

SHD-IoV: Secure Handover Decision in IoV

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Abstract—Internet of Vehicle (IoV) is the smartest thing being connected over the Internet. With continuously increasing urban population and swiftly growing of cities, causes moving vehicles with various speeds. These high speeds may increase the handover delay (HoD), accordingly causing an insecure connection due to the handover interruption. For instance, some of the network protocols try to overcome the problem without considering transport layer supports. This article proposes a dynamic HO algorithm with a cross-layer architecture called Secure Handover Decision (SHD) in IoV to assist the protocol layers aware of consecutive HOs of the vehicle. The results show that vehicle communication in IoV is more secure and lossless by reducing HoD in both sides of vehicle and network during fast movement.

Keywords—Internet of Vehicle (IoV); HO; L2; Stream Control Transmission Protocol (SCTP); Secure Handover Decision (SHD); security

I. INTRODUCTION

The need for mobile internet connectivity has increased as more users travel from place to place, for example, town to town over long distances. In a vehicular network, the user's vehicle connects to the internet through a fixed infrastructure installed on the side of a road for vehicle-to-infrastructure (V2I) communication. Another type of vehicle network communication is vehicle-to-vehicle (V2V) communication, which addresses the transmission of information among vehicles. However, this type of infrastructure contains gateways as well as BSs that offer services like the Internet of Vehicles (IoV) [29, 35, 36, 37, 38, 39]. In the IoV network, the vehicles are highly dynamic and can move at a high speed, which may cause a high handover (HO) rate leading to a communication delay or disruption (Fig. 1). Additionally, V2I communication is expected to meet many difficulties like poor channel quality plus connectivity because higher vehicle speeds lead to HO delay. Thus, there is a crucial need for efficient communication such as protocol or BS type communication that considers the specific characteristics of vehicular networks [4, 16, 17, 25, 26].

From the protocol side, most of the network layer (L3) protocols have a long HO delay, which affects the communication of the vehicles while moving. On the other hand, the current transport layer protocols suggested for better mobility can't address mobility alone because most of these ideas rely on the network layer mobility management necessities for the handover. Their proposal is purely to reduce the degradation in the performance of the transport layer caused by the handover. Several of these newly evolving protocols for L4 such as mobile Stream Control Transmission

Protocol (*mSCTP*), offer a basis for mobility support because they have multi-homing features that allow a mobile station to use a new IP address, while still assigning the previous IP address [5-9, 34].

In a data link layer (L2), an HO delay compromises the BS in completing the HO procedure with the next target BS (TBS) along the vehicle's path. Many network technologies such as cellular networks (GSM, 3G, 4G standard) [1, 23, 33] have been developed for broadband wireless access to meet the demand for high data rates in the wireless service. The most important improvement in this type of network for maintaining mobility is HO support. The HO is performed to maintain a continuous data-transmission service for all applications when the user is moving across the cell borders of the BSs. Three basic types of HO [3] have been defined for cellular networks: a hard handover (HHO), the macro-diversity handover (MDHO), and fast base station switching (FBSS). MDHO and FBSS are soft optional handovers, whereas HHO is a mandatory handover in WiMAX and LTE systems. HHO adopts a break-before-make method, where the user stops its radio link to the serving BS before establishing its radio link with the target BS [30, 32]. Because HHO is a simple method, it causes a long HO delay and disrupts service for certain applications, especially when the user is traveling at a high speed, such as traveling on a highway.

In a vehicular environment, as the vehicles are moving, the traffic generated by other background vehicles connected to the same BS decreases the available amount of bandwidth as the collision rates at the data link layer increase [31]. Under these network conditions, the HO may trigger repeatedly even for a static wireless station.

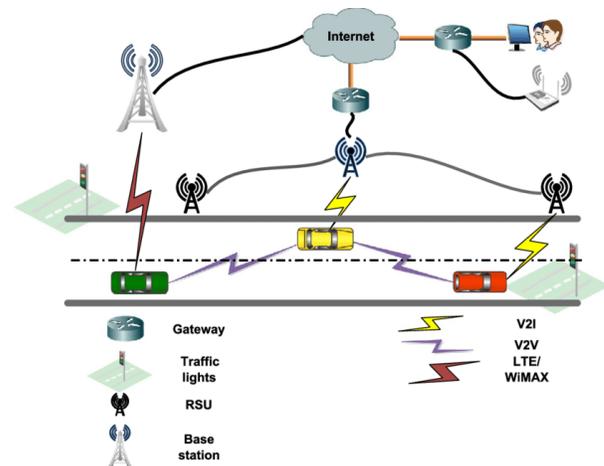


Fig. 1. IoV Networks Model.

This paper discusses a case in which a vehicle moves at a high speed from one BS to another in the IoV scenario, and it will cause long HO delays to the current Internet connection. To reduce this delay accordingly packet-loss rate during movements of the vehicle, an enhancement over the existing mSCTP protocol in L4 to support mobility has been proposed. This achieves through a cross-layer design of L2 and L4 to optimize the performance in terms of HO delay at L2, L4, and L3 consequently. The cross-layer design generates an L4 awareness regards to the vehicle movement using the radio signal strength indicator (RSSI) in L2 and utilizes the LM to track the vehicle movement with high speed along with the network.

The rest of this paper is organized as follows. An overview of the previous related studies is introduced in Section II in terms of mobility management of the protocol layers, vehicle, and cross-layer as well. The framework of vehicle mobility management to overcome the stated problem at high speed is discussed in Section III. Section IV presents the idea of the work of the smooth adaptive handover management for vehicle users. Then Section V shows the simulation test and Section VI details the results and analysis. Finally, Section VII provides some concluding remarks regarding this research.

II. RELATED WORK

A. Management of Mobility in different Protocol Layers

1) *Network layer mobility solutions:* The most common examples of network layer mobility solutions are Mobile IPv4 (MIPv4) and Mobile IPv6 (MIPv6) [4]. The Mobile IP permits transparent packet routing to the mobile user, as opposed to each node being allocated a permanent IP address that correlates to the home network. Furthermore, when a mobile user roams across several foreign subnets, each subnet receives a new IP address (Care-of-Address (CoA)). The mobile user then sends a binding update to its home agent (HA), which keeps track of the node CoA's current location and tunnels traffic from the mobile user to the mobile user. Routing optimization, hierarchical, and predictable algorithms have all been reported as breakthroughs for Mobile IP handover [5]. Furthermore, by tunneling traffic to the mobile user's AP, triangle routing is avoided [14].

The network is divided into domains by Hierarchical Mobile IPv6 (HMIPv6) [4], [8], each of which contains numerous access routers (AR) and a Mobility Anchor Point (MAP) that links the domain to the Internet. The MAP takes mobile user packets and tunnels them to the domain level CoA, as well as controlling the domain's mobility. This reduces changeover delay and loss by completing a micro-level address while still doing the macro-level handover, which has a large latency.

Fast MIPv6 (FMIPv6) [8] as a Fast Handover Protocol that uses L2 triggering for handover to improve speed and decrease packet loss. This is performed by announcing the existence of mobile users as well as the new AR's readiness to receive data from the new CoA. The necessity for collaboration between the user and for both prior and new AR, as well as the high unpredictability of packets arriving at the Aps is the system's

main drawbacks. In a comparison of several ways, FMIPv6 outperforms HMIPv6 in terms of handover delay and packet loss, however using both methods improves performance through each of them alone [4, 8, 15, 22].

2) *Transport layer mobility solutions:* the TCP and UDP protocols have been enhanced to provide mobility transport layer protocols, which are still the most commonly used on the Internet [1, 2, 11, 12, 21]. Another of these protocols is Stream Control Transmission Protocol (SCTP), which allows each endpoint of an association to utilize several IP addresses, allowing a mobile user to multi-home. The mobile Stream Control Transmission Protocol (mSCTP), which uses the SCTP IP address extension to allow an association's terminals to change their main IP address without breaking their current connection [21][24], is another innovation. Even while mSCTP can provide precise conditions for faultless handover when the main address must be changed, there is still an issue. Even while mSCTP can provide precise conditions for faultless handover when the main address must be changed, there is still an issue. A cross-layer design across several levels has been proposed in several studies [1, 2, 10] to improve the mobility of transport layer protocols such as SCTP and mSCTP. They were able to demonstrate that SCTP can give lower handover latency than mobile IP and a much reduced handover latency for several different types of handover in such studies.

3) *Cross-Layer mobility management for vehicle users:* Several solutions [11, 13, 14] that seek to promote smooth handover in high-speed users (e.g. cars) were explored. The authors of [11] utilize a system that forecasts vehicle motion to optimum performance in a high-speed environment, and they estimate that there will be no concerns as the length of connectivity increases. In the 802.21 method, the authors of [14] adopt a previous knowledge technique wherein network information is collected from both the mobile user and the network infrastructure in order to establish a connection with a new subnet ahead of time. A similar research [13] proposed lowering the effect of a service outage among high-speed users. This proposal offered a packet forwarding control which would select a point of agreement for forwarding packets in order to transmit them through a shorter path during a handover. The author in [14] proposes a network mobility protocol (NEMO) for usage in a vehicle networks (VANET) environment on a roadway. Despite the fact that each vehicle is traveling at a high rate and in a fixed direction in this case, vehicle-to-vehicle (V2V) connections might provide the vehicle with an IP address.

B. Cross-layer Mobility Solution

Various cross-layer efforts have been created in an attempt to reduce the HO delay. The author in [26] describes VSPLIT, transport layer performance improvement architecture for Internet-based Vehicle-to-Infrastructure (V2I) communications in vehicular networks based on TCP cross-layering and splitting methods. The primary goal of this strategy is to enhance TCP handover performance in 802.11 networks. The

VSPLIT-TCP cross-layer TCP protocol, which uses IEEE 802.21 Media Independent Handover (MIH) services to modify congestion control during the changeover by learning various network parameters after the handover. SHSBM, a Smooth Handover Scheme based on mSCTP, is proposed in the literature of [27]. To best support fast-moving users, SHSBM takes use of SIGMA [7, 10, 18, 19, 20, 21] and employs Buffer and Tunnel. They also provide two ways for dealing with the issue presented by the Buffer-scheme—sequence Out of Order. In comparison to SIGMA and Mobile IPv6 upgrades, performance criteria such as packet loss rate, throughput, and handover time were used to evaluate performance.

In their study, [28] provides a framework for linking vehicle networks to the IPv6-based Internet. This concept provides a road domain-based architecture to minimize the frequency of mobility handovers. In this study, they are developing a distributed address configuration mechanism for car networks. Using this method, a vehicle obtains a unique address from the nearest access point (AP), avoiding the detection of duplicate addresses. On the basis of this architecture, a routing mechanism based on geographical position is suggested. A car connects to the Internet by connecting to the nearest access point, and the routing algorithm has been applied to the link layer. During the mobility procedure, the vehicle's home address is always used to identify it, and no care-of address is necessary. As a result, packet loss due to a change in address is avoided. Additionally, packet loss is greatly reduced since a vehicle can receive data from the same AP during the mobility changeover phase. Their approach can minimize communication latency and packet loss, but IPv6 introduces a new delay that can affect upper-layer connectivity. They offer a cross-layer rapid handover strategy that communicates physical layer information with the link layer to decrease handover delays in automobile networks. The WiMAX mobile multi-hop relay mechanism, which allows inter-vehicle communications to connect to the Internet through a relay vehicle, provides the foundation for this technique. However, IP mobility is not included in the program. The need for flawless communication in high-speed settings is an appealing and difficult problem that necessitates accurate IoV in most modern networks [35, 36, 37]. While the majority of the preceding work focused on changeover for and moderate speeds, the requirement for smooth communication under high-speed situations is an appealing and demanding issue since most new networks require precisely IoV. In this situation, employing the lower layer's handovers and the transportation layer's communication layer will make handover awareness and avoid communication interruption, minimizing packet loss and, as a result, increasing network QoS.

III. VEHICLE MOBILITY MANAGEMENT FRAMEWORK

A. System Architecture

Any moving user traveling at varied speeds while communicating over the same network technology can use the SHD architecture. The vehicle and BS modules are the two most important modules in the design. A graphical representation of this is shown in Fig. 2. The vehicle module is in charge of protocol design and handles one SCTP relationship with a Domain Name Server (DNS) entity.

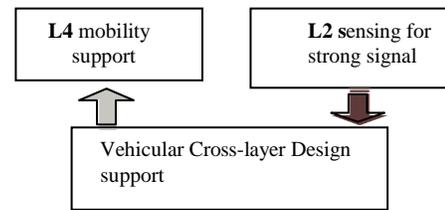


Fig. 2. Mobility Management's System Architecture.

The DNS entity, on the other hand, monitors and tracks the vehicle's mobility via the Dynamic Host Configuration Protocol (DHCP) server [6-9] (as shown in Fig. 5 and Fig. 7), which first monitors and tracks the vehicle's global movement by saving the current vehicle address in the server across networks to support L4 multi-homing. Second, the BS module controls the vehicle's HO using an adaptive algorithm in L2 that is dependent on factors like the received Signal to Noise Ratio (SNR), Received Signal Strength Indicator (RSSI), and vehicle speeds. The flow under this design begins when the vehicle initiates a handover to the TBS at a specified speed. Once the BS module has assessed speed and RSS/SNR, HO signals are delivered to the vehicle through the network. When the vehicle module gets the information marking the start of HO, cross-layer communications are sent. As a result, the SHD approach updates upper layers in response to the rapid change in speed.

B. Vehicle Mobility Management using Cross-Layer Design

The cross-layer design is suggested in this paper for managing transport layer mobility. The design proposes the mSCTP transport layer protocol, which is based on transport signaling messages and supports vehicle mobility handover over an IP network. As a result, the SHD's purpose is to ensure that any protocol may be used at any tier. In this case, the SHD's HO method permits information about the HO choice to be shared between layers. The next sections go over HOs at the L2, L3, and L4 levels in great depth.

1) *L2 HO Delay*: The WiMAX BS delay is employed to accomplish the HO operation at the datalink layer in this study. Signal strength is routinely measured in these types of BSs using parameters like the Received Signal Strength Indicator (RSSI) [34]. As a result, the HO is started as soon as the RSSI from the presently serving BS falls below a certain level. When the HO is necessary, this threshold is fixed (2dBm for traditional WiMAX) and is utilized to launch and execute it. When communication quality deteriorates, the vehicle's L2 looks for the best BS for HO and uses it as a TBS. We reduce the time here by restricting the number of scanning TBS to three (Fig.3, N=3).

The impact of an L2 delay on SHD performance may be split into two categories. The influence of the BS's HO process time is the first, while the vehicle speed is the second. L2 initiates a handover and the scanning procedure for the TBS begins if the SBS signal quality deteriorates, which takes roughly 15 ms for a high-speed vehicle [24]. Until the TBS completes the HO, communication is disabled. The whole

delay of L2 compromises the synchronization time (T_{sync}) between BSs and frame duration:

$$T_{L2} = T_{sync} + T_{frame} \quad (1)$$

Upon synchronization with the arriving downlink for other HO messages related to the BS HO, the downlink packet may be broadcast immediately (DAD procedure, tunneled packets, delay of each hop in a wired, resolution procedure, ranging process, re-authorization during HO, and re-registration). The L3 HO delay explains the role of L3 at the HO delay time.

2) *L3 HO Delay*: The network layer delay of handover is roughly 1 minute due to DAD and other HO messages on the network. L3 HO delay can be sent over a cross-layer of L2 and L4, allowing the delay to be linked solely to L2 and L4 HO. The issue is that the SCTP relies on the LM/DNS to keep track of the vehicle's current location when the IP domain changes. As shown in Fig. 4, it may be done during SCTP's HO, when the vehicle L4 updates the LM with the updated BS after HO. This enables real-time tracking of the new car. The performance of the L2 HO at various vehicle speeds, as well as the computations required for a successful HO to adjust L4 to each speed are discussed in the next section.

3) *L4 HO Delay*: The protocol detecting a HO causes L4 delay, which might last several seconds depending on the round-trip duration (approximately 10 ms) between the vehicle and the CN. This might lead to packet loss and, as a result, a decrease in throughput. The mSCTP, on the other hand, is utilized to facilitate multi-homing when going in a fast vehicle. The vehicle HO process is depicted in Fig. 3 from the time the vehicle gets the network's HO decision (SBS) until the time the dynamic HO is executed at L2.

To complete the HO between the vehicle and CN, the ASCONF SET PRIMARY/DEL IP messages that cause the HO delay at L4 are necessary. Because the connection latency for updating the LM has no influence on the SHD handover delay, the time necessary to update the LM of REG.REQ/RSP is disregarded. As a result, the L4 transfer's total interruption time is:

$$T_{L4} = T_{(ASCONF\ SET\ PRIMARY/DEL\ IP)} + RTT \quad (2)$$

4) *Adaptation between L2 and L4*: The vehicle adapts the L4 protocol SCTP and the vehicle speed at L2 using algorithms. At varying speeds, this technique dynamically manages the SCTP protocol's handover decision. It runs the vehicle's L2 protocol in order to make a HO decision based on the SBS's current signal quality, which is indicated by the RSSI in the MOB-NBR-ADV message. On the other hand, depending on this number, the HO execution produces the strongest TBS signal. Fig. 3 shows the flow of the HO algorithm. As shown in this picture, when a vehicle enters the HO region of the TBS, it receives a message about the availability and amount of TBSs. The algorithm leverages the vehicle speed supplied by the BS to make a dynamic HO choice when the vehicle signal strength begins to decline. To

relate the vehicle's speed to the HO choice, the computer use Equation 3.

$$Th_{HO} = Th_{loss} (1 + \log_2 (v+1)) \quad (3)$$

Furthermore, the adaptive method is based on the following conditions to avoid performing unnecessary actions such as lengthy HO delays or squandering network resources with unnecessary HOs, both of which can result in substantial system performance degradation:

$$RSSI_{SBS} < TH_{HO} \quad (4)$$

$$RSSI_{TBS} > Th_{loss} + \Delta D \quad (5)$$

When the RSSI falls below the TH_{HO} in Eq.4, the HO operation will start. In addition, in Eq.5, the HO is only done if another BS has an RSSI that is at least D greater than the Th_{loss} . These equations change the handover threshold (TH_{HO}) based on the current vehicle speed (v) and RSSI of the SBS, which have varying values at different points in the coverage area. To make the threshold dynamically adapt with speed, Eq.3 mentions the link between the TH_{HO} and the speed v . The communication's loss threshold (TH_{loss}) and the hysteresis value D govern the TBS. When the vehicle's speed rises, TH_{HO} rises as well, and the vehicle executes a straight handover to the following TBS to prevent a delay. TH_{HO} , on the other hand, uses Th_{loss} to achieve the lower limit when the speed is low. After that, the system compares TH_{HO} to the current RSSI (as in Eq.4 and Eq.5). The selection is made based on the vehicle's speed as well as the RSSI. As a result, two scenarios are examined for a HO operation. If TH_{HO} is bigger than RSSI (as in Eq.4), the HO operation is first carried out at the highest TBS signal intensity. Otherwise, the BS executes the HO by comparing the SNR with the neighboring BSs (NBSs). The second option is taken to minimize communication interruption due to fast changes in the received signal level caused by distortion or short-term shadowing of high-speed vehicles (Eq.5).

Due to the numerous HOs that occur at greater speeds, the adaptive HO algorithm's objective is to avoid a delay and packet loss during transmission. TH_{HO} and Th_{loss} are computed for each TBS at each handover (the method for initiating and performing a HO from the SBS to the TBS of vehicular users) (Eq.3). Because the HO delay is small, packet loss does not need a drop in the packet loss rate if the adaptive algorithm effectively controls the occurrence of a HO. Due to the additional latency, our approach employs an upgraded SCTP to decrease packet loss.

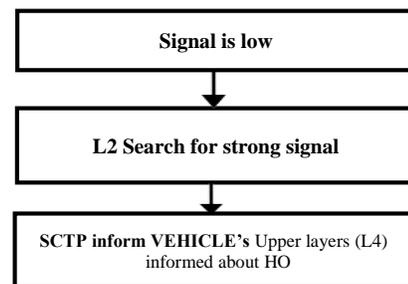


Fig. 3. Proposed Speed-Adaptive Algorithm.

However, the majority of the L4 HO delay in this architecture is due to SCTP's set primary chunk as well as removing old IP (ASCONF SETPRIMARY/DEL-IP) handover messages, as well as the RTT of messages between the vehicle and CN (about 1–10 ms). This HO process is a conventional SCTP procedure with the addition of the LM/DNS server in the design. Because the handover delay is unaffected by the connection delay in updating the LM, the time for the location.

Finally, as shown in Fig. 5, the delay of our cross-layer design between L2 and L4 of the vehicle is around 34s, which is insignificant when compared to the L2 delay time. A cross-layer design's overall handover latency may be computed as follows:

$$(T_{HO}) = T_{L2} + T_{L4} (\text{ASCONF SET-PRIMARY/DEL-IP}) + \text{RTT} \quad (6)$$

The data connection layer delay is TL2, while the transport layer delay is TL4. We can eliminate the L3 duplicate address detection (DAD) delay, which is connected to the new address through the LM, and update the vehicle position at the TBS without an additional delay using this architecture. The LM can also be used to solve the problem of triangular packet routing between the CN and the vehicle. Because the CN continually delivers packets to the vehicle's current address across the LM, the mSCTP may work collaboratively with the LM to decrease the handover latency along with different layers. The interruption time from L2 is around 10 ms, which is minimal for L3. The HoD for this design is estimated from the vehicle to the CN. ASCONF to SET-PRIMARY/DEL-IP takes around 0.045 milliseconds in the L4 protocol, resulting in a total handover latency of about 20 milliseconds.

C. Design Goals

The following are the key objectives of this design:

1) As a mobile node, a vehicle must be connected to the network internationally. The SDH approach, on the other hand, accomplishes this purpose by employing a DNS server and an LM to track the vehicle's present location and forward packets quickly.

2) The whole vehicular network is utilized. This is a good goal for increasing mSCTP performance on the IoV network, since the protocol suffers from a large number of handovers. Our goal is to maximize the throughput of the SCTP flows before any losses or other delays occur. Between conflicting speeds and mSCTP flows, a fair handover choice is made. Handovers conducted by vehicle users traveling at various speeds might result in unfair behavior in the mSCTP. Users that stay connected to the same BS for a long time obtain better throughput in present mSCTP implementations because they experience fewer handovers. Furthermore, users who drive at fast speeds do not have enough time to receive a HO at the proper operating point. By swiftly tailoring T_{HO} to the vehicle speed and network circumstances (i.e., SNR), our handover technique can decrease changeover latency and interruption time, ensuring improved fairness between different vehicle speeds and competing SCTP flows.

V. SIMULATION TEST

A. Simulation Environment

The simulated architecture illustrates that the vehicle is traveling at high speeds along the highway (70–120 km/h) and is connected to the network through the IoV (Fig. 6). The coverage area of each BS that links automobiles to the Internet is about (1000 - 10000 m), with a 200-meter overlap between the two BSs. On the network side, the BSs are connected through the AR, with every two ARs connected to one MAP. This scenario creates an IoV communication by joining the network directly. The upper component of the network, as illustrated in the diagram, links the vehicle's present position and transmits traffic to it according to IoV services. The OMNET++ simulation was utilized to assess this architecture, together with MATLAB to compare network settings.

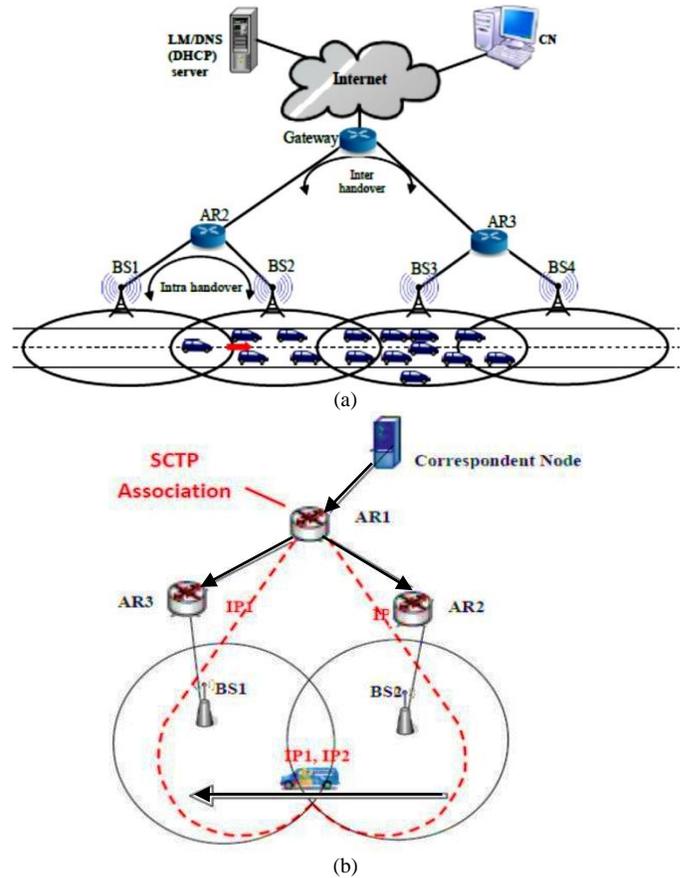


Fig. 6. Network Scenario. (a) One Vehicle Scenario. (b) Background Traffic Scenario.

The simulation performance compares two simulation models in the following way:

1) Scenario A: a single vehicle mobility management system (Fig. 6(a)). In the single vehicle instance, a vehicle drives in a straight path from the SBS to the TBS zone, with no traffic or network load. That is, the background traffic will have no effect on the car. In this instance, the handover may be limited to simply one vehicle.

2) Scenario B: Traffic mobility management in the background (Fig. 6(b)). The car is going ahead to the TBS with background traffic in the Background traffic mobility example. The HO happens when there are ten cars on the network, indicating that the vehicle is affected by the crowded network. In this situation, the car would be handed over after a longer period of time.

In order to detect and assess the performance of the proposed design and its impacts on the background traffic, we measured the HO latency and throughput for data transfer as a performance parameter of the system.

B. Background Traffic Implementation

Ten automobiles are deployed as background traffic inside the coverage area of the TBS on the network in this simulated scenario to assess the network's performance. Every vehicle travels at a different pace, and multiple of them communicate with their own networks, causing network congestion. This background traffic is created in two phases, each of which correlates to a different car count (up to ten). Each stage has different traffic levels, such as one car in the first and 10 vehicles in the second.

The background traffic conveyed to the SBS by other cars (Fig. 7(b)) raises the loss rates at L2 and hence limits the amount of available bandwidth. Even for static moving vehicles, this is a crucial element that impacts load variation and, as a result, activates the HO. The job of HO control in this situation is combined with the load-balancing service necessary to maintain an optimal decision point for deciding HO. This design evaluates performance in a variety of scenarios, such as background traffic.

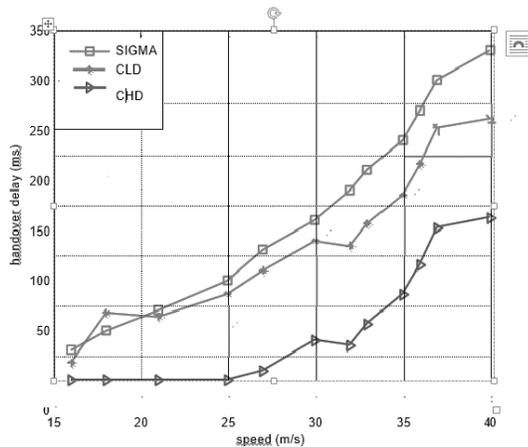


Fig. 7. HO Delay Comparison.

VI. RESULTS AND ANALYSIS

A. Performance Evaluation

To assess this concept, SHD compares three mobility options in terms of scalability, as measured by the number of vehicles executing simultaneous handovers and vehicle speed. For scalability, two mobility scenarios were investigated, in which a single vehicle and ten vehicles, respectively, transit the overlapping region at varied speeds between 10 and 40 m/s. As demonstrated in the findings, this simulation can assess the

ability of each handover strategy to maintain a shorter HO latency in various vehicle mobility models with changing network characteristics. The following sections go over the performance in further depth.

1) *Handover evaluation:* First, when the triggering time of L2 is roughly 15ms for the BS, the total HO latency of the SHD design is compared to the other design advancements. This L2 HO latency is consistent with what is seen in networks for high-speed users. When the traveling speed is increased to 40 m/s, as shown in Fig. 8, the HO delay of SHD is clearly reduced. This is because while the car communicates with the CN via the old way, it may simultaneously do L2 triggering on the other user interface. As a result, as compared to the other design advancements, the impact of these latencies can be significantly reduced (SIGMA). Because there is insufficient time for a vehicle to prepare for a new course, the HO delay of the SIGMA upgrades is roughly 2.40–2.49 s, which is substantially greater than that of the SHD design.

The HoD between vehicles is around 20ms, depending on the RTT to CN. Fig. 8 and 9 illustrate a comparison between the proposed design and existing HoD designs, while Fig. 10 displays the HoD when the network load is high. Four different scenarios were evaluated to validate the concept, as illustrated in Fig. 9.

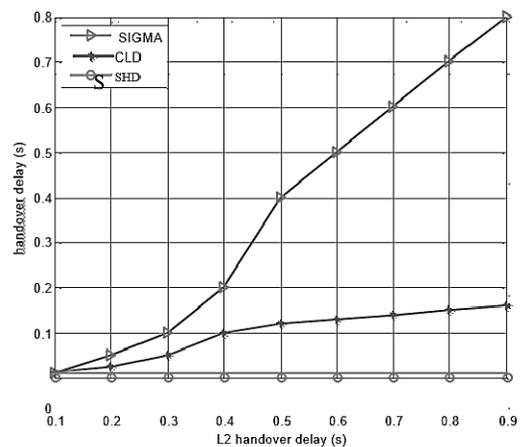


Fig. 8. Impact of an L2 HO Delay.

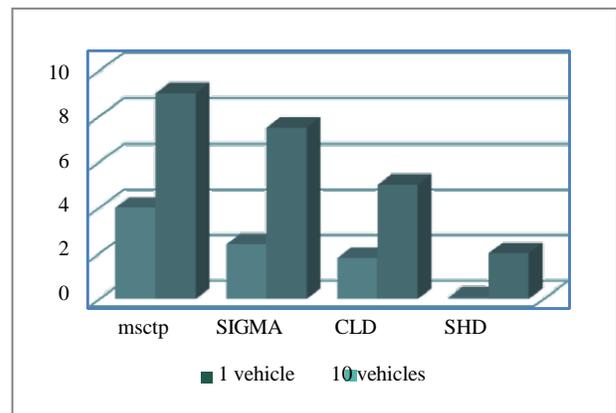


Fig. 9. Handover Delay with Background Traffic.

The first design employs the mSCTP to support a HO during a speed fluctuation; this design uses a cross-layer design to update L4 with current speed [1]. The second design (SIGMA) employs IP diversity in conjunction with SCTP to provide a multi-homing HO mechanism through the LM without the usage of L2 or a cross-layer [5-7]. The third design, SHD, is a cross-layer design between L2 and L4 enabling a speed-independent handover. However, the most recent design SHD uses an adaptive algorithm to create an ideal seamless HO during high-speed vehicle movement using a cooperative cross-layer mechanism between L2 and L4. The numbers show the outcomes of the tests.

2) *Throughput and packet loss*: For different vehicle speeds, communication time in one BS coverage region is around 67s, and HoD is about 25ms. This indicates that for high-speed automobiles with a repeating HO, the vehicle is unable to receive packets for 0.2 seconds before receiving packets for 66.8 seconds owing to the HO. As a result, in a highly dynamic handover situation, the throughput is much higher than earlier SCTP designs. Fig.10 compares the throughput of several designs versus the SHD design at high speeds using 10 automobiles as an example.

However, as shown in Fig. 10, mSCTP architecture operates effectively when at least one network is low loaded or has no load at all. For all BS load conditions, the throughput is optimal (4 Mbps), except when the BS is totally loaded (50–100s), in which case the throughput reduces to 2.5 Mbps. The same trend can be seen when looking at the packet loss in Fig. 11. Because the car is still connected to the same BS when the network is crowded and a speed-adaptive strategy is not used, the QoS suffers greatly. When background traffic decreases, the network becomes lightly burdened.

Otherwise, there is no load at all, and the maximum QoS improvement is determined, as shown in the Fig. 10 for the 100–150s interval. Table I concludes all the parameters for the three designs. At the end it is clear that the SHD has the outstanding in both cases with and without background.

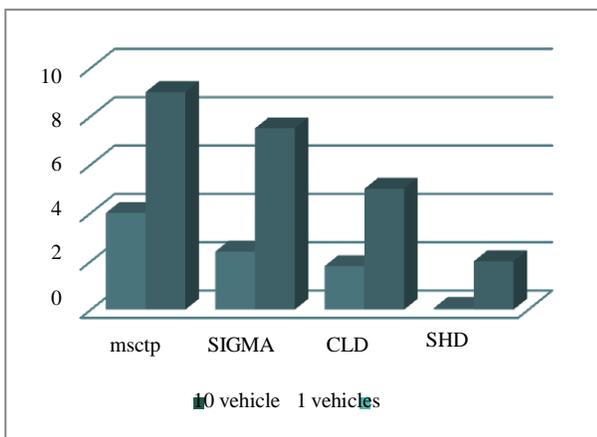


Fig. 10. Throughput of the Background Traffic.

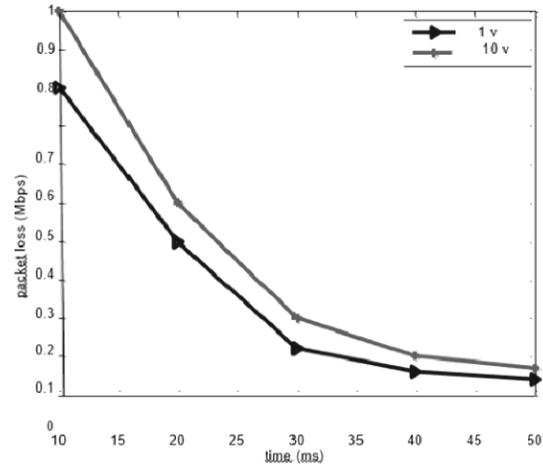


Fig. 11. Packet Losses for Two Cases.

TABLE I. HO DELAY, THROUGHPUT, LOSS, AND AVERAGE SNR, WHEN PERFORMING HANDOVER WITH HIGH SPEED OF 40M/S

| Scheme | CL | HO delay | SNR (dB) | Throughput (Mbps) | Loss (Mbps) |
|--------|----|----------|----------|-------------------|-------------|
| SHD | 1 | 0.07 | 64.3 | 11.8 | 0.04 |
| | 10 | 7.5 | 51.9 | 9.4 | 0.07 |
| CLD | 1 | 1.8 | 45.24 | 8.43 | 0.06 |
| | 10 | 5 | 35.33 | 7.1 | 0.1 |
| SIGMA | 1 | 2.4 | 33.76 | 5.8 | 0.12 |
| | 10 | 2 | 24.5 | 4.5 | 0.2 |

VII. CONCLUSION

Vehicles which normally move among cities at fast speeds have become basic computation in internet communication as IoV, thanks to the rapid growth of communication networks through the Internet. This sort of connection (IoV) may encounter a number of problems that degrade the quality of the Internet connection by lengthening the handover time (HoD). This work presents an approach that uses a cross-layer architecture SHD to dynamically lower the HoD in order to improve connection continuity while dealing with fast-moving data. The suggested architecture has reduced the delay by assisting L4 of the protocol for handover existence, allowing it to complete the handover in advance, resulting in even more secure and lossless vehicle communication. The numbers clearly indicate the improvements in throughput, latency, and packet loss.

ACKNOWLEDGMENT

“This work was funded by the Deanship of Scientific Research at Jouf University under grant No (DSR-2021-02-0360)”.

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