Performance Analysis of Physical Layer Security in Wireless Network

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***Abstract*—The world is shrinking with the improvement of communication technology. Where the amount of cyber crime is all time high, the necessity of data security is inevitable. In recent years the special agencies are using methods like steganography, cryptography to hide their information to communicate. In this paper, we are using steganography for physical layer security for audio signal. All three channels of the image will be transmitted simultaneously using a combination of digital(BPSK, QPSK and QAM) and analog(FDM) modulation demodulation technique. We have compared accuracy and bit error rate varying noise levels for ultimately analyzing the performance of different combinations of modulation demodulation techniques.**

***Index Terms*—QAM, FDM, BPSK, QPSK, SNR, AWGN, BER,Steganography**

I. Introduction

Steganography [1] is the technique of hiding secret data within an ordinary, non-secret, file or message in order to avoid detection; the secret data is then extracted at its destination. Cryptography is used to add another layer of security. It is done to prevent any other parties to access the hidden data. Steganography can be used to conceal almost any type of digital content, including text, image, video or audio content; the data to be hidden can be hidden inside almost any other type of digital content. Steganography can be done in many ways. Most commonly used algorithms are, Least significant bit insertion [2], [3], Masking [4] and filtering [5], Redundant Pattern Encoding [6], [7] etc.

QPSK [8], [9], BPSK [10], QAM [11], OOK [12], ASK [13], for digital modulation and demodulation part and for analog FDM [15], [16], TDM [14] CDM [17] have gained supreme popularity for communicating . For transmission the methods used previously are wireless communication [21] optical communication [22]. Also for transmission many real life hindrances are considered, such as noise, attenuation.

We are taking an audio file as secret data and an image as ordinary data which will be concealed into the image, so that it cannot be detected. We have selected the LSB method to do the steganography and to send the image via wireless medium, first the image is split into 3 RGB channels. Each channel is digitally modulated and then combined using FDM technique and transmitted. At the receiver end, the opposite is done. The transmission wireless channel is designed to have different levels of Gaussian noise [18], [19].

We will be comparing the results for BPSK, QPSK and QAM to simultaneously send 3 channels of an image where the analog modulation/demodulation technique is always FDM.

II. Methodology

A. The principles of BPSK, QPSK, QAM and FDM modulation and Demodulation

1) QAM - Quadrature Amplitude Modulation: The QAM modulator essentially follows the idea n carrier signals having with a phase shift of (180°/n) between them. Like for 2 bits QAM, the phase difference of two carriers will be 90°.These are then amplitude modulated with the two data streams known as the I or In-phase and the Q or quadrature data streams. The QAM demodulator is very much the reverse of the QAM

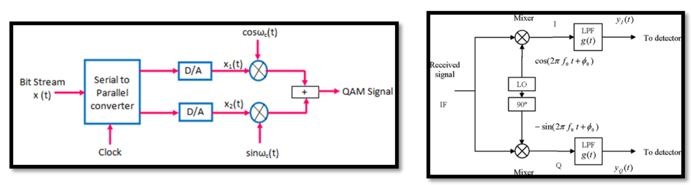

Fig. 1. (left)qam modulation, (right)qam demodulation

modulator. The signals enter the system, they are split and each side is applied to a mixer. One half has the in-phase local oscillator applied and the other half has the quadrature oscillator signal applied.

2) BPSK - Binary Phase Shift Keying: BPSK is the simplest and the most robust of all the PSK [23] modulation techniques. The binary sequence is multiplied with sinusoidal carrier and the BPSK modulated signal is obtained.At the receiver end, it is necessary to reconstitute the carrier. Next, the BPSK modulated signal is multiplied with the carrier, pass through an integrator and then decision circuit give the modulating signal at the end.

3) QPSK - Quadrature Phase Shift Keying: The QPSK is a variation of BPSK. Unlike BPSK, QPSK sends two bits of digital information at a time. The QPSK Modulator uses a bit-splitter, two multipliers with local oscillator, a 2-bit serial to parallel converter, and a summer circuit. Following is the block diagram for the same. At the modulator's input, the message signal's even bits and odd bits are separated by the bits splitter.

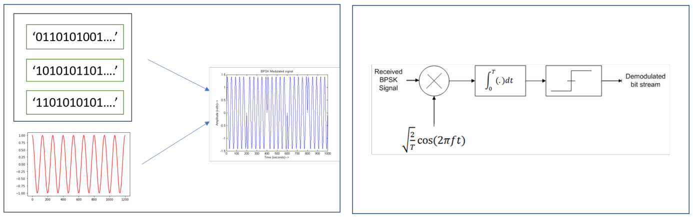

Fig. 2. (left)bpsk modulation, (right)bpsk demodulation

The even bits are multiplied by a carrier and the odd bits are multiplied by a carrier which is 90 degrees shifted from the previous one.

The QPSK de-modulator uses two product de-modulator circuits with local oscillator, two band pass filters, two integrator circuits, and a 2-bit parallel to serial converter, Following is the diagram for the same. The two product detectors at he input of de-modulator simultaneously demodulates the two BPSK signals. The pair of bits are recovered here from the original data. These signals after processing, are passed to the parallel to serial converter.

4) FDM: The operation of frequency division multiplexing is based on sharing the available bandwidth of a communication channel among the signals to be transmitted. This means that many signals are transmitted simultaneously with each signal occupying a different frequency slot within a common bandwidth. Each signal to be transmitted gets modulated with a different carrier. The modulated signals are then added together to form a composite signal which is transmitted over a single channel.

At the demodulation part, the composite signal is applied to a group of band pass filters. Each BPF has a center frequency corresponding to one of the carriers. The BPFS have an adequate bandwidth to pass all the channel information without any distortion. The channel de-modulator then removes the carrier and recovers the original signal back.

In our setup we have 3 RGB signal so we have 3 message signals which was passed with carrier frequency of R to 3 MHz, B to 12 MHz and G to 21 MHz in the modulation part. In the demodulation part, the signals are passed through bandpass filter and then passed through a low pass filter to avoid extra ripples and noises from the signal. The Bit rate is 1Mbps in all digital modulation cases.

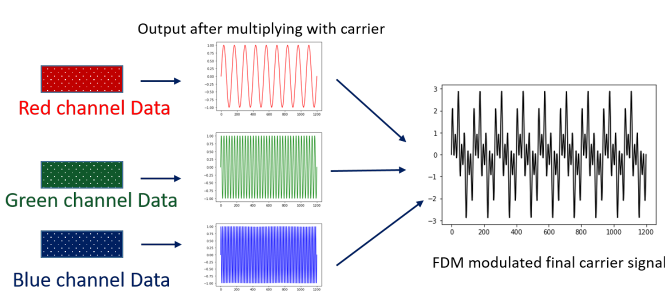

Fig. 3. FDM used in our proposed method

B. Design of the Workflow

At first, the Audio file is processed which is resampled at 12Khz then quantized to 256 levels. Then the audio is encoded into 8 bit digital data which we preserve by converting to row vector. Then we move forward to the image data. First, We resize the image to 720*1280 which is next split into 3 RGB channels. Each channel has a total of 720*1280 pixels having color values between 0 to 255. We first convert the array into a 1D row vector. Then, the decimal value of each element is turned into a binary value of 8 bits. At this stage, the pixel matrix dimensions are (921600*8).

As we are using the LSB method to do the steganography, the seventh and eighth bit of every pixel value will be replaced by the bit values of the audio row vector. From some easy calculation, in an image of size 720*1280, we can hide up to 7 minutes and 40 seconds of audio data.

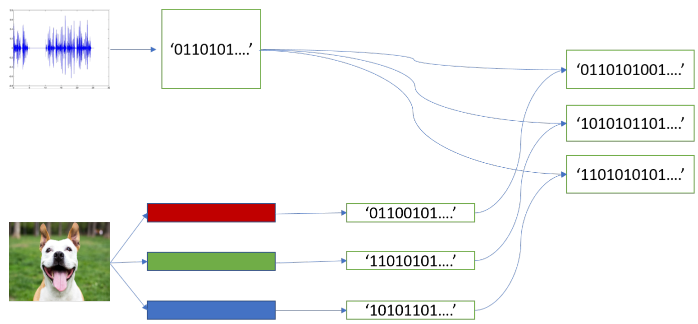

Fig. 4. Audio and Image data processing

At this stage, the data streams are ready to be modulated. To do so, we have used 3 techniques for digital modulation. BPSK, QPSK, QAM. We have used different QAM configurations too (4QAM, 8QAM, 16QAM....) Then the 3 digitally modulated data streams are frequency division multiplexed to create 1 data stream which is transmitted through a wireless medium having Gaussian noise as hindrance.

At the receiver end, the opposite of transmission is done. First the signal is received as a single data stream. Band pass filters are used to separate the 3 channels. Then each band passed data streams are passed through a low pass filter to get the final output FDM demodulator.

We have 3 row vectors. Each row vector is digitally demodulated and the seventh and eighth bits are extracted to recover the audio file. These data are turned into a row vector. Then every 8 bits are converted to double values which are reshaped between 0.2 and -0.2. Thus, the audio file is reconstructed. After this the low passed row vectors are converted to 720*1280-pixel matrices for reconstructing the image.

C. Results and Discussion

For our experimental setup, we have varied different Signal to Noise Ratio(SNR) value for BPSK, QPSK and QAM methods for transmitting the image [24]. Here we are showing some plots of the reconstructed image, different accuracy values and bit-error peak rate plots and finally the state of the transmitted audio.

TABLE I
TRANSMISSION ACCURACY(%100) AND BER PEAKS DIFFERENT QAM TECHNIQUE

Bits	Accuracy	BER Peaks
4QAM	100	0
32QAM	81.54	674.35
256QAM	69.44	1085.46
1024QAM	67.36	1195.89

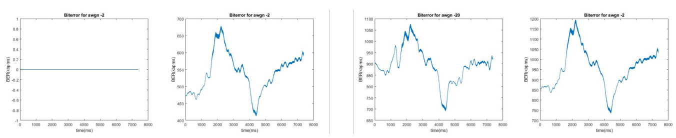

Fig. 5. Bit error rate for QAM technique a)4QAM b)32QAM c)256QAM at AWGN 20 d) 1024QAM

Fig. 6. Transmitted image variation for QAM bits - a)4QAM AWGN 20 b)32QAM c)256QAM at AWGN 20 d) 1024QAM

As the value of Bits(M) increased, the quality of the transmission decreased rapidly.

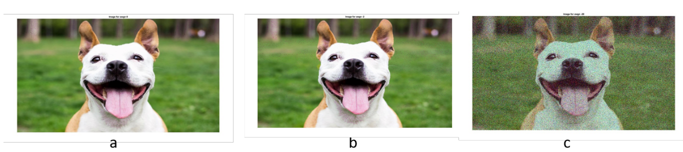

Fig. 7. Image transmitted using BPSK for a)SNR = 0, b)SNR = -2 c)SNR = -20

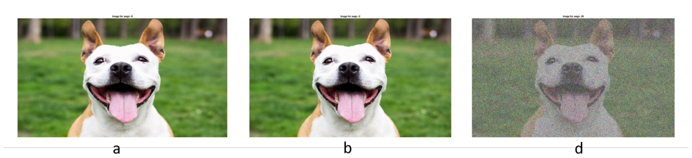

Fig. 8. Image transmitted using QPSK for a)SNR = 0, b)SNR = -2 c)SNR = -20

Among the BPSK and QPSK technique, though QPSK was faster the image quality deteriorated for same setup

As we can see, in SNR = -20 setup, the audio signal can not be retrieved despite of having good quality in the overall image performance.

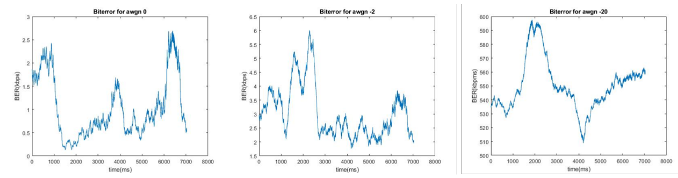

Fig. 9. BER for BPSK varying SNR(from left) = 0, -2, -20

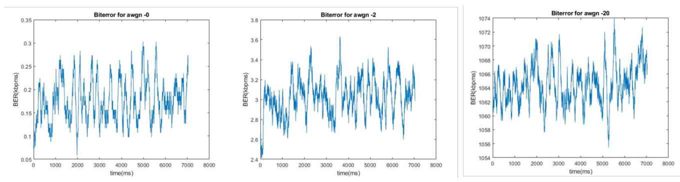

Fig. 10. BER for QPSK varying SNR(from left) = 0, -2, -20

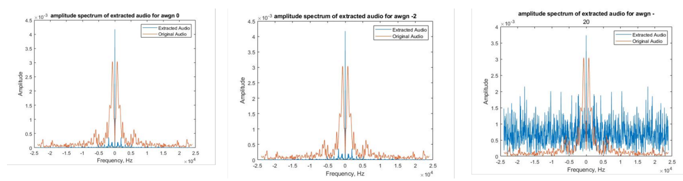

Fig. 11. After transmission using BPSK varying SNR(from left) = 0, -2, -20; observing the FFT plot of the original and received audio

TABLE II
ACCURACY(%100) FOR DIFFERENT MODULATION AND DEMODULATION TECHNIQUE FOR DIFFERENT AWGN CHANNEL SETUP

SQNR \ Mod/demodulation	BPSK	QPSK	QAM
0	99.97	99.90	100
-2	99.90	99.90	100
-20	82.08	65.34	65.34

TABLE III
BIT ERROR RATE(BER) PEAKS FOR DIFFERENT MODULATION AND DEMODULATION TECHNIQUE FOR DIFFERENT AWGN CHANNEL SETUP

SQNR \ Mod/demodulation	BPSK	QPSK	QAM
0	2.45	0.30	0
-2	6	3.58	0
-20	597.82	1074.00	225.67

Comparing these results, we can see that BPSK was the most accurate among all the techniques, but it had very slow computation time. For small amount of noise QPSK is showing a pretty accurate result and much faster. While the less bits QAM is giving an ideal transmission result, as the bits increase the performance change rustically.

D. Conclusion

We have analyzed the modulation techniques BPSK, QPSK, QAM on basis of quality of the image, the accuracy and Bit-error Rate measurement and restore ability of the audio and the transmission time. Here QPSK has come out to be the most efficient algorithm combining FDM . As every algorithm had some drawbacks and faced some difficulty, in future algorithms' improvement combining other analog modulation and demodulation techniques with more challenge in the transmission channel can be considered.

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