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# Next-Gen Network: Microwave Perspective: Impact, Challenges and Opportunity

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***Abstract:*** ***Our need for higher performance and improved efficiency has led to the invention of 4G from 1G. This tendency to never settle has now brought us to a new generation of mobile communication - 5G. It is expected to provide more than just a faster network. Reduced latency, enormous netwrok capacity, greater reliability and overall improved user experience. This has come into focus with the possibility that the unused spectrum - (300 MHz to 30 GHz) can also be brought into use in the telecommunication inductry. As we know, everything comes with its own demerits and in this review paper, we shall discuss the health effects that microwave radiation has on living organisms with the antennas and connected devices being in close proximity to users and other organisms. Thereafter, we shall discuss the challenges and opportunities of the same.***

***Keywords: next generation network, millimeter waves, health impact, tissue heating, radiation***

## I. INTRODUCTION

For the ease of transmission of data, a wider frequency band is required to reduce the traffic of existing mobile networks. The spectrum of higher frequency is more desirable than lower frequency in advanced communication systems. Higher frequency bands fail to pass through obstacles but have a better capacity of transmission due to the large supply of high frequency spectrum that enables transmitting more information in a broader frequency band.

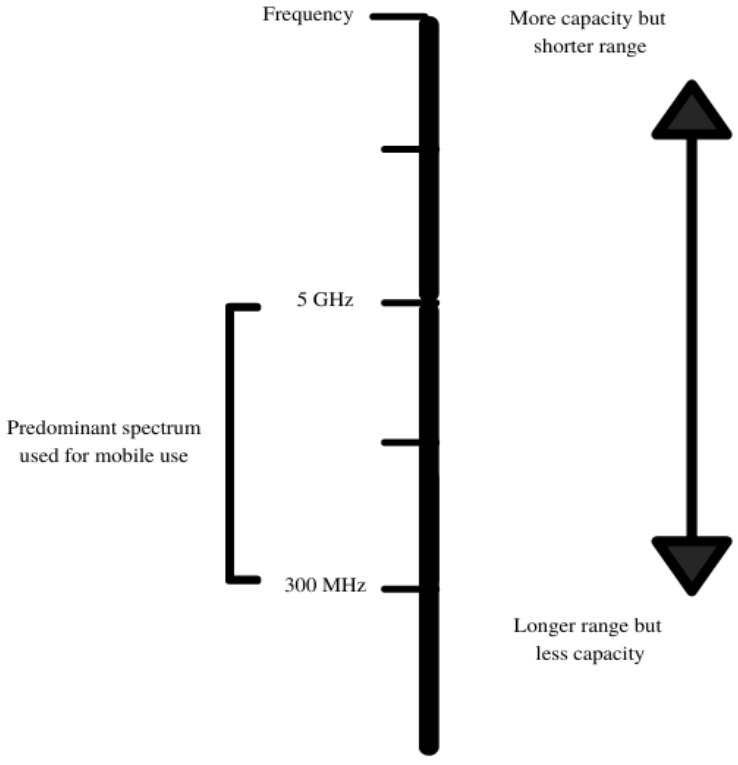


Fig.1 frequency range which uses previous generation network and unused spectrum is shown above

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The 5G technology is being deployed for this very reason using millimeter waves for wireless networks. The foundation of 5G includes five brand new technologies - Millimeter waves, Small Cell, Massive MIMO, Beamforming and Full Duplex.

1) *Millimeter Waves:* Using millimeter waves ranging from frequencies 30-300 GHz will open up new broadcasting range. This will be the first time that this spectrum will be put to use. Since these waves won't be able to travel through obstacles and will get absorbed by trees and rains, researchers have come up with small cell networks.
2) *Small Cell:* Present communication industry high powered cell towers which can broadcast their signals over long distances but for higher frequency waves like millimeter waves, small cell networks need to be installed at frequent distances. These will be low-powered and help in transmitting signals through obstacles.
3) *Massive MIMO:* (multiple input multiple output) - These base stations can support an enormous number of ports which shall increase the present network capacity by a factor of twenty-two or more. But using this will lead to traffic and interference between signal transmission as signals from these are produced in every direction. To solve this problem, we use beamforming.
4) *Beamoforming:* This will allow the base station to send a focused stream of data to specific users. Less interference and more efficiency is expected from this technology.
5) *Full Duplex:* Researchers have used reciprocity and have also developed silicon transistors to create hgih speed switches that would enable a full duplex system among antennas.

All of this is going to increase the magnitude of ionizing radiation around us. Ionizing radiation causes fundamental changes in atoms. Now this is of prime importance to us, because our body constitutes of organs, which is made up of several tissues, which is built by billions of cells which constitute molecules and the building block of molecule is the ATOM.

## II. HEALTH IMPACT

1) The average human body is around 21-22 sq. feet, entirely covered with skin. The skin is most receptive to millimeter waves. Easily absorbed within 1 to 2 mm of human skin, it acts as the primary target of such radiation. Skin is made of tissues and several capillaries and nerve endings, and once it comes in constant contact with MMW, biological effects may occur through the nervous system. Other issues like hair loss, sterility in males and females and cataract may also occur after continuous exposure to short durations of radiation, leading to such chronic ailments.
2) MMW are a type of electromagnetic waves which upon travelling and reflection through a surface, cause vibration that induce thermal energy. Hence, if the power density of MMW goes beyond 5-10 $mW/cm^2$ and increased exposure will lead to pain and physiological damage by impacting the growth, morphology and metabolism of cells, inducing production of free radicals, and damaging DNA.
3) Damage caused by ionizing radiation is basically classified into direct and indirect damage. Direct damage is when the ionizations interact with atoms of DNA, hence shutting it's ability to function or when the chromosomes are affected to the extent that cell replication and survival is not possible any more. Indirect damage is caused by interaction of radiation with water present in the cells. Due to this interaction the bonds of water molecule break to form hydrogen and hydroxyls, which may recombine to form water, but they could also form hydrogen peroxide that leads to destruction of cell.
4) The MMW have destructive effects on the cell plasma membrane and genome according to a research published in 2016 that said that there are chances of communication between bacteria and other cells through the electromagnetic field. Such interactions leads to desensitizing the bacteria to antibiotic drugs, which eventually will be a contributing factor in degrading our health.
5) A paper declassified in 2012 by the CIA, based on a 1977 study by N.P. Zalyubovskaya said that after being irradiated for 15 minutes daily for 60 days, there were structural and cellular alterations in the body of mice.
6) 'Qualitative and quantitative changes of the blood and bone marrow composition and changes of conditioned reflex activity, tissue respiration, activity of enzymes participating in the process of tissue respiration and nucleic metabolism. The degree of unfavourable effect of MMW depended on the duration of radiation and individual characteristics of the organism.' The investigation also showed 'changes in processes of oxidative phosphorylation in the liver, kidneys, heart and brain of the animals. It inhibited oxygen consumption rate by mitochondria of those organs in the active phosphorylating state and slowed down by the rate of respiration upon exhaustion of the ATP.'
7) Another study conducted with observations of state of health of 97 people working with generators of millimeter range showed that 'radio waves affected the metabolic processes in the organism, that is, changes of indicators of protein and carbohydrates metabolism and disturbances of indicators of immuno-biological reactivity and of the blood system.'

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*8)* The WHO, together with the International Agency for Research on Cancer (IARC) has classifed all radio frequency radiation (of which mobile signals are a part) as "possibly carcinogenic". Major three areas where effects of low doses of radiation are observed:

*a)* *Genetic Effects:* Radiation being one of the physical mutagenic agents, it causes the sperm or egg cells to undergo mutation which are then passed to the offspring.

*b)* *Somatic Effects:* Radiation workers and other individuals exposed to radiation owing to their occupation, are usually the ones who suffer from these effects.

*c)* *In-utero Effects:* Embryo exposed during fetal stage suffers from malformations while developing.

*9)* Tissue heating is a result of interaction between radiofrequency fields and the human body. Frequencies ranging from 1.8 to 2.2 GHz can cause the skin to absorb electromagnetic energy leading to a rise in temperature, albeit minimum, in your brain and body.

## III. CHALLENGES OF 5G NETWORK

The technical challenges for 5G network deployment are the multiiple service requirements, legislation, infrastructure, security and communication. But health and environmental impact remains the most alarming challenge.

EMFs from mobile phones are a causative factor for DNA damage in mice and rats and these EMFs can be of any frequency range, according to a 2019 and 2016 animal studies respectively.

We all can agree with the fact that 5G is the way forward. The amount of our dependence and usage of electronic devices will need a stronger network which 5G will provide us. But we also have to consider the risks that it brings with it.

The entire argument boils down to one solution, that is to reduce the exposure of living organisms to such strong radiation. As of today, two main bodies have issued radio frequency exposure guidelines :

*The International Commission on Non-Ionizing Radiation Protection (ICNIRP)*
*https://www.icnirp.org*
which states the average restrictions for frequencies >6 GHz, restrictions for brief (<6 minutes)exposures for frequencies >6 GHz and the reduction of averaging area for frequencies >6 GHz, but this specifies limits only on the thermal paradigm and not on RF radiation on humans, hence are insufficient to protect public health.

*The Institute of Electrical and Electronics Engineers (IEEE) : link - https://standards.ieee.org/standard/C95_1-2019.html*
Relative damage done by radiation is given by: number of rems (rem=roentgen equivalent for man) = RBE (relative biological effectiveness) x number of rads (radiation absorbed dose)
with RBE approx 10 for alpha radiation, 2(+) for protons and neutrons, and 1 for beta and gamma radiation.
As the 5G network consists of higher frequencies, an increased number of base stations will be set up to enable direct connectivity to the electronic devices. So following the above mentioned guidelines will hep us in reducing the healht risks and enable safe integration of the 5G network in our lives.

## IV. OPPORTUNITIES

All our efforts are aimed towards enhancing the user experience, and 5G-enabled IoT is one of the most potential opportunities that the technology holds in helping us achieve this. With the present developments in electronics and technology, we expect a full blown revolution in the networking field. The 5G microwave is expected to support developments like - virtual reality appliances, remote surveillance, self-driving cars, telemedicine and telesurgery. Continuous evolution of online gaming, also suggests that 5G will be required for the development of cloud gaming too.

## V. CONCLUSION

By creating an intricate network of antennas and transmitters, 5G will be covering all urban areas, railways, major roads and other major businesses. Opening up a whole new world for the engineering community, we have to be prepared to face the challenges and work for not only improving user experience but also to ensure safety by minimising potent health risks. Only then do we achieve our goal of successful development towards a stronger network.

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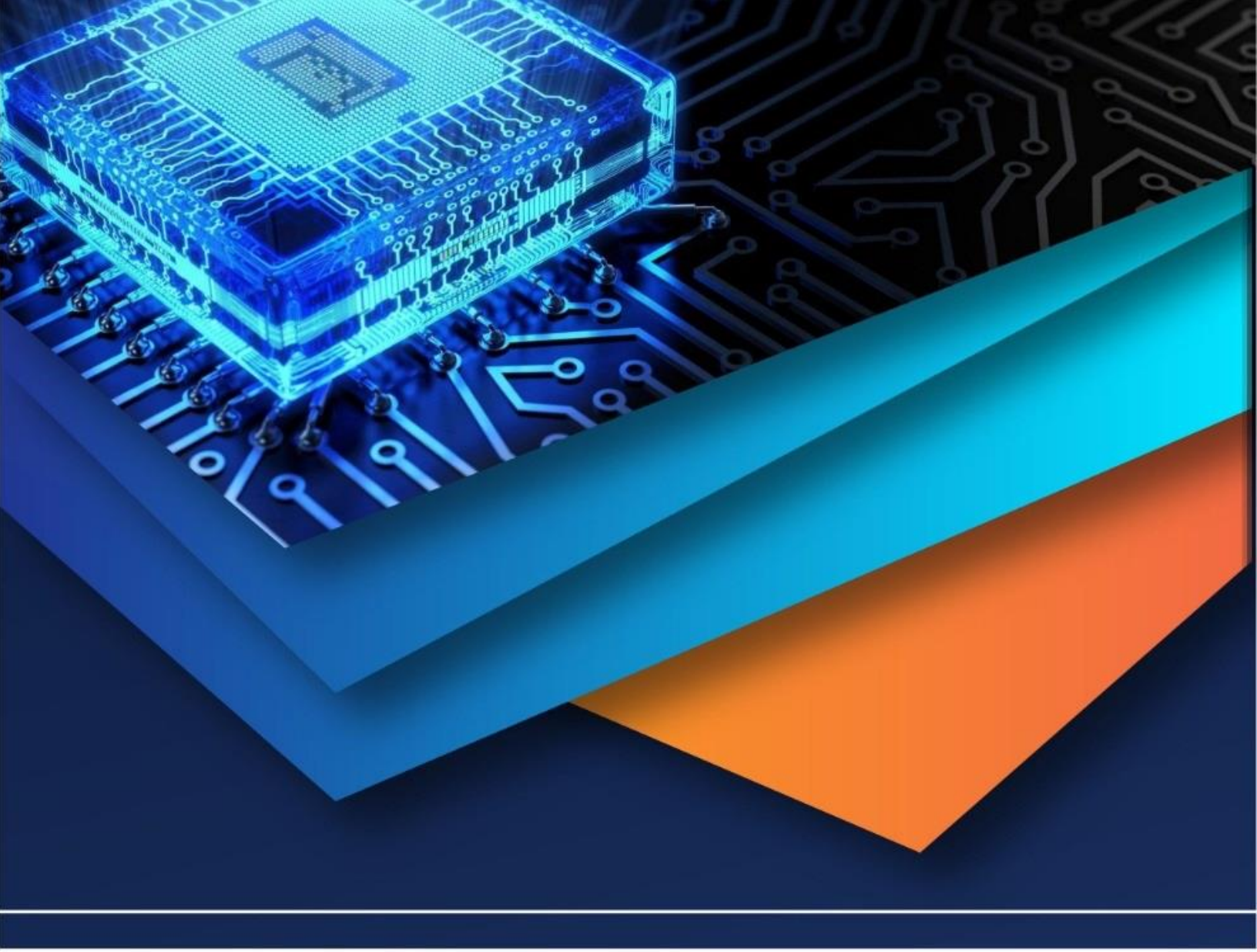

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