RELATE: A Research Training Network on Engineering and Provisioning of Service-Based Cloud Applications

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ABSTRACT

The RELATE Initial Training Network (ITN), funded by the EU in the Marie Curie Actions programme, is a multidisciplinary training network of European academic and industrial partners working together to train academic researchers and next generation experts in the area of engineering and provisioning of service-based Cloud applications. In this paper, we present the up-to-date goals and strategy of the RELATE project and give an overview of the ongoing research activities within the training network.

Categories and Subject Descriptors

C.2.4 [**Computer-Communication Networks**]: [Distributed Systems-Cloud Computing]

General Terms

Design, Performance

Keywords

service-based applications, optimization, adaptation, MDE

1. INTRODUCTION

Cloud Computing poses a definite change in the provisioning of IT resources and services. The emergence of Cloud Computing in combination with the advancement in mobile computing poses new challenges in the area of service engineering and provisioning. Service operation is decoupled from the service access layer to form a new service provisioning model where everything is being provided as a service (XaaS). Thus, the decoupling of the Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) layers that are under different administrative control make the design and delivery of next generation IT services within the cloud landscape a challenging task [7]. In particular, the increased system complexity and dynamics of the future cloud service ecosystems together with the separation of service providers and infrastructure providers leads to inability to provide QoS and dependability guarantees. Furthermore, new threats and vulnerabilities due to resource sharing jeopardise the security in cloud service ecosystems and lead to lack of trust towards the cloud service providers.

The RELATE ITN aims to address the above challenges by designing and developing novel concepts and mechanisms for QoS management taking into account the separation of infrastructure and service providers. In that respect, an important research area in the RELATE project addresses the run-time service optimization and adaptation in cloud-based platforms that may consist solely of cloud infrastructure, i.e., data centre infrastructure or may include the service access layer consisting of devices with heterogeneous computing capacity, e.g., mobile devices or laptops. Model-driven service engineering, ontology-based modelling, and different optimization techniques are used to tackle the problems of appropriate design, configuring and composing multiple elementary cloud services to build high level business processes. To this end, several topics concerning the service design and optimization span over the PaaS and SaaS layer. In addition to these research activities, cross-cutting issues such as the resource modelling in cloud infrastructures, the trust and reputation modelling and the dependability issues are being considered within the RELATE project. Finally, a better insight of the possible benefits and hurdles of cloud adoption and selection of cloud providers from a cloud consumer's perspective is part of the ongoing research activities.

Although the different topics in RELATE span over different service layers and hardware infrastructures, they cooperatively form the vision of the RELATE project to investigate the whole value chain of cloud services and promote the state-of-the-art in the engineering and provisioning of service-based cloud applications. To this end, the overall goal of the RELATE project is to inspire early-stage and experienced researchers to deepen their knowledge beyond the scope of their specific topic and to obtain solid back-

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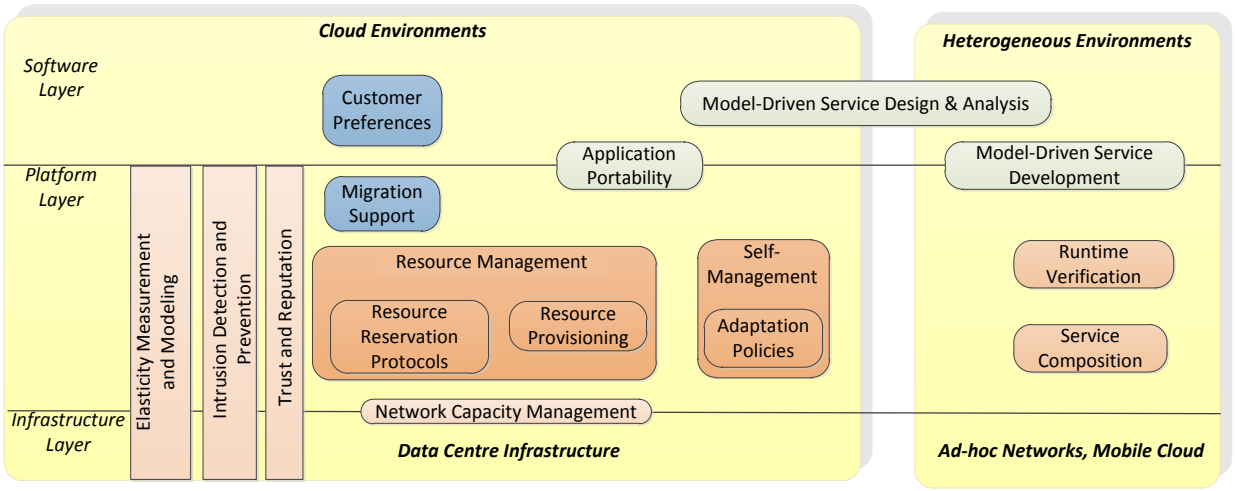

Figure 1: Research Topics Overview

ground knowledge in the area of Cloud Computing. In this paper, we present the goals and strategy of the RELATE ITN and we give an overview on the ongoing research activities within the project.

2. RELATE GOALS AND STRATEGY

The goal of the RELATE ITN project is two-fold: (a) to train researchers in the area of service-based cloud applications, and (b) to advance the state-of-the-art in the related areas of model-driven engineering and formal methods, security, performance, trust and quality management in service-based cloud applications. To this end, academic and industrial partners across Europe formed a cooperative training network in an effort to educate and train the 21 fellows (including 17 early-stage and 4 experienced researchers) within the network. Each fellow is in charge of an individual research project that tackles a specific research topic within the area of service-based cloud applications. The individual research topics form a research roadmap that covers the areas of service engineering, optimization, performance, trust and quality management.

3. RELATE RESEARCH AREAS

In this section, we give an overview of the ongoing research activities in the RELATE ITN project by presenting the main research challenges that RELATE aims to address. Fig. 1 gives an overview of the research topics investigated within the ITN. In the next paragraphs, we discuss the main research challenges that are tackled within the project classifying the individual research topics in four main research areas:

Model-Driven Service Engineering. The design and development of service-based cloud applications is one of the main research areas in which RELATE aims to contribute. Within the scope of this research area, problems related to the support of service variability, adaptability, portability and provenance-awareness are addressed. In particular, one of the main research challenges is to extend modelling languages to express the variability that typically characterizes cloud computing environments. In order to tackle this problem, techniques from Software Language Engineering and Software Product Lines are applied. Beyond the modelling of service variability, there is a need for designing an analysis framework of provenance awareness for service composition, in order to detect at design time if the selected services are provenance aware, i.e., they can answer future expected queries of the users. To this end, provenance data specifications should be provided for assisting the service composition at design time [18]. Moreover, existing approaches fail to fully address the adaptability of cloud applications in heterogeneous resource environments spanning from mobile terminals to cloud infrastructure nodes. To this end, model-driven service design and development could be used to enable the adaptation of cloud applications [3, 12, 9, 2]. FFinally, another important research challenge relates to the portability of cloud applications, i.e., creating applications such that they can be deployed on multiple target cloud platforms with as few changes as possible [10]. This issue is extremely important to avoid lock-in effect, which is considered to be one of the main risks in adopting cloud computing solutions.

Run-time service management, optimization and adaptation. Beyond the service optimization at design-time, this research area aims to promote state-of-the-art in the run-time service management, optimization and adaptation. The research problems addressed within this area are mainly motivated by the limitations of existing solutions to provide QoS guarantees and adapt cloud services according to dynamic conditions. One of the main research challenges within this area, is to reduce the inherent uncertainty of resource consumption in cloud computing environments that leads to difficulties in controlling resource allocations from an infrastructure provider's perspective and uncertainty in the operational costs from a service provider's perspective. In that respect, a resource reservation mechanism that projects the resource needs by analysing workload predictions, usage patterns and service monitoring data is necessary [14]. Related to the efficient resource management, resource pro-

visioning algorithms should be able to handle different optimization goals dependent on the current system load and the up-to-date user requirements. Since current approaches in resource provisioning for cloud computing environments address this problem by considering only some of the optimization goals, there is a need for providing a flexible model that can adapt to different optimization goals according to the specific needs [4, 15]. One step further, self-adaptation does not relate only to resource management adaptation, but also to other actions that may include software adaptation, service replacement, etc. Therefore, self-adaptation mechanisms are necessary to enable the autonomous adaptation of cloud services according to the different event triggers. In that respect, the adaptation policies of the cloud provider can be defined through the use of ontologies [6, 5].

Beyond the service management in large data centres that typically form the hardware infrastructure in the Cloud, the consideration of the service access layer that may consist of highly volatile environments (e.g., ad-hoc networks) motivates the need for run-time service optimization and adaptation in heterogeneous environments. Since these heterogeneous environments have different characteristics (dynamics, reliability, etc.) compared to data centre infrastructures, different mechanisms for service optimization and adaptation have to be designed for such systems. To this end, there is a need for continuous validation of services to find the optimal configuration to meet a given set of user requirements in a dynamic environment such as a pervasive system. In particular, self-adaptation techniques for distributed systems should be analysed by defining which adaptations can be done at design time and which ones at run-time. Finally, the problem of service composition becomes challenging in the setting of highly dynamic distributed and heterogeneous environments. In that respect, a major research challenge becomes the automated exploration and maintenance of optimal composition configurations based on dynamic user preferences and conditions [8].

Cross-cutting concerns: Security, Trust, Performance modelling. Cross-cutting concerns relate to security, trust and reputation and performance modelling issues. A main research challenge in performance modelling is the design of a model for describing the cloud resources in IaaS layer. Existing approaches do not support modelling the network properties of cloud infrastructures. Therefore, a holistic approach that models both the computing as well as the networking infrastructure should be applied [16, 17]. Related to performance modelling, there is a need for the definition of an elasticity metric for cloud services. The existence of well-defined elasticity metrics will enable, on the one hand, cloud providers to differentiate their services based on the achieved elasticity and, on the other hand, cloud service users to compare cloud services with respect to their elasticity. On the cross-cutting issue of security, new threats and vulnerabilities emerge due to resource sharing. In that respect, the evaluation of Intrusion Detection Systems (IDS) in cloud computing environments become challenging. Therefore, there is a need for the systematization of knowledge on benchmarking IDS and the design of an architecture for IDS evaluation in cloud environments [13].

Customer-driven service evaluation and selection. This research focuses on the service evaluation and selection from the customer's point of view to decide on the appropriateness of cloud services offered in the market. Given that the cloud market is still immature, it is essential to get insights on the way that customers perceive cloud adoption and selection of cloud services. Moreover, since there is a lack of standard mechanisms to assist cloud service users and to build appropriate mechanisms and tools that help users during the decision making process, a major research challenge is to support enterprises in migrating to the cloud [11, 1]. Special considerations of this problem relates to the legislation and performance issues when enterprises move a part of their services to a public Cloud.

4. CONCLUSIONS AND SUMMARY

We presented an overview of the structure and research goals of the RELATE ITN project. As a first step towards the realization of the RELATE goals, the project established a network of academic and industrial partners in an effort to train high calibre researchers and experts in the area of service-based cloud applications. The main research challenges currently being addressed by the individual research projects within RELATE were discussed and summarized. The presented research roadmap will drive the future research activities of the fellows in an effort to advance the state-of-the-art in the area of Cloud Computing.

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