Preface: Agents and semantic techniques as pillars of the as-a-service paradigm

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The SWISM and A4C 2012 Workshops brought together scientists, engineers, computer users, and students to exchange and share their experiences, new ideas, and research results about all aspects (theory, applications and tools) of intelligent methods applied to cloud and web-based systems, and to discuss the practical challenges encountered and the solutions adopted.

The Semantic Web/Cloud Information and Services Discovery and Management workshop (SWISM 2012) was held in Palermo, Italy on July 4th–5th 2012 in conjunction with CISIS 2010 Conference (Complex, Intelligent and Software Intensive Systems). We accepted ten excellent and interesting papers. All submissions were reviewed by technical committee members. We believe all of these papers and topics will not only provide novel ideas, new theoretical and experimental results, work in progress and state-of-the-art techniques in this field, but also stimulate the future research activities in the area of semantic web, ontology, grid, service-oriented architectures and web services. SWISM's program concerns itself, information retrieval, methodology and practice of semantic grid and web, semantic grid, ontologies, intelligent agents, knowledge management, semantic web, and semantic web services.

The Agent for Cloud Workshop (A4C 2012) was held in Calabria, Italy, September 24th–26th 2012 in conjunction with the IDC 2012 Conference (International Symposium on Intelligent Distributed Computing). We accepted four excellent papers. All submissions were reviewed by the technical committee members. They address cloud/agents programming and technologies discussing the practical challenges encountered and the solutions adopted, including monitoring QoS in cloud infrastructures, performance evaluation of cloud applications, cloud interoperability and agents-based cloud platforms. A4C's program concerns itself agents-based applications and services, brokering and trading models agents for ITC business, security mechanisms, simulation tools, autonomic systems, semantic cloud, and sky computing.

Application of semantic technologies to cloud computing is gaining momentum (Di Martino and Cretella, 2013), together with the adoption of the cloud computing paradigm in many scientific areas and application fields. Cloud service semantic discovery is a very desired feature in the current scenario where many cloud providers offer services using different terminology and models. The idea to use semantics for the development of cloud services was proposed for the first time in a book chapter by Chen et al. (2011). In that paper, it is suggested to add semantics to

WSDL using extensibility in elements and attributes supported by its specification. Using this extensibility, they relate existing WSDL constructs to DAML+OIL ontology. Their approach aims to store the semantic annotation of cloud services in the existing structure of UDDI and then provide and interface to construct queries that use ontological concepts to build a template to express service requirements. The matching between the request expressed by template and the services is performed by calculating semantic similarity between input and output and optionally between preconditions and effect. This approach is quite similar to the one adopted by the most of service discovery systems based on OWL-S (Burstein et al., 2004) and WSMO (Feier et al., 2005), which are the two most used languages to annotate web services. This approach, however, can not be used as a tool in the application development process.

A number of approaches, tools and systems, which may be used as support in the cloud application development process exist. Some initiatives aim to provide search engines specialised in discovering cloud services. A notable example is Cloudle (Kang and Sim, 2011), which is a multi-criteria cloud service search engine based on matchmaking and is not based on the classical approach of service description through standard language. In Cloudle, users can identify the cloud services queried by means of three kinds of requirements: functional requirement (like programming language for PaaS service type), technical requirement (like CPU clock or RAM for IaaS service type) and cost requirement (like maximum price) as input parameters. Cloudle inspects an internal cloud ontology through matchmaking algorithms and returns the list of cloud services ordered by service utility, which is determined by three similarity criteria. Differently from the Cloudie approach, the semantic engine (Cretella and Di Martino (2012) retrieves resources and API functionalities by specifying abstract functional level operations and functionalities, and application domain-oriented concepts and application patterns. mOSAIC's semantic engine distinguishes it from the above approaches because it:

- covers both the design and application deployment part
- extensively relies and promotes the cloud agnostic principles of application development
- aligns APIs of various cloud providers in a complex ontology
- captures the various complexity levels.

Agent-based cloud computing is concerned with the design and development of software agents for bolstering cloud service discovery, service negotiation, and service composition (Sim, 2012). Agents paradigm has been widely used to address negotiation and brokering problems and the applications in the cloud context have been provided by the scientific community in the last years (Amato et al., 2012). The current cloud computing technologies offer a limited support for dynamic negotiation of SLAs between participants. There are no mechanisms for automatic allocation of resources to multiple competing requests. Furthermore, current cloud computing technologies are not able to support customer-driven service management based on customer profiles and requested service requirements. It is impossible, according to Buyya et al. (2009), to derive appropriate market-based resource management strategies that encompass both customer-driven service management and computational risk management to sustain SLA-oriented resource allocation. The work presented in Kertesz et al. (2009) represents a first proposal to combine SLA-based resource negotiations with virtualised resources in terms of on-demand service provision, which involves multiple brokers. Cloud multi-agent management architecture is proposed in Cao et al. (2009). A simpler agents-based architecture has been also proposed in You et al. (2009). The implementation that was presented in Sim (2010) is very interesting from this point of view because it is supporting dynamic negotiations. Other investigations on related topics have been presented in Aversa et al. (2010) and Venticinque et al. (2011).

Also, the monitoring and management of distributed and cloud infrastructure using agents have been investigated. In Talib et al. (2011a), the authors introduce an integrity layered architecture of a typical cloud based on MAS architecture consists of two main layers cloud resources layer (cloud server-side) and MAS architecture layer (cloud client-side). In Ilarri et al. (2008) the authors claim that an approach based on software agents is a natural way to tackle the monitoring tasks in the aforementioned distributed environments. Agents move and distribute themselves to perform their monitoring tasks. Agents for monitoring of QoS on volunteer cloud resources have been investigated in Aversa et al. (2011). In Liu and Chen (2011), an optimal control of mobile monitoring agents in artificial-immune-system-based (AIS-based) monitoring networks has been studied. An agents-based platform that allocates service resources suitable for mobile devices in cloud computing environment is presented in Kim et al. (2011). Even if it is conceived for cloud customers, however, the proposed solution is targeted to agents programmers and not to cloud users, and does not address cloud issues, but uses cloud for improving supporting social media services. The A4C workshop includes also other topics like security that has been addressed in the context of agents an cloud by the scientific community. For example, in Talib et al. (2012) a comprehensive security framework based on multi-agent system (MAS) architecture for CDS to facilitate confidentiality, correctness assurance, availability and integrity of users' data in the cloud is proposed. Agents-based cloud data access is presented in Talib et al. (2011b) Agent-based testbed to simulate distributed workflow execution (Gutierrez-Garcia and Sim, 2012, 2013) or jobs scheduling over cloud infrastructure (Palmieri et al., 2013) are other examples of integrated utilisation of these two paradigms.

'Addressing the interoperability in cloud: the vendor agent' by Alba Amato, Luca Tasquier and Adrian Copie.

The paper addresses the problem of interoperability at IaaS level due to the current lack of standards and to the heterogeneity of technologies. An agent-based solution to abstract IaaS services for negotiation and management of cloud resources is presented. This abstraction, that is a wrapper to a specific provider technology, represents a key driver towards interoperability giving users the opportunity to choose and use services provided by many different cloud vendors based on various criteria, so helping to realise the true potential of cloud computing.

'A taxonomic view of cloud computing services' by Teodor-Florin Fortiş, Victor Ion Munteanu and Viorel Negru. Then authors identify and offer an overview of the major requirements for developing of a semantic repository for cloud services. Such a repository, set in the context of the envisioned cloud governance, could enable important steps in the lifecycle of cloud services, and offer relevant links with business part via operational support services. In the age of mobility of devices and people, many times a certain teacher, a student or a document must be integrated inside various different e-learning systems. Focusing on the computer science field, it is presented here a services-oriented solution for annotating and retrieving the documents and persons involved in this domain, enhancing their mobility inside the pervasive e-learning systems. The solution is based on the ACM classification system, which is used in order to develop user competence profiles, to annotate materials, and to retrieve them. The ontology-based retrieval mechanism will investigate not only the matches with the concepts involved in a query, but also with their related concepts inside the ACM classification system; the ranking algorithm will consider the documents content as well as the user competence.

'How to monitor QoS in cloud infrastructures: the QoSMONaaS approach' by Giuseppe Cicotti, Luigi Coppolino, Salvatore D'Antonio and Luigi Romano. The contribution falls in the area of quality of service monitoring in cloud computing environments. The paper presents a reliable and timely QoS monitoring application, called QoSMONaaS, which focuses on the quality of service delivered at the business process level. QoSMONaaS is based on the *as a service* paradigm, and can thus be made available to any cloud user in a seamless way.

'Performance prediction of cloud applications through benchmarking and simulation' by Antonio Cuomo, Massimiliano Rak and Umberto Villano. In this work, the authors propose a methodology for evaluating Clouds Services performance through the adoption of the mOSAIC framework. The target of predictions are mOSAIC applications, described through a file (the descriptor), and composed of cloudlets, distributed software agents that cooperate through cloud resources as queues and KV stores. The proposed methodology automatically generates a set of benchmark applications and of simulation models that can be used to evaluate the cloud providers and to predict the performance behaviour of the target application under different workload conditions.

'Managing 3D objects for real world scenes reconstruction' by Flora Amato, Antonino Mazzeo, Vincenzo Moscato, Antonio Picariello and Carlo Sansone. In this paper, the authors present a framework that allows to create a 3D complex scene using a novel 3D data model and query algebra and to link such data to heterogeneous multimedia information, as a platform for several real applications in different domains. The model is enough powerful to include nowadays 3D web standards such as Collada and X3D. Several examples are provided and preliminary results are discussed, showing the main advantages of the proposed system for both 3D objects building and retrieval goals.

'Semantically driven documents composition in CloSe cloud system' by Flora Amato, Antonino Mazzeo, Nicola Mazzocca and Sara Romano. In this work, the authors propose the evolution, in cloud technology, of a monolithic system architecture for document processing, based on semantic methodologies, that we have developed in the past years which offers editing/composing aiding services. Migration guarantees several advantages in terms of usability, scalability and fault tolerance. The proposed system will help the users in the process of writing documents, exploiting information and data contained in apposite document bases, collected from heterogeneous sources, in order to suggest proper fragments to be inserted into the document.

'Agents-based deployment of heterogeneous IaaS clouds' by Călin Şandru and Salvatore Venticinque. The paper concerns the provisioning of computing resources and deployment of applications using heterogeneous infrastructure as a service (IaaS) clouds. The addressed issues include problems related to SLA brokering, integration of different technologies used by providers, proposed standards and vendor lock-in problems. The paper presents design and development, within the research activities of the mOSAIC European Project, of an agents-based solution that provides a uniform interface to IaaS provisioning and management. The cloud agency uses a set of vendor agents implementing adapters to different commercial cloud providers and open source cloud technologies. Starting from the computational constraints and from the application requirements the vendor agents allow the users to negotiate the best IaaS solution that is available in the cloud market and to build and deploy his/her cloud infrastructure.

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