Accepted Manuscript

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PII: S0167-739X(17)31459-0
DOI: https://doi.org/10.1016/j.future.2017.09.070
Reference: FUTURE 3726

To appear in: *Future Generation Computer Systems*

Received date : 1 July 2017
Revised date : 15 September 2017
Accepted date : 26 September 2017

Please cite this article as: D. Bendouda, A. Rachedi, H. Haffaf, Programmable architecture based on Software Defined Network for Internet of Things: Connected Dominated Sets approach, *Future Generation Computer Systems* (2017), https://doi.org/10.1016/j.future.2017.09.070

Programmable architecture based on Software Defined Network for Internet of Things: Connected Dominated Sets approach

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***Abstract*—In this paper, we propose a new programmable architecture based on Software Defined Network (SDN) paradigm for network control functionalities in Internet of Things (IoT) using the Connected Dominating Sets (CDS). In order to reduce the traffic load and to avoid a single point of failure at the controller node, we distribute the controllers role by introducing three levels of control: Principal Controller (PC), Secondary Controller (SC), the Local Controller (LC). The PC has a global view of the network infrastructure which is not the case of SC where it focuses only on one network technology. The LC acts locally by managing and relaying signaling messages from ordinary nodes to the SC. In order to select the LC nodes, we propose a Distributed Local Controller Connected Dominating Set algorithm (DLC-CDS). The DLC-CDS is a distributed algorithm with single phase and supports the dynamic network topology. The selection strategy of DLC-CDS is based on an important function named score, which is computed using the fuzzy logic and it depends on several parameters such as: the connectivity degree, the average link quality, and the rank. The performance of the proposed DLC-CDS are evaluated and compared with another solution named Distributed Single Phase-CDS (DSP-CDS) using many scenarios with different parameters: the node density and the radio range. The obtained results show that the DLC-CDS converges rapidly with a minimum CDS size compared to a DSP-CDS.**

Keywords*—Internet of Things (IoT), Software Defined Networks (SDN), centralized/distributed and semi-distributed, Conected Dominated Set (CDS).

I. Introduction

The Internet of Things (IoT) is a new concept that is promptly gaining success in the field of modern wireless telecommunications. The basic concept idea of IoT is the pervasive presence around us of a variety of smart objects or things through the internet, which can be considered as Radio-Frequency IDentification (RFID) tags, sensors, actuators, mobile phones, machines, devices, vehicles, and people equipped with wired or wireless communication ability. These smart objects, through unique addressing schemes, are able to interact with each other and cooperate with their neighbors to reach common goals [1], [2].

The application field is large such as: smart cities, healthcare, intelligent transportation systems, future manufacturing, border monitoring, etc. [3], [4], [5], [6], [7]. The IoT paradigm needs a specialized software with networking functionality and IP support, it combines the dimensions of conceptual and technical orders. From a conceptual point of view, the IoT characterizes connected physical objects having their own digital identity and capable of communicating with each other [3]. This network creates a gateway between the physical world and the virtual world. From a technical point of view, the IoT consists of direct and standardized digital identification (IP address, SMTP protocol, http...) of a physical object by means of a wireless communication system which can be a smart thing such as RFID, Bluetooth, or WiFi [8]. Many communication and network technologies are proposed for IoT context without taking into account coexistence and interoperability.

We distinguish licensed and unlicensed technologies. In the case of unlicensed technologies and according to applications context an important number of standards can be used such as: IEEE802.11 (WiFi), IEEE802.15.1 (Bluetooth), IEEE803.15.3 (UWB), IEEE802.15.4 (Zigbee, 6lowpan), IEEE802.15.6 (WBAN), etc. In the case of pervasive communication, licensed technologies are well adapted such as: LTE-A with Machine-Type Communication (MTC) and Device-to-Devices (D2D) communication in 5G. That is why it is important to propose a hybrid and programmable architecture able to consider the different technologies' characteristics, and to ensure their coexistence.

In this paper, we tackle the heterogeneity of wireless network technologies in the IoT context by proposing a new hybrid and programmable architecture based on Software Defined Network (SDN) paradigm. The main aim is not only to consider the heterogeneity of network technologies, but also to reduce the overhead related to network control mechanisms. Unlike the classical SDN, we propose a semi-distributed approach with three control levels: Principal (PC), Secondary (SC), and Local (LC) controllers.

The PC is located in the network core and it has a global view of the network infrastructure. On the other hand, SCs are located in the edge network and focus only on one technology by acting as controller. Finally, LCs are acting locally in access network by managing and relaying signaling messages from ordinary nodes to the SC. In order to select LCs nodes, we propose a new Distributed Local Controller algorithm (DLC-CDS) based on Connected Dominating Sets (CDS) and Fuzzy set approaches. The DLC-CDS algorithm