**Performance Enhancement through Two-Hop Network by Relay Selection in V2X Communication**

**Chapetr.1 Introduction**

* 1. **Background**

In recent decades, issues emerge with the development of transportation: about traffic congestion, especially in urban centres; about the impacts on energy consumption and air pollution; and about highway-related fatalities and injuries due to crashes. [J., Powell, G., R., Yoon, R., Fikentscher, J., Doyle, C., Sade, D., Lukuc, M., Simons, J., & Wang, J. (2014, August). *Vehicle-to-vehicle communications: Readiness of V2X technology for application.* (Report No. DOT HS 812 014). Washington, DC: National Highway Traf c Safety Administration]. Governments and organizations all over the world have recognized the need to address these issues. According to the World Health Organization (WHO) fact sheet about road traffic injuries, on a global scale, around 1.25million people die from traffic crashes every year. [‘'Scenarios, requirements and KPIs for 5G mobile and wireless system,” ICT-317669-METIS/D1.1, METIS deliverable D1.1, Apr. 2013. [On- line]. Between 20 and 50 million more people suffer non-fatal injuries, with many incurring a disability as a result of their injury.

Between 20 and 50 million people suffer from a disability as a result of traffic crashes. Without sustained action, road traffic crashes are predicted to become the seventh leading cause of death by 2030. Human error is the main reason leading to traffic crashes. World Health Organization. [(2016, November) Road track injuries-fact sheet. (last accessed 03-March-2017). [Online]. Available: http://www.who.int/mediacentre/ factsheets/fs358/en.]. So it is urgent to create wireless communication to enable the vehicles to exchange their datum with each other and roadside infrastructures. This new creating wireless communication technology is designed to provide a solution to ensure high reliability under challenging vehicular environment, such as high relative speed between transmitters and receivers. Also, low latency is required for safety-related applications. Such as vehicle trash ahead of the highway. Messages should be broadcast to all vehicles close to the location in a short time. [Alotaibi M M, Mouftah H T. Relay Selection for Heterogeneous Transmission Powers in VANETs[J]. IEEE Access, 2017, 5(99):4870-4886.]

**1.2 History of C-ITS**

In the recent times, the development of Cooperative Intelligent Transport Systems(C-ITS) has the potential to play a significant role in addressing the increasing problems of congestion, safety and environment in Europa. [study on the deployment of C-ITS in Europa: final report] The C-ITS Platform has been launched in 2014 and has delivered the final report of its first phase in January 2016.Preparatory work for the Delegated Act has started in May 2016 with a first meeting of Member State experts. And the preparatory work builds on the findings of the first phase of the Platform for the Deployment of C- ITS in the EU. The Amsterdam Group complements the work of the C-ITS Platform through connecting the C-ITS pilots and deployment initiatives with the goal of interoperable deployments which is facilitated by sharing information as well as discussing and mitigating possible divergent approaches. The Amsterdam Group was formed in 2011 as a strategic partnership between the automotive industry within the CAR 2 CAR Communication Consortium (C2C-CC) and infrastructure organisations (CEDR, ASECAP, POLIS) as committed core stakeholders in the C-ITS deployment. [State-of-the-Art Analysis of C-ITS Deployment]

**1.3. The best solution for solving the issue**

Recently, governments and companies are supporting the development about C-ITS and vehicle-to-everything (V2X) communication.V2X communication involved with automatically connected vehicles and road infrastructures has arisen great attention. [Li X, Hu B J, Chen H, et al. Multi-hop delay reduction for safety-related message broadcasting in vehicle-to-vehicle communications[J]. Communications Iet, 2015, 9(3):404-411.] which serves as one of the key technologies for realising a plenty of applications related to vehicles, drivers, passengers and pedestrians. Some obvious benefits of V2X communications, including improving road safety by warning drivers under some dangerous condition, reducing time delays when vehicles pass the tollbooths, reducing energy consumption, enhancing mobility, increasing service reliability, enabling groups of cars to exchange multimedia information, and supporting economic development [ Matolak D W, Sun R, Liu P. V2X channel characteristics and models for 5 GHz parking garage channels[C]//Antennas and Propagation (EuCAP), 2015 9th European Conference on. IEEE, 2015: 1-4.] And V2X communication is a remarkable embodiment to support road safety and traffic efficiency applications in future C-ITS. Investigations on all aspects of ITS are rapidly increasing. [ITS project, <http://www.its.dot.gov/index.htm,Nov.2007>] Also, governments, industries and academia have invested plenty of capital for V2X and C-ITS. [ Matolak D W, Sun R, Liu P. V2X channel characteristics and models for 5 GHz parking garage channels[C]//Antennas and Propagation (EuCAP), 2015 9th European Conference on. IEEE, 2015: 1-4.]

United States of America (USA) is one of the leading countries in this field. On July 6, 2012, President Obama signed into law a two-year transportation reauthorization bill, the Moving Ahead for Progress in the 21st Century Act. Part of this law is dedicated to ITS activities. The possibility to reduce crashes in USA brought about the focus on a set of critical crash V2X safety applications. [112th Congress-Public Law 112-141, “Moving ahead for progress in the 21st century act (MAP21),” U.S. Government Printing O ce, pp. 1–584, January 2012.]

Also in china, State Council announced plan to build Intelligent Connected Vehicles Pilot Area in Shanghai on September 2015. [C-ITS Status in China — To the 8th ETSI ITS Workshop Sophia Antipolis, March 08,2015] <http://www.gov.cn/zhengce/2015-09/30/content_2940909.htm>

**1.4 Main challenge**

In contrast to the traditional cellular mobile radio link, the V2X propagation channel is much more dynamic, since it consists of two non-stationary transceivers, closely located to the ground level. Current legacy solutions for V2X communications are based on 802.11p standard with infrastructure assistance in long term evolution (LTE) network. [C. Lottermann, M. Botsov, P. Fertl, and R. Mullner, “Performance evaluation of automotive off-board applications in LTE deployments,” in *IEEE Vehicular Networking Conference (VNC)*, 2012.] However, 802.11p legacy solution is mainly optimized for a WLAN-type of environment with much lower mobility. V2X communications are often divided into varied environments, such as highway, urban, and rural areas. Vehicles under these scenarios always need higher velocity, [Matolak D W, Sun R, Liu P. V2X channel characteristics and models for 5 GHz parking garage channels[C]//Antennas and Propagation (EuCAP), 2015 9th European Conference on. IEEE, 2015: 1-4.] especially under highway scenario. In this paper, highway is the main scenario which used for analysing the performance of V2X.

On the other hand, the operating performance for vehicular communication is not enough, especially in the field of latency and reliability. So the new generation of wireless communication should be able to meet the high requirements of reliability and availability. In order to meet the demand of new developing service types like vehicular communications, fifth generation(5G) is designed to fulfil these requirements. [Lianghai J, Liu M, Weinand A, et al. Direct vehicle-to-vehicle communication with infrastructure assistance in 5G network[C]//Ad Hoc Networking Workshop (Med-Hoc-Net), 2017 16th Annual Mediterranean. IEEE, 2017: 1-5.]

[Le L, Festag A, Mader A, et al. Infrastructure-assisted communication for car-to-X communication[C]//Proceedings of the ITS world congress. 2011.]

[Vinel, A. *3GPP LTE Versus IEEE 802.11p/WAVE: Which Technology is Able to Support Cooperative Vehicular Safety Applications* Wireless Communications Letters, IEEE, vol.1, no.2, pp.125,128, April 2012.]

[Araniti, G.; Campolo, C.; Condoluci, M.; Iera, A.; Molinaro, A. *LTE for vehicular networking: a survey* Communications Magazine, IEEE, vol.51, no.5, pp.148,157, May 2013]

**1.5 Thesis structure**

The structure of this master thesis is organized as the following chapters.

**Chapter 2** Describes V2X communication and the user cases of V2X communication. It also describes the system architecture of V2X communications and advantages and disadvantages.

**Chapter 3** Describes the system models, and analyze system parameters. Meanwhile, it explains the dedicated channel model for V2X communication system in our work.

**Chapter 4** Describes the two-hop network and resource allocation between the two hop direct V2X communications. And introduces the advantages of this network with mathematics support. Also, we decide the way how we assign frequency bandwidth for these two hops with mathematics analysis.

**Chapter 5** Describes the relay selection algorithm and compares different relay selection methods. And introduces the advantages of our algorithm.

**Chapter 6** Analyses the result according to BLER and SINR, and achieve some important results through chart analysis. In addition, we summarize the achievements of our work.

**Chapter 7**

Presents the conclusion of our work, and underlines the

objectives achieved in this paper. Next step is to set up for future

development.