CHAPTER IV.1

The ASCENS Case Studies: Results and Common Aspects*

Nikola Šerbedžija
Fraunhofer FOKUS, Berlin, Germany

Abstract. This chapter focuses on pragmatic aspects of the ASCENS project illustrating the role and significance of the three major application domains (swarm robotics, cloud computing and e-mobility) that motivate and pragmatically justify the approach to construct autonomous systems. A special insight is given into similarities and differences of the ASCENS case studies and their common abstract characteristics that led to a general-purpose methodology for expressing, evaluating and deploying knowledge-based, self-aware and adaptive behaviors. From this perspective selected ASCENS tools and methods to support the system development lifecycle are further discussed and illustrated on concrete examples. Finally future plans are given pointing out to the use and further evolvement of the ASCENS technology.

Keywords: application of collective adaptive systems, service component ensembles, software development life cycle, real-life systems

1 Introduction

The application domain, represented by three major case studies, namely swarm robotics, science cloud and e-mobility, played a central role in the ASCENS project. They provide a source of motivation for the ASCENS technology and a treasury of trial examples upon which ASCENS solutions could be tested in practice. Case studies also served as a gravity for joint work among different partners and work packages as the whole spectrum of results had to be put together and applied on the case studies scenarios. This constant interaction between theory and practice made the ASCENS highly theoretical approach unified, pragmatic and well suited for a range of application domains, far beyond the specific areas of the ASCENS case studies.

The ASCENS project deals with the development and deployment of autonomous systems with special attention paid to technical awareness and adaptive behavior of the underlying systems on one side and to rigorous and formal reasoning about the correct system functioning on the other. In the early project

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* This work has been sponsored by the EU project ASCENS IP 257414 (FP7).

1 ASCENS website: [http://www.ascens-ist.eu/](http://www.ascens-ist.eu/)
phase the development lifecycle for autonomous systems has been proposed (see Chapter III.1 [16] of this book) tracing the methodology and the roadmap for system design and development. A number of distinct phases of the development process have been identified and many tools have been developed to support the modeling and development in each of the lifecycle stages. Due to a highly non-deterministic character of the autonomous systems, whose behavior is dynamic and sensitive to unpredicted situation, system validation and verification plays an important role in the project.

Contrary to the majority of computing systems now in use, autonomous systems’ behavior is highly dynamic and reactive to unexpected situation. This makes the system verification process extremely difficult as the system alters its behavior at run-time replying to changes of the state of the environment and to new knowledge acquired about its own state. Those circumstances cannot be predicted in advance and a system cannot be fully tested and debugged before it is used. Furthermore, when an autonomous system is deployed, its variable behavior is a run-time response to a live situation and it is hard to distinguish correct behavior from malfunctioning. The ASCENS response to such difficulties is to verify and validate the system in all of its development and deployment phases applying rigorous methodologies and formal methods, from requirement analyses and modeling up to the run-time monitoring.

Having all these challenges in mind, ASCENS strategy was to demonstrate its methodology throughout the development process with the concrete and non-trivial applications. That makes the role of ASCENS case studies manifold:

- Inspirational
- Experimental
- Verifiable
- Pragmatic

From the very beginning of the project, initial concepts for requirement specification, awareness, adaptation and overall system modeling have been taken from the problem-rich application domains of swarm robotics, cloud computing and e-mobility. Both typical examples from the application domain and concrete trial scenarios were thoroughly studied. Inspired and motivated by a wide problem space of ASCENS case studies, a number of new methods have been developed, almost from scratch, and a number of existing methods were modified to reply to these challenges. Out of thorough problem specification, a structured knowledge representation in form of KnowLang [31] approach has been designed allowing for a sound (self-) awareness definition based on knowledge. Further system modeling could use this knowledge to exercise awareness rich behavior, making a system aware of its functional and non-functional requirements. It furthermore led to development of a unique adaptation model called SOTA [1] that defines adaptation as a system journey in a multidimensional space where the coordinates are awareness aspects of the system. By deploying SOTA on case studies a general-purpose catalog of adaptation patterns have been defined that help designer express and exercise with adaptive behavior.