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Current Trends in Internet of Things: A Survey

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***Abstract*—** "Internet-of-Things" - a keyword which covers numerous aspects related to the advancements of the Internet into physical reality. The two trending technologies for the IoT are, RFID and wireless sensor networks (WSNs). But since, IoT requires the features of both the technologies, a need for a new communication technology arises. Currently, Nanotechnology is providing the engineering community with a new set of tools to control matter at an atomic and molecular level. Nanotechnology integrates Nano-components and creates a basic functional unit called Nano-machine which performs vital tasks like sensing and actuating. The integration of Nano scale devices and communication networks with High Speed Internet has developed a new technology - "Internet of Nano-Things (IoNT)". Further, ubiquitously arrayed multimedia Nano-devices, communication networks and Internet are being blended which has developed another communication system which is called as Internet of Multimedia Nano-Things (IoMNT).

***Keywords*—**Nanotechnology, IoT, IoNT, IoMNT

I. INTRODUCTION

"Internet-of-Things" or IoT is a keyword which covers several aspects related to the development of the Internet into physical reality. Internet of Things is an emerging topic of technical, social, and economic significance [1]. Consumer products, automobiles, industrial and utility components, sensors, and other everyday objects are being interconnected through Internet and equipped with powerful data analytic capabilities and embedded sensing and actuation capabilities. The concept of IoT, was proposed by Ashton [1] in 1999 and is linked to concept of RFID in recent years. IoT, is acquiring the Internet by integrating objects or devices through embedded systems and is making it a highly distributed network of communication with humans and devices [5].

The two main technologies in IoT are, RFID tags and wireless sensor networks (WSNs). RFID tags can be easily embedded in all categories of things due to their tiny size and their battery-less operation. But, RFID tags do not generally have processing, data storing or sensing capabilities. On the other hand, WSNs can enable IoT with necessary computing, data storing, and sensing functionalities, but the size, complexity and energy constraints of existing sensors limit the usefulness of this approach [8]. But since, IoT requires the features of both the technologies, there is a need for a new communication technology for the IoT.

Currently, Nanotechnology is facilitating the engineering community with a new set of tools to control matter at an atomic and molecular level. Nanotechnology deals with the engineering of functional systems at the molecular scale. Nanotechnology targets to build complete, high performance products. Nanotechnology [2] has addressed many real-time issues in the areas like Military applications, Biomedical, Biotechnology Industry, Agriculture etc. using modern techniques and tools. Nanotechnology integrates Nano-components and creates a basic functional unit which performs the important tasks like sensing and actuating. This functional unit is called Nano-machine. Apt cooperation and coordination among Nano-machines helps to address the complex problems. The integration of Nano devices and communication networks with High Speed Internet has led to new evolution which is called as "Internet of Nano-Things (IoNT)" [2]. The blending of ubiquitously arrayed multimedia Nano-devices with existing communication networks and Internet defines a truly cyber–physical system referred as the Internet of Multimedia Nano-Things (IoMNT). The IoMNT facilitates more advanced applications in fields like bio-medical, Defense and security, advanced multimedia applications etc.

This survey paper gives the overview of the trending technologies developed by blending the concepts of IoT, nanotechnology, modern communication protocols and Internet. The paper is organized as follows. Section I contains introduction. Section II contains the overview and applications of Internet of Nano-Things. Section III contains the overview and applications of Internet of Multimedia Nano-Things. Section IV contains the conclusion followed by references.

II. INTERNET OF NANO- THINGS (IONT)

The basic building block of Internet of Nano Things (IoNT) is Nanotechnology. IoNT involves exchange of information through Nano Communication between Nano networks of objects.

Internet of Nano Things (IoNT) structure can be set up by combining Nano devices with several other technologies like Sensor Network, Cloud Computing, and Big Data Analytics etc. The structure of IoNT is dependent on the essential bandwidth and area of operation required for the specific application. The development and wide range acceptance of IoNT is due to its processing capabilities, large storage at low costs, smart antennas and Smart RFID tag technology.

IoNT uses two broad areas of communication:

• Electromagnetic Nano-Communication: In this communication system, the transmission and reception of electromagnetic (EM) radiation from components based on Nano-materials takes place.

• Molecular Communication: In this communication system, the transmission and reception of information encoded in molecules takes place.

A. Network Architecture of Internet of Nano Things[6]

The Architecture of Internet of Nano Things comprises of:

1. Nano-Nodes: Nano-nodes are the smallest Nano machines which perform numerous tasks such as, computation and transmission of the data over short distances. It has very less memory.

E.g.: Body Sensor Networks, Biological sensors fitted in Human Body

2. Nano-Routers: Nano-routers have huge computational power when compared to Nano nodes. Nano-routers act as aggregators of information coming from Nano-nodes. Nano-routers also play important role in controlling Nano-nodes by interchanging control commands.

3. Nano-Micro interface devices: These devices perform the task of accumulation of information coming from Nano-routers and transmit it to the micro scale devices and vice-versa. They act as hybrid devices to communicate in Nano scale using Nano communication methods and also with traditional communication networks with classical network protocols.

4. Gateway: It permits the remote control of complete Nano things network over the Internet. Example:

Body Sensor Network- This type of sensor allows to access data from human body from anywhere and anytime through Internet.

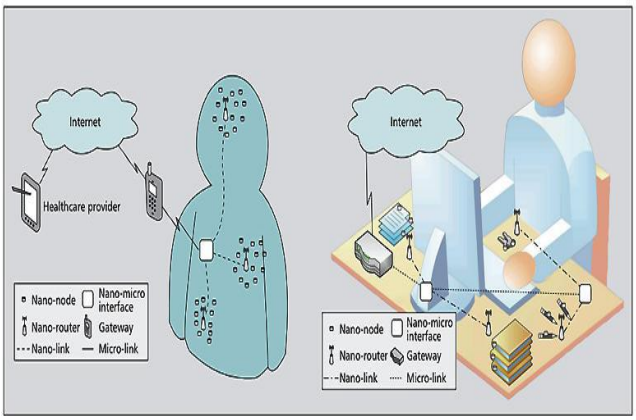

Fig 1. Network architecture of IoNT [6]

B. Applications of IoNT

The most advanced methodologies are used by IoNT for data collection. This enables IoNT to increase its area of coverage as compared to IoT. Following are various fields where IoNT is being used efficiently.

Health Care Monitoring through Nano-technology Based Body Sensor Network:

This application of IoNT is prominently being used in today's digital world. The doctors present at distant places are treating patients through the help of IoNT technology. The Nano-technology Based Body Sensors fitted in the body provides data to the doctor which helps to provide appropriate treatment to the patient.

Environmental Monitoring:

Real time monitoring of Traffic, Air Pollution, and Temperature can be done more efficiently by using Nano-technology Based Sensors. The sensors can be placed in public places and the data can be obtained and later analysed.

Agriculture:

The introduction of IoNT technology in the field of agriculture has led to the development of many precision farming techniques. The use of Nano devices equipped with Nano Sensors help to effectively and efficiently monitor various activities in the fields by sitting at the long distance. The activities like Grass Monitoring, Animal Health and Feed Management, Agriculture Field Condition, Effective monitoring of usage of Pesticides and Insecticides in the Agriculture field can be controlled and monitored.

Other Possible Applications: IoNT is being used in Military for Battlefield Monitoring and navigation systems. Usage of devices like Nano-Drones and Nano-Robots has brought a phenomenal change in the respective fields. Usage of IoNT devices in various industries has eased the process of production, Smart Campus (Educational and Industrial), Smart Cities. [9] Etc.

III. INTERNET OF MULTIMEDIA NANOTHINGS (IOMNT)

Nanotechnology is aiding the development of innovative devices which are capable in producing, processing and transmitting multimedia data at Nano scale. The interconnection of multimedia Nano-devices through existing communication protocol forms a unique communication model - Internet of Multimedia Nano-Things (IoMNT) [4].

Nano materials are currently being used to develop photo detectors and acoustic transducers which can be used to generate multimedia content at the Nano scale. These unique Nano-devices will be able to capture visual and acoustic information with outstanding resolution and accuracy compared to the currently existing devices. The combination of the devices such as, Nano-phones, Nano-cameras, Nano sensors, equipped with Nano-processors, memories, and other Nano-components will aid the development of more cutting-edge multimedia Nano devices. These advanced Nano-devices will overcome the drawbacks of existing multimedia sensor devices by providing higher quality image and audio sensing capabilities, higher computational and storing capacities, higher energy efficiency and expectedly higher wireless communication data-rates than classical multimedia sensors.

A. Architecture of a multimedia Nano-thing [3,4]

The Nano-components such as processor, memory and camera, can be incorporated into a device with a total volume as small as just a few cubic micro meters (Fig. 2). Many solutions have been recommended for each component.

- Nano-cameras: The photo detectors based on unique Nano-structures have been developed. Their main properties are-

– Small size (which allows the integration of very dense arrays).

– High sensitivity at low energy levels (improved low-light conditions imaging).

– Low power consumption.

The production of very dense arrays will equip the Nano-cameras with very high pixel and spatial resolution and very high colour sensitivity.

- Nano-phones: The integration of Nano scale acoustic transducers into miniaturized arrays will aid the development of unique Nano-phones (i.e., Nano scale micro-phones) with the following features.

– Higher directional resolution (surround audio sensing and recording).

– Better frequency resolution (higher quality audio, ultra-sound recording).

- Scalar Nano sensors: A Nano sensor is a device that makes use of the unique properties of Nano-materials to recognise and measure novel types of happenings in the Nano scale, such as the physical characteristics of structures just a few Nano-meters in size, chemical compounds in concentrations as low as one part per billion, or the presence of biological agents such as virus, bacteria or cancerous cells. Physical, chemical and biological Nano sensors have been developed by using graphene and other Nano-materials.
- Nano-processors: These are being empowered by the development of tinier FET transistors in different forms. The smallest transistor that has been experimentally tested to date is based on a thin graphene strip made of just 10 by 1 carbon atoms. These transistors are smaller and are able to operate at higher switching frequencies. The complexity of the operations that a Nano-processor will be able to handle depends on the number of integrated transistors in the chip, and thus on its total size.
- Nano-memories: Nano-materials and unique engineering procedures are enabling the development of single atom Nano-memories, in which, the storage of one bit of information requires only one atom.
- Power Nano-systems: Powering Nano-devices needs new types of Nano-batteries as well as Nano-scale energy harvesting systems. The energy generated out of the processes like piezoelectric effect can be stored in a Nano-battery and can be dynamically consumed by the device.

Graphene has also been used to enhance the absorption of light in innovative organic photovoltaic cells. The rate at which energy is harvested and the total energy that can be stored in a Nano-device depends ultimately on the device size.

- Nano-antennas and Nano-transceivers: A graphene-based Nano-antenna can efficiently radiate electromagnetic (EM) waves in the terahertz band (0.1–10 THz), due to the unique propagation characteristics of surface Plasmon polariton waves in this Nanomaterial. This frequency range matches the predictions for the operation frequency of graphene-based radio frequency (RF) transistors. Given the very small antenna size, very large antenna arrays can be created, with a total number of active elements at least one order of magnitude above current systems.

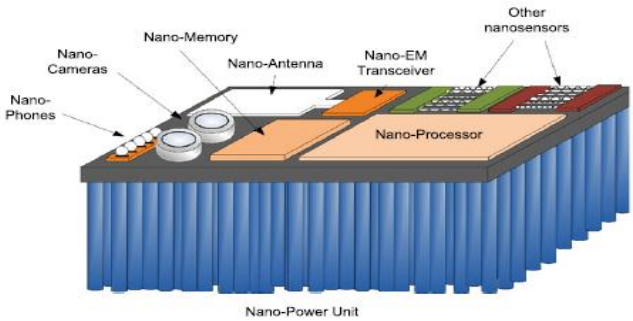

Fig 2. Architecture of IoMNT[4]

B. Applications of IoMNT:

The IoMNT is not only compliant with the intended applications of the IoT, but it also enables more advanced applications in various fields [7].

• Biomedical applications: e.g., advanced health monitoring and treatment systems which combine biological and chemical scalar Nano sensors, high-resolution ultrasensitive Nano-cameras and ultrasonic Nano-phones, for early cancer detection and treatment of diseases.

• Defence and security applications: e.g., imperceptible Nano-cameras for remote Nano scale imaging, ultrasonic Nano-phones for concealed objects detection, and biological and chemical Nano sensors as a countermeasure for unprecedented Nano technology-enabled attacks.

• Advanced multimedia applications: e.g., ultra-high-resolution imaging, for example, of crime scenes (application in forensics); ultra-high-resolution imaging of distant objects, for example, in far-field aerial or satellite imaging; and high-definition holographic videoconferencing.

IV. CONCLUSION

The advancement of Nano machines with communication abilities and their interconnection with small and large scale devices will enable the inter-networking of Nano-Things. This unique system will have an extraordinary outcome in almost all fields. In this paper, the concepts of Internet of Nanotechnology (IoNT) and Internet of Multimedia Nanotechnology (IoMNT) have been summarized. A brief introduction about IoNT and IoMNT, their architectures and applications have been discussed in this paper. The introduction and combination of Nano-Things like Nano-nodes, Nano-routers, Nano-micro interface devices, gateways, Nano-cameras, Nano-phones, Nano-sensors, processors, memories, antennas, transceivers with the communication protocols has helped to develop novel applications in the field of Healthcare, Environment, Agriculture, Monitoring, Military, Education and so many. In near future, significant work can be expected in the field of IoNT and IoMNT in various sectors.

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