Introduction

The Nobel Committee's Report of 2016's Nobel Prize in chemistry[3] ends, "we are at the dawn of a new industrial revolution of the twenty-first century, and the future will show how molecular machinery can become an integral part of our lives. The advances made have also led to the first steps towards creating truly programmable machines, and it can be envisaged that molecular robotics will be one of the next major scientific areas."

There have been many advancements in the area of Nanotechnology and Biotechnology since then, leading to improvements in its Internet of Things (IOT) applications, New Ideas shift the horizons of the technology everyday.

One of the major reasons for progress and study in this field is the pre-existing natural framework of Bio-NanoThings (BNTs), Which offers a solid foundation for modelling artificial Nanonetworks composed of Nanomachines. Nanomachines are independently operating fully-featured devices theoretically capable of all tasks their Macro-Scale counterparts are, such as data-storage, sensing and actuation. However, at such a small scale, individual devices provide us with scarce capabilities, leading to the establishment of Nanonetworks.[2] Several nanonetworks are naturally occurring all of which have their own complexity and applications in Internet of Bio-NanoThings (IoBNT), and are reviewed in this paper. The ones proven to be useful for IoBNT applications are:

- Mammalian Nervous systems [1][4]
- Bacterial Networks [7][8][11][13][14]
- Plant and Fungal Networks

For the creation of any network, as with a Nanonetwork, a few requirements must be met, Namely: Communication between Individual Nodes, and Storage of Energy. In a biological environment, we must also make sure of compatibility with preexisting biological systems. To fulfill the technical challenges some of the solutions proposed are:

1. **Communication and Interfacing Methods**

Developing better communication methods is one of the foremost technical challenges to be overcome, as conventional communication methods like Electromagnetic Transmission cannot be used at the Nano-Scale due to the size and energy constraints. The following technologies have emerged as the leading techniques for communication in nanonetworks.

- Molecular communication: it is already used by Natural BNT in an incredibly Energy Efficient Manner[5][9]
- High Frequency EM based methods: While conventional EM methods are not possible at the Nano-Scale, Graphene-Based antennas allow us to use the terahertz bands, proving promising for the high operating frequencies of BNTs
- Acoustic Communication: Ultrasonic Communication has been considered because of its advantages over its RF counterparts inside a fluidic environment like the human body.
- Optical based methods: Förster Resonance Energy Transfer (FRET) is non-radiative, high-rate energy transfer between fluorescent molecules, which promises a High rate of energy transfer in the order of Mbps.
- There are various other techniques as in Redox, Optogenetics and Fluorescence based techniques

2. **Energy Issues**

Efficient supply, storage, and usage of energy is another necessary challenge to overcome for the realization of IoBNT as a practical technology. While living cells have evolved over Billions of years to use the biochemical energy in the most efficient way possible, artificial systems are missing a metabolism system for their energy management. Thus, following methods are discussed for the problem:

1. Energy Harvesting:
   - Harvesting from various Intrabody vibrations,
   - Ambient RF EM waves,
   - Active Wireless Power Transfer
2. Energy Storage
   - Nano-Scale Lithium Batteries

- Micro-super capacitors
- Conducting Polymers like PE-DOT/PSS and various polymer heterostructures.[6]

3. **Biocompatibility** concerns with the materials used in the physical architecture of BNTs, the energy solutions as well as the interfacing process. However it remains an unsolved issue as there is no standardised procedure for testing Biocompatibility yet.

We provide a comprehensive review of the these problems in a later section, along with a brief overview of the previously existing framework of BNTs. However, along with the technical challenges there are many social challenges to overcome which are also discussed.