HYBRID SPREAD SPECTRUM TECHNIQUES FOR CELLULAR MOBILE COMMUNICATION SYSTEM

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ABSTRACT

In addition to the frequency hopped and direct sequence, spread spectrum multiple access technique, there are certain other hybrid combinations that provide the advantage in the area of cellular mobile communication system. The available wideband spectrum is divided in to a number of subspectras with smaller bandwidth. Frequency Hopped Multiple Access Technique (FHMAT) consists of a direct sequence modulated signal whose center frequency is made to hop periodically in a pseudorandom fashion. In this paper we provide a Hybrid Spread Spectrum Techniques using Time Division Code Division Multiple Access (TDCDMA) system in which different spreading codes are assigned to different cell within each cell, only one user per cell is allotted a particular time slot. Time Division Frequency Hopping Multiple Access (TDFHMA) Technique has an advantage in severe multipath or when severe co-channel interference occurs. The subscriber can hop to new frequency to new frequency at the start of a new time division multiple access frames. These different areas covered by the antenna beam may be served by the same frequency or difference frequency.

Keywords: *Frequency Hopped Multiple Access, Time Division Code Division Multiple Access, Time Division Frequency Hopping, Space Division Multiple Access.*

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1. INTRODUCTION

Spread spectrum techniques spread information over a very large bandwidth specifically, a bandwidth that is much larger than the inverse of the data rate. In this paper we are discussing various ways of providing multiple access by spreading the spectrum. We start out with the conceptually simplest approach, Frequency Hopping (FH). We then proceed to the most popular form of spread spectrum, Direct Sequence-Code Division Multiple Access (DS-CDMA). Finally, we elaborate on time-hopping impulse radio, a relatively new scheme that has gathered interest in recent years because of its application to ultra wideband systems.

We want to transmit as much information per available bandwidth as possible. Thus it might seem like a strange idea to spread information over a large bandwidth in a commercial cellular mobile communication.

This seeming paradox can be resolved when we recognize that different users can be spread across the spectrum in different ways. This allows multiple users to transmit in the same frequency band simultaneously; the receiver can determine which part of the total contribution comes from a specific user by looking at data with specific spreading pattern. Thus capacity (per unit bandwidth) is not necessary decreased by using spread spectrum techniques, and can even be increased by exploiting.

Spread Spectrum Multiple Access (SSMA) uses signals which have a transmission bandwidth that is several orders of magnitude greater than the minimum require RF bandwidth. A pseudo-noise (PN) sequence converts a narrow band signal to a wideband noise-like signal before transmission. SSMA also provide immunity to multipath interference and robust multiple access capability. SSMA is not very bandwidth efficient in multiple user environments. A hybrid wireless network architecture is a network that provides dedicated relay stations and embedded host-cumrelay stations with mobile terminals; further, the architectures can be divided into single-mode hybrid, where mobile terminals only perform a single hop, and multi-mode hybrid, where either multi-hop or single-hop happens in mobile terminals. The recent attempts at throughput enhancement in hybrid networks include multi-hop cellular network (MCN) [1], multi-power architecture for cellular networks (MuPAC) [2], integrated cellular and ad hoc relaying system (iCAR) [2], self-organizing packet radio networks with many kinds of access schemes have been studied to achieve ideal behavior in fading channels. Code division multiple access (CDMA), which does not require precise control of carrier frequencies or transmission timing, is a more promising approach than frequency division multiple access (FDMA) or time division multiple access (TDMA).

Among CDMA systems, the hybrid slow frequency hopping (SFH)/DS CDMA scheme is an attractive alternative in preventing bit error degradation under frequency selective fading channels [4]. These hybrid S W D S schemes show improved bit error performance when they are combined with some diversity or coding techniques. However, synchronization of the hopping frequencies and spread sequences for these hybrid systems is difficult to implement in a practical system. The frequency hopping synthesizer must acquire its output frequency precisely and rapidly at every hop. To achieve a hybrid FWDS CDMA system, the key is to reduce the complexity overlay (SOPRANO) [5] etc.

2. FREQUENCY HOPPED MULTIPLE ACCESS

Frequency hopped multiple access is a digital multiple access system in which the carrier frequencies of the individual users are varied in a pseudorandom fashion within wideband channel. The digital data of each user is broken in to uniform sized burst which are transmitted on different channels within the allocated spectrum band. The instantaneous bandwidth of any one transmission burst is much smaller than the total spread bandwidth. The pseudorandom change of the channel frequencies of the user randomizes the occupancy of a specific channel at any given time, thereby allowing for multiple access over a wide range of frequencies. In the FH receiver, a locally generated PN code is used to synchronize the receiver's instantaneous frequency with that of transmitter. A frequency hopped system provides a level of security, especially when a large number of channels are used, since an unintended receiver that does not know the pseudorandom sequence of frequency slots must retune rapidly to search for the signal it wishes to intercept. In addition, the FH signal is somewhat immune to fading, since error control coding and interleaving can be used to protect the frequency hopped signal against deep fades which may occasionally occur during the hopping sequence [6]. In frequency hopping systems, the carrier frequency of the transmitter abruptly changes (or hops) in accordance with a pseudo random code sequence. The order of frequencies selected by the transmitter is dictated by the code sequence. The receiver tracks these changes and produces a constant IF signal. See figure 1.

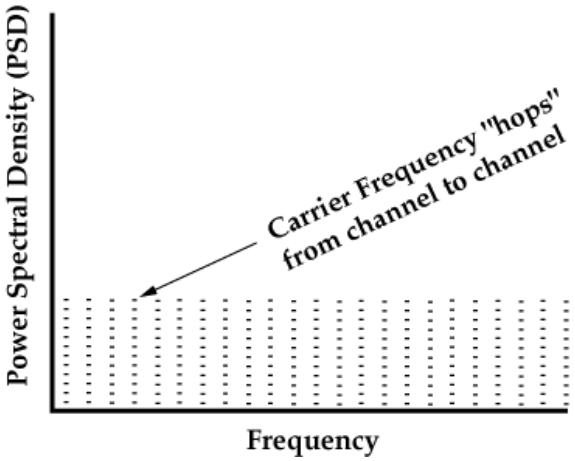

Fig. 1. Frequency Hopping Systems

3. HYBRID SPREAD SPECTRUM TECHNIQUES

In addition to the frequency hopped and direct sequence, spread spectrum multiple access techniques, there are certain other hybrid combination that provide certain. These hybrid techniques are described are described below.

3.1 Hybrid FDMA/CDMA

These techniques can be used as an alternative to the DS-CDMA techniques discussed. The available wideband spectrum is divided in to a number of subspectras with smaller bandwidths. Each of these smaller sub channels becomes a narrow band CDMA system having processing gain lowers than the original CDMA system. This hybrid system has an advantage in that the required bandwidth need not be contiguous and different users can be allotted different sub spectrum bandwidth depending on their requirements. The capacity of this FDMA/CDMA technique is calculated as the sum of the capacities of a system [7].

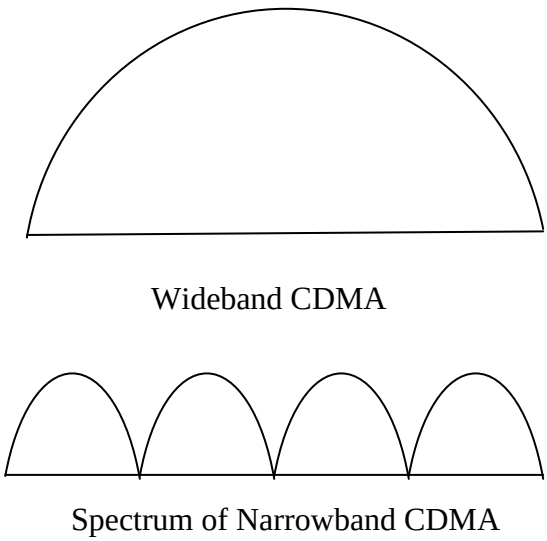

Fig. 2 Spectrum of wideband CDMA compared to the spectrum of a hybrid, frequency division direct sequences multiple access [7].

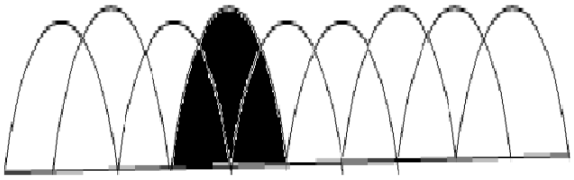

Fig. 3. Frequency spectrum of a hybrid FH/DS system.

3.2 Hybrid Direct Sequence /Frequency Hopped Multiple Access

This technique consists of a direct sequence modulated signal whose center frequency is made to hope periodically in a pseudorandom fashion, figure. 3 shows the frequency spectrum of such a signal [Dix94]. Direct sequence, frequency hopped systems have an advantage in that they avoid the near-far effect. However frequency hopped CDMA systems are not adaptable to the soft handoff process since it is difficult to synchronize the frequency hopped base station receiver to the multiple hopped signals [7].

3.3 Time Division CDMA

In a TCDMA (also called TDMA/CDMA) system, different spreading codes are assigned to different cells. Within each cell, only one user per cell is allotted a particular time slot. Thus at any time, only one CDMA user is transmitting in each cell. When a handoff takes place, the spreading code of the user is changed to that of new cell. Using TCDMA has an advantage in that it avoids the near-far effect since only one user transmits at a time within a cell [7].

3.4 Time division Frequency Hopping

This multiple access technique has an advantage in severe multipath or when severe co-channel interference occurs. The subscriber can hop to new frequency at the start of new TDMA frame, thus avoiding a severe fade or erasure event on a particular channel. This technique has been adopted for the GSM standard, where the hopping sequence is predefined and the subscriber is allowed to hop only on certain frequencies which are assigned to a cell. Thus scheme also avoids co-channel interference problem between neighboring cells if two interfering base station transmitter are made to transmit on different frequencies at different times. The use of TDFH can increase the capacity of GSM by several folds [7].

3.5 Space Division Multiple Access

Space Division Multiple Access controls the radiated energy for each user in space. SDMA serves different users by using spot beam antennas. These different areas covered by the antenna beam may be served by the same frequency (in a TDMA or CDMA) system or different frequencies (in an FDMA systems). Sector zed antennas may be thought of as a primitive application of SDMA. In the future, adaptive antennas will likely be used to

simultaneously steer energy in the direction of many users at once and appear to the best suited for TDMA and CDMA base station architecture.

The reverse link presents the most difficulty in cellular systems for several reasons. First, the base station has complete control over the power of all the transmitted signals on the forward link [7].

4. CONCLUSION

These techniques can be used as an alternative to the DS-CDMA techniques discussed. The available wideband spectrum is divided in to a number of subspectras with smaller bandwidths. The digital data of each user is broken in to uniform sized burst which are transmitted on different channels within the allocated spectrum band. The instantaneous bandwidth of any one transmission burst is much smaller than the total spread bandwidth. This multiple access technique has an advantage in severe multipath or when severe co-channel interference occurs. The subscriber can hop to new frequency at the start of new TDMA frame, thus avoiding a severe fade or erasure event on a particular channel.

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