# A CROSS LAYER APPROACH FOR HANDOVER DECISION IN VEHICULAR COMMUNICATION

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***ABSTRACT****—The article suggests a handover (HO) approach for a new architecture based on a stream control transmission protocol (SCTP). A cross-layering technique and adaptive algorithm also proposed for optimizing the transport layer performance in vehicular networks. Our approach mainly pretends to enhance the performance of SCTP handovers for Vehicle-to-Infrastructure (V2I) communications in 802.16e networks. The design contains a cross-layer SCTP protocol, called CL-SCTP that assumes the HO decision with vehicle current speed. It can achieve by learning the new network parameters during the handover and the algorithm decides and performs HO procedure. We include the most interesting performances evaluation results, which show a good performance of our proposal for the intended scenario.*

**Keywords**— Handover; cross-layer; V2I; SCTP; 4G.

## I. INTRODUCTION

The wireless communication technologies become widely advanced in many areas and information services become more personalize to provide ubiquitous services anytime and anywhere. For that reason, the access technologies major goal is providing a high quality of service (QoS), real-time multimedia services in the new generations of wireless networks. However, real-time services such as Voice over IP (VoIP) and Internet Protocol Television (IPTV), over heterogeneous networks, are still a big challenge. Real-time multimedia services demand a guaranteed quality of service (QoS). In the case of VoIP, it requires voice packets to receive and play out in the same rate as they are being generated and send. In addition, due to the interactive and real-time nature of voice communications, the delay and loss rate of voice packets must be guaranteed during the HO. On the other hand, when the mobile devices are moving constantly in a heterogeneous network environment, handovers will be executed between various networks to ensure service continuity. However, the handover process often results in extended delays and packet losses and damages the quality of VoIP services. Thus, how to perform inter-network handovers while maintaining an uninterrupted service is an important issue in today's wireless applications.

Starting from Mobile IPv6 (MIPv6), several approaches [10, 11] to the seamless mobility support have been proposed at the network layer. Network layer approaches may be beneficial as mobility support has been transparent to the transport layer or upper layers. However, these approaches counter to a few undesirable characteristics: network architecture complexity due to additional special entities, the overhead due to triangular routing and tunneling, complicated security issues, etc.

Furthermore, the transport layer may not be able to control the transmissions optimally because it is transparent to the handover as well as the new network situations. On the other hand, an end-to-end approach based on transport layer might alleviate these problems, while such an approach requires a mechanism to map a new endpoint address to the existing connection. Stream Control Transmission Protocol (SCTP) is among standard transport layer protocols and provides good potential for the dynamic address mapping problem. Inherently, SCTP supports multi-homed end hosts with more than one IP address allocated to it [1, 2, 3].

Some ITS applications require Internet access through an infrastructure or Internet gateway in the vehicle to infrastructure (V2I) communication scenario. The Internet gateway can provide global addressability and bidirectional Internet connectivity to the MN [4]. However, if the MNs can be far away from its SBS, their traffic can be relayed through intermediate MNs. Otherwise, it will change the point of attachment SBS to nearest TBS to perform the handover procedure. This handover procedure includes two phases; handover-decision management phase and a handover execution phase for the mobility management system in V2I communication. These two phases are supposed to be executed in a short time to allow the MN to be reached on any BS that might be its target during the roaming with different speeds.

## II. RELATED WORKS

Mobility support for users and vehicular networks requires network connection as interactive and real-time applications become increasingly important. Therefore, many seamless-mobility approaches have been developed to avoid service disruption and minimize the awareness of service degradation while the mobile device is moving fast. The study of [1] proposed a cross-layer scheme called CEAL to support mobility in the transport layer protocol, mSCTP using the data link layer primitives. The performance evaluation shows less handover delay in WLAN environments. In [12], they presented a cross-layer handover scheme, called vehicular fast handover scheme, where the physical layer information is shared with the MAC layer, to reduce the handover delay. Using the lower layer's handovers, the transportation layer will not be aware of the handover, which may cause packet loss and degradation of the network QoS.

Transport layer-based approach such as mobile SCTP (mSCTP) influences the ability of SCTP to have multiple IP addresses per association. mSCTP utilizes a feature of SCTP, which allows an MN dynamically switch between available access networks thus affecting seamless handovers. The authors of [6] provide analysis that mSCTP can provide lower handover latency than mobile IP and give much smaller handover latency for vertical handover. Hierarchical transport layer mobility protocol, which is a new proposed option that deals with the local and global mobilities to improve throughputs during the handover period. This protocol exploits the dynamic address reconfiguration feature of SCTP and introduces anchor mobility uniting order to complete more efficient handover procedures. The previous work mainly focuses on low or medium speeds. However, the needs to maintain seamless communication in high-speed situations is becoming a highly attractive and challenging issue that needs to be tackled [3,4,11].

## III. HIGH-SPEED USER'S HANDOVER

Handover is one of the most challenging research issues for vehicular networks to support a variety and the requirement (e.g., high mobility) of network communication. The handover management in vehicular networks should ensure that the user reaches the correspondent nodes (CN) in the Internet as well as the global reachability to vehicles (users). For this reason, the handover management has confined requirements such as follows: **Seamless mobility:** where the mobility of vehicles should be seamless regardless of the vehicle's location and wireless technology [1,11]. Moreover, accessibility and service continuity should be guaranteed. **Fast handover:** is needed for delay sensitive ITS applications (e.g., safety, Internet access, etc.). Fast handover is also a crucial requirement for wireless networks with small coverage area (e.g., WiFi network), since the vehicle with high speed spends a short period of time at each point of attachment (e.g., Base station) consequently, the higher handover rate [5]. **Protocol support:** the global reachability requires a comprehensive and reliable routable IP address for each MN. IPv6 with large address spaces can support a unique address for all mobile devices in the vehicles. In addition,

IPv6 also has better support of security and quality of service (QoS) which are the necessary requirements of ITS applications. **High speed:** In the Internet, access is expected to be constantly connected regardless of the movement speed. It is highly desirable to make these contents available and reliable regardless of time, place, fixed, or mobile. As the speed of vehicle increases, the successful probability of handover decreases as the handover execution time is increased. **Movement detection:** vehicle needs to detect the availability of different types of access networks (e.g., 3GPP, 4G base stations) known as data link layer handover (L2), and obtain addresses in these networks for communication.

**Movement detection:** in location management scheme, which deals with the storage, maintenance, and retrieval of MN location information, are needed in VANETs [2,6,10].

### A. Transport Layer Mobility Support

Much effort has been made to support mobility management in the Transport layer without changing current Internet architecture. For instance, mobile Stream Control Transmission Protocol (mSCTP) was designed at L4 owing to the multi-homing feature. Conversely, the interfaces linking network layer and transport layer have to modify as well as CNs's transport layer have to change. On the other hand, mSCTP defines as an SCTP implementation with its ADDIP extension, for supporting soft handover in L4. With mSCTP, each endpoint is now able to add or delete an IP address to or from the existing association and to change the primary IP address for the SCTP association [10,11]. However, in mSCTP soft handover procedure in the transport layer, the MN initiates an SCTP association with the CN in IPv6 networks.

### B. Handover in V2I

In V2I communication the Internet gateway can provide global addressability and bidirectional Internet connectivity to the mobile nodes in a VANET [6,7,8]. In a VANET, mobile nodes can be far away from an Internet gateway, and their traffic can be relay through intermediate mobile nodes. This is referred to as multi-hop communications. However, in such a scenario, traditional MIPv6-based mobility management solutions cannot be apply directly since they require a direct connection between a mobile node and infrastructure. Therefore, when integrating MIPv6-based solutions into VANETs, many issues arise (e.g., movement detection and handover decision).

## IV. ADAPTIVE TRANSPORT LAYER FRAMEWORK

This section describes the work idea to support the L4 mobility influence of the concept of mSCTP. The adaptation is used to dynamically manage and control the data flow from an ongoing L4 association as appearing in Fig. 1. An SCTP vehicle will be considered to the HO if there is more than one transport address that can be used as a destination address to reach that endpoint. With this multi-homed node, the node shall select one of the multiple destination addresses of a multi-homed peer endpoint as the primary path to transmit data packets.

### A. Enhance SCTP for Mobility Support

This approach allows the vehicle to transmit data packets through the CN maintains several IP addresses for the vehicle with which it is communicating because we focus on a vehicle equipped with a single network interface. Moreover, the end-to-end mobility support can be achieved by the aid of ASCONF and ASCONF-ACK control chunks, which may contain different request parameters for the peer [11-13].

The HO scenario of this design is demonstrated in Fig. 1, where the vehicle is multi-homed node moving with high speed connection through two wirelesses BSs. The CN is a single-homed node sending traffic to the vehicle, which corresponds to the services like file downloading or web browsing by mobile users and the location manager control the address in the network.

### B. Handover Procedure

This design handles the handover problem much more efficiently using the transport layer protocol using the concept of mSCTP and available information from L2 (RSSI). The information from multiple protocol layers of this protocol design can be effectively exchanged to improve the performance of mobility management schemes. An algorithm to improve L4 handover to be aware when the communication cut is mentioned below. When the user receives MOB-NBR-ADV message from SBS he can calculate the signal strength from the receives information. At that time he decided to initiate HO to the TBS or check another parameter as SNR. There are two cases, either he finds that RSSI below the acceptable level of communication (the standard for 4G is 2dB) to initiate handover. Or when the RSSI is high he will check whether SNR is high or not to initiate the handover. Then the procedure for handover will complete by SBS to connect the user with TBS for handover.

Also, Fig.2 shows the flow of the design while the vehicle moves from first steps in SBS towards TBS, along this time signal strength degrades.

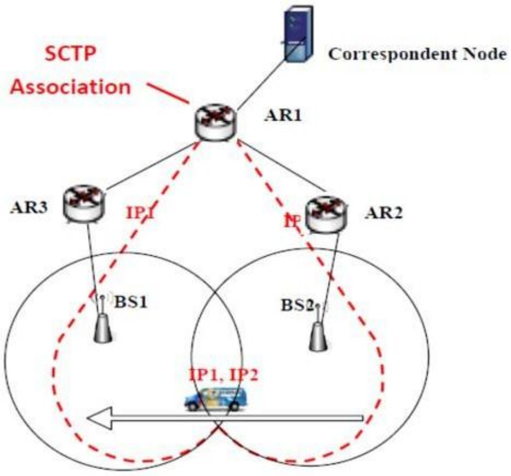


**Fig.1 Handover overview of the design**.

**Algorithm.1** The enhanced SCTP HO procedure for high vehicle speed.

*When receiving MOB-NBR-ADV*
*msg. from SBS If RSSI of SBS low*
*then*
*Initiate HO to TBS & send cross-layer msg.*
*from L2 to L4 Else If RSSI of SBS high &*
*SNR high*
*Initiate HO to TBS & send cross-layer msg.*
*from L2 to L4 End If*
*End If*
*Execute HO to TBS*
*Send cross-layer msg. from L2 to L4 to*
*send data packet End.*

Then vehicle inter through HO area next step at that time L2 sends to upper layers link status change.ind message. Then the vehicle inside HO area and communication with SBS is stopped so it sends L2 messages to upper layer asking the number of BSs, LinkConnect to TBS. Last is the finishing of HO, L2 receive's LinkUp.ind to indicate signal strength going up and L3 message to inform of reaching network.

C. Cross-Layer Design

This design provides many functions to the vehicle user in order to achieve better performance during the handover procedure from SBS to TBS. The idea is illustrated in Fig. 2 of the flow of signals between L2 and L4 of the vehicle. In this algorithm, the first steps, where the vehicle in the coverage area of SBS the vehicle receives MOB-NBR_ADV from SBS with the information of SBSs. When the signal strength begins to degrade below the HO threshold ($TH_{HO}$), SBS starts scanning to the best TBS with the strongest RSSI. In this step the adaptive HO algorithm (mentions in Fig. 2) works to adapt speed variations, then cross-layer messages of L2 send to upper layers (LinkStatusChanged.ind, PoAList.req/conf to L3 and AddrAdded.ind/resp to L4) to inform about connection degradation to prepare for HO. On the other hand, when L4 of the vehicle found a new address added directly it sends to CN a protocol message (New IP add.req) to inform them about HO will take place. On the reverse way, the cross-layers messages return back (LinkConnect.req to L2, LinkDown.ind to L3 and ReachabilityLost.ind to L4) again to lower layers about signal degrades. At this point, the communication between the BSs cut and L2 HO procedure takes place as mentioned earlier. When the vehicle completes the HO procedure and reaches the TBS coverage area, the cross-layer sends linkup messages to L3 and L4 (L2-LinkUp.ind and L3-ReachabilityUp.ind). Consequently, L4 of vehicle sends a protocol message of new address (ASCONF chunk) to CN to continue the communication through TBS and the packets sent again as mentioned in Fig. 2.

The handover procedure of the CL-SCTP at L4 is explained in details the following steps: When the user moves away from SBS toward TBS, it makes the HO decision according to signal quality in radio signal strength indicator (RSSI) at L2. It will choose the TBS with the highest RSSI among scanned TBSs. Then the cross-layer messages between L2, L3 and L4 exchange to inform upper layers with starting off the HO as shown in Fig. 2 in details. Then L4 start to obtain a new IP address (IP2) through several methods as DHCP. Consequently, the vehicle's L4 notifies CN about the availability of the new IP address through DAR of mSCTP multi-homing procedure [18] and two new chunk types will define (ASCONF and ASCONF- ACK) and several parameter types (Add IP Address, Delete IP address, and Set Primary). Next, the cross-layer messages send from upper to lower layers to indicate communication cut-down and this means that the signal degrades and the BS's HO will take place. After handover completed, the cross-layer messages send from upper to lower layers to inform about the link quality going up to continue the session. Consequently, L4 of vehicle sends to CN to set a new IP address as primary to redirect the data packet and delete the old IP address. Accordingly, the LM updated to maintain the database recording the correspondence between vehicles identity and vehicles current primary IP address. The vehicle can use any unique information as to its identities such as home address like MIP, or domain name. Here an important difference between our design and MIP is that location management and data traffic forwarding functions are coupled together in MIP, while in this design they are decoupled to speedup HO and make the deployment more flexible. The last step is to delete or deactivate obsolete IP address when the vehicle moves out of the coverage of SBS, no new or retransmitted data should be directed to address IP1. In ACL, vehicle notifies CN that IP1 is out of service for data transmission by sending an ASCONF chunk to CN to delete IP1 from CNs available destination IP list.

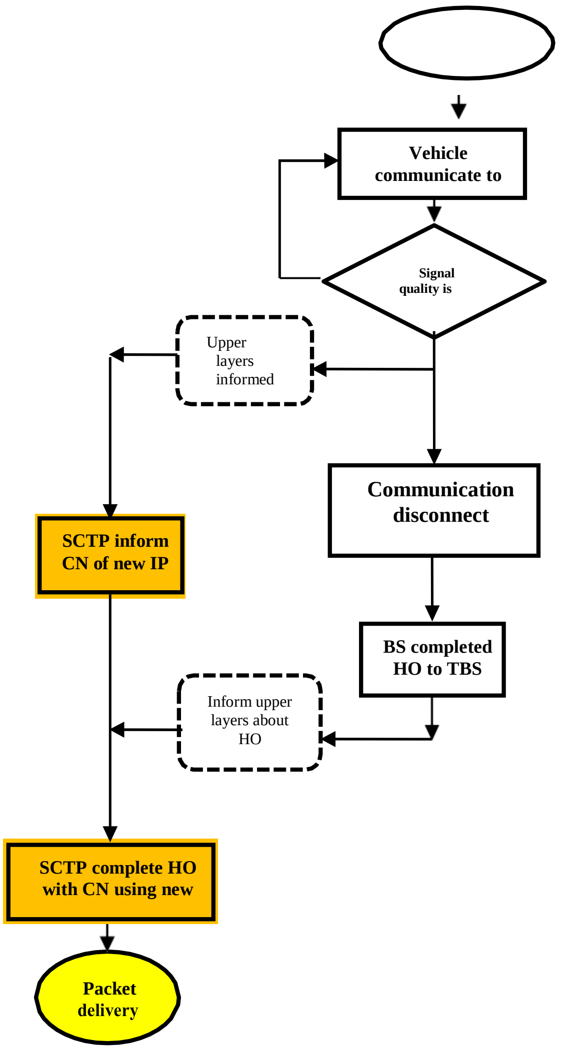


**Fig.2 Cross-Layer Concept**

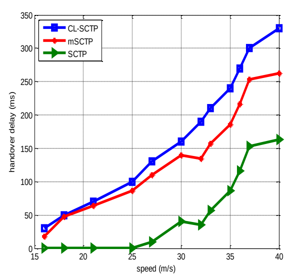


**Fig.3 handover delay comparison**

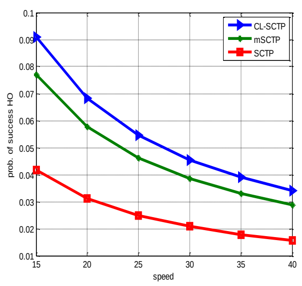


**Fig.4 Comparison of Successful HO.**

A. Performance evaluation

As mentioned earlier the network scenario consist of three access routers (AR1, AR2 as PAR and AR3 as NAR) nd 2 BSs as shown in Fig. 2. The vehicle moving with the speed of 20 km/hr up to 40 km/hr connected to the CN using the SCTP protocol for communication. We use OMNET++ and MATLAB to compare the performance of our design CL-SCTP and some other designs.

We measure the handover latency of mSCTP, other cross-layer design using SCTP and our design CL-SCTP from same direction user to CN. Fig. 3 and 4 show the handover delay and the probability of successful handover comparison. We can see from the figure that our design achieves the lowest delay compared to other designs. Moreover, the throughput of our design has improved the throughput between the user and the CN as appear in Fig.5.

## V. CONCLUSION

In this article, The mSCTP protocol has been used to support multi-homing for the high-speed vehicle in L4 as well as reduce L3 delay of the HO related to the network side. Then, design of cross-layer has been made to adapt L4 and L2 protocols for efficient handover procedure of the high mobility vehicle. In the design CL- SCTP, the L2 dynamically updates L4 of handover at the time when network parameters (RSSI, SNR) degrade to unacceptable level. This proposed design estimates the performance of

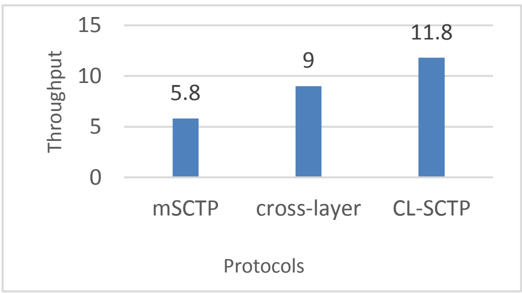


**Fig.5 Throughput at 40 m/s Vehicle Speed.**

the network and overall system when the vehicle passes a background traffic in one BS's coverage area. Finally, our design can handle an efficient HO procedure adapting with different speeds about 30% improvement than other protocol's designs.

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