GROUP 4

Second Group Assignment

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Question 2

A) Differentiate the projected 5G and 6G Network generations

5G is the 5th generation mobile network. It is a new global wireless standard after 1G, 2G, 3G, and 4G networks. 5G enables a new kind of network that is designed to connect virtually everyone and everything together including machines, objects, and devices.
5G wireless technology is meant to 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.

6G (sixth-generation wireless) is the successor to 5G cellular technology. 6G networks will be able to use higher frequencies than 5G networks and provide substantially higher capacity and much lower latency. One of the goals of the 6G internet is to support one microsecond latency communications.

Below are the differences between the 5G and 6G network

- **Use of different spectrum :** 5G and 6G use wireless spectrum of higher range for data transmission faster than 4G, 3G, and 2G networks. However, when comparing 5G vs 6G, the former one is allocated for low band and high band frequencies – sub-6 GHz (Gigahertz) and above 24.25 GHz respectively. The latter one will be operative at the frequency range 95 GHz to 3 THz (Terahertz). Since, different spectrum is used, 5G vs 6G technology can have multiple use cases for a variety of industrial sectors to enhance their efficiency.
- **Faster than 5G technology :** Taking into the performance factor, 6G will contribute to higher performance which is far better than newly deployed 5G wireless networks. Operating at terahertz frequency bands, 6G will deliver a peak data rate of 1,000 gigabits/s having air latency less than 100 microseconds. When we talk about 5G vs 6G network speed, 6G speed is expected to be 100 times faster than 5G with enhanced reliability and wider network coverage.
- **6G wireless accelerates IoT after 5G :** Internet of Things (IoT) is becoming a reality today with the implementation of 5G based solutions following extensive 5G network testing which was not possible with previous networks like 4G LTE due to poor planning of frequencies applied. Frequencies used were too narrow and crowded for transmitting data required by smart devices

to give desired results. This is where 5G filled in the gap and moving ahead with 6G we expect to connect ten times more devices per square kilometer with increase in number of connected devices in the upcoming years.

- **Low latency in both G's :** The time taken by a packet of information transmitted over a frequency is known as latency. 4G networks had a latency of about 50 milliseconds (ms) whereas 5G networks had ten times lower latency than 4G i.e., 5ms. With 6G internet, latency will slip down to range 1millisecond to 1microsecond, lowering latency to five times than that of fifth-generation network making massive data transmissions possible in less than a second.

Their differences on a table;

	5G	6G
Spectrum	It is allocated for low band and high band frequencies. That is sub 6-hz and above 24.25GHz respectively	Operates at extremely high frequency range 95GHz to 3THz
Speed	5G network is designed to deliver peak data rates up to 20Gps and much more network capacity	The sixth network generation is expected to deliver peak data rate of 1,000GB
Low Latency	4G networks had a latency of about 50 milliseconds while 5G network had 10 times lower latency i.e a latency of 5ms	The 6G internet is determined to do away with latency by slipping it down to a range of 1millisend to 1microsecond which makes massive data transmissions possible.
Architecture	Dense sub 6 GHz smaller BSs with umbrella macro BSs Mm wave small cells of about 100 meters (for fixed access)	Cell free smart surfaces at high frequencies (mm wave tiny cells are used for fixed and mobile access) Temporary hotspots served by drone mounted BSs or tethered Balloons. Trials of tiny THz cells (under progress)

IOT implementation	The 4G network is too narrow and crowded to transmit data at speeds that smart devices need to function optimally. However 5G network has made IOT implementation possible due to its high speed and capacity	The 6G is aimed to increase the speed of testing and implementation of technology in the smart devices

B) <u>Outline major technological advancements and challenges expected from both 5G and 6G network generations</u>

<u>Technological advancements expected in 5G</u>

- **Advancement of IOT implementation**

Since the conception of IOT in 1999, its implementation has been problematic due to high latency and low network capacity experienced in the previous technologies. However, %G is expected to make the implementation of IOT more possible because of its low latency and high network capacity which eliminates the biggest limitations to IOT expansion. As a result, 5G and IOT gives a nearly real-time ability to sense and respond which is expected to impact nearly every industry and consumer.

- **Broadband-Like mobile services**

Many smaller communications service providers, intend to deploy 5G mobile networks that will deliver broadband-like services, such as high-definition streaming video without dreaded buffering. With a vastly increased network capacity, 5G is also predicted to reduce slowdowns during usage spikes—for example, sports fans can still stream during the big game.

- **Virtual reality and augmented reality**

As a result of low latency factor and high computing efficiencies, 5G will revolutionize and create an impressive future for the HD gaming experience. Every piece of data, inclusive of processing, storage and fetching will be done directly from the cloud, hence significantly increasing the speed.
The augmented reality lets you encounter all the machine details and its functionality without screwing it on and off. With 5G augmented reality googles, it becomes easier for a technician to witness repair parts and get an idea of how to repair them.

<u>Technological advancements expected in 6G</u>

6G aims at making it possible to access multiple high-end services seamlessly and instantly in real time. Even though this technology will require powerful devices and batteries, it aims to enhance the energy efficiency of the Telkom network by 2 times in comparison to 5G.

- **Machines AS primary user**

Unlike 5G which aims at boosting the mobile human users experience along with facilitating M2M interaction, 6G is designed by targeting machines as the primary users. This is backed up by the measuring information society report which showed that the number of global connected devices has already surpassed human population.
The optimal data rate and minimal latency delivered by 6G will boost the functionality and performance of many connected devices and machines, robots, drones, driver-less vehicles, smart displays, home appliances, and devices with smart sensors. Also, the wireless network will enable human users to access the next-generation mobile devices like high-fidelity holograms, augmented reality AR glasses and virtual reality headsets seamlessly.

- **AI-driven wireless communication tools**

6G will transform wireless communications by leveraging artificial intelligence by leveraging the practical applications of artificial intelligence. This will help the telcos to improve operational efficiency by determining the best location for base stations, make the networks consume less energy, and manage complex networks automatically.

- **Personalized network experience**

6G will use OpenRAN as a mature technology unlike 5G which leverages OpenRAN as young and evolving technology. Open radio access network, openRAN, is a technology that makes hardware and software components produced by different vendors to interact with each other seamlessly over open and interoperable network. The AI-driven RAN will enable mobile network operators to deliver personalized network experience to the users on the real-time user information collected from various sources

<u>Challenges expected from both 5G and 6G</u>

- 6G uses cell-less architecture and multi-connectivity.in cell-less architecture, the user equipment connects to the RAN and not a single cell. The challenge here is to design the new network architecture.
- 6G uses Terahertz frequency for some of its communications. The THz signal is very sensitive to shadows which has great impact on coverage. Additionally, lower frequency terahertz frequency requires ultra-large-scale antenna which requires an extremely high bandwidth and massive quantitative resolution.
- In order to manage large number of terminals and networking equipment’s more efficient and less energy consuming 6G system is a must. In order to fulfill this, network and terminal equipment’s circuitry and the communication protocol stack design is a challenge.

C) **Describe major technologies/industries which will better their service delivery when 5G network generation is fully implemented**

As 5G edge computing becomes more common, industries will be able to dramatically scale up their use of data and act on insights faster—often instantly and automatically.
Here are some of the industries/technologies which will better their service delivery when 5G network generation is fully implemented.

- **Healthcare**

5G healthcare use cases will enable doctors and patients to stay more connected than ever. Wearable devices could alert healthcare providers when a patient is experiencing symptoms—like an internal defibrillator that automatically alerts a team of ER cardiologists to be ready for an incoming patient, with a complete record of data collected by the device.

- **Retail**

For 5G retail applications, the customer experience will be everything. Stores of tomorrow may no longer look like today's aisles of stocked shelves. Imagine a store that's more like a showroom—one that lets you add items to a virtual cart rather than shopping with a physical one.
Stores may also use 5G to manage inventory and stocking in real time. Consumers could even see changes like cashierless stores that simply track what you put in your cart in lieu of the traditional checkout line.

- **Agriculture**

Farms of the future will use more data and fewer chemicals. Taking data from sensors located directly in fields, farmers can identify with pinpoint precision which areas need water, have a disease, or require pest management.
As wearables become less expensive and 5G makes it easier to scale networks containing large numbers of IoT devices, health monitoring for livestock may also emerge. With more accurate health data, farmers can reduce the use of antibiotics without compromising the safety of the food supply.

- **Manufacturing**

Factory floors will be totally transformed by the convergence of 5G, AI, and IoT. Beyond predictive maintenance that helps control costs and minimize downtime, factories will also use 5G to control and analyze industrial processes with an unprecedented degree of precision.
With the connectivity boost provided by 5G, manufacturers can also change traditional quality assurance processes, streamlining them with sensor technology and AI.

- **Logistics**

In shipping and logistics, keeping track of inventory is expensive, slow, and difficult. 5G offers the potential for greater communication among vehicles, as well as between vehicles and infrastructure itself.
Fleet monitoring and navigation will become significantly easier at scale with 5G. Driver navigation could potentially be powered with an augmented reality system that identifies and flags potential hazards without diverting a driver's attention away from the road.

- **Transport sector**

Through both vehicle-to-vehicle and vehicle-to-infrastructure connections, IoT innovations that will change the way we navigate road, rail and sea, could become a reality. Using data such as live traffic updates and passenger numbers, connected bus stops could help users choose the quickest and most comfortable route to work. Whilst on the bus, a user could connect to the free Wi-Fi and start working or finish last night's box set.

QUESTION 4

A) Outline the meaning of cloud computing.

Cloud computing is the on-demand availability of computer system resources, especially data storage (cloud storage) and computing power, without direct active management by the user. Large clouds often have functions distributed over multiple locations, each location being a data center. Cloud computing relies on sharing of resources to achieve coherence and typically using a "pay-as-you-go" model which can help in reducing capital expenses but may also lead to unexpected operating expenses for unaware users

B) Differentiate cloud computing from quantum computing.

Cloud computing can be defined as delivering various services like data storage, servers, networking, and databases through the internet. Quantum computing is a type of computation that harnesses the collective properties of quantum states, such as superposition, interference, and entanglement, to perform calculations. The devices that perform quantum computations are known as quantum computers.

C) Suggest areas which have/can benefit from cloud computing and from quantum computing systems.

1. Cryptography

The most common area people associate quantum computing with is advanced cryptography. The ordinary computers we use today make it infeasible to break encryption that uses very large prime number factorization (300+ integers). With quantum computers, this decryption could become trivial, leading to much stronger protection of our digital lives and assets. Of course, we'll also be able to break traditional encryption much faster.

2. Aviation

Quantum technology could enable much more complex computer modelling like aeronautical scenarios. Aiding in the routing and scheduling of aircrafts has enormous commercial benefits for time and costs. Large companies like Airbus and Lockheed Martin are actively researching and investing in the space to take advantage of the computing power and the optimization potential of the technology

3. Data Analytics

Quantum mechanics and quantum computing can help solve problems on a huge scale. A field of study called topological analysis where geometric shapes behave in specific ways, describes computations that are simply impossible with today's conventional computers due to the data set used. With quantum computing this can be boiled down to relatively simple calculations.

NASA is looking at using quantum computing for analyzing the enormous amount of data they collect about the universe, as well as research better and safer methods of space travel.

4. Forecasting

Predicting and forecasting various scenarios rely on large and complex data sets. Traditional simulation of, for example, the weather is limited in the inputs that can be handled with classic computing. If you add too many factors, then the simulation takes longer than for the actual weather to evolve.

Nearly 30% of the US GDP is affected by weather in some way or another, and being able to more accurately forecast it would have great economic benefits.

5. Banking sector

Quantum computing has gained popularity in the banking and finance services business, aimed at accelerating trade operations, transactions, and data processing by orders of magnitude. In a data-heavy environment, ever-more-powerful computers are required to effectively calculate probability. With this in mind, some banks are turning to a new breed of computers that use quantum physics principles to crunch massive quantities of data at high speed.

6. Healthcare

Quantum computing has the potential to enhance medical image analysis, as well as processing stages like edge detection and image matching. These advancements would vastly improve image-aided diagnostics. For quite some time, medical professionals have predicted the potential benefits of quantum computing in healthcare.

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