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Guest Editorial

Management Information Model Engineering

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1. INTRODUCTION

Information Modeling is an important aspect of software systems and has been used in various fields of information technology over the years. Its importance has become greater with the advent of object-oriented systems during the last decade. Object-oriented information modeling aims to provide an abstract view of a system in terms of the constituent objects and their relationships. In the world of system, network and service management, management information modeling has similar requirements as in other fields of information science but faces stronger restrictions due to the nature of the problem domain. Special information modeling techniques, notations and methodologies have been developed, leading to a management-specific approach which we will term *Management Information Model Engineering*.

The latter can be defined as the set of activities and tools that contribute to the design of an information model used in the context of a management solution. It also embraces activities which take place later in the design and development process of that solution. Such activities include: the validation of information models; their reuse in management applications; the mapping of generic models to specific management approaches, e.g., OSI Systems Management (OSI-SM), Internet Management, etc.; their deployment and distribution; and finally the testing of the deployed system against the initial information model.

A key difference between *Management Information Model Engineering* and other information modeling approaches lies in the very nature of management. Management is a distributed task for which the information model abstracts the underlying distributed system to be managed. Distribution is not considered in

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the initial stage of the information model design but appears later, during the development process of a management solution. There is little work to date towards a methodological approach for the transition from the information model to the concrete engineering view of a distributed management solution.

Another difference with other information modeling approaches is that a management information model aims to be standardized in order to support interoperable management applications. This implies that it cannot be designed with a specific application in mind, but it has to be generic and rich enough so that it can be used by a variety of applications. In addition, when modeling resources of similar technologies, the information model should be general enough to project a unified view of those technologies, e.g., a network model must be applicable to both an Asynchronous Transfer Mode (ATM) network and to a Synchronous Digital Hierarchy (SDH) one. Finally a management information model can only be standardized if it satisfies the requirements of all the parties involved in the standardization process. These constrains make the design of a Management Information Model a very difficult task.

2. MANAGEMENT INFORMATION MODEL ENGINEERING EVOLUTION

Since the late 1980's there has been a lot of standards bodies work that led to the definition of information models in each management framework. Generic support objects were defined first, e.g., those related to the requirements of the OSI Systems Management Functions (SMFs). Specific objects followed, such as the Internet MIB-II in the Simple Network Management Protocol (SNMP) framework, and the Generic Network Information Model in the Telecommunications Management Network (TMN) framework. The latter was subsequently specialized for SDH, ATM and other technologies. The definition of those models reached a level of maturity after the initial iterations, and management applications supporting those models have already been deployed. Despite the efforts of the standards bodies, though, there exist aspects of those models that are still ambiguous, e.g., operational state behavior propagation among termination points and circuits in network information models.

In the TMN framework, a methodology has been produced for assisting the designers of management information models, the "TMN Interface Specification Methodology". This is a step in the right direction, but it is still far from addressing all the aspects of Management Information Model Engineering. Extended languages and notations have also been proposed to support better information model specifications, e.g., the General Relationship Model (GRM). Unfortunately, no standardized information model today makes use of the GRM.

In the last few years, a key activity of Management Information Model Engineering has been the integration of information models from different frame-

works. The Network Management Forum's (NMF) ISO/ITU-T Internet Management Coexistence (IIMC) group addressed first the mappings between the Internet Structure of Management Information (SMI) specifications and the OSI Guidelines for the Definition of Managed Objects (GDMO). Subsequently, NMF and The Open Group's Joint Inter-Domain Management (JIDM) task force addressed the mappings between the SNMP SMI/OSI-SM GDMO and the Common Object Request Broker Architecture (CORBA) Interface Definition Language (IDL).

The fact that Management Information Model Engineering is only a limited part of the overall distributed system design process was recognized early enough in the Telecommunications Information Networking Architecture (TINA) framework; this follows the concepts and principles of Open Distributed Processing (ODP). In this context, information modeling is intimately coupled with the computational specification of the system in terms of interacting objects. The actual physical deployment of those objects is an issue considered in the engineering viewpoint.

3. CHALLENGES FOR INTEGRATED MANAGEMENT INFORMATION MODELING ENGINEERING

The first challenge towards tomorrow's management information model engineering concerns the ability to provide a framework-independent modeling approach. This means that one must be able to define a management information model without being concerned at this early level of the design process with a specific management framework, e.g., SNMP, OSI-SM, CORBA, etc. The key requirement is the necessity to agree on a framework-neutral notation such as the Object Modeling Technique (OMT), the Unified Modeling Language (UML), or even GDMO, which can be considered as a general-purpose information modeling language. An associated requirement is the existence of powerful tools for the manipulation of those information models.

At a later stage of the design process, another methodology is required to govern the transition from a neutral modeling approach to a framework-specific one. Various approaches have been proposed concerning the integration of different information models, but these have always addressed the problem in a bottom-up fashion. They may still prove to be useful though for future top-down integration approaches.

If framework-independent information modeling is the approach in the future, Management Information Model Engineering must also take into consideration existing information models and provide rules for their reverse engineering into the framework-neutral representation. The relevant bi-directional translation should ideally be "entropy-free", so that the same model is reached from two successive translations.

Last but not least, management information modeling approaches should provide facilities for richer definitions, especially in terms of the behavioral description of managed objects and their relationships. Existing formal methods such as the Specification and Description Language (SDL) and the Z notation may be used in addition to information modeling languages such as GDMO to describe unambiguously the behavior of managed objects, their state, and response to stimuli. A behavioral description will be useful in all the stages of Management Information Model Engineering, from the information model design to the testing of object implementations.

Some of these requirements are addressed in different management frameworks but no existing framework provides a complete solution to all these requirements. A promising approach is the emerging ISO/ITU-T Open Distributed Management Architecture (ODMA). This tries to be framework independent from the beginning, using ODP as the meta-framework which can be mapped onto both OSI-SM and CORBA. On the other hand, few concerns have been placed on the behavioral description of managed objects as well as on the different viewpoint notations.

4. ANSWERS IN THIS SPECIAL ISSUE

In this special issue, the reader will find some answers to the challenges discussed earlier in addition to state of the art information on the current advances and directions in management information modeling.

The paper "Temporal Network Management Information Model and Services," by T. K. Apostolopoulos and V. C. Daskalou, addresses the issue of enriched information models and associated services by presenting an approach which allows the integration of temporal information into SNMP-based information models at both specification and implementation level.

The paper "Formalizing GDMO Action and Notification Definitions: Results from a Case Study," by A. Franzke and B. Frohnhoff, addresses the enrichment of information models with behavior at the specification level. Here enrichment of the information model is addressed by experimenting with the use of formal methods to describe unambiguously the managed object behavior.

Two papers are concerned with particular information models. The first one, "TINA Network Resource Information Model," by N. Natarajan, provides a description of a technology independent network resource model in the context of the TINA architecture. It illustrates the requirements for generic information models addressed in this editorial and shows the advantages of using an ODP approach combined with a framework independent modeling notation using OMT and the TINA Quasi-GDMO/GRM. The second paper "Multimedia Resources: An Information Model its Application to an MPEG2 Video Codec,"

by C. Gbaguidi, S. Znaty, and J-P. Hubaux, addresses the definition of an information model for multimedia resources. A generic model is proposed and is specialized for an MPEG-2 Video codec.

Finally the last paper is concerned with Management Information Model integration. This paper "Management Information Models Integration: From Existing Approaches to New Unifying Guidelines," by A.-I. Rivière and M. Sibilla, provides an overview of existing approaches to information model integration and proposes a novel approach for the future integration of diverse information models.

We would finally like to thank all the authors of this special issue together with the reviewers around the world who evaluated the papers and contributed through their constructive comments to the quality of this issue.

George Pavlou received his Diploma in Electrical, Mechanical and Production Engineering from the National Technical University of Athens and his M.Sc. and Ph.D. in Computer Science, both from University College London. Over the last 10 years he has been undertaking and directing research in the areas of protocols, performance analysis and evaluation, distributed systems, broadband network technologies, network management and service engineering. He has been involved in a number of European research projects, addressing the management of the next generation broadband networks and services. He has been contributing to ISO, ITU-T, NMF, OMG and TINA, and he is the author of about 35 papers in international refereed conferences and journals. In 1998 he joined the University of Surrey, School of Electrical Engineering and Information Technology, as a Professor in Information Networking.

Olivier Festor received his Ph.D. in computer science from the University of Nancy, France, in 1994. During his Ph.D. studies (1990–94) he was also working within the Network Management Department of IBM European Networking Center in Heidelberg, Germany in the area of TMN Management Information Model specification, simulation and validation. After a postdoc at the EURECOM Institute, he joined the French National Institute for Research in Computer Science and Control (INRIA) where he is now leading a group in advanced technologies for service and network management. The work of this group focuses on new information models and supporting platforms and applications for service and network management integration in the area of TMN and Active Networks.