MULTI-HOMING ENABLED COGNITIVE RADIO BASED INTER-VEHICLE COMMUNICATION SYSTEM

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ABSTRACT

Cognitive radio based inter vehicle communication system was proposed by the researchers in 2010. They have proposed cognitive radio site (CR-Site) inside the vehicle to solve the problems associated with the single radio access technologies (GSM/GPRS, CDMA, Wi-Fi) based IVC systems. Our main work is regarding the introduction of multi-homing module in CR-Site. After receiving quality of service (QoS) parameters from application cognitive system monitor (CSM) initiates white space optimization module to optimize the white spaces package according to the requested QoS parameters. GA optimizes the white spaces and sends them into the optimized white spaces pool. On the reception of admission acceptance, application sends the data for transmission to the scheduler via CSM. Scheduler initiates its sub module devisor to divide the data into the packets according to the smallest bandwidth in the optimized whitespace package. Then these packets are sent using multi white spaces in parallel fashion. Simulation and analytical experiments reveal that using multi-homing heavy files (videos and text) can be transmitted in less time as compared to the non multi-homed single RAT (GSM or CDMA or LTE) based V2V communication systems.

KEYWORDS

V2V communication system, cognitive radio, CR-Site, Multi-homing

1. INTRODUCTION

Road crashes are common all over the world and thousands of people lose their lives on daily basis. To overcome this issue, Inter-Vehicle Communication system (IVC) as part of Intelligent Transport Systems (ITS) is an active research area [1]. Current ITS comprise of Single Radio Access Technology(Single-RAT), latest computer hardware and real time protocols to enhance performance, safety, efficiency, environmental impacts and energy consumption .In the last ten years a new approach known as cooperative driving based on vehicle-to-vehicle (V2V) and

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vehicle-to-infrastructure (V2I) has got immense intention of researchers [2-5]. Different type of IVC systems are proposed by the researchers, among them cognitive radio based IVC system are getting popular due to their capability of full filling the bandwidth demand of highly congested vehicles [8-10]. The focus of this research is introducing the multi-homing concept in cognitive radio site (CR-Site) introduced by researchers in [11] to improve the reliability and data communication speed of IVC network in terms of more data rate and efficient utilization of wasted bandwidth. The main problem in some Asian countries is slower cellular networks for internet utilisation. This problem has been solved by introducing and enhancing the existing multi-homing functionality. V2V communication system is utilised to test the enhanced multi-homing functionality in terms of sending a single file on multi-links in parallel fashion. Multi-homing is a technique in which systems are configured with multiple available network interfaces as well as with multiple IP addresses [12] [13]. CR-Site provides the facility of channel shifting, when the signals of one channel will drops or loses the strength then cognitive radio will help the user to shift to other available RATs. A Cognitive Radio (CR) is a radio that can change its transmitter parameters based on interaction with the environment in which it is operating [6]. Research performed by several organizations in the US, shows that up to 70% of total spectrum allocated in different areas is ideal at some time of the day [7]. Cognitive radio can utilized this wasted bandwidth in efficient manners by using its opportunistic spectrum access method. The proposed scheme is compared with GSM, CDMA and LTE based V2V communication systems, and it is found that data transmission time can be decreased using multi-homing enabled CR-Site. The remaining paper is arranged as follow. Literature review is elucidated in section 2, existing CR-Site main functions are discussed in sub section 2.1.The enhancement in CR-Site has been discussed in section 3.Performance evaluation of proposed scheme has been detailed in section 5 and paper has been concluded in section 6.

2. LITERATURE REVIEW

A thorough Literature review has been performed about the existing work of multi-homing, but very few papers have been found about the multi-homed vehicle to vehicle communication in the popular research databases like IEEE, Springer link and Taylor & Francis etc. However, extensive research work has been found about simple multi-homing concepts. In [12] a concept of multi-homing technique using SCTP protocol at transport layer is discussed and the issue of maintaining a continuous connection between two end users during the changing of addresses has been solved. In [13] a comparison study of different transport layer protocols like SCTP and TCP-MH in terms of Multi-homing has been performed. In [14] researchers have discussed the functionality of multi-homing over protocols like SCTP and BGP in the scenario of ipv4 and ipv6 based networks. In [15] proposition of different retransmission policies using multi-homed SCTP protocol has been made for the reduction of false impact of receiver side buffers. The multi-homing concept to enhance the reliability of vehicle to vehicle communication and vehicle to infrastructure is used in [16] [17]. In [16] a concept of networked vehicles with multi-homing capabilities is discussed. For communication reliability two radio access technologies CDMA2000 IxEV-DO and IEEE 802.11b is used. In [17] an intelligent distributed QoS control scheme using multi-homing is introduced for better vehicle to infrastructure V2I communication. In all over literature survey no research study has been found for the utilization of multi-homing concept for improving the communication speed between V2V and V2I in terms of decreasing time required to send or receive files.

2.1 Cognitive Radio Site

A cognitive radio site shown in fig.1 was proposed by researchers to full fill the high bandwidth requirements of congested vehicles [11].

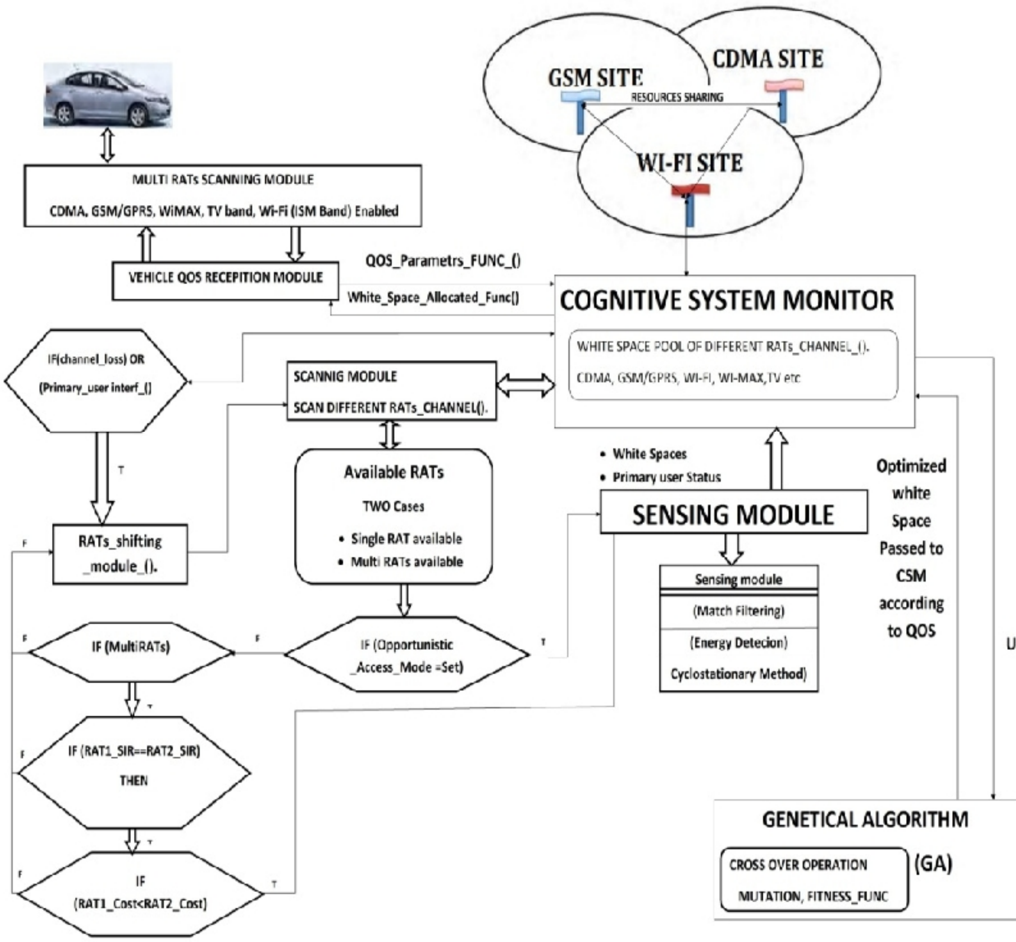

Fig. 1 Internal Architecture of CR-Site [11]

The step by step functionality of cognitive site is given below. Vehicle generates a call request for channel allocation to the cognitive system monitor, for this purpose vehicle has to pass QoS demand to the CSM as well.

Cognitive system monitor (CSM) invokes scanning module to scan all the available RATs using Multi-RAT scanning enabled hardware.

After the scanning module CR-Site has two options.

In first option if opportunistic spectrum access mode is set, then available channels information is passed to the sensing module. In sensing module match filtering, energy detection, and cyclostationary techniques are employed to detect the primary user. In the result white spaces are passed to the CSM, which maintains the pool of available white spaces.CSM then employ genetic algorithm to find optimized white spaces from the pool of available white spaces according to the QOS parameters received from vehicle. CSM then assigns the optimized white space to the vehicle. In the last shift module is invoked to switch on assigned white space. After the successful white space allocation, CSM continuously analyze that allotted white space is good enough to full fill the needs of user. Meanwhile sensing module continuously senses the channels, and keeps up to date CSM about primary (PU) user activation status. If CSM finds primary user status active on assigned white space, then new white space will be allocated to the vehicle, after performing optimized white space, and shifting process.

In second option a suitable RAT is selected among available RATs on the basis of signal to interference ratio (SIR), and then further on the basis of cost. The most suitable channel is passed to the CSM, which allocates it to the vehicle. CSM continuously monitor the channel condition, as the channel degrade its performance up to a certain threshold, it starts again new channel allocation process.

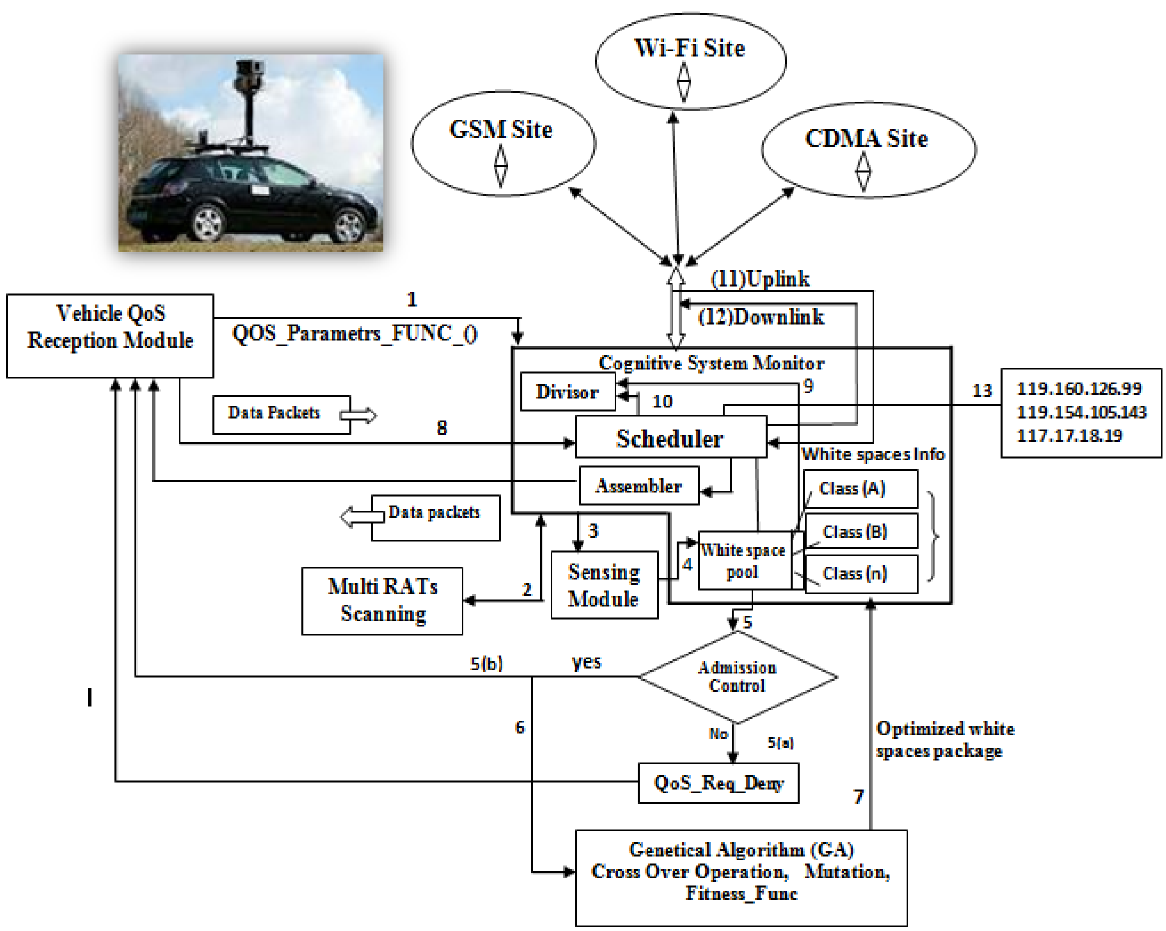

Fig. 2 Internal Architecture of Multi-homing enables CR-Site

3. COGNITIVE RADIO-SITE ENHANCEMENT USING MULTI-HOMING

In this research study we have double up the cognitive radio benefit by introducing concept of multi-homing inside the cognitive radio site, by introducing some changes in the basic architecture of CR-Site shown in figure 2

1) Vehicle will generate a request for channel allocation to the CSM (cognitive site parameter).for this purpose it passes a QoS (quality of service) demand to the CSM. . In CSM there are three different modules i) Scanning ii) Sensing and iii) Scheduler.
2) The main function of a Scanning module is to scan all available RATS in surrounding. Once the scanning process is completed scanning information is passes to the sensing module.
3) The next phase is to sense the white space. It is reported in [26] [29] [27] [28] [30] spectrum sensing technology can effectively used to find out the spectrum holes to perform dynamic spectrum access (DSA). For spectrum sensing any one of the following methods can be used by the SU. The methods are energy detection reported in [19][20],or wave from-based sensing reported in [25][22][24] or cyclostationary reported in [18][20][23][21] can be used. After completing the scanning process detected white spaces will be passed to the Scheduler.

There are three different processes in Scheduler.

i) Maintaining the pool of the white spaces, ii) Devisor, iii) Assembler

4) In step 4 Scheduler received all the white spaces from the Scanner and maintains a pool of white spaces. With in a pool white spaces are arranged in different classes. This arrangement is depend on the QoS of the spaces.
5) When vehicle sent the QOS parameters to the CSM, it initiates the Scheduler to perform the admission control by consulting the available white spaces pool. Here two possibilities exist.

(5a) In the case of non availability of white spaces service admission will be denied otherwise case (5b) will be performed.

(5b) The service admission will be granted and in the meantime CSM will request the white space optimization module to optimize the white spaces package according to the requested QoS parameters.

6) GA will optimize the white spaces using its steps like crossover and mutation.
7) In this step optimizer send the optimized white spaces to another pool known as optimized whitespace pool.

The list of optimized whitespaces IPs will be broadcasted by the vehicle using the mechanism described below

Table 1. Ufone cell ids.

UFONE			
Tower id	**Cell id(1)**	**Cell id(2)**	**Cell id(3)**
1024	2376	3463	8742
1025	9267	8734	2344
1026	9834	8743	3454

A new IP exchange scheme has been proposed between the vehicles to perform the proposed multi-homing scheme, using the GSM Tower id and then further the one of the three cell ids of the specific GSM tower. Before proposing this scheme a survey was conducted to gather the information of different GSM service provider's towers and cells ids. Table 1 and 2 are showing the tower ids along with their three cell ids of two leading GSM service providers of Pakistan named Ufone and Telenor. The reason of choosing GSM network for exchanging IPs list is its largest area coverage and service availability. The basic outline of the scheme is given as under.

Table 2. Telenor Cell ids.

Telenor			
Tower id	**North Cell id (1)**	**Cell id (2)**	**Cell id (3)**
607	22763	12179	32432
608	23432	34323	34235
609	25434	87643	43988

After allocating the white spaces class according to the requested QoS, a list of IPs of corresponding white spaces will be managed by CR-Site.

Before initiating data communication using multi-homing technique the IP list maintained by a CR-Site will be broad cast using GSM white space for other vehicles to update the information about their surrounding vehicles. A broadcast packet as shown in table 3 will consist of following fields tower id, cell id, list of IPs and current longitude and latitude of transceiver, this field will help the vehicles with in cell range to find out the distance between each other to avoid the possible collision as well.

Table 3. Broadcast message field.

Tower id	Cell id	IP addresses	Lat, Long	Port No.

8) A specific application will send the data for transmission to the scheduler via CSM.
9) Devisor will be passed the information of assigned optimized white space package.
10) Scheduler will initiate its sub module devisor to divide the data into packets according to the smallest bandwidth in the optimized whitespace package.
11) Then in the last phase these packets will be sent using multi- RAT links with the help of scheduler

12) On the downlink side, in the case of the reception of data packets, a buffer has been maintained, from where assembler takes the frames from different Radio access networks (RAN) to re-assemble them and pass it to the specific application via scheduler.
13) Scheduler also maintains the table of IP addresses of neighboring nodes as the sender machine needs the list of different IPs of different whitespaces.

The benefit of multi-homing is that it provides reliable and enhanced network connectivity as compared to the non multi-homing network. System connects with multiple networks simultaneously. So it can send and receive data traffic through multiple channels.

In this research study to get the benefits of multi-homing for IVC network, three basic modules has been defined which are scheduler, assembler and devisor.

The scheduler as shown in figure 3 is the main term used in multi-homing.it is the responsible of division of packets, arrangement of white space classes and reassembling of data traffic as shown in fig 3.

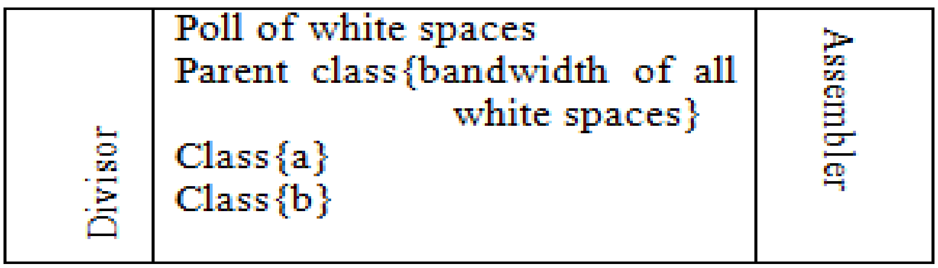

Fig 3. Scheduler

Another job of a scheduler is to divide data stream in to small chunks using its sub component known as devisor. It is also called as data fragmentation [31].Fragmentation of data packets depends on the bandwidth of white spaces. In Pakistan the maximum bandwidth of GPRS and Edge is 135 kbps and 172 kbps respectively. So each data packet is less than or equal to the 135kbps and 172kbps as shown in fig 4

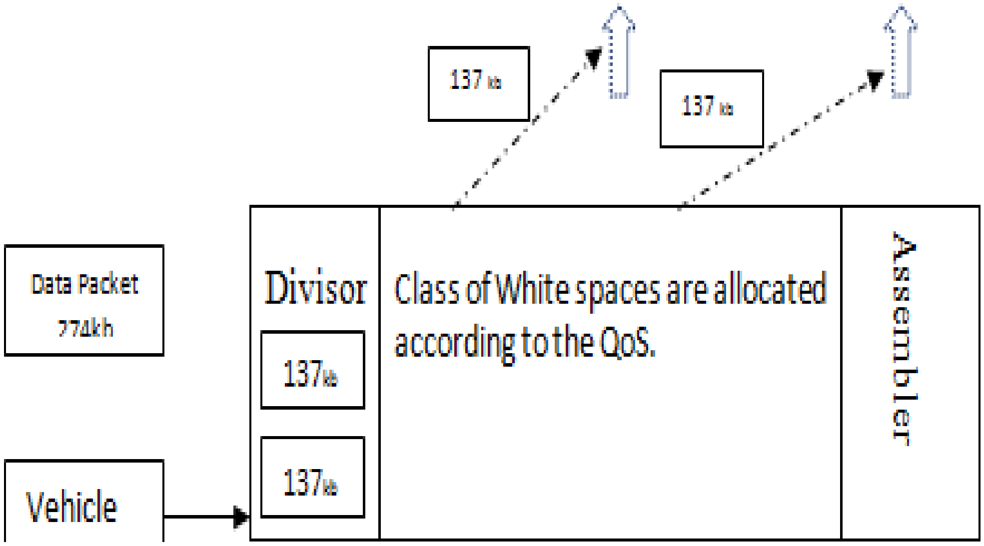

Fig 4. Divisor module of CR-Site

The main function of assembler is to receive data from multiple terminals and send them in to a single host in advocate fashion. There is great relationship between the divisor and assembler. The assembler is responsible for assembling the data on downlink as shown in fig 5

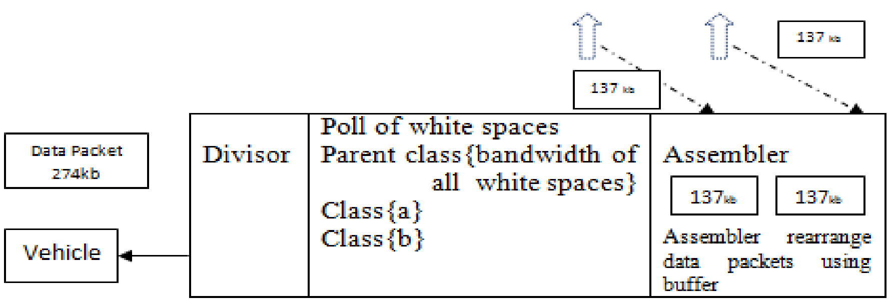

Fig 5. Assembler module of CR-Site

3.1 Working of Scheduler

The scheduler is the main term used in multi-homing. Two sub modules devisor to divide packets for uplink and assembler to assemble the packets of same file on downlink also works under scheduler. After sensing the white spaces, a poll of white spaces is maintained and the record of available white spaces is maintained by scheduler. All the white spaces of different channels are rearranged in different classes with in a poll by the scheduler. The assignment of white spaces to each class is based on QoS parameters. It is the job of CR-Site to have a pre GPRS connection to send data packets. Cognitive site send its identity number/IMSI for GPRS activation .After authentication, IP addresses are assigned to the white spaces from the network operator. Each white space has its own temporary IP address. Before sending and receiving date traffic, both cognitive parties (vehicles) share IP information with each other through which they communicate with each other [15]. In case of primary user activation cognitive site has to perform spectrum mobility in such manners that ongoing transmissions do not interrupted. For this purpose both cognitive sites should exchange their new IP addresses of newly assigned white spaces. Both sender and receiver have single physical upstream and downstream link but have multiple channels (multiple white spaces). So vehicles can send multiple data packets by using multiple channels (multiple white spaces) having different IP addresses. If physical upstream and downstream link fails, connectivity is down for all IP addresses. Next function of a scheduler is to divide data stream from application in to small chunks, this is also known as fragmentation. After fragmentation, Scheduler assigned traffic to each class. Assigning the classes depends on the QOS parameters of the application. If the QOS of the application/ traffic does not match to the QOS of any particular class, then scheduler assign any class near to the QOS request. As each class multiple white spaces. Vehicle can use these white spaces to send and receive data traffic. Using multi-homing approach each data fragment is assigned to one suitable white space, in this way N fragments are assigned to n suitable white spaces of a single or multiple classes. So multiple fragments of a packet can be transmitted at once using software defined radio (SDR) and proper cognitive radio front end hardware. Before transmitting data packets control information is attached i.e. host and destination IP address and sequence number. Each data packet has different host and same destination IP addresses, because each white space has different IP address. On the receiving side, assembler received multiple packets from different RATS. In multiple-RAT environment out of order packet will become serious problem. To solve this problem a buffer is used to reorder the packet at receiving side [32].All the packets in buffer are arranged according to their sequence number.

5. PERFORMANCE EVALUATION OF PROPOSED MULTI-HOMING SCHEME

In this section performance evaluation of proposed scheme has been performed with GSM based V2V communication system, CDMA based V2V communication system and LTE based V2V communication system.

Table 4. White Space Pool maintained by Multi-homing enabled CR-Site.

$\mathbf{RAT_i WS_{ijk}}$	RAT_1WS_{111}	RAT_1WS_{322}	……...	RAT_1WS_{nnn}
$\mathbf{RAT_i WS_{ijk}}$	RAT_2WS_{111}	RAT_2WS_{122}	……...	RAT_1WS_{nnn}
$\mathbf{RAT_i WS_{ijk}}$	RAT_3WS_{111}	RAT_3WS_{222}	……...	RAT_1WS_{nnn}
$\mathbf{RAT_i WS_{ijk}}$	RAT_4WS_{111}	RAT_4WS_{122}	……...	RAT_1WS_{nnn}
$\mathbf{RAT_i WS_{ijk}}$	RAT_5WS_{111}	RAT_5WS_{222}	……...	RAT_1WS_{nnn}

In table 4 a pool of white spaces maintained by CR-Site is shown. Let RAT_iWS_{ijk} where $1 \le i \le N, 1 \le j \le N, 1 \le k \le N$ like RAT_1WS_{111} is representing ($RAT_1 = GSM, RAT_2 = CDMA, RAT_3 = LTE, RAT_4 = Wi-Fi, RAT_5 = WiMax$). Where as in WS_{ijk}, i represents service provider {(when $i = 1$ represents UFONE, for $i = 2$, TELENOR and $i = 3$ for MOBILINK), (j represents tower number of service provider and k represents the number of white spaces)}. RAT is GSM, Service provider is Ufone, BTS is 1 and white space number is 1. When a SU has to transmit data then a white space is optimized according to the QoS parameters of application from the available white spaces within the white space pool. For optimization of white spaces, GA is considered a best one solution. A pictorial representation of using different white spaces during travel time of SU (vehicle) equipped with SDR has been shown in figure 6. Different signal strength levels have been shown using different colour scheme. According to the signal strength a SU has different white space pool.

Let $T_E(WS_{ijk})$ defines the occupied time of a whitespace by a PU. As reported in [31], value of $T_E(WS_{ijk})$ is directly proportional to the expected transmission time. If $T_E(WS_i)$ is a large value than expected transmission time will be higher and vice-versa. We have considered minimum value of $T_E(WS_i)$ as it is reported in [33] that small value of $T_E(WS_i)$ is, the higher successful space data transmission will be N. The following scheme has been conceived from [33] value of $T_E(WS_i)$ depends on following factors. First, one is spectrum occupied ratio of different white spaces of different RATs, second one is signal strength of these spectrum holes, and third one is bandwidth of these spectrum holes.

It has been noted that if the occupied ratio of spectrum is higher by the primary user (PU) then the secondary user (SU) has less chance to use spectrum holes. With strong signal strength and large bandwidth, SU can achieve higher transmission rate. The transmission rate is normally computed by the bandwidth and the signal strength.

Our proposed scheme is inspired by two already proposed spectrum mobility schemes in [33] & [34]. In [34] a spectrum mobility scheme in LTE network has been proposed in which a predictive channel selection algorithm is devised to select the channel with the maximum idle time. Where it has been found that considering only a channel with maximum idle time cannot be optimal for the data transmission time where in [34] a spectrum mobility scheme in LTE network has been proposed to select a channel with the maximum channel size and the maximum idle time. Our proposed scheme is inspired from the scheme proposed in [33] but giving the solution of spectrum mobility not for Single-Rat based technology but for Multi-Rat technologies like (GSM, CDMA, Wi-Fi, WiMax).

After the allocation of optimized white space smart application of vehicle starts communication with other vehicle. Spectrum visibility is very frequent in the case of IVC system because of its very mobile nature. At vehicle speed, a vehicle has to perform spectrum nobility due to following reasons

Reclaiming of white space under utilization of SU

Decrease in the $SNR = \frac{P_{signal}}{P_{noise}}$

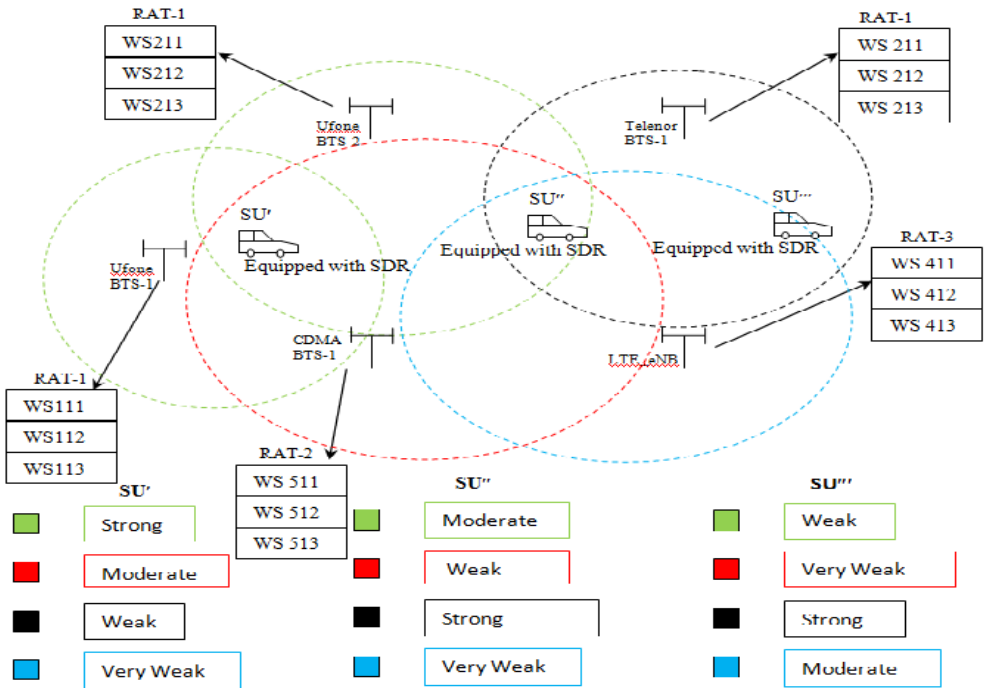

Fig 6. Vehicle spectrum handoff scenario

Let T_{req} be the time SU takes to send his data.

The algorithm consists of three steps.

1) Finding the unoccupied probability of each sensed white space $RAT_i WS_{ijk}$, by using following equation

Probability (PU (WS_{ijk}, T_{req})

2) Pass this information to computation and analysis phase.

3) Estimation of signal strength of each white space using $SNR_{db} = 10\log_{10}\frac{P_{signal}}{P_{noise}}$

Three cases exist.

a) In case of decreasing SNR or PU activation, initiates computation and analysis phase.

b) If the SU experiences degradation in SNR_{db} or PU activation then the following algorithm will be followed.

(1) Using $SNR=\frac{P_{signal}}{P_{noise}}$ obtaining from different signal received from different RATs evaluate the (WS_{ijk})

(2) To transmit the remaining data RD. for the estimation of required transmission time to transmit the remaining data Rd of SU, the maximum transmission rate is calculated using received strength.

Let TR represents the transmission rate for WS_{ijk}. In case of GSM a channel consists of 200 kHz. In case of LTE a resource block consists 180 kHz. In CDMA a resource block consists of 5 MHz. A white space consists of n time slots in case of GSM/GPRS, n resource blocks in case of LTE, so the bandwidth of a white space is n*RB.

$$T_{rate} = N \times RB \times \log_2(1 + SNR_{db}) \quad ..1$$

Required transmission time can be calculated as given in [33].

$$T_{req} = \frac{R_d}{n \times RB \times \log_2(1 + SNR_{db})} \quad ..2$$

(3) Using poisson distribution unoccupied probability of WS_{ijk}, PU (WS_{ijk}, T_{req}) is calculated. The general equation of poisson distribution is

$$P(K, T) = \frac{(\lambda T)^k}{k!} e^{-(\lambda T)} \quad ..3$$

$$Pu(n, T_{req}) = \pi_{n=1}^{m} P_n(0, T_{req}) = e^{-\sum_{n=1}^{m} \lambda_n T_{req}} \quad ..4$$

We have three white spaces, as shown in fig.4, RAT_1 WS_{111} , GSM (UFONE) RAT_2, WS_{211},

CDMA, RAT_3 , WS_{311} , there signal to noise ratio is $SNR' = \frac{P'_{signal}}{P'_{noise}}$, $SNR'_{dB} = 10\log_{10}\frac{P'_{signal}}{P'_{noise}}$,

$SNR'' = \frac{P''_{signal}}{P''_{noise}}$, $SNR'_{dB} = 10\log_{10}\frac{P'_{signal}}{P'_{noise}}$ and

$SNR''' = \frac{P'''_{signal}}{P'''_{noise}}$, $SNR''_{dB} = 10\log_{10}\frac{P''_{signal}}{P''_{noise}}$ respectively.

$$T_R = \frac{dt}{numbers \times timeslot \times \log_2(1 + SNR_{db})} \quad ..5$$

In case of transmitting data using RAT_1 WS_{111}only, where RAT_1 WS_{111} is the GSM Ufone tower 1 white space. First we calculate the Transmitting Rate by using equation (1) devised in [33].

$$T_{rate} = number \times time\ slots \times \log_2(1 + SNR_{dB})$$

By putting values in formula we get

$$T_{rate} = 3 \times 200 \times \log_2(1 + SNR_{dB})$$

Here $SNR_{dB} = 15$ dB

$$SNR_{dB} = 10\log_{10}\left(\frac{s}{n}\right)$$
$$= 10 \log_{10}(15)$$

$= 10\left(\frac{15}{10}\right)$
$= 31.6$ (eq 2)

Putting the value in equation 1

$T_{rate} = 3 \times 200 \times \log_2(1 + SNR_{dB})$
$= 3 \times 200 \times 5.068$
$T_{rate} = 3040.8$ kbps

Which is the total T_{rate} of $RAT_1\ WS_{111}$.

Now we calculate the T_{req} by using formula devised in [33]

$$T_{req} = \frac{dt}{\text{number} \times \text{time slots} \times \log_2(1 + SNR_{dB})}$$

Here dt is a data to send by the SU.

Hence $T_{req} = \frac{16\ Mb}{3040.8kbps}$
$\simeq \frac{16384\ kb}{3040.8\ kbps}$

$T_{req} = 5.38$ sec

So the total time required to transmit 16 Mb data over $RAT_1\ WS_{111}$ is 5.38sec.

Now we calculate the T_{rate} of CDMA white space ($RAT_2\ WS_{111}$).

$$T_{rate} = \text{number} \times \text{time slots} \times \log_2(1 + SNR_{dB})$$

By putting values in formula we get

$$T_{rate} = 2 \times 1250KHz \times \log_2(1 + SNR_{dB}) \text{ (eq 1)}$$

Here SNR = 15 dB

$SNR_{dB} = 10 \log_{10}\left(\frac{s}{n}\right)$
$= 10 \log_{10}(15)$
$= 10\left(\frac{15}{10}\right)$
$= 31.6$ (eq 2)

Putting the value in equation 1

$T_{rate} = 1 \times 1250 \times \log_2(1 + 31.6)$
$= 1 \times 1250 \times 5.068$
$T_{rate} = 6335$ kbps

Which is the total T_{rate} of RAT_2 WS_{111}.
Now we calculate the T_{req} by using formula devised in [33]

$$T_{req} = \frac{dt}{\text{number} \times \text{time slots} \times \log_2(1 + SNR_{dB})}$$

Here dt is a data to be sent by the SU (vehicle).

$$\text{Hence } T_{req} = \frac{16\ \text{Mb}}{6335\ \text{kbps}}$$

$$= \frac{16384\text{kb}}{6335\ \text{kbps}}$$

$$T_{req} = 2.58\ \text{sec}$$

So the total time required to transmit 16Mb data over RAT_2 WS_{111} is 2.58 sec.
In step three we calculate the T_{rate} of LTE white space (RAT_3 WS_{111})

$$T_{rate} = \text{number} \times \text{time slots} \times \log_2(1 + SNR_{dB})$$

By putting values in formula we get

$$T_{rate} = 2 \times 180 \times \log_2(1 + SNR_{dB}) \text{ (eq 1)}$$

Here SNR = 15 dB

$$SNR_{dB} = 10 \log_{10}\left(\frac{s}{n}\right)$$
$$= 10 \log_{10}(15)$$
$$= 10\left(\frac{15}{10}\right) \quad \text{(eq 2)}$$
$$= 31.6 \text{ (eq 2)}$$

Putting the value of (eq 2) in (eq 1)

$$T_{rate} = 2 \times 180 \times \log_2(1 + 31.6)$$
$$= 2 \times 180 \times 5.068$$
$$T_{rate} = 1824.48\ \text{kbps}$$

Which is the total T_{rate} of RAT_3 WS_{111}.
Now we calculate the $T_{req}$by using formula devised in [33]

$$T_{req} = \frac{dt}{\text{number} \times \text{time slots} \times \log_2(1 + SNR_{dB})}$$

Here dt is a data to send by the SU.

Hence $T_{req} = \frac{16\ Mb}{1824.48\ kbps}$

$= \frac{16384kb}{1824.48\ kbps}$

T_{req}= 8.98 sec

So the total time required to transmit 16 Mb data over RAT_3 WS_{111} is 8.98 sec.

Now we want to transmit data over a multiple white spaces to minimize the T_{req}using multi-homing scheme. For transmitting data over a multiple white spaces, we first divide data packets in to small chunks. Each data chunk is equal to white space which have smallest T_{rate} (Transmission Rate).

In our scenario RAT_3 WS_{111} has smallest T_{rate} i.e 1824.48 kbps. So each data chunk is not more than 1824.48 kb size.

So Total number of chunks = Total data size / Smallest T_{rate}.

$$= \frac{16\ Mb}{1824.48kb}$$

$$= \frac{16384kb}{1824.48\ kb}$$

$$= 9 \text{ packets.}$$

Now we transmit all nine packets together over RAT_1 WS_{111} , RAT_2 WS_{111}, RAT_3 WS_{111}.
First we calculate T_{req} by formula devised in [34] for, RAT_3 WS_{111}

$$T_{req} = \frac{dt}{\text{number} \times \text{time slots} \times \log2(1 + SNR_{dB})}$$

$$T_{req} = \frac{1824.48kb}{2 \times 180 \times 5.02680}$$

$$= \frac{1824.48kb}{1824.48kbps}$$

$$T_{req} = 1 \text{ sec}$$

Now we calculate RAT_1 WS_{111}

$$T_{req} = \frac{dt}{\text{number} \times \text{time slots} \times \log2(1 + SNR_{dB})}$$

$$T_{req} = \frac{1824.48kb}{3 \times 200 \times 5.02680}$$

$$= \frac{1824.48kb}{3040.8kbps} = 0.6 \text{ sec}$$

Now we calculate $T_{req}$for, RAT_2 WS_{111}

$$T_{req} = \frac{dt}{\text{number} \times \text{time slots} \times \log 2(1 + SNR_{dB})}$$

$$T_{req} = \frac{1824.48kb}{2 \times 1250 \times 5.02680}$$

$$= \frac{1824.48kb}{6335\ kbps}$$

$$= 0.28\ sec$$

Only one packet is transmit over $RAT_3\ WS_{111}$, two packets are transmitted over $RAT_1\ WS_{111}$ and six packets over $RAT_2\ WS_{111}$.

The total time is required to transmit 9 packets is 1.68 sec. The total time required for sending different sizes data files by using GSM, CDMA, LTE and multi-homed CR-Site has been shown in table 5. It can be seen obliviously in figure 7 that using proposed scheme high speed communication can be achieved in cognitive radio based V2V communication system as compared to the single RAT non multi-homed enabled V2V communication systems.

Table 5. Results outcome of Proposed Solution VS Existing Communication Technologies

Serial No.	**File Size**	**T_{req} RAT_1(GSM)**	**T_{req} RAT_2(CDMA)**	**T_{req} RAT_3(LTE)**	**Proposed Solution**
1	16 Mb	5.38 sec	2.58 sec	8.98 sec	1.68 sec
2	18 Mb	6.06 sec	2.90 sec	10.10 sec	1.96 sec
3	20 Mb	6.73 sec	3.23 sec	11.22 sec	2.24 sec
4	22 Mb	7.40 sec	3.55 sec	12.34 sec	2.24 sec
5	24 Mb	8.08 sec	3.87 sec	13.47 sec	2.36 sec
6	25 Mb	8.41 sec	4.04 sec	14.03 sec	3 sec
7	27 Mb	9.09 sec	4.36 sec	15.15 sec	3sec

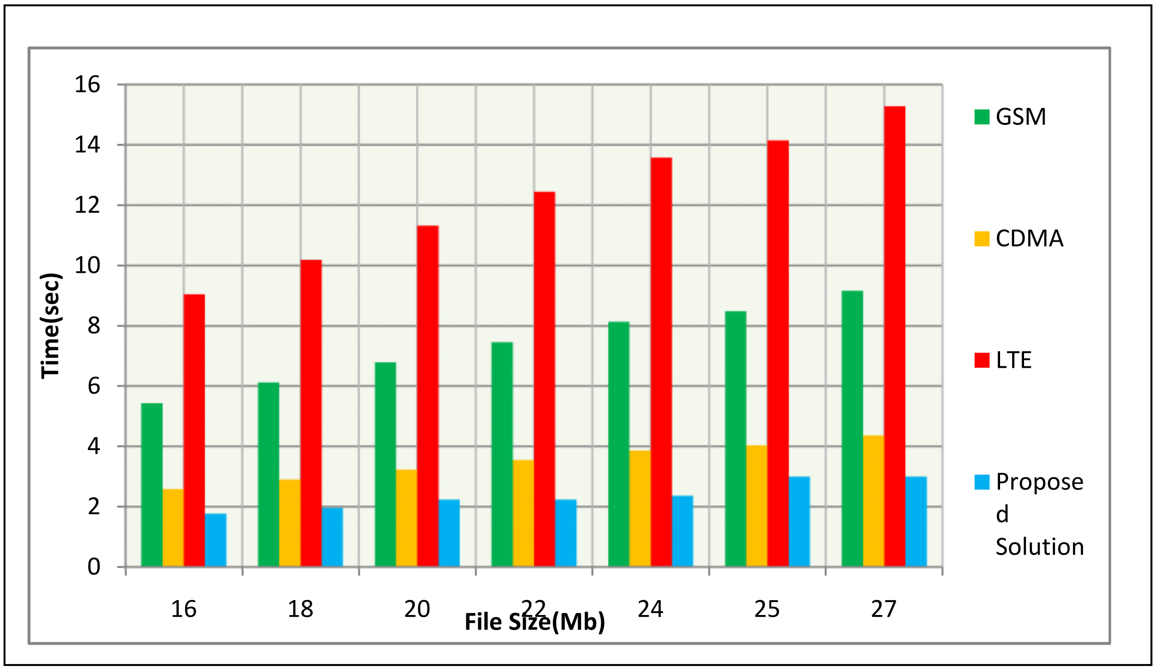

Fig 7. Single RAT Vs. Proposed Multi-homing Technique Comparison with GSM,CDMA and LTE based V2V communication system

It can be seen clearly from the figure 7 that proposed multi-homing scheme based V2V communication system can send the different data files in less time as compared to the single GSM or single CDMA or single LTE based V2V communication systems.

6. CONCLUSION

Multi-homing technique is considered best for the reliable transmission. But a new approach has been introduced in this research work in terms of another benefit of multi-homing and that is less data transmission time for cognitive radio based V2V communication system. Now the CR-Site mounted in vehicle is able to transmit heavy videos and text files in less time as compared to the GSM, or CDMA or LTE based V2V communication systems.

REFERENCES

[1] Tsugawa, S.;, "Inter-vehicle communications and their applications to intelligent vehicles: an overview," Intelligent Vehicle Symposium, 2002. IEEE, vol.2, no., pp. 564- 569 vol.2, 17-21 June 2002

[2] Tan, H.-S.; Jihua Huang; , "DGPS-Based Vehicle-to-Vehicle Cooperative Collision Warning: Engineering Feasibility Viewpoints," Intelligent Transportation Systems, IEEE Transactions on , vol.7, no.4, pp.415-428, Dec. 2006

[3] M. Kais, L. Bouraoui, S. Morin, A. Porterie, and M. Parent, "A collaborative perception framework for intelligent transportation systems applications," in World Congress on Intelligent Transport Systems, November 2005

[4] J. Luo and J.-P. Hubaux, “A survey of inter-vehicle communication,” School Computer Commun. Sci., Swiss Fed. Inst. Technol., Lausanne ,Switzerland, 2004.

[5] Y. Shiraki, T. Ohyama, S. Nakabayashi, and K. Tokuda, “Development ofan inter-vehicle communications system,” OKI Tech. Rev. 187, vol. 68,pp. 11–13, 2001.

[6] Next generation\dynamic spectrum access\cognitive radio wireless network :A survey lan F.Akyildiz,Won-Yeol Lee,Mehmet C.Vuran*,Shantidev Mohanty Broadband and Wireless Networking Laboratory,School of Electrical and Computer Engineering,Georgia Institute of Technology,Atlanta,GA 30332,United States Accessed Date:19 January 2012

[7] Tae (Tom) Oh1, 1, Young B. Choi2,” Reeling In Cognitive Radio: The Issues of Regulations and Policies Affecting Spectrum Management”, International Journal of Future Generation Communication and Networking Vol. 3, No. 3, pp. 71-79, September 2010

[8] Fawaz, K.; Ghandour, A.; Olleik, M.; Artail, H.; , "Improving reliability of safety applications in vehicle ad hoc networks through the implementation of a cognitive network," Telecommunications (ICT), 2010 IEEE 17th International Conference on , vol., no., pp.798-805, 4-7 April 2010

[9] Husheng Li; Irick, D.K.; , "Collaborative Spectrum Sensing in Cognitive Radio Vehicular Ad Hoc Networks: Belief Propagation on Highway," Vehicular Technology Conference (VTC 2010-Spring), 2010 IEEE 71st , vol., no., pp.1-5, 16-19 May 2010

[10] Xiao Yu Wang; Pin-Han Ho; , "A Novel Sensing Coordination Framework for CR-VANETs," Vehicular Technology, IEEE Transactions on , vol.59, no.4, pp.1936-1948, May 2010

[11] Faisal Riaz, Syed Ismail Shah, Gulraiz Akhter "Inter Vehicle Communication System Using Cognitive Radio: A Novel Approach to Safe Driving ",Germany: Lambert Academic Publisher, Aug 2011

[12] Tuomas Aura Pekka Nikander and Gonzalo Camarillo “Effects of Mobility and Multihoming on Transport-Protocol Security”.internet. http://goo.gl/EdGHU dated [nov 23,2010].

[13] OlgaAntonova.”Introduction and Comparison of SCTP, TCP-MH, DCCP protocols”. Internet. http: //google / vlver. April 26,2004 [dec 2,2010]

[14] Amine Dhraief and Abdelfettah Belghith .” Multihoming support in the Internet: A state of the art.Internent: www.icst-alliance.org/papers/files/120.pdf,[dec.19,2011].

[15] Preethi Natarajan , Janardhan R. Iyengar , Paul. D. Amer and Randall Stewart. “Concurrent multipath transfer using transport layer multihoming performance under network failures”.in Proc. MILCOM'06 Proceedings of the 2006 IEEE conference on Military communications, (Sabir & Riaz)2006.

[16] Wootton, J.R.,Garcia Ortiz,A.,Amin,S.M.: Intelligent Transportation Systems-Global Perspective.MComM 22(4-7),259-268(1995)

[17] Miles,J., Chen,K.(eds): The Intelligent Transport Systems Handbook,2nd denote World Road Association(PIARC),Swanley(2004).

[18] S.Shankar, C.Corderio, and K. Challapali, “ Spectrum agile redios”utilization and sensing architecture,” in Proc.IEEE int . Symposium on NEW frontiers in Dynamic Spectrum Access etworks, Baltimore, Maryland, SA, Nov,2005,pp 160-169.

[19] G. Ganesan and Y. Li, “Agility improvement through cooperative diversity in cognitive radio, “in Proc. IEEE Global Telecom.Conf.(Globecom), vol. 5, St. Louis, Missouri, USA, Nov./Dec. 2005, pp. 2505-2509.

[20] D. Cabric, S. Mishra, and R.Brodersen, “Implementation issues in spectrum sensing for cognitive radios, “in proc. Asilomar Conf. on Signal, Systems and Computers, vol.1, Pacific Grove, California, USA,Nov.2004, pp.772-776.

[21] Federal Communication Commission, “Notice of proposed rule marking: Unlicensed operation on TV broadcast bands,”ET Docket No.04-186 (FFC 04-13), May 2004.

[22] Sahai, R.Tandra, S.M. Mishra, and N.Hoven, “Fundamental design tradeoffs in cognitive radio system,” in Proc.of int. Workshop on Technology and policy for Accessing Spectrum , Aug. 2006.

[23] N.Khambekar, L.Dong, V.Chaudhary, “Utilization OFDM guard interval for spectrum sensing, ”in Proc.IEEE Wireless Commum,and Networking Conf., Hong Kong, Mar.2007, pp.38-42.

[24] S. t. B. S. M. Mishra, R. Mahadevappa, and R. W. Broderson, " Cognitive technology for ultra-wideband /WiMax coexistence," in Proc.IEEE Int. Symposium on New Frontiers in Dynamic Spectrum Access Networks, Dublin, Ireland, Apr.2007, pp. 179-186.
[25] L. Bortkiewicz. "Das Gesetz Der Kleinen Zahlen". BG Teubner, Leipzig, 1898.
[26] D. Cabric, SM Mishra, and RW Brodersen. "Implementation Issues in Spectrum Sensing for Cognitive Radios". Proceedings of Asilomar Conference on Signals, Systems and Computers (ACSSC), Pacific Grove, California, USA, pp. 772-776, November 2004.
[27] SM Mishra, A. Sahai, and RW Brodersen. "Cooperative Sensing Among Cognitive Radios". Proceedings of IEEE International Conference on Communications (ICC), Singapore, pp. 1658-1663, November 2006.
[28] P. Pawelczak, C. Guo, R.V. Prasad, and R. Hekmat. "Cluster-based Spectrum Sensing Architecture for Opportunistic Spectrum Access Networks". International Research Centre Telecommunications and Radar, Vol. 12, pp. 13-18, February 2006.
[29] Z. Li and Z. Guoxin. "Adaptive QoS-aware Channel Access Scheme for Cognitive Radio Networks". Int. J. Ad Hoc and Ubiquitous Computing , Vol. 6, No. 3, pp. 172-183, 2010.
[30] T. Yucek and H. Arslan. "Spectrum Characterization for Opportunistic Cognitive Radio Systems". Proceedings of IEEE Military Communication conference (MILCOM), Washington, DC USA, pp. 1-6, October 2006.
[31] Behrouz A Forouzan " Network Layer Internet Protocol" Data Communications and Networking, 4th ed. New Delhi, :Mc Graw Hill, 2010, pp.589-592.
[32] M. Subramaniam and D. Manjula.(2011,oct). "Performance Metrics of Multipath State Aware Concurrent Multipath Transfer using Redundant Transfer in Stream Control Transmission Protocol Multihoming for Symmetric Paths." Journal of Computer Science.[on-line].(12): 1859-1866. Available: thescipub. Com / pdf /10.3844/jcssp.2011.1859.1866[Feb.7,1012].
[33] Yuh-Shyan Chen , Ching-Hsiung Cho , Ilsun You , and Han-Chieh Chao, September 27, 2010, "A Cross-Layer Protocol of Spectrum Mobility and Handover in Cognitive LTE Networks, Elseivier,pp:1-31.
[34] Yuh-Shyan Chen, and Jia-Shiang Hong, "A Relay-Assisted Protocol for Spectrum Mobility and Handover in Cognitive LTE Networks . IEEE 2010,pp1-37