

# Internet of Nano Things (IoNT): Next organic process Step in technology

Dr.I.Lakshmi

Assistant Professor, Stella Maris College,  
Cathedral Road, Chennai-600086.

**Abstract** Nanotechnology, since its origination has provided increased and economical solutions to numerous applications in medicine, industry, agriculture and military applications. engineering has light-emitting diode to the evolution of nano-machines that ar small elements comprising of organized set of molecules activity pre-determined tasks. The interconnection of nanosensors and nanodevices with net has light-emitting diode to development of next generation normal supported IoT referred to as “Internet of Nano Things” (IoNT). the most objective behind this paper is to supply in-depth read of net of Nano Things (IoNT)- design, Application areas and Challenges to create researchers attentive to IoNT normal for overcoming existing challenges and creating use of IoNT in various areas in close to future for speedy preparation.

**Keywords** Nanotechnology, Internet of Things (IoT), Internet of Nano Things (IoNT), Nanosensors, Nano-machines, Sensors, Body Sensor Networks, Nano Communication, Wireless Networks

## 1. Introduction

The next revolution within the space of computing are going to be all outside the realm of ancient desktop. the net of Things (IoT) [1, 2] is considered new revolution that's discovering large quality within the world of contemporary wireless telecommunications. The backbone behind net of Things (IoT) is that the pervasive presence of wide selection of things or objects like RFID (Radio Frequency Identification) tags, sensors, actuators, mobile technology, NFC (Near Field Communication), good Phones, Tablets etc. having distinctive addressing schemes to move and communicate among one another to realize desired objectives. IoT idea, these days being a reality, was planned by choreographer [3] in 1999 and is connected to new idea of RFID relating to its usage in offer chain. IoT, day by day is gaining the iniquitousness of net by group action each object for interaction via embedded systems, creating it a extremely distributed network of devices human action each ways that with humans and even with devices. The idea of IoT marks high impact on numerous aspects of everyone's life as wide selection of devices and communication protocols area unit below speedy development method by industries and researchers in numerous fields like e-health, e-agriculture, e-industry, good cities, e-military etc. Internet of Things (IoT) [18] produces heaps of information that has got to be properly keep, processed and bestowed in economical manner-for that numerous different computing technologies like Cloud Computing provides a virtual infrastructure for such utilities that integrates observation devices, storage of knowledge, information analytics tools and shopper based mostly information delivery models. With growing trend of 4G Networks, LTE and WiMAX, the vision towards IoT is additionally evolving. net of Things (IoT) needs [4]: shared understanding of state of affairs of users and devices; code architectures and pervasive networks to gift discourse information; and high performance information analytical tools depiction good technology. net of Things, little question has remodeled the employment of net and Device to Device communications during which devices, sensors and objects move with {one another|each different} and exchange information and has additionally born to many other domains like Wireless Body sensing element Networks (WBAN), net of Nanotechnology-Nano Things (IoNT) and everything is resulting in one combined nomenclature i.e. net of Everything (IoE).

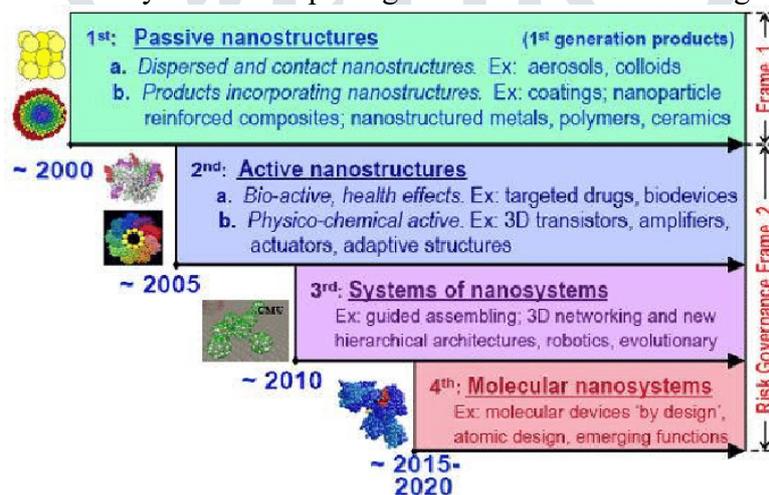
The basic definition of applied science is “Nanotechnology is that the engineering of useful systems at the molecular scale. In its original sense, “Nanotechnology” refers to the projected ability to construct things from very cheap up, mistreatment techniques and tools being developed these days to form complete, high performance product. applied science [7, 8] has provided numerous High grade solutions to several globe application areas like Biotechnology, Biomedical, Industry, Agriculture, Military applications because it is developing devices in scale of 4-8 five one to few hundred nanometres. so as to power applied science, the backbone is Nanomachine. A Nanomachine is outlined because the basic useful unit integrated via nano-components to perform basic tasks like sensing or causative. Effective cooperation and coordination among nano machines expands kind of applications in terms of complexness and operations. In shell, the combination of nanoscale devices with exiting ancient communication networks with High Speed net has LED to new evolution that is termed as “Internet of Nano-Things(IoNT)” [5, 6]. With the appearance of net of applied science (IoNT), analysis within the space of Nano communication has additionally hyperbolic 10 times with associate objective to make new standards for Nano devices to speak among one another and may even be

deployed in numerous applications. net of Nano-Things (IoNT) can comprise of miniature sensors connected to every different via Nano networks to get information from objects. So, successively net of Nano things can open new doors of analysis within the space of Nano Sensors, Nano communication and Nano Devices. The idea of net of Nano Things (IoNT) was planned by Ian Akyildiz and Josep Jornet [6] within the paper “The net of Nano-Things” and explicit a brand new networking paradigm and state of art magnetic force communication among nano scale devices and additionally bestowed major analysis challenges in terms of channel modelling, data secret writing and protocols for Nano networks and planned “Internet of Nano-Things”. the target of this paper is to gift a Comprehensive Review of net of Nano-Things (IoNT)- design, Applications, Challenges bodily fluid analysis directions.

## 2. Overview of Nano Technology and Nano Machines [9]

### 2.1. Brief Introduction

The construct of technology was explicit by “Richard Feynman”-A man of science Nobelist in 1965 in his celebrated speech titled “There’s many space at the Bottom” in Gregorian calendar month 1959 [10]. the most plan behind his speech was to spotlight the realm of shrinking and way forward for making powerful and tinier devices. The construct of “Nanotechnology” was initial quoted by N. Taniguchi [11] as “Nanotechnology chiefly comprise of process of, separation, consolidation, and deformation of materials by one atom or by one molecule. the essential ideology behind development and usage of technology is shrinking and fabrication of devices in scale of one to a hundred nano meters. Mihail Roco [12] from U.S.A. National technology has outlined four generation of technology development. the present era, as per Roco, is Passive Nanostructures i.e. Materials designed to perform one task. The second part includes “Active Nanostructures” for multitasking that involves development of extremely economical sensors, actuators and drug delivery devices. The third generation includes “Feature Nano systems” comprising of thousands of interacting elements.



**Figure 1. Nanotechnology Generations- As Depicted by Mike Roco of US. National Nanotechnology Institute [12]**

In brief, technology is explicit as “Engineering small machines- the projected ability to make things from rock bottom up victimization tools and techniques to create complete and extremely advanced merchandise. Technology, these days, is leading to Nano producing revolution and is creating nice impact on economic, social, environmental and military primarily based real time applications.

### 2.2. Nano Machines

With shrinking and fabrication of devices via technology techniques, the last word consequence that is developed is termed as “Nano-Machines”. Nano-machine [13] is considered small parts comprised of organized set of molecules to perform straightforward machine, sensing and activating tasks. Nano-machines are often more used as foundation for development of nano-bots, nano-processors, nano-memory and nano-clocks.

A Nano-Machine [14] is outlined “An Artificial Eutatic computer that depends on nanometre-scale components”. Nano-machine, in straightforward terms are often outlined as, “A computer that performs a helpful operate victimization parts of nanometre-scale and outlined molecular structure which has each artificial nano-machines and present devices found in biological systems”. so as to develop Nano-Machines, there square measure varied approaches- high down approach, bottom-up approach and Bio Hybrid Approach. [9]

**Top down Approach:** Focussed on downscaling existing electronics and micro-electro-mechanical technologies while not atomic level management. Example: Micro-contact printing and development of Nano-machines like Nano-electromechanical systems (NEMS).

**Bottom up Approach:** Focussed on style of nano-machines victimization individual molecules. This approach is additionally referred to as molecular producing. Example: Nano machines like molecular switches, molecular shuttles etc.

**Bio-hybrid Approach:** Focussed on style of latest nano-machines additionally referred to as biological nano-machines supported molecular signalling. Example: Bio-nano robots, nano-biosensors, biological storing parts etc.

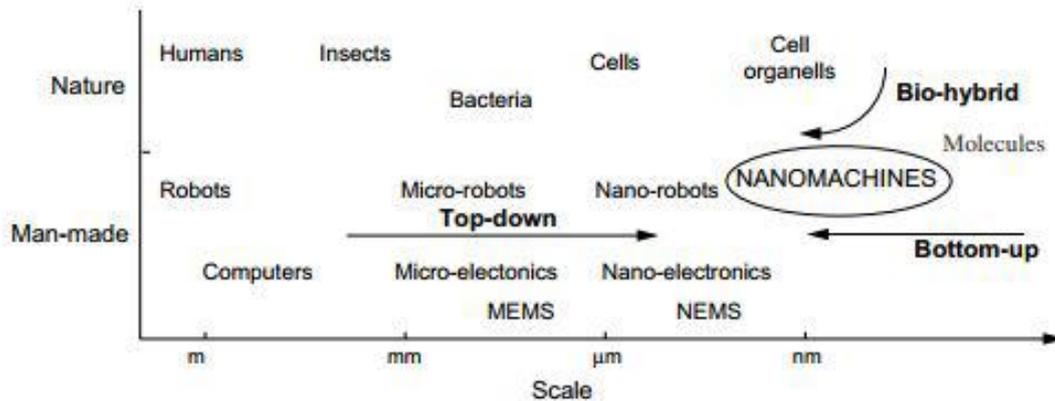


Figure 2. Nano-Machines Development Approaches [9]

### 2.3. Nano-Machine Architecture

Nano-machine comprise of 1 or a lot of elements integrated with one another in varied levels of quality and vary from straightforward miniaturisation machine to high finish and complex nano-robotics.

The following are the elements that structure a Nano-Machine:

- Management Unit:** management unit functions because the heart and central system for nano-machine and will the task for death penalty all the directions to perform the required task. Management unit conjointly controls all different elements of nano-machine and conjointly act as storage unit for saving all the info from nano-machine to be employed by users.
- Communication Unit:** This unit will the task of causation and receiving of knowledge at nano-level.
- Replica Unit:** replica unit performs fabrication of every element of nano-machine mistreatment external parts and assemble them effectively to form up the nano-machine.
- Power Unit:** It will the task of powering all the elements of nano-machine. It collects energy from varied external sources like temperature, light etc. for next task of consumption and distribution.
- Sensors and Actuators:** Sensors and Actuators acts as bridge between nano-machine and surroundings. Sensors utilized in nano-machines are of assorted varieties like Temperature, Chemical, clamps, motor etc.

### 3. Internet of Nano Things (IoNT) [5-7]

The basic building block of net of Nano Things (IoNT) is engineering. The IoNT is comprised of nano scale network of physical objects that exchange info among one another battery-powered by Nano Communication. The idea was developed by Ian F. Akyildiz and Josep Miguel Jornet from Georgia Institute of Technology and outlined IoNT as follows:

The Interconnection of nanoscale devices with existing communication networks and ultimately the net, defines a brand new networking paradigm known as “Internet of Nano-Things”.

As per the recent research reports by analysts, IoNT market is anticipated to grow from \$4.26 billion in 2016 to \$9.69 billion by 2020, at AN calculable Compound Annual rate (CAGR) of twenty-two.81% from 2016 to 2020. Internet of Nano Things (IoNT) infrastructure may be deployed by mixture nano devices alternative [and several other} other technologies like IoT, Sensors Network, Cloud Computing, huge information Analytics etc. The IoNT infrastructure depends on the realm of operation and needed information measure needed by specific application. The sweetening and wide selection adoption of IoNT depends on process capabilities, massive storage at low prices, good antennas and good RFID tag technology. a number of the foremost players within the IoNT market square measure Intel Corporation, Cisco Systems INC., Qualcomm Incorporated, Juniper Networks and IBM Corporation in U.S., Schneider electrical and Alcatel-Lucent S.A. in France, and SAP S.E. and Siemens silver in Germany among others. Even having high future adoptability prospects, the expansion of the IoNT market faces a number of challenges because of privacy and security problems. Since crucial information is communicated between devices over the net, considerations associated with securities of the info have up. Another issue that hinders the expansion of IoNT market is that the immense capital investment needed for the event of engineering. IoNT uses 2 broad areas of communication:

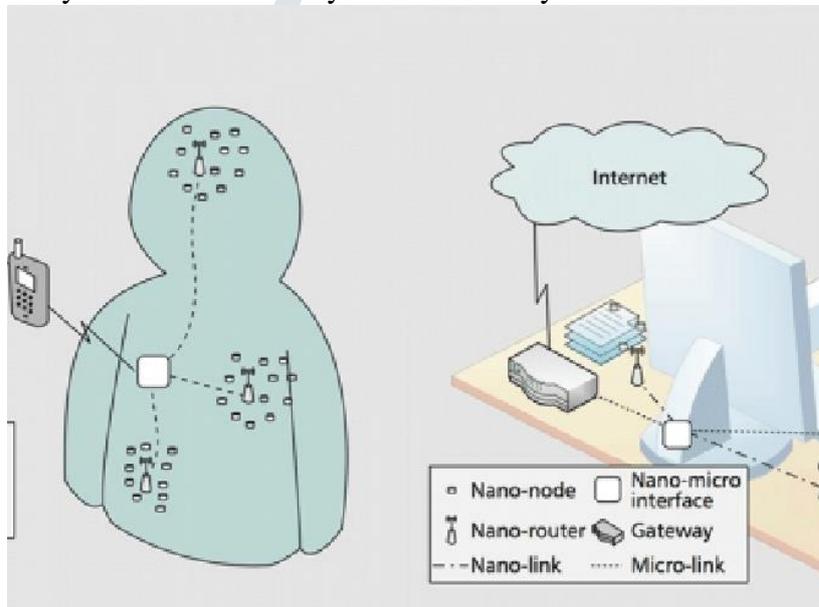
- Electromagnetic Nano-Communication [8, 15]: it's considered transmission and receiving of magnetic attraction (EM) radiation from parts supported nanomaterials.

- Molecular Communication [6, 7]: it's considered transmission and receiving of knowledge encoded in molecules.

### 3.1. 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 ingredient are the trump part of Architecture of Internet of Nano Things:

1. Nano-Client : Nano-lymph gland are regarded as the smallest and simplest nano machines which perform various job s like reckoning and transmittal if the information over short distances and have less memory. Considering Physical structure Detector Networks, Biological sensors fit in Human Body are considered as Nano-Nodes.
2. Nano-Routers: Nano-router have large computational power as compared to nano nodes and they act as aggregators of information approaching from nano-nodes.
3. Nano-routers also play crucial role in restraint ling nano-nodes by telephone exchange control mastery . Nano-Micro interface device s: These device perform the task of collecting of information coming from nano-routers and transmit it to the microscale and vice versa. They act as hybrid device to communicate in nanoscale using Nano communication techniques and also with traditional communication networks with classical network protocols. four
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.



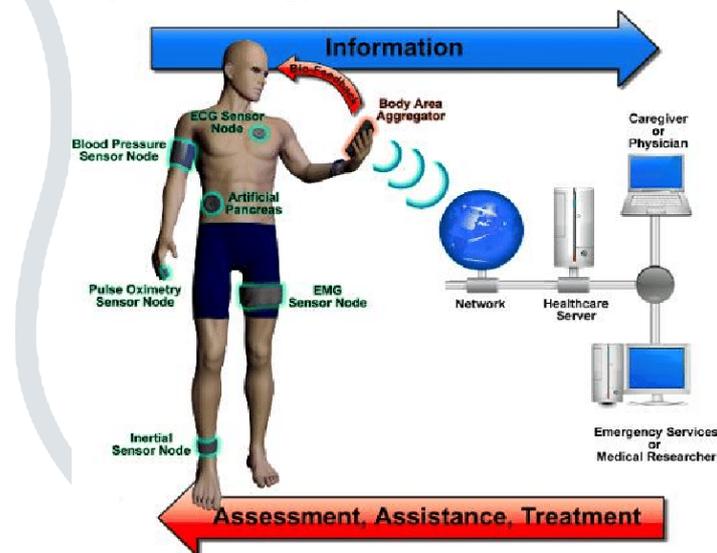
**Figure 3. Typical Architecture and Common Components making up Internet of Nano Things (IoNT)**

### 3.2. Applications

The most sophisticated and advanced methodological analysis are used by IoNT for data collection, which enables IoNT to extend its base from existing application to wide range of new and advanced application as compared to IoT. In the Figure 3. Typical Architecture and Common Ingredient making up Internet of Nano Things (IoNT) is highlighted. Health Charge Monitoring/Nano-Sensing element Based Consistency Sensor Meshwork [5, 16]: The First and the foremost application where IoNT can be seen these days in real number public is Body Sensor Network (BSN) comprising of in-body nano sensors playing a crucial theatrical role in collection and monitoring patient's biological activity and other point . 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 . → Environmental Monitoring: With the use of nano sensors in Environmental monitoring via deployment in public locations like Railway Stations, Bus 11 senses of stop , Aerodrome , Hotels and Restaurants and other Public places, live and real time monitoring of Dealings , Air Pollution, Temperature Monitoring is done more efficiently. → Precision Agriculture [18]: The use of IoNT in Department of Agriculture will lead to growth of several preciseness farming applications and with the live implementation of Nano-Sensors based Nano 5 senses of device will lead to efficient environs monitoring, crop growth and even brute monitoring. With the development of Radio Nano Sensor Network (WNSN) various agriculture activities can be performed like Grass Monitoring, Fauna Health and Feed Direction, Agriculture Field Condition Monitoring and Effective monitoring of usage of Pesticides and Insecticides in the Agriculture field. → Other Possible Applications programme in Real World: Considering IoNT advantages, in the near hereafter IoNT can also be applied by Military for Battleground Monitoring, Development of Nano-Robotics and Nano-Drones,

Space Based Applications, Industriousness Product and many more. The most sophisticated and advanced methodological analysis are used by IoNT for data collection, which enables IoNT to extend its base from existing application to wide range of new and advanced application as compared to IoT. In the Figure 3. Typical Architecture and Common Ingredient making up Internet of Nano Affairs (IoNT) is highlighted. Health Charge Monitoring/Nano-Sensing element Based Consistency Sensor Meshwork [5, 16]: The First and the foremost application where IoNT can be seen these days in real number public is Body Sensor Network (BSN) comprising of in-body nano sensors playing a crucial theatrical role in collection and monitoring patient's biological activity and other point . 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 .

- ❖ Environmental Monitoring: With the use of nano sensors in Environmental monitoring via deployment in public locations like Railway Stations, Bus 11 senses of stop , Aerodrome , Hotels and Restaurants and other Public places, live and real time monitoring of Dealings , Air Pollution, Temperature Monitoring is done more efficiently.
- ❖ Precision Agriculture [18]: The use of IoNT in Department of Agriculture will lead to growth of several preciseness farming applications and with the live implementation of Nano-Sensors based Nano 5 senses of device will lead to efficient environs monitoring, crop growth and even brute monitoring. With the development of Radio Nano Sensor Network (WNSN) various agriculture activities can be performed like Grass Monitoring, Fauna Health and Feed Direction , Agriculture Field Condition Monitoring and Effective monitoring of usage of Pesticides and Insecticides in the Agriculture field.
- ❖ Other Possible Applications programme in Real World: Considering IoNT advantages, in the near hereafter IoNT can also be applied by Military for Battleground Monitoring, Development of Nano-Robotics and Nano-Drones, Space Based Applications, Industriousness Product and many more.



**Figure 4.** Health Monitoring via Nano Sensors comprising Real Time Health Monitoring Internet of Nano Things (IoNT)

#### 4. Issues/Challenges of Internet of Nano Things (IoNT)

IoNT is viewed as the most scaled down nano sensor systems having the capacity to be in that capacity adoptable progressively applications in different fields. Be that as it may, despite the fact that of having huge amounts of cutting edge points of interest, IoNT additionally endures with a few issues and difficulties which should be tended to so IoNT can end up imperative piece of humankind in not so distant future with no hiccup. Scientists must address the issues with respect to setting administration, security and protection, benefit arrangement and disclosure. Aside from taking a shot at exploring on different application regions and advancement of Nanotechnology based IoNT gadgets, new security and protection instruments should be tended to concerning the information being gathered by nano sensors. Administrations ought to likewise be improved and new administration situated designs should be proposed to make nano sensors and nano systems perfect to hold huge amounts of huge assortments of information.

#### 5. Conclusions and Future Scope

The development of Nanotechnologies, nano machines, net of Things (IoT), net of Nano Things (IoNT) can have an excellent impact on advanced development in virtually each field in close to future. Researcher's area unit presently operating in development of nano machines comprising IoNT for live preparation in varied areas in close to future. during this paper, exhaustive review with respect to net of Nano factor (IoNT) is given that is

thought to be next biological process step in world of technology additionally to nano machines, applications and analysis areas.

### Future Scope

In the near future, work would be done on developing own IoNT based Nano Sensing element Network for Manufacture or Department of Agriculture for various monitoring activeness.

### REFERENCES

- [1] Xia, F., Yang, L. T., Wang, L., & Vinel, A. (2012). Internet of things. *International Journal of Communication Systems*, 25(9), 1101.
- [2] Atzori, L., Iera, A., & Morabito, G. (2010). The internet of things: A survey. *Computer networks*, 54(15), 2787-2805.
- [3] K. Ashton, "That 'Internet of Things' thing", *RFID Journal* (2009).
- [4] Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Generation Computer Systems*, 29(7), 1645-1660.
- [5] Balasubramaniam, S., & Kangasharju, J. (2013). Realizing the internet of nano things: challenges, solutions, and applications. *Computer*, 46(2), 62-68.
- [6] Akyildiz, I. F., & Jornet, J. M. (2010). The internet of nano-things. *IEEE Wireless Communications*, 17(6), 58-63.
- [7] I. F. Akyildiz, F. Brunetti, and C. Blázquez, "Nanonetworks: A New Communication Paradigm," *Computer Networks (Elsevier) J.*, vol. 52, no. 12, Aug. 2008, pp. 2260–79.
- [8] I. F. Akyildiz and J. M. Jornet, "Electromagnetic Wireless Nanosensor Networks," *Nano Communication Networks (Elsevier) J.*, vol. 1, no. 1, Mar. 2010, pp. 3–19.
- [9] Akyildiz, I. F., Brunetti, F., & Blázquez, C. (2008). Nanonetworks: A new communication paradigm. *Computer Networks*, 52(12), 2260-2279.
- [10] Feynman, R. P. (1961). There's plenty of room at the bottom. *Miniaturization* (HD Gilbert, ed.) Reinhold, New York.
- [11] N. Taniguchi, On the basic concept of nano-technology, in: *Proceeding of the International Conference on Production Engineering*, 1974.
- [12] Roco, M. C., Mirkin, C. A., & Hersam, M. C. (2011). *Nanotechnology research directions for societal needs in 2020: retrospective and outlook (Vol. 1)*. Springer Science & Business Media.
- [13] T. Suda, M. Moore, T. Nakano, R. Egashira, A. Enomoto, Exploratory research on molecular communication between nanomachines, in: *Proceedings of Genetic and Evolutionary Computation Conference (GECCO'05)*, June 2005.
- [14] E. Drexler, *Nanosystems: Molecular Machinery, Manufacturing, and Computation*, John Wiley and Sons Inc., 1992.
- [15] C. Rutherglen and P. Burke, "Nanoelectromagnetics: Circuit and Electromagnetic Properties of Carbon Nanotubes," *Small*, vol. 5, no. 8, Apr. 2009, pp. 884–906.
- [16] Jarmakiewicz, J., & Parobczak, K. (2016, May). On the Internet of Nano Things in healthcare network. In *Military Communications and Information Systems (ICMCIS), 2016 International Conference on* (pp. 1-6). IEEE.
- [17] Bhargava, K., Ivanov, S., & Donnelly, W. (2015, September). Internet of Nano Things for Dairy Farming. In *Proceedings of the Second Annual International Conference on Nanoscale Computing and Communication* (p. 24). ACM.
- [18] Nayyar, A., & Puri, V. (2016). Data Glove: Internet of Things (IoT) Based Smart Wearable Gadget. *British Journal of Mathematics & Computer Science*, 15(5).