DESIGNING OF A COMMUNICATION SYSTEM FOR PARAMEDIC APPLICATION at 2.4 GHz

Mukesh Kumar Maheshwari, Shah Najmus Saqib Mahmood and Taimoor Zafar

Abstract—**Sudden injuries such as road accident, earth quake or natural disasters are major health risks. The health risk due to heart attack is one the major disease in South Asia. Health risks can be reduced by providing services to such sudden injuries through use of communication technologies. This paper suggests an approach for designing of paramedic system. The design system has three types of data voice, picture and patient monitoring data, operating frequency of 2.4GHz, bandwidth of 10 kHz and SNR 50dB 20% of the time. By assigning priority to ambulances multiple critical patients can be served. The simulation result shows that after interleaving and hamming encoding the system has better performance at low value of SNR.**

Keywords: **Voice, Picture, Patient monitoring data.**

I. INTRODUCTION

Nowadays the improvement in technology has provided service to sudden injuries or illness. Paramedic system is an emergency medical service which provides fast and capable medical assistance to the victim of the sudden injuries or illness [1]. It is a service which provides communication with a hospital or from hospital to the ambulance. Paramedic system provides the critical time to patient by providing the appropriate first aid and other life saving support systems.

The paramedic system discussed below consists of three forms of data viz. voice, picture and patient monitoring data. The system has bandwidth of 10 kHz, operating frequency of 2.4GHz and SNR (signal to noise ratio) of 50dB, 20% of the time. The data generated by patient monitoring system is at the rate of 100 bits per second.

Section II tells the importance of data. Section III discusses the block diagram of the system, selection of codec, multiplexing, interleaving and modulation techniques that system can use. In section IV BER (bit error rate) performance of system is obtained using Hamming code and last section conclusion.

II. IMPORTANCE OF DATA

The data generated by paramedic consist of voice, picture and patient monitoring data. Voice is one of the important components of data in paramedic communication. By voice communication Doctor can communicate and also can direct to avoid a serious health risk.

Mukesh Kumar Maheshwari, Shah Najmus Saqib Mahmood and Taimoor Zafar, Department of Electrical Engineering, Bahria University Karachi Campus, Pakistan.
Karachi, Pakistan. Email: mkm15@alumni.le.ac.uk

Picture is another important form of data e.g. the case of burning. The picture must have enough quality at the receiver side, so it can analyze very properly.

The patient monitoring data consist of blood pressure, temperature, pulse rate, sugar, electrocardiography and so many other things. Without this information doctor is not able to analyze the patient. Patient monitoring info is updated periodically.

III. BLOCK DIAGRAM

The paramedic system consists of voice, picture and patient monitoring data. This is transmitted from ambulance or voice and picture other way around. Using Shannon Hartley formula the maximum capacity of system obtained is 166.096kbps [2].

In order to design the system having capacity of 166.096kbp, with above specification the block diagram shown in figure (3) discussed below.

A. Codec

In the case of paramedic application, system has very low bandwidth and it is not possible to transmit voice and picture. In order to transmit both if codec is used then system can work efficiently.

For voice transmission instead of PCM (Pulse Code Modulation) used in landline, GSM (global system for mobile) full rate speech codec can be used. PCM require data rate of 64kbps while on the other hand GSM full rate speech codec have data rate of 13kbps [3].

There are two types image file compression lossless and lossy. The lossless image compression is TIFF (tagged image format) format. It requires very small time to compress and decompress and needs very high capacity [4]. While on the other hand the lossy format in which picture is compress in very small size but original cannot be recovered. The JPEG (joint photograph expert group) is one of the widely image compression technique used nowadays require very small size and can store the data in 24-bit colour pixel instead of 8-bit colour pixel. JPEG is easy to implement no need extra hardware and software there option available in camera to select the required format [5].

B. Multiplexer and De-Multiplexer

Multiplexer is device which combines the many input signal into one. In order to transmit the voice, picture and

 ISSN – 1999-4974

patient monitoring data, all were multiplexed [6]. Before the Multiplexer and after De-multiplexer handshaking protocol is implemented in order to make sure data has been correctly received. If picture and patient monitoring data is not correctly received than the transmitter is acknowledge for resending the part of the data which is in error. However this protocol is not well suit for voice transmission.

C. Encoding and Decoding

In order to remove the error in data at the receiver, data is encoded. There are so many ways to encode the data, Forward Error Correction technique is one of them. Using forward error correction technique the errors can be detected and corrected.

In forward error correction technique Hamming and Viterbi encoding techniques are famous. The hamming code can detect two errors and can remove 1 error for code length of 7 [7]. While using Convolutional code, it checks the entire data path and the take data with less number of errors. In soft detection it has some information about the data transmitted, while hard decision it does not have any information [7].

The figure (1) shows the BER vs Eb/N0 (energy per bit to noise density) for Hamming code and Convolutional code. It is observe that when Eb/N0 has value less than 0dB Hamming coding technique has better performance as compare to Convolutional. At Eb/N0 of 4dB BER of Convolutional code is 2x10-5 while on the other hand Hamming code has BER of 10-3. At 2x10-5 BER coding gain of 2.5dB, as BER increase coding gain decreases.

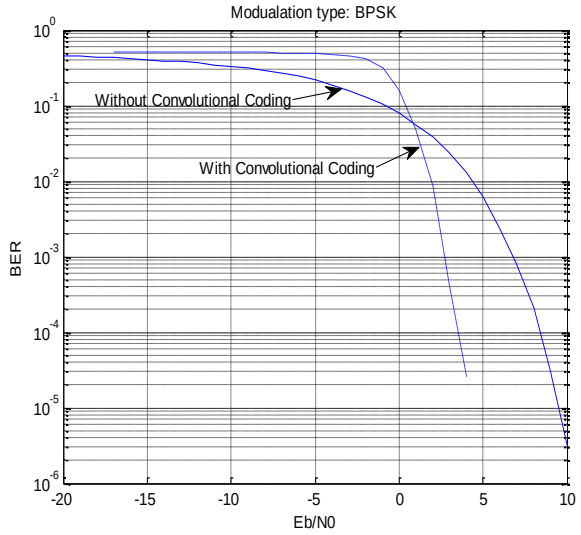

Fig. 1. BER vs Eb/N0 for Hamming Code and Convolutional Code.

From above discussion it observed that at low value of SNR Hamming encoding has better performance. As SNR of system is not known 80% of the time, so hamming code technique can be used which can work better at both low and high value of SNR.

At the receiver, decoding has been performed in order to convert the data in original format and to detect and correct the error.

D. Interleaver and De-Interleaver

In communication when transmitter or receiver is moving than Doppler Shift take place. Due to the Doppler Shift the information has been corrupted. Doppler Effect produces a bunch of errors in information [8].

In order to overcome these errors, there is technique known as interleaving is used. Interleaving is a technique in which bits are mixed together before they are transmitted. If there is a bunch of errors than at the receiver after de-interleaving all these errors are distributed over whole region and these errors can be easily detected, corrected using forward error correction technique [7].

In the paramedic application case the ambulance is moving at the rate 120km/h and having frequency of 2.4GHz. Due to this speed of ambulance the Doppler shift has value of 222.222Hz. Due to Doppler shift of 222.22 Hz, the frequency is shifted by 2.400000222 GHz or 2.399999778 GHz and the time of this shift is 4.5ms [8]. If the baseband bandwidth is greater than Doppler spread than the effect is negligible [8]. During the duration of 4.5ms the bunch of errors occurs in the information, If the information has been interleaved using an interleaver for the duration of 50ms than the errors will distributed over the region and results in decrease BER of the system.

E. Modulation and Demodulation

Modulation is the process of conversion the data from digital to analog. There are so many ways to convert data in analog form some of them are ASK (Amplitude Shift Keying), FSK (Frequency Shift Keying) and PSK (Phase Shift Keying).

In the case of paramedic FSK has been used than system not able to give the require performance because FSK require a very large bandwidth while it is 10 KHz [9].

In ASK modulation amplitude of the signal has been modulated. If it the signal is transmitted using ASK modulation than at the receiver the signal has been so much faded because of high fluctuation in amplitude above the air link and it difficult to recover it at the receiver [9].

Using PSK phase shift keying the signal can transmit very easily above the air link. Because phase is less resistance to the distortion and if there is any distortion in phase can be easily recovered at the receiver side by using coherent detection [9].

F. Data Transmission

The multiple access technique allows different users to share the finite bandwidth. This sharing creates a high capacity in small bandwidth [10]. The popular multiple techniques are FDMA (Frequency Division Multiple Access), TDMA (Time Division Multiple Access), CDMA

ISSN – 1999-4974

(Code Division Multiple Access) and FDD (frequency division duplexing) [11].

By using FDMA, most bandwidth of system has been wasted if ambulances are not communication at all the time. By using FDMA the bandwidth assign to each ambulance is very low, through which communication may not take place [11].

Using TDMA, it is noted that by dividing the time in slots [11], most of the slots are wasted if ambulance is not transmitting or this may be the case that one ambulance has emergency than others, it require more time slots which is not possible to assign.

As bandwidth of the system is limited, and the bandwidth requirement is infinite in CDMA [10]. This creates problem between multiple ambulances.

FDD frequency division duplexing is technique in which bandwidth is divided in two parts [10]. By dividing doing this transmission and reception take place at a time. Using FDD the total bandwidth of 10 KHz is divided in two parts with a guard band between them. (e.g. 2.4GHz-2.400006 GHz for transmission, 2.400006 GHz - 2.4000065GHz Guard Band and 2.400065GHz-2.40001GHz for reception). Using this technique one ambulance can transmit and receive at same time. The guard band is taken size of 0.5 kHz, if there is Doppler shift then it will not cause interference.

G. Multiples Ambulances and SNR

If five ambulance are assumed and they want to communicate with the Hospital, than it is not possible to communicate all of them together because if bandwidth is divide in five equal parts than bandwidth available for each ambulance is 2kHz which is very low. On this bandwidth both ways communication is not possible.

In order to communicate with all ambulances the priority has been set according to the condition of the patient. If the patient is serious like heart patient than assign him a first priority as compare to patient whose leg is broken. By assigning this priority the patient with serious condition is first served.

The SNR of the system is greater than 50dB 20% of the time. At this SNR system has capacity of 166.09kbps ideally, in real it is less than that and during this time all data can transmitted together. If SNR decrease to 10dB than system has capacity of 34.594kbps and all data can be transmitted. If SNR falls less than -10 dB than system has very low capacity on that time only patient monitoring data is transmitted.

For reliable communication the BER of the system is checked every time at the receiver and the transmitter is acknowledged for that. At high value of BER means low value of SNR transmitter transmits only the voice and patient monitoring data. If BER increase more than transmitter only transmits the patient monitoring data.

H. Fading

When data is transmitted over the air link than data is corrupted due to the effect of noise and fading. As AWGN is White Gaussian Noise and its value is constant, it can be overcome by increase the Eb/N0. The Rician fading is dominant in the town, because of the NLOS (non line of sight) between transmitter and receiver. Due to which loss is very high as compare to LOS (line of sight path). This loss is due to multipath effect resulting in ISI (inter symbol of interference) at the receiver [12].

IV. SIMULATION OF SYSTEM USING HAMMING CODE

The system is simulated using Matlab. In the simulation the sample time 0.0001, so it generates a data of 10 KHz and after that data is hamming encoded and interleaved using matrix interleaver size of 49x49 to distribute the errors over the whole region. After running the above simulation the plot of Eb/N0 vs BER is obtained shown in figure (2).

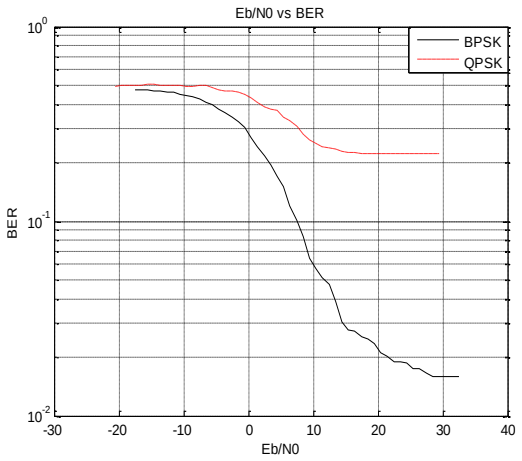

Fig. 2. Eb/N0 vs BER using BPSK, QPSK Modulation, Hamming code and interleaving.

From above figure (2) it is observed that using BPSK modulation (black line) at low value of Eb/N0 BER is very high. BER has value of 3x10-1 at Eb/N0 has value of 0. As the Eb/N0 increase to 10 the BER reaches to 6x10-2. As Eb/N0 increased the BER of the system becomes decreases and it will be constant when Eb/N0 30. While using QPSK modulation (red line) the BER of system is very high as compare to BPSK at high value of Eb/N0.

V. CONCLUSION

From above discussion it concludes that by using GSM full rate speech codec and for picture JPEG, three types of data can be transmitted in bandwidth of 10 KHz. All three types of data can be transmitted together when SNR has value of 50dB. When SNR is less than 0dB on that time only patient monitoring data is transmitted. By assigning priority multiple ambulances can be communicated. Using FDD transmission and reception can take place at a time. By using of BPSK modulation, Hamming encoding and

ISSN – 1999-4974

interleaving system can work well even at low value of SNR.

REFERENCES

[1] J.Steve Adler: "Emergency Medical Service Communication Service Design", IEEE Transaction on Vehicular Technology, VT-2, No.4 November 1976.

[2] Shannon C.E. "A Mathematical Theory of Communications", Bell Systems Technical Journal, , July, October, 1948, pp. 379–423, 623-56.

[3] Stegmund M. Redl, Matthias Weber and Malcolm W. Oilphant, "GSM and Personal Communications Handbook", Artech House, INC, 1998.

[4] TIFF Revision 6.0 Final — Aldus Corporation, June 3, 1992.

[5] Gregory K.Wallace "The JPEG Still Compression Standard" , IEEE Transaction on Consumer Electronics, Vol.38, No.1, February 1992.

[6] Roger L. Freeman, 2005, "Fundamentals of Telecommunication", 2nd Edition, John Wiley & Sons, Inc. Hoboken, New Jersey.

[7] Gary M. Miller and Jeffery S. Beasley, "Modern Electronic Communication", 7th Edition, Prentice Hall, Upper Saddle River, New Jersy Columbus Ohio, 2002.

[8] Rapparport, T.S, "Wireless Communication Principles & Practice, Prentice Hall", USA, 2002.

[9] Andy Batman, "Digital Communications: Design for Real World", Pearson Education Limited Edinburgh England, 1999.

[10] Shankar, P.M, Introduction to Wireless system, John Wiley & Sons, USA, 2001.

[11] Green D.C, Radio Communication, Pearson Education Limited, Edinburgh Gate, England, 2000.

[12] Lal Chand Godara, "Smart Antennas", CRC Press LLC, Boca Raton, Florida, USA, 2004.

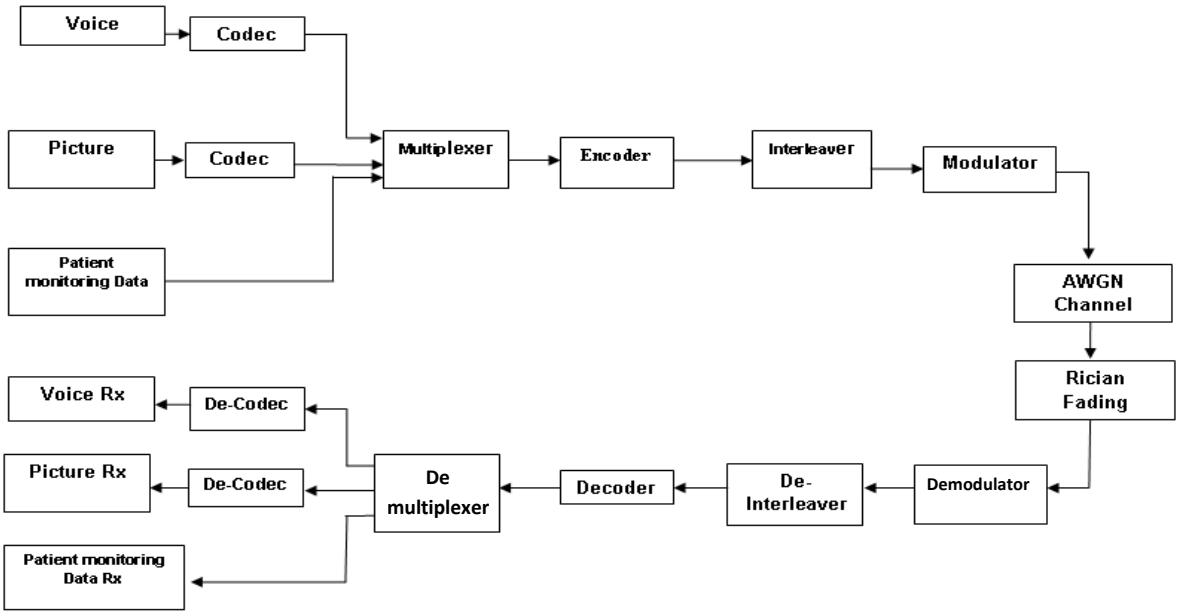

Fig. 3. Block Diagram of the System.

 ISSN – 1999-4974