Mini Review

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Internet of bionano-things: perspective and future directions

Abstract

This paper intends to present a brief overview of Internet of BioNano-Things. We intend to discuss the molecular communication paradigm, the characteristics of bionanomachines as well as the network formation. Also, we present a brief discussion over how to exchange data with traditional networks.

Keywords: internet of things, internet of nano-things, internet of bionano-things, molecullar communications

Volume 3 Issue 1 - 2017

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Received: July 03, 2017 | **Published:** July 25, 2017

Abbreviations: IoT, internet of things; IoNT, internet of nano-things; IoNBT, internet of bio nano-things

Introduction

Recent advances in communications and computing technologies have made a growing number of smart devices available for use and communicate. The integration of intelligent objects on the Internet is known as Internet of Things (IoT).[1] The IoT can be defined as a world of interconnected objects, capable of being identified, addressed, controlled and accessed via the Internet. These objects can communicate with others, with other resources available on the web, and with information systems and human users. As the size of the devices is reduced due to improvements in nanotechnology (such as graphene) emerges the concept of Nanonetworks. Nanonetworks are networks formed by the interconnection of nano-sized devices hereinafter called nanomachines. From the interconnection of these nanomachines with the Internet emerged the concept of Internet of NanoThings (IoNT). This nanosized devices are used in many fields varying from healthcare, body sensing networks and environmental monitoring. These nanomachines can be either artificial or biological. Nowadays research has led to the use of artificial, usually graphene based. Although the graphene has made the nanomachines feasible and operational for several applications, there are applications where their artificial nature make unfeasible to deploy (such as intrabody applications). In this sense emerge the Internet of Bio-Nano Things (IoBNT) where the nanomachines are no longer artificial but based on biological cells built through the procedures of synthetic biology. Some of the applications intended by IoBNT are intra-body sensing and actuation networks, and environmental control of toxic agents and pollution.[2] This new paradigm poses new challenges in terms of communication and networking using biochemical infrastructure while enabling an interface to the electrical domain of the Internet. The rest of the paper is divided as follows: (i) in section II we discuss the challenges in IoBNT and (ii) in section 3 we present some conclusions.

Discussion

As the concept of Internet of BioNano-Things becomes more popular several challenges arise. The first challenge is related to the development of Bionanomachines, including molecular transceptors, energy sources, processing units. In the work of[1] it is presented a proposal of mapping between an artificial nanomachine and biological nanomachine. As stated above, artificial nanomachines are not feasible for every situation, so there is a need to replicate the artificial nanomachine architecture into a cell. From an architectural viewpoint, nanomachines are composed of controls units (cell nucleus), reproduction units (responsible for replication substituting the deployment of devices from external environments), power units (mitochondrion), sensors and communication units. Regarding the last component is clear that traditional communication technologies are not fit for intrabody nanonetworks. So, the second challenge is related to a novel communication paradigm called molecular communication. In the case of IoBNT, molecular communication is especially suited[3] since it is a process already done by the cells without any external influence. There are several approaches in literature for molecular communication such as calcium signaling, molecular motors, pheromones diffusion and others.[4] Although there are some drawbacks such as the small throughput, propagation issues and interferences in the environment (such as changes in temperature and pH).[3] Also in this challenge, there is a discussion about protocol design. In[4] it is discussed the challenges on developing new medium access control, codification, error correction and congestion control mechanisms using molecular communication. The greatest issue is how to associate a chemical signal to the traditional electrical to provide a similar reliability level of the traditional networks to the nanonetworks. Finally, the interface the IoBNT and the Internet is possibly the greatest challenge of all. The challenge relates to the definition of standard interfaces for information exchange between the nanonetworks and the Internet. Only after the translation of the molecules it is possible to obtain relevant information. These interfaces should be available for participating nanonetwork systems, such as network monitoring in biomedical or military areas. According to[5] these interfaces may be application based but this is still an open issue.

Conclusion

The Internet of BioNano-Things presents both challenges and

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opportunities in the communication field. Most of these challenges nowadays are related on how to build a reliable and efficient communication infrastructure and how to exchange data with the internet.[1,6] Most of the potential applications are related to healthcare and smart environments. Future works tend to investigate new ways to establish communication links. Several studies have investigated biological ways of exchanging chemical information (such as carbon nanotubes, the use of bacteria, pollination process). Further studies will investigate different process information exchange data in nature. Also, another challenge refers to the development of simulation tools and datasets.

Acknowledgements

This paper was supported by Brazil's National Research Council by grant CNPQ 304527/2015-7.

Conflict of interest

The author declares no conflict of interest.

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