RelMan : a GRM-based Relationship Manager

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Abstract

The modeling of physical and logical network resources provides the main interface to network management software applications. The object-oriented information model defined in the OSI management framework provides notations to specify such interfaces. This framework has been recently extended with a relationship model. Relationship modeling adds informations upon isolated object specifications and offers new services for the management of these relationships. In this paper, we address some practical issues on network management architectures. To implement this new model, we start from relationship specifications up to the provision of a relationship service within the manager role of a management system. Our study outlines some lacks in the standardized relationship model and extends the notations with new statements to allow the development of a generic relationship provider. We also present a simple prototype that works on our Managed Object Development Environment. This prototype is a first implementation towards a complete tool for relationship management.

Keywords

Management, Applications, GRM, Information Model, OSI, Relationships, TMN, Architecture.

1 INTRODUCTION

The need for relationships in the design phase of Information Models has been recognized in various places and several proposals have been made in this direction [Kilov 95, Clemm 93b]. Some proposals have been precursors for the General Relationship Model such as the work done by A. Clemm [Clemm 94, Clemm 93a]. Other ones have proposed their own notation such as S. Bapat in [Bapat 94].

Despite the standardisation of the General Relationship Model (GRM) , which is in fact recent [CCITT.X.725 95], very few Information Models currently include such specifications and many persons seem to be reserved to use it for three main reasons: lack of experience, unavailability of applications and poorly identified application domains.

Thus, one challenge for its acceptance is the provision of valuable results showing that the GRM is useful along different phases of the development of Information Models. Concerning the use of these relationship specifications, several results have already been obtained in combining GRM and behavior specifications for the formal description of information models. The results are reported in the following studies: [Sidou 95] [Marshall 93] [Festor 94] [Keller 95].

From our point of view, the GRM may also be very useful in the operating phase of a management application. A first approach to this issue was proposed in [Clemm 93a] where relationships have been implemented in an agent as Managed Objects. The current standard GRM allows more representations of relationships in agents, i.e. operations, name-bindings, attributes. Unfortunately, the existing approaches do not address all these representations.

In this paper we present a novel way of exploiting GRM specifications in the operating phase of a management system. This approach is based on defining a service level at the manager side called RelMan which allows both standard CMIS operations on MOs and relationship management operations based on the standardised GRM notation. RelMan supports all types of relationship representations. This element provides a full relationship management interface to any applications and is generic in the way that it can act on any loaded information model containing GRM and GDMO* specifications.

The remainder of the paper is organized as follows. Section 2 provides an overview of the GRM standard and illustrates some of its limits. Section 3 contains a presentation of our RelMan application and how this application exploits the GRM-based relationship specifications found within an Information Model. Finally, section 4 concludes the paper and outlines some research issues we are currently working on.

2 THE GENERAL RELATIONSHIP MODEL

Some information specification documents based on the OSI network management framework [ISO-10040 92] contain a mix of Managed Object Class (MOC) definitions in GDMO and entity-association (E/A) diagrams, as in [ITU-T.M.3100 95, NMF 94]. The use of the Chen model [Chen 76] or derived ones, allows the specification of relationships between MOCs. Afterwards these relationships must be represented in the MOCs themselves with attributes or extra MOCs. Specifiers and implementers must deal with several formal methods and most important, they must share the same semantics. This is not a trivial assumption [Kilov 92]. The GRM provides a mean of expressing relationships in way similar to GDMO. Moreover, it enables a uniform specification of relationship representations in this

*Guidelines for the Definition of Managed Object [ISO-10165.4 92]

Management Information Model (MIM) [ISO-10165.1 92]. In this section, we will summarize the main features of this model and give a simple example of its use.

2.1 Basic Characteristics

The final text of the GRM [ISO-10165.7 95] provides a conceptual model and notational tools for designing Managed Relationship Classes (MRCs) and their representation in terms of MIM features. The MRC specifications permit the description of behavior dependencies between Managed Objects (MOs, that are instances of MOCs). The specifications also enable the management of these MOs as a whole through a Managed Relationship (MR, that is an instance of a MRC). All described dependencies are maintained inside the MOs through the representation means. MRC specifications are defined in terms of roles, operations, attributes and behaviors.

- Each MO in a MR fulfils at least one of the relationship role. One role is defined by a compatible MOC that constraints the effective MOC characteristics of the MO fulfilling the role. A role is also constrained by the number of MOs that can fulfil it and by the number of MRs (of the same MRC) in which a given MO fulfils the same role.
- Operations are generic. They are: ESTABLISH for creating a new instance of a MRC, TERMINATE for deleting a MR, QUERY for information retrieval purpose, BIND and UNBIND for adding or removing one or more MOs from a MR, NOTIFY as a notification facility from MRs, and USER-DEFINED for anything else. These operations can have an extra label, e.g. to distinguish two ESTABLISH operations within one MR.
- Specification of relationship attribute emphasize particular MO attribute. Indeed each relationship attribute must belong to exactly one of the participant MO and so their read/write capabilities are thoses defined by the MOC.
- Behavior definitions are, as usual in this context, expressed in natural language.

2.2 A simple example (from M.3100)

In this section, an example of using the GRM is extracted from the ITU-T M.3100 recommendation [ITU-T.M.3100 95]. On this information model, we perform reverse engineering to obtain the corresponding GRM specification. Figure 1 shows an E/A representation of the cross connection relationship that exists between MOs of the `terminationPoint` MOCs (we will only say `terminationPoint` MOs), or group of `terminationPoint` MOs (GTP MOs) and `crossConnection` MOs inside a managed element (as a switch). The diagram lacks of precision and the behavior in the `crossConnection` MOC adds extra constraints. The `terminationPoint` MOC is an abstract class and there is constraints for the choice of the subclasses. By example, when the cardinality is $n = 2$, there should be one `connectionTerminationPointSource` MO and one `connectionTerminationPointSink` referenced by attributes in the `crossConnection` MOC. Moreover, the E/A does not specify

that only GTP MOs must be cross connected with GTP MOs (and `terminationPoint` derived MOCs together).

Figure 1 Entity/Association diagram from the recommendation M3100

Other behavior disseminations between the E/A diagram and MOC specifications exist in the model. Here we focus only on the case above and write the MRC specification in GRM accordingly. The resulting specification is illustrated in figure 2. There are three declared generic operations (lines 3-5), and two attributes in 6 and 7 respectively. We define three roles, the role *from* and *to* (lines 8-11 and 16-19) for the `terminationPoint` MOC (lines 9 and 17) and one role *connector* (12-15) for the `crossConnection` MOC. There must be exactly one MO fulfilling each one (lines 10 and 18) and each of these MOs can only be in at most one MR of this class in the same role (lines 11, 16 and 19, the maximum is at 1), but can exist without participating at this relationship (the minimum is at null). This specification is more detailed than the simple diagram of figure 1; it shows the structure of the relationship and explicits the operations that can be applied on it. We do not detail here in which other MOCs configuration this MRC can be reused by derivation. We do this with interconnection between managed elements and point to multi point cross connections in a managed element. The behavior (line 2) is not given for conciseness. The actual one is constructed with the behavior specifications of the `crossConnection` and `terminationPoint` MOCs from which statements about the cross connection have been selected.

The second step of the modelling process aims at representing MRCs in the information model with the use of the RELATIONSHIP MAPPING template [Sibilla 93, Kilov 95]. Figure 3 shows one example of mapping for the above MRC. For one MRC, there can be several mappings. Thus the mapping template must indicate which MRC it maps (line 2). For each role of the referenced MRC, one should specify the MOCs (that must be compatible with the MRC role), as in lines 4 and 6. One can also specify the representation means, i.e. what are the MIM features used to save the MRs composition inside the MOs fulfilling the various roles. This is done in line 5 where we use an attribute to represent MOs in the *from* role. The relationship attributes are mapped onto some of the MOC in the *connector* role (line 7). The next statement concerns the mapping of relationship operations into system operations (lines 8-13). As an example, the ESTABLISH operation is mapped onto a CREATE CMIS service on the *connector* role, i.e. a CREATE operation of the `crossConnection` MOC. We also show the mapping of the QUERY operation where one relationship operation is mapped on two management system operations (lines 11-13). At execution time, these operations are all encapsulated in CMIS requests. The behavior specification (not detailed here) contains state-

- (1) *pointToPointCrossConnection* RELATIONSHIP CLASS
- (2) BEHAVIOUR *pointToPointCrossConnectionBehavior*;
- (3) SUPPORTS ESTABLISH,
- (4) TERMINATE,
- (5) QUERY;
- (6) QUALIFIED BY *signalType*,
- (7) *directionality*;
- (8) ROLE *from*
- (9) COMPATIBLE WITH *terminationPoint*
- (10) PERMITTED-ROLE-CARDINALITY-CONSTRAINT 1..1
- (11) PERMITTED-RELATIONSHIP-CARDINALITY-CONSTRAINT 0..1
- (12) ROLE *connector*
- (13) COMPATIBLE WITH *crossConnection*
- (14) PERMITTED-ROLE-CARDINALITY-CONSTRAINT 1..1
- (15) PERMITTED-RELATIONSHIP-CARDINALITY-CONSTRAINT 0..1
- (16) ROLE *to*
- (17) COMPATIBLE WITH *terminationPoint*
- (18) PERMITTED-ROLE-CARDINALITY-CONSTRAINT 1..1
- (19) PERMITTED-RELATIONSHIP-CARDINALITY-CONSTRAINT 0..1;
- (20) REGISTERED AS {*m3100.Relationship.pointToPoint*};

Figure 2 A relationship class for the cross connection

ments about the representation, explaining that the attribute *fromTermination* is one of the *crossConnection* MOC, or giving some indications to assign value to the encapsulated CMIS service parameters.

2.3 Current limits

The GRM helps MIB modellers to specify dependencies between MOs, but the MRCs are not integrated enough in the MIM. Currently, by the means of GDMO, MIB specifications and CMIS/CMIP definitions, a network management application can only be written in terms of MO manipulations that will be effectively sent over the network to distant MOs (i.e. by CMIS operations or actions). In this context, we have identified the following limits within the GRM:

- the MRs do not explicitly exist in MIBs;
- the MRC template does not enable the description of relationship operation parameters;
- a relationship attribute could not be computed from several MOs attributes (see [Bapat 93] for this issue);
- the specification of the behavior is not formally expressed, this is one of our research topic and results are emerging [Festor 94, Sidou 95, Nataf 96], recent works as [Keller 95] are studied.

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(1)  circuitPointToPointConnectionMapping RELATIONSHIP MAPPING
(2)  RELATIONSHIP CLASS pointToPointCrossConnection;
(3)  BEHAVIOUR circuitPointToPointConnectionMappingBehavior;
(4)  ROLE from RELATED-CLASSES circuitTerminationPointSource
(5)  REPRESENTED-BY ATTRIBUTE fromTermination,
(6)  ROLE connector RELATED-CLASSES crossConnection
(7)  QUALIFY signalType directionality,
    ...
(8)  OPERATIONS MAPPING
(9)  ESTABLISH MAPS-TO-OPERATION
(10) CREATE OF connector,
    ...
(11) QUERY MAPS-TO-OPERATION
(12) GET fromTermination OF connector
(13) GET toTermination OF connector;
(14) REGISTERED AS {m3100.RelationshipMapping.CircuitPointToPoint};

```

Figure 3 A relationship mapping for the cross connection

As MOC, MRC implementation is a local matter outside the scope of standardization. We think we can extend the GRM towards a better integration of both the MIM and the network management applications. In the next section, we show how a logical uniform repository for MRs can be automatically generated from GRM specifications and how a set of relationship information services can be provided to either the network engineer or any application in the Manager role of a management interaction.

3 THE RELMAN RELATIONSHIP MANAGER

RelMan is a software tool that takes place as an application service element (ASE) at the Manager side of a Manager/multi-Agent architecture. RelMan is strongly coupled with CMIS. It has an internal framework designed to receive GRM and GDMO specifications. These specifications must be already known by agents on the managed network.

3.1 Goals

RelMan adds two new concepts in the standardized framework.

- A Relationship Management Information Base (RMIB) that is a logical repository of MRs (we do not impose a particular database scheme here; relationship database does not mean relational database).
- A Common Relationship Information Service (CRIS) that is a CMIS equivalent for the relationship management. It is more detailed than the generic definitions

of the GRM concerning the relationship management operations and notifications (part 8.1 of the GRM standard).

3.2 Architecture

We propose a relationship management model that extends the system management model of [ISO-10040 92] from which figure 4 is partially extracted. The "Managing Open System" box contains our extension, the "Communicating" large arrow and the "Managed Open System" box are those of the standard.

Figure 4 Relationship management model

The Relationship Information Service User (RIS-User) manages MRs by relationship operation invocations and notification receptions. We define a **relationship management interaction** as a single relationship operation, a single notification or an identified set of logically related relationship management operations and notifications, during which the manager role does not change. In an interaction, one relationship operation or notification can be mapped on several system operations or notifications respectively. Thus, one **relationship management interaction** can imply several **system management interactions**[†]. Furthermore a MR can bind MOs in several MIBs and the **systems management interactions** generated by a **relationship management interaction** may not occur between all the same MIS-User in the agent role (but we assume with the same RIS-User in the relationship manager role).

Figure 4 details some parts of the RIS-User. The RIS-User in the active role requests management relationship services (establish, terminate, query, ...) to MRs. These requests will be translated in management information services requests in accordance to the OPERATIONS MAPPING specifications and will be sent to the MIS-User in the manager role (the one of the standard). The later receives notifications (we will see later which ones in the next section) from managed systems and forwards them to the RIS-User in the reactive role. This RIS-User has two mains functionalities. On one hand it must translate system notifications to relationship ones (with the help of the OPERATIONS MAPPING specifications). On the other it

[†]defined in [ISO-10040 92]

must look at the state of MOs that participate in MRs in order to guarantee their consistency and update the MRs accordingly.

3.3 The Relationship Management Information Base

The Relationship Management Information Base (RMIB) is part of the RIS-User where each MR is modelled with sufficient information in order to enable relationship operations requests to be performed.

A MR can be modelled in the RMIB by a tuple of the global identifier of each MO it binds. We propose an optimization of the tuple size based on the use of the REPRESENTED-BY specification of a role. In a MRC mapping, roles may be inter-related in several manners (ATTRIBUTE, NAMING, RELATIONSHIP OBJECT and OPERATION). As an example, the mapping given in figure 3 shows that MOs in the *from* and the *to* role are represented by attributes of the MO in the *connector* role. In this case, one MR could be modelled in the RMIB only by the identifier of the MO in the *connector* role. We thus define the *connector* role as **representative** of the MRC and its mapping. The MOCs that are **representative** can be found in a determinist manner from MRCs mapping specifications. All the required information can be obtained from **representative** MOs via CMIS requests.

Optimizing the tuple size of representative MOs leads to some performance issues. By example, to find MOs participating in a MR, one should first query (CMIS GET) the **representative** MOs to retrieve other MO identifiers, and then act on these MOs. If this relationship is often used, the MRC will be better modelled by the whole MOs tuple. On the other hand, the use of the representative MOs prevents the growth of the RMIB and avoids major consistency problems of the repository since information is distributed across agents.

Without regarding the relationship operations defined in the MRCs, the RMIB can provide a general query service that enables the discovery of all the MRs of a given MRC. Other provided services are dependent of relationship operations.

3.4 Relationship services

The relationship services are provided to manage MRs. These relationship operations may be linked to a set of standard CMIS operations. A full description of relationships services and their mapping onto CMIS services is given in [Clemm 94]. Conversely to this work, we do not suppose that each MRC is represented by a specific MOC but by an arbitrary relationship mapping. Our work is in progress to formally define the behavior of these services. FDTs as [Schneider 92, CCITT-Z-105 95] combined with ASN.1, will be probably used.

3.5 RIS-User in the reactive role

A MR's state depends on the participating MOs states and MOs can be accessed by other MIS-User (or RIS-User). The only means for a manager to know about MOs states is to poll them frequently or to wait for notifications emitted from the

MOs (or a mix). In our architecture, we construct the RIS-User in the reactive role (figure 4) in order to receive notifications and update in the RMIB the MRs from which sender MOs belong too. Two notifications types are taken into account:

- notifications that are the system operations mapped from a NOTIFY relationship operation;
- notifications that are side effects of MOs manipulations by a manager (i.e. directly performed CMIS operations by a manager).

By example, lines 9 and 10 of the figure 3 leads the RIS-User to wait for *objectCreation* (defined in [ISO-10164.1 92, ISO-10165.2 92]) from the *connector* role. A good integration of these notification scrutations requires the creation of *eventForwardingDiscriminator* MOs within the agents [ISO-10164.5 92] [ISO-10165.5 92].

3.6 Early results

We have implemented the RelMan layer over the OSIMIS [Pavlou 95] platform combined with our MODERES[†] [Festor 95] toolkit for Information Model processing. Within this application we currently provide to a human manager the possibility to request and act upon multiple agents through either a standard CMIS interface or a relationship interface which is the union of all relationship operations defined within the known Information Model(s).

Early results are very encouraging. First, the use of a relationship-oriented interface is very smart and easy to use since one can combine in one relationship operation several standard CMIS calls. Second, the extensions to the GRM defined within RelMan are also useful in earlier stages of the development, i.e. at the specification stage and especially if one wants to define formally the Information Model before any implementation.

Thus such a relationship-based service provides a more flexible and powerful interface to applications and network managers. Moreover this service requires little overhead.

One issue we have not addressed so far, is the problem of inter-agent relationship consistency and update. Update over multiple agents is possible in RelMan but no support for Distributed Transaction Processing to ensure consistency of updates is currently provided.

Last but not least, GRM specifications appear to be easily readable. GRM provides just two templates which appears to be a reasonable size and complexity extension to GDMO. But beware of this apparent simplicity: writing GRM specifications is a very difficult task that requires a lot of efforts.

[†]Managed Object Development Environment by RESEDAS

4 CONCLUSION AN FUTURE WORK

In this paper, we have presented a new application domain for GRM specifications within Information Models. With the development of the RelMan prototype we have shown the feasibility of automated exploitation of GRM specifications as a service at the manager side. In this approach we have also identified some limits of the current GRM notation to allow a complete automation of its exploitation. To overcome this, we have slightly extended the notation and integrated these extensions in the RelMan application. By developing the GRM support at the manager side, we allow relationships to be represented within or between agents by all representations defined within the standardized GRM mapping model, i.e. name-bindings, attributes, operations, relationship objects.

Our current work focusses on extending the service provided by the RelMan in providing a standardized representation of the relationship instances as a MIB within the manager. This manager will then act as an intermediate manager. To upper level managers it provides both CMIS and CRIS relationship services. These services are then mapped to standardized CMIS operations sent to the lower level agents hosting managed objects. This is done as part of our JASOM intermediate manager project. Another domain we are currently working on is the link of a fault management application to RelMan in order to allow this application to collect parts of its configuration information needs from the relationships among MOs. These relationships are there not hard-coded in the fault management application but defined like MOs in the Information Model and expressed in GRM.

Future work covers research on the design process of the relationships among MOs and its integration in the design process of management information models. In fact, it is not clear in the MIM design process when and where relationships have to be defined. Early work on this subject by our group tends to distinguish between two relationship types: application specific and generic ones whereas the first ones may cover some of the later ones. Another research domain covers the knowledge add-on provided by explicit relationship specifications in the Information Model. In this case the GRM should embed a knowledge description language to provide more description power to Information modellers. This will allow applications to be more flexible and exploit better the Information Model. In this context, the JASOM application will probably feed us with a set of primary requirements.

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