Chapter 4

A Scalable Multiagent Architecture for Monitoring Biodiversity Scenarios

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ABSTRACT

Recently, there has been an explosive growth in the use of wireless devices, mainly due to the decrease in cost, size, and energy consumption. Researches into Internet of Things have focused on how to continuously monitor these devices in different scenarios, such as environmental and biodiversity tracking, considering both scalability and efficiency while searching and updating the devices information. For this, a combination of an efficient distributed structure and data aggregation method is used, allowing a device to manage a group of devices, minimizing the number of transmissions and saving energy. However, scalability is still a key challenge when the group is composed of a large number of devices. In this chapter, the authors propose a scalable architecture that distributes the data aggregation responsibility to the devices of the boundary of the group, and creates agents to manage groups and the interaction among them, such as merging and splitting. Experimental results showed the viability of adopting this architecture if compared with the most widely used approaches.

INTRODUCTION

In the last years, an explosive growth has been observed in researches and real-world applications to ecological monitoring and wildlife tracking, spread over several scenarios, such as biodiversity, environmental, agriculture, and social biology, among others (Huang et al., 2010; Hart & Martinez, 2015; Dlodlo & Kalezhi, 2015). This growth is sustained mainly due to the decrease in cost, size, and energy consumption of wireless sensor devices used for monitoring those scenarios (Galluccio et al., 2011).
For example, in the biodiversity scenarios, sensor devices allow to collect and to monitor the behavior exhibited by a group of birds flying in a certain area, known as flocking, in order to provide a sustainable ecological development. For technologically supporting the high demand of information collected, shared and transmitted by the sensors devices, a relative new paradigm has emerged, called Internet of Things, whose vision is to integrate these physical devices (or things) into the virtual environment (Kaukalias & Chatzimisios, 2016). A thing is a real world device which provides services to sense, to communicate, and to cooperate with other devices and with its environment. In this paradigm, researches have focused on how to continuously monitor a large number of devices, considering both scalability and efficiency while searching and updating information of a group of devices, because the large number of them imply an explosion in the traffic communication and energy consumption (Borgia, 2014).

Current alternatives use a combination of a widely recognized method, called data aggregation (Ren et al., 2013), and a widely adopted distributed structure, called Distributed Hash Table (DHT) (Stoica et al., 2001), in order to monitor these devices. The data aggregation method chooses one device for collecting and for managing the information of all devices that form a group, minimizing the number of transmission and saving energy. The distributed structure is used for efficiently retrieving the chosen device when another device needs to join a group. However, there are still some open issues faced by the method: single point of failure (also known as SPOF) and scalability.

On the one hand, single point of failure issues arise when the chosen device interrupts its aggregation data responsibility due to a malfunction (e.g., the total consumption of energy, the transmission signal is lost in some areas, among others) which must be considered in the device behavior. As a consequence, the group information is inaccessible until a new device is chosen. On the other hand, scalability issues arise when the group increases its members, either because new devices join the group or when various group of devices need to be merged in one. This increment let the chosen device overloaded when collecting information until a point at which the device is unable to continue managing the group. As a consequence, the group information is inaccessible even if a new device is chosen.

In order to know how the system will behave when its members are overloaded, it is necessary to deploy and test such system in the real world, that could be sometimes not feasible due to the characteristics of the scenario. For example, it is complex to test how the different path of the clouds or the wind could affects the climate on some region (Duraccio et al., 2007). For overcoming the problems mentioned above, simulations come as an interesting alternative. The idea is to create computational models of the scenario that simulate the real world behavior (Ilhan et al., 2015). Different approaches have proved to be useful for simulating the real world behavior in different scenarios, such as meteorological conditions (Duraccio et al., 2007), how the agricultural affects the environment (Prada et al., 2015) or how to predict bee colonies behavior under adverse temperature conditions (Kridi et al., 2014). Nevertheless, these works do not focus on analyze the scalability of the system.

In this chapter, a scalable architecture has been proposed for discovering and updating the localization and movement of group of devices. The architecture is composed of two layers, a device and a multiagent layer. The device layer consists in groups of connected devices geographically closer. To support scalability in the updating information process, each group assigns the responsibility for aggregating and for sending its information -such as localization and movement- to the devices in its boundary. The multiagent layer consists in agents responsible for managing the information of groups and for verifying if there is any interaction with other groups -such as merging and splitting. To support scalability in the updating information process, agents can create new agents (agentifying devices) in order to share the responsibility for managing the group.