A Novel Intelligent Cluster-Head (ICH) to Mitigate the Handover Problem of Clustering in VANETs

A.H. Abbas*[1], Mohammed I. Habelalmateen[2], L. Audah[3], N.A.M. Alduais[4]
Wireless and Radio Science Centre (WARAS) Faculty of Electrical and Electronic Engineering
Universiti Tun Hussein Onn Malaysia 86400 Parit Raja, Batu Pahat, Johor, Malaysia[1, 2, 3, 4]
Department of Computer Technical Engineering, College of Technical Engineering
The Islamic University, 54001 Najaf, Iraq[2]

***Abstract*—The huge development in the number of Vehicle factories have resulted in many people having lost their life due to accident, which has made vehicular Ad-hoc networks (VANETs) hot topic to enable improved communication between vehicles aimed at reducing the loss of life. The main challenge in this area is vehicle mobility, which has direct effect on network stability. Thus, most previous studies that discussed clustering focused on cluster formation, cluster-head selection and the stability of cluster to reduce the impact of mobility in the network, with little attention given to the clusters when passing from base-station to neighbor base-station. Therefore, this study focused on handover problem that occurs after cluster formation and cluster-head election during cluster passing from base station to base station, known as overlapping area. As the cluster in an overlapping area receives two signals from different base stations, the signal arriving at the cluster becomes weak due to interference between two frequencies resulting in loss of cluster information in the overlapping area. In this study, proposed a novel method named Intelligent Cluster-Head (ICH), which is a controller on two clusters that are used to change uplink between clusters to solve the handover problem in the overlapping area. The proposed method was evaluated with VMaSC-1hop method. The proposed method achieved percentage of packet loss up to 0.8%, percentage of packet delivery ratio (PDR) 99%, percentage of number of disconnected links 0.12% and percentage of network efficiency 99% in the cells edge.**

Keywords*—Vehicular Ad-Hoc networks; ITS; clustering; overlapping area; handover; ICH

I. Introduction

This template, Vehicular Ad-hoc Networks (VANETs) is a sub-part of mobile Ad-hoc networks (MANETs). The main idea of VANETs is to establish communication between vehicles for the personal safety of the vehicle's occupants. VANETs has two main types of communication: 1) vehicle to vehicle (V2V), which allows vehicles to communicate between others in point to point link by using IEEE802.11p standard protocol. The advantages of this type are free of cost, no infrastructure required and easy network deployment. However, it triggers some issues when there are an insufficient number of vehicles, which result in disconnect problem and packet loss [1], [2]; 2) vehicle to infrastructure (V2I), which solves this issue by making sure that the vehicles are directly connected to the base station (BS). BS coverage is large because the higher transmission range decreases disconnect problem [3], [4]. However, there are still some issues that arise in this type, such as cost, difficult deployment network and network load. All of the above issues result from high vehicle mobility. High speed of vehicles causes a change in topology, which results in an unstable network. Therefore, clustering is used to reduce the above issues by combining vehicles in a group called cluster. Cluster means connecting a number of vehicles that are in the same transmission range. One of these vehicles is called cluster-head (CH) and the remaining vehicles are called cluster-members (CMs), with the CH responsible for managing intra and inter-cluster communication [5]. The benefit of clustering enhancement network performance is that it reduces connection congestion at the base-stations in the network. Nevertheless, vehicle mobility is still the main challenge in the clustering according to [6]–[9]. Most of the previous studies focused on reducing the effect of mobility by increasing cluster stability since VANETs is sub-part of MANETs. However, although the maximum nodes speed are 8 km/h [10], the handover between neighboring base-stations (BS) in MANETs is a big challenge. Therefore, handover has become a huge challenge in VANETs. According to the National Speed Limits of Malaysia, the speed limit in urban areas is 90 km/h. In addition, according to local cellular networks in Malaysia, the average coverage area of LTE-BS in the city is between 300 and 400 meters, which leads to vehicles passing from one BS to another in short time duration, resulting in more vehicle information required during handover. Therefore, this paper has proposed a new method to solve the handover in the overlapping area, a method called Intelligent Cluster-Head (ICH). This paper is organized as follows; section II is focused on handover problem, section III described previous work related to a heterogeneous network, section IV describes the new method (ICH) and theoretical analysis, section V presents simulation and result analysis, section VI presents the conclusion and future work.

The introduction should briefly place the study in a broad context and highlight why it is important. It should define the purpose of the work and its significance. The current state of the research field should be reviewed carefully, and key publications cited. Please highlight controversial and diverging hypotheses when necessary. Finally, briefly mention the main aim of the work and highlight the principal conclusions. As far as possible, please keep the introduction comprehensible to scientists outside your particular field of research. References should be numbered in order of appearance and indicated by a numeral or numerals in square brackets, e.g., [1] or [2,3], or [4–6]. See the end of the document for further details on references.

*Corresponding Author

II. Handover Problem Statement

This section discussed the handover problems in VANETs. Handover, which has been studied in cellular networks, occurs in the area between two neighbors BSs known as overlapping area [24]. This area resulted from overlap in the transmission range of both BSs and the signal in this area is weak because of interference in the frequencies of neighbor BSs, as shown in Fig. 1. Interference occurs between two neighbor BSs in the mobile cellular network, as proposed in [25]. Based on a literature review, no previous work has focused on handovers that occur in the overlapping area in the clustering of VANETs. Handover problem in clustering of VANETs is a more serious problem than in mobile devices because vehicles have ten times higher speed than mobile devices according to [10]. Vehicles in the overlapping area received two frequencies, one frequency from each BS, therefore vehicles are confused about sending its information to which base-station, while at the same time, the signal in this area has become weaker due to interference frequencies [25]. Three reasons why the handover problem occurs more frequently in VANETs is because vehicles are moving in high mobility, the vehicles are capable to move quickly from one BS to another, and vehicles require link established when moving, which cause increased handover in the network. According to Malaysian local cellular networks, the transmission range of BS in the urban city is limited so as to reduce the effect on people's health, and this has resulted in a high number of BSs, which is another reason to increase handover in the city. The use of clustering in this research has led to handover becoming a serious problem because communication with BS is done by cluster-head. In addition, the information that is sent to BSs consists of both CH and its CMs information, which may cause loss of cluster information when CHs is in the overlapping area. This is another reason that motivates us to solve this problem. Fig. 2 shows the handover problem in the overlapping area of clustering in VANETs.

From Fig. 2, CH2 is in the overlapping area, therefore it received two weak signals from two neighbor base-stations. Thus, during the handover with CH 2, information of cluster is lost. The proposed method aimed to solve the above problem by using intelligent cluster-head (ICH) as discussed in the next section.

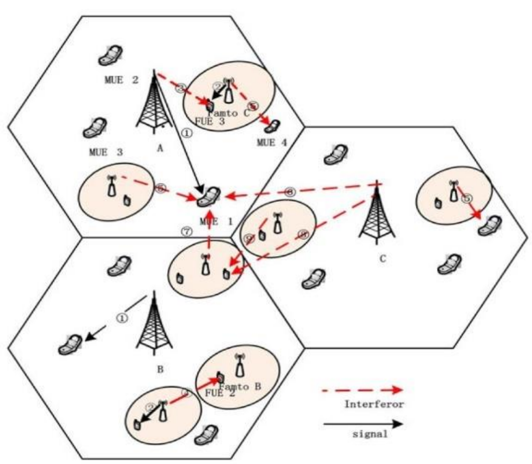

Fig. 1. Interference between Two BSs in the Mobile Network [25].

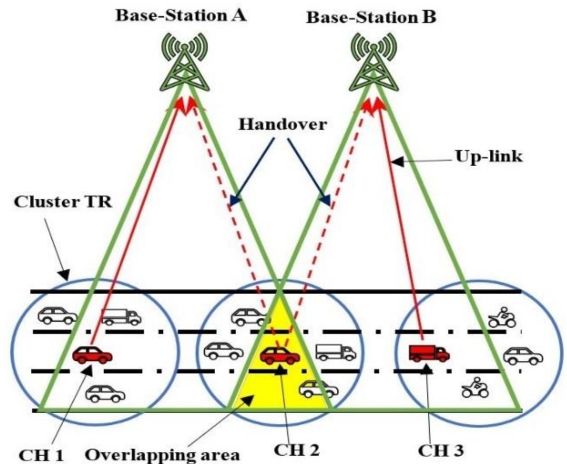

Fig. 2. Handover Problem in the Overlapping Area of Clustering in VANETs.

III. Related Works

This part introduced previous works that used clustering with cellular networks (heterogeneous networks) in VANETs. The main challenge in this area is high vehicle mobility that results in a dynamic topology change. This has raised several issues, which are the stability of the cluster, overhead, delay, and disconnect problem. In previous work, [11] proposed centralized clustering-based hybrid vehicular networking architecture (CC-HVNA) that combines both IEEE 802.11p and LTE in VANETs to enhance data dissemination by creating roadside units (RSUs) or BS to elect and form a cluster. This method resulted in improved delay and packet delivery ratio (PDR). The authors in [12] proposed hierarchical cluster-based location service in city environments (HCBLS) to reduce overhead and increase cluster stability. Overhead is reduced by reducing the update location costs. Stability is enhanced by the selection of vehicle in the centric of neighbor's vehicles, known as CH. The outcome of this method is reduced location updates and increased cluster lifetime. In previous work, [13] proposed a novel multi-hop moving zone (MMZ) clustering scheme CH selection based on average relative speed, relative distance, and link life. The result of this method is increased CH lifetime and reduced delay. Moreover, authors in [14] proposed a new Vehicular Cloud (VC) model to enhance data dissemination by using LTE with IEEE802.11p, leading to increased PDR and reduced delay. Other authors in [15] proposed intelligent naïve Bayesian probabilistic estimation practice for traffic flow to form a stable clustering in VANET (ANTSC) algorithm to increase cluster stability by selected cluster head from the lane that has the heaviest traffic flow. In addition, authors in [16] proposed a novel destination and interest-aware clustering (DIAC) mechanism to reduce link failures between vehicles and LTE network based on the vehicle having the highest link-quality becoming the CH. The authors in [17] proposed a hybrid vehicular multi-hop algorithm for stable clustering (VMaSC) with LTE and IEEE802.11p multi-hop clustering. LTE was used to increase PDR and reduce delay, while VMaSC was used to form a stable cluster by selecting CH based on the relative speed of vehicles in the same transmission range (TR). The combination of VMaSC with

LET in a hybrid network, known as (VMaSC -LTE), was intended to reduce load at BS by reducing the number of clusters in the merge mechanism. However, while reduction in the number of clusters will reduce load at BS, the handover problem remains in the overlapping area. Other previous works focused on the use of gateway (GW) to reduce the load at BSs by a reduced number of CHs in the network. The GW is a normal node has two types based on the location of GW. The first type is the GW that is positioned between more than one CHs. This type of GW is used to send the CH information to other CHs that are within its transmission range with the aim to make each CH know about the neighboring CHs [18]–[20]. However, these CHs are still connected to the BSs even though GW is available. The second type of GW is the GW has a location at the beginning and end of the transmission range of CH. This type is not used to exchange information between CHs but is responsible for inter-cluster communication and used to inform its CH about new neighbor CH for merge mechanism [21]. The main goal of both types of GW is to achieve merge mechanism to merge several CHs in one CH to decrease the number of CH in the network according to a specific condition. The disadvantage of GW is that this re-broadcast caused flooding in the network. However, most researches used GW in multi-hop to increase cluster scalability and reduce the number of CH in the network. There is no procedure to select GW based only on the location of the node, therefore more than one GWs between two CHs caused more flooding and only one GW can do the same work of all the GWs. The concept of relay node (RN) is that a normal node is used to rebroadcast CH message to reach all CMs according to [22], [23]. The RN also caused flooding in the network. None of the previous related works have focused on handover problem that occurs in the overlapping area during using clustering in VANETs, therefore this study has proposed a new method call Intelligent Cluster-Head (ICH) to solve this problem. The concept of ICH is completely different from GW and RN. Table I shows the difference between GW, RN, and ICH. Summary of related works is presented in Table II.

IV. Proposed Method

This section discusses the proposed new method to solve the handover problem that occurs after cluster formation mentioned in the previous section. The aim of this new method, known as Intelligent Cluster-Head (ICH), is to control the connection link between CHs as discussed in section (C).

A. Features of ICH are

- ICH works as a controller on CHs and has the capability to move connection between CH and BS from one CH to another CH, thereby reserving signal strength (RSS) of CHs to prevent handover in the overlapping area because the proposed method can control on CHs by changing connection from CH has weak signal to another CH has good signal from BS.
- ICH is not a broadcast beacon that CHs use to broadcast for CMs to reduce flooding in the networks. However, ICH checks RSS in the beacons and when RSS of one CHs becomes weak, the ICH sends a notification to this CH about moving the connection to another CH during ICH to guarantee the information of vehicles in the CH that has weak RSS is not consumed by overhead.
- ICH reduced the number of up-links between CH and BS by allowing only one CH to communicate with BS, and another CH sends its vehicle information during ICH to the CH that has a connection with BS. With this method, the number of up-link connections is reduced by half as compared to that available in all previous methods that used a heterogeneous network.
- ICH calculated dynamic threshold speed for both clusters according to simple Equation. ICH elected in accurate method. The details of this point are presented in the next sub-section.

B. Elected ICH

Should note, in this study clusters formation and CH election based on same method used in VMaSC-1hop in [17]. This study focuses on electing ICH after clusters formation and CH elected. When a vehicle received two beacon messages from different CHs, it does not change its state directly like GW. This vehicle checks the direction of new CH; if it is in the opposite direction, the vehicle drops the beacon and continues as CM in its original CH. However, if a beacon message is in the same direction, there are two cases according to Fig. 3.

In the first case, if the original CH (OCH) is in front of new CH (NCH), the vehicle that received a new beacon from NCH first checks the NCH speed; if the speed is less than OCH speed, the vehicle drops beacon and continues as CM. However, if NCH has a higher speed than OCH speed, the vehicle calculates dynamic threshold speed (Dthr) from Equation (1) and (2), then calculates the speed difference between NCH and OCH according to Equation (3). Table III shows the symbols of this paper.

$$D_{thrO} = |OCH - VS| \quad (1)$$

$$D_{thrN} = |OCH - VS| \quad (2)$$

$$DCHs = NCH - OCH \quad (3)$$

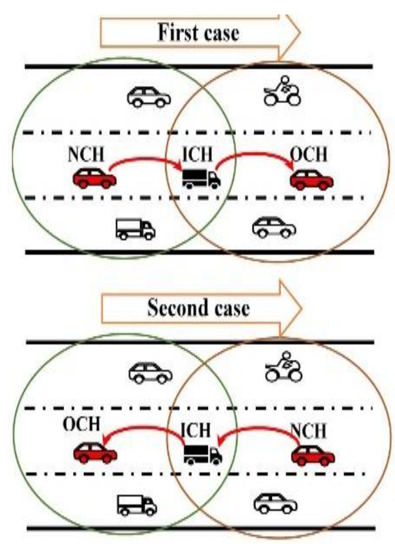

Fig. 3. Two Cases of CH.

TABLE. I. DIFFERENCE BETWEEN GW, RN AND ICH

NO.	GW [18]–[21]	RN [22], [23]	Proposed ICH
1	Broadcast beacon and merge clusters	Only for broadcast beacon	Controller by moving connection link between CHs based on RSS
2	Increased flooding in the network	Increased flooding in the network	Avoid flooding beacon problem
3	Reduced number of up-link if merge occur	Does not reduce the number of up-link	Reduce the number of up-link without need for merge mechanism
4	Increased network scalability	Not did	Increased network scalability
5	Elected based on location or CH elect GW	CH elect RN	Elected according to a special procedure as shown in section (B)
6	Not used	Not used	Used DDthr and DSthr to increase link lifetime between CHs
7	More than one in each CH or between CHs	More than one in each CH	Only one between CHs

TABLE. II. SUMMARY OF RELATED WORKS

Ref.	Method	Problem	Domain	Outcome	Solve handover problem
[11]	CC-HVNA	• Data dissemination	Highway	• Reduce Delay. • Increase PDR.	NA
[12]	HCBLS	• Overhead. • Stability	Urban	• Increase cluster lifetime. • Reduce location update.	NA
[13]	MMZ	• Overhead	Highway	• Increase CH lifetime. • Reduce delay	NA
[14]	VC	• Data dissemination	NA	• Increase PDR. • Reduce delay.	NA
[16]	DIAC	• Link Failures	Urban	• Increase CH and CM duration. • Reduce overhead. • Increase PDR.	NA
[17]	VMaSC	• Stability • Overhead	Highway	• Increase CH duration. • Reduce the number of cluster in the network. • Increase PDR. • Reduce delay.	NA

TABLE. III. LIST OF SYMBOLS

NO.	Symbol	Description	NO.	Symbol	Description
1	OCH	Original cluster-head	13	$LLT_{O,I}$	Link lifetime between OCH and ICH
2	NCH	New cluster-head	14	$LLT_{N,I}$	Link lifetime between NCH and ICH
3	D_{thrO}	Dynamic threshold speed of OCH	15	$\Delta D_{O,N}$	The relative distance between OCH and NCH
4	D_{thrN}	Dynamic threshold speed of NCH	16	P_O	Position of OCH
5	VS	Vehicle speed	17	P_I	Position of ICH
6	DCHs	Different CH speed	18	P_N	Position of NCH
7	$\Delta D_{CH,CM}$	The relative distance between CH and CM	19	$\Delta V_{O,N}$	The relative speed between OCH and NCH
8	$\Delta V_{CH,CM}$	The relative speed between CH and CM	20	V_O	Speed of OCH
9	V_{CH}	Speed of CH	21	V_I	Speed of ICH
10	V_{CM}	Speed of CM	22	V_N	Speed of NCH
11	$LLT_{CH,CM}$	Link lifetime between CH and its CM	23	TR_O	Transmission range of OCH
12	$LLT_{O,N}$	Link lifetime between OCH and NCH	24	TR_I	Transmission range of ICH

When the difference in speed between OCH and NCH is less than dynamic threshold speed according to Equation (4), the vehicle sends message to OCH that contains all previous details. The OCH then checks how many vehicles have received beacon message from NCH, then the Competing vehicles be made ICH (CICH); if there is only one vehicle, the CH sends a confirmation message to the vehicle and the vehicle becomes ICH. If there is more than one vehicle proposed to be ICH, the OCH calculates the different dynamic threshold for each vehicle according to Equation (5). Vehicles with low different dynamic threshold speed, distance near to the half of transmission range (TR) become ICH. The remaining CICH vehicles are arranged in the table ranged from low different dynamic threshold speed to high, with the benefit that when ICH loses connection in any way, the vehicle in the second row of the table directly becomes ICH in order to not repeat the process again for more flexibility in the network.

$$DCHs \leq D_{thrO} \quad (4)$$

$$ICH = |D_{thrO} - D_{thrN}| \quad (5)$$

In the second case, the vehicle's original CH (OCH) backs off new CH (NCH). The vehicle that received a new beacon from NCH first checks NCH speed, and if this speed is greater than OCH speed, the vehicle drops the beacon and continues as CM. However, if NCH has a lower speed than OCH speed, the vehicle calculates dynamic threshold speed (Dthr) from Equation (1) and (2), then calculates different speed between NCH and OCH according to Equation (6). The same step above is used for Equation (4) and (5).

$$DCHs = OCH - NCH \quad (6)$$

In the above cases, in this study, assume the vehicle that received a new beacon from another CH belongs to the OCH. However, if vehicles belong to NCH, the same above cases occur but the main difference is that validation will be with the value of NCH. This means that in all cases, the validation is done with the value of CH that owned the ICH. Fig. 4 shows the flowchart for elected ICH in both cases.

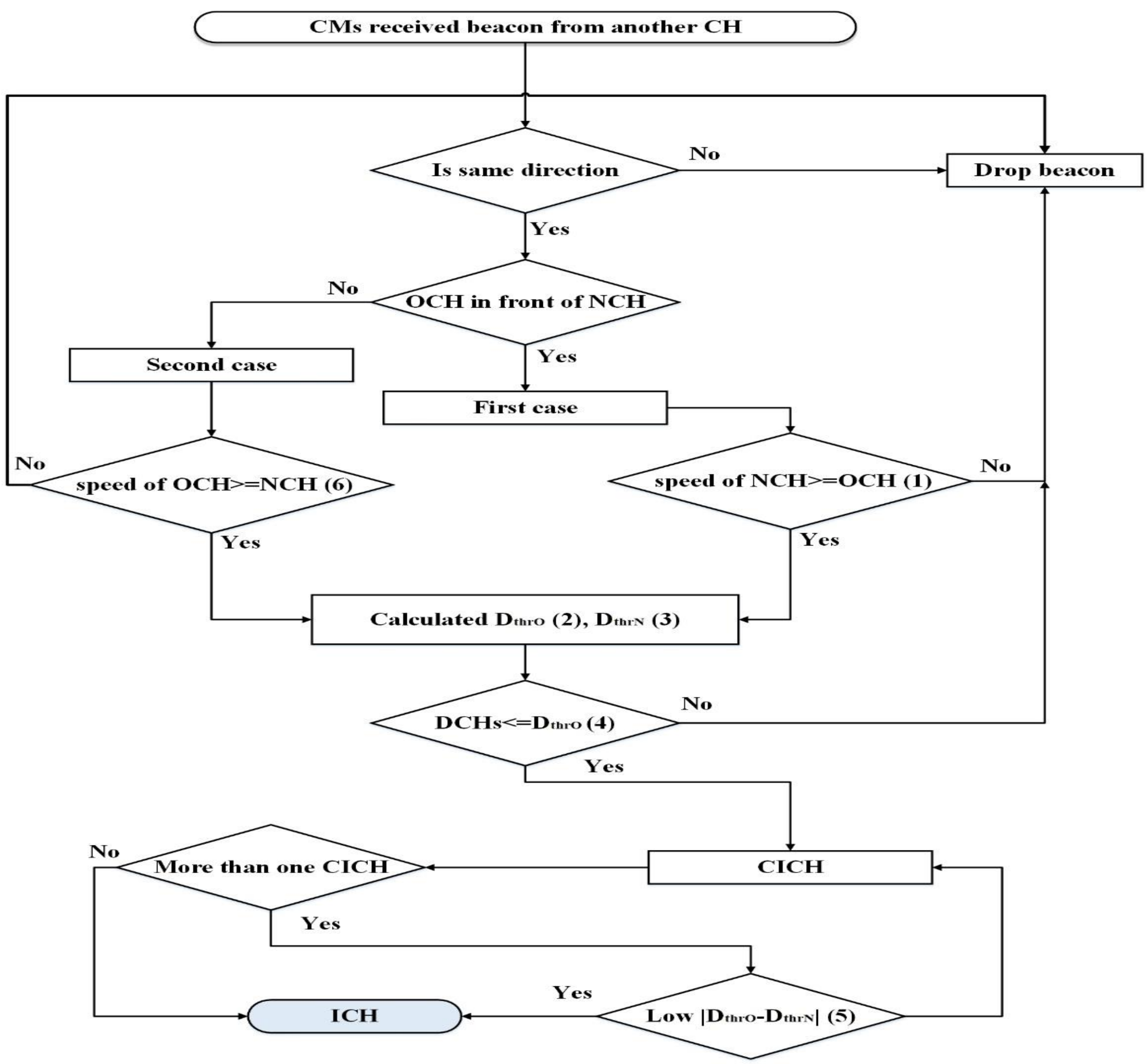

Fig. 4. Flowchart of ICH Election Process.

C. Solve Handover Problem by Applying ICH Method

This section introduced how ICH manages neighbor clusters and changes up-link from one CH to another to solve the handover problem in the overlapping area. After CH sends a confirmation message to the proposed vehicle that has high qualification according to the previous section, the vehicle changes its state from CM to ICH then informs another cluster of this change. ICH begins to listen to both messages coming from CHs, and this message has CH-ID, direction of CH, speed of CH, number of CMs in the CH, different relative speed between CH and each CM, different relative distance between CH and its CMs, location of all clusters (location of each CM in addition to location of CH itself) and RSS of CH. The ICH compares the RSS of both CHs, and the CH having the highest RSS sends vehicle information for both clusters to the BS, while the CH that has low RSS sends its cluster information directly by using IEEE802.11p standard to ICH. The ICH sends this information to CH having the highest RSS. During this process, the CH that is connected in the BS remains connected in the BS until it has received two RSS from two BSs (this means the CH has arrived at the overlapping area). The CH then sends a weak signal message to ICH to change uplink connection with the BS to another CH in order not to lose vehicles' information. When ICH received a weak signal from CH, the ICH sends a message to another CH to establish a link with the BS. The ICH sends vehicle information of CH having two signals to another cluster, and then another cluster begins to send information to the BS while CH that received two signals disconnects the uplink with BS. Fig. 5 shows how ICH works.

As shown in Fig. 5, CH 2 received two signals because it is in the overlapping area. Thus, CH2 sends a weak signal message to ICH, which then sends a message to CH 1 to establish a link with the BS to send vehicle information. After the link has been established, the ICH sends CH 2 information to CH1, which is then sent to BS. By using ICH, the handover problem that occurs in the overlapping area is solved. Also, the use of ICH reduced the number of up-link connections with the BS, thereby increasing the cluster stability in the network. Fig. 6 shows the flowchart of vehicles that work as ICH.

Based on previous work [26], the LLT between CH and CM is collected from the following equation.

$$\Delta D_{CH,CM} = |P_{CH} - P_{CM}| \quad (7)$$

$$\Delta V_{CH,CM} = |V_{CH} - V_{CM}| \quad (8)$$

Collected LLT between CH and CM has two cases according to the following:

1) First case: When CM is in back of CH, LLT is collected according to Equation (9) in [26]

$$LLT_{CH,CM} = \frac{\Delta V_{CH,CM} * \Delta D_{CH,CM} + \Delta V_{CH,CM} * TR_{CH}}{(\Delta V_{CH,CM})^2} \quad (9)$$

2) Second case: When CM is in front of CH, LLT is collected according to Equation (10) in [26].

$$LLT_{CH,CM} = \frac{-\Delta V_{CH,CM} * \Delta D_{CH,CM} + \Delta V_{CH,CM} * TR_{CH}}{(\Delta V_{CH,CM})^2} \quad (10)$$

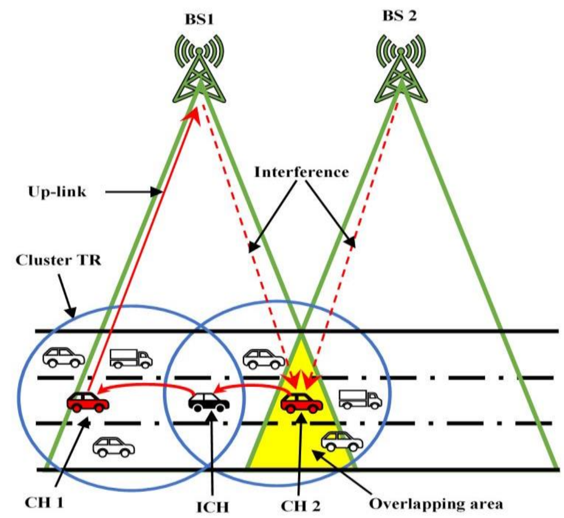

Fig. 5. Work of Intelligent Cluster-Head (ICH).

In this method, LLT is collected between two CHs during ICH. Also, there are two cases to collect LLT according to Fig. 3. The total LLT between OCH and NCH in this study was calculated according to Equation (11), while the different distance and different velocity were calculated according to Equation (12) and (13), respectively.

$$LLT_{O,N} = LLT_{O,I} + LLT_{N,I} \quad (11)$$

$$\Delta D_{O,N} = |P_O - P_I| + |P_N - P_I| \quad (12)$$

$$\Delta V_{O,N} = |V_O - V_I| + |V_N - V_I| \quad (13)$$

3) The first case according to Fig. 3: each case has two LLTs, one between OCH and ICH, while another LLT is between NCH and ICH. This means this method that the ICH must be in front of one CH and behind another CH. In Fig. 3, in this study, assume ICH belongs to OCH, only in both cases the purpose is to validate with the value of OCH only. The same scenario applies when ICH belongs to NCH exactly but validated with the value of NCH. According to Fig. 3, the ICH is behind OCH; therefore the LLT is collected according to Equation (14). In the same case where the ICH is in front of NCH, the LLT is collected according to Equation (15).

When ICH is behind OCH, LLT is collected according to Equations (8), (9) and (10).

$$LLT_{O,I} = \frac{\Delta V_{O,I} * \Delta D_{O,I} + \Delta V_{O,I} * TR_O}{(\Delta V_{O,I})^2} \quad (14)$$

$$LLT_{N,I} = \frac{-\Delta V_{N,I} * \Delta D_{N,I} + \Delta V_{N,I} * TR_I}{(\Delta V_{N,I})^2} \quad (15)$$

To get the total LLT between two CHs (OCH and NCH), substitute Equations (14) and (15) in Equation (11).

$$LLT_{O,N} = \frac{\Delta V_{O,I} * \Delta D_{O,I} + \Delta V_{O,I} * TR_I}{(\Delta V_{O,I})^2} + \frac{-\Delta V_{N,I} * \Delta D_{N,I} + \Delta V_{N,I} * TR_I}{(\Delta V_{N,I})^2} \quad (16)$$

Simplify equation (16) to get the best equation to collect LLT between two CHs in Equation (17).

$$LLT_{O,N} = \frac{\Delta V_{O,I} * \left(\Delta D_{O,I} + TR_I\right)}{(\Delta V_{O,I})^2} + \frac{\Delta V_{N,I} * \left(-\Delta D_{N,I} + TR_I\right)}{(\Delta V_{N,I})^2}$$

$$= \frac{\Delta D_{O,I} + TR_I}{(\Delta V_{O,I})} + \frac{-\Delta D_{N,I} + TR_I}{(\Delta V_{N,I})}$$

$$= \frac{(\Delta V_{N,I}) * \left(\Delta D_{O,I} + TR_I\right) + (\Delta V_{O,I}) * (-\Delta D_{N,I} + TR_I)}{(\Delta V_{O,I}) * (\Delta V_{N,I})}$$

$$= \frac{\Delta V_{N,I}*\Delta D_{O,I}+\Delta V_{N,I}*TR_I - \Delta D_{N,I}*\Delta V_{O,I}+\Delta V_{O,I}*TR_I}{(\Delta V_{O,I})*(\Delta V_{N,I})} \quad (17)$$

4) The second case according to Fig. 3: this case is different than other cases in that the signals are based on the location of ICH according to OCH and NCH as shown in Equation (18).

$$LLT_{O,N} = \frac{-\Delta V_{O,I}*\Delta D_{O,I}+\Delta V_{O,I}*TR_O}{(\Delta V_{O,I})^2} + \frac{\Delta V_{N,I}*\Delta D_{N,I}+\Delta V_{N,I}*TR_I}{(\Delta V_{N,I})^2} \quad (18)$$

D. Theoretical Analysis and a Numerical Example

Based on the real-data collected from local cellular networks in Batu Pahat, Johor, Malaysia, the transmission range of LTE-base-station is between 300 to 400 meters. Therefore, there are many BSs on the road, which leads to a lot of overlapping areas that resulted in more handovers as vehicles move on the road. Handover caused serious problems, especially in clustering, because each cluster represents the CH of each vehicle, and passing CH in the overlapping area caused loss of all CMs information resulted from handover between two BSs. [17] proposed VMaSC-LTE that is closest to the idea of this study, where the load on the BS is reduced due to a number of clusters in the network. However, reduction in the number of clusters will reduce load at BS but not solve handover problem because the remaining clusters still have a handover. Also, there has been no focus on the overlapping area. In this paper, we proposed ICH to solve handover problems by positioning the ICH at the end of clusters-transmission range. Thus, the front CH that received two signals from two different BSs is directed to stop sending vehicle information to the BS in order to not lose its cluster information and sends this information to ICH and then to another CH that is not in the overlapping area. Also, ICH reduced uplink by half because every two clusters that have ICH use only one uplink to connect both clusters in the BS. This is because of the use of IEEE802.11p protocol to connect inter and intra cluster and this protocol has data rate 27 Mbps according to [27]. This study focuses on broadcast safety message that has a size between (512 and 1000) byte according to [10], [14], [17], [28], therefore the link between CH and BS can send both CHs information during IEEE502.11p. For example, if each CH has a maximum number of CMs, this means 20 CMs according to [29], therefore the total number of both clusters within the CHs becomes 42 vehicles. According to above, each vehicle sends safety message 1000 bytes in size, therefore the total size of safety message for both clusters become (42x1000= 42,000 bytes. Divided by 1000 to convert to KB, the size becomes 42 Kbps and the link can send up to 27 Mbps). Also, a reduced number of up-link results in reduced overhead cost and increased cluster stability in the network. Since VMaSC-LTE is used in highway scenario, in order to evaluate this method with VMaSC-LTE, the idea of this method was applied in this paper, scenario in the numerical example.

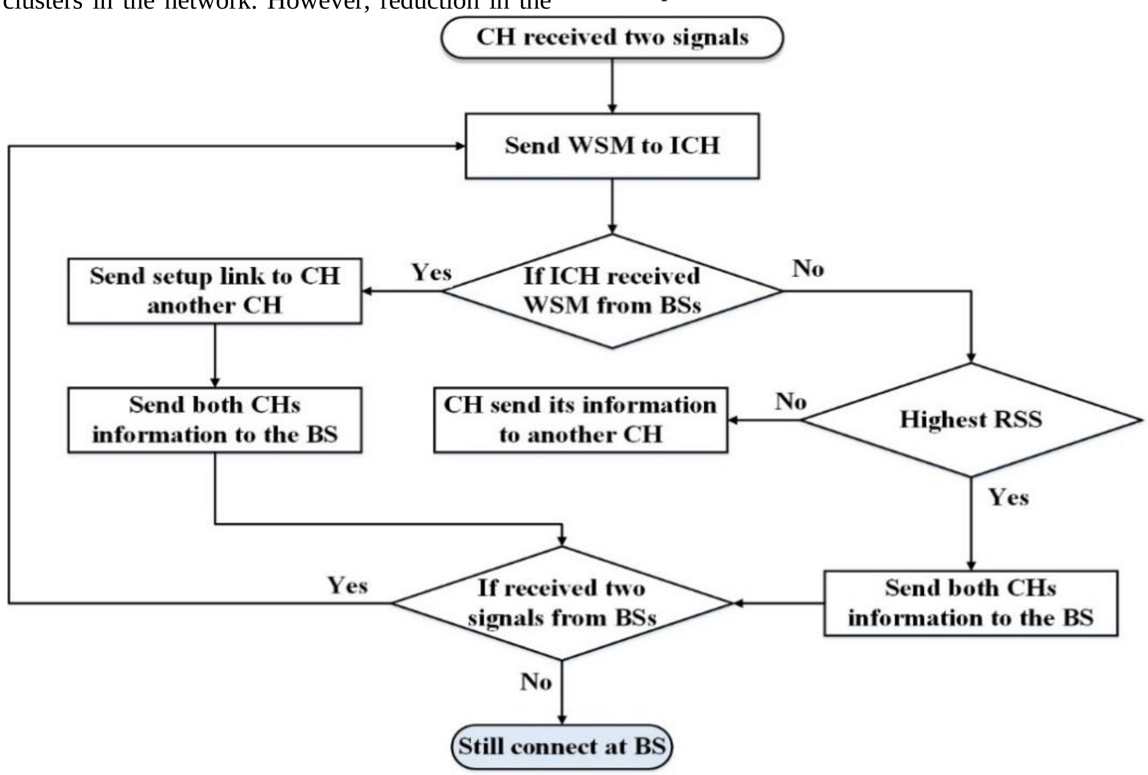

Fig. 6. Flowchart of Vehicles that Work as ICH.

If assumed length of road to be 10 km in urban Batu Pahat, Johor, Malaysia, and number of vehicles (N-V) to be 100 according to real-data of local cellular network in Batu Pahat, the TR of BS 300 m, the number of BSs (N-BS) is closer to 33 BS according to the real-data collected from local cellular networks. This resulted in 32 overlapping area (OA), the number of CMs (N-CMs) in each cluster is 20; therefore the total number of CHs (N-CHS) in this road is 5. These clusters in VMaSC-LTE have handover (HO) in each overlapping area. Therefore, a number of handovers in VMaSC-LTE are 32x5x20 = 3200 handovers for total cluster according to the number of CMs in each cluster over a 10 km road from 100 vehicles. However, in this method, no handover occurs in the clusters having ICH, but the handover occurs if the cluster does not have ICH. However, most of the clusters in proposed method have ICH because of high vehicle density in the urban area, especially in Batu Pahat city. From the above example and because the ICH connects only two CHs, in the above example one of five CH has handover in the overlapping area. Therefore, the number of packets lost in this cluster is calculated according to 32x1x20= 640 handover in the network on the same road.

As shown in Fig. 7(A), there is no handover in the overlapping area because ICH changed the up-link when CH 2 received two signals from BS1 and BS2. However, in Fig. 7(B), the CH2 has no other choice than to send its cluster information, therefore the probability of handover occurrence is high. The number of handovers increases as road length and number of vehicles on the road increases. Table IV shows the result of a numerical example.

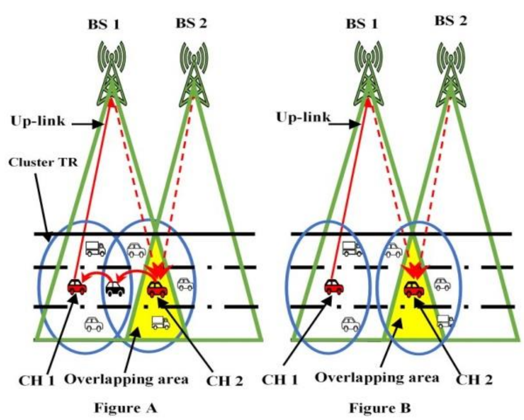

Fig. 7. Illustration of the difference between ICH and VMaSC-LTE Methods.

TABLE. IV. RESULT OF A NUMERICAL EXAMPLE.

Method	Road	N-V	N-CH	N-BS	OA	HO
VMaSC-LTE [17]	10km	100	5	33	32	3200
ICH	10km	100	5	33	32	640

V. SIMULATION MODELING

In this section, evaluated and validated ICH method with VMaSC-1hop method [17]. The evaluation was done by applying the concept of VMaSC-1hop on the scenario. VMaSC-1hop method has been selected for evaluation because it is close to the proposed idea. The VMaSC-1hop used GW to merge clusters to reduce load at BSs, which consist of packet loss, packet delivery ratio, disconnect problem and number of uplink connection. Unfortunately, this method did not discuss the handover problem that occurs in the overlapping area. Therefore, the proposed method reduces the load at BSs in the overlapping area. Both methods are applied by using MATLAB-a 2018 in the simulation. The simulation parameters used in this study are shown in Table V.

A. Performance Metrics

- Packet loss: This is defined as the number of CHs that failed in sending the cluster information to the BSs. In this study, the packet loss is measured in the overlapping area (cell edges) only. Also, the information related to CHs loss in this area consists of information of CH and its CMs. The packet loss increased when the number of clusters increased and the number of CMs in each CH increased.

- Packet delivery ratio (PDR): This is defined as the number of CHs that successfully sent its cluster information to the BS during cell edge. The PDR increased when the number of CH that successfully sent its cluster information in the cell edge increased and the number of CMs in each CH increased.

- A number of disconnections: It is the number of CH that lost connection with BS during cell edges from the total number of CH that successfully connects with the BS in this area.

- Network efficiency: The average ratio of a number of packet loss to the total number of PDR in the cells edge. Increased percentage of packet loss during cells edge result in reduced network efficiency.

B. Performance Comparison between ICH Method and VMaSC-1hop Method

Table VI shows the ICH method has less packet loss than VMaSC-1hop method in cells edge because of the ICH transfer communication up link from CH that received two signals from different BSs to another CH. By this process, the number of packet loss is reduced. The VMaSC method used GW to make the connection between neighbors' CHs for merge mechanism without any permission to move up link connection because it is a normal node; therefore, the packet loss occurs in the cells edge. From the table, the ICH method also has packet loss, but much less than VMaSC method. The packet loss in the proposed method results from CH that had no neighbor CH. Therefore, in this case, the packet loss occurred in ICH method. The average percentage of packet loss at a cell edge in the ICH method and VMaSC-1hop method is 0.8% and 84%, respectively.

Fig. 8 shows the ICH method has higher packet delivery ratio than the previous method, and the reason is that proposed method can deliver packets even in cell edge by changing uplink from CH that has weak signal or confused single to CH that has good signal or only one signal. Thus, the percentage of PDR in proposed method is greater than the previous method. The average percentage of PDR at the cell edge in ICH method and VMaSC-1hop method is 99% and 15%, respectively.

TABLE. V. SIMULATION PARAMETERS

Parameters	Value
Simulation time	300 s in each run
MAC protocol	IEEE 802.11p
Transmission range	300 m
Number of vehicles	100,200,300,400,575
Road length	17.8 km
Number of lanes in the road	3
Length of car	3 m
Maximum lane speed	10-100 km/h
Number of hops	One hope
maximum number of CMs in each CH	20
Number of iterations	100
Number of runs	10

TABLE. VI. NUMBER OF PACKET LOSS IN BOTH METHODS IN THE CELLS EDGE

Number of Vehicles	Proposed	VMaSC-1hop [17]
100 Vehicles	181	6920
200 Vehicles	167	16422
300 Vehicles	151	25314
400 Vehicles	190	34466
575 Vehicles	149	50467
The average number of packet loss in the cell edge	167.60	26717.8

Fig. 9 shows the number of disconnect in the cells edge between ICH method and VMaSC-1hop method. The ICH method resulted in fewer disconnect than the previous method because the ICH allows CH to connect in the BS, even the CH in the cell edge, while the previous method during cell edge has disconnect because the CH received two signals from different BS and GW cannot transfer uplink connection to neighbor CH.

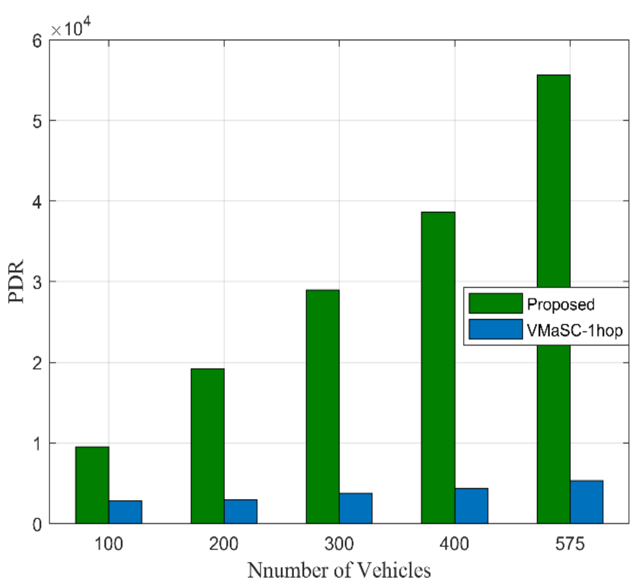

Fig. 8. PDR in the Cells Edge.

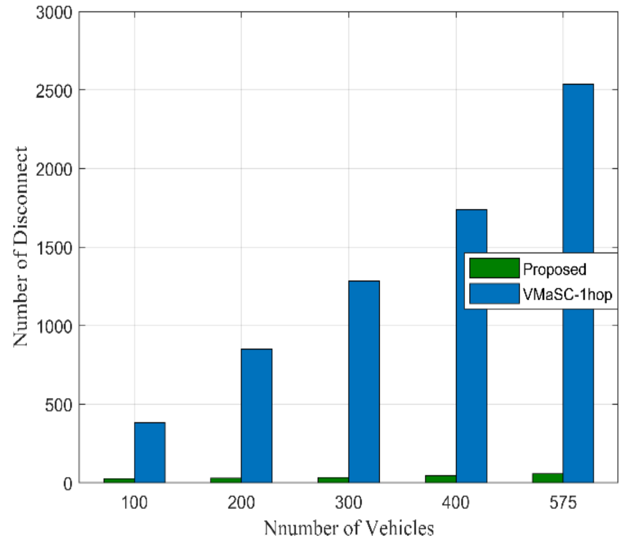

Fig. 9. Disconnect Problem During Cells Edge.

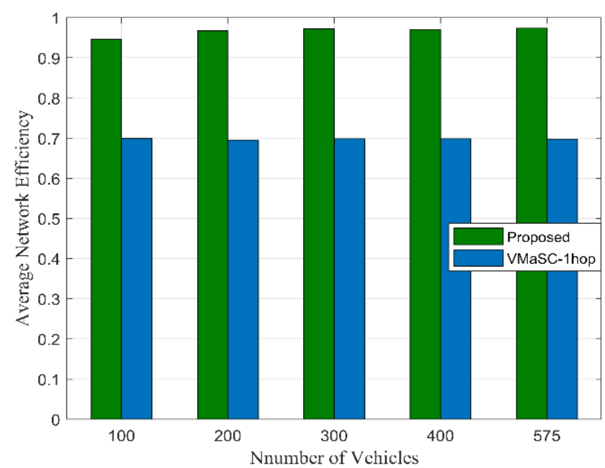

Fig. 10. Network Efficiency in the Cells Edge.

Fig. 10 shows the network efficiency of ICH and VMaSC-1hop method. From the figure, the ICH method results in a higher percentage of network efficiency than VMaSC-1hop method because ICH method has less percentage of packet loss, less percentage of disconnect problem and a higher percentage of PDR than VMaSC-1hop method. Therefore, the network efficiency in ICH method is higher than in VMaSC-1hop method. The average percentage of network efficiency in the ICH method and VMaSC-1hop method is 96% and 70%, respectively.

VI. CONCLUSION

This paper has proposed a novel method known as Intelligent Cluster-Head to solve the handover problem that occurs in the overlapping area (cell edge) when the cluster is passed from one BS to another neighbor BS. ICH is a controller vehicle that controls a neighbor's CHs and specifies the cluster having the higher RSS to send vehicle information of both clusters to BS. Also, ICH has the ability to change uplink from one cluster to another to solve handover problem of CH receiving two signals from different BSs in direct contact with ICH, and the ICH then changes the uplink to another cluster. The evaluation was done by using MATLAB software during evaluating the ICH method with the concept of VMaSC-1hop and the result shows the ICH method and VMaSC-1hop have an average percentage of packet loss of 0.8% and 84%, respectively. The percentage of PDR in ICH method and VMaSC-1hop is 99% and 15%, respectively. The number of disconnect in ICH method is less than VMaSC-1hop method and the network efficiency in ICH method VMaSC-1hop method is 96% and 70%, respectively. In future work, will analyse and evaluate the effect of delay and overhead when using the proposed method. Also, we will apply this method on a highway scenario.

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