REVIEW ON MULTIPLE ACCESS TECHNIQUES USED IN MOBILE TELECOMMUNICATION GENERATIONS

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ABSTRACT - *This review paper presents the analysis of mobile telecommunication generations and the different multiple access techniques used in them. The multiple access is a technique used by telecommunication networks to accommodate more users over the single channel. And in these channels, the data is in packet form. As the telecommunication systems evolved i.e. 1G, 2G, 3G, 4G, so did the access techniques used in them. The multiple access techniques (circuit-switching) are mainly of 4 types i.e. FDMA (Frequency Division Multiple Access), TDMA (Time Division Multiple Access), CDMA (Code Division Multiple Access), SDMA (Space Division Multiple Access). And the packet switching used in these circuits are collision-recovery (ALOHA, Slotted ALOHA, etc.), collision-avoidance (CSMA/CD, CSMA/CA, etc.), collision-free (token bus, token ring).*

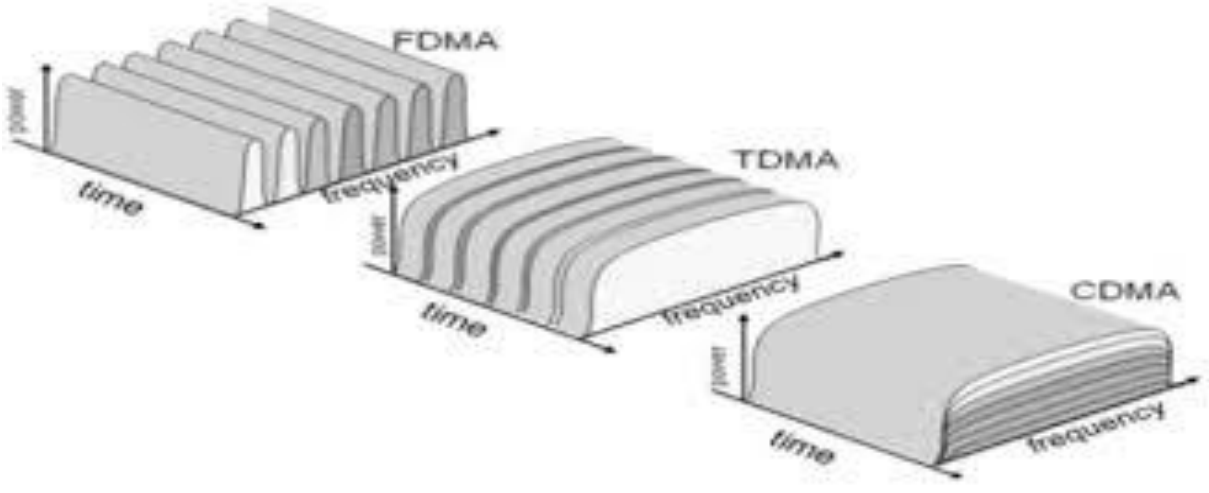
INTRODUCTION

In computer networks and in telecommunication technique, the concept of multiple access is commonly encountered. Basically, multiple access is the technique where a single channel is accessed by multiple users. This is an important technique in telecommunication methodology for effective use of bandwidth between several users. The basic question encountered in the concept of multiple access is the factual difference between multiplexing and multiple access. Multiplexing is the technique which differentiates between how the signals are going to be shared in the common channel or bandwidth but on the other hand, multiple access is the technique which defines which signals are to be used while the bandwidth or the channel is shared. In other words, multiplexing notifies how the channel is to be split while multiple access is the technique which depicts which signal needs to be used while the channel or bandwidth is shared. A channel or bandwidth here is defined as the physical or wireless medium through which multiple users are connected to each other. This channel is used for transfer of data between different users and is used to establish a connection between different users. It can also be defined as the system resource allocated for the transfer of data or to establish a connection between the users and the network. Each channel can only support the transfer of data from a single user to the network or vice versa one at a time. Thus, for different users to send or transfer data to the network on a limited bandwidth or in a channel with a limited amount of space simultaneously, multiple access technique is used.

Mobile telecommunication generation specifies the generation of wireless-communication between two users. This communication can be analog or digital, voice or data, audio or video, etc. In wireless communication systems, many users are made to transfer different data/signal to the base station. Each base station covers an area where multiple users which are connected to the network are made to exchange or transfer data to the allocated base station. The base stations are installed to increase the capacity of the channel width and to accommodate an increasing number of users.

BACKGROUND CONCEPTS

1. Multiple Access Techniques



A) **Frequency Division Multiple Access**(FDMA): This Channel access scheme is based on Frequency Division Multiplexing where different frequency bands are allocated different bandwidths on the same channel. In Frequency division multiple access (FDMA), these bandwidths are allocated to different users or nodes or devices connected to the network on the common channel.

In this technique, for every phone call, each and every phone call was assigned a specific uplink frequency and a different downlink frequency. The message signal was modulated on a specific carrier frequency. A similar technique used in fiber optic communication was the WDMA (Wavelength Division Multiple Access). In this technique, wavelength division multiplexing was incorporated, where data streams were represented with different colors.

An advanced version of FDMA used in the implementation of 4G is OFDMA. Orthogonal Frequency Division Multiple Access encodes digital data on multiple carrier frequencies. It has been developed for wideband digital communication. The basic principle underlying in this technique is the division of high rate data stream into parallel low rate data streams using FFT (Fast Fourier Transformation). The limitations of this technique are that all subcarrier signals are needed to be orthogonal to each other and accurate synchronization of frequency between the transmitter and the receiver is required.

One more technique that is used in the implementation of Single-Carrier FDMA (SC-FDMA). Basically, in this method, single carrier modulation is implemented and the overall structure used in this method is same as that used in OFDMA. Like every method in multiple access technique, this method also segregates the bandwidth/channel among different users. The only difference and an advantage of this technique over OFDMA is that it has a lower Peak to Average Power ratio.

B) **Time Division Multiple Access**: In this technique, a channel of limited space is divided into different time slots. These time slots are allocated to different users connected to the network. This technique is based on the time division multiplexing scheme. For example, if node1 is allotted slot1, node 2 would be allotted time slot 2, the same continues with successive nodes until the last transmitter. Then the allotment starts all over again, in a repetitive manner, until the connection has ended and that slot becomes vacant or is allocated to different device or node.

Another form of TDMA known as Dynamic TDMA (DTDMA) is the advanced version of this technique, where different slots may be given to different slots in the network depending on the vacancy of time slots.

Statistical Time Division Multiplexing is also another form of Time Division Multiplexing. In this technique dynamic bandwidth allocation takes place. The Media Access Control (MAC) is required. Common examples of this technique are CSMA/CD & CSMA/CA. the former is used in Ethernet bus and hub networks, while the later is used in wireless networks.

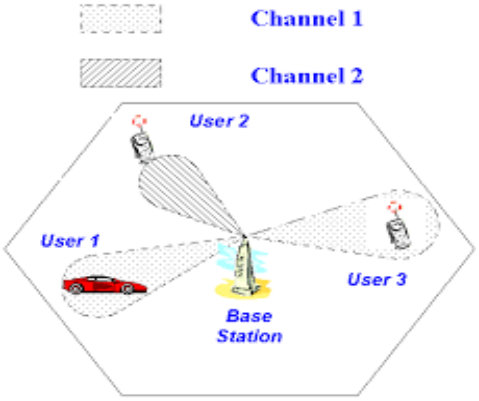
C) **Code Division Multiple Access**: This technique is based on spread spectrum, which means that a wider radio spectrum compared to a data rate of each transferred bit streams is used. Several message signals are transferred over the same channel utilizing different spreading codes are used. The wide band is used to send the data on a carrier signal with a poor signal to noise ratio of much less than 1 dB. In other words, the transmission power can be reduced to a level below the level of noise and co-channel interference from message signals sharing the same frequency.

Their different methods which implement CDMA technique:

In MC-CDMA, each user symbol is spread in the frequency domain.in other words, each symbol is transferred over multiple parallel subcarriers but is phase shifter depending on the code value. These code values differ depending on the subcarrier and user. In the receiver section, by weighing these to compensate varying signals strength and undo the code shift. The receiver can also separate signals from different code values present in different signals sent by different users. In Direct Sequence Spread Spectrum (DS-CDMA), each information symbol is represented by a long sequence of codes of several pulses called chips. The spreading code is the sequence and the information symbol uses a different spreading code.

Another form of CDMA is the frequency hopping CDMA (FH-CDMA), where the transmitting radio signals are done by rapidly switching carriers among many frequency channels. This is done by using Pseudorandom sequence known to both transmitter and receiver. It is a wireless technology and "hop" is referred to the carrier switching.

D)Space Division Multiple Access (SDMA):



In this technique smart antenna technology and difference in spatial location of mobile units within the cell are used. In traditional mobile cellular network systems, the base station does not have information on the location of the mobile units within the cell and hence it radiates the signal in all directions within the cell so as to give radio coverage as a result of which there is wastage of power on transmissions when there are no mobile units to reach and also causing interference to adjacent cells (co-channel cells) using the same frequency.

In SDMA the base station is aware of the distance (but not direction) of a mobile phone by use of a technique called "timing advance" (TA). The base transceiver station (BTS) can determine how far the mobile station (MS) is by interpreting the reported TA. This information, along with other parameters, can then be used to power down the BTS or MS, if a power control feature is implemented in the network, hence ensuring a better battery life for MS and also less exposure to electromagnetic radiation for the user. HC-SDMA (High Capacity SDMA) is a type of SDMA but is not currently in use.

2.Packet Switching Methods

A) Carrier Sense Multiple Access / Collision Detection (CSMA/CD): In carrier sense multiple access techniques, the station sharing a bandwidth continuously sense the channel. This is done to identify whether the channel is idle or in use by different stations. These stations follow this protocol to avoid a collision and to increase the efficiency of the system network in use. In CSMA/CD, the stations sense the channel to detect any collision between packets sent by different stations at the same time. The stations following this protocol adapt a procedure as they transmit frames of data. First, the station checks whether the frame is ready for transmission, if positive, it proceeds further to check whether the channel is idle or not. If no, it waits for a particular period of time. If yes, the station starts transmitting the frame. As it transmits its frame, it monitors the channel for any collision. If the collision occurs the station follows one of the following procedure

(i) Send a jamming signal to block off all other transmitting signal and continue its transmission.
(ii) Increment its retransmission counter.
(iii) Check for the maximum number of attempts, if current attempt exceeds the maximum attempts, abort transmission.
(iv) Calculate and wait for a random time known as the back-off time which is calculated based on the number of collisions.
(v) Re-enter main procedure at first stage.

After taking a particular course of action, the transmission counter, in the end, is reset along with end frame transmission.

B) Carrier Sense Multiple Access / Collision Avoidance (CSMA/CA): In Carrier sense multiple access collision avoidance, the station nodes, continuously sense the channel to avoid collisions between different frames. Like CSMA CD, the transmission of data frames only takes place only when the channel used or shared is idle. The stations follow a procedure during transmission. First, the station checks whether its frame is ready for transmission. Second, the station senses the channel whether its idle or not. If not, the station calculates a random back-off time. After waiting for a random back-off time, the station again senses whether the channel is idle or not. If not, again it waits for a random back-off time and this process continues until the channel is idle. When the channel is sensed to be idle, the station starts sending its data frame. As it sends its frame, the station continuously checks the channel for collision. If a collision is detected, the station calculates a random back-off time and waits till the channel is idle again. If no collision is detected, the transmission counter along with end transmission counter is reset.

C) Aloha: It is also known as ALOHAnet was developed at the University of Hawaii. This technique used UHF and a new type of medium access for its operation. Basically, under ALOHAnet there are two types:

(i) Pure Aloha: In this technique, the message frame is sent directly if ready and the collision is detected when the receiver obtains a different message packet or frame from the different station. The stations using this protocol does not check whether the channel is idle or not. When the collision is detected, the station resends the message frame, this leads to wastage of resources. Thus the protocol does not use its 100 percent capacity.

The throughput of the protocol is given by

$S_{pure} = G*e^{-2G}$

And the vulnerable time where the collision might take place is given by

$V_t = 2*T$

The throughput calculated in pure ALOHA mostly goes up to 18.4%

(ii) Slotted Aloha: Slotted ALOHA was invented as an improvement to pure aloha. This technique introduced the concept of timeslots(discrete) which increased the throughput of the network system. In this network, each station is allotted a particular time slot. In each time slot allocated to a particular station, data had to be transmitted by that station only. But it was observed that in different time slots, stations whose transmission time is different, transmitted their message frame during the session for transmission of the second consecutive frame. This leads to collisions in turn decreasing the throughput of the system.

The throughput of the system is given by:

$S_{slotted} = G*e^{-G}$

The throughput calculated in pure ALOHA mostly goes up to 36.8%

D)Token Ring: The token bus is a network adapts a token ring concept making a virtual ring on a coaxial cable. A token is circulated between nodes in a network. This is done to prevent collision between different message. The station possessing the token is allowed to transmit data. The station is made to wait till it receives the token for transmission of data. The wait time depends on the position of the station in the virtual ring. Since, a ring structure needs to be implemented in this system network, failure of any device leads to failure of the whole network. In addition, if any device or station needs to be added to the network, difficulties were faced. Thus, this technique is deemed to be unreliable due to the above difficulties.

3.Mobile Telecommunication Generations

A) 1G generation is the first generation of wireless cellular technology. 1G was introduced in the 1980s and was functional until it was replaced by 2G. The radio signals used by 1G network are analog. 1G provides voice only communication meaning only voice signals could be sent. It provides speed up to 2.4Kbps. The multiple access technique used in 1G is Frequency Division Multiple Access (FDMA). This generation uses circuit switching method for data transmission. It was used in mobile technology.

B) 2G is also called second-generation cellular technology. Second-generation 2G cellular networks were commercially launched on the GSM standard in Finland by Radiolina (now part of Elisa Oyj) in 1991. Three primary benefits of 2G networks over their predecessors were that:

- Conversation via phone were encrypted digitally.
- 2G spectrum is more efficient has greater penetration level for wireless communication.
- 2G initialized data service. Due to which facilities like SMS (Short Message Services) MMS (Multimedia Messages Services) were enabled.

Download and upload speeds in 2G technology were up to 236 Kbps. This generation uses circuit switching method for data transmission. 2G technologies enabled the networks to provide multi-media services like SMS, MMS. Because data transmission is digital over 2G so the data encryption was possible which caused only the intended receiver to read the message. Second generation cell phone technology uses time division multiple access (TDMA). As the no. of users increased over time TDMA became obsolete. Because TDMA caused lower speed for each individual user.

C) 3G is the third generation of wireless mobile telecommunications technology. It is the upgrade for 2G networks for faster internet speed. Third generation cell phone technology uses direct sequence code division multiple access (DS- CDMA). 3G networks can offer speeds of 3.1 megabits per second (Mbps) or more. 3G networks were first installed in 1998. 3G uses packet switching method for data transmission. The application of 3G concept is found in wireless telephony, mobile Internet access, wireless Internet access, conference calls and portable TV.

D) 4G wireless is the term used to describe the fourth-generation of wireless cellular service and is the current standard of cellular service. 4G is a big step up from 3G and is up to 10 times faster than 3G services. Sprint was the first carrier to offer 4G speeds in the U.S. beginning in 2009. 4G networks can offer download speeds between 5 and 12 Mbps and upload speeds between 2 and 5 Mbps, eventually giving a maximum speed of 50Mbps. Third generation cell phone technology uses code division multiple access (CDMA). 4G cellular communication system uses advance version of FDMA scheme i.e. OFDMA (Orthogonal Frequency Division Multiple Access). This generation uses packet switching method for data transmission. 4G speed is useful in areas without broadband connections.

CONCLUSION

In this review paper, we have observed the evolution of multiple access techniques in different generation. We have also observed different multiple access techniques and their under lying principles. Without the use of multiple access techniques, it has been observed that different types of difficulties would rise. Thus, each technique has its own under lying principle eliminating different disadvantages building up speed, accuracy, capacity and efficiency in different network communications.

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