Indian Journal of Science and Technology, Vol 9(20), DOI: 10.17485/ijst/2016/v9i20/89973, May 2016
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Variable Modulation Schemes for AWGN Channel based Device to Device Communication

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Abstract

Background/Objective: In modern trends device-to-device communication is an exciting and innovative networking technology for achieving high data rates. **Methods/Statistical Analysis**: The existing device-to-device communication model specifies that control and data signals in direct communication, links between smart devices owned by cellular users within an operator's network. **Findings:** This paper analyzes the bit error rate of device to device communication under different modulation schemes like BPSK, 4QAM, 16QAM. In order to assess the bandwidth competency and to sustain the QOS in AWGN channel, SNR is varied. By implementing device to device communication for a higher order modulation schemes will Increase the data rates with high bit error rate.

Keywords: AWGN Channel, Bit Error Rate, Device-to-Device Communication, Modulation Schemes

1. Introduction

The important feature of the mobile networks is the Device to Device (D2D) communication. In Local peer to peer communication, D2D communication will operate as an underlay to an advanced IMT cellular network[1]. It is the technology component for LTE-A. The existing technology increases the spectral efficiency and data rate speed. A direct link is established between the users to exchange the information. The base station involvement in D2D communication is reduced. This distinguishes it from femtocell. In femtocell, communication between users is handled by a base station. The D2D communication will provide the higher capacity compared to the regular cellular communication in which base station involves in data exchange between users[2].

The Table 1 analyzes the various wireless technologies.

2. Device to Device Communications

Direct communications between the devices are existing in the ad hoc mode communication has existed in radio technologies for many years[3]. Communication between the devices is autonomous and doesn't require any intermediate nodes. Licensed cellular spectrum is used for it. Proximity of the equipment provides high data rates/reduced amount of delays and consumed energy is very low. In this, spectrum can be availed by D2D and cellular devices in parallel and more than once[4]. It uses the already available cellular resources they offer extra service and extended support to already available services and applications.

This communication requires fast discovery, Low energy utilisation, reduced external interference to the WAN and resource dreadful conditions[5].

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Table 1. Analysis of various technologies

Feature Name	D2D	Wi-Fi Direct	NFC	Femto/Pico/Relay
Standardization	3GPP LTE-A	802.11	ISO13157	3GPP (Release 9,10,11)
Frequency Band	Licensed band for LTE-A	2.4,5GHz	13.56MHz	Licensed band for LTE-A
Max Transmission Distance	1000m	200m	0.2m	1-2KM
Max Data Rate	1Gbps	250Mbps	424Kpbs	100-500Mbps
Uniformity of Service Provision	Yes	No	No	No
Application	Offload Traffic, Public Safety, Context Sharing, Local Advertising, Cellular Relay	Context Sharing, Group Gamming, Device Connection	Contact less payments, Bluetooth & Wi-Fi Connections	A. Beater coverage and prolonged hand set Battery life. B. Better Coverage for cell edge users. C. System Capacity gain from smaller cell size. D. Complete operator control
Infrastructure	Users transferred data directly in licensed band	Users transferred data directly in un -licensed band		User transfer data through central controller(Femto/Pico/Relay) in licensed band
Expenses	**CAPEX:** No Cost, As users are using the same terminal. **OPEX:** Very low cost in terms of Battery usage	**CAPEX:** No Cost, As users are using the same terminal. **OPEX:** Very low cost in terms of Battery usage		**CAPEX:** Subsidized Femtocells Hardware. Installing new cell sites, Installing new cell towers. **OPEX:** Electricity Site lease and Backhaul. Providing a scalable architecture to transport data over IP: Upgrading femtocells to newer standards.

3. AWGN Channel

Adaptive White Gaussian Noise (AEGN) is a most popular and regular model of the imperfections that a communication channels consists of. When a signal is transmitted via a channel i.e., free space or atmosphere or copper line, which is to be received at the other end (receiver side), there are disturbances (aka noise) present in the channel (space/atmosphere/copper line) due to a large variety of possibilities.

One of the possibilities is the thermal noise and it is due to movement of charged particles in the circuits being used at transmission as well as receiving side of the signal. This unwanted trouble or noise is mathematically represented as AWGN

Let's first see the time-domain behaviour of this noise:

Additive: The noise gets added to the signal which is transmitted and is not multiplied with the signal. The received signal $a(t) = d(t) + n(t)$, where $d(t)$ is the original transmitted signal, and $n(t)$ referred as noise or unwanted trouble in the channel. **Gaussian**: This thermal noise is random in nature, noise can't be deterministic otherwise you would subtract the deterministic noise from $a(t)$ as soon as you receive $a(t)$. So, this random thermal noise has Gaussian distribution with zero mean and variance as the Noise power. Just leave the variance part if you don't understand it now, remember only that, if variance of Gaussian is high then it's bad. $d(t)$ power should be raised else probability of error is high. If the expected value of noise (E{x (t)}) during the T amount of time interval is zero then it is termed as zero mean. It also means that on an average, n(t) will take zero value. Probability of n(t) = 0 is the maximum and if magnitude of n(t) is further increased probability decreases rapidly.

4. Modulation Schemes

4.1 BPSK

In digital modulation, data is transmitted with a change in phase of a message signal is generally termed as Binary Phase Shift Keying (BPSK). The signal is expressed into the magnetic field x, y area by varying the sine and cosine inputs at precise time. It is extensively used for wireless LAN's, RFID, Bluetooth transmission. Finite number of phases is used in BPSK as the digital modulation uses the limited number of unique signals to express digital data. In Phase Shift Keying, the uniform angular spacing around a circle is positioned in constellation points. BPSK uses the two phases which are separated by 180

4.2 QAM

The digital modulation scheme which can be done in both analog and digital form is referred as Quadrature Amplitude Modulation (QAM). Using the analog Shift Keying or Amplitude Modulation it is possible to transmit 2 analog signals or 2 digital bit streams. In this, the carrier waves are 90 degrees out of phase sinusoidal which are referred as quadrature carriers.

It is extremely used in the digital telecommunication systems. With the appropriate constellation size, linearity of communication channel and limited noise level high spectral efficiencies can be attained in this modulation scheme. In optical fiber systems it is extensively used to increase the transmission bit rate. QAM can be implemented in 16, 64,256 bits. By using higher order QAM, we can send more bits per symbol. In digital broadcasting 256 QAM is used.

4.3 Bit Error Rate

In digital transmission, competence of a communication channel is evaluated by Bit Error Rate (BER) as a general metric[6]. BER is a per unit time basis measurement of how many number of error bits. It can be termed as the ratio of number of bit errors to the total transmitted bits during a specific time interval. BER is a unit less parameter. BER at receiving side is effected by large number of factors like noise, interference, distortion, bit synchronization, attenuation, and wireless multi path fading[7].

Information BER is the number of decoded bits remains incorrect after the error correction is divided by the length of the decoded bits[8,9]. Information BER is smaller than the transmission BER. The information BER is affected by the forwarded error correction code.

5. Design Methodology

In this paper, to test the various modulation schemes MAT Lab tool is used. MAT Lab is a GUI based tool for analysis and simulation of mathematical models. MAT Lab is very user-friendly and integrates data assessment programs that are repeatedly used. Thus, complex data evaluation approach can also be performed.

6. System Design

The technique of amalgamating the carrier signal with message signal is termed as modulation; the carrier wave contains the message or digital data (zeros or ones). Modulation will be done at the transmitter end and the original data will be retrieved at the receiver end is termed as demodulation. In digital communication the main task is to retrieve the original data as sent from the transmitter.

It is essential to analyze the system performance in terms of error rate[10–12]. Generally error rate depends on the modulation technique, while dealing with signals each modulation scheme will have specific system performance i.e., higher order modulation schemes (64 QAM) are effective in delivering high data rates but they are not reliable like lower order modulation schemes (QPSK) which deliver low data rates[13–15]. In this paper we are analyzing different modulation schemes using Additive White Gaussian Channel (AWGC) to determine the speed and probability of error in device to device communication.

7. Simulations and Comparison

Device to device communication model with various modulation schemes have been simulated in this paper. The performance comparisons are done on the basis of Bit Error Rate (BER) vs Signal to Noise Ratio (SNR) i.e., by varying the signal to noise ratio to analyze the Bit Error Rate (BER) and Quality Of Service (QOS) in AWGN channel. In all the simulated models a random complex signal is represented with 100000 bits and is transmitted to the receiving side through AWGN channel.

For all the simulated models noise channel is developed using zero mean with a varying standard deviation. Once the complex signal is passed through the AWGN at the receiving end a corrupted complex signal is received. The corrupted signal at the receiver end is compared with original signal and BER is calculated.

AWGN channel is considered here is having different characteristics and are described below:

- For QPSK shown in Figure 1 and Figure 2 the standard deviation of the channel varies from 0.0001 to 0.707 with a linear step size of 0.0141. In QPSK the amplitude of the signal extends from –1 to 1.
- For 16QAM shown in Figure 3 and Figure 4 the standard deviation of the channel varies from 0.0001 to 1.118 with a step of 0.0224 and amplitude extends from –3 to 3.
- For 64 QAM shown in Figure 5 and Figure 6 the standard deviation of the channel varies from 0.0001 to 1.8708 with a step of 0.0374 and the amplitude of constellation extends from –5 to 5.

For every signal value energy per bit (Eb/No) and SNR (Signal to Noise Ratio) is calculated. QPSK, 16 QAM and 64 QAM are tested in AWGN (Eb/No) channel; the comparison is drawn on the basis of Bit Error Rate (BER) vs Signal to Noise Ratio (SNR).

Figure 7 illustrates the SNR VS BER of Various Modulations Schemes in D2D Communication. From Figure 2, Figure 4, Figure 6, we can clearly say that 64 QAM performance is very effective i.e., in 64 QAM BER is 10-5 at 18dB SNR. For 16QAM the same BER value reaches at 13 dB SNR, for QPSK BER value reaches at 10db

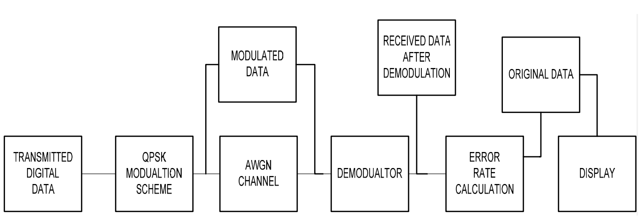

Figure 1. D to D communication using QPSK modulation scheme.

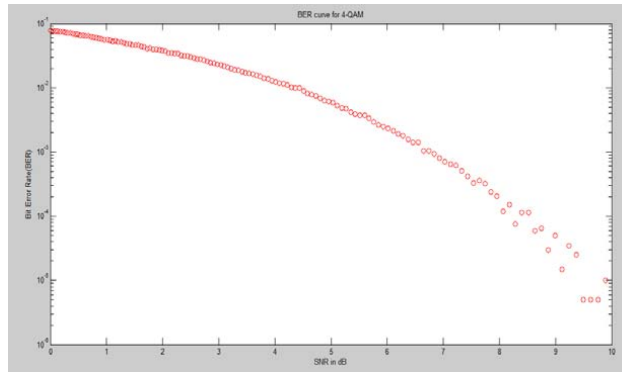

Figure 2. BER VS SNR curve using QPSK modulation scheme.

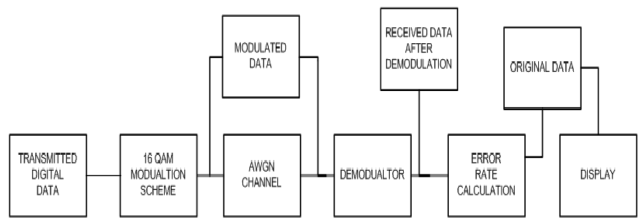

Figure 3. D to D Communication using 16 QAM modulation scheme.

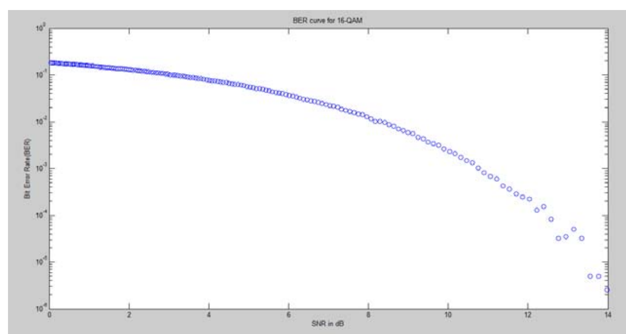

Figure 4. BER VS SNR curve using 16 QAM modulation scheme.

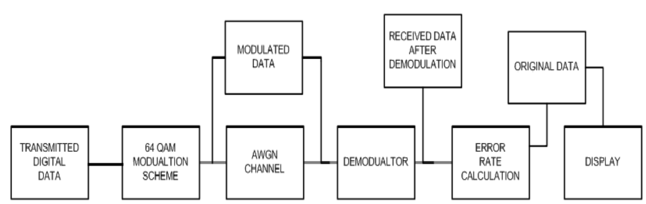

Figure 5. D to D communication using 64 QAM modulation scheme.

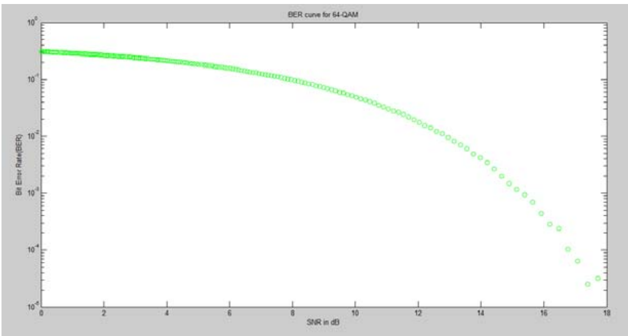

Figure 6. BER VS SNR curve using 64 QAM modulation scheme.

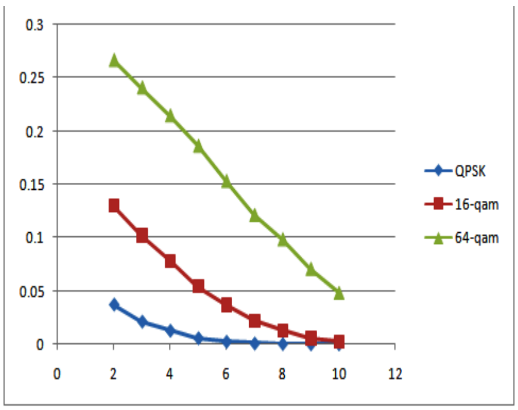

Figure 7. SNR VS BER of various modulations schemes in D2D communication.

Table 2. SNR Vs BER of various modulations

SNR (dB)	QPSK	16 – QAM	64 – QAM
2	0.03696	0.1295	0.267
3	0.02105	0.1018	01413
4	0.01261	0.07816	0215
5	0.005615	0.05408	0.1866
6	0.00231	0.03692	0.1536
7	0.000715	0.02229	0.1217
8	0.000265	0.01259	0.0987
9	230E-05	0.0057	0.07111
10	5.00E-06	0.002678	0.04841

SNR. Table 2 shows the discrete comparison between the all considered modulation schemes in device to device communication systems. Table 3 shows comparisons of various modulation schemes and its data rates**.**

Table 3. Data rate of various modulation schemes

Modulation Schemes	Data Rate/Throughput in bits / sec
QPSK	2,00,000
16 – QAM	4,00,000
64 – QAM	6,00,000

8. Conclusion

We have analyzed that higher order modulation schemes will produce high data rates at the same time high bit error rate, in order to minimize the high BER the transmitting power is increased by increasing the Signal to Noise Ratio.

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