SIT 406 INFORMATION TECHNOLOGY TRENDS

GROUP FOUR.

Q. EXPLAIN 5G & 6G TECHNOLOGY AND ITS APPLICATIONS.

Chapter 1 INTRODUCTION TO CELULAR TECHNOLOGY

In the early days of human civilization, communication was always direct face-to-face communication. The sender of a message had to seek the recipient and deliver the message face to face. Over time, messengers who carried word of mouth from point to point emerged, with time writing was perfected (3400 BCE) and messengers carried written documents. Throughout this period other forms of communication like drums and horns were also used although they had limited range and prone to misinterpretation.

In the first century CE, printing was invented in china, Wang Chen perfected this art in 1297 and 153 years later, Johannes Gutenberg reinvented the printing press in Mainz, Germany. His first printed book was the Gutenberg bible (1452). The first printed newspaper was printed and circulated in Strasbourg, France on 1605 (History Editors, 2018). Up until now all of human communication was limited to the speed of man, his carriages, boats or ships but this was about to change.

In 1752, (Atkinson, 2014) Ben Franklin discovered electricity, 48 years later; the first electric battery was invented by Italian physicist Alexandro Volta. In 1831, Michael faraday invented the electric dynamo as a way of producing electricity. The first bulb was invented in 1878 and first lights were installed and lit on September 1882. From this point on all communication inventions relied in one way or another to electricity and its derivatives.

The idea of the telegraph took shape in the 1700's and was implemented in a rough design by the French in 1798. It worked by connecting two points by an electric conductor (copper wire). A trained coder would encode letters into signals on one end and send it. Another coder would decode the signals into letters on the other end. In 1843, Samuel Morse developed the telegraph in the USA and with the help of the government commercialized it. He also developed the Morse' code for standard encoding and decoding of telegraph messages. In 1866 the first undersea telegraph line was built between USA and the UK (Imagining the internet, 2022). The telegraph allowed instance communication over long distances.

The telephone was next in line to revolutionize human communication. Italian innovator Antonio Meucci conceptualized the basic telephone in 1849. In 1976, Alexander Graham Bell patented the telephone in the USA and the fist telephone line with a switchboard was unveiled in 1878

(Imagining the internet, 2022). This was the first device to offer direct voice communication between two parties. To place a call you needed to have a phone and electricity. The phone was connected to your local switching center (central exchange) which was connected to other centers. On placing a call, the switchboard operator would pick it and ask for the recipient's name (later names were replaced by numbers) the operator would then connect your phone line to line of the intended recipient completing the circuit and allowing communication. Later on switchboard operators were replaced by switching algorithms.

An Italian Inventor Guglielmo Marconi invented radio in 1895 in the UK. He named it wireless telegraph and had a range of up to 1 kilometer. By 1914 General electric had developed electric alternators that were powerful enough to sustain voice and music transmission over thousands of miles. It was briefly used in military but in 1914, the first radio station (NBC Radio) went live. In 1923, Charles Jenkins transmitted images over radio for over 100 miles; later on in 1925, he invented radio-vision and predicted the television. In the 1930's early television-stations were set up and within 20 years television overtook radio as the primary form of American mass media.

Mobile phone.

The very first iteration of a mobile two-way communication device was the push to talk communication device commonly known as walkie-talkie. Donald Hings developed it in Canada in 1939. The first version was a bulky backpack with a telephone like communicator. It needed two people to operate and was largely used in military. The device employed Amplitude Modulation of the radio spectrum to transmit voice in one direction at a time. The device had a receiver and a transmitter. The receiver was always on enabling one to receive messages. The transmitter was activated when one pushed a button and this earned the device the push to talk nickname. With time, this technology advanced to completely handheld bulky systems and then moved from AM to FM and later on, from analog to digital transmission.

Zero G mobile Technology.

These were the predecessor to cellular mobile technology. It was the first time anyone could remotely have two-way communication. These devices were named mobile telephones. They transmitted data in the analog method via amplitude modulation. They were bulky systems mounted on cars and included a transceiver, antenna, dial and handset. The transceiver allowed two-way simultaneous communication as it acted as both a receiver and transmitter at a given time. Live active voice communication was finally possible.

Implementation.

It borrowed heavily from classic telephone service; there was a phone tower in a central location in the city. The phones would connect to this tower via radio waves when communicating. The phone tower provided 64 frequencies for communication. Thus, only 32 people could communicate simultaneously at a given time. The phone tower plugged into the local telephone network and the calls were routed to the destination.

Disadvantages.

- Poor voice quality
- Poor battery life
- Large phone size
- No security
- Limited capacity
- Poor reliability

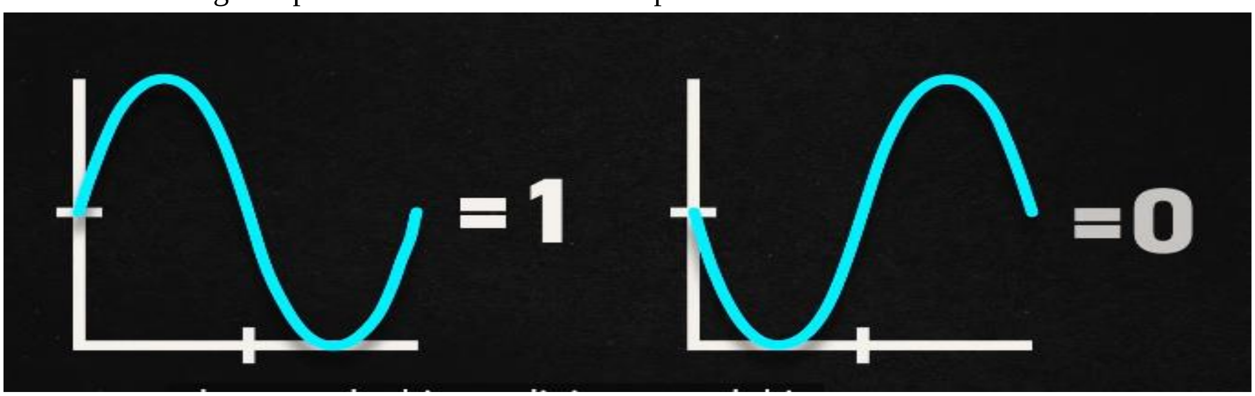
CELL TECHNOLOGY.

To address the problems associated with 0G wireless phone networks the engineers developed cell technology. This technology is the basis of all generations of mobile phone networks. Remember that due to various use cases and importance of the radio spectrum of the electromagnetic radiation, governments regulate the use of this spectrum. Telephone companies were allocated 832 frequencies by the government. [FCC]. The first 42 bands were used for backend communication. This leaves us with 790. We need two different frequencies for two-way communication. Thus, 790 / 2 = 395 channels are all we have to work with in a given city. The engineers divided the land area they intended to serve into hexagons. These hexagons are referred to as cells. A cell site is located at a central location within the cell. The cell is surrounded by 6 others. To avoid interference two adjacent cells cannot use the same frequencies. Now the number of frequencies drops down to 395/ 7 = 56.4. (Sam, 2022)

If we implement mobile networks this way using analog communication only 56 people will be able to communicate simultaneously in a given cell, this raises many problems.

Digital transmission.

Analog is continuous but digital is distinct 0nes and zeros. We can use Amplitude modulation to denote one as high amplitude and zeros as low amplitude below a certain threshold. We can also



use Frequency modulation with smaller wavelengths denoting ones and larger ones denoting zero. Furthermore we can segment a waveform into phases ie.

We can have more than one phase per cycle and this allows us to transmit even more data. These phases can be manipulated up-to 8 per cycle. Allowing us to represent 3 bits. If we add amplitude modulation to this, we get an extra bit allowing us to transmit 16 bits per cycle. We can manipulate these wave properties to transmit even more data digitally. (Angel, 2014)

Chapter 2 , ONE G TO 4 G

Simply, the "G" stands for "GENERATION" . While you connected to internet, the speed of your internet is depends upon the signal strength that has been shown in alphabets like 2G, 3G, 4G etc. right next to the signal bar on your home screen. Each Generation is defined as a set of telephone network standards, which detail the technological implementation of a particular mobile phone system (Patil, 2012). The speed increases and the technology used to achieve that speed also changes.

The aim of wireless communication is to provide high quality, reliable communication just like wired communication(optical fibre) and each new generation of services represents a big step(a leap rather) in that direction.

1G - First Generation

This was the first generation of cell phone technology . The very first generation of commercial cellular network was introduced in the late 70's with fully implemented standards being established throughout the 80's. It was introduced in 1987 by Telecom (known today as Telstra), Australia received its first cellular mobile phone network utilizing a 1G analog system. 1G is an analog technology and the phones generally had poor battery life and voice quality was large without much security, and would sometimes experience dropped calls (Agrawal, 2015). These are the analog telecommunications standards that were introduced in the 1980s and continued until being replaced by 2G digital telecommunications. The maximum speed of 1G is 2.4 Kbps .

2G - Second Generation

Cell phones received their first major upgrade when they went from 1G to 2G. The main difference between the two mobile telephone systems (1G and 2G), is that the radio signals used by 1G network are analog, while 2G networks are digital . Main motive of this generation was to provide secure and reliable communication channel. It implemented the concept of CDMA and GSM . Provided small data service like sms and mms. Second generation 2G cellular telecom networks were commercially launched on the GSM standard in Finland by Radiolinja (now part of Elisa Oyj) in 1991. 2G capabilities are achieved by allowing multiple users on a single channel via multiplexing. During 2G Cellular phones are used for data also along with voice. The advance in technology from 1G to 2G introduced many of the fundamental services that we still use today, such as SMS, internal roaming , conference calls, call hold and billing based on services e.g. charges based on long distance calls and real time billing.

3G - Third Generation

This generation set the standards for most of the wireless technology we have come to know and love. Web browsing, email, video downloading, picture sharing and other Smartphone technology were introduced in the third generation. Introduced commercially in 2001, the goals set out for third generation mobile communication were to facilitate greater voice and data capacity, support a wider range of applications, and increase data transmission at a lower cost (Nakajima, 2001).

The 3G standard utilises a new technology called UMTS as its core network architecture - Universal Mobile Telecommunications System. This network combines aspects of the 2G network with some new technology and protocols to deliver a significantly faster data rate. Based on a set of standards used for mobile devices and mobile telecommunications use services and networks that comply with the International Mobile Telecommunications-2000 (IMT-2000) specifications by the International Telecommunication Union. One of requirements set by IMT-2000 was that speed should be at least 200Kbps to call it as 3G service.

4G - Fourth Generation

4G is a very different technology as compared to 3G and was made possible practically only because of the advancements in the technology in the last 10 years. Its purpose is to provide high speed , high quality and high capacity to users while improving security and lower the cost of voice and data services, multimedia and internet over IP. Potential and current applications include amended mobile web access, IP telephony , gaming services, high-definition mobile TV, video conferencing, 3D television, and cloud computing.

The key technologies that have made this possible are MIMO (Multiple Input Multiple Output) and OFDM (Orthogonal Frequency Division Multiplexing) (Roberts, 2006). The two important 4G standards are WiMAX (has now fizzled out) and LTE (has seen widespread deployment). LTE (Long Term Evolution) is a series of upgrades to existing UMTS technology and will be rolled out on Telstra's existing 1800MHz frequency band.

Chapter 3 INTRODUCTION TO 5G

5G is the 5th generation mobile network standard after 1G, 2G, 3G, and 4G networks with a theoretical peak speed of 20 Gbps. It enables a new kind of network that is designed to connect virtually everyone and everything together including machines, objects, and devices, deliver higher multi-Gbps peak data speeds, ultra low latency, more reliability, massive network capacity, increased availability, and a more uniform user experience to more users. Higher performance and improved efficiency empower new user experiences and connects new industries. 5G is based on OFDM (Orthogonal frequency-division multiplexing), a method of modulating a digital signal across several different channels to reduce interference. 5G uses 5G NR air interface alongside OFDM principles. 5G also uses wider bandwidth technologies such as sub-6 GHz and mmWave. Like 4G LTE, 5G OFDM operates based on the same mobile networking principles. However, the new 5G NR air interface can further enhance OFDM to deliver a much higher degree of flexibility and scalability (Björnson E, 2014). This could provide more 5G access to more people and things for a variety of different use cases.

The 5G networking architecture consists of three different network types that will work together in the future, but the three tiers of radio signals have different characteristics;

- **Low Band 5G**

Low band spectrum 5G is best understood as a blanket layer for nationwide coverage. It will be a baseline level of 5G. One low band 5G tower — transmitting on the same frequency that was once used for TV broadcasts — can serve customers within hundreds of square miles, also covering more rural locations.

This baseline tier is already approximately 20% faster than 4G LTE networks. CES® exhibitor and Consumer Technology Association (CTA)® member AT&T was the first to offer low band 5G across 19 cities, and it now has nationwide coverage.

- **Mid Band 5G**

About six times faster than 4G LTE, mid band 5G is likely to be more available in major metropolitan areas of the United States. Mid band 5G offers service within smaller areas compared to low band 5G, and because carriers can allocate more resources in mid band, data speeds are higher than for low band 5G.

For everyday users, mid band 5G may prove to be the ideal tier in terms of performance and proximity to a tower.

- **Millimeter-Wave High Band 5G**

Characterized by extremely low latency and approximately 10 times faster than 4G LTE networks, millimeter wave (mmWave) 5G enables messages to transmit almost immediately, but it requires close proximity to a tower.

The new high band spectrum is what is referenced in applications in Verizon's 5G Innovation Lab as well as in remote health care and more. Because 5G networks operate on a higher mmWave frequency with a wider spectrum bandwidth, it enables higher capacity for transferring data. And the wider the spectrum, the more devices that can join and operate at a faster rate.

Even at its base level, 5G can enable quicker downloads, better communications and improved access to information, making businesses more efficient and powering applications across vehicle technologies, smart cities, education and more (Ces, 2020).

5G brings a wider bandwidths by expanding the usage of spectrum resources, from sub-3 GHz used in 4G to 100 GHz and beyond. 5G can operate in both lower bands (e.g., sub-6 GHz) as well as mmWave (e.g., 24 GHz and up), which brings extreme capacity, multi-Gbps throughput, and low latency. It is designed to not only deliver faster, better mobile broadband services compared to 4G LTE, but can also expand into new service areas such as mission-critical communications and connecting the massive IoT. This is enabled by many new 5G NR air interface design techniques, such as a new self-contained TDD subframe design. Like 4G LTE, 5G is also OFDM-based (Orthogonal frequency-division multiplexing) and operates based on the same mobile networking principles. However, the new 5G NR (New Radio) air interface further enhances OFDM to deliver a much higher degree of flexibility and scalability and not only does it deliver faster, better mobile broadband services compared to 4G LTE, but it also expands into new service areas, such as mission-critical communications and connecting the massive IoT (P. Schulz et al, 2017). This is enabled by many new 5G NR air interface design techniques, such as a new self-contained TDD subframe design.

5G technology introduces advances throughout network architecture. 5G New Radio, the global standard for a more capable 5G wireless air interface, it covers the spectrums not used in 4G. New antennas incorporates technology known as massive MIMO (multiple input, multiple output), which enables multiple transmitters and receivers to transfer more data at the same time. But 5G technology is not limited to the new radio spectrum. It is designed to support a converged, heterogeneous network combining licensed and unlicensed wireless technologies. This adds bandwidth available for users. 5G architectures is software-defined platforms, in which networking functionality is managed through software rather than hardware. Advancements in virtualization, cloud-based technologies, and IT and business process automation enable 5G architecture to be agile and flexible and to provide anytime, anywhere user access. 5G networks can create software-defined subnetwork constructs known as network slices. These slices enable network administrators to dictate network functionality based on users and devices (P. Schulz et al, 2017).

5G specifications are;

- Up to 10Gbps data rate - > 10 to 100x speed improvement over 4G and 4.5G networks
- 1-millisecond latency
- 1000x bandwidth per unit area
- Up to 100 times number of connected devices per unit area (compared with 4G LTE)
- 99.999% availability
- 100% coverage
- 90% reduction in network energy usage
- Up to 10-year battery life for low power IoT device

5G also enhances digital experiences through machine-learning (ML)-enabled automation. Demand for response times within fractions of a second (such as those for self-driving cars) require 5G networks to enlist automation with ML and, eventually, deep learning and artificial intelligence (AI). Automated provisioning and proactive management of traffic and services reduces infrastructure cost and enhance the connected experience. With the emergence of the fifth generation (5G) wireless networks, not only is the increase in mobile broadband targeted, but also the support of various novel use cases, such as industrial automation, autonomous vehicles, e-health, and Internet of Things together with their requirements leading to highly heterogeneous wireless networks. This requires a re-design of the network architecture to ensure the coexistence of these use cases and guarantee user experience and service requirements. Therefore, 5G networks are highly flexible and supports online learning and autonomous decision making capabilities in a centralized and distributed manner to ensure highly efficient management of wireless and network resources (M. Simsek, 2007).

Chapter 4 APPLICATION OF 5G IN VARIOUS FIELDS

5G is the next evolution of cellular networks and 5th generation wireless technology. 5G will be able to provide download speeds that are 10x faster than 4G, which means that it can support not only your mobile phone but also a number of other devices in an increasingly connected world. 5G will also allow for more robust connections between IoT devices and their corresponding networks, making 5G one of the most important technological advancements in logistics history.

5g in logistics

Logistics refers to the process of coordinating and moving resources- people, materials, inventory and equipment- from one location to storage at a desired destination.

The Effects of 5G on Logistics

5G will play an integral part in the logistics industry as it becomes the primary communication method with vehicles. 5G speeds will allow for a more efficient transportation system between 5G-enabled vehicles and 5G-enabled roadside units.

This will reduce delays and improve traffic flow by reducing the time it takes to send messages back and forth. 5G speeds also provide better security in that they are immune to hacking attacks due to their encryption process. The increased bandwidth afforded by 5G networks has many benefits within logistics industries as well .

The proliferation of 5G technology will have a significant impact on how businesses operate across most of the logistics sector. It’s predicted that 5G will result in these effects:

- 5G networks will allow for a whole new intuitive logistics and transportation level, such as better inventory management and fleet management.

• A major benefit of 5G networks in the logistics industry is that they will produce better supply chains. That means it will be easier than ever before to track an item from point A to point B – whether or not they're located across oceans. 5G networks should also improve parts tracking and inventory management, leading to fewer out-of-stock items.

• 5G technology will make sending urgent or time-sensitive freight easier with greater accuracy than ever before. It is thought that 5G connectivity may lead to lower fuel consumption which should be suitable for everyone involved .

<u>5g in medicine</u>

The need for new approaches to the provision of remote healthcare and to ensure health services are responsive and adaptable was dire especially during the previous pandemic. Being faster and more reliable, 5G will enable significant progress in telemedicine and thus improve access to healthcare for the greatest number of people. The effect of 5g use can be seen in the following areas, in regards to medicine [2].

- Facilitating teleconsultations

5G provides a better connectivity standard than previous generations of mobile networks, which will enhance remote consultations thanks to the higher quality of video feeds and the high speed at which physicians will be able to retrieve information from connected devices—such as blood pressure, detailed photographs, weight, etc.

Moreover, the capacity to exchange high-definition content quickly and securely (e.g., from scanners, MRIs, etc.) will further support teleconsultation and multidisciplinary consults between institutions [2].

- Contributing to the development of remote surgery

With data or results that will ensure better image quality and more fluidity, 5G will enable surgeons with connected automated arms to operate on patients remotely around the world

- Improving patient follow-up

Patients returning from the hospital will benefit from closer follow-up at home, as 5G will facilitate data transmission from connected devices in the homes of patients, the elderly or sufferers of chronic diseases. Such devices may include small glucose monitors, wireless blood pressure sensors or connected scales. The data collected will be sent directly to doctors, who can remotely adjust treatments, give advice or ask patients to make new appointments.

Thus, by improving connection speed, network reliability and inter-device connectivity, 5G will support the development of the various aspects of telemedicine and facilitate its use by healthcare professionals and patients [2].

5g in manufacturing

5G networks offer manufacturers and telecom operators the chance to build smart factories and truly take advantage of technologies such as automation, artificial intelligence, augmented reality for troubleshooting, and the Internet of Things (IoT).

With 5G, operators can create new revenue streams. Alongside energy and utility, manufacturing represents one of the most significant sectors for new revenue potential for operators addressing industry digitalization with 5G technologies

5G technologies provide the network characteristics essential for manufacturing. Low latency and high reliability are needed to support critical applications. High bandwidth and connection density secure ubiquitous connectivity. These are requirements that manufacturers currently rely on fixed-line networks. The mobile 5G technology will allow for higher flexibility, lower cost, and shorter lead times for factory floor production reconfiguration, layout changes, and alterations.

Ways 5g will impact manufacturing.

- Enhanced Data Collection

The companies in the manufacturing industry are increasingly using organizational data to draw valuable insights to boost operational intelligence. The usage of data analytics in the manufacturing industry is not new. The organizations derive considerably high ROI through big data analytics, from improving manufacturing processes through advanced analytics, to ensuring quality assurance with thousands of tests for predictive analysis.

- Increased Automation

The ultra-computing capabilities afforded by 5G will enable manufacturers to design robots that benefit from increased data integration and real-time decision making. E.g. the auto manufacturing industry has already started using collaborative robots/cobots to complete tasks such as reaching into tight spaces and working in dangerous conditions/positions that are not suited for humans.

- Supply Chain Unification

Digitalizing the modern manufacturing unit, introducing a greater degree of automation and the advent of smart devices is the focal point of the fourth industrial revolution. 5G in manufacturing industry enables supply chains to transition from a series of independently managed locations to an increasingly connected network of devices that share knowledge in real-time. As manufacturing units become smarter with the integration of smart devices, 5G in manufacturing industry enables advanced communication capabilities between devices, unifying the production process.

5g in agriculture

5G, the next generation of connectivity, promises ultrafast speeds and near-real time response. One bright spot is in agriculture. IoT devices and sensors used on farms and crop fields could get a real boost from the near real-time speeds that 5G networks offer.

5G will greatly aid how farmers digitally transform ways of working. Smart farming and precision agriculture are highly dependent on IoT devices to support communication between data from the field and smart devices used for farm management.

Smart devices and sensors can help farmers increase yields and increase efficiency, but require immense resources and data speeds. With more devices and data, it will be challenging even for some 4G networks to cope. 5G can overcome this, providing real-time, high-speed communications among these sensors and devices. This could be a watershed for precision agriculture; here is how

Access to greater connectivity and more possibilities — farmers can implement a broad suite of technologies that are able to work in tandem, such as mobile apps, automated equipment, drones, sensors and data transmission.

Faster two-way communication and more accurate field operations by sharing data more quickly and efficiently. This data provides farmers with important information to relay to veterinarians or nutritionists, and keeps them well-informed of potential health problems on the farm.

Ability to make faster and better decisions while improving machine performance for greater productivity, efficiency, and yields. This has been targeted to optimize the performance and efficiency of smart agricultural devices, through the ability of 5G technology to seamlessly transmit and process data as well as improve the control accuracy of drones and robots.

The benefits of 5G-enabled smart farming will also have broader positive effects that will be transferred to the global food system. The collective ability of farmers to produce more food more efficiently may be how the world feeds the global population, which will hit nine billion by 2030 according to projections by the United Nations.

5g in autonomous driving.

Automated driving is the term used to describe a scenario where a fully interconnected and intelligent road transport system is created as a result of these capabilities.

Enabling an even faster connection between transport systems, the 5G network will offer new application options advancing the development of autonomous cars. Not only will they be able to make autonomous decisions in the future, they will also communicate and cooperate with each other.

Safety aspects are of course also a focus of attention for driving a car. In addition to the 4G capabilities, 5G offers special features for safety-relevant requirements that no other wireless network can provide.

Automated systems reach their limits when unexpected or unknown situations occur. In such a case an "autopilot" will decide to deactivate the system for safety reasons, if in doubt. An automated car would then return the task and responsibility of driving to the human driver. However, if the vehicle is not taken over by the driver, or not as quickly as required, then the car will be moved to the roadside in a secure driving mode.

With 5G, the car could, for instance, be controlled remotely by an external operator acting as traffic controller. The remote control through an operator is, however, definitely impossible without a 5G network, which offers key features such as very short response times and guaranteed network resources .

Benefits of 5G for autonomous driving

One huge benefit of 5G is what is known as network slicing. The wireless network is subdivided into virtual network levels. One network level is then used only for automated driving, for instance. This ensures that safety-relevant notifications to self-driving cars will not end up in a traffic jam on the data highway and will be given priority over other infotainment services used in parallel.

Another benefit is the data processing and storage in data centers that are in close proximity to the transport routes. Such "edge" data centers ensure that data can be processed even faster in the network.

Sensors are used to implement car-to-car communication for automated driving. This includes, for example, intelligent camera systems, which enable the direct exchange of data between the cars. These systems have crucial physical disadvantages, however. They can neither look around corners, nor over hills, nor through obstacles. This is why they restrict the functioning of self-driving cars. This simple form of automation is also unsuitable at higher speeds.

This is where the 5G network offers another huge advantage. The mobile technology expands the scope of autonomous mobility through direct and, above all, fast and broadband data communication with cars and an appropriately equipped transport infrastructure, such as traffic lights. This can ensure improved traffic flows, for example by enabling cars to travel at higher speeds or reducing their speed in good time when necessary [5].

Chapter 5 PROBLEMS FACING 5G

- 5G network development

When moving from 3G to 4G we had an advantage of reusing the old cell towers from the previous generation of mobile communication technology. 5G however is very different from 4G. It utilizes millimeter and other short wavelength ultrahigh frequency ranges that drastically reduce its range. These smaller, high frequency waves ensure high transmission speeds but have limited range, consume more power and are affected by heavy weather such as smog and fog. For 5G to work we need smaller lower (closer to the ground) cell towers. These cell towers are expensive to develop, install and maintain. On top of that they can only be accessed by a limited number of people at a time despite their only being feasible in dense urban centers. The waves also do not penetrate thick vegetation or building walls.

- 2. Costs

Adding 5G network infrastructure components means that more hardware and supporting software are necessary. A microcell costs around $200,000 to set up, while small cells come in at around $10,000 each. The plan for 5G to fulfil its promise is to install 60 small cells per square mile. On top of this are the costs to buy, configure, test and manage networks – and of course, those networks will need to be maintained and continuously updated. At an ever-increasing cost as user needs increase and internet costs plummet.

- 3. 5G issues with backhaul

When we moved from 3G to 4G providers had to upgrade their cell sites to rely on fibre-optics and high capacity microwave . This investment has paid off very well in the 10 – 12 years it has been in service. With 5G offering speeds of upto and exceeding 1Gbps and the advent of microcells, operators need a way to carry all this data to their switching centers. He old 4G infrastructure could be used but the micro cells involved in 5G are so small and very high bandwidth that 4G backhaul is not enough. This calls for the laying of more fibreoptic cables in mosty urban environments which is challenging.

- 4. Wave spectrum

Challenges with 5G include the ability to provide the necessary bandwidth to users with the devices capable of higher data rates. Using a frequency above six gigahertz enables networks to do this. However, high frequencies entail problems with 5G. For starters, its range is short, which again, is why multiple small cells are needed to cover an area. Trees, buildings and other objects can obstruct signals, requiring cell towers to avoid signal path loss. . By implementing more antennas, a massive MIMO network resists signal interference and jamming. However, line of sight will still be a 5G problem when high frequencies are involved, so most likely, we will need to get used to more base stations on top of roofs.

- 5. 5G security concerns

Like all networks, 5G is ridden with security concerns. Most of them have been addressed by the various protocols available for 5G but there is one glaring problem. There are multiple towers in small dense urban areas. This increases the network edge which in turn increases the attack surface.

The various components involved in 5G are spread over large distances, this makes physical routine inspection and security difficult. This leaves them vulnerable to physical attacks.

5G doesn't change the fundamentals of security. The difference now is, lapses in security for 5G mobile wireless networks can have catastrophic results – think autonomous driving and remote surgery.

This flaw is addressed by 5G network slicing, which enables operators to divide their 5G telecom network infrastructure into smaller portions. These portions are devoted to specific use cases. Examples include automotive, healthcare and critical infrastructure. (Network essential components, Nd.)

<u>How does 5G affect the environment?</u>

Like many technological advancements, 5G can affect the environment positively and negatively. Let’s start with the positive.

- ✓ 5G can help reduce energy consumption.

Combined with the Internet of Things (IoT), a 5G network will allow devices to come on and turn off automatically when they’re being used. Meanwhile, appliance sensors, transportation networks, buildings, factories, street lights and homes can monitor and evaluated their energy needs and consumption in real time and optimize their energy use on the spot.

- ✓ Reduced greenhouse gas emissions

If 5G networks reduce energy use, greenhouse gas emissions will be decreased as well. For example, GE’s Digital Power Plant Software could lower carbon emissions by 3% and fuel use by 67,000 tons of coal annually. An Ericsson study forecasted that IoT could decrease carbon emissions 15% by 2030.

- ✓ Additional energy sources

If a city’s main grid were to falter, 5G and IOT could bring micro grids online, making it easier to use intermittent renewable energy sources like wind and solar into the grid. The Columbia Climate School noted that Massachusetts-based Ameresco replaced its old steam plant with an automated plant that 20,000 solar modules and its own micro grid supported at the U.S. Marine Corps Recruit Depot on Parris Island, S.C. The new systems decreased the company’s energy use by 75 percent.

- ✓ Less vehicle emissions

Technology helped a lot of businesses keep running during the COVID-19 pandemic. Reliable wireless connectivity allowed workers to keep in touch through videoconferencing platforms like Zoom. Not only can 5G make out-of-office communication possible, but it reduces the need for as many people to drive to the office or fly for business trips. More people conducting business from their homes can mean less greenhouse emissions from vehicles and airplanes.

Meanwhile, if someone has to drive, 5G can still help the environment. Sensors and cameras that operate on a 5G network can use real time data to keep traffic moving and change stop lights to prevent delays. Less traffic congestion and idling helps keep reduce fuel usage and vehicle emissions.

How can 5G be harmful to the environment?

With many new technologies, there is a downside and 5G is no exception. Although a number of ways 5G could save energy have already been shared, it is possible that it could lead to more energy consumption and emissions

- ✓ Power consumption

Meanwhile the number of IOT devices around the world could total 125 billion by 2030. If those forecasts are correct, information technology would make up 20% of all of the global electricity consumption and generate 14% of worldwide greenhouse gas emissions by 2040. It's all the more reason why any system put in place needs to be energy efficient. If not, 5G will do more environmental harm than good.

- ✓ New network, new products, more e-waste.

Some of the newly released cell phones are 5G enabled, but a lot of users will likely need to purchase a new device if they want 5G access. The surge to buy new 5G mobile phones could lead to more greenhouse gas emissions. Additionally, making more IoT devices, phones and small cells will lead to more mining and using a lot of non-renewable metals that are tough to recycle. Plus if customers purchase a 5G-enabled phone they'll likely toss their old device unless there's some sort of recycling or buyback program available to them. (Deyton)

PUBLIC OPINION

Public opinion on technology determined the success or failure of lots of technologies. Some good very useful technologies have disappeared due to a negative company image, sabotage via the media and conspiracy theories. In the years following the launch of 5G in the west, public opinion on the technology has sparked debate in twitter and other social platforms.

Some of the topics discussed include:

- ✓ Speed – most people were fascinated by the insane uplink and downlink speeds 5G affords. Folks flocked regions with 5G to test and experience the massive speeds as most people already own devices that support 5G.
- ✓ Security: In addition, another highly discussed topic related to 5G was the security of 5G services. Most of the Twitter users were positive towards the current security of the services for 5G. For example, "5G is more secure than 4G." (Dashtipour, 2021)
- ✓ Performance – the performance of 5G especially in terms of range and reliability in various terrain and weather conditions was a topic of controversy. Most people were disappointed when their devices wouldn't pick up the network when the line of sight was blocked by a

tree a car or a shed. This coupled with reports of shorter ranges and a misconception on the effects of high radio frequencies did not help its case

- ✓ 5G expose users to cancer- There was surprisingly a large amount of people who believed in the myth that 5G causes cancer. This serves as proof of the effects of illiteracy and blind faith in dogma. A good number of tweets, podcasts and even mainstream media covered this story. Some users moved away from areas where 5G towers were installed in fear of the same while in some places towers were outright destroyed.
- ✓ Cost – the cost of mobile internet services has come a long way from dial up to 4G. 5G is a relatively new technology and users must understand and be ready to pay the early adopter "tax" as with all new technologies. Smartphones with 5G are more expensive nad cell carriers charge even more for access to these services. This does not sit well with most of the republic.

Chapter 6 INTRODUCTION TO 6G.

6G, or the sixth-generation wireless communications system, is the successor to 5G cellular technology. It is anticipated that 6G networks will be able to use higher frequencies than 5G networks, enabling higher data rates to be achieved and for the 6G network to have a much greater overall capacity. Lower latency levels will certainly be a requirement (Yang et al., 2019). Overall it is expected that 6G mobile technology will support one micro-second or even sub-microsecond latency communications, making communications almost instantaneous.

In the fastest-growing world, technological innovation and industrial transformation are accelerating. The enhancement of Information and Communication Technology and its various applications like artificial intelligence, virtual reality, the internet of things, and blockchain technology have directed the development of the 6G communication system (Maier, 2021). Considering 5G as a base, the 6G revolution and its growth have a default influence on intelligent communication, including smart connectivity, faster communication, and holographic connectivity. In this paper, we have reviewed existing recent articles related to 6G.

<u>How 6G Works</u>

What will 6G look like?

It is hard to say what 6G will look like—after all, it doesn't exist yet. But in media interviews and research papers, wireless companies and academics describe 6G as a fully integrated, internet-based system that allows instantaneous communications between consumers, devices, vehicles, and the surrounding environment (Maier, 2021). We have the Internet of Things (IoT) with smartphones and smart home devices. Eventually, we could arrive at an all-encompassing Internet of Everything. But that will depend on future developments like 6G and how it works. Here's a rundown of what experts are talking about when they talk about 6G:

- ✓ 1 Tbps speed

Some experts believe that 6G networks could one day allow you to hit max speeds of one terabit per second (Tbps) on an internet device. That is a thousand times faster than 1 Gbps, the fastest speed available today on most home internet networks. It's 100 times faster than 10 Gbps, the hypothetical top speed of 5G (Yang et al., 2019). So, yeah, it's a rosy guesstimate, and we are a long way off from achieving those speeds.

Fundamentally, though, researchers predict that 6G will emphasize extremely high bandwidth and reliability. On 6G, the internet will be instantly and continuously accessible, woven for many of us into the tapestry of everyday life.

- ✓ Terahertz waves

In 2019, the Federal Communications Commission (FCC) opened the gates to a potential 6G future by allowing companies to begin experimenting with what's being called "terahertz waves" or "submillimeter waves." These radio bands fall in the spectrum of 95GHz to 3THz (terahertz) (Maier, 2021). Terahertz waves come at a higher frequency than millimeter waves, which today are being touted as a kind of Holy Grail solution to network congestion and bandwidth limitations. Advanced versions of 5G depend on millimeter wave bands to carry vast amounts of data at ultrafast speeds with minimal response time, making it possible to develop things like automated cars and remote surgeries.

- ✓ Artificial intelligence and edge computing

Automated cars and drones, remote-controlled factories, and other uses of artificial intelligence (AI) have been getting a lot of discussion amid the rise of 5G. The advent of 6G is expected to make this even more of a thing, and some experts think artificial intelligence will be required to keep it all coordinated and running smoothly (Maier, 2021). It is part of an emerging trend called "edge computing," which moves network management away from centralized clouds towards more localized devices, making everything work way smoother and reducing response times.

- ✓ Immersive technologies

Virtual reality is expected to play a big role in 5G. But this is just the beginning. In the 6G era years from now, some experts imagine the emergence of even more immersive technologies, such as cellular surfaces, connected implants, and "wireless brain-computer interfaces."

Chapter 7 APPLICATIONS OF 6G

Super-smart society:

The superior features of 6G will accelerate the building of smart societies leading to life quality improvements, environmental monitoring, and automation using AI-based M2M communication and energy harvesting. The 6G wireless connectivity will make our society super smart through the use of smart mobile devices, autonomous vehicles, and so on. In addition, many cities in the world will deploy flying taxis based on 6G wireless technology (Nayak, 2022). Smart homes will become a reality because any device in a remote location will be controlled by using a command given from a smart device.

Extended reality and Gaming Industry:

Extended reality (hereinafter XR) services including augmented reality (AR), mixed reality (MR), and VR are very important features of 6G communication systems. All these features use 3D objects and AI as their key driving support the true implementation of BCI systems for living a smart life. In Gaming, 6G speed is expected to be 100 times faster than 5G with enhanced reliability and wider network coverage (Ji, 2021). This means that games streaming in the cloud and mobile devices have the opportunity to be far more intricate and complex than ever imagined.

Smart healthcare:

Medical health systems will also benefit by the 6G wireless systems because innovations, such as AR/VR, holographic telepresence, mobile edge computing, and AI, will help build smart healthcare systems. A reliable remote monitoring system in the healthcare system will be facilitated by the 6G systems. Even remote surgery will be made possible by using 6G communication. A high-data-rate, low latency, and ultra-reliable 6G network will help to quickly and reliably transport huge volumes of medical data, which can improve both the access to care and the quality of care (Chowdhury, 2020).

Automation and manufacturing:

Full automation based on AI will be provided by 6G. The term "automation" refers to the automatic control of processes, devices, and systems. The 6G automation systems will provide highly reliable, scalable, and secure communications using high-data-rate and low latency networks (Ji, 2021). The 6G system will also provide network integrity because it ensures error-free data transfer without any data loss between transmission and reception.

Internet of everything:

IoE is the seamless integration and autonomous coordination among a very large number of computing elements and sensors, objects or devices, people, processes, and data using the internet infrastructure. The 6G system will provide full IoE support. It is basically a kind of internet of things (IoT), but it is an umbrella term that integrates the four properties, such as data, people, processes, and physical devices, in one frame. IoT is generally about the physical devices or objects and communicating with one another, but IoE introduces network intelligence to bind all people, data, processes, and physical objects into one system. IoE will be used for smart societies, such as smart cars, smart health, and smart industries (Nayak, 2022).

Haptic Communication:

Haptic communication is a branch of nonverbal communication that uses the sense of touch. The proposed 6G wireless communication will support haptic communication; remote users will be able to enjoy haptic experiences through real-time interactive systems. The superior features of 6G communication networks (Bandi, 2022) will facilitate the implementation of haptic systems and applications.

Five sense information transfer:

To experience the world around them, humans use their five senses of hearing, sight, taste, smell, and touch. The 6G communication systems will remotely transfer data obtained from the five senses (Chowdhury, 2020). This technology uses the neurological process through sensory integration. It detects the sensations from the human body and the environment and uses the body effectively within the environment and local circumstances. The BCI technology will effectively boost this application.

Chapter 8 PROBLEMS FACING 6G

With the expected transition from 5G to 6G, multiple limitations will likely hinder its implementation. They include;

- **Devices capacity.** AI is a key factor in 6G communications, and like every other generation, it will be determined by the capability of user equipment. UE capability thus requires high computational power to execute such AI algorithms. Since such equipment needs more power, it is a significant challenge for companies that build them to make them more efficient (Ahmed & Matin, 2020).
- **Mobile edge computing**. This concept facilitates cloud computing and IT services at the edge of the network to ease users. It is thus needed to reduce latency to the applications and services and save on bandwidth consumption. In the implementation of 6G, issues such as mobile data, session management functions, and computation offloading are crucial for implementing MEC in 6G technology (Nayak & Patgiri, 2022).
- **Advanced network access**. 6G will provide very high data rates but will require a considerable growth of the backhaul capacity. The deployment of VLC and THz communication systems will thus increase the density of access points, supporting high data rate connections for communication. Therefore, 6G has to deal with backhaul networks to help manage the amount of data between access points and the centralized networks (Ahmed & Matin, 2020).
- **Security**. Security is critical in implementing 6G wireless networks, especially in implementing Terrestrial Space Integrated Network (STIN) technology. It thus requires various security modes such as advanced network security coupled with low complexity and high safety standards (Ahmed & Matin, 2020).

- **Terahertz Frequencies**. Recent developments indicate that 6G will utilize frequencies in the THz range and above. Unlike 5G, which doesn't exceed 140GHZ due to challenges such as channel understanding and lack of propagation modeling, 6G will utilize the spectrum beyond that capacity. However, the range of communications and antennae size (Nayak & Patgiri, 2022) influences the scope.

- **Artificial Intelligence**. Mobile wireless communication in 6G will be genuinely AI-driven, i.e., the communication system will be able to route the data. Additionally, federated AI will be able to share the learning process among the objects, i.e., intelligent gadgets will be able to exchange information. As a result, 6G will be even more efficient when quantum machine learning is used. 6G mobile networks, on the other hand, already include these approaches. In addition, most of these methods are still in their infancy (Nayak & Patgiri, 2022). Thus, 6G will confront a new difficulty when using AI in the communication process. The Physical layer, meanwhile, will be helped by artificial intelligence. However, implementing AI is problematic because of the complexity of the physical layer and the limited learning ability of AI algorithms.

- **Interoperability of protocols**. Non-terrestrial and terrestrial networks will be integrated into the 6G network in the future. TCP/IP protocols are not suited for non-terrestrial communication networks, such as satellite communication, because they utilize in terrestrial communication networks. TCP/IP protocols are less efficient because of the high bit error rate, ultra-wide bandwidth, and significant transmission delays; TCP/IP protocols are less efficient. TCP/IP protocol modifications are needed to efficiently enable both terrestrial and non-terrestrial communication networks (Ahmed & Matin, 2020). In addition, the protocols used in these types of networks are different. Protocol interoperability becomes a problem in this scenario.

Environmental factors facing 6G

As a result of the production of the numerous elements needed to build a 6G network, major environmental concerns are involved with its deployment. New gadgets that utilise the 6G network, which is linked to an increase in demand from customers for new 6G-dependent products, will have significant environmental effects..

In today's world, energy use is a major contributor to climate change, and a rise in energy use would have a significant impact on climate change. More devices will be able to connect to the network since 6G uses a higher frequency section of the spectrum. Due to the millimeter waves' lower size compared to radio frequency waves, a wider bandwidth may accommodate significantly greater jobs and more data can be exchanged more quickly (Curran, 2022). Consumers are more likely to acquire and utilize gadgets if they have the option of using many devices on the same network. Increased energy usage will have a negative influence on the environment.

The fact that 6G technology promises to increase the number of devices that can communicate could be the most alarming feature of the new technology. 6G. Environments are put at risk by the manufacturing of cell phones, laptops, and other common electronics. Energy production accounts for 25 percent of the world's greenhouse gas emissions, according to a report by the Environmental Protection Agency (EPA). Carbon dioxide is the primary gas released by this industry, as coal and natural gas are used to generate power (Curran, 2022). In our atmosphere, carbon dioxide is one of the most frequent greenhouse gases. As heat tries to escape into space, it retains it in the atmosphere, resulting in a warming environment.

Another problem with the 6G network is that it requires a lot of tiny cells in order to perform correctly. 6G technology uses millimeter waves that are so faint that tiny cells will need to be positioned about 250 meters apart to ensure continuous connectivity. The manufacture and upkeep of these tiny cells will generate a significant amount of trash. The use of nonrenewable resources in the production of technology and the eventual disposal of that technology in landfills have a significant negative impact on the environment (Curran, 2022). It will have a significant influence on technology waste if these tiny cells are used in major cities where they must be positioned at such high density.

Public opinion on 6G

Marconi's transatlantic radio transmission in the early 1900s marked the beginning of wireless communication. Every element of our life has been transformed since mobile communication became widely available in the 1980s. We're all curious about 6G now that 5G has opened up many new possibilities. As a more powerful next-generation mobile communication technology, 6G has the potential to do more than communicate. (Perspective, 2022)With it, the physical, biological, and cyber world will be joined to lead to genuine Intelligence of Everything, as it will function as a distributed neural network with linkages that enable integrated communication, sensing, and computing capabilities. After 5G, 6G will continue the evolution of linked people and things to connected intelligence. Thanks to this, everyone everywhere will have access to intelligence, opening up a whole new world of possibilities for new products and services.

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