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Hybrid Multi-perspective NLOS Localization Framework (HM-NLOS-LF) for effective node localization in VANETs

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Abstract**—** In Vehicular Adhoc Networks the position information of vehicles has to be exchanged between the communicating vehicles as it plays a huge responsibility in avoiding fatal accidents. Many applications rely upon the safety message which also requires location information. The vehicles within the communication range exchanges these messages. In real time scenario the direct communication between the vehicles can be blocked by the presence of road side or dynamic obstacles creating a Non Line Of Sight between the vehicles. A HYBRID MULTI-PERSPECTIVE NLOS LOCALIZATION FRAMEWORK (HM-NLOS-LF) is proposed which uses the merits of Range based, Range Free and Range optimized to identify the NLOS based on the NLOS Factor. If the NLOS Factor between 0.3 and 0.5 Range based optimization is initiated. In contrary, the NLOS Node Localization Module enforces the range-free and range-optimizations-based NLOS node detection when the NLOS determination Factor between 0.5 and 0.8 respectively.

Keywords**—** Non Line Of Sight; Range Based; Range Optimization; Range Free

I. INTRODUCTION

The dissemination of emergency messages has to be transmitted in the network needs the cooperation between the vehicular nodes [1]. As the emergency messages has to reach the vehicles in the stipulated time and the delayed arrival of the emergency messages leads the drivers to take wrong conclusion which results in fatal accidents. The occurrence of the NLOS nodes in the network are considered to be a major threat to the network as the response to the emergency messages will be obstructed by the vehicles such as car or trucks or it can be due to fixed infrastructure such as tree or buildings. A Broaden survey was taken against the methods presently available methods to identify NLOS based on the Range based, Range optimized and Range free approaches

Most of the NLOS localization approaches are not potent in improving the neighbourhood awareness rate with reduced latency in emergency message exchanges [2]. The existing NLOS localization condition schemes are not capable of reducing the use of maximum reference nodes in the network [3]. Thus, an integrated Hybrid Multi-Perspective NLOS Localization Framework is essential for upgrading the neighbourhood rate by preventing the impacts of NLOS conditions in the network [4]. Hence, the proposed HM-NLOS-LF framework facilitates the process of identifying NLOS nodes in the vehicular network through the derivation of factors such as Time Difference Of Arrival (TDOA), Time Of Arrival (TOA) [5], Angle of Arrival (AOA), Hop Count and Received Signal Strength Indicator (RSSI) [6] that are considered for appropriate incorporation of range, range-free and range-optimizations based localizing technique depending on the situation of enforcement.

The major factor which led to the motivation of the research is that
(i) The presence of Non Line Of Sight in the network created a communication barrier to the approaching vehicle.
(ii) So the NLOS nodes have to be identified in an effective way to avoid fatal accidents as it involves human lives.
(iii) The existing methods which are identified in the literature are found to have drawbacks.
(iv) So, an effective framework has been designed by analyzing the drawbacks based in the literature for effective node localization.

The organization of the paper is as follows: Section 2 discusses about the various methodologies used by researchers to identify the Position of the NLOS nodes and their demerits. Section 3 discusses about the methodologies used in framework such as Weighted Distance-vector Hyperbolic Prediction-Based Detection Scheme, Weighted Inertia-based Dynamic Virtual Bat Algorithm and Rank Criteria Improved Confidence-based Centroid. Section 4 depicts about HYBRID MULTI-PERSPECTIVE NLOS

LOCALIZATION FRAMEWORK (HM-NLOS-LF). Section 5 discusses about the Simulation results Section 6 discusses about conclusion and Future work followed by references.

II. Related Work

This section gives a detailed analysis of the noteworthy works of literature which has contributed to the impending localization of NLOS nodes which details about their advantages and disadvantages.

An ECHOBDS mechanism was anticipated by Sastry et al. for effectively identifying the position of the Non Line of Sight nodes [7]. This approach identifies the location verification of the nodes by eliminating the major issue of securing in-region [8]. By using the merits of in region validation, ECHO protocol helps in precise identification of the NLOS in the network. The major benefit of this approach is that it uses minimal hardware and it utilizes ultrasound methods to precisely identify the NLOS nodes. The major curb of this scheme is that it incurs high overhead while detection.

Capkum et al. made use of multilateral verification methodology to effectively identify the NLOS nodes [9]. This technique makes use of signal propagation time and it also measures the time in flight to authenticate the location of the vehicles. This technique identifies the position of utmost three base stations which is of close proximity using the distance bound. The major setback of this approach is that it is only capable of identifying only three base stations, but when the NLOS nodes are found to dynamically increase the system fails to handle the situation.

Anjum et al. further proposed a localization methodology which uses sensors to detect the position of NLOS and it doesn’t make use of any specific hardware [10]. It makes use of sensing bounding method which eliminates the nanosecond precision issue which is considered to be major factor of advantage. But it makes use of finite number of anchor node for exploring the location of NLOS which is found to be within the range of communication.

In addition, Alodadi, et al. devised a Co-operative Volunteer Election-Based Localization Mechanism (CVEBLM) that makes use of the on board units through the sensitive components present in it [11]. The On-Board units are completely responsible for gathering the information such as the position of the vehicles and respond in an effective way during crisis situations. CVEBLM is found to be an effectual methodology when compared with GRANTBLM proposed by Capkum et al. as it makes use of anchor nodes in detecting the position of NLOS by reduced channel overhead and improved channel utilization. The major drawback of this approach is that it incurs high time consumption in electing anchor nodes.

Song et al. proposed Time of Flight technique to thwart bogus notification received during localization [12]. It uses time of flight metric to calculate the distance between the reference node and NLOS node. The Foci based approach is used to converge the position of non-reference node with the help of the anchor node chosen. The major con of this approach it incurs high computation overhead when the density of the network increases.

The Position Verification Secure Message-Based Localization Mechanism (PVSMBLM) approach was designed to secure the discovery of the vehicles using hash indexing mechanism [13]. This mechanism is found to localize the position of NLOS better when compared to the time of flight metric and ECHO protocol. One of the major setbacks in this approach is each time a new session key has to be generated for hashing which indirectly increases the network overhead.

Analyzing the merits of properties of plausibility, a Fuzzy trust method FLSTM-NLOS (Fuzzy Logic-based Secure Trust Model for NLOS detection) was proposed to ensure the aptness of the source from which data is originated during communication process [14]. It ensures the improvisation of rate of impression and uncertainty rate which is independent of the malicious activity introduced in the network.

A Novel Trust Framework for NLOS detection (NTF-NLOS) was proposed by Hui Xia et al. for preventing the attacks and to improvise the routing effectiveness of the network [15]. This frame work makes use of Bayesian game for calculating direct trust and based on the credibility evaluation indirect trust is calculated. The fuzzy based approach is used in calculating the total trust value by fuzzifying the values obtained during direct and indirect trust calculation. The obtained trust value is used to identify and eliminate the malicious nodes and a secure route is established. This system has improved in minimizing delay and control overhead. The major con of this approach is that the system must have prior knowledge about the network while calculating the direct trust and occurrence of false positive is found to be high.

Lyu, F. et al proposed Novel Congestion Resistive Beaconing-based Secure Model for NLOS detection (NCR-BSM-NLOS) it makes use of Distributed Beacon message methodology for effectively controlling the beacon activities [16]. It has two machine learning phases Naïve Bayes and Support Vector Machine which is used to analyze the NLOS link prediction. Based on the link status information obtained link-weighted safety benefit maximization (L-SBM) is formulated which is been proved to be NP-hard. This system has better control over the beacon messages over the rate of transmission.

The aforementioned limitation which is observed during the literature forms the base of HYBRID MULTI-PERSPECTIVE NLOS LOCALIZATION FRAMEWORK (HM-NLOS-LF) which is designed for improving the emergency message transfer rate and increased channel utilization.

III. Overview of HM-NLOS-LF Framework

This Framework is based on the integration of Weighted Distance Hyperbolic Prediction-Based Detection Scheme (WDHPBDS), Weighted Inertia-based Dynamic Virtual Bat Algorithm (WIDVBA) and Rank Criteria Improved Confidence-based Centroid Scheme (RCICCS).

Weighted Distance Hyperbolic Prediction-Based Detection Scheme (WDHPBDS) uses the merits of hyperbolic positioning methods to converge the position of the NLOS [17]. Thus the distance between anchor node and NLOS is periodically updated by minimizing the least squared error and also it makes use of non linear optimization for precise localization.

Weighted Inertia-based Dynamic Virtual Bat Algorithm (WIDVBA) [18] is an improved version of Bat Algorithm [19] which is mainly designed by analyzing the merits of Bio inspired algorithms such as Particle Swarm Optimization and Simulated Annealing. The position, velocity and frequency of the vehicles are periodically updated which helps in better localization of the vehicles which the help of search agents. The use of Meta-Heuristic approaches helps in better localization of the vehicles by using degree of exploration and exploitation [20].

Rank Criteria Improved Confidence-based Centroid Scheme (RCICCS) has been proposed to estimate the location information of the vehicles with the help of the reference nodes [21-24]. This method initially calculates the location information of the vehicles based on the metrics namely Time of Arrival (TOA), Time Difference of Arrival (TDOA) and Angle of Arrival (AOA). The information gathered is shared between the vehicles through distributed manner. Next improvisation that must be made in Simultaneous Perturbation Stochastic Approximation Method (SPSAM) is calculating the primitive cost which makes use of actual distance and forecasted distance. During the primitive cost calculation, the network error which arises will penetrate in the network. So, to control the network error adaptive penalty cost is calculated by making use of hop count. But when trade-off is found in the calculated hop length, degree of penalization is imposed to reduce the network error. But penalty method is found to have a drawback as it incurs high cost. So neighbourhood estimation method is used to calculate the adaptive penalty cost and finally the cumulative cost is calculated based on adaptive penalty cost and primitive cost. The position of the NLOS is further improved by neighbourhood confidence which makes use of the location confidence such as the trust value of the node, distance measure confidence which calculates the possible neighbourhood sets. The position of the NLOS is determined with the help of perturbation process using the limits of positive and negative gradients.

The aforementioned Meta-Heuristic approaches are used in designing the HM-NLOS-LF framework which has found to overcome the drawbacks faced during the survey.

IV. Meticulous Portrayal of the proposed HM-NLOS-LF Framework

The HM-NLOS-LF framework assists in detection of the NLOS nodes in the network based on the utilization of the modules namely; i) Network parameters section (ii) Selection of the parameters on the utilization of NLOS detection schemes (iii) Anticipation of NLOS localization methodologies iv) Selection of parameters based on employed NLOS detection v) NLOS localization scheme which is portrayed in the Figure 1.

At first the parameters such as Time Difference Of Arrival (TDOA), Time Of Arrival (TOA), Angle of Arrival (AOA), Hop Count and Received Signal Strength Indicator (RSSI) are unruffled from the network in the network parameter section. The above said parameters constitute to range, range-free and range optimization used in detecting the position of NLOS nodes in the network.

The aforesaid metrics is used to localize the position of the NLOS in a most precision approach. The range based approach utilizes the metrics like angle and distance between the vehicular nodes which is extracted the network parameter modules. So, it has to make use of Time of Arrival, Angle of Arrival and Time Difference of Arrival.
The Range –free and Range optimized makes use of the triangulation and maximum likelihood estimation which makes use of the metrics of Hop count and Received Signal Strength Indicator (RSSI). The range free approaches have advantages of low cost in detecting the NLOS nodes and also this approach utilizes low energy in NLOS detection.

The NLOS localization factor plays a vital role in accurate estimation of the position of the NLOS nodes in the network. Then the NLOS localization scheme initiates the range based approach when the value of NLOS factor falls between 0.3 and 0.5 and if the value falls between 0.5 and 0.8 then range free or range optimization can be used.

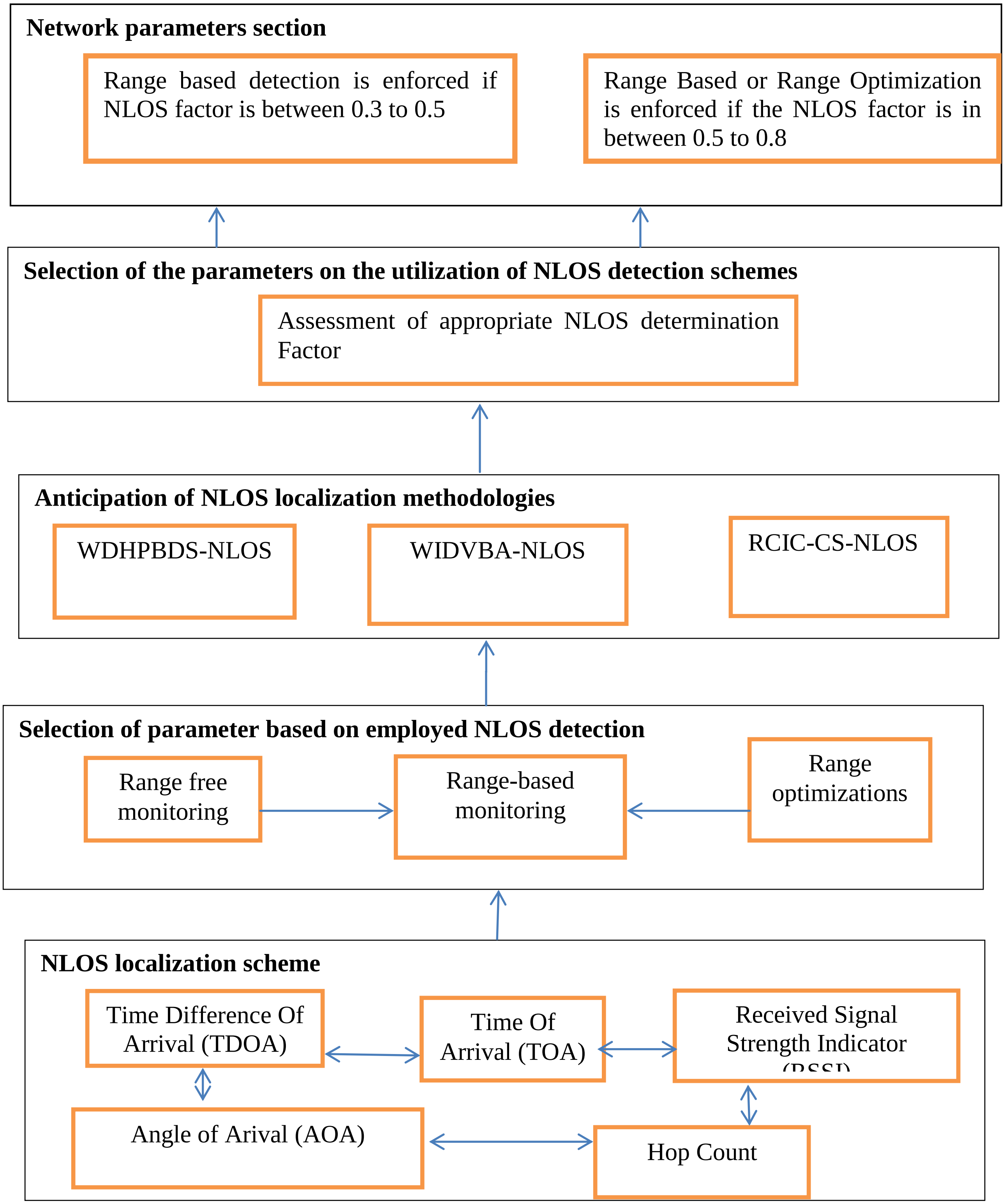

Figure 1: Architecture of the proposed HM-NLOS-LF Framework

The upcoming section discusses about the calculation of the NLOS factor.

The first step in the calculation of NLOS Factor is the forecasting stage. This step first identifies the neighbour node list which is updated and the centre hop based neighbours list coordinates are determined. If the distance between the vehicular node and its distance hop neighbour is less than one fourth of the estimated distance between the reference node and the coordinating neighbourhood is considered to be the central coordinates from the region of the left and the region of right of the origin point of the reference node is considered as the reference box.

From the origin point of the reference node to its entire left and right constitutes the border of the reference box. From the reference box 50 sample points are extracted. In the updating step the geometrical tendencies which is obtained from the reference box is considered to be the position of the NLOS when the sample points is obtained to be non zero. On the other case the geometrical area centre obtained from sample points of the reference box is considered to be the current location of the NLOS when the number of sample points is zero.

Lastly, the geometrical centre (NLOS Localization Factor) among the reference nodes that exists between the communication range with the highest ranked reference nodes and non-detectable NLOS nodes is determined based on Equation (1)

Lastly, the obtained geometrical centre (NLOS Factor) among the reference nodes which exist in the communication range between the highest ranked reference node and the NLOS nodes is based on the Equation (1)

$$LF_{NLOS} = \frac{1}{m}\sum_{k=1}^{m} Bx_{(i)} * Channel_{width} y_{(i)} \quad (1)$$

'm' is the number of reference nodes and $x_{(i)}$ and $y_{(i)}$ denotes the coordinates of the reference box, which is determined using equation (2-5)

$$x_{(i)}(l) = \left(\frac{Channel - \mathrm{Re}\,gion\_width}{2}\right) \quad (2)$$

$$x_{(i)}(h) = \left(\frac{Channel + \mathrm{Re}\,gion\_width}{2}\right) \quad (3)$$

$$y_{(i)}(l) = 0 \quad (4)$$

$$y_{(i)}(h) = \mathrm{Re}\,gion\_width(\mathrm{Re}\,f\_box) \quad (5)$$

The NLOS node localization approach is selected and the position of the NLOS is determined based on the value of LF_{NLOS}.

V. Simulation Results and Discussions of the proposed HM-NLOS-LF Framework

The implication of HM-NLOS-LF Framework is compared with FLSTM-NLOS, NTF-NLOS and NCR-BSM-NLOS through the Estinet simulator which is used in comparing the HM-NLOS-LF with the above said existing framework as it posse's effective capabilities like IEEE 802.11p for network simulation and real time destination based vehicular movements can be implemented in VANETs. The postulation and variations which are permitted in the simulator for the accomplishment of the HM-NLOS-LF are i) Routing information table is created and maintained in OBU of the vehicular nodes for stable discovery of the NLOS nodes. ii) The data's related to the routing are shared between the vehicles at frequent time intervals. iii) The routing information possess the information such as the distance between the vehicles at the intersection of roads, lane merging with the vehicles unique ID. Simulation parameters and its environmental factors are discussed in Table 1.

Table 1-Simulation parameters and values- HM-NLOS-LF

Parameters used for Simulation	**Values**
Area of Simulation	1500mx15000m
Time of Simulation	350sec
Range of transmission	200m
Mobility Generator Type	OpenStreetMap
Maximum Vehicles' speed	50 m/hr and 70 m/hr
Size of warning messages	512 Bytes
Type of traffic	Constant Bit Rate (CBR)
Type of MAC protocol	IEEE 802.11p
Maximum number of Vehicles	1000

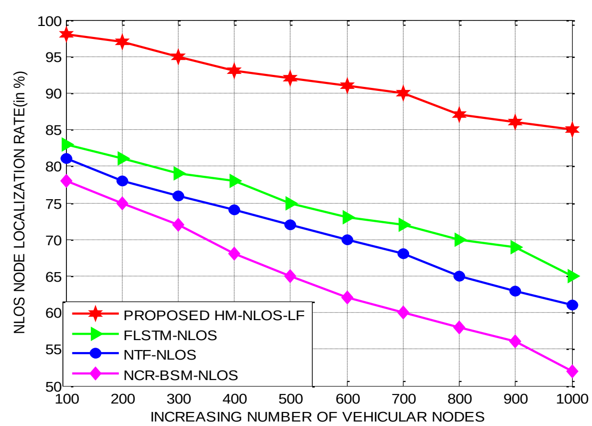

Figure 2 : Node localization rate under increasing number of vehicular nodes

In Figure 2, the node localization of the proposed HM-NLOS-LF framework is found to be enhanced by 15%, 18% and 20% when compared with the framework FLSTM-NLOS, NTF-NLOS and NCR-BSM-NLOS.

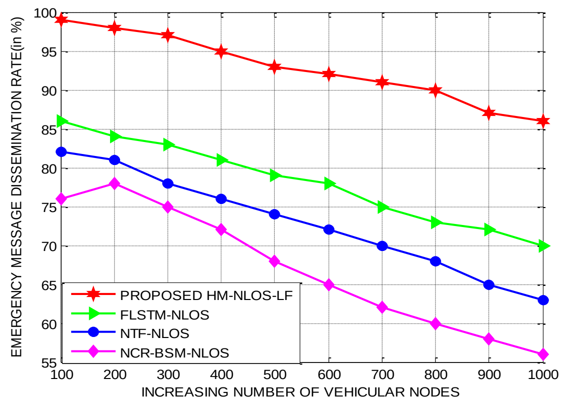

Figure 3 : Emergency Message dissemination under increasing number of vehicular nodes

In Figure 3, the dissemination of the emergency rate is found to be improved by HM-NLOS-LF Framework by 12%, 15% and 18% when compared with the framework FLSTM-NLOS, NTF-NLOS and NCR-BSM-NLOS.

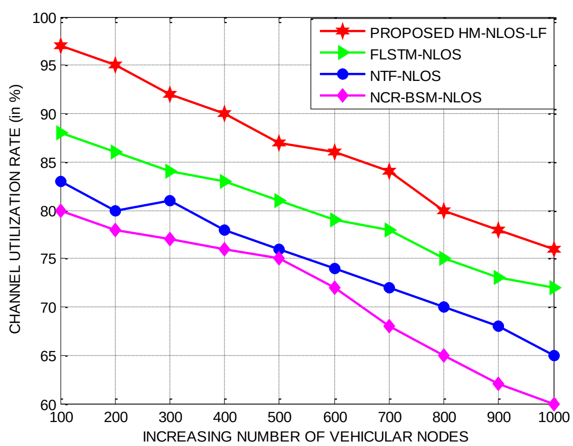

Figure 4 : Channel Utilization Rate under increasing number of vehicular nodes

In Figure 4, the anticipated HM-NLOS-LF when it is evaluated for the channel utilization rate it is found to be improved by 12%, 14% and 17% when compared with the existing framework which is used for localization such as FLSTM-NLOS, NTF-NLOS and NCR-BSM-NLOS.

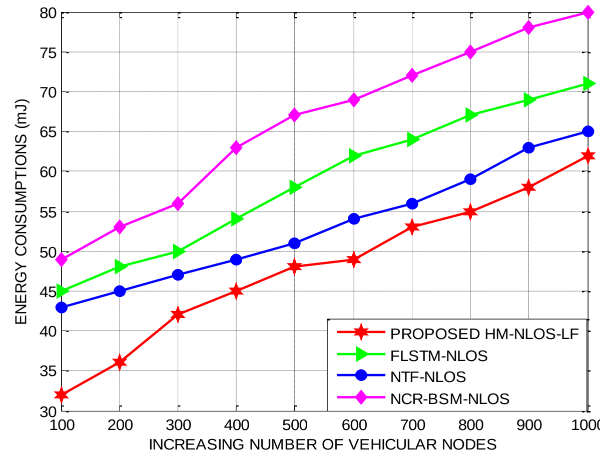

Figure 5: Energy consumption under increasing number of vehicular nodes

In figure 5, it portrays about the reduction in energy utilization rate of the nodes under increased number of the vehicles by 13%, 16% and 18% when compared with FLSTM-NLOS, NTF-NLOS and NCR-BSM-NLOS localization framework.

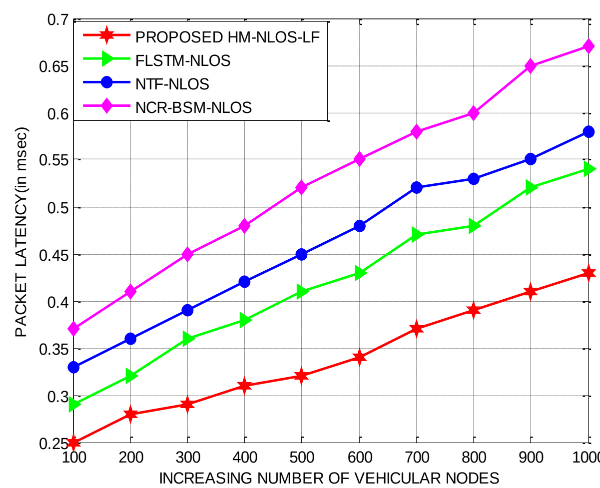

Figure 6: Packet delay under increasing number of vehicular nodes

In Figure 6, the proposed framework is used to minimize the delay of arrival of packet by 11%, 14% and 16% when compared with existing baseline of NLOS detection frameworks. The reduction in energy utilization rate and packet latency is mainly achieved because of the proper adaptations of the range-based, range-free and range optimization schemes integrated schemes.

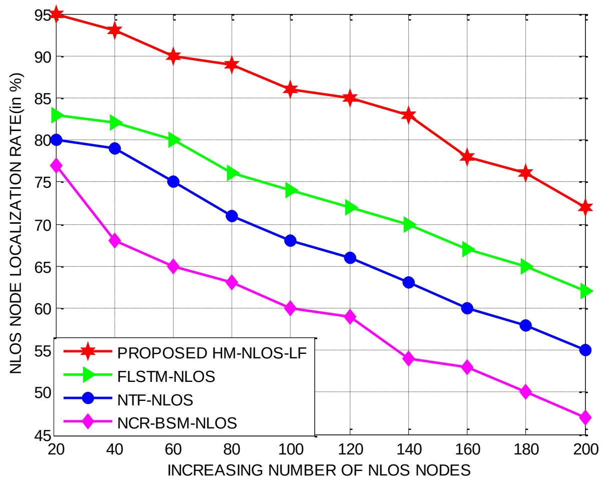

Figure 7: Node localization rate under increasing numbers of NLOS nodes

In Figure 7, the NLOS node localization of the proposed HM-NLOS-LF framework is found to be increased by 13%, 16% and 18% when compared with the baseline FLSTM-NLOS, NTF-NLOS and NCR-BSM-NLOS detection frameworks.

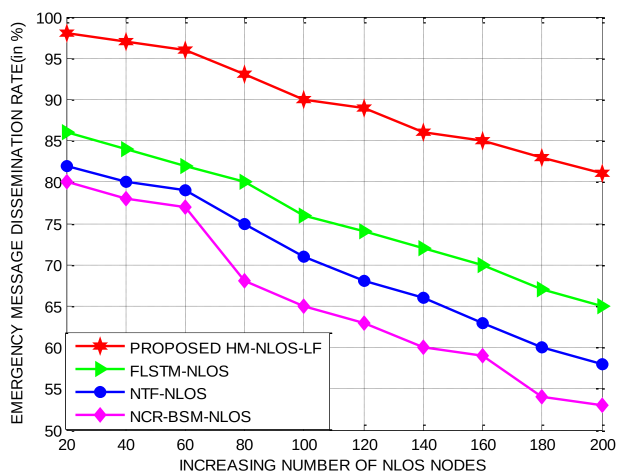

Figure 8: Emergency Message dissemination rate under increasing numbers of NLOS nodes

In Figure 8, the proposed HM-NLOS-LF framework under increased number of the NLOS nodes in the network is found to have improved the emergency message dissemination 11%, 14% and 19% when compared with the existing baseline framework.

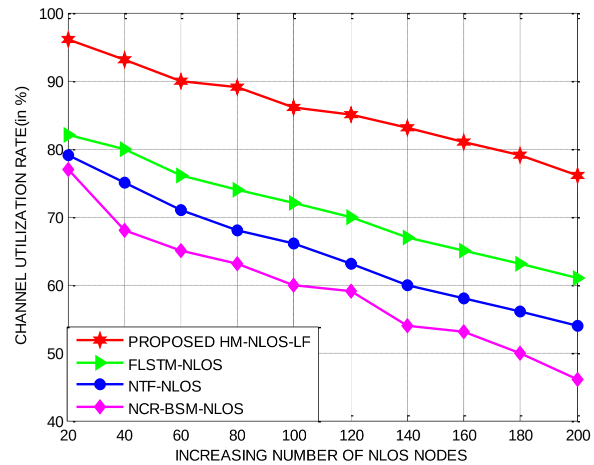

Figure 9: Channel Utilization Rate under an increasing number of NLOS nodes

In Figure 9, the channel utilization rate of the HM-NLOS-LF under increase in the density of NLOS nodes was found to be improvised by 14%, 17% and 19% on comparing with the base line. From the results it is inferred that the rate of channel utilization is found to be maximum under increased number of NLOS nodes in the network.

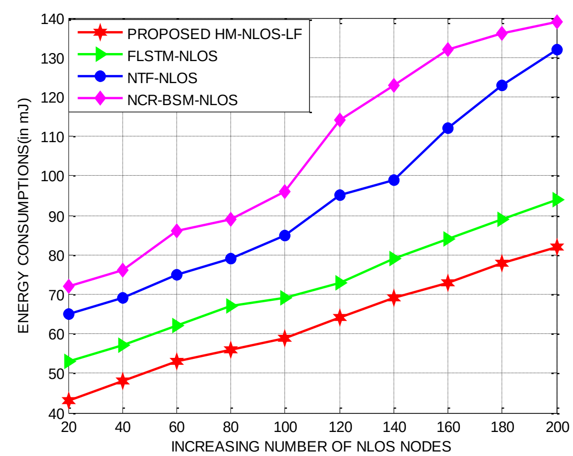

Figure 10: Energy consumptions under an enhanced number of NLOS nodes

In Figure 10, the proposed framework utilizes minimum amount of energy and the energy consumption rate is found to be minimum by 10%, 13% and 16% when compared with the baseline of the existing work.

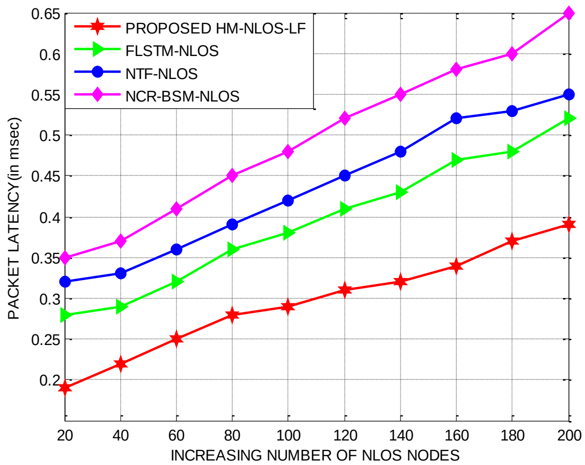

Figure 11 : Packet Latency under an increasing number of NLOS nodes

In Figure 11, the packet delay is found to be minimized by 12%, 15% and 18% under varying NLOS nodes in the network when compared with the existing NLOS detection framework.

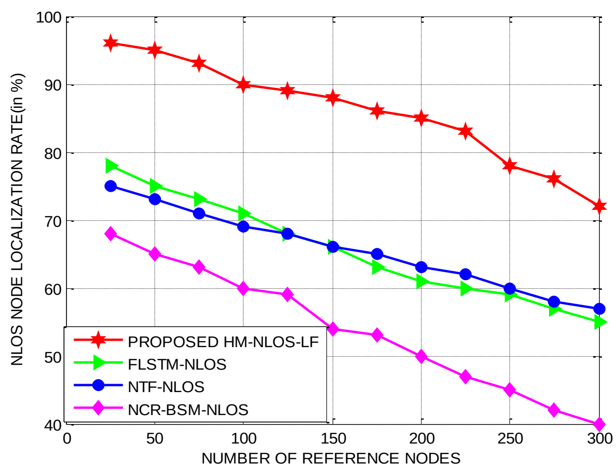

Figure 12: Node localization rate under increasing reference nodes

In Figure 12 it portrays that the node localization rate is improved by 12%, 14% and 17% when compared with the existing NLOS detection framework.

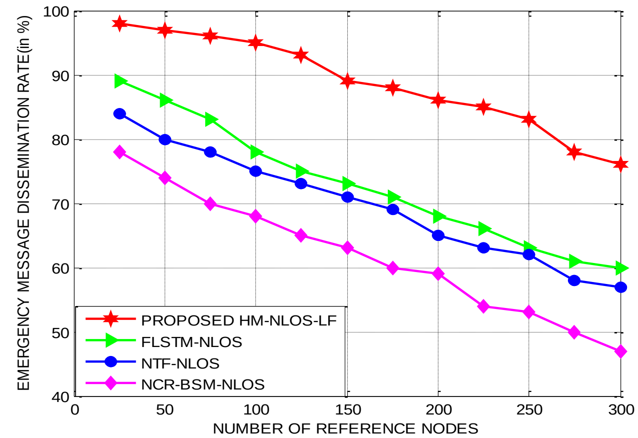

Figure 13: Emergency Message dissemination rate under increasing reference nodes

In Figure 13, the emergency message dissemination rate under varying number of reference nodes is found to be improved by 10%, 13% and 16% when compared with FLSTM-NLOS, NTF-NLOS and NCR-BSM-NLOS detection frameworks.

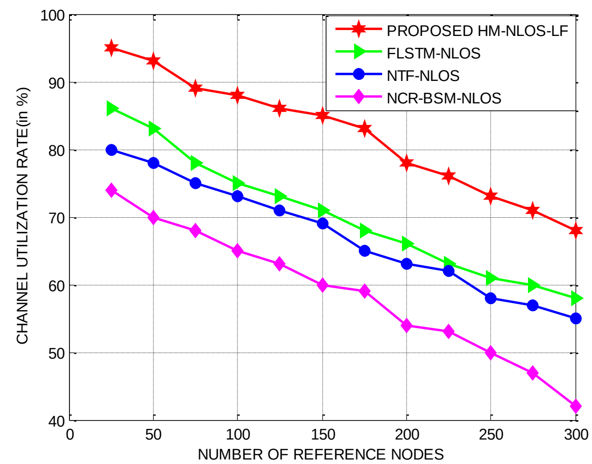

Figure 14: Channel Utilization Rate under increasing reference nodes

From Figure 14, it depicts that the channel utilization rate is under varied reference nodes is found to be enhanced by 15%, 17% and 21% when compared with baseline of the existing work.

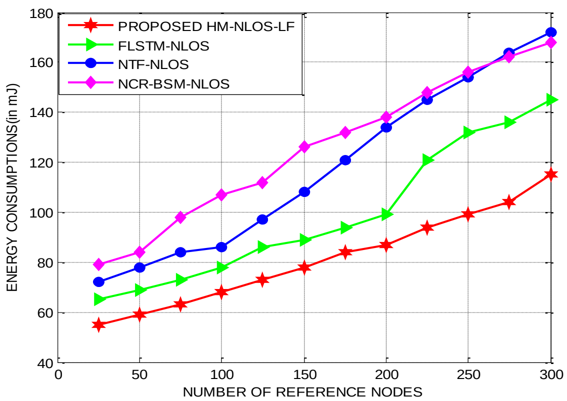

Figure 15: Energy consumptions under increasing reference nodes

In Figure 15, the energy consumption of the proposed framework is found to be minimized by 16%, 19% and 22% when compared with the existing framework FLSTM-NLOS, NTF-NLOS and NCR-BSM-NLOS.

VI. Conclusion and Future Scope

This paper makes an detailed analysis about the impacts which is been aroused due to the presence of NLOS has been analyzed and it also discusses about the drawbacks of the existing methods used for localization. There led an urge in designing an effective localization mechanism by analyzing the drawbacks. So, a HM-NLOS-LF Framework is been proposed with the implication of effective localization by eradicating the drawbacks faced in the literature. The proposed framework is found to have improvised the efficiency in terms of the compared baseline frameworks FLSTM-NLOS, NTF-NLOS and NCR-BSM-NLOS. The simulation based examination when conducted for HM-NLOS-LF Framework it is found to have predominant impact in the vehicular network in terms of node localization rate, emergency message dissemination rate, channel utilization rate, energy consumptions and packet delay under different degrees of vehicular nodes, NLOS nodes and reference nodes. The proposed framework can also be adopted in other Adhoc Networks for effective localization.

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