

A Review Paper on Multiple Access Techniques for Mobile Communication

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Abstract- Very limited amount of frequencies are available for mobile communications. One main research topic in mobile communications involves determining how to use available frequencies more efficiently by allowing more number of communications to take place. The purpose of this paper is to introduce different multiple access techniques for mobile communication. The paper explains a new concept in multiple access techniques for two-way mobile communications through single link called “Paired Carrier Multiple Access” (PCMA). PCMA is novel methods for frequency re-use which allows two mobile nodes to use the same frequency, time slots, and/or CDMA code at the same time.

Index Terms- Paired Carrier Multiple Access, Multiple access techniques, Frequency reuse techniques, Mobile communication

I. INTRODUCTION

In recent years, there have been tremendous efforts in research activities related to multi-carrier transmission techniques which have been proven to increase the application bit rates of mobile communications. Different techniques have been studied to improve the bandwidth, efficiency and increase the number of users that can be accommodated within each cell. The next generation wireless communications systems require higher data rates transmission in order to meet the higher demand of quality services. Research in wireless digital communications techniques have been expending very rapidly in the last few decades, resulting more reliable wireless communication systems that operate at higher spectral efficiency. Since there have been an increased in demand for higher data rate transmission, the systems are incorporating the multi-carrier transmission techniques.

II. MULTIPLE ACCESS TECHNIQUES

Multiple access technique is the ability of mobile nodes to simultaneously interconnect and communicate their data through a common channel or medium. The multiple access problems are fundamental to mobile

communications. Very limited amount of frequencies are available for communications. One main research topic in mobile communications involves determining how to use available frequencies more efficiently by allowing more number of communications to take place. Multiple access techniques allow several users to share a medium with minimum or no interference. Several multiple access techniques that are available today are:

1. SDMA: Space Division Multiple Access
2. FDMA: Frequency Division Multiple Access
3. TDMA: Time Division Multiple Access
4. CDMA: Code Division Multiple Access

2.1 Space Division Multiple Access (SDMA):

Very limited range of frequency is available for mobile communication. Therefore there is necessity for Frequency-Reuse. Implementing Space Division Multiplexing allows the frequency reuse.

If one transmitter is far away from another transmitter (i.e. outside the interference range), then they both can reuse same frequencies for their transmissions as they are separated in space. Here Transmitter T1 and Transmitter

T2, both reuse same frequency F1, as they are outside the interference range of each other.

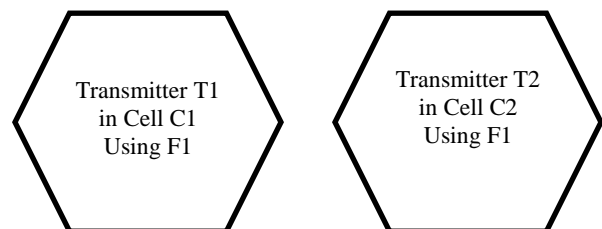


Figure 1: SDMA

The interference of the two transmitters that are in same space can be separated using two different frequency bands through frequency division multiple access technique.

2.2 Frequency Division Multiple Access (FDMA):

Channel medium is able to transfer a range of signal wave frequencies from source to destination (i.e. Bandwidth of Channel). Bandwidth of the channel is divided into the small band of frequencies. And each transmitter is given a small band of frequency to transmit their data. Thus many transmitters can transmit their data signals on same channel, but they are separated in frequency.

Bandwidth of the channel F	Transmitter T1 using F1 frequency band to transmit data
	Transmitter T2 using F2 frequency band to transmit data
	:
	Transmitter Tn using Fn frequency band to transmit data

Figure 2: FDMA

2.3 Time Division Multiple Access (TDMA):

The interference of the two transmitters that are in same space and use same frequency band can be separated through Time Division Multiple Access technique. Here the transmitters transmit data using same frequency band but at different time. Thus they are separated in time.

Bandwidth of the channel F	Transmitter T1 using F1 frequency band at time t1	Transmitter T2 using F1 frequency band at time t2
	:	:	.
	:	:	.
	:	:	.

Figure 3: TDMA

2.4 Code Division Multiple Access (CDMA):

The interference of the two transmitters that are in same space and use same frequency band at same time can be separated through Code Division Multiple Access technique. Here the transmitters transmit data using same frequency band and at same time but use different codes.

Thus, they are separated in code.

Bandwidth of the channel F	Transmitter T1 use code C1	
	Transmitter T2 use code C2		...
	:		
	:		

Figure 4: CDMA

III. PAIRED CARRIER MULTIPLE ACCESS:

PCMA is a concept in multiple access techniques for two way mobile communications. PCMA is a “frequency reuse” technique that takes advantages of “loop back” broadcast nature of communication medium. It allows two mobile nodes to use the same frequency, time slots, and/or CDMA code at the same time.

3.1 Paired Carrier Multiple Access concept:

Two way communications involve two links, uplink and downlink. The Uplink is used for transmitting and downlink is used for receiving.

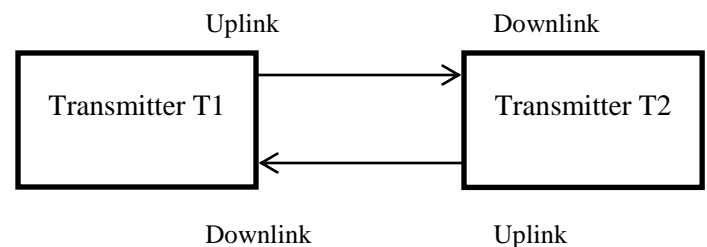


Figure 5: Two way communication without PCMA

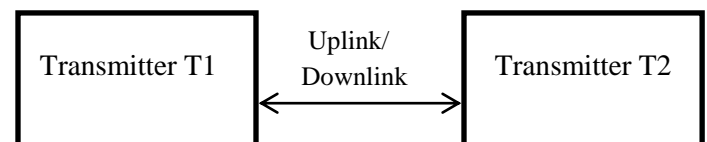


Figure 6: Two way communication with PCMA

In figure 6, we see that using PCMA concept uplink and downlink is replaced with only one link which is used for both transmission and reception.

For PCMA, we require the following assumptions:

1. The communication operates in a “loop back” mode. That is, signals transmitted by each terminal can also be received by each terminal (with some, undefined signal to noise ratio).
2. The communication uses a “bent-pipe” transponder. (Transponder is a device for receiving a radio signal and automatically transmitting a different signal).

Each terminal transmits an uplink signal and receives a downlink signal from the other terminal. Without PCMA the communication links has separate uplink and downlink signals in one or more dimensions using one or more of the common multiple access techniques (e.g. TDMA, FDMA, and/or CDMA).

1. In FDMA, the uplink and downlink signals use non-overlapping frequency bands to transmit data.
2. In TDMA, the uplink and downlink signals use same frequency band to transmit data, but transmit data during different time slots.
3. In CDMA, the uplink and downlink signals use same frequency band and time slot, but transmit data using distinct CDMA codes.
4. Hybrid systems combine different multiple access techniques, but still rely on uniqueness in one or more dimensions to allow a receiver to distinguish and detect a signal from other terminals.
5. In PCMA, the uplink and downlink signals use same frequency band, time slot, CDMA code, but take advantage of the bent-pipe, loop back nature of communications to separate uplink transmission from downlink transmission.

With PCMA, we allocate the exact same multiple access dimensions (i.e. frequency, time, code) to a pair of satellite terminals. Each terminal is able to separate its own transmission from that of the other terminal by taking advantage of bent-pipe, loop back nature of communication.

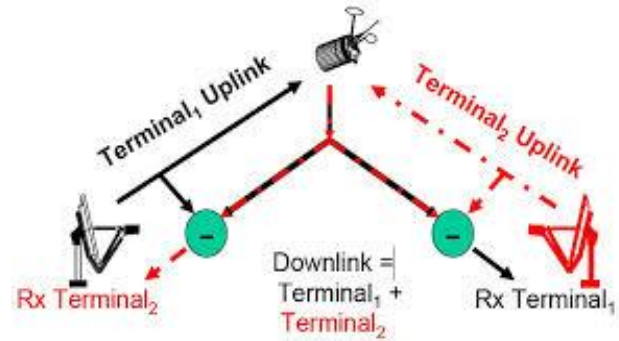


Figure 7: Two way communication with PCMA

1. The data1 is transmitted by terminal1 to terminal2 and the data2 is transmitted from terminal2 to terminal1. In fig-7, the data1 is represented in by black line and the data2 is represented by red line.
2. Due to bent-pipe, loop-back nature of communication, signal transmitted by terminal1 (data1) can also be received by terminal1 and the signal transmitted by terminal2 (data2) can also be received by terminal2.
3. Terminal1 uplink transmits data1 to satellite. Terminal2 uplink transmits data2 to satellite. Terminal1 downlink receives data2 from Terminal2 plus its own data (data1) due to the loop back nature of communication. Similarly Terminal2 downlink receives data1 from terminal1 plus its own data (data2) due to the loop back nature of communication.

The fundamental concept of PCMA is very powerful.

Each terminal knows:

1. Exactly what information is sent.
2. And knows the Processing that its signal undergoes when it is transmitted through its own uplink and its own receiver.

Therefore each terminal can estimate the contribution of its own component to the composite downlink consisting of itself plus the desired signal from the other terminal in the pair. The Own portion of the signal can be subtracted, leaving only the desired signal. The benefit of this new method is that it collapses two separate transmissions into exactly the same overlapping dimensions of frequency, time and code space. For symmetric links this doubles the apparent bandwidth of the system.

3.2 Signal Suppression:

Of course, a terminal's own signal parameters cannot be perfectly estimated, so the own signal is not perfectly cancelled by subtracting the estimate, but is

attenuated, or suppressed by some amount (say X dB). This is shown in fig-8 (Signal Suppression).

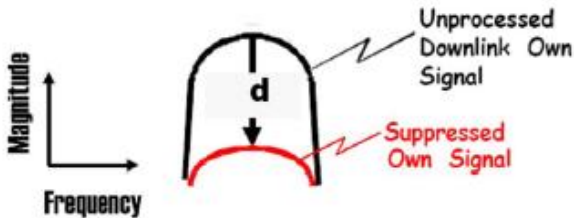


Figure 8: Signal suppression

The suppressed own signal adds “noise” to the signal receiver.

2.3 PCMA Block diagram:

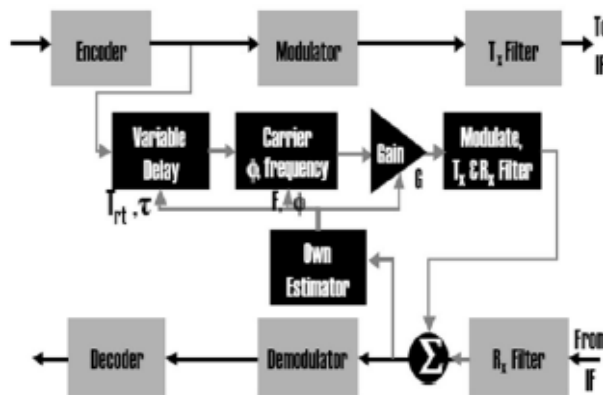


Figure 9: PCMA Block diagram

PCMA requires several additional processing elements as shown in figure 9.

1. An own signal estimation block which derives the parameters of the own signal from the composite downlink
2. Delay, Frequency, Phase and Gain adjustment blocks which are used to align the locally generated cancellation signal with the own component of the downlink signal.
3. Modulator and Filter blocks, which compensate for uplink and downlink filtering effects.

Transmitter1 first encodes signal1 using Encoder, encoded signal then is modulated using Modulator; modulated signal is then sent to Transmitter filter (Tx), Filtered signal is then transmitted to via uplink. Transmitter1 receives signal2 sent by Transmitter2 plus loop-back signal1 via downlink. Transmitter1, in order to detect signal2 it has to estimate loop-back signal1 and subtract it from downlink signal. To generate loop-back signal1 at receiver of transmitter1, the encoded signal1 is passed through Variable Delay block, Carrier Phase and frequency block, Gain block and then to Modulator and filter block. Loop-back signal1 is

estimated by Variable Delay block which compensate time offset, Carrier Phase and frequency block which compensate phase offset and offset and Gain block which compensate gain or attenuation in amplitude, Modulator block which compensate modulator of uplink transmitter and Filter blocks which compensate for uplink and downlink filtering effects. The estimated Loop-back signal1 is subtracted from downlink signal. Resulting signal is then fed to Own Estimator block, which provides feedback loop to Estimator blocks and adjusts them to maximize the suppression of loop-back signal1. Thus signal2, got after suppressing loop-back signal1 from downlink signal is sent to Demodulator block and Decoder block of the receiver.

IV. PCMA IN FDMA, TDMA AND CDMA

PCMA can be applied to the 3 common multiple access techniques (FDMA, TDMA, and CDMA).

4.1 PCMA in FDMA:

The figure 10 shows “Normal FDMA”. The uplink originating at Terminal1 would be at f_1 Hz and the uplink originating from Terminal2 would be at f_2 Hz. The carrier center frequencies would be far enough apart so that the two signals, each of bandwidth W Hz, do not overlap.

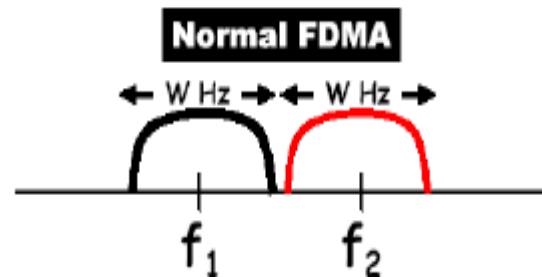


Figure 10: Normal FDMA

With PCMA, both signals are placed at the exact same uplink frequency f_0 . Each receiver demodulates the desired signal by suppressing its own signal.

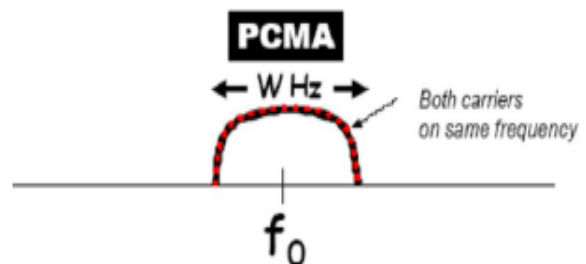


Figure 11: PCMA in FDMA

4.2 PCMA in TDMA:

Normal TDMA: In normal TDMA each terminal would transmit in a different TDMA time slot.

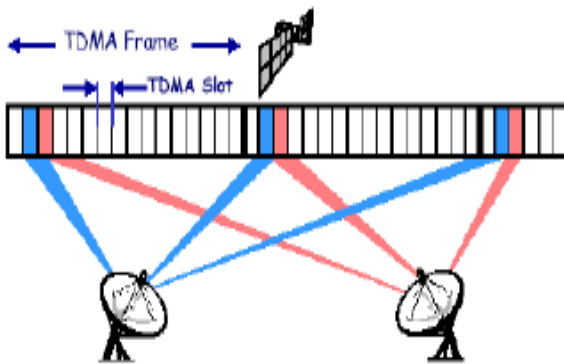


Figure 12: Normal TDMA

PCMA TDMA: With PCMA, a pair of terminals would both transmit in the exact same time slot. This cuts the total number of time slots needed for a 2-way circuit in half, reducing the total effective bandwidth used.

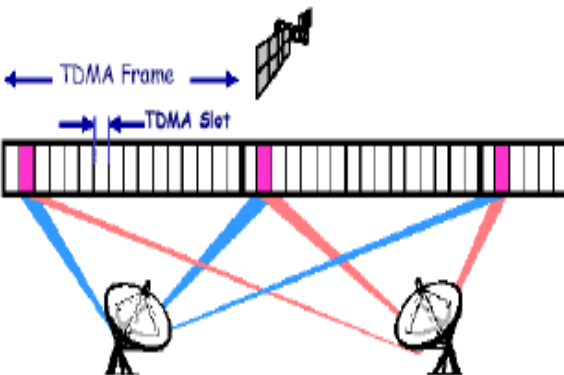


Figure 13: PCMA in TDMA

4.3 PCMA in CDMA:

Normal CDMA: PCMA can be applied to CDMA in a similar manner. In normal CDMA, each transmitting terminal uses a unique CDMA code to distinguish its signal. In some situations, the CDMA code space may be the limiting factor. The available code space is a function of the transponder bandwidth and the information rate.

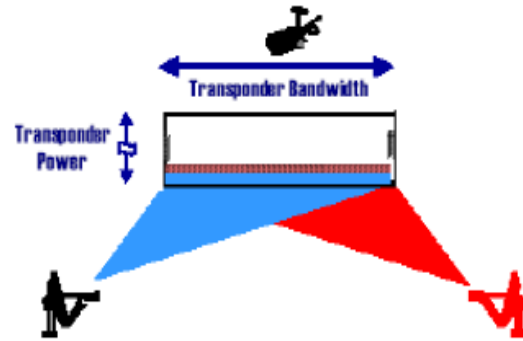


Figure 14: Normal CDMA

PCMA CDMA: With PCMA, each terminal in the pair transmits using a single CDMA code. This effectively doubles the code space, which may be equivalent to doubling the bandwidth.

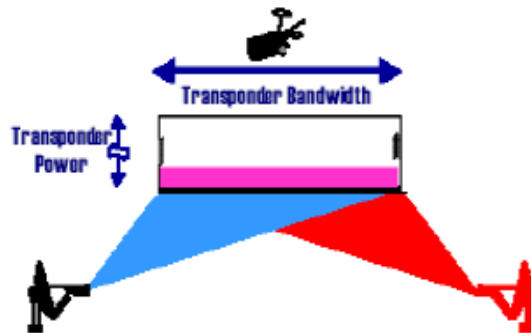


Figure 15: PCMA in CDMA

V. CONCLUSION

PCMA is a novel multiple access technique which reduces the bandwidth requirement of the mobile communication by half when used along with FDMA, TDMA and CDMA. With PCMA concept we can replace uplink and downlink by only one transmission link there by it reduces the communication cost, but adds some additional processing of signal suppression in the receiver end.

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