DEFINING THE SEMANTICS OF IT SERVICE MANAGEMENT MODELS USING OWL AND SWRL

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Abstract: Service management is a set of specialized organizational capabilities that provide value to customers in the form of services. Many organizations are aware of the need to adopt best practices in order to create an effective *IT Service Management* (ITSM) for enabling Business and IT integration. However, the reuse and interchange of service models is still quite limited in the area of IT service support due to the problems in connecting with natural language. In this context, this paper presents the *ITIL-based Service Management Model* aimed at capturing ITSM best practices by means of a formal ontology-based business DSL (*Domain-Specific Language*). We show how this DSL can be formally represented adopting the *Web Ontology Language* (OWL) and the *Semantic Web Rule Language* (SWRL). This ontology will precisely define the semantics associated to *IT service management models*, enabling different tools to interchange them without ambiguities. These models will be defined just in terms of the business logic, without any architectural or platform-specific consideration. That is, according to the OMG's four-layered architecture, the proposed model could be placed at a CIM level.

1 INTRODUCTION

IT Service Management (ITSM) is one of the fastest growing fields nowadays that includes a set of specialized organizational capabilities and a professional practice supported by an extensive body of knowledge, experience and skills for providing value to customers in the form of services. However, the complexity of both service management and the development of the supporting information systems is still a challenging problem in the industry.

In this paper, we study how current advances in the area of ontologies, domain-specific modelling languages and model transformations can be used in the context of IT service support.

Our research goals are to demonstrate: 1) how the knowledge of ITIL (*Information Technology Infrastructure Library*), the best practice guidance in ITSM, can be captured and formally described in a business *Domain-Specific Language* (DSL) by means of an ontology, and 2) how this ontology-based DSL can also be used as basis for building a variety of ITIL-compliant information systems that underpin the IT services applying a model-driven approach.

We aim at translating perceptions (*semantics*) of the "real-world" expressed in natural language to an ontology which is a formal representation of the IT service management domain. The proposed ontology defines an optimal management of IT services that enables to draw inferences and automated reasoning. Due to their deep semantic support, the resulting specifications can be reused and interchanged among different tools, avoiding ambiguities, uncertainties, and contradictions. Also, as a DSL, our ontology can be used in the area of Software Engineering addressing the process of domain modelling. Therefore, we can use the ontology as a description of a formal DSL to obtain lower level domain models by means of (automated) model

transformations. These target models will describe high-level requirements of software systems that implement the tasks defined as part of the IT service management models.

The rest of this paper is structured as follows. Section 2 covers the background. Section 3 summarizes the processes we followed for creating an ontology from ITSM best practices. We describe how constraints can be modelled and executed in Section 4. Finally, we conclude in Section 5 with some final remarks and outlines future work.

2 BACKGROUND

2.1 IT Service Management

Due to the popularity of shared services and outsourcing, IT services need to evolve and must be adapted quickly to new needs and technologies of different organizations. Services must improve their functionality, and fulfil the business requirements in the least time possible and with an acceptable estimate. This means that organizations should apply an appropriate management of the services, providing a business focus to enable integration between business and IT.

There are several well established good practice frameworks used to create an effective IT Service Management system. Nowadays, ITIL (http://www.itil-officialsite.com/ home/home.asp) is the best known and most widely accepted guidance and it has become the de facto standard for ITSM.

For sake of clarity, we select only one part of ITIL to describe the work presented in this paper: the *Incident Management* process from the *Service Operation* stage. From a customer viewpoint, *Service Operation* is where actual value is seen (OGC, 2007). The *Incident Management* process helps *IT service providers* in evaluating how customers perceive a specific service. Also, this process is a relatively simple one with a reasonable number of classes and properties associated.

2.2 The Model-Driven Engineering

The emerging *Model-Driven Engineering* (MDE) addresses the inability of third-generation languages to cope with increasing software complexity, allowing designers to describe domain concepts effectively (Schmidt, 2006). MDE revolves around models (defined in terms of formal meta-models), and model transformations, which provide a powerful mechanism for incremental and automatic software development.

The *Model-Driven Architecture* (MDA) approach (OMG, 2003), defined and supported by the *Object Management Group* (OMG), defines a particular MDE process aimed at separating the business logic from the technological platforms. MDA proposes three modelling layers specified as MOF meta-models, namely (ordered from highest to lowest levels of abstraction): CIM (*Computation Independent Models*), PIM (*Platform Independent Models*), and PSM (*Platform Specific Models*). From a Software Engineering perspective, ontologies are considered as descriptions of CIMs.

3 AN ONTOLOGY FOR REPRESENTING ITIL-BASED SERVICE MANAGEMENT MODELS

In this section, we discuss an approach to build an ontology-based DSL for ITSM from the *ITIL Service Management Model*, aimed to take advantage of the ontologies and the model-driven approach capabilities. The Onto-ITIL is the representation of the *ITIL Service Management Model* formalized by means of a MOF-compliant DSL, aimed to enable the formal creation of models, which can be processed and transformed by means of different modelling frameworks, such as the *Eclipse Modelling Framework* (EMF).

Our approach allows organizations (*IT service providers*): (1) to catalogue the best practices in ITSM, (2) to obtain a simplified representation of *ITIL Service Lifecycle*, (3) to provide a common shared domain conceptualization of ITSM, (4) to formally define the elements of the *ITIL Service Lifecycle* and their interactions in a machine-processable way, (5) to adopt and adapt ITIL according to the needs of the organization, (6) to focus in a specific process in order to implement it, (7) to enable the separation of the meaning from the processing and (8) to obtain a high-level requirements model. This model can be reused to develop the information systems that underpin IT services by means of model transformations in the context of MDE.

The proposed ontology is defined by adopting the *Web Ontology Language* (OWL) (Smith et al., 2004), which provides automated and efficient reasoning facilities, together with the *Semantic Web*

Rule Language (SWRL) (Horrocks et al., 2004) for the semantic constraints and knowledge inference.

The open source Protégé-OWL tool (http://protege.stanford.edu/) is used in this research as an ontology editor to demonstrate the applicability of our work. Protégé includes the SWRLTab which is an extension for editing and executing SWRL rules in conjunction with Jess (http://www.jessrules.com/), a rule engine.

3.1 Onto-ITIL Principles

The IT service management model proposed in this work is based on two concepts and two relations. The concepts are *specification* and *activity*, and the relations are *coordination* and *conformance*: an *activity* represents the actual ITIL-based activity carried out by an organization and is said to be *coordinated by* an *organization specification*, and an *organization specification* is said to conform to its *ITIL specification*.

These principles enable us to provide a definition of what is an IT service management model in the Onto-ITIL context.

3.2 Onto-ITIL Ontology

In order to take advantage of existing ontologies to create our approach for ITIL-based service management domain, we have defined some classes in terms of an upper ontology that is independent of a particular domain. This allows us to relate ITIL-based service management data to other data expressed on the Semantic Web. In this case, we use OpenCyc (http://www.opencyc.org), the public version of the Cyc technology (Lenat, 1995) that represents the most complete general knowledge base and reasoning engine. We use the prefix "oc" to reference the namespace of the OpenCyc ontology.

An *oc:Specification* is the super class for all concrete specification types that constitute the underlying IT service management model. *ActionTemplate*, *Lifecycle*, *Stage* and *Process* are examples of subclasses of *oc:Specification* in the ITIL ontology. In our context, an *oc:Specification* represents an abstract work that constitutes a description of how IT services have to be managed in order meet business user's expectations.

An *ActionTemplate* represents the different kinds of actions for describing the activities designed to achieve a particular result. A *Lifecycle* represents the various stages in the life of any IT service management model element (*IT Service*, *Configuration Item*, *Incident*, *Problem*, etc.). The *Lifecycle* defines the categories for status and status transitions that are permitted using the *hasStage* property.

A *Stage* represents any phase of a *Lifecycle*. *Stages* are composed of *Processes* (*hasProcess* property). A *Process* defines the set of activities designed to accomplish a specific objective, the scope, risks, challenges, value to business, technologies, and interfaces that are needed to implement it.

Processes, *Services* and *Activities* are measured in terms of *Metrics*. *Metrics* must be designed in line with customer requirements for service management. A *Metric* is considered as a KPI (*Key Performance Indicator*) when it measures the success with the SLAs defined with a *Customer*.

An *oc:Action* is the super class for all concrete action types, and it is used for the workflow dimension (process flow) of our ontology, i.e. the *Activity* composed of a set of *actions* that are carried out and coordinated by the *specifications* as part of a business process, during which documents or information are passed from one participant to another, according to a set of procedural rules. All *oc:Action*s are performed by an *oc:IntelligentAgent*, i.e. the actor who is responsible for. The Opencyc concept *oc:PurposefulAction* is the subclass of *oc:Action*. An *oc:PurposefulAction* represents the actions that are consciously, volitionally, and purposefully performed by at least one *agent*.

An *ITService* is a service provided to one or more *Customer*s by an *ITServiceProvider*. An *ITService* represents the means of delivering value to *Customer*s by facilitating outcomes.

To control roles, we use the *oc:IntelligentAgent* class. *SuperUser* and *oc:Organization* are examples of subclasses of *oc:IntelligentAgent*.

An *ITServiceProvider* is a service that provides *ITService*s to internal or external *Customer*s. A *Shift* is a group or team of people who carry out a specific role for a fixed period of time. A *SupportGroup* is a group of people with technical skills.

Each *oc:IntelligentAgent* may have several roles (*RoleRelation* class). A *Role* represents a set of *Responsibilities* granted to a person or team that takes part in an *oc:PurposefulAction*. One *Role* may have multiple responsibilities, which are defined according to the *RACI matrix* in ITIL V3. Specific *roles* and *responsibilities* are defined for each *oc:IntelligentAgent* in an *oc:PurposefulAction* using the *hasRoleRelation*, *hasRoleType*, *hasRACICode* and *roleValue* properties.

4 MODELING CONSTRAINTS AND ADDITIONAL KNOWLEDGE WITH RULES

In our approach, we use SWRL for consistency checking, model validation, business rules analysis, etc. Rules defined in SWRL are combined with an OWL ontology providing all the relevant aspects of the ITIL specification and improving the management of IT services.

In order to test our approach with regard to reasoning capabilities, these rules are executed in Protégé using the Jess rule engine. This enables us to verify constraints and inconsistencies in the IT service management model, and incorporate new knowledge into the model to better management of IT services. We consider two types of rules: *service management consistency* and *organization rules*. *Service Management consistency* represents rules that are related to all instances of Onto-ITIL models.

Organization rules represent rules that are specific to organizations. *Organization rules* are part of an *organization specification*.

5 CONCLUSIONS

In this paper, we show how ITSM models, formalized by means of an ontology-based DSL, may help organizations adopt and adapt best practices in ITSM in a well-defined manner for business success. Our work captures the knowledge of best practice guidance in ITSM, including the workflow specifications and the rest of ITIL-based IT service management model elements, such as metrics and formal documents.

The Onto-ITIL principles separate the ITIL specification part from the organization specification part of an IT service management model in order to manage their evolution and coordinate the actual ITIL-based activities associated to all the organizations specifications.

One of the main benefits of our approach is that we can define the semantics and constraints associated to IT service management models avoiding ambiguities. These semantics-enriched specifications are defined just in terms of the IT service management domain, independent of any software consideration. Also, the resulting software-independent models, defined by means of OWL, can be transformed into formal models that are fully in accordance with MOF. These models describe the high-level requirements (i.e., the ontology engineering part) of the ITIL-based information systems that underpin the IT services.

OWL and SWRL are used to represent our proposed ontology and the underlying constraints, and the Protégé tool is used to test the approach. We have grouped the SWRL rules into two different categories that will be used as the basis for defining service management rules. The combination of ontology-based and rule-based reasoning capabilities is used: (1) to validate the *ITIL Service management model* (*service management consistency*) and (2) to manage ITIL-based organization specifications (*organization rules*). To the best of our knowledge, such a formal *ITIL Service V3 Management Model* definition has not been proposed for the existing ontologies in ITSM.

Future work of this proposal includes: (1) to complete the definition of the proposed ontology and the underlying constraints for ITIL-based IT service management, and (2) to implement a (semi-)automated model transformation from Onto-ITIL-based high-level requirements models to system models that provide lower level requirements models by means of a M2M transformations using the ATL (*Atlas Transformation Language*) (http://www.eclipse.org/m2m/atl/) or the QVT (*Query/View/Transformation*) (OMG, 2008) specifications.

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