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TECHNICAL PAPER

Physical layer design for image transmission between WiMAX/DSRC system

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Abstract In order to enhance and meet the demands of vehicular communication several authors have proposed the possibility of convergence between two different technologies. In context to this, authors of this paper proposed a novel combined hybrid infrastructure for efficient vehicular communication. The novelty of this approach is the vehicular standard, i.e. dedicated short range communication (DSRC) can be converged with the existing wireless mobile communication network, i.e. Worldwide Interoperability for Microwave Access (WiMAX) technology. Authors critically explored the two different systems in terms of their physical layer, frame structure and packet format. As these technologies are based on the Institute of Electrical and Electronics Engineers therefore we do not intend to change the standards, instead we are attempting to change only a few possible parameters which can be configured to create a bridge between the physical layers of the mentioned technologies. By using this bridge we are able to establish the image transmission between WiMAX and DSRC system. The MATLAB simulation result shows that the hybrid system can be implemented to establish communication in vehicular network.

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1 Introduction

1.1 Dedicated short range communication (DSRC)

DSRC is a single or multi hop short to medium range wireless communication with low latency and is based on IEEE standard 802.11p which can also be called as wireless access vehicular environment (WAVE) (Alexander et al. 2011). It offers very high data rate and operates on 5.9 GHz frequency allocated by the federal communications commission (FCC). DSRC maintains its service at vehicle speeds up to 120mph, which leads to the enhancement of road safety, traffic management control and other applications for intelligent transport system (ITS) (DSRC Committee 2011). DSRC provides point-to-point communication and it is advantageous in vehicular communications between vehicles or between vehicles and roadside infrastructure unit where the communication environment is varying or information needs to be transferred at high data rates. The DSRC characterize the radio channel at (5.850–5.925) GHz frequency band with 75 MHz allocated licensed spectrum for vehicular communication. In DSRC, vehicles are equipped with antennas to broadcast safety messages between vehicles and vehicle to infrastructure and it communicates with road side infrastructure to obtain information about traffic movement, navigation, monitor the location map, traffic lights as well as communication between vehicles. DSRC focused on physical layer in terms of its orthogonal frequency division multiplexing (OFDM) channel that addresses both time and frequency domain up to 10 MHz bandwidth signal and the duration of OFDM symbol. The 802.11p OFDM parameters are similar to WiMAX (ASTM International 2003) OFDM. DSRC convey that the communication takes place over shorter distance which is around 1000 meters between vehicles.

DSRC physical layer scenario focuses on road safety application and consequently providing highly reliable communication for vehicular networking. The DSRC channel structures are given in US Federal Communications Commission (1998, 2003) and DSRC Committee (2009). The first DSRC channel has 5 MHz channel bandwidth is under reserved for data transmission. The reversed channel capacity approximately 5.850–5.9 GHz can be used for remote sensing or any other spread spectrum techniques for digital RADAR system (Kandar et al. 2010).

DSRC can be characterized in two operational modes (Bai et al. 2010):

(a) Distributed multi-hop communication between vehicles is characterized of ad-hoc mode.
(b) Centralized single-hop communication between vehicle and infrastructure is characterized of infrastructure mode.

The IEEE 1609 family for WAVE standards to describe an standardized architecture and a corresponding set of interfaces and services for enabling secure wireless vehicular communications. These principles are being adopted by vehicle manufacturers. These standards are designed considering the best of both to offer an initiation for a wide range of ITS applications.

1.2 WiMAX for vehicular communication

The initiation of high speed broadband communication services such as long-term evolution (LTE), WiMAX, or any other wireless networks standards do not emerge to be “a single solution solves all scheme ”. IEEE 802.16 for WiMAX standard is also known as wireless “metropolitan area networks (MAN)”. WiMAX offers digital broadband wireless access (BWA) up to 50 kilometers (km) for fixed basestation, and 10–30 km for mobile base stations. By comparing the similarity of IEEE 802.11/Wi-Fi standard is also known as wireless local area network (WLAN) is very limited in terms of coverage range up to 30–100 m. IEEE 802.16 operates on both licensed and un-licensed frequency spectrum, providing a feasible economic model for wireless environment. WiMAX networks can provide wireless services in limited cell coverage up to 5–10 km ranges for non line of sight (NLOS) applications due to scattering of building walls and trees. The average cell ranges for most of the line of sight (LOS) applications offers a wireless service ranges up to 15–30 km depending upon the capable of radio frequencies. IEEE 802.16d (802.16-2004) is called as fixed WiMAX, it covers the cell radius up to 30–50 km ranges as well as IEEE 802.16e (802.16-2009) is also known as mobile WiMAX, it offers wireless access up to 10–30 km ranges. The current WiMAX technology is provides broad range communication with high speed data access to a large number of users. The mobile WiMAX weakness depends on the connectivity of increased number of users. This present framework’s physical layer (PHY) of mobile WiMAX works on frequencies between 2 to 11 GHz and is also based on orthogonal frequency division multiple access (OFDMA) air interface and non line of sight (NLOS) applications (Doyle et al. 2011). One important peculiarity about the scalable OFDMA framework utilized as a part of IEEE 802.16e is the simple versatility of the framework to adjust to unstable bandwidth for data transmission range in between 1.25 and 20 MHz The system parameters should be maintained by both channel and keeping the frame size constant. Mobile WiMAX can handle every user request hence on this basis it is considered to be much superior to contending 3G technologies. WiMAX is frequently referred to have an efficient spectrum of 5 bps/Hz, which is great compared to 3G wireless networks and broadband technologies. The analysis of performance is done in Tao et al. (2007) utilized the IEEE 802.16d and 802.16e standard with an physical layer OFDM frame format. IEEE 802.16e standard (WiMAX-Part 2006) utilize to some degree distinctive frame structure in order of association for exceptionally portable circumstances. Mobile WiMAX, instead of OFDM utilizes S-OFDMA frame structure (WiMAX-Part 2006). S-OFDMA characterizes data bandwidth allocation between both time and frequency domain duplexing (TDD and FDD) as well as subset of accessible subcarriers using sub-channelization.

1.3 Motivation and scope of the proposed approach

In recent years, a lot of research activities are undergone on vehicular communication based on long range communication and multi standard interoperability in dynamic vehicular environment. An empirical study on existing vehicular communication technologies to understand the various issues and possibilities to design a combined hybrid technology for future vehicular communication. In this paper, authors focuses on addressing the shortfalls identified in current vehicular communication networks. IEEE 802.11p standard specifically designed for vehicular safety communication use and it supports short range communication between vehicles within 1000 m range. WiMAX offers broadband wireless access more than 5 km up to 50 km approximately and it supports wide area connectivity of vehicles. In general, the convergence of DSRC and WiMAX was initiated from the many similarities associated with the physical layer parameters and different vehicular communication scenario. The proposed combined hybrid technology has overcome the issues on existing vehicular communication networks. By improving the road safety as well as it can be achieving wide range vehicular communication for different architectural setup.

2 Related work

Nabih Jaber in his paper (ASTM International 2003) shows the possibility of convergence of technologies by designing a novel combined architecture of DSRC and Worldwide Interoperability for Microwave Access (WiMAX) for a more efficient vehicular network. They designed WiMAX tunnel using DSRC with specific changes like network entry and handover processes in the WiMAX protocol which are redesigned to behave differently when operated over DSRC. By this proposed design, the authors claimed to have improved WiMAX technology by dropping the communication of WiMAX user's connection between vehicles which reduces the traffic congestion at WiMAX base station with an increase in the throughput performance. Various authors have computed the performance of the system associated with DSRC and IEEE 802.16 by considering metrics such as throughput, delay, packet loss ratio and mean for VANETs (Bhakthavathsalam and Starakjeet Nayak 2011). The mobility model is generated using a network traffic simulator (SUMO) which supports network simulation software (NS-2) in a typical traffic scenario. The authors of this paper also proposed a vehicular network application called "Street Congestion warning" to assess the performance of DSRC and IEEE 802.16 where they concluded that WiMAX is comparatively better than IEEE 802.11p for the size of larger networks. Wireless fidelity (WiFi) and WiMAX has also been considered for convergence (Al-Sherbaz et al. 2009), where the main vertical trends like efficient bandwidth usage, wireless mesh networks (WMN) and multi standard convergence are brought into picture. WiFi has low cost compared to WiMAX and the possibility interoperability of both these technologies are explored in this paper. Therefore, the authors proposed a convergence bridge which is a thin layer between physical and MAC layers, responsible for matching the different FFT subcarrier sizes of WiFi and WiMAX. authors selected IEEE 802.11n OFDM for WiFi physical layer while it is being developed and tried to set up the functions by configuring the possible parameters for WiFi and WiMAX. An infrastructure design for heterogeneous network with demonstration for the incorporation of wireless standard IEEE 802.11 and IEEE 802.16, where handover management aspects is the main focused is presented in Pontes et al. (2008). To integrate WiFi and WiMAX the authors used a media framework for independent handover (MIH) among the various networks. Mir et al. (2014) describes in his paper by evaluating the performance and a comparative study of both the technologies i.e., LTE and DSRC by studying the standard in details for a given variety of parameters configured such as vehicle density, vehicle average speed and beacon transmission frequency. Both technologies are compared and evaluated in terms of consistency, delay, control overhead and mobility support in terms of several application perspectives and under different vehicular network situations. Based on the study, the authors concluded that DSRC provides end to end time delays below 10 ms with 10 kbps throughput which supports the requirement to a more lenient traffic efficiency applications.

Morgan (2010) described the issues and limitations on DSRC communication as DSRC offers an medium or short range communication for vehicular networks and it supports one hop or multi hop wireless communications within the range of 5.850–5.925 GHz RF frequency. He focused to design on the DSRC core feature which is also known as WAVE. A detailed tutorial of the WAVE standard is given in detailed in response to vehicular communication environment mainly focusing on road safety by DSRC technology. Areas such as MAC services, service management and QoS are described with the use of channel coordination. Keeping the main generic view of DSRC as the base technology for vehicular communication and parallel efforts to promote DSRC in more technical aspects is the main concern. Aguado et al. (2008) presented the deployment of WiMAX network as a candidate for broadband and low latency vehicular to infrastructure communication architecture. In this paper inter-access service network (ASN) handover is being recognized as the most vital point to be handled so that the proposed architecture meets the requirements of the WiMAX radio system profile by deploying real time applications such as VoIP. Dhilip Kumar et al. (2016) authors evaluated the performance of hybrid combined WiMAX and DSRC system for efficient vehicular communication. Their work describes an uplink and downlink communication between fixed and mobile WiMAX. Furthermore, the bit error rate has also been calculated to evaluate the effectiveness of combined hybrid vehicular networks. Msadaa et al. (2010) evaluated the performance of hybrid vehicular technology through comparative study between DSRC and WiMAX. This paper proposed the effectiveness of combined technology by impacting vehicle speed and data rate on both wireless standards.

Chou et al. (2009) proposed an empirical study on hybrid wifi and wimax infrastructure for efficient vehicular communication scenarios and real time implementation of DSRC performance. Kato et al. (2013) proposed a combined cloud based LTE architecture to broadcast the downlink communication to vehicles by locating the cloud server to improve the effectiveness of wide range vehicular communication as well as road safety use. Trichias et al. (2011) proposed a comparative study between DSRC

Table 1 Comparisons between DSRC (802.11p) and WiMAX (802.16e) standards

Requirements	DSRC (802.11p)	WiMAX (802.16e)
Operating frequencies	5.9 GHz	Frequencies between 2 and 11 GHz for NLOS applications
Data rate	Maximum 27 Mbps	It supports 63 Mbps
Operating radio frequencies	5.875–5.925 GHz	2–11 GHz
Modulation technique supported (PHY)	OFDM	OFDM/OFDMA
MAC layer	Point to point (P2P)	point to multipoint (PMP) and mesh.
Maximum coverage	1000 m (3000 ft)	10 and 50 kms for LOS propagation
Channel capacity	7–10 MHz channels	3.5 to 20 MHz
Total FFT size	64	128, 512, 1024, 2048
Data subcarriers	48	72, 360, 720, 1440
Pilot subcarriers	4	12, 60, 120, 240
Number of used sub-carriers	52	84, 420, 840, 1680
Guard band subcarriers	12	44, 92, 184, 368
Subcarrier frequency spacing	156.25 KHz	10.94 KHz
Useful symbol time (μ sec)	64	91.4

and LTE technology. Performance evaluation of various scheduling schemes has been calculated through analytical and simulation based approach for future ITS. Caballero-Gil et al. (2013) proposed an architecture for smart phone based vehicular networks. This architecture exploits various vehicular network applications by utilizing wireless technologies such as bluetooth, wifi and mobile networks such as 3G, 4G etc. Corti et al. (2012) proposed a universal mobile telecommunications system (UMTS) based vehicular network. Their work focuses on centralized vehicular communication for advance driver assistance system for road safety application.

Architecture for a centralized location service in an urban VANET scenario has been proposed and evaluated in Katsaros et al. (2013) based on the homogeneous DSRC (802.11p) and a heterogeneous integration of DSRC and LTE networks. The performance of this hybrid solution was solved by considering certain performance metrics like the system overhead and end to end delay and this resulted in a heterogeneous network where DSRC can be utilized for data delivery and for location service and better performance in high load scenarios and high density LTE can be utilized which can be potentially done by deploying femtocells. Evaluation of IEEE 802.21 standard architecture for implementing the QoS mechanisms by integrating advance mobility based scenario is presented in Matos et al. (2009). The authors claimed that by integrating WiFi and WiMAX seamless mobility is supported which is capable for the future communication environments and the overall performance and with the enhanced version of combined mobile IP and media independent handover (MIH) minimum packet loss is observed in the phase of handover implementation.

3 Comparison between DSRC (802.11p) and WiMAX (802.16e)

A detailed comparison between DSRC (Federal Communications Commission 1999, 2003) and mobile WiMAX (802.16e) systems are highlighted in this paper shown in Table 1 in contrast to their functional requirements and their operating factors (Yin et al. 2004; Jaber et al. 2012). The physical layer OFDM is one of the important factors to establish communication process. Which can be used in both DSRC and WiMAX standards. Since mobile WiMAX uses OFDMA, It can be separated into multiple OFDM subcarriers based on frequency spectrum. The initial step of convergence is matching frequencies between DSRC and WiMAX. Authors have considered common radio frequency 5.850–5.925 GHz from 2 to 11 GHz frequency for downlink scenario.

4 Proposed DSRC: WiMAX infrastructure for vehicular communication

There are several potential advantages in utilizing this specific combined architecture rather than WiMAX or DSRC alone. Roadside side unit (RSU) can be used for longer range communication between vehicles without a significant interest in road side infrastructure. The mobile WiMAX (802.16e) architecture is to minimize the establishment of excessive WiMAX base station (BS) as well as reducing cost efficiency. DSRC act as an on board unit (OBU), which can capture various advantages by providing high bandwidth and low cost services along with modern safety applications for dynamic environment. In this paper, authors proposed a novel hybrid

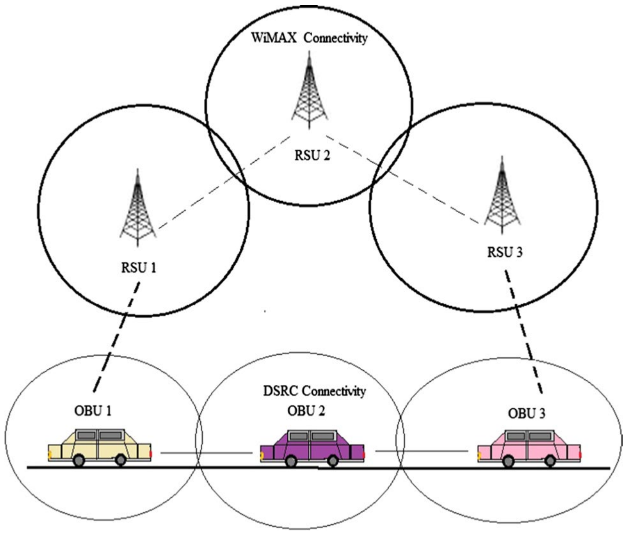

Fig. 1 WiMAX DSRC architecture

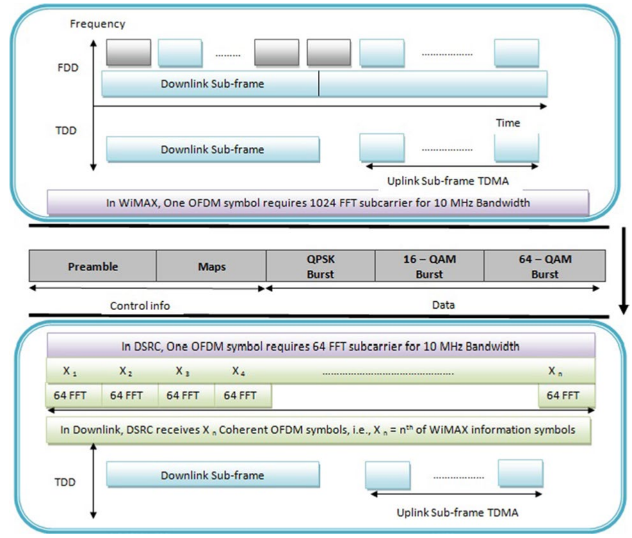

Fig. 2 Frame structure of WiMAX/DSRC (downlink)

combined system of DSRC vehicular safety system with WiMAX technology. An assumption is made where all vehicles are equipped with both WiMAX and DSRC transceivers. The architecture scenario is shown in Fig. 1.

Short range communication i.e., vehicle to vehicle (within 1000 M) can be incorporated by IEEE 802.11p technology. DSRC units are equipped on vehicle (on board unit) which can provides communication to other vehicle by ad-hoc communication mode. Several such units will form a cluster. All mobile base stations formed a group of clusters. Each cluster is dynamically configured and independently controlled by clustering and gateway nodes. These clusters are designed for establishing the communication between vehicles and road side infrastructures to provide an efficient communication for vehicular networks. As OBUs are moving, cluster shapes changes rapidly. For longer distance (about 50 kms) communication, one OBU communicates to another unit through RSU. WiMAX is installed in RSUs which are acting as base stations (BS) where both OBUs and RSUs support WiMAX as well as DSRC system. OBU1 establish communication to RSU1, which can be transmitted to the destination OBU3 through RSU2 and RSU3 respectively by using WiMAX/DSRC hybrid technique. However, RSU1 and RSU3 establish downlink WiMAX communication between them.

4.1 Frame structure of OFDM for downlink WiMAX: DSRC communication

Figure 2 describes the DSRC (802.11p) and WiMAX (802.16e) frame structure.It represents the combined frame structure of 1024 FFT and 64 FFT of 10 MHz bandwidth. In WiMAX OFDM, information is transmitted into frames, during the downlink burst, the entire frame is transmitted to DSRC sub frame. A duplexing method based on frames is taken into consideration to establish transmission between DSRC and IEEE 802.16e. In DSRC-OFDM physical layer, the FFT size is 64 and OFDM symbol is made up of three subcarriers, where 48 bit subcarrier frequency are used for data transmission in addition to 4 pilot subcarriers and 12 Guard bands. In the WiMAX OFDM physical layer the FFT size is1024 required for 10 MHz bandwidth. The uplink transmission of image operates on TDD (Time division multiplexing) mode and downlink transmission operates on both TDD and FDD (frequency division multiplexing). Here, the downlink transmission requires 840 out of 1024 subcarriers. In OFDM frame consist of control and data information. This information is transmitted through short and long preamble. It contains OFDM symbol assigned to all DSRC data subcarriers. i.e., 52 FFT for DSRC and 768 FFT for WiMAX. These transmitted 1024 FFT OFDM symbol modulated by 16 QAM modulation burst, which can be support to DSRC 64 FFT downlink sub-frame. Therefore subcarrier spacing is independent of OFDMA channels, it represents both time and frequency allocations. But in DSRC physical layer, an OFDM channel is represented only on TDD (IEEE Std 2009). In DSRC downlink sub-frames, signals are received from the 1024 FFT size which are allotted in various time slots depending on modulation technique and it splits into 64 FFT subcarrier frequencies spread across its spectrum.

4.2 Block diagram for WiMAX/DSRC transceiver in the downlink

Figure 3 depicts the block diagram and The input image is converted into set of parallel bit streams by using serial

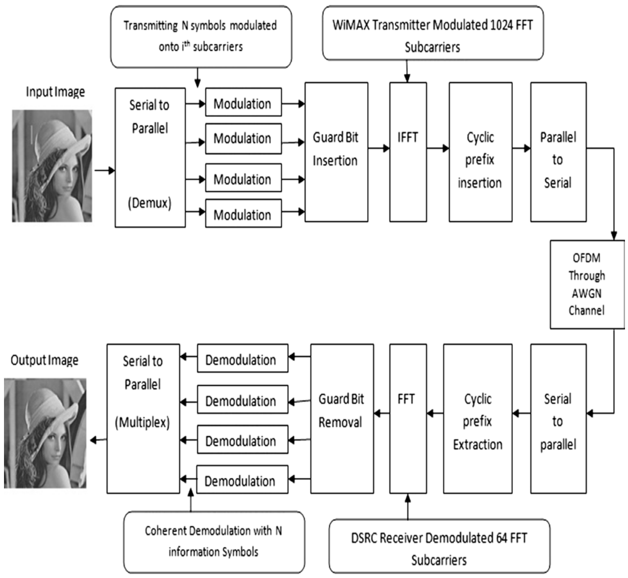

Fig. 3 Block diagram for WiMAX/DSRC transceiver

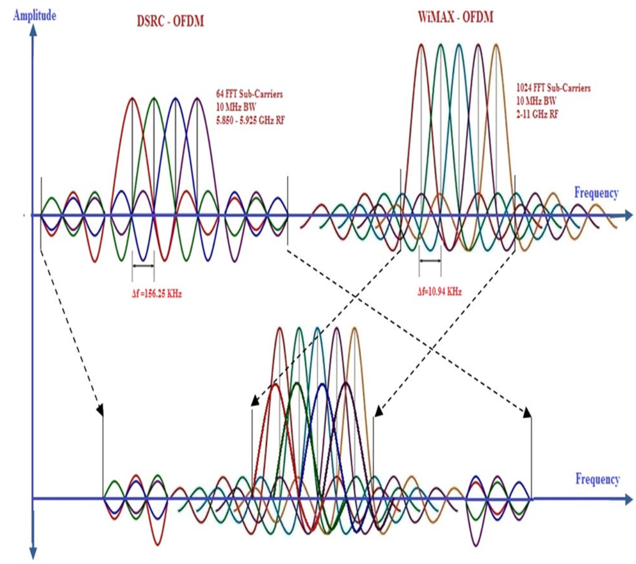

Fig. 4 WiMAX and DSRC spectrums and frequency conversion

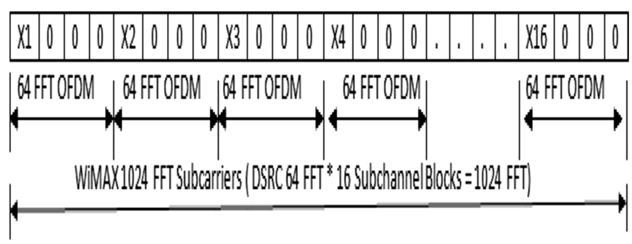

Fig. 5 Subcarrier matching

to parallel converter and it demultiplex the overlapped orthogonal subcarriers into multiple modulated data is then mapped for data modulation. The guard bit insertions used to avoid inter-symbol interference in a cyclic prefix for preventing inter carrier interference. In mobile WiMAX supports 1024 FFT subcarriers depending on 10 MHz channel bandwidth. The use of IFFT blocks in the transmitter to convert frequency domain samples to time domain samples. The total number of subcarriers N defines the IFFT length is present in the WiMAX OFDM technology with 16 QAM modulation scheme. The modulated OFDM signal convert into parallel bit stream and the signal is transmitted through AWGN channel to the DSRC receiver end. The DSRC receiver performs the inverse process of the WiMAX transmitter and it demodulated into 64 FFT DSRC subcarriers. The coherent demodulation of N information symbols are multiplexed into single carrier bit stream for extract the output image in the DSRC receiver end.

4.3 Center–radio frequency convergence

Figure 4 depicts the basic structure of a DSRC-OFDM frequency domain which have 64 FFT subcarriers spread over 10 MHz bandwidth with 156.25 KHz subcarrier spacing, while the downlink WiMAX OFDM requires 1024 FFT subcarriers for 10 MHz bandwidth with 10.94 KHz subcarrier spacing and 2–11 GHz frequency range (Ran et al. 2002). Therefore DSRC and WiMAX standard (IEEE 802.11e) are specified over the air interface for efficient vehicular communication with respect to their frequency conversion by taking their individual spectrums.

The IEEE 802.16-2005 amendment was extended to develop the standard of 802.16d air interface for mobile applications. This uses OFDMA with a 128, 512, 1024 and 2048-point transform is based the radio frequency bands (2 âĂŞ 11 GHz) and is specially designed for NLOS operation. In the OFDMA mode, all the FFT subcarriers are splitted into subsets of subcarriers depends on number of sub-channels. In the downlink scenario, a sub-channel may be projected for different receiver. In the uplink scenario, a sub-channel may be defined for different transmitters. These uplink and downlink sub-channels may not be adjacent.

4.4 Subcarriers matching between WiMAX and DSRC

In Fig. 5 subcarrier matching is depicted where DSRC is pictured with one OFDM symbol which takes into account 64 FFT subcarriers, meanwhile by considering WiMAX technology we need to match 64 FFT into 1024 FFT carriers by using zero padding. Each block contains 16 bits subcarrier. i.e., between the subcarriers blocks, 4 carrier counts are considered. Therefore, we pad zeroes to match the carrier count which is given as follows:

$$
\begin{aligned}
&Padding\ zeros = Carrier\ symbol\ count * Carrier\ count;\\
&Symbol\ count(x_n) = 16;\\
&i.e., x_n = x_1, x_2, x_3, \ldots, x_{15}, x_{16};\\
&Carrier\ count = 4;\\
&i.e., 16\ subchannels * 4\ carrier\ count = 64\ FFT\ subcarrier
\end{aligned} \tag{1}
$$

Therefore, by transmitting 64 FFT DSRC OFDM symbol 4 bits subcarriers are taken including 3 zero padded bits.

4.5 Data capacity and efficiency calculation using AMC subchannelization

The payload efficiency and data rate capacity has been calculated using 16 QAM modulation scheme and adaptive modulation coding (AMC) sub-channelization. Therefore,

$$Datarate\ (R) = \frac{M * N_{data}}{T_s} \tag{2}$$

M is the modulation order, (i.e., 16 QAM = 4 bits/symbol), N_{data} = number of data subcarriers and T_s is OFDM symbol time.

$$S(t) = Re\left\{ e^{j2\pi fct} . \sum_{K=-N_{used/2}}^{N_{used/2}} C_k . e^{j2\pi k \Delta f(t-T_g)} \right\} \tag{3}$$

$S(t) = Transmitted\ OFDM\ signal$

Therefore, real part of transmitted signal is

$$Re\left\{ e^{j2\pi fct} . \sum C_k . e^{j2\pi k \Delta f(t-T_g)} \right\} \tag{4}$$

Channel bandwidth (MHz) = (WiMAX = 10, DSRC = 10)

FFT size (for 10 MHz bandwidth) (N_{FFT}), for WiMAX = 1024, DSRC = 64

$$C_k = Data\ part\ (input\ files); \quad e^{j2\pi fct} = Carrier\ frequency; \tag{5}$$

$$e^{j2\pi k \Delta f} = Subcarriers; \quad Guard\ time\ (T_g) = \frac{T_b}{8}, \tag{6}$$

WiMAX = 11.425, DSRC = 0.8

$T_b = \frac{1}{\Delta f}$; $(DSRC = 6.4\,\mu s;\ WiMAX = 91.407\,\mu s)$

$Subcarrier\ frequency\ spacing\ (\Delta f) = \frac{F_s}{N_{FFT}}$;

(DSRC = 156.25 KHz, WiMAX = 10.94 KHz)

$Central\ frequency\ (f_c);$ $DSRC = 5.9\,GHz, WiMAX = 2{-}11\,GHz.$

$N_{used} = Number\ of\ used\ subcarriers;$

DSRC = 48, WiMAX = 720.;

$T_s\,(\mu s) = T_b + T_g = (1 + G);$

Table 2 Simulation parameters table

Parameters	Values
Input file size	128 × 128 pixels
File format	Jpg (grayscale image)
IFFT size	1024
Number of subcarriers	64
Modulation schemes	BPSK, QPSK, 16 QAM, 64 QAM
Amplitude	9 dB
Signal to noise ratio (SNR)	14 dB

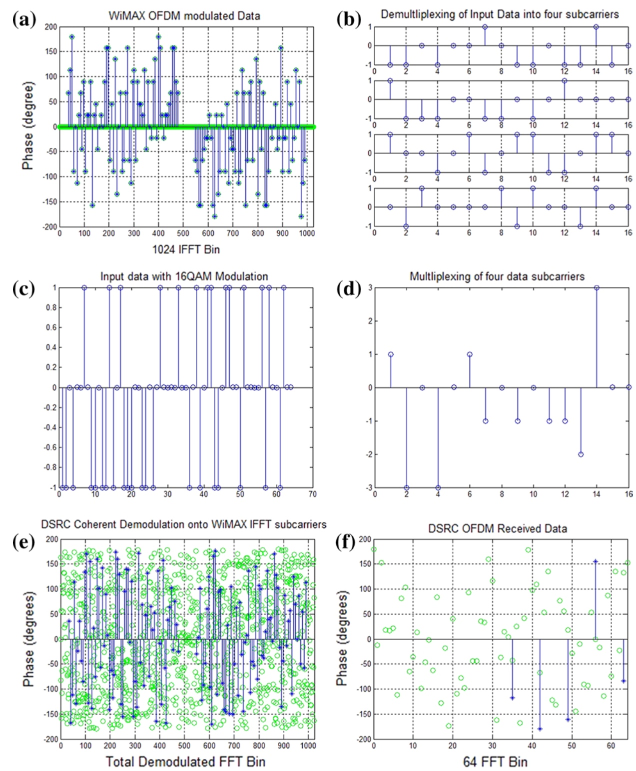

Fig. 6 Simulation results

$G = \frac{1}{4}\ for\ DSRC, \frac{1}{8}\ for\ WiMAX.$

$T_s = (DSRC = 8\,\mu s;\ WiMAX = 103\,\mu s)$

i.e., Data rate (R) is 28 Mbps for WiMAX and 24 Mbps for DSRC by using 16 QAM modulation scheme. (i.e M = 4bits per symbol).

In AMC subchannelization, number of subchannels for 1024 FFT is 48. It can be taken for uplink and downlink scenario and 8 data subcarriers + 1 pilot subcarrier = to form a 1 bin for AMC permutations. Therefore by evaluating the data capacity (NDC for uplink and downlink scenario in 1024 FFT) is

$$N_{DC} = \frac{48\ Subchannels * \frac{8\ Data\ carriers}{Bin} * \frac{2\ Bins}{Symbol}}{\frac{1\ Bin}{tile}} \tag{7}$$

$$N_{DC} = 768 \; Data\ subcarriers \tag{8}$$

The above equation describes the factor to transmit and receive the carrier frequency signals from DSRC (5.9 GHz) or WiMAX (2–11 GHz). NFFT size is a major factor of combining two different technologies depends on transmitting OFDM symbols in 10 MHz bandwidth frequency. Therefore, by using AMC sub-channelization (Melki et al. 2009) and 16 QAM modulation scheme we can evaluate the data capacity and data range for WiMAX-DSRC convergence. 768 Data subcarriers are used for establishing communication from 1024 FFT subcarriers and data rate will be 28 Mbps for WiMAX and 24 Mbps for DSRC. The WiMAX spectrum has a 1024 FFT subcarrier within the range of 2–11 GHz RF band (Altera 2007) whereas DSRC signal spectrum has a 64 FFT subcarrier frequencies within (5.89–5.9 GHz) band of 10 MHz bandwidth for orthogonal subcarriers.

5 Simulation results

5.1 WIMAX/DSRC simulation

The input parameters considered for this proposed system is given in Table 2. The results we obtained from this system are illustrated in Fig. 6a–e.

In the WiMAX transmitter side illustrated in Fig. 6a, an image is given as input into the system, the transmitted input image stream is divided into four subcarriers and it can be encoded in the form of 1024 IFFT binary bit stream (X-axis) and phases will be varying either −180 to 180° (Y axis). These transmitted N symbols are modulated onto the ith subcarriers, hence the demultiplexing data is transformed into parallel data of four OFDM subchannel blocks so that each blocks contains 16 subcarrier counts as depicted in Fig. 6b. Therefore 1024 IFFT subcarriers are chosen to be one WiMAX OFDM symbol, each symbol padded with a guard interval and cyclic prefix, and then it can be transmitted through an additive white Gaussian noise (AWGN) channel. Then in Fig. 6c, it is depicted that each of these transmitted IFFT input data of each subchannel is modulated by 16 QAM modulation scheme as it improves data rates and provides the best performance and coverage range when combined with the OFDM system. At the DSRC receiver end, the receive carriers are demodulated into 64 FFT OFDM subcarriers and it can be transformed onto coherent WiMAX 1024 IFFT information symbols as illustrated in Fig. 6d, e. Hence the multiplexing of received WiMAX OFDM symbols in DSRC receiver is demodulated into 64 FFT OFDM symbols and the binary bit stream are decoded to convert and restore the source image file to its original file.

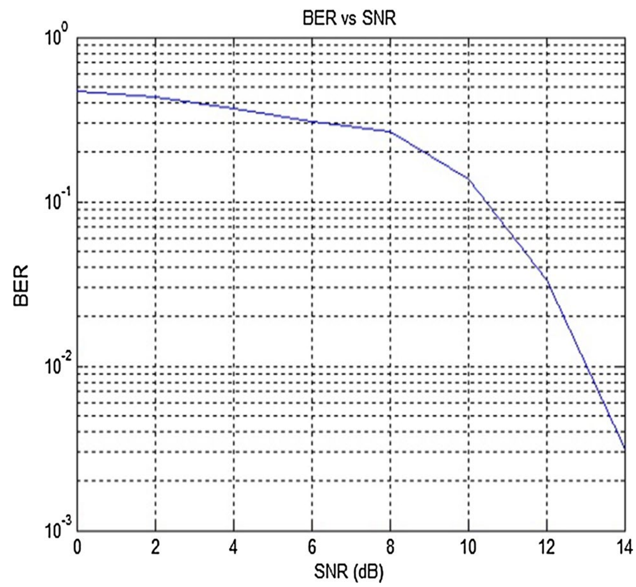

Fig. 7 BER vs SNR

5.2 Simulation results for calculating BER at the DSRC receiver end (downlink)

Finally, the impact of different subcarriers between transmitter and receiver are addressed in Fig. 7. On the other hand, we can analyzed the effectiveness of the proposed combine DSRC/WIMAX system by evaluating the signal to noise ratio (SNR) for proposed combined hybrid system which can be defined as follows, Where, MSE is an acronym for mean squared error between the WiMAX input image and DSRC received image and fb is the data rate of 16 QAM modulation.

$$SNR_{(dB)} = 10\log_{10}\left(\frac{E_b * f_b}{N_0 * MSE}\right) \tag{9}$$

Simulation results of the performance of the system are carried out according to the simulation parameters used to calculate BER vs SNR are: the number of OFDM subcarriers is considered to be 64 FFT and decoding with convolution coding with 16 QAM modulation scheme. The resolution of input image is 128 × 128 pixels 8-bit grayscale image. In order to achieve the impact of the proposed hybrid technology the SNR can be reduced nearly from 14 to 12 dB by decreasing the padded zeros in the received image respectively.

6 Conclusion

Considering the configurable parameters which can be configured in both the technologies, authors have proposed that DSRC-WiMAX infrastructure can be used commercially in order to improve the vehicular communication performance. The fresh hybrid system in combining the vehicular communication system with the existing wireless mobile communication network is the main motivation that drives many researchers to dig deep to meet the needs of wireless communication. Though, the Downlink image transmission is simulated in MATLAB environment, the Uplink transmission is yet to explore. As well as data capacity and data rate can be calculated by using AMC sub-channelization and 16QAM Modulation scheme, which can enhance the spectral efficiency of this Hybrid technology. The clustering algorithm between the DSRC to DSRC system has to be incorporated to bring into the final realization of such system. Handover issues in such dynamic environment are an open research issue in this context.

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