Modelling Dependencies of IT Infrastructure Elements

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I. *Introduction*

The management of IT-Infrastructures has gained increased relevance to business as business processes and thus the business profit rely on IT services, which in turn depend on the underlying infrastructure [1].

Even one single distributed IT service already depends on the correct interaction of many distributed IT resources within the IT infrastructure. The term *service infrastructure* in this context denotes the IT infrastructure resources which are involved within a service and are thereby in a relationship among each other. The behaviour of an IT service during its production-time manifests itself by changing attribute states of the enlisted IT resources for instance a rising load of a CPU or an increased network throughput of an interface. Generally speaking, the state of an IT resource can be described by attributes and actual attribute values (e.g. attribute = "CPU-load", value = "3"). But the change of one attribute value of a single resource may have also an effect on the state of other resources and thereby on other services. Based on this observation, we define a *resource dependency* as a coherent change of values of attributes of IT resources. This means the change of one value B is caused by the change of a value A. Thus A is the antecedent and B the dependent value. More than one dependency between two resources is possible, also with diverse directions (antecedent, dependent). Following [2] one dependency between N different values can be decomposed into a set of dependencies regarding only pairs without loss of generality.

The changing states of resources and resource dependencies manifest the *behaviour of the infrastructure* and is correlated with the *behaviour of a service* facing the user and thus with the *service quality*. Thereby resource dependencies are of interest in the context of BDIM [3],[4].

II. *Focus and Scenario*

Models from the *service design* stage provide information about functional static resource relations. Such models are necessary and valuable but from an operational point of view they need to be enhanced by adding information about (critical) resource dependencies identified at production-time of a service. Therefore we focus on the following management related question:

- Assuming a resource dependency was identified, how can this information about its existence be processed in a way that management applications can cope with it as a managed element?

Regarding management architectures this implies analysis how to express dependency knowledge within the information model. Thus we ask for an appropriate information model for distributed management architectures to support this demand.

Although naturally of basic interest in this context we neither address in this work the question of how to automatically derive dependency information from measured values of resource attributes, nor do we aim at investigating *behaviour modelling*. Such demands have to be investigated in detail separately.

A. Scenario

Figure 1 gives a functional, static view of a prototypic infrastructure: An *E-Mail transport service* and a typical *Webmail service*. The Webmail-service use a *Directory service* for the purpose to authenticate users.

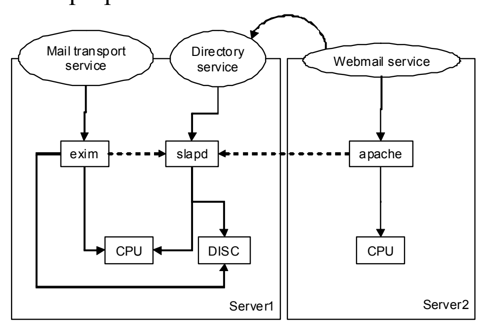

Figure 1 Scenario for Investigation

The *Directory service* can have impacts on service level agreements on both the *Mail transport service* or the *Webmail service* due to the fact that it competes for physical resources which it has not for exclusive access. This is a simple example for overlapping service infrastructures.

The following resource dependencies can be stated:

- exim:mailqueue-size <> slapd:response-time
- slapd:response-time <> apache:response-time

and thus

- exim:mailqueue-size <> apache:response-time

Especially the last (inter)dependency induced through the overlapping service infrastructures, cannot be derived from the design of the single services.

III. Generic Approach Modelling Dependencies

To model *resource dependencies*, based on the initial proposed assumption taking the attributes and attribute values into account, we need an adequate information model. We initially use a generic approach for a Meta model and an Infrastructure model to be free of disadvantages of existing models. The Meta model defines shape, appearance and behaviour of the model elements of the Infrastructure model.

B. *Meta Model, Infrastructure Model*

To achieve the possibility to fix dependencies within the Infrastructure model by values of attributes, this has to be modelled within the Meta model. This particular behaviour is otherwise not expressible in the Infrastructure model without loss of generality.

We applied similar to [2] the concept of entity as a central element to our Meta model: An entity is a distinct definable object, on which information can be assigned. As these objects can be either physical or insubstantial, by using the term entity, we achieve an abstraction from the real character of the very objects.

Figure 2 shows the Meta model elements in conjunction with the instantiated Infrastructure model elements in terms of an UML class diagram..

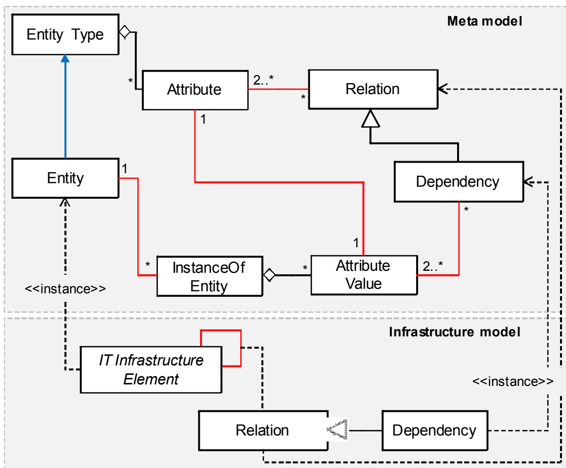

Figure 2 Meta Model - Instantiated Infrastructure Model Elements

The Meta model (Figure 2, upper half) separates the static (functional and structural) view, using the model elements *Entity* and *Attribute,* from the dynamic (operational) view, using the element *InstanceOfEntity* and *AttributeValue*. An *Entity*, is a specialization of an *Entity-Type* which in turn is composed of one or more *Attribute* elements, while an *InstanceOfEntity* element is characterized by one or more *AttributeValue* elements. According to this draft, a *Relation* exists between *Attributes* and thereby between *Entity* elements while a *Dependency* exists between *AttributeValue* elements.

IV. *CIM Integration*

As a proprietary attempt is not reasonable for a wider acceptance we integrated our approach into CIM [5] as a widely used, standardized information model in the area of IT management. Compared to our concept of resource dependency

- the CIM Meta model defines the association root element *association* between *class* elements, but not between *property* elements.
- the CIM metrics model affords modelling concrete values of managed elements through the notions of *MetricValues* or the *UnitOfWork* concept, but there exists no possibility to directly express dependencies between *MetricValues* respectively *UnitOfWork* elements.

To integrate our approach into CIM we built an appropriate CIM extension schema using MOF (Managed Object Format, [5]), based on elements of the CIM Core Schema and the Metrics Model. This extension schema was then used for a prototypic WBEM-based (www.dmtf.org/standards/wbem) management application to capture the information about resource dependencies of our simplified scenario as managed elements.

V. *Summary and Outlook*

Our work presents an approach to model resource dependencies among IT infrastructure elements. Although our proposed attempt formalizing dependencies within IT infrastructures is very basic we see many aspects of application. As the relation and dependency elements of our model may be flexible enhanced adding attributes, calculation rules, etc., possible benefits could be:

- Assignment of properties to dependencies and relations elements as proposed in [2] or [6]. For example to support root cause analysis to identify service performance degradation caused through resource dependency problems.

An aspect directly concerning the BDIM approach:

- [7] presented a monitoring architecture acting on metrics collected from instrumented web services. Our approach may be used to enhance the monitoring architecture with relevant management information and options: (1) Integration of infrastructure relevant management information. (2) Directly traceable impact of infrastructure elements to services.

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