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Adaptive Transmissionfor Different WBAN Applications with Variable Length Spreading Sequence

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Abstract: Urgent medical cases considered to be one of the difficult communication situations in which it require two contradicting conditions to be satisfied, namely, short transmission time and high reliable communication. In [1] we proposed a scheme which adaptively changes the length of the spreading code according to the variation in the existence number of active users which allow the system to utilize the transmission time in an efficient way. But using short spreading code keep the reliability inadequate. Our proposal is to use parallel transmission with the short code to improve the reliability and maintaining the reasonable transmission speed. The simulation results show an improvement in terms of BER for the proposed system over conventional transmission. It shows also that changing the length of the parallel transmitted bits improve the performance. The simulation assumed an AWGN channel.

Keywords: Parallel transmission, DS-UWB, BAN, Variable Length Spreading Sequence (VLSS).

1. Introduction

Recently, there has been a high demand for the body area networks (BANs) devices that supports both medical and entertainment purposes. From the viewpoint of QoS, Medical and non-medical applications are on different sides in terms of reliability and performance. Medical applications usually require more reliable transmission which postulatesa longer PN sequences withdramaticincrease in the processing time and the complexity (cost) of the system. On the other hand, the entertainment applications attracted toward higher performance without strongrestrictions on the reliability of the data which can easily achieved by short spreading code withdecrease in the processing time and the complexity (cost) of the system.

In [1], we proposed an adaptive variable length spreading codesscheme for Body Area Networks (BANs) applications. To achieve the required Quality of Service (QoS), we adaptively change the spreading code length, long spreading code for high reliability communication and short spreading code forhigher data rate. The proposed scheme changes the sequence length according to the existing number of active users in the system. The proposed scheme has a good result in terms of the processing time especially when the number of active users is small.

As a challenge for this system, a situation likeurgent medical case which has a special nature in that it needsboth data reliability and high speed transmission. The difficulty increases by the increase in the number of active users in the system because in that time we need longer sequences in order to grantee a high reliabilityand we have to trade the reliability off with the speed.

Our proposal is to adaptively change between the conventional (serial) transmission and the parallel transmission for the different medical cases. For the urgent medical cases,we proposeto use parallel transmission with short length spreading code. This allows us to increase the transmission speed maintaining the system reliability in the same time. For the regular medical cases, wewill use the serial transmission and adaptively change the spreading code length according to the number of active users in the system so we can utilize the transmission time. Finally, for non-medical (entertainment) cases, we will use a fixed short spreading code to provide high data rate.

2. System Model

In our system we assume a fixed occupied bandwidth. Also we assume a fixed chip rate of all the sequences. The system assumedto hasa contention free protocol in MAC (e.g. TDMA) so that we don't consider the existence of Multi User Interference (MUI).

3. Adaptive DS-UWB scheme with Variable Length PN Sequence

3.1. System Configuration

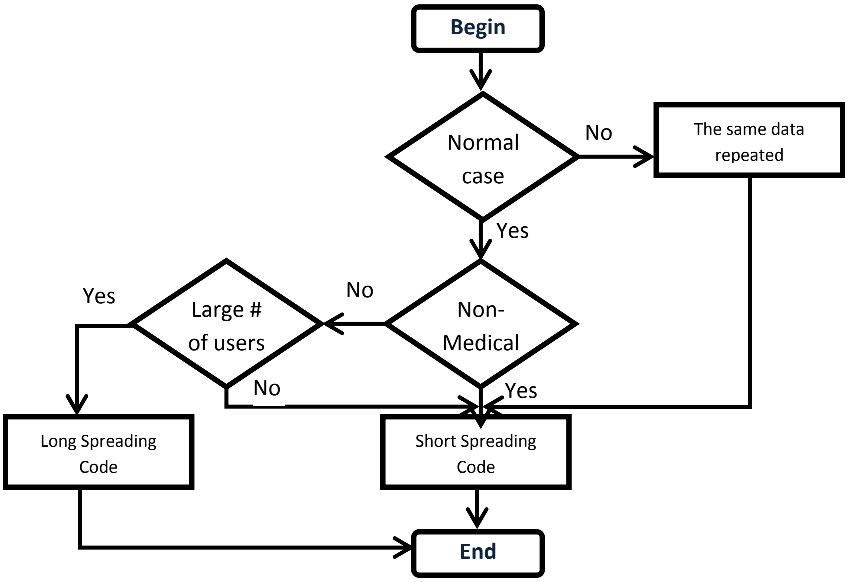


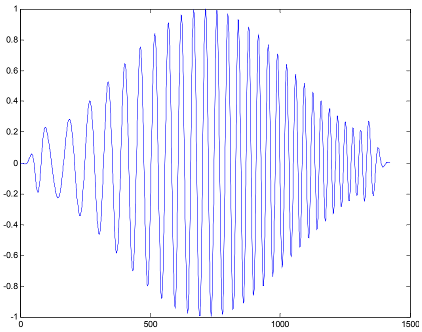
Fig. 1 Flowchart of the proposed system with 3 different cases (Non-medical, Normal Medical and Urgent Medical)

3.2. Transmitter Design

In our system we use chirp pulse (eq. 1) as the transmission pulse because it is robustness, excellent autocorrelation and can be generated and processed without complex digital circuitry, thereby increasing battery life and reducing production costs.

$$w(t) = e^{2\pi i(f_c t + \frac{kt^2}{2})} \qquad (1)$$

wheref_c is the central frequency and k is the chirp rate. If $k>0$ the pulse calledupchirp(Fig. 2) and if $k<0$ the pulse is downchirp. In our system, we use upchirp pulse with change in the pulse phase to represent 1 and



0 respectively.

Fig. 2Upchirp Pulse

In normal medical and non-medical cases, the transmitted signal from user i represented by

$$s^{(i)}(t) = \sum_{j=0}^{N-1} \left(2d_j^{(i)} - 1\right) p_j w(t - jT_c)$$

Where $d_j^{(i)}$ is the j^{th} bit for i^{th} user, T_c is the chip time, p_j is the j^{th} chip of the spreading sequence, N is the spreading code length.

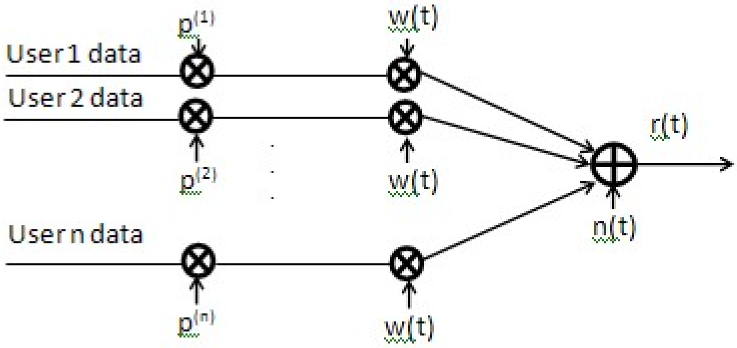


Fig 3: Block diagram of serial transmission

The transmitted signal in the urgent medical cases is the same but the transmitted data bit $d_j^{(i)}$ should be equal for all users.

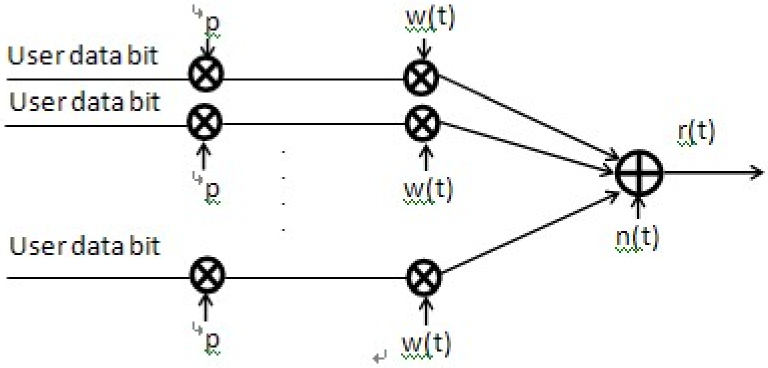


Fig 4: Block diagram of parallel transmission

3.3. Receiver Design

Assuming that the channel is AWGN channel, the received signal in normal medical and non-medical caseswould be

$$r(t) = \sum_{i=1}^{M} \sum_{j=0}^{N-1} (2d_j^{(i)} - 1) p_j w(t - jT_c) + n(t)$$

where*n(t)* is the Additive White Gaussian Noise (AWGN), *M* is the number of active users.

Figure 5 shows that the receiver is a matched filter receiver, matched every user's bit represented pulses with this user'ssignature waveform.

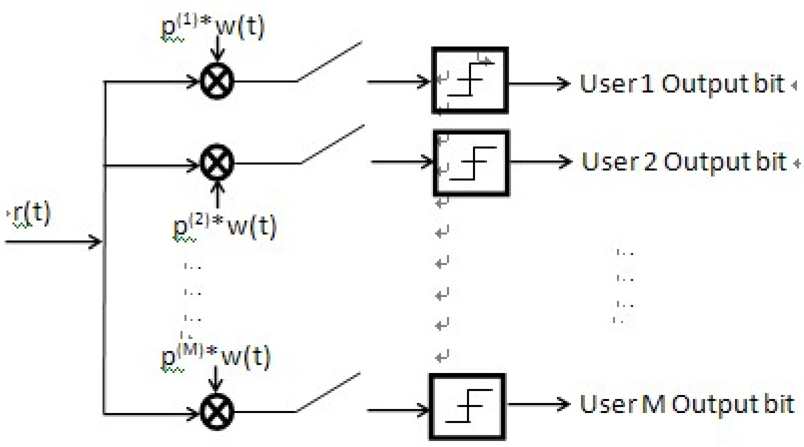


Fig 5: Block diagram of serial receiver

For urgent medical cases, the proposed scheme assumes sending multiple copies for every target bit with short spreading code length. The receiver works the same for the normal medical cases except when taking a final decision about the received bit, we consider another threshold depend on the number of duplications we have. The choice of the threshold should take in consideration a margin of errors resulted from noise. The existence of this duplications assist in decreasing the probability of error ratio for the target bit. The received signal for urgent medical cases would be

$$r(t) = \sum_{i=1}^{M} \sum_{j=0}^{N-1} (2d-1) p_j w(t - jT_c) + n(t)$$

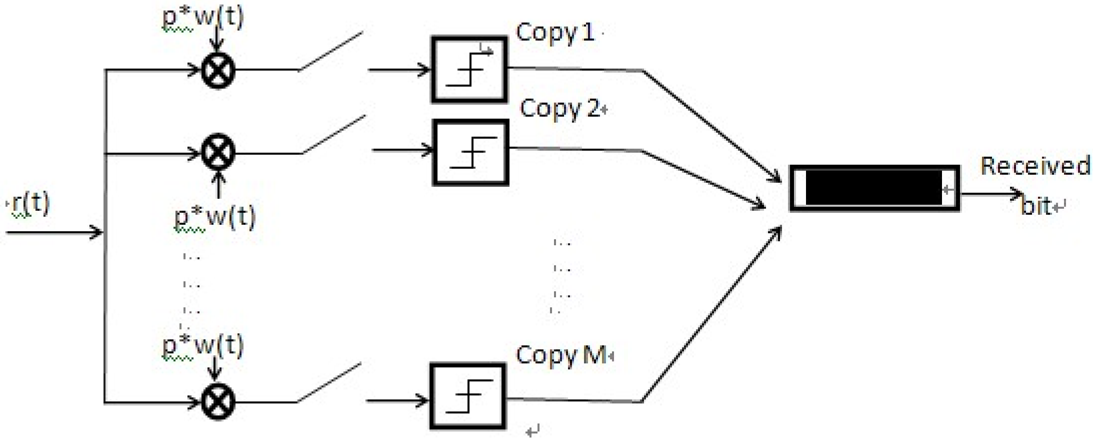


Fig 6: Block diagram of parallel receiver

4. Performance Analysis

Simulation parameters

Chirp Pulse width	64 nSec
Central frequency	4.49 GHz
Number of data bits	100,000
Modulation	BPSK
Channel	AWGN
Detection	Coherent
Chip bandwidth	520 MHz

In the simulation results, we compare between the conventional (serial) system and the proposed (parallel) scheme for urgent medical case. We run the simulation for different spreading code length.

As we can see in Fig.7, there is an improvement in the system performance after using the proposed parallel transmission over the conventionally used serial transmission. Even for a short length of the spreading code, the parallel transmission BER still superior over the serial one.

Since the medical applications usually require BER of order 10^{-5} or less, Fig 7 shows the system performance using the proposed parallel transmission for different values of the number of duplication used for every data bit. The figure shows that the system performance improves within the increase in the number of duplication. A considerable tradeoff shows here between the receiver complexity and the change in the number of duplication bits, andwe left it for the future work to find out what is the optimum number of duplication which satisfies the required QoS.

5. Conclusion

The simulation results show that the system performance with proposed parallel transmission outperform its performance with conventional serial transmission. Transmitting duplication of the data in parallel with short spreading code length grantee a high data rate and reliable data transmission almost equal to the one we get with a longer spreading code. In consideration of urgent medical cases, the proposed scheme is a step toward applying the coexistence of medical and non-medical devices.

6. Future Work

We will analyze the system mathematically to identify the best number of duplication that can satisfy a significant performance with reasonable receiver complexity. Also, we will use a better technique for multiuser detection to improve our system performance.

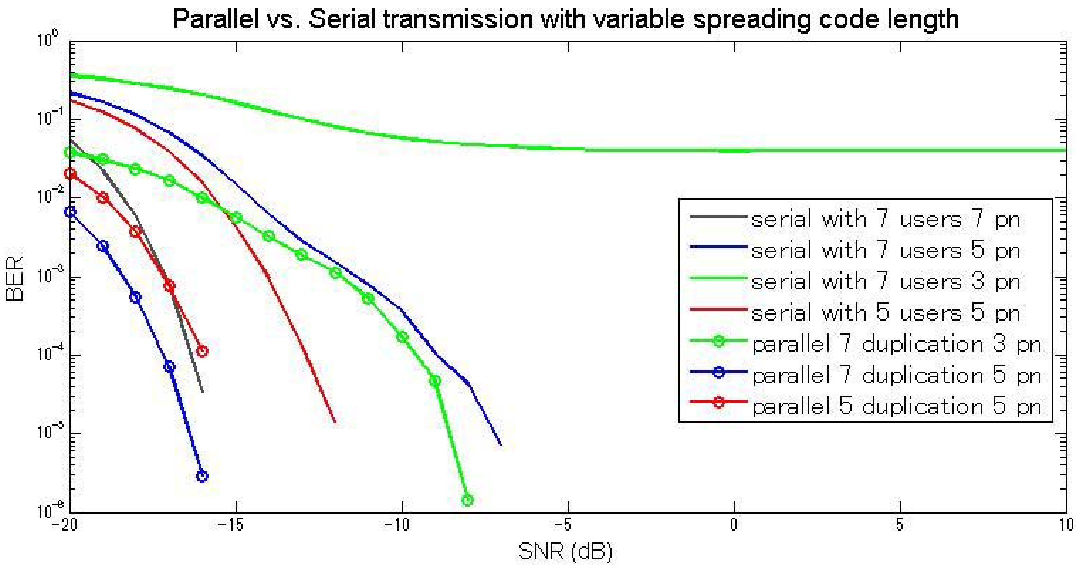


Fig. 7:BER performance comparison according to various spreading code length in case of serial and parallel transmission

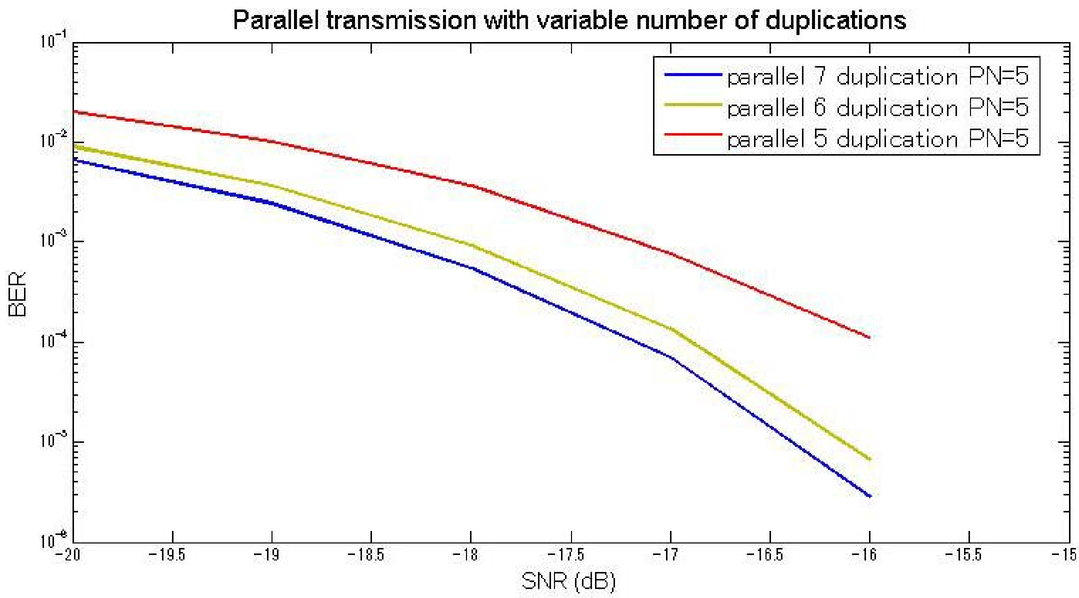


Fig. 8: Parallel transmission with change in number of duplicated bits

7. References

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