AN OPTIMIZED OF CONGESTION CONTROL MECHANISM OF VANETs FOR NON-SAFETY MESSAGES TRANSMISSION USING TAGUCHI METHOD

by

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LIST OF ABBREVIATION

AP	Access Point
AODV	Ad hoc On-Demand Distance Vector
BE	Best Effort Traffic
BK	Background Traffic
BSS	Basic Service Set
CCH	Control Channels
CRaSCH	Cooperative Reservation of SCH
CSMA/CA	Carrier Sense Multiple Access with collision avoidance
DSRC	Dedicated Short Range Communication
DCF	Distributed Coordination Function
DSCA	Dynamic Service-Channels Allocation
DYMO	Dynamic MANET On-demand
DSR	Dynamic Source Routing
EDCA	Enhanced Distributed Channel Access
FCC	Federal Communications Commission
FIFO	First in First out
GPRS	General Packet Radio Service
GPS	Global-Position-System
IEEE	Institute of Electrical and Electronics Engineers
ITA	Intelligent Transport Application
ITS	Intelligent transports system
ISM	Industrial, Science and Medical

MAC	Medium Access Control
MANET	Mobile ad hoc Network
MF	Mobility Framework
NHTS	National Highway Traffic Safety Admin
NAs	Network-Authorities
OBE	On-board-Equipment
OBU	On board units
OFDM	Orthogonal Frequency Division Multiplexing
OSI	Open System Interconnect
PCF	Point Coordination Function
PDR	Packet Delivery Ratio
RERR	Route Error
RREQ	Route Request
RREP	Route Reply
RSU	Road-side-unit
RTAs	Regional-Transportation-Authorities
SPAT	Signal-Phase-and-Timing
SCH	Service Channels
TEA	Transport-Efficiency-Applications
TSA	Transport-Safety-Applications
UMTS	UTRA Terrestrial Radio Access Time Division Duplex
VIN	Vehicle Identification Number
VSC	Vehicle-Safety-Communication

VSCC	Vehicle Safety Communication Consortium
VANET	Vehicular Ad hoc Network
V2V	Vehicle to Vehicle
V2R	Vehicle-to-Roadside
V2I	Vehicle-to-Infrastructure
V2I	Vehicle to Infrastructure
VCI	Variable CCH interval
VO	Voice Traffic
VI	Video Traffic
WAVE	Wireless Access in Vehicular Environment
WLAN	Wireless Local Area Network

Pengoptimuman Mekamisme Kawalan Kesesakan dalam VANETs Untuk Non-Safety Mesej Transmisi Menggunakan Kaedah Taguchi

ABSTRAK

VANETs adalah konsep teknologi baru terkini terhasil daripada MANETs. Kelajuan tinggi dan perubahan topologi rangkaian yang kerap adalah ciri-ciri utama VANETs dan akses Internet. Teknologi rangkaian menyediakan aplikasi kenderaan yang tidak berkesudahan, termasuk bukan keselamatan, keselesaan dan hiburan. Kelajuan tinggi dan mobiliti nod dan pemotongan servis yang kerap adalah sukar untuk merekabentuk skim MAC dalam VANETs yang memenuhi keperluan servis kualiti (QoS) dalam semua senario rangkaian. Dalam tesis ini, kami menyediakan penilaian yang komprehensif pada kesan pergerakan dan perubahan terhadap IEEE 802.11p MAC. Kajian ini menggunakan metrik prestasi asas seperti nisbah kelewatan, nisbah penghantaran paket (PDR) dan pemprosesan, serta kesan mobiliti. Kajian ini juga membahaskan hubungan antara faktor-faktor mobiliti dan kesan akses mengikut perubahan dalam persekitaran rangkaian yang diujilari. Selain itu, masalah kelajuan relatif nod dikenalpasti untuk scenario bandar (eCCOM), lebuh raya (paMAC) dan hibrid (inHAN). Untuk mencapai prestasi yang baik, kami mencadangkan mekanisme pengoptimuman yang bijak bagi kawalan kesesakan dan algoritma untuk mengurangkan kemerosotan prestasi rangkaian. Keputusan simulasi yang diujilari menunjukkan kesan yang ketara ke atas prestasi mobiliti IEEE 802.11p MAC, pengenalpastian masalah ketidakadilan baru dalam V2I komunikasi. Akhirnya, kesimpulan eksperimen kami untuk eCCOM, kami meminimumkan kelewatan dengan purata peningkatan sehingga 21%, 5%, 13%, 18% dan 17% untuk dalam tempuh penghantaran, saiz paket, masa simulasi, saiz kadar bit dan bilangan kenderaan . Kami juga mengoptimumkan PDR dengan peningkatan purata sehingga 22%, 19%, 35%, 4% dan 15% dan pemprosesan yang lebih baik dengan peningkatan purata sehingga 25%, 5%, 32%, 11% dan 8% dalam tempuh penghantaran, saiz paket, masa simulasi, saiz kadar bit dan bilangan kenderaan masing-masing. Dalam paMAC penggurangan kelewatan dengan purata peningkatan sehingga 34%, 6%, 28%, 8% dan 9% untuk dalam tempuh penghantaran, saiz paket, masa simulasi, saiz kadar bit dan bilangan kenderaan. Kami juga mengoptimumkan PDR lebih baik dengan purata peningkatan sehingga 23%, 8%, 15%, 7% dan 14% dan pemprosesan yang lebih baik dengan purata peningkatan sehingga 33%, 7%, 29%, 11% dan 7% untuk dalam tempuh penghantaran, saiz paket, masa simulasi, saiz kadar bit dan bilangan kenderaan masing-masing. Bagi inHAN penggurangan kelewatan dengan purata peningkatan sehingga 27%, 13%, 10%, 9% dan 26% dalam tempuh penghantaran, saiz paket, masa simulasi, saiz kadar bit dan bilangan kenderaan. Kami juga mengoptimumkan PDR lebih baik dengan purata peningkatan sehingga 36%, 33%, 7%, 23% dan 27% dan pemprosesan yang lebih baik dengan purata peningkatan sehingga 39%, 24%, 20%, 10% dan 23% untuk dalam tempuh penghantaran, saiz paket, masa simulasi, saiz kadar bit dan bilangan kenderaan masing-masing. Mekanisme kami memperkenalkan metrik yang dinamik dalam ujilari kepadatan kenderaan didalam senario eCCOM, paMAC dan inHAN untuk mengawal penghantaran paket antara kenderaan dan infrastruktur. Keputusan kami menunjukkan potensi yang besar untuk penyelidikan masa depan dan penggunaan teknologi tinggi dalam bidang VANETS.

An Optimized Congestion Control Mechanism of VANETs for Non-Safety Messages Transmission using Taguchi Method

ABSTRACT

Vehicular ad hoc networks (VANETs) are emerging technology concept in mobile ad hoc networks (MANETs). High speed and frequent network topology changes are the main characteristics of vehicular networks and Internet accessibility. This networking technology provides vehicles with endless possibilities of applications, including non-safety, comfort and entertainment. Due to high speed and mobility of nodes and their frequent disconnections, it is difficult to design a MAC scheme in VANETs that satisfies the Quality-of-Service (QoS) quality-of-service requirements in all networking scenarios. In this thesis, we provide a comprehensive evaluation of the mobility impact on the IEEE 802.11p MAC performances. The study evaluates basic performance metrics such as delay, packet delivery ratio (PDR), throughput, as well as the impact of mobility factors. The study also presents a relation between the mobility factors and the respective medium access impact according to the changes in tested network environment. Moreover, a new discriminatory problem according to node relative speed is identified for city (eCCOM), highway (paMAC) and hybrid (inHAN) scenarios. To achieve better performance, we propose smart optimization mechanism for congestion control and algorithm to alleviate network performance degradation due to high mobility. Extensive simulation results show the significant impact of mobility on the IEEE 802.11p MAC performance, an identification of a new unfairness problem in the vehicle-to-infrastructure (V2I) communications. Finally, we conclude the experiment for eCCOM by minimize the delay with the average improvements of up to 21%, 5%, 13%, 18% and 17% in send interval, packet size, simulation time, bit rate size and number of vehicles. We also optimize PDR better with the average improvements of up to 22%, 19%, 35%, 4% and 15% and the throughput performs better with the average improvements of up to 25%, 5%, 32%, 11% and 8% in send interval, packet size, simulation time, bit rate size and number of vehicles respectively. In paMAC we minimize the delay with the average improvements of up to 34%, 6%, 28%, 8% and 9% in send interval, packet size, simulation time, bit rate size and number of vehicles. We also optimize PDR better with the average improvements of up to 23%, 8%, 15%, 7% and 14% and the throughput performs better with the average improvements of up to 33%, 7%, 29%, 11% and 7% in send interval, packet size, simulation time, bit rate size and number of vehicles respectively. As for inHAN we minimize the delay with the average improvements of up to 27%, 13%, 10%, 9% and 26% in send interval, packet size, simulation time, bit rate size and number of vehicles. We also optimize PDR better with the average improvements of up to 36%, 33%, 7%, 23% and 27% and the throughput performs better with the average improvements of up to 39%, 24%, 20%, 10% and 23% in send interval, packet size, simulation time, bit rate size and number of vehicles respectively. Our mechanism introduces a dynamic metric that depends on the vehicular density on eCCOM, paMAC and inHAN in order to control the packet transmissions inter-vehicle-infrastructure. Our results show great potential for future research direction and usage in the area of vehicular technology.

CHAPTER 1

INTRODUCTION

1.1 Background

The rapid evolution and cost reduction of wireless communication technologies in the last decade have made them suitable for a wide spectrum of mobile and wireless applications. There are huge number of vehicles travelling along highways and streets around the world which produce millions of data being transmitted daily throughout the entire world. Therefore, there is a growing demand for real-time collision avoidance and warning technology to improve data transmission both for safety and non-safety messages and applications. Vehicular ad hoc networks (VANETs) consist of smart vehicles on the road and provide useful communication services among arbitrary-formed collections of vehicles that are geo-located and with road side infrastructures. Due to quick advance technology, vehicles nowadays come with embedded computers, route planner, GSM/GPRS/WCDMA cellular networks, Global Positioning System (GPS), access to road-side wireless sensors devices and WiFi access point (Chao and Zeadally, 2008). Vehicular ad-hoc networks (VANETs) are derived from MANET mobile networks and wireless communication is applied between vehicles as mobile network nodes (Janech, Lieskovsky, & Krsak, 2012; Tayal & Triphathi, 2011). VANET communication has recently become a common research topic in the area of wireless networking. The goal of VANET research is to formulate a vehicular communication system that provides the increase in data usage for passengers' safety and comfort (Lan & Chou, 2008).

According to T. C. Wang & Chang, (2011), there are two main categories of VANET applications: safety applications and user (or non-safety applications). The former is designated on the safety of vehicle on the road and can be used to warn cars of accidents as well as to prevent traffic jams. In addition, these applications can trigger the drivers to be wary of the early warnings to prevent accidents from happening. The latter implementation provides value added services in particular entertainment. For example, the drivers are able to share audio or video data between roadside units or vehicles T. C. Wang & Chang, (2011); Barberis & Malnati, (2011).

The envisioned applications range from critical safety applications, services and advanced driver assistance systems to traffic management and infotainment applications for intelligent transport applications, and comfort applications (Sichitiu & Kihl, 2008). For non-safety applications to work, it is significant that non-safety message must be reliably delivered to the designated vehicle in a timely manner. In line with this, a number of studies have been done to design and develop a reliable routing protocols in VANET (Ros et al., 2009; Lai et al.,2009 ; Yadumurthy, et al. 2005). However, in VANET, a single hope transmission is usually unable to cover all the intended receivers due to limited radio range across a larger distance. Therefore, a multi hop broadcast protocol is necessary to establish communication between vehicles. As a result, it is necessary to develop reliable and robust routing protocols in VANETs.

The implementation of message dissemination is one of the main challenges of VANET. In VANET, the network topology changes rapidly, which causes frequent