

Software Defined Networking Approach for Efficient Information Dissemination in Vehicular Networks

Abstract

Vehicular ad-hoc networks (VANET) have emerged as a viable solution for the network related problems in intelligent transportation system (ITS). However, with its current architecture, especially with the unavailability of global network information, VANET has not been able to fulfill some of the necessities for efficient information dissemination and most critically still lacking flexibility and programmability. Recently, software defined networking (SDN) has been introduced into the vehicular domain in order to overcome the shortcomings in VANET. SDN is capable of handling the dynamic nature of networks with intelligent applications while lowering operational costs through simplified hardware and software. Yet, the architectural limitations of presented software defined vehicular networks (SDVN), especially the centralization of control plane and its placement, have imposed doubts on its usability especially in the midst of stringent delay requirement of VANET applications.

Alternatively, in this thesis, we propose a novel hierarchical distributed controller architecture for SDVN (HD-SDVN) in which multiple controllers are hierarchically distributed and a layer of control is brought down to the Road Side Unit (RSU) level cutting down the southbound communication latency, while still leveraging the logically centralized pros such as collective global network view. Further, an optimized placement of controllers in several selected RSUs is proposed together with a proactive flow instantiation (FI) to further reduce the operational latency of SDVN. Implementation of HD-SDVN and proposed proactive operational mode in NS3 exhibits latency measurements in tens of milliseconds which is satisfactory to most of the VANET applications.

The thesis further emphasizes the effect of software defined approach on efficient information dissemination in vehicular networks by scrutinizing the link stability in multi-hop data routing. As a middle ground for the shortest path approach and most stable path approach in the current literature, we propose an optimization based data routing model, which scrutinizes multiple stable enough paths with less travel times, that can deliver a given set of packets using SDVN. The problem formulation follows a minimum cost capacitated flow problem, embedded with an incremental packet allocation scheme to shift the computational complexity to a realizable level for real-time communication. Moreover, a source routing based FI scheme with effective route caching is presented to reduce the extent of communication with the control plane while still utilizing the knowledge of the controller. We further acknowledge the possible limitations in network information which confine the improvement of aforementioned proposals and incorporate both centralized and distributed routing techniques in combinations to overcome the black holes in the network. The simulation experiments with realistic mobility patterns support the stated claims with enhanced packet reception ratios among competitive latencies and routing overheads.

We finally present a primordial study on cooperative scheduling of diverse vehicular communication channels for a better dissemination of data in multi-hop routing scenarios. The system utilizes vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and infrastructure-to-vehicle (I2V) channels of dedicated short range communication (DSRC), and infrastructure-to-infrastructure (I2I) interface cooperatively to maximize the delivery of data packets under delay tolerance and link connectivity regions. The model avoids possible packet collisions, multiple simultaneous transmissions, routing loops by means of constraints while scrutinizing the wireless nature of links. The problem is formulated as an integer linear programming (ILP) problem and it further thrives on the minimization of service delay based on the traffic type as well.

The proposed SDVN system model and information dissemination schemes highlight the improvement that can be brought upon vehicular networks via SDN, which is the core objective of this thesis. This study further exhibits, unlike in VANET, how intelligent applications can be easily incorporated to scrutinize diverse features/attributes of vehicular networks for an enhanced performance.