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The Internet Of Nano-Things And Applications : A Survey

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Abstract:
The Internet of Nano-Things (IoNT) is interconnection of the nanoscale devices which are connected using existing network Internet. IoNT is derived from the merged concept of IoT and Nanotechnology which are considered as a new revolution with a huge popularity in the world of modern wireless telecommunications. IoNT is the combination of IoT and Nanotechnology which is a new revolution and has transformed the use of the Internet. IoT connects various types of objects, sensors, and devices that can interact and form pervasive networks that enhance our daily lives. Next generation standards based on IoT called (IoNT) are set up for various applications in which nanotechnology is providing effective solutions. Various fields benefited from this technology include military, agriculture, medical industry and smart cities.

I. Introduction

The Internet of Nano Things (IoNT) concept was proposed by Ian Akyildiz and Josep Jornet in the paper "The Internet of Nano-Things"[1]. Nanotechnology has enabled better and efficient opportunities for numerous applications including health monitoring, industry, agriculture, smart cities, military, etc. It has resulted in the development of nanomachines, which are very small elements encompassing of organized set of molecules carrying out predetermined operations. Nanotechnology allows nanodevices to collect, create, compute, process and transmit data at nanoscale dimension. The interconnection of nanosensors and nanodevices with existing classical communication networks with the high speed Internet has led to the evolution of what is called the Internet of Nano Things (IoNT) [2]. Nano networks, apart from being downscaled networks, have several properties stemming from the nanoscale that question the well-established networking concepts. IoNT operates through two broad areas of communication, which are electromagnetic nano-communications and molecular communications [3][4].

As per the recent research reports by analysts, The Internet of Nano Things market was valued at USD 6.42 billion in 2017, and is expected to reach a value of USD 22.04 billion by 2023, growing at a CAGR of 22.81% during the forecast period (2018-2023). The nanotechnology market has witnessed rapid growth in the last decade, buoyed by technological innovations and their increasing adoption in the healthcare sector. Although the commercial viability of nanotechnology is yet to be ascertained completely, it holds the promise to bring about marked changes in the way humans lead their daily lives. The development of nano-machines with communication capabilities and interconnection with micro- and macro-devices will empower IoNT, which is being increasingly seen as the next major innovation in technology [5].

II. Nanotechnology And Nanomachines : Overview

Nanotechnology refers to make change in the structure of the material on small number of nanometers starting from 0.1 nm to 100 nm at atoms or molecular positioning and arrangement. The insight of Nanotechnology was successfully initiated by "Richard Feynman"-A Physicist Nobel Laureate in 1965. According to him, "the scheme must highlight the area of tininess device manufacturing". The perception of "Nanotechnology" was initially stated by N. Taniguchi [11] as "Nanotechnology generally consist of separating, Combining, and warping of materials by means of molecular level or atomic level." The concept of Nanotechnology is trimness as well as an invention of the devices and objects in the extent level of 1 to 100 nanometers. Passive Nano structure is accomplishing its task by good attribute to change the state during application and or in response to an external control to which it applied. The "Active Nanostructures" are normally used for changing their properties and these active nanostructures targeting the drugs and involves in the task like polymer based drug delivery. The next generation of nano technology will support more number of interacting devices on real time applications especially society and corporate.

Nanomachine is also called as nanite, which consist of mechanical or an electromechanical device.The Nanomachine has the size in terms of nanometers (millionths of a millimeter, or units of 10 -9 meters).

Nanomachines are widely used in the scientific research-and-development, but some ancient devices have been tested .It is being utilized both in artificial nanomachines and naturally in the work devices found in biological systems. The working styles of Nano-Machines have the following approaches. [8]

Top down Approach: It requires a very specific processing of materials with high cost. It is required at when the component size is nano scale dimensions. Example: Nano-electromechanical systems (NEMS).

Bottom up Approach: The nano-machines can be designed with individual molecules. This approach is also known as molecular manufacturing. Example: Nano machines like molecular switches, molecular shuttles etc.

Bio-hybrid Approach: The numbers of nanoscale components which present in the biological cells are considered as nano machines which in turn be used to perform the desired function with the help of set of instruction code written on it. Example: Bio-nano robots, nano-biosensors, biological storing components etc. [6]

III. Network Architecture Of Iont

The global IoNT market is expected to grow in the near future, attributed to growth in a number of connected devices, high demand for ubiquitous connectivity, high adoption of IoT among end-user industries, and need for better connectivity across the world. IoNT nanosensors are connected to physical objects to collect, process, and share data with end users. However, the interconnection of nanomachines with current communication techniques need to develop new network architectures [7, 8].

The components of the IoNT network is changed according to the context. However, there are essential elements for the network architecture of IoNT in various applications, as shown in Figure 1.

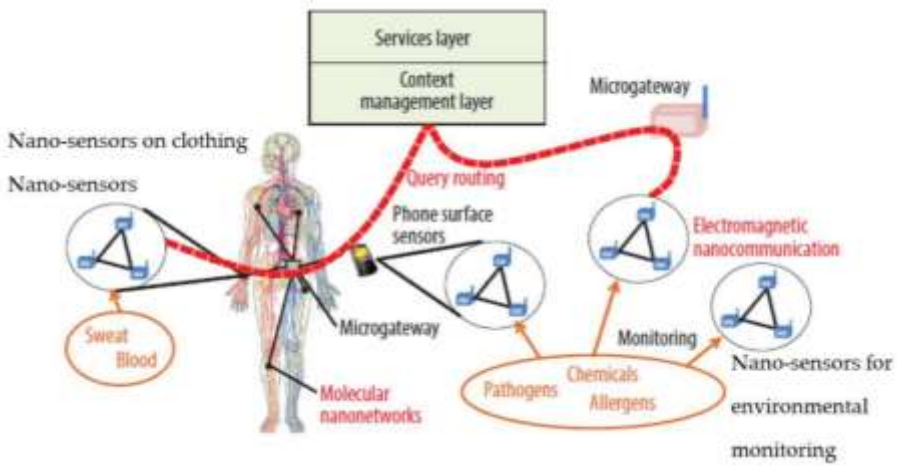

Figure 1. Classical Architecture of Internet of Nano Things (IoNT)[10]

These elements include:

Nanonodes: These nodes are considered to be the smallest and simplest nanomachines. Because of their limited energy, low memory, and limited communication capabilities, they can perform simple operations and transmit information over very short distances. Nanosensor nodes and nanomachines with communication capabilities are integrated into various objects such as human body [8].

Nanorouters: Compared to nanonodes, nanorouters have larger computational resources which are appropriate to combine information coming from different nanomachines. Nanorouters can also manage the behaviour of nanonodes by transmitting simple control commands such as sleep, on/off, read value, etc. Increasing the capabilities of these devices result in increasing their size which makes their deployment more difficult [10].

Nano-micro interface devices: These devices are used to combine the information collected from nanorouters to transport it to the microscale domain, and vice versa. Nanomicro interfaces are supposed to be hybrid devices that able to communicate in the nanoscale domain using both non communication techniques and traditional communication approaches in classical communication networks [10].

Gateway: It is used to control the entire system remotely over the internet. For instance, in an intrabody network, the information received by an advanced cell phone from a nano micro interface in the wrist can be forwarded to the healthcare provider [10].

IV. Issues And Challenges Of Internet Of Nano Things

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.

V. Applications

IoNT has involved in several applications such as multimedia, military, industry, smart cities, agriculture, and health monitoring. This section gives an overview of common applications where IoNT can use nanotechnology to add more benefits to various domains, as shown in Figure 2.

1. Oil and Gas : Nanosensors can be used to enhance the discovery rates of the oil. They can travel through the pores of the rocks and help to find the oil bounded to the rocks. Although cross-well imaging tools add more impact to the field, their provided resolution is very low such that the location of the oil is identified using huge magnetic source and receiver to map the nanoparticles that are inserted using recycled water. In IoNT, nanosensors interact and communicate with each other by molecular communication and the collected information can be conveyed in real-time using a nearby gateway. This allows the location of oil to be efficiently mapped without requiring a specific magnetic source and receiver.

2. Military : The war strategy has changed with the existence of new advanced biological and chemical weapons that make the difference in any battle. In the military, the IoNT can use nanosensors to discover the existence of a chemical composite in a concentration of even only one molecule. The composition of molecules of a room or the battlefield can be identified by nanosensors without the need for external tools such as the devices used for spectroscopy. In addition, nanosensors have the capability to identify the problems of very small cracks in bridges, civil structures, vehicles, textiles and rockets.

Figure 2. IoNT Applications

3. Agriculture : There are many successful scenarios where IoNT can improve the productivity of the agriculture. For instance, there are numerous types of nanoparticles that have proved its efficiency in pest management. Nanoparticles also can be used to control fungi in plants. These particles can be embedded into a nanosensor and used to control and monitor the planting process using the IoNT. For example, the fertilizer can

be sent out to the plant based 72 on monitoring conditions of the plant. Moreover, the information collected regarding the infected plant can be transmitted to the owner to check the plants status and trigger the release of nanosensors. In brief, IoNT can enable precision farming that uses facilities of satellite communication, geographic information systems, and remote sensing to enhance the efficiency and productivity of the agriculture.

4. Smart Cities : The implementation of a smart city provides a smooth interaction and communication with home appliances, monitoring sensors, surveillance cameras, actuators, vehicles, and others. The roadmap of the smart city depends on geographical environments and people lifestyle. All communication technologies provided by the smart city can be used by anyone regardless of their economic condition. With IoNT, nanosensors can be used to monitor and identify locations of pollution discovered in the air in high concentration and trigger nanosensors to clean up that specific location. In addition, with the existence of a countless number of nanosensors, it can be used to collect huge amounts of real-time information to improve the quality of life and provide new services and applications [10].

5. Multimedia : Nanotechnology has offered new nonmaterial that can be used to manufacture a novel generation of miniature photodetectors and acoustic nano-transducers. This allows creating new multimedia content at the nanoscale dimension that can add more benefits to various multimedia applications such as ultra-high-resolution imaging of distant objects for satellite imaging and ultra-high resolution imaging for crime scenes. Increasing resolution and accuracy of visual and acoustic information is not an easy task, but with nano-cameras and nano-phones, this issue can be handled by enabling higher computational and storing capacities, higher quality image and audio sensing capabilities, and higher energy efficiency.

6. Health Monitoring : Nanosensors have several applications in health monitoring. Several parameters such as cholesterol, glucose, and sodium can be observed using nanosensors. Cancer-causing tumours and other harmful agents can be also detected by nanosensors. In addition, nanosensors can be used to fix the demyelinated neurons by finding the affected zone and employing a myelin sheath. Although identifying the precise location to place the sheath is very difficult to know, IoNT nanosensors can relay the nerve impulse signal to the destination or towards the other end of the nerve [10].

7. Industry : IoNT can provide several benefits to the industry. It can improve the sensitivity of touch technology using air through nanosensors to identify movements of a particular figure in the air and translate it into signals [2]. Most industries use Radio Frequency Identification (RFID) tags to identify and monitor the production components, but RFID tags are mostly passive and require nearby readers to exchange information. While with IoNT, nanosensors can be used to transmit the information of the production line directly over the Internet. Also, Product Lifecycle Management (PLM) tool can be used to detect any unexpected action and trigger an alarm on the production line manager‟s personal device.

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