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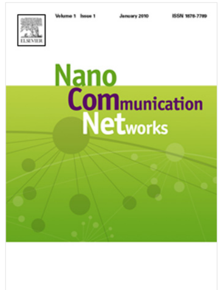

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Nano-networks Communication Architecture: Modeling and Functions

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Abstract

Nano-network is a communication network at the Nano-scale between Nano-devices. Nano-devices face certain challenges in functionalities, because of limitations in their processing capabilities and power management. Hence, these devices are expected to perform simple tasks, which require different and novel approaches. In order to exploit different functionalities of Nano-machines, we need to manage and control a set of Nano-devices in a full Nano-network using an appropriate architecture. This step will enable unrivaled applications in the biomedical, environmental and industrial fields. By the arrival of Internet of Things (IoT) the use of the Internet has transformed, where various types of objects, sensors and devices can interact making our future networks connect nearly everything from traditional network devices to people. In this paper, we provide an unified architectural model of Nano-network communication with a layered approach combining Software Defined Network (SDN), Network Function Virtualization (NFV) and IoT technologies and present how this combination can help in Nano-networks' context. Consequently, we propose a set of functions and use cases that can be implemented by Nano-devices and discuss the significant challenges in implementing these functions with Nano-technology paradigm and the open research issues that need to be addressed.

Keywords: nano-machine, nano-network, internet of nano-things, software defined network, fog computing, network function virtualization.

1. Introduction

Nano-technology is providing a new set of tools to the engineering community to design Nano-machines. Nano-machines are the basic functional Nano-devices that able to perform very simple tasks. A standalone Nano-device is highly constrained by limited energy, processing and communication range. Besides Nano-network is the network of Nano-machines, it expands the capabilities of a single Nano-device by providing a way to cooperate and share information. In general way, Nano-communication is the exchange of information at the Nano-scale on the basis of any wired or wireless interconnection of Nano-machines in a Nano-network [1]. Nano-network has different applications in various areas, extending from environment monitoring, industrial manufacturing and building labs-on-a-chip to an enormous number of applications in medicine, like drug delivery, diagnostics, tissue regeneration and surgical operations [2] [3]. In the healthcare domain, Nano-network can collect vital patient information and provide it to computing systems making more accurate and efficient way of health monitoring. The implementation of the Internet of Nano-Things (IoNT) in healthcare systems will provide diagnostic and aid in the treatment of patients through accurate and localized drug delivery, in addition to tumor detection process.

Nano-network holds greater communication and processing potential that overcomes the limitations of standalone Nano-machine through Nano-devices cooperation. A Nano-network can carry the data to an external device such as a smartphone or a gateway enabling Nano-devices to wirelessly communicate with powerful external processing devices. This gateway can be connected to Internet. When the Nano-networks connect to an Internet gateway, they enable a new network paradigm called the Internet of Nano-Things (IoNT) [4]. With the continuous growth of IoT, a strain on traditional networks has been released. It is not just a matter of more bandwidth, IoT data is fundamentally different from the voice and video packets that comprise much of the traffic on modern networks. IoT traffic can be hard to predict, requiring additional network appliances [5]. It is worth remarking that Software Defined Networking (SDN) and Network Function Virtualization (NFV) are two useful technologies for IoT services. By outlining the way of combining SDN, NFV, IoT and Fog computing technologies, we can study how these technologies will be used in Nano-networks' context.

Nano-devices are not capable of handling complicated communication protocols, because of their limitations of computational capabilities in processing and power management. The functionalities of Nano-network can be powered by capacities provided by additional technologies, in order to be able to organize and optimize the behavior of the Nano-devices by means of decisions taken from strategies and algorithms executed with High Performance Computing (HPC). Therefore, a hierarchical architecture is required in order to manage the Nano-devices and run externally the complex computations with their required decisions, hence enabling a controlled large-scale Nano-network. Moreover, using a hierarchical architecture will shift the processing complexity from Nano-devices to more power-

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