Chapter 35
An Extension of the MiSCi Middleware for Smart Cities Based on Fog Computing

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ABSTRACT

In a Smart City is required computational platforms, which allow environments with multiple interconnected and embedded systems, where the technology is integrated with the people, and can respond to unpredictable situations. One of the biggest challenges in developing Smart City is how to describe and dispose of enormous and multiple sources of information, and how to share and merge it into a single infrastructure. In previous works, we have proposed an Autonomic Reflective Middleware with emerging and ubiquitous capabilities, which is based on intelligent agents that can be adapted to the existing dynamism in a city for, ubiquitously, respond to the requirements of citizens, using emerging ontologies that allow the adaptation to the context. In this work, we extend this middleware using the fog computing paradigm, to solve this problem. The fog extends the cloud to be closer to the things that produce and act on the smart city. In this paper, we present the extension to the middleware, and examples of utilization in different situations in a smart city.

INTRODUCTION

Smart Cities should integrate information and communications technology (ICT) in their spaces, in order to exploit the wealth of information and knowledge generated, to improve their planning and public services offered to their citizens. ICT can computerize, interconnect and automate virtually all processes that occur in a city: infrastructure management, power consumption, communication system, traffic, health, etc., ubiquitously integrated (with sensors and actuators) in all elements of the city. This allows a more sophisticated resource management, and emergent behaviors from the interrelationships of these systems.

Applications that run on smart cities, must consider that the context changes continually: situations, availability of services (based on ICT), as well as the requirements and preferences of its citizens. They must, therefore, react to this changing environment at runtime, considering that there are emerging situations, new needs, emerging interactions, and new availability of services, which cannot be predicted a priori. The continuous awareness of context, and the gradual adaptation, become the key to deliver value-added services based on ICT, to address the dynamics of continuously changing environment.

Some of the biggest challenges in developing a Smart City is how to dispose of the enormous and multiple sources of information and services in a given time and in the right way. Cloud Computing is an alternative to use in Smart Cities, since it is a group of computers and servers connected together over the Internet, to form a network for the storage of large amounts of data and services.

In Aguilar, Jérez, Mendonca, and Sánchez, (2016) we have proposed an Autonomic Reflective Middleware for Smart Cities, called MiSCi, based on these ideas. MiSCi is composed by a multi-layer architecture based on a Multi-Agent System (MAS), allowing it having capabilities of such systems, like: sociability, proactivity, adaptability, intelligence, etc. Its architecture is based on web services, allowing its services to be consumed by the applications (in our case, agents), aware of context or not. Agents can create temporary or permanent emerging ontologies, which allow solving a particular situation, according to context.

In a smart city, where there are multiple nodes and applications that interact to offer services to citizens, high quality and low latency are of great importance. The deployment of MiSCi, and classical middleware for smart cities based on a cloud computing paradigm, can become a problem for applications that require real-time response, mobility support and/or Geo-distribution.

The need in the Smart Cities for large amounts of data to be accessed more quickly, and locally, is ever-growing. A new platform is needed to meet these requirements. The Fog Computing paradigm can be the solution. Fog Computing is a distributed infrastructure, in which certain application processes, or services are managed, at the edge of the network by a smart device, but others are still managed in the cloud. Fog Computing enables a new breed of applications and services, and there is a fruitful interplay between the Cloud and the Fog, particularly when it comes to data management and analytics (Bonomi, Milito, Zhu, & Addepalli, 2012).

Fog Computing can offer data, compute, storage and service to the end-user in the edge of the network. This paradigm has characteristics that make it an appropriate platform for critical services and applications, such as those presented in a Smart City. The distinguishing fog characteristics are its proximity to end-users, its dense geographical distribution, and its support for mobility.

In this work, we propose an extended version of the MiSCi architecture proposed in Aguilar et al., 2016, based on the Fog Computing paradigm. The extension is, essentially, a middle layer between the

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