Multiuser systems review with their limits

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***Abstract*— In multiuser systems the system recourses must be divided into multiple users. This paper discusses these various techniques to allocate recourses to multiple users, as well as drawbacks of multiuser system. Also we will discuss multiuser channel capacity for both uplink and downlink system.**

Index Terms—**: FDMA, TDMA, CDMA**.

I. INTRODUCTION

Multiple access techniques divide up the total signalling dimensions into channels and then assign these channels to multiple users. We know that signal of bandwidth B and time duration T occupy a signal space of dimension 2BT. In order to support multiple users, the signal space dimension of multiuser system must be allocated to different users. Allocation of signalling dimensions to specific users is called multiple access. Multiple access systems perform differently in different multiuser channels. In order to make full use of available bandwidth in optical fibre, it is necessary to multiplex low rate data streams. There are three types of multiplexing techniques in optical domain.

1. Frequency division multiple access (FDMA)
2. Time division multiple access (TDMA)
3. Code division multiple access (CDMA)

Here in this paper i have tried to review all these multiplexing techniques.

II. MULTIUSER CHANNELS

Multiuser channels are the channels that must be shared among multiple users. There are two different types of multiuser channels: Uplink channel and downlink channel. Downlink channel is a forward channel has one transmitter sending to many receivers. Since signals transmitted to all users originates from the downlink transmitter, the transmitted signal $s(t)=\sum_k^K =1\ S_k(t)$, is the sum of signals transmitted to all k users. Synchronization of all users is easy in downlink because all signals originate from same transmitter.

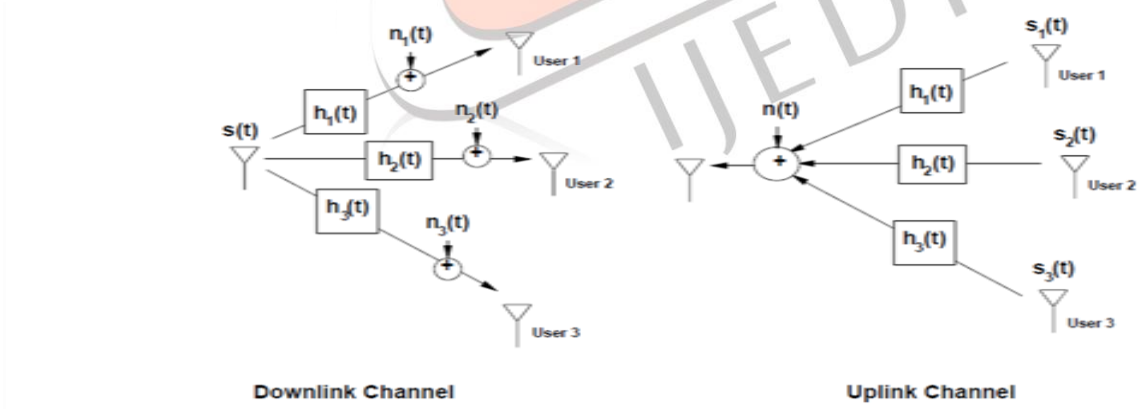

Fig.1 Downlink and Uplink channel

Also the signal and the interference are distorted by the same channel. e.g.. All radio and television broadcasting.
Downlink channel is also called as reverse channel. It has many transmitters sending signal to one receiver, where each signal must be within total system bandwidth. In contrast to downlink, in uplink each user has individual power constraints. Figure indicates that the signal of different users in the uplink travel through different channels, so if transmitted power are same, the received powers associated with different users will be different if their gains are different. Ex. Laptop wireless LAN cards, mobile terminals and base station.

III. MULTIPLE ACCESS

Multiple access techniques divides up the total signaling dimensions into channels and then assign these channels to different users. The most common methods to divide up these signal space are along time, frequency and code axes. The different user channels are then created by orthogonal and non orthogonal division along these axes. FDMA and TDMA are orthogonal where as CDMA is non orthogonal.

A] FREQUENCY DIVISION MULTIPLE ACCESS (FDMA)

In FDMA system the signaling dimensions are divided along frequency axis into non overlapping channels and each user is assigned a different frequency channel as shown in figure 2.

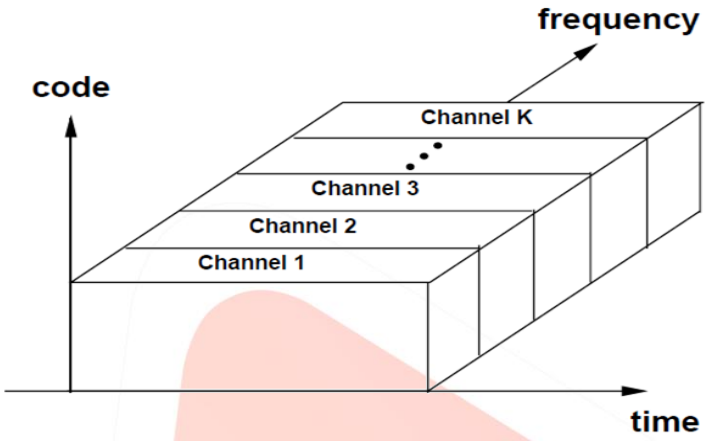

Fig.2 Frequency division multiple access

Commission to a given cellular network into frequency bands or channels and each pair of users was assigned a pair of simplex channels in each cell with narrowband frequency modulation used for communication. This resulted in a hard limit to the system capacity (maximum number of users the system can support simultaneously). A device within each mobile radio, called a duplexer or diplexer, enabled the same antenna to be used for both transmission and reception (Different frequencies for forward and reverse channels). This is the basis of Frequency Division Multiple Access or FDMA.
An FDMA channel carries only one phone call at a time. During the period of the call, no other user can use the same channel. An important aspect of FDMA is that when a frequency channel is not in use, it sits idle and cannot be used by others to share until another user places a demand for its use.
Once a voice channel is assigned, the base station and mobile user transmit simultaneously and continuously even when no one is talking! The complexity of an FDMA system is far less than that of a TDMA system, although this is becoming less relevant as digital signal processing methods improve. FDMA systems require duplexers and tight RF filtering to minimize adjacent channel interference [1-2].

B] TIME DIVISION MULTIPLE ACCESS (TDMA)

In TDMA the system dimensions are divided along time axis into nonoverlapng channels and each user is assigned a different time slot as shown in figure. A multiplexer allocates a frequency channel to a given user for a brief time slot and then offers the channel to another user for the next time slot etc. Time division multiple access allows multiple users to operate in both the forward and reverse directions using the same frequency channel, thus eliminating the necessity of a frequency duplexer. Careful synchronization is required by the system to ensure that the correct information is routed from the intended transmitter to the intended receiver. TDMA channels therefore have a guard bands between them to compensate for synchronization errors and multipath. The transmission from various users is interlaced into a repeating structure called a frame.

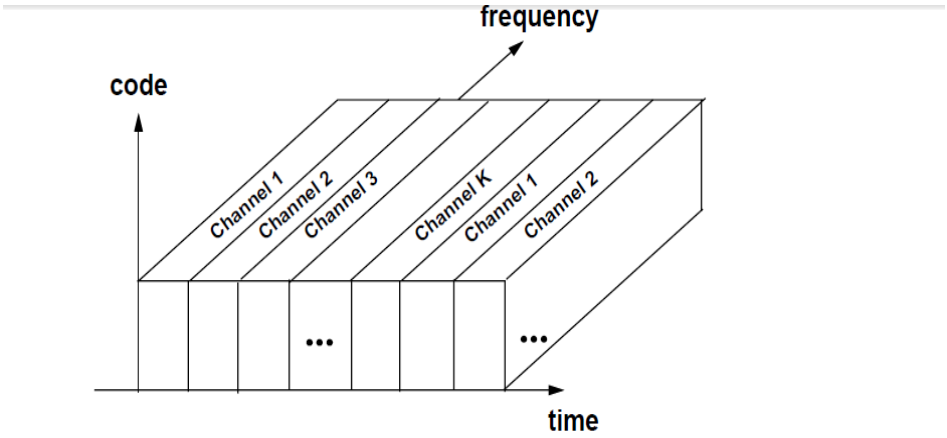

Fig. 3 Time division multiple access (TDMA)

Another difficulty of TDMA is that with cyclically repeating time slots, the channel characteristics change on each cycle. Thus the receiver functions must have to re-estimate the channel on each cycle.
TDMA shares a single carrier frequency with several users where each user makes use of nonoverlapping time slots. Data transmission in TDMA is not continuous, but occurs in bursts. This results in low battery consumption since the transmitter and receiver can be turned off when not in use (which is most of the time). Adaptive equalization is usually necessary in TDMA systems since the transmission rates at generally very high compared to FDMA systems.
High synchronization overhead is required in TDMA system because the burst transmissions. TDMA transmission is slotted in time, and this requires the receivers be synchronized for each data burst [2].

C] CODE DIVISION MULTIPLE ACCESS (CDMA)

In CDMA systems, the narrowband message signal is multiplied by a very large bandwidth spreading signal composed of a pseudorandom sequence of +/- 1's. The chip rate is orders of magnitude greater than the data rate. All users in a CDMA system use the same carrier frequency and may transmit simultaneously. Each user has a separate codeword which is orthogonal to all othercode words. All other codewords appear as noise. Multiplication by the correct codeword despreads the CDMA signal. In CDMA information signal of different users are modulated by orthogonal and non orthogonal spreading codes. The resulting spreading signals simultaneously occupy the same time and bandwidth as shown in figure 4.

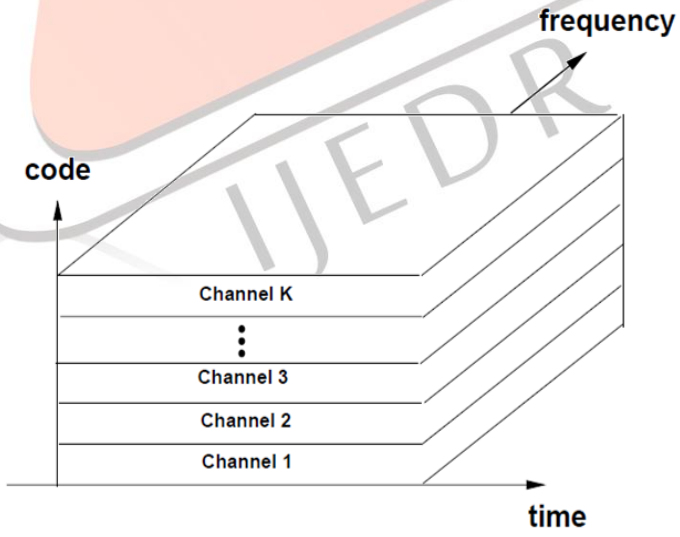

Fig.4 Code division multiple access

The receiver uses the spreading code structure to separate out different users.
Downlink typically use orthogonal spreading codes such as Walsh-Hadamard codes, but there is a problem that orthogonality degrades by multipath. Uplinks generally use non-orthogonal codes due to difficulty of user synchronization.
However because non-orthogonal codes cause mutual interference between users, so that more the users, higher the level of interference. Due to this performance of all users degrades. A non-orthogonal CDMA system also requires power control in the uplink to compensate near far problem.
The near far effect arises in the uplink because the channel gain between the user's transmitter and the receiver is different for different users. Suppose that one user is very close

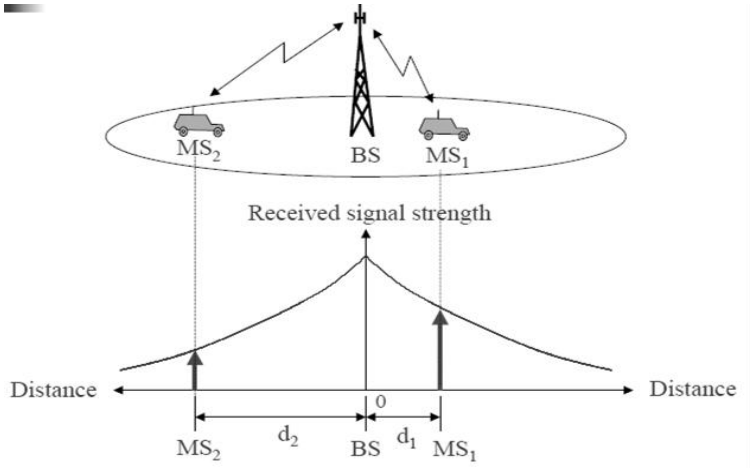

Fig.5 Near-Far problem

to base station and another is far away as shown in figure 5. If both the users transmit at the same power level, then interference from the close will inundate the signal from the far user.

So the power control is used to maintain roughly same power level if all received signals. Thus power control eliminates near far effect by distributing equal amount of power.

CDMA also refers to digital cellular telephony systems that make use of this multiple access scheme, such as those pioneered by QUALCOMM, and W-CDMA by the International Telecommunication Union or ITU. CDMA has been used in many communications and navigation systems, including the Global Positioning System and in the OmniTRACS satellite system for transportation logistics [3-6]

IV. CONCLUSION

As per above study and overview of multiple access system, it shows that each system have some latencies over other. There are also some remedies to overcome some difficulties and some which degrades the performance. As FDMA can be used with both analog and digital signal but requires high-performing filters in the radio hardware, in contrast to TDMA and CDMA. Due to the frequency filtering, FDMA is not sensitive to near-far problem which is pronounced for CDMA. In FDMA it is impossible for receiver to receive the data from more than one station at a single point of time. In TDMA the dead time between time slots can limit the potential bandwidth of channel. Also TDMA can be affected from the noise impairment , which is an additional signal inserted between the sender and the receiver. In Code Division Multiple Access (CDMA) systems all users transmit in the same bandwidth simultaneously, but affect from near-far effect and it can be controlled by power control. One important advantage of CDMA is privacy due to unknown random codes.

V. REFERENCES

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