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

Md. Shariful Islam [a,1,*], Md. Ashek Raihan Mahmud [a], Md.Jashim Uddin [a], Tapan Kumar Jodder P. [a]

[a] Department of Information and Communication Technology, Islamic University, Kushtia-7003, Bangladesh
[1] afmsi76@ice.iu.ac.bd
* corresponding author

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ABSTRACT

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

1. Introduction

Bangladesh is now being transformed into Digital Bangladesh and one of the main objectives of it is to “Connect the citizens in a meaningful way”. Mobile operators are striving to construct a virtual society in Bangladesh through allowing connections. To achieve the vision-mission 2021 goals, mobile technology is played a special role which has gained recognition in the world 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 effort has been successful and will be successful in many undeveloped fields in the near future. However, to achieve this goal, uninterrupted fastest internet connection is mandatory. Internet based operations have become part of the daily activities of people around the world including Bangladesh, such as internet banking, webmail, social network services, online chatting and gaming [2]. Mobile phones/Mobile Station (MS) are utilized by the bulk of customers 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 of them the use of social media. Remarkably, cellular gadgets account for greater than half of all video streaming [4]. A statistics shows that the use of mobile internet in daily media in the world has increased by 504% since 2011. The number of mobile internet users is predicted to expand at the same rate as computation and storage move to the cloud. Considering the circumstances, the necessity of the world's connection is constantly changing, data usage is increasing. So, it is not possible to cover all services with existing technology like 3G or 4G networks [5]. As a result, Internet service vendors preserve to attempt to make present networks pretty scalable, making sure excessive availability and occasional latency. 5G mobile network is surely had to satisfy the above goal. Some key characteristics of 5G networks is shown in Table 1.

Table 1. Key performance indicators (KPIs) for 5G wireless technology

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 coverage area	1000 (Bbit/s)/m^2	eMBB
Coverage	Total network coverage in designated zones	Near 100%	

Although establishing 5G networks is a difficult task for a developing country, it is not so hard for Bangladesh, despite some hurdles, because the country has already advanced to the middle-income. Table 2 Shows when some developing countries including Bangladesh are started using 4G mobile networks.

Table 2. 4G deployment time in Developing country including Bangladesh (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

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

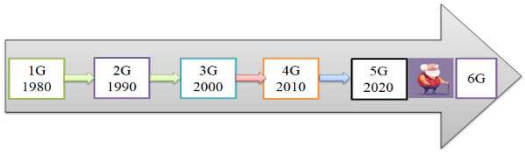

Figure 1. Evolution of mobile generation networks

Setting up 5G mobile network for the least evolved nations could appear to be a massive chance for mobile operators as the quantity of cash so as to be invested increases the query of whether or not the cash can be returned. Some least evolved nations are nevertheless the use of 3G mobile networks [6]. Although 4G cellular networks were applied in the ones nations however operators/service vendors are reluctant to go back their investment. In the case of Bangladesh, the implementation and use of 4G cellular network, operators are in quality degree that is shown in Table 3[7]. In this report, it is regarded how the Bangladeshi users done at the four national cellular network operators in Bangladesh-Airtel, Banglalink, Grameenphone, and Robi- over the direction of ninety days, starting off April 1, 2021 to June 29, 2021. On the idea of the aforementioned discussion it could be concluded that the 5G cellular network in Bangladesh, just like the advanced nations, may be applied in a quick time period through the present infrastructure.

Table 3. Mobile Network Experience in Bangladesh

Video Experience Additional Metrics in 0 – 100 Points				
	Airtel	Banglalink	Grameenphone	Robi
4G Video Experience	55.2 (±2.10)	65.4 (±2.17)	54.5(±2.62)	51.8 (±2.12)
3G Video Experience	43.8(±5.03)	43.2 (±4.51)	35.5 (±4.95)	34.1 (±4.10)
Game Experience Additional Metrics in 0 – 100 points				
4G Game Experience	39.2 (±1.28)	47.1 (±2.66)	38.5 (±0.79)	37.5 (±0.95)
3G Game Experience	32.9 (±0.94)	34.3 (±0.61)	31.1 (±0.53)	33.0 (±0.73)
Voice App Experience Additional Metrics in 0 – 100 points				
4G Voice App Experience	69.9 (±1.22)	73.9 (±1.18)	68.8 (±0.84)	67.3 (±1.25)
3G Voice App Experience	62.5 (±2.80)	66.0 (±2.21)	57.9 (±1.90)	59.5 (±2.30)
Download Speed Experience Additional Metrics in Mbps				
4G Download Speed	8.5 (±0.44)	13.0 (±0.54)	8.9 (±0.25)	6.9 (±0.35)
3G Download Speed	4.8 (±0.33)	4.7 (±0.29)	4.2 (±0.22)	3.4 (±0.21)
Upload Speed Experience Additional Metrics in Mbps				
4G Upload Speed	4.0 (±0.23)	4.9 (±0.24)	4.4 (±0.14)	3.8 (±0.18)
3G Upload Speed	1.0 (±0.10)	1.0 (±0.08)	1.0 (±0.08)	0.8 (±0.07)
4G Availability % of time				
4G Availability	80.6	75.2	78.9	79.8
4G Coverage Experience in 0 – 10 points				
4G Coverage Experience	6.6	4.2	7.2	6.6

Significantly higher mobile broadband speeds and increasingly extensive mobile data consumption will be assured with the forthcoming implementation of 5G mobile networks. The usage of extra higher frequency bands 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 regarded as the foundational technology for the Iot. (IoT), which allows devices to connect with one another (M2M communication). At the same time, a shift in human and environmental radiation hazards (EMF) is expected [8, 9]. Within multiple different frequency bands, the 5G network will operate as shown in Fig 2. The development of wireless communication devices

that operate within the high frequency parts of the spectrum has sparked a flurry of health-related analysis [10]. These studies include research on humans (both epidemiology and experimental investigations), animals, and in vitro systems [11, 12, 13, 14]. Also their results are indicating that RF exposure can cause cancer, the International Agency for Research on Cancer (IARC) categorized RF EMF as "possible carcinogenic to human" (Group-2B). In Comparison to the current situation, 5G mobile networks and the associated IoT would considerably increase the number of wireless devices, demanding a high density of infrastructure. As a result, substantially more mobile data volume per geographic region will be generated. Because the higher frequencies have shorter ranges, a higher network density is required. The concern that emerges is whether or not employing higher frequencies can have negative health consequences. In most countries, WHO-recommended exposure limits for both general public and occupational exposure are published and approved by the WHO, based on International Commission on Non-Ionizing Radiation Protection ICNIRP [15] or IEEE [16] guidelines. Such limitations, which take into account a lot of safety issues, are set so that the biological material doesn't get too hot (thermal effects). Thus, 10W/m2 is recommended as the fundamental constraint for 10 GHz to 300 GHz (no thermal impacts), with reference values for 400 MHz to 2GHz (2-10W/m2) and > 2 GHz (10 W/m2) for 400 MHz to 2GHz. It should be noted that the existing ICNIRP guidelines [15] are presently being changed, and new versions should be available soon. Of course, predicting the actual exposures to 5G networks is difficult. The antennas for 5G, on the other hand, will have narrow antenna beams with direct alignment to the receiving device [12]. When compared to the current exposure situation, this could potentially result in a large reduction in environmental exposure. However, it is also claimed that adding a large number of 5G network components will increase total EMF exposure in the environment, and that increased exposures to higher frequencies can have negative health consequences.

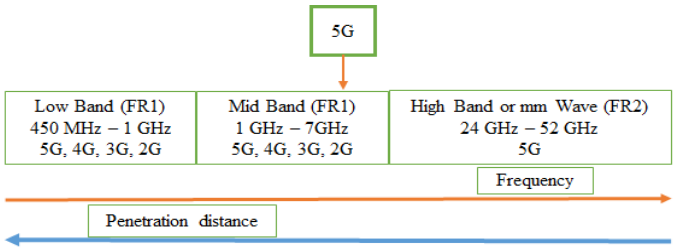

Figure 2. Radio frequency spectrum of 5G

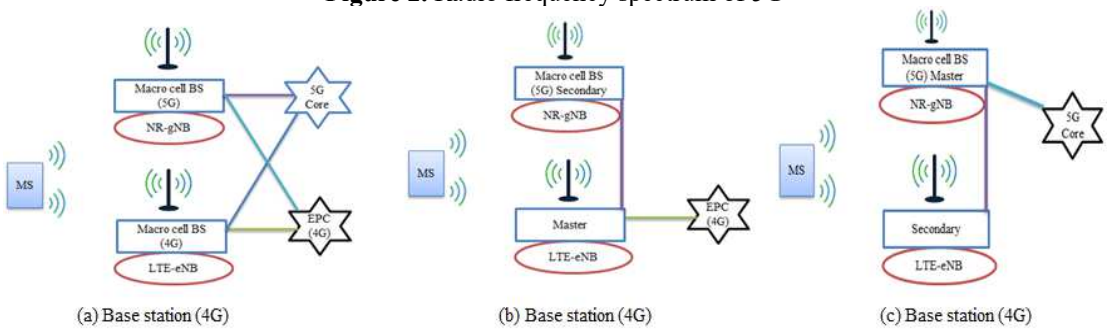

Figure 3. Procedure of coexist of 4G with 5G mobile networks (a) 4G eNB master (b) 5G gNB master (c) eNB and gNB coexist together

2. 5G Implementation Ideas

It is expected that the 5G network will work with the existing 4G networks in the beginning and then gradually it will be released in standalone mode. The Fig 3. Shows how 5G mobile networks will work with 4G mobile networks.

5G Radio Access Networks (5G-RAN): The 5G radio access network (RAN) is made up of overlapping macrocells, picocells, and femtocells as shown in Fig 4 [18]. Its goal is to make it possible for mobile devices to connect to the main core. The 5G macro cell is made up of gNB base

stations that use new radio technology to cover a larger region. The new 5G radio 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. The new millimeter wave (mmWave) frequencies are used by small cells with micro base stations. As a result, their connection range (usually 10 m) and coverage area are significantly reduced. They are, however, dispersed in clusters pattern.

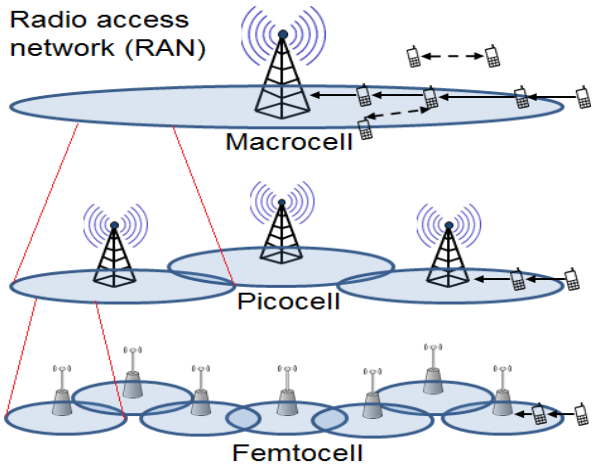

Figure 4. 5G Radio Access Networks

MIMO (multiple input, multiple output, also known as massive MIMO) antennas, which comprise of a huge number of multiple elements or connections and may function in full-duplex mode, are used in the new radio technology of 5G Macro cells. As a result, the system is very scalable and can handle multiple users at the same time.

3. 5G Core Network

5G core network as shown in Fig 5 [19]. The 5G core, like previous generations, is the mobile exchange network that manages mobile voices. It also houses the data network that manages mobile data and internet connections, as well as being reconfigured to interface with cloud-based services. Surprisingly, the 5G core includes distributed servers scattered across wide geographic regions, allowing material to be accessible locally and in a distributed manner near the client's location. Edge computing is enabled via distributed servers, which allows the majority of data to be processed at the client's end without overloading the core network. The 5G core also handles two other crucial features: network slicing and network function virtualization. Several independent virtualized logical networks can be formed on top of the same physical 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 [20].

The control features validate consumer-precise provider call for and configure sources. Depending on the application's requirements, every consumer gets a completely unique set of community sources and topologies. In order to allow great ranges of IoT connectivity, community cutting is critical [21]. Network feature virtualization, on the opposite hand, decouples community features like domain name services, encryption, and firewalls from committed networking components on client premises and actions them to digital servers within side the cloud.

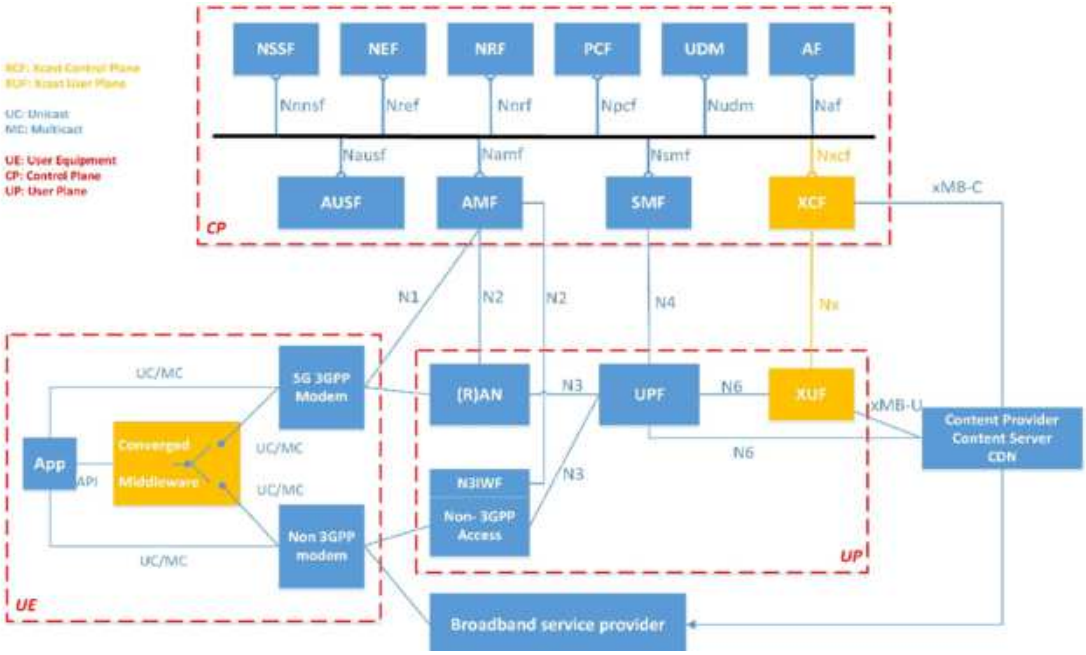

Figure 5. 5G core network

Technical Barriers and Obstacles: Despite the several possible advantages, implementing 5G and getting the most out of it poses major obstacles. Given the high levels of investment required to establish 5G networks, as well as 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:

The price of the spectrum: According to a recent study, spectrum prices in developing countries are more than three times higher than in affluent countries [22]. The essential 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 price and allocation modality of spectrum will be crucial. Operators will struggle to make a financial case for 5G adoption in Bangladesh at the present price of spectrum. To make the 700 MHz, 3.5 GHz, and 26-28 GHz bands suitable for 5G rollout, a lot of cleaning and harmonization is necessary. The keys to encouraging investments in 5G are affordable access to this frequencies and a clear road map of their availability.

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 a excessive frequency band (mmWave within side the 26-100 GHz range) for micro cells. Fig 6. depicts a normal cutting-edge spectrum consumption in growing countries.

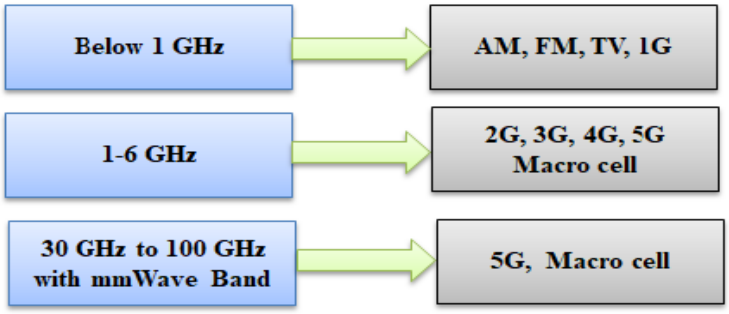

Figure 6. Spectrum distribution for the developing countries.

It's worth noting that making the necessary spectrum accessible for 5G will include a number of clean-ups, interoperability, and policy-level initiatives, which may provide additional obstacles. For example, if a portion of spectrum in the required band has previously been sold to a third party for other uses (such as Wi-Max implementation), 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 go through a lengthy negotiation process to reclaim them.

Infrastructure Constraint: One of the most important factors in ensuring 5G coverage and capacity is infrastructure access [23]. In order 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 to 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.

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 number of base stations installed over a terrain in comparison to the population determines the network density. A higher density necessitates a higher price. The density of 5G networks must be substantially higher to sustain the cluster of micro cells. This requirement adds to the issue of funding and constructing adequate base stations to support 5G network coverage [24].

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 the establishment of a spectrum sharing policy among mobile carriers, since otherwise, discovered opportunities will be unable to be utilized owing to a payment issue. In order to avoid revenue losses, regulatory agencies in Developing countries normally prohibit spectrum sharing between operators.

4. Case of Implementation 5G

5G implementation case shown in Fig 7.

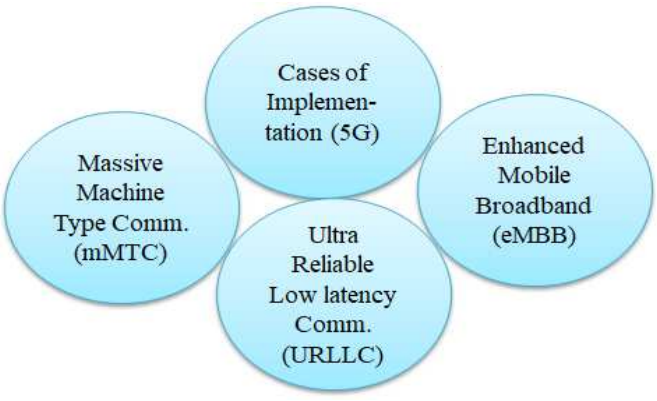

Figure 7. Different categories of 5G use cases implementation

Consumers will benefit from an improved "Unlimited" mobile experience thanks to eMBB. Consumers will be able to access rich material in more places thanks to superfast 5G networks with peak data rates of >10 Gbps, which will permit the streaming of live events and high-resolution media. 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 most likely focus on eMBB since it can handle the expanding communications needs of a developing digital economy like Bangladesh

right away. 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 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 super-fast, 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 will be able to 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, which will support 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. Asset tracking, logistics, and worker safety apps, on the other hand, 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 of the use-cases that 5G can provide in Bangladesh. These services can help utilities better manage demand and supply, as well as improve customer service.

Aspects of Security and Threats: The adoption of new technology to achieve the 5G network's envisioned aims has created its own set of 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 wide range of security vulnerabilities, developing countries including Bangladesh (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 [25] 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 of 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 main culprits, namely: a scarcity of security professionals, lack of reliable infrastructure, Less funding in Research and Development, Security education is in short supply, and Change apprehension.

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 placed close to people. Protesters also point to a lack of scientific evidence that 5G transmissions are safe, particularly those that broadcast in the millimeter wave section of the electromagnetic spectrum. Mobile devices today operate at frequencies below 6 gigahertz, 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 from the fact that its cell towers are so different from those supporting today's 3G and 4G cellular networks, according to Waterhouse. Those towers are spaced kilometers apart and atop towering, elevated structures that are 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 in close proximity 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 transmission power in the millimeter-wave (mm-Wave) frequencies [26]. 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	Cances	Sleeping Problems
Aches and pains	Brain Tumors	Cognitive impairments
Headaches	Segmented DNA	Memory loss
Reduce sperm motility	Cell Mutated	Brain Fog
Burning sensations	Neurological	Anxiety and Mood
Anxiety, stress, irritability		

The majority of human publicity to ionizing radiation takes place from herbal reasserts together with cosmic rays and terrestrial radiation [27]. As mentioned in preceding sections that 5G technology is targeted on excessive frequency spectrum i.e., millimeter wave spectrum, it is vital to investigate the conduct of the identical over human body. There are sure traits of mm wave indicators that have an effect on the human body parts just like the millimeter wave can effortlessly be absorbed through the human pores and skin inside 1~2 millimeter. The cornea which is the obvious a part of the iris also can take in the radiation. Nerve endings are related with the pores and skin to the radiation can attain our frightened and DNA system [28].

5G radiation contains carcinogens: In 2011 IARC had evaluated RF radiation as one of the feasible human carcinogens. An IARC Monographs Working Group reviewed epidemiological evidence, most cancers bioassays, and mechanistic and different applicable information to attain conclusions as to the carcinogenic hazard to human beings from publicity to the electromagnetic fields which can arise from 2G, 3G, 4G handsets in addition to from base station radiations [29]. Furthermore, there is compelling evidence that long-term exposure to mobile phone frequencies raises the risk of brain tumors in both people and animals [30]. Nevertheless, in comparison to prior techniques, 5G's use of high band spectrum, beam forming, and MIMO techniques, as well as a high amount of radiation, might cause cell mutations, which can lead to cancer and tumors. Low-intensity radio frequency radiations (RFR) also cause oxidative effects in live cells, such as a rise in reactive oxygen species levels (ROS) [31]. Reactive oxygen species are oxygen-containing chemically reactive entities that play a role in cell signaling. Overproduction of reactive oxygen species (ROS) that is not even counterbalanced by endogenous antioxidants (superoxide dismutase (SOD), catalase (CAT),

glutathione peroxidase (GPx), glutathione (GSH), melatonin) or exogenous antioxidants (Vitamin C, Vitamin E, carotenoids, polyphenols) leads to the formation of free radicals that oxidize and damage DNA, proteins, membrane lipids and mitochondria as shown in Fig 8 [32].

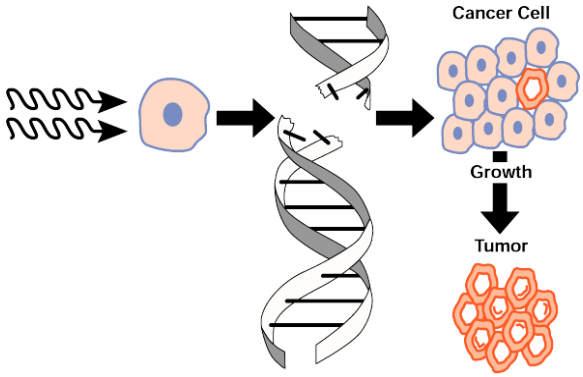

Figure 8. Radiation effects on Cell

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 [33]. 5G uses MIMO antennas and beam forming techniques, and as the number of towers grows, the number of beam forming antennas pointed at a single user via a highly directional beam may become dangerous. 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 a multitude of 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. Radiofrequency (RF) radiation from wireless devices, big radar installations, and medical equipment can raise body core temperature or induce localized temperature rises, both of which can have negative health consequences. The current exposure standards (ICNIRP 1998; IEEE 2005, 2010) define limitations for frequencies above 10 MHz in order 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 durations were calculated using the in vivo temperature evolution time constant. Figure 9 shows an example of transient temperature during a single oscillation phase. Short pulses, on the other hand, can cause significant temperature oscillations, which are exacerbated 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) [34].

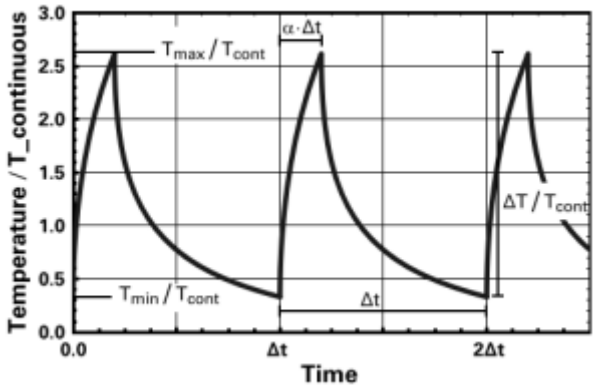

Figure 9. Transient Temperature oscillations caused by a pulse train that resulted in a 1K temperature increase with continuous exposure

Melano Derm^{TM}, is a pigmented human skin model that has been widely used to explore the physiological mechanisms of skin pigmentation. It exhibits in-vivo-like morphological properties of human epidermis and has been widely utilized to study the physiological mechanisms of skin pigmentation. It also usually grows more pigmented as the days go by in the cultivation process. There was no difference in visual evaluation (Figure 10A) or image analysis for brightness after 5 days of continuous exposure to LTE at 8 W/kg (Figure 10B). 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 10C). 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 10D) and image analysis for brightness, the results revealed no significant changes in pigmentation (Figure 10E). The amount of melanin was not enhanced, according to H&E and FM staining (Figure 9F) [35].

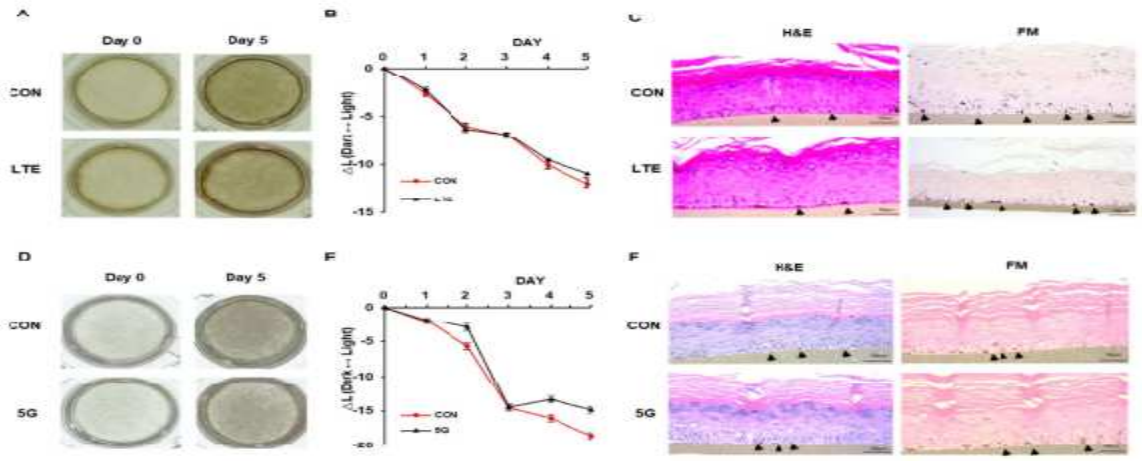

Figure 10. EMFs effects for radiation using LTE and 5G on Melano Derm TM, a model of Artificial Pigmented Skin

Eye repercussions: The radiation impacts are much stronger than with older technology thanks to massive MIMO and beam shaping techniques, while the transmitting signal power is much lower [36]. A cataract is a clouding of the lens of the eye that causes visual loss. The tissues of the eye will be in direct touch with the radiation during the near field exposure of a 5G antenna. As a result, the risk of cataract 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 adequately disperse heat. As illustrated in Fig. 11, there is some evidence that repeated low-level microwave radiation exposure can develop cataracts.

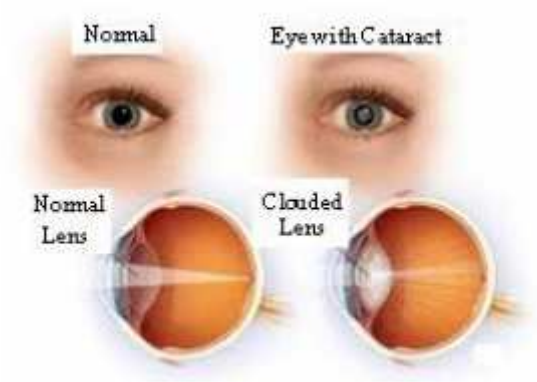

Figure 11. Radiation effects on eyes

There are also others effects, like Neurological, Thermal and Non-thermal have been shown [37-41].

7. Conclusion

In this paper, we give a brief analysis of the feasibility of deploying 5G networks in the current setting of developing countries including Bangladesh (middle-income country). Creating contiguous spectrum from 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. It is possible for Bangladesh to address the discussed issues and launch 5G mobile network very quickly. 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 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 suffering from radiation-related illnesses. Bangladesh will fully utilize all of the benefits of the impending 5G network and apply them to create a completely digital Bangladesh.

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