Design and Implementation of IoNT based communication systems

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Abstract:

Nanoscience is a field of study concerned with manipulation of matter on an atomic, molecular, and supra-molecular scale. Nanotechnology refers to the application of nanoscience to build nano-components based on the manipulation of matter with at least one dimension sized from 1 to 100 nanometers. Nanotechnology has been slowly progressing for decades and is anticipated to make a big impact in certain key industry verticals including aerospace, clothing, construction, energy management, healthcare, electronics, manufacturing, packaging, and more. In our paper we discuss about Leveraging computing and telecommunications technologies represents a substantial opportunity for nano-devices and nano-sensors to communicate as part of a nano-network. Also in this paper focus on the nanotechnology issues in telecommunication engineering and also provides a review of applications and future technologies in field of telecommunication based on nanotechnology. In modern sciences, nanotechnology is considered as the next industrial revolution which it may give more possibilities exceed our expectations in many fields. In telecommunication engineering nanotechnology could provide effective solutions for power efficient computing, sensing, memory enlargement, and human machine interaction. Nanotechnology in communication systems also provides ability for manufacturers to produce computer chips and sensors that are considerably smaller, faster, more energy efficient, and cheaper to manufacture than their present-day modules. Autonomous nano-communications, supported by Internet of Things (IoT) technologies, will create the opportunity for signalling, monitoring, and control of nano-systems for the benefit of many industry verticals. Internet of Nanoscale Things (IoNT) networks represents nanotechnology embedded with physical things, leveraging IoT to form an interconnected system.

Keywords: Nanotechnology, Molecular communication, IoNT, Nano machines, Nano-communications

I. Introduction:

For mobile communication systems the application of Nano science is used to make the control process to a Nano meter scale which will be in Nano scale range. Nanotechnology known as Molecular Nano Technology (MNT), represents Atom by atom and molecule by molecule based control of the structure of matter. The impact of mobile and core network capsulated together in mode of operation of the nanotechnology as well as perfection in security and the better impact on the sensor makes the nanotechnology the most significant technology in these areas[1]. The Internet of Things (IoT), built from inexpensive microsensors and microprocessors paired with tiny power supplies and wireless antennas, is rapidly expanding the online universe from computers and mobile gadgets to ordinary pieces of the physical world: thermostats, cars, door locks, even pet trackers.

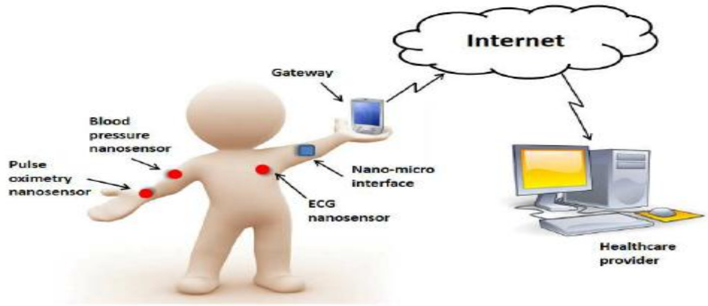


Fig1: IoT based wireless communication

As shown in fig1.The explosion of connected items, especially those monitored and controlled by artificial intelligence systems, can endow ordinary things with amazing capabilities—a house that unlocks the front door when it recognizes its owner arriving home from work, for example, or an implanted heart monitor that calls the doctor if the organ shows signs of failing. But the real Big Bang in the online universe may lie just ahead[2]. 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.

II. Molecular Transceiver:

Molecular transceivers will be easy to integrate in Nano-devices due to their size and domain of operation. These transceivers are able to react to specific molecules and to release others as a response after performing some type of processing. Recent advancements in molecular and carbon electronics have applied a new generation of electronic Nano-components such as Nano batteries, Nano-memories, logical circuitry in the nanoscale and even Nano-antennas Some of the most advanced nanosensors to date have been crafted by using the tools of synthetic biology to modify single-celled organisms, such as bacteria[3,4]. The goal here is to fashion simple biocomputers that use DNA and proteins to recognize specific chemical targets, store a few bits of information, and then report their status by changing color or emitting some other easily detectable signal. Synlogic, a start-up in Cambridge, Mass., is working to commercialize computationally enabled strains of probiotic bacteria to treat rare metabolic disorders. Beyond medicine, such cellular nanosensors could find many uses in agriculture and drug manufacturing.

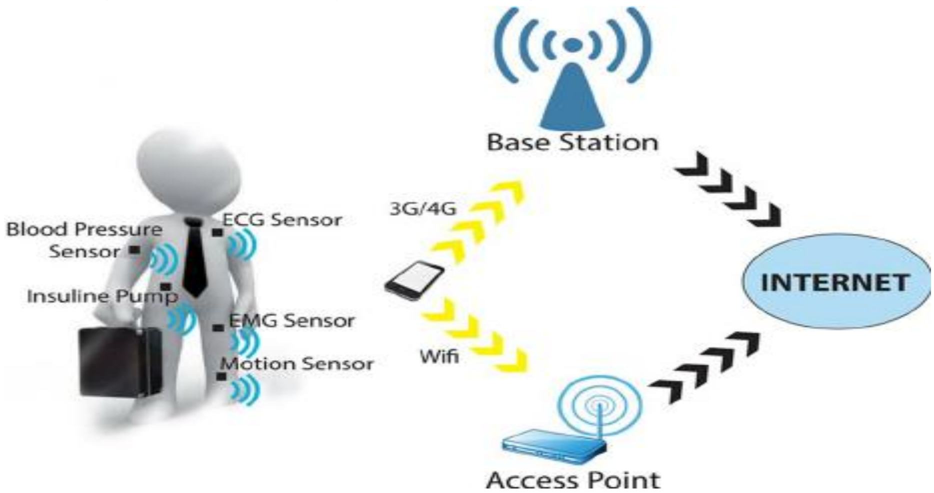


Fig 2: Molecular transceivers

In this article, we focus on electromagnetic communication among nano-devices and provide an in-depth view of this new networking paradigm from the communication and information theory point of view as shown in fig2.

We begin our discussion by introducing a reference architecture for the Internet of Nano-Things. We motivate the study of the Terahertz band for nano-electromagnetic communication and outline the main research challenges in terms of channel modeling, information modulation and networking protocols for nano-devices. Finally we conclude the article. This paper focus on the nanotechnology issues in telecommunication engineering and also provides a review of applications and future technologies in field of telecommunication based on nanotechnology. The rest of the paper is organized as follows[5]. A nanotechnology in communication systems is reviewed, provides details on many issues related to nanotechnology in Nano communication systems.

III. NANOTECHNOLGY:

Nanotechnology was first developed in 1965, it consists of the processing of, separation, consolidation, and deformation of materials by one atom or by one molecule[6]. It's fabrication of devices in a scale ranging from 1 to 100 nanometers. Nanotechnology will enable manufacturers to produce computer chips and sensors that are considerably smaller, faster, more energy efficient, and cheaper to manufacture than their present-day counterparts .Micromechanical sensors also became an elementary part of automotive technologies in mid-1990, roughly ten years later more miniaturized micromechanical sensors are enabling novel features for consumer electronics and mobile devices. Within the next ten years the development of truly embedded sensors based on nanostructures will become a part of our everyday intelligent environments as shown in fig3.

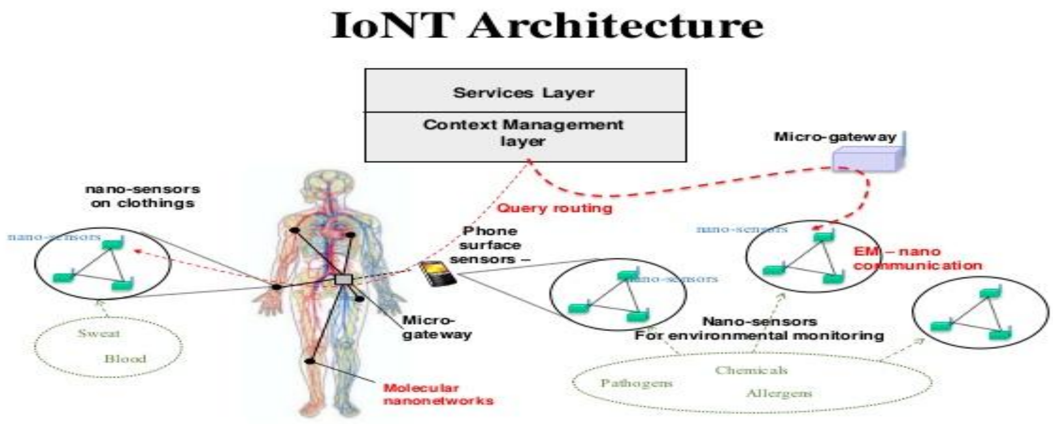
Fig 3: Nano Technology everyday intelligent environments

IV. IoNT NETWORK ARCHITECTURE

The interconnection of nanomachines with existing communication networks and eventually the Internet requires the development of new network architectures. We introduce the architecture for the Internet of Nano-Things in two different applications, namely, intrabody nanonetworks for remote healthcare, and the future interconnected office as shown in below figure.

•In intrabody networks, nanomachines such as nanosensors and nanoactuators deployed inside the human body are remotely controlled from the macroscale and over the Internet by an external user such as a healthcare provider[7,8]. The nanoscale is the natural domain of molecules, proteins, DNA, organelles and the major components of cells. Amongst others, existing biological nanosensors and nanoactuators provide an interface between biological phenomena and electronic nano-devices which can be exploited through this new networking paradigm.

Many nanosensors have also been made from non-biological materials, such as carbon nanotubes, that can both sense and signal, acting as wireless nanoantennas. Because they are so small, nanosensors can collect information from millions of different points. External devices can then integrate the data to generate incredibly detailed maps showing the slightest changes in light, vibration, electrical currents, magnetic fields, chemical concentrations and other environmental



conditions.

The transition from smart nanosensors to the IoNT seems inevitable, but big challenges will have to be met. One technical hurdle is to integrate all the components needed for a self-powered nanodevice to detect a change and transmit a signal to the web. Other obstacles include thorny issues of privacy and safety. Any nanodevices introduced into the body, deliberately or inadvertently, could be toxic or provoke immune reactions[9]. The technology could also enable unwelcome surveillance. Initial applications might be able to avoid the most vexing issues by embedding nanosensors in simpler, less risky organisms such as plants and non-infectious microorganisms used in industrial processing.

Nano-nodes:

these are the smallest and simplest nanomachines. They are able to perform simple computation, have limited memory, and can only transmit over very short distances, mainly because of their reduced energy and limited communication capabilities[10]. Biological nanosensor nodes inside the human body and nanomachines with communication capabilities integrated in all types of things such as books, keys, or paper folders are good examples of nano-nodes.

Nano-routers:

these nano-devices have comparatively larger computational resources than nano-nodes and are suitable for aggregating information coming from limited nanomachines. In addition, nano-routers can also control the behavior of nano-nodes by exchanging very simple control commands (on/off, sleep, read value, etc.). However, this increase in capabilities involves an increase in their size, and this makes their deployment more invasive.

When it arrives, the IoNT could provide much more detailed, inexpensive, and up-to-date pictures of our cities, homes, factories—even our bodies. Today traffic lights, wearables or surveillance cameras are getting connected to the Internet. Next up: billions of nanosensors harvesting huge amounts of real-time information and beaming it up to the cloud.

Nanoscale technology is enabling the development of devices as small as one to a few hundred nanometers (10^{-9} meters). To give a sense of scale, a strand of human DNA is roughly 2.5 nanometers in diameter. At this scale, a nanomachine is defined as the most basic functional unit and able to perform simple tasks such as sensing or actuation. Coordination and information sharing among several nanomachines will expand the potential applications of individual devices both in terms of complexity and range of operation, according to the Georgia Institute of Technology. The resulting nano-networks will be able to cover larger areas, and reach hard-to-reach locations. Moreover, the interconnection of nanoscale devices with classical networks and the internet defines a new networking paradigm, to which Georgia Institute of Technology refers to as the "internet of nano-things."

V. INFORMATION MODULATION

Nanomachines require new simple modulation techniques suitable for their limited hardware. Inspired by the huge bandwidth provided by the Terahertz channel, we envision a new communication paradigm based on the exchange of very short pulses, just a few femtoseconds long. The power of a femtosecond-long pulse is contained within the Terahertz frequency band and, thus, it can be radiated by a graphene-based nanoantenna[11]. By transmitting these pulses distributed over time rather than in a single continuous packet or burst, the requirements on the power unit of nanomachines are also relaxed. Note that the transmission of short pulses is also at the basis of Impulse Radio Ultra-Wide-Band (IRUWB) systems. In that case, tiny bursts of subnanosecond- long pulses are used with a time between bursts in the order of hundreds of nanoseconds. Orthogonal time hopping sequences are used to interleave different users in a synchronous manner. For nanonetworks, the complexity of such advanced systems is totally out of scope.

5.1. Use cases

Some potential applications include:

- In-body networks monitoring real-time blood, sickness and breath tests;
- Use in public locations to monitor the spread of viruses and diseases; and
- Hooked up to wearable health and environmental trackers.

When it arrives, the internet of nanoscale things could provide much more detailed, inexpensive and up-to-date pictures of our cities, homes, factories – even our bodies. Today traffic lights, wearables or surveillance cameras are getting connected to the internet with billions of expected nanosensors harvesting huge amounts of real-time information and beaming it up to the cloud, according to Scientific American[12].

5.2. Methods of communication

It is still not clear how nanomachines are going to communicate. Georgia Tech presents two main alternatives for communication in the nanoscale, namely molecular communication and nano-electromagnetic communication:

- Molecular communication
  - This is defined as the transmission and reception of information encoded in molecules. Molecular transceivers are expected to be easily integrated in nano-devices due to their size and domain of operation. These transceivers are able to react to specific molecules, and to release others as a response to an internal command or after performing some type of processing.
- Nano-electromagnetic communication:
  - This is defined as the transmission and reception of electromagnetic radiation from components based on novel nanomaterials.

The unique properties observed in these materials will decide the specific bandwidth for emission of electromagnetic radiation, the time lag of the emission and the magnitude of the emitted power for a given input energy.

VI. CONCLUSIONS

The development of Nanotechnologies, nano machines, Internet of Things (IoT), Internet of Nano Things (IoNT) will have a great impact on advanced development in almost every field in near future. Researchers are currently working in development of nano machines comprising IoNT for live deployment in varied areas in near future.The development of nanomachines with communication capabilities and their interconnection with micro- and macro-devices will enable the Internet of Nano-Things. This new networking paradigm will have a great impact in almost every field of our society, ranging from health-End-to-end reliability in nanonetworks and the Internet of Nano-Things has to be guaranteed both for the messages going from a remote command center to the nano-nodes, as well as for the packets coming from the nanomachines to a common sink. In this article, we have introduced the reference architecture for this new paradigm and discussed the state of the art of research on electromagnetic nanonetworks. Many researchers are currently engaged in developing the hardware underlying future nanomachines. In this paper, in depth review with regard to Internet of Nano Thing (IoNT) is presented which is regarded as next evolutionary step in world of nanotechnology in addition to nano machines, applications and research areas.

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