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A Framework for Comparing Cloud-Environments

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***Abstract*—Cloud-services are more and more part of so-called cloud-environments. Cloud-environments provide a set of cloud-services and resources. Management interactions allow configuring services and resources to individual requirements. Enterprises selecting a cloud environment have not only to consider the functionality of the cloud-services, but also the management interactions offered by the cloud-environment. Therefore, a framework for the comparison of cloud-environments is introduced. It uses meta-services to specify both the functional and non-functional properties of t management interactions.**

I. Introduction

CLOUD-computing [1], [2] integrates concepts and ideas such as service-oriented computing [3] and information systems outsourcing [4] [5] in order to realize utility computing [6]. Cloud-Services are services provided by services providers using the cloud-computing approach [1] [2]. Cloud-Services may be software-, platform or infrastructure services (SaaS/PaaS/IaaS) [1] [2].

In the beginning, cloud-services have been offered in isolation. Nowadays cloud-services are more and more offered as part of so-called cloud-environments. Prominent examples are Office365 [7] and Google Apps [8]. They provide a set of cloud-services such as text-processing, email, spreadsheet calculation and provide storage for text and spreadsheets. Cloud-environments provide management interactions in order to adapt cloud-environments to individual requirements. There are three basic types of management interactions: integrate/disintegrate, configure, and import/export as shown in Fig. 1. The first kind of interaction is the integration of services (1) and resources (3) into the cloud-environment. To finish the usage of a source or resource, there is also a disintegrate interaction. E.g. both Office 365 and Google Apps allow to integrate the active directory services [9]. Integrated services and resources can be used for service provisioning but remain outside the sphere of control of the cloud-environment.

Resources, however, can also be moved into the cloud-environment. To do so, an import interaction is provided (4). To avoid a vendor-lock-in, it must be possible to export resources. Both Office 365 and Google Apps allow to import files up into the cloud-environment or to export them. The configure interactions allow to adapt services (2) and resources (5) to individual requirements. E.g. it is possible to configure the email services by changing the reply-address, defining an out-of-office message etc.

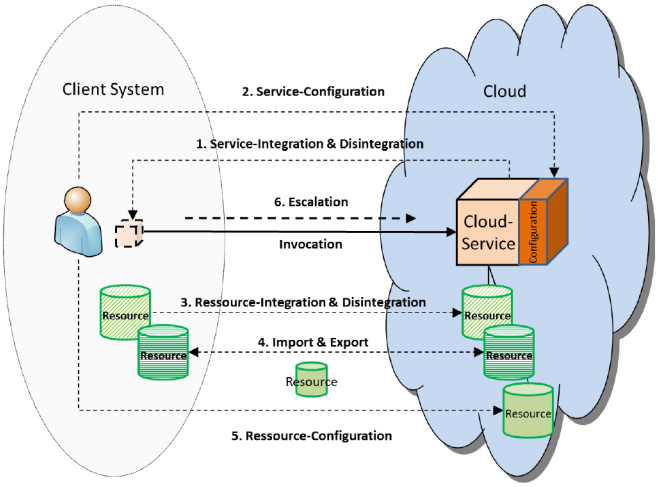

Fig. 1 Management interactions with Cloud-environment

There are a number of approaches to describe cloud-services in the same way as other types of services, e.g. the Unified Service Description Language [10]. However, these approaches do not consider management interactions. Thus, the description of cloud-environments remains incomplete. Therefore, in this paper a framework for the description and comparison of cloud-environments is introduced. The framework uses meta-services [11] [12] to formalize the management interactions.

The paper proceeds as follows. First a formalized description of cloud-environments it is created. Then meta-services are used to represent management interactions. Using them a comparison framework for cloud-environments is created. It is then used to compare two popular cloud-environments, Office365 [7] and Google Apps [8]. Finally, a conclusion and outlook is given.

II. FORMALIZING CLOUD-ENVIRONMENTS

To create a solid basis for the framework, cloud-environments have to be formalized. Cloud-environments contain services and resources which can be configured to individual requirements. Thus, a cloud-environment can be regarded as a configuration of services and resources, as shown in Fig. 2. A configuration consists of a set of configuration items representing individual services or resources. Configuration items can be associated in different ways. By introducing the entities configuration and configuration item, it is possible to separate abstract specifications from the real services and resources. Thus, a layer of indirection is created that allows assigning real services and resources.

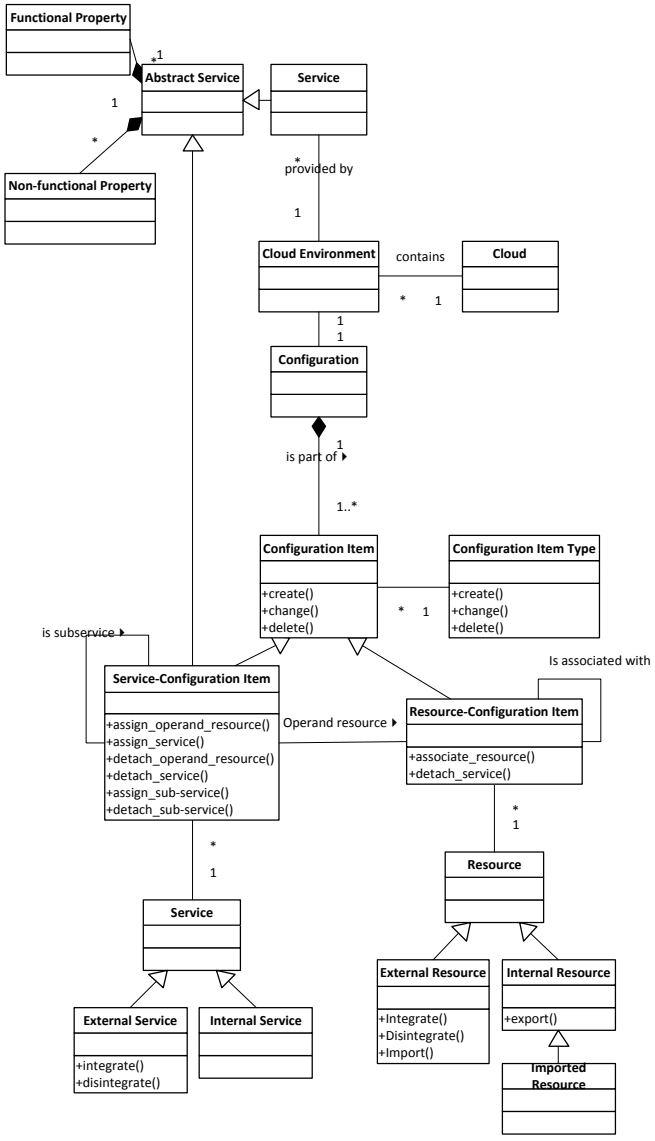

Fig. 2 Formalized Cloud-environment

There are two types of configuration items, service and resource configuration items. Service configuration items specify services to be used for service provisioning. Resource configuration items specify resources to be used for service provisioning. Both service and resource configuration items may be nested. The configuration items can be connected in different ways to represent the relationships of services and resources. Services may use sub-ordinated services in order to provide a service. Service may act upon resources. Resources may be associated with one another.

Both services and resources are differentiated into internal and external ones. External services and resources may be used by the cloud environment for service provisioning. They are outside the sphere of control of the cloud environment. That means the service or resource cannot be influenced in its lifecycle status by the cloud-environment. On the contrary, internal services and resources can be influenced by the cloud-environment in their lifecycle status.

It may be necessary to move a resource into the sphere of control of the cloud-environment in order to manage it more efficiently, e.g. change it in the context of a transaction [13]. To do so, an external resource is imported and becomes an imported resource. Both imported resources and internal resources in general may be outside the sphere of control of the cloud-environment. Therefore not only an import but also an export operation is provided.

The entities of the formalized cloud-environment and the operations defined on them can now be used to represent the management interactions of cloud-environments. Especially differences in the power of management interactions can be expressed exactly. Integration interactions may offer three levels of variability. First, it may be possible to integrate every type of service or resource. This can be expressed by the creation of new entities of configuration item types. Then, concrete services or resources may be assigned. Second, only the integration of services and resources of predefined types may be possible. This is expressed by the creation of configuration items. Third, also the cardinality may be restricted. In this case, it is only possible to assign services and resources to already existing configuration items. Also, the possibilities to change the assignment between configuration items and services and resources can express important properties of the cloud-environment. The capability to change the assignment of services and resources expresses the capability to replace cloud-services. If this capability is missing, the set of cloud-services may be extended, but the assignment of the already existing services may not be changed. The disintegration of a service or resource can be described as deletion of a configuration item. The configuration of services and resources is denoted by the modification of configurations items and their relationships.

III. COMPARING OFFICE 365 AND GOOGLE APPS USING META-SERVICES

At first sight, it seems to be sufficient to define the functionality of the interactions only. However, to an enterprise is may be a very decisive point, how fast and

reliable management interactions are performed. Therefore, to represent both the functionality and the non-functional properties management interactions, meta-services [11] [12] are used. Meta-Services are services acting upon services [11]. Thus, the interactions are defined as services acting upon the cloud-services and their resources.

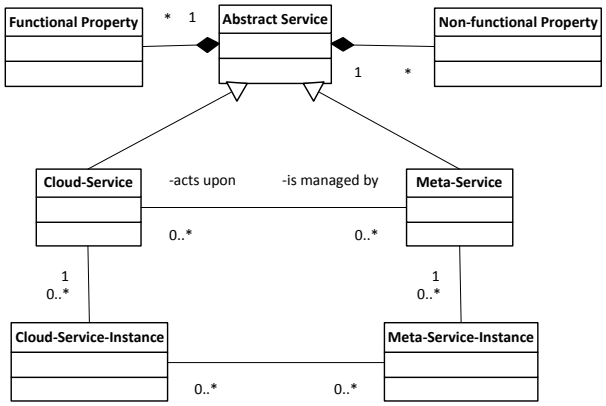

Fig. 3 Meta-Services

Using meta-services also has the advantage of creating a homogeneous approach for describing both services and management interactions. The meta-services identified create a framework for the comparison of cloud-environments. To evaluate it, two popular cloud-environments shall be compared: Office365 [7] and Google Apps [8]. The results are summarized in tables containing the functionality of the meta-services and their non-functional properties, as far as available. Non-functional properties are written in italics.

A. *Integration-oriented Meta-Services*

Office 365 does not allow enlarging the set of services and resources. This incapability can be described as the lack of a meta-service to create service and resource configuration item types.

However, Office365 allows the integration of predefined services such as the Active Directory Service [9]. A configuration item represents the external active directory service. Also, the integration of resources is restricted: it allows integrating Azure-based resources, only. All integration meta-services are immediately effective.

TABLE I.
COMPARING THE INTEGRATION ORIENTED META-SERVICES

Cloud-environment	Integration		Disintegration	
	Service	**Resource**	**Service**	**Resource**
Office 365	Active Directory	Azure resources	Yes	Yes
	Immediately	*Immediately*	*Immediately*	*Immediately*
Google Apps	Gadgets	File resources using an adapter	Yes	Yes
	Immediately	*Several hours*	*Immediately*	*Several hours*

Google Sites allow integrating external services into web pages using gadgets. Again, only an existing configure item can be used to represent a predefined type of service, but no integration of arbitrary types of services can take place. The integration takes place immediately. File resources can be integrated using an adapter. They allow to access external services. As same as Office 365, Google Apps allows integrating an external Active Directory Service [9]. Integration may take several ours due to the configuration effort. Office 365 supports the disintegration of integrated services and resources; the same applies to Google Apps. The non-functional-properties are the same as for the integration meta-services.

B. *Import/Export Meta-Services*

Office 365 supports the import and export of documents either manually or in batch mode. User accounts can be imported. Google Apps supports the import and export of documents both manually and automatically. There is also the possibility to import user accounts.

C. *Configuration Meta-Services*

Both Office 365 and Google Apps allow changing the configuration of the services and resources already available. Thus, both provide meta-services for changing configuration items of services and resources. Changes become effective immediately. Office 365 does not allow deleting services or resources from the cloud-environment. Google Apps allows deleting services that have been added using the Google apps Marketplace. This may need one day.

IV. RELATED WORK

Up to now, there are only some ad-hoc approaches for identifying management interactions in the context of services. In [14], a first approach for capturing interactions in the context of cloud-services is developed. However, this approach only considers interactions for defining services and does not support other kinds of interactions. The approach in [15] provides means to model conversations within complex web-services. In particular it allows specifying valid operations in every status of the web service. However, it handles the operating phase only. The WSDM-standard created by OASIS (Web Services Distributed Management) [16] is based on the OASIS Web Services Resource Framework (WSRF) [17]. The WSDM-standard manages the operational status of web services, but not the interactions outside the operation phase of the web service. One of the earliest ones is the Web Service Description Language [18] which has been augmented by the following approaches: The Web Service Modelling Ontology [19] provides the semantic description of web services in order to facilitate the discovery, combination and invocation of web services. It is limited to the static properties of web services and does not take into account their life-cycle. OWL-S [20] is an ontology describing web services by a profile, grounding and a process. However, it does only cover the operational phase of the service. The grounding defines how to interact with the service. To do so, a mapping

between the process of the process model and concrete operations in WSDL is defined.

Cloud-environments relate to the term service system introduced by Maglio et al. [21]. They define a service system "as an open system capable of improving the state of another system through sharing or applying its resources and capable of improving its own state by acquiring external resources". Thus, service systems parallel with cloud-environments by the ability to acquire resources. However, there is no formalization of service systems so far.

Nevertheless, the literature on service systems confirms the separation between abstract configurations and concrete services and resources. In [22] a service system is defined as "a value co-production configuration of people, technology, other internal and external service systems, and shared resources (such as language, processes, metrics, prices, policies, and laws)".

V. Conclusion

Cloud-services are more and more embedded into cloud-environments. Cloud-environments contain a set of cloud-services such as text processing, email. Cloud-environments also provide interactions to configure services, integrate resources etc. Therefore, the existing means for describing services had to be extended by means for capturing the interactions provided by the cloud-environments. To accomplish this, a description of cloud-environments have been analysed and formalized. The conceptualisation of cloud-environments has been used to define meta-services representing the interactions provided by cloud-environments. These meta-services create a framework, that allows to compare different cloud-environments not only by the functionality of the cloud-services provided, but also by the capabilities for configuration, integration, import and export.

The meta-services identified are of particular importance because their availability within a cloud-environment strongly influences the value provided by a cloud-environment offered. To a customer not only the functionality provided by the cloud-environment is important, but also possibilities to tailor the cloud-environment to individual needs or to adapt it to changed requirements. Furthermore, by describing the interactions as meta-services, not only the possibility to configure, integrate resources etc. is described, but also the time necessary to perform such interactions is defined, as same as a number of further quality attributes. By this means the definition of the meta-services of a cloud-environment becomes a metric for the agility of the cloud-environment.

Further work will have to give more details on the framework. In particular, not only the meta-services itself but also their results should be described. E.g. the integration of resources may lead to different levels of integration. There may be a read-only access, a write access and there may be an transaction-protected integration.

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