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## SeaClouds Project

### D1.7.3

## 2<sup>nd</sup> SeaClouds Scientific Workshop

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## Dissemination Level

Project co-funded by the European Commission within the Seventh Framework Programme		
PU	Public	X
PP	Restricted to other programme participants (including the Commission)	
RE	Restricted to a group specified by the consortium (including the Commission)	
CO	Confidential, only for members of the consortium (including the Commission)	

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## Executive Summary

Two scientific workshops have been promoted and organized, as planned, by the SeaClouds project, and both were accepted as part of the European Conference on Service-Oriented and Cloud Computing (ESOCC) program in the last two editions. The first one, held on September 2<sup>nd</sup>, 2014 in Manchester, United Kingdom (see D1.7.1), and the second one, on September 15, 2015 in Taormina, Italy. In both cases, the objective was to provide a forum to discuss challenges, solutions and perspectives of ongoing research and standards development activities aimed at enabling an efficient and adaptive management of service-based applications across multiple clouds. This second edition of the workshop was organized in conjunction with the CloudWave project (EC-FP7-ICT-610802, <http://cloudwave-fp7.eu>).

Key conclusions from the workshop include:

- The diversity of cloud solutions has increased the challenges for interoperability and portability. New issues are raised on QoS management when multi-cloud deployment is involved, and modules are composed in different clouds.
- Multi-cloud deployment (cross-cloud deployment) on heterogeneous cloud providers, has raised out new challenges for monitoring; in particular, for data distributed on different clouds.
- Discovery has been usually related with QoS and technical requirements matching capabilities. However, other important issues have to be dealt with when risk-driven cost-benefit analysis is considered for multi-cloud selection of services.
- Coordination and adaptation techniques have proved to be useful for improving QoS experienced by the application users.

## 1. Introduction

### 1.1 Objectives

The objective of the workshop was to provide a forum to discuss problems, solutions and perspectives of ongoing research activities, aimed at enabling an efficient and adaptive management of service-based applications across multiple clouds. Of course, also the dissemination of SeaClouds outcomes was also a declared objective for this workshop.

This forum, held within the European Conference on Service-Oriented and Cloud Computing (ESOCC) framework, was a good opportunity to cooperate with other interesting initiatives in the cloud landscape. It also intended to generate knowledge-transfer by fostering discussion about important cloud-related topics like:

- Design of portable multi-cloud applications
- Feedback-driven development
- Analysis of multi-cloud application specifications
- Cloud services discovery
- Adaptive deployment of multi-cloud applications
- Efficient and programmable monitoring of cloud infrastructures
- Efficient monitoring of multi-cloud applications
- Adaptive reconfiguration of multi-cloud applications
- Algorithms and data models for infrastructure and application dynamic adaptations
- Controlled migration of application modules across multiple clouds
- Emerging standards supporting multi-cloud application management
- Case studies and best practices in single-cloud and multi-cloud applications

As the first edition, this workshop also aimed at contributing to the SeaClouds' **dissemination strategy** by not only raising the awareness about the project, but also establishing relationships with other ongoing research projects, which may be useful for future **collaborations**. The workshop research contributions will be published by Springer in the Communications in Computing and Information Science (CCIS) series, such as it was made for past edition.

### 1.2 Program

The second edition of the workshop “**Seamless Adaptive Multi-Cloud Management of Service-based Applications**” (<http://www.scenic.uma.es/workshops/seaclouds2015/>) was promoted by the ongoing European research projects EC-FP7-ICT-610531 SeaClouds and EC-FP7-ICT-610802 CloudWave, and it was accepted as an ESOCC (European Conference on Service-Oriented and Cloud Computing; <http://esocc2015.unime.it>) workshop, which was held on **15-17 September 2015 in Taormina, Italy**. The Program Chairs of the workshop (Ernesto Pimentel, UMA, and Francesco Longo, University of Messina) formed an international Program Committee, which included nineteen internationally recognized experts from nine different

countries. Eight contributions were submitted in response to the call for papers. The originality and relevance of those contributions were evaluated with a peer-review process carried over by the Program Committee, which unanimously decided to accept three of those contributions as regular papers, and one other contribution was accepted as presentation of work in progress (with a fewer pages in the proceedings). Comparing with the first edition of the workshop, the number of submissions was higher, but the number of accepted papers was the same.

In addition to the presentations of the contributed papers, the program included an opening keynote on self-aware adaptive clouds. Following the successful initiative which was initiated in the past year edition of the workshop, a session devoted to presentations of the development and initial results of **12 ongoing EU research projects** was also organized. Given the success of these presentations in 2014, ESOC and SeaClouds organized this track for the full conference, chaired by Antonio Brogi, UPI, and Silvana Muscella, from Trust-IT Services. This presentation track concluded with a very interesting round-table, where scientists from academia and industry (especially from SMEs) discussed about trends in research and development in the field of cloud computing. All participants in the round-table agreed that the sessions devoted to presentations of EU projects was very interesting. On the other hand, they talked about the importance of the fact that innovation and exploitation aspects are highlighted in new EU projects, and at the same time, participants in the round-table pointed out the need that EU invests more funding in basic research. About 60 people from both academia and industry attended the EU project track, and 20 people during the afternoon sessions.

### Agenda

The following is the final program of the SeaClouds workshop, which included a shared track devoted to presentations of ongoing EU project, a round-table, an invited talk, and four presentations of the contributed papers.

Time	Plan
09:00 – 12:00	<p><b>Invited presentations of ongoing research projects</b></p> <p><i>Chairs: A. Brogi (University of Pisa, Italy) and S. Muscella (Trust-IT Services, Italy)</i></p> <p>SeaClouds – A. Brogi (U. of Pisa, Italy)</p> <p>PANACEA – L. Wang (Imperial College, UK)</p> <p>DICE – P. Jamshidi (Imperial College, UK)</p> <p>MODAClouds – P. Jamshidi (Imperial College, UK)</p> <p>CloudWave – P. Leitner (U. Zurich, Switzerland)</p> <p>AppHub – C. Thomas (OW2, France)</p> <p>PaaSage – A. Rossini (SINTEF, Norway)</p> <p>Broker@Cloud – I. Paraskakis (SEERC, Greece)</p> <p>BEACON – P. Massonet (CETIC, Belgium)</p> <p>EUBrazil Cloud Connect – S. Muscella (Trust-IT Services, Italy)</p> <p>CLIPS – R. Di Bernardo (Engineering, Italy)</p>

Con formato: Alemán (Alemania)

	FrontierCities – A. Celesti (U. of Messina, Italy)
12:00 – 13:00	<b>Round-table</b> A. Brogi (U. of Pisa, Italy), P. Jamshidi (Imperial College, UK), P. Leitner (U. Zurich, Switzerland), S. Muscella (Trust-IT Services, Italy), I. Paraskakis (SEERC, Greece), A. Rossini (SINTEF, Norway), L. Wang (Imperial College, UK), Daniela Baglieri (UniME, Italy), Valeria Schifilliti (Start UP ME, Italy), Mauro Draoli (AgID, Italy)
14:15 – 14:45	<b>Workshop opening</b> Chairs: E. Pimentel (Univ. of Málaga) and F. Longo (Univ. Messina)
14:45 – 15:25	<b>Invited talk</b> “Cognitive Packet Network for Self-Aware Adaptive Clouds” by E. Gelenbe (Imperial College) – substituted by L. Wang
15:25 – 15:50	<b>Session 1</b> “A Model-Based Approach to Pragmatic Service Choreography Deployment” by Raphael Gomes, Júnio Lima, Fabio Costa, Ricardo Couto A. Rocha and Nikolaos Georgantas
16:15 – 17:25	<b>Session 2</b> "Supporting Cloud Service Selection with a Risk-driven Cost-benefit Analysis" by Aida Omerovic "Multi-level adaptations in a CloudWave infrastructure: a Telco use case" by Dario Bruneo, Francesco Longo and Boris Moltchanov “An Approach for Generic, Flexible, and Comprehensive Monitoring and Adaptation of Cross-Cloud Applications” by Jörg Domaschka, Daniel Seybold, Frank Griesinger and Daniel Baur
17:25 – 17:45	<b>Conclusions and closing</b>

### Program Committee

The Program Committee of the workshop (please see the table below) included nineteen internationally recognized experts from nine different countries (France, Germany, Ireland, Israel, Italy, Norway, Portugal, Romania, Spain, Sweden).

<b>Program Chairs</b>	- Ernesto Pimentel, University of Malaga, Spain - Francesco Lungo, University of Messina, Italy
<b>Program Committee</b>	- Marcos Almeida, Softeam, France - Antonio Brogi, University of Pisa, Italy

	<ul style="list-style-type: none"><li>- Dario Bruneo, University of Messina, Italy</li><li>- Martin Chapman, Oracle, Ireland</li><li>- Javier Cubo, University of Malaga, Spain</li><li>- Francesco D'Andria, ATOS, Spain</li><li>- Elisabetta Di Nitto, Politecnico di Milano, Italy</li><li>- Nicolas Ferry, SINTEF, Norway</li><li>- Andreas Metzger, Univ. Duisburg-Essen, Germany</li><li>- Boris Moltchanov, Telecom Italia, Italy</li><li>- Simon Moser, IBM, Germany</li><li>- Eliot Salant, IBM, Israel</li><li>- Francisco J. Nieto de Santos, ATOS, Spain</li><li>- Marc Oriol, University of Pisa, Italy</li><li>- Dana Petcu, West University of Timisoara, Romania</li><li>- Achim Streit, Karlsruhe Institute of Technology, Germany</li><li>- Karl Wallbom, Intel, Ireland</li><li>- Chris Woods, Cloudmore, Sweden</li><li>- Marcel Zalmanovici, IBM, Israel</li></ul>
<b>Publicity Chair</b>	- Giovanni Merlino, University of Messina, Italy
<b>Webmaster</b>	- Adrián Pérez, University of Málaga, Spain

## 2. Outcomes

The outcomes of the full-day event may be organized in two parts. On the one hand, the EU projects presented during the morning sessions, which ended with a concluding round table, where all the participants gave their view on the academic research and industrial applications of the projects' contributions. On the other hand, the research papers covered a wide part of the workshop topics, mainly coinciding with the SeaClouds project.

### 2.1 Participating EU Projects

The development and initial results of 12 ongoing EU research projects were presented in a session co-organized by the dissemination manager of SeaClouds, Antonio Brogi. In the following lines, we provide a brief introduction of these projects and their presentations. A more extended abstracts for each project presentation are included in the Annex.

#### (1) Adaptive application management over multiple clouds

A description of the SeaClouds project opened the EU project track.

#### (2) TAP: A Task Allocation Platform for the EU FP7 PANACEA Project

The Cloud supports diverse workloads, and simple schemes are needed to allocate jobs with satisfactory QoS and low overhead. The PANACEA project's Task Allocation Platform (TAP) uses on-line observation of the servers in a Cloud system to dynamically allocate tasks. TAP is a Linux kernel module which embeds measurement agents into hosts. The talk illustrated its usage with a smart algorithm inspired by the Cognitive Packet Network (CPN) which uses reinforcement learning, and with a "sensible" policy that probabilistically selects the host with best measured QoS.

#### (3) Towards Quality-Aware Development of Big Data Applications with DICE

Model-driven engineering (MDE) has been extended in recent years to account for reliability and performance requirements since the early design stages of an application. While this quality-aware MDE exists for both enterprise and cloud applications, it does not exist yet for Big Data systems. DICE is a novel Horizon2020 project that aims at filling this gap by defining the first quality-driven MDE methodology for Big Data applications. Concrete outputs of the project will include a data-aware UML profile capable of describing Big Data technologies and architecture styles, data-aware quality prediction methods, and continuous delivery tools.

#### (4) On MODAClouds' Toolkit Support for DevOps

MODAClouds participants have recently experienced the enhancement of model-driven development with the possibility of exploiting models not only as part of design but also as part of the runtime. Through this enhancement the system model becomes

a live object that evolves with the system itself and sends back to the designers powerful information that enables a continuous improvement of the system. This approach goes into the direction of offering a valid tool to support development and operation in a seamless way, i.e to support DevOps concepts. In this short note authors present the MODAClouds Toolkit which helps lowering existing barriers between development and operations teams and therefore smooths the way to DevOps practice.

#### **(5) CloudWave – Leveraging DevOps for Cloud Management and Application Development**

DevOps describes the convergence of application development and operation activities. In a DevOps team, software developers and system administrators collaborate in joint task forces and work towards common goals. This reduces friction, enables faster feature release times, and allows for cross-fertilization among stakeholders. The main claim of the CloudWave project is that a full-stack DevOps approach to cloud management can lead to more efficient usage of clouds as well as to better applications. This is achieved by aligning the goals of cloud application developers and cloud operators, and by allowing developers to leverage deeper knowledge of the cloud hosting environment. For cloud operators, the CloudWave model enables more efficient instance management, as application developers collaborate with the cloud provider, for instance by exposing adaptation enactment points or emitting relevant business metrics. In return, cloud application developers gain deep insight into the internals of the cloud system, and can hence build and tune their application based on real-time feedback from the cloud. Similar to DevOps, the collaborative model of CloudWave removes friction between cloud operators and software developers by breaking up the black boxes that clouds and applications traditionally are to each other.

#### **(6) AppHub – The European Open Source Market Place**

As the current context of IT budget restriction creates business opportunities for open source software (OSS) the market is becoming increasingly competitive. To be successful, vendors must differentiate themselves through their pre-sales services, their ability to quickly deliver operational business solutions. With current information systems migrating toward virtual and cloud environments, vendors must be able to manage several kinds of deployments and cloud technologies. And in the OSS market specifically, vendors must show a community of contributors, and demonstrate adequate project governance. AppHub helps collaborative projects and SMEs meet these demands in a few hours instead of weeks.

#### **(7) Cloud Application Modelling and Execution Language (CAMEL) and the PaaSage Workflow**

Model-driven engineering (MDE) is a branch of software engineering that aims at improving the productivity, quality, and cost-effectiveness of software development by promoting models and model transformations as the primary assets in software

development. Models can be specified using general-purpose languages like the Unified Modelling Language (UML). However, to fully unfold the potential of MDE, models are frequently specified using domain-specific languages (DSLs), which are tailored to a specific domain of concern. The PaaSage project delivers a platform to support the modelling, execution, and adaptation of multi-cloud applications (i.e., applications deployed across multiple private, public, or hybrid cloud infrastructures). In order to cover the necessary aspects of the modelling and execution of multi-cloud applications, PaaSage adopts the Cloud Application Modelling and Execution Language (CAMEL).

#### **(8) Broker@Cloud: Enabling Continuous Quality Assurance and Optimisation in Future Enterprise Cloud Service Brokers**

The Internet of Services brings about significant advantages for enterprises by reducing upfront investment costs and diminishing risks in pursuing innovative ideas. Nevertheless, at the same time, it transforms the enterprise IT environment into a complex ecosystem of interwoven and variably-sourced infrastructure, platform, and application services. In order to deal effectively with this complexity, future enterprises are anticipated to increasingly rely on cloud service brokerage (CSB). In this respect, the Broker@Cloud project sets out to construct a generic brokerage framework which provides capabilities with respect to two dimensions of CSB, namely Quality Assurance Service Brokerage, and Service Optimisation Brokerage.

#### **(9) BEACON – Enabling Federated Cloud Networking**

Cloud federation enables cloud providers to collaborate and share their resources to create a large virtual pool of resources at multiple network locations. Different types of federation architectures for clouds and datacenters have been proposed and implemented. An effective, agile and secure federation of cloud networking resources is key to impact the deployment of federated applications. The main goal of this project is two-fold: research and develop techniques to federate cloud network resources, and to derive the integrated management cloud layer that enables an efficient and secure deployment of federated cloud applications.

#### **(10) EUBrazil Cloud Connect: a federated e-Infrastructure for cross-border science**

EUBrazil Cloud Connect is an international co-operation project aimed at accelerating scientific discovery to advance knowledge on several challenges with high social impact. It provides a user-centric, federated e-infrastructure for European & Brazilian research communities. Major outputs over 24 months include the design and implementation of new programming models and tools enabling the deployment of three scientific use cases on heterogeneous computing resources. It has also deployed multiple federated cloud services based on open standards, successfully meeting the needs of scientific users and also analysing business competencies for sustainable usage. Thanks to the high impact results achieved in the project, the scientific community and industry can now benefit from stable components for big data analysis.

### **(11) CLIPS – Cloud approach for Innovation in Public Services**

Nowadays, Public Sector is facing two external factors conflicting and apparently irreconcilable: the reduction of budget available and the growing demand for innovation in public services. In this situation, Public Authorities find in the Cloud a valuable ally such as management model of IT infrastructure and SaaS environment, but it is not enough. There is the need for new approaches and business models that enable the delivery of value-added IT services for public utility, built on top of those provided by Public Authorities, thanks to the involvement of new actors (e.g. SMEs, Services Providers), so empowering a real, sustainable business ecosystem. Even though the cloud computing advantages are relevant and clear, security and privacy issues are the primary obstacles to wide adoption in public sector. In this frame, the research project CLIPS ([www.clips-project.eu](http://www.clips-project.eu)), co-funded under CIP-ICTPSP (Grant 621083), wants to provide city community with a methodology and a set of technological assets that allow public administration, citizens and enterprises to cooperate in the development and provisioning of new and innovative public services. In this way the final aim of CLIPS is to build an ecosystem in which all the actors can play an active role providing a strong cooperation.

### **(12) FrontierCities: Leveraging FIWARE for Advantages in Smart Mobility**

FIWARE represents a new European Cloud platform that aims to land on the international ICT market bringing prominent novel advantages for societies. In fact, it provides new compelling and novel software components, available through APIs, able to give developers new valuable Cloud platform functionalities. FrontierCities \European Cities Driving the Future Internet" is a European FP7 founded project related to the FI-PPP Phase 3 CP-CSA call. It aims to leverage the FI-WARE technology in order to support SMEs and start-ups in developing new innovative smart mobility applications for the cities of the future.

## **2.2 Additional Research Contributions**

In this workshop, four contributions related to cloud deployment were accepted after the peer-review process, three as regular papers and one more as presentation of work in progress. The accepted research contributions will be published by Springer in the Communications in Computing and Information Science (CCIS) series, and their full presentations at the workshop can be found in Annex. In the following, we present a brief introduction and discussion for the four research contributions.

### **(1) A Model-Based Approach to Pragmatic Service Choreography Deployment**

The development of applications using service choreographies is becoming one of the de facto standards for the Future Internet. However QoS-aware management of compositions is usually performed without considering service sharing issues. This simplifying assumption makes choreography deployment less feasible in real scenarios, in which a single service is typically shared in many scenarios. In this paper, authors

discuss the problem of managing multiple choreographies in multi-cloud environments and they advocate that sharing-aware deployment is a more effective and resource-efficient approach. Authors also propose a model for the combined deployment of multiple choreographies on top of a shared set of services, and they further investigate the problem through experiments.

### **(2) Supporting Cloud Service Selection with a Risk-driven Cost-benefit Analysis**

Earlier work by author indicates feasibility of eliciting multi-cloud requirements and thus identifying selectable cloud services based on a risk-driven approach. Once an overview of the selectable services that treat a specific risk is obtained, a decision needs to be taken regarding the final selection. This position paper focuses on providing a practical and simple approach to choosing a concrete cloud service (or a set of thereof) when several alternatives are available. Author proposes a risk-driven cost-benefit analysis approach and exemplifies how a decision maker, such as a business analyst or a multi-cloud architecture designer, can apply it in the context of cloud service selection. The strength of the approach is in its simplicity, since the approach is based on a set of relatively comprehensible guidelines. Still, author considers this to be work in progress, since an analysis of how to combine a set of interdependent cloud services (which address several respective risks) is necessary for enabling a full scale design of a multi-cloud based architecture.

### **(3) Multi-level adaptations in a CloudWave infrastructure: a Telco use case**

CloudWave is a FP7 EU project whose aim is delivering novel technologies and methods for improving both the development of Cloud services and the management of their operation and execution. Such goal is reached by providing mechanisms and policies for coordinating multiple adaptations both at the level of the Cloud infrastructure and at the level of the hosted applications. In this paper, authors describe the CloudWave Telco application use case and they provide a proof of concept discussing how the QoS experienced by the application users can be improved thanks to the technologies provided by CloudWave.

### **(4) An Approach for Generic, Flexible, and Comprehensive Monitoring and Adaptation of Cross-Cloud Applications**

The vendor lock-in has been a major problem since cloud computing has evolved as it hinders a quick transition between cloud providers. Furthermore, it hinders an application deployment over multiple clouds at the same time (cross-cloud deployment). While the rise of cross-cloud deployment tools has to some extent limited the impact of vendor lock-in and given more freedom to operators, the fact that applications now are spread out over multiple cloud platforms tremendously complicates their work as either the user interfaces of multiple cloud providers have to be used or custom management tools have to be applied. This is particularly true when it comes to the task of auto-scaling an application and adapting it to load changes. This paper introduces a novel approach to monitoring and adaptation management that is able to flexibly gather various monitoring data from virtual machines distributed across

cloud providers, flexible aggregate the data in the cheapest possible manner, and finally, to evaluate the processed data in order to adapt the application according to user-defined rules.

### 3. Conclusions

From the organizational point of view, this event may be considered as a success, in particular for the EU project track, and the invited talk, not only for the number of attendees, but also for their positive feedback. As it was planned, one of the objectives of this workshop organization was the dissemination of the SeaClouds project.

Regarding the content of the workshop, there were several aspects discussed by participants, focused around the QoS-based cloud deployment, vendor lock-in problems, discovery approaches for cloud service selection matching risk-driven cost requirements, and monitoring management. A collection of key takeaways can be found in the Executive Summary. Concerning the round-table, all participants agreed that the sessions devoted to presentations of EU projects was very interesting, providing a global and wide view of the status of the research and innovation actions in Europe on multi-cloud. On the other hand, they talked about the importance of the fact that innovation and exploitation aspects are highlighted in new EU projects, and at the same time, participants in the round-table pointed out the need that EU invests more funding in basic research.

Multi-cloud was the main focus for the workshop. The evolution experienced by multi-cloud in the last years, has evolved towards an increasing business need. The added complexity generated by multi-cloud is still a big challenge, but outweighed by the benefits provided (e.g. enhanced QoS, management, risk costs optimization, etc.).

#### **Annex: Additional Material**

The additional materials are included in a separate PDF file attached to this deliverable, which contains all of the presentation materials at the workshop.

