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EFFICIENT RESOURCE ALLOCATION IN VANET

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Abstract*- Service availability in wireless networks is highly dependent on efficient resource allocation and guaranteed Quality of Service (QoS) amid overloads and failures. This addresses optimal bandwidth allocation in a hybrid network (cellular and ad hoc), where added reach through an ad hoc overlay is combined with the stability and essential services of a cellular network. The paper builds on a near optimal approach in which Resource-Utility functions are used as a means of adaptive delivery of QoS, user differentiation, and maximisation of system level utility. It distinguishes between non-adaptive, semi-adaptive, and fully adaptive applications. First, the global cellular bandwidth allocation (in the presence of multiple routes through ad hoc relays) is cast in terms of a Linear Programming problem. Second, a heuristic algorithm that has far lower computational overhead and accrues at worse 12% less than the utility of the optimal solution is presented. Both algorithms are implemented within a model of a hybrid network on top of the JSim simulation environment. Comparative studies are made to show effective load balancing and crash tolerance in the presence of a high traffic overload. Our work is diverse from previous mechanism in to facilitate we present topical advances and open inspect directions on applying cognitive radio in vehicular ad hoc networks (CR-VANETs) focusing on architecture, machine knowledge, support, reprogram ability, and spectrum supervision as well as QoE optimization for infotainment applications.

I. INTRODUCTION

Vehicular Ad-Hoc Network (VANET) is a subset of Mobile Ad-Hoc Network (MANET) where smart vehicles act as mobile nodes and their movement is governed by road topologies [1]. The aim to develop VANET is to provide drivers and passengers with a reliable and safe environment. A typical VANET environment is composed of vehicles and infrastructure as shown in Fig. 1. The vehicles communicate each other with the help of vehicle-to-vehicle (V-2-V) communication and with Road-Side Unit (RSU) with the help of vehicle-to-infrastructure (V-2-I) communication. Each vehicle is equipped with an On-Board Unit (OBU) that has computational and communication capabilities [2]. According to Dedicated Short Range Communication (DSRC) standard, a vehicle periodically broadcasts traffic and safety related messages known as beacons [3].

These beacons contain information such as vehicle's speed, location, direction and traffic events such as congestion or accident. This information helps drivers forming a contextual view of traffic conditions that enable them to avoid situations like congested routes or accidents. However, the privacy of such information is critical because it may reveal whereabouts of a traveller. For instance, starting and ending positions of a private vehicle can often be the address of home and office of a commuter. Currently, the US Federal Communications Commission (FCC) has allocated 75 MHz and the European Telecommunications Standards Institute (ETSI) allocated 30 MHz of spectrum in 5.9 GHz band for the deployment of Intelligent Transportation Systems (ITS) services. However, a significant rise in vehicular applications, especially in urban environments, with several vehicles, may lead to overcrowding of the band and thereby resulting in degraded vehicular communication efficiency for safety applications, as pointed out in Moreover, not only safety applications, but also growing demand and usage of in-car entertainment and information systems comprising bandwidth demanding multimedia applications (e.g., video streaming). [5][7][8]

II. EXISTING METHOD

Consider cellular networks coexist with ad hoc networks sharing the same spectrum, as shown in Fig. 1. The spectrum belongs to the cellular network and it is reused by different cells. The locations of BSs and MUs are modeled as two independent homogenous PPPs $\Pi b = \{xi, i \in Z\}$ and $\Pi m = \{yi, i \in Z\}$ with intensities λb and λm, respectively. Each MU is served by its nearest BS. As plotted in Fig. 1, the cellular network forms a

Poisson Tessellation of the plane and each cell is known as a Voronoi cell. Each BS communicates with one randomly selected MU in its cell via a downlink. The adhoc network is overlaid with the cellular network and it forms the secondary system.[8][9]

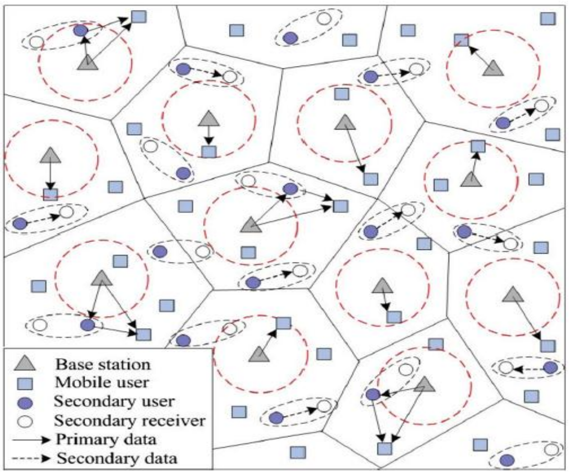

Figure 1.cellular networks coexist with ad hoc networks

The locations of SUs follow another PPP with intensity λs, i.e., Πs = {zi, i ∈ Z}. Each SU has a receiver departed d meters away. This assumption may be easily relaxed but at the cost of complicating the derived expressions without providing additional insight as picking the distance d from a random distribution only reduces the transmission capacity by a constant factor. The Aloha-type protocol is adopted in the ad-hoc network to control the channel access of SUs. Whether a SU could access the channel or not is determined by the media access probability (MAP) $\xi \in (0, 1)$.[10]

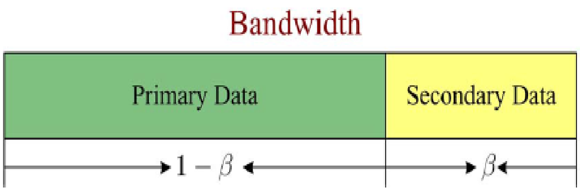

Figure 2. Band Width Model

The channel between any pair of terminals u1 and u2 undergoes small-scale block fading and large-scale path-loss. The channel power gain Gu1, u2 is exponentially distributed with unit mean, and it is independent across links. The path-loss is _−α u1, u2, where _u1, u2 is the distance and α is the path-loss exponent. The symbol u2 in the subscript is omitted for brevity if u2 lies at the origin. The interference-limited environment is considered and the effect of noise is neglected.[1]

A. SPECTRUM SHARING MODEL

We consider the overlay spectrum sharing, where a fraction of spectrum is released to the ad-hoc network in exchange for its cooperation for the cell-edge communication. Without loss of generality, the total bandwidth is set as one and the spectrum released to the secondary system is $\beta \in (0, 1)$, while the remaining $1 - \beta$ fraction of spectrum is reserved by the primary system, as shown in Fig. 2. The primary system and secondary system do not interfere with each other as they use disjoint frequency bands. If the randomly selected MU lies at the cell-interior of its serving BS, the direct transmission is performed, because the channel is usually good and the interference is relatively weak. The bandwidth release may be tolerated by the primary downlink. The interior area is defined as a circular area entered at the BS with radius $c0$. However, if the MU lies at the cell-edge of its serving BS, cooperative communications are employed. With the cooperation from SUs, the throughput of primary data transmission can be enhanced to combat the strong interference. Moreover, the benefits of cooperation can be exploited to combat the negative effect of spectrum.[1]

B. COOPERATION MODEL

The truncated automatic repeat request (ARQ) scheme with one-time retransmission is adopted for the communication between BS and its cell-interior MU. If the original transmission is successful, the acknowledgement (ACK) frame is fed back and the BS continues to transmit a new data packet. Otherwise, the negative acknowledgement (NACK) frame is released and the BS retransmits the same data packet. The received signals in both the original and the retransmission phases are maximal ratio combined (MRC) by the cell interior MU for the detection.

The existing cooperative truncated ARQ scheme based on
DF protocol which is also known as the DF based incremental relaying is adopted to assist the data transmission between the BS and its cell-edge MU. As shown in Fig. 3, a cooperation region is applied between the BS and its cell edge MU, which can be designated by the BS through a handshake process or determined automatically by each SU using its estimated location obtained from the localization technique[3][5]

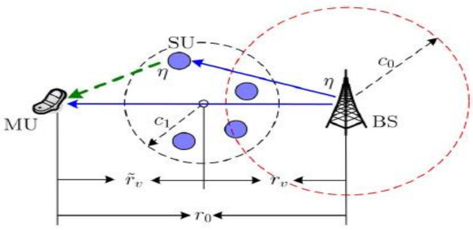

Figure 3.3 Cooperation model

The distance between BS and the center of cooperation region is denoted as rv = ζr0 with 0 < ζ < 1, while the distance between the center of cooperation region and the cell-edge MU is ˜rv = (1 − ζ)r0. The SUs in the cooperation region will help the primary data transmission. In the original phase, the BS broadcasts its data to the intended cell-edge MU and all the SUs in the cooperation region. The SUs that can correctly decode the original primary data are called decoding SUs. Three cases will occur according to whether the MU and the SUs correctly receive the primary data or not.

• **Case I:** The cell-edge MU correctly receives the data packet, and the ACK frame is broadcast. The SUs in the cooperation region refresh their memories and the BS continues to transmit a new data packet.

• **Case II:** The cell-edge MU erroneously receives the primary data and a NACK frame is fed back. There are no SUs or no decoding SUs in the cooperation region. In this case, the BS retransmits its original data and all the SUs in the cooperation region keep silent.

• **Case III:** The cell-edge MU erroneously receives the primary data and a NACK frame is released. There exists at least one decoding SU in the cooperation region and the one with best channel state towards the cell-edge MU retransmits. The best decoding SU can be selected in a distributed way using the time back-off or signalling burst scheme. When the selected SU performs the retransmission, the BS together with all the other SUs in the cooperation region will keep silent.[2][8]

C. TRANSMISSION CAPACITY OF SECONDARY SYSTEM

Maximize the transmission capacity of secondary system while satisfying the primary performance requirement. The optimization problem is formulated as

$$\max_{\lambda_s > 0, 0<\beta<1} \; C_s^{\epsilon} = \xi \lambda_s (1-\epsilon) T_1$$
$$\text{s.t.} \quad P_{\text{out}}^{s}(\lambda_s, \beta) \le \epsilon$$
$$\frac{V_c(\lambda_s, \beta) - V_d}{V_d} \ge \rho$$

Where Cs is the transmission capacity of secondary system. The transmission rate of each secondary link is assumed to be the same and it is denoted as T1. The outage probability Ps out(λs, β) of each secondary link should be no larger than the target outage probability. The average throughput of primary system with and without cooperative spectrum sharing is denoted as Vc(λs, β) and Vd, respectively. The parameter ρ ≥ 0 represents the required throughput improvement ratio of the primary downlink introduced by the cooperative spectrum sharing. The optimal SU density λs and the optimal bandwidth allocation factor β are investigated for the optimization problem. Since SUs transmit according to an Aloha-type protocol. The simultaneous transmitting SUs form a homogeneous PPP˜Π s with density ξλs, which is obtained through an independent thinning of Πs. The achievable rate of secondary data transmission is given as

$$R_s = \beta \log_2\left(1 + \frac{G_{z_0} d^{-\alpha}}{\mathcal{I}_s}\right)$$

Where *Gz*0 is the small-scale power fading. The pre-factor *β* is applied in due to the division of bandwidth for the spectrum sharing. The interference term in is expressed as

$$\mathcal{I}_{\mathrm{s}} = \sum_{z \in \tilde{\Pi}_{\mathrm{s}} / \{z_0\}} G_z \ell_z^{-\alpha}$$

Where all the active SUs except the typical one contribute to the aggregate interference. The outage probability of this typical secondary link is derived as

$$\begin{aligned} P_{\mathrm{out}}^{\mathrm{s}}(\lambda_{\mathrm{s}}, \beta) &= \mathbb{P}\{R_{\mathrm{s}} < T_1\} = \mathbb{P}\{G_{z_0} < \tau_1 d^{\alpha} \mathcal{I}_{\mathrm{s}}\} \\ &= 1 - \exp\left[-\xi \lambda_{\mathrm{s}} \pi \tau_1^{\frac{2}{\alpha}} d^2 \frac{2\pi/\alpha}{\sin(2\pi/\alpha)}\right] \end{aligned}$$

The increase of β leads to the decrease of τ1. With the decrease of τ1, the outage probability gets smaller. Therefore, the higher bandwidth allocation is beneficial to support the secondary transmission and hence reduce the outage probability. However, the primary performance gets worse with the increase of β, as less bandwidth is left for the primary data transmission. (2) The outage performance gets worse with the increase of SU density λs, because the more concurrent secondary transmissions, the stronger the interference and hence the worse the performance.

D. DISTANCE DISTRIBUTION AND INTERFERENCE MODEL

One typical MU is located at the origin and the typical MU is served by its nearest BS located at *x*0. Their distance is denoted as *r*0, which is a realization of the random variable *R* (the random distance between a BS and its intended MU in the serving area). The complementary cumulative distribution function (CCDF) is given as

$$\begin{aligned} \Pr\{R > r_0\} &= \Pr\{\text{No BS closer than } r_0\} \\ &= \exp\left(-\lambda_{\mathrm{b}} \pi r_0^2\right). \end{aligned}$$

$$\mathcal{I}_{\mathrm{p}} \approx \sum_{x \in \Pi_{\mathrm{b}} \setminus \{x_0\}} P_x G_x \ell_x^{-\alpha}$$

Where *Px* = **1**(*rx* ≤ *c*0) + *η***1**(*rx* > *c*0). The indicator random variable **1**(*A*) equals 1 if condition *A* is satisfied, otherwise it equals 0. The indicator random variable denotes whether the interfering BS communicates with a cell-interior MU with normalized unit power or communicates with a cell-edge MU with normalized power *η* ≥ 1. The approximation is given because the position of the cooperative SU is not the same as its serving BS when it performs the retransmission towards the cell-edge MU. The location of the relaying SU in the cell of *x* ∈ Πb (the intended MU of *x* is at cell-edge) is denoted as *xz* = *x* + *f*(*x*), where *f*(*x*) is the relative location of the selected SU from its serving BS *x*. Since almost surely we have |*f*(*x*)| < ∞, to simplify the analysis of aggregate interference without degrading the accuracy, the distance between the selected SU and the typical MU can be approximated as the distance between its serving BS and the typical MU.[10][12]

III. PROPOSED SYSTEM

A. VEHICULAR COMMUNICATIONS

Modern vehicles are making inroads in the market. These vehicles are not only equipped with global positioning system (GPS) and navigation systems, but also more advanced features such as environmental awareness to prevent vehicle collisions, multimedia systems, and integrated wireless access systems to improve vehicle performance and user experience. In addition, there is much interest in improving the efficiency of vehicular communications. For this purpose ITS aim at improving safety, reliability, efficiency, and quality of transport infrastructure and vehicles through the use of information and communication technologies (ICT). Additionally, ITS focus on providing sustainable and affordable transportation by designing advanced applications and services to optimize transportation times and energy consumption. ITS support different communication scenarios including all types of communications in vehicles, between vehicles, as well as between vehicles and roadside infrastructure.[2][5]

B. STANDARDIZATION

The process of standardization for wireless access technology to provide connectivity in

VANETs is a work in progress. Older DSRC standards were developed for V2V or V2R for safety and other services, such as fee collection in toll plazas. As mentioned earlier, new DSRC is mostly used as a generic name for short-range, point-to-point communication. It is also used to name the worldwide channels in the 5.9 GHz band, which are reserved for vehicular communications. Currently, several standards and technologies are available including cellular (2G/3G/4G) technology and IEEE802.11p standard that can be used for high-speed vehicular communication. The challenge is to make different technologies and standards interoperable. Cellular (2G/3G/4G) technology provides good coverage and sufficient security, but it is relatively costly.

C. SPECTRUM POLICY AND REGULATIONS

Several portions of the radio spectrum are regulated by the governments or regulatory bodies for an efficient use of the limited radio spectrum. The increasing use of wireless communications systems dedicated to vehicles will require spectrum availability for V2V communication system. Consequently, FCC has allocated 75 MHz of radio spectrum at 5.9 GHz for V2V and V2I in the USA. However, due to the unavailability of a continuous spectrum of 75 MHz in DSRC band in Europe, Car2Car Communication Consortium (C2C CC), a nonprofit, industry-driven European organization, has proposed to allocate 2 × 10 MHz for primary use of safety critical applications at 5.9 GHz range (5.875 to 5.925 GHz). Since this band is used as control channel in the USA, its allocation in Europe will allow for worldwide harmonization.

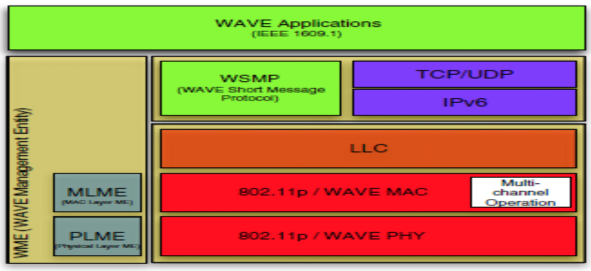

Figure 4.1 Spectrum policy and regulations

Presently, the number of wireless-enabled vehicles is very low and their spectral bandwidth requirements are low as well. However, the increasing number of wireless enabled vehicles, vehicular communication applications, and high data rate traffic flows will lead to more and more V2V and V2I information exchanges facilitated by wireless communications. ITS will more and more use different wireless access technologies to improve the efficiency and safety of vehicular communication and transportation. In general, different types of ITS depend on radio services.[6][8]

D. DISTRIBUTED AD HOC COORDINATION AND ONE-CHANNEL VS. MULTIPLE-CHANNEL PARADIGM

In V2I communications, the fixed roadside units can serve as coordinators. However, V2V communications are expected to be self-organizing and to function with or without roadside assisting units. Consequently argue that one-channel paradigm, with a single shared control channel, is a good solution for V2V communications in the absence of central coordination, considering that various applications will be broadcasting messages to many neigh boring vehicles. However, one channel paradigm comes with the problem of hidden terminal and poses difficult requirements on the design of MAC protocol for V2V communications. Though IEEE 802.11 carrier sense multiple access (CSMA)-based MAC is good for V2V communications, its performance degrades in the presence of high number of users. Moreover, if we reach a larger number of vehicles, the dissemination protocols could lead to a larger overhead. Multiple-channel paradigm can be a potential solution for such scenarios where instant sharing of message is required between vehicles and thereby reducing congestion on common control channels (CCC). Currently, the approach that is in use is to let all vehicles synchronize to a global time reference and alternate between a common control channel and separate service channels every 100 ms.[11]

E. PRIVACY, SECURITY, AND SAFETY

Privacy and security issues are highly important in VANETs due to potential threats to traffic flow and human lives by any malicious attempt, for example, fake messages leading to traffic disruption and fatal accidents. Some of the security and privacy issues related to ITS have been discussed. Security protocols for vehicular networks should take into account their specific characteristics such as high mobility and requirements such as trust (vehicles should be able to trust the received messages), resiliency (for interference), and efficiency (e.g., ability to authenticate message in real time). In addition, privacy concerns include preserving anonymity so as to prevent tracking or identification of vehicle for non-trusted parties based on vehicular communication. Nevertheless, such security mechanisms generally come at the cost of degraded communication performance.

F. COGNITION CYCLE

Here we first describe the two main features of CR: cognitive capability and reconfigurability. Then, we briefly discuss the concept of cognition cycle of CR as well as some specifics related to CR-VANETs. A CR-enabled device adapts its operational parameters as a function of its environment. CR components are mainly radio, sensor, knowledge database, learning engine, optimization tools, and a reasoning engine. CR has cognitive as well as reconfigurability capabilities. Cognitive capability allows CR to sense and gather information (e.g., different signals and their modulation types, noise, transmission power, etc.) from its environment and, for example, secondary users can identify the best available spectrum. The reconfigurability features of CR allow it to optimally adapt the operational parameters as a function of the sensed information.[5][7]

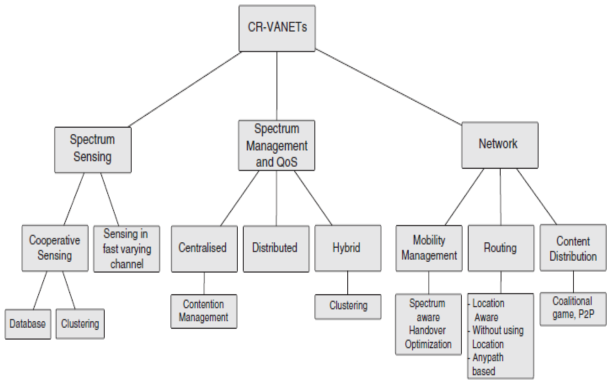

Figure 4.2 Cognition cycle

CR systems involve PU and SU of the spectrum; primary users are license holders, while secondary users seek to opportunistically use the spectrum through CR when the primary users are idle. The cognition cycle of CR consists of multiple phases: Observe Analyze, Reason, and Act. The goal is to detect available spectrum, select the best spectrum, select the best operational parameters, coordinate the spectrum access with other users, reconfigure the operational parameters, and vacate the frequency when a primary user appears. A spectrum hole refers to a portion of spectrum not being used by the primary/licensed user at a particular place and time. It is detected through spectrum sensing and signal detection techniques. The SUs opportunistically access the spectrum if the sensed portion of spectrum is found empty.

IV. NETWORK SIMULATOR

A. INTRODUCTION

A network simulator is a software program that imitates the working of a computer network. In simulators, the computer network is typically modeled with devices, traffic etc and the performance is analyzed. Typically, users can then customize the simulator to fulfill their specific analysis needs. Simulators typically come with support for the most popular protocols in the use today, such as Wireless LAN, Wi-Max, UDP, and TCP. A network simulator is a piece of software or hardware that predicts the behavior of a network, without an actual network being present. NS is an object oriented simulator, written in C++, with an OTcl interpreter as a frontend.

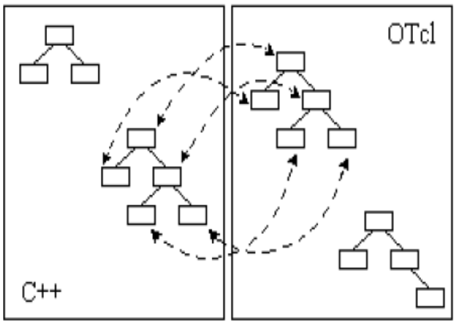

Figure 5.1 Flow chart for C++ and OTcl

The simulator supports a class hierarchy in C++ and a similar class hierarchy within the OTcl interpreter. The two hierarchies are closely related to each other; from the uses perspective, there is one-to-one correspondence between a class in the interpreted hierarchy and one in the compiled hierarchy. The root of this hierarchy is the class Tcl object. Users create a new simulator objects through the interpreter; these objects are instantiated within the hierarchy. The interpreted class hierarchy is automatically established through methods defined in the class Tcl object. There are other hierarchies in the C++ code and OTcl scripts; these other hierarchies are not mirrored in the manner of Tcl object.

B. USES OF NETWORK SIMULATORS

Network simulators serve a variety of needs. Compared to the cost and time involved in setting up an entire test bed containing multiple networked computers, routers and data links, network simulators are relatively fast and inexpensive. They allow engineers to test scenarios that might be particularly difficult or expensive to emulate using real hardware- for instance, simulating the effects of sudden bursts in the traffic or a Dos attack on a network service. Networking simulators are particularly useful in allowing designers to test new networking protocols or changed to existing protocols in a controlled and reproducible environment. various types of Wide Area Network (WAN) technologies like TCP, ATM, IP etc and Local Area Network (LAN) technologies like Ethernet, token rings etc, can all be simulated with the typical simulator and the user can test, analyze various routing etc.

C. NETWORK SIMULATOR 2 (NS2)

NS2 is an open- source simulation tool that runs on Linux. It is a discreet event simulator targeted at networking research and provides substantial support for simulation of routing, multicast protocols and IP protocols, such as UDP, TCP over wired and wireless (local and satellite) networks. It has many advantages that make it useful tool, such as support for multiple protocols and the capability of graphically detailing network traffic. Additionally, NS2 supports several algorithms in routing and queuing. Queuing algorithms include fair queuing, deficit round-robin and FIFO. REAL is a network simulator originally intended for studying the dynamic behaviour of flow and congestion control schemes in packet switched data network. NS2 is available on several platforms such as FreeBSD, Linux, Sim OS and Solaris. NS2 also builds and runs under Windows.

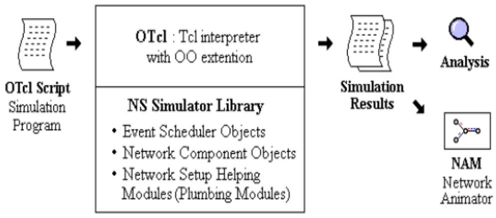

Figure 5.2 Simplified user's view of NS2

D. SIMULATION RESULTS

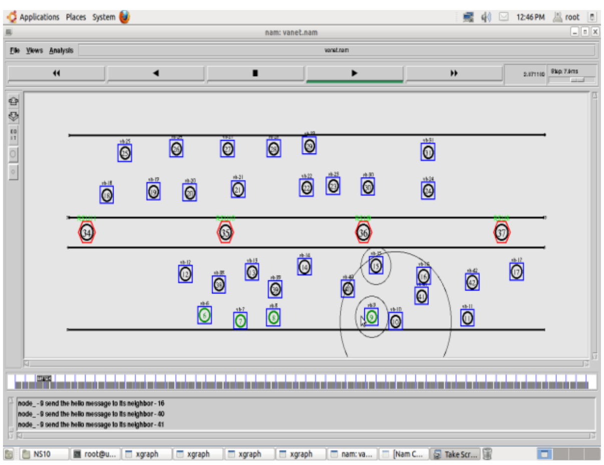

Figure 5.3 communications between various nodes

Figure 5.3 The overlaid wireless network with PPP modeling for both systems. Each mobile user (MU) is associated with its nearest base station (BS), so the Voronoi cell is formed in the cellular network. The circular area around each BS represents the cell-interior area, with radius c0. In each Voronoi cell, the outside of the circular area represents the cell-edge area. The potential secondary users (SUs) in each cell can actively help the cell-edge downlink communications in exchange for a fraction of disjoint spectrum band.

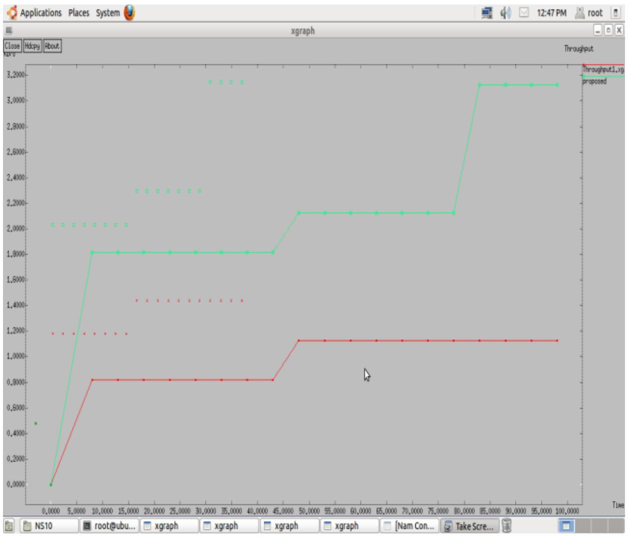

Figure 5.4 comparison between Existing and proposed output

Figure 5.4 Average throughput of the primary system w.r.t. the relative distance ζ. The system settings are $\alpha = 3$, $c0 = 9$ m, $c1 = 1$ m, $\lambda b = 10-3$, $\lambda m = 10-2$, and $\lambda s = 0.9$. The bandwidth allocation $\beta = 0.2$ is used for the cooperative spectrum sharing, while it is zero for the stand-alone cellular network without spectrum sharing. The theoretical results are obtained.

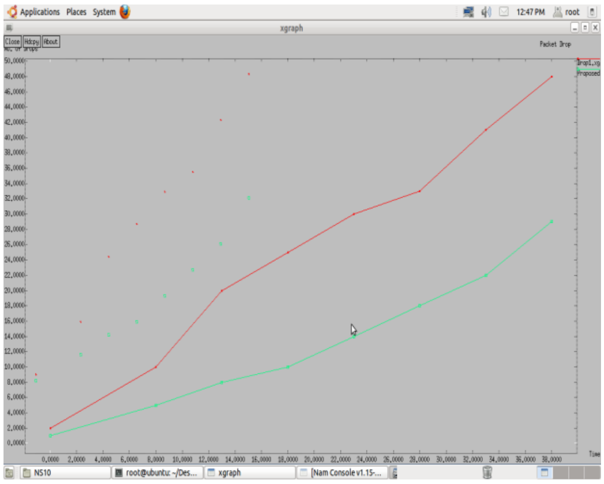

Figure 5.5 Comparison between Packet drop

Figure 5.5 Transmission capacity of secondary system write the primary throughput improvement ratio ρ for different $c0$. The system settings are $\alpha = 3$, $c1 = 1$ m, $\zeta = 0.501$, $T0 = 2$ bits/s/Hz, $T1 = 1$ bits/s/Hz, _ = 0.1, $\xi = 0.2$, $d = 0.1$, and $\lambda b = 10-3$.

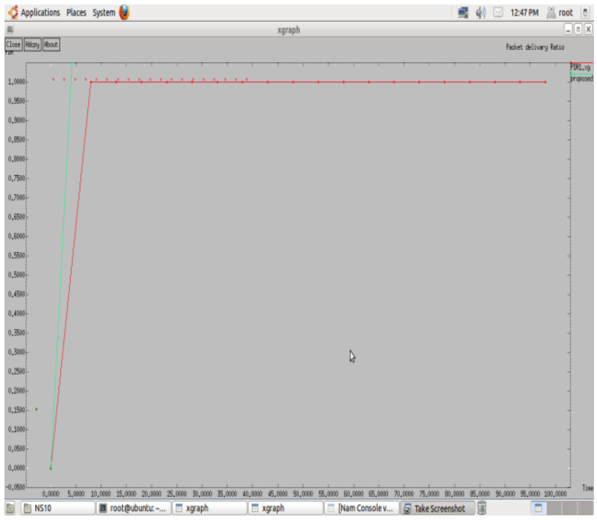

Figure 5.6 Comparison between Existing and proposed method PDR

Figure 5.6 shows the impact of SU density λs to the primary performance with different values of bandwidth allocation factor β. The region division radius of each cell is set as $c0 = 9$ m, while the radius of the cooperation region is set as $c1 = 1$. The average throughput of the primary downlink deteriorates with the decrease of the SU density λs.

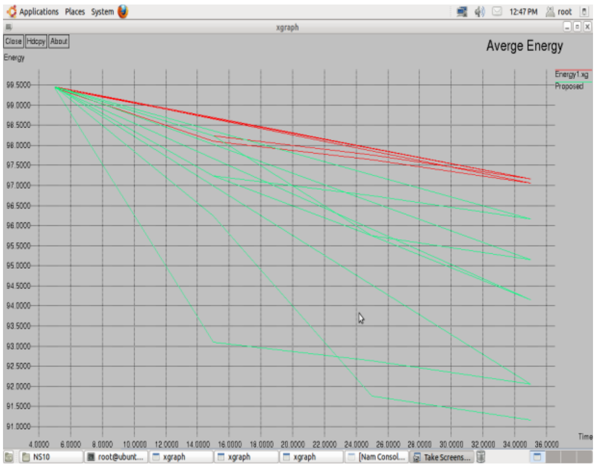

Figure 5.7 Comparison between Average Energy value

Figure 5.7 Average throughput of the primary system write the bandwidth allocation factor β. The system settings are α = 3, $c1$ = 1 m, ζ = 0.501, $T0$ = 2 bits/s/Hz, λb = 10−3, λm = 10−2, and λs = 0.9.

V. CONCLUSION AND FUTURE WORK

Although CR operation in vehicular networks is still in the beginning stage, CR-VANETs have the prospective of appropriate a killer CR function in the future due to a massive consumer market for vehicular communications. However, the investigate solutions future for general-purpose CR networks cannot be directly applied to CR-VANETs due to their unique features that need to be considered while designing the spectrum management functions for CR-VANETs. In this framework, a number of challenges and requirements for CR-VANETs have been celebrated. We have provided recent advances and open research directions on applying cognitive radio for vehicular networks focusing on architecture, machine learning, and cooperation, reprogram ability, and spectrum management as well as QoE optimization for infotainment applications.

Taxonomy of recent advances in CR-VANETs is also provided. In addition, some existing testbeds and research projects related to CR-VANETs have been described The rapid developments in the field of ad hoc networking allows the nodes to form a self-creating, self-organizing and self-administering wireless network. Its inherent flexibility, be short of communications, ease of exploitation, auto construction, low cost and prospective function makes it an important division of future pervasive computing environments. This check aims to ascertain ad hoc network architecture, application, features and also mentions about various challenging issues and provides the feasible solution based on new technology.

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