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Smart Handoff Technique for Internet of Vehicles Communication using Dynamic Edge-Backup Node

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Abstract: A vehicular adhoc network (VANET) recently emerged in the the Internet of Vehicles (IoV); it involves the computational processing of moving vehicles. Nowadays, IoV has turned into an interesting field of research as vehicles can be equipped with processors, sensors, and communication devices. IoV gives rise to handoff, which involves changing the connection points during the online communication session. This presents a major challenge for which many standardized solutions are recommended. Although there are various proposed techniques and methods to support seamless handover procedure in IoV, there are still some open research issues, such as unavoidable packet loss rate and latency. On the other hand, the emerged concept of edge mobile computing has gained crucial attention by researchers that could help in reducing computational complexities and decreasing communication delay. Hence, this paper specifically studies the handoff challenges in cluster based handoff using new concept of dynamic edge-backup node. The outcomes are evaluated and contrasted with the network mobility method, our proposed technique, and other cluster-based technologies. The results show that coherence in communication during the handoff method can be upgraded, enhanced, and improved utilizing the proposed technique.

Keywords: Edge computing; cluster; handoff; mobility; traffic; vehicular

1. Introduction

A vehicular adhoc network (VANET) is mainly introduced to manage communication between vehicle-to-vehicle (V2V) and vehicle-to-road side infrastructure (V2I) for exchanging road information for providing safety for onboard passengers, by promptly exchanging vehicles' crash information to the surroundings as a way to avoid what is known as a "chain-of-accidents." On the other hand, VANET is meant to provide entertainment, commercial-advertisements and infotainment applications to the road's users. As a result of these developed applications that require reliable network infrastructure, Internet of Vehicles (IoV) has picked up a great deal of fame in scholarly research and industry for a long time. In [1], it is shown that giving consistent mobility is a serious prerequisite for the upcoming generation of network applications. Mainly, VANET uses broadcasting for sending and receiving the messages that show the existence of vehicle nodes in the vicinity.

The V2V communication system provides a 360-degree view of similarly-equipped vehicles within communication range. Vehicle control information includes the transmission state, brake status, the steering wheel angle, and the vehicle's path history with path prediction. Another computational need in vehicular communication is providing a direct information exchange, single-hop and multi-hop method of communication. This type of exchanged information could substantially reduce the volume of accidents (by exchange hazard awareness messages) and time of travel, extended driving vision, and help others in making their drives more comfortable. In contrast, within V2I the information exchanged in a bi-directional packet communication and there is a high bandwidth link between the vehicle and roadside equipment that needs to be additionally provided to maintain a communication between vehicle and roadside unit. The work in [2] has listed the following four applications of VANET.

1.   Commercial orientation gives entertainment and services to the drivers.
2.   Safety orientation monitors the surrounding road.
3.   Convenience orientation deals with traffic management to enhance or upgrade traffic efficiency.
4.   Internet connectivity, as shown in Figure 1, is required to provide uninterrupted provision of the above three services.
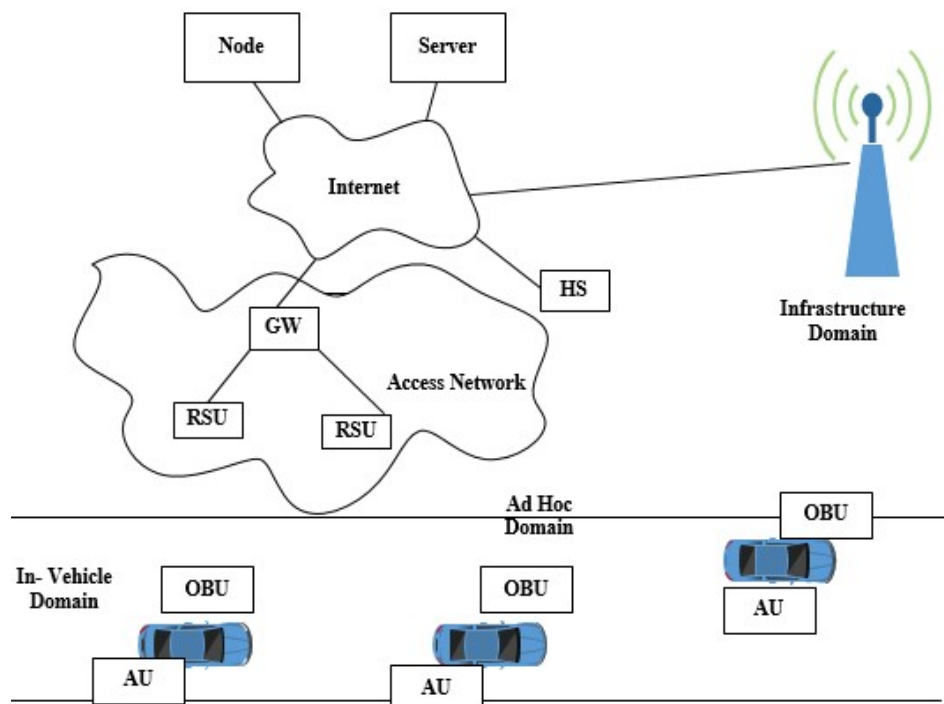

Figure 1. Applications of a vehicular adhoc network (VANET).

In order to form an IoV-enabled technology, vehicles should be interconnected efficiently with less linkage breakdown probability. In achieving this, a robust handoff mechanism needs to be properly involved. Accordingly, handling such a process, the handoff algorithm is normally implemented to manage the procedure. The aim of the handoff management is to maintain the active connections when a mobile node (MN) changes its point of connection. This handoff management involves computational process and overview image of the wider scope of the mobility cluster that with conventional vehicular communication will not be visible. Hence, recently the concept of mobile-edge computing (MEC) has shifted most of the processing overhead from the end mobile device to the edge-server that is physically closer to the MN and provides very low latency and prompts responses for the computational tasks. Hence, utilizing this concept for IoV could achieve a tremendous benefit out of MEC.

To accomplish the handoff in the IoV networks, the handoff system is directed to be effective in assigning and reassigning the IP addresses. This process known as a mobility handoff stage, and

guarantees the consistent Internet availability while handoff is being performed. The Mobile Internet Protocol Version 4 (MIPv4) proposed in [3], contains a few issues, such as triangular routing, the short scope of communication, and the feeble security component. The MIPv6 was acquainted with the necessary improvements which defeated the issues from MIPv4. It provides a preferable security system and effectiveness over MIPv4. The necessity of a consistent network in VANET was not satisfied by MIPv6 [4] due to its elevated mobility of nodes. Hierarchical Mobile Internet Protocol (HMIPv6) was proposed to give an answer to MIPv6. In HMIPv6 protocol, in points of on-link, few entities are involved in providing IP-Mobility handoff process. The care of address (CoA) is locally obtained via Mobile anchor point (MAP) and the regional care of address (RCoA) is globally obtained. The MAP is utilized to deal with mobility area-handoff of the mobile client. The MAP is classified into two sections, micro-mobility and macro mobility. Mobile host (MH) uses the micro-mobility management method to produce an LCoA and launches a compulsory message to MAP, whereas mobile host (MH) uses a macro mobility management method to produce an LCoA and launches a compulsory message to its home agent (HA). It includes a handoff process which basically means changing the connection point during communication. In [5] the authors proposed the advanced mobility handoff scheme, whereby the mobile node utilizes a unique home IPv6 address developed to maintain communication with other corresponding nodes without a care of address during the roaming process. Moreover, a temporary MN-ID was generated by an access point (AP) each time an MN was associated with a particular AP and temporarily saved in a developed table inside the AP. However, as was highlighted by the authors in this work, there is still a need for a predictor to act proactively in a smart way to anticipate the possible handoff about to take palace.

Figure 2 shows the traditional concept that whenever a mobile station is connected to a base station(BS), there is a need to change to the BS. This is called handoff or handover.
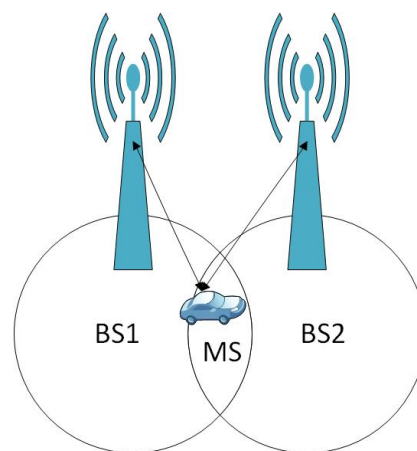

Figure 2. Traditional concept of handoff/handover.

Generally speaking, handoff processes could be performed as reactive or proactive; they use a similar concept as in any wireless technology. The handoff process involves one client node and at least two infrastructure nodes in which the client node should be attached to one of the infrastructure nodes. In order to achieve a low latency handoff, the process should be triggered proactively; hence, numerous methods were proposed over the past few years to address this challenge within vehicular communication. In [6] the author proposed a model which was made such that VANET still experiences issues of handoff due to delay and failure of packet delivery. As discussed in [7,8], the procedure of handoff generally occurs when a mobile user moves into the range of neighboring cell and can be controlled within the BS; the controller of BS manages numerous BS. Handoff Management in IoV is performed by re-routing to construct a new path to the destination. When a MN moves, a cluster of neighbor's changes and a new path of data transfer needs to be established rapidly without any delay for better handoff performance, as shown in Figure 3. Having this process managed from

a distant cloud server makes the process introduce some delay—more than required. In MEC, the concept is to occupy each BS controller with computational resources to shift this handoff processing to the edge of vehicles to achieve the minimum possible delay.
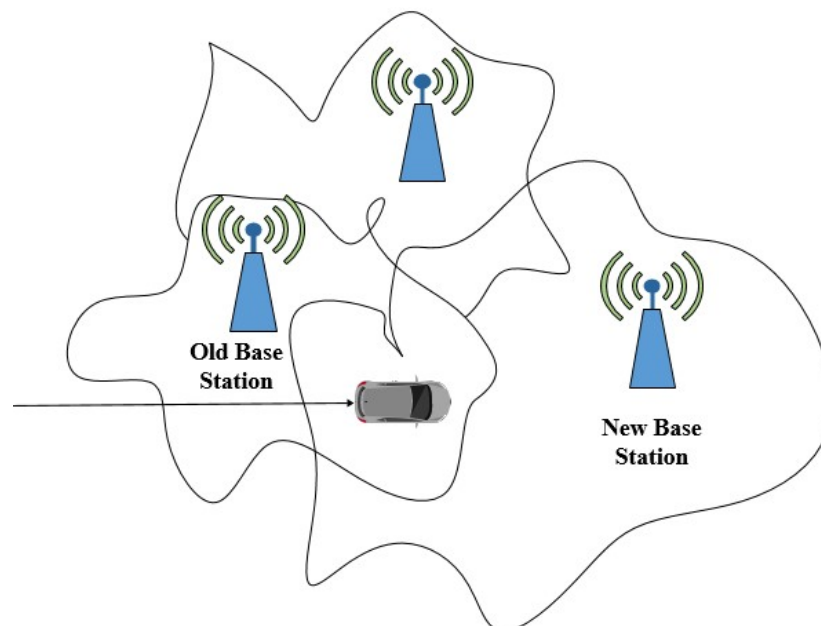

Figure 3. Handoff scenario.

This paper specifically tends to the handoff challenges, cluster-based handoff using the proposed dynamic edge-backup node (DEBCK). Furthermore, this paper also examines the handoff delay, throughput techniques, and parameters of handoff for some related studies. Many strategies are used for improvements of this issue. We also outline the handoff research challenges that need to be addressed for better handoff performance. Handoffs can be categorized on the basis of different factors; i.e., types of network, elements involved in network or live connections, and kind of traffic the network provides. In order to familiarize the reader with the main types of handoff, a list of these types is given below along with the discussion.

1.   Hard handoff;
2.   Soft handoff;
3.   Horizontal handoff;
4.   Vertical Handoff.

In a hard handoff channel, the source cell will be out of coverage and only the channel within the specified cell is involved [9]. Therefore the connection between source and destination will breakdown before or as the connection to target gets created; for this purpose, handovers are also called hard handoffs. When a node is between BS, then the node can move with any BS. So, BS springs up the link with the node back and forth. This mechanism is also called ping-ponging. On the other hand, when a new connection is established before the previous connection is broken, this defined as a soft handoff [9]. In a soft handoff, the channel in a source area is reserved and used in parallel with channel in target area. In this scenario the connection to the target is established before the connection to source is breakdown. Therefore, this handoff is known as make-before-break. Soft handovers may include connections to more than two cells. As another scenario, when nodes switch between networks of the same infrastructure type while changing their connection in order to maintain active connection, this switching process is called horizontal handoff. E.g., from one GSM ne twork to another or from one WiFi AP to another. In contrast, as a way to maintain an active connection while nodes switch between networks of different types while changing the connection, the process is known as vertical handoff.

Vertical handoff is the process of changing the mobile active connection between different wireless technologies. Vertical handoffs can be further distinguished into downward vertical handoff (DVH) and upward vertical handoff (UVH). In DVH, the mobile user hands off to the network that has higher bandwidth and limited coverage, while in UVH the mobile user transfers its connection to a network with a lower bandwidth and wider coverage.

The structure of rest of the paper is as follows. Section 2 includes a literature review of some related research and a comparative analysis of the existing handoff techniques. Section 3 includes proposed methodology. In Section 4, we discuss the performance evaluation while Section 5 concludes the paper. All abbreviations and mathematical notations are listed in Appendix A, Tables A1 and A2 accordingly.

2. Literature Review

This section provides a background survey of the existing handoff methods and techniques in vehicular networks. For instance, the authors in [10] proposed an adaptive handover prediction (AHP) method for seamless mobility based network that merges the AP prediction model with fuzzy logic and gives the cognitive ability to handover decision making. On the other hand, the study in [11] provides a brief review of the handoff process for VANET over LTE-A wireless networks. This work also discusses some key parameters for handoff scheme. Through studying this paper, new research options can be explored by understanding the gaps in previous studies. Paper [1] presented a handoff protocol, discussed necessities of protocol, improved the vehicular handoff in detail, and analyzed the partner selection problems on VANET by initiating a vehicle link expiration time (VLET) metric. The authors in [12] describe some information about the background of the problem in VANET, and the scheme being used by the authors provides speedy handoff methods by using RFID tags which shortened the handoff latency and minimized the Quality of Service (QoS) of the network. The IEEE802.11p is a [13] draft standard whose aim is to support wireless access in vehicular environment (WAVE). The IEEE802.11p is a draft standard intended to support WAV, which operates over a frequency band of 5.9 GHz. WAVE consists of IEEE 802.11p and IEEE 1609.X. The IEEE 802.11p deals with the physical layer (PHY)/medium access layer (MAC) and IEEE 1609.X considers upper layers. In 1609.X standard family, 1609.3 defines network and transport layers and 1609.4 specifies the multi-channel operation. In the multi-channel operation, a WAVE system uses one common control channel (CCH) and several service channels (SCHs). It was reported in the literature to support the flawless handoff procedure for real-time service of the demanding application and decrease the whole time taken by the handoff. The research [14] mainly focused on quick and recent location-based handoff scheme for VANETs. Two schemes are discussed in this paper; one is called detection scheme, and the second one is called the AP selection scheme.

The work in [15] reviews the literature related to VANETs, and the authors proposed an efficient proxy mobile IPv6 (E-PMIPv6)-based on handoff management that assured session continuity for urban mobile users. A series of previous studies [16] has indicated that the recent techniques of vertical handoff decision algorithm are used by comparing the multiple parameter values to choose the top available networks. In this paper [17] for fast handoff using AP in VANET, a proactive approach was proposed. For VANETs, previous schemes need to minimize the delay of handoff and for fast handoff, existing schemes are purely based on context transfer. In the literature review [18], the main focus is on the quality of the video streaming which has been downloaded by the moving vehicle. Vehicles move from one road side unit (RSU) to another RSU during the process of video streaming. A more comprehensive description [19] can be found in WAVE, in which handoff is most the repeated in wireless networks. In this paper, a prescanning method and quality scan scheme are proposed for improving the performance of handoff in VANETs.

The authors of [20] provide a considerable body of literature in VANET state which consists of wireless local area networks (WLAN) and universal mobile telecommunication systems (UMTS) as they relate to the vertical handoff performance of vehicles. The NS2 simulator is used for implementing the vertical handoff scheme. In [21], there is a brief review on the standard protocols improved by new

proposals. For dealing with the handoff problem some standard approaches are used on the basis of new proposals, such as multiway proactive caching, VFMIPv6, and EBR-PMIPv6 to reducing the handover expenses. The authors of [22] give a progressively exhaustive analysis, including the beacon frequency, the speed of the vehicle, and the size of the beacon.

In [23] the authors improved the handoff process of network-based DMM by using the HO-initiate procedure and IEEE 802.21 media independent handoff services. Their proposed technique begins the problem of compulsory registration delay by using the HO-initiate process and lessens the delay of determining the next access network and candidate mobile anchor access routers (MAARs). The authors of [11] provide a brief overview of communication and information exchange between vehicles and provide the latest scheme for handoff algorithm which relies on the vehicular communications specifically focused on the vehicle to infrastructure (V2I).

In highlighting the impact of the new emerged concept of mobile edge computing in the field of VANET, see the authors of [24,25]. In this paper, vehicular edge computing (VEC) was investigated as an important application of mobile-edge computing in vehicular networks.

2.1. Handoff Techniques

Some handoff techniques in the literature are the vehicular fast handoff scheme, the IP passing scheme, the cluster-based handoff scheme, the two antenna scheme and the network mobility (Nemo) scheme. The [26] vehicular fast handoff scheme is known as the layer handoff scheme, which classifies three kinds of vehicles. These are RV (relay vehicle), OSV (oncoming side vehicle) and BV (broken vehicle). The [27] discussed the vehicular fast handoff scheme (VFHS) as RV is a larger vehicle than the others. The [28] discussed that for the spreading network topology message (NTM) to BV and OSV utilize predefined frequency channel. Reference [29] explains the preferred AP and early handoff. Each AP makes a list of PAP, which gives early information and helps out the vehicle to carry out the handoff from continuing AP. In [30] they proposed an intelligent network selection (INS) method focused on enhancing the scoring function to rank efficiently from existing wireless network nodes.

2.1.1. IP Passing Scheme

IP addresses the switch between the vehicles when V-1 moves from the space of Base Station-1 (BS-1) towards BS-2 and V-2 moves from the area of BS-2 towards BS-1. The IP addresses are switched when these two vehicles traverse each other in inverse ways. A vehicle resources another vehicle behind it so as to play out a handoff. DHCP is capable of controlling the allocating of IP delivers to ensure extraordinary distinguishing proof after handoff is performed.

Following 3 steps are necessary for checking the passed IP address.

1. The IP address is produced by an authentic DHCP.
2. No manufacturing is done previously or amid the going of an IP address from vehicle to vehicle.
3. The IP address is checked at the receiving vehicle, on the off chance that its manufactured IP will be disposed of, and asked for from DHCP straight forwardly, rather than tolerating a passed IP from a vehicle.

2.1.2. Cluster-Based Handoff Scheme

In cluster-based handoff, vehicles are moving into a gathering or a cluster in highway and each group contains a cluster head. Cluster head straightforwardly communicates with BS and another vehicle communicates with the cluster head. Reference [31] mentions that cluster heads are responsible for maintaining the whole network, so a cluster head must choose the basic metrics like storage capacity, communication range, energy, etc. In [32] authors proposed the CBHBCK in which a predefined backup mobile edge-node and cluster head were used. Backup node prepares the handoff and updates the list of BSs while cluster head performs the physical handoff.

The overhead of a cluster node decreases, but the drawback is if the backup mobile edge-node or cluster head stops working then the communication can be distorted.

2.1.3. Two Antenna Scheme

This methodology clarifies that two remote interface cards are given to the vehicles while each card has an antenna. These two antennas deal with common base usefulness. One antenna has given an undertaking to check the quality of the flag and perform handoff when required. The other antenna conveys flawlessly, which results in less parcel misfortune and hands-off time necessity.

2.1.4. Network Mobility (NEMO) Scheme

In this method collection of vehicles is set up on the premise of the multi-bounce transfer idea. For communication with BS, NEMO utilizes a mobile router (MR). Its idea is same as that of a bus that contains two MRs in which the front switch is known as Front MR and a back switch is known as Rear MR. Front MR is appointed to handoff and Rear MR gives administrations to systems.

2.2. Comparative Analysis

Table 1 shows the comparative analysis of existing handoff techniques in VANENT. The authors in [1] have proposed approach named vehicle link expiration time (VLET) metric. In this approach packet loss rate cannot decrease but handoff delay reduces. RFID Tags proposed by Midya, S., et al. (2016) [12]. Packet loss rate decreases in the proposed scheme and handoff latency reduces. In another attempt, the work presented in [13] gives the multichannel functions method. The authors have maintained the handoff process in vehicular network based on IEEE 802.11p network standard. Wi-Fi was also utilized to interface every one of the hosts with MRs and WI-MAX is utilized to associate MRs to the web. In NEMO clusters of vehicles are considered as transports. The primary vehicle in the gathering is considered as front MR, while the last vehicle is assigned to be as back MR, which is the proposed mobile edge-node. Pre-handoff performance for last MR is the requirement of front MR.

This approach reduces the handoff delay and support real-time services. Almulla, M., et al. (2014) [14] proposed schemes called turned detection scheme and AP selection scheme. They worked on handoff delay by using location-based handoff approach specifically build for vehicular communication system. According to movement route and positions of vehicle information and nearby APs information, the proposed protocol guesses many APs that the vehicle may be visit in future and allocates these APs different priority levels.

Sabariah Salihin, S., et al. (2018) [15] proposed a new optimal handover decision model. Packet loss rate decreases in this approach but handoff delay cannot reduce. Bi, Y., et al. (2016) [16] proposed efficient proxy mobile IPv6 (E-PMIPv6).

E-PMIPv6 allows mobile nodes to get continuous internet connectivity from static roadside units or mobile routers and enhance cache usage at the local movement fixed by binding the cache data of the mobile users. In the handoff procedure E-PMIPv6 focuses on multiple handoff circumstances in the urban vehicular surroundings and gives mobility support to individual mobile users or group of users in an identical network without disturbing continuous sessions. Dawei, M., G. Xianlei, and C. Rong. (2013) [17] provides a scheme named the vertical handoff scheme. Packet loss rate decreases and also handoff delay reduces in this scheme. In this approach vertical handoff evaluation of vehicular users in VANET environment comprise of different mobile systems and wireless networks. Simulation is performed in network simulator 2.

This work details the investigation of the handoff challenges in cluster-based handoff using proposed DEBCK. The outcomes are contrasted with NEMO and cluster-based Technologies. The result portrays that coherence in communication during handoff method can be upgraded, enhanced, and improved utilizing the proposed technique.

Table 1. Comparative analysis of existing handoff techniques.

S. No	Author/Date	Technique/Algorithm/Methodology	Decrease Packet Loss Rate	Reduce Handoff Delay/Latency
01	SabariahSalihin, S., et al. (2018) [11]	New Optimal handover decision model	✓	×
02	Ahmed, H., S. Pierre, and A. Quintero, (2018) [1]	Vehicle Link Expiration Time (VLET) Metric	×	✓
03	Midya, S., et al. (2016) [12]	RFID Tags	✓	✓
04	Patel, M. and V. Ukani. (2012) [13]	Multichannel functions	×	✓
05	Almulla, M., et al., (2014) [14]	Turned Detection Scheme and AP Selection Scheme	×	✓
06	Bi, Y., et al., (2016) [15]	Efficient Proxy Mobile IPv6 (E-PMIPv6)	✓	✓
07	Kumaran, U. and R.S. Shaji. (2014) [16]	Handover Decision Algorithm	×	✓
08	Das, D. and R. Misra. (2013) [17]	A proactive approach for fast handoff	×	×
09	Smida, E.B., S.G. Fantar, and H. Yousef. (2017) [18]	Predictive handoff mechanism	×	×
10	Tin-Yu, W., et al. (2011) [19]	Pre-scanning method and Quality scan scheme	×	×
11	Dawei, M., G. Xianlei, and C. Rong. (2013) [20]	Vertical handoff scheme	✓	✓
12	Batish, S., et al., (2015) [2]	AOA technique	✓	✓
13	Ghosh, A., et al., (2014) [22]	Full-blown analytical Model	✓	×
14	Balfaqih, M., et al., (2017) [23]	Analytical Expression, DMM, HO-initiate process	✓	✓

3. Proposed Methodology

There are some existing methods which are furnishing us with network connectivity among nodes and cluster nodes during the handoff. The proposed technique in this study is purely dependent on the clustering mechanism of the vehicle. In IoV group is arranged by various clusters of vehicles by means of relative movement and afterward information is distributed amongst all the vehicles in a group.

In the proposed methodology for maintaining the safe track of the handoff process, two nodes are used. The following lines provide discussion of the two nodes. The first node being used here is called head node and the second node is called an edge backup node. It is assumed that in the working of a network system, nodes are further divided by making more groups later on. Both nodes being used here are dynamically selected on basis of the following three parameters.

1. Storage capacity;
2. Communication range;
3. Energy.

A list of candidate backup mobile edge-nodes will be created and scores will be calculated on the bases of these parameters. When a node is entered in the cluster, its score will be calculated and entered into the candidate backup list. Both cluster head and backup edge node have a copy of this list. If the cluster head faces disconnection, the backup mobile edge-node will become the cluster head and a high-scoring backup mobile edge node from candidate backup list will be selected. If the backup node faces disconnection. the head node will select a high-scoring backup mobile edge-node from the list. Issues of overhead on cluster head and packet loss rate are decreased and improved through this methodology. The following points show the proficient performance of the proposed technique.

1. Provision of non-stop and steady connectivity through handoff performance;
2. Maximized and efficient network performance;
3. Network disconnectivity issue resolved;
4. Reduced problem of the cluster heads' overhead.

Cluster stability can be explained with multiple methods; our procedure computes the stability from the distance, variation in speed, and probability arguments. A cluster head is selected with keen value stability. We assume that vehicles are equipped with GPS systems through which each one can gain information related to current position, and IEEE 802.11p radio transceivers which are used for communication with other vehicles. In the proposed algorithm, each vehicle can run the clustering method. When a vehicle needs to discover a cluster head, it propagates a message to its neighbors; if no response is received, it begins the group formation procedure. Vehicles moving in the same direction are grouped in the one cluster. Each vehicle transmits the message to its group vehicle; the message contains: the location, ID, and speed. After that, it places the arguments in an array of the neighborhood and calculates:

- The distance between the neighbor Q and vehicle N itself:

$$Distance_{N,Z} = \sqrt{(x_N - x_Q)^2 + (y_N - y_Q)^2} \tag{1}$$

where (x, y) is the location of the vehicle.

- The variation in speed among the neighbor Δ V and vehicle N itself.

$$\Delta V_{N,Q} = V_N - V_Q \tag{2}$$

- The probability of the vehicle being the cluster head:

$$Probability = (E + 2 * density\ of\ the\ node + V)/P_{max} \tag{3}$$

where E is the energy intake of the node for sending/receiving a packet, (here, energy refers to the power that a node consumes for the transmission process) and V is the speed of vehicle. Probability value will be between 0 and 1. We have normalized the range of E, *vehicle density, and velocity* within the range of (0–1). All captured values will be divided by the maximum value of the obtained probability. In each iteration, the maximum obtained probability—by setting the maximum values of all mentioned metrics, *Pmax*—can be defined. Example, $P_{max} = E_{max} + 2 * Density_{max} + V_{max}$ » $P_{max} = 1 + 2 \times 1 + 1 = 4$; hence, each time, calculating the probability of having a vehicle as the cluster head will be divided by the value 4 (P_{max}); hence the range value of probability will end up with the scale of 0–1. Bear in mind that when the value gets close to 1, it indicates a poor candidate; while when it is closer to 0 it is considered the best candidate, as it would be a minimization problem; the minimum is the best.

Obviously this value is highly dependent on the energy consumption of vehicles, density of the node, and speed of the vehicles. Cluster heads are selected according to the probability of optimal cluster heads being decided by the this equation, taking into account the metrics of each network's cluster. After the selection of cluster heads, the clusters are constructed, and the cluster heads start communicating. The cluster head which would consume the least energy during its communication would have a greater chance of becoming the cluster head. Here, energy means the power that a node consumes for transmission.

$$E = K * E_{con} \tag{4}$$

where E_{con} describes the energy intake of the wireless send/receive circuit.

- The $S_{N,Q}$ stability factor computed for all neighbor vehicles Q in the transmission chain:

$$\begin{aligned} S_{N,Q} &= \alpha_1 + \alpha_2 * Distance_{N,Q} + \alpha_3\ \Delta V_{N,Q} + \alpha_4 * P + \alpha_5 * Distance_{N,Q} * \Delta V_{N,Q} + \alpha_6 * Distance_{N,Q} * P \\ &+ \alpha_7 * P * \Delta V_{N,Q} + \alpha_8 * Distance_{N,Q} * P * \Delta V_{N,Q} + \varepsilon \end{aligned} \tag{5}$$

where: $\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6, \alpha_7$ *and* α_8 *are called real coefficients of the model.*

$$\left| \alpha_1 \ldots \alpha_8 \right| = (X^t * X)^{-1} * (S * X)^t \tag{6}$$

where S, output, and X are the impacts of matrix. S is the stability of cluster. Cluster stability is an important goal that clustering algorithms try to achieve, and it is to be considered a measure of performance of a clustering algorithm. Cluster stability can be explained using multiple methods; our procedure computes the stability from the distance, variation in speed, and probability arguments. Cluster head is selected with keen value stability [33].

Results of the experimentation used to change all the three components (the difference in speed between the vehicle, the distance ΔV and probability) in the following limits:

	low degree: -1	high degree: $+1$
Distance	near	far
speed	low	high
Probability	low	high

- The component of stability S:

    All vehicles exchanges measures of stability with neighbor vehicles in its cluster. Cluster head is the vehicle with the larger value of stability.

$$S = \sum S_{N,Q} \tag{7}$$

Algorithm

Algorithm 1 of the proposed methodology works through the following steps: A list of Candidate backup mobile edge-nodes will be created on the basis of storage capacity, communication range, and energy. If a backup mobile edge-node has gone away from its cluster (took another intersection), then it sends a message to the cluster head prior to its movement to provide an alert to start new election process for new backup node. The cluster head will select another high scoring backup node from the candidate list. At the time when handoff is not performing, after the time span of one minute, the backup mobile edge-node sends a hello message. Location is improved and the list of BS is handled and maintained. Associate BS1 and BS2, which are as of late framed and set up close to the cluster head. For physical handoff, send a physical affirmation of handoff to the cluster's head

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Algorithm 1 Cluster Formation.

Input:

$V_d1 = \{V_{11}, V_{12}, V_{13}, ..., V_{1n}\}$// groups of Vehicles

Output:

$H_{d1} = \{h_{11}, h_{12}, h_{13}, ..., h_{1k}\}$// groups of vehicles to be selected as cluster midpoints from set V_d1

1: The vehicles moving in a static direction **d1** within the coverage area of a particular
2:   **MAG** belongs to the set **V_d1**.
3: 'N' vehicles are randomly selected from set **V_d1** as the cluster midpoints and
4:   Sorted in set **H_d1**
5: Repeat
6: For each j = **1** to **N** do
7:   A vehicle cj from set H_d1 is selected as one of the cluster midpoints
8:   The distance, dist(**cj, xi**), between cj and every xi vehicle in set **V_d1** is
9:   calulated
10:   While |**Clj**| <= 30 && **max (dist (cj, xi)) <= d** do
11:   The vehicles xi having the minimum distance form cj are associated to
12:   **Cj** and is sorted in set **Cli**
13:   Done
14: Done
15: Until (All the vehicles from set **V_d1** have been assigned to any one of the **Clj**)
16:   The new cluster midpoints of formed clusters are calculated using to find a)
17:   Better solution and stored as **cj (new)**
18: Repeat steps 4-6 to generate new members of **Clj(new)**, which replaces
19:   **Clj** taking **cj (new)** as new midpoint
20:   Step 4 to 9 are repeated until to new cluster midpoints **cj (new)** are found.

Due to the complex nature of a road network with vehicles frequently joining and leaving the network (like an urban network), this challenge of dynamic topology that exists with vehicular communication makes the connection link unstable and there is high possibility of the link breaking down [34]. For this reason, our proposed DEBCK was introduced to overcome this issue as the dynamic nature inherently involved with it in proactively forming the backup cluster node that will take over the lead whenever a breakdown with the topology has occurred, due to vehicles' redirections. Hence, the periodic info exchanged along with direction each time will be calculated to form a decision in deciding on the backup node so that can avoid such a situation.

As BS1 is more remote BS along these lines, separate from it and make another connection with BS3 because of its closest area. Set up a physical connection with new BS and begin refreshing the list of nodes more than once. When handoff is not playing out, the location is refreshed through the backup mobile edge-node by sending a hello message within range of a 30-meter range BS. At that point, the adjacent BS gets a route request (RREQ) message through the backup mobile edge-node and send route reply (RREP) messages to the node. The separation of accessible BS is determined through the backup mobile edge-node and spares them in its list. The packet loss ratio is reduced by BS which is closest and has a far stronger signal capacity. When the connection between the old BS and cluster head detaches, the productive communication between the backup mobile edge-node and the devices builds up to increase steadily and ceaselessly on the network. It reduces the packet loss rate and low handoff aggravation is accomplished.

Finally, cluster head sets up a connection with new BS. The area is again refreshed through the backup mobile edge-node. Support of run down is done through seeking BS by backup mobile edge-node. The delicate signal comes, and connection with a different BS is set up as indicated by the closest area.

4. Performance Evaluation

In this section, the simulation result of our work is described. The simulation parameters are shown in Table 2. Network Simulator2 NS-2 [35] simulator was used to implement the proposed method. The simulation running time was 200 s. The plotting of average results evaluates the performance of the system. It is worth mentioning that our proposed DEBCK method was implemented using street map of the city of Erlangen, which was integrated via "Simulation of Urban Mobility" SUMO [36] into our simulated scenario of NS-2 simulator. This map was extracted from the open-source "OpenStreetMap," which was widely used by the researchers in deploying their VANET methods [37,38]. Figure 4 demonstrates the selected city sector that was simulated of Erlangen city.

**Figure 4.** Simulated section of Erlangen city using SUMO.

Performance metrics of interest are:

1. Packet Loss: It describes the number of lost packets in the handoff procedure.
2. Handoff jitter: The handoff jitter is calculated during the handoff time.
3. Delay: Time elapsed during handoff procedure.
4. Throughput: It describes the average rate of successful message delivery to a destination with NEMO and cluster-based methodologies. The proposed work is compared to them.

Network size	1000 m × 1000 m
Maximum Number of vehicles in the cluster	100
Speed of vehicle	0–100 km/h
Size of Packet	300 bytes
Time of Simulation	200 s
Rate of packets	90 packets/s
Transmission range of WIFI	300 m
Transmission range of 3G or LTE	1000 m

The results clearly describe that cluster-based handoff with backup mobile edge-node works better. Figure 5 shows that for 30 and 60 vehicles, the packet loss rates is the same as NEMO and DEBCK. With an increased number of vehicles, the packet loss rate goes on increasing in NEMO and cluster-based methods due to overhead of the cluster head. Seamless hand-off of the cluster head is achieved through the backup mobile edge-node. Communication between the cluster head and other nodes minimizes the packet loss rate, even with hundreds of vehicles in the cluster.
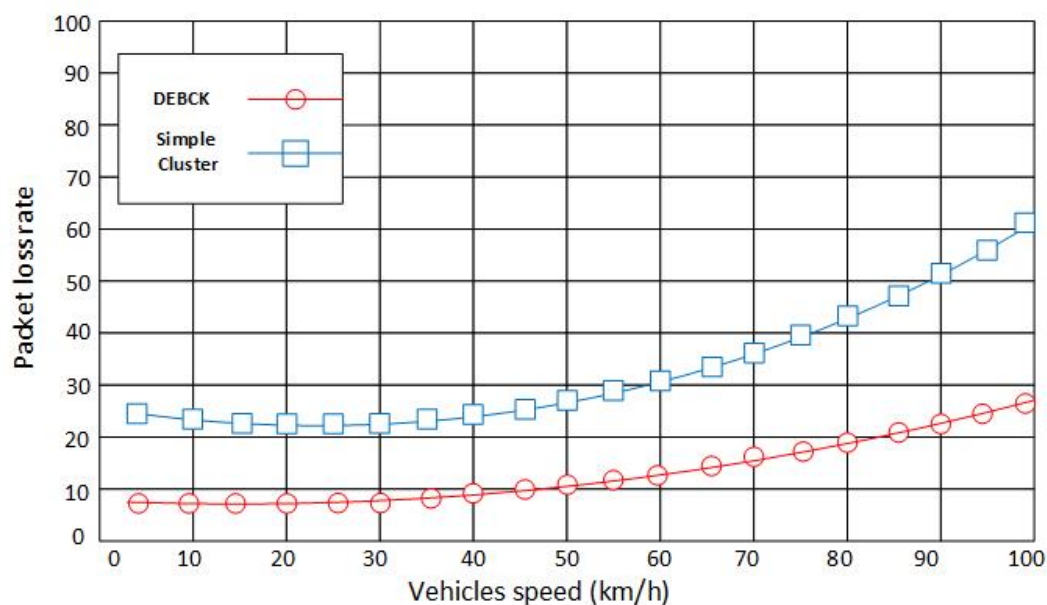
Figure 5. Packets loss rate versus vehicle speed.

In Figure 6, simulations of cluster-based and DEBCK are shown. Diagrammatically it is shown that for 10 vehicles, throughout is probably the same. With a cluster expansion and an increment in the number of vehicles, throughput decreases. Throughput is gradually minimized in cluster-based technology, whereas in DEBCK throughput did not decreased as much as cluster-based.
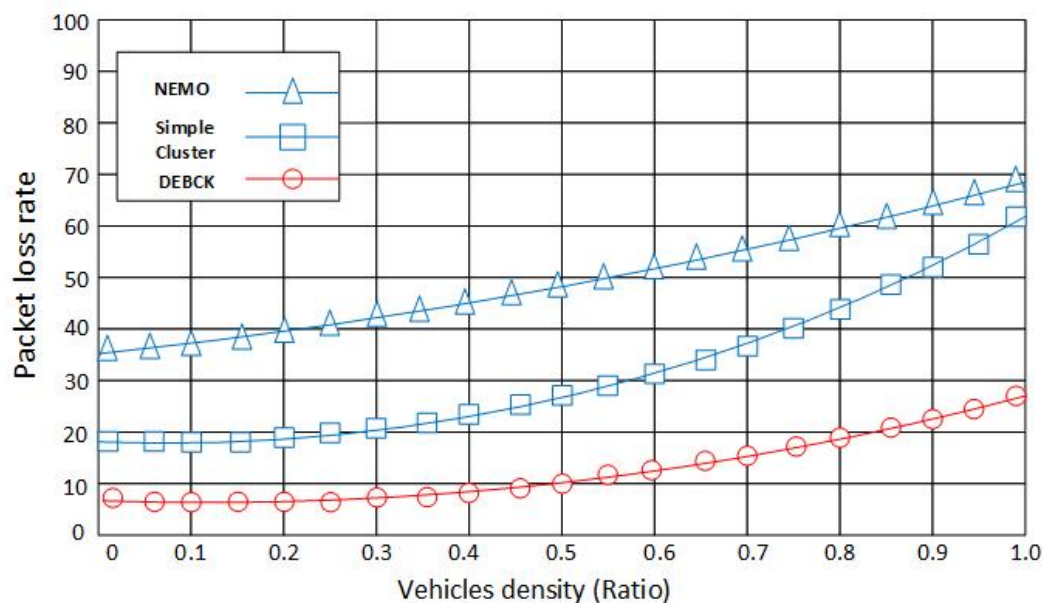
Figure 6. Packet loss rate versus vehicle density.

In Figure 7 the proposed DEBCK algorithm was benchmarked with its representatives from the related work in-terms of delay measuring metric with respect to vehicle velocity. It was observed that our proposed algorithm could maintain on average a lower delay while the velocity was increasing. The reason behind the improvement is that our proposed algorithm has utilized the introduced backup mobile edge-node that could maintain an intermediate session to backup the directed traffic data to the vehicle that performed the handoff procedure; thus transport protocol did not face increasing packet loss. When the connection is maintained with a smaller number of retransmissions, this will reflect directly on the delay produced on data communication and on the handoff latency. Another winning factor from the proposed concept of the backup mobile edge-node was having more resources dedicated to such a node in support of the handoff process.
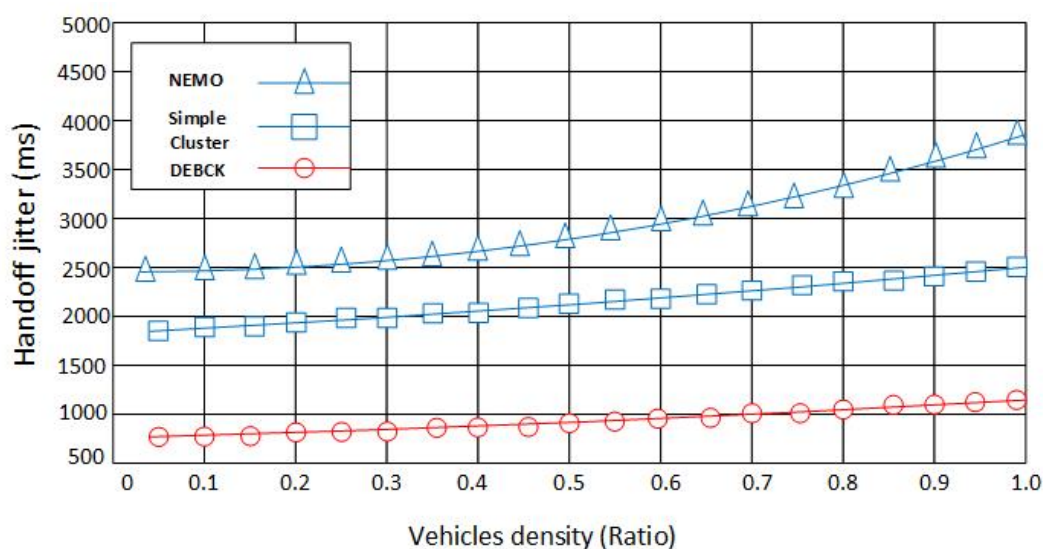

Figure 7. Handoff jitter versus vehicle density.

Figure 8 shows the performance measure of our proposed DEBCK algorithm along with the other methods with regard to handoff jitter variations as the speed of the vehicle increases. It was observed that our proposed method could maintain on average a lower delay while the speed of

vehicle increased. The reason behind this improvement is that our proposed algorithm has utilized the backup mobile edge-node that could maintain an intermediate session to backup the directed traffic data of the vehicle performing the handoff procedure; thus transport protocol has not faced an increasing packet loss rate in comparison with the other benchmark methods.

On the other hand, Figure 9 demonstrates the handoff delay compared to the velocities of vehicles. Diagrammatically it is shown that an up to 3 msec delay is the same when compared to simple cluster methodology. While the velocity of vehicles increases, delay is reduced when compared to a simple cluster-based method. This improvement was due to the factor introduced to the probabilistic method used: the cluster head would have been highly selected when it held a lower velocity value. In other words, a vehicle that travels with relatively low velocity has a higher chance of being selected as a cluster head. Hence, this factor will lead to a lower handoff delay, as there will be a lower frequency of obtaining a network switching over time.
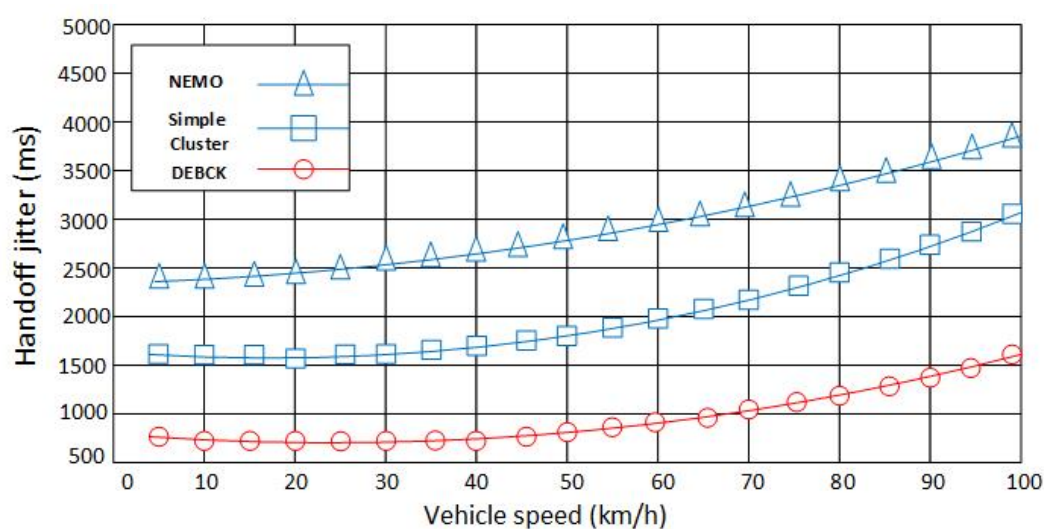

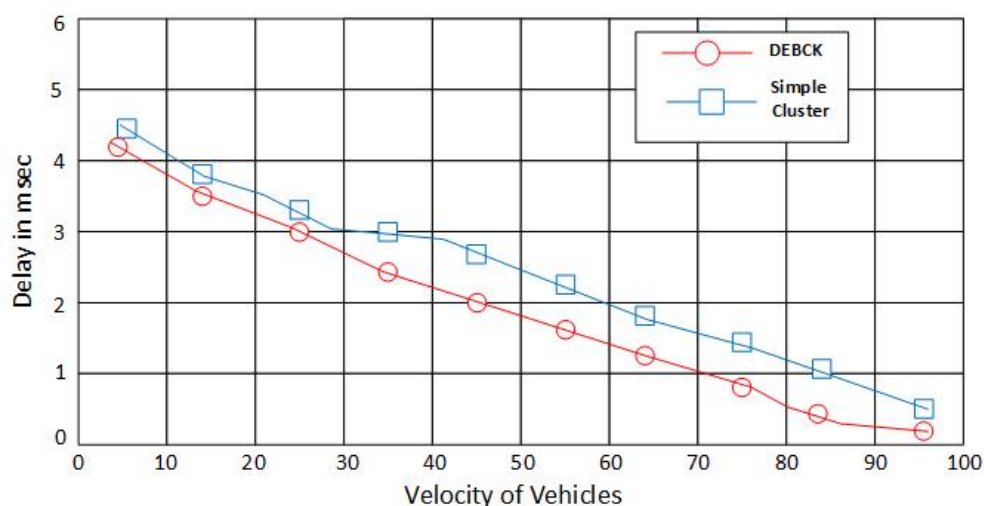**Figure 8.** Handoff jitter versus the vehicle speed.

Figure 9. Delay in msec versus velocity of vehicles.

In order to investigate the cost value when a cluster head attempts to leave the existing clustered network, an experiment was conducted with 10 scenarios. Figure 10 shows the obtained average cost factor of our proposed DEBCk algorithm compared across the benchmark methods. We have conducted 10 different simulation scenarios; the first starts with a single intersection and increases

additively up to 10. The obtained cost was the average data loss during the cluster head forming process. We observed that our proposed method could maintain a relatively low average within no more than 0.6 (60 percent). The reason behind this is that our proposed methodology can maintain a safety net for the handoff process; two nodes are used. The first node being used here is called the head node and the second node is called an edge backup node. It was assumed that in the working of a network system, nodes are further divided by making more groups later on. Both nodes being used here are dynamically selected on the basis of the following three parameters.

1. Storage capacity;
2. Communication range;
3. Energy.

A list of candidate backup mobile edge-nodes will be created, and scores will be calculated on the bases of these parameters. When a node is entered in the cluster, its score will be calculated and entered into the candidate backup list. Both cluster head and backup edge nodes have a copy of this list. If the cluster head faces disconnection, the backup mobile edge-node will become the cluster head and a high-scoring backup mobile edge node from the candidate backup list will be selected. Hence, we have observed that when our selected backup node faces disconnection the head node will select a high-scoring backup mobile edge-node from the list. Issues of overhead on the cluster head and packet loss rate are decreased and improved through this methodology compared NEMO and simple cluster methods.
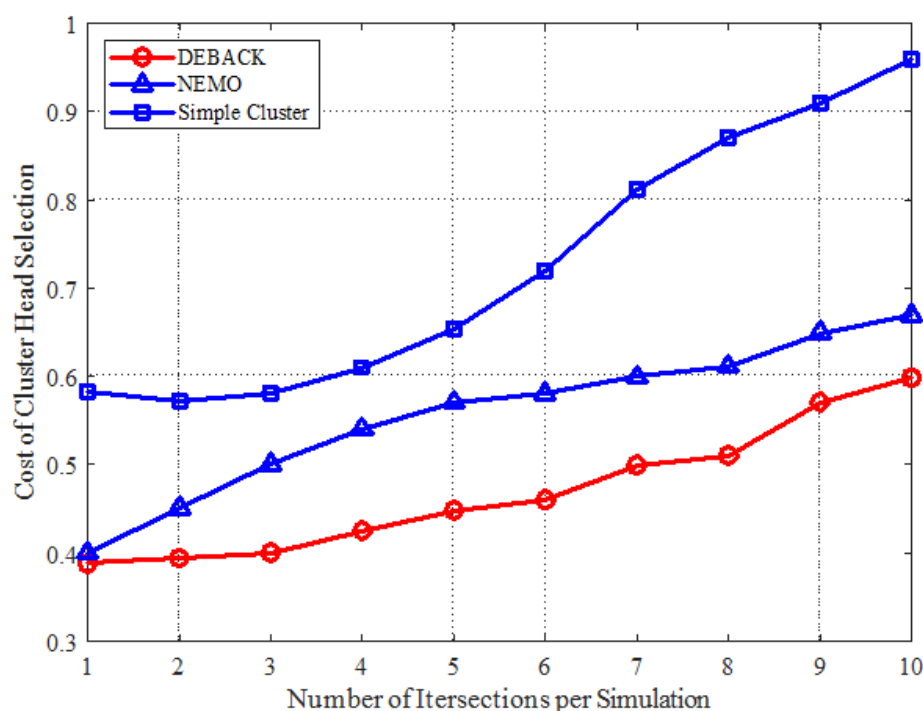

Figure 10. Normalized cost of cluster head selection versus the number of intersections per simulation.

5. Conclusions

In this paper, we have reviewed some of the handoff management techniques, their importance, and major issues within handoff process in VANET. Additionally, different technologies and algorithms of handoff management with respect to throughput, latency, and delay in VANET were investigated to point out the gaps and challenges that led us to conduct this study. The proposed technique was founded on cluster handoff exploring the recent concept of mobile edge computing in IoV communication. The backup mobile edge-node was added to upgrade the current cluster-based

methodology, which enables the group of connected vehicles to play out its obligations. The weight on a cluster is limited so that it is responsible for communication and physical handoff of the dynamic feature of the backup mobile edge-node. Accordingly, the responsibility of the proposed node was to refresh the BS list and the location as the cluster of vehicles moves. This method was formed and named DEBCK. At the point when a cluster is connected with BS, the proposed backup node is configured to send a hello message. When a backup mobile edge-node or cluster head, at runtime, faces disconnection, the new backup provision's ability to deal with the situation makes the proposed method better than other methods. The proposed technique was contrasted with other related methods in regard to network disconnectivity, packet loss rate, and throughput. The proposed DEBCK could effectively minimize the packet loss rate and decrease the overhead on the clustering forming process. On top of that, DEBCK has increased the throughput and provided a more reliable connection using the concept we introduced: the edge mobile node. In the future work, research will be conducted to optimize the handoff decision scheme by constructing an objective function for minimizing packet loss, which the authors of this paper are currently working on. Furthermore, radiowave propagation, Doppler phenomena, and terrain affects are very important factors; taking them into consideration in our improved version of the DEBCK method would provide more reliability during the process of backup node formulation; these factors are to be further investigated in our future work.

Author Contributions: K.M.A. has contributed mainly in formulating the main conceptual idea of the proposed algorithm and its design and implementation, while M.N. has contributed to the writing the original draft preparation, A.S.S., has contributed in writing the modified version of the paper and verifing and validating the simulation model as well as address some of the modifications suggested by the reviewers on the new simulated work. On the other hand, A.A., I.K. and K.R. have contributed in the final editing and funding acquisition. All authors have read and agreed to the published version of the manuscript.

Appendix A

Table A1. List of abbreviations.

Abbreviation	Meanings	Abbreviation	Meanings
VANET	Vehicular Adhoc Network	IoV	Internet of Vehicles
V2V	vehicle-to-vehicle	V2I	Vehicle to infrastructure
MN	Mobile Node	MEC	Mobile-Edge Computing
MIPv4	Mobile Internet Protocol Version 4	HMIPv6	Hierarchical Mobile Internet Protocol
CoA	Care of Address	MAP	Mobile Anchor Point
RCoA	Regional Care of Address	MH	Mobile Host
HA	Home Agent	DEBCK	Dynamic Edge-Backup Node
DVH	Downward Vertical Handoff	UVH	Upward Vertical Handoff
AHP	Adaptive Handover Prediction	VLET	Vehicle Link Expiration Time
WAVE	Wireless Access in Vehicular Environment	PHY	Physical layer
MAC	Medium Access layer	CCH	common control channel
SCHs	several service channels	AP	Access Point
E-PMIPv6	Efficient Proxy Mobile IPv6	RSU	Road Side Unit
WLAN	Wireless Local Area Network	UMTS	Universal Mobile Telecommunication System
MAARs	Mobile Anchor Access Routers	VEC	Vehicular Edge Computing
Nemo	Network Mobility	RV	Relay Vehicle
OSV	Oncoming Side Vehicle	BV	Broken Vehicle
VFHS	Vehicular fast handoff scheme	NTM	Network Topology Message
PAP	Preferred Access Point	INS	Intelligent Network Selection
MR	Mobile Router	VLET	Vehicle Link Expiration Time
RREQ	route request	RREP	Route Reply

Table A2. List of mathematical symbols.

Mathematical symbol	Meanings
+	Addition
−	Subtraction
$\sqrt{}$	Square root
.	Multiplication
/	Division
ϵ	Epsilon
α	real coefficient of the model
Δ	Delta
$\sum$	Summation

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