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Determination of number of channels in multiple access techniques for wireless communications

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ABSTRACT

In wireless communications system, it is desirable to allow the subscriber to send simultaneously information to the base station while receiving information from base station. Multiple access techniques are used to allow many mobile users to share simultaneously a finite amount of radio spectrum. Frequency division multiple access (FDMA), time division multiple access(TDMA), and code division multiple access (CDMA) are the three major access techniques used to share the available bandwidth in a wireless communication system. In this paper we calculated the number of channels required for FDMA & TDMA techniques depending on various factors such as spectrum, channel band width etc.

Key words: TDMA, FDMA, CDMA, Channel, Spectrum.

1. INTRODUCTION

In narrow band FDMA, a user is assigned to a particular channel which is not shared by other users. Narrow band TDMA allows users to share the same radio channel but allocates a unique time slot to each user in a cyclical fashion on the same channel. In wideband multiple access systems a large number of transmitters are allowed to transmit on the same channel.TDMA allocates time slots to many transmitters on the same channel and allows only one transmitter to access the channel at any instant of time.CDMA allows all of the transmitters to access the channel at the same time [1-4].

2. FREQUENCY DIVISION MULTIPLE ACCESSES (FDMA)

FDMA assigns individual channels to individual users; each user is allocated a unique frequency band or channel. These channels are assigned on demand to users who request service. During the period of call no other user can share the same channel. Once the call established the base station and the mobile station transmit data continuously. FDMA is usually implemented in narrow band systems. The symbol time of narrow band signal is large as compared to the delay spread. This shows the inter symbol interference is low. FDMA requires fewer bits are needed for overhead purposes. It requires RF filtering to minimize adjacent channel interference. Frequency Division Multiple Access or FDMA is a channel access method used in multiple-access protocols as a channelization protocol. FDMA gives users an individual allocation of one or several frequency bands, or channels. It is particularly commonplace in satellite communication. FDMA, like other Multiple Access systems, coordinates access between multiple users (Fig.1).

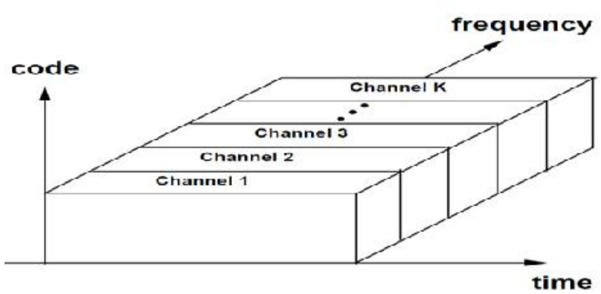

Figure 1

Frequency division Multiplexing

In FDMA all users share the satellite simultaneously but each user transmits at single frequency .FDMA can be used with both analog and digital signal. FDMA requires high-performing filters in the radio hardware, in contrast to TDMA and CDMA.FDMA is not vulnerable to the timing problems that TDMA has. Since a predetermined frequency band is available for the entire period of communication, stream data (a continuous flow of data that may not be packetized) can easily be used with FDMA .Due to the frequency filtering, FDMA is not sensitive to near-far problem which is pronounced for CDMA. Each user transmits and receives at different frequencies as each user gets a unique frequency slot

FDMA is distinct from frequency division duplexing (FDD). While FDMA allows multiple users simultaneous access to a transmission system, FDD refers to how the radio channel is shared between the uplink and downlink (for instance, the traffic going back and forth between a mobile-phone and a mobile phone base station). Frequency-division multiplexing (FDM) is also distinct from FDMA. FDM is a physical layer technique that combines and transmits low-bandwidth channels through a high-bandwidth channel. FDMA, on the other hand, is an access method in the data link layer. FDMA also supports demand assignment in addition to fixed assignment. *Demand assignment* allows all users apparently continuous access of the radio spectrum by assigning carrier frequencies on a temporary basis using a statistical assignment process.

The number of channels that can support in a FDMA system is calculated as

$$N=\frac{B_t - 2B_{guard}}{B_c}$$

B_t = total spectrum allocation

$2B_{guard}$ =guard band allocated at the edge of the spectrum band

B_c = channel bandwidth

3. TIME DIVISION MULTIPLE ACCESS (TDMA)

In TDMA systems the radio spectrum is divide into time slots and each slot only one user is allowed to either transmit or receive. The data transmitted in TDMA systems by using buffer-and-burst method in the form of frames. Each frame consists of a preamble, an information message, and tail bits. The preamble contains the address and synchronization information of both the base station and subscriber's information. It uses different time slots for transmission and reception (Fig.2).

In TDMA the system dimensions are divided along the time axis into non overlapping channels, and each user is assigned a different cyclically-repeating timeslot. These TDMA channels occupy the entire system bandwidth, which is typically wideband, so some form of ISI mitigation is required. The cyclically repeating timeslots imply that transmission is not continuous for any user. Therefore, digital transmission techniques which allow for buffering are required. The fact that transmission is not continuous simplifies overhead functions such as channel estimation, since these functions can be done during the timeslots occupied by other users. TDMA also has the advantage that it is simple to assign multiple channels to a single user by simply assigning him multiple timeslots.

TDMA is used in the digital 2G cellular systems such as Global System for Mobile Communications (GSM), IS-136, Personal Digital Cellular (PDC) and iDEN, and in the Digital Enhanced Cordless Telecommunications (DECT) standard for portable phones. It is also used extensively in satellite systems, combat-net radio systems, and PON networks for upstream traffic from premises to the operator for usage of Dynamic TDMA packet mode communication.

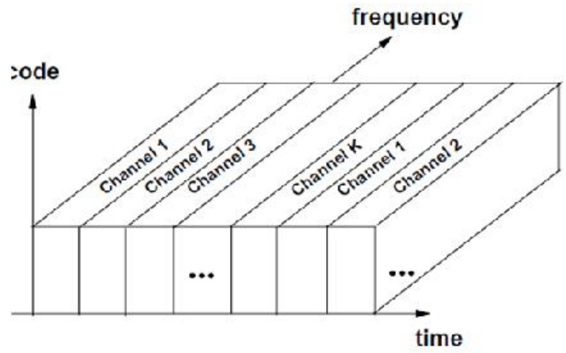

Figure 2
Time division Multiplexing

3.1. TDMA characteristics

- Shares single carrier frequency with multiple users
- Non-continuous transmission makes handoff simpler
- Slots can be assigned on demand in dynamic TDMA
- Less stringent power control than CDMA due to reduced intra cell interference
- Higher synchronization overhead than CDMA
- Advanced equalization may be necessary for high data rates if the channel is "frequency selective" and creates Intersymbol interference
- Cell breathing (borrowing resources from adjacent cells) is more complicated than in CDMA
- Frequency/slot allocation complexity
- Pulsating power envelope: Interference with other devices

The number of channels that can support in a TDMA system is calculated as

$$N = \frac{m\,(B_t - 2B_{guard})}{B_c}$$

B_t =total spectrum allocation
$2B_{guard}$ =guard band allocated at the edge of the spectrum band
B_c = channel bandwidth

4. COMPARISON WITH OTHER MULTIPLE-ACCESS SCHEMES

In radio systems, TDMA is usually used alongside Frequency-division multiple access (FDMA) and Frequency division duplex (FDD); the combination is referred to as FDMA/TDMA/FDD. This is the case in both GSM and IS-136 for example. Exceptions to this include the DECT and PHS micro-cellular systems, UMTS-TDD UMTS variant, and China's TD-SCDMA, which use Time Division duplexing, where different time slots are allocated for the base station and handsets on the same frequency.

A major advantage of TDMA is that the radio part of the mobile only needs to listen and broadcast for its own time slot. For the rest of the time, the mobile can carry out measurements on the network, detecting surrounding transmitters on different frequencies. This allows safe inter frequency handovers, something which is difficult in CDMA systems, not supported at all in IS-95 and supported through complex system additions in Universal Mobile Telecommunications System (UMTS). This in turn allows for co-existence of microcell layers with macrocell layers (Fig.3).

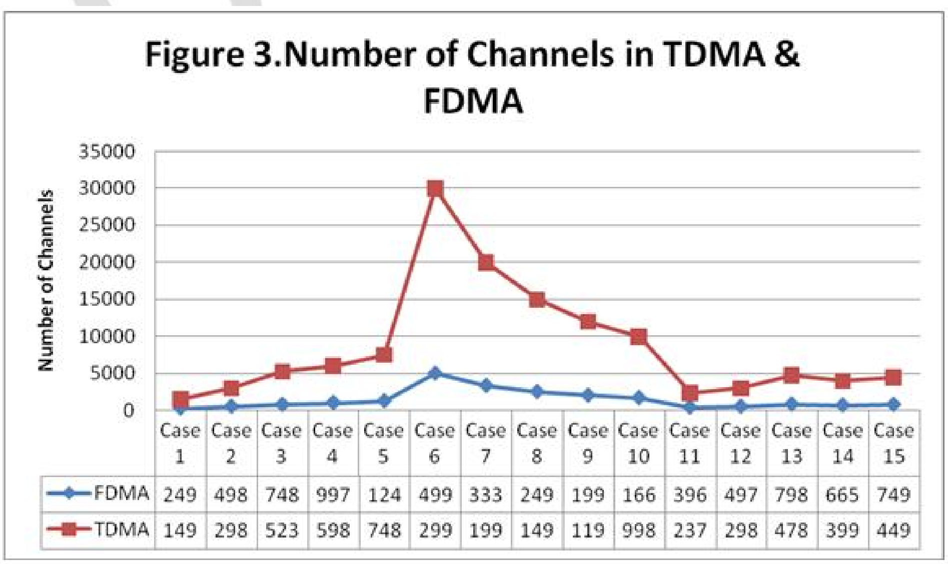

Figure 3
Number of channels in TDMA & FDMA

CDMA, by comparison, supports "soft hand-off" which allows a mobile phone to be in communication with up to 6 base stations simultaneously, a type of "same-frequency handover". The incoming packets are compared for quality, and the best one is selected. CDMA's "cell breathing" characteristic, where a terminal on the boundary of two congested cells will be unable to receive a clear signal, can often negate this advantage during peak periods.

A disadvantage of TDMA systems is that they create interference at a frequency which is directly connected to the time slot length. This is the buzz which can sometimes be heard if a TDMA phone is left next to a radio or speakers. Another disadvantage is that the "dead time" between time slots limits the potential bandwidth of a TDMA channel. These are implemented in part because of the difficulty in ensuring that different terminals transmit at exactly the times required. Handsets that are moving will need to constantly adjust their timings to ensure their transmission is received at precisely the right time, because as they move further from the base station, their signal will take longer to arrive. This also means that the major TDMA systems have hard limits on cell sizes in terms of range, though in practice the power levels required to receive and transmit over distances greater than the supported range would be mostly impractical anyway.

FREQUENCY DIVISION MULTIPLE ACCESS, N = (Bt-2Bguard)/Bc				
	Bt	Bc	B guard	N
Case-1	5 MHZ	20 KHZ	10 KHZ	249
Case-2	10 MHZ	20KHZ	15 KHZ	498
Case-3	15MHZ	20KHZ	20 KHZ	748
Case-4	20 MHZ	20KHZ	25 KHZ	997
Case-5	25 MHZ	20KHZ	30 KHZ	1247
Case-6	50 MHZ	10 KHZ	20 KHZ	4996
Case-7	50 MHZ	15 KHZ	25 KHZ	3330
Case-8	50 MHZ	20 KHZ	30 KHZ	2497
Case-9	50 MHZ	25 KHZ	35 KHZ	1997
Case-10	50 MHZ	30 KHZ	40 KHZ	1664
Case-11	2 MHZ	5 KHZ	10 KHZ	396
Case-12	4 MHZ	8 KHZ	10 KHZ	497
Case-13	8 MHZ	10 KHZ	10 KHZ	798
Case-14	10 MHZ	15 KHZ	10 KHZ	665
Case-15	15 MHZ	20 KHZ	10 KHZ	749

TIME DIVISION MULTIPLE ACCESS, N = m (Bt-2Bguard)/Bc					
	m	Bt	Bc	B guard	N
Case-1	6	5 MHZ	20 KHZ	10 KHZ	1497
Case-2	6	10 MHZ	20KHZ	15 KHZ	2988
Case-3	6	15MHZ	20KHZ	20 KHZ	5236
Case-4	6	20 MHZ	20KHZ	25 KHZ	5985
Case-5	6	25 MHZ	20KHZ	30 KHZ	7482
Case-6	6	50 MHZ	10 KHZ	20 KHZ	29976
Case-7	6	50 MHZ	15 KHZ	25 KHZ	19980
Case-8	6	50 MHZ	20 KHZ	30 KHZ	14982
Case-9	6	50 MHZ	25 KHZ	35 KHZ	11982
Case-10	6	50 MHZ	30 KHZ	40 KHZ	9984
Case-11	6	2 MHZ	5 KHZ	10 KHZ	2376
Case-12	6	4 MHZ	8 KHZ	10 KHZ	2985
Case-13	6	8 MHZ	10 KHZ	10 KHZ	4788
Case-14	6	10 MHZ	15 KHZ	10 KHZ	3991
Case-15	6	15 MHZ	20 KHZ	10 KHZ	4494

5. CONCLUSION

- In frequency division multiple access by keeping the channel band width as constant, the number of channel in the technique are increased.
- FDMA by keeping the total spectrum allocation as constant and by varying channel band width, guard band allocated at the edges of the spectrum band then the number of channels in the method are decreasing.
- In FDMA by keeping the guard band allocated at the edge of the spectrum band is kept constant and by varying channel band width and total spectrum allocation the number of channels are increasing linearly.
- In time division multiple access technique by keeping speech channels and channel band with are kept constant, and by varying guard band allocation, total spectrum allocation the number of channels are increased.
- In time division multiple access technique by keeping speech channels and total spectrum allocation as kept constant, by varying channel band width, guard band allocated at the edge of the spectrum band the number of channels are decreased.
- In TDMA keeping speech channels and guard band as constant, by varying spectrum allocation and channel band with the number of channels are increased rapidly.

REFERENCES

1. Wireless Communications- S Theodore Rappaport
2. Wireless Sensor networks- Anantharamaswamy, Qing Zhao, Yao-winhong, Lang tom
3. Wireless Sensor networks- Ion F. Akyildiz & Mehmetcanvuran
4. Wireless Network Security – Y.Xiao, X.Chen.

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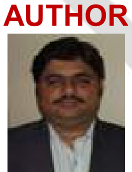

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