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5G Technology and its Health Impact in Africa

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ABSTRACT

The emergence of the 5th generation (5G) of mobile and wireless communications technology aimed at driving complex operations and sophisticated applications has drawn attention in the public domain. The need to monitor overall business processes, improve the customer experience, save time and money, enhance employee productivity, integrate and adapt business models, make better business decisions and generate more revenue have facilitated this technology. This paper seeks to provide basic information about this technology vis-a-visa exploring the basic scientific principles of 5G Technology, its health implications and impact.
Keyword: 5G, Radiation, Health

INTRODUCTION

In technology utilization today, the improvement and enhancement of technology is statutory to provide additional functionality and capacity to manage current user needs and meet productivity demands. Most user applications today require high speed broadband access at the expense of device technology. Over the years, mobile communications technology have tried to match this demand as seen by the various technologies rolled out, starting from the first generation up to the present 5th generation. In contrast with previous generations of mobile technologies which were characterized by a single monolithic system design streamlined towards a particular need and ecosystem (i.e. mobile broadband), 5G stands out as it was designed for multi-service and multi-tenancy support [1]. The use case for 5G cuts across diverse sectors such as the transportation, health, agricultural, energy sector etc. The main service types that would be supported by this emerging technology includes:

- **Enhanced mobile broadband (eMBB):** 5G would enhance quick access to multi-media content, services and data with improved performance and increasingly seamless user experience. At such speeds, Multimedia contents in the Giga byte range would be downloaded within seconds as opposed to other technologies. 5G would also improve radio coverage and capacity practically anywhere and anytime with visibly improved user data rates compared to other technologies.
- **Ultra-reliable and low-latency communications (URLLC):** 5G will be a strong driver of the new industrial revolution tagged industry 4.0. Its impact would be felt by most sectors of the economy because it would foster a reliable and latent wireless connectivity required for medical activities, autonomous and collaborative driving, smart cities, etc [2].
- **Massive machine-type communications (mMTC):** In an attempt to drive the connection of physical devices around the world to connecting them to the internet, internet of things (IOT) comes into play. This requires a robust wireless network standard like 5G

or higher. A thing (or Object) in the IOT can be a person with a heart monitor implant, a farm animal with a bio chip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low or any other natural or man-made object that can be assigned an Internet Protocol (IP) address and is able to transfer data over a network [3]. Perhaps the common claim that the 5G technology or IOT affects humans today. Obviously, when fully adopted and deployed it will control the Objects that have the Internet Protocol running on them. Africa like the rest of the world must embrace IoT. Currently there are records of small scale deployment of sensors in some of her industries and businesses. These form quite a number of connected devices typically communicating with themselves and a remote server. With the data rates hosted by 5G, such applications in sectors like agriculture, medicine, etc would be boosted to enable seamless communication and easier interoperability [4].

Figure 1: Overview of 5G Connected Community
(Source:http://www.emfexplained.info/?ID=25913)

The use case for most African countries would most likely be in the agricultural and health sector. Previous generations of mobile technologies that support data services had supported research efforts aimed at improving these sectors, only that 5G boasts to do more. With the high frequency band employed by 5G, several debates have ensued on the health implication related to the safety level of Electromagnetic Field (EMF) exposure to humans. With 5G technology advancing towards commercial deployments all over the world and in Africa particularly, there are certain design questions that are still controversial and open to research. At this stage in 5G deployment, this paper aims not only to present an overview of what this technology is all about, but also to look at its health implication.

Review of Mobile technologies

In this section, a brief overview of the technological architectures ranging from the first Generation 1G system to 5G is carried out. Mobile telecommunication systems were first introduced in the early 1980s. 1G system dates back to early 1980s and were solely analogue systems. The spectral efficiency of such systems was very poor and thus had a very small capacity. The second generation (2G) systems deployed in the early 1990s provided a better spectral efficiency than1G and were the first to use digital technology [5]. These systems were originally designed to support only voice application but were later enhanced to support instant messaging through the Short Message Service (SMS). Popular amongst the 2G system was the Global System for Mobile Communications (GSM). This technology would later be upgraded to incorporate the General Packet Radio Service (GPRS) and Enhanced Data Rates for GSM Evolution (EDGE) to enable data download. By the year 2000, third generation (3G) systems were introduced and they proved to be a better replacement of previous systems. 3G systems could handle increased amount of data rates because they employed enhanced radio transmission and reception techniques that were different from their 2G predecessors. The world's dominant 3G system is the Universal Mobile Telecommunication System (UMTS). UMTS was developed from GSM by completely changing the technology used on the air interface, while keeping the core network almost unchanged. The system was later enhanced for data applications, by introducing the 3.5G technologies of high speed downlink packet access (HSDPA) and high speed uplink. The UMTS air interface has two slightly different implementations. Wideband code division multiple access (WCDMA) is the version that was originally specified, and the one that is currently used through most of the world. Time division synchronous code division multiple access (TD-SCDMA) is a derivative of WCDMA, which is also known as the low chip rate option of UMTS TDD mode. TD-SCDMA was developed in China, to minimize the country's dependence on Western technology and on royalty payments to Western companies. For many years, voice calls dominated the traffic in mobile telecommunication networks [6]. The growth of mobile data proliferated with the advent of smart phones that could support the creation of applications by third party developers. This resulted to an explosion in the number and use of mobile applications. The Internet Service Providers (ISP) also contributed in the growth of mobile data usage with the introduction of flat rate charging schemes that permitted unlimited data downloads. At this point, data consumption soared, consequently making 2G and 3G networks to become congested in the years around 2010, leading to a req0uirement to increase network capacity [7]. LTE was then introduced to increase capacity, by delivering peak data rates of 100 Mbps in the downlink and 50 Mbps in the uplink (though Initial systems could not meet this target). Research efforts were later geared towards enhancing the capabilities of LTE, and resulted to a specification known as LTE-Advanced which met and surpassed the initial specification for LTE. With the heightened demand for an enhanced mobile broadband experience, it was essential for the deployment of a technological framework that could handle such demands. The evolution of LTE plays an important part in the overall 5G radio-access solution. The International Telecommunication Union – Radio communication (ITU-R) defined a set of capabilities for 5G use case and usage scenarios, some of the key capabilities that are easily quantifiable are presented in figure 2. From the specifications, the maximum achievable data rate under ideal conditions is 20Gbit/s for downlink and 10Gbit/s for uplink. The spectral efficiency which gives the average data throughput per Hz of spectrum and per "cell," for 5G was set to three times the spectrum efficiency target of 4G.

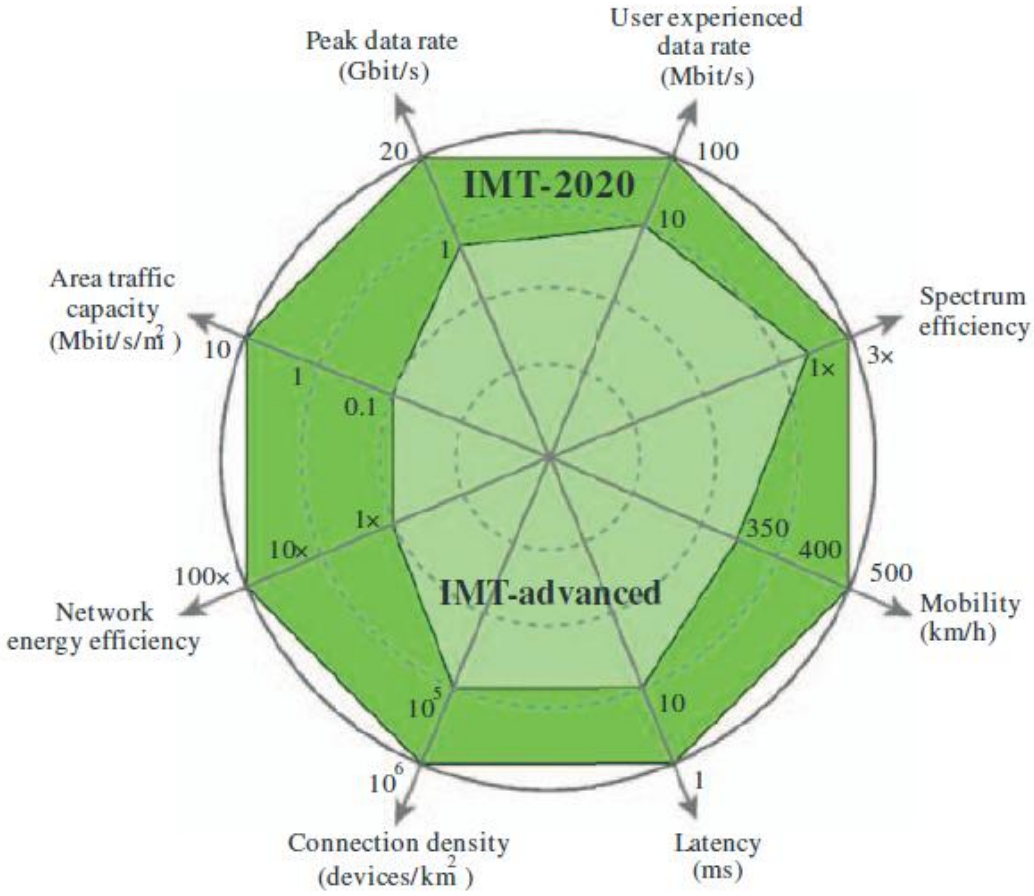

Figure 2: 5G key specifications

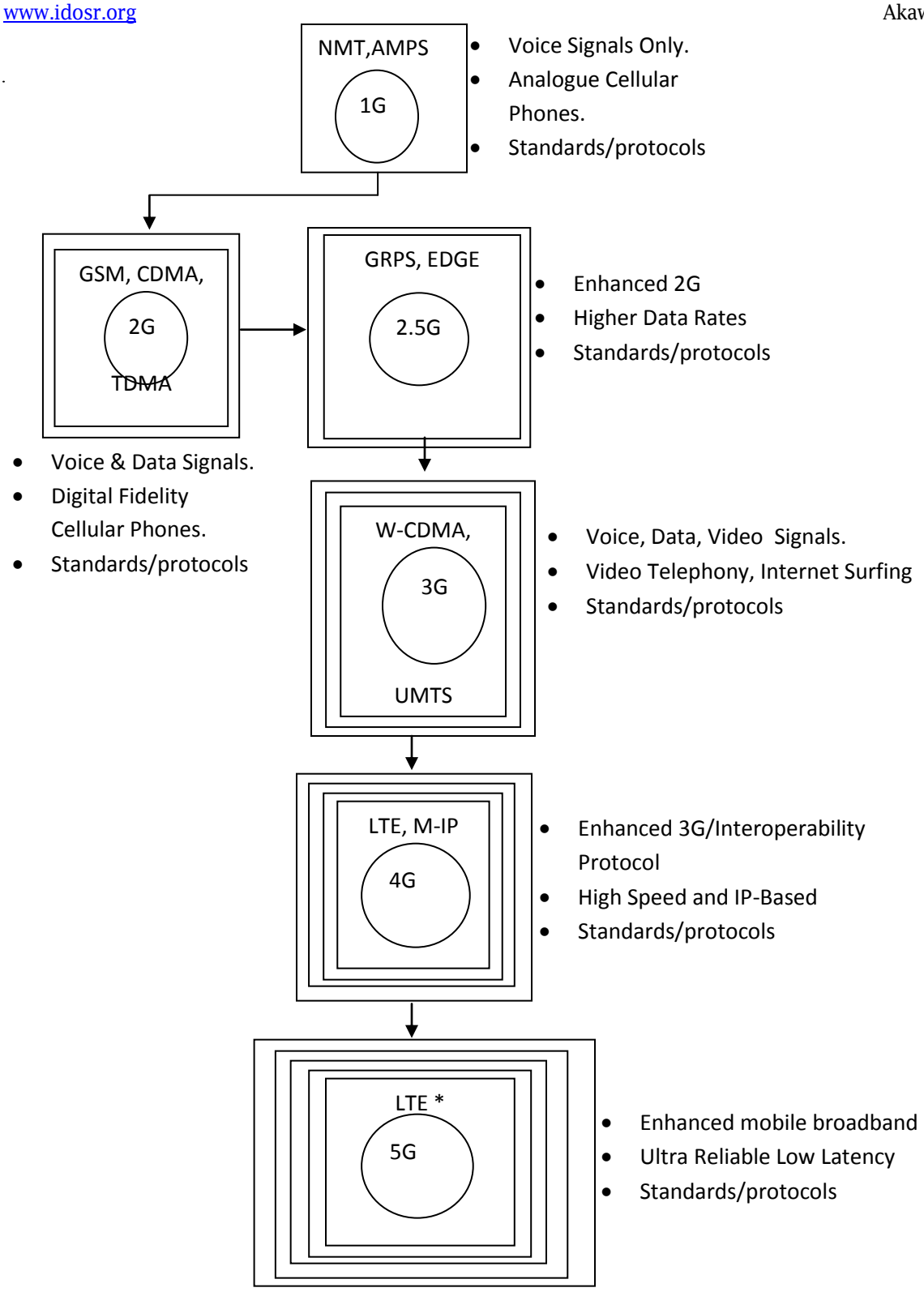

Figure 3: Mobile Standard Genealogy Evolution Model (Authors Model)

5G and the Electromagnetic Spectrum

The central principle to Wireless Communication and 5G technology is Electromagnetic Field (EMF) or commonly put, Electromagnetic Radiation (EMR) or Electromagnetic Energy (EME) propagated from device to systems to systems to devices over distances on various infrastructural platforms. Electromagnetic fields are present everywhere in our environment – the earth, sun and ionosphere are all natural sources of EMF (http://www.emfexplained.info). Though electromagnetic radiation unlike sound can travel through a vacuum; similar to sound, it can also travel through material media such as air, fluids and metals. The earth's surface is filled with air and this air provides a medium for the propagation of wireless communications signals, which is the heart of wireless networking. Air-interface is the propagation channel by which information flows between computer devices and the wireless infrastructure. Think of communication through a wireless network as similar to talking to someone. As you move farther apart, it's more difficult to hear each other, especially when a loud noise is present. Wireless information signals also travel through the air, but they have special properties that enable propagation over relatively long distances. Wireless information signals cannot be heard by humans, so it's possible to amplify the signals to a higher level without disturbing human ears. The quality of transmission, however, depends on obstructions in the air that either lessen or scatter the strength and range of the signals.

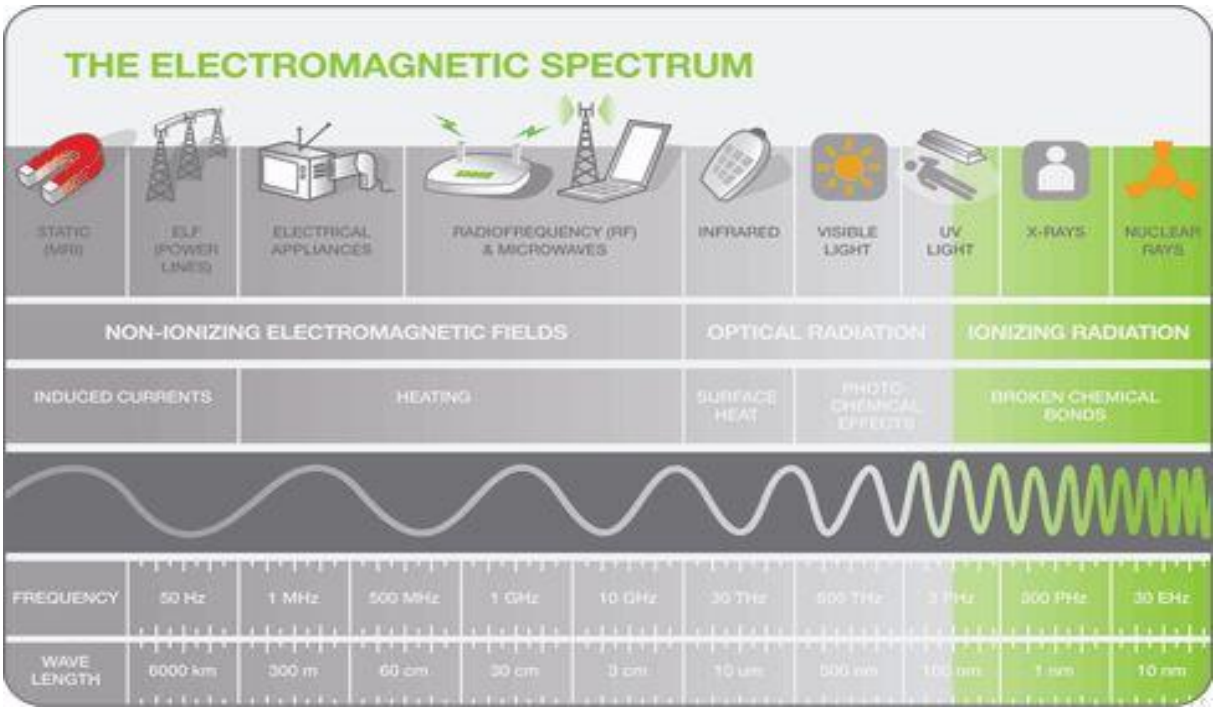

Figure 4: Electromagnetic Spectrum
(Source: http://www.emfexplained.info/?Page=25192)

Electromagnetic fields exist everywhere in the environment including our home,

school and work place. Electromagnetic fields are generated either by natural or human-made sources.

Natural sources of electric and magnetic fields include; the Earth's Magnetic Field (this makes a compass point north), Lightning (lightning generates EMF), Visible light (we can see using optical radiation).While **Human-made sources of electromagnetic fields include** Electrical Appliances (vacuum cleaners, hair-dryers, refrigerators) and Radio Communications Devices(AM / FM radio and television, emergency service radio (police, fire, ambulance), air traffic control, cordless phones, remote controls, mobile phones, Wi-Fi modems).

The Electromagnetic spectrum is categorized into non-ionizing electromagnetic field and ionizing electromagnetic field. Radio frequency and microwave constitutes the 5G technology which falls under the non-ionizing electromagnetic field. Some electromagnetic waves carry such large quantities of energy that can break down the chemical bonds between particles of matter (resulting in ionization). X-rays used for both diagnostic and therapeutic purposes (radiotherapy), gamma-rays (emitted by radioactive materials) and cosmic radiation, all have this ability and are known as ionizing radiation. Electromagnetic fields which cannot break down molecular bonds are called non-ionizing radiation. From recent literatures, many artificial sources of electromagnetic fields, by which we are surrounded daily (including radio signals), are non-ionising. In other words, the quantity of energy they carry cannot break down chemical bonds within cells and tissues. 5G supports licensed-spectrum operation from below 1 GHz up to about 60 GHz. These bands are often called mm-wave bands and offer the possibility for large amounts of spectrum and very wide transmission bandwidths. At these high frequencies, a large number of steerable antenna elements are used for both transmission and reception. Primarily, these antennas help to extend coverage using a principle known as beamforming and also enable massive MIMO (Multi Input Multi Output) at lower frequencies for interference avoidance. One major challenge with operations in higher-frequency bands is with the regulatory aspects. At frequency bands above 6 GHz, regulations defining human exposure to RF electromagnetic fields (EMFs) restricts the maximum output power of user devices to levels significantly lower than what are allowed for lower frequencies. International RF EMF exposure limits, for example those recommended by the International Commission on Non-Ionizing Radiation (ICNIRP) and those specified by the Federal Communications Commission (FCC) in the US, have been set with wide safety margins to protect against excessive heating of tissue due to energy absorption [8].

ElectromagneticField (EMF) and Human Safety

Exposure to electromagnetic fields in everyday life is not a recent experience or development. Humans have been exposed to natural EMF throughout their lifetime. Human made sources of electromagnetic fields have increased in recent times with the development of technology and radio communications.

Scientific research over many decades has enabled national and international health authorities to establish safety limits for exposure to electromagnetic fields. Exposure limits vary depending on the type of EMF and incorporate large safety margins for added protection. Radio waves are part of the non-ionising electromagnetic spectrum. Over 50 years of scientific research has already been conducted into the possible health effects from radio communication systems including mobile phones, base stations and other wireless services. The conclusions from these researches have been analysed by many expert review groups. Weighing the whole body of evidence, there is no evidence to convince experts that exposure below the guidelines set by the International Commission on Non-Ionizing Radiation

Protection (ICNIRP) carries any health risks, for adults or children.

In relation to EMF and health, the World Health Organization (WHO) says,

"Extensive research has been conducted into possible health effects of exposure to many parts of the frequency spectrum including mobile phones and base stations. All reviews conducted so far have indicated that exposures below the limits recommended in the [9] EMF guidelines, covering the full frequency range from 0-300 GHz, do not produce any known adverse health effect. However, there are gaps in knowledge still needing to be filled before better health risk assessments can be made."

However, in 2011, the International Agency for Research on Cancer (IARC) concluded that microwave radiations are possibly carcinogenic to humans and grouped them in 2B category asserted [10] [11]

On the other hand, in a systemic review based on the available studies regarding 6 to 100GHz, Simko and Mattsson noted that the available studies did not provide adequate and sufficient information for a meaningful safety assessment, [12].

There is paucity of study on the health implications of 5G technology per se in the available literature and the health implications of non-ionizing radiation (which 5G falls within) in the available literature, shows a lot of controversies, [13], [14]. However, a careful look at these available researches shows some areas of health concern that need to be studied in details vis-a-vis the 5G technology. Some of these include: radiation induced hypersensitivity reactions, interference with neuronal functions such as cognitive ability, cancer induction, interference with fertility, cardiovascular abnormalities, and interference with sleep. [7] [8].

It should be noted that human bias as a result of various interests whether declared or not, can profoundly influences the researches. This controllable factor if not strictly checked, will sway the results of many researches and lead to conflicting and confusing outcomes. The African countries will need to contend with this factor in the investigation of the health implications of the 5G technology on the health of its citizens and inhabitants.

In conclusion, the 5G technology has its merits and demerits. In particular, unbiased studies of its health implications need to be embarked upon before its acceptance or otherwise in Africa.

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