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"Third Generation of unwiredcommunication technology (3G) and its comparison with earlier generation Unwired communication technology"

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ABSTRACT

The wireless technology is developing having rapid speed with advanced techniques. It is an emerging technology in various fields of communication like internet access, location-based services, mobile entertainment services, mobile financial services and video conferencing system etc. The users may use such applications at anytime and anywhere via mobile communication. The wireless communication technologystarted with the first generation of mobile phones known as 1G also. Basically, this was an analog telecommunications technology. The first generation of mobile wirelesscommunicationsystem (1G) was launched in Japan in 1979 by NTT. In the beginning, it was started in Tokyo and within next five years expanded to cover the whole area of Japan. It was theanalogmobiletelecommunications systemwhich wasin use up to 1980s and were replaced by 2Gnetwork so termed as second generation of wireless communication technology. In the year 1991, the second-generation of wireless communication technology was commercially launched on the Global System for mobile communication (GSM) standard in Finland by Radiolinja.The second-generation (2G) of wireless communication technology also known as cellular network, was a group of technology standards employed for cellular networks. Basically, it is a set of standards made for wireless mobile telecommunication that are maintained and described by the International Telecommunication Union. Such technology uses CODEC algorithms in order to compress and multiplex voice data. Consequently, 2G can bundle more calls per amount of bandwidth. Which offers services like short message serviceand email too. There were an error checking and voice quality can be improved by lowering the noise floor.

Since 1979 when the first generation 1G of wireless cellular technology to the third generation 3G, telecommunication developed speedily to give better end-user knowledge than earlier.The word 3G denotes the third generation of mobile communication technology which was introduced in the year 2000. 3G networks were offered to eradicate various problems tackled by 2G and 2.5G networks particularly the low speed and incompatible technologies like Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA). The speed of 3G technology is ranges 125Kbps-2Mbps.

INTRODUCTION

A cellular phone, handphone, cell phone, cellphone, mobile phone, hand phone or pocket phone, sometimes calledas simply mobile or cell or just phone, which is a portable telephone set, can make and receive calls over

a radio frequency link however the user is moving within a telephone service area(Rehman et al 2006 and Srivastava et al 2013).The word mobile is used because it is very easy to move it from place to place.

First generation of mobile wireless communication technology (1G) was introduced in Japan in the year 1979 by Nippon Telegraph and Telephone (NTT). Initially, it wasbegun in Tokyo and within a very short span of time of about next five years spread out to whole part of the Japan country.In the year 1981, a new company named as Nordic Mobile Telephone (NMT) was launched in many European countries. In 1983, Ameritech started 1G mobiles in the USA through Motorola mobile phones. Use of mobile communication technology was then come after by several countries around the world.

The term "1G" refers is the first generation of wireless communication or mobile communicationtechnology. Basically these are analogmobiletelecommunications systems which were introduced in the year 1980s and were superseded by second generation (2G) of wireless communication system.

During the evolution of first generation of wireless communication technology, various "1G" cellular standards were started and were used in region across the globe.Butthe most generalused global system were the Nordic Mobile Telephone(hereafter referred as NMT also) and Advanced Mobile Phone System (hereafter referred as AMPS also) systems.The unexposed positive points of digital technology over the analog technology are that 2G networks went on to in due coursecompletely took place of previously adopted technology so called firstgenerationofwirelesscommunication technology (1G). Across the globe, almost all the firstgenerationofwirelesscommunication technology (1G) networks were vanished,however at some places, it still continued to operate up to the year 2010s.

The predecessor to first generation of wireless communication technology (1G) was themobile radio telephone. In this system of communication, the portablephones would connect to a centralized operator. 1G refers to the very first generation of cellular networks (Rehman et al 2006). Cellular systemis named because it uses a network of cells across the geographical area by using low-power radio transmission system (Srivastava et al 2013).

The second-generation (2G) of wireless communication system also known as cellular network, was a group of technology standards employed for cellular networks. The second-generation (2G) of wireless communication system was commerciallylaunchedon the GSM standard in Finland in the year 1991 (Kumar[a & b] et al 2022).After evolution of the second-generation (2G) of wireless communication technology, the old mobile wireless network systems were posteriorly dubbed 1G communication technology. The radio signals on first generation (1G) of wireless communication systemwere purely analog, however that on second generation (2G) of wireless communication network systemwere completely digital.However, in both the technologyonly digital signaling were used to connect the cellular radio towersto the rest of the mobile network system(Krishna et al 2014).

The most common 2G technology was the time-division multiple access (also referred as TDMA)-based Global System for Mobile communication (also referred as GSM) standard, used in most of the world outside Japan and North America. In North America, digital Advanced Mobile Phone Service (also referred asAMPS) (IS-54 and IS-136) and Code Division Multiple Access **(**also referred ascdma) One (IS-95) were the main systems.In Japan, the ubiquitous system was Personal Digital Cellular (also referred as PDC) though another,Personal Handy-phone System (also referred as PHS), also existed(Xenakis 2019). Initially, 2G transfer speeds didn't exceed 9.6

kbit/s. By the time the 2G era ended, 40 kbit per second had become a reality.Enhanced Data rates for GSM Evolution (also referred asEDGE) technology offered up to 1Mbps. However, the speed was slow as compared to what we have today, back in the year 1990s, 2G revolutionized telecommunications.

The third generation of wireless technology (3G) was known in the 2000s as International Mobile Telecommunications-2000 (Pachauri 2009). The third generation of wireless technology (3G) has the highest speed as compared with 1G and 2G, it enables transferring packet switch data at higher and better bandwidth. It offers great services to the end users such as clear voice calls services, high security methods faster communication, high broadband capabilities, video conferencing, 3D gaming and high-speed web however there are many disadvantages such as expensive fees for third generation of wireless technology (3G) licenses services, big size of mobile phones, expensive in nature, higher bandwidth requirements etc.

OBJECTIVE OF THIRD GENERATION OF WIRELESS NETWORK (2G)

The objective of the third generation of wireless communication technologyis to provide fairly high-speed wireless communications to support multimedia, data, and video in addition to voice.

EVOLUTION OF FIRST GENERATIONOF MOBILE TECHNOLOGY

The first generation of wireless communication technology (1G) was developed in Japan in the year 1979 by Nippon Telegraph and Telephone (also referred as NTT). Initially, itwas started in Tokyo. But within very short span of time (i.e. only in five years), it was expanded to cover the whole of Japan.

In whole world, Japan is the pioneer country who developed the first commercialcellularnetwork. In Japan, it was launched by Nippon Telegraph and Telephone (NTT) in the year 1979.In the beginning phase, it was started only in the metropolitan areas of Tokyo, Japan. The first practical phone which usedsuch network was called TZ-801 built by Panasonic (Mouton 2012). Within very short span of time (i.e. only in five years), the NipponTelegraph and Telephone (NTT) network covers the entire population of Japan and has got the position of first nationwide 1G per cellular network system howeverbefore the Nippon Telegraph and Telephone (NTT) network in Japan, Bell Laboratoriesbuilt the first cellular network around Chicago in 1977 however trialed this one in 1978 (Williams 2008).

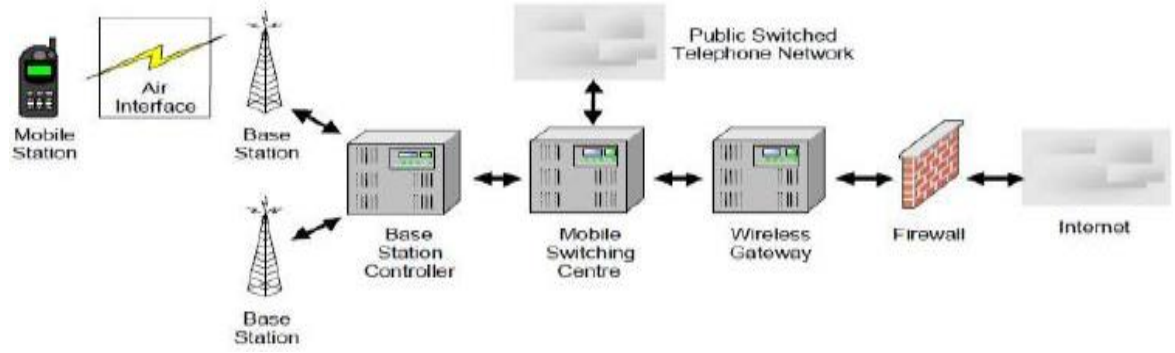

Figure 1: Architecture of Advance Mobile Phone Services*

*Source: www.igi-global.com

Some year later in the year 1981, one more company, Nordic Mobile Telephone (also referred as NMT) was started in some of the European countries. In the year 1983, one more company named as Ameritech also

developed the first generation of wireless communication system (1G) mobiles in the USA. This company uses the Motorola mobile phones (Figure 1). After that the use of mobile communication system was followed by several other countries across the world.

As before the cellular era, the Nordic countries were holding the position of the pioneers in wireless communication system. All these countries combinedly work together and designed new system named asNordic Mobile Telephone (NMT)standard which were first time launched in Sweden (Europe) in the year 1981(Xenakis 2019). Nordic Mobile Telephone (NMT) was pioneer company of the mobile phone network in the world in order to have the feature of roaming at international level. In the year 1983, the first 1G cellular networkknown as first generation of wireless communication system (1G) cellular network, was started in the United States of the world. Thiswas completely Chicago-basedAmeritechby using the Motorola Dyna TACmobilephone.

EVOLUTION OF SECOND GENERATION OF MOBILE WIRELESS COMMUNICATION TECHNOLOGY (2G):

Jesse Eugene Russell is the pioneer person of second generation of mobile wireless communication network (2G). This gentleman is an African-American inventor and is one of the visionaries whose innovative viewpointdeeplydetermine the wireless communications company, the pioneer of growth in 21st century in the field of wireless communication technology. He is an electrical engineer at Tennessee State University and Stanford University and have global recognitionlike a thought-leader, technocrats and developer in the field of wireless communication for over 20 years. He has played a significant role in developing the wireless communicationstechnology.

2.5G ("second and a half generation") is used to describe 2G-systems that have implemented a packet-switched domain in addition to the circuit-switched domain(Xenakis 2019). It not necessarily gave faster service due to bundling of timeslots. It is used for the circuit-switched data services also.

Different researchers have announced that 2G technology in the part of Australia, Japan, United Statesand also some other countries are in the process of being shut down, or have shut down 2G services already. As a result, the carriers can reclaim those radio bands and reprocess them for latest technologies (Colas et al 2019 and Serr et al 2017).

In the year 2022, Android 12 introduced a technology setting to disable 2G connectivity for the device, claimed to diminish the security concerns linked with 2G networks (Amadeo et al 2022).

EVOLUTION OF THIRD GENERATION OF MOBILE WIRELESS COMMUNICATION TECHNOLOGY (3G)

The third Generation Partnership Project (also referred as 3GPP) was formed in 1998 to foster deployment of 3G networks that descended from GSM. 3GPP technologies evolved in the following ways:

- Long-Term Evolution (LTE) or Evolved Universal Terrestrial Radio Access (E-UTRA) aimed for 100 Mbps.
- General Packet Radio Service (GPRS) offered speeds up to 114 Kbps.

- High-Speed Downlink Packet Access (HSDPA) boosted the downlink to 14 Mbps.
- Universal Mobile Telecommunications System (UMTS) Wideband CDMA (WCDMA) offered downlink speeds up to 1.92 megabits per second (Mbps).
- Enhanced Data Rates for Global Evolution (EDGE) reached up to 384 Kbps.

TRANSMISSION SYSTEM

In data Communication, transmission system are the links which carry messages between two or more devices. The transmission system can be classified into two categories named as wired media or guided transmission system and wireless media or unguided transmission system (Figure 2)(Kumar[a] [&] [b] et al 2022). The Core Network of wireless communication system is shown in Figure 3. These two systems are explained as follows:

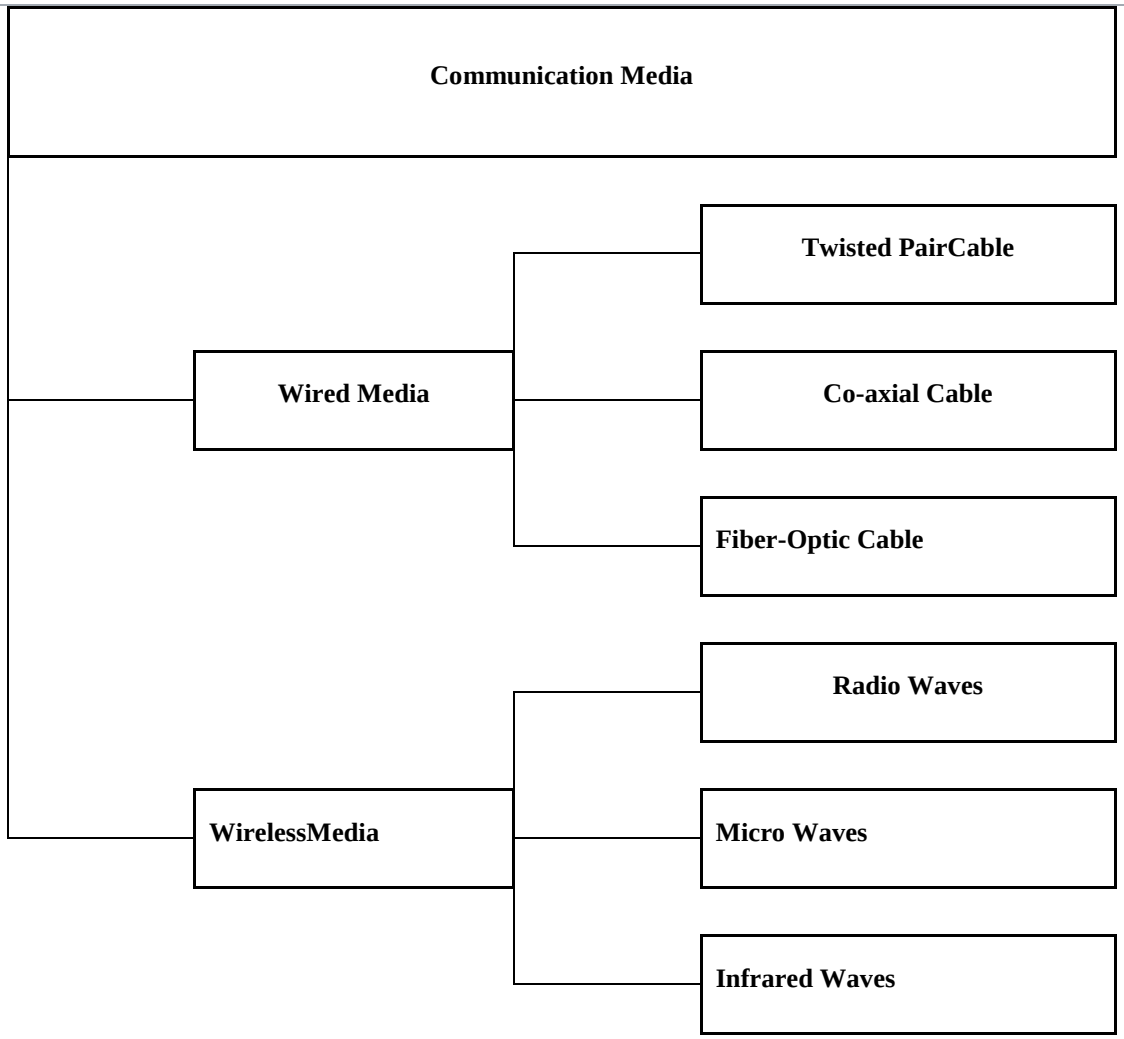

Figure 2: Classification of Communication system*

*Source: Kumar[a] et al (2022).

A) **Wired media or Guided transmission system:** In this system, there is a physical connection made up of wire or cable. Through this connection data in the form of signals are propagated between the nodes. These are normally of three types:

a) Twisted pair cable,

b) Co-axial cable and

c) Fiber-optic cable.

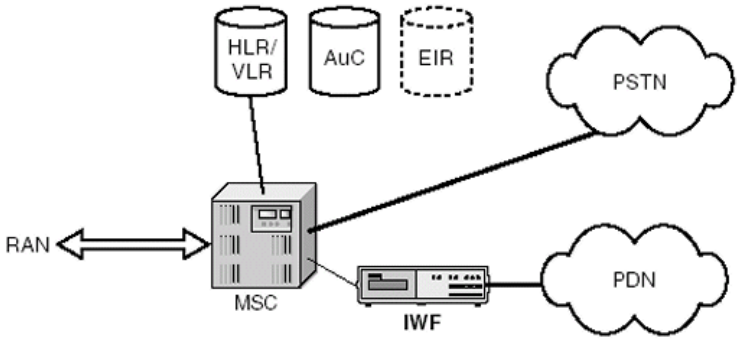

Figure 3: Core Network of wireless communication system*

*Source: https://www.informit.com/articles/article.aspx?p=98132&seqNum=2

B) **Wireless media or Unguided transmission system:** In this system, there is no physical connection. The data is transferred in air in terms of electromagnetic wave through an antenna. These are also of three types:

a) Radio waves,

b) Micro waves and

c) Infrared waves (IR waves).

TECHNOLOGY USED

The third-generation wireless technology (3G) make use of TDMA and CDMA. The third-generation wireless technologies (3G) make use of value-added services like mobile television, global positioning system (GPS) and video conferencing. The basic feature of third generation wireless technology (3G) is fast data transfer rates. However, this feature is not currently working properly because, ITU 200 is still making decision to fix the data rates. It is expected that 2mbit/sec for stationary users, while 348kbits when moving or traveling. ITU sell various frequency rates in order to make use of broadband technologies. Network authentication has won the trust of users, because the user can rely on its network as a reliable source of transferring data. The third-generation wireless technology (3G) is much flexible, because it is able to support the 5 major radio technologies. These radio technologies operate under CDMA, Time Division Multiple Access (TDMA) and frequency division multiple access (FDMA).CDMA holds for IMT-DS (direct spread), IMT-MC (multi carrier). Time Division Multiple Access (TDMA) accounts for IMT-TC (time code), IMT-SC (single carrier). Frequency division multiple access (FDMA) has only one radio interface known as IMT-FC or frequency code. The third-generation wireless technology (3G) is really affordable due to the agreement of industry. This agreement took pace in order to increase its adoption by the users. The third-generation wireless technology (3G) system is compatible to work with the second generation wireless (2G) technologies. The third-generation wireless technology (3G) technologies holds the vision that they should be expandable on demand. The aim of third generation wireless technology (3G) is to allow for more coverage and growth with minimum investment. The third Generation Mobile Cloud Service infrastructures is shown in Figure 4.

Figure 4 :Third Generation: Mobile Cloud Service infrastructures*

*Source: researchgate.net

STANDARDS

During the era of first generation of wireless communications technology, Europe required the need for a general mobile telephony service. It was becausevarious countries had differing analog networks and consequently roaming of subscribers between these networks was not possible. Conference European des Postal Telecommunications (also referred as CEPT) is a standardization arena in Europe. A new group called Group Special Mobile (also referred as GSM) was formed within Conference European des Postal et Telecommunications (CEPT) in 1982 whose task was to specify a unique radio communication system for Europe at 900 MHz.

CODE DIVISION MULTIPLE ACCESS (ALSO REFERRED AS CDMA) IS-95

Code Division Multiple Access (CDMA) is a relatively latest technology in the industry of mobile cellular network. Commercial networks were first positioned in the mid1990s. However, they are growing rapidly and they account for about 25% of the wireless networks globally.The Code Division Multiple Access (CDMA) standard referred to as IS-95 is specified by TIA/EIA. The architecture of CDMA is shown in figure 5.

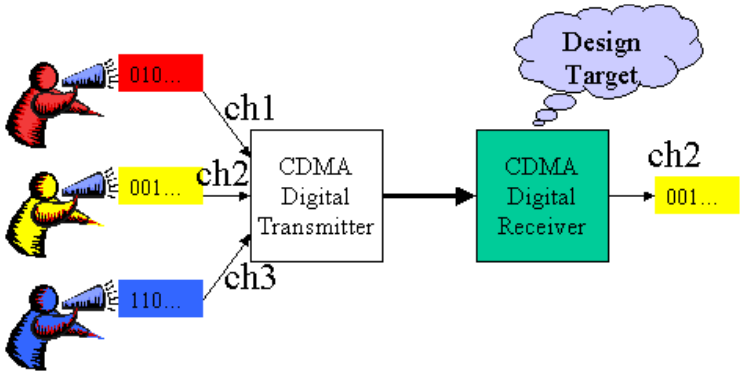

Figure5: CDMA Architecture*

*Source: Venkata et al (2014)

SPREAD SPECTRUM

The wireless communication is a scanty resource having tight regulations in terms of usage and power radiated along with licenses needed for its operation. This is correct for all the wireless technology in place. However, interference is thesignificant issue which wireless networks must contend with it.Spread spectrum is one of the techniques employed that inherently is less sensitive to interference. Spread spectrum techniques typically use more bandwidth than necessary to transmit and receive bits.The specification of first to thirdgeneration of wireless communication technologyare shown in Table 1 given as follows:

Table 1*

Comparative Specification of 1st generation (1G), 2nd generation(2G) and 3rd generation (3G)of wireless communication technology

Features	1st generation of wireless communication technology (1G)	2nd generation of wireless communication technology (2G)	3rd generation of wirelesscommunication technology (3G)
Start	1970	1980	1990
Development	1984	1999	2002
Technology	AMPS, NMT, TACS	GSM	WCDMA
Frequency	30 Khz	1.8 Ghz	1.6- 2 GHz
Bandwidth	2 kbps	14.4 – 64 kbps	2 Mbps
Average speed	2 kbps	9.6-14.4 kbps	3 Mbps
Core Network	PSTN	PSTN	Pocket Network
Access System	FDMA	TDMA/ CDMA	CDMA

*Source: http://net-informations.com/q/diff/generations.html

ADOPTION OF NEW TECHNOLOGY

In all over the world, after Japan, the earliest commercial cellular networks launched in the year 1981 in Sweden, Norway and Saudi Arabia, after that in Denmark, Finland and Spain in 1982, the U.S. in 1983 and Hong Kong, South Korea, Austria and Canada in 1984. By the year 1986, networks had also launched in Tunisia, Malaysia, Oman, Ireland, Italy, Luxembourg, Netherlands, United Kingdom, West Germany, France, South Africa, Israel, Thailand, Indonesia, Iceland, Turkey, the Virgin Islands and Australia also (Vasco et al 2004). Generally, African countries were slower to take up first generation of wireless communication system (1G) networks, while Eastern European were among the last because of some political reasons (Mingtao 2007).

The second generation of mobile networks appeared under the GSM standard in 1991 in Finland. Finally, the calls could be encrypted, increasing security and creating a variety of new communication possibilities for different industries (Chatterjee et al 2018). Meanwhile, voices were carried with much bigger clarity, reducing static, and other background noises.

It’s worth noting that 2G was something far beyond simple telecommunication improvement. It became the foundation of the next era of interaction. Besides calling, people could now send text, pictures, and multimedia messages by clicking buttons on their phones. The opportunities offered by such digital interactions seemed

endless.Businesses quickly adjusted to the new options, revolutionizing marketing efforts, and boosting sales in many industries.

Initially, 2G transfer speeds didn't exceed 9.6 kbit/s. By the time the 2G era ended, 40 kbit/s had become a reality. Enhanced Data rates for GSM Evolution (**EDGE)**technologyoffered up to 1Mbps. Even though the speeds were slow compared to what we know today, back in the 1990s, 2G revolutionized telecommunications.

There are two specifications-setting groups that cater to the objectives to 3G worldwide: 3GPP and 3GPP2.

3GPP: 3G specifications are focused on evolved Global System for Mobile communication(GSM) core networks, known as Universal Mobile Telecommunications Systems (UMTS), and the radio access technologies based on them. This therefore includes Universal Terrestrial Radio Access (UTRA), General Packet Radio Service (GPRS) and Enhanced Data rates for GSM Evolution (EDGE).

3GPP2: 3G specifications, on the other hand, are designed for CDMA2000 systems, which are based on Code Division Multiple Access (CDMA). Of the two, 3GPP specifications are more widely used owing to the fact that majority of the cellular networks on the planet are based on Global System for Mobile communication (GSM).

Key features of Third generation of wireless communication technology (2G):

The key features of third generation of wireless communication technology (3G) was as follows:

- It has new radio spectrum to relieve overcrowding in existing systems.
- It has better bandwidth, security, and reliability.
- It is interoperability between service providers.
- It has fixed and variable data rates.
- It has asymmetric data rates.
- It has backward compatibility of devices with existing networks.
- It is always-online devices.

Drawbacks of Secondgeneration of wireless communication technology (2G):

- If digital signals would weak then no network coverage in that specific area.
- Unable to handle complex data such as Videos.
- Required strong digital signals.

Security Factorof Third generation of wireless communication technology (3G):

- 3G networks offer greater security than their 2G predecessors. By allowing the UE (User Equipment) to authenticate the network it is attaching to, the user can be sure the network is the intended one and not an impersonator. 3G networks use the KASUMI block cipher instead of the older A5/1 stream cipher. However, a number of serious weaknesses in the KASUMI cipher have been identified (Colin 2003).
- In addition to the 3G network infrastructure security, end-to-end security is offered when application frameworks such as IMS are accessed, although this is not strictly a 3G property.

Applicationsof Third generation of wireless communication technology (3G):

- The bandwidth and location information available to third generation (3G) devices gives rise to applications not previously available to mobile phone users. It became possible to conveniently surf the internet on a

third generation (3G) network on the go with minimum hassle, and do many other tasks previously a slow and difficult hassle on second generation (2G).

- Medical devices, fire alarms, ankle monitors use this network for accomplishing their designated tasks alongside mobile phone users (Ashworth et al 2022). This network marked the first for a cellular communications network to be used in such a wide variety of tasks, kick-starting the beginning of widespread usage of cellular networks.

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