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APPLICATION OF NANOTECHNOLOGY IN ELECTRONICS AND COMMUNICATION

S. Gangadhara T Venkadesh, Department of Electronics, K.R. college of Arts & Science, K.R.Nagar, Kovilpatti, Thoothukudi District, Tamilnadu, India.

E.Mail: g_venkadesh86@rediffmail.com

ABSTRACT

Nanotechnology is enabling the development of devices in a scale ranging from (1 -100) nanometers. Coordination and information sharing among these nano-devices will lead towards the development of future nano networks, rising new applications of nanotechnology in the communication, military, civil, chemical engineering, health care (Ex. drug delivery), aeronautics, and electronics field etc. In telecommunication engineering nanotechnology could provide effective solutions for power efficient computing, sensing, memory enlargement, and human machine interaction. The next-generation high data rate wireless communication systems are expected to offer a completely new ways to access information and services. Based on analyzing IoT, which includes under layer network distribution, convergence gateway access, inter-connected network integration and terminal user application. The protocol structure of IoT consists of network protocol layers, network control platform and application terminal platform, and the key technologies for IoT have been concern with hardware and software. The graphene- based electronics have opened the door to electromagnetic communication among nano-devices in the terahertz band (0.1-10 THz). The communication challenges in terms of terahertz channel modelling information encoding and protocols for nanosensor networks. Nanocommunication for pervasive sensing computing, devices of ultra-high speed, long-range communication links, portable and power-efficient computing devices, high-density memory and logics and robust energy devices can be manufactured with the help of nanotechnology. The nanotechnology could play a significant role for continuing innovation in mobile devices. The 5G technologies will change the way most high bandwidth users access their Mobile Radio Communication (MRC).

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KEYWORDS:

Nanocommunication, Nanosensors, IoT, Mobile Radio Communication, 5G Network.

1. INTRODUCTION

Next generations of telecommunication systems expected to be built in nanotechnology modules, especially in electronics fields and interactive processes. For mobile communication systems the application of Nano science is used to make the control process to a Nano meter scale which will be in Nano scale range. The concept of Nanotechnology was stated by "Richard Feynman"-A Physicist Nobel Laureate in 1965 in his famous speech titled "There's Plenty of Room at the Bottom" in December 1959. The main idea behind his speech was to highlight the area of Miniaturization and future of creating powerful and tinier devices. The concept of "Nanotechnology" was first quoted by N. Taniguchi as "Nanotechnology mainly comprise of processing of, separation, consolidation, and deformation of materials by one atom or by one molecule. Figure-1:Shows the size comparison with different materials. Nanotechnology known as Molecular Nano Technology (MNT) represents atom by atom and molecule by molecule based control of the structure of matter. The impact of mobile and core network capsulated together in mode of operation of the nanotechnology as well as perfection in security and the better impact on the sensor makes the nanotechnology the most significant technology in these areas. Other issue in communication system based on nanotechnology is discovering new materials on the nanometer length scale expected to play an important role in future challenges in the field of communication systems such in devices of ultra-high-speed for long and short range communications links, power efficient computing devices, high density memory and logics, and ultra-fast interconnects. Also the use of molecules, instead of electromagnetic or acoustic waves, to encode and transmit the information represents a new communication paradigm that demands novel solutions such as molecular transceivers, channel models or protocols for Nano networks. Molecular transceivers will be easy to integrate in Nano-devices due to their size and domain of operation. These transceivers are able to react to specific molecules and to release others as a response after performing some type of processing. Recent advancements in molecular and carbon electronics have applied a new generation of electronic Nanocomponents such as Nano batteries, Nano-memories, logical circuitry in the

nanoscale and even Nano-antennas. This paper focus on the nanotechnology issues in telecommunication engineering and also provides a review of applications and future technologies in field of telecommunication based on nanotechnology. Nanofabrication possibilities are bright for future technologies. One of the fundamental visions of the wireless industry is to have ambient intelligence i.e. computation and communication which are always available and are ready to serve the user in an intelligent way. This requires that the devices are mobile. The intelligence that is embedded in human environments – home, office, public places –in conjunction with mobile devices will create a new platform which will enable ubiquitous sensing, computing, and communication. The Internet of Things (IoT) is regarded as new revolution that is picking up huge popularity in the world of modern wireless telecommunications. The backbone behind Internet of Things (IoT) is the pervasive presence of wide range of things or objects like RFID (Radio Frequency Identification) tags, sensors, actuators, mobile technology, NFC (Near Field Communication), Smart Phones, Tablets etc. The concept of IoT marks high impact on various aspects of everyone's life as wide range of devices and communication protocols are under rapid development process by industries and researchers in diverse fields like e-health, e-agriculture, e-industry, smart cities, e-military etc. Internet of Things (IoT) produces tons of data. In nutshell, the integration of nanoscale devices with exiting traditional communication networks with High Speed Internet has led to new evolution which is termed as "Internet of Nano-Things(IoNT)". With the advent of Internet of Nanotechnology (IoNT), research in the area of Nano communication has also increased ten times with an objective to create new standards for Nano devices to communicate among each other and should also be deployed in diverse applications So, in turn Internet of Nano things will open new doors of research in the area of Nano Sensors, Nano communication and Nano Devices.

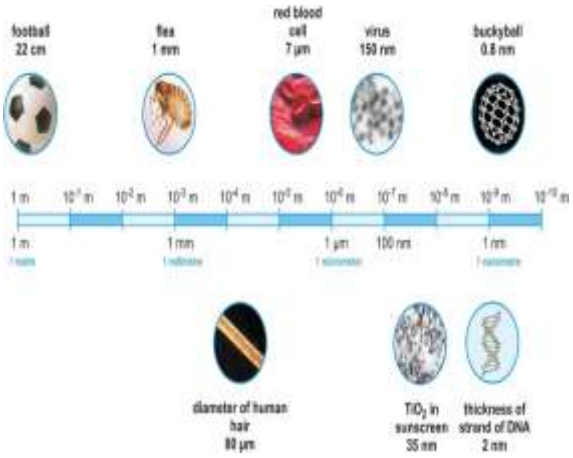

Figure -1: *Size Comparison*

Figure -2: Shows the applications of nanotechnology in various fields.

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Figure-2: Applications of Nano technology.

2. NANOTECHNOLOGY GENERATIONS:

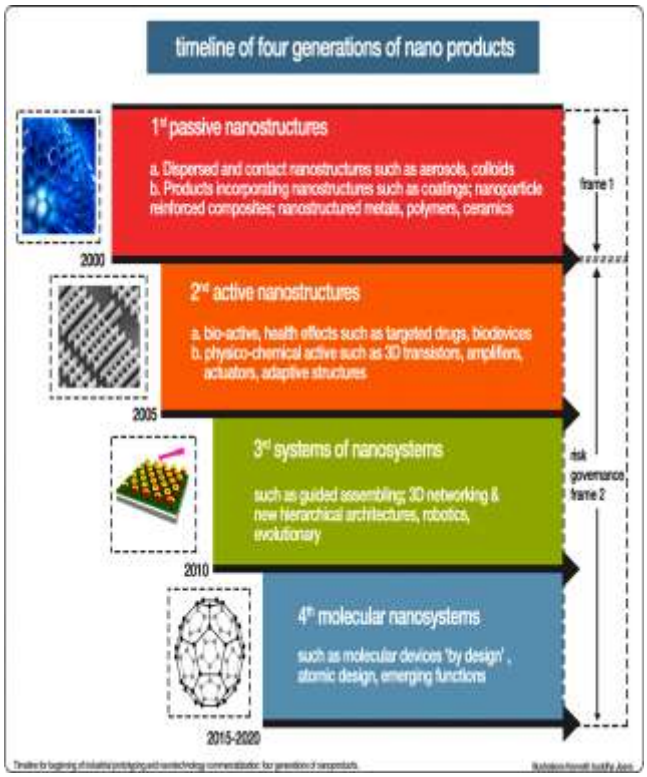

Figure-3: *Generation of Nanotechnology.*

Above figure-3: shows the generation of Nano products based on Nanotechnology. Nanocommunication is the exchange of information at the nanoscale and it is at the basis of any wired/wireless interconnection of nanomachines in a nanonetwork. The way in which the nanomachines can communicate depends strongly on the way they are realized. Moreover, the particular application for which the nanonetworks will be deployed constrains the choice on the particular type of nanocommunication. For the time being, several alternatives have been proposed. These range from downscaling well established communication means based on electromagnetic, optical, acoustic, or mechanical communication, up to defining completely new paradigms inspired by biology. Nanomachines With miniaturization and fabrication of devices via Nanotechnology techniques, the ultimate end product which is developed is termed as "Nano-Machines". Nano-machine is regarded as tiny components comprised of arranged set of molecules to perform simple computational, sensing and actuating tasks. Nano-machines can be further used as foundation for development of nano-processors, nano-memory and nano-clocks. Nano-machine, in simple terms can be defined as, "A Mechanical device that performs a useful function using components of nanometre-scale and defined molecular structure which includes both artificial nano-machines and naturally occurring devices found in biological systems". In order to develop Nano-Machines, there are various approaches-

Top down approach and Bottom-up approach.

2.1. Top down Approach:

Focussed on downscaling existing microelectronic and micro-electro-mechanical technologies without atomic level control. Example: Micro-contact printing and development of Nano-machines like Nano-electromechanical systems (NEMS).

2.2. Bottom up Approach:

Focussed on design of nano-machines using individual molecules. This approach is also known as molecular manufacturing. Example: Nano machines like molecular switches, molecular shuttles etc.

3. MOBILE RADIO COMMUNICATION

The tools provided by nanotechnology are enabling the extension of well-known communication techniques to the nanoscale. First of all, carbon nanotubes and graphene nanoribbons have been proposed for electromagnetic nanoantennas. A graphene-based nanoantenna is not just a mere reduction of a classical antenna, but there are several quantum phenomena that affect the propagation of electromagnetic waves on graphene. As a result, the resonant frequency of these nanostructures can be up to two orders of magnitude below that of their noncarbon-based counterparts. However, their radiation efficiency can also be impaired because of this phenomenon. Carbon nanotubes have also been proposed as the basis of an electromechanical nano-transceiver or nano-radio, able to modulate and demodulate an electromagnetic wave by means of mechanical resonation delay of more than 100ms, the results define reliable and simple models, which can be used off the shelf in the design of molecular communication systems based on the free diffusion of molecules. We expanded our understanding of the molecular diffusion channel by analyzing the most relevant diffusion-based noise sources, whose origins are intrinsically different than for noise sources in EM communication.

Figure – 4: *Mobile devices become gateways to ambient intelligence and needed information.*

4. WIRELESS TECHNOLOGY

The telecommunication enterprise will radically get changed into the brand new Nanotechnology. Nanotechnology effect in operation of both cellular as well as core network, and by addition perfection in security and the better effect on the sensor make the nanotechnology the hugest from previous traditional technologies. Wireless technology industries have promised at the implementation of the intelligent operations that allows ensuring that the computation and communication are to be had as desired. The advent of intelligent and Nano technology concepts in the mobile devices will assist in embedding the devices inside the human environments that can create a brand new platform on the way to permit the ever present sensing, and computing. The Nano devices may be loaded to achieve some capabilities like self-powering, sensible to the environment or smart interaction with other systems.

Nanotechnology can help in the advancement of new types of insightful Nano devices and Nano sensors that can able to communicate with these organic frameworks. Example of using nanotechnology in wireless devices like remote sensors which are an especially huge region of research in the improvement of military nanotechnologies. Nano sensors in observation applications could likewise assume a key part in enhancing the precision of weapons conveyance and boosting the lethality of assaults, for instance by giving data to change control levels. Nano wireless devices could be scattered over a combat for catching an information on temperature, weight, vibration, increasing speed, light, magnetic, or acoustics and impart this data constantly.

5. NANO COMMUNICATION AND NETWORKS

Communication based on electromagnetic waves is the most basic strategy to interconnect microelectronic devices and these waves can propagate with low loss along wires or wirelessly. To establish a bidirectional wireless Nano communication, radio frequency systems should to be coordinated in the Nano machine which required a development in Nano scale antennas for very high frequencies. The communication between the Nano scale machines is defined by which is knows as Molecular communication represent the transmission and reception of information encoded in molecules. Molecular communication can be used to interconnect multiple Nano machines, resulting in Nano networks which are using the message is encoded using molecules. The coding techniques can be considered to represent the information in Nano networks called molecular encoding, uses internal parameters of the molecules to encode the information such as the chemical structure, relative positioning of molecular elements or polarization. The receiver must be able to detect these specific molecules to decode the information. This technique is

similar to the use of encrypted packets in communication networks, in which only the intended receiver is capable to read the information. As shown in Figure-5 below molecular encoding is used in phenomenal communication, where only members of the transmitter specie can decode the transmitted message. Text, voice and video are usually transmitted over traditional communication networks. By contrast, in Nano networks, since the message is a molecule, the transmitted information is more related to phenomena, chemical states and processes. The communication between Nano machines take place as in the traditional communication that means the systems have to transmit a message over a carrier to the receiver and the information carried should be encoded in transmitter side and decoded in receiver but the message in molecular communication is a molecule, This molecular message will present a predefined external structure that will allow an easy recognition at the receiver it will be inactive means that molecular messages will not be prone to react to other molecules in the medium in addition that molecular messages should easily be eliminated without any side effect they are decoded at the receiver Nano machine

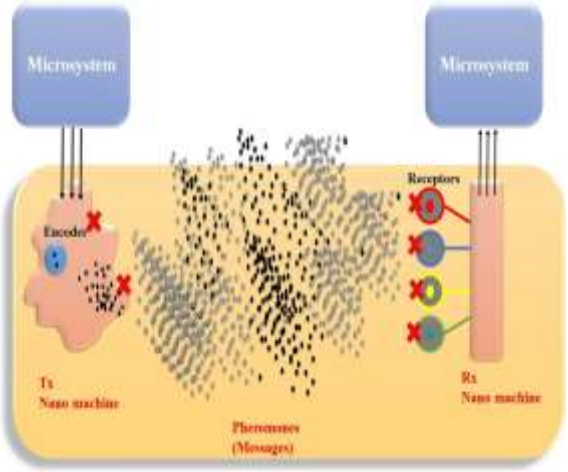

Figure – 5: Molecular communication based on pheromones encoding.

6. NANO SENSORS AND NANO DEVICES

Nano sensors and nano devices are providing new solutions for many aspects such in environmental and biological sensing that offers a high degree of detection sensitivity, and availability in static or dynamic situation in many applications such as health, safety, and monitoring. Due to the increasing in many applications of industrial facilities and its global distributions, there is an urgent need to develop new type of sensors and devices that are able to detect and identify rapidly the source of pollutant, and other threat agents at any point. From other side taking deep concept, it's also required to develop sensors and devices that are able to interact with other machines in manufacturing areas, to detect many types of fluctuations during industrial process. Healthcare is also becomes an important area that required developing a new generation of

nano sensors and nano devices with rapid response and high sensitivity in nano scale areas may be inside the human body. Nano sensors are any biological, chemical, or surgical sensory points used to convey information about nano particles to the macroscopic world. Nano devices are used mainly in various medicinal purposes as gateways to building other Nano products, such as computer chips that work at the nanoscale and Nano robots. In human body area communications, Nano sensors deliver real-time information about the antibodies to antigens, cell receptors to their glands, and DNA and RNA to nucleic acid with a complimentary sequence. The transducing mechanism may be Optical, Mass or Electrochemical. In optical mechanism many phenomena's can be used to detect various chemical metrics such phenomena's like Luminescence to detect the concentration of (H_2O) hydrogen peroxide (H_2O_2) by using luminescent optical sensors, Absorption, Polarization, and Fluorescence. In the near future Nano sensors will provides many new applications such as enabling personalized images for viruses and pathogens, or to fabricate a screen geomatics DNA for large set of Single nucleotide polymorphisms (SNPs). Other future applications that can be developed will promise a spectacular interaction between physics, materials, computing and communication by integrate the Nano scale sensors, Nano processors. Optical communication and Nano micro electro mechanical systems all together to design a new generation of Nano satellites that able to act as a bio explorer with high sensitivity or monitoring harsh environments.

7. TERAHERTZ BAND:

7.1. Ultra-Broadband Communications in Nano Networks.

Focusing on the use of grapheme based nano-antennas and thinking of the expected maximum size of a nanomachine, the Terahertz Band (0.1THz−10THz) enters the game. Indeed, we have recently shown that a one-micrometer-long graphene-based nano-antenna would expectedly resonate in the aforementioned band. This very high-frequency range, in between the microwaves and the far-infrared radiation, has recently caught the attention of the scientific community because of its applications in security screening and nano scale imaging systems. In our case, we think of the Terahertz Band as a very large transmission window that can support very high transmission rates in the short range, that is, up to a few Terabits per second for distances below one meter, or as several transmission windows more than 10 gigahertz. For the time being, it is not clear how nanomachines with limited capabilities can exploit the properties of this huge band, but several options come to mind. For example, we have recently proposed the use of very low energy femto second-long pulses as a simple but robust

communication paradigm for nano material-based nanomachines. Moreover, having a very large available bandwidth introduces major changes in classical networking protocols.

8. INTERNET OF NANO THINGS (IoNT):

The basic building block of Internet of Nano Things (IoNT) is Nanotechnology. The IoNT is comprised of nano scale network of physical objects which exchange information among each other powered by Nano Communication. The Interconnection of nanoscale devices with existing communication networks and ultimately the Internet, defines a new networking paradigm called "Internet of Nano-Things". Internet of Nano Things (IoNT) infrastructure can be deployed by mixing nano devices and several other technologies like IoT, Sensors Network, Cloud Computing, Big Data Analytics etc. The IoNT infrastructure depends on the area of operation and required bandwidth required by particular application. The enhancement and wide range adoption of IoNT depends on processing capabilities, large storage at low costs, smart antennas and Smart RFID tag technology. Some of the major players in the IoNT market are Intel Corporation, Cisco Systems Inc., Qualcomm Incorporated, Even having high future adoptability prospects, the growth of the IoNT market faces a few challenges due to privacy and security issues. Since critical data is communicated between devices over the internet, concerns related to security of the data have risen. Another factor which hinders the growth of IoNT market is the huge capital investment required for the development of nanotechnology. IoNT uses two broad areas of communication:

Electromagnetic Nano-Communication.

It is regarded as transmission and receiving of electromagnetic (EM) radiation from components based on nanomaterial's.

Molecular Communication.

It is regarded as transmission and receiving of information encoded in molecules. Network Architecture of Internet of Nano Things Internet of Nano Things (IoNT) is picking up the pace in rapid areas. Regardless of the application areas, the following components are the trump part of Architecture of Internet of Nano Things:

8.1. Nano-Nodes:

Nano-nodes are regarded as the smallest and simplest nano machines which perform various tasks like computation and transmission if the data over short distances and have less memory. Considering Body Sensor Networks, Biological sensors fitted in Human Body are considered as Nano-Nodes.

8.2. Nano-Routers:

Nano-routers have large computational power as compared to nano nodes and they act as aggregators of information coming

from nano-nodes. Nano-routers also play crucial role in controlling nano-nodes by exchange control commands.

8.3. Nano-Micro interface devices:

These devices perform the task of aggregation of information coming from nano-routers and transmit it to the microscale and vice versa. They act as hybrid devices to communicate in nanoscale using Nano communication techniques and also with traditional communication networks with classical network protocols. 4. Gateway: It enables the remote control of entire nano things network over the Internet. Example: Considering Body Sensor Network- With the use of Gateway all the sensor data from the Human Body can be accessed anywhere and everywhere via doctors over Internet.

In the Figure -6: Shows the Health Care Monitoring / Nano-Sensor Based Body Sensor Network. The First and the foremost application where IoNT can be seen these days in real world is Body Sensor Network (BSN) comprising of in-body nano sensors playing a crucial role in collecting and monitoring patient's biological activity and other details. Nano sensors being used in BSN provides real time data on a wearable device being used by the doctor for getting timely information regarding patient's health. With the use of nano sensors in Environmental monitoring via deployment in public locations like Railway Stations, Bus Stops, Airports, Hotels and Restaurants and other Public places, live and real time monitoring of Traffic, Air Pollution, Temperature Monitoring is done more efficiently. Precision Agriculture the use of IoNT in agriculture will lead to development of several precision farming applications and with the live implementation of Nano-Sensors based Nano devices will lead to efficient environment monitoring, crop growth and even animal monitoring. With the development of Wireless Nano Sensor Network (WNSN) various agriculture activities can be performed like Grass Monitoring, Animal Health and Feed Management, Agriculture Field Condition Monitoring and Effective monitoring of usage of Pesticides and Insecticides in the Agriculture field. Considering IoNT advantages, in the near future IoNT can also be applied by Military for Battlefield Monitoring, Development of Nano-Robotics and Nano-Drones, Space Based Applications, Industry Production and many more. Challenges of Internet of Nano Things (IoNT) IoNT is regarded as the most miniaturized nano sensor networks having huge potential to be as such adoptable in real time applications in diverse fields. But even though of having tons of advanced advantages, IoNT also suffers with some issues and challenges

which needs to be addressed so that IoNT can become indispensable part of mankind in near future without any hiccup. Researchers must address the issues regarding context management, security and privacy, service composition and discovery. Apart from working on researching on various application areas and development of Nanotechnology based IoNT devices, new security and privacy mechanisms needs to be addressed with regard to the data being collected by nano sensors. Services should also be enhanced and new service-oriented architectures needs to be proposed to make nano sensors and nano networks compatible to hold tons of large varieties of data.

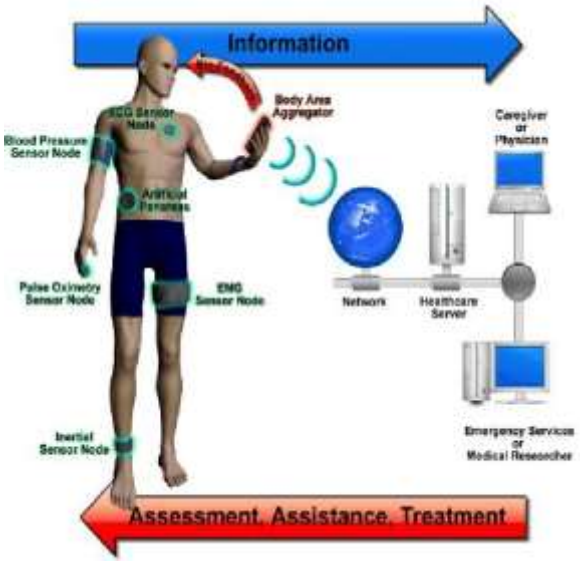

Figure - 6: *Health Monitoring via Nano Sensors comprising Real Time Health Monitoring (IoNT).*

8.4. Applications of IoNT:

The most sophisticated and advanced methodologies are used by IoNT for data collection, which enables IoNT to extend its base from existing applications to wide range of new and advanced applications as compared to IoT.

9. FIFTH GENERATION SYSTEMS (5G)

In fifth generation of mobile systems, cells are referred as Nano devices as they are equipped up with nanotechnology. One of the relevant visions of the wireless industries is to achieve a means of Nano intelligent technologies to be prepared to serve the person in a smart manner. This requires that the network devices and mobile together with the intelligence means are all mind to be embedded in human environments such as home, workplace, or public places and will create a new platform that allow to sensing, and computing, in Nano communication systems.

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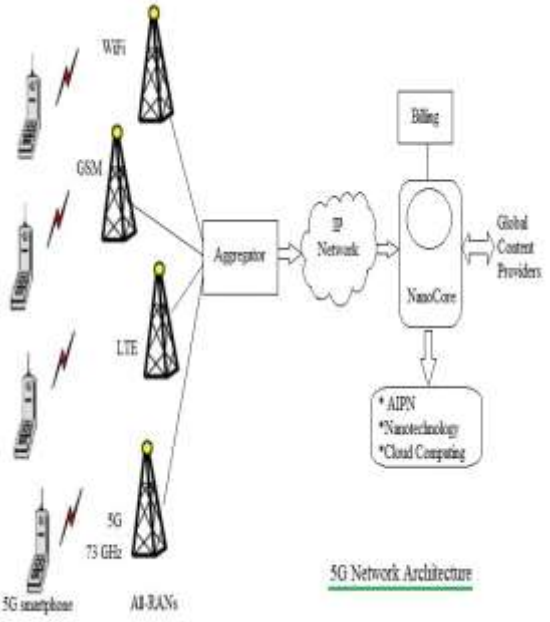

Figure - 7: *5G Network Architecture.*

5G Wireless Communication System is not deployed yet. The big challenge for the design and deployment of 5G wireless system can be faced easily as proposed features and architecture (shown in above figure-7) that will increase system capacity and quality within the limited available frequency spectrum, whose frequency band and Data Bandwidth will be 3-300GHz‘ and 1Gbps & higher (as demand)‘ successively. The remarkable issue, there don‘t have any limitation in 5G as respect to user demands in the future years. The 5G also implies the whole wireless world interconnection (WISDOM—Wireless Innovative System for Dynamic Operating Mega communications concept), together with very high data rates of the Quality of Service (QoS) applications. The usage of 5G is shown in below figure-8.

Figure - 8: *Usage of 5G*

9.1. Why is there a need for 5G?

5G is to be a new technology that will provide all the possible applications, by using only one universal device, and interconnecting most of the already existing communication infrastructures. The 5G terminals will be an upgradable multimode and cognitive radio- enabled. It will have software defined radio modulation schemes. All the required upgradable software should be downloaded from the Internet on the run. The 5G mobile networks will focus on the development of the user terminals where the terminals will have access to different wireless technologies at the same time and will consolidate various flows from various technologies. Besides, the terminal will make the ultimate choice among different wireless/mobile access network providers for a given service. The 5G network can provide more facilities approach to a common man to utilize his

available possessions in an enormous way to make him to feel the real progress. As a user point of view, the major difference between current generations and expected 5G techniques must be something else than increased maximum throughput; other requirements include

- It could make better revenue for current global operators as well as interoperability will become more feasible.
- Improved and innovative data coding and modulation techniques, which includes filter bank multi carrier way in schemes.
- For wireless access and back haul use of millimetre wave frequencies is very useful.
- With the support of different conduction points with related coverage and surrounding the option of a supple usage of resources for uplink and down link transmission in each cell is achieved by superior intrusion and mobility management.
- To make 5G practical for all sorts of radio access technologies there should be a common platform unique for all the technologies.
- Lower battery consumption.
- Lower outage probability.
- Better coverage and high data rates available at cell edge.
- Multiple concurrent data transfer paths.
- Possible to1Gbps and higher data rate in mobility.
- More secure; better cognitive radio/SDR Security.
- Higher system level spectral efficiency.
- World Wide Wireless Web (WWWW), wireless-based web applications that include full multimedia capability beyond 4G speeds.
- More applications combined with Artificial Intelligent (AI) as human life will be surrounded by artificial sensors which could be communicating with mobile phones.
- Not harmful to human health.
- Cheaper traffic fees due to low infrastructure deployment costs.

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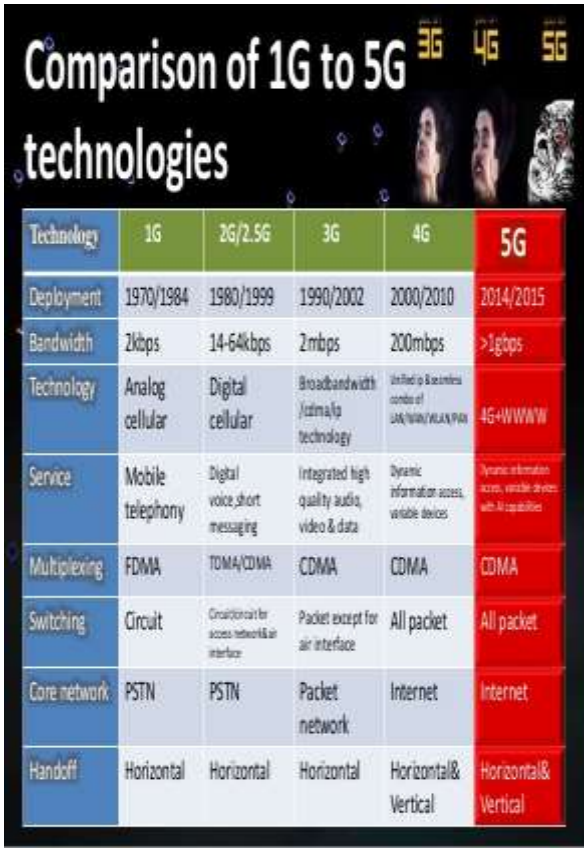

Figure – 9: *Comparison of 1G to 5G.*

10. FUTURE POSSIBILITIES

Nanotechnology opens the best way to deal with many fields, for example, Telecommunications, Bio Engineering, Medical Electronics and Robotics. In communicate and information exchange the use of the nanotechnology will be recognized new estimates of unbelievable ways to offer smart transmission media. Due to revolutionized in telecommunications, other aspects can be achieved such a revolution in computing, and networking industries. The emerging innovation technologies may be in Nanomaterials with novel optical, electrical, and magnetic properties, faster and smaller non-silicon-based chipsets, memory, and processors, new science computers based on Quantum Computing, Advanced microscopy and manufacturing systems. 5G technology offer high resolution for crazy cell phone user. 5G technology will provide supper and perfect utilization of cellular communication in future. We can monitor any place of the world from anywhere, observe space and watch TV channels at HD clarity in our mobile phones without any interruption. Nanotechnology can add more of Electronics and communication techniques that cannot be predicted currently and may outweigh ratio imagination because this technology in the first phase of research, particularly in the field of telecommunications engineering research.

11. CONCLUSIONS

Now a day the use of Electronic devices and communicating equipments are rapidly increasing and quickly expanding. The fundamental drivers for the utilization of nanotechnology in wireless devices and systems are superior, bring down power utilization and minimized size of communication components. Nanotechnology is set to significantly influence communication systems provoking to less requesting meeting of related advancements, enormous capacity information, minimized limit devices, and

higher execution registering. Nanotechnology for Telecommunications covers ask about and developmental issues and what's more future course of nanotechnology as they apply to broadcast communications systems. The development of Nanotechnologies, nano machines, Internet of Things (IoT), Internet of Nano Things (IoNT) will have a great impact on advanced development in almost every field in near future. Researchers are currently working in development of nano machines comprising IoNT for live deployment in varied areas in near future. The new coming 5G technology is available in the market to fulfil user demands in affordable rates, bright and high peak future also much reliability as well as exceptional applications. This paper has presented the use of nanotechnology in more sophisticated area and widely used in Electronics and Communications engineering techniques in present and expected to be used in a more intelligent in the future.

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