Various Effects of Modulation Schemes on Wi-Fi Network of Urban Scenarios Using QUALNET Simulator

Sabyasachi Chatterjee, Siladitya Sen

Abstract— Thousands of enterprises worldwide are cutting the wires to their local area networks (LANs) to enjoy greater productivity from their unwired work force. Many wireless networking systems were established to manipulate urban networks in order to provide internet, data and video etc. connectivity. A significant drawback of traditional Wi-Fi system based on IEEE 802.11b standard is that they are quite vulnerable to sources of interference. Spread spectrum modulation techniques resolve the problem by spreading the information over a broad frequency range. This paper describes and summarizes a study of transmission techniques are explored in order to determine a favorable modulation technique for a particular wireless application for urban scenario. By comparison, it is observed that digital modulation techniques struggles neck to neck for getting low bit error rate (BER), but still with slight change in BER the quality changes a lot.Quality of service (QoS) of any Wi-Fi network is a very important aspect for customer satisfaction. Here QUALNET 5.0 is used to simulate the scenario by changing different modulation schemes (GMSK, QAM64, DQPSK, FSK8) and is analyzed by four parameters (average jitter, average end-to-end delay, throughput, signal Received but with error). The comparative analysis of all the four parameters according to different modulation schemes is done and it will be concluded, which modulation technique gives the best performance and quality of service for URBAN Wi-Fi scenarios.

Index Terms— WI-FI, LAN, IEEE 802.11b, Digital Modulation, Bit Error Rate, Quality of Service, QUALNET 5.0

1 Introduction

The intelligent application of efficient digital modulation techniques provides one means of achieving improved spectral efficiency at reasonable cost. Digital modulation is a technique that is used to modulate digital information so that it can be transmitted via microwave, satellite and cable pairs. In telecommunications digital modulation is the process of conveying a message signal. Digital modulation technique is used to transmit a digital bit stream over an analog band pass channel [1]. The goal of a modulation technique is not only to transport a message signal through a radio channel, but to achieve this with the best quality, power efficiency and the least amount of bandwidth possible.

In a wireless network, the network adapters in each computer convert digital data to radio signals from other network element back to digital data. The Institute of Electrical and Electronics (IEEE) has produced a set of standards and specifications for wireless network under the title "IEEE 802.11" that defines the format and structure of those signals. The wireless networking standard IEEE 802.11b was approved in 1999. It uses CSMA/CA media access method. IEEE 802.11b is a direct extension of the DSSS (Direct sequence Spread Spectrum) modulation technique. It utilizes an 11-bit chipping code called the Barker Sequence for signal spreading with modulation being achieved using either binary phase shift keying (BPSK) or quadrature phase shift keying (QPSK) techniques. Technically 802.11b standard uses complementary code keying (CCK). The bit stream is processed with a special coding and then modulated using Quadrature Phase Shift Keying (QPSK). The combination of QPSK and CCK is what enables 802.11b's maximum data rate of 11 Mbps. It uses point to multipoint configuration. It operates in 2.4 GHZ frequency band [2] [3].

2 Performance Requirements for Wi-Fi

Modulation schemes for digital transmission systems are also categorized as either bandwidth efficient or power efficient. Bandwidth efficiency means that a modulation scheme (e.g. 8-PSK) is able to accommodate more information (measured in bits/sec) per unit (Hz) transmission bandwidth. Bandwidth efficient modulation schemes are preferred more in digital terrestrial microwave radios, satellite communications and cellular telephony. Power efficiency means the ability of a modulation scheme to reliably send information at low energy per information bit [1].

Wi-Fi means wireless fidelity. It is a mechanism through which wireless devices can exchange data wirelessly over a computer network using an access point (AP). Access point is a device which allows wireless devices connect to wire network using Wi-Fi [4].

Selection of a modulation scheme for Wi-Fi application is not always straightforward. Wi-Fi makes use of adaptive modulation and varying levels of forward error correction to optimize transmission rate and error performance. Following are some preferable requirements for a Wi-Fi network [4].

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a) Very high data rate should be supported between the end users.
b) Signal transmission should take place over least transmission bandwidth.
c) BER should be well within the specified limit.
d) Minimum transmission power should be used.
e) The system should be cost-competitive.

3. Modulation Schemes

3.1 Gaussian Minimum Shift Keying (GMSK)

GMSK is a simple yet effective approach to digital modulation for wireless data transmission. GMSK modems reduce system complexity, and in turn lower system cost. Gaussian Minimum Shift Keying, or to give it its full title Gaussian filtered Minimum Shift Keying, GMSK, is a form of modulation used in a variety of digital radio communications systems. GMSK modulation is based on MSK, which is itself a form of continuous-phase frequency-shift keying. One of the problems with standard forms of PSK is that sidebands extend out from the carrier. To overcome this, GMSK can be used [5]. It gives the improved spectral efficiency when compared to other phase shift keyed modes. It can be amplified by a non-linear amplifier and remain undistorted. This is because there are no elements of the signal that are carried as amplitude variations [6]. This means that is immune to amplitude variations and therefore more resilient to noise, than some other forms of modulation, because most noise is mainly amplitude based.

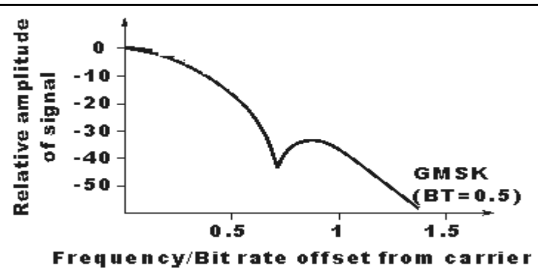

Fig1. Frequency/Bit offset from carrier Spectral density of GMSK signals

3.2 Quadrature Amplitude Modulation 64 (QAM64)

Quadrature amplitude modulation is widely used in many digital data radio communications and data communications applications.QAM may be used when data-rates beyond those offered by 8-PSK are required by a radio communications system. This is because QAM achieves a greater distance between adjacent points in the I-Q plane by distributing the points more evenly. And in this way the points on the constellation are more distinct and data errors are reduced [5].

QAM 64 is simply the method used for encoding data.To send data; the transmitter varies the amplitude and phase of a carrier signal. In QAM64 there are 64 possible combinations of amplitude and phase for each period of time, or symbol, of the carrier [7]. Thus increasing the data capacity four fold but making it more difficult for the receiver to discriminate between each signal. For domestic broadcast applications QAM64 is used.

It's easiest to visualise by looking at the constellation diagram.

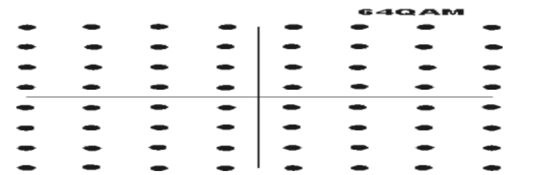

Fig2. The constellation diagrams show the different positions for the states

3.3 Differential Quadrature Phase Shift Keying (DQPSK)

DQPSK modulation uses a so called 'Super Mach-Zehnder' structure [10]. The signal is split and each tributary is, in effect, DPSK modulated. DQPSK modulation is subsequently obtained by interfere the two tributaries with a suitable chosen phase shift (either -π/2 or π/2). For experimental evaluation of DQPSK modulation, a pseudo random quaternary sequence (PRQS) can be used to ensure that all possible sequences up to a given length are tested [9].

It captures all modulation formats in which the phase of the carrier is modulated. DQPSK is promising format for ultra high speed optical networking because the symbol rate on the transmission line is half the bit rate. The complexity of DQPSK is less compared to a coherent QPSK scheme because precise recovery of carrier phase is not necessary in the receiver [10].

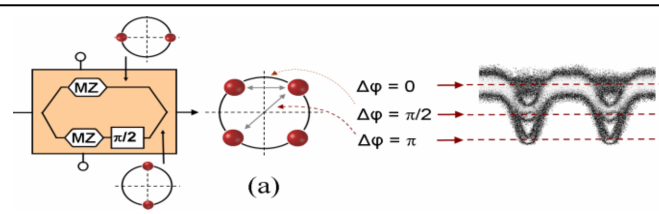

Fig3. DQPSK modulation and signal constellation

3.4 Frequency shift keying 8(FSK8)

Frequency-shift keying (FSK) is a frequency modulation scheme in which digital information is transmitted through discrete frequency changes of a carrier wave. The FSK mode was introduced for use with mechanical teleprinters in the mid-1900s. The standard speed of those machines was 45 baud, equivalent to about 45 bits per second. When personal computers became common and networks came into being, this signaling speed was tedious. Transmission of large text documents and programs took hours; image transfer was unknown. During the 1970s, engineers began to develop modems that ran at faster speeds, and the quest for ever-greater bandwidth has continued ever since. Today, a standard telephone modem operates at thousands of bits per second [5].

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FSK8 signals based on a zero crossing method [8].The zero crossing interval sequence {ya(i)} is reported to be a staircase type signal in [Hsue and Soliman, 1989] where the stair levels correspond to the signal states. By observing the histogram of {ya(i)}for FSK8, it is found that the first peak in the histogram is slightly higher for FSK8.

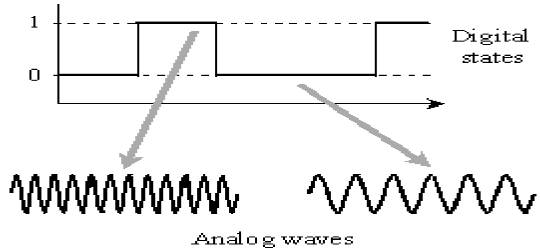


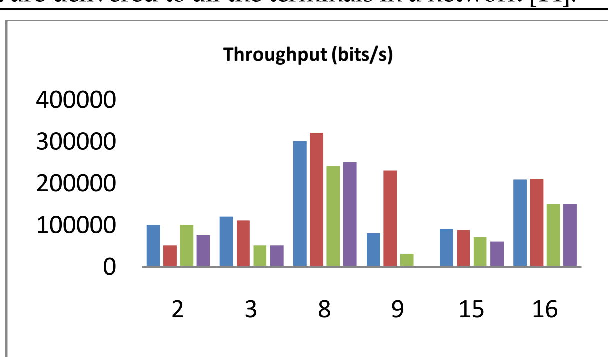
Fig4. FSK8 signal generation

4. CASE STUDY

Network simulation is a very efficient and cost-effective way to develop new network technologies. By building virtual networks in a lab environment, researchers can test, optimize, and integrate next generation network technologies at a fraction of the cost of deploying physical test beds. QUALNET is network model software that predicts performance of networks through simulation and emulation. QUALNET is the cornerstone for virtual networking labs that enable the deployment of a mind-boggling plethora of applications in wireless, wired and mixed network platforms.
Here in this paper we have taken case study of Wi-Fi network of urban scenario. Network consists of only one access point, 16 nodes and 6 CBR (constant bit rate) applications. Here we have used two ray path loss model. As per 802.11b FCC (Federal Communication Commission) regulations max transmit out power can be 30dbm and antenna gain can be 6bb for omni directional antenna. So we have set max transmit out power 30dbm and antenna gain 2 db for our case study. Average roof height is 27m and building separation is around 10m. With CBR application we have used 0 precedence bit and interval set at 0.001s. As MAC protocol we have used 802.11. Considering hundred items to be send and size of each is five hundred twenty six bytes. We have set simulation time at 3000s. The objective of this paper is to evaluate best possible modulation scheme for urban Wi-Fi networks.

4.1 Throughput

In communication network, throughput or network throughput is the average rate of successful message delivery over a communication channel. Data may be delivered over a physical or logical link, measured in bits per second. The system throughput or average throughput is the sum of the data rates that are delivered to all the terminals in a network [14].



Here we have calculated throughput for different modulation schemes and we can see the variation at different nodes for different modulation schemes. Maximum throughput strength is given by QAM64. At all the nodes with QAM64 and GMSK modulation technique we got standard connectivity strength. Now the graph has shown below gives average throughput strength for all the nodes at same time.

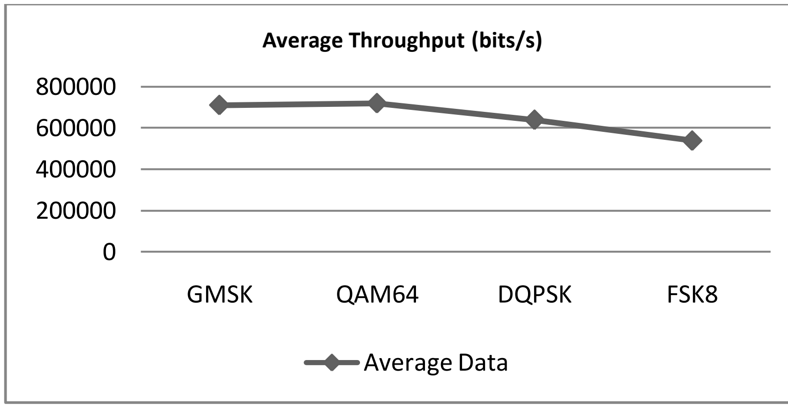


Fig6. Average Throughput strength of all the nodes

4.2 End-to-End Dealy

Due to queuing and different routing paths, a data packet may take a longer time to reach its destination .The end-to-end delay experienced by the packets for each flow the individual packet delay are summed and the average is computed. [12]

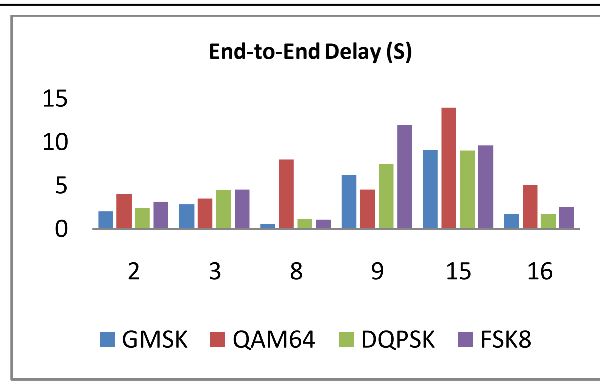
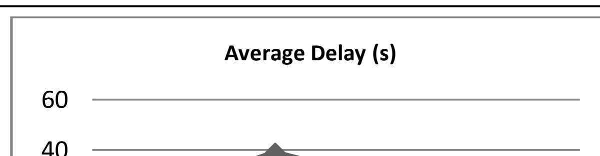


Fig7. Delayed time at every node

Above graph gives the delay time during the transmission at all the connected nodes. For QAM64 we are facing maximum delay and with GMSK we can achieve the minimum delay during Wi-Fi transmission. Now the graph shown below gives average End-to-End delay time.



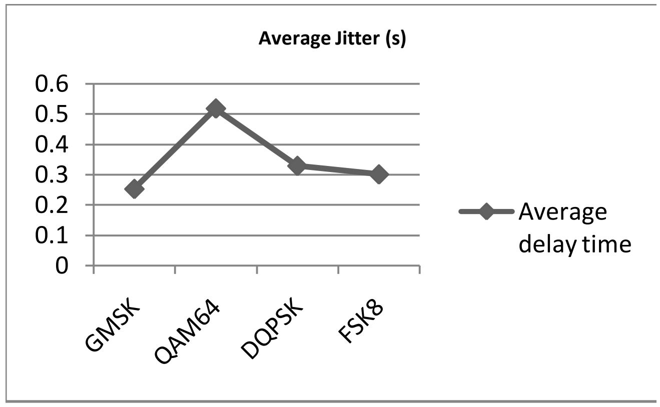


Fig10. Average Delay among each packet transmission

4.3 Jitter

As the packets transmit from source to destination will reach the destination with different delays. A packet's delay varies with its position in the queues of the routers along the path between source and destination and this position can vary unpredictably. This variation in delay is known as Jitter. The jitter increases at switches along the path of a connection due to many factors, such as conflicts with other packets wishing to use the same links, and nondeterministic propagation delay in the data-link layer. Jitter can seriously affect the quality of streaming audio and/or video. A network could possibly have zero Jitter. Jitter for respective precedence bits are calculated and compared. [11]

The difference between this two is that end-to-end delay is the time it takes a packet to travel across the network from source to destination and delay jitter is the fluctuation of end-to-end delay from packet to the next packet.

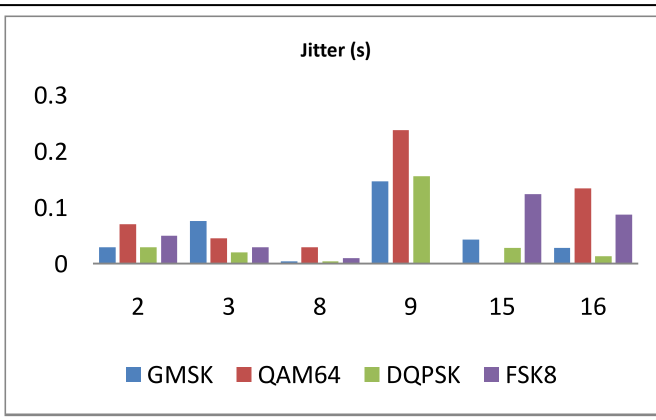


Fig9. Delay between two packets

Here we can see time delay in packet transmission between two nodes. When Qam64 modulation technique has used delay coming maximum, means waiting time is increasing in data transmission which is not desirable. With GMSK technique we are able to minimize the delay time compare to other modulation technique. Average delay time between each node in packets transmission shown below

4.4 Signal Received but with Error

A voltage that depends on the signal received from the target in a tracking system, having a polarity and magnitude dependent on the angle between the target and the centre of the scanning beam. Here received signal is erroneous. That means nodes are not receiving desired signal. [13]

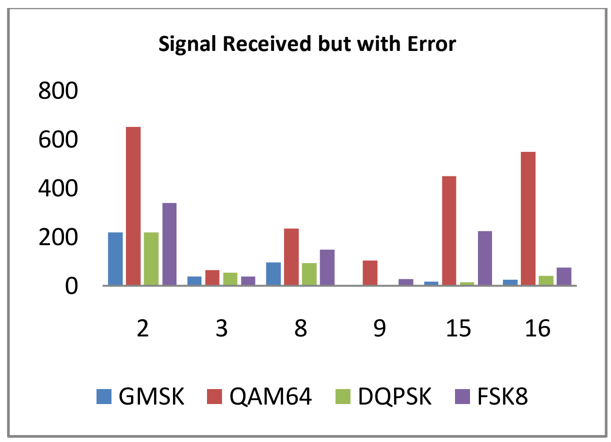
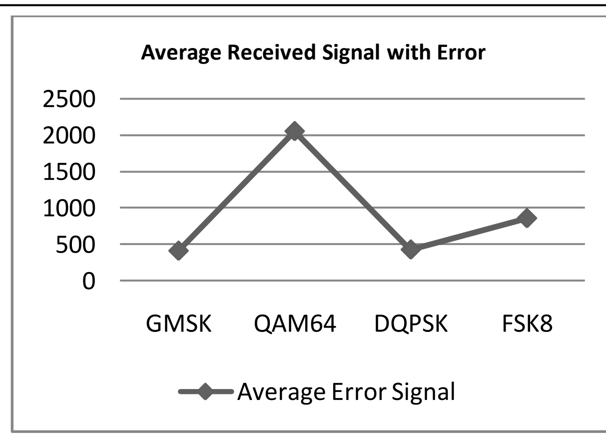


Fig11. Undesired signal received by nodes

QAM64 has very high data rates but also has higher error rate. Here we found maximum error signal or undesired signal has received by nodes during QAM64 modulation technique. During GMSK technique we found minimum error signal or undesired received signal. Average error signal received by all the nodes for different modulation technique shown below.



Discussion

The results above indicate that Both DQPSK and GMSK have strong features that provide a desirable Wi-Fi environment.Due to its linear amplification feature, DQPSK is able to maintain low spectral sidelobes; thus providing good adjacent channel performance. This is an important contribution to wireless systems because it enables a higher channel reuse factor.However, DQPSK effectively utilizes bandwidth. But in terms of ISI tolerence and bandwidth efficiency, GMSK is better than DQPSK. Because of minimum phase shifts in GMSK the bandwidth efficiency is better than DQPSK.

CONCLUSION

All above analysis says that even if QAM64 gives better throughput compared to GMSK, GMSK is better because it gives fewer amounts of signals with errors. Also we can achieve minimum delay and jitter for an urban Wi-Fi network. So we can conclude that GMSK is the best possible modulation technique for any urban Wi-Fi networks.

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References

[1] Pebbles, P. Jr., "Digital Communication Systems," Prentice-Hall, Englewood Cliffs,NJ, 1987

[2] JiZyren and AI Petrick, "IEEE 802.11 Tutorial," a white paper from-Wire1essEthernet, www.wirelessethernet.orgJdownloads IIEEE 80211 rimer.pdf.

[3] C Smith, C Gervelis, "Wireless network performance Handbook", Chapter 3, Mc Graw-Hill Networks, 2003.

[4]"OK, What Is Wi-Fi?" a white paper from Wi-Fi Consulting, www.wificonsulting.coml Wi-FilOIl wifilOI.htm.

[5] G. Arulampalam, V. Ramakonar, A. Bouzerdoum,and D. Habibi, "Classification of Digital Modulation Schemes Using Neural Networks",Proceedings of ISSPA '99, pp. 649-652, August1999.

[6] Murota, K. and Hirade, K., "GMSK Modulation for Digital Mobile Radio Telephony," IEEE Transactions on Communications, vol COM-29, No. 7. pp. 1044-1050, July 1981

[7] Stoneback, D., Howald, R., Brophy, T. and Sniezko, O., Distortion Beat Characterization and the Impact on QAM BER Performance, 48th Annual NCTA Convention, Chicago, Illinois, June 13-16, 1999

[8] Classification of bandlimited fsk4 and fsk8 signals Visalakshi Ramakonar,Edith Cowan University,Daryoush Habibi Edith Cowan University ,Abdesselam Bouzerdoum

[9] R. A. Griffin, et. al., in Proc. OFC'02, paper FD6.

[10] D. van den borne, et. al., in Proc. OECC'07, paper 13P-10.

[11]"Jitter Control in QoS Networks" Yishay Mansour and Boaz Patt-Shami

[12] Lea Skorin-Kapov, Darko Huljenic, Dario Mikic, Danko Vilendecic, "Analysis of End-to-End QoS for Networked Virtual Reality Services in UMTS" IEEE Communications Magazine, April 2004

[13]Discrete model reference adaptive control with an augmented error signal Tudor Ionescu†, Richard Monopoli§

[14]Sabyasachi Chatterjee, Siladitya Sen, Suchismita De "Effects on Throughput for Different Data rates of IEEE 802.11b Standard on Wi-Fi Network using QualNet Simulator" National Conference on Materials, Devices andCircuits in Communication Technology (MDCCT 2012)