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ASCENS

Autonomic Service-Component Ensembles

D9.4b: Demonstration and Exploitation of Project Results

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SEVENTH FRAMEWORK PROGRAMME

Executive Summary

This report describes the efforts performed in the ASCENS project to achieve the demonstration and exploitation objectives, which are defined in the Annex I "Description of Work" of the project contract. The dissemination and exploitation strategy is described in deliverable D9.1a.

The report includes a section describing the demonstrations that were prepared for the final review and a section that addresses the exploitable knowledge that was produced within the scope of the ASCENS project.

Contents

1 Demonstrations

Different scenarios of the ASCENS case studies were used to perform several internal and public demonstrations along the project. Internal demonstrations were used to exemplify theoretical results in the meetings. Public demonstrations were related on the one hand to presentations of research papers and on the other hand those presented at the exhibitions. In particular, the demonstration on the ICT 2013 attracted many visitors to the stand and allowed us to discuss also the foundations of the ASCENS approach. Demonstrations based on the autonomic cloud, swarm robots and collaborative e-vehicles were prepared for the CeBIT 2015 (March 16-20) and for the final review. A brief summary is given in the following; for a detailed description the reader is referred to deliverable D7.4.

1.1 Robot Swarms

At ICT 2013 exhibition the ASCENS robot competition demonstration was a success; for example it was included in the official video "Highlights of the opening of ICT 2013"(3:01-3:30). The aim of the demonstration was to show the advantages of relying on autonomic systems, operating in changing or partially unknown environments and the analysis of such autonomic systems. In the exhibit we presented modeling techniques for autonomous systems at three different abstraction levels.

- We had two real robots one of which is programmed according to our autonomic paradigm and another was controllable via a joystick by visitors. Visitors had to compete with the autonomic robots experiencing the robots' perspective (See fig. 1).
- We showed a robot simulator (ARGoS) that let visitors appreciate the adaptive behavior of robot swarms.
- We provided also experimental results about how formal methods enable a designer to predict the behavior of robots and provide measures of the quality of the proposed solutions.

At the final review the demonstration will focus on the new features of the hardware and the simulation. Regarding the robot this is the new gripper. A life demonstration as well as videos of real experiences and simulations will be shown.

1.2 Cloud Computing

The autonomic cloud is built following the concepts of a Platform-as-a-Service, that is, it provides a development and runtime platform for applications. However, the scenario where the cloud will be deployed and the parts it consists of are very different from that of a classic cloud implementation. In particular, the nodes forming this cloud will not be well-maintained and secured servers. Instead, the cloud relies on *autonomic nodes* — machines and software which are provided on a case-by-case basis, mostly voluntarily, and can be withdrawn or change in load at any time. Furthermore, the communication structure is based on peer-to-peer computing which emphasizes the self-adapting nature of the cloud.

The ASCENS project has contributed many techniques and methods to the area of self-aware and self-adapting systems; several were used in the implementation of the Science Cloud Platform and therefore contributed to validate these project results. The first of these are *adaptation patterns* which serve as a way of structuring the cloud on an architectural level. Following this, we discuss modeling of ensemble behavior in a rigorous way by using the *Helena approach*. System specification is best executed using specifically developed language primitives, namely from the *SCEL language* and *SPL* played a role in the deployment and evolution feedback control loop.

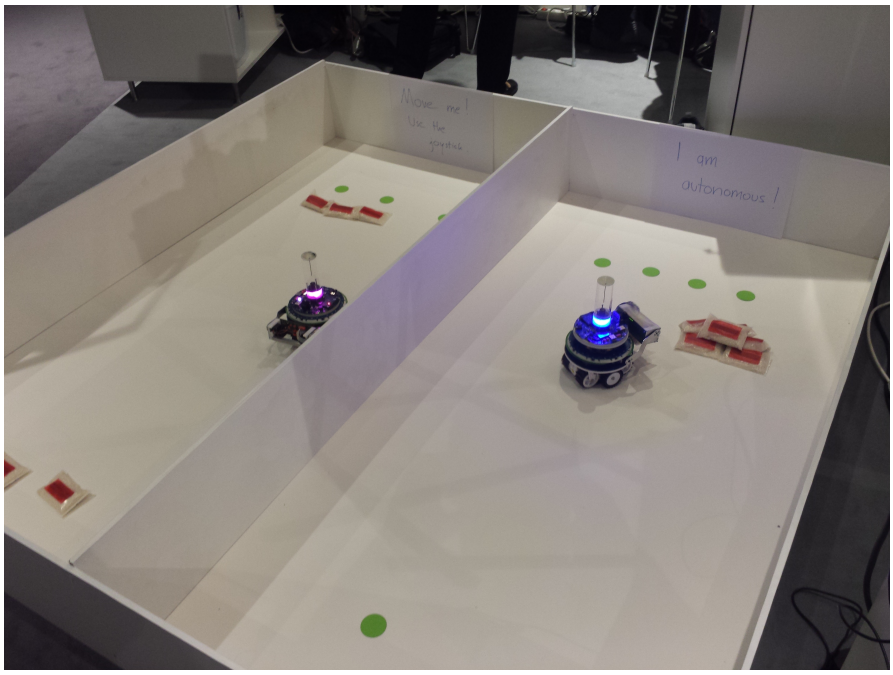

Figure 1: ICT 2013: demonstration

The video prepared for the CeBIT 2015 and the live demonstration at the final review will provide a visualization of the main features of the autonomic cloud prototype focusing on the failover functionality (2).

1.3 E-Mobility

The e-mobility case-study demonstrates modeling and implementation of the problem of intelligent navigation of parking of connected smart vehicles in urban setting. The case-study is modeled via ASCENS concepts of autonomous service components and service component ensembles. In particular, it employs the DEECo component model, which is a reification of SCEL coordination language for distributed decentralized CPS. The modeling of the case-study further integrates results on soft-constraints specifications and adaptation patterns.

The implementation of the case-study is done in JDEECo (a Java-based implementation of DEECo). For the purposes of evaluation, the case-study is simulated in JDEECo combined with MATSim (a simulator of urban mobility). In this settings, JDEECo provides simulation components and ensembles along with the inter-component communication and ensemble formation; MATSim provides simulation of the urban traffic (See fig. 3). The simulation is further equipped with visualization (over Google Maps).

The simulation of the case-study demonstrates adaptive behavior of components (in this case representing vehicles and parking lots) and their dynamic organization to ensembles. Further, from the software development perspective, the whole case-study shows viability of ASCENS approach which allows modeling and implementation of a complex adaptive system via a few easy to understand components and ensembles.

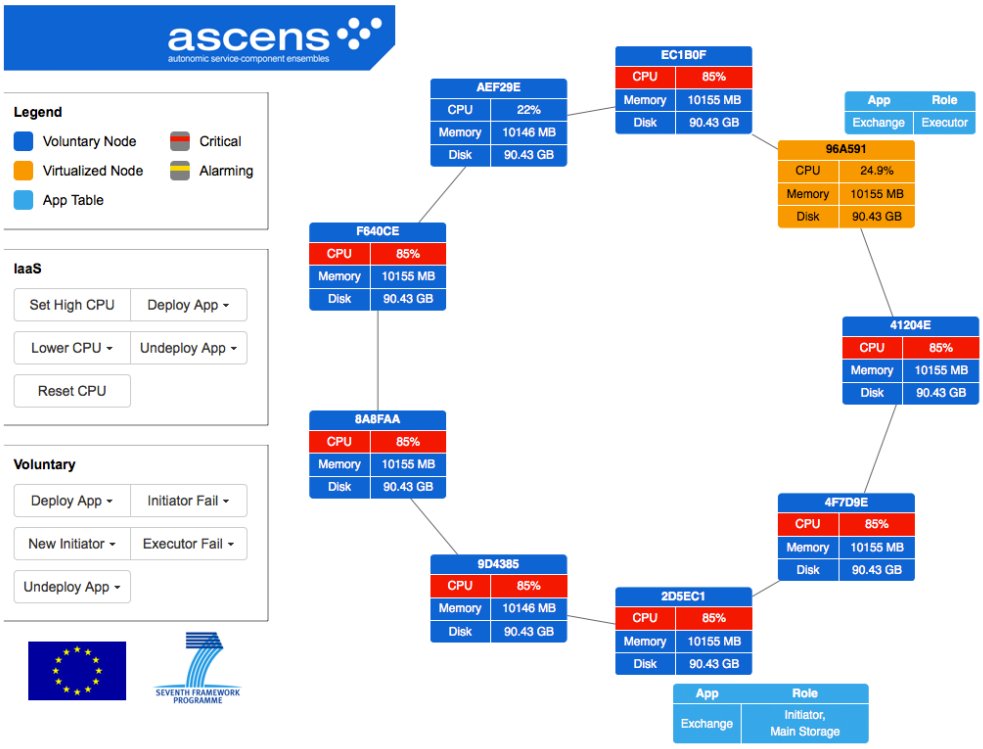

Figure 2: Science Cloud Platform Demo

2 Exploitable Knowledge

Although the ASCENS project has a strong theoretical orientation focusing on basic research activities around engineering autonomic service-component ensembles, project results are planned to be demonstrated in pragmatic case studies. For example, the partners with expertise in robotics, Université Libre de Bruxelles, Ecole Polytechnique Fédérale de Lausanne and Mobsya are very interested as well in transferring the developed methods, analysis and technologies for ensembles to concrete robot swarms. In particular, the industrial partners, Volkswagen AG and Zimory GmbH are keen to transfer the research results into prototypes and in the future into products; more details in the following sections.

2.1 Exploitation Strategies of Industrial Partners

The industrial partners Volkswagen AG and Zimory GmbH defined initial exploitation strategies. Volkswagen AG is planning a new generation of interactive and intelligent e-Vehicles. The ASCENS engineering approach will help Volkswagen to overcome e-Mobility restrictions by developing such e-Vehicles and to support the flexible integration of new services such as e-Charging into the vehicle under consideration. Zimory developed a unique technology to build federated cloud environments integrated in the current production solutions. This technology enables customers to build infrastructure clouds across their own partner networks. The results of the ASCENS engineering approach will be used by Zimory to improve the cloud environment providing solutions for very critical workloads. In particular, self awareness in such cloud environments will reduce the starting time even more.

The following table provides an overview of the components that Volkswagen and Zimory are

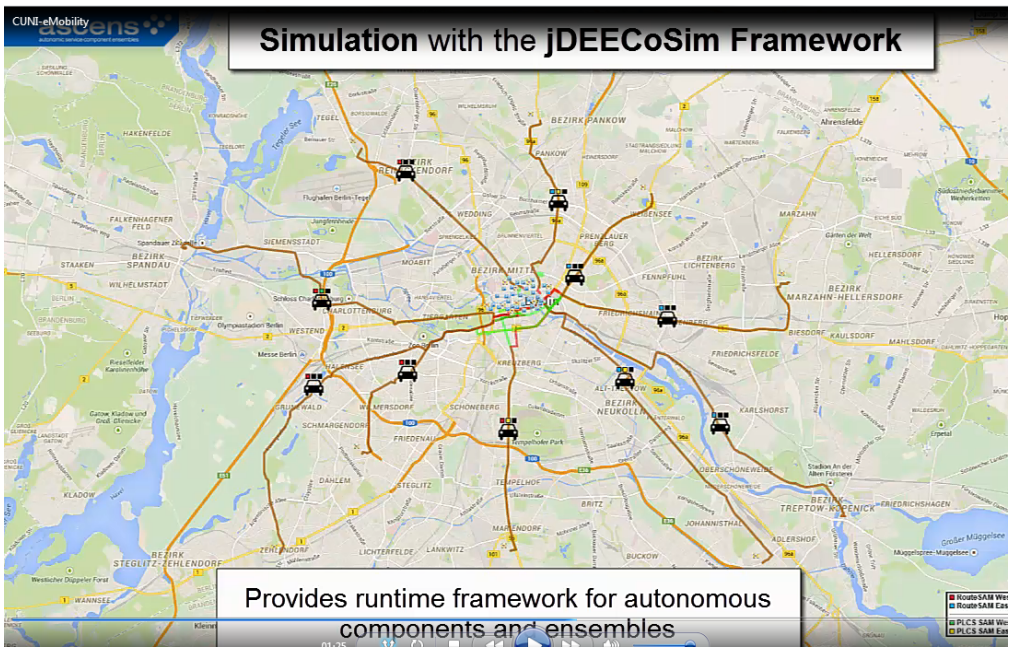

Figure 3: E-mobility: JDEECo Simulation

developing within the scope of the ASCENS project. The vehicle service planner, the user service planner and the cloud application scheduler are briefly described in the sections below.

Type of Exploitable foreground	**Description of exploitable foreground**	**Confi-dential**	**Exploitable products**	**Sectors of application**
Mobility Scheduling Unit	Software component allowing the user to automatically optimize his daily travel pattern	yes	Mobility Assistant	e-mobility
Simulation	Simulation allowing the verification of the behaviour of autonomous, distributed SCs	yes	Simulation	e-mobility
Cooperative scheduling Unit	Software component allowing to automatically optimize local travel of individual users and negotiate the said local results on the global system level. The system provides cooperative travel solutions to the user.	yes	Cooperative Mobility Assistant	e-mobility

Type of Exploitable foreground	Description of exploitable foreground	Confi-dential	Exploitable products	Sectors of application
Cloud scheduling component	Software component allowing the autonomous application scheduling in a distributed cloud environment	yes	Cloud application scheduler	cloud computing
MarXbot Gripper	Miniature gripping mechanisms	no	marXbot gripper for research purposes, gripping principle, gripper components	robotics, manufacturing, market of research tools, education

2.1.1 Mobility Assistant

Mobility planning services intend to improve mobility resource usage and customer satisfaction. In a connected mobility system, these services need to handle distributed knowledge and operate seamlessly in diverse environments. Sensing, cognition and execution units are distributed on different devices such as vehicles, mobile phones and clouds. The mobility assistant aggregates user-, vehicle- and infrastructure-related information and proposes optimal travel patterns to the user. Human-machine interaction may be realized by web-services, mobile phone applications or in-vehicle navigation services. Based on the personal calendar of the user, the mobility assistant schedules and displays travel information. Results of the scheduling process include route proposals and charging recommendations, which are based on the user preferences. Moreover, the mobility assistant raises the user's awareness of traffic flow, charging station availability and vehicle energy consumption. The mobility assistant continuously observes the energy consumption and intervenes if necessary. The mobility assistant can be understood as a further development of the user journey planner and the vehicle journey planner as described by last year's report.

The development of a distributed, autonomous version of the mobility assistant is greatly suppoted by ASCENS concepts, in particular the design and the verification phase.

2.1.2 Simulation of Distributed, Autonomous Agents

Products of autonomous behaviour that are designed in a distributed fashion require extensive evaluation. An extended traffic simulation framework is developed in order to deploy SCs and both verify their behaviour and validate the improvement potential. The traffic simulation is to be used to validate future autonomous services.

2.1.3 Cloud Scheduling Component

During the last 4 years and in collaboration with the partners in the Project, Zimory has been able to apply some of the techniques and results to the Infrastructure-as-a-Service management software that the company develops. The main impact has been into Zimory's cloud-scheduling component, where the autonomic and distributed control of instances developed through the project, can be applied for the optimization of consumers hybrid cloud setups. Multi-level applications being deployed

across multiple providers can benefit from the results of the project by having its individual nodes communicating directly to each other to prevent and react to situations of high load and failures of nodes.

This represents a major step towards more reliable clouds minimizing downtimes and optimizing the resource usage and costs. In the future, and by extending the rules that govern each autonomic component will be possible a full distributed decision-making network of nodes, which will expand the mentioned benefits.

In addition and as a helping-system for the cloud-scheduling component, a metadata distribution system, which includes a properties distribution system and a configuration management system has been developed and integrated into Zimory's product. This was required by the project in order to configure the VMs deployed in the infrastructure with the SCPi software and place it properly within the infrastructure, being able to allocate new nodes. This functionality, as mentioned, is now used by Zimory's customers to fully customize standard OS templates and by cloud providers to reduce placement costs of new VMs. The participation in the Project has impacted Zimory in the way of how architectural work is being done. The move towards a fully decentralized architecture where non-reliable nodes can exist and make decision to self-optimize the platform as a whole is a major shift that will benefit Zimory's software and its customers. These innovations will be further developed in Zimory's new venture project: Deutsche Börse Cloud Exchange.

2.1.4 MarXbot Gripper

Mobsya is supporting several research labs with the marXbot robot platform. The marXbot robot is among the most advanced modular mobile robots in its size. The gripper that has been developed in ASCENS is a key element to progress the exploration of robotic technologies. A brilliant example is the implementation – done within the scope of a thesis – of a 3D printer module inside the gripper allowing to 3D-print everywhere in the environment.

Within Mobsya, the development of the marXbot gripper allows to improve the expertise in mechatronical design and the integration of new technologies in the robotic field. The RFID reader, integrated into the gripper, has shown to be an interesting approach for the recognition of objects and could be used in new robotic products. More specifically, Mobsya will use the advancements achieved during the ASCENS project in his next generation of educational robot. Educational robotics will have a swarm component enabling both robot-robot interaction and interaction with the users. The ASCENS approach to the control of such a distributed system is excellent for this type of products. Manipulation is also the next key features of mobile robotics and the magnetic switch is a potentiality low-cost and highly efficient solution for such design.

In addition, one of Mobsya's goals is to create a link between research and general public. The gripper with its manipulation capabilities is an excellent demonstrator, as we were able to show in several demos during the ASCENS project.

2.2 Patents

No patents have been registered during the first three periods of the ASCENS project.

2.3 Exploitation Strategies of Academic Partners

The use of ASCENS results through academic partners falls into two categories. In the first category, academic partners use the research results in advanced seminars and practical lab courses. In these teaching activities, scientific results of the ASCENS project are presented to students in a way that is embedded within their regular curriculum. Here, the research results presented are leveraged to give

students insights into technologies and techniques that go beyond well-established state-of-the-art. In the second category, the ASCENS results are exploited in research activities. Here, PhD students build upon and foster the materials produced in the ASCENS project to advance their research.

In particular, the following partners have performed exploitation strategies on top of the more explicitly mentioned dissemination and exploitation activities (such as invited talks, conference presentations, tutorials, and panels) reported in Deliverable D9.4a.

- LMU – Ludwig-Maximilians-Universität München
  - Graduate Seminar: Dynamic and adaptive systems (WS 2010/11, 2011/12, 2012/13, 2013/14, 2014/15)
  - Graduate Seminar: Engineering intelligent distributed systems (SoS 2013)
  - Proseminar: Adaptive Systeme (in German) (SoS 2012)
  - PhD Students: Annabelle Klarl, Christian Kroiß, Lenz Belzner
- UNIPI – Università di Pisa
  - Organization of the kick-off meeting of the CINA project (Italian MIUR, PRIN 2010), held in Pisa on February 4-6, 2013. The CINA project involves, among other italian universities and research centers, UNIPI, UDF, CNR-ISTI and is led by IMT Lucca. The rest of the consortium includes the University of Bologna, the University of Turin, the University of Venice, the University of Camerino, the University of Udine, the University of Pavia and the Bruno Kessler Institute for Scientific and Technological Research in Trento. The CINA project deals with the issues related to the development and management of open-ended IT systems consisting of heterogeneous, highly parallel, massively distributed components with complex interactions and behaviours, and with autonomy in terms of individual behaviour, objectives and decision-making. The main objective is to develop a coherent, integrated set of languages, methods and tools to build systems that can operate in open-ended, unpredictable environments while adapting to changing contexts or requirements, and that behave reliably and are able to cope with failures and attacks. The workshop included the presentation of ASCENS case studies, languages, models and tools, offering a mean to veiculate the ASCENS approach to a large audience (more than 50 attendees) that included senior and young researchers, Postdocs and PhD students, who are very active in ASCENS related projects, like the recently approved "ALLOW Ensembles" (7th framework programme).
  - Invited talk at ACCAT 2013 (8th Workshop on Applied and Computational Category Theory, Rome, Italy 17th March 2013): Indexing Processes with Computational Resources (Ugo Montanari)
  - PhD Students: Matteo Sammartino (UNIPI) , Gianluca Mezzetti (UNIPI), Alain Tcheukam (IMT), Olga Pustovalova (IMT).
- UDF – Università di Firenze
  - PhD Students: Luca Cesari, Andrea Margheri
  - Advertising activity: distribution of the ASCENS flyer at DisCoTec 2013 (Firenze, June 3-5 2013)
- Fraunhofer Gesellschaft

  - Conference Tutorial: International Conference on Autonomic and Autonomous Systems, ICAS 2013
  - Conference Panel: International Conference on Autonomic and Autonomous Systems, ICAS 2013
  - Public Outreach: Science Museum's Dana Centre,London (Aware project initiative)

- VERIMAG Laboratory
  - PhD Students: Souha Ben rayana, Ayoub Nouri, Christian Von essen

- UNIMORE – Università di Modena e Reggio Emilia
  - Presentation of ASCENS Scientific Results at the annual meeting of the industrial association of Reggio Emilia (October 2013)
  - Presentation of ASCENS Goals and Results at Telecom Italia, Software Systems Lab

- ULB – Université Libre de Bruxelles
  - ARGoS: used to perform research experiments, as well as teaching activities for the Swarm Intelligence course of ULB.
  - ARGoS-Lua: mainly used for educational purposes, for the Swarm Intelligence course of ULB.
  - ARGoS-MultiVeStA: currently under testing, used to verify the current implementation.

- EPFL – Ecole Polythechnique Fédérale de Lausanne
  - MarXbot robot gripper, used to perform various experiments.

- Lero – University of Limerick
  - Lero Annual meeting in Athlone, Ireland (WS 2010/11, 2011/12, 2012/13, 2013/14)
  - International Workshop on Formal Methods for Self-Adaptive Systems (FMSAS) – a workshop organized by Lero: FMSAS 2012 (Montreal, Canada), FMSAS 2014 (Ho Chi Minh City, Vietnam)
  - Invited talk at ICCASA 2013 (2nd International Conference on Context-Aware Systems and Applications, Phu Quoc, Vietnam); talk title: "Awareness in Software-Intensive Systems" (Emil Vassev)
  - Invited seminar talk at Concordia University, Montreal, Canada (January 17th, 2012); talk title: "Engineering Self-Adaptive Systems- Challenges and Approaches" (Emil Vassev); the seminar attracted a large audience of more than 100 academics and students; the seminar was one of a "Distinguished Speaker Lecture Series"

- IMT Lucca
  - PhD Students: Andrea Vandin, Alessandro Celestini, Alain Tcheukam
  - Transfer of ideas to the EU project QUANTICOL, especiall in what regards languages and tools for collective adaptive systems
  - Teaching of ASCENS topics in several courses (see event lists, e.g. AWASS summer schools, keynotes)

  - SCEL as main topic in an advanced course (MSc&PhD) at the Technical University of Denmark (2015).

- CUNI – Charles University in Prague
  - Ph.D. students – R. Al Ali, I. Gerostathopoulos, M. Kit, J. Keznikl, V. Horký
  - Several department seminars throughout the year on the work in progress
  - May – September 2013: J. Keznikl worked on an intelligent navigation project at Volkswagen, AG, Wolfsburg

- CNR – ISTI
  - Coordination of the organization of the joint ASCENS – QUANTICOL meeting, held in Lausanne on July 3, 2013. QUANTICOL is a new EU STREP Project, which started on april 1, 2013 involving, among others, CNR-ISTI, IMT Lucca, and LMU. The main objective of the QUANTICOL project is the development of an innovative formal design framework that provides a specification language for Collective Adaptive Systems and a large variety of tool-supported, scalable analysis and verification techniques.