



Cairo University

SINGLE CHANNEL SLOTTED CONTENTION FOR COGNITIVE RADIO VEHICULAR NETWORKS

By

Nada Gamal Ahmed Ibrahim Elgaml

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Electronics and Communications Engineering

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Title of Thesis:

Single Channel Slotted Contention For Cognitive Radio Vehicular Networks

Key Words:

Cognitive Radios; Vehicular Networks; Slotted Contention; IEEE 802.11p.

Summary:

Cognitive Radio Vehicular Ad-hoc Networks (CR-VANETs) exploit the dynamic spectrum capability of cognitive radios to allow the vehicles to access the unused channels in their vicinity. The existing VANETs protocols are not originally designed as enablers for cognitive radios. Therefore, CR-VANETs do not only suffer the traditional CR problems, especially in spectrum sensing, but also suffer new challenges due to the highly dynamic nature of VANETs. This thesis presents a spectrum sensing and reporting protocol for non-safety applications, which counters the deficiencies of typical CR-VANETs in high-density networks. We introduce the Single Channel Slotted Contention (SC)² protocol for highly dense vehicular traffic on highways. The proposed protocol consists of three main components: random single channel sensing, slotted contention and implicit aggregation. The proposed (SC)² protocol can be easily incorporated with the IEEE 802.11p. Simulation results show that the proposed protocol increases the secondary throughput and spectrum utilization while significantly decreasing the radio environment map time in high densities when compared to the legacy IEEE 802.11p based protocols. A trade-off between the primary outages and the secondary throughput can be controlled via the contention window size. We also analytically study the collision probability and secondary throughput of the (SC)² and the IEEE 802.11p based protocols.

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Dedication

To my beloved parents,
Gamal Elgaml & Sahar Saad

My dear siblings,
Sara, Ali & Mostafa

My beautiful nieces,
Bisan & Nuria

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List of Abbreviations

1G	1st Generation
2G	2nd Generation
3G	3rd Generation
4G	4th Generation
AC	Access Categories
<i>AC_BE</i>	Access Categories- Best Effort
<i>AC_BK</i>	Access Categories- Background
<i>AC_VO</i>	Access Categories- Voice
<i>AC_VI</i>	Access Categories- Video
ADC	Analog to Digital Converter
AIFS	Arbitrary Inter-Frame Spacing
AIFSN	Arbitrary Inter-Frame Spacing Number
AODV	Ad-Hoc On Demand Distance Vector
ANPR	Automatic Number Plate Recognition
AU	Application Unit
ASIRD	Association for Safe International Road Drive
AWGN	Additive White Gaussian Noise
argmax	Arguments of Maxima
argmix	Arguments of Minima
BP	Belief Propagation
CCH	Control Channel
CCCH	Common Control Channel

CH	Cluster Head
CoVANET	Cognitive Vehicular Ad-hoc Networks
Cog-V2V	Cognitive Vehicular-to-Vehicular
CR	Cognitive Radio
CR-VANET	Cognitive Radio- Vehicular Ad-hoc Networks
CSMA/CA	Carrier Sensing Multiple Access/ Collision Avoidance
CW	Contention Window
DCF	Distributed Coordination Function
DIFS	DCF Inter-Frame Space
DSA	Dynamic Spectrum Access
DSR	Dynamic Source Routing
DSRC	Dedicated Short Range Communication
DTN	Delay-Tolerant Networking
EDCA	Enhanced Distributed Channel Access
FC	Fusion Center
FCC	Federal Communication Commission
FFT	Fast Fourier Transform
FIFO	First-In-First-Out
GPS	Global Positioning System
GSM	Global System for Mobile-communication
GNSS	Global Navigation Satellite System
HCM	Highway Capacity Manual
IEEE	Institute of Electrical and Electronics Engineers
IFS	Inter-Frame Spacing
ISM	Industrial, Scientific and Medical

ITS	I ntelligent T ransport S ystem
LOS	L ine O f S ight
LTE	L ong T erm E Evolution
MAC	M edium A ccess C ontrol
MLR	M aximum L ikelihood R atio
NHTSA	N ational H ighway T raffic S afety A dministration
OBU	O n B oard U nit
OFDM	O rthogonal F requency D ivision M ultiplexing
OSA	O pportunistic S pectrum A ccess
PCF	P oint C oordination F unction
PDF	P robability D ensity F unction
PN	P rimary N etwork
PU	P rimary U ser
PHY	P hysical
QoS	Q uality of S ervices
REM	R adio E nvironment M ap
RSU	R oad S ide U nit
SCH	S ervices C hannels
$(SC)^2$	S ingle C hannel S lotted C ontention
SIFS	S hort I nter- F rame S pacing
SIO	S ense- I n- O rders
SNR	S ignal to N oise R atio
SU	S econdary U ser
TORA	T emporally- O rders R outing A lgorithm
TXOP	T ransmission O pportunities