The Internet of Nano Things (IoNT) Existing State and Future Prospects

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***Abstract*— The Internet of Nano-Things (IoNT) is a system of nano connected devices, objects, or organisms that have unique identifiers to transfer data over a computer or cellular network wirelessly to the Cloud. The data delivery, caching, and energy consumption are among the most significant topics in the IoNT nowadays. The nano-networks paradigm can empower the consumers to make a difference to their well-being by connecting data to personalized analysis within timely insights. The real-time data can be used in a diversification of nano-applications in the Internet of Nano-Things (IoNT), from preventive treatment to diagnostics and rehabilitation. In this paper intelligibly explains the Internet of Nano Things (IoNT), its architecture, challenges, explains the role of IoNT in global market, IoNT applications in various domains. Internet of things has provided countless new opportunity to create a powerful industrialized structure and many more.**

The key applications for IoNT communication including healthcare, transportation and logistics, defense and aerospace, media and entertainment, manufacturing, oil and gas, high speed data transfer & cellular, multimedia, immune system support and others services. In the end, since security is considered to be one of the main issues of the IoNT system, we provide an in-depth discussion on security, communication network and Internet of Nano Things (IoNT) market trends.

Index Terms: **Internet Of Nano Things (IoNT); Nanoscale Devices; Nano-Bioscience; Sensors; Internet Of Things (IoT); Internet Of Bio-Nano Things (IoBNT); Body Sensor Network (BSN).**

I.INTRODUCTION

The arrival of the internet of things has transformed the day to day functionality of each life's intensely. The Internet is a highly connected global network which promises to connect physical and digital devices. Several IoT applications have been implemented and deployed in the modern years. The Internet of things (IoT) extends the objective of the internet to many devices and objects from different domains by interconnecting them. Internet of Things (IoT) the new dawn technology that describes how data, people, and interconnected physical objects act based on communicated information, and big data analytics have been adopted by diverse domains for varying purposes.

The IoNT involves a large number of nanosensors that used to provide more precise and detailed information about a particular object to enable a better understanding of object behavior. IoNT adds a new scale in IoT incorporating nano-sensors in the devices, which in turn allows it to connect and communicate through the nanotechnology network with internet. The IoNT is embedded with nanotechnology (a technology which is deployed in desired devices within the nanotechnology radius), which helps in seamless transmission and communication of data within a given range of operations. This vision and model has been greatly evolving with respect to the number and types of things that are being connected, and in the technologies for collecting, processing, and sharing. The IoNT infrastructure allows different combinations of nano cameras, nano phones, nano things &objects, nano-sensor network technologies, and many more.

The IoNT is increasing fast, prominently improving the mighty IoT. In IoNT infrastructure, these "nano things" will realize and explore each other and learn to take advantage of each other's data by sharing resources and dramatically enhancing the scope and dependability of the resulting services. The concept of the IoNT is introduced as a type of IoT where nano-devices whose dimensions may range from 1 to 100 nm [9] are interconnected with classical networks leading to new networking paradigms. Internet of Nano Things (IoNT) communications can

be structured by integrating nano devices and a number of other technologies such as IoT, Sensors Network, Cloud Computing, Big data analytics etc. This new networking paradigm will have a great impact in almost every field of our society, ranging from healthcare to homeland security or environmental protection.

II. IDENTIFY, RESEARCH AND COLLECT IDEA

The Internet of nano things is a newly emerging technology that is arriving faster than ever and holds the promise of solving many of the world's most pressing challenges. It performs the way we connect devices in case of Internet of Things but the major difference is it can connect the nano components which is not possible with Internet of Things. Thus, it creates a state of the art revolution in electromagnetic communication areas among nano scale devices.

The real-time data can be used in a variety of nano-applications in the Internet of Nano-Things (IoNT), from preventive treatment to diagnostics and rehabilitation. IoNT introduces significant challenges as well as opportunities for wearable sensor-based big data analysis research. Traditional algorithms do not offer flexibility to handle such large volumes of diverse data, and this creates a need for proper mechanisms for data analysis to be able to keep up with the managing, processing, and response requirements along with the data reliability.

About Internet of Nano Things (IoNT)

The Internet of Nano Things (IoNT) is a convergent point where nanotechnology, the Internet of Things (IoT) and Industry 4.0 meet. The premise of the IoNT is pretty simple; it is essentially a nanoscale version of the IoT. These areas also converge within sensors that can be used in conventional IoT systems, but the IoNT is the manifestation of small-scale IoT systems that is ideal solution for remote environmental monitoring and medical applications. The IoNT involves a large number of nanosensors that used to provide more precise and detailed information about a particular object to enable a better understanding of object behavior.

III. HOW INTERNET OF NANO THINGS (IONT) FUNCTIONING

The Nanotechnology can be combined with the IoT is in the creation of a physical network, composed of nanomaterials that facilitates the exchange of data through different components communicating with each other at the nano level. This is known as the Internet of Nano Things (IoNT). In terms of development, it is not yet at the level of other IoT systems, but it is attracting interest from the communication and medical sectors. One such example is in field-based applications, where remote sensing is required, or for measuring different points within a human body.

The any system, there are multiple components, and the IoNT is no different. There are also two common ways that these components communicate with each other, and these are through electromagnetic nano-communication (transmission and receiving of electromagnetic waves) and molecular communication (information encoded in molecules). As for the components themselves, there are four main areas of the IoNT that help to facilitate the transfer of information these are nano nodes, nano-routers, nano-micro interface devices, and gateways. There are four basic components to an IoNT system shown in figure 1. These are called the nano nodes, nano-routers, nano-micro interface devices, and gateways. The smallest component is the nano node . These are colloquial to sensors in conventional IoT networks and are essentially basic nano machines. Because of their small size and small internal memory, the operations that they can perform are limited, as is the distance that they can transmit data. However, many nano nodes can be connected to one or more nano-routers much like where sensors transmit the localized data to a localized hub before sending the information over long distances. Nano-routers are much larger than the nano nodes, and therefore possess a much higher computational power that enables them to collect and aggregate all the data from the surrounding nano nodes and transmit this data over long distances to the nano-micro interface device. A Nano node is the simplest and smallest component within the IoNT setup and is seen as a basic nano machine. These small nano machines are used to transmit data and perform basic computations. However, their small size (and energy) limits the distance that they can transmit data, and they possess a very small internal memory.

Nevertheless, they can be placed in a specific location and transmit data to a larger nano-router, which then transmits the data over longer distances. Therefore, the nano nodes can often be the actual sensor component of the system. The nano nodes pass the data on to the nano-router, which is a nano machine with a much larger computational power. Because they possess a much higher computational power, they act as an aggregator for all the surrounding nano nodes that obtain the initial data. They can then control the exchange commands between the nano nodes and send the information to the nano-micro interface device. These interface devices aggregate all the data from the nano-routers and transmit the data to the micro scale (and vice versa) using a combination of nano-communication techniques and classical network protocols. The gateway then acts as the controller of the whole system and enables the data to be accessed anywhere via the internet. So, the IoNT does show some similarities with how IoT systems operate, but the small size of components means that some of the hubs need to be closer together.

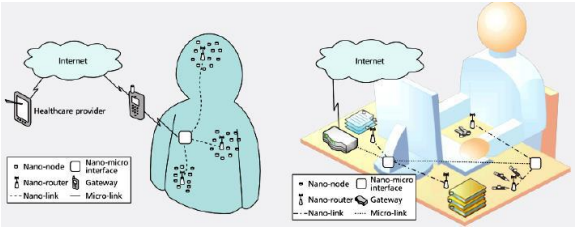

Figure 1 The Functioning of Internet of Nano Things (IoNT)

IV. THE MAIN REASON OF INTERNET OF NANO THINGS (IONT)

The development of Nanotechnologies, nano machines, Internet of Nano Things (IoNT) will have a great impact on advanced development in almost every field in near future. The interconnection of nanoscale devices with existing communication networks and ultimately the Internet defines a new networking paradigm that is further referred to as the Internet of Nano Things.

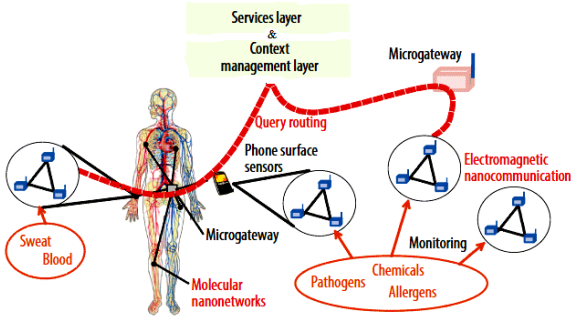

Figure 2 The Nano Communication in Internet of Nano Things

The IoNT is an extension of the Internet of everything , but where you have the possibility of incorporating nano-sensors in various objects and using nano-networks. That is, the reasonof IoNT consists of the capacity to interconnect diverse types of devices developed at a nano-scale in a communication network, where it allows the collection of data in places with difficult access . The figure 2 show the interconnection which is established between different devices, as are nanosensors through nano-networks, with the aim provides essential information within complex-to-access areas. For example, on-body nano-sensors could provide electrocardiographic and other vital signals, while environmental nano-sensors could collect information about pathogens and allergens in a given area . The term as nano-networks are not a simple extension of traditional communication networks at the nano-scale. They are a complete new communication paradigm, in which most of the communication processes are inspired by biological systems found in nature.

V. THE AREA OF INTERNET OF NANO THINGS (IONT)

The Internet of Nano Things (IoNT) contains two areas firstly the Internet of the Nano-Things Multimedia (IoMNT)and secondly the Internet of the Bio-Nano Things (IoBNT], also, the architecture of the nano devices can be different, depending on the capabilities that it provides nano technology. The perspective of multimedia nano-things concludes that nano components have to be integrated into a single device.

In figure 3, a single device is made up of different nano components (nano cameras, nano-phones, nano-antenna, etc.). Additionally, this device must be tiny of at least a few cubic micrometers

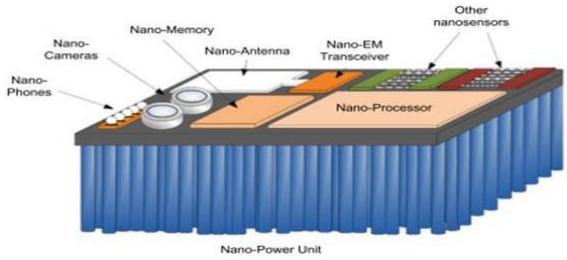

Figure 3TheArchitecture of Multimedia Nano Things

In the Internet of the Nano Things Multimedia (IoMNT) architecture contain a Nano Cameras photo-detector designed at nano-scale which is of great importance in telecommunications. It allows the detection of signals and acquisition of optical images and Nano-Phones Consist of ultrasonic transducers with nanoscale dimensions .In the Scalar nano sensors are able to devices of a new generation of sensors. A nano sensor is not just a tiny sensor, but a device that makes use of the novel properties of nanomaterials to identify and measure new types of events in the nanoscale and Nano processor is high performance transistors. They are smaller and can work at high frequencies. The Nano memories are indicated that these memories are not yet ready and available for the nano devices. Nano-materials and new manufacturing processes are considered as the starting point for their development, using single-atom memories, where each bit of information requires only one atom and power nano systems type of batteries requires new models or techniques that allow energy storage in a very different way than conventional batteries. Again, nano antennas and nano transceivers use of nano materials has generated that many investigations can be made and with this the possibility of manufacturing nano-antennas .These antennas are much more compact than the traditional antennas, that is based on graphene and have the chance of working on the frequency of the Terahertz band. The capabilities of multimedia, processing, data

Open Research Internet of Nano Things (IoNT) Challenges

The Internet of Nano Things technology can face the many challenges during implementation. The first important challenge nano devices collect large volumes of confidential data, concerns regarding privacy and security need to be addressed. Users of Internet of Nano Things infrastructure need to be informed regarding who has access to their data and how their data will be used. Also, the collected data needs to be stored in a secure location with encryption and state-of-the-art cyber security protocols. If left unsecured, cyber criminals can illegally access this confidential data. In the case of a cyber-security attack, users may want to know who could be held responsible and which mitigation strategies can be executed. Hence, IoNT developers need to consider these issues before the mass production and utilization of IoNT devices.

There are still many challenges and open research issues that need to be taken into account regarding the performance improvements of the IoNT. One of them is terahertz band channel modeling. The IoNT needs to transmit very large amounts of data in a timely and reliable manner. Therefore, the impact of molecular absorption on the path loss and noise should be accurately analyzed. This will help to locate the best transmission window in terms of achievable information rates and channel capacity. Moreover, the impact of multi-path propagation on the capacity and achievable information rates should be accurately investigated. Nano-devices addressing scheme as Nano-devices have limited energy and computational processing, addresses with reasonable size are needed to consume less processing power. Moreover, the address domain shall be adequate to support the expected enormous number of fabricated Nano-machines. IPv4 provides 32-bit address space of four billion addresses; however it is not even enough to give each person on earth a unique identifier. By addressing Internet of things usingIPv6 concept, there is no need to fear that there will not be enough IP addresses for things. IPv6 is providing 128-bit addresses, this makes the address needs of IoNT will be sufficient. The real question is whether ‘‘everything’’ needs its own IP address. The answer of this question is no, because in today’s Internet, things are mostly servers and switches, firewalls, routers, laptops, phones and tablets with IP to IP connectivity. When we start talking about refrigerators, clothing, thermostats, light bulbs and Nano devices & machines, they do not need to be directly on the Internet with an IP address

[85].Another important challenge is related to the MAC protocol. The terahertz band supports very high bit rates and has a specific relation between the available transmission window, the bandwidth for each window, and the transmission distance. Therefore, research into transmission schemes would be beneficial in order to develop novel transmission techniques using the relation between the transmission bandwidth and the transmission distance. The MAC protocol should also guarantee that the transmitter and receiver are properly aligned before the transmission of the data packet.

Compliance with ethical standards

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Disclosure of conflict of interest

All authors declare that there is no conflict of interest regarding the publication of this paper

VI. CONCLUSION

The current development of communication devices and wireless network technologies continues to advance the new era of the Internet and telecommunications. The various “things”, which include not only communication devices, but also every other physical object on the planet, are also going to be connected to the Internet, and controlled through wireless networks. The Internet of Nano Things (IoNT) paradigm will take IoT to a new level, where devices that will be connected to the Internet will be focused on nano devices that are constructed from nanomaterials and components. These nano devices will communicate to a micro-device, which in turn communicates to the Internet. Currently the scientists have started shrinking sensors from millimeters or microns in size to the nanometer scale, small enough to circulate within living bodies and to mix directly into construction materials. This is a crucial first step toward an Internet of Nano Things (IoNT) that could take medicine, energy efficiency and many other sectors to a whole new dimension.

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