EU Projects Track
Preface of EU Projects Track

Following the success of the session devoted to presenting ongoing EU projects on cloud and services, which was held at the ESOCC 2014 SeaClouds Workshop in Manchester, ESOCC 2015 decided to run a “EU Projects Track” on September 15 in Taormina, Italy.

The track was organized in a two-hour general session entirely devoted to presenting the status and perspectives of ongoing EU research projects on cloud and services.

The presentation of the 12 selected ongoing projects – SeaClouds, Panacea, Dice, MODAClouds, CloudWave, AppHub, PaaSage, Broker@Cloud, Beacon, EUBrazil, Clips, and FrontierCities – succeeded in providing an up-to-date view of the achievements and challenges of EU-funded research activities on the cloud and services.

A two-page description of each project presented is included in this volume.

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Adaptive Application Management over Multiple Clouds

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Abstract. SeaClouds is a European FP7 research project, whose goal is to provide a novel open source platform to enable application developers to configure, deploy, and manage complex applications across multiple heterogeneous IaaS and PaaS clouds in an efficient and adaptive way.

The SeaClouds project\textsuperscript{1} aims at supporting application developers during all phases of the cloud application management lifecycle. Users provide as input to the SeaClouds platform the application they wish to deploy on the cloud together with different types of requirements — namely, technical, Quality of Service (QoS) and Quality of Business (QoB) requirements — for the modules composing their application as well as for the whole application. SeaClouds employs OASIS TOSCA\textsuperscript{2} to represent the topology and the requirements of the application to be deployed. SeaClouds users can both interactively specify (in a TOSCA transparent way) the topology and requirements of their application via a graphical user interface featured by the SeaClouds Dashboard (Fig. 1) and/or directly provide a TOSCA specification of their application via the SeaClouds API.

Given the application to be deployed, the SeaClouds Planner generates a set of possible deployment plans satisfying the requirements specified by the user. To achieve that, the Planner first performs a matchmaking step, to select the available cloud offerings (periodically fetched by the Discoverer from different IaaS and PaaS providers) that satisfy the user requirements. After that, a multi-objective optimization step is performed to determine the best deployment plans satisfying the user requirements.

The deployment plan chosen by the user is then passed to the Deployer, that exploits Apache Brooklyn\textsuperscript{3} to perform the actual deployment of all application

\textsuperscript{1} EU-FP7-ICT-610531 “Seamless adaptive multi-cloud management of service-based applications”. http://www.seaclouds-project.eu.
\textsuperscript{2} https://www.oasis-open.org/committees/tosca.
\textsuperscript{3} https://brooklyn.incubator.apache.org.
modules on the chosen target clouds. Right after the application is deployed, the SeaClouds Monitor starts to perform a distributed monitoring over the target clouds in order to detect possible violations of the application requirements or of the Service License Agreement (SLA) devised by the SLA Service. In case of violations that can be repaired without need to migrate application modules, the Monitor directly triggers the Deployer. In case of violations that require to migrate some application module(s), the Monitor asks the Planner to generate a reconfiguration plan.

SeaClouds features two case studies: A gaming application whose deployment dynamically adapts depending on the number and location of users, and a healthcare application exploiting SeaClouds SLA management and, possibly, cloud bursting.

Besides the aforementioned relations with OASIS TOSCA and Apache Brooklyn, SeaClouds is collaborating also with the MODAClouds project. In particular SeaClouds monitoring relies on and extends the monitoring methodology developed by MODAClouds. Last, but not least, a cross-fertilization effort is currently ongoing with the Alien4Cloud project to assess the feasibility for SeaClouds to use Alien4Cloud TOSCA YAML parser and for Alien4Cloud to use SeaClouds Deployer.

SeaClouds adopted from the very beginning of the project an open source strategy, which includes transparent development and Apache 2.0 licensing. Such strategy is intended to serve as enabler for three main impact paths: (1) To exploit SeaClouds-extended Apache Brooklyn application management

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4 http://www.modaclouds.eu.
5 http://alien4cloud.github.io.
framework as a vehicle for SeaClouds post-project value proposition, with new TOSCA, PaaS and multi-cloud support extending a solution already present in the market, (2) To provide a European platform compliant with the OASIS TOSCA standard that is emerging in the PaaS segment, and (3) To allow industrial SeaClouds members — in particular ATOS and Cloudsoft — to integrate SeaClouds open source assets into their commercial offerings.
TAP: A Task Allocation Platform for the EU FP7 PANACEA Project

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Abstract. The EU FP7 PANACEA project has designed a QoS driven smart Task Allocation Platform for varied QoS objectives in the Cloud.

The Cloud [9] supports diverse workloads [1, 2, 6, 7, 10] 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. We illustrate its usage with a smart algorithm inspired by the Cognitive Packet Network (CPN) [3, 5, 8] which uses reinforcement learning [11], and with a “sensible” policy [4] that probabilistically selects the host whose measured QoS is the best. TAP is a practical system shown in Fig. 1 which exploits several different task allocation algorithms such as the two we mention. It is implemented as a Linux kernel module on PCs with Linux OS.

Fig. 1. Architecture of the Task Allocation Platform (left) and its test-bed (right).

A synthetic benchmark is generated, and jobs are sent at fixed intervals denoted by CR, or according to a Poisson process with a fixed rate denoted by EXP. The QoS goals used here are either (i) the minimization of either the execution time on the host, or (ii) the minimization of the response time at TAP, which includes the message sent to activate the job at a host and the time it takes for an ACK to provide information back to TAP. The CPN based
scheme was tested with both (i) and (ii), whereas the sensible decision approach only used (ii). The experiments are carried out for average job arrival rates of 1, 2, 4, 8, 12, 16, 20, 25, 30, 40 jobs/sec with each experiment lasting 5 mins. As the average job arrival rates grows, the sensible decision algorithm outperforms the RNN, as shown in Fig. 2. Also the RNN algorithm with online measurement of job execution time performs better than the RNN with the metric of job response time, and the sensible decision is always best under high job arrival rates.

References

Towards Quality-Aware Development of Big Data Applications with DICE

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Abstract. 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.

Keywords: Quality-driven development · Big Data · UML

1 Overview

Big Data systems [4] are rapidly emerging and their popularity on the ICT market calls for novel software engineering methods to support their development. In particular, independent software vendors (ISVs) need to create novel data-intensive products, but this is complicated by the lack of expertise in technologies such as NoSQL databases, MapReduce/Hadoop analytics, or real-time processing. Pressure to hit the market first can therefore shift the development focus primarily on functional aspects, at the expense of non-functional properties such as reliability, performance or safety of the resulting applications.

The goal of the DICE project is to deliver a methodology and a toolchain to help ISVs develop Big Data applications without compromising on quality. DICE proposes innovations concerning both functional and non-functional properties of data-intensive software systems. For what concerns functional properties, DICE wants to extend model-driven engineering approaches based on UML with a novel profile to annotate properties of data such as volume, velocity, location or data transformations. The traditional ecosystem of models used in MDE,
which encompasses model ranging from platform-independent to technology-
specific, will also consider technologies and architecture styles that are specific
to Big data, such as the lambda architecture\textsuperscript{1}. The main challenge of this gen-
eralization is to develop the model annotations, a consistent methodology, and
the underpinning model-to-model transformations. Furthermore, DICE aims at
translating such high-level design models into a concrete deployment plan and
execute it.

On the non-functional side, the extended UML models will be annotated with
performance and reliability requirements using specific annotations, such as the
UML MARTE and UML DAM profiles [1, 3], but also with novel annotations
that describe the data used by the application. Then, tools will be developed to
predict the fulfillment of these requirements before and during application de-
velopment. In particular, DICE envisions the co-existence of multiple simulation,
verification, and testing tools that can guide the developer through the quali-
ity assessment of early prototypes of the Big Data application. For example, a
developer could initially describe the application architecture, an expected user
behaviour, and the technologies to be used; based on this specification, he could
then explore the forecasted response times under increasing volumes or rates of
data intakes. This information can be helpful to assess if a given architecture
design is appropriate to meet customer requirements. The novelty is the explicit
accounting for the data volumes or rates in the predictions.

Application Domains. The DICE development environment will offer a gen-
eral methodology, that can be useful in a number of application domains. In
particular, the project plans to develop demonstrators in the areas of News &
solutions that connect to social platforms will need to be modelled, together
with Hadoop/MapReduce processing of the acquired social data. The case of
e-Government provides a test scenario for the DICE methodology to apply in
an environment with legacy data systems, where decision-making related to the
best Big data technologies to adopt is complex. Lastly, Maritime Operations is
a sector where streaming data related to vessel movement needs to be processed
and analyzed in real-time to guarantee safe and correct port operations.

Future Work. The DICE project has started in February 2015 and a first public
release of the DICE MDE tools is scheduled for Spring 2016. News and updates
on the project are available at http://www.dice-h2020.eu and a detailed project
vision can be found in [2].

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On MODAClouds’ Toolkit Support for DevOps

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Abstract. We have recently experimented 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 we present the MODAClouds Toolkit which helps lowering existing barriers between development and operations teams and therefore smooths the way to DevOps practice.

The main goal of MODAClouds project\textsuperscript{1} is to provide methods, a decision support system, an open source integrated development environment (IDE) and runtime environment for the high-level design, early prototyping, semi-automatic code generation, and automatic deployment of applications on Multi-Clouds with guaranteed Quality-of-Service (QoS). The concept aligned with this goal was introduced in the early paper [1]. The approach was described in several papers enumerated on the project web site\textsuperscript{2}.

The MODAClouds model-driven approach is supported by the MODAClouds Toolbox\textsuperscript{3}. It consists in there main components (see Fig. 1): (1) Creator4Clouds, an IDE for high-level application design; (2) Venues4Clouds, a decision support system that helps decision makers to identify and select the best execution venue for Cloud applications, by considering technical and business requirements; (3) Energizer4Clouds, a Multi-Cloud run-time environment energized to provide automatic deployment and execution of applications with guaranteed QoS on compatible Clouds.

Creator4Clouds includes plugins focusing on: (i) analysing the QoS/cost trade-offs of various possible application configurations (SpaceDev4Clouds); (ii) mapping high level data models into less expressive but more scalable NoSQL (DataMapping4Clouds); (iii) deploying the resulting application on

\textsuperscript{1} MODAClouds project, partially funded by the European Commission through the FP7-ICT Grant agreement 318484.
\textsuperscript{2} List of publications available at http://www.modaclouds.eu/publications/.
\textsuperscript{3} All tools are available as open source, see http://www.modaclouds.eu/software/.

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Multi-Clouds by exploiting the CloudML language. Overall, Creator4Clouds is a unique tool supporting design, development, deployment and resource provisioning for Multi-Cloud applications. It provides features to assess the QoS guarantees required by the application and offers support to the definition of the application SLA.

Energizer4Clouds includes the frameworks to support monitoring (Tower4Clouds) and self-adaptation (SpaceOps4Clouds), together with utilities that perform ancillary tasks in the platform (ADDeapters4Clouds). Energizer4Clouds is one of the few existing solutions that addresses, in a single framework, the needs of operators willing to run their applications in a Multi-Cloud environment. Through Tower4Clouds, operators are able to perform complex monitoring and data analyses from multiple sources. Moreover, thanks to SpaceOps4Clouds, it identifies and actuates proper self-adaptation actions that take into account the current and foreseen state of the system under control.

All three main components of MODAClouds Toolbox are built with the idea to reduce the gap between development and operations teams, according to DevOps philosophy. Therefore, we have included in the design of the MODAClouds architecture what we call Feed-Back Loop technologies that extend capabilities offered by Creator, Venues and Energizer4Clouds. Thanks to the Feed-Back Loop approach, Tower4Clouds connects with Creator4Clouds and Venues4Clouds, respectively. The first connector is responsible for providing developers and the QoS engineers with the perspective of the application behavior at runtime to improve the development process and incorporate DevOps techniques and tools into the process. The second connector allows Venues4Clouds to adapt its knowledge base according to real live data. This helps in offering to users an updated vision of services quality for future recommendations. The capability of the runtime to influence the design time is in line with current research and is a very important feature to empower Multi-Cloud application developers.

Reference

CloudWave – Leveraging DevOps for Cloud Management and Application Development


The CloudWave Project Consortium

1 Introduction

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. The vision of the CloudWave project\(^1\) 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 example 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. CloudWave will provide a reference implementation of these ideas based on Openstack\(^2\).

2 Project Consortium

CloudWave (full title Agile Service Engineering for the Future Internet) is an FP7 ICT Call 10 funded European research project. The project is coordinated by Eliot Salant (IBM Research Israel). In addition, the CloudWave consortium consists of SAP SE, Intel Ireland, Telecom Italia, Atos, Cloudmore, University of Duisburg-Essen, University of Messina, Technion, and University of Zurich.

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\(^1\) http://cloudwave-fp7.eu/.
\(^2\) http://www.openstack.org.
3 Project Overview

A high-level outline of CloudWave is sketched in Fig. 1. At the heart of the project, monitoring data is generated, analyzed, and aggregated on all levels of the cloud stack, i.e., on physical, virtual, network, and application level. This data is further enriched with information coming from external sources. We refer to this monitoring approach as 3-D monitoring [1]. 3-D monitoring fuels two primary use cases, coordinated adaptation and feedback-driven development.

Coordinated adaptation is to improve the quality of adaptation decisions, taken by the infrastructure and application, through reasoning on the global state of the cloud stack provided by 3-D monitoring. By taking decisions in a coordinated manner, more effective adaptations are taken and operated by different components [2]. To this aim, adaptation models of the application (e.g., turning optional application features on or off based on load) and infrastructure (e.g., scaling up or out) are captured by Feature-based models and adaptation plans are derived by an intelligent engine.

Conversely, feedback-driven development (FDD) aims to bring 3-D monitoring data to software developers, giving them a better understanding of how the application is actually operated (and adapted) at runtime. This goes way beyond traditional application performance monitoring (APM) solutions, as the CloudWave monitoring solution integrates data from the application stack with infrastructure metrics, information on triggered adaptations, and data from other applications launched by the same tenant. CloudWave demonstrates how this data can provide added value to software developers, for instance via visualizing (and warning about) performance-critical code directly in the Integrated Development Environment (IDE), or by enabling what if analysis of performance and costs for different deployment options [3].

References


Abstract. This short paper describes the AppHub project, an EU funded initiative that supports open source software providers to facilitate the adoption of their products by making them ready for the cloud.

Keywords: Open source software · Cloud computing

1 A Market Outreach Accelerator

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.

AppHub, the European Open Source Market Place, provides a neutral distribution channel for trustworthy software developed by EU-supported projects and OSS SMEs in general. It showcases SMEs and European collaborative projects best practices and pre-sales services to facilitate the adoption of their OSS. It leverages a breakthrough software technology to offer easy-to-download software and online pre-sales services. With AppHub, software vendors and services providers can show suitable Proof-of-Concept to their potential customers very quickly, adapting them to the right physical, virtual or cloud environment. AppHub helps accelerate the adoption of cloud
and multi-clouds solutions by both enterprise and cloud service providers. AppHub also helps reduce the learning curve for new cloud infrastructure, and the time required by successive stages of software development, adaptation and testing.

2 The AppHub Platform

AppHub is comprised of three main parts: the Directory, the Factory and the Store:

- The AppHub Directory helps software architects and developers identify the right OSS components for their needs. As of June 2015, the Directory lists 51 projects and 122 assets coming from European SMEs and EC-funded collaborative projects.
- The AppHub Factory provides services to model and build ready-to-deploy and ready-to-use applications for a large diversity of environments. As of June 2015, the Factory supports 12 virtual formats and 12 cloud formats.
- The AppHub Store addresses OSS consumers. It exposes the software either as a template, or as images built with the AppHub Factory. Images can be deployed to any cloud environment, templates can be customized by the consumer if needed.

3 Services That Foster Software Adoption

The AppHub Factory generates image formats suitable for a variety of deployment environments. Because it supports many different environments, AppHub facilitates the migration of OSS applications between them. It enables SaaS software vendors to address the entire market represented by the deployment environments and distributions provided by AppHub.

For cloud service brokers and end-user companies it speeds up the adaptation of any software to any specific environment. With AppHub, they can by quickly customize the complete stack by incorporating additional scripts, easily changing an OS or software package version, adding packages, adding their own middleware, adapting the installation profile of the application, etc.

The AppHub Factory automates the production of images and software clones regardless of the deployment model: private cloud, public cloud or hybrid cloud. The complete stack and its settings can be adapted.

4 The AppHub Project

AppHub is a Horizon 2020 support action funded by the European Commission. The partners that run and promote AppHub, the OW2 open source organization, the Fraunhofer FOKUS research institute and the UShareSoft ISV, combine unparalleled expertise in community management, EU research projects and a breakthrough technology in software asset management. AppHub builds on the experience gained by developing the directory for open source cloud computing during the FP7 OCEAN project.
Cloud Application Modelling and Execution Language (CAMEL) and the PaaSage Workflow

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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 Modeling 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) [5].

CAMEL integrates and extends existing DSLs, namely the Cloud Modelling Language (CloudML) [1], Saloon [4], and the Organisation part of CERIF [2]. In addition, CAMEL integrates new DSLs developed within the project, such as the Scalability Rule Language (SRL) [3].

CAMEL enables PaaSage users to specify multiple aspects of multi-cloud applications, such as provisioning and deployment topology, provisioning and deployment requirements, service-level objectives, metrics, scalability rules, providers, organisations, users, roles, security controls, execution contexts, execution histories, etc.

In order to facilitate the integration across the components managing the lifecycle of multi-cloud applications, PaaSage leverages upon CAMEL models that are progressively refined throughout the modelling, deployment, and execution phases of the PaaSage workflow (see Fig. 1):

- **Modelling Phase**: The PaaSage users design a cloud-provider independent model (CPIM), which specifies the deployment of a multi-cloud application along with its requirements and objectives in a cloud provider-independent way.

- **Deployment Phase**: The Profiler component consumes the CPIM, matches this model with the profile of cloud providers, and produces a constraint problem. The Reasoner component solves the constraint problem (if possible) and produces a cloud-provider specific model (CPSM), which specifies the deployment of a multi-cloud application along with its requirements and objectives.

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1 http://www.paasage.eu.

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in a cloud provider-specific way. The Adapter component consumes the CPSM and produces *deployment plans*, which specify platform-specific details of the deployment.

- **Execution Phase**: The Executionware consumes the deployment plans and enacts the deployment of the application components on suitable cloud infrastructures. Finally, the Executionware records monitoring data about the application execution, which allows the Reasoner to look at the performance of previous CPSMs when producing a new one.

By leveraging upon CAMEL models not only at design-time but also runtime, PaaSage enables self-adaptive multi-cloud applications (i.e., multi-cloud applications that automatically adapt to changes in the environment).

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**References**


Broker@Cloud: Enabling Continuous Quality Assurance and Optimisation in Future Enterprise Cloud Service Brokers

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Abstract. We outline Broker@Cloud – a project which offers methods and mechanisms for facilitating two types of cloud service brokerage, namely Quality Assurance Service brokerage and Service Optimisation brokerage.

Keywords: Cloud computing · Cloud service brokerage · Governance and quality control · Optimisation · Failure prevention and recovery · Service description

1 Setting the Context

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.

2 Broker@Cloud in a Nutshell

Broker@Cloud offers brokerage mechanisms that provide capabilities that are organised around three general themes: (i) governance and quality control; (ii) failure prevention and recovery, and (iii) optimisation. The 1st theme is concerned with checking the compliance of services with pre-specified policies constraining technical, business and legal aspects of service delivery and deployment. It is also concerned with testing services for conformance with their expected behaviour, and with continuously monitoring their operation for conformance to SLAs. The 2nd theme is concerned with the reactive and proactive detection of cloud service failures, and the selection of suitable adaptation strategies to prevent, or recover, from failures. The 3rd theme is concerned with continuously identifying opportunities to optimise service consumption.
with respect to such consumer preferences as, for example, cost, quality, and functionality.

Clearly, in the context of a generic CSB framework, such as the one offered by Broker@Cloud, the aforementioned capabilities must be offered orthogonally to any particular cloud service delivery platform. In this respect, a 4th theme is discerned, namely platform-neutral description of cloud services. This is concerned with the development of methods underpinning the Broker@Cloud framework and which enable the expression of such artefacts as service descriptions, policies and consumer preferences in a manner generic and platform-agnostic.

3 Broker@Cloud Methods and Mechanisms

We briefly outline progress achieved with respect to the aforementioned themes. Concerning the 1st theme, the Service Completeness-Compliance Checker (SC$^3$) has been developed. SC$^3$ is an ontology-driven mechanism which continuously evaluates the quality of services by checking their compliance with pre-specified policies concerning their deployment and delivery; in addition, SC$^3$ evaluates the correctness of the policies themselves. A governance registry system for dynamically managing the service lifecycle has also been developed. With respect to testing, an XML-based service specification language has been constructed and tools have been created to interpret this language, including verification and validation tools and automatic test-generation tools.

Concerning the 2nd theme, prototype software has been developed to support continuous failure prevention and recovery. The prototype incorporates a CEP engine which derives higher-order events relating to impending service failures from low-level events detected, through monitoring, at the infrastructure level. It also incorporates a reasoner for determining suitable adaptation or recovery actions.

Concerning the 3rd theme, the PuLSaR mechanism has been devised to support continuous optimisation of cloud service delivery, based on the fuzzy AHP (analytic hierarchy process) approach. This offers a unified method for performing an optimal multi-criteria decision making, based on precise (i.e. measurable) and imprecise (i.e. fuzzy) decision criteria. Service consumers may express their preferences for service optimisation using exact numerical or imprecise linguistic terms.

Concerning the 4th theme, an ontological framework has been developed for the generic and platform-agnostic specification of service descriptions, business policies, and consumer preferences. The framework draws upon Linked USDL, a lightweight easily-extensible RDF vocabulary for describing services and their pertinent artefacts.

As a means to validate the methods and mechanisms outlined above, two prototype service brokerage platforms have been built. The one is hosted by CAS Software AG (Karlsruhe), as an extension to the CAS Open platform, whilst the other is hosted by Singular Logic (Athens), as an extension of the Orbi platform.

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BEACON – Enabling Federated Cloud Networking

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Abstract. 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.

Keywords: Cloud computing · Network virtualization · Cloud federation · Security

1 Introduction

The BEACON H2020 project \cite{1} aims at enabling federated cloud networking. The recent development of software defined networking and network virtualization technologies has created the opportunity to fully integrate network virtualization technologies into cloud middleware. This will enable management of advanced hybrid clouds and heterogeneous cloud federations. Network virtualization technologies from the OpenDove project will be integrated with open source cloud middleware OpenNebula and OpenStack.

2 BEACON Federated Cloud Networking Architecture

The BEACON project aims to enhance cloud middleware market with network virtualization technology to support the management of hybrid clouds and cloud federations. Our proposal will deliver a homogeneous virtualization layer, on top of heterogeneous underlying physical networks, computing and storage infrastructures, providing enablement for automated federation of applications across different clouds and datacenters. The figure below shows the BEACON federated cloud architecture. The service manager is responsible for the instantiation of the application by requesting the creation and configuration of virtual machines for each service component included.
in the service definition, using the interfaces exposed by the cloud manager. The Cloud Manager is responsible for the placement of VMs into VM Hosts. It receives requests from the Service Manager through the Cloud interface to create and resize VMs, and finds the best placement that satisfies a given set of constraints. The Cloud Manager is free to place, and move, the VMs anywhere, even on remote sites within the federation, as long as the placement satisfies the constraints. The network manager is responsible for allocating network resources to manage federated cloud virtual network and overlay networks across geographically dispersed sites. The right part of the figure shows a second cloud stack running on a different cloud provider. Together they form a federation with two cloud providers. The middle part of the figure shows that the cloud manager and network managers of the two cloud providers communicate to share resources and manage the federation.

3 Open Source Results

Cloud networking aspects will be based on OpenDove, a collaborative project under The Linux Foundation. We will extend the OpenDOVE project with new rich inter-cloud APIs to provision cross-site virtual network overlays. The new inter-cloud network capabilities will be leveraged by existing open source cloud platforms, OpenNebula and OpenStack, to deploy multi-cloud applications. Different aspects of the platforms will be extended to accommodate the federated cloud networking features like multi-tenancy, federated orchestration of networking, compute and storage management or the placement and elasticity of the multi-cloud applications.

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EUBrazil Cloud Connect: A Federated e-Infrastructure for Cross-Border Science

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Abstract. 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.

1 EUBrazilCC: A Federated Cross-Atlantic Infrastructure

Cloud computing has profoundly changed the way in which business services are created and how we conduct scientific research to tackle challenges of significant socio-economic impact by meeting needs such as intense computation capacity, data access, and elastic management of resources. However, major advances are still needed to create novel cloud technologies applicable to a large set of scientific problems in different fields, such as biodiversity, climate, & medical informatics.

EUBrazil Cloud Connect (EUBrazilCC) (www.eubrazilcloudconnect.eu) is a transatlantic open source project federating heterogeneous cloud resources in Brazil and Europe, and facilitating cross border co-operation by implementing innovative programming models and tools for the development of scientific applications. This new joint cloud infrastructure has built on European and Brazilian excellence in cloud technology, standardisation efforts and scientific applications with the availability of large data sets provided by diverse ecosystems.

EUBrazilCC focuses on an interoperable-by-design approach to manage a heterogeneous infrastructure, which includes private clouds, supercomputing and opportunistic desktop resources, using different middleware to manage the IaaS resources. Interoperability is achieved by implementing cloud computing open

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standards for the design of the architecture, federation and high level services, including customised scientific gateways and programming models to efficiently use the infrastructure and foster data sharing. The implementation of relevant standards, with interoperability testing, eases the integration of the tools in other systems while contributing to standardisation initiatives globally.

EUBrazilCC architecture adopts the European Grid Infrastructure (EGI) federated cloud model by supporting open standards: OCCI for IaaS management and VOMS for resource level authorisation management. These standards are essential for help manage heterogeneous resources and deploy on different cloud middleware, such as OpenStack, OpenNebula, which are federated using Fogbow. Fogbow is a middleware that provides a very lightweight business model for the federation of private IaaS providers, based on the exchange of resources. The execution and provision of services can also be performed via the Infrastructure Manager (IM) and CSGrid. IM provides a high-level service to customise and deploy independently from the underlying platform. CSGrid offers the abstraction of the computational resources to facilitate scientific applications’ management and transparent access to supercomputers.

The EUBrazilCC approach to the deployment and execution of large-scope scientific use cases on federated cloud resources mainly focuses on including in the architecture high-level services. COMPSs and e-Science Central programming frameworks provide functionalities to run complex workflow managers on top of different infrastructures, while reducing the use cases’ development cycle. Parallel Data Analysis Service (PDAS) manages large volume of scientific data for big data analytics. Data access and transfer is done by means of graphical interfaces developed via the mc2 framework for scientific gateways.

These tools are the foundation of the EUBrazil Cloud Connect assets that will ensure long-term sustainability through dedicated exploitation plans.

2 Impact and Innovation via Scientific Use Cases

The main impact of EUBrazilCC is the close collaboration between European and Brazilian institutions, in the area of eScience applications on virtualised infrastructures, to demonstrate the efficiency and cost-effectiveness of tools via 3 use cases with high socio-economic impact with mutual benefit to EU & Brazil.

The Leishmaniasis Virtual Lab (LeishVL) is a web-based application that offers a dedicated set of tools and services to data sources and powerful computing systems to run experiments for the surveillance of Leishmaniasis, a disease affecting the poorest of the poor. The Vascular System Simulation involves simulations of the heart and the arterial system to model pathologies and test therapies under development, which can be examined in-silico, reducing design costs and times. The Climate Change and Biodiversity studies the mutual interactions (status and changes) between biodiversity dynamics and climate change, by using earth observation and ground level data together with simulated data.

EUBrazilCC has a high impact to international associations and industries thanks to the use of project assets and establishment of synergies. COMPSs
is already adopted in the EGI Federation Cloud, while mc2, e-Science Central, and LeishVL are available on EGI marketplace. The Fogbow component is being considered by RNP, the Brazilian research network, for federating their cloud infrastructure and under testing by SERPRO.

EUBrazilCC has demonstrated a consolidated representation as an important vehicle driving ICT policy dialogue between Europe and Brazil and contributing cloud technologies to interoperability, e-infrastructure and scientific applications.
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 [1] a valuable ally such as management model of IT infrastructure and SaaS environment [3], 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) [4], 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 [6]. In this frame, the research project CLIPS (www.clips-project.eu), co-funded under CIP-ICT-PSP (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.

In order to support “cloudization” of PA legacy IT systems and the reuse of resources, overcoming the aforementioned obstacles, CLIPS project makes use of the micro-service concept, introduces the micro-proxy one and leverages a hybrid integration approach [2]. More in details (Fig. 1): (1) a micro-service represents a service providing atomic business functionality and is located on the cloud. Being atomic, this maximizes its reusability. All the micro-services deployed in CLIPS ecosystem are resources potentially sharable (building blocks); (2) a micro-proxy represents a service creating the connection between CLIPS cloud environment and PA IT systems. It represents a sort of last mile integration element, on the one hand leaving the full control on personal/sensible data to the single PA and, the other hand, providing access to them according to CLIPS platform dictates.

CLIPS proposes [10]: (1) a Visual Service Mash-up tool, making potentially all stakeholders capable to identify available building blocks (i.e. micro-services and Open Data) and to compose them in a visual way to create new value added services. This represents the adaptative part of the integration approach (called also citizen integration); (2) an integration framework, based on Talend [11], in order to overcome more sophisticated integration (in particular dealing with the creation of micro-proxies). This represents the systematic part of the approach.
Moreover, to face security issues, CLIPS architecture [4, 10] includes four modules each one operating at different levels: (1) a set of security best practices to be followed by each CLIPS component design; (2) the integration with Secure idenTity acrOss boRders linKed (STORK) [6] framework; (3) the employment of the Remote Attestation [8] (feature provided by the Trusted Computing technology) in order to enforce the trustworthiness of CLIPS infrastructure; (4) a cloud-oriented logging component to monitor the events occurring within the infrastructure.

CLIPS will be piloted in several European cities around a common the scenario of a “family moving across countries/cities” facing with typical complexities such move could entail. CLIPS pilot cities are: Bremerhaven (DE), Lecce (IT), Novi Sad (RS), and Santander (ES). The services to be piloted belong to several fields (e.g. kindergarten registration, payment services, register with administration, get licenses and permissions) and will be run also in cross-border situations paying attention to privacy and ethical issue, being analysed and investigated during the project [9].

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FrontierCities: Leveraging FIWARE for Advantages in Smart Mobility

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Abstract. 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 an European FP7 founded project related to the FI-PPP Phase 3 CP-CSA call. It aims to leverage the FIWARE technology in order to support SMEs and start-ups in developing new innovative smart mobility applications for the cities of the future.

Keywords: Cloud computing · Internet of Things · FIWARE · Smart mobility

1 FIWARE at Glance

Cloud computing and Internet of Things (IoT) are enabling key technologies for Future Internet (FI). In this context, the European Commission (EC) envisioned the possibility to foster the wide adoption of such technologies, in total openness, avoiding vendor lock-in and simplifying the composition of new services. To this end, the EC has started the Future Internet Private Public Partnership (FI-PPP) program [1] that has brought to the delivery of a new complex European Cloud platform, called FIWARE. The aim of FIWARE is to yield an open standard platform and an open, sustainable, global ecosystem. The FIWARE reference architecture includes a set of general-purpose platform functions called Generic Enablers (GEs) [2]. GEs are related to network and device interfaces, advanced web-based user interfaces, application/service ecosystems and delivery networks, Cloud hosting, data/context management, IoT service enablement, and security. FIWARE provides GE Open Specifications (that are public and royalty-free) and their implementations (GEi). Moreover, FIWARE provides at least one open source reference implementation of each GE (GEri) with a well-known open source license. The advantage in using FIWARE is that software architects can rely on a consolidated set of open source general-purpose platform functions that are supported by a world-wide community. In fact, there are GEs
for many specific needs that allow developers to apply agile development strategies. In order to promote the FIWARE Technology, the EC has promoted the Future Internet Accelerator Programme including 16 accelerators related to different application fields. FrontierCities [3] is one these 16 accelerators specifically focusing on smart mobility.

2 FrontierCities

FrontierCities “European Cities Driving the Future Internet” is a proposal presented for the FI-PPP Phase 3 CP-CSA call. The project is built on the FI-PPP Phase I and II, and it is directly linked to the work carried out in FI-Phase II instant mobility and outsmart use cases. Mobility and transport are essential for the proper functioning of a city. A smart city should be easily accessible to visitors and residents, and travelling across a city should be problem-free. The aim is to provide a multifaceted, efficient, safe, and comfortable transport system, which is linked to ICT infrastructures and open data. FrontierCities aims to support SMEs and start-ups for the development of innovative smart mobility applications. While building upon Phase II, FrontierCities is however in line with the significant change in focus required under Phase III, and represents an ambitious, market-focused project. Core objectives are to solicit and select high-calibre grant applications from SMEs and start-ups through a mix of strategies and market the results to a pan-European audience of cities. The main objective of the project is to support grantee projects for a secure market commercialisation of their applications and services considering both cities and wider private sector uptakers and enablers (e.g., corporations and investors). In particular, the project aims to disburse EUR 3.92 million in grant funding to SMEs and start-ups through a streamlined two-step application process. The frontierCities consortium is made up of seven partners (New Frontier Services, Engineering – Ingegneria Informatica SPA, University of Surrey, European Business and Innovation Centre Network, InnovaBic, Energap, Università degli Studi di Messina), each one bringing experience and expertise in management, technology and business development.

3 Preliminary Results

Currently, the assessment of proposals in step 1 is completed. We were thrilled to see such a strong interest in our call with 594 submitted and finalised applications. In particular, we had 201 successful step 1 applicants, who have been invited to participate in step 2.

References

### Author Index

<table>
<thead>
<tr>
<th>Name</th>
<th>Page(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abbate, Tindara</td>
<td>276</td>
</tr>
<tr>
<td>Abidi, Leila</td>
<td>216</td>
</tr>
<tr>
<td>Alessi, Marco</td>
<td>448, 451</td>
</tr>
<tr>
<td>Andronico, Giuseppe</td>
<td>353</td>
</tr>
<tr>
<td>Balalaie, Armin</td>
<td>201</td>
</tr>
<tr>
<td>Bär, Florian</td>
<td>263</td>
</tr>
<tr>
<td>Barrientos, M.</td>
<td>422</td>
</tr>
<tr>
<td>Bartoloni, Leonardo</td>
<td>111</td>
</tr>
<tr>
<td>Baur, Daniel</td>
<td>184</td>
</tr>
<tr>
<td>Bouzereau, Olivier</td>
<td>435</td>
</tr>
<tr>
<td>Brehm, Lars</td>
<td>289</td>
</tr>
<tr>
<td>Brogi, Antonio</td>
<td>111, 422</td>
</tr>
<tr>
<td>Bruno, Dario</td>
<td>175, 432</td>
</tr>
<tr>
<td>Bua, Filippo</td>
<td>353</td>
</tr>
<tr>
<td>Buccarella, M.</td>
<td>422</td>
</tr>
<tr>
<td>Carrasco, J.</td>
<td>422</td>
</tr>
<tr>
<td>Casale, Giuliano</td>
<td>427, 430</td>
</tr>
<tr>
<td>Cascella, Roberto G.</td>
<td>444</td>
</tr>
<tr>
<td>Cavallo, Marco</td>
<td>5</td>
</tr>
<tr>
<td>Celesti, Antonio</td>
<td>33, 48, 79, 276, 325, 338, 450</td>
</tr>
<tr>
<td>Cérin, Christophe</td>
<td>216</td>
</tr>
<tr>
<td>Ciampolini, Anna</td>
<td>363</td>
</tr>
<tr>
<td>Costa, Caio H.</td>
<td>238</td>
</tr>
<tr>
<td>Costa, Fábio</td>
<td>153</td>
</tr>
<tr>
<td>Cretella, Giuseppina</td>
<td>404</td>
</tr>
<tr>
<td>Cubo, J.</td>
<td>422</td>
</tr>
<tr>
<td>Cusmà, Lorenzo</td>
<td>5</td>
</tr>
<tr>
<td>Dadashi, Aryan</td>
<td>432</td>
</tr>
<tr>
<td>D’Andria, F.</td>
<td>422</td>
</tr>
<tr>
<td>D’Antonio, Salvatore</td>
<td>126</td>
</tr>
<tr>
<td>da Rocha, Ricardo</td>
<td>153</td>
</tr>
<tr>
<td>De-Santos, Francesco Javier Nieto</td>
<td>432</td>
</tr>
<tr>
<td>Deussen, Peter H.</td>
<td>435</td>
</tr>
<tr>
<td>Di Bernardo, Roberto</td>
<td>447, 451</td>
</tr>
<tr>
<td>di Martino, Beniamino</td>
<td>404</td>
</tr>
<tr>
<td>Di Modica, Giuseppe</td>
<td>5</td>
</tr>
<tr>
<td>Di Nitto, Elisabetta</td>
<td>422, 427, 430</td>
</tr>
<tr>
<td>Distefano, Salvatore</td>
<td>389</td>
</tr>
<tr>
<td>Domaschka, Jörg</td>
<td>184</td>
</tr>
<tr>
<td>Erdal, Olai-Bendik</td>
<td>63</td>
</tr>
<tr>
<td>Esposito, Antonio</td>
<td>404</td>
</tr>
<tr>
<td>Fargetta, Marco</td>
<td>353</td>
</tr>
<tr>
<td>Fazio, Maria</td>
<td>33, 48, 276</td>
</tr>
<tr>
<td>Fowley, Frank</td>
<td>374</td>
</tr>
<tr>
<td>Gaivoronksi, Alexei A.</td>
<td>63</td>
</tr>
<tr>
<td>Geldwerth-Feniger, Danielle</td>
<td>216</td>
</tr>
<tr>
<td>Gelenbe, Erol</td>
<td>425</td>
</tr>
<tr>
<td>Georgantas, Nikolaos</td>
<td>153</td>
</tr>
<tr>
<td>Ghamsari, Majid Salehi</td>
<td>435</td>
</tr>
<tr>
<td>Giacobbe, Maurizio</td>
<td>276</td>
</tr>
<tr>
<td>Giorgio, Emidio</td>
<td>353</td>
</tr>
<tr>
<td>Gomes, Raphael</td>
<td>153</td>
</tr>
<tr>
<td>Grieco, Luigi Alfredo</td>
<td>141</td>
</tr>
<tr>
<td>Griesinger, Frank</td>
<td>184</td>
</tr>
<tr>
<td>Gugliara, Giuliano</td>
<td>126</td>
</tr>
<tr>
<td>Guglielmo, Alessio</td>
<td>353</td>
</tr>
<tr>
<td>Heydarnoori, Abbas</td>
<td>201</td>
</tr>
<tr>
<td>Hof, Hans-Joachim</td>
<td>289</td>
</tr>
<tr>
<td>Huedo, Eduardo</td>
<td>325</td>
</tr>
<tr>
<td>Ibrahim, Ahmad</td>
<td>111</td>
</tr>
<tr>
<td>Jamshidi, Pooyan</td>
<td>201</td>
</tr>
<tr>
<td>Johansen, Finn-Tore</td>
<td>63</td>
</tr>
<tr>
<td>Jugel, Dierk</td>
<td>308</td>
</tr>
<tr>
<td>Keller, Barbara</td>
<td>263</td>
</tr>
<tr>
<td>Khoshkbarforoushha, Alireza</td>
<td>228</td>
</tr>
<tr>
<td>Lafaille, Marie</td>
<td>216</td>
</tr>
<tr>
<td>Lamers, Arjan</td>
<td>93</td>
</tr>
<tr>
<td>Laubis, Kevin</td>
<td>249</td>
</tr>
<tr>
<td>Lefebvre, Alexandre</td>
<td>435</td>
</tr>
<tr>
<td>Leitner, Philipp</td>
<td>432</td>
</tr>
<tr>
<td>Levin, Anna</td>
<td>79, 325, 338</td>
</tr>
<tr>
<td>Lima, Júnio</td>
<td>153</td>
</tr>
<tr>
<td>Llorente, Ignacio M.</td>
<td>325</td>
</tr>
<tr>
<td>Longo, Francesco</td>
<td>175</td>
</tr>
<tr>
<td>Loreti, Daniela</td>
<td>363</td>
</tr>
</tbody>
</table>
Maia, Paulo H.M.  238
Massonet, Philippe  79, 325, 338, 442
Melis, Jaime  325
Mendonça, Nabor C.  238
Merlino, Giovanni  325, 389
Miron, Avi  432
Mohring, Michael  263, 308
Moltchanov, Boris  175, 432
Monforte, Salvatore  353
Mongiello, Marina  141
Montero, Rubén S.  325
Moreno-Vozmediano, Rafael  325
Mufari, Davide  33
Muscella, Silvana  444

Nesse, Per Jonny  63
Nieto, A.  422
Nuel, Catherine  435
Nurcan, Selmin  263

Omerovic, Aida  166
Oriol, M.  422

Pahl, Claus  374
Panarello, Alfonso  48
Paone, Maurizio  353
Paraskakis, Iraklis  440
Parker, Stephanie  444
Petcu, Dana  430
Pérez, D.  422
Pimentel, E.  422
Pinheiro, Manuele Kirch  20
Polito, Carmelo  5
Ponomarev, Andrew  299
Puliafito, Antonio  33, 48, 389

Ranjan, Rajiv  228
Richard, Alban  435
Rocha, Lincoln S.  238
Romano, Carlo Francesco  126
Romano, Luigi  126
Rossini, Alessandro  437

Salant, Eliot  432
Schmidt, Rainer  263, 289, 308
Schour, Liran  325, 338
Schuller, Alexander  249
Sciancalepore, Massimo  141
Seybold, Daniel  184
Sharifloo, Amir Molzam  432
Sheridan, Craig  442
Simko, Vilian  249
Smirnov, Alexander  299
Spahr, Stefan  325
Spais, Ilias  427
Steffenel, Luiz Angelo  20
Strazdins, Peter  228

Thomas, Cédric  435
Tomarchio, Orazio  5

van Eekelen, Marko  93
Vázquez, Constantino  325
Veloudis, Simeon  440
Villari, Massimo  33, 48, 79, 276, 325, 338, 353, 450
Vogli, Elvis  141

Wallbom, Karl  432
Wang, Lan  425
Whigham, Darren  325
Woods, Chris  432

Xiong, Huanhuan  374

Zenzaro, S.  422
Zimmermann, Alfred  263, 308