Interference Cancellation Technique on Wireless Packet Communication System

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Abstract

This paper shows a method that demodulates a small desired packet colliding with a large interfering packet in wireless packet communications. The small desired packet is given by canceling the received signal by the replicate for the large interfering packet whose amplitude and phase are estimated in the non-colliding part from the received signal. As the results of computer simulation, we confirm that our system can demodulate both small desired packet and large interfering packet.

1. Introduction

The digital transmission is becoming the predominant technique in mobile radio communication systems. Interference has to be considered as a very important problem in the large demand for mobile and personal radio communications. The packet transmission is suitable for the burst data communication provided from computers. The packet communication that consists of some packet users adapts for co-channel blank time to increase the channel efficiency. However, the packet network systems cause the co-channel interference or collision degrades the transmission efficiency.

ALOHA system is well known for a random access packet transmission system divided into two types, pure-ALOHA and slotted-ALOHA. Pure-ALOHA system, the most simple random access system, has many advantages like easiness of control for transmission and simplified systems without synchronization between users. In slotted-ALOHA technique, terminals concurrently communicate with a central station over the co-channel in a synchronous fashion.

When multi-terminals transmit their packets simultaneously, collisions occur at the receiver. In this case, the central station may not receive any packet. Pure-ALOHA system cannot avoid packet collisions and most of the collisions must be partial collisions, not perfect collisions. Even a partial collision usually means no success transmission of the packet.

Accordingly, It was suggested that slotted-ALOHA employing the synchronization between terminals only with the packet collision has high transmission efficiency. However, the synchronization scheme is a big burden for the system.

We propose a new method to overcome the packet collision to improve transmission efficiency in pure-ALOHA system, which is the simplest one.

For radio communication systems co-channel interference canceling techniques have been considered. These techniques utilize the estimation of an interference signal and subtract from the received signal. But these require, training signals, the window for detecting pilot symbols or a frequency offset between the signals. This paper proposes a new interference canceling system, which picks up the small packet suppressed by the large packet. Using the replicate of the large packet that is composed of the amplitude does the cancellation and phase estimated from the reliable non-colliding part of the large packet and the data recovered owing to the capture effect. It is assumed that the packet length is short enough to have constant phase and amplitude in the length.

This paper is organized as follows. The proposed canceling system is described in Chapter 2. In chapter 3, the performance of the systems is evaluated by computer simulation. And the conclusion is described in chapter 4.

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2. System Description

2.1. Capture Effect

Even a partial collision, the collision damages all the packets. When the receiver in the wireless communication has two different signals with unequal amplitudes at the same time, the data of the weaker signal no longer exists at the demodulator output or at least is attenuated to a very weak level. This phenomenon is known as the capture effect. Since the amplitudes of the packets can be control almost same in the wired packet communication. So all packets related to a collision cannot be demodulated. While, most receivers have different powers between colliding packets due to the fading, shadowing and near/far effects, the wireless packet communication system.

Thus P1 and P2 are the respective powers of the two signals, capture effect occurs if

$$\frac{P_1}{P_2} > R$$

Where R(≥ 1) is the capture ratio.

In ALOHA system, the unsuccessful terminal, whose packets have not been acknowledged, re-transmits a packet according to some predetermined protocol until they reach a success receiving. In the usual model, an ALOHA system without the capture effect is plagued in a low system throughput and high user delay.

2.2 Measuring of Times in Colliding and Non-Colliding Parts

It was shown in the chapter 1 that most of collisions in pure-ALOHA are partial ones with the colliding and non-colliding part as shown in Fig 1. To find the non-colliding part of the strong packet is required to estimate the phases and amplitudes for making the string packet's replica. We assume that all packets have the same length T that makes easy to find the boundary time between the colliding and non-colliding parts.

For example, a packet arrives at t_0. If this packet is observed longer than the fixed packet length (T), we find that it includes collision. If the received signal finishes at t_2. We calculate the later packet arrives at t_1.

$$t_1 = t_2 - T$$

Because packet length is T, we estimate the colliding pare within t1 to t0 + T. One of the non-colliding parts of the former packet is estimated within t0 to t1 and the other part of the latter packet is estimated within t0 + T to t1 + T. We can separate the three parts from the received signal.

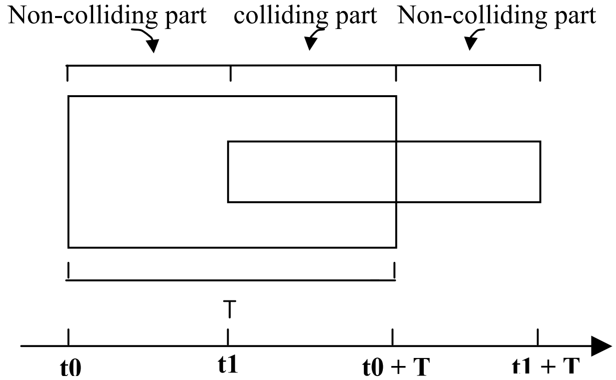

Fig. 1 Colliding Packet

2.3. Estimation of Colliding Packets

This section shows how to pick up each packet from the collision. Since the proposed system is based on the block signal processing with the memory, we can ignore the time direction in the processing for separating the two packets. We assume that the packet length is fixed as mentioned in Section 2.2 and short enough to ignore the fluctuations of the phase and amplitude even in the fading channel.

2.3.1. Large Packet Replica

Avoiding the colliding part, the phase θ_a, frequency off-set Δw_a from the local oscillator in the block demodulator are estimated from the reliable pare of the large packet. In addition, the data a_i , (=0,1) is recovered not only from the non-colliding part, but also from the colliding part due to the capture effect. The replica is shown as follows.

$$C_a(t) = P_a \cos(2\pi(f_c + \Delta f_a)t + \phi_a + a_i\pi)$$

Where we assume the modulation type of all packets is BPSK(Binary Phase Shift Keying) in simplicity.

2.3.2. Small Packet Detection

After the received signal that consists of the large packet, small packet and noise are subtracted by the large packet replica mentioned above; the small packet can be detected.

2.4 Extension of Capture Effect

When the capture ratio is large, the colliding packets are demodulated. If the capture effect is not large enough, the conventional system cannot detect the colliding packets.

A method to overcome this problem is discussed in the paper [8] whose treated signals are not packet type ones, but continuous signals with training sequence and synchronous pilot symbols and windows. We use the above method to extend the capture effect.

2.5 Throughput Performance

Here we solve the throughput performance of the system. This we do by solving for throughput(S) in terms traffic(G). The channel capacity is then find by maximizing S with respect to G.

In the pure-ALOHA system, each terminal transmits its packet over the data channel in a completely unsynchronized manner. A given packet will overlap with another packet if there exists at least one start of transmission within T seconds before or after the start time of the given packet.

$$S = Ge^{-2G}$$

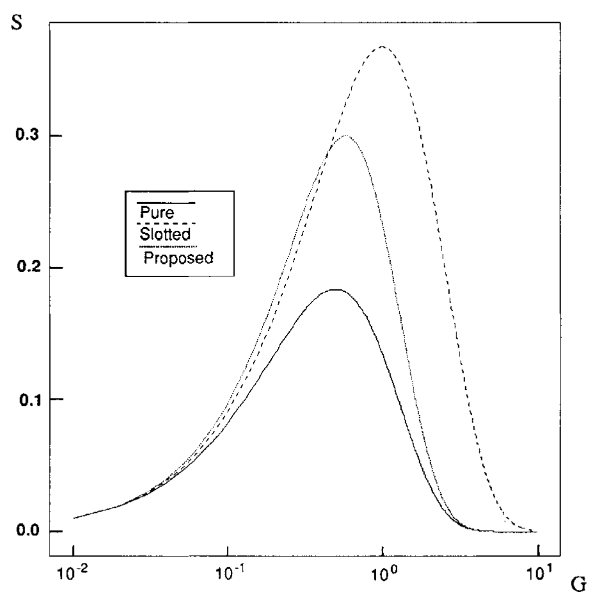

Fig. 2 Throughput Performance

In the slotted-ALOHA, if two packets collide, they will overlap completely rather than partially. The throughput equation then becomes

$$S = Ge^{-G}$$

In the proposed system, we assume two conditions. If packet exists at least is start of transmission within T before and after the start time of the given packet.

$$S_1 = Ge^{-2G}$$

Next, we can detect when two packets collide. If packets collides only one packet and no other packet collide within T.

$$S_2 = 2 \times G^2 e^{-3G}$$

Thus, the throughput in the proposed system

$$S = Ge^{-2G} + G^2 e^{-3G}$$

Fig. 2 shows throughput performance.

3. Computer Simulation

Table 1 shows the parameters for computer simulations. We assume that the collision occurs only between two packets and the former packet power is larger than the later packet. The parameters for signal estimation are amplitude, initial phase difference between the packets and the local oscillator. The first simulation is for calculating desired signal power / interference power ratio vs. the average bit error probability performance when the overlap ratio is constant. The second simulation is for calculating overlap ratio vs. the average bit error probability when CIR is constant. The average bit error(BER) shows the error in colliding part. This means the BER given here are measured pessimistically.

Table 1. Simulation Conditions

Modulation	BPSK
Roll-off rate	0.5 (root cosine roll-off)
Packet Length	512 bit
Demodulation	Block Demodulation
Noise	White Gaussian Noise
Overlap Rate	70 %

3.1. BER Performance vs. CIR

Fig. 3 shows BER performance of the large packet under SNR = 15[dB]. The BER only in the colliding part is calculated. Fig. 4 shows BER performance, of the small packet in the colliding part under SNR = 15[dB]. The conventional system without a canceller cannot detect the small signal suppressed by the large signal. But the proposed system can detect the small signal.

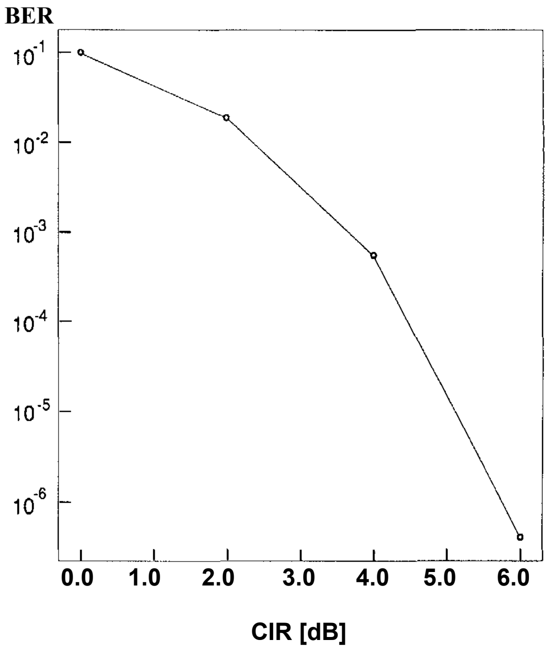

Fig. 3 BER performance only in the colliding part vs. CIR. (Large Packet)

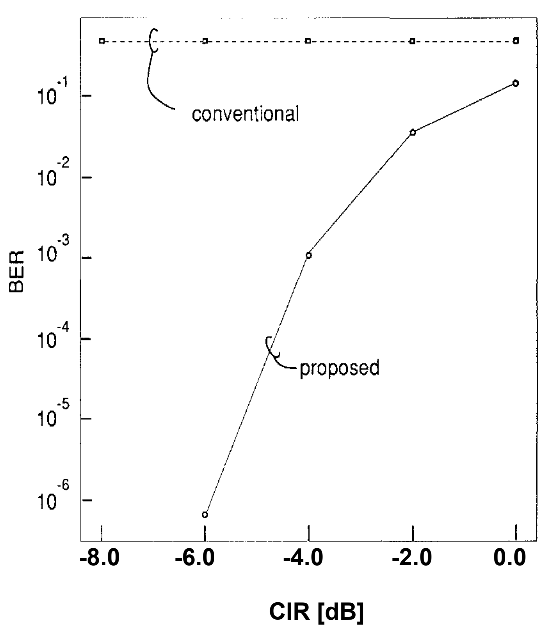

Fig. 4 BER performance only in the colliding part vs. CIR. (Small Packet)

3.2. Overlap Rate Consideration

Fig. 5 shows BER performance vs. the overlap ratio in CIR = 6[dB], SNR = 15[dB]. These simulation results how long non-colliding part of packet that this system requires for estimation. In 100% overlap ratio, the perfect collision, we cannot detect the small signal.

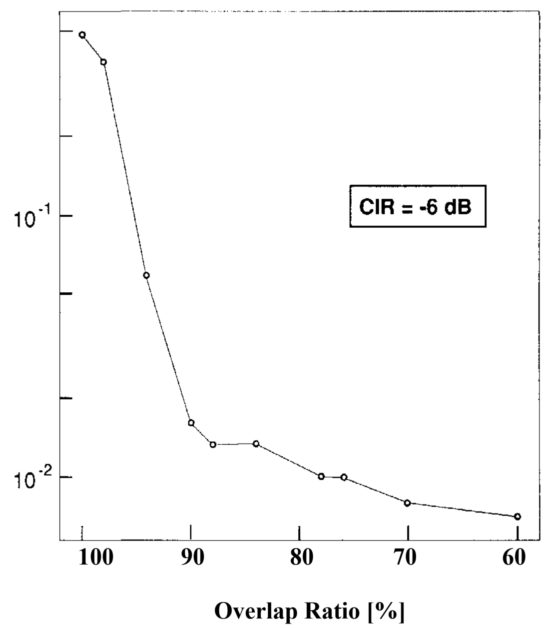

Fig. 5 BER performance vs. Overlap ratio for small Packet

4 Conclusions

This paper shows that the proposed system can demodulate a small desired packet colliding with a large interfering packet by using the feature of the partial collision between the two packets.

This proposed system does not require any training signal or pilot symbol and window. As the results of computer simulations, we confirm the usefulness of our method.

References

[1] Young-an KIM, Choong-seon HONG: R-ALOHA Protocol for Inter-Vehicle Communication in Ad-hoc Network. Korea ITS Conference 2002, (2002), pp. 31-34.

[2] Masao Nakagawa: Personal Communication and Consumer Communication. Baihuukan.

[3] Kazuhiko Fukawa, Hiroshi SUZUKI: An Adaptive Signal Processing without Information of Interference Signal. TECHNICAL REPORT OF IEICE. RCS04-27, (2004), pp. 69-76.

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[4] H. Singh, S. Singh: A MAC Protocol based on Adaptive Beacon Forming for Ad Hoc Networks. In Proceeding of the 14th IEEE Personal, Indoor and Mobile Radio Communication Conference, (2003).

[5] Akinori Hirukawa, Hitoshi Takanashi: Inter-Base-Station TDMA Frame Synchronization Technique for Street Microcellular System. IEEE PIMRC'94.,Vol. D-3, (1994), pp. 358-362.

[6] James. A. Roberts, Juan M.Bargallo: DPSK Performance for Indoor wireless Rician Fading Channels. IEEE Trans. Commun., Vol com-42, (1994), pp. 592-596.

[7] Takeshi CHISHAKI, Nobuak INOUE: Engineering of Traffic Planning. Kyoritsu Syuppan, Japan, (1993).

[8] Hitoshi YOSHINO, Kazuhiko Fukawa, Hiroshi SUZUKI: Adaptive Interference Canceller Based upon RLS-MLSE, THE TRANS. Of IEICE.