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Original Article

Analysis of the Feasibility and Constraints of Implementing Next-Technology Mobile Networks in Bangladesh with its Outcomes on Human Body

Md. Shariful Islam[1], Md. Ashek Raihan Mahmud[2], Md. Jashim Uddin[3]

[1,2,3]*Department of Information and Communication Technology, Islamic University, Kushtia-7003, Bangladesh*

[1]*Corresponding Author: afmsi76@ice.iu.ac.bd*

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Abstract *- As the range of customers in the cellular era is increasing at a geometrical rate, the call for and complexity of the provider is rising, making sure within side they want for cellular operators to migrate the provider using difficulty to their core technology to switch extra information with excessive speed. The 5G cell networks are the consequences of this paradigm shift and are currently being deployed in advanced nations regardless of the reality that they might be able to put 6G cell networks in force. However, a maximum of the growing nations in addition to Bangladesh (A middle-earnings country) are, or will be, using 3G or 4G cellular networks of late, for which the general position is not but complete. This study is now exploring how much emphasis can be placed on setting up the 5G cell networks in Bangladesh and the health effect of 4G and upcoming 5G cellular networks. First, take note of the display that there may be the capability for tackling foremost technological demanding situations in Bangladesh while implementing the 5G cellular networks. The numerous protection factors of 5G cellular networks were provided, which is an ongoing hassle, and Bangladesh is technologically ready to deal with many protection issues. At the same time, it has been proven that the context of the usage of 5G networks in Bangladesh is relevant. As a result, the 5G networks in Bangladesh will take place now, not as expected. Finally, the outcomes of using 4G and 5G cellular networks on human health were presented.*

Keywords *- Mobile cellular communication; Mobile cellular generation; EMW radiation; 5G networks; Base Transceiver Station.*

1. Introduction

Bangladesh is now being transformed into Digital Bangladesh, and one of its main objectives is to "Connect the citizens in a meaningful way". Mobile operators strive to construct a virtual society in Bangladesh by allowing connections. Mobile technology has played a key part in achieving the vision-mission 2021 goals which have gained recognition worldwide as a middle-income country. The present government is working to build a digital Bangladesh by utilizing the talents of the huge population of the country [1]. To a large extent, this initiative has been effective and will continue to succeed in many underdeveloped fields in the coming days. However, to achieve this goal, uninterrupted fastest internet connection is mandatory. Internet-based operations have become part of people's daily activities worldwide, including in Bangladesh, such as internet banking, webmail, social network services, online chatting and gaming [2]. The majority of people are using mobile phones/Mobile stations (MS) to get entry to the internet. According to a current survey [3] completed in October 2021, there had been 4.88 billion active internet users worldwide, with 4.55 billion using social media. Cellular gadgets account for over half of all video streaming [4]. According to data, mobile internet use in daily activities has risen by 504% globally since 2011. Cellular internet users are expected to grow at the same rate as cloud computing and storage. Considering the circumstances, the necessity of the world's connection is constantly changing; data usage is increasing. Accordingly, existing technologies such as 3G or 4G networks cannot cover all services [5]. As a result, Internet service vendors preserve to attempt to make present networks pretty scalable, ensuring excessive availability and occasional latency. 5G mobile network is surely had to satisfy the above goal. Table 1 shows some major aspects of 5G networks.

Although installing 5G networks is a tough task for a developing country, some countries are trying to establish a 6G network [6]; it is not so arduous for Bangladesh, despite some barriers, because the country has already progressed to the middle-income category. Table 2 shows when some developing countries, including Bangladesh, started using 4G mobile networks.

Table 1. Some major aspects of 5G networks

Indicator	Description	5G Target	Category
Peak data rate	Downlink: 20 Gbps Uplink: 10 Gbps	20 Gbps	eMBB
Packet latency	20 ms (10 ms encouraged)	1 ms	eMBB, URLLC
Reliability	Maximum packet loss	00001 Pkt/s	URLLC
Mobility	Dense Urban: up to 30 Km/h Rural: up to 500 Km/h	Same as description	eMBB
Connection density	Total number of devices per unit area	1×10^6 devices/Km^2	mMTC
Energy efficiency	Energy consumption (by device or network)	10% of 4G	eMBB
Spectrum efficiency	Throughput per unit wireless bandwidth and per network cell	4 × 4G	eMBB
Area traffic capacity	Total traffic across the coverage area	1000 (Bbit/s)/m^2	eMBB
Coverage	Total network coverage in designated zones	Near 100%	-

Table 2. Time for 4G implementation in developing countries, such as Bangladesh (a middle-income country)

Name of the Country	Deployment Year	Company/ Service Provider
Bangladesh	2018	Grameenphone, Airtel, Robi & Banglalink
Senegal	2018	Orange
Afghanistan	2017	AWCC
Nepal	2017	Nepal Telecom
Uganda	2017	Airtel
Somalia	2017	Somnet
Bhutan	2016	TashiCell

Fig.1 Shows the evolution of mobile generation networks. Every decade since the 1980s, the mobile community has had a new generation of technology. Although 4G networks began to be used in developed countries by 2010, their use in developing countries began several years later, as shown in Table 2.

Setting up a 5G mobile network for the least evolved nations could be a massive chance for mobile operators as the quantity of cash to be invested increases the query of whether or not the cash can be returned. Nevertheless, some least evolved nations use 3G mobile networks [7].

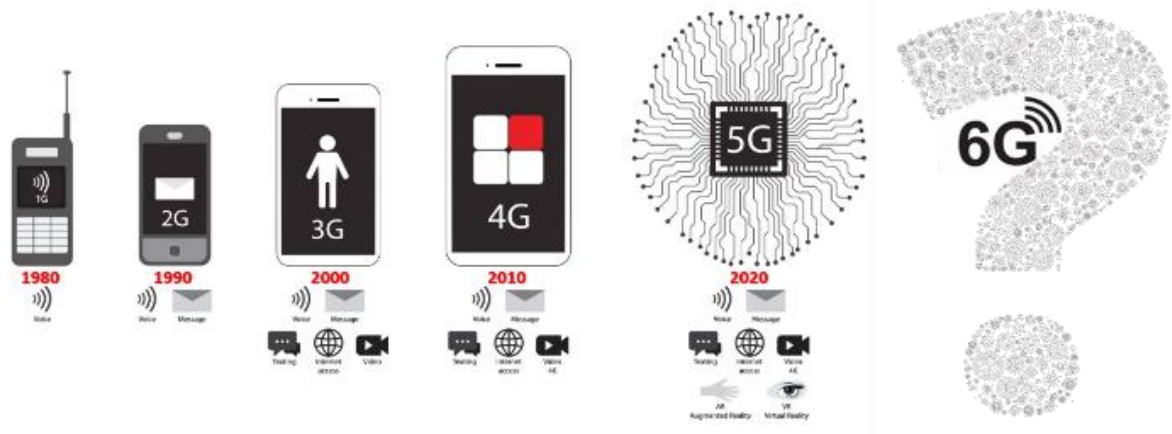

Fig. 1 Evolution of mobile generation networks

Although 4G cellular networks were applied in one's nation, operators/service vendors are reluctant to return their investment. In the case of Bangladesh, the implementation and use of 4G cellular network operators are in the quality degree shown in Table 3[8]. In this report, it is regarded how the Bangladeshi users have done at the four national cellular network operators in Bangladesh-Airtel, Banglalink, Grameenphone, and Robi-over ninety days, starting April 1, 2021, to June 29, 2021. Based on the discussion mentioned above, it could be concluded that the 5G cellular network in Bangladesh, just like the advanced nations, may be applied quickly throughout the current infrastructure.

Significantly higher mobile broadband speeds and increasingly extensive mobile data consumption will be ensured with the forthcoming implementation of 5G mobile/cellular networks. The usage of extra bands of higher frequency allows for this. 5G is designed to be the meeting point of all forms of communication, from virtual reality to self-driving cars to the industrial Proliferation of smart cities. Furthermore, 5G is the foundational Internet of Things (IoT) technology. (IoT),which allows devices to connect with one another (M2M communication). Meanwhile, a shift in human and environmental radiation hazards (EMF) is expected [9]-[11]. Within multiple different frequency bands, the 5G network will operate as shown in Fig 2.

Table 3. Mobile Network Experience in Bangladesh

Video Experience Additional Metrics in 0 – 100 Points				
	Airtel	Banglalink	Grameenphone	Robi
Video Knowledge for 4G	55.19 (±2.10)	65.39 (±2.17)	54.49(±2.62)	51.79 (±2.12)
Video Knowledge for 3G	43.79(±5.03)	43.19 (±4.51)	35.49 (±4.95)	34.09 (±4.10)
Game Experience Additional Metrics in 0 – 100 points				
4G Game Experience	39.19 (±1.28)	47.09 (±2.66)	38.49 (±0.79)	37.49 (±0.95)
3G Game Experience	32.89 (±0.94)	34.29 (±0.61)	31.09 (±0.53)	33.0 (±0.73)
Voice App Experience Additional Metrics in 0 – 100 points				
4G Voice App Experience	69.89 (±1.22)	73.89 (±1.18)	68.79 (±0.84)	67.29 (±1.25)
3G Voice App Experience	62.49 (±2.80)	66.0 (±2.21)	57.89 (±1.90)	59.49 (±2.30)
Download Speed Experience Additional Metrics in Mbps				
4G Download Speed	8.49 (±0.44)	13.0 (±0.54)	8.89 (±0.25)	6.89 (±0.35)
3G Download Speed	4.79 (±0.33)	4.69 (±0.29)	4.19 (±0.22)	3.39 (±0.21)
Upload Speed Experience Additional Metrics in Mbps				
4G Upload Speed	4.0 (±0.23)	4.89 (±0.24)	4.39 (±0.14)	3.79 (±0.18)
3G Upload Speed	1.0 (±0.10)	1.0 (±0.08)	1.0 (±0.08)	0.79 (±0.07)
4G Availability % of time				
4G Availability	80.59	75.19	78.89	79.79
4G Coverage Experience in 0 – 10 points				
4G Coverage Experience	6.59	4.19	7.19	6.59

The development of wireless communication devices that function within the portions of the spectrum with a high frequency has sparked a flurry of health-related analysis [12]. These studies include research on humans (both epidemiology and experimental investigations), animals, and in vitro systems [13]-[16]. Also, their results indicate that RF exposure has been linked to cancer development. The International Agency for Research on Cancer (IARC) categorized RF-EMF as "possibly carcinogenic to humans" (Group-2B). Compared to the current situation, 5G mobile networks and the allied IoT would consider having a lot of wireless equipment, demanding infrastructure with a greater population. As a result, substantially more mobile data volume per geographic region will be generated. Since the higher frequencies have lesser ranges, a higher network density is required. The concern is whether or not employing higher frequencies can negatively affect health. The WHO publishes and approves WHO-recommended exposure levels for general public and workplace exposure in most countries, based on International Commission on Non-Ionizing Radiation Protection ICNIRP [17] or IEEE [18] standards. Such limitations, which consider many safety issues, are set so that the biological material doesn't get too hot (thermal effects). Thus, 10W/m^2 is recommended as the fundamental constraint for 10 GHz to 300 GHz (no thermal impacts), with values as a guideline of 400 MHz to 2GHz (2-10W/m^2) and > 2 GHz (10 W/m^2) for 400 MHz to 2GHz. It should be noted that the existing ICNIRP guidelines [17] are presently being changed, and a new iteration should be available soon. Of course, predicting the real exposures to 5G networks is difficult. On the other hand, the antennas for 5G will have narrow antenna beams width aligned directly to the receiving device [14]. Compared to the current exposure situation, this could potentially result in a large reduction in environmental exposure. However, it is also stated that increasing total EMF exposure in the environment by adding a large number of 5G network components will increase total EMF exposure in the environment, and greater exposure to higher frequencies can have detrimental health repercussions.

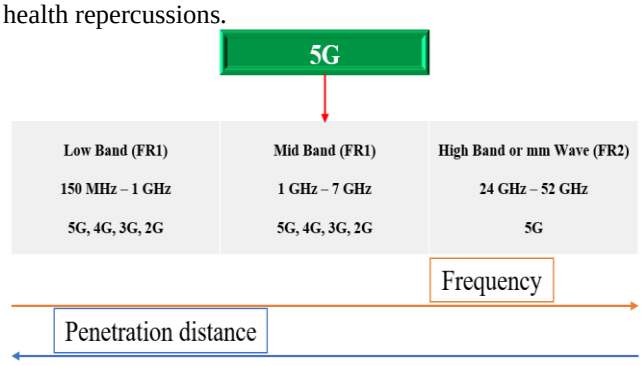

Fig. 2 Radio frequency spectrum of 5G

2. 5G Implementation Ideas

It is expected that the 5G network will work with the existing 4G networks in the beginning and then gradually release in standalone mode. The Fig 3. Shows how a 5G mobile network will work with 4G mobile networks. 5G Radio Access Networks (5G-RAN): The 5G radio access networks overlap macrocells, picocells, and femtocells, as shown in Figure 3a [19]. Its goal is to make it possible for mobile devices to connect to the main core.

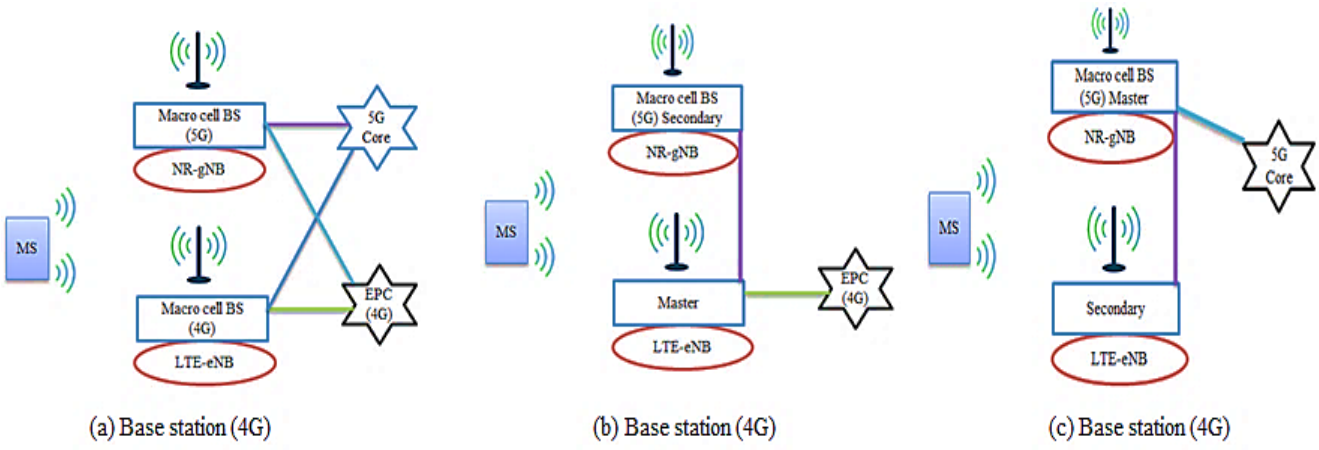

Fig. 3 Procedure of coexisting of 4G with 5G mobile networks (a) 4G eNB master (b) 5G gNB master (c) eNB and gNB coexist together

The 5G macrocell is made up of gNB base stations that use new radio technology to cover a larger region. The new 5G is a more adaptable variant of LTE radios that can also be software configured to accommodate substantially higher data rates. It is, however, still based on OFDM in 5G networks; a novel concept of small cells has been created to provide a continuous connection. Small cells with micro base stations employ the new millimeter wave (mm Wave) frequency. As a result, their connection range (usually 10 m) and coverage area are significantly reduced. They are, however, dispersed in clusters pattern.

MIMO (multiple input, multiple outputs, also known as massive MIMO) antennas, which comprise a huge number of interconnected pieces or links and may function in full-duplex mode, are used in the new radio technology of 5G Macro cells. As a result, the system is highly scalable and can support several users at once.

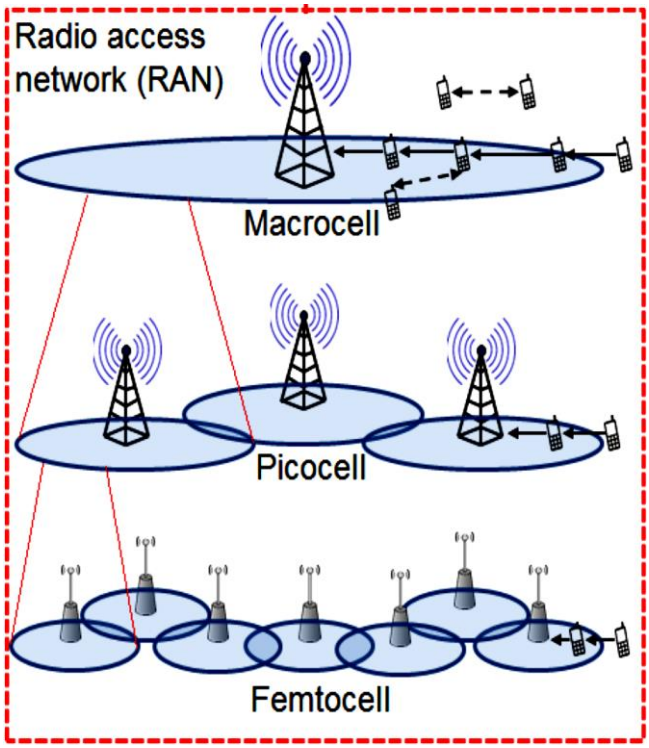

Fig. 3a 5G Radio Access Networks

3. 5G Core Network

5G core network, as shown in Fig 4 [20]. The 5G core, like previous generations, is the network of mobile phone exchange that manages mobile voices. It also houses the data network that manages Internet and cell phone data connections and is reconfigured to interface with cloud-based applications. Surprisingly, the 5G core includes distributed servers scattered across wide geographic regions, allowing the material to be accessible regionally and across a distributed network close to the client's location. Edge computing is enabled via distributed servers, which allows the vast majority of data to be performed at the client's end without overloading the core network. The 5G core also handles two other crucial features: network splitting and network function virtualization. Multiple virtual logical networks independent of one another can be formed on top of the existing network equipment via network slicing. The network slices can then be assigned to a certain application or user. Orchestration is used to pick resources in order to meet service demands in the most efficient way possible [21].

The control features validate consumer-precise provider call for and configuring sources. Depending on the application's requirements, every consumer obtains a unique set of community sources and topologies.

Out of it poses major obstacles. Given the high levels of investment required to establish 5G networks and its reliance on device and app ecosystem compatibility, operators are wary of the financial rationale. In such a scenario, policymakers' actions will make a significant difference in promoting a strong 5G investment case.

The following are some of the most pressing issues:

3.1. The price of the Spectrum

According to a recent study, Spectrum prices are more than three times higher in underdeveloped countries than in affluent countries [22]. The vital characteristics of 5G, such as speed, dependability, and capacity, are mostly due to the addition of new frequency bands. In the business cases of 5G operators, the expense of spectrum and how it is allocated will be crucial.

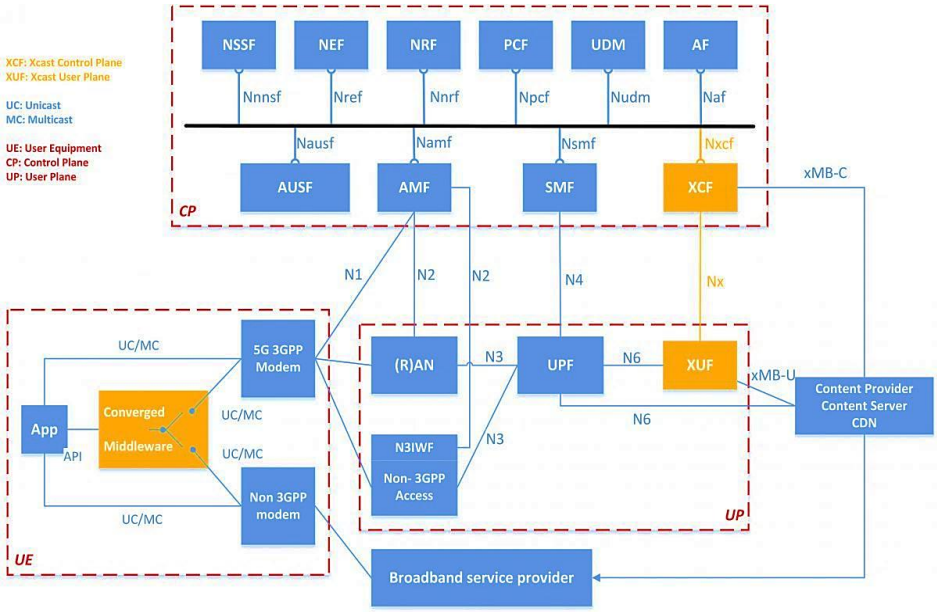

Fig. 4 5G core network

Operators will strive to create a business case for 5G adoption in Bangladesh at the present spectrum price. A lot of cleaning and harmonization is necessary to make the 700 MHz, 3.5 GHz, and 26-28 GHz bands appropriate for 5G rollout. Affordable access to these frequencies and a clear timeline for their availability are critical to stimulating investments in 5G.

3.2. Distribution of Spectrum

5G calls for a massive quantity of spectrum to reap quicker statistics prices and full-size network capacity. A low-frequency band of much less than 1 GHz is required, in addition to a mid-frequency band (within side the 2.3-3.5 GHz range) for macro cells and an excessive frequency band (mmWave within side the 26-100 GHz range) for microcells. Fig. 5 shows a typical use of the cutting-edge spectrum in underdeveloped countries.

It's worth noting that making the necessary spectrum accessible for 5G will include several clean-ups, interoperability, and policy-level initiatives, which may provide additional obstacles. For example, suppose a portion of the spectrum in the required band has previously been transferred to a third party for a different purpose (such as Wi-Max implementation).

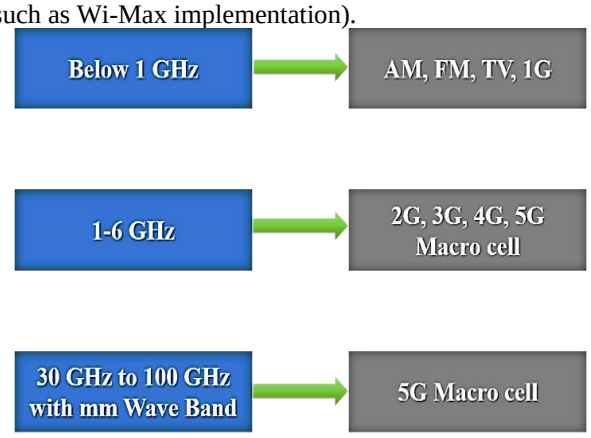

Fig. 5 Spectrum distribution for the developing countries.

In that case, a buy-back option is required, which may not always be viable. It may result in legal ramifications. Furthermore, some parts of the spectrum may have already been given to government agencies, and the regulating authority will have to undergo a lengthy negotiation process to reclaim them.

Infrastructure Constraint: Infrastructure access is one of the most vital parts of assuring 5G coverage and capacity [23]. To achieve 5G capacity and coverage, easy and affordable access to infrastructure (poles and towers, antenna, fiber network) is also critical. As a result, emphasis should be made on reforming some Tower-company and Nationwide Telecommunication Transmission Network (NTTN) laws so that all parties can offer their complementing assets and talents under a unified 5G infrastructure sharing guideline.

3.3. Improved Network Density Comes at a Price

Even though the spectrum is plentiful, the network capacity that can be achieved will be limited if the network density is poor. The network density is determined by the overall number of base stations installed on top of the terrain compared to the population. A higher density necessitates a higher price. The concentration of 5G networks must be substantially higher to sustain the cluster of microcells. This requirement adds to the issue of funding and constructing adequate base stations to assist 5G network coverage [24].

3.4. Spectrum sharing in a Changing Environment

The utilization of cognitive radios is one of the distinguishing characteristics of 5G. This sort of radio can detect and utilize available channels in the neighborhood on the fly. However, this also necessitates establishing a spectrum sharing policy among mobile carriers since otherwise, discovered opportunities will be unable to be utilized owing to a payment issue. Regulatory agencies in

Developing countries normally prohibit spectrum sharing between operators to avoid revenue losses.

4. An Example of 5G Implementation

5G implementation case is shown in Fig 6.

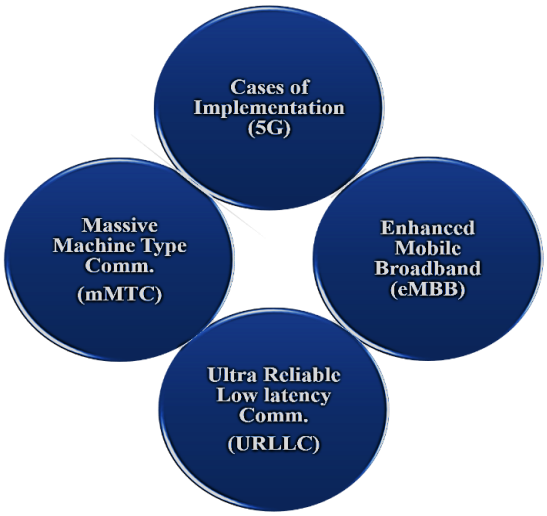

Fig. 6 Different categories of 5G use cases implementation

Consumers will benefit from an improved "Unlimited" mobile experience thanks to eMBB. Consumers can access rich material in more places thanks to superfast 5G networks with peak data rates of >10 Gbps, which will permit live events and high-resolution media streaming. The increased network capacity of 10,000 times above today's networks will accommodate more users, especially in congested regions like huge public events, and provide at least 100 Mbps throughput per user during peak hours. Early 5G deployments will likely focus on eMBB since it can immediately handle the expanding communications needs of a developing digital economy like Bangladesh. The mMTC will enable enormous Internet-of-Things (IoT) implementations, such as asset tracking, smart agriculture, smart cities, energy monitoring, smart homes, and remote monitoring, by enabling the widespread and dense deployment of sensors and other network-connected devices. The mMTC will drastically lower power requirements (battery life of up to ten years) while also providing flexible coverage across many spectrum bands and the capacity to serve over one million devices per square kilometer. The URLLC will advance human-machine interaction by providing sub-millisecond latency and ultra-reliable (one in a million) communications networks that support the delivery of critical communications—playing a role in the technology ecosystem that supports autonomous vehicles, smart grids, remote patient monitoring and telehealth, and industrial automation.

5. Bangladesh Can Benefit From 5g Technologies

The benefits of using 5G mobile networks for consumers, businesses and the government of Bangladesh are discussed below:

The country's 92 million (and growing) mobile broadband customers will benefit from superfast yet inexpensive 5G networks, which will deliver new services and experiences. The first wave of 5G deployments is expected to focus on eMBB use-cases and provide users with an unlimited mobile and home broadband experience, significantly superior to today's 4G and WiFi connectivity. Consumers can access a wide range of data-hungry applications, including HD streaming and gaming, smooth video conferencing and sharing, and augmented reality (AR) and virtual reality (VR) services, thanks to ultra-high-speed and low-latency connections. All of these services are projected to be used in the future. The eMBB services will also assist the country's nascent SME and corporate firms in migrating to the cloud, supporting various cloud-based software, unified communication, and conferencing requirements. Companies in the RMG, pharmaceuticals and FMCG sectors will be able to use the mMTC to implement various assembly line and supply chain automation techniques, greatly increasing their efficiency.

On the other hand, asset tracking, logistics, and worker safety apps will assist organizations in increasing their production. Perhaps the most revolutionary effects of 5G for Bangladesh will be in the government sector. Smart Cities powered by 5G may implement use-cases such as smart parking, smart trash management, smart streetlights, smart public safety, and more, enabling smart decision-making and planning to improve inhabitants' quality of life and productivity. Smart metering, service quality monitoring, fault localization, automation and control, infrastructure management, and demand management are just a few use cases that 5G can provide in Bangladesh. These services can help utilities manage demand and supply and improve customer service.

5.1. Aspects of Security and Threats

The adoption of new technology to achieve the 5G network's envisioned aims has created security challenges. Three main 5G technologies, Software Defined Networking (SDN), Network Function Virtualization (NFV), and Internet of Things (IoT), have identified security risks [2]. While the 5G network presents a large number of security options vulnerabilities, developing countries, including Bangladesh (a middle-income country), lack the resources to combat them. In the past, developing countries have been found to be incapable of dealing with security breaches in other domains. For example, the Bangladesh Bank Robbery [45] in 2016, often known as the Bangladesh Bank cyber heist, is a notable example of undetectable cyberattacks. Security hackers fraudulently transferred $101 million from Bangladesh Bank during this attack. Such incidents clearly call into question the ability to developing countries to deal with security breaches on 5G mobile networks. However, Bangladesh has now achieved a lot advanced in the IT sector. The defense capabilities of the less developed countries regarding the matter may be the main culprits: a scarcity of security professionals, lack of dependable

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6. Health and Environmental Impacts with 5G

Citizens in developed countries like Aspen, Colo; Bern, Switzerland; San Diego, California; and England have protested the deployment of 5G wireless base stations due to concerns about the detrimental effects these network nodes may have on humans, animals, and plants. They raise concerns about the dangers of radio frequency (RF) radiation emitted by antennas close to people. Protesters also pointed there is not enough scientific proof that 5G transmissions are safe, particularly those that broadcast in the millimeter wave section of the electromagnetic spectrum. Mobile devices currently operate at frequencies less than 6 GHz, but 5G will use frequencies ranging from 600 megahertz to over 600 megahertz, including millimeter wave bands between 30 GHz and 300 GHz. Because of the widespread worry over 5G, some communities have decided to cancel or postpone the installation of base stations. Most of the concerns about 5G's alleged harmful influence on health originate due to the reason that its cell towers are so dissimilar from those supporting today's 3G and 4G cellular networks, according to Waterhouse. Those towers are spaced kilometers apart and atop towering, elevated structures normally found far from inhabited areas. A 5G base station may be placed almost anywhere, even on top of light poles, streetlights, and rooftops, because it is smaller than a rucksack. That implies the stations will be close to homes, apartments, schools, stores, parks, and farmers. The exponential growth in cell data demand would allow the 5th generation (5G) broadband network to use unprecedented power of transmission in the millimeter-wave (mm-Wave) frequencies [27]. Dr. Pall's research into the biological impacts of EMF radiation provides vital information regarding how EMF radiation affects our body, as shown in Table 4.

Table 4. Impact of EMF on human health

Health Effects (Short-Term)	Health Effects (Long-Term)	Sensitivity due to Electrical
Insomnia	Cancers	Sleeping Problems
Aches and pains	Brain Turners	Cognitive impairments
Headaches	Segmented DNA	Memory loss
Reduce sperm motility	Cells Mutated	Brain Fog
Burring Sensations	Neurological	Anxiety and Mood
Anxiety, Stress, Irritability		

The vast majority of people's publicity to ionizing radiation takes place from herbal reasserts, Cosmic rays, and radiation from the ground [28]. As previously stated in the prior parts, 5G technology is targeted on the excessive frequency spectrum, i.e., millimeter wave spectrum; it is vital to investigate the conduct of the similar throughout the human body. Certain characteristics of mm-wave indicators affect human body parts, such as the millimeter wave can easily be absorbed by human pores and skin within 1~2 millimeter. The cornea, the most visible component of the iris, can also absorb radiation. Nerve endings are linked to the skin, allowing radiation to reach our frightened DNA system [29].

6*.1. 5G Radiation Contains Carcinogens*

In 2011, the International Agency for Research on Cancer (IARC) classified RF radiation as a possible human carcinogen. An IARC Monographs Working Group examined epidemiological evidence, cancer bioassays, and mechanical and other relevant material to conclude the carcinogenic risk to humans from exposure to electromagnetic fields emitted by 2G, 3G, and 4G handsets, as well as base station radiations [30]. Furthermore, long-term exposure to mobile phone frequencies has increased the risk of brain cancers in humans and animals [31]. Nonetheless, 5G's usage of high-band spectrum, beam forming, and MIMO techniques, as well as a large amount of radiation, may cause cell mutations, which can lead to cancer and tumors, compared to previous systems. Low-intensity radiofrequency radiations (RFR) have oxidative effects on living cells, including an increase in reactive oxygen species levels (ROS) [32]. Reactive oxygen species are chemically reactive oxygen-containing substances that function in cell signaling. Excessive production of reactive oxygen species (ROS) that is not counterbalanced by endogenous antioxidants (superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx), glutathione (GSH),

melatonin) or exogenous antioxidants (Vitamin C, Vitamin E, carotenoids, polyphenols) results in the formation of free radicals that oxidize and destroy DNA, proteins, membrane lipids and mitochondria as shown in Fig 7 [33].

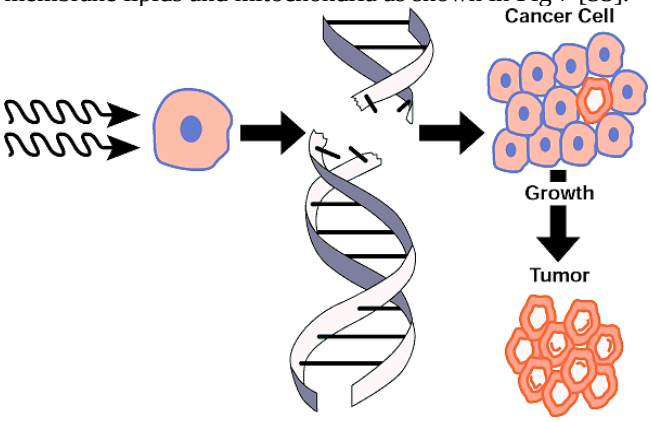

Fig. 7 Radiation effects on Cell

6.2. Impact of 5G radiation, including LTE, on Pigmented Human Skin model

Radiation effects may heat the skin, while heat-generating effects may change the temperature distribution [34]. 5G uses MIMO antennas and beam forming techniques. As the number of towers grows, the number of beam-forming antennas pointed at a single user via a highly directional beam may become hazardous. The outer epidermis and underlying dermis of human skin have thicknesses ranging from 0.06 to 0.1 mm and 1.2 to 2.8 mm, respectively. The relative permittivity of the skin falls as the frequency increases, whilst the conductivity increases. Even at non-thermal levels, low-intensity millimeter microwave induces many biological changes, including cell membrane impacts. Data may be transmitted in bursts of a few milliseconds to seconds using extreme broadband wireless devices operating over 10 GHz. Even if the time- and area-averaged power density levels for continuous exposure are within acceptable safety limits, these bursts may cause brief temperature increases in exposed people's skin. Transient exposure to high PAR (peak to average power) can cause substantial temperature fluctuations in the skin, with peak temperature spikes in the tens of degrees, exceeding tissue damage thresholds after brief exposure times. Wireless instruments emitting radiofrequency (RF) radiation, big radar installations, and medical equipment can raise body core temperature or induce localized temperature rises, which can have negative health consequences. The current exposure standards (ICNIRP 1998; IEEE 2005, 2010) define limitations for frequencies above 10 MHz to limit tissue heating. Limits are specified in terms of time-averaged values since exposure is typically transitory and pulsed rather than continuous. The International Council on Non-Ionizing Radiation Protection (ICNIRP) recommends an averaging duration of 68 fG - 1.05 min (where fG is the frequency in GHz), while IEEE recommends 19.63fG - 1.079 min for frequencies less than 30 GHz and 2.524fG - 0.476 min for frequencies greater than 30 GHz. The average duration was calculated using the in vivo temperature time for development constant. Fig. 8 depicts a temperature fluctuation during a single oscillation period. Short pulses, on the other hand, can cause major temperature oscillations, which are compounded at high frequencies (>10 GHz, fundamental to 5G), where the shallow penetration depth causes intense surface heating and a steep, rapid temperature rise (e.g., proportional to sqrt(t) for plane-wave exposure) [35].

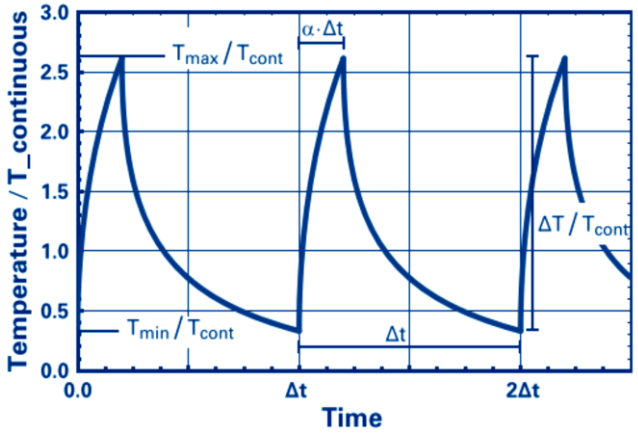

Fig. 8 Transient Temperature oscillations caused by a pulse train that resulted in a 1K temperature increase with continuous exposure

Melano Derm™ is a pigmented human skin model that has been extensively used to explore the physiological mechanisms of skin pigmentation. It reveals in-vivo-like morphological properties of the human epidermis and has usually been utilized to study the physiological mechanisms of skin pigmentation. It also usually grows more pigmented as the days go by in the cultivation process. In terms of visual judgment, there was no difference (Figure 9A) or image analysis for brightness after 5 days of continuous exposure to LTE at 8 W/kg (Figure 9B). On the last day of the experiment, the tissues were stained with hematoxylin and eosin (H&E) and Fontana–Masson (FM) melanin stain, confirming that there was minimal difference between the control and the LTE-exposed sample (Figure 9C). It was subjected to 5G at 10 W/m 2 for 5 days to confirm the effect of 5G on skin pigmentation. In visual inspection (Figure 9D) and image analysis for brightness, the results revealed no significant changes in pigmentation (Figure 9E). The amount of melanin was not enhanced according to H&E and FM staining (Figure 9F) [36].

6.3. Eye Repercussions

The radiation impacts are much stronger than older technology obligations to massive MIMO and beam shaping techniques, while the transmitting signal power is much lower [44]. A cataract is a clouding of the eye's lens that causes vision loss. The eye's tissues will be in direct touch with the radiation during the near-field exposure of a 5G antenna. As a result, the risk of cataracts will rise. Microwave radiation is also a well-known cause of cataracts, with heat as the primary mechanism. The eyes may not have enough blood flow to disperse heat adequately. As illustrated in Fig. 10, there is some evidence that repeated low-level microwave radiation exposure can develop cataracts.

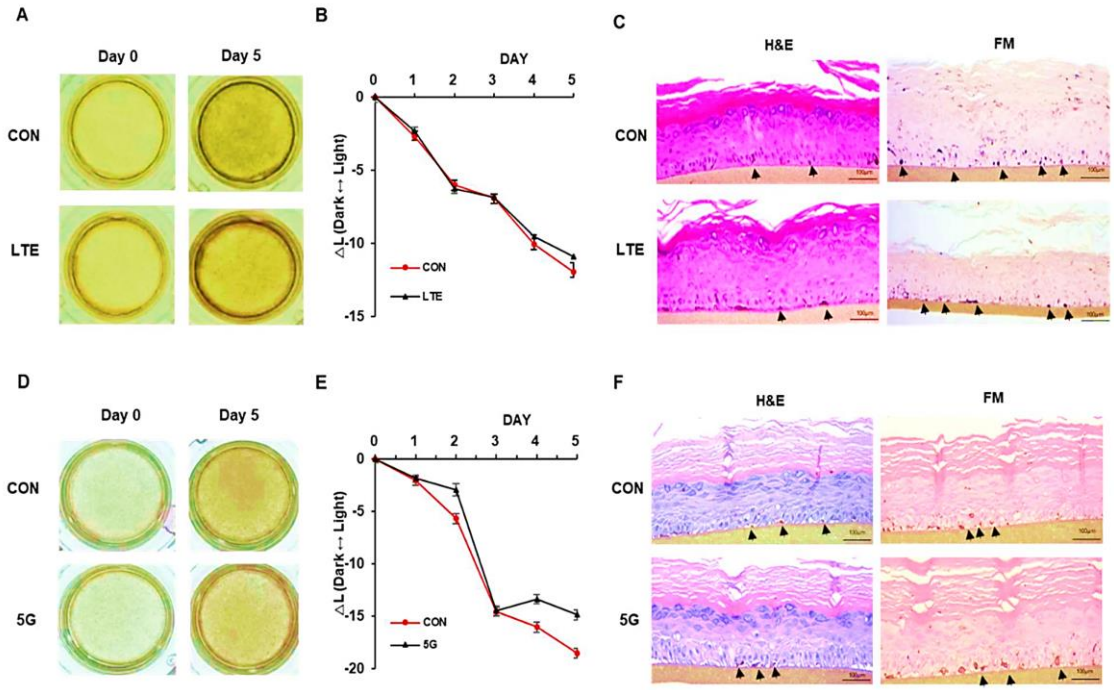

Fig. 9 EMFs effects for radiation using LTE and 5G on Melano Derm ™, a model of Artificial Pigmented Skin

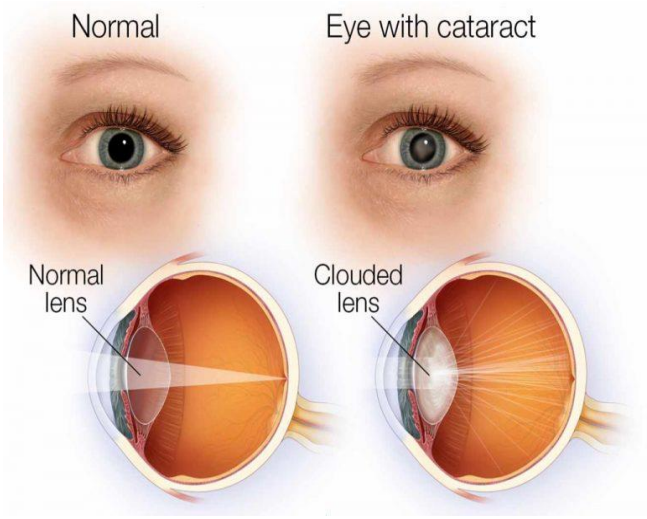

Fig. 10 Radiation effects on eyes

Other effects, like Neurological, Thermal and Non-thermal, have been shown [38]-[43].

7. Conclusion

In this paper, we briefly analyze the feasibility of deploying 5G networks in the current setting of developing countries, including Bangladesh (a middle-income country). Creating a contiguous spectrum from the scattered assigned spectrum, high spectrum prices, weak mobile network infrastructure, and a lack of policy in dynamic spectrum sharing are some of the technological problems. Handling these difficulties necessitates a significant investment of both financial and human resources. Bangladesh can quickly address the discussed issues and launch the 5G mobile network. In a growing economy like Bangladesh, 5G is projected to play a vital role in boosting economic growth, improving citizen experiences, and opening up new business prospects. Bangladesh's 5G deployment would be distinct from the rest of the globe, as the country is transitioning from a wholly analog to a digital economy without the need for intermediary phases. This improved technology necessitates significantly closer antennas and transmitters than the current 4G, thus posing a higher health danger in Bangladesh's densely populated population. According to the study, more than half of all existing 4G BTS towers produce radiation that exceeds allowed limits. As a result, residents closer to the BTS are suffering from radiation-related illnesses. Bangladesh will fully utilize the benefits of the impending 5G network and apply them to create a completely digital Bangladesh.

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