Chapter 10
Decision Making in IoT Systems Based on Guided Self-Organization and Autonomic Computing in the Context of the I4.0 Era

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ABSTRACT

Internet of things (IoT) systems are taking an important role in daily life. Each year the number of connected devices increases considerably, and it is important to keep systems working appropriately. There are some options related to decision support systems to perform IoT systems tasks such as deployment, maintenance, and its operation on environments full of different connected devices and IoT systems interacting among them. For the decision-making process, the authors consider the complexity nature observed in IoT systems and their operational context and environments. In this sense, rather than using grain and fixed control rules/laws for the system design, the use of general principles, goals, and objectives are defined to guide the system adaptation. This has been referred to as guided self-organization (GSO) in the literature. The GSO design approach is based in evaluating the system entropy to reduce the emergence and enable self-organization. Also, in this chapter, a series of study cases from different IoT application domains are presented.

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INTRODUCTION

Today the Internet of Things (IoT) systems have acquired considerable relevance in people's daily lives, from the basic automation of primary processes in our homes, through ubiquitous computer systems with which we interact without even giving us account, until its widespread use in the manufacturing industry and activities such as food production. Even during 2020 and early 2021, the use of IoT devices increased significantly due to the Coronavirus COVID-19 pandemic, especially in the health area to perform medical processes and in open public spaces to perform medical procedures safely, monitoring the people's temperature and being able to apply sanity measures to prevent the spread of the virus in public spaces.

Although there have been significant advances in IoT and decision-making processes in recent years, there are still opportunities for improvement and some questions remain unanswered: Is the current decision-making process in IoT systems sufficient to satisfy current needs? How to carry out the decision-making process in IoT systems with a high level of uncertainty? Is there a way to measure chaos in IoT systems?

This chapter presents a study of how IoT challenges such as high device volume, heterogeneity, diversity, and security can be addressed in overall design, considering how current non-functional properties (Self-Adaptation, Self-Configuration, and Interoperability) can be extended using the Self-Star* autonomic computing properties proposed by Kephart from IBM. For this, the incorporation of knowledge and objective bases based on the Autonomic Control Loop (ACL) MAPE-K (Modeling - Analysis - Planning - Execution - Knowledge) is introduced. Four properties were considered in the proposed architectural designs: Self-Configuration, Self-Optimization, Self-Healing, and Self-Protection. These designs are intended to reduce human intervention and dependency during the life cycle of IoT systems after implementation. Furthermore, this work considers Industry 4.0 design guidelines in terms of vertical and horizontal integration in the end-to-end value chains related to the application domain.

For the decision-making process, it is important to consider the complexity observed in IoT systems and their context and operating environments, using different principles, goals, and objectives it is possible to design the adaptation of the system (Guided Self-Organization (GSO)). The GSO design approach proposed is based on evaluating the entropy of the system to reduce chaos and allow self-organization. In this context, an algorithm calculates the entropy value and uses it for the decision-making process, taking as a reference the knowledge previously obtained from the information processing.

The objectives that will be discussed in this chapter are to provide an overview of decision making in IoT systems when they are under uncertainty, propose an

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