An Overview of Various Technologies in Mobile Computing

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Abstract: The mobile networks need to increase high bandwidth and capacity for inaccessible areas. Wireless and mobile network have excellent growth in the last decay years. The mobile users need to access the data anywhere and anytime at the movement. The wireless and mobile generations has many improvements along with the fast data transmission. This transmission with the mobile generation many changes to the user interact with other person. The recent mobile network 4G to reach all the mobile users in the next few of months. After fourth generation network the 5G mobile generation technology has a lot of advantages compare with 4G at the next generation mobile users. This paper gives complete review of the recent and upcoming mobile generation.

Keywords: 3G, 4G, 5G, FDMA, TDMA, CDMA, OFDM(A)

I. INTRODUCTION

During last decay wireless and mobile communication has many changes. Nowadays have different wireless and mobile communication technologies which deployed in many countries. This development has experienced several generations such as 1G - 5G. Each generation have some standards, new and advanced features from the previous generations. In the busy world, the number of mobile phone subscriber is increasing by every day.

In early 1980s the analog or first generation (1G) mobile network was deployed based on the AMPS. The AMPS system was support circuit switching of frequency modulation radio accessing that is Frequency Division Multiple Accessing (FDMA) technique. Mainly the analog system had a bandwidth range between 10 to 30 KHz depending on the system type.

In 1990s second generation (2G) mobile network was deployed. It supports digital data in Time and Frequency Division Multiple Access (FDMA/TDMA). Third generation (3G) mobile network are very popular and it has many technology from 3GPP. Significant features of 3G systems are that support higher data transmission rates with high capacity for high-speed data applications as well as for voice calls. Sometime 3G called as GSM, UMTS, and CDMA technique. [1,2].

Nowadays the peoples are widely using this mobile network include variety of interfaces like GSM which based on the circuit and packet switching. All wireless and mobile networks implements with IP principle that is all data signal will be transferred via IP (Internet Protocol) on network layer. The 3GPP of WiMAX and mobile WiMAX network support Orthogonal Frequency Division Multiplexing (OFDM) technique. In 2015 the fourth generation (4G) wireless mobile multimedia network can be completely launched without limitation which makes wireless real World Wide Wireless Web (WWW). It supports WCDMA and LTE of 4G with Multiple-Input and Multiple-Output-OFDM (MIMO-OFDM) technique. [1,2].

The upcoming fifth generation (5G) based on 4G technology. It support by the Large Area Synchronized Code Division Multiple Access (LAS-CDMA), Multi-carrier Code Division Multiple Access (MCCDMA) and IPv6. Additionally it offers high data capabilities and high data broadcast. It will be release future around 2020. The following section we present the detail study about various mobile generations and analyzing multiple accessing technique. [1,2].

II. MOBILE GENERATIONS (1G-5G)

In this section to show the short evolution of wireless and mobile system based various key technologies.

A. First Generation (1G)

In 1970s the pre-cellular (0G) mobile telephone system was used. These system were usually mounted in cars or truck, through the briefcase models were made. 0G system included Push to Talk (PTT), MTS, IMTS, and AMTS. The
first generation (1G) cellular system was developed in 1980s. [3]. It has continuous signal varying some feature of the signal representation of time quantity, which is naturally analog radio signal with frequency 150 MHz. It introduced Mobile Telephone System (MTS) and Advanced Mobile Telephone System (AMTS). 1G is voice call modulation using Frequency Division Multiple Access (FDMA). It has low capacity unreliable handoff, poor voice call and no security in radio towers, making this call to dropping by other call. [1,3,4]

Table 1 to show various technologies in mobile generations.

<table>
<thead>
<tr>
<th>Mobile Generations</th>
<th>Family</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1G</td>
<td>AMPS</td>
<td>AMPS (TIA/EIA/ANSI/EIA-553 (IS-3) N-AMPS (TIA/EIA/IS-91)</td>
</tr>
<tr>
<td></td>
<td>other</td>
<td>Hicap, Mobitex, Data TAC.</td>
</tr>
<tr>
<td>2G</td>
<td>GSM/3GPP</td>
<td>GSM</td>
</tr>
<tr>
<td></td>
<td>3GPP2</td>
<td>cdmaOne (TIA/EIA/IS-95 AND ANSI)</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>iDEN, PDC</td>
</tr>
<tr>
<td>2.5G &amp; 2.75G</td>
<td>GSM/3GPP</td>
<td>GPRS/EDGE/EGPRS</td>
</tr>
<tr>
<td></td>
<td>3GPP2</td>
<td>CDMA2000 1X</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>WiDEN</td>
</tr>
<tr>
<td>3G (IMT-2000)</td>
<td>3GPP</td>
<td>UMTS, W-CDMA FDD, TD-SCDMA (TDD LCR), TD-CDMA (TDD HCR)</td>
</tr>
<tr>
<td></td>
<td>3GPP2</td>
<td>CDMA2000 1XEV-DO</td>
</tr>
<tr>
<td>3.5G, 3.75G, 3.9G</td>
<td>3GPP</td>
<td>HSPA, HSDPA, HSUPA, HSPA+, LTE</td>
</tr>
<tr>
<td></td>
<td>3GPP2</td>
<td>CDMA2000 1xEV-DO Revision A, EV-DO Revision B.</td>
</tr>
<tr>
<td></td>
<td>IEEE</td>
<td>Mobile WiMAX (IEEE 802.16e), Flash-OFDM.</td>
</tr>
<tr>
<td>4G</td>
<td>3GPP</td>
<td>LTE Advanced</td>
</tr>
<tr>
<td></td>
<td>IEEE</td>
<td>WiMAX (IEEE 802.16m)</td>
</tr>
</tbody>
</table>

B. Second Generation (2G)

In 1991 Second generation (2G) cellular system commercially launched on the GSM standard in Finland by Radiolinja now part of Elisa Oyj. Some time it called as GSM (Global System for Mobile Communication). It uses digital modulation to improve voice quality and offers limited data services. 2G technology is a security for both sender and the receiver. It provide data rate up to 10Kbps. All text messages are digitally encrypted. This encryption system to allow in sender and receiver only can read it. 2G support TDMA (Time Division Multiple Access) and CDMA (Code Division Multiple Access). idEN use a small spectrum efficiency and the number of channels for TDMA and GSM from 25 KH (TDMA) to 1.25 MHz (CDMA). [1,3,4]

C. Second and half Generation (2.5G)

2.5G is stands second and half generation of cellular wireless technology between 2G and 3G. It called as General Packet Radio Services (GPRS). GPRS is a radio technology for GSM network. It has packet switched protocol in circuit switched domain. It is an important technology towards 3G system. Because GPRS made possible for the user to make calls and to transmit data at same time. GPRS architecture provides both Circuit and Packet Switched data for voice and data traffic respectively. The Circuit Switched data goes to PSTN network and the Packet Switched data goes Internet Backbone Network. And it is a beginning work of EDGE and 3GPP for CDMA 2000. GPRS provide data rate from 56Kbps up to 115Kbps. It can be used for services such as Wireless Application Protocol (WAP) access, Multimedia Messaging Service (MMS), e-mail and WWW. [1,3,4].

D. EDGE (2.75G)

In 1999 2.75G was introduced with data rate of 384Kbps. Originally is called as EDGE (Enhanced Data rates for GSM Evolution). EDGE is radio technology and is a part of third generation. This technology is preferred over GSM due to flexibility to carry packet switch data and circuit switch data. The main difference between GSM and EDGE is data modulation which is based on 8-PSK encoding. In this encoding technique used by EDGE three times better than GSM network (i.e. Data rate up to 384Kbps). Enhanced GPRS (EGPRS) is the combination of EDGE and GPRS technique. EDGE and HSCSD is combined called as Enhanced Circuit Switched Data (ECSD), it provides data rate also three times higher than HSCSD. [3,5]

E. Third Generations (3G, 3.5G, 3.75G)

In 2000, the first commercial 3G technology was launched by NTT in Japan. 3G stands for Third Generation of mobile technology. Nowadays many of the people in this world using 3G network. Because the people finds many of the applications such as Mobile TV, Video Conference, MMS, clear voice calling, Global Positioning System (GPS) etc., 3G technologies as W-CDMA, GSM, UMTS, CDMA 2000,
WiMAX. The initial 3G is fast data transfer rates. That use TDMA and CDMA for the value added services like mobile television and video conferencing. 3GPP family in 3G having HSPA, HSUPA, HSDPA, HSPA+. [3,5]

**HSPA:** High Speed Packet Access has two protocols, that is HSDPA (High Speed Down-link Packet Access) and HSUPA (High Speed Up-link Packet Access). It improve performance of existing 3G mobile network in the WCDMA. [3,5]

**HSDPA/HSUPA:** It has higher data speeds and capacity. Recent in 2013 it deployed can support down-link speed up to 99.3Mbps. And it has following four technologies, HS-DSCH, H-ARQ, Fast Packet scheduling, Adaptive modulation and coding and Dual-Cell HSDPA.

After HSDPA refer to technology of HSUPA (High Speed Up-link Packet Access) with UMTS/WCDMA up-link evolution that was in 3.75G technology. It will enhance advanced person-to-person data application transmission for symmetric data rate, as like mobile e-mail and real time gaming. It initially is increasing WCDMA up-link to 1.4 - 5.8Mbps. [3,5]

**F. Fourth Generations (4G-LTE & WiMAX)**

Fourth Generation of mobile Communion started from 2008 by ITU-R. It provides mobile ultra-broadband internet access. 4G system supports mobile application include mobile web access, IP telephony, mobile on-line gaming services, high-definition mobile TV, video conferencing, 3D television and cloud computing. 4G system followed with 3G multimedia support has spread spectrum transmission minimum 200Kbps. It refers to all IP packet switched networks, mobile ultra-broadband with gigabit-speed access to multi-carrier transmission. In this multi-carrier transmission to achieve in OFDM. It basically high quality audio/video streaming over end-to-end Internet Protocol. There are two 4G systems commercially deployed. That is Mobile WiMAX and LTE standard. [1,3,6,15],

**LTE:** Stands Long Term Evolution of high speed for mobile and data network. It was first proposed by NTT DoCoMo of Japan in 2004 and this standard officially launched 2005. Generally LTE based on GSM/EDGE/UMTS/HSPA network technologies. The advanced features such as LTE-Advanced network to specify with the deployment of HSPA+ and WiMAX at 2011. The main goal of LTE to increase the capacity and speed of data network using Digital Signal Processing technique. LTE provide down-link peak rates 300Mbps and up-link peak rates 75Mbps at bandwidth 1.4 MHz - 20 MHz.

LTE has following features, [3, 5, 6,15]

- Packet switched radio interface.
- It supports Multicast-Broadcast Single Frequency Network.
- It serves Mobile TV using DVB-HD based TV.
- Support for all frequency bands.
- Support for both FDD and TDD communication system with same radio access technology.

**WiMAX:** It stands for Worldwide Interoperability for Microwave Access developed by IEEE 802.16 standards, It support point to multi-point system in LOS environment at 10-66GHz. In Non-LOS environment is support 2-11GHz band using OFDM. Some time it called as Wireless MAN (WMAN). It provides global effort to fixed and mobile WiMAX with 3G/4G and upcoming advanced feature of mobile wireless technology. The IEEE standards to given this technology has 802.16x (IEEE 802.16d support for fixed and IEEE 802.16e support for mobile WiMAX). [14].

**G. Fifth Generations (5G)**

Fifth Generation of mobile communication system does not yet deployed. But it may be introduce in the early like 2020. 5G has under the many research from the demand of 4G network. It changes to use in the mobile phone very high bandwidth. 5G technology use CDMA/W-CDMA and BDMA with millimeter wireless and that enable to greater than 100Mbps to 1Gbps data rates. [1,3]

The major difference between 4G and 5G is the maximum throughput, higher spectral efficiency, high data bit rate in large coverage area, support more applications. In 5G the data coding and modulation techniques, include filter bank multi-carrier or non-orthogonal multiple access schemes. So the transmission point equipped with very large number of antennas that simultaneously serve multiple users with MIMO multiple terminal. It can be transmitted to beam-forming gain while minimizing the data interference. [1,3,15]

- 5G network has following features, [1,3,6,15]
  - Improved data coding and modulation techniques.
  - Support Cloud computing network structure.
  - It has better coverage and high data rates at the edge of each cell.
  - It employing distributed antenna and Radio-over-Fiber technique.
  - It allows different radio technologies to share the same spectrum efficiently with multiple data path.
  - The spectrum sharing with high efficiency between device to device and LTE-A in 5G
  - It enable World Wide Wireless Web (WWW), wireless based web applications include multimedia capability beyond 4G speed.
  - Support high QoS from end to end between network elements.
  - 5G networks assigned IPv6 of all mobile IP address according to location and connected network.
  - It has Dynamic Adhoc Wireless Network (DAWN), MANET, WMN combined with smart antenna.

**III. MULTIPLE ACCESS TECHNIQUE**

Multiple access technique is used to allow many mobile users share radio resources to achieve high capacity, good quality by the radio channels. At the beginning of multiple access technique, the multiplexing deals with the division of radio resources to create multiple channels. It can create the channels in frequency, time division multiplexing. But the amount of spectrum is limited. So we need to increase allow multiple users to share the same available spectrum. It is an important technique in the communion system. The multiple access technique can be divided two part. [8,9].

They are,

1. **Reservation based (Channel based)**
   a) **FDMA (Frequency Division Multiple Access):**
This technique divides frequency resource and allot them to respective mobile station and to give multiple accessing.

b) **TDMA (Time Division Multiple Access):** This technique divides time resource and allot them to respective mobile station and to give multiple accessing.

c) **CDMA (Code division Multiple Access):** This technique allot orthoganal codes to respective mobile stations, which allows the mobile stations to give multiple accessing.

### TABLE II
**COMPARISON VARIOUS FEATURES IN MOBILE TECHNOLOGIES (1G-5G)** [1, 4, 6, 10]

<table>
<thead>
<tr>
<th>Features</th>
<th>1G</th>
<th>2G/2.75G/2.75G</th>
<th>3G/3.5G/3.75G</th>
<th>4G</th>
<th>5G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data bandwidth</td>
<td>~2Kbps</td>
<td>~10Kbps - 200Kbps</td>
<td>~384Kbps - 30Mbps</td>
<td>2Mbps - 1Gbps</td>
<td>More than 1Gbps</td>
</tr>
<tr>
<td>Frequency</td>
<td>800 - 900 MHz</td>
<td>850 - 1900 MHz</td>
<td>1.6 - 2.5 GHz</td>
<td>2 - 11 GHz (Fixed)</td>
<td>~16 GHz and higher</td>
</tr>
<tr>
<td>Technology</td>
<td>Analog</td>
<td>GSM/CDMA/GPRS/EDGE</td>
<td>WCDMA/UMTS/HSUPA/HSUPA/1xEVDO</td>
<td>LTE/WiMAX</td>
<td>WWWWW</td>
</tr>
<tr>
<td>Services</td>
<td>Voice</td>
<td>Digital Data</td>
<td>Broadband CDMA</td>
<td>Mobile Broadband</td>
<td>Mobile Broadband with WWWWW</td>
</tr>
<tr>
<td>Multiplexing/</td>
<td>FDMA</td>
<td>TDMA/CDMA</td>
<td>TDMA/CDMA</td>
<td>TDMA/WCDMA/MIMO/OFDM(A)</td>
<td>WCDMA/BDMA/OFDM(A)</td>
</tr>
<tr>
<td>Multiple Access</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>under the research</td>
</tr>
<tr>
<td>Switching</td>
<td>Circuit</td>
<td>Circuit (2G) and packet (2.5G)</td>
<td>Packet and circuit</td>
<td>All packet</td>
<td>All packet</td>
</tr>
</tbody>
</table>

If data traffic is continuous and a small transmission delay is required (for voice communication) this time reservation based multiple access is used. In reservation based multiple access technique the channel is assigned to nothing data transmit (the user is idle), while other users may have data waiting to be transmitted. This problem is critical when data generation is random and has a high peak-rate to average-rate ratio.

2. Random based (Packet based)
   a) ALOHA and Reservation ALOHA
   b) CSMA (Carrier Sense Multiple Access)

If the data arrives in a random manner, and the data length is large then random multiple access combined with reservation protocol will perform better than both random and reservation based schemes. In a channelization system the total spectrum is divided into a large number of narrow channels that are defined by carrier frequency. Each radio channel consists of a pair of frequencies. The following Figure 2 to show the variations of FDMA, TDMA and CDMA.[8,9].

![Fig. 2 Comparisons FDMA, TDMA and CDMA](image)

The frequency used for transmission from the base station to the mobile station is called the forward channel (down-link channel) and the frequency used for transmission from the mobile station to the base station is called the reverse channel (up-link channel). A user is assigned both frequencies for the duration of the call. The forward and reverse channel is assigned widely separated frequencies to keep the interference between transmission and receiving to the system. In this section to explain the detail in advance multiple access technique of OFDM (A) system. The following table to show multiple access scheme used in the wireless access technique.[8,9].

### TABLE III
**MULTIPLE ACCESS IN WIRELESS NETWORK**

<table>
<thead>
<tr>
<th>Wireless System</th>
<th>Access Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMPS (1G)</td>
<td>FDMA/FDD</td>
</tr>
<tr>
<td>Digital Cellular</td>
<td>TDMA/FDD or TDD</td>
</tr>
<tr>
<td>GPRS</td>
<td>FDMA/CDMA</td>
</tr>
<tr>
<td>EDGE</td>
<td>TDMA/TDD</td>
</tr>
<tr>
<td>W-CDMA system</td>
<td>CDMA/FDD or TDD</td>
</tr>
<tr>
<td>IEEE 802.11a/b</td>
<td>FDMA/CSMA or TDD</td>
</tr>
<tr>
<td>LTE/WiMAX</td>
<td>MIMO-OFDM(A)</td>
</tr>
<tr>
<td>5G (in research)</td>
<td>CDMA/BDMA</td>
</tr>
</tbody>
</table>

A. **OFDM(A) (Orthogonal Frequency division Multiplexing/Multiple Accessing) technique:**

OFDM is a technology used to compress a large amount...
of data into a small amount of bandwidth. This is done by dividing a large amount of data into smaller chunks, then sending that data simultaneously over a number of frequencies. The specific techniques OFDM uses allow a large amount of data to be transmitted quickly and reliably, with a minimum of loss or interference. Using OFDM, a data channel is subdivided into the smallest size bands of frequency that can carry a small bit of information without overlapping or interfering with each other. Data is then split up and transmitted over all the sub-channels simultaneously. Because the data is split over so many channels, and because the channels are spaced exactly far enough apart so as not to interfere with each other. The following Figure 3 to show the orthogonal sub-carrier of OFDM.[11].

OFDM is more accurate, and thus more efficient, than current cellular data standards. OFDM technology is used in certain variants of Wi-Fi (802.11a, 802.11n, MIMO), WiMax (802.16) and WiBro, ADSL, as well as number of digital broadcasting technologies such as DAB and DVB-T.

OFDM promises to play an important part in any 4G (fourth generation) cellular standards as well. The main advantages of OFDM are the signal that overcomes channel impairments.

The following Figure 4 to show the difference between OFDM and OFDMA.

![OFDM Sub-Carriers](image)

Fig. 3 OFDM Sub-Carriers.

OFDMA is multi-user version of OFDM digital modulation scheme. In OFDMA the Multiple Accessing is achieved subsets of sub-carriers to the individual users. The comparison of OFDM and OFDMA as shown given below, [12]

1. OFDM transmit a high-speed data stream by dividing it into multiple low-data-rate subcarriers.
2. It enables smooth upgrading from low-speed to high-speed transmission by simply augmenting the sub carrier and spectrum.
3. OFDM can support dynamic packet access and integrated with smart antenna.
4. OFDM sub-carriers do not interfere with each other. It can be used for high-speed multimedia applications with lower service cost.
5. MIMO system can be easily obtained with OFDM.
6. It simplifying channel estimator for different modulator scheme.
7. High spectrum efficiency can be achieved by OFDM with overlapped sub-carrier arrangement, so the system capacity can be greatly increased.

### B. Basic OFDM Model.

The basic principle of OFDM technology difficulties like digital implementation of FFT/IFFT. The digital implementation of OFDM system is achieved through the mathematical operations called Discrete Fourier Transform (DFT) and its counterpart Inverse Discrete Fourier Transform (IDFT). These two operations are extensively used for transforming data between the time domain and frequency domain. In case of OFDM, these transforms can be seen as mapping data onto orthogonal sub-carriers. OFDM signal is formed using the Inverse Fast Fourier Transform (IFFT), and it adding a cyclic extension and performing to get a spectral modulator.

<table>
<thead>
<tr>
<th>Multiplexing</th>
<th>Multiple Access</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiplexing is a process where multiple analog message signal or digital data streams are combined into one signal over a shared medium.</td>
<td>Multiple access or channel access method allows several terminals connected to the same multi-point medium to transmit over it.</td>
</tr>
<tr>
<td>The signal is transmitted over communication channel.</td>
<td>It based on the several data streams of multiplexing.</td>
</tr>
<tr>
<td>It support TDM, FDM, WDM, OFDM</td>
<td>TDMA, FDMA, WDMA, OFDMA, SC-FDMA, CDMA, MC-CDMA</td>
</tr>
<tr>
<td>It support following applications, FTTH, Video and audio broadcasting.</td>
<td>It support high capacity of DVB and DAB in the advanced RF application.</td>
</tr>
</tbody>
</table>

From the OFDM transmitter, the current signal modulation format that is QPSK, QAM is to send IFFT transformation. And the modulation signal send to next level of D/A converter. [12]. The demodulation format the data send inverse of FFT transformation then to user as shown in the Fig. 5.
In order to perform frequency domain data into time domain data, IDFT correlates the frequency domain input data with its orthogonal basis functions, which are sinusoids at certain frequencies. In other ways, this correlation is equivalent to mapping the input data onto the sinusoidal basis functions. In practice, OFDM systems employ combination of fast Fourier transform (FFT) and Inverse fast Fourier transform (IFFT) blocks which are mathematical equivalent version of the DFT and IDFT. [11,12].

At the transmitter side, an OFDM system treats the source symbols as though they are in the frequency domain. These symbols are feed to an IFFT block which brings the signal into the time domain. If the N numbers of sub-carriers are chosen for the system, the basic functions for the IFFT are N orthogonal sinusoidal of distinct frequency and IFFT receive N symbols at a time. Each of N complex valued input symbols determines both the amplitude and phase of the sinusoid for that sub-carrier. The output of the IFFT is the summation of all N sinusoids and makes up a single OFDM symbol. The length of the OFDM symbol is NT where T is the IFFT input symbol period. In this way, IFFT block provides a simple way to modulate data onto N orthogonal sub-carriers. [11,12].

C. CONCLUSION

Wireless and mobile technology is popular fast growing data transmission in the present and future emerging world. The current mobile communication network 4G to support multimedia and many applications. The recent multiple access technique of OFDM is incorporate with many of application in the wireless communication system. In the future mobile generation of 5G network need to support advanced multimedia and core network with mobile IP. In this paper we review of various mobile generations and advanced multiple access technology of OFDM(A) has been analyzed. And upcoming mobile communication network easily merge with OFDM system. This review of the paper to help further direction of the mobile computing field.

REFERENCES


