The Evolution of Network Wireless Communication (A Case Study for Jeddah City)

By: Rakan Ahmed Arab

Master of Business Administration (MBA), Business Administration Department, Jeddah

International College, Saudi Arabia

Email: Rak_arab@hotmail.com

Abstract

The aim of this study is to provide the historical development of the different types of Cellular network generations. This study discussed the evolution of cellular networks from 1G to 5G and explained how 6G, which will bloom in 2030, is better than 5G. This study focused on showing how did 5G improve communication networks and how the development of 6G will improve network communication and shape our lives. The study demonstrated that the Saudi Ministry of Communications and Information Technology started incorporating the 6G wireless technology and announced that it will be the successor to 5G cellular technology by 2030. Moreover, this study surveyed 57 participants to show their knowledge level of cellular networks and their needs for network characteristics and evolution. In addition, this study conducted an interview with cellular network companies operating in KSA to understand technical issues of network deployment and the need to implement new network communication technologies.

Finally, the most findings of this study are that about 60% of participants mentioned that there is a slight difference between 4G and 5G. the participant if they had heard of 6G, about 79% of the participants didn't know it yet and never heard of 6G. (84.2%) answered that they have 5G network coverage in their district. The study recommends that telecom companies spread awareness about the 6G for the public, as well as the all advantages of the 5G, as well as the need to conduct more studies in other cities in the Kingdom, and allocate each company specifically.

Keywords: Evolution, Network Wireless Communication, 5G, 6G, Jeddah City

Dedication:

This dissertation is dedicated to multiple people who have helped and supported me. My Father (May Allah Mercy his spirit) , Mr. Ahmed F. Arab, who encouraged me to apply for the master's degree and always kept me positive. Thank you, Dad, for the knowledge, experience, support, and wisdom you added to me. Dad; passed away less than a year ago. Today will not be with me celebrating, but I'm sure Allah will reward him for everything. Mother; Manal Azraq, thank you for pushing me to continue with each step in the degree. Mom; you have encouraged me even though you have been through too many difficulties this year after my father has passed away. My Brothers and Sister, thank you for your support too.

1. Introduction:

1.1. Background Information:

A wireless network refers to a computer network by using a radio frequency connection. Wireless networks are a popular solution for homes, businesses, and telecommunication networks (Fortinet, Inc, 2023). 1G, 2G, 3G, 4G, and 5G are the five generations of mobile networks where G stands for Generation, and the number denotes the generation number. 5G is the latest generation whereas 1G networks are obsolete (Ghayas, 2020).

A new generation of cellular technology has arrived each decade since the first (1G) networks (Oughton & Lehr, 2022). The world has been through different communication networking evolutions since the second generation (2G) mobile radio network systems were deployed in the early 1990s. Whereas the first generation appeared in about 1980, which was a simple analogy system with data speeds of up to 2.4 kbps optimized for voice conversations (Ahmed Solyman & Yahya, 2022).

Each generation has shown improvement over its predecessor. Bellow table is a comparison between 2G, 3G, 4G, and 5G.

Table 1: Cellular Network Generations

Technology Era	1G	2G	3G	4G	5G
Year	1979	1991	2001	2009	2019
Technology standard	AMPS, NMT, TACS, J-TACS, C-Netz	GSM, D-AMPS, IS-95	UMTS (WCDMA) and CDMA2000	LTE (Long Term Evolution)	NR (New Radio)
Use Cases	Analog System, Dropped calls, Giant cell phones	Texting (SMS), MMS, Conference calls, long distance call tracking	Cheap data transmission, GBS, Web browsing, SD Video streaming	HD Video Streaming, Wearable Devices, High Speed Applications	Internet of Things, Cloud storage, Remote surgical robots
Frequency	30 KHZ	1.8 GHZ	1.6-2 GHZ	2-8 GHZ	3-30 GHZ
Bandwidth	2 kbps	364 kbps	3 Mbps	100 Mbps	10 Gbps
Avg Speeds	2 kbps	40 kbps	300 kbps	25 Mbps	150 Mbps
Range	N/A	50 mi	35 miles	10 miles	1.000 ft

As described above, showing the differences between the 1st generation toward the 5th generation, there is an optimal difference either in the technology standard, used cases, frequency, bandwidth, average speed, and the range. The Table shows that the bandwidth was two kbps and has reached today to 10 Gbps. Also, the average speed started as 2 Kbps and reached today to 150 Mbps. Moreover, the use cases of previous technology were Analog systems with limited capabilities, whereas today, the technology bloomed different use cases, such as Internet of Things, Cloud Computing, Smart Cities, Remote Surgical Robots, etc (Capital, 2020; Ghayas, 2020).

6G will be the communications medium for tomorrow's world. 6G promises to help blur the line between the digital and the physical worlds, extending the end-user experience beyond the boundaries of physical reality (MCIT, 2022). Users can visualize, monitor, operate, or even simulate physical objects in the digital world without encountering the usual physical constraints.

Volume 6 – Issue 61

International Journal of Research and Studies Publishing

المجلة الدولية لنشر البحوث والدراسات

Issued on: 20 November 2024

ISSN: 2709-7064

IJRSP

As mentioned in the Saudi Ministry of Communications and Information Technology that 6G connectivity is expected to provide complete network reliability based on an Artificial Intelligence (AI) native core. It will interconnect devices across different networks through a multi-layered, three-dimensional architecture. While the technical requirements of 6G are yet to be fully defined, R&D is already underway in the various parts of the new ecosystem (MCIT, 2022).

This study will explain the differences between these generations showing the development and deployment of each generation leading to how 6G will be an added value.

1.2. Problem Statement

In this thesis, we will consider the question of how vital is telecommunication and wireless networks to the end users and to the business sector, and what do we need for better network performance and improved connections? Therefore, a study needs to be conducted to show the evolution of 4G, 5G, and 6G. Also, in what ways was 6G developed to enhance the challenges of 5G technology? This study will discuss the differences between these technologies which might insight into the assumption of where the future is leading the country and how users and business cases are influenced by this evolution. Therefore, it is essential to show the Saudi strategy and vision to cope with this evolution and implement emerging wireless technologies like 5G and 6G.

The Saudi government has set a Vision for its future called the 2030 Vision. This vision has manipulated all sectors of the government to reach success and ensure sustainability. For instance, the tourism strategy and mega projects have put the country on track to achieve its goal of diversifying its economy and achieving its strategic goals. Moreover, tourism in the region has made a significant commitment to supporting this sector. The government supported all sectors to work together to ensure they all reached the strategy and the goals the government has implemented.

Therefore, telecommunication has received important support and funding as other sectors, from industry to business, need its services and will highly depend on its evolution. Furthermore, the technology of the fifth generation (5th) networks provides tremendous prospects for making the most of the country's tourist attractions. This technology is being adopted to provide an improved experience for visitors and create new revenue streams for business and job creation. The Kingdom of Saudi Arabia developed 5G networks by setting regulatory standards, research and development, and infrastructure deployment networking, building a value chain for the sector,

and sharing use case scenarios. Some challenges remain unresolved or overlooked in current 5G standards, such as dealing with signal propagation loss, which will inevitably increase with higher frequencies (beyond 20 GHz), or maintaining efficient network management under increasingly complex networks (Salameh & El Tarhuni, 2022).

Global adoption of 5G technology is progressing rapidly. During the technology's development phase, several small-scale use cases were developed and tested. The launch of commercial networks in 2020 has driven pilot projects to widespread adoption across various industry sectors. Use cases based on 5G networks are being piloted in the tourism sector, as well as in the education and industry sectors, to enhance customer experience and better develop these sectors. Thus, several new use cases will emerge with the 5G evolution.

The possibility of connecting to the fifth-generation networks provides distinct technical advantages compared to the old communication technologies of the fourth-generation, third-generation and second-generation networks, as enhanced mobile broadband communications are one of the most important and oldest use cases that end users are exposed to. Service providers are preparing their own 5G network offerings, to increase consumer subscriptions. In terms of business, many use cases are being developed in the fifth-generation network system. 5G will benefit organizations in various technical fields, such as robotics, Internet of Things, and analytics. These projects will be the first of many unprecedented efforts aimed at transforming Saudi Arabia into a world-class tourism hub powered by the latest technology (Amuhaysin, 2022).

In addition, fixed 5G wireless access is being implemented in various locations to provide continuous and reliable connectivity for visitors. Thus, fixed 5G wireless access presents a massive opportunity for users to have always-on connectivity in indoor shopping malls, transportation centers, smart stadiums, smart ports, etc. Use cases based on 5G networks are being piloted in the tourism sector to enhance customer experience and develop the sector.

Amuhaysin (2022) described that some of the use cases are being prepared in partnership with the Saudi Federation for Cybersecurity, Programming and Drones including enhancing cybersecurity, using drones for security purposes, monitoring, managing smart facilities based on artificial intelligence, tracking assets, and monitoring the environment.

The technology is also expected to attract a younger audience. Use cases include mobile virtual reality for heritage sites and immersive mobile video-on-demand exploration over 5G networks at developed World Heritage sites.

Volume 6 – Issue 61

Issued on: 20 November 2024

International Journal of Research and Studies Publishing

المجلة الدولية لنشر البحوث والدراسات

ISSN: 2709-7064

IJRSP

Network Segmentation for Visitor Safety, demonstrating how 5G network segmentation with the help of software-defined network SDN monitoring can enhance visitor safety by managing mission-critical communications infrastructure in real-time (Amuhaysin, 2022).

1.3. Research Objectives

This research aims to achieve the following objectives:

1. Study the historical development of Cellular Generations and use cases evolution.
2. Show the difference between 5G and 6G technologies.
3. Study the availability and coverage of 5G in KSA by visualizing it using a map.
4. Applying a questionnaire (Survey) to understand users' knowledge about 5G technology, applications, and related advantages.
5. Analyze the need of users for 6G and the available applications, and the optimum benefits of new technologies.

1.4. Research Questions

The research paper attempted to answer the following research questions to satisfy the study's objectives:

The main question of this research is:

In what ways did 5G improve the communication networks and technical development for business and industry sectors, and how will the development of 6G improve network communication and shape our life?

2. Literature Review:

2.1. Introduction

Since the beginning of the cellular networking evolution, which has taken place for five decades, different generations have occurred. Each generation showed technological development that was the greatest in its time being. From 1G to 2.5G and from 3G to 5G, this world of telecommunication has seen a few improvements and improved performance with every passing day. Anyhow, the exponential growth of wireless mobile traffic, both voice and data; and the emerging applications and business use cases, pose new requirements for the future networks.

2.2. Cellular Wireless Networking Generations Use Cases.

In this section, we will explain the network evolution from the technical perspective and the differences between the network generations and related use cases,

Volume 6 – Issue 61

Issued on: 20 November 2024

International Journal of Research and Studies Publishing

المجلة الدولية لنشر البحوث والدراسات

ISSN: 2709-7064

IJRSP

First-generation mobile communication (1G) is a simple analog system with data speeds of up to 2.4 kbps optimized for voice conversations. RentCell (2019) said that G1 "has a 30 kHz bandwidth and uses frequency modulation (FM) and frequency division multiple access (FDMA) communication technologies (BW)" (RantCell, 2019). 1G has many shortcomings, such as i) due to the use of analogy modulation, no encryption, poor quality, and security; ii) limited users because of the use of FDMA technology; iii) insecure base station power radiation, lack of transfer procedures; iv) supports voice services only; and v) divergent systems because of inadequate of consistent international standards (Munir, 2005).

The second-generation network (2G) has been internationally recognized as the start of a new era in digital communications. The aforesaid comes as no surprise based upon the exploding communication rate between users in the form of SMS texts and phone calls (Salameh & El Tarhuni, 2022, p. 5). Salaameh (2022) described that this exploding rate of communication has caused the world to experience a paradigm shift on all levels from individual users to large corporations, which created room for new business models. Since then, the focus has been on offering faster communication speeds and supporting more users.

Munir (2005) mentioned that 2G is the global mobile communications (GSM), which was introduced in the 1990s. GSM is "a straightforward digital cellular system that uses Gaussian minimum frequency shift keying (GMSK) modulation, time division multiple access (TDMA) transmission technologies, with bandwidth=200 kHz for voice communications" (Munir, 2005). The characteristics of this generation are i) formulated a unified international mobile communication standard, promoted the development of global mobile communication technology; ii) improved services; iii) improved network security through encrypted numbers; and iv) improved the capacity of the system; and v) the mobile phone battery life is longer because the radio signal uses less power. However, the lower data rate of GSM has prompted improvements in cellular systems that use general packet radio service technology (GPRS).

Later upon, third-generation (3G) systems were introduced in the early 2000s with innovations that were considered to be the most notable being the Universal Mobile Telecommunications System (UMTS), which has wideband code division multiple access at its essence (Salameh & El Tarhuni, 2022). Gawas (2015) mentioned the 3rd Generation embarks on the requirements because wireless technological know-how. Web browsing, email, video downloading, photo dividing or vile Smartphone technological know-how had been introduced inside the 0.33 generation.

Volume 6 – Issue 61

Issued on: 20 November 2024

International Journal of Research and Studies Publishing

المجلة الدولية لنشر البحوث والدراسات

ISSN: 2709-7064

IJRSP

Introduced commercially in 2001, the dreams started for 1/3 cellular technology conversation had been after facilitating increased voice and facts capacity, assisting a broader range of applications, then amplifying records transmission at a lower cost (Gawas, 2015). 3G has Multimedia applications guide among union along streaming are greater popular. The significant benefits of the previous third-generation (3G) communications involve increased data rates (compared to the second-generation of mobile devices), seamless mobility within large geographical areas, along with global reachability (Gavrilovska et al., 2015).

4G, introduced around 2010, demonstrating then that it was so far the most successful generation since 1990s. Gawas (2015) mentioned that 4G ought also to lie a particular specific science namely compared according to 3G and was once instituted viable practically only gratefulness in imitation of the advancements within the science within the closing ten years. Its cause is according to furnish high speed, excessive characteristics, and excessive capability in imitation of customers while improving protection or decreasing the virtue on ring and data services, multimedia, and web above IP. Potential then modern services consist of amended cell internet access, IP telephony, gaming services, high-definition cell TV, video conferencing, 3D television, or wind computing (Gawas, 2015). The authorization technologies so bear instituted this feasible are MIMO (Multiple Input Multiple Output) and OFDM (Orthogonal Frequency Division Multiplexing) (Munir, 2005). the two vital 4G requirements are WiMAX (has at last fizzled out) and LTE (has seen massive deployment).

LTE (Long Term Evolution) may want to additionally lie a collection of improvements following present UMTS technological know-how or might also stand unrolled concerning Telstra's existing 1800MHz waveband (Gavrilovska et al., 2015).

Salamed & Tarhuni (2022) mentioned that "5G is expected to be inadequate for the future network requirements". 5G is considered the next generation of wireless network technology that has a significant effect on the development of communication networks (Paramonov et al., 2020). Paramonov et al. explained that a large proportion of users can access the communication networks through wireless technologies that lie on the 5G networks.

5G promises notably faster records rates, greater coalition density, a lower latency, amongst sordid improvements. 5G includes device-to-device communication, and higher battery consumption than average Wi-Fi coverage. The maximum velocity concerning 5G is aimed towards being as fast as 35.46 Gbps, which is 35 instances quicker than 4G.

Volume 6 – Issue 61

Issued on: 20 November 2024

International Journal of Research and Studies Publishing

المجلة الدولية لنشر البحوث والدراسات

ISSN: 2709-7064

IJRSP

Liljana Gavrilovska et al. (2015) Identify the technical requirements of 5G technology such as: Rigorous latency and reliability, which will be very useful in healthcare, security, logistics, automotive applications, and mission-critical control.

2.2.1. 5G Used Cases

Salami et al. indicated that latency and reliability of communications, are indeed a key to meeting the needs of the industrial world (Slalmi et al., 2021). 5G is expected to enable virtual reality devices to offload the extensive computing work you need in data storage coupled with increased accuracy in virtual reality experiences, and this will enable the devices themselves to become smaller and easier to use.

For example, 5G networks were applied in the Holly Mosque area. This enabled visitors to experience a remote tour of the Grand Mosque in Mecca. Amuhaysin (2022) explained that "High-resolution 360-degree video feeds from the pilot project were projected onto screens larger than room size to provide an immersive experience" (Amuhaysin, 2022). The study indicated that transmissions over 5G networks with video controls provided greater security for visitors too.

Moreover, Amuhaysin (2022) mentioned that airport operations were lagging as the number of passengers was increasing which caused much of pressure daily. Airports keep up with these aspirations, as travellers expect consistently high-quality, personal experiences. Therefore, with the support of 5G network coverage by artificial intelligence, the Internet of Things,

and cloud platforms for video and extensive data services, airports have succeeded in adapting and developing to the required expected solutions. Amuhaysin (2022) stated " The General Authority of Civil Aviation is working with technology partners to implement smart airport solutions based on the latest technologies to ensure that the Kingdom's airports are equipped with modern technologies to quickly manage the large influx of tourists"(Amuhaysin, 2022)

2.2.2. 6G Use Cases

It is expected that 6G will enable the Internet of Sense (IoS), which will bring mind, smell, sight, taste, touch, and sound to the digital world. By combining these senses, 6G can enable various use cases, such as connected sustainability (be anywhere) and sensational services (the ability to touch, smell, and see any digital object) (MCIT, 2022). 6G will be the communications medium for tomorrow's world. 6G promises to help blur the line between the digital and the physical worlds, extending the end-user experience beyond the boundaries of physical reality.

Volume 6 – Issue 61

Issued on: 20 November 2024

International Journal of Research and Studies Publishing

المجلة الدولية لنشر البحوث والدراسات

ISSN: 2709-7064

IJRSP

6G connectivity is expected to provide complete network reliability based on an AI native core. It will interconnect devices across different networks through a multi-layered, three-dimensional architecture. Moreover, the interconnection of the physical and digital worlds will be enabled through four main areas of innovation: Firstly, 6G will enable the twinning of physical and digital systems. Sensors and actuators will enable complete digital replication of the physical reality, producing twins of cities, factories, and even our bodies in the form of digital avatars. This will permit significant data mining and highly efficient control of digital domains.

Secondly, the connected intelligence of the 6G AI systems will enable virtual representations of people and physical entities to exchange information in the digital domain seamlessly. Thirdly, 6G will provide immersive communication that will enable people to extend the range of their senses through the digital domain. All these innovations will become possible due to the capabilities of 6G networks, which is expected to overpass 5G almost in all dimensions: 5-x times higher throughput, twice higher mobility, 10x times lower latency, 1000 more connected devices per tower etc (MCIT, 2022).

KSA Ministry of Communications and Information Technology website described the Sixth-generation wireless (6G) technology and announced that it would be the successor to 5G cellular technology. Also, the MCIT announced that 6G is expected to launch commercially in 2030 in the Kingdom of Saudi Arabia.

The technology makes greater use of the distributed radio access network (RAN) and the terahertz (THz) spectrum to increase capacity, lower latency and improve spectrum sharing (MCIT, 2022).

2.3. Differences between 5G and 6G

This chapter has shown technology development and researchers participation in solving issues since the appearance of 1G to 5G. While 6G is about to overtake, many companies and researchers have studied and predicted the evolution of 6G. These researchers have indicated many differences between 5G and 6G. Below are some of the features of 6G which shows the differences between 5G and 6G. 6G will interconnect the physical and digital worlds, which enables different areas of innovation that are: 6G will enable the linking of physical and digital systems. This will lead that sensors will enable complete digital replication of the physical reality that will produce more cities, factories, and even our bodies in the form of digital avatars (MCIT, 2022).

Connected intelligence of the 6G AI systems will enable virtual representations of people and physical entities to support exchanging information in the digital domain. Moreover, 6G will provide more assertive communication, which will enable people to extend the range of their senses through the digital domain. Furthermore, AI-assisted cognitive technologies will produce compelling convincing human-machine interactions enabling machines to interpret and replicate human intentions, desires, and moods.

All these innovations will become potential because of the capabilities of 6G networks, which are expected to overpass 5G almost in all dimensions (MCIT, 2022).

6G's high level of connectivity will be enabled by four new technologies:

- Twinning physical and digital systems (See Figure 1).

- Connected intelligence.

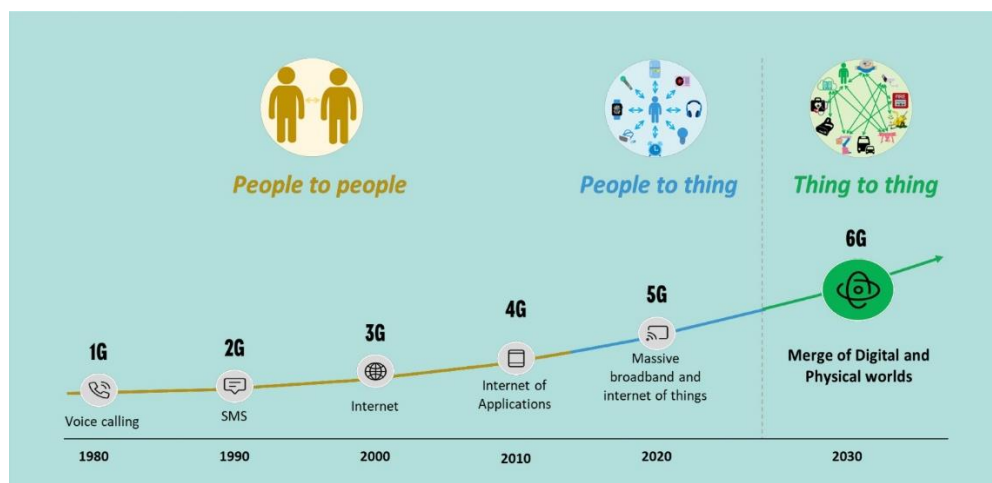- Immersive communication.

- Cognition.

Figure1: Evolution of the 6th Generation by (MCIT, 2022)

6G networks will connect trillions of things and billions of people. The network technologies will have many defining features, such as:

- 6G connectivity is expected to provide complete network reliability.

- The 6G network is expected to have an AI native core.

- 6G will interconnect devices across different networks.

- 6G networks will be multi-layered (three-dimensional architecture).

6G security enhancements will provide trustworthy systems.

3. Research Methodology:

3.1. Introduction:

According to Kumar (2018), research methodology is organized around all the operational steps that form the research process for quantitative, qualitative, and mixed research methods. It includes procedures and techniques utilizing to identify, select, process, and analyze information concerning a research topic. This research utilizes information from published sources and existing information such as journals, credible websites, books, academic sites and articles and primary sources (Kumar, 2018).

3.2. Study Design and Approach:

This study conducted an interview that was sent to telecommunication company managers and executives, and a questionnaire that was sent to end users. Fourteen questions have been deployed for the interview; The interview questions were sent to STC, Mobily, and Zain managers. Also, 10 questions have been deployed for the questionnaire (survey).

The questionnaire has been sent to 57 consumers targeting different levels of income and different age groups to retrieve as much as possible feedback on the service quality and technology used.

Google Forms were used to survey participants. A link was distributed to participants via social media channels such as Twitter, WhatsApp, Email. The study was conducted during the year 2023-2024.

The survey questions measured users' knowledge of the different cellular network generations deployed and provided feedback on the limitations and benefits of these technologies, in addition to available use cases and applications.

3.3. Interview and Survey Questions:

3.3.1. Interview Questions:

1- Why there is no 5G coverage in all areas in Jeddah?

2- How much does it cost to cover the remaining areas?

3- What is the average cost for consumers to access 5G?

4- How do you decide where to put the base stations to cover the required areas?

5- What methods and tools do you use to count the number of base stations needed in an city or district?

Volume 6 – Issue 61

Issued on: 20 November 2024

International Journal of Research and Studies Publishing

المجلة الدولية لنشر البحوث والدراسات

ISSN: 2709-7064

IJRSP

6- Is there a coverage map (that can be shared) of the spread of 5G coverage and a future coverage plan for new district areas that will be covered?

7- What are the company revenues behind deploying 5G compared to 4G?

8- What are the differences between 5G and 6G?

9- What is the difference in deployment cost between 5G and 6G?

10- What are the differences in terms of the needed tools and resources to deploy 5G and 6G?

11- What are the differences of offered services between 5G and 6G?

12- How will 6G improve communication and shape our life?

13- What kind of business projects and use cases will 6G implement to meet the goals and strategy of the kingdom vision 2030?

14- When will 6G take over?

3.3.2. Survey Questions:

1- What is your age range?

2- Income level?

3- District Area?

4- Do you have 5G Coverage in your living Area?

5- While using cellular network (4G,5G) in your opinion, which has better coverage availability?

6- While using cellular network (4G,5G) in your opinion, which has better speed and better downloading rate?

7- How would you rate the 5G subscription cost?

8- In your opinion is there any difference between 4G and 5G

9- Have you heard of 6G?

10- In your opinion will 6G help in which are (Select all that apply)

- Automated cars become more common.
- Virtual reality / Augmented reality become more popular.
- Internet of things devices to be in most of the houses
- building smart cities
- Reliable telemedicine
- Better user experience

3.4. Interview and Survey Development:

3.4.1. Outline Development:

The survey and Interview have been implemented via Google Forms, which are easy to access and use. This survey has used a variety of these different forms as shown in the appendix.

3.4.2. Distribution of Interview and Survey:

The survey was distributed through various communication channels such as Facebook, Twitter, and Email. Also, the survey was sent to Jeddah International College email students and employees (Administration and Faculty).

3.4.3. Response Rate:

As clarified previously that there are an interview and a survey for participants. Below are the responses to the Interview and the survey.

3.4.3.1. Interview Responses and Feedback:

The interview questions were distributed to three different executives working in STC, Mobily, and Zain at Jeddah City. Only one response was received. The response belonged to the executive of Zain Company who is Mr. Alan Loh, innovation and solutions executive general manager. Below is the response to each question that was provided by Mr. Loh. Each question shows the purpose of the question and indicates the responses.

Question 1: Why there is no 5G coverage in all areas in Jeddah?

Response:" Zain is continuously building 5G network to provide wider 5G coverage to our customers. There is other method to improve 5G experience for example you can locate 5G CPE in an optimum location at home to improve 5G speed. There is a video explaining the steps https://www.youtube.com/watch?v=pssZQEEZ0ik"

This response was so beneficial that it showed that the company has a strategic plan to expand and optimize the coverage. In addition, Mr. Loh, explained strategies of how to expand and increase bandwidth coverage even internally "inside homes "and have provided a video that explains the steps and requirements needed.

Question 2: How much does it cost to cover the remaining areas?

Response: "It is depending on many factors like desire coverage area, building penetration, minimum speed requirement, etc. "

Volume 6 – Issue 61

Issued on: 20 November 2024

International Journal of Research and Studies Publishing

المجلة الدولية لنشر البحوث والدراسات

ISSN: 2709-7064

IJRSP

The purpose of the question was to understand the strategy used to understand how telecommunication companies identify the installation cost for a certain bandwidth. The respons did not specify the strategy, but still did clarify some of the factors that they obtained to clarify the cost.

Question 3: What is the average cost for consumers to access 5G?

Response: "Depending on type of device, traffic usage and network load in the serving area"

The purpose of this question was still to understand the strategy "methodology" used to identify the monthly cost. The response identified some factors that are optimum for the company in identifying such a strategy.

Question 4: How do you decide where to put the base stations to cover the required areas?

Response: "Based on existing coverage, capacity and load of existing site, predicted traffic, customer usage behavior, quality of service."

The response identified the factors that support the decision to where to locate stations and will be helpful in further and future research studies.

Question 5: What methods and tools do you use to count the number of base stations needed in a city or district?

Response: "There is many professional network planning tools to do it but it is mainly taking the considerations factors of the previous answer above "

The response showed that the company does use a professional planning tool but they didn't provide it.

Question 6: Is there a coverage map (that can be shared) of the spread of 5G coverage and a future coverage plan for new district areas that will be covered?

Response: " https://sa.zain.com/en/5g-coverage "

Mr. Loh provided a coverage map that specifies the coverage for all the kingdom cities. However, the map did not include future planned coverage (See Figure 13).

Question 7: What are the company revenues behind deploying 5G compared to 4G?

Response: "Current most successful 5G use case Fixed Wireless Access (FWA) having partnership with content service providers like cloud gaming and video streaming. From consumer side it is expected to extend into VR/AR and metaverse use cases. From enterprise side, private 5G network with wide range of industrial applications that couple with AI/ML capability provided over cloud."

The response showed how telecom companies are in investing in 5G as it plays a vital role in technology development by providing different applications to the end users, and it demonstrated how 5G and the appearance of 6G will shape our life.

3.4.3.2. Survey Responses and Feedback:

There were 57 participants who contributed to the survey who lived in Jeddah City. The purpose of the survey was to understand participants level of knowledge regarding to cellular wireless network usage. For instance, a question of their age will indicate the importance of network usage. The older the person is the more business usage might occur.

The survey results have shown the participant's knowledge of the use of emerging network generations and highlighted the better opportunities and applications provided by 6G with advanced features and characteristics.

As mentioned previously that 57 participants have participated who are either students, faculty, or employees. Below is a description of each question showing the meaning of the question, the purpose of the question, and indicating the responses to the question.

Question1 "What is your age range" This question was optional too. The purpose of this question was to understand the grouping age of participants; where ages under 18 have interest different than ages between 18 and 40 and older ages have different interests too (See Figure 2).

3 participants (5.3%) were under the age of 18. About 46 participants were between the age of 18 and 40 (80% of the participants were between the age of 18 and 40)
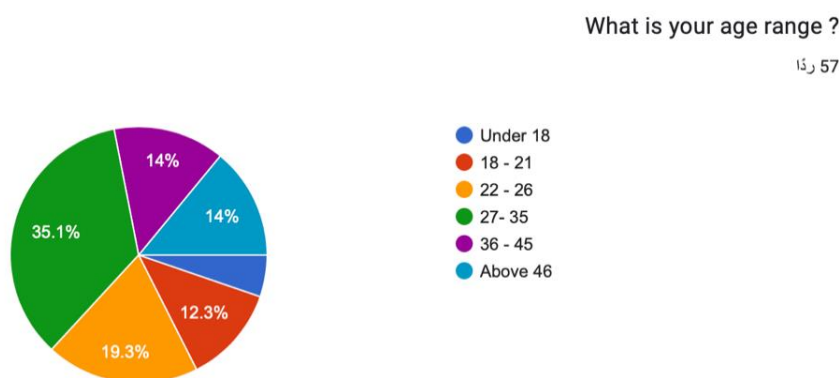

Figure2: Participant Responses for Question 1

Question2 "Income level" this question was a required question. This question is related to the further question that was asking participants opinion of the cost pricing of 5G subscription.

Volume 6 – Issue 61

Issued on: 20 November 2024

International Journal of Research and Studies Publishing

المجلة الدولية لنشر البحوث والدراسات

ISSN: 2709-7064

IJRSP

The purpose of knowing people income to support the study to acknowledge the right pricing for 5G. About 21participant (37%) was below 5000 Saudi Riyals (SR). While about 22 participant (38.6%) income were in the range between 5000SR to 15000SR. 14 participants (24.6) were above the monthly income of 15000SR (See Figure 3).
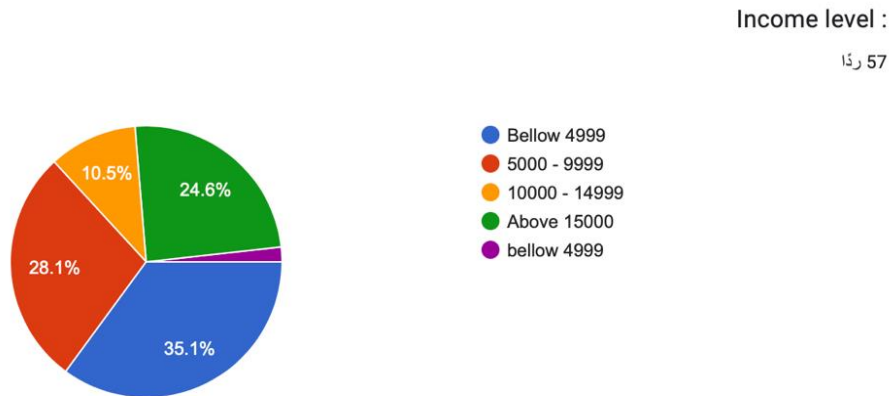

Figure3: Participant Responses for Question 2

Question3 "District Area" this question was a required question. It showed which district the participant lived in. The purpose of this question was to understand the quality of 5G in the district area for further questions and future study. Jeddah city included many districts that are about 42 district areas (See Figure 4) that were available in the questioner and participant can select the area he lives in. Most of the participant lived in either Obhour Al Janobiyah (10 participants, 17%) or Almarwah (6 participants, 10.5%)
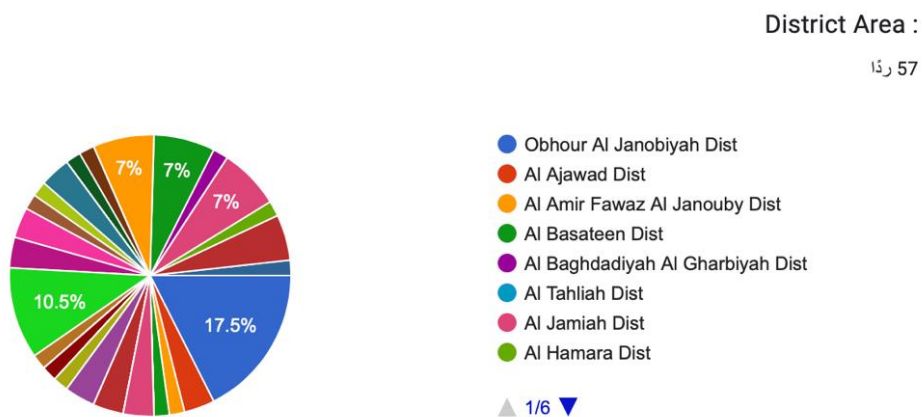

Figure 4: Participant Responses for Question 3

Volume 6 – Issue 61

International Journal of Research and Studies Publishing

Issued on: 20 November 2024

المجلة الدولية لنشر البحوث والدراسات

ISSN: 2709-7064

IJRSP

Question4 "Do you have 5G Coverage in your living Area" this question is a required question and is related to the previous question of the participant district area that they live in. The purpose of this question to filter the areas that does not have 5G and compare it to provers company map. 9 participants (15.8 %) responded that they don't have a 5G service in their district. 48 participants (84.2%) responded they have 5G service in their district area "living area" (See Figure: 5).
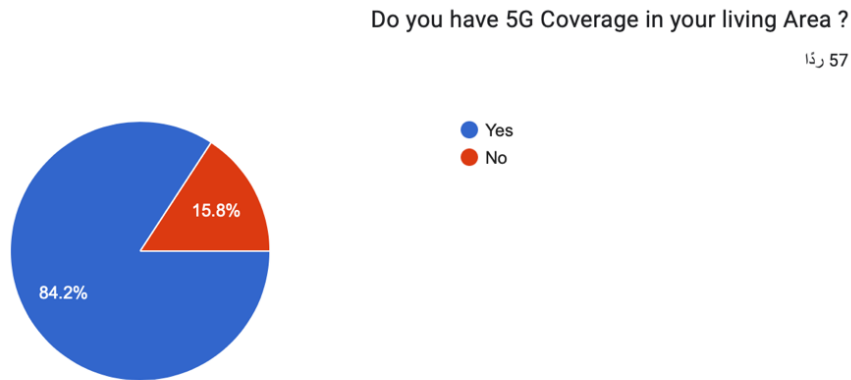

Figure5: Participant Responses for Question 4

Question5 "While using cellular network (4G,5G) in your opinion, which has better coverage, availability" this question is a required question. It shows if the participant knowledge of the difference and the benefits between 4G and 5G. The purpose of this question was to understand if there is need to aware people of the differences and the available applications and services while using 4G and 5G. 22 participants (39.3%) of the 57 mentioned that there is no difference between the two cellular networks (See Figure: 6).
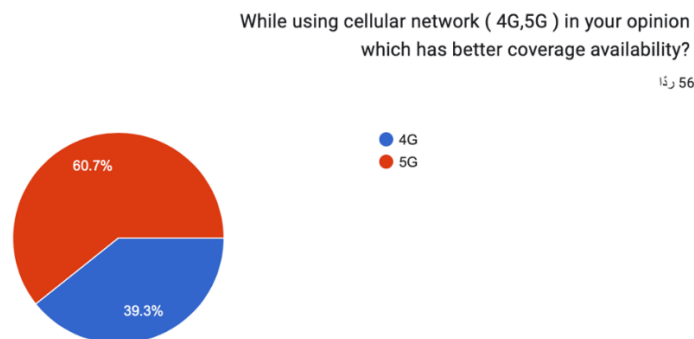

Figure6: Participant Responses for Question 5

Volume 6 – Issue 61

Issued on: 20 November 2024

International Journal of Research and Studies Publishing

المجلة الدولية لنشر البحوث والدراسات

ISSN: 2709-7064

IJRSP

Question6 "While using cellular network (4G,5G) in your opinion, which has better speed and better downloading rate" this question is a required question. It shows if the participant knowledge and if they realize a difference in speed and download rate between 4G and 5G. The purpose of this question was to understand if there is need to aware people that there is a difference in speed and download rate between the two cellular networks. 44 participants (78.6%) of the 57 mentioned that there is a difference of speed and download rate between the two cellular networks. While only 13 (21.4%) participants mentioned that there is no difference between the two networks (See Figure 7).
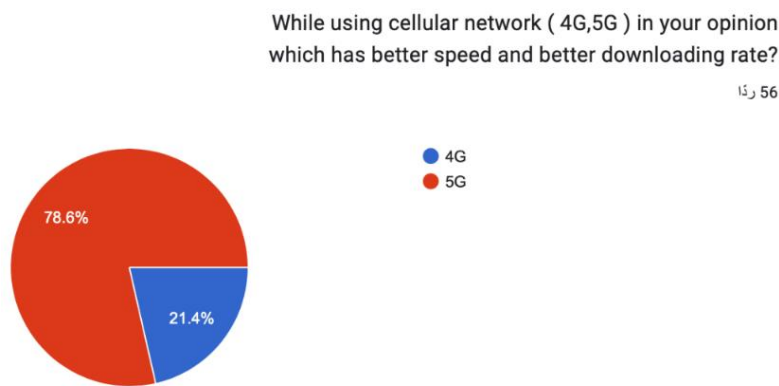

While using cellular network (4G,5G) in your opinion which has better speed and better downloading rate?

56 ردًا

- 4G
- 5G

78.6%

21.4%

Figure7: Participant Responses for Question 6

Question7 "How would you rate the 5G subscription cost" this question is a required question. It shows participants opinion of the subscription cost. The purpose was to compare participants income and their opinion of the subscription cost. About 36 (63.2%) participants mentioned that the subscription is expensive. While 20 (35.1%) participants responded that the costs fair and only one (1.8%) participant said it is cheap (See Figure 8).
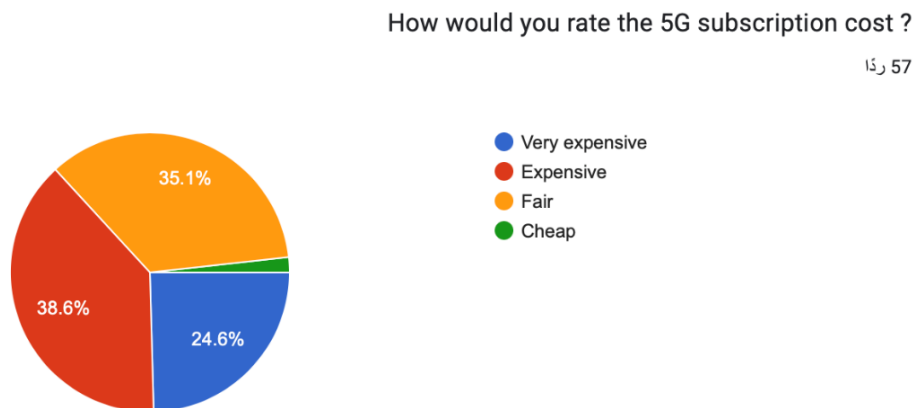

How would you rate the 5G subscription cost ?

57 ردًا

- Very expensive
- Expensive
- Fair
- Cheap

35.1%

38.6%

24.6%

Figure8: Participant Responses for Question 7

Volume 6 – Issue 61

Issued on: 20 November 2024

International Journal of Research and Studies Publishing

المجلة الدولية لنشر البحوث والدراسات

ISSN: 2709-7064

IJRSP

Question8 "In your opinion is there any difference between 4G and 5G" this question is a required question. It shows participants opinion of the difference between the two networks to ensure their responds for the previous two questions. Also, their responds will open a possibility if there is need to aware people of the difference between 4G and 5G which should be a task for telecommunication provers. Unfortunately, 34 (about 60%) participants said there is a small difference between 4G and 5G (See Figure 9).
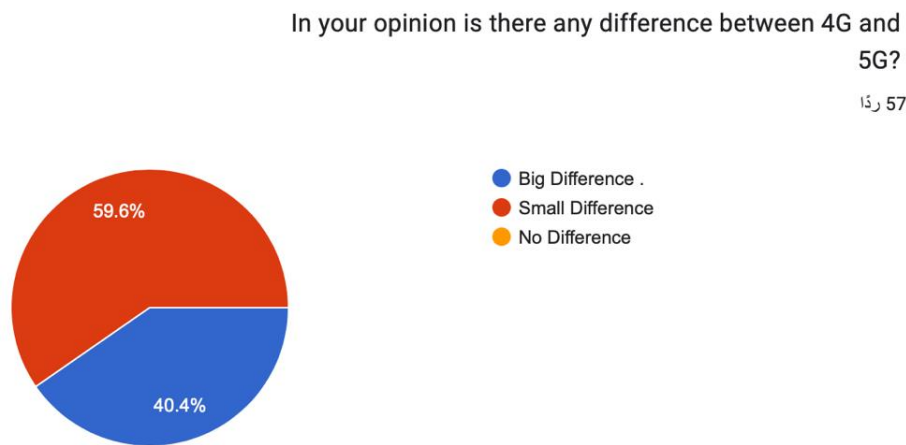

Figure 9: Participant Responses for Question 8

Question9 "Have you heard of 6G" this question is a required question. It shows participants acknowledgment of the 6G. Also, it informs if there is need to aware and market this new telecommunication to people which should be a task of the provider companies. About 45 (about 79%) participants said they have not heard or know 6G (See Figure 10).
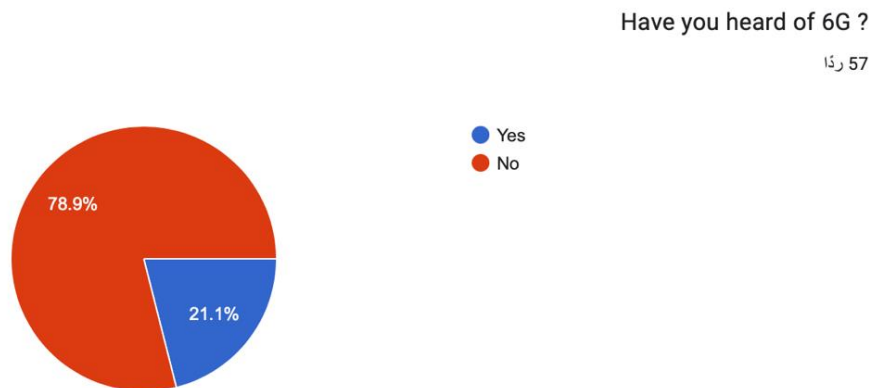

Figure10: Participant Responses for Question 9

Question10 "In your opinion will 6G help in which area (select all that apply)" this is a required question. This question indicates the level of background of participants of how 6G will improve and shape out life. 35 0f the 57 (61.4%) participants chose Building Smart Cities.

The second most selected were "Internet of Things Devices to be in most of the houses" whereas 34 (59.6%) participants selected this choice. The third most selected choice was "Better User Experience" whereas 30 (52.6%) participants selected this choice. The least item selected with only 1 participant (1.8%) were "Automated Cars, IOT Devices, and Telemedicine Easier" See Figure 11).
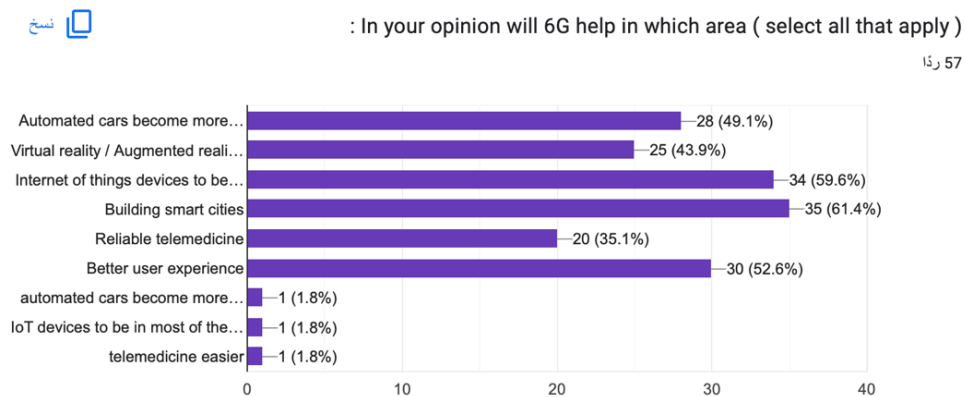

نسخ

: In your opinion will 6G help in which area (select all that apply)

57 ردًا

- Automated cars become more... — 28 (49.1%)
- Virtual reality / Augmented reali... — 25 (43.9%)
- Internet of things devices to be... — 34 (59.6%)
- Building smart cities — 35 (61.4%)
- Reliable telemedicine — 20 (35.1%)
- Better user experience — 30 (52.6%)
- automated cars become more... — 1 (1.8%)
- IoT devices to be in most of the... — 1 (1.8%)
- telemedicine easier — 1 (1.8%)

Figure11: Participant Responses for Question 10

4. Results and Discussion:

4.1. Interview Results and Discussion:

There were 14 questions that were distributed to three different executives that worked in STC, Mobily, and Zain. Only one response was received. The response belonged to the executive of Zain Company who is Mr. Alan Loh, innovation and solutions executive general manager. Below is the summary response that was provided by Mr. Loh.

Question 1 showed that the company has a strategic plan to expand and optimize the coverage. In addition, Mr. Loh, explained strategies of how to expand and increase bandwidth coverage even internally "inside homes "and have provided a video that explains the steps and requirements needed.
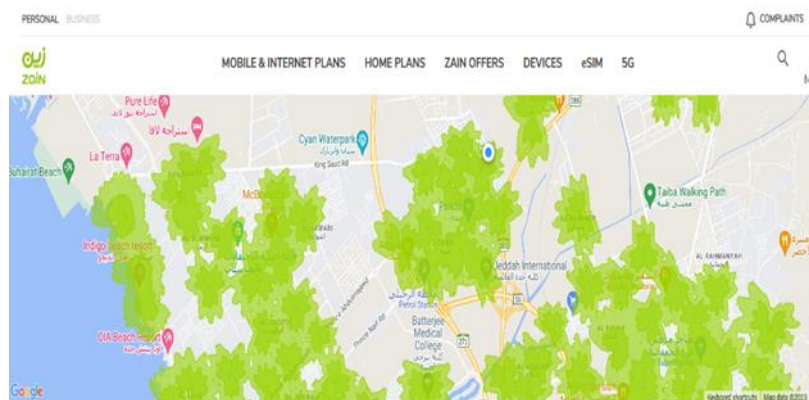

Figure12: Zain 5G Coverage Map, Jeddah City

Volume 6 – Issue 61

Issued on: 20 November 2024

International Journal of Research and Studies Publishing

المجلة الدولية لنشر البحوث والدراسات

ISSN: 2709-7064

IJRSP

The purpose of question 2, that asked about the cost to cover a certain area, was to understand the strategy used to understand how telecommunication companies identify the installation cost for a certain bandwidth. The responses didn't specify the strategy but still did clarify some of the factors that they obtain upon to justify the cost. Question 3 was to understand the strategy or "methodology" used to identify the monthly cost for consumers. The responses identified some factors that are optimum for the company in identifying such strategy. In question 4, Mr. Loh, explained the factors that support the decision to where to locate wireless base stations and access nodes. Mr. Loh, showed that the company does use a professional planning tool to count the number of base stations needed in a city or district. Mr. Loh provided a coverage map that specifies the current 5G coverage for all the kingdom cities (See Figure 12). But the map showed uncovered area and unfortunately it didn't include future planned coverage.

Mr. Loh's responses showed how 5G is playing an important role in technology development with variety of applications and use cases and demonstrated how 5G and the appearance of 6G will shape our life by explaining that the most successful 5G use cases with Fixed Wireless Access (FWA) have partnership with content service providers like cloud gaming and video streaming. From consumer side, it is expected to extend into Augmented Reality vs. Virtual Reality (VR/AR) and metaverse use cases. From enterprise side, private 5G network will have a wide range of industrial applications that are coupled with Artificial Intelligence vs. Machine Learning (AI/ML) capability provided over cloud and the Internet of Things.

Mr. Loh differentiated between 5G and 6G by identifying that 6G is the successor to 5G cellular technology. He also mentioned that 6G networks will be able to use higher frequencies than 5G networks and will provide more substantially more reliability, higher capacity, and much lower latency.

Mr. Loh said that 5G evolution was about the internet of things while 6G evolution will be about Things-to-Things or the internet of everything. He described that the Physical world will be merged with the digital world soon. These features will provide a different world with different services to the business and industry that will be fully identified by 2030. Mr. Loh expected that 6G will be available by 2030 as mentioned by the MCIT.

4.2. Survey Results and Discussion:

This chapter presents the findings of the research as per the feedback obtained from the questionnaire and in line with the research questions.

Volume 6 – Issue 61

Issued on: 20 November 2024

International Journal of Research and Studies Publishing

المجلة الدولية لنشر البحوث والدراسات

ISSN: 2709-7064

IJRSP

The interpretations and a discussion of these questions will be summarized and noted here.

About 46 participants were between the age of 18 and 40 (80% of the participants were between the age of 18 and 40). This implies that most participants were mid-aged. Thus, the responses were inclusive of young and experienced, and this gave quality and reliable research. Also, this range of age is most likely called the age of internet usage. A study inducted in the United States shows that ages between 18 to 29-year-olds "were internet users, making it the age group with the highest level of internet penetration in the country" (Petrosyan, 2023).

Therefore, most of participants were into using mobiles, gaming, and other networking tools for their daily life.

About 21 participants (37%) were below 5000 Saudi Riyals (SR) Salary. About 16 Participants (28.1%) were between 5000 and 10,000 Salary. This indicated that more than half of the participants were midle income. This question will align with the subscription cost question. About 36 (63.2%) participants mentioned that the subscription is expensive. While 20 (35.1%) participants responded that the costs are fair and only one (1.8%) participant said it is cheap. Most of the participants were not satisfied with the cost of subscription which is reasonable, while their income level was mid ranged income.

Moreover, in one of the questions comparing between 4g and 5G, about 60% of participants mentioned that there is a slight difference between 4G and 5G, which indicates that more awareness should be deployed to explain the differences and the benefits that could be applied. In another question asking the participant if they had heard of 6G, about 79% of the participants didn't know it yet and never heard of 6G. This indicates that the telecommunication sector has not marketed the new technology that will bloom in about 2030.

Additionally, Jeddah has about 42 districts. While conducting the questionnaire, we realized that about 30% of the participants live either in Obhour Al Janobiyah (10 participants, 17%) and AL Marwah District (6 participants, 10.5%). While 21% Lived in three districts which are AL Samir, Al Salamah, and Muhammadiyah. Finally, 9 participants indicated that they don't have 5G coverage. This study showed which areas don't have coverage that are Mushrefah District, Jawharat Jeddah District, Al Ajawad District, and Al Rahmanyah District. The map of Zain Telecommunication Company indicated the non-coverage of these areas specified above.

While 57 participated in the questionnaire and about 48 of them (84.2%) answered that they have 5G network coverage in their district, this indicated that there is good coverage in all districts,

Volume 6 – Issue 61

Issued on: 20 November 2024

International Journal of Research and Studies Publishing

المجلة الدولية لنشر البحوث والدراسات

ISSN: 2709-7064

IJRSP

but after revising the list of district areas that participants were living in, we discovered that we need to find more participant that live in other districts. Therefore, an important aspect of showing which districts do not cover 5G would enhance this study. Later upon, a further questionnaire will be conducted for users who live in these non-coverage districts.

5. Conclusion and Recommendations:

5.1. Conclusion:

A new generation of cellular technology is arriving each decade since the first (1G) networks (Oughton & Lehr, 2022). The world has been through different communication networking evolutions since the second generation (2G) mobile radio network systems were deployed in the early 1990s.

This study has explained in detail the specification and services of each generation starting from the first generation towards the fifth generation and showing a bloom of a newer generation arriving by 2030 called the 6th Generation.

This study also identified the difference of speed, Range, Frequency, Bandwidth, and Technology Standards between the five generations. Even though, 6G will be deployed soon, this study shows how 5G has succeeded with all its services.

Moreover, this study has conducted an interview and questionnaire that provided a high level of understanding of the technology use and end users' involvement and expectations. In addition, it showed the telecom company's executive insights on technology deployment and coverage. It identified customer's knowledge and use for the technology availability, coverage, and cost. The results of this study encourage to deploy further studies on 6G deployment strategy in KSA.

5.2. Limitations:

This study, as mentioned previously, has conducted an interview and a questionnaire to make the critical analysis on 5G and 6G deployment and coverage highlighting technology differences and applications. However, the questionnaire surveyed limited cities which could not show the diversity of coverage and users' involvement in technology. While conducting the interview with telecommunications companies that are STC, Zain, Mobily, and Huawei, not all the companies responded to the questions considering that some data are private, except Zain Company. Even though Zain has responded, these responses were not detailed to the level that granted the full knowledge we can rely upon it.

5.3. Future Studies:

After finalizing this study and having all valuable outcomes mentioned and explained in the results and discussion, it has been realized how important it is to apply more research and conduct further interviews with telecommunication companies to better understand 6G deployment advantages and associated costs. Also, as it has been found that most questionnaire participants were living in specific districts, thus, we believe that further studies on other cities in the kingdom will contribute to more valuable results.

6. References:

Ahmed Solyman, A. A., & Yahya, K. (2022). Evolution of wireless communication networks: From 1G to 6G and future perspective. *International Journal of Electrical and Computer Engineering (IJECE)*, *12*(4), 3943. https://doi.org/10.11591/ijece.v12i4.pp3943-3950

Amuhaysin. (2022, September 15). *Huawei—5G Whitepaper_Tourism-sector_september_compressed (2).pdf*. https://www.mcit.gov.sa/sites/default/files/2022-10/Huawei%20-%205G%20Whitepaper_Tourism-sector_september_compressed%20%282%29.pdf

Capital, D. (2020, November 20). 5G: The Revolution Begins [Substack newsletter]. *Drawing Capital Research*. https://drawingcapital.substack.com/p/5g-the-revolution-begins

Fortinet, Inc. (2023). *What Is a Wireless Network? Types of Wireless Network*. Fortinet. https://www.fortinet.com/resources/cyberglossary/wireless-network

Gavrilovska, L., Atanasovski, V., Latkoski, P., & Rakovik, V. (2015). Analysis of Reconfigurability, Control and Resource Management in Heterogeneous Wireless Networks. *International Journal of Computers Communications & Control*, *10*(3), 318. https://doi.org/10.15837/ijccc.2015.3.602

Gawas, A. U. (2015). An Overview on Evolution of Mobile Wireless Communication Networks: 1G-6G. *International Journal on Recent and Innovation Trends in Computing and Communication*, *3*(5).

Ghayas, A. (2020, March 3). *What do the terms 1G, 2G, 3G, 4G and 5G really mean? – Commsbrief*. https://commsbrief.com/what-do-the-terms-1g-2g-3g-4g-and-5g-really-mean/

Kumar, R. (2018). *Research Methodology: A Step-by-Step Guide for Beginners*. SAGE.

MCIT. (2022, August 1). *ON THE PATH TO 6G*.
https://www.mcit.gov.sa/sites/default/files/2022-
12/20220912_6G%20document_v3%20%281%29.pdf

Munir, M. W. (2005). *Different Generations of Cellular Networks System*.
https://doi.org/10.13140/RG.2.1.3341.2004

Oughton, E. J., & Lehr, W. (2022). Surveying 5G Techno-Economic Research to Inform the
Evaluation of 6G Wireless Technologies. *IEEE Access*, *10*, 25237–25257.
https://doi.org/10.1109/ACCESS.2022.3153046

Paramonov, A., Muthanna, A., Aboulola, O. I., Elgendy, I. A., Alharbey, R., Tonkikh, E., &
Koucheryavy, A. (2020). Beyond 5G Network Architecture Study: Fractal Properties of
Access Network. *Applied Sciences*, *10*(20), 7191. https://doi.org/10.3390/app10207191

Petrosyan, A. (2023). *Internet usage by age in U.S. 2021*. Statista.
https://www.statista.com/statistics/266587/percentage-of-internet-users-by-age-groups-in-
the-us/

RantCell. (2019). *Comparison of 2G 3G 4G 5G | 2G vs 3G vs 4G vs 5G*.
https://rantcell.com/blog.html

Salameh, A. I., & El Tarhuni, M. (2022). From 5G to 6G—Challenges, Technologies, and
Applications. *Future Internet*, *14*(4), 117. https://doi.org/10.3390/fi14040117

Slalmi, A., Rachid, S., Chehri, A., & Kharraz Aroussi, H. (2021). *How Will 5G Transform
Industrial IoT: Latency and Reliability Analysis* (pp. 335–345).
https://doi.org/10.1007/978-981-15-5784-2_27