CLOSER 2016
Final Program and Book of Abstracts

6th International Conference on Cloud Computing and Services Science

Rome - Italy
April 23 - 25, 2016

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INSTICC - Institute for Systems and Technologies of Information, Control and Communication

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Foreword

This book contains the abstracts of the 6th International Conference on Cloud Computing and Services Science (CLOSER 2016) held in Rome, Italy from 23 to 25 of April 2016. This conference was organized and sponsored by the Institute for Systems and Technologies of Information, Control and Communication (INSTICC), technically co-sponsored by IEEE Cloud Computing, SINTEF and EGI and held in cooperation with the Association for Computing Machinery - Special Interest Group on Management Information Systems.

The technical program of CLOSER 2016 covered areas like “Cloud Computing Fundamentals”, “Services Science”, “Cloud Computing Platforms and Applications”, “Cloud Computing Enabling Technology” and “Data as a Service”. We expect that these proceedings will appeal to a broad audience of engineers, scientists and business people interested in cloud computing and service systems. We further believe that the papers in these proceedings demonstrate new and innovative solutions, and highlight technical problems in the mentioned areas that are challenging and worthwhile.

The conference was also complemented with the workshop entitled Towards Convergence of Big Data, SQL, NoSQL, NewSQL, Data streaming/CEP, OLTP and OLAP - DataDiversityConvergence (co-chaired by Ricardo Jimenez-Peris, Marta Patiño-Martinez, Patrick Valduriez and Theodora Varvarigou), a special session entitled Experiences with OCCI - OCCI (chaired by Augusto Ciuffoletti) and a special session entitled Tools for an Energy Efficient Cloud - TEEC 2016 (chaired by Karim Djemame).

CLOSER 2016 received 123 paper submissions from 35 countries. From these, 25 papers were published and presented as full papers.

The high quality of the CLOSER 2016 programme was enhanced by five keynote lectures, delivered by experts in their fields, including: Pierangela Samarati (Università degli Studi di Milano, Italy), Frank Leymann (University of Stuttgart, Germany), Peter Sloot (University of Amsterdam, Netherlands; Complexity Institute Singapore, Singapore; ITMO St. Petersburg, Russian Federation), Verena Kantere (University of Geneva, Switzerland) and Mohammed Atiquzzaman (University of Oklahoma, United States). The meeting was also complemented with a Doctoral Consortium on “Cloud Computing and Services Science”.

The high number and high quality of the papers received imposed difficult choices in the review process. Each paper was reviewed by at least two experts. Those papers that, according to the reviews, were considered adequately balanced in terms of quality, originality and relevance to the conference themes were selected. We hope that these Conference Proceedings, submitted for indexation to Thomson Reuters Conference Proceedings Citation Index, INSPEC, DBLP, EI and Scopus, may help the Cloud Computing community to find interesting research work. All presented papers will be available at the SCITEPRESS digital library. Furthermore, a short list of presented papers will be selected and their authors invited to submit an extended and revised version of their paper to be included in a forthcoming book of CLOSER Selected Papers to be published in CCIS Series by Springer during 2016. A short list of papers will also be selected for publication in a Special issue of Future Generation Computer Systems Journal.

At the closing session, awards based on the best combined marks of paper reviewing, as assessed by the Program Committee, and the quality of the presentation, as evaluated by the chairs at the conference venue, were conferred to the best papers and the best student papers submitted to the conference. The best paper award for this year´s edition was sponsored by Dell.

As a final point, we would like to express our thanks, first of all, to the authors of the technical papers, whose work and dedication make possible to put together a program that we believe is very exciting and of high technical quality. Next, we would like to thank all the members of the program committee and auxiliary reviewers, who helped us with their expertise and time. We would also like to thank the invited speakers for

their invaluable contribution and for sharing their vision with the CLOSER 2016 audience. Special thanks should be addressed to the INSTICC Steering Committee whose invaluable work made this event possible and finally, a word of appreciation for the hard work of the secretariat: organizing a conference of this level is a task that can only be achieved by the collaborative effort of a dedicated and highly capable team.

Jorge Cardoso, University of Coimbra, Portugal and Huawei European Research Center, Germany
Donald Ferguson, Columbia University, United States
Víctor Méndez Muñoz, Universitat Autònoma de Barcelona, UAB, Spain
Markus Helfert, Dublin City University, Ireland

Social Event and Banquet

Guided bus tour of Rome, followed by a dinner at "Archeologia" restaurant with an Opera show
Sunday 24, 19:00 – 23:30

Since its founding over 2,500 years ago, Rome has been a top historical and cultural destination of the world. The Eternal City boasts the unique combination of a captivating living museum and a heavily-populated, modern metropolitan city. Rome is filled with breathtaking ancient ruins and monuments, but you will also fall in love with its charming piazzas, family-owned shops, and cobblestone streets.

The bus tour will take the conference attendees through the major sites of Rome and the tour guide will present and integrate them in the history and culture of the Roman capital, so all the attendees get an overall view of the city, especially if they plan to leave Rome directly after the conference or want to plan their visit if they are staying in Rome in the aftermath of the conference.

After having being delighted by the magnificence of the monuments of Rome, we head to the "Archeologia" restaurant.

Antique post station for horse exchange that transported goods from the Mediterranean to Rome. The Archeologia is immersed in the wonderful Antique Appian Park and the grand Roman tomb ruin is like a stage in this superb garden, dominated by a majestic wisteria that for over 300 years has bloomed, creating a delicious and fresh shade. The Archeologia is a mix between culture and cuisine, between modern and antique, between good food and love for roman history.

The entire restaurant is placed on the mausoleum of the hypogeum grave that in antique times it rose for about six meters. In the wine cellar one can notice, in the Antique Appian Way direction, a small window.

Here a tube was inserted from the small carriages that would empty the Castelli wine directly in the barrels to keep it fresh. The old owners had a very large vegetable garden where they grew artichokes. These were cooked under a large fire at the center of the garden at the grand feast that followed the harvest. At last, the extraordinary frame of the Antique Appian Way, Queen Viarum. A unique system of landscape elements of great beauty and an artistic and archaeological patrimony of inestimable value.

Their cuisine has a unique ingredient: history. This because the Archeologia restaurant with its 400 years is not only a simple frame, but an element of exploitation of every dish. To taste the great tradition of Rome in their pleasant and refined halls is a unique experience, capable of satisfying who is looking for intimacy as well as who wants to spend some time in company. An unique emotion, that you will never get tired of repeating. The Archeologia wants to join cuisine with culture, offering a unique occasion to immerse oneself in our regional cooking and to invite their guests to discover new flavors.

During the dinner we will have an Opera show with the Soprano voice of Emanuela Mari.

General Information

Welcome Desk/On-site Registration
Friday, April, 22 – Open from 16:30 to 18:30
Saturday, April, 23 – Open from 08:15 to 18:30
Sunday, April, 24 – Open from 08:30 to 18:45
Monday, April, 25 – Open from 08:30 to 18:45

Opening Session
Saturday, April 23, at 09:00 in the Auditorium room.

Welcome Drink
Saturday, April 23, at 18:30.

Closing Session
Monday, April 25, at 18:30 in the Auditorium room.

Farewell Drink
Monday, April 25, at 18:45.

Meals
Coffee-breaks will be served in the Foyer to all registered participants.
Lunches will be served in the Restaurant to all registered participants. Please check the hours in the Program Layout.

Communications
Wireless access will be provided free of charge to all registered participants.

Secretariat Contacts
CLOSER Secretariat
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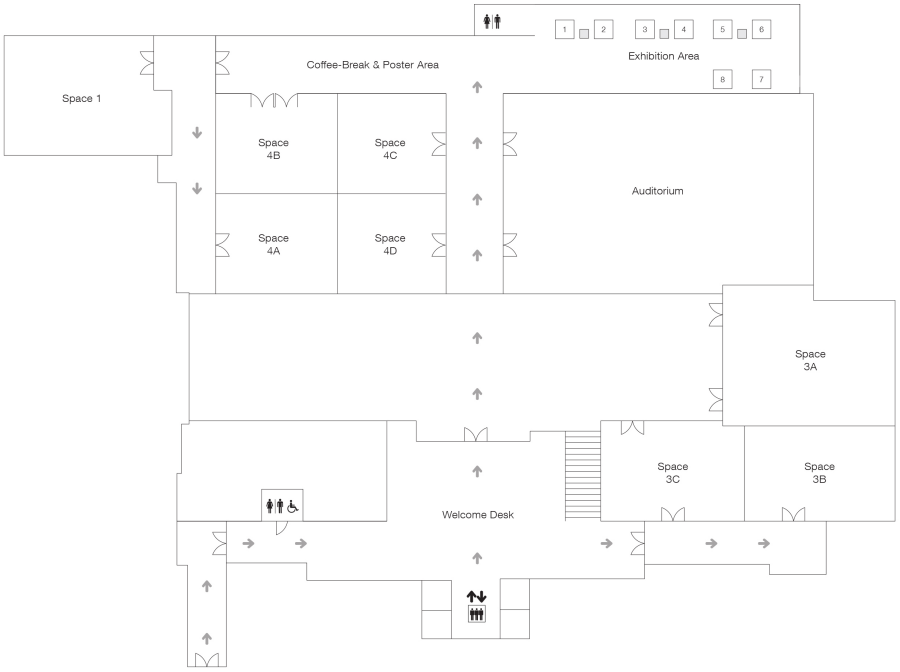
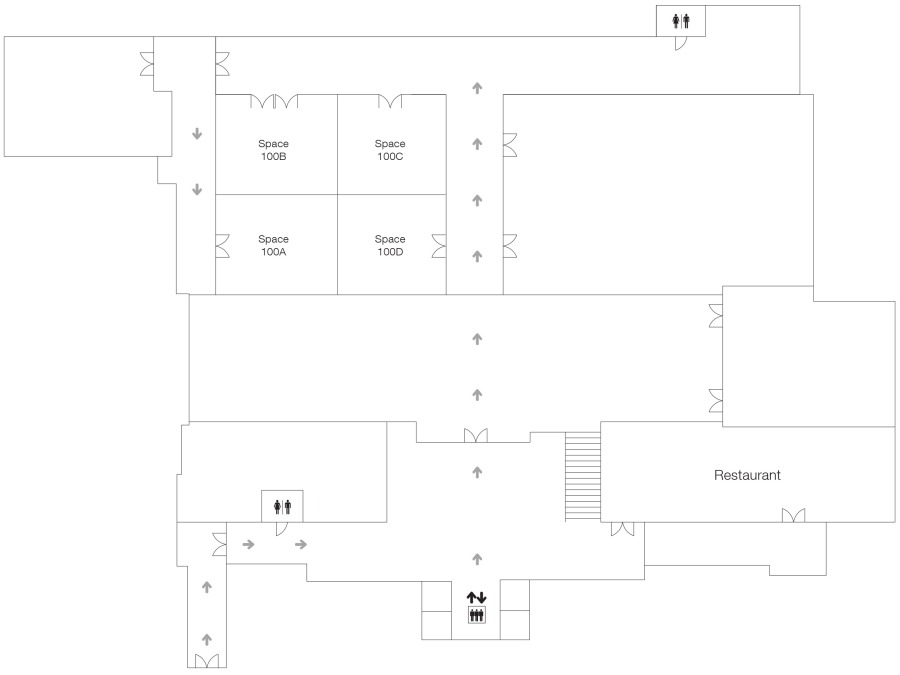
Rooms Layout

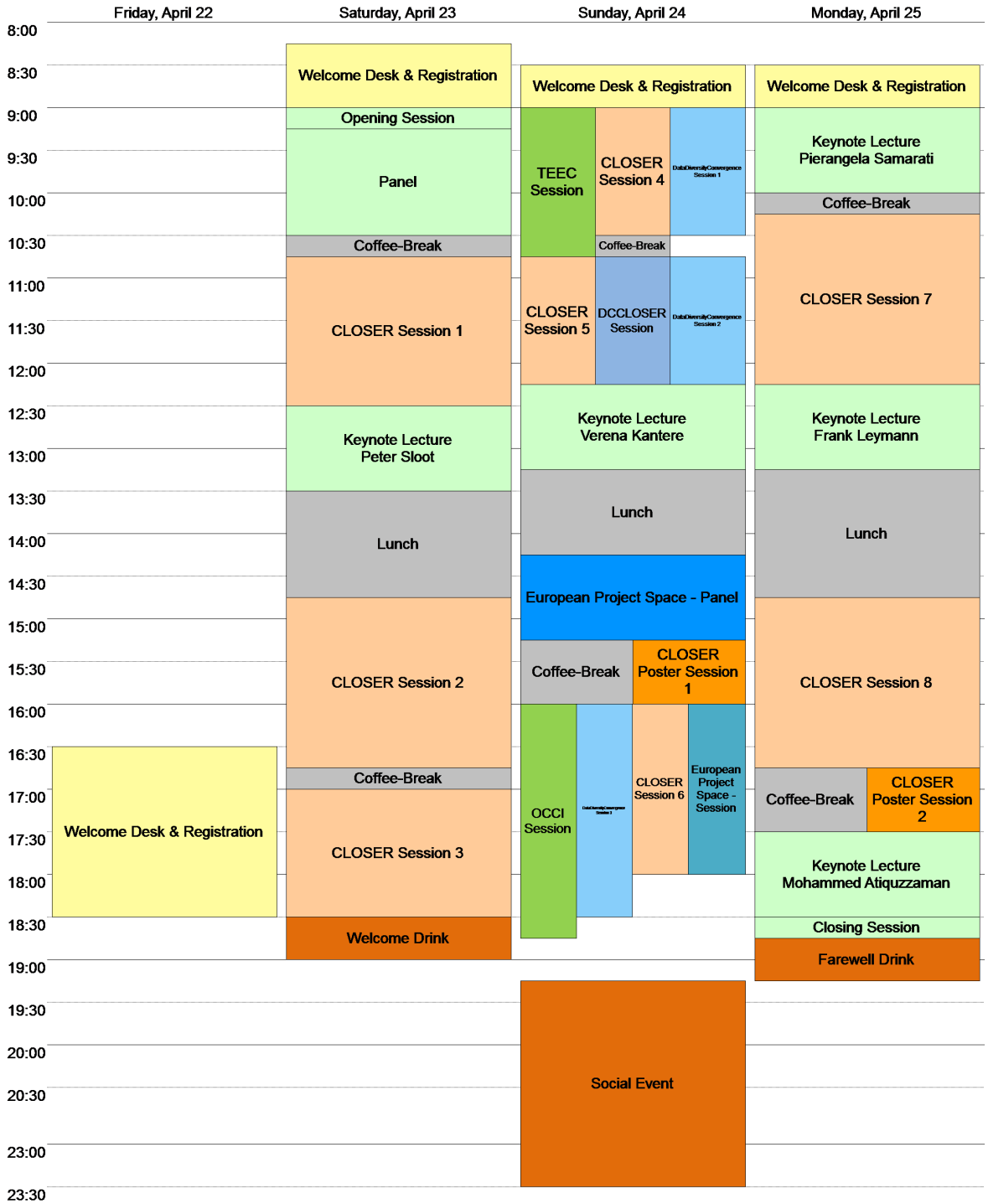
Floor -2



Floor -1



Program Layout



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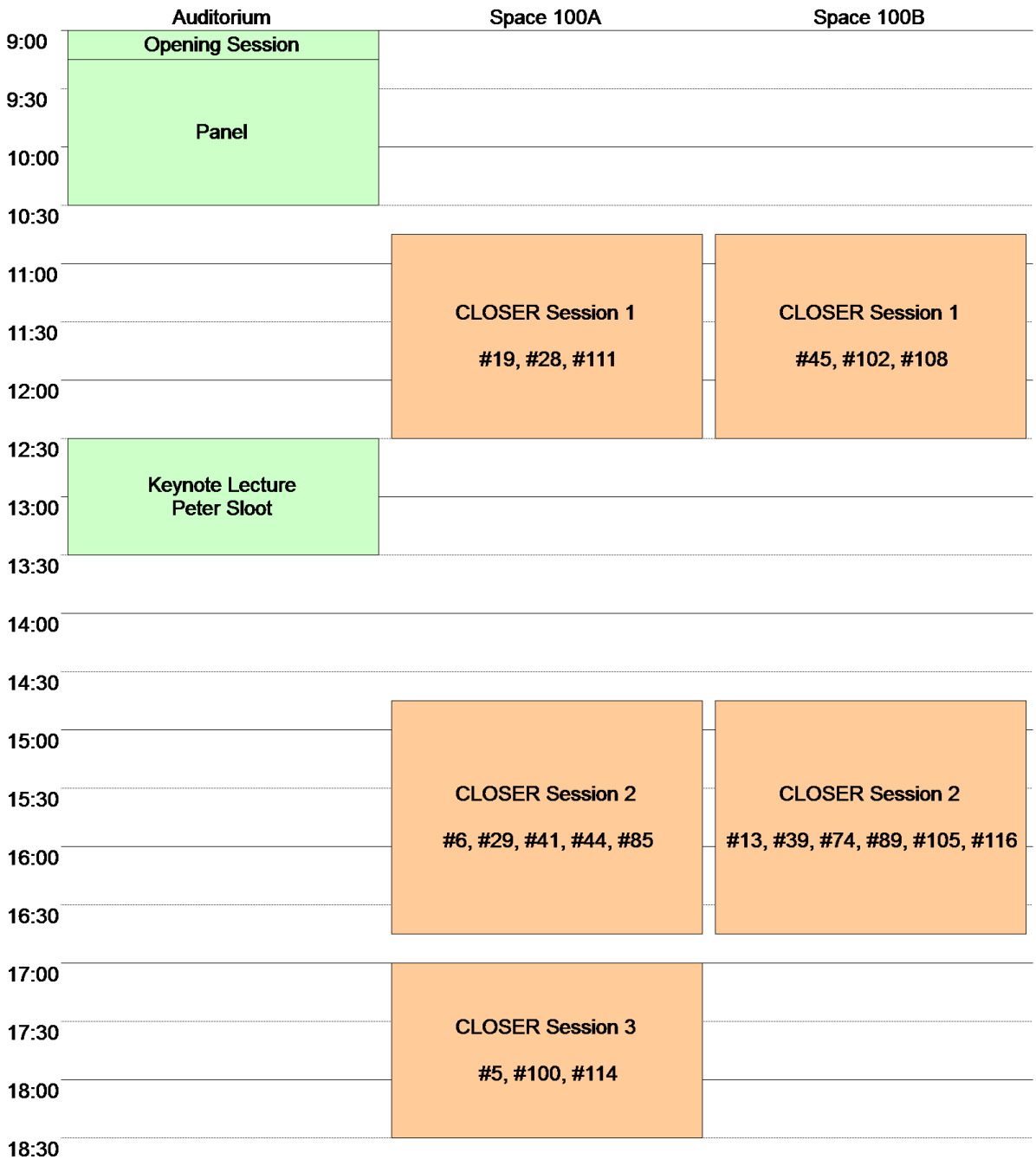

Opening Session	CLOSER
09:00 - 09:15	Room Auditorium

Panel	CLOSER
09:15 - 10:30	Room Auditorium

Parallel Session 1	CLOSER
10:45 - 12:30	Room Space 100A

Paper #19

Privacy-preserving Data Retrieval using Anonymous Query Authentication in Data Cloud Services

Mohanad Dawoud and D. Turgay Altilar
Istanbul Technical University, Istanbul, Turkey

Keywords: Privacy, Data Retrieval, Anonymous Authentication, Cloud Computing, Homomorphic Encryption.

Abstract: Recently, cloud computing became an essential part of most IT strategies. However, security and privacy issues are still the two main concerns that limit the widespread use of cloud services since the data is stored in unknown locations and retrieval of data (or part of it) may involve disclosure of sensitive data to unauthorized parties. Many techniques have been proposed to handle this problem, which is known as Privacy-Preserving Data Retrieval (PPDR). These techniques attempt to minimize the sensitive data that needs to be revealed. However, revealing any data to an unauthorized party breaks the security and privacy concepts and also may decrease the efficiency of the data retrieval. In this paper, different requirements are defined to satisfy a high level of security and privacy in a PPDR system. Moreover, a technique that uses anonymous query authentication and multi-server settings is proposed. The technique provides an efficient ranking-based data retrieval by using weighted Term Frequency-Inverse Document Frequency (TF-IDF) vectors. It also satisfies all of the defined security requirements that were completely unsatisfied by the techniques reported in the literature.

Paper #28

Enabling GPU Virtualization in Cloud Environments

Sergio Iserte, Francisco J. Clemente-Castelló, Adrián Castelló, Rafael Mayo and Enrique S. Quintana-Ortí
Universitat Jaume I, Castelló de la Plana, Spain

Keywords: Cloud Computing, GPU Virtualization, Amazon Web Services (AWS), OpenStack, Resource Management.

Abstract: The use of accelerators, such as graphics processing units (GPUs), to reduce the execution time of compute-intensive applications has become popular during the past few years. These devices increment the computational power of a node thanks to their parallel architecture. This trend has led cloud service providers as Amazon or middlewares such as OpenStack to add virtual machines (VMs) including GPUs to their facilities instances. To fulfill these needs, the guest hosts must be equipped with GPUs which, unfortunately, will be barely utilized if a non GPU-enabled VM is running in the host. The solution presented in this work is based on GPU virtualization and shareability in order to reach an equilibrium between service supply and the applications' demand of accelerators. Concretely, we propose to decouple real GPUs from the nodes by using the virtualization technology rCUDA. With this software configuration, GPUs can be accessed from any VM avoiding the need of placing a physical GPUs in each guest host. Moreover, we study the viability of this approach using a public cloud service configuration, and we develop a module for OpenStack in order to add support for the virtualized devices and the logic to manage them. The results demonstrate this is a viable configuration which adds flexibility to current and well-known cloud solutions.

Paper #111

Sublimated Configuration of Infrastructure as a Service Deployments

MING: *A Model- and View-Based Approach for Cloud Datacenters*

Ta'id Holmes
Deutsche Telekom Technik GmbH, Darmstadt, Germany

Keywords: Cloud, Code Generation, Configuration, Datacenter, Deployment, DSL, IaaS, JuJu, MBE, Metamodel, OpenStack.

Abstract: For establishing the basic cloud service model, a datacenter (DC) needs to deploy an infrastructure as a service (IaaS) solution. The planning, setup, implementation, and operation of DCs – involving hard- and software – comprises multiple activities. At least, software-related aspects such as IaaS deployment can be automated. Yet, in the forefront of an automated installation extensive configurations need to take place. These configurations often relate to the design and characteristics of the respective DC. Using existing deployment technologies, however, information from various aspects are scattered and tangled. For avoiding respective drawbacks and resulting adverse effects, MING (?) – a model-based approach – is presented. It decouples configuration from automated deployment technologies. This way, various further benefits of model-based engineering are leveraged such as separation of concerns through view-based models, platform independent representation of information, and the utilization of existing deployment technologies through code generation.

Parallel Session 1	CLOSER
10:45 - 12:30	Room Space 100B

Paper #45

From Architecture Modeling to Application Provisioning for the Cloud by Combining UML and TOSCA

Alexander Bergmayr[1], Uwe Breitenbücher[2], Oliver Kopp[2], Manuel Wimmer[1], Gerti Kappel[1] and Frank Leymann[2]
[1] *TU Wien, Vienna, Austria*
[2] *University of Stuttgart, Stuttgart, Germany*

Keywords: TOSCA, UML, Model-Driven Software Engineering, Cloud Computing, Cloud Modeling.

Abstract: Recent efforts to standardize a deployment modeling language for cloud applications resulted in TOSCA. At the same time, the software modeling standard UML supports architecture modeling from different viewpoints. Combining these standards from cloud computing and software engineering would allow engineers to refine UML architectural models into TOSCA deployment models that enable automatic provisioning of cloud applications. However, this refinement task is currently carried out manually by recreating TOSCA models from UML models because a conceptual mapping between the two languages as

basis for an automated translation is missing. In this paper, we exploit cloud modeling extensions to UML called CAML as the basis for our approach CAML2TOSCA, which aims at bridging UML and TOSCA. The validation of our approach shows that UML models can directly be injected into a TOSCA-based provisioning process. As current UML modeling tools lack cloud-based refinement support for deployment models, the added value of CAML2TOSCA is emphasized because it provides the glue between architecture modeling and application provisioning.

Paper #108

LADY: Dynamic Resolution of Assemblies for Extensible and Distributed .NET Applications

Steffen Viken Valvåg, Robert Pettersen, Håvard D. Johansen and Dag Johansen

University of Tromsø - The Arctic University of Norway, Tromsø, Norway

Keywords: Mobile, Cloud, Latency, Extensible Distributed Systems.

Abstract: Distributed applications that span mobile devices, computing clusters, and the cloud, require robust and flexible mechanisms for dynamically loading code. This paper describes LADY, a system that augments the .NET platform with a highly reliable mechanism for resolving and loading assemblies and arranges for safe execution of partially trusted code. Key benefits of LADY are the low latency and high availability achieved through its novel integration with DNS.

Paper #102

IoT-A and FIWARE: Bridging the Barriers between the Cloud and IoT Systems Design and Implementation

Alexandros Preventis, Kostas Stravoskoufos, Stelios Sotiriadis and Euripides G. M. Petrakis

Technical University of Crete (TUC), Chania, Greece

Keywords: Cloud Computing, Internet of Things, IoT-A, FIWARE, Cloud Service Interoperability.

Abstract: Today, IoT systems are designed and implemented to address specific challenges based on domain specific requirements, thus not taking into consideration issues of openness, scalability, interoperability and use-case independence. As a result, they are less principled, lacking standards, vendor oriented and hardly replicable since the same IoT architecture cannot be used in more than one use-cases. To address the fragmentation of existing IoT solutions, the IoT-A project proposes an architecture reference model that defines the principles and standards for generating IoT architectures and promoting the interoperation of IoT solutions. However, IoT-A addresses the architecture design problem, and does not focus on whether existing cloud platforms can offer the tools and services to support the implementation of IoT-A compliant IoT systems. In this work we propose an architecture based on IoT-A that focuses on the FIWARE open cloud platform that in turn provides the building blocks of future Internet applications and services. We further correlate FIWARE and IoT-A projects to identify the key features for FIWARE to support IoT-A compliant system implementations.

Keynote Lecture **CLOSER**
12:30 - 13:30 **Room Auditorium**

Complexity Science with the Internet of Things

Peter Sloot

University of Amsterdam, Netherlands; Complexity Institute Singapore, Singapore; ITMO St. Petersburg, Russian Federation

Abstract: We have covered the planet with sensors, cameras, microphones, drones, tracking devices, you name it. All that data is coming at us with an incredible diversity, volume and speed. It is the goal of the Internet of Things (IoT) to provide an infrastructure that can deal with this paradigm shift in ICT. Business and industry have already discovered the huge potential the IoT will provide them with. Up to now however the scientific world seems to wait and see. In this talk I will explore the new science we can expect from using the IoT as an experimental platform to study truly complex systems. The need for that is urgent and knocking at our door: We live in a complex world and are surrounded by complex systems: from a biological cell, made of thousands of different molecules that seamlessly work together, to millions of computer systems that should work together, to our society, a collection of seven billion individuals that try to work and live together. These complex systems display endless signatures of order, disorder, self-organization and self-annihilation.Understanding, quantifying and handling this complexity is one of the biggest scientific challenges of our time. I will discuss ways in which the IoT can help us to make sense of the world around us, to analyze, predict and nudge control its amazing complexity.

Parallel Session 2 **CLOSER**
14:45 - 16:45 **Room Space 100A**

Paper #6

SemNaaS: Semantic Web for Network as a Service

Mohamed Morsey[1], Hao Zhu[1], Isart Canyameres[2], Samuel Norbury[1], Paola Grosso[1] and Miroslav Zivkovic[1]

[1] *University of Amsterdam, Amsterdam, The Netherlands*

[2] *i2CAT Foundation, Barcelona, Spain*

Keywords: Cloud Computing, Network as a Service, Network Markup Language, Semantic Web.

Abstract: Cloud Computing has several provisioning models, namely Infrastructure as a service (IaaS), Platform as a service (PaaS), and Software as a service (SaaS). However, cloud users (tenants) have limited or no control over the underlying network resources and services. Network as a Service (NaaS) is emerging as a novel model to bridge this gap. However, NaaS requires an approach capable of modeling the underlying network resources and capabilities in abstracted and vendor-independent form. In this paper we elaborate on SemNaaS, a Semantic Web based approach for supporting network management in NaaS systems. Our contribution is three-fold. First, we adopt and improve the Network Markup Language (NML) ontology for describing NaaS infrastructures. Second, based on that ontology, we develop a network modeling system that is integrated with the existing OpenNaaS framework. Third, we demonstrate the benefits that Semantic Web adds to the Network as a Service paradigm by applying SemNaaS operations to a specific NaaS use case.

Paper #29

Design Time Validation for the Correct Execution of BPMN Collaborations

Jonas Anseeuw, Gregory Van Seghbroeck, Bruno Volckaert and Filip De Turck
Ghent University, Gent, Belgium

Keywords: Cloud Computing, Distributed Computing, Service Modeling, Collaboration, Business Process Management, Business Process Modeling, BPMN 2.0.

Abstract: Cloud-based Software-as-a-Service (SaaS) providers want to grow into the space of business process outsourcing (BPO). BPO refers to the systematic and controlled delegation of many steps of a company's business process. BPO is a new and important extension to SaaS, as it allows the provider to add more value in the online application services and as it enables the outsourcer to obtain more cost efficiency. BPO results in decentralized federated workflows. To describe these workflows, companies often use business process modeling languages. Currently, Business Process Modeling Notation (BPMN) is one of the best-known standards. It is crucial to ascertain that the modeled workflow is executed as intended. Errors that happen during execution of a federated workflow can come with huge costs. Validating the model is limited to syntactical checks and there is little support for validating the execution at design time. In this paper a method is presented to validate the correct execution of BPMN 2.0 Collaborations. The methods in this research use concepts from virtual time previously described for Web Services Choreography Description Language (WS-CDL). To validate the results of this research, the Eclipse BPMN modeler was extended with an implementation of the validation method.

Paper #41

Consolidation of Performance and Workload Models in Evolving Cloud Application Topologies

Santiago Goméz Sáez, Vasilios Andrikopoulos and Frank Leymann
University of Stuttgart, Stuttgart, Germany

Keywords: Cloud Application Topology, Cloud Application Distribution, Cloud Application Performance Engineering, Cloud Application Workload.

Abstract: The increase of available Cloud services and providers has contributed to accelerate the development and has broaden the possibilities for building and provisioning Cloud applications in heterogeneous Cloud environments. The necessity for satisfying business and operational requirements in an agile and rapid manner has created the need for adapting traditional methods and tooling support for building and provisioning Cloud applications. Focusing on the application's performance and its evolution, we observe a lack of support for specifying, capturing, analyzing, and reasoning on the impact of using different Cloud services and configurations. This paper bridges such a gap by proposing the conceptual and tooling support to enhance Cloud application topology models to capture and analyze the evolution of the application's performance. The tooling support is built upon an existing modeling environment, which is subsequently evaluated using the MediaWiki (Wikipedia) application and its realistic workload.

Paper #44

A Hadoop based Framework to Process Geo-distributed Big Data

Marco Cavallo, Lorenzo Cusma', Giuseppe Di Modica, Carmelo Polito and Orazio Tomarchio
University of Catania, Catania, Italy

Keywords: Big Data, Mapreduce, Hierarchical Hadoop, Context Awareness, Integer Partitioning.

Abstract: In many application fields such as social networks, e-commerce and content delivery networks there is a constant production of big amounts of data in geographically distributed sites that need to be timely elaborated. Distributed computing frameworks such as Hadoop (based on the MapReduce paradigm) have been used to process big data by exploiting the computing power of many cluster nodes interconnected through high speed links. Unfortunately, Hadoop was proved to perform very poorly in the just mentioned scenario. We designed and developed a Hadoop framework that is capable of scheduling and distributing hadoop tasks among geographically distant sites in a way that optimizes the overall job performance. We propose a hierarchical approach where a top-level entity, by exploiting the information concerning the data location, is capable of producing a smart schedule of low-level, independent MapReduce sub-jobs. A software prototype of the framework was developed. Tests run on the prototype showed that the job scheduler makes good forecasts of the expected job's execution time.

Paper #85

Energy-efficient Task Scheduling in Data Centers

Yousri Mhedheb and Achim Streit
Karlsruhe Institute of Technology, Karlsruhe, Germany

Keywords: Cloud Computing, Distributed Systems, Energy Efficiency, Power Management, DVFS.

Abstract: A data center is often also a Cloud center, which delivers its computational and storage capacity as services. To enable on-demand resource provision with elasticity and high reliability, the host machines in data centers are usually virtualized, which brings a challenging research topic, i.e., how to schedule the virtual machines (VM) on the hosts for energy efficiency. The goal of this Work is to ameliorate, through scheduling, the energy-efficiency of data center. To support this work a novel VM scheduling mechanism design and implementation will be proposed. This mechanism addresses on both load-balancing and temperature-awareness with a final goal of reducing the energy consumption of a data centre. Our scheduling scheme selects a physical machine to host a virtual machine based on the user requirements, the load on the hosts and the temperature of the hosts, while maintaining the quality of the service. The proposed scheduling mechanism on CloudSim will be finally validated, a well-known simulator that models data centers provisioning Infrastructure as a Service. For a comparative study, we also implemented other scheduling algorithms i.e., non power control, DVFS and power aware ThrMu. The experimental results show that the proposed scheduling scheme, combining the power-aware with the thermal-aware scheduling strategies, significantly reduces the energy consumption of a given Data Center because of its thermal-aware strategy and the support of VM migration mechanisms.

Parallel Session 2 **CLOSER**
14:45 - 16:45 **Room Space 100B**

Paper #13

An Off-line Analytical Approach to Identify Suitable Management Policies for Autonomic Cloud Architecture

Marwah Alansari and Behzad Bordbar
University of Birmingham, Birmingham, U.K.

Keywords: Coloured Petri-Nets, Autonomic Cloud Platform, Management Policies, Rules-set, Formal Analysis, Cost Analysis, Modelling.

Abstract: Delivering cloud services with better quality-of- service demands infrastructures which are autonomic and self- manageable. In particular, there is a clear scope for developing automated methods for enforcing suitable management policies that would run such infrastructures. An example of a management policy is the one that governs the triggering of migration of virtual machines to manage energy consumption. Although there is extensive research on developing novel methods of implementing such policies in an autonomic manner, the identification of suitable policies in terms of cost reduction has received less attention. This requires an analysis of two given sets of policies to identify which one is more suitable. This paper presents a method involving Coloured Petri Nets for an offline modelling and analysis of an autonomic cloud platform which executes sets of policies. We use traces of execution in Petri Nets for calculating minimum cost associated to each set of policies. Petri Net models can generate infinite traces because of the appearance of loops. However, as migration of virtual machines entails cost, many of the infinite traces will not result in the identification of the minimal cost. This paper presents an analytical method using Integer Programming to find the minimum cost of energy consumption for a given policy. We evaluated our approach with the help of an energy management case study.

Paper #39

An Optimized Model for Files Storage Service in Cloud Environments

Haythem Yahyaoui and Samir Moalla
University of Tunis el Manar, Tunis, Tunisia

Keywords: Cloud Computing, Data Centers, File Storage, File Redundancy, Virtual Data Center.

Abstract: Cloud computing represents nowadays a revolution in the distributed systems domain because of its several services. One of the most used services in Cloud environments is file storage, which consist on uploading files to the Cloud's data center and using them at anytime from anywhere. Due to the highest number of Cloud customers we risk to have a bad management of cloud's data center such as losing space by files redundancy which can be provided by uploading one file for several times by only one customer or the same file by many customers. Such a problem is very frequent when we have a big number of customers. Many studies have been done in this order, researchers propose many solutions and each one has its advantages and disadvantages. In order to save space and minimize costs we propose an optimized model which consists on deleting file redundancy before the duplication step in the data centers. Experimentally, during the evaluation phase, our model will be compared with the some existing methods.

Paper #74

Privacy-preserving Data Sharing in Portable Clouds

Clemens Zeidler and Muhammad Rizwan Asghar
University of Auckland, Auckland, New Zealand

Keywords: Portable Cloud, Privacy, Data Sharing, Data Migration, Migration Costs, Migration Agent.

Abstract: Cloud storage is a cheap and reliable solution for users to share data with their contacts. However, the lack of standardisation and migration tools makes it difficult for users to migrate to another Cloud Service Provider (CSP) without losing contacts, thus resulting in a vendor lock-in problem. In this work, we aim at providing a generic framework, named *PortableCloud*, that is flexible enough to enable users to migrate seamlessly to a different CSP keeping all their data and contacts. To preserve privacy of users, the data in the portable cloud is concealed from the CSP by employing encryption techniques. Moreover, we introduce a migration agent that assists users in automatically finding a suitable CSP that can satisfy their needs.

Paper #89

Performance Analysis of an OpenStack Private Cloud

Tamas Pflanzner[1], Roland Tornyai[1], Balazs Gibizer[2], Anita Schmidt[2] and Attila Kertesz[1]
[1] *University of Szeged, Szeged, Hungary*
[2] *Ericsson Hungary, Budapest, Hungary*

Keywords: Cloud Computing, Performance Analysis, OpenStack.

Abstract: Cloud Computing is a novel technology offering flexible resource provisions for business stakeholders to manage IT applications and data responding to new customer demands. It is not an easy task to determine the performance of the ported applications in advance. The virtualized nature of these environments always represent a certain level of performance degradation, which is also dependent on the types of resources and application scenarios. In this paper we have set up a performance evaluation environment within a private OpenStack deployment, and defined general use cases to be executed and evaluated in this cloud. These test cases are used for investigating the internal behavior of OpenStack in terms of computing and networking capabilities of its provisioned virtual machines. The results of our investigation reveal the performance of general usage scenarios in a local cloud, give an insight for businesses planning to move to the cloud and provide hints where further development or fine tuning is needed in order to improve OpenStack systems.

Paper #105

On the Next Generations of Infrastructure-as-a-Services

Dana Petcu[1], Maria Fazio[2], Radu Prodan[3], Zhiming Zhao[4] and Massimiliano Rak[5]

[1] *Institute e-Austria and Computer Science Department, Timişoara, Romania*

[2] *University of Messina, Messina, Italy*

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[4] *University of Amsterdam, Amsterdam, The Netherlands*

[5] *Second University of Naples, Aversa, Italy*

Keywords: Infrastructure-as-a-Service, Surveys, Previsions.

Abstract: Following the wide adoption by industry of the cloud computing technologies, we can talk about a second generation of cloud services and products that are currently under design phase. However, it is not yet clear how the third generation of cloud products and services of the next decade will look like, especially at the delivery level of Infrastructure-as-a-Service. In order to answer at least partially to such a challenging question, we initiated a literature overview and two surveys involving the members of a cluster of European research and innovation actions. The results are interpreted in this paper and a set of topics of interest for the third generation are identified.

Paper #116

CLOUDLIGHTNING: A Framework for a Self-organising and Self-managing Heterogeneous Cloud

Theo Lynn[1], Huanhuan Xiong[2], Dapeng Dong[2], Bilal Momani[2], George Gravvanis[3], Christos Filelis-Papadopoulos[3], Anne Elster[4], Malik Muhammad Zaki Murtaza Khan[4], Dimitrios Tzovaras[5], Konstantinos Giannoutakis[5], Dana Petcu[6], Marian Neagul[6], Ioan Dragon[6], Perumal Kuppudayar[7], Suryanarayanan Natarajan[7], Michael McGrath[7], Georgi Gaydadjiev[8], Tobias Becker[8], Anna Gourinovitch[1], David Kenny[1] and John Morrison[2]

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Keywords: Cloud Computing Models, Cloud Infrastructures, Cloud Architecture, Cloud Computing, Cloud Services Self-organisation, Self-management, Heterogeneous Resources, Resource as a Service, Cloud Orchestration, Data Flow Engine, Many-integrated Cores, MIC, GPU, FPGA, DFE.

Abstract: As clouds increase in size and as machines of different types are added to the infrastructure in order to maximize performance and power efficiency, heterogeneous clouds are being created. However, exploiting different architectures poses significant challenges. To efficiently access heterogeneous resources and, at the same time, to exploit these resources to reduce application development effort, to make optimisations easier and to simplify service deployment, requires a re-evaluation of our approach to service delivery. We propose a novel cloud management and delivery architecture based on the principles of self-organisation and self-management that shifts the deployment and optimisation effort from the consumer to the software stack running on the cloud infrastructure. Our goal is to address inefficient use of resources and consequently to deliver savings to the cloud provider and consumer in terms of reduced power consumption and improved service delivery, with hyperscale systems particularly in mind. The framework is general but also endeavours to enable cloud services for high performance computing. Infrastructure-as-a-Service provision is the primary use case, however, we posit that genomics, oil and gas exploration, and ray tracing are three downstream use cases that will benefit from the proposed architecture.

Session 3 **CLOSER**
17:00 - 18:30 **Room Space 100A**

Paper #114

Evaluating the Effect of Utility-based Decision Making in Collective Adaptive Systems

Vasilios Andrikopoulos[1], Marina Bitsaki[2], Santiago Goméz Sáez[1], Michael Hahn[1], Dimka Karastoyanova[1], Giorgos Koutras[2] and Alina Psycharaki[2]

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Keywords: Utility, Decision making, Collective Adaptive Systems, Choreography.

Abstract: Utility, defined as the perceived satisfaction with a service, provides the ideal means for decision making on the level of individual entities and collectives participating in a large-scale dynamic system. Previous works have already introduced the concept into the area of collective adaptive systems, and have discussed what is the necessary infrastructure to support the realization of the involved theoretical concepts into actual decision making. In this work we focus on two aspects. First, we provide a concrete utility model for a case study that is part of a larger research project. Second, we incorporate this model into our implementation of the proposed architecture. More importantly, we design and execute an experiment that aims to empirically evaluate the use of utility for decision making by comparing it against simpler decision making mechanisms.

Paper #5

Monitoring Energy Consumption on the Service Level

A Procedure Model for Multitenant ERP Systems

Hendrik Müller, Carsten Görling, Johannes Hintsch, Matthias Splieth, Sebastian Starke and Klaus Turowski

Otto-von-Guericke-University Magdeburg, Magdeburg, Germany

Keywords: Energy Consumption, Accounting, Pricing, Service, Cloud, Enterprise Resource Planning, Multitenancy.

Abstract: In this paper, we describe a procedure model for monitoring energy consumption of IT services. The model comprises the steps for identifying and extracting the required data, as well as a mathematic model to predict the energy consumption on both the infrastructure and the service level. Using the example of a distributed and shared ERP system, in which services are

represented by ERP transactions, we evaluate the procedure model within a controlled experiment. The model was trained on monitoring data, gathered by performing a benchmark, which triggered more than 1,116,000 dialog steps, initiated by 6000 simulated SAP ERP users. During the benchmark, we monitored the dedicated resource usage for each transaction in terms of CPU time, database request time and database calls as well as the energy consumption of all servers involved in completing the transactions. Our developed procedure model enables IT service providers and business process outsourcers to assign their monitored hardware energy consumption to the actual consuming ERP transactions like creating sales orders, changing outbound deliveries or creating billing documents in watt per hour. The resulting dedicated energy costs can be transferred directly to overlying IT products or to individual organizations that share a multitenant ERP system. The research is mainly relevant for practitioners, especially for internal and external IT service providers. Our results serve as an early contribution to a paradigm shift in the granularity of energy monitoring, which needs to be carried forward to comply with an integrated and product-oriented information management and the ongoing extensive use of cloud- and IT service offerings in business departments.

Paper #100

Testing of Web Services using Behavior-Driven Development

Ahmet Furkan Oruç and Tolga Ovatman
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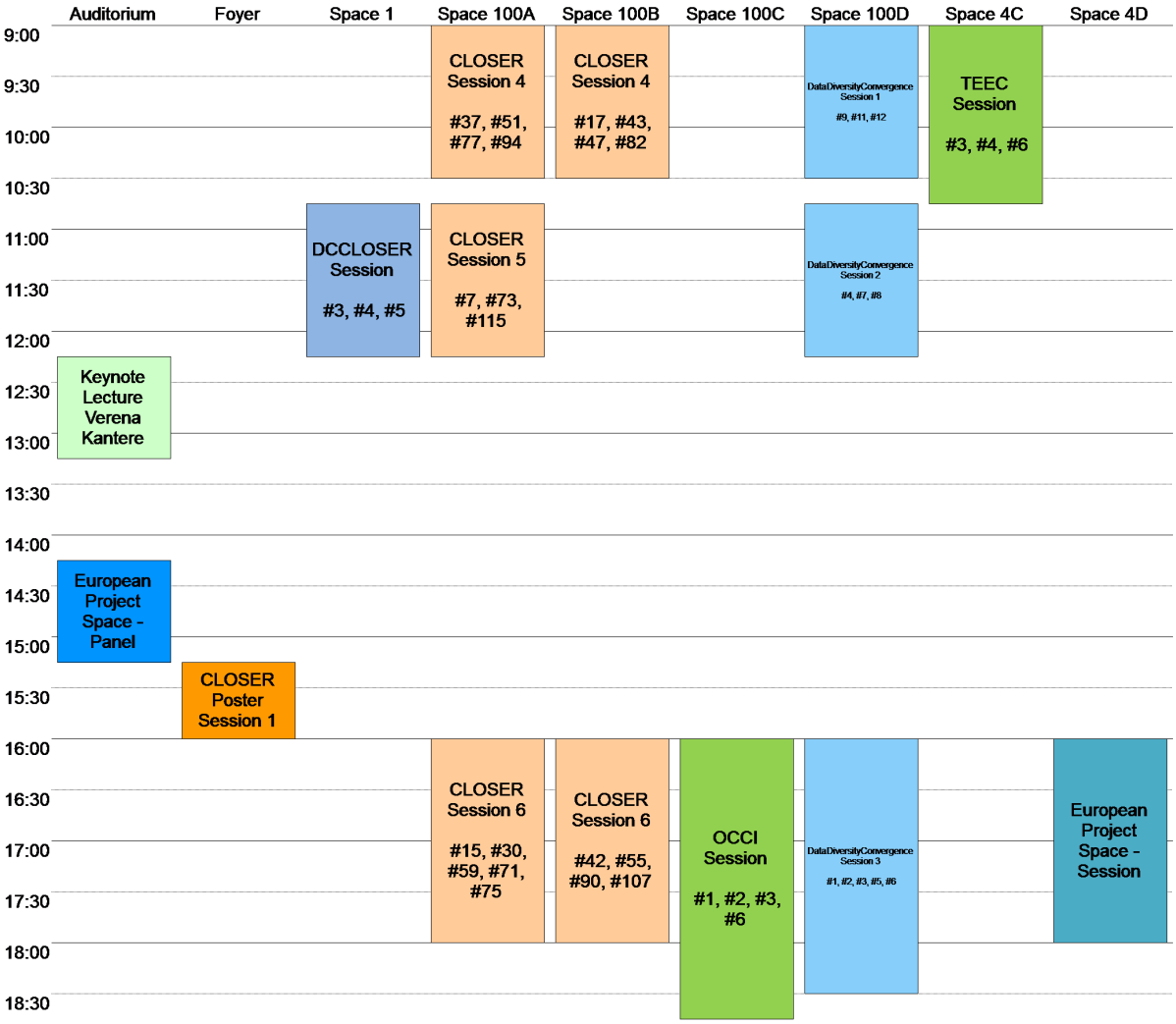
Keywords: Behavior-Driven Development, Gherkin, JMeter, Software Testing, Testing of Web Services, Web Services.

Abstract: Web services are commonly used in the communication of software over the web. To fully trust a web service, it should be tested and certified, but testing of web services provoke new challenges. Behavior-Driven Development (BDD) can be applied to the testing of web services. Gherkin language is used to define scenarios in BDD. We used Gherkin language to define test cases for web services and we developed a tool to convert these test cases into JMeter test scripts.

Sunday Sessions: April 24

Sunday Sessions: April 24 Program Layout



Parallel Session 4 **CLOSER**
09:00 - 10:30 **Room Space 100A**

Paper #37

Individual Service Clearing as a Business Service: A Capable Reference Solution for B2B Mobility Marketplaces

Michael Strasser[1], Nico Weiner[1] and Sahin Albayrak[2]
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[2] *Technical University of Berlin, Berlin, Germany*

Keywords: Individual Service Clearing, Service Marketplaces, Service Platforms, Service Interface Design, Smart City Mobility Services.

Abstract: The paper presents an approach for individual and outsourced service clearing within Business-to-Business marketplaces for mobility services in a Software as a Service fashion. The lack of service clearing possibilities within today's marketplaces solutions for mobility services have been confirmed by interviews experts who highlight the need for clearing. To enable service clearing, appropriate interfaces which enable access upon data are required. Current solutions lack those interfaces and thus service clearing to charge service transactions is not possible. The paper discusses interfaces for outsourced service clearing according to their design, data and role dependencies. A reference solution is implemented to demonstrate the feasibility of the interfaces and the overall clearing approach. A clearing algorithm has been developed to validate the interfaces' reliability and correctness. Our presented clearing approach enables marketplace participants to outsource the transaction clearing to a provider which offers clearing capabilities. The work on hand contributes to interface and protocol standardization in respect to service clearing and marketplace interconnectivity.

Paper #51

Using a Predator-Prey Model to Explain Variations of Cloud Spot Price

Zheng Li, William Tärneberg, Maria Kihl and Anders Robertsson
Lund University, Lund, Sweden

Keywords: Cloud Computing, Cloud Spot Pricing, Cloud Spot Market, Predator-Prey Model.

Abstract: The spot pricing scheme has been considered to be resource-efficient for providers and cost-effective for consumers in the Cloud market. Nevertheless, unlike the static and straightforward strategies of trading on-demand and reserved Cloud services, the market-driven mechanism for trading spot service would be complicated for both implementation and understanding. The largely invisible market activities and their complex interactions could especially make Cloud consumers hesitate to enter the spot market. To reduce the complexity in understanding the Cloud spot market, we decided to reveal the backend information behind spot price variations. Inspired by the methodology of reverse engineering, we developed a Predator-Prey model that can simulate the interactions between demand and resource based on the visible spot price traces. The simulation results have shown some basic regular patterns of market activities with respect to Amazon's spot instance type m3.large. Although the findings of this study need further validation by using practical data, our work essentially suggests a promising approach (i.e. using a Predator-Prey model) to investigate spot market activities.

Paper #77

Interactions in Service Provisioning Systems for Smart City Mobility Services

Michael Strasser[1], Nico Weiner[1] and Sahin Albayrak[2]
[1] *Bosch Software Innovations GmbH, Berlin, Germany*
[2] *Technical University of Berlin, Berlin, Germany*

Keywords: Service Provisioning, Service Roaming, Business Actions, Business Action Theory, Smart City, Service Marketplace.

Abstract: In times of smart city and internet of things and services a lot of data is produced. However, there is no benefit in collecting the data without processing it. Smart services are one possibility to enable data access for data processing. Smart services have attracted research along their domain and requirements, benefits for the common as well as possible business models are developed. This work addresses the way how service consumers and service operators conduct business in an open B2B service marketplace. The paper presents and discusses phases of a business relationship in an digital service environment as well as discusses the business actions' sequence. A role-action framework for service provisioning systems is developed. It contributes to a better understanding of service provision systems and demonstrates of what processes it constitutes. It furthermore presents what needs to be done by the systems' participants to offer or consume services.

Paper #94

A Container-centric Methodology for Benchmarking Workflow Management Systems

Vincenzo Ferme[1], Ana Ivanchikj[1], Cesare Pautasso[1], Marigianna Skouradaki[2] and Frank Leymann[2]
[1] *University of Lugano (USI), Lugano, Switzerland*
[2] *University of Stuttgart, Stuttgart, Germany*

Keywords: Benchmarking, Docker Containers, Workflow Management Systems, Cloud Applications.

Abstract: Trusted benchmarks should provide reproducible results obtained following a transparent and well-defined process. In this paper, we show how Containers, originally developed to ease the automated deployment of Cloud application components, can be used in the context of a benchmarking methodology. The proposed methodology focuses on Workflow Management Systems (WfMSs), a critical service orchestration middleware, which can be characterized by its architectural complexity, for which Docker Containers offer a highly suitable approach. The contributions of our work are: 1) a new benchmarking approach taking full advantage of containerization technologies; and 2) the formalization of the interaction process with the WfMS vendors described clearly in a written agreement. Thus, we take advantage of emerging Cloud technologies to address technical challenges, ensuring the performance measurements can be trusted. We also make the benchmarking process transparent, automated, and repeatable so that WfMS vendors can join the benchmarking effort.

Parallel Session 4 **CLOSER**
09:00 - 10:30 **Room Space 100B**

Paper #17

Unified Compliance Modeling and Management using Compliance Descriptors

Falko Koetter[1], Maximilien Kintz[1], Monika Kochanowski[1], Christoph Fehling[2], Philipp Gildein[2], Frank Leymann[2] and Anette Weisbecker[1]

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Keywords: Business Process Management, Compliance Modeling, Model-Driven Architecture, Business Process Compliance

Abstract: Due to innovations in the field of cloud computing business processes become distributed, encompassing a combination of services spanning multiple IT systems. Due to a growing number of regulations, managing business process compliance in this cloud environment is a necessary task for companies, leading to a growth in compliance management and compliance checking approaches. Compliance stems from laws and is implemented in all parts of enterprise IT. Thus, both a connection between business and IT as well as a broad coverage of compliance scenarios is necessary. To solve both challenges, we use an integrating compliance descriptor for conceptual compliance modeling. This descriptor is used to configure a compliance management architecture, integrating different types of compliance checking. For creating compliance descriptors, it proved necessary to introduce a formalism and a graphical notation, which is introduced and evaluated in a prototype and expert interviews.

Paper #43

Deployment over Heterogeneous Clouds with TOSCA and CAMP

Jose Carrasco, Javier Cubo, Ernesto Pimentel and Francisco Durán

Universidad de Málaga, Málaga, Spain

Keywords: Cloud Applications, Cross-cloud, Cross-deployment, Standards, TOSCA, CAMP.

Abstract: Cloud Computing providers offer diverse services and capabilities, which can be used by end-users to compose heterogeneous contexts of multiple cloud platforms to deploy their applications, in accordance with the best offered capabilities. However, this is an ideal scenario, since cloud platforms are being conducted in an isolated way by presenting interoperability and portability restrictions. Each provider defines its own API, non-functional requirements, QoS, add-ons, etc., and developers are often locked-in a concrete cloud environment, hampering the integration of heterogeneous provider services to achieve cross-deployment. This work presents an approach to deploy cross-cloud applications by using standardisation efforts of design, management and deployment of cloud applications. Specifically, using mechanisms specified by the TOSCA and CAMP standards, we propose a methodology to describe the topology and distribution of modules of a cloud application and to deploy the inter-connected modules over heterogeneous clouds. We present our prototype TOMAT, which supports the automatic distribution of cloud applications over multiple providers.

Paper #47

Proactive Learning from SLA Violation in Cloud Service based Application

Ameni Meskini[1], Yehia Taher[2], Amal El gammal[3], Béatrice Finance[2] and Yahya Slimani[1]

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Keywords: Cloud Service based Application, SLA Violations Prevention, Cloud Environments, Decision Tree.

Abstract: In recent years, business process management and Service-based applications have been an active area of research from both the academic and industrial communities. The emergence of revolutionary ICT technologies such as Internet-of-Things (IoT) and cloud computing has led to a paradigm shift that opens new opportunities for consumers, businesses, cities and governments; however, this significantly increases the complexity of such systems and in particular the engineering of Cloud Service-Based Application (CSBA). A crucial dimension in industrial practice is the non-functional service aspects, which are related to Quality-of-Service (QoS) aspects. Service Level Agreements (SLAs) define quantitative QoS objectivesandis a part of a contract between the service provider and the service consumer. Although significant work exists on how SLA may be specified, monitored and enforced, few efforts have considered the problem of SLA monitoring in the context of Cloud Service-Based Application (CSBA), which caters for tailoring of services using a mixture of Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS) and Infrastructure-as-a-Service (IaaS) solutions. With a preventive focus, the main contribution of this paper is a novel learning and prediction approach for SLA violations, which generates models that are capable of proactively predicting upcoming SLAs violations, and suggesting recovery actions to react to such SLA violations before their occurrence. A prototype has been developed as a Proof-Of-Concept (POC) to ascertain the feasibility and applicability of the proposed approach.

Paper #82

An Evolutionary Cultural Algorithm based Risk-aware Virtual Machine Scheduling Optimisation in Infrastructure as a Service (IaaS) Cloud

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Keywords: Cultural Algorithm, Service Reliability, Risk Management, Virtual Machine Scheduling, Optimisation.

Abstract: Cloud service reliability is one of the key common performance concerns of both Cloud Service Provider (CSP) and Cloud Service User (CSU). As the capability and scale of a Cloud infrastructure increase, the requirements of maintaining and improving the reliability of services is increasingly crucial for the CSP and CSU. Risk management is the process of analysing the potential risk factors associated with the reliability deterioration of a service provided by a CSP, assessing the uncertainties and consequences associated with this kind of deterioration, and finally identifying the system wide appropriate mitigation strategies for risk treatments. In this paper, an evolutionary Cultural Algorithm based risk management method is proposed to facilitate the

identification (i.e., probability and consequences) and treatment (i.e., mitigations) of Cloud infrastructure reliability related risk for Virtual Machine scheduling optimisation.

Workshop - Session 1	**DataDiversityConvergence**
09:00 - 10:30	**Room Space 100D**

Paper #9

3D Vizualization of Large Scale Data Centres

Giannis Drossis[1], Chryssi Birliraki[2], Nikolaos Patsiouras[2], George Margetis[2] and Constantine Stephanidis[2,3]

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[3] *University of Crete, Crete, Greece*

Keywords: Data Centre Visualization, Big Data Visualization, Interactive Real-Time Visualization, 3D Visualization, Virtual Reality, Immersive Visualization, Data Centre Infrastructure Management, Large High-Resolution Displays, Data Centre Resource Planning, Gestural Interaction.

Abstract: This paper reports on ongoing work regarding interactive 3D visualization of large scale data centres in the context of Big Data and data centre infrastructure management. The proposed approach renders a virtual area of real data centres preserving the actual arrangement of their servers and visualizes their current state while it notifies users for potential server anomalies. The visualization includes several condition indicators, updated in real time, as well as a color-coding scheme for the current servers' condition referring to a scale from normal to critical. Furthermore, the system supports on demand exploration of an individual server providing detailed information about its condition, for a specific timespan, combining historical analysis of previous values and the prediction of potential future state. Additionally, natural interaction through hand-gestures is supported for 3D navigation and item selection, based on a computer-vision approach.

Paper #11

Big IoT and Social Networking Data for Smart Cities

Algorithmic Improvements on Big Data Analysis in the Context of RADICAL City Applications

Evangelos Psomakelis[1,2], Fotis Aisopos[1], Antonios Litke[1], Konstantinos Tserpes[2,1], Magdalini Kardara[1] and Pablo Martínez Campo[3]

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Keywords: Internet of Things, Social Networking, Big Data Aggregation and Analysis, Smart City Applications, Sentiment Analysis, Machine Learning.

Abstract: In this paper we present a SOA (Service Oriented Architecture)-based platform, enabling the retrieval and analysis of big datasets stemming from social networking (SN) sites and Internet of Things (IoT) devices, collected by smart city applications and socially-aware data aggregation services. A large set of city applications in the areas of Participating Urbanism, Augmented Reality and Sound-Mapping throughout participating cities is being applied, resulting into produced sets of millions of user-generated events and online SN reports fed into the RADICAL platform. Moreover, we study the application of data analytics such as sentiment analysis to the combined IoT and SN data saved into an SQL database, further investigating algorithmic and configurations to minimize delays in dataset processing and results retrieval.

Paper #12

PaaS-CEP

A Query Language for Complex Event Processing and Databases

Ricardo Jiménez-Peris[1], Valerio Vianello[2] and Marta Patiño-Martinez[2]

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Keywords: CEP, DBMS, SQL.

Abstract: Nowadays many applications must process events at a very high rate. These events are processed on the fly, without being stored. Complex Event Processing technology (CEP) is used to implement such applications. Some of the CEP systems, like Apache Storm the most popular CEPs, lack a query language and operators to program queries as done in traditional relational databases. This paper presents PaaS-CEP, a CEP language that provides a SQL-like language to program queries for CEP and its integration with data stores (database or key-value store). Our current implementation is done on top of Apache Storm however, the CEP language can be used with any CEP. The paper describes the architecture of the PaaS-CEP, its query language and the algebraic operators. The paper also details the integration of the CEP with traditional data stores that allows the correlation of live streaming data with the stored data.

Special Session - Session	**TEEC**
09:00 - 10:45	**Room Space 4C**

Paper #3

Integrated Energy Efficient Data Centre Management for Green Cloud Computing

The FP7 GENiC Project Experience

J. Ignacio Torrens[1], Deepak Mehta[2], Vojtech Zavrel[1], Diarmuid Grimes[2], Thomas Scherer[3], Robert Birke[3], Lydia Chen[3], Susan Rea[4], Lara Lopez[5], Enric Pages[5] and Dirk Pesch[4]

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[2] *University College Cork, Cork, Ireland*

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[4] *Cork Institute of Technology, Cork, Ireland*

[5] *ATOS Spain SA., Madrid, Spain*

Keywords: Energy Efficient Data Centres, Workload Management, Thermal Management, Integrated Energy Management Platform.

Abstract: Energy consumed by computation and cooling represents the greatest percentage of the average energy consumed in a data centre. As these two aspects are not always coordinated, energy consumption is not optimised. Data centres lack an integrated system that jointly optimises and controls all the operations in order to reduce energy consumption and increase the usage of renewable sources. GENiC is addressing this through a novel scalable, integrate energy management and control platform for data centre wide optimisation. We have implemented a prototype of the platform together with workload and thermal management

algorithms. We evaluate the algorithms in a simulation based model of a real data centre. Results show significant energy savings potential, in some cases up to 40%, by integrating workload and thermal management.

Paper #4

An Energy-aware Scheduling Algorithm in DVFS-enabled Networked Data Centers

Mohammad Shojafar[1], Claudia Canali[1], Riccardo Lancellotti[1] and Saeid Abolfazli[2]
[1] *University of Modena and Reggio Emilia, Modena, Italy*
[2] *YTL Communications, Kuala Lumpur, Malaysia*

Keywords: Virtualized Networked Data Centers, Optimization, Dynamic Voltage Frequency Scaling, Resource provisioning, Energy-efficiency.

Abstract: In this paper, we propose an adaptive online energy-aware scheduling algorithm by exploiting the reconfiguration capability of a Virtualized Networked Data Centers (VNetDCs) processing large amount of data in parallel. To achieve energy efficiency in such intensive computing scenarios, a joint balanced provisioning and scaling of the networking-plus-computing resources is required. We propose a scheduler that manages both the incoming workload and the VNetDC infrastructure to minimize the communication-plus-computing energy dissipated by processing incoming traffic under hard real-time constraints on the per-job computingplus-communication delays. Specifically, our scheduler can distribute the workload among multiple virtual machines (VMs) and can tune the processor frequencies and the network bandwidth. The energy model used in our scheduler is rather sophisticated and takes into account also the internal/external frequency switching energy costs. Our experiments demonstrate that the proposed scheduler guarantees high quality of service to the users respecting the service level agreements. Furthermore, it attains minimum energy consumptions under two real-world operating conditions: a discrete and finite number of CPU frequencies and not negligible VMs reconfiguration costs. Our results confirm that the overall energy savings of data center can be significantly higher with respect to the existing solutions.

Paper #6

Towards Design-time Simulation Support for Energy-aware Cloud Application Development

Christophe Ponsard, Renaud De Landtsheer, Gustavo Ospina and Jean-Christophe Deprez
CETIC Research Centre, Gosselies, Belgium

Keywords: Energy Efficiency, Cloud, Sustainability, Green-IT, Discrete Event Simulation, Self-adaptation.

Abstract: Cloud application deployment is becoming increasingly popular for the removal of upfront hardware costs, the pay-per-use cost model and their ability to scale. However, deploying software on the Cloud carries both opportunities and threats regarding energy efficiency. In order to help Cloud application developers learn and reason about the energy consumption of their application on the server-side, we have developed a framework centred on a UML profile for relating energy goals, requirements and associated KPI metrics to application design and deployment elements. Our previous work has focused on the use of such a framework to carry out our run-time experiments in order to select the best approach. In this paper, we explore the feasibility of a complementary approach for providing support at design time based on finer grained deployment models, the specification of Cloud and energy adaptation policies and the use of a discrete event simulator for reasoning on key performance indicators such as energy but also overall performance, delay and costs. The goal is to support the Cloud developer in pre-selecting the best trade-off that can be further tuned at run-time.

TANGO - Transparent heterogeneous hardware Architecture deployment for eNergy Gain in Operation

Django Armstrong
University of Leeds, U.K.

Session 5 **CLOSER**
10:45 - 12:15 **Room Space 100A**

Paper #73

Benchmarking Hadoop Performance in the Cloud

An in Depth Study of Resource Management and Energy Consumption

Aymen Jlassi[1,2] and Patrick Martineau[1]
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Keywords: Cloud Computing, Virtualization, Green Consumption, Docker Container, Hadoop, Resources Consumption.

Abstract: Virtual technologies have proven their capabilities to ensure good performance in the context of high performance computing (HPC). During the last decade, the big data tools have been emerging, they have their own needs in performance and infrastructure. Having a wide breadth of experience in the HPC domain, the experts can evaluate the infrastructures used to run big data tools easily. The outcome of this paper is the evaluation of two technologies of virtualization in the context of big data tools. We **compare the performance and the energy consumption of two technologies of virtualization (Docker containers and VMware) and benchmark the software Hadoop (JoshBaer, 2015) using these environments**. Firstly, the aim is the reduction of the Hadoop deployment cost using the cloud. Secondly, we discuss and analyze the assumptions learned from the HPC experiments and their applicability in the big data context. Thirdly, the Hadoop community finds an in-depth study of the resource consumption depending on the deployment environment. We come to the point that the use of the Docker container gives better performance in most experiments. Besides, the energy consumption varies according to the executed workload.

Paper #115

Context-aware Security Models for PaaS-enabled Access Control

Simeon Veloudis[1], Yiannis Verginadis[2], Ioannis Patiniotakis[2], Iraklis Paraskakis[3] and Gregoris Mentzas[2]

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Keywords: Context-aware Security, Ontologies, Access Control, Data Privacy, Security by Design.

Abstract: Enterprises are embracing cloud computing in order to reduce costs and increase agility in their everyday business operations. Nevertheless, due mainly to confidentiality, privacy and integrity concerns, many are still reluctant to migrate their sensitive data to the cloud. In this paper, firstly, we outline the construction of a suitable Context-aware Security Model, for enhancing security in cloud applications. Secondly, we outline the construction of an extensible and declarative formalism for representing policy-related knowledge, one which disentangles the definition of a policy from the code employed for enforcing it. Both of them will be employed for supporting innovative PaaS-enabled access control mechanisms.

Paper #7

ppbench

A Visualizing Network Benchmark for Microservices

Nane Kratzke and Peter-Christian Quint

Lübeck University of Applied Sciences, Lübeck, Germany

Keywords: Microservice, Container, Docker, Cluster, Network, Performance, Reference, Benchmark, REST, SDN.

Abstract: Companies like Netflix, Google, Amazon, Twitter successfully exemplified elastic and scalable microservice architectures for very large systems. Microservice architectures are often realized in a way to deploy services as containers on container clusters. Containerized microservices often use lightweight and REST-based mechanisms. However, this lightweight communication is often routed by container clusters through heavyweight software defined networks (SDN). Services are often implemented in different programming languages adding additional complexity to a system, which might end in decreased performance. Astonishingly it is quite complex to figure out these impacts in the upfront of a microservice design process due to missing and specialized benchmarks. This contribution proposes a benchmark intentionally designed for this microservice setting. We advocate that it is more useful to reflect fundamental design decisions and their performance impacts in the upfront of a microservice architecture development and not in the aftermath. We present some findings regarding performance impacts of some TIOBE TOP 50 programming languages (Go, Java, Ruby, Dart), containers (Docker as type representative) and SDN solutions (Weave as type representative).

Workshop - Session 2 **DataDiversityConvergence**
10:45 - 12:15 **Room Space 100D**

Paper #4

KVFS: An HDFS Library over NoSQL Databases

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Foundation for Research and Technology – Hellas (FORTH), Heraklion, Greece

Keywords: Distributed File Systems, NoSQL Data Stores, Key-value Stores, HBase, HDFS.

Abstract: Recently, NoSQL stores, such as HBase, have gained acceptance and popularity due to their ability to scale-out and perform queries over large amounts of data. NoSQL stores typically arrange data in tables of (key,value) pairs and support few simple operations: get, insert, delete, and scan. Despite its simplicity, this API has proven to be extremely powerful. Nowadays most data analytics frameworks utilize distributed file systems (DFS) for storing and accessing data. HDFS has emerged as the most popular choice due to its scalability. In this paper we explore how popular NoSQL stores, such as HBase, can provide an HDFS scale-out file system abstraction. We show how we can design an HDFS compliant filesystem on top a key-value store. We implement our design as a user-space library (*KVFS*) providing an HDFS filesystem over an HBase key-value store. *KVFS* is designed to run Hadoop style analytics such as MapReduce, Hive, Pig and Mahout over NoSQL stores without the use of HDFS. We perform a preliminary evaluation of *KVFS* against a native HDFS setup using DFSIO with varying number of threads. Our results show that the approach of providing a filesystem API over a key-value store is a promising direction: Read and write throughput of *KVFS* and HDFS, for big and small datasets, is identical. Both HDFS and *KVFS* throughput is limited by the network for small datasets and from the device I/O for bigger datasets.

Paper #7

Data Collection Framework

A Flexible and Efficient Tool for Heterogeneous Data Acquisition

Luigi Sgaglione[1], Gaetano Papale[1], Giovanni Mazzeo[1], Gianfranco Cerullo[1], Pasquale Starace[1] and Ferdinando Campanile[2]

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Keywords: Big Data, Data Collection.

Abstract: The data collection for eventual analysis is an old concept that today receives a revisited interest due to the emerging of new research trend such Big Data. Furthermore, considering that a current market trend is to provide integrated solution to achieve multiple purposes (such as ISOC, SIEM, CEP, etc.), the data became very heterogeneous. In this paper a flexible and efficient solution about the data collection of heterogeneous data is presented, describing the approach used to collect heterogeneous data and the additional features (pre-processing) provided with it.

Paper #8

Direct Debit Frauds: A Novel Detection Approach

Gaetano Papale[1], Luigi Sgaglione[1], Gianfranco Cerullo[1], Giovanni Mazzeo[1], Pasquale Starace[1] and Ferdinando Campanile[2]

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Keywords: Data Fusion, Real-time Correlation, Data Analytics.

Abstract: Single Euro Payments Area (SEPA) is an initiative of the European banking industry aiming at making all electronic payments across the Euro area as easy as domestic payments currently are. One of the payment schemes defined by the SEPA mandate is the SEPA Direct Debit (SDD) that allows a creditor (biller) to collect directly funds from a debtor's (payer's) account. It is apparent that the use of this standard scheme facilitates the access to new markets by enterprises and public administrations and allows for a substantial cost reduction. However, the other side of the coin is represented by the security issues concerning this type of electronic payments. A study conducted by Center of Economics and Business Research (CEBR) of Britain showed that from 2006 to 2010 the Direct Debit frauds have increased of 288%. In this paper a comprehensive analysis of real SDD data provided by the EU FP7 LeanBigData project is performed. The results of this data analysis will conduct to define emerging attack patterns that can be execute against SDD and the related effective detection criteria. All the work aims at inspire the design of a security system supporting analysts to detect Direct Debit frauds.

Doctoral Consortium - Session	**DCCLOSER**
10:45 - 12:15	**Room Space 1**

Paper #3

Prospects of Cloud and Mobile Computing Adoption for Dissemination of Agricultural Information in Developing Countries

Edore Akpokodje and Chris Price

Aberystwyth University, Wales, U.K.

Keywords: Cloud computing, Mobile computing, ICT in Agriculture, Agricultural information delivery, developing countries, ICT

Abstract: Timely access to agricultural information by farmers is critical to agricultural productivity. ICT has the potential of improving agricultural information delivery and farmers' productivity. Most developing countries however lack both the resources and the expertise to build and maintain many data centres distributed around the country. These countries have to look for other ways to access Information and Communications Technology infrastructure and services. This research investigates whether cloud computing combined with mobile computing provides an efficient, effective, sustainable way of bridging this digital divide between developed and developing countries, delivering appropriate expertise to remote areas.

Paper #4

Cloud Service Mediation through Brokerage Service

Claudio Giovanoli

University of Applied Sciences and Arts Northwestern Switzerland, Olten, Switzerland

Keywords: Cloud Computing, Cloud Brokering, Cloud Service Mediation, Service Mapping, Cloud Requirements

Abstract: As the cloud service market everywhere is rapidly growing, specially small and medium companies often are struggling by choosing the right service. Furthermore, already claiming the own requirements to such kind of service is a hurdle to use cloud services for SMEs. Thus, this research project copes with the issues of cloud requirement elicitation and the mapping of such requirements to the right service.

Paper #5

Trust Management for Vehicular Cloud Computing

Marcela Roxana Farcasescu

West University of Timisoara, Timisoara, Romania

Keywords: cloud computing, vehicular cloud, trust management

Abstract: A recent challenge has been raised in the cloud computing world: vehicular cloud computing. Vehiculars will start to use intensively the cloud computing, especially for entertaiment. In a few years all the infotaiment units from our vehicles will have the same operating systems as our tables and phones. All our day-to-day applications will be used also in our vehichles. Still, this confort brings several challenges regarding the privacy of the driver personal data and the vehicle geolocation. This is the reason why trust management represents the key factor for a secure adoption of cloud computing for vehicles.

Keynote Lecture	**CLOSER**
12:15 - 13:15	**Room Auditorium**

The New Era of Multi-dimensional Data Management

Verena Kantere

University of Geneva, Les Acacias, Switzerland

Abstract: Ubiquitous computing and modern data collection tools have given rise to a new era of data management, in which the data as well as the processing environments are enormous and diverse. In this era in which the terms Big Data and Cloud Computing prevail, the success of data management relies in optimizing data processing on multiple dimensions and delivering data services with multifarious quality guarantees. In this talk we will discuss the challenges and the opportunities of the new era of data management and we will explore the possibilities and limitations of multi-dimensional data management. We will focus more on the incorporation of the notion of cost in traditional and new techniques and the role of data heterogeneity. The talk will summarize recent work on a novel economy model for a cloud where users pay on-the-go for the data services they receive and user payments can be used for service provision, infrastructure maintenance and profit. The discussion will go further to the

requirement of approximately querying big heterogeneous data in such an environment. The talk will conclude with a discussion on the special management requirements of big analytical data collections and how these could be fulfilled employing cloud data services.

European Project Space - Panel	**CLOSER**
14:15 - 15:15	**Room Auditorium**

Poster Session 1	**CLOSER**
15:15 - 16:00	**Foyer**

Paper #10

Toward Cloud-based Classification and Annotation Support

Tobias Swoboda[1], Michael Kaufmann[2] and Matthias L. Hemmje[1]

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[2] *Lucern University of Applied Sciences and Arts, Horw, Switzerland*

Keywords: Text Categorization, Evaluation, Architecture, Cloud Cost Analysis, Internet of Services, XaaS, Cloud Services.

Abstract: Manually annotating content-based categories to existing documents is a time-consuming task for human domain experts. In order to ease this effort, automated text categorization is used. This paper evaluates the state of the art in cloud-based text categorization and proposes an architecture for flexible cloud-based classification and annotation support, leveraging the advantages provided by cloud-based architectures.

Paper #24

Towards a Proof-based SLA Management Framework

The SPECS Approach

Miha Stopar[1], Jolanda Modic[1], Dana Petcu[2] and Massimiliano Rak[3]

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[2] *Institute e-Austria Timisoara and West University of Timisoara, Timisoara, Romania*

[3] *Second University of Naples, Aversa, Italy*

Keywords: Cloud Storage, Cloud Security, Security SLA, SLA Management.

Abstract: We present a framework that allows monitoring of the cloud-based applications and environments to verify fulfilment of Service Level Agreements (SLAs), to analyse and remediate detectable security breaches that compromise the validity of SLAs related to storage services. In particular, we describe a system to facilitate identification of the root cause of each violation of integrity, write-serializability and read-freshness properties. Such a system enables executing remediation actions specifically planned for detectable security incidents. The system is activated in an automated way on top of storage services, according to an SLA, which can be negotiated with customers.

Paper #38

A Pattern for Enabling Multitenancy in Legacy Application

Flavio Corradini, Francesco De Angelis, Andrea Polini and Samuele Sabbatini

University of Camerino, Camerino (MC), Italy

Keywords: Multi-tenancy, Cloud Migration, Cloud Pattern.

Abstract: Multitenancy is one the new property of cloud computing paradigm that change the way of develop software. This concept consists in the aggregation of different tenant in one single istance in contrast with the classic single-tenant concept. The aim of multitenancy is the reduction of costs, the hardware needed is less than single-tenant application, and also the mantainance of the system is less expensive. On the other hand, applications need an high configuration level in order to satisfy the requirements of each tenant. In this paper is presented a pattern that enable legacy applications to handle a multitenancy database. After the presentation of the different approach that implements multitenancy at database system, it is proposed the pattern that aims to interact with this kind of database managing the different customization of different tenant at database level.

Paper #58

Disruption-resilient Publish and Subscribe

Noor Ahmed[1,2] and Bharat Bhargava[1]

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Keywords: Cloud Computing, OpenStack, Byzantine Fault Tolerant, Publish and Subscribe Middleware.

Abstract: Publish and Subscribe (pub/sub) dissemination paradigm has emerged as a popular means of disseminating selective time-sensitive information. Through the use of event service or *broker*, published information is filtered to disseminate only to the subscribers interested in that information. Once a *broker* is compromised, information can be delivered unfiltered, dropped, delayed, perhaps colluding among the *brokers* in virtualized cloud platforms. Such disruptive behavior is known as Byzantine faults. We present a Disruption–Resilient Publish and Subscribe (DRPaS) system designed to withstand faults through continuously refreshing the virtual instances of the broker. DRPaS combines advances in cloud management software stack *(i.e., OpenStack nova and neutron)* to control the *broker's* susceptibility window of disruption. Preliminary experimental results show that the defensive security solutions enabled by the underlying cloud computing fabric is simpler and more effective than the ones implemented at the application/protocol level to withstand disruptions.

Paper #62

Survey of the Cloud Computing Standards Landscape 2015

Bernd Becker[1], Emmanuel Darmois[2], Anders Kingstedt[3], Olivier Le Grand[4], Peter Schmitting[5] and Wolfgang Ziegler[6]

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Keywords: Cloud Computing, User Survey, Standards, Certification.

Abstract: Cloud Computing is increasingly used as the platform for IT infrastructure provisioning, application/systems development and end user support of a wide range of core services and applications for businesses and organisations. Cloud Computing is drastically changing the way IT is delivered and used. However, many challenges remain to be tackled. Concerns such as security, vendor lock-in, interoperability and accessibility are examples of issues that need to be addressed. Standards and certification programs play an important role in terms of increasing the market confidence in Cloud Computing. The availability of Cloud Computing standards and certification schemes that address current concerns will ensure that both customers/users as well as providers are likely to regard Cloud Computing with the same level of reliability, trust and maturity as traditional IT. In February 2015, the Cloud Standards Coordination Phase 2 (CSC-2) was launched by ETSI to address issues left open after the initial Cloud Standards Coordination work was completed at the end of 2013. CSC-2 is investigating some specific aspects of the Cloud Computing Standardization landscape, in particular from the point of view of the Cloud Computing users (e.g., SMEs, Administrations). In this paper, we will present final results of the work.

Paper #87

Empowering Services based Software in the Digital Single Market to Foster an Ecosystem of Trusted, Interoperable and Legally Compliant Cloud-Services

Juncal Alonso Ibarra, Leire Orue-Echevarria, Marisa Escalante and Gorka Benguria

Parque Científico y Tecnológico de Bizkaia, Bizkaia, Spain

Keywords: SLA, QoS, Cloud Services, Cloud Service Broker, Digital Single Market, Services Aggregation, Cloud Service Intermediator.

Abstract: The software industry has evolved from software on the shelf based applications deployed in dedicated servers , to Software as a service based components running on public or private Clouds and now to Cloud Service Brokers . So, Cloud service brokerages have emerged as digital intermediaries in the information technology (IT) services market (Shang, 2013), creating value for cloud computing clients and vendors alike. This paper presents an approach to foster next generation cloud service brokers through an ecosystem of trusted, interoperable and legally compliant cloud services through an added value Cloud Services intermediator. This ecosystem will offer, create, consume and assess trusted, interoperable, and standard Cloud Services, where to (semi-)automatically deploy the next generation service based software applications.

Paper #93

An Enhanced Workflow Scheduling Algorithm in Cloud Computing

Nora Almezeini and Alaaeldin Hafez

King Saud University, Riyadh, Saudi Arabia

Keywords: Cloud Computing, Scheduling Algorithm, Fault Tolerant, Pricing Models, Workflow.

Abstract: Cloud Computing has gained high attention by provisioning resources and software as a service. Throughout the years, the number of users of clouds is increasing and thus will increase the number of tasks and load in the cloud. Therefore, scheduling tasks efficiently and dynamically is a critical problem to be solved. There are many scheduling algorithms that are used in cloud computing but most of them are concentrating on minimizing time and cost and some of them concentrate on increasing fault tolerance. However, very few scheduling algorithms that considers time, cost, and fault tolerance at the same time. Moreover, Considering pricing models in developing scheduling algorithms to provide cost-effective fault tolerant techniques is still in its infancy. Therefore, analysing the impact of the different pricing models on scheduling algorithm will lead to choosing the right pricing model that will not affect the cost. This paper proposes developing a scheduling algorithm that combines these features to provide an efficient mapping of tasks and improve Quality of Service (QoS).

Paper #101

Towards a Case-based Reasoning Approach for Cloud Provisioning

Eric Kübler and Mirjam Minor

Goethe University, Frankfurt am Main, Germany

Keywords: Cloud Management, Case-based Reasoning, Intelligent Cloud Provisioning.

Abstract: Resource provisioning is an important issue of cloud computing. Most of the recent cloud solutions implement a simple way with static thresholds to provide resources. Some more sophisticated approaches consider the cloud provisioning problem a multi-dimensional optimization approach. However, the calculation effort for solving optimization problems is significant. An intelligent resource provisioning with a reduced calculation effort requires smart cloud management methods. In this position paper, we propose a case-based reasoning approach for cloud management. A case records a problem situation in cloud management and its solution. We introduce a case model and a retrieval method for previously solved problem cases with the aim to reuse their re-configuration actions for a recent problem situation. The case model uses the container notion correlated with QoS problems. We present a novel, composite similarity function that allows to compare a recent problem situation with the cases from the past. During retrieval, the similarity function creates a ranking of the cases according to their relevance to the current problem situation. Further, we describe the prototypical implementation of the core elements of our case based-reasoning concept. The plausiblility of the retrieval approach has been tested by means of sample cases with simulated data.

Poster Session 1 **OCCLOSER**
15:15 - 16:00 **Foyer**

Paper #1

ClouNS - Proposing a Reference Model for Cloud-Native Applications

Nane Kratzke
Lübeck University of Applied Sciences, Lübeck, Germany

Keywords: Reference model, Cloud-native application, Standardization, OCCI, CIMI.

Abstract: Standardization coverage in cloud computing decreased from about 70% in 2006 down to 20% in 2016. Standards like OCCI and CIMI only cover a small part of relevant cloud service models. Standardization processes are slow compared with service release pace of public cloud service providers. Therefore a reference model for cloud-native applications is proposed to guide, to codify and to shortcut further standardization approaches in cloud computing. It is inspired by the OSI network model which showed successful and positive impacts on standardization processes in networks.

Parallel Session 6 **CLOSER**
16:00 - 18:00 **Room Space 100A**

Paper #71

Towards Auditing of Cloud Provider Chains using CloudTrust Protocol

Thomas Rübsamen, Dirk Hölscher and Christoph Reich
Furtwangen University, Furtwangen, Germany

Keywords: Cloud Computing, Audit, Federated Cloud, Security, Digital Evidence.

Abstract: Although cloud computing can be considered mainstream today, there is still a lack of trust in cloud providers, when it comes to the processing of private or sensitive data. This lack of trust is rooted in the lack of transparency of the provider's data handling practices, security controls and their technical infrastructures. This problem worsens when cloud services are not only provisioned by a single cloud provider, but a combination of several independent providers. The main contributions of this paper are: we propose an approach to automated auditing of cloud provider chains with the goal of providing evidence-based assurance about the correct handling of data according to pre-defined policies. We also introduce the concepts of individual and delegated audits, discuss policy distribution and applicability aspects and propose a lifecycle model. Our previous work on automated cloud auditing and Cloud Security Alliance's (CSA) CloudTrust Protocol form the basis for the proposed system for provider chain auditing.

Paper #75

Process Mining Monitoring for Map Reduce Applications in the Cloud

Federico Chesani, Anna Ciampolini, Daniela Loreti and Paola Mello
University of Bologna, Bologna, Italy

Keywords: Business Process Management, Map Reduce, Monitoring, Cloud Computing, Autonomic System.

Abstract: The adoption of mobile devices and sensors, and the Internet of Things trend, are making available a huge quantity of information that needs to be analyzed. Distributed architectures, such as Map Reduce, are indeed providing technical answers to the challenge of processing these big data. Due to the distributed nature of these solutions, it can be difficult to guarantee the Quality of Service: e.g., it might be not possible to ensure that processing tasks are performed within a temporal deadline, due to specificities of the infrastructure or processed data itself. However, relaying on cloud infrastructures, distributed applications for data processing can easily be provided with additional resources, such as the dynamic provisioning of computational nodes. In this paper, we focus on the step of monitoring Map Reduce applications, to detect situations where resources are needed to meet the deadlines. To this end, we exploit some techniques and tools developed in the research field of Business Process Management: in particular, we focus on declarative languages and tools for monitoring the execution of business process. We introduce a distributed architecture where a logic-based monitor is able to detect possible delays, and trigger recovery actions such as the dynamic provisioning of further resources.

Paper #15

A Task Orientated Requirements Ontology for Cloud Computing Services

Richard Greenwell[1], Xiaodong Liu[1], Kevin Chalmers[2] and Claus Pahl[3]
[1] *Edinburgh Napier University, Edinburgh, U.K.*
[2] *Napier University, Edinburgh, U.K.*
[3] *Dublin City University, Dublin, Ireland*

Keywords: Cloud, Service, Description, Semantic, Requirements, Engineering, Ontology.

Abstract: Requirements ontology offers a mechanism to map requirements for cloud computing services to cloud computing resources. Multiple stakeholders can capture and map knowledge in a flexible and efficient manner. The major contribution of the paper is the definition and development of an ontology for cloud computing requirements. The approach views each user requirement as a semantic intelligence task that maps and delivers it as cloud services. Requirements are modelled as tasks designed to meet specific requirements, problem domains that the requirements exist in, and problem-solving methods which are generic mechanisms to solve problems. A meta-ontology for cloud computing is developed and populated with ontology fragments on to which cloud computing requirements can be mapped. A critical analysis of the usage of ontologies in the requirements process is made and a case study is described that demonstrates the approach in a real-world application. The conclusion is that problem-solving ontologies provide a useful mechanism for the specification and reuse of requirements in the cloud computing environment.

Paper #30

Microservices: A Systematic Mapping Study

Claus Pahl[1] and Pooyan Jamshidi[2]
[1] *Free University of Bozen-Bolzano, Bolzano, Italy*
[2] *Imperial College London, London, U.K.*

Keywords: Mircoservices, Container, Cloud, Systematic Literature Review, Systematic Mapping Study.

Abstract: Microservices have recently emerged as an architectural style, addressing how to build, manage, and evolve architectures out of small, self-contained units. Particularly in the cloud, the microservices architecture approach seems to be an ideal complementation of container technology at the PaaS level However, there is currently no secondary study to consolidate this research. We aim here to identify, taxonomically classify and systematically compare the existing research body on microservices and their application in the cloud. We have conducted a systematic mapping study of 21 selected studies, published over the last two years until end of 2015 since the emergence of the microservices pattern. We classified and compared the selected studies based on a characterization framework. This results in a discussion of the agreed and emerging concerns within the microservices architectural style, positioning it within a continuous development context, but also moving it closer to cloud and container technology.

Paper #59

Design and Evaluation of Automatic Workflow Scaling Algorithms for Multi-tenant SaaS

Ankita Atrey, Hendrik Moens, Gregory Van Seghbroeck, Bruno Volckaert and Filip De Turck
Ghent University, Gent, Belgium

Keywords: Cloud Multi-tenancy, Cloud Simulation, Cloud Resource Provisioning, SLA Provisioning.

Abstract: Current Cloud software development efforts to come up with novel Software-as-a-Service (SaaS) applications are, just like traditional software development, usually no longer built from scratch. Instead more and more Cloud developers are opting to use multiple existing components and integrate them in their application workflow. Scaling the resulting application up or down, depending on user/tenant load, in order to keep the SLA, no longer becomes an issue of scaling resources for a single service, rather results in a complex problem of scaling all individual service endpoints in the workflow, depending on their monitored runtime behavior. In this paper, we propose and evaluate algorithms through CloudSim for automatic and runtime scaling of such multi-tenant SaaS workflows. Our results on time-varying workloads show that the proposed algorithms are *effective* and produce the best *cost-quality* trade-off while keeping *Service Level Agreements (SLAs)* in line. Empirically, the *proactive* algorithm with careful parameter tuning always *meets the SLAs* while only suffering a *marginal* increase in average *cost* per service component of $\approx 5-8\%$ over our baseline *passive* algorithm, which, although provides the least cost, suffers from prolonged violation of service component SLAs.

Parallel Session 6 **CLOSER**
16:00 - 18:00 **Room Space 100B**

Paper #55

A Scalable Architecture for Distributed OSGi in the Cloud

Hendrik Kuijs[1], Christoph Reich[1], Martin Knahl[1] and Nathan Clarke[2]
[1] *Furtwangen University, Furtwangen, Germany*
[2] *Plymouth University, Plymouth, U.K.*

Keywords: OSGi Service Architecture, Load Balancing, Distributed OSGi, PaaS Management, SaaS.

Abstract: Elasticity is one of the essential characteristics for cloud computing. The presented use case is a Software as a Service for Ambient Assisted Living that is configurable and extensible by the user. By adding or deleting functionality to the application, the environment has to support the increase or decrease of computational demand by scaling. This is achieved by customizing the auto scaling components of a PaaS management platform and introducing new components to scale a distributed OSGi environment across virtual machines. We present different scaling and load balancing scenarios to show the mechanics of the involved components.

Paper #42

Providing Security SLA in Next Generation Data Centers with SPECS: The EMC Case Study

Valentina Casola[1], Massimiliano Rak[2], Silvio La Porta[3] and Andrew Byrne[3]
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[2] *Seconda Università di Napoli, Aversa, Italy*
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Keywords: Cloud, ngDC, Cloud Security, Security SLA.

Abstract: Next generation Data Centers (ngDC) are the cloud-based architectures devoted to offering infrastructure services in flexible ways: managing in an integrated way compute, network and storage services. This solution is very attractive from an organisation's perspective but one of the main challenges to adoption is the perception of loss of security and control over resources that are dynamically acquired in the cloud and that reside on remote providers. For a full adoption, datacenter customers need more guarantees about the security levels provided, creating the need for tools to dynamically negotiate and monitor the security requirements. The SPECS project proposes a platform that offers security features with an as-a-service approach, furthermore it uses Security Service Level Agreements (Security SLA) as a means for establishing a clear statement between customers and providers to define a mutual agreement. This paper presents an industrial experience from EMC that integrates the SPECS Platform and their innovative solutions for ngDC. In particular, the paper will illustrate how it is possible to negotiate, enforce and monitor a Security SLA in a cloud infrastructure offering.

Paper #90

A Big Data Analysis System for Use in Vehicular Outdoor Advertising

Emmanuel Kayode Akinshola Ogunshile
University of the West of England, Bristol, U.K.

Keywords: Big Data Analytics, Outdoor Advertising, Visual Analytics, GPS Analysis, Javascript, Query Algorithm Optimisation.

Abstract: Outdoor advertising is an old industry and the only reliably growing advertising sector other than online advertising. However, for it to sustain this growth, media providers must supply a comparable means of tracking an advertisement's effectiveness to online advertising. The problem is a continual and emerging area of research for large outdoor advertising corporations, and as a result of this, smaller companies looking to join the market miss out on providing clients with valuable metrics due to a lack of resources. In this paper, we discuss the processes undertaken to develop software to be used as a means of better understanding the potential effectiveness of a fleet of private car, taxi or bus advertisements. Each of the steps present unique challenges including big data visualisation, performance data aggregation and the inherent inconsistencies and unreliabilities produced by tracking fleets using GPS. We cover how we increased the metric aggregation algorithm performance by roughly 20x, built an algorithm and process to render data heat maps on the server side and how we built an algorithm to clean unwanted GPS 'jitter'.

Paper #107

Revisiting Arguments for a Three Layered Data Warehousing Architecture in the Context of the Hadoop Platform

Qishan Yang and Markus Helfert
Dublin City University, Dublin, Ireland

Keywords: Data Warehouse Architecture, Three Layers, Hadoop, Hive, HBase.

Abstract: Data warehousing has been accepted in many enterprises to arrange historical data, regularly provide reports, assist decision making, analyze data and mine potentially valuable information. Its architecture can be divided into several layers from operated databases to presentation interfaces. The data all around the world is being created and growing explosively, if storing data or building a data warehouse via conventional tools or platforms may be time-consuming and exorbitantly expensive. This paper will discuss a three-layered data warehousing architecture in a big data platform, in which the HDFS (Hadoop Distributed File System) and the MapReduce mechanisms have been being leveraged to store and manipulate data respectively.

European Project Space - Session **CLOSER**
16:00 - 18:00 **Room Space 4D**

Workshop - Session 3 **DataDiversityConvergence**
16:00 - 18:30 **Room Space 100D**

Paper #1

Reducing Data Transfer in Parallel Processing of SQL Window Functions

Fábio Coelho, José Pereira, Ricardo Vilaça and Rui Oliveira
INESC TEC & Universidade do Minho, Braga, Portugal

Keywords: Window Functions, Reactive Programming, Parallel Systems, OLAP, SQL.

Abstract: Window functions are a sub-class of analytical operators that allow data to be handled in a derived view of a given relation, while taking into account their neighboring tuples. We propose a technique that can be used in the parallel execution of this operator when data is naturally partitioned. The proposed method benefits the cases where the required partitioning is not the natural partitioning employed. Preliminary evaluation shows that we are able to limit data transfer among parallel workers to 14% of the registered transfer when using a naive approach.

Paper #2

Design of an RDMA Communication Middleware for Asynchronous Shuffling in Analytical Processing

Rui C. Gonçalves[1], José Pereira[1] and Ricardo Jimenez-Peris[2]
[1] *INESC TEC & U. Minho, Braga, Portugal*
[2] *LeanXcale, Madrid, Spain*

Keywords: Shuffling, Analytical Processing, Middleware, RDMA.

Abstract: A key component in a distributed parallel analytical processing engine is *shuffling*, the distribution of data to multiple nodes such that the computation can be done in parallel. In this paper we describe the initial design of a communication middleware to support asynchronous shuffling of data among multiple processes on a distributed memory environment. The proposed middleware relies on RDMA (Remote Direct Memory Access) operations to transfer data, and provides basic operations to send and queue data on remote machines, and to retrieve this queued data. Preliminary results show that the RDMA-based middleware can provide a 75% reduction on communication costs, when compared with a traditional sockets implementation.

Paper #3

Design and Implementation of the CloudMdsQL Multistore System

Boyan Kolev[1], Carlyna Bondiombouy[1], Oleksandra Levchenko[1], Patrick Valduriez[1], Ricardo Jimenez-Peris[2], Raquel Pau[3] and José Pereira[4]

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[4] *INESC TEC and Universidade do Minho, Braga, Portugal*

Keywords: Cloud, Multistore System, Heterogeneous Data Stores, SQL and NoSQL Integration.

Abstract: The blooming of different cloud data management infrastructures has turned multistore systems to a major topic in the nowadays cloud landscape. In this paper, we give an overview of the design of a Cloud Multidatastore Query Language (CloudMdsQL), and the implementation of its query engine. CloudMdsQL is a functional SQL-like language, capable of querying multiple heterogeneous data stores (relational, NoSQL, HDFS) within a single query that can contain embedded invocations to each data store's native query interface. The major innovation is that a CloudMdsQL query can exploit the full power of local data stores, by simply allowing some local data store native queries (e.g. a breadth-first search query against a graph database) to be called as functions, and at the same time be optimized.

Paper #5

Towards Quantifiable Eventual Consistency

Francisco Maia, Miguel Matos and Fábio Coelho

INESC TEC & U. Minho, Braga, Portugal

Keywords: Large Scale, Data Stores, Epidemic Protocols.

Abstract: In the pursuit of highly available systems, storage systems began offering eventually consistent data models. These models are suitable for a number of applications but not applicable for all. In this paper we discuss a system that can offer a eventually consistent data model but can also, when needed, offer a strong consistent one.

Paper #6

Towards Performance Prediction in Massive Scale Datastores

Francisco Cruz, Fábio Coelho and Rui Oliveira

INESC TEC & Universidade do Minho, Braga, Portugal

Keywords: Performance, Cloud Computing, NoSQL Databases.

Abstract: Buffer caching mechanisms are paramount to improve the performance of today's massive scale NoSQL databases. In this work, we show that in fact there is a direct and univocal relationship between the resource usage and the cache hit ratio in NoSQL databases. In addition, this relationship can be leveraged to build a mechanism that is able to estimate resource usage of the nodes composing the NoSQL cluster.

Special Session - Session **OCCI**
16:00 - 18:45 **Room Space 100C**

Paper #1

Evolution of the Open Cloud Computing Interface

Boris Parák[1], Zdeněk Šustr[1], Michal Kimle[1], Pablo Orviz Fernández[2], Álvaro López García[2], Stavros Sachtouris[3] and Víctor Méndez Muñoz[4]

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Keywords: Cloud, Standards, Architecture, Interoperability, Management, OCCI.

Abstract: The OCCI standard has been in use for half a decade, with multiple server-side and client-side implementations in use across the world in heterogeneous cloud environments. The real-world experience uncovered certain peculiarities or even deficiencies which had to be addressed either with workarounds, agreements between implementers, or with updates to the standard. This article sums up implementers' experience with the standard, evaluating its maturity and discussing in detail some of the issues arising during development and use of OCCI-compliant interfaces. It shows how particular issues were tackled at different levels, and what the motivation was for some of the most recent changes introduced in the OCCI 1.2 specification.

Paper #2

Easing Scientific Computing and Federated Management in the Cloud with OCCI

Zdeněk Šustr[1], Diego Scardaci[2,3], Jiří Sitera[1], Boris Parák[1] and Víctor Méndez Muñoz[4]

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Keywords: Federated Cloud, Cloud Standards, Cloud Interoperability, Cloud Solution Design Patterns, Cloud Application Architectures, Cloud Middleware Frameworks, Open Cloud Computing Interface.

Abstract: One of the benefits of OCCI stems from simplifying the life of developers aiming to integrate multiple cloud managers. It provides them with a single protocol to abstract the differences between cloud service implementations used on sites run by different providers. This comes particularly handy in federated clouds, such as the EGI Federated Cloud Platform, which bring together providers who run different cloud management platforms on their sites: most notably OpenNebula, OpenStack, or Synnefo. Thanks to the wealth of approaches and tools now available to developers of virtual resource management solutions, different paths may be chosen, ranging from a small-scale use of an existing command line client or single-user graphical interface, to libraries ready for integration with large workload management frameworks and job submission portals relied on by large science communities across Europe. From lone wolves in the long-tail of science to virtual organizations counting thousands of users, OCCI simplifies their life through standardization, unification, and simplification. Hence cloud applications based on OCCI can

focus on user specifications, saving cost and reaching a robust development life-cycle. To demonstrate this, the paper shows several EGI Federated Cloud experiences, demonstrating the possible approaches and design principles.

Paper #3

SLAaaS: an OCCI Compliant Framework for Cloud SLA Provisioning and Violation Detection

Gregory Katsaros, Thijs Metsch and John Kennedy
Intel Corporation, Leixlip, Ireland

Keywords: Service Level Agreements, OCCI, Cloud, Violations, Open Source.

Abstract: SLAs are an integral part of all modern service provisioning operations. They have been a topic of discussion, research and development for many years but still the norm is the use of rigid, complex and not easy to automate Service Level Agreements. In this paper we are presenting a service framework that is leveraging the OCCI specification in order to facilitate standardized SLA provisioning and violation detection. This SLA as a Service (SLAaaS) offering is provided as an open source framework to any Service Provider that wants to efficiently enhance his infrastructure with SLA support.

Paper #6

Beyond Nagios

Design of a Cloud Monitoring System

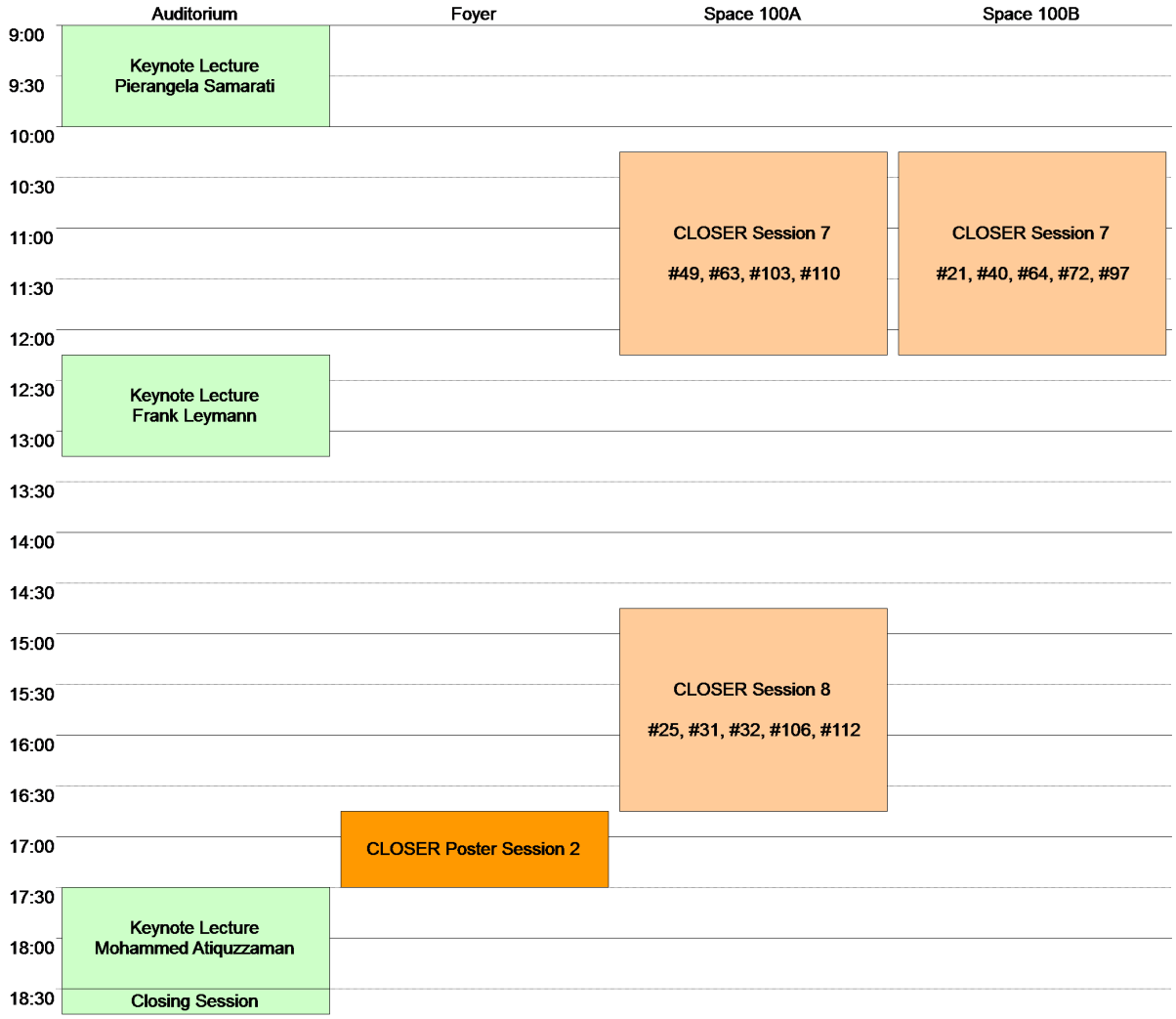
Augusto Ciuffoletti
Università di Pisa, Pisa, Italy

Keywords: Resource Monitoring, On-demand Monitoring, Cloud Computing, Open Cloud Computing Interface (OCCI), Containers, REST Paradigm, WebSocket.

Abstract: The paper describes a monitoring system specially designed for cloud infrastructures. The features that are relevant for such distributed application are -) scalability, that allows utilization in systems of thousands of nodes, -) flexibility, to be customized for a large number of applications, -) openness, to allow the coexistence of user and administration monitoring. We take as a starting point the Nagios monitoring system, that has been successfully used for Grid monitoring and is still used for clouds. We analyze its shortcomings when applied to cloud monitoring, and propose a new monitoring system, that we call Rocmon, that sums up Nagios experience with a cloud perspective. Like Nagios, Rocmon is plugin-oriented to be flexible. To be fully interoperable and long-living, it uses standard tools: the OGF OCCI for the configuration interface, the REST paradigm to take advantage of Web tools, and HTML5 WebSockets for data transfers. The design is checked with an open source Ruby implementation featuring the most relevant aspects.

Monday Sessions: April 25

Monday Sessions: April 25 Program Layout



Keynote Lecture	CLOSER
09:00 - 10:00	Room Auditorium

Security and Privacy in the Cloud

Pierangela Samarati
Università degli Studi di Milano, Crema, Italy

Abstract: The rapid advancements in Information and Communication Technologies (ICTs) have enabled the emerging of the “cloud” as a successful paradigm for conveniently storing, accessing, processing, and sharing information. With its significant benefits of scalability and elasticity, the cloud paradigm has appealed companies and users, which are more and more resorting to the multitude of available providers for storing and processing data. Unfortunately, such a convenience comes at a price of loss of control over these data and consequent new security threats that can limit the potential widespread adoption and acceptance of the cloud computing paradigm. In this talk I will illustrate some security and privacy issues arising in the cloud scenario, focusing in particular on the problem of guaranteeing confidentiality and integrity of data stored or processed by external cloud providers.

Parallel Session 7	CLOSER
10:15 - 12:15	Room Space 100A

Paper #49

A Method for Reusing TOSCA-based Applications and Management Plans

Sebastian Wagner, Uwe Breitenbücher and Frank Leymann
University of Stuttgart, Stuttgart, Germany

Keywords: Cloud Management, TOSCA, Workflow Reusability, Process Consolidation.

Abstract: The automated provisioning and management of Cloud applications is supported by various general-purpose technologies that provide generic management functionalities such as scaling components or automatically redeploying parts of a Cloud application. However, if complex applications have to be managed, these technologies reach their limits and individual, application-specific processes must be created to automate the execution of holistic management tasks that cannot be implemented in a generic manner. Unfortunately, creating such processes from scratch is time-consuming, error-prone, and knowledge-intensive, thus, leading to inefficient developments of new applications. In this paper, we present an approach that tackles these issues by enabling the usage of choreographies to systematically combine available management workflows of existing application building blocks. Moreover, we show how these choreographies can be merged into single, executable workflows in order to enable their automated execution. To validate the approach, we apply the concept to the choreography language BPEL4CHOR and the Cloud standard TOSCA. In addition, we extend the Cloud application management ecosystem OpenTOSCA to support executing management choreographies.

Paper #63

Leveraging Use of Software-license-protected Applications in Clouds

Wolfgang Ziegler[1], Hassan Rasheed[2] and Karl Catewicz[2]
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[2] *Fraunhofer Institute FIT, Sankt Augustin, Germany*

Keywords: Cloud Computing, Software, IPR.

Abstract: Running software license-protected commercial applications in IaaS or PaaS Cloud environments is still an issue that is not resolved in a satisfying way that benefit both the independent software vendor (ISV) and its customers. Due to the mandatory centralised control of license usage at application run-time, e.g. heartbeat control by the license server running at the home site of a user, traditional software licensing practices are not suitable especially when the distributed environment stretches across administrative domains. Although there have been a few bilateral agreements between ISVs and Cloud providers in the past to allow customers of these ISVs to run some of the ISVs license-protected applications in Clouds of certain providers a general solution is still lacking. In this paper we present an approach for software licensing that allows location independent use of software licenses both in form of delegation of already purchased on-site licenses to the Cloud and with authorisations for individual application executions in the Cloud.

Paper #103

Embedding Cloud Computing inside Supercomputer Architectures

Patrick Dreher and Mladen Vouk
North Carolina State University, Raleigh, U.S.A.

Keywords: High Performance Computing, Cloud Computing, Scientific Workflows, Virtual Computing Laboratory, Supercomputing, HPC/Cloud, Supercomputer/Cloud, Future Supercomputer/Cloud Architectures.

Abstract: Recently there has been a surge of interest in several prototype software systems that can embed a cloud computing image with user applications into a supercomputer’s hardware architecture. This position paper will summarize these efforts and comment on the advantages of each design and will also discuss some of the challenges that one faces with such software systems. This paper takes the position that specific types of user applications may favor one type of design over another. Different designs may have potential advantages for specific user applications and each design also brings a considerable cost to assure operability and overall computer security. A “one size fits all design” for a cost effective and portable solution for Supercomputer/cloud delivery is far from being a solved problem. Additional research and development should continue exploring various design approaches. In the end several different types of supercomputer/cloud implementations may be needed to optimally satisfy the complexity and diversity of user needs, requirements and security concerns. The authors also recommend that the community recognize a distinction when discussing cluster-type HPC/Cloud versus Supercomputer/Cloud implementations because of the substantive differences between these systems.

Paper #110

Availability Considerations for Mission Critical Applications in the Cloud

Valentina Salapura and Ruchi Mahindru
IBM T.J. Watson Research Center, Yorktown Heigths, U.S.A.

Keywords: Enterprise Class Applications, HA Clusters, ERP Cloud Solutions.

Abstract: Cloud environments offer flexibility, elasticity, and low cost compute infrastructure. Enterprise-level workloads – such as SAP and Oracle workloads - require infrastructure with high availability, clustering, or physical server appliances. These features are often not part of a typical cloud offering, and as a result, businesses are forced to run enterprise workloads in their legacy environments. To enable enterprise customers to use these workloads in a cloud, we enabled a large number of SAP and Oracle workloads in the IBM Cloud Managed Services (CMS) for both virtualized and non-virtualized cloud environments. In this paper, we discuss the challenges in enabling enterprise class applications in the cloud based on our experience on providing a diverse set of platforms implemented in the IBM CMS offering.

Parallel Session 7 **CLOSER**
10:15 - 12:15 **Room Space 100B**

Paper #21

DSaaS
A Cloud Service for Persistent Data Structures

Pierre Bernard le Roux[1], Steve Kroon[1,2] and Willem Bester[1]
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[2] *CSIR/SU Centre for Artificial Intelligence Research, Stellenbosch, South Africa*

Keywords: DaaS, SaaS, Cloud Computing, Persistent Data Structure, Version Control System, Hash-Array Mapped Trie.

Abstract: In an attempt to tackle shortcomings of current approaches to collaborating on the development of structured data sets, we present a prototype platform that allows users to share and collaborate on the development of data structures via a web application, or by using language bindings or an API. Using techniques from the theory of persistent linked data structures, the resulting platform delivers automatically version-controlled map and graph abstract data types as a web service. The core of the system is provided by a Hash Array Mapped Trie (HAMT) which is made confluently persistent by path-copying. The system aims to make efficient use of storage, and to have consistent access and update times regardless of the version being accessed or modified.

Paper #40

Decision Support System for Adoption of Cloud-based Services

Radhika Garg, Marc Heimgartner and Burkhard Stiller
University of Zürich UZH, Zürich, Switzerland

Keywords: Cloud Computing, Cloud Adoption, Decision Support System, Multi-attribute Decision Algorithms.

Abstract: Adoption of any new technology in an organization is a crucial decision as it can have its impact at technical, economical, and organizational level. One of such decisions is related to adoption of Cloud-based services in an organization. Cloud Computing provides elastic resources as per the demand and provides the facility to pay as per the use. Thus, it is changing the way IT infrastructure is used today with huge benefit of cost savings. However, if the solution adopted by an organization is not fulfilling the requirements, it can have tremendous negative consequences at technical, economical, and organizational level. Therefore, the decision to adopt Cloud-based services should be based on a methodology that supports a wide array of criteria for evaluating the available alternatives. Also, as these criteria or factors can be mutually interdependent and conflicting, a trade-offs-based methodology is needed to make such decisions. This paper, therefore, discusses the design, implementation, and evaluation of the prototype developed for automating the theoretical methodology of Trade-offs based Methodology for Adoption of Cloud-based Services (TrAdeCIS) developed in (Garg and Stiller, 2014). This system is based on Multi-attribute Decision Algorithms (MADA), which selects the best alternative, based on the priorities of criteria of decision maker. In addition the applicability of this methodology to the adoption of cloud-based services in an organization is validated with several use-cases towards the end of the paper. Furthermore, the extendibility of this system to other domains is being evaluated with respect to Train Operating Companies, who wish to find out the best alternative of providing Internet connectivity and voice calls on-board trains.

Paper #64

Toward an Understanding of Government Cloud Acceptance
A Quantitative Study of G-Cloud Acceptance by Saudi Government Agencies using Extended UTAUT

Maha A. Al Rashed and Mutlaq B. Alotaibi
Al-Imam Muhammad Ibn Saud University, Riyadh, Saudi Arabia

Keywords: Cloud Computing, Government Cloud, Technology Acceptance, Unified Theory of Acceptance and Use of Technology (UTAUT), Trust.

Abstract: With today's rapid advances in Information and Communication Technologies (ICT), an increasing number of governments worldwide are seeking solutions to enhance their IT infrastructures and services, and reshape their e-government systems to meet public needs of providing easily accessible, cost-effective, high quality, and reliable e-services. In recent years, government cloud (G-Cloud) has emerged as a new and innovative computing paradigm with a promising opportunity for many governments to rationalize the way they manage their services and resources. Government cloud's potential benefits has been recognized by many governments around the world. This paper will study the acceptance of cloud computing technologies and services in Saudi government agencies by investigating the significant and influential factors that affect the behavioral intentions to use G-Cloud. Moreover, in light of the rising concerns over trust issues in cloud computing which have been reported to be one of the major barriers to the adoption of the cloud, the study proposes an extended Unified Theory of Acceptance and Use of Technology (UTAUT) model by incorporating trust as a key factor in the acceptance of G-Cloud.

Paper #72

Towards a Goal-oriented Approach to Adaptable Re-deployment of Cloud-based Applications

Patrizia Scandurra[1], Marina Mongiello[2], Simona Colucci[2] and Luigi Alfredo Grieco[2]

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[2] *Politecnico di Bari, Bari, Italy*

Keywords: Cloud Applications, Adaptation, Deployment, Goal-model.

Abstract: Due to the on-demand and dynamic nature of Cloud, there is an increasing interest for automated management of adaptation and (possibly) re-deployment of cloud applications to realize quality requirements and evolution needs autonomously at run-time. This paper proposes a fast and automated approach for adapting and redeploying a cloud application at run-time as dictated by evolution needs and sudden changes in the operating environment conditions. The proposed approach exploits a graph-based model and an algorithm that extracts a sub-graph identifying the adaptation processes to be executed according to evolution changes. The approach is general enough to be implemented by any cloud application management framework. A TOSCA-based description of the structure and management aspects of the cloud application may be updated according to the above mentioned sub-graph. Then, this description may be processed by a TOSCA-compliant runtime environment to effectively adapt and possibly re-deploy the cloud application in an automated manner. The paper also illustrates the instantiation of this generic approach for adapting an e-commerce cloud application.

Paper #97

Towards Resilience Metrics for Future Cloud Applications

Marko Novak[1], Syed Noorulhassan Shirazi[2], Aleksandar Hudic[1], Thomas Hecht[1], Markus Tauber[1,3], David Hutchison[2], Silia Maksuti[1,3] and Ani Bicaku[1,3]

[1] *Austrian Institute of Technology, Vienna, Austria*

[2] *Lancaster University, Lancaster, U.K.*

[3] *University of Applied Science Burgenland, Eisenstadt, Austria*

Keywords: Security Metrics, Technology Trend Analysis, Threat Trend Analysis, Cloud Applications, Resilience.

Abstract: An analysis of new technologies can yield insight into the way these technologies will be used. Inevitably, new technologies and their uses are likely to result in new security issues regarding threats, vulnerabilities and attack vectors. In this paper, we investigate and analyse technological and security trends and their potential to become future threats by systematically examining industry reports on existing technologies. Using a cloud computing use case we identify potential resilience metrics that can shed light on the security properties of the system.

Keynote Lecture **CLOSER**
12:15 - 13:15 **Room Auditorium**

Native Cloud Applications - Why Virtual Machines, Images and Containers Miss the Point!

Frank Leymann

University of Stuttgart, Stuttgart, Germany

Abstract: Due to the current hype around cloud computing, the term “native cloud application” becomes increasingly popular. It suggests an application to fully benefit from all the advantages of cloud computing. Many users tend to consider their applications as cloud native if the application is just bundled in a virtual machine image or a container. Even though virtualization is fundamental for implementing the cloud computing paradigm, a virtualized application does not automatically cover all properties of a native cloud application. In this work, we propose a definition of a native cloud application by specifying the set of characteristic architectural properties, which a native cloud application has to provide. We demonstrate the importance of these properties by introducing a typical scenario from current practice that moves an application to the cloud. The identified properties and the scenario especially show why virtualization alone is insufficient to build native cloud applications. Finally, we outline how native cloud applications respect the core principles of service-oriented architectures, which are currently hyped a lot in the form of microservice architectures.

Session 8 **CLOSER**
14:45 - 16:45 **Room Space 100A**

Monday, 25

Paper #32

Evidence Collection in Cloud Provider Chains

Thomas Rübsamen[1], Christoph Reich[1], Nathan Clarke[2] and Martin Knahl[1]

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[2] *Plymouth University, Plymouth, U.K.*

Keywords: Cloud Computing, Audit, Federated Cloud, Security, Digital Evidence.

Abstract: With the increasing importance of cloud computing, compliance concerns get into the focus of businesses more often. Furthermore, businesses still consider security and privacy related issues to be the most prominent inhibitors for an even more widespread adoption of cloud computing services. Several frameworks try to address these concerns by building comprehensive guidelines for security controls for the use of cloud services. However, assurance of the correct and effective implementation of such controls is required by businesses to attenuate the loss of control that is inherently associated with using cloud services. Giving this kind of assurance is traditionally the task of audits and certification. Cloud auditing becomes increasingly challenging for the auditor the more complex the cloud service provision chain becomes. There are many examples for Software as a Service (SaaS) providers that do not own dedicated hardware anymore for operating their services, but rely solely on other cloud providers of the lower layers, such as platform as a service (PaaS) or infrastructure as a service (IaaS) providers. The collection of data (evidence) for the assessment of policy compliance during a technical audit is aggravated the more complex the combination of cloud providers becomes. Nevertheless, the collection at all participating providers is required to assess policy compliance in the whole chain. The main contribution of this paper is an

analysis of potential ways of collecting evidence in an automated way across cloud provider boundaries to facilitate cloud audits. Furthermore, a way of integrating the most suitable approaches in the system for automated evidence collection and auditing is proposed.

Paper #112

A Wavelet-inspired Anomaly Detection Framework for Cloud Platforms

David O'Shea[1], Vincent C. Emeakaroha[1], John Pendlebury[1], Neil Cafferkey[1], John P. Morrison[1] and Theo Lynn[2]

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[2] *Dublin City University, Dublin, Ireland*

Keywords: Anomaly Detection, Wavelet Transformation, Cloud Monitoring, Data Analysis, Cloud Computing.

Abstract: Anomaly detection in Cloud service provisioning platforms is of significant importance, as the presence of anomalies indicates a deviation from normal behaviour, and in turn places the reliability of the distributed Cloud network into question. Existing solutions lack a multi-level approach to anomaly detection in Clouds. This paper presents a wavelet-inspired anomaly detection framework for detecting anomalous behaviours across Cloud layers. It records the evolution of multiple metrics and extracts a two-dimensional spectrogram representing a monitored system's behaviour. Over two weeks of historical monitoring data were used to train the system to identify healthy behaviour. Anomalies are then characterised as deviations from this expected behaviour. The training technique as well as the pre-processing techniques are highly configurable. Based on a Cloud service deployment use case scenario, the effectiveness of the framework was evaluated by randomly injecting anomalies into the recorded metric data and performing comparison using the resulting spectrograms.

Paper #25

A FLOSS License-selection Methodology for Cloud Computing Projects

Robert Viseur

UMONS, Mons, Belgium

Keywords: Cloud Computing, Saas, Paas, Iaas, PaaSage, Governance, License, FLOSS, Open Source.

Abstract: Cloud computing and open source are two disruptive innovations. Both deeply modify the way the computer resources are made available and monetized. They evolve between competition (e.g. open source software for desktop versus SaaS applications) and complementarity (e.g. cloud solutions based on open source components or cloud applications published under open source license). PaaSage is an open source integrated platform to support both design and deployment of cloud applications. The PaaSage consortium decided to publish the source code as open source. It needed a process for the open source license selection. Open source licensing scheme born before the development of cloud computing and evolved with the creation of new open source licenses suitable for SaaS applications. The license is a part of project governance and strongly influences the life of the project. In the context of the PaaSage European project, the issue of the open source license selection for cloud computing software has been addressed. The first section of the paper describes the state of the art about open source licenses including the known issues, a generic license-selection scheme and the automated source code analysis practices. The second section studies the common choices of licenses in cloud computing projects. The third section proposes a FLOSS license-selection process for cloud computing project following five steps: (1) inventoring software components, (2) selecting open source license, (3) approving license selection (vote), (4) spreading practical details and (5) monitoring source code. The fourth section describes the PaaSage use case. The last section consists in a discussion of the results.

Paper #31

Challenges and New Avenues in Existing Replication Techniques

Furat F. Altukhaim and Almetwally M. Mostafa

King Saud University, Riyadh, Saudi Arabia

Keywords: Load Balance, Replication, Replication Challenges, Active Replication, Primary-Backup Replication, Chain Replication, Mencius, Egalitarian Paxos, Object Ownership Distribution.

Abstract: Over recent years, the curve of the importance of data replication has risen steeply owing to the fact that databases are increasingly deployed over clusters of different workstations over time. A variety of replication techniques have been introduced to the distributed systems field which, in this paper, are classified based on whether they have an unbalanced load between servers or not (classic and modern). Replication techniques from both categories can be enhanced by avoiding some of the challenges that are illustrated in detail in this paper. Moreover, this paper analyses replication techniques in each category by exploring their strengths and weaknesses as well as providing possible novel solutions that can diminish or eliminate these challenges and introduces a brief description of the Dynamic Object Ownership Distribution Protocol that aims at increasing throughput by increasing the rate of performing transactions locally in addition to viewing a promising preliminary results of its performance.

Paper #106

Methodology to Obtain the Security Controls in Multi-cloud Applications

Samuel Olaiya Afolaranmi[1], Luis E. Gonzalez Moctezuma[1], Massimiliano Rak[2], Valentina Casola[3], Erkuden Rios[4] and Jose L. Martinez Lastra[1]

[1] *Tampere University of Technology, Tampere, Finland*

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Keywords: Multi-cloud, Security-by-design, Cyber-security Methodologies, Threat Modelling.

Abstract: What controls should be used to ensure adequate security level during operation is a non-trivial subject in complex software systems and applications. The problem becomes even more challenging when the application uses multiple cloud services which security measures are beyond the control of the application provider. In this paper, a methodology that enables the identification of the best security controls for multi-cloud applications whose components are deployed in heterogeneous clouds is presented. The methodology is based on application decomposition and modelling of threats over the components, followed by the analysis of the risks together with the capture of cloud business and security requirements. The methodology has

been applied in the MUSA EU H2020 project use cases as the first step for building up the multi-cloud applications' security-aware Service Level Agreements (SLA). The identified security controls will be included in the applications' SLAs for their monitoring and fulfilment assurance at operation.

Poster Session 2 **CLOSER**
16:45 - 17:30 **Foyer**

Paper #50

A Repeatable Framework for Best Fit Cloud Solution

Emmanuel Kayode Akinshola Ogunshile
University of the West of England, Bristol, U.K.

Keywords: AH – Authentication Header, CPU – Central Processing Unit, DNS – Domain Name Server, EPM – Evans Property Management, ESP – Encapsulation Security Payload, IaaS – Infrastructure as a Service, LAN – Local Area Network, NAS – Network Area Storage, PaaS – Platform as a Service, SaaS – Software as a Service, SME – Small Medium Enterprise, SMTP – Simple Mail Transfer Protocol, SSL – Secure Socket Layer, VPN – Virtual Private Network.

Abstract: To respond to business challenges with agility, modern businesses have to evolve quickly to stay competitive. Unfortunately, in many situations, proliferation of heterogeneous Information Technology shifts act as a barrier to innovations instead of as a driving force. Crucially, this is due to the confusions that they sometimes cause whilst Small Medium Enterprises (SMEs) are trying to elect the right technology solution appropriate for a given business challenge i.e. amidst various comparable options, claims, features and benefits from different technology vendors available in the market. To help small SMEs quickly make timely decision on what technology solutions are appropriate for a given business challenge i.e. given the vast array of solutions available in today's market, this paper proposes a guideline for an implementable solution for any SME with similar requirements to our chosen fictitious customer called EPM. The paper will cover main areas such as introducing a generic SME business case, analysing hardware solutions and methods typically employed in cloud networks to reduce costs. Then the paper will introduce the solutions as a repeatable framework to be critically analysed to find a suitable solution for the customer, this will then be looked into with any other cloud principals that could create a better fitting solution for the customer.

Paper #54

Generic Cloud Computing Framework Understanding and Implementation

Emmanuel Kayode Akinshola Ogunshile
University of the West of England, Bristol, U.K.

Keywords: VLAN – Virtual Local Area Network, IaaS – Infrastructure as a Service, SaaS – Software as a Service, PaaS – Platform as a Service, CAD – Computer Aided Design, CRM – Customer Relationship Management, vCPU – Virtual Central Processing Unit, COTS – Components of the Shelf.

Abstract: The rate of adoption of cloud services is increasing year on year as organisations realise the many benefits that moving operations onto a cloud based platform provides. However, there is an argument to be made that with the multitude services that offer cloud solutions in various forms, that choosing the right technology for a business is not straight forward and cloud services may not always provide all the benefits suggested by the service providers. Using the case study of *OneDrum Ltd* as a comparison of compatibility, an analysis of current cloud providers as well as hardware that is used to provide cloud solutions is considered. With these examples, potential solutions for the *OneDrum Ltd* scenarios have been devised with the aim to create transferable solutions for other small manufacturing businesses.

Paper #69

Application Splitting in the Cloud: A Performance Study

Franz Faul[1], Rafael Arizcorreta[1], Florian Dudouet[2] and Thomas Michael Bohnert[2]
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[2] *Zurich University of Applied Sciences, Winterthur, Switzerland*

Keywords: Cloud Computing, Performance, Database, Hybrid Cloud.

Abstract: Cloud-based deployments have become more and more mainstream in recent years, with many companies evaluating moving their infrastructure to the cloud, whether a public cloud, a private cloud, or a mix of the two through the hybrid cloud concept. One service offered by many clouds providers is Database-as-a-Service, where a user is offered a direct endpoint and access credentials to a chosen type of database. In this paper, we evaluate the performance impact of application splitting in a Hybrid Cloud environment. In this context, the database may be located in a cloud setting and the application servers on another cloud or on-premises, or the other way around. We found that for applications with low database latency and throughput requirements, moving to a public cloud environment can be a cost saving solution. None of the cloud providers evaluated were able to provide comparable performance for database-heavy database applications when compared to an optimized enterprise environment. Evaluating application splitting, we conclude that bursting to the cloud is a viable option in most cases, provided that the data is moved to the cloud before performing the requests.

Paper #80

Towards Automatic Service Level Agreements Information Extraction

Lucia De Marco[1,2], Filomena Ferrucci[1], M-Tahar Kechadi[2], Gennaro Napoli[1] and Pasquale Salza[1]
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[2] *University College Dublin, Dublin, Ireland*

Keywords: Cloud Computing, Service Level Agreements, Natural Language Processing, Information Extraction.

Abstract: Service Level Agreements (SLAs) are contracts co-signed by an Application Service Provider (ASP) and the end user(s) to regulate the services delivered through the Internet. They contain several clauses establishing for example the level of the services to guarantee, also known as quality of service (QoS) parameters and the penalties to apply in case the requirements are not met during the SLA validity time. SLAs use legal jargon, indeed they have legal validity in case of court litigation between the parties. A dedicated contract management facility should be part of the service provisioning because of the contractual importance and contents. Some work in literature about these facilities rely on a structured language representation of SLAs in order to make them machine-readable. The majority of these

languages are the result of private stipulation and not available for public services where SLAs are expressed in common natural language instead. In order to automate the SLAs management, in this paper we present an investigation towards SLAs text recognition. We devised an approach to identify the definitions and the constraints included in the SLAs using different machine learning techniques and provide a preliminary assessment of the approach on a set of 36 publicly available SLA documents.

Paper #96

Secure Cloud Reference Architectures for Measuring Instruments under Legal Control

Alexander Oppermann[1], Jean-Pierre Seifert[2] and Florian Thiel[1]

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[2] *Technische Universität Berlin, Berlin, Germany*

Keywords: Cloud Computing, Trusted Cloud, Homomorphic Encryption, PKI, Verified Computing, Legal Metrology.

Abstract: Cloud Computing has been a trending topic for years now and it seems it has finally become mature enough for widespread commercial application. In this paper, the authors describe their approach to establish a secure cloud architecture which conforms to the Measuring Instruments Directive of the European Union while keeping the flexibility and benefits that cloud computing promises for companies and customers alike. The authors introduce a modular concept of a secure cloud system architecture which will ensure cross-virtual machine collaboration and a legitimate, secure and protected flow of measurement data.

Paper #99

How Cloud Will Transform the Retail Banking Industry

Stella Gatziu Grivas, Ruven Schürch and Claudio Giovanoli

University of Applied Sciences Northwestern, Olten, Switzerland

Keywords: Banking Trends, Cloud Computing, Banking Processes, Customer Centricity, Branches, Cloud for Enterprise Business Transformation, Cloud Scenarios.

Abstract: This paper focusses on current trends in the banking industry and on illustrating how these trends can be supported by cloud computing. The main characteristics of cloud computing that could support transformation are facilitated data accessibility, enabled processing of data from various sources and the opportunity of an easier integration of functions or data. Trends in the banking industry are increasing customer centricity, redesigning of branches and deployment of new communication and distribution channels. For each trend we report quotes general information to provide an overview of the transformation caused by this trend. We identify which business processes are influenced, how they are affected and we explain how cloud computing could support the identified changes.

Paper #104

Towards Modelling a Cloud Application's Life Cycle

Reginald Butterfield[1,2], Silia Maksuti[2,3], Markus Tauber[2,3], Christian Wagner[3] and Ani Bicaku[2,3]

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[3] *Austrian Institute of Technology, Vienna, Austria*

Keywords: Cloud Application Life Cycle, Security Software Development Life Cycle, Security, Business Requirements, Risk, Governance, Decision-making.

Abstract: The success of any cloud-based application depends on appropriate decisions being taken at each phase of the life cycle of that application coupled with the stage of the organisation's business strategy at any given time. Throughout the life cycle of a cloud-based project, various stakeholders are involved. This requires a consistent definition of organizational, legal and governance issues regardless of the role of the stakeholder. We proffer that currently the models and frameworks that offer to support these stakeholders are predominantly IT focused and as such lack a sufficient focus on the business and its operating environment for the decision-makers to make strategic cloud related decisions that benefit their individual business model. We propose an emerging framework that provides a stronger platform on which to base cloud business decisions. We also illustrate the importance of this approach through extrapolating the subject of security from the initial Business Case definition phase, through the Decision Making phase and into the Application Development phase to strengthen the case for a comprehensive Business-based framework for cloud-based application decision-making. We envisage that this emerging framework will then be further developed around all phases of the Application Life Cycle as a means of ensuring consistency.

Keynote Lecture	**CLOSER**
17:30 - 18:30	**Room Auditorium**

Extending the Internet to Space

Mohammed Atiquzzaman

University of Oklahoma, Oklahoma, U.S.A.

Abstract: Data communications between Earth and spacecrafts, such as satellites, have traditionally been carried out through dedicated links. Shared links using Internet Protocol-based communication offers a number of advantages over dedicated links. The movement of spacecrafts however gives rise to mobility management issues. This talk will discuss various mobility management solutions for extending the Internet connection to spacecrafts. The talk with provide an overview of the network layer based solution being developed by the Internet Engineering Task Force and compare with the transport layer based solution that have been developed at University of Oklahoma in conjunction with the National Aeronautics and Space Administration. Network in motion is an extension of the host mobility protocols for managing the mobility of networks which are in motion, such as those in airplanes and trains. The application of networks in motion will be illustrated for both terrestrial and space environment.

Closing Session	**CLOSER**
18:30 - 18:45	**Room Auditorium**

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