차량 네트워크에서 수평 수직 핸드오버를 위한 SDN 기반 프록시 모바일 IPv6

SDN based Proxy Mobile IPv6 for Horizontal and Vertical Handover in Vehicular Networks

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Abstract

This paper proposes a SDN based Proxy Mobile IPv6 (PMIPv6) architecture for heterogeneous vehicular networks (SDN-VANET), to provide the continuity of service during the horizontal handovers and to reduce the delay during vertical and horizontal handovers. SDN-VANET mainly relies on DSRC road side units (RSUs) for V2I communication and to overcome the coverage problem SDN-VANET performs the vertical handover between DSRC and LTE/UMTS. To date there is no standard to perform network layer vertical handovers. Therefore the proposed SDN-VANET architecture also doesn't provide any mechanism for vertical network layer handovers, but solves the horizontal network layer handovers in DSRC or LTE/UMTS through introducing PMIPv6 in the architecture.

1. Introduction

In the current and future vehicles, wireless communication plays a pivotal role. For the future vehicles, wireless communication based infotainment services like media streaming, news updates, web browsing, traffic updated, hazard warnings etc. are considered to be necessary. To provide the infotainment services to the passengers, vehicles connect to variety of wireless networks like WIFI, DSRC, LTE, UMTS etc. However due to dynamic and fast nature of the vehicle movement, the requirements for vehicular networks (VANETs) are different than what current technologies are designed for.

For Vehicle to infrastructure (V2I) communication 802.11 b/g/n is considered to be the best bet; however 802.11 structure is inadequate to provide services to the fast moving vehicles. Efforts have been done to modify 802.11 to support vehicular communication and as a result of this effort 802.11p/WAVE is recently standardized. Dedicated short rage communication (DSRC) systems are also considered for V2I VANETs. Major limitation for DSRC based road side units (RSUs) or 802.11b/g/n/p based hotspot is the coverage along the complete stretch of the road which is very crucial for the infotainment services. To overcome this limitation other option is to use well deployed cellular networks like LTE or 3G to provide disruption free services to the vehicle. This is why currently we see automobile manufacturers provide LTE/3G based services in the vehicles. However LTE/3G based services are not free and can incur customer (vehicle owner) huge cost if the communication between vehicle and infrastructure is frequent, therefore first priority is to use DSRC whenever possible.

This paper proposes an architecture of SDN based Proxy Mobile IPv6 (PMIPv6) for heterogeneous vehicular networks (SDN-VANET), to provide the continuity of service during the horizontal handovers and to reduce the delay during vertical and horizontal handovers. SDN-VANET mainly relies on DSRC road side units (RSUs) for V2I communication and to overcome the coverage problem of DSRC system LTE network is used as a backup.

2. Background

Proxy Mobile IPv6 (PMIPv6) [3] is a network based mobility management standard, which handles all the mobility related signaling without involving the MN. In PMIPv6, All data communication between mobile node (MN) and corresponding node (CN) moves through local mobility anchor (LMA). When the mobile node first enters in PMIPv6 domain it needs to register itself with the LMA.

Openflow (OF) [4] has emerged as the first implementation of SDN. Researchers have opted OF to implement SDN concept in different domains of networks, e.g. wireless sensor networks, mesh networks, data centers etc. OF network architecture consists of OF-enabled network devices (switch/router/access point) and an OF controller (OFC). Data plane in the OF switch is responsible for packet forwarding whereas control plane of the OF switch takes care of communication between OF switch and OFC over a secure TCP connection. The main objective is to make control functions more centralize rather than distributed. OFC performs all the control logic and manages all the forwarding elements using OF protocol.

In the paper [1], authors have explained the network mobility management protocol to maintain the seamless internet connectivity of vehicles. However, the NEMO-BS shows unacceptable long handover latency and increased traffic load to the vehicles. In another paper [2], authors proposed the timely handover of IP services in an asymmetric VANET and then, they proposed a multhop-authenticated Proxy Mobile IP (MA-PMIP). In other words, they use the standard IP mobility scheme for multihop VANETs, but taking advantage of the location and road traffic information to predicts and enable timely handover.

3. SDN-VANET Architecture

The proposed SDN-VANET architecture takes care of two problems related with vehicular networks: 1) service outage problem 2) disruption in network layer connection. To handle the first problem SDN-VANET considers the vertical handover between DSRC road side units (RSUs) and LTE eNodeB, and to address the later problem SDN-VANET utilizes the PMIPv6. Along with PMIPv6 SDN-VANET also incorporate SDN concept in its architecture. To realize the concept of SDN, SDN-VANET utilizes the OpenFlow which is the most renowned implementation of SDN to date, however any other implementation of SDN concept can also be used. The benefits of incorporating the SDN (OpenFlow) are twofold:

1. OpenFlow controller (OFC) provides a central point where vehicle's mobility related information is gathered, much like traffic control center (TCC) in other proposed works. However in case of TCC, mobility information is explicitly sent either by vehicle or network devices, whereas OFC gathers the mobility information based on vehicle control signaling with the RSU or eNodeB
2. OpenFlow protocol provides a mechanism for a central entity like OFC to communicate and control different network devices in the network

In the SDN-VANET all the RSUs and eNodeBs are considered to be OpenFlow enabled and communicate with a single OFC present in the core network. Also from the PMIPv6 perspective RSUs and eNodeBs are considered mobile access gateways (MAGs). SDN-VANET separates the control signaling path from the data communication path. Logically, the OFC in SDN-VANET virtualizes multiple RSUs and eNodeBs as one MAG and performs the control signaling with the LMA on behalf of multiple RSUs and eNodeBs, therefore logically we can consider it as a virtual mobility access gateway (vMAG). Communication between RSUs/eNodeB and the vMAG is over the OF protocol. This logical separation is evident from the Figure 1 where OFC performs the PMIPv6 control signaling with LMA and AAA on behalf of RSUs and eNodeBs. As control signaling has been offloaded from RSUs and eNodeBs therefore they are only responsible for establishing layer 2 connection with the vehicle.

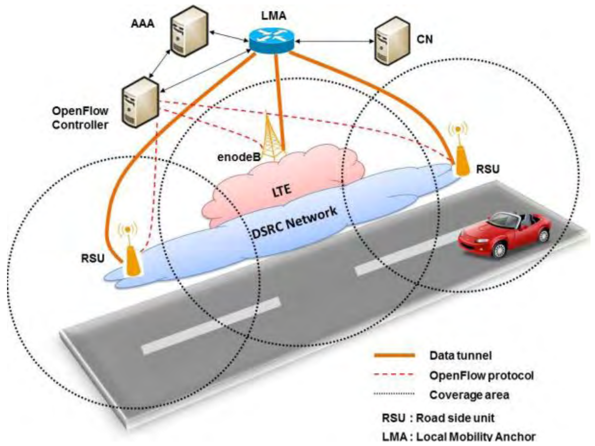

Figure 1: SDN-VANET architecture

In SDN-VANET architecture RSUs and eNodeB are assumed to be connected to the OFC through the network of the service provider. LMA and AAA server resides in the home network of the vehicle. OFC communicates with LMA and AAA through layer 3 messages. IP in IP data tunnel is created between LMA and RSUs/eNodeBs for the transmission of data packets from and to vehicle.

ACKNOWLEDGMENT

This research was supported in part by the ICT R&D program of MSIP/IITP and MOE, Korean government, under ANC(IITP-14-911-05-006), NGICDP(2010-0020727) and PRCP(NRF-2010-0020210) through NRF, respectively.

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