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A Study on Telecommunication Network

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Abstract – The telephone system was originally designed to carry analog voice signals, the advent of computers and data communication has led to it being increasingly used to also carry computer data traffic. At the same time, telephone networks have evolved to take advantage of the digital technology made available by computers. Modern telecommunication networks are designed to carry information in a variety of forms (e.g., voice, data, video, fax). Telecommunication and data communication are fast converging.

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TELEPHONE NETWORKS

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The 1st generation (1G) systems that was 1st deployed in Norway in 1981, analog communications was governing, and the voice transmission was the only service that was supported. Although it was a breakthrough, the urge for improvement arose. There was a need to achieve a higher network capacity, higher speed and improved power efficiency while reducing the overall cost (Goldsmith 2005).

Therefore, second generation (2G) systems emerged satisfying the required needs. The most popular 2G technologies is known as Global Systems for Mobile Communications (GSM) which was developed in Europe. It uses Frequency Division Multiple Access (FDMA) to split the available frequency spectrum, and Time Division Multiple Access (TDMA) to divide each frequency carrier into eight time slots allowing eight simultaneous users to utilize the same frequency. Meanwhile, Code Division Multiple Access (CDMA) technology was developed in North America which uses spread spectrum and special coding techniques to allow users having uniquely assigned codes to be multiplexed over the same channel (V. Pereira 2004). 2G systems were able to handle low data rate services such as fax and Short Message Service (SMS). Even such capabilities weren't enough to catch up with the data intensive applications and with the rise of the internet. Therefore, the 2.5G systems added packet data capability to GSM networks by introducing General Packet Radio Service (GPRS) and Enhanced GPRS (EGPRS), thus enhancing the data capacity of GSM. This adds Internet Protocol (IP) support to the existing GSM network(V. Pereira 2004).

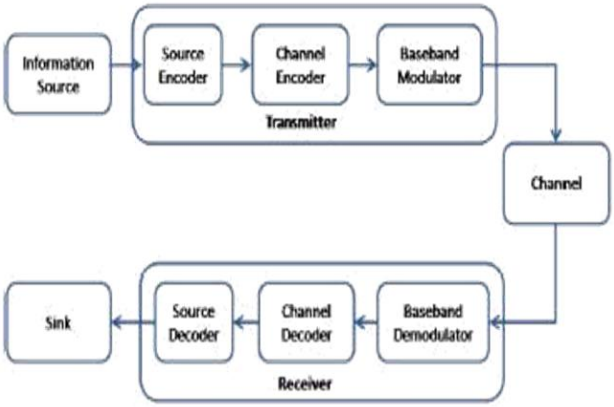
As mobile broadband internet access has become a necessity besides the bandwidth demanding wide spread multimedia applications, something was supposed to be done to support such needs. Therefore third generation systems (3G), known as Universal mobile telecommunications system (UMTS), which were the vision to reach International Mobile Telecommunications (IMT) 2000 standard, came into sight to comply with the high data rate requirements, and higher network capacity. UMTS uses the Wideband Code Division Multiple Access (W-CDMA) radio technology which is characterized by utilizing a wider band than CDMA. This was followed by High Speed Packet Access (HSPA) allowing data rates up to 20 Mega bit per second (Mbps) (E. Dahlman 2008).

With this high data rate provided, 3G seems to satisfy what users want. But is it enough? Of course not! The internet is unleashing more bandwidth intensive applications, shaping the way we communicate, providing a better user experience and influencing our everyday life. So, new technologies started emerging to reach IMT-Advanced specifications ranging from spectral efficiency to reduced latency, and cutting down overall system cost thus fulfilling the current demands. Long Term Evolution (LTE) is the first step into the fourth generation systems (4G) world providing data rate up to 300 Mbps. This technology had to replace the air interfaces used in previous technologies in order to meet IMT-Advanced objectives (Rumney 2008). As a result, the new radio access network used in LTE is now based on

Orthogonal Frequency Division Multiplexing (OFDM) air interface

DIGITAL COMMUNICATION SYSTEMS

A communication system in general consists of a transmitter, a channel, and a receiver as shown in the figure



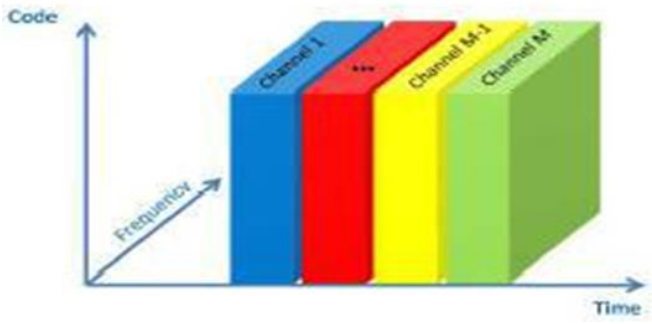
Shannon's Digital communication Model

Digital communication systems in particular are a subclass where the information to be sent is represented by bits. The information source produces the message to be sent; the transmitter encodes the message to signals and transmits it over the communication channel. The channel alters the transmitted signals by applying different types of distortions/imperfections. The receiver tries to decode the received distorted signals to recover the message that has been transmitted. Another challenge is to let different users communicate over the same channel medium. This issue can be tackled using the different multiple access schemes.

Multiple Access Schemes

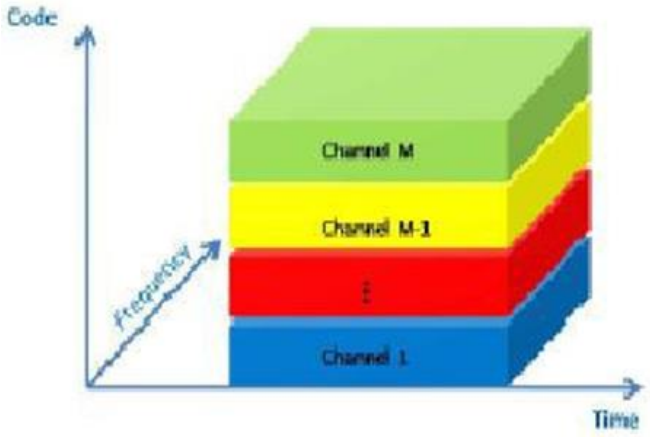
The main three multiple access schemes are: TDMA, CDMA, and FDMA. Below is a brief description of the characteristics of each.

TDMA



In TDMA, time is divided into slots, where each user occupies the whole frequency spectrum at a specific time slot. To do its job properly, it requires time synchronization. A major advantage of TDMA is that users can operate at multiple data ratesand this depends on how many time slots are assigned to each user. To decrease the interference between users, guard times are needed between the users' time slots.

CDMA

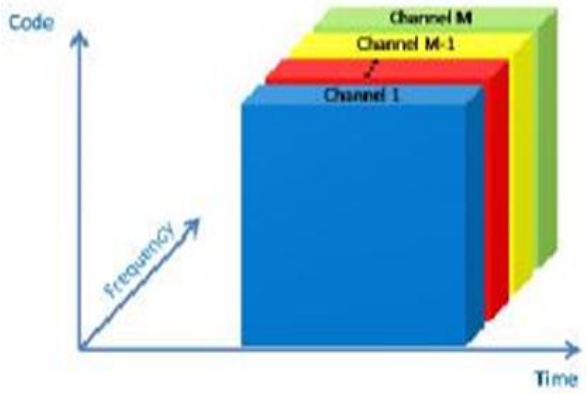


CDMA SYSTEM

In CDMA, users share the same channel in both time and frequency but they are differentiated from each other, by the unique code that is assigned to each user. So by assigning multiple codes to the same user, this will lead to increased data rates. Power control in the uplink is a necessity to control the possible interference between the different users.

FDMA

In FDMA, the total available system bandwidth is divided into orthogonal frequency channels, where users transmit at the same time but each using the assigned frequency channel. Guard bands are needed to reduce the interference between the different users.



DMA SYSTEM

Orthogonal FDMA (OFDMA) is a modified version of FDMA which makes use of overlapping carrier frequencies to transmit data on thus increasing the data rates achieved per user, this issue that was difficult to achieve in the classical FDMA. Since the subcarriers are overlapping with minimum frequency

separation, the spectral efficiency is very high compared to the conventional frequency division multiplexing(FDM) or FDMA where guard bands are required between the adjacent subcarriers.

Though it is highly spectral efficient, it still suffers from high peak-to-average power ratio (PAPR) which reduces the high power amplifiers (HPA) efficiency. The disadvantages are rectified by Single Carrier FDMA (SC-FDMA) which applies DFT-precoding to the conventional OFDMA systems.

Since these multiple access schemes involve multi-users, different subcarrier allocation schemes can be deployed. The possible allocation schemes are LFDMA where consecutive subcarriers are assigned to a user, B-IFDMA or B-EFDMA where inter-leaved blocks with a specific size are given to a user, and IFDMA where individual subcarriers with equidistant frequency spacing are allocated to a user. Each of these multiple access schemes offers a different trade-of between how much frequency diversity can be collected to take advantage of the fading channels, how much power amplifier efficiencies can be reached, and how much performances can be achieved with the absence of proper channel knowledge at the receiver.

CONCLUSION

The telecommunication industry has quickly leveled from offering local and long distance telephone services to providing many other comprehensive communication servicemen, including fax, pager cellular phone, internet messenger, images, e-mail, computer and web data transmission, and other data traffic. The integration of telecommunication computer network, internet and numerous other means of communication and computing is also under way moreover, with deregulation of the telecommunication industry in many countries and the development of new computer and communication technologies. the telecommunication market is rapidly expanding and highly competitive. This creates a great demand for data mining in order to help understand the business fraudulent activates, make better use of resources, and improve the quality of service.

Mobile telecommunication, web and information services, and mobile computing are becoming increasingly integrated and common in our work and life. One important feature of mobile telecommunication data is its association with spatiotemporal information. Spatiotemporal data mining may become essential for finding certain pattern. For example, usually busy mobile phone traffic at certain locations may indicate something abnormal happening in these locations.

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