Jürgen Schönwälder
Joan Serrat (Eds.)

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Ambient Networks

16th IFIP/IEEE International Workshop
on Distributed Systems: Operations and Management, DSOM 2005
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Jürgen Schönwälder
International University Bremen
P.O. Box 750 561, 28725 Bremen,Germany
E-mail: j.schoenwaelder@iu-bremen.de

Joan Serrat
Universitat Autonòma de Barcelona
Computer Vision Center
Edifici O, 08193 Cerdanyola, Spain
E-mail: joan.serrat@uab.es

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Preface

This volume of the Lecture Notes in Computer Science series contains all the papers accepted for presentation at the 16th IFIP/IEEE International Workshop on Distributed Systems: Operations and Management (DSOM 2005), which was held at the University Politècnica de Catalunya, Barcelona during October 24–26, 2005.

DSOM 2005 was the sixteenth workshop in a series of annual workshop and it followed the footsteps of highly successful previous meetings, the most recent of which were held in Davis, USA (DSOM 2004), Heidelberg, Germany (DSOM 2003), Montreal, Canada (DSOM 2002), Nancy, France (DSOM 2001), and Austin, USA (DSOM 2000). The goal of the DSOM workshop is to bring together researchers in the areas of networks, systems, and services management, from both industry and academia, to discuss recent advances and foster future growth in this field. In contrast to the larger management symposia, such as IM (Integrated Management) and NOMS (Network Operations and Management Symposium), the DSOM workshops are organized as single-track programs in order to stimulate interaction among participants.

The focus of DSOM 2005 was "Management of Ambient Networks". Ambient networks is a new vision to provide accessibility and distributed services through the dynamic composition of networks. The wide adoption of packet switched networking technologies and the fast growing wireless networking infrastructures in public as well as in private spaces allow systems to choose how to obtain connectivity. Systems may also dynamically form new networks and the devices or the whole network may be mobile. Furthermore, many ambient networks will be in private spaces, owned and "operated" by non-technical users (home networks). The heterogeneity of the services and resources participating in ambient networks and the dynamics associated with the composition of networks poses new management challenges. While some papers presented at the workshop address some of these challenges, there was also room for papers addressing general topics related to the management of distributed systems.

This year, DSOM 2005 was for the first time co-located with several related events, namely the 8th International Conference on Management of Multimedia Networks and Services (MMNS 2005), the 5th IEEE International Workshop on IP Operations & Management (IPOM 2005), the 2005 Symposium on Self-Stabilizing Systems (SSS 2005), and the 1st IEEE/IFIP International Workshop on Autonomic Grid Networking and Management (AGNM 2005). All these events together formed the 1st International Week on Management of Networks and Services (MANWEEK 2005).

DSOM 2005 attracted a total of 87 papers with authors from 23 different countries. Every submitted paper received at least three reviews. The authors were invited to write a rebuttal to the reviews while the members of the Technical

Program Committee discussed the papers online. The final paper selection was based on the reviews, the author's feedback and the online discussions within the Technical Program Committee. Out of the 87 submitted papers, 23 were finally accepted for presentation in eight paper sessions.

This workshop owes its success to all members of the Technical Program Committee who did a great job of encouraging their colleagues to submit high-quality papers. The Technical Program Committee members and all the reviewers also deserve special thanks for their constructive and detailed reviews, which were key to assuring the high quality of the workshop. We also thank Lisandro Zambenedetti Granville for running the online paper submission system JEMS which again proved to be invaluable.

Last but not least, we thank all sponsors and patrons who helped to make DSOM 2005 a success and a very enjoyable experience.

August 2005

Jürgen Schönwälder
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On the Formalization of the Common Information Model Metaschema

Jorge E. López de Vergara[1], Víctor A. Villagrá[2], and Julio Berrocal[2]

[1] Departamento de Ingeniería Informática, Universidad Autónoma de Madrid, Escuela Politécnica Superior, Francisco Tomás y Valiente, 11, E 28049 Madrid, Spain
jorge.lopez_vergara@uam.es

[2] Departamento de Ingeniería de Sistemas Telemáticos, Universidad Politécnica de Madrid, ETSI de Telecomunicación, Ciudad Universitaria, s/n, E 28040 Madrid, Spain
{villagra, berrocal}@dit.upm.es

Abstract. Integrated network management frameworks include a common definition of the managed resources, known as an information model, which is a key factor to describe the domain to be managed. In this scope, it is important to understand the semantics each information model provides to allow interoperation among different integrated management architectures. For this, ontology languages have recently been proposed, because thanks to their formalization they can deal with the semantics of information. Nevertheless, they need to be adapted to meet the management requirements. An alternative to the use of ontology languages can be the formalization of the management information languages to cope with the semantics of the information models. This paper provides a way to formalize one of these management languages: the Common Information Model metaschema. The formalization is based on the use of the Object Constraint Language to define in a formal way the set of natural language rules that describe this metaschema, improving its semantics, comparing also this solution to those based on ontologies.

1 Introduction

Network and service management has been a field in which traditionally proprietary solutions from different vendors were usually imposed. In these solutions the management of those equipments could only be performed with those vendor products. Then, integrated network management architectures appeared that defined standard protocols and information models allowing the interoperability between multiple vendors managers and managed elements.

Due to historical reasons, two different management frameworks have survived the standardization process: Internet network management framework (also known as SNMP, Simple Network Management Protocol) and OSI network management framework (also known as its protocol: CMIP, Common Management Information Protocol). These frameworks are incompatible, so finally each one has got its own application field, even though both frameworks have to coexist in some environments, such as telecommunication companies.

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Later on, other integrated network management architectures have appeared that use other technologies for resources management, different to SNMP or CMIP. The most significant example is the Web-Based Enterprise Management (WBEM) and its associated Common Information Model, CIM.

Each integrated management architecture deals with its own information, defined in a different language: same concepts can be defined to model a resource using incompatible formats, which cannot be directly translated. This issue is a combination of syntax and semantic problems. One way to deal with the semantics of the management information is the use of ontologies: they are formal [1], and thus, the meaning of this information is machine-interpretable.

By applying this knowledge representation technique, the work presented in [2] provided a way to analyze management information languages, being useful to identify their semantic expressiveness. One of the results obtained was that the Common Information Model (CIM) had most of the elements usually contained in ontology languages. However, it was not a model appropriate to deal with the semantics of the information because of its lack of formalization: rules about its structure have been defined in natural language, which is not machine interpretable, so that they cannot be processed and checked.

Then, ontology languages have been proposed to describe the management information [3, 4, 5, 6]. In this case, these languages have a formalized semantics. Still, they have to be adapted to the management scope, as there are some constructs they do not include.

Another way to deal with the semantics of management information is the formalization of the CIM metaschema: in this case a management specific information model is used, and a computer would be able to interpret the information defined in such way. With respect to the formalization of a management language, some works have been found [7, 8], but they are related to GDMO (Guidelines for the Definition of Managed Objects), the language used for OSI Systems Management, which had less constructions in common with ontology languages than CIM, as stated in [2]. The formalization of the CIM metaschema also reinforces the information defined in the CIM schema, which currently includes in its last release more than a thousand classes that base their relationships on that metaschema.

This paper presents an approach to formalize the CIM metaschema. For this, first of all, an analysis of this metaschema is given. Then, it is also compared to UML (Unified Modeling Language) metamodel. Next, a set of rules defined in OCL (Object Constraint Language) are shown that match natural language rules about CIM elements, providing a formalization of the metaschema. After that, this approach is compared with the use of a formal ontology language. Finally, conclusions and future works are also presented.

2 CIM Metaschema Analysis

CIM [9] is the information model defined by DMTF to be used in the Web Based Enterprise Management architecture, and has a considerable acceptation in the industry. This model is object-oriented and much more powerful than SNMP SMI (Structure of Management Information). However, its complexity is lower than

GDMO, as discussed in [2]. With this format, classes can have properties (the name they use for attributes) and methods. Other facets can be defined, thanks to the possibility of specifying new qualifiers [9]. This information model can also be expressed in XML (Extended Markup Language) to exchange the information.

As stated before, CIM has the information model metaschema with a largest number of elements usually included in ontology languages. It includes these characteristics, when comparing it to ontology languages [2]:

- Concepts or classes: They are a collection of instances with the same properties and methods. CIM can define:
  - Metaclasses: This item deals with the possibility of defining classes as instances of other ones. In CIM it is possible to define new statements with qualifiers, which indirectly makes feasible the redefinition of classes.
  - Attributes: Concepts usually have attributes. In CIM they are defined in the local scope of a class and can be instance attributes, class attributes, and polymorph attributes.
  - Facets: Attributes usually have a set of predefined properties or facets. In CIM default value, data type constraint, cardinality constraint, and documentation can be found among other facets such as the access, the key or index, and the identifier. In addition, CIM can define new facets by using qualifiers.
- Taxonomy: Concepts are usually organized in taxonomies, with generalization/specialization relationships among them. CIM allows the definition of subclasses with simple inheritance.
- Relations and functions: Relations represent a type of interaction between concepts. Functions provide a unique value from a list of valued arguments. CIM can define both relations among classes and functions for every class, with data type constraints.
- Instances: They represent elements of a given concept, a relation or an assertion. CIM allows the definition of class and relation instances.
- Axioms: They model expressions that are always true, and are usually used to define constraints. CIM does not currently support constraints, although a qualifier could be defined with this purpose.

Also, CIM schemas are structured in a similar way to ontology libraries [10]. In this way CIM schemas could be considered an ontology except for their lack of formalism. On the other hand, CIM uses the Unified Modeling Language (UML) class diagrams to model the management information, and several works [11, 12] have identified UML as a valid ontology modeling language.

This set of reasons presents CIM as a good candidate to define management information from a semantic viewpoint. Nevertheless, there is a problem that has to be solved to achieve this goal: as stated before, CIM is not formal (the rules about its metaschema are written in natural language, which cannot be processed and checked by computers), so it is not valid for the definition of heavyweight ontologies. To solve this problem it will be necessary the formalization of its metaschema. For this, the Object Constraint Language (OCL) [13], used in UML to define constraints can be applied, rewriting CIM metaschema rules, avoiding existing ambiguities that are caused because they are currently written in natural language. Other rule languages such as SWRL (Semantic Web Rule Language) [14] would also be useful for this