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BER of Wireless Mesh Networks- A Review

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Abstract- This paper is a review on calculation of Bit Error Rate/Symbol Error Rate of Wireless mesh networks. WMNs have emerged as a flexible, reliable and cost effective way of providing broadband internet access over wide areas through multi hop communication. In this work the BER (Bit Error Rate) performances is shown analytically and by means of simulation for Rayleigh fading multipath channels and AWGN Gaussian channel. This work focuses on error performance of phase modulation schemes in different channel conditions and on the method to reduce bit error rates.

INDEX TERMS: WMNS, BER/SER, PHASE SHIFT KEY (PSK), BPSK, QPSK, RAYLEIGH FADING CHANNEL, QAM

1. INTRODUCTION

With the evolution to Third and Fourth-Generation (3G & 4G) systems, wireless communications networks are expected to support various multimedia services such as voice, data and video, which require multirate transmission and large bandwidth. Major improvements in the current state of wireless technology are necessary. Fourth and future generation systems promise unparalleled wireless access in ways that have never been possible before. Correlative web session, Multi-megabit Internet access, and simultaneous voice data access with multiple parties at the same time are some of the attractive features of 4G.

Wireless mesh network is the key technology for present generation in wireless networking for providing fast and hassle free services to users. Nodes in wireless mesh networks comprise mesh routers and mesh clients. Each node works as a host and also as a router, forward packets in account of other nodes that may no be in within direct transmission wireless range. Connectivity between nodes in wireless mesh networks is automatically established and maintained among the participating nodes. Hence making wireless mesh network a dynamically, self-organized, and self-configured wireless network. This type of feature brings many benefits such as low installation cost, low cost maintenance, sturdiness and reliable service coverage.

It also serves as a cost effective technique for establishing robust and reliable broadband access between Internet service providers (ISPs) and other end-users. The general architecture of WMNs consists of three distinct elements: mesh gateway, mesh routers and mesh clients. Static mesh routers form the wireless backbone, mesh clients interconnect to each other and access the network through mesh routers.

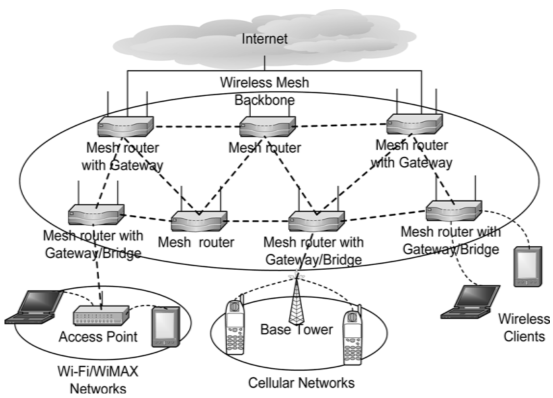


Fig 1: Network Architecture of wireless mesh network

1.1 Communications Systems Model

A communications system necessarily consists of three parts: a transmitter, a receiver, and a channel. A simple block diagram of a communications system is shown below in Fig.1.2

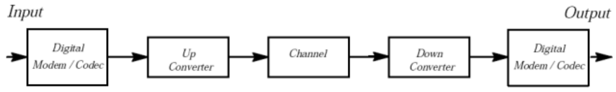


Fig 1.2 Communication System Model•

The transmitter takes a signal, whether analog or digital, and formats it for transmission over the channel. A wireless channel can be water, air, or vacuum, and may contain obstructions such as buildings, terrestrial features, or planets, depending on the medium. The receiver captures the transmitted signal and performs signal processing, changing it from a form that can be transmitted over the channel into a form that can be viewed, heard, or stored Multi-hop communication

1.2 Bit Error Rate

In digital transmission, the number of bit errors is the number of received bits of a data stream over a communication channel that have been altered due to noise, interference, exaggeration or bit synchronization errors. The bit error rate or bit error ratio (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER/SER (Symbol Error Rate) is a unitless performance measure, generally expressed in percentage.

The bit error probability p_e is the expectation value of the BER. The Bit Error Rate can be acknowledged as an approximate estimate of the bit error probability. This estimation is precise for a long time interval and a high number of bit errors.

1.3 Signal Propagation and Channel Effects

Besides the lack of readily available bandwidth and the number of users who desire access to wireless systems, the largest obstacle to building systems is that of noise and fading [24] . This was seen in the early transmission experiments, the Morse code dots and dashes were hidden in noise, making long-distance transmission a challenge. Noise in car radios is a familiar phenomenon, as you drive away from a transmitter, the station becomes noisier until it finally drops out and all you can hear is static. This effect derives from the decreasing power in a received signal as the transmitter-receiver separation increases. The power at the receiver is governed by the following equation

$PR = PT\ ATARC2/(4\pi fd)2$

where P_R and P_T are the received and transmitter power, respectively, A_R and A_T represent the amplification of the receiver and transmitter antennas, c is the speed of light $\left(3\times10^8\ m/s\right)$, f is the signal frequency, and d is the distance between the transmitter and receiver. We can see from this equation that the received power decreases with the square of the distance from the radio to the transmitting antenna.

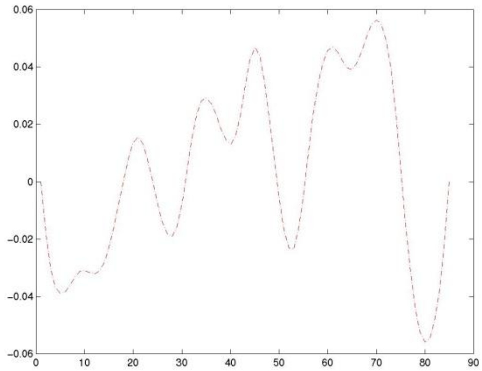
1.4 Modulation for Analog and Digital Transmission

In order to transmit a baseband signal, which is an analog signal composed of frequencies near 0 Hz, at radio frequencies we need to change or modulate a high-frequency carrier with our signal [13]. There are two primary methods of analog modulation, amplitude modulation (AM) and frequency modulation (FM); this is where our radio transmission schemes take their names.

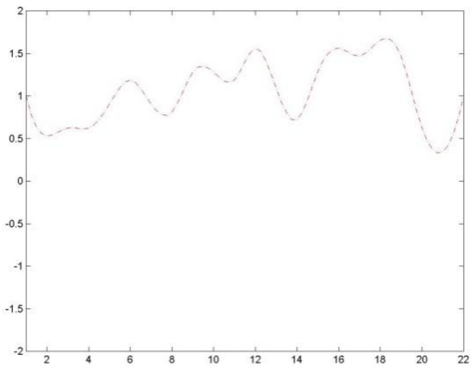
In AM we change the amplitude of a carrier by our message. For AM radio the carrier or sinusoidal wave has frequencies in the range of 540-1700 kHz. The equation for AM is given by

$$v_c(t) = A_C[1+\mu v(t)]\cos(2\pi f_c t)$$

Where $v_c(t)$ is the modulated signal to be transmitted, $A_c\cos(2\pi f_c t)$ is a carrier of amplitude A_c and frequency f_c, and the baseband analog signal, $v(t)$, is scaled by a modulation index μ. The construction of the AM signal is shown in Fig.1.5. Fig.1.5 (a) shows the original signal, while Fig.1.5(b) shows the signal scaled by the modulation index and shifted by 1. Fig.1.5(c) shows the original carrier, which has a frequency much greater, typically by several orders of magnitude, than that of the baseband signal. Finally, Fig.1.5 (d) shows the modulated signal [28]. Observe how the message, the original baseband signal $v(t)$, is contained in the amplitude



(a) Original Signal



(a) Scaled and Raised signal

2. MODULATION TECHNIQUES

2.1 Quadrature Amplitude Modulation (QAM)

Quadrature Amplitude Modulation or QAM is a form of modulation which is widely used for modulating data signals onto a carrier used for radio communications. Quadrature Amplitude Modulation (QAM), a signal wherein two carriers shifted in phase by 90 degrees are modulated and the resultant output consists of variation of both amplitude and phase. In view of the fact that both type of variations are present it may also be considered as a mixture of amplitude and phase modulation.

2.1.1 Analogue and Digital QAM

Quadrature amplitude modulation may exist in terms of either analogue or digital formats. The analogue version of QAM is usually used to allow multiple analogue signals to be carried on a single carrier. It is used in PAL and NTSC television systems, where the various type of channels provided by QAM enable it to carry the components of chroma or colour information. In radio applications a system is generally known as C-QUAM is used for AM stereo radio. At this juncture the different channels facilitate the two channels required for stereo to be carried on the single carrier. Digital formats of QAM are frequently referred to as "Quantised QAM" and they are being increasingly used for data communications often within radio communications systems. These communications systems varies from cellular technology through wireless systems counting WiMAX, and Wi-Fi 802.11 use a multiplicity of forms of QAM, and the use of Quadrature Amplitude Modulation only increase within the field of radio communications.

Quadrature amplitude modulation, used for digital transmission for radio communications applications is able to carry higher data rates than ordinary amplitude modulated schemes and phase modulated schemes. As by phase shift keying, the number of points at which the signal can rest. The number of points on the constellation is indicated in the modulation format explanation, e.g. 16 QAM uses 16 point constellation. While using QAM, the constellation points are normally arranged in a square grid with equal vertical and horizontal spacing and as a result the most common forms of QAM use a constellation with the number of points equal to a power of 2 i.e. 2, 4, 8, 16 . . . .By using higher order modulation formats, for more points on the constellation, it is promising to transmit extra bits per symbol. However the points are nearer collectively and they are therefore more susceptible to noise and data errors. To provide an example of how QAM operates the table below provides the bit continuance, and the related amplitude and phase states. It can be seen that a uninterrupted bit stream may be grouped into threes and represented as a sequence of eight permissible states.

2.2 Phase shift keying (PSK)

Phase shift keying, PSK, is widely used these days within a whole raft of radio communications systems. It is mainly well compatible to the growing area of data communications. PSK facilitate data to be carried on a radio communications signal in a more efficient manner than Frequency Shift Keying, FSK, and some other modulation techniques. Akin to any other form of shift keying, there are defined states or points that are used for signalling the data bits. The indispensable type of binary phase shift keying is known as Binary Phase Shift Keying (BPSK) or it is occasionally called Phase Reversal Keying (PRK). A digital signal alternating between +1 and -1 (or 1 and 0) will create phase annulment, i.e. 180 degree phase shifting as the data shifts state.

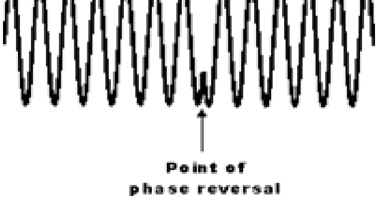


Fig 2.2 Bpsk Signal

The problem with phase shift keying is that the receiver cannot know the exact phase of the transmitted signal to determine whether it is in a mark or space condition. It would not be promising even if the transmitter and receiver clocks were accurately linked because the path length would determine the exact phase of the received signal. To triumph over this crisis PSK systems use a differential method for encoding the data onto the carrier. This is consummate, for example, by creating a change in phase equal to a one, and no phase modify equal to a zero. Supplementary advancement can be made upon this basic system and a number of other types of phase shift keying have been developed. One simple advancement can be made by building a change in phase by 90 degrees in one way for a one, and 90 degrees the other direction for a zero which preserve the 180 degree phase reversal between one and zero states, but gives a dissimilar alteration for a zero. In a vital system without using this process it may be possible to loose synchronization if a long series of zeros are delievered. This is because the phase will not modify state for this occurrence. Other common forms include QPSK (Quadrature phase shift keying) where four phase states are used, each at 90 degrees to the former, 8-PSK where there are 8 states and so forth.

3. LITERATURE REVIEW

The objective of the literature review is to find the BER in Wireless Mesh Networks and also what are the different problems in previous techniques. The main motive of this literature review is to find the gaps in existing research and methods and also what will be the possible solutions to overcome these holes.

Mohamed-Slim Alouini, and Andrea J. Goldsmith [1] studied Shannon capacity of adaptive transmission techniques in conjunction with assortment combining. This scope provides an upper bound on spectral efficiency using these techniques. Optimal power and rate adaptation yields a small increase in capacity over just rate revoking, which increase diminishes as the average received carrier-to-noise ratio (CNR) or the number of diversity branches esclation. Channel contradiction suffers the largest capacity penalty relative to the optimal technique; however, the penalty decrease with increased diversification. Main focus is on link spectral efficiency, defined as the average transmitted data rate per unit bandwidth for a specified average transmit power and bit error rate(BER).

Kentaro Kato, Masao Osaki, Masahide Sasaki, and Osamu Hirota [2] analyze the performance of the error probability and the mutual information for quadrature amplitude modulation (QAM) and phase-shift keying systems based on quantum detection theory. It is shown that the quantum receiver called square root measurement provides about 5.7 dB improvement in power by comparison it with the classical one. Moreover, the quantum QAM systems surpass PSK in both the error probability and the mutual information.

Fumiyuki Adachi [3**]** analyzed the average bit error rate (BER) performances of coherently observed 2PSK, 4PSK, and 16QAM in frequency selective slow Rayleigh fading. Analytical expressions for the conditional BER for the given transmitted symbol sequence are derived, and the average BER performances are evaluated by Monte Carlo simulation. This paper theoretically analyzes 16-square QAM in frequency-selective slow Rayleigh fading channels

M Abdur Razzak, Fatou Ndiaye, Omar Khayam [4] described the performances of M-ary modulation schemes (MPSK, MQAM and MFSK) in terms of symbol error probability as a function of SNR per bit. The channel capacity in terms of bit rate per bandwidth is also investigated to analyze the performance .In this mathematical expressions for error probability in closed form are derived using bounds and approximations to calculate and compare the performances of different modulation schemes theoretically and simulation results are obtained using Monti Carlo.

M.Anand and P.Vijay Kumar [5**]** described the construction of family of sequences over 8-ary AM-PSK Constellation that has maximum nontrivial correlation magnitude. These families are constructed by interleaving set of sequences.

Hsin-Piao Lin, Ming-Chien Tseng, Ding-Bing Lin [6] proposed a scheme of applying M-ary PSK adaptive modulation scheme in Rayleigh long normal fading channel. .The close-form expression of the average BER and the average data throughput (BPS) of a proposed adaptive modulation system with constant transmitted power over fading channel are conferred. The effect of overcasting on BER and throughput in adaptive modulation system is also measured. These results show the analytical expressions of the average BER and data throughput derived for transmission over Rayleigh-Lognormal fading channel.

Mohammad Riaz Ahmed, MD. Rumen Ahmed [7] showed the comparison of symbol error probability (SEP) for different M-ary modulation techniques over slow, flat, analogously independently dipursed Rician fading channel. Fading is one of the major limitations in wireless communication, so modulation technique with diversity is used to transmit message signal conveniently. Exact scrutiny of symbol error probability for M-ary differentially encoded or differentially decoded phase shift keying(PSK) and coherent M-ary phase shift keying, Approximate formula has been used to show symbol error probability for M-ary quadrature amplitude modulation over a Gaussian channel transmitted over Rician fading channel has been performed.

4. CONCLUSION AND FUTURE WORK

This paper has reviewed certain security issue of WMNs. WMNs have emerged as a malleable, decisive and worthwhile way of providing broadband internet access over wide areas through multi hop communication. This paper has reviewed different modulation techniques to analyze the bit error rate or symbol error rate of WMNs. The review has shown that the existing work has neglected many issues. No technique is effective of every kind of circumstances.

In near future A more complicated model would have to be developed for the case of wide bandwidth transmission. There are many other potential causes of implementation loss in frequency conversion stages that were not tackled in this work. Potential areas for investigation are the effect of filter group delay and bandwidth, and amplifier nonlinearities, on higher order modulation schemes.

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