MOUNT: Mountain-oriented Optimal Ubiquitous Networked Transportation

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Connected Vehicles (Vehicle Ad-Hoc Network, VANET) have the potential to transform the way people travel through the creation of a safe, interoperable wireless communications network that includes cars, buses, trucks, traffic signals, cell phones, and other devices. However, most connected vehicle research didn't consider the impact of terrain. Therefore existing connected vehicle research is not applicable to the development of connected vehicle applications in the mountainous terrain. The main challenge in the mountainous terrain is the realization of efficient and reliable wireless links to establish multiple hops and efficiently disseminate data for seamless operation. Furthermore, the propagation characteristics of electromagnetic (EM) waves in the mountainous terrain prevent a straightforward characterization of wireless channel. Hence, advanced propagation and multi-path models are required to investigate the effects of mountains in wireless communication.

This research provides advanced models and techniques to completely characterize the mountainous wireless channel and lay out the foundations for efficient communication in the connected vehicle environment. This model aims to characterize the propagation of EM wave in mountains by considering multipath, and other factors. Based on these peculiarities of communication in mountains, an optimization framework is developed to characterize cross-layer communication aspects in connected vehicle environment in the mountainous terrain. This framework jointly models problems at various protocol layers such as medium access control, routing, and transport in a cross-layer fashion. Moreover, a cross-layer framework is investigated to analyze the effects of various error control techniques and determine the optimal packet size in a connected vehicle environment in the mountainous area. This optimization framework is based on three main optimization functions in terms of energy consumption, throughput, and resource utilization. Consequently, efficient communication protocols can be developed based on the foundations of the channel model developed in this research and the most efficient error control techniques determined by this framework.

The main difference between the VANETs in the mountainous areas and the VANETs in plains is the impact of mountains on vehicle-to-vehicle (V2V) and vehicle-to-infrastructure

(V2X) communications by use of Dedicated Short Range Communications (DSRC) Technology. In this project, we first investigate the wireless channel characteristics in mountainous areas and their impact on connected vehicle applications. Then based on the analysis, the network, data link and physical layer protocols are developed to realize a curve speed warning prototype system which is particularly useful in mountainous areas.

The findings from this project could guide the development of other connected vehicle applications in the mountainous terrain. On one hand, these applications not only include safety applications to increase situational awareness and reduce or eliminate crashes , but also mobility applications to manage the transportation system for optimum performance, and environmental applications to support and facilitate "green" transportation choices. On the other hand, these applications are expandable to other mountainous areas of the United States, including Colorado, Maine, New Hampshire, and New Jersey.

With the support of West Virginia Higher Education Policy Commission, we have established a connected vehicle testbed called Mountain-oriented Optimal Ubiquitous Networked Transportation (MOUNT) at West Virginia University. To our knowledge, this testbed is the first transportation cyber-physical system testbed in the world tailed to the needs of improving traffic safety, mobility and environmental protection in the mountainous terrain.

Bio

Houbing Song is an assistant professor of Electrical and Computer Engineering at West Virginia University and the founding director of both West Virginia Center of Excellence for Cyber-Physical Systems (WVCECPS) and Security and Optimization for Networked Globe Laboratory (SONG Lab). Dr. Song's research interests lie in the areas of wireless communications and networking, cyber-physical systems, internet of things, connected vehicles, and intelligent transportation systems. Dr. Song's research has been supported by the National Science Foundation, West Virginia Higher Education Policy Commission, and West Virginia Department of Transportation.

He received the Ph.D. degree in Electrical Engineering from the University of Virginia in 2012, the M.S. degree in Civil Engineering from the University of Texas in 2006, and the M.S. degree in Electrical Engineering from Xi'an Jiaotong University in 2004. In 2007, he was an engineering research associate at the Texas A&M Transportation Institute.

He was the principal developer of DynaCHINA (Dynamic Consistent Hybrid Information based on Network Assignment), one of three real-time traffic estimation and prediction systems in the word (the other two are DynaMIT and DynaSMART).

Dr. Song is a member of IEEE and ACM. Dr. Song has served on the technical program committee for numerous international conferences, including ICC, GLOBECOM, INFOCOM, WCNC, SmartGridComm, SECON, ICCVE, VNC, OFC, ICCPS, GreenCom, WiMob, ICIP, ICCIT, ICIIP, CEAT, PECON, ISIEA, EUSPN and ChinaCom. Dr. Song was the general chair of the first IEEE ICCC International Workshop on Internet of Things (IOT 2013), held in Xi'an, China, and the general chair and the technical program committee chair of the first symposium on Cyber-Physical Systems (CPS 2013), held in Montgomery, WV. Dr. Song is an area editor or associate editor for several international journals and a lead guest editor of a special issue. Dr. Song has been the associate editor-in-chief of the blue book series in internet of things since 2011. Dr. Song has published more than 40 academic papers in peer-reviewed international journals and conferences.