed in such a network is more. So power control is chosen as parameter and larger weight of this parameter is chosen in selecting the cluster head. During the network deployment process, the choosing of cluster head process also begins and whenever the nodes move from one cluster to another, the respective cluster head updates its neighbouring list and not invoking the cluster head selection process again.

The procedure for selecting the predictor node is as described below:

Step 1: The degree of node dv is defined for every neighbors present in the neighbor node list using $dv = | N(v) |$

Step 2: For each node v calculate the difference of degree using $\Delta v = |dv - \delta|$.

Step 3: The neighbor node distance Dv is computed for each neighbor node using $Dv = \sum_{v' \in N(v)}^{n} \{dist(v', v)\}$

Step 4: For each node find the average speed till the current time instant T. It is defined as $Mv = \frac{1}{T}\sum_{t=1}^{T}\sqrt{(Xt - Xt - 1)2 + (Yt - Yt - 1)2 + (Zt - Zt - 1)2}$

where (X, Y, Z) are node v's Cartesian Positions at time.

Step 5: Compute P_v, the battery power consumed for a cluster head node V.

Step 6: For each node v compute the total weight W_v as, $W_v = w_1\Delta_v + w_2 D_v + w_3 M_v + w_4 P_v$, the network weight metrics chosen are w_1, w_2, w_3, and w_4.

Step 7: The cluster head node is selected which has smallest weight Wv. These cluster head does not involve in the process of election.

Step 8: Repeat the above step 2 to 7 for remaining nodes to choose as a cluster head or in cluster.

In our work we choose predictor node from our elected cluster head. The predictor node will function as mobility control by predicting 1-hop mobility prediction function.

3.1.2. Phase 2 Mobility Prediction

Once the selection of the Predictor nodes from the available node set in the network is completed, the nodes periodically run the mobility prediction function for the identification of nodes that are moving out of range. Several mobility prediction algorithms use past mobility patterns and have gained attention in recent research studies. These approaches are based on the prediction of previous states which help in finding the future paths of the nodes in the network. But most of these algorithms fail in

ISSN: 2233-7857 IJFGCN

predicting accurately due to the techniques applied and implementation of algorithms.
The prediction mechanisms like the pattern matching are comparatively not much useful like the machine learning approaches as these learning models use real world data that are learnt independently from the prior computations and produce more accurate consistent data.
The extreme learning machine (ELM) [42] predicts more accurately and realistically by using different standardized mobility models.

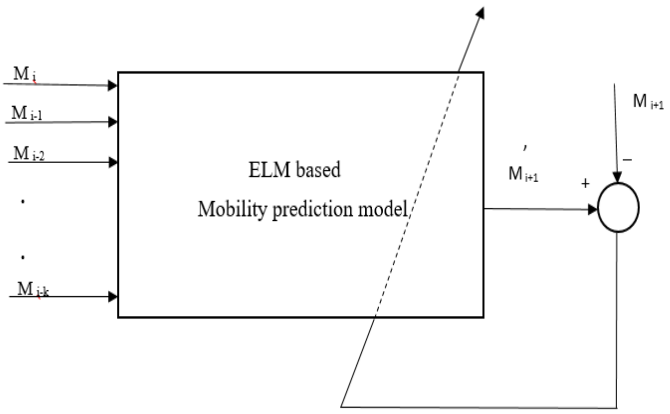

Figure 4: ELM architectures of Mobility prediction model

Our proposed mobility prediction function is illustrated in the steps below.

Step 1: The predictor or cluster head will gather the neighbor nodes mobility state. The mobility state Mn for node n is represented as tuple <Pn,Vn) where Vn is the velocity in which the node as travelled from one location to other and Pn is the current Cartesian coordinate of node n.
Step 2: The collection of mobility state information of any node is in the form of timestamp series. The predictor will predict the future mobility state of the nearest node from the mobility information available.
Step 3: The timestamp series is fed into machine learning algorithm to determine the next mobility prediction information. In our proposed method we have used Extreme Learning Machine Learning algorithm called Single Hidden Feedforward Networks. The size of the time series is optimized based on the entropy factor. It determines the randomness and predictability of mobile nodes. If entropy value is high, it means the randomness is high and system order is less.
Step 4: The predictor node calculates the transmission range to find which nodes are moving out from the range from a predicted mobility state. The range is calculated from current Cartesian coordinates to a predicted Cartesian coordinates. The control packets are sent to the predicted nodes once selected.

3.1.3 Phase 3 Mobility Control

The predictor nodes periodically run the mobility prediction function for the identification of nodes that are moving out of range. A flag is set by the predictor node whenever the target nodes transmit out of its transmission range. Mobility control process is executed by the predictor nodes to modify the next paths of the destination nodes.

The mobility control process on each predictor node is described in the steps below:
Step 1: The next state information to modify the mobility state is sent by the predictor node to the target node in the control packet .The control packet contains the information related Cartesian Coordinates, the velocity in which it has sent and a tuning parameter. The other fields present in the control packet

ISSN: 2233-7857 IJFGCN

includes type, priority, source IP, destination IP, predictors IP address and their port numbers. The different levels of randomness is specified using tuning parameter (α) for its node mobility. The values of x, y and z represents the time, speed, and direction of each mobile node in a 3-dimensional vector. These values are computed at regular interval of time and recorded as 3D-cartesian coordinates respectively.

Step 2: Once the control packet from the predictor node is received, the next mobility state information is updated in the target nodes table and uses the updated information for future transmissions.

Step 3: The quality of communication between the target node and neighbor node coordinator is computed based on different network parameters. These values will specify the selected route as best route. The different network parameters are transmission rate, energy, end-to-end delay and packet delivery ratio. The quality of communication Q is calculated on the basis of following equation: $Q=TR+E+D+PDR$. Each of these parameters are computed based on weight associated to each parameters. The value lies between 0 and 1.

Step 4: The newly computed quality of communication Q is compared with the standard AODV protocol for the stability of route. The predefined stability threshold value is used to compare with new computed value. If the computed value is nearest to threshold then the coordinator will exit because the current position is more appropriate otherwise the process will repeat from step 1. The process of mobility control will exist when an appropriate route path is found for reliable data transmission with high availability.

The newly found target position is updated and process will be repeated starting from mobility prediction phase.

The nodes mobility and transmission of packet through unsecured nodes might result in loss of packets. The loss of packets due to this process can be handled in the following steps

i. Identify if there is any packet loss.
ii. Find the basis and check what is causing the packet loss.
iii. Find alternative path for sending the control packet from predictor node to target node in case of unsecured node. Else if the cause is mobility, then Increase the transmission range of the node.

4. Results and discussion

The simulation setup for our proposed Mobility Prediction and Control mechanism created using NS-3 in Ubuntu 14.04 OS. The setup consists of nodes and links which varies from 20 to 100. The network evaluation parameters are computed for our proposed protocol and the same is compared with AODV protocol. The simulation setup uses Gauss–Markov mobility (GMM) model because of its nature of representing 3-D Cartesian coordinate system for close mobility movement and its prediction. In the following section different network parameter results are discussed in detail for AODV, DSDV and OLSR with our proposed method.

Firstly, the results of packet delivery ratio are compared by varying number of nodes using GMM model with our proposed mobility prediction and control mechanism as shown in figure 5. The PDR results are better with our proposed method when compared to existing protocols.

ISSN: 2233-7857 IJFGCN

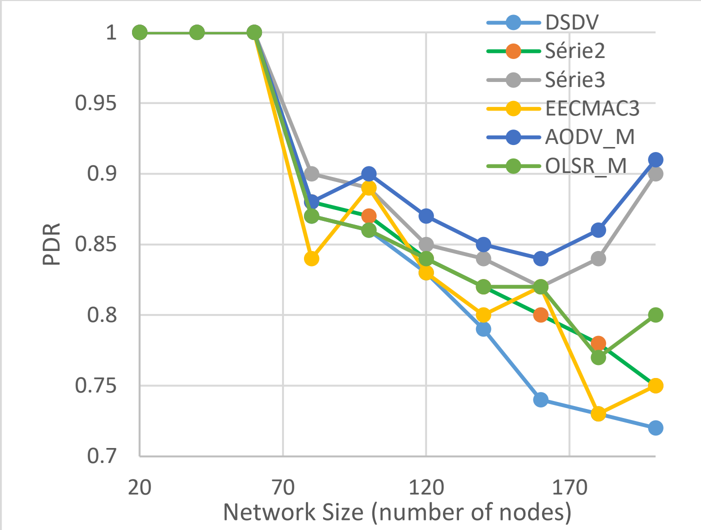

Figure 5: Evaluation of PDR in relation to network size

Secondly, we will compare the end-to-end delay results by varying the number of nodes in the network as shown in figure 6. The delay is less in our proposed mobility prediction and control mechanism when compared with DSDV, OLSR protocols. The results are compared with and without mobility control.

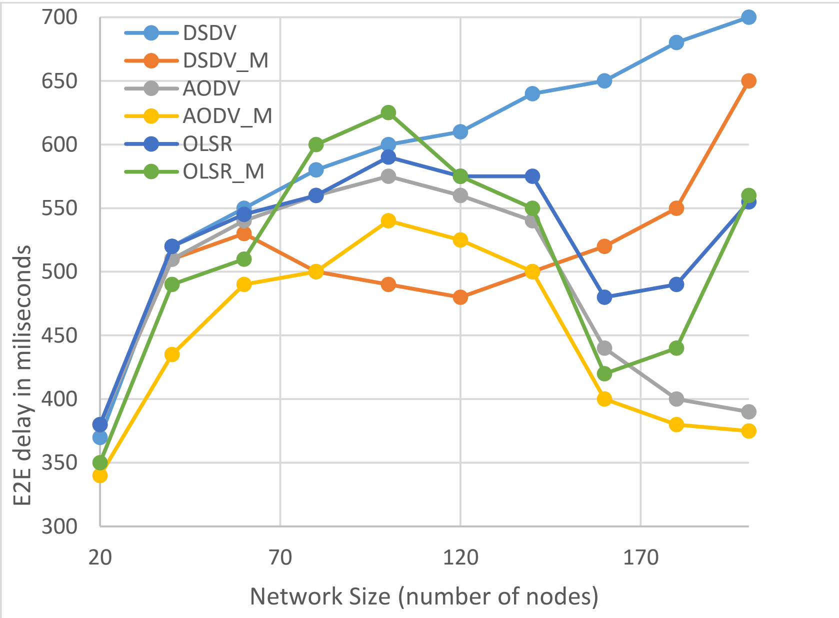

Figure 6: Evaluation of E2E latency in relation to network size

Lastly, we will measure the important network parameter called throughput by varying the number of nodes. The improved throughput is noted in our proposed protocol when compared to existing protocols. The mobility prediction and control mechanism with and without mobility control is measured and computed as shown in figure 7 below.

The proposed mobility prediction and control protocol is also evaluated for same network parameters by varying motilities in figure 8. The probability factor is used for randomizing the mobility of nodes.

ISSN: 2233-7857 IJFGCN

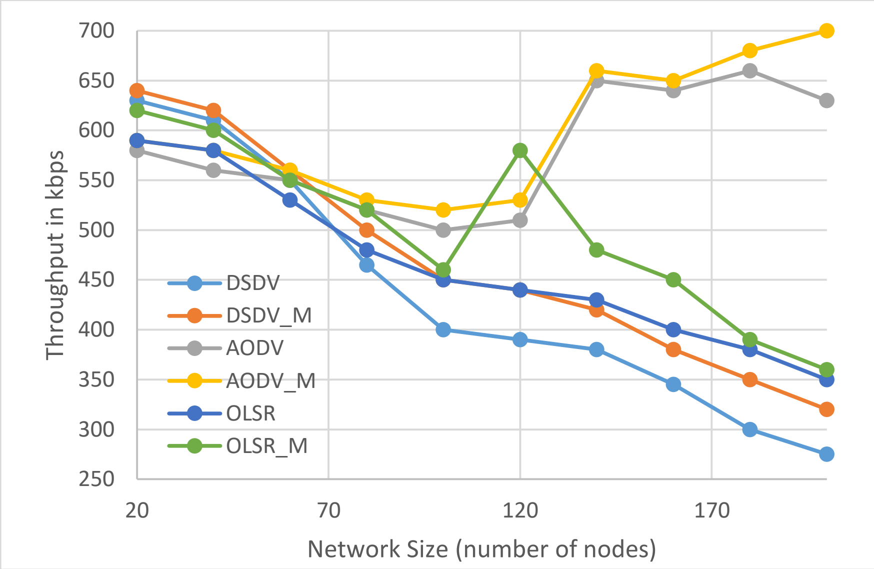

Figure 7: Evaluation of throughput in relation to network size

The mobility variation is considered as tuning factor and computed using step-1 and ranges from 0 to 1. The randomness is more when mobility variation is high.

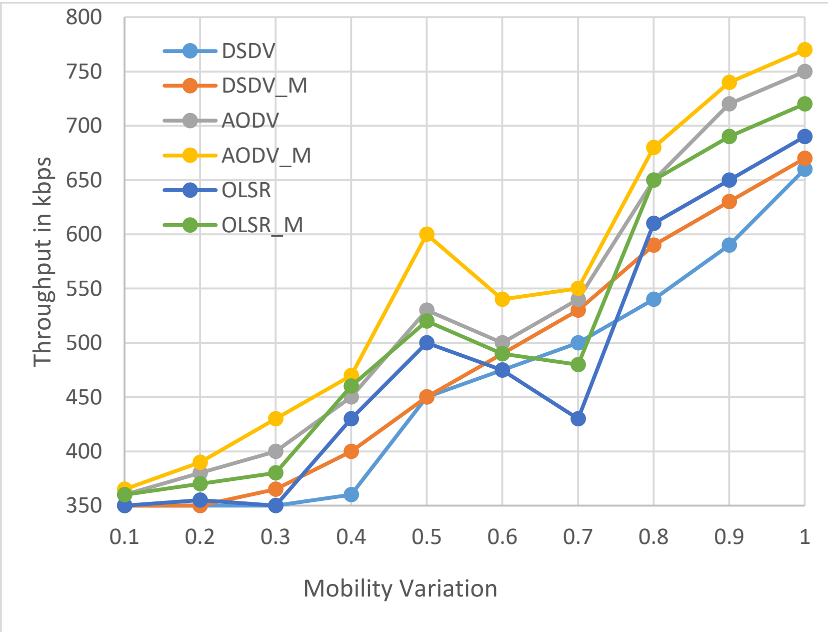

Figure 8: Evaluation of PDR with respect to mobility variation

Another set of simulations we have run for measuring the PDR, End-to-End delay and throughput. The PDR is calculated for our proposed method with respect to mobility variation and compared with existing protocols. The results show in figure 8 depicts that the PDR is high in our proposed scheme even in highly dynamic mobility environment also.

ISSN: 2233-7857 IJFGCN

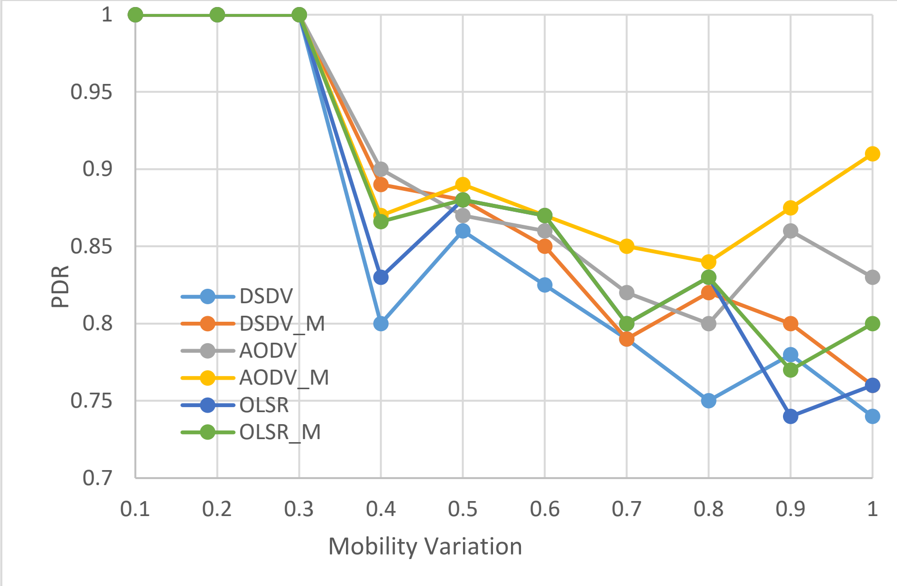

Figure 9: Evaluation of throughput in relation to mobility variation

The proposed protocol also tested for end-to-end delay as well as for throughput and compared with existing protocols in figure 9 and it clearly shows that our proposed mobility prediction and control mechanism has high throughput and has efficient better end-to-end delay results. Our proposed protocol produces improved results even in high dynamic environment even with variation in mobility.

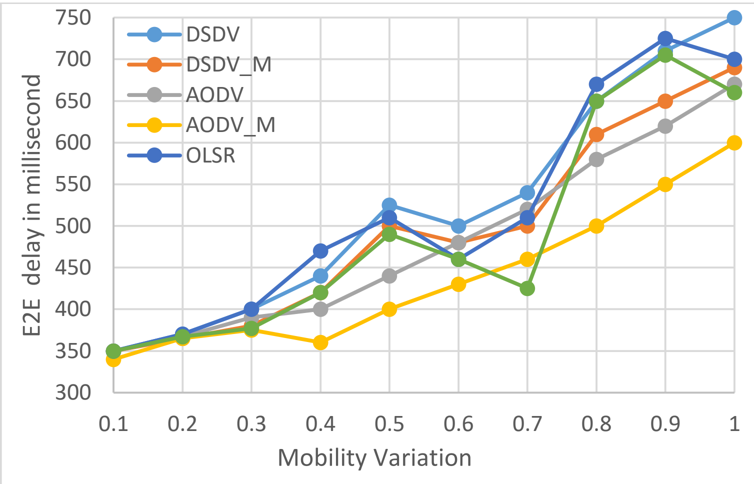

Figure 10: Evaluation of E2E delay in relation to mobility variation

From the above results our proposed mobility prediction and control mechanism is reliable, stable by varying the number of nodes present in the network and also varying the mobility of the nodes. This ensures for the network is stable and reliable for data transfer. This work may be extended in future to consider the security features to secure the MANET network.

5. Conclusion

In this work, we have proposed mobility prediction and control mechanism algorithm to predict the mobility of nodes. This aids in improving the stability of network and reliable route for data transfer. Our proposed protocol is implemented in three phases. Initially, the predictor nodes are identified using clustering algorithm to control the mobility of nodes. Secondly, the machine learning techniques are applied to find the nodes which are moving out of the range of predictor nodes and finding a route for data transfer. In the last stage, the proposed protocols send control packet data containing the information related to next mobility state of a node. Our proposed algorithm manages the reliable data

ISSN: 2233-7857 IJFGCN

transfer with network stability even in highly dynamic environment and also in larger networks. This work may be extended in future to consider the security features to secure the MANET network.

References

[1] Laneman, J.; Tse, D.; Wornell, G.: Cooperative diversity in wireless networks: Efficient protocols and outage behavior. IEEE Trans. Inf. Theory 50(12), 3062–3080 (2004)

[2] Grossglauser, M.; Tse, D.N.C.: Mobility increases the capacity of ad hoc wireless networks. IEEE/ACM Trans. Netw. 10(4), 477–486 (2002)

[3] Lloyd, E.L.; Liu, R.; Marathe, M.V.; Ramanathan, R.; Ravi, S.S.: Algorithmic aspects of topology control problems for ad hoc networks. In: Proceedings of the MobiHoc, pp. 123–134 (2002)

[4] Wieselthier, J. E.; Nguyen, G. D.; Epheremides, A.: On the construction of energy-efficient broadcast and multicast trees in wireless networks. In: Proceedings of the INFOCOM, pp. 585– 594 (2000)

[5] Ramanathan, R.; Rosales-Hain, R.: Topology control of multihop wireless networks using transmit power adjustment. In: Proceedings of the INFOCOM, pp. 404–413 (2000)

[6] Blough, D.; Leoncini, M.; Resta, G.; Santi, P.: The K-Neigh protocol for symmetric topology control in ad hoc networks. In: Proceedings of the MobiHoc, pp. 141–152 (2003)

[7] Liu, J.; Li, B.: MobileGrid: capacity-aware topology control in mobile ad hoc networks. In: Proceedings of the ICCCN, pp. 570– 574 (2002).

[8] Cartigny, J.; Simplot, D.; Stojmenovic, I.: Localized minimumenergy broadcasting in ad hoc networks. In: Proceedings of the IEEE INFOCOM, pp. 2210–2217 (2003)

[9] Seddigh, M.; Solano, J.; Stojmenovic, I.: RNGand internal node based broadcasting in one-to-one wireless networks. ACM Mob. Comput. Commun. Rev. 5, 37–44 (2001)

[10] Rodoplu, V.; Meng, T.H.: Minimum energy mobile wireless networks. IEEE J. Sel. Areas Commun. 17, 1333–1344 (1999)

[11] Li, L.; Halpern, J.Y.: Minimum energy mobile wireless networks revisited. In: Proceeding of the ICC, pp. 278–283 (2001)

[12] Li, N.; Hou, J.C.; Sha, L.: Design and analysis of and MST-based topology control algorithm. Proc. INFOCOM 3, 1702–1712 (2003)

[13] Abiuzi, L. B.; Cesar, C. D. A. C.; Ribeiro, C. H. C.: A-LMST: an adaptive LMST local topology control algorithm for mobile ad hoc networks. In: 2016 IEEE 41st Conference on Local Computer Networks (LCN), Dubai, pp. 168–171 (2016)

[14] Williams, B.; Camp, T.: Comparison of broadcasting techniques for mobile ad hoc networks. In: Proceedings of the MobiHoc, pp. 194–205 (2002)

[15] Dai, F.; Wu, J.: Performance comparison of broadcast protocols for ad hoc networks based on self-pruning. IEEE Trans. Parallel Distrib. Syst. 15(11), 1027–1040 (2004)

[16] Wu, J.; Dai, F.: Mobility-sensitive topology control in mobile ad hoc networks. IEEE Trans. Parallel Distrib. Syst. 17(6), 522–535 (2006)

[17] Mousavi, S. M.; Rabiee, H. R.; Moshref, M.; Dabirmoghaddam, A.: Mobility aware distributed topology control in mobile ad hoc networks with model based adaptive mobility prediction. In: Third IEEE International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob 2007), USA, pp. 86–86 (2007)

[18] Khaledi, MH.; Mousavi, S. M.; Rabiee, H. R.; Movaghar, A.; Khaledi, MJ.; Ardakanian, O.: Mobility aware distributed topology control in mobile ad hoc networks using mobility pattern matching. In: 2009 IEEE International Conference on Wireless and Mobile Computing, Networking and Communications, Morocco, pp. 453– 458 (2009)

ISSN: 2233-7857 IJFGCN

[19] Urrea, E.; Sahin, C.S.; Hokelek, I.; Uyar,M.U.; Conner,M.; Bertoli, G.; Pizzo, C.: Bio-inspired topology control for knowledge sharing mobile agents. Ad Hoc Netw. 7(4), 677–689 (2009)

[20] Hunjet, R. A.; Coyle, A.; Sorell, M.: Enhancing mobile ad hoc networks through node placement and topology control. In: 7th IEEE International Symposium on Wireless Communication Systems, UK, pp. 536–540 (2010)

[21] Tague, P.: Improving anti-jamming capability and increasing jamming impact with mobility control. In: 7th IEEE International Conference on Mobile ad hoc and Sensor Systems, USA, pp. 501– 506 (2010)

[22] Hosek, J.; Molnar, K.; Jakubek, P.: Map-based direct position control system for wireless ad hoc networks. In: 2011 34th International Conference on Telecommunications and Signal Processing (TSP), Budapest, pp. 195–200 (2011)

[23] Stankovic, M. S.; Johansson, K. H.: Distributed mobility and power control for non-cooperative robotic ad hoc and sensor networks. In: 50th IEEE Conference on Decision and Control and European Control Conference (CDC-ECC), USA, pp. 2938–2943 (2011)

[24] Roh, H. T.; Dai, F.: Joint mission and communication aware mobility control in mobile ad hoc networks. In: 10th IEEE International Symposium on Modeling and Optimization in Mobile, Ad Hoc and Wireless Networks (WiOpt), Germany, pp. 124–129 (2012)

[25] Gundry, S.; Zou, J.; Kusyk, J.; Uyar, M. Ü.; Sahin, C. S.: Fault tolerant bio-inspired topology control mechanism for autonomous mobile node distribution in MANETs. In: MILCOM 2012–2012 IEEE Military Communications Conference, Orlando, FL, pp. 1–6 (2012).

[26] Gundry, S.; Zou, J.; Kusyk, J.; Sahin, C. S.; Uyar, M. Ü.: Differential evolution based fault tolerant topology control in MANETs. In: MILCOM 2013–2013 IEEE Military Communications Conference, San Diego, CA, pp. 864–869 (2013)

[27] Li, J.; Gong, E.; Sun, Z.; Li, L.; Xie, H.: Fault-tolerant topology control in aeronautical ad hoc networks. In: 2014 IEEE International Conference on Mechatronics and Automation, Tianjin, pp. 368–372 (2014)

[28] Zhang, X.M.; Zhang, Y.; Yan, F.; Vasilakos, A.V.: Interferencebased topology control algorithm for delay-constrained mobile ad hoc networks. IEEE Trans. Mob. Comput. 14(4), 742–754 (2015)

[29] Namdev, A.; Mishra, A.: Interference-based topology control algorithm for delay-constrained mobile ad hoc networks. In: 2016 IEEE Students' Conference on Electrical, Electronics and Computer Science (SCEECS), Bhopal, pp. 1–6 (2016)

[30] Hu, Y.; Liu, D.; Wu, Y.: A new distributed topology control algorithm based on optimization of delay in ad hoc networks. In: 2016 First IEEE International Conference on Computer Communication and the Internet (ICCCI), Wuhan, pp. 148–152 (2016)

[31] Sheu, J. P.; Tu, S. C.; Hsu, C. H.: Location-free topology control protocol in wireless ad hoc networks. In: 2007 IEEE Wireless Communications and Networking Conference, Kowloon, pp. 66– 71 (2007)

[32] Yamini, K. A. P.; Arivoli, T.: Improved location-free topology control protocol in MANET. In: 2013 International Multi-Conference on Automation, Computing, Communication, Control and Compressed Sensing (iMac4s), Kottayam, pp. 835–838 (2013)

[33] Li, H.: Energy Efficient Topology Control for QoS of ad hoc wireless network. In: 2014 IEEE/ACIS 13th International Conference on Computer and Information Science (ICIS), Taiyuan, pp. 17–22 (2014)

ISSN: 2233-7857 IJFGCN

[34] Hayashi, Y.; Harayama, M.: MANET topology control based on the node degree and energy detection threshold. In: 2015 Internet Technologies and Applications (ITA), Wrexham, pp. 41–46 (2015)

[35] Zhang, W.; Peng, L.; Xu, R.; Zhang, L.: Topology control in wireless mobile ad hoc networks with directional antennas. In: 2016 2nd IEEE International Conference on Computer and Communications (ICCC), Chengdu, pp. 1701–1705 (2016).

[36] Qin, H.; Mi, Z.; Dong, C.; Wang, H.: A practical topology control method for smartphone based ad hoc networks experiment. In: 2016 8th International Conference on Wireless Communications & Signal Processing (WCSP), Yangzhou, pp. 1–5 (2016)

[37] Konak, A.: A distributed multi-agent algorithm for topology control in mobile ad hoc networks. In: 2017 18th International Conference on Advanced Robotics (ICAR), Hong Kong, pp. 244–249 (2017)

[38] Stephan, J.; Fink, J.; Kumar, V.; Ribeiro, A.: Concurrent control of mobility and communication in multirobot systems. IEEE Trans. Robot. 33(5), 1248–1254 (2017)

[39] Tang, Z.; Zhou, Y.; Deng, W.; Wang, B.: LISP-HNM: Integrated fast host and network mobility control in LISP networks. In: 2017 15th International Symposium on Modeling and Optimization in Mobile, Ad Hoc, and Wireless Networks (WiOpt), Paris, pp. 1–6 (2017)

[40] Kitagawa, T.; Ala, S.; Eum, S.; Murata, M.: Mobility-controlled flying routers for information-centric networking. In: 2018 15th IEEE Annual Consumer Communications & Networking Conference (CCNC), Las Vegas, NV, pp. 1–2 (2018)

[41] Gao, Y.; Kitagawa, T.; Eum, S.; Ata, S.; Murata, M.: Realization of mobility-controlled flying router in information-centric networking. J. Commun. Netw. 20(5), 443–451 (2018)

[42] 42.Huang, G.; Zhu, Q.; Siew, C.: Extreme learning machine: theory and applications. Neurocomputing 70(1–3), 489–501 (2006)

ISSN: 2233-7857 IJFGCN