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Information Technology – Framework for Metamodel Interoperability

-- Part-1: Reference model

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity.

ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO/IEC 19763 may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

International Standard ISO/IEC19763 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 32, *Data management services*.

ISO/IEC 19763 consists of the following parts, under the general title *Information technology — Framework for Metamodel interoperability*:

_ *Part 1: Reference model*

_ *Part 2: Core model*

_ *Part 3: Metamodel for ontology registration*

_ *Part 4: Metamodel for model mapping*

Introduction

Due to the spread of E-Business and E-Commerce over the Internet, the effective exchange of business transactions and other related information across countries and cultures has become a prime concern for people both inside and outside the IT industry.

Following these trends, many standardization activities have focused on the facilities or schema that could enable the collaborations among different organization, such as;

a) Modelling facilities or modelling architectures such as UML or MDA

b) E-Business procedures and exchange format such as ISO/IEC15944, ebXML , XMI or SOAP

c) Description facilities of information resources such as XML, RDF or WSDL

d) Business process integration facilities such as BPEL or BPMN

e) Registry facilities such as ISO/IEC 11179 (MDR), ebXML R&R, or UDDI

f) Meta-modeling facilities such as MOF

g) Ontology descriptive facilities such as OWL, DAML+OIL

h) Descriptive facilities for Logics such as CL, SCL, CG or DL.

In Addition to the above, other activities which focused on the contents to be treated by facilities, have emerged as subjects of standardization.

These include;

a) Common models for various business domain, such as GCI, CPFR or HL7

b) Modelling profiles or modelling patterns such as UML profile for EDOC or EAI

c) Registry metamodels such as ebXML RIM or HL7 RIM,

d) Metamodels such as CWM for data warehouse or ODM for Ontology,

e) Metadata specifications, such as Dublin Core or ebXML Core Component

f) Ontology models, such as SNOMED in the Healthcare, SUO in the engineering and ISO/IEC15944-4 e-Business economic and accounting ontology.

Those contents could be stored in the registries in order to enable the effective sharing among different organizations.

Many registries and repositories have been developed and implemented. However, due to differences in their metamodels or disharmony in their semantics, effective collaboration among organizations or communities has been difficult. New facilities are required that enable a harmonized federation among those registries.

To satisfy these requirements, this Meta Model Framework for Interoperability family of standards provides the facilities for describing various types of registries or metamodels as a consolidated set of metamodel frameworks.

This consolidated metamodel framework will provide features as follows.

a) Metamodel registering mechanisms for enabling the federation of registries.

b) Description and registering mechanisms for various modelling constructs to facilitate their reuse.

c) Description and registering mechanisms for rules of model mapping and transformation to enable the harmonization of registry contents.

This part of metamodel framework for interoperability family standards describes the basic concept of metamodel framework which should be used in the development of other parts of

MMF in this family. The issues and requirements to be considered in this development are also described.

Information Technology–Framework for Metamodel interoperability –Part 1: Reference Model

1 Scope

The metamodel framework family of standards consists of multiple parts which are to be used in the development of a harmonized metamodel to facilitate the interoperation of existing registries or metamodels.

Figure 1 illustrates the overall structure of the standards. However, this structure does not exclude the possibility of future extensions adding other useful metamodel frameworks, such as for model constructs or the registration procedure.

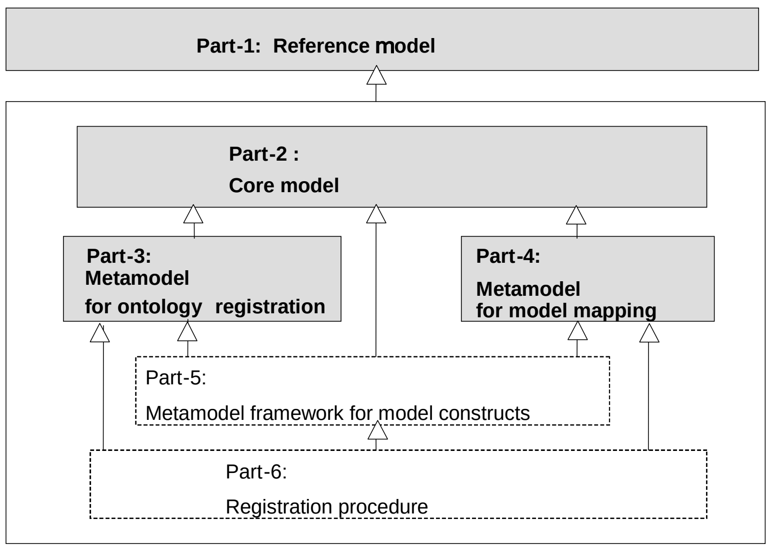

Figure 1 - Overall structure of the metamodel framework standard

Part-1 Reference model

This part of the standard describes the concepts and an overall architecture of the metamodel framework standard to be applied in the development and the registration of the following individual metamodel frameworks.

Part-2 Core model

This part of the standard describes the core model of the metamodel framework to be used in the development of metamodel framework standards. The core model provides a mechanism for metamodel description and normative constructs to be used in the development of metamodel framework standards.

Part-3 Metamodel for ontology registration

This part of the standard describes a metamodel that provides a facility to register administrative information of ontologies.

Part-4 Metamodel for model mapping

This part of the standard describes a metamodel framework for describing any sort of mapping between objects such as metamodels, model elements or data elements.

1.1 Scope - Metamodel Interoperability

1.1.1 Objectives

The objectives of this family of standards are focused on improving the interoperability of metamodels defined by different standards groups in ISO or outside ISO, providing a normative metamodel framework for registering individual metamodels.

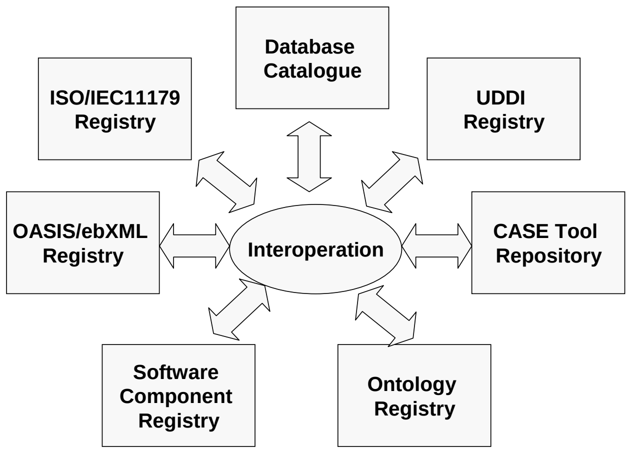

Figure 2 - Registry federation with metamodel framework

1.1.2 Problems to be addressed

Many standards committees or organizations, both in ISO and outside ISO, have developed registries to enable the sharing and exchanging of various types of business objects such as object contracts, transaction messages, or product information. Most of them use a particular modeling facility such as UML to represent business process models and transaction protocols to be shared.

In so doing, they developed metamodels in their registries for the effective sharing of those objects and for implementation of the registries.

Today, a lot of commercial registries are available in the market. However, one of the issues in metamodel implementation, especially in business, is a lack of harmony in the metamodel technologies and methodologies they use. Even if they could use a common modeling facility, such as UML or MOF, the contents of the metamodel and model constructs that they use might be incompatible with one another. Then it might be difficult for registry users to find an appropriate target to collaborate with.

1.2 Scope - Metamodel Framework Architecture

This part provides an architectural view of a consolidated set of metamodel framework standards in order to obtain the objectives of this family of standards (See Figure 3). This view is needed to guide the metamodel framework standard development efforts by showing the concepts and relationships among metamodel frameworks.

In this family of standards, every metamodel framework is governed by the core model and inherits the concepts and constructs of the core model.

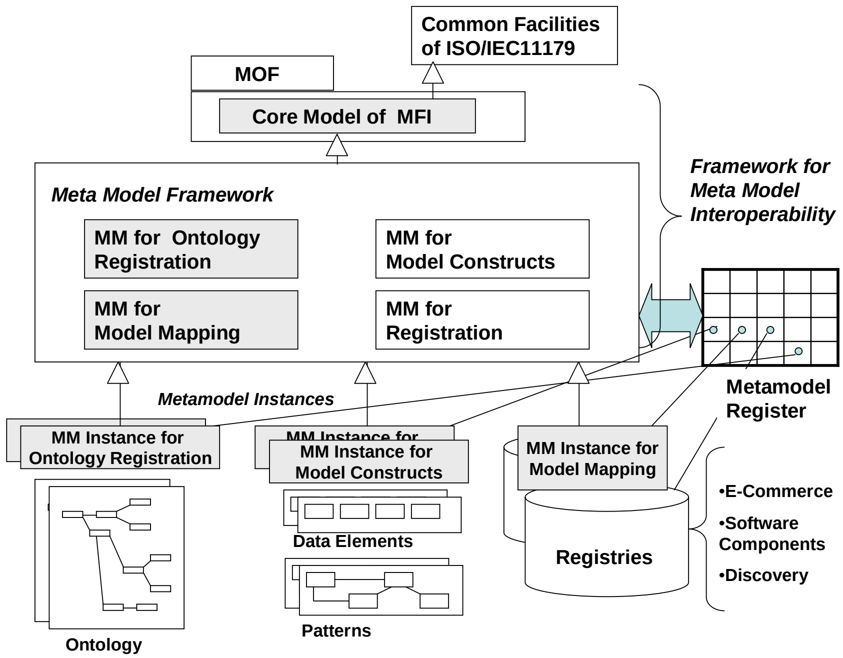

Figure 3 - Conceptual View of Metamodel Framework Architecture

The core model of this family is formulated by inheriting both MOF meta-meta model and the MDR (ISO/IEC 11179-3) metamodel; accordingly all of the metamodel frameworks have to follow the metamodel concept and basic meta objects of MOF and MDR.

The more detailed structure of the architecture is discussed in clause 4 of this part.

1.3 Scope – Exclusions

The following are not covered in the scope of this family of standards.

a) Standardization of the modeling methodologies

b) Standardization of the contents of the metamodel such as particular ontology schemes or object values

c) Standardization of the contents of model constructs

1.4 Scope – Area of Applicability

This standard is intended to be applied in the following areas.

1.4.1 Consistent model development

The major purpose of the metamodel technologies is providing a base for model development efforts in terms of clear semantics and syntax of the modeling facility to be used.

The standardization of the metamodel framework for a modeling facility could improve the efficiency of modeling efforts by avoiding unnecessary duplication in the model definitions and discrepancies between the modeling rules and models to be developed.

1.4.2 Model and software component sharing

Another purpose of the standardization of the metamodel framework is to encourage the sharing of various types of modeling constructs such as software components, modeling patterns and domain best practice models in the developments of software systems at an organization or among organizations.

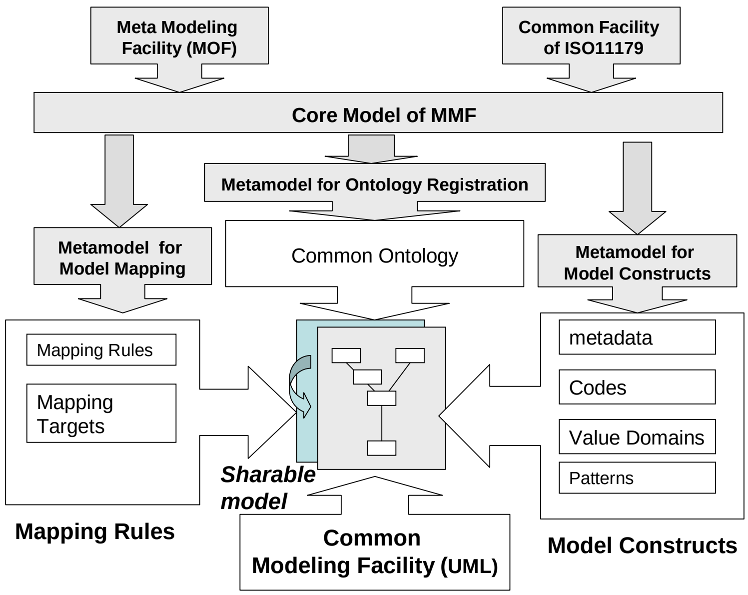

Figure 4 - Metamodel Frameworks to support sharing of model constructs

1.4.3 Business collaboration through EC or EB

Today, E-business and E-commerce have proliferated over the world, facilitating specific standards such as ebXML or RosettaNet. By the nature of E-business, it is not limited to a single industrial domain or territory. Different domains are linked by the internet, and inevitably users or consumers will need to access different private individual registries.

The metamodel framework family of standards facilitates business collaborations through E-business or E-commerce by providing mechanisms for describing metamodels in each registry in order that they may be shared among different business domains.

Particularly, the core model of the metamodel framework provides a mechanism for describing each different metamodel in local registries and enables their registration in the registry.

Also, the metamodel framework for model mapping provides a facility for registering mapping rules to enable federation among different registries.

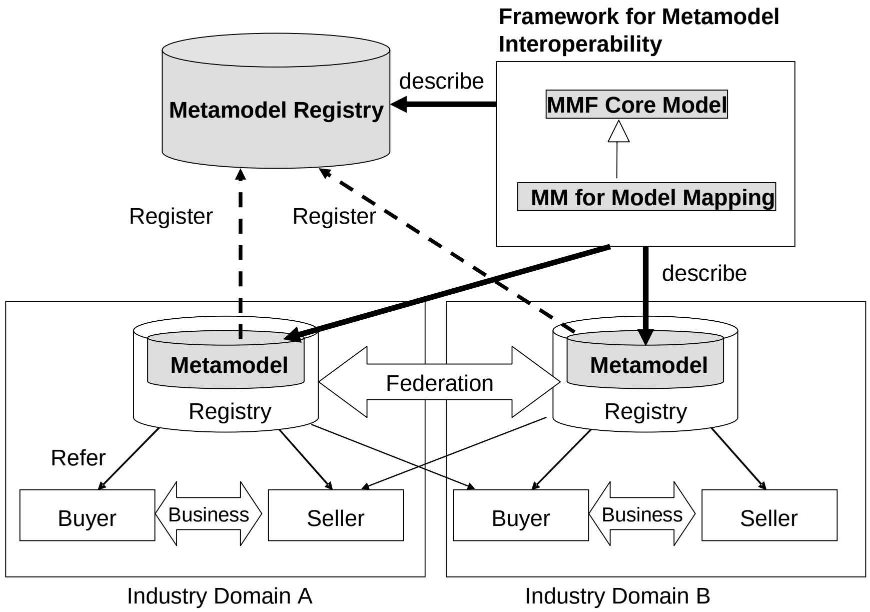

Figure 5 - Registry Federation by the Metamodel Frameworks

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 11179-1, Information technology – Metadata registries (MDR) - Part 1 : Framework

ISO/IEC 11179-3, Information technology – Metadata registries (MDR) - Part 3 : Metamodel

ISO/IEC 19501-1:2005, Information technology - Open Distributed Processing- Unified Modeling Language (UML) Version 1.4.2

ISO/IEC 19502:2005, Information technology – Meta Object Facility (MOF)

3 Definitions

3.1 Definition of Metamodel Concepts

3.1.1 business object

Objects which represent various business entities or business processes.

Note: Typical business objects are Customer, Products, and Ordering, etc. [OMG, 1995.]

3.1.2 domain model

A model which represents a particular domain

3.1.3 metadata

Data which describes other data.

See. ISO/IEC 11179-1

See. ISO/IEC 19502

3.1.4 metamodel

A model which governs other models.

3.1.5 metamodel construct

Model constructs which is used in metamodels

See. Modeling constructs

3.1.6 meta-modeling facility

A modeling facility used for meta-modeling.

Note: MOF is an example of a meta-modeling facility. See. Modeling Facility

3.1.7 model

A representation of an universe of discourse (UOD) using a normative modeling facility and modeling constructs.

3.1.8 model construct

A unit of notation for modeling.
Note: More generic term for modeling element. Sometimes the term is used to include metadata, code and object patterns rather than the notations of a particular modeling facility such as UML.

3.1.9 modeling facility

A set of rules and notations for use when modeling.

Note: UML is a typical example.

3.1.11 Upper model

A model which restricts or guides other models.

Note: A typical upper model is a metamodel itself. However, in this family of standards, the following types of relation among models could be recognized as an upper model.

- A model to be inherited as a model which provides abstract syntax to lower models
- A whole model to which a lower model belongs as a part
- A template or pattern to be applied to a model
- A pre-existing model to be considered in the definition of lower models

(See. 4.1.3)

3.1.12 Lower model

A model which is restricted or guided by another (upper) model.

3.2 Abbreviations

3.2.1 BPMN

Business Process Modeling Notation

3.2.2 BPEL

Business process Execution Language

3.2.3 CWM

Common Warehouse Metamodel

3.2.4 GCI

Global Commerce Initiative

3.2.5 CPFR

Continuous Planning Forecasting & Replenishment

3.2.6 CL

Common Logic

(see. ISO/IEC 24707, in process)

3.2.7 ebXML

electronic business XML

3.2.8 HL7

Healthcare Level 7

3.2.9 MDA

Model Driven Architecture

3.2.10 MOF

Meta Object Facility

See: ISO/IEC 19502: 2005

3.2.11 MMF

Meta Model Framework

Note: This family of standards (ISO/IEC 19763)

3.2.12 ODM

Ontology Definition Metamodel

3.2.13 OWL

Web Ontology Language

3.2.14 RDF

Resource Definition Framework

3.2.15 SNOMED

Systematized Nomenclature of Medicine

3.2.16 UDDI

Universal Description, Discovery & Integration

3.2.17 UML

Unified Modeling Language

3.2.18 UOD

Universe of Discourse

3.2.19 XML

eXtended Markup Language

4. Metamodel Framework Architecture

4.1. Overall Structure of the Metamodel Framework Architecture

This section describes the structure of the metamodel framework architecture and the detail concept of both metamodel framework and the metamodel framework architecture.

The metamodel framework architecture consists of a core model and several types of metamodel framework, such as a metamodel framework for ontology, a metamodel framework for mapping and a metamodel framework for model constructs. However, other useful metamodel frameworks are expected to be proposed. (See Figure 6).

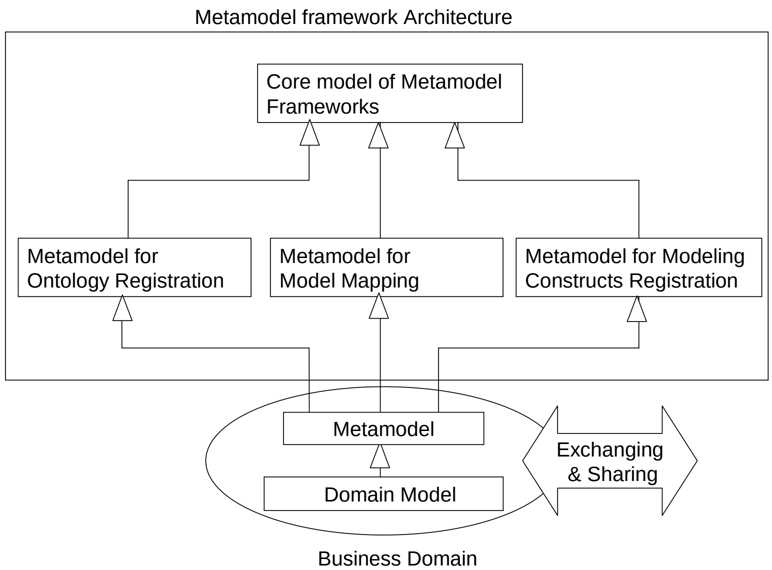

Figure 6 - Metamodel Framework Architecture

4.1.1 Definition of the Metamodel

A metamodel is a model which describes other models. That is, a metamodel governs models, modeling facilities or modeling constructs to be integrated into a particular model instance.

To establish harmony and consistency among metamodels, a metamodel framework and a core model are defined in this family of standards. Figure 7 illustrates the relationship among those models. (M0, M1, denotes meta hierarchy levels used in MOF).

In this context, "Govern" dose mean that a metamodel should describe targets not only in a single aspect of the target, such as type or syntax, but also describe relationships to be applied among targets or model constructs specifying type of relationships or end of the relationship.

A metamodel could provide beneficial additional capabilities for the use of models. These are:

a) Model Expandability

b) Object Polymorphism

c) Model integration and transformation

d) Parallel execution and model control

e) Model dynamism and flexibility

Usually, in modeling or meta modeling efforts, some particular modeling aspects or modeling concerns regarding a Universe of Discourse (UOD) have to be captured by a model developer. Most of the difficulties in the sharing of models are caused by the inconsistency of the perspective of those aspect and concerns between model developers, even if they could use a normative modeling facility, such as UML.

In the traditional practical way for regulating the modeling activity, some sort of guidelines are produced which describe design rules or procedure using textual sentences.

One of the benefits of guiding peoples by metamodel mechanisms rather than using textual representation of rules or methods, is its clarity and elimination of ambiguity.

So the first priority for preparing metamodel frameworks is providing a common base for normalizing modeling aspects or concerns such as;

a) What kind of meta objects should be applied to represent a metamodel?

b) How to make relationships and what type of relationship should be used?

c) What type should be chosen for an selected meta object?

d) What kind of constructs should be used?

e) How to represent rules for mapping or transformation between objects?

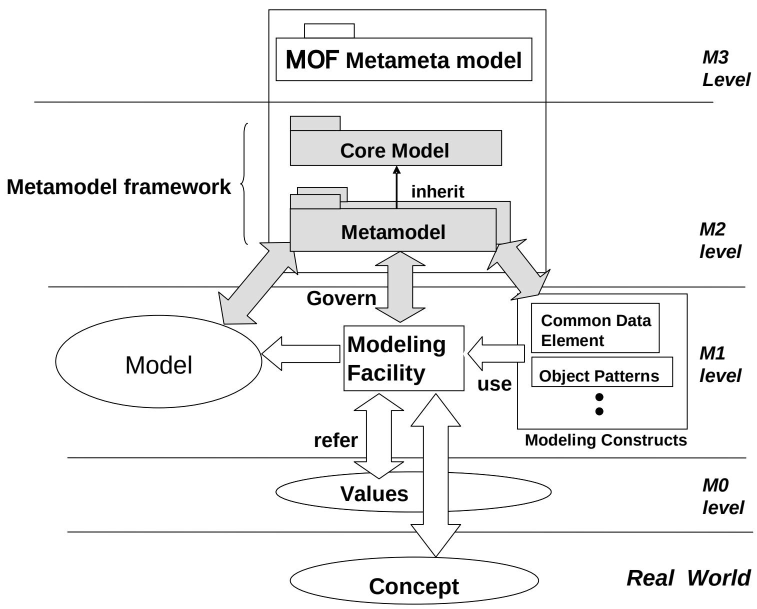

Figure 7 - Metamodel Framework Architecture and overall structure of meta hierarchy

The metamodel framework architecture defines an architectural view to the consolidation of metamodel framework standards to meet the objectives of this standard.

The metamodel framework architecture is a set of normative metamodel framework standards that could be used to registering individual metamodels produced by registry implementers in order to enable harmonized exchanging and reusing of various types of business objects, by providing a unified view of the normative metamodels and the normative modeling aspects to be applied to capture the contents to be described in an individual metamodel.

The purpose of the metamodel framework architecture is to provide:

a) a clear concept of the relationship between model and metamodel;

b) a unified view of the functional classification of metamodels;

c) a common infrastructure for different modeling facilities to establish interoperability between them.

4.1.2 Definition of a Metamodel Framework

A metamodel framework is a set of normative metamodels and metamodel constructs to be used in the development of a metamodel in the actual implementation of a registry. A metamodel framework has as its scope a particular meta-modeling concern or a metamodel domain, such as mapping or registering model constructs.

The purpose of a metamodel framework is to provide:

a) a normative use of metamodel to meet a particular metamodel concern;

b) a normative use of metamodel constructs specified by the core model to meet a particular metamodel concern.

A metamodel framework is to be used to represent a particular metamodel for a domain, such as selecting ontologies, model constructs, mapping between models or model constructs.

4.1.3 Structure of the Metamodel Framework Architecture

The metamodel framework architecture represents the concept that was described above with inheriting meta-meta model of MOF (ISO/IEC19502) and the common facility of MDR (ISO/IEC 11179).

However, due to the nature of MOF, only abstract syntax of the metamodel constructs were provided by MOF, then, it is needed to define specialized own metamodel constructs to represent metamodel frameworks.

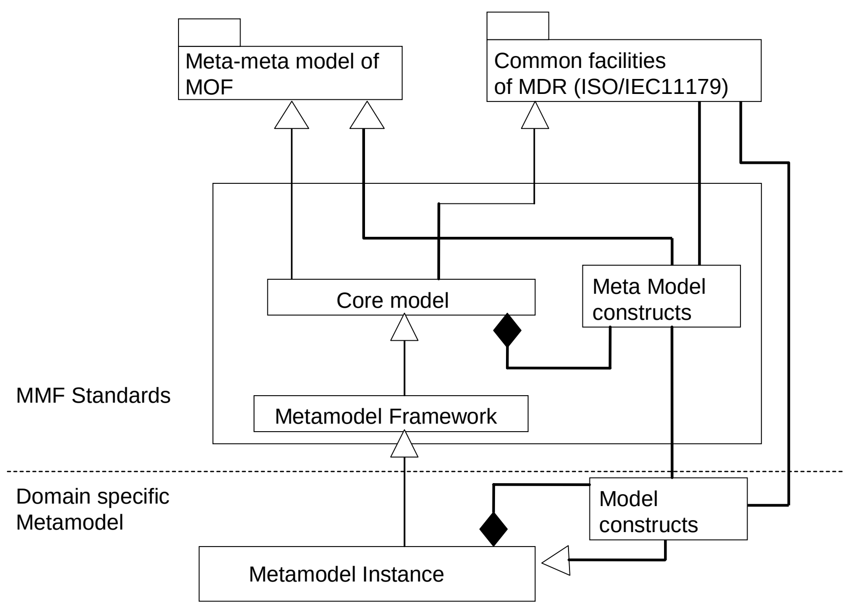

Figure 8 - Structure of the metamodel framework architecture

4.1.4 Concept of the registration

The MMF family of standards provides mechanisms for the registration of various types of models or metamodels. To understand the MMF Core model, the concept of the registration should be clarified.

In the MMF standard, the registration is intended not only to record items for administrative attributes, but also it is needed to specify an upper model which provides an abstract syntax to the models to be registered as well.

To materialize sharing of models and basic object such as data elements, terminologies, basic classes, basic relationships, the common facility of MDR (ISO/IEC11179) which is consisted of a naming space or identification scheme and classification scheme should be able to be shared by different metamodels.

The common upper model for every instance of metamodel or model, must be the MOF model which provides an object oriented abstract syntax to them.

The registration also requires the detail modeling constructs which consist of a model or a metamodel to be registered. This implies that the models and metamodels should be developed using normative pre-existing constructs in order to materialize the share-ability of the models.

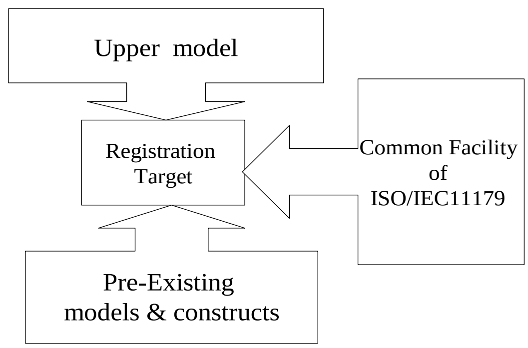

Figure 9 - MMF registration concept

4.2 MMF Core model (19763 Part-2)

The core model is a vital part of this family of standards as the MMF for Interoperability Part-2. The core model provides a common descriptive mechanism for each metamodel framework such as the MMF for Ontology (Part-3), the MMF for Model mapping (Part-4).

In the core model, the MOF is used as a meta modeling facility, and for an object defining facility, the defining scheme of the MDR (Meta Data Registry: ISO/IEC 11179-3) metamodel is used, with some extensions to those facilities.

Since MDR provides a generic object defining scheme such as the concept, the conceptual domain, the element and the values, then the benefits of using the MDR metamodel in this standard come from the expandability of the representing object.

In this standard, key portion of the MDR is represented by using the MOF metamodel in order to add a capability to handle structured objects.

Figure 10 illustrates the meta-meta model which is materialized with the integration of both MDR and MOF facilities. For more detail see document ISO/IEC CD19763-2 (Core model).

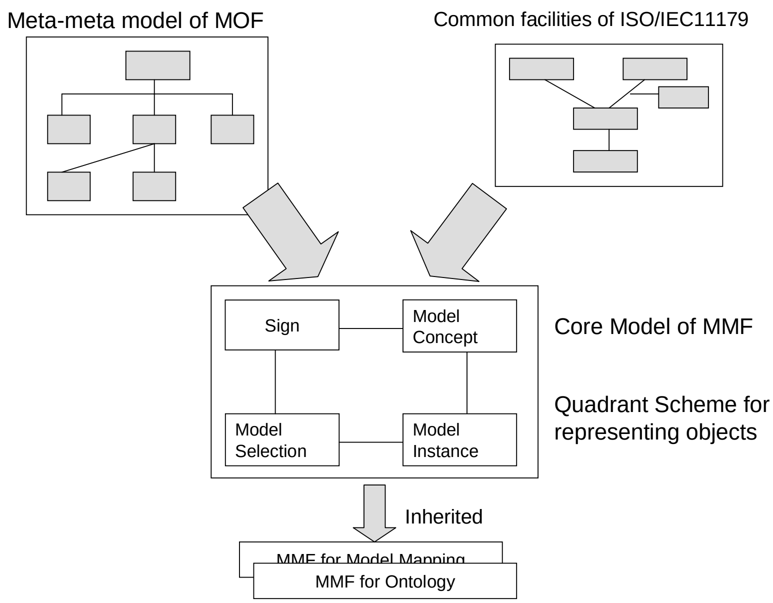

Figure 10 - Core model as a successor of both MOF and MDR

4.2.1 Mechanism for the registration

This standard defines a framework for registration describing the relationship between metamodel and model. In the layer M2 of the metamodel architecture, standards related to business object models which are developed by standardization organizations, are registered specifying a certain namespace and definitions of concept.

In addition, the model instances conforming those standards, for instance, concrete stereotypes or model patterns also are registered. Users of the registry, such as model developers, select and use some stereotypes and patterns that are appropriate to build the own model in the localized standard layer. The localized standard layer has similar structure to the global standard layer, consisting of named element and namespace ("Sign"), model domain ("ModelDomainProfile") and model classifier ("ModelConcept"), model component ('"ModelInstances") and selected model element ("ModelSelection").

As shown in Figure 11, the conceptualization of a registration target means that a particular name (sign) should be specified and some actual definitions should be provided to the target.

Specification of those concepts is defined through matamodels from various scopes, purposes and viewpoints. Then instances of the model governed by the metamodels can be referred to as referents. The sign stands for those referents.

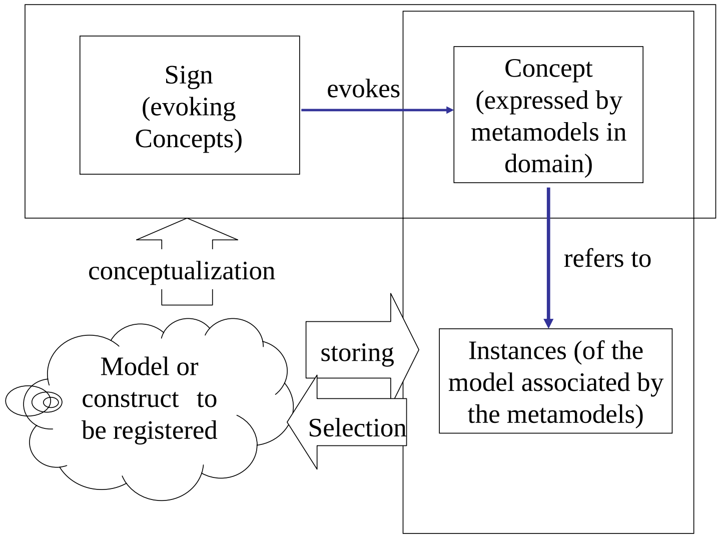

Figure 11 - Concept of the four quadrant registration scheme

One of the benefits of the quadrant scheme in the defining objects or models is that this scheme provides a base for defining an object by specifying it's concept by name (sign) and possible variations correspond to the concept.

Following these manner, the object could be defined from view points such as, the name, possible details and actual instance.

By those mechanisms, the core model could be able to describe models and metamodels which consist of many structured objects of various types of business domains.

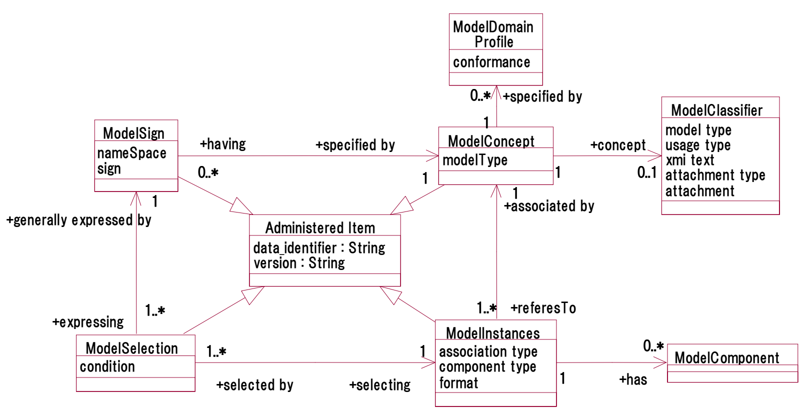

Figure 12 - Basic view of MMF core model I

4.2.2 Registration example

MMF core model provides a scheme of registering objects or models to enable specifying upper model to be inherited or model constructs to be used in the modeling. Figure 12 shows a basic metamodel for representing a target model which follows the registering scheme described in Figure 13. .

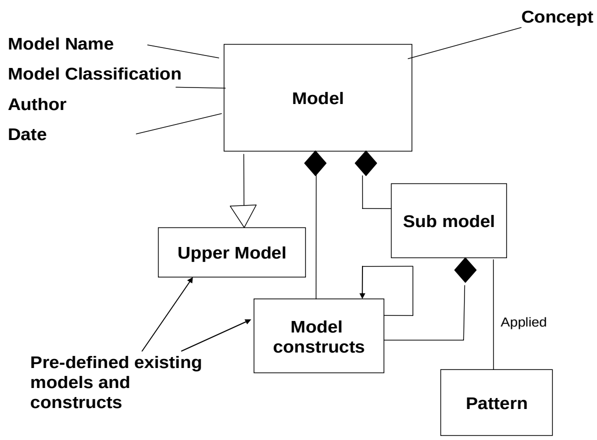

Figure 13 - scheme for model registration

Figure 14 shows mechanism for the concept representation in the MMF core model. The concept of a metamodel or a model to be registered could be identified by a sign following a particular namespace. The concept of the model should be classified by a classifier and a model type specifying upper model. Detail information of the concept could be provided as a profile and actual documents.

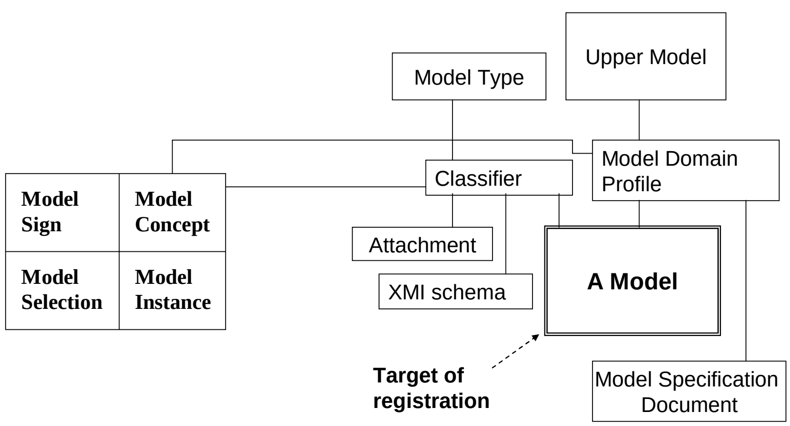

Figure 14 - Representation of Concept

Figure 15 illustrates an actual registration of a domain metamodel which represent a software system in a particular domain such as an application system in an organization. At the registration, the MOF model provides an abstract syntax to the metamodel to be registered specifying a sign in a particular namespace and a concept which could be described by a profile.

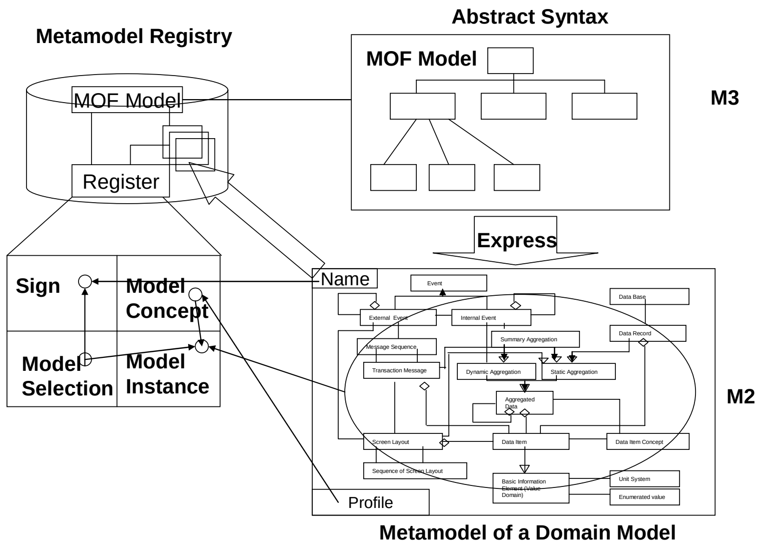

Figure 15 - Registration of an upper model

According to the metamodel that was registered previously, an actual detail model could be able to be registered. Figure16 shows the registration of more detailed model which represents a particular potion of a whole model of the system.

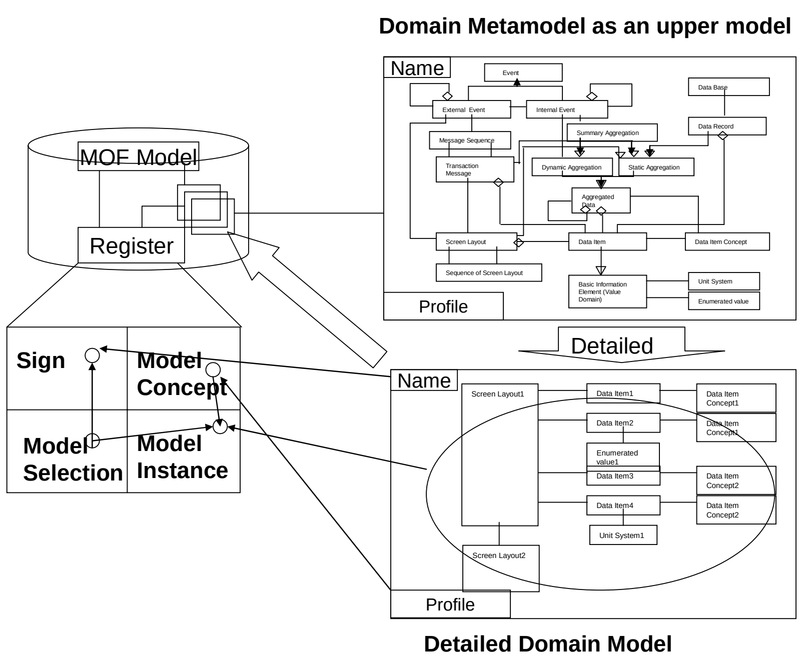

Figure 16 - registration of target model

The Core model is used in the development of normative metamodel such as the Meta Model Framework (MMF) for Ontology Registration and the Metamodel for Model Mapping.

4.3 Metamodel for ontology registration

This standard is a part of the metamodel framework family of standards (Part-3). It is based on the inheritance of the core model.

Today, a lot of consortia or organizations have defined ontologies in their own way. To enable the harmonized sharing of ontologies within a business domain also among them, this part of the standards prescribes a metamodel that provides a facility to register an administrative information of ontologies.

This standard represents a normative metamodel which enables the registration of administrative information of ontologies that are described by a normative ontology descriptive metamodel, such as ODM (Ontology Definition Metamodel) or future extension of MDR standard.

Figure 17 illustrates the integration of MMF and MDR on the registration of ontology or semantic elements. MMF-3 will be a HUB for connecting ODM metamodels and MDR metamodel that enable to facilitate both normative semantic elements in MDR and descriptive mechanism provided by ODM metamodels.

MMF-3 and ODM both metamodels are represented with MOF, then it is more closer to the machine implementations while MDR provides implementation independent metamodel for more wider use of semantic elements.

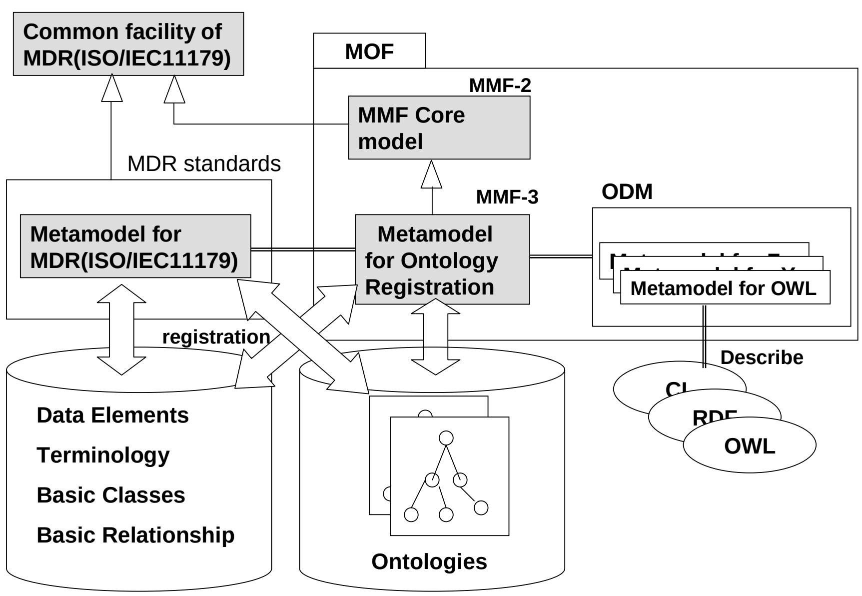

Figure 17 relationship between MMF -3 and MDR (11179)

Today, many organizations are in charge of the standardization of the ontology or the ontology related topics. In the ISO/IEC SC32, the Common Logic standardization was initiated. Also, in the W3C, RDF(Resource Description Framework) and the OWL (Web Ontology Language) are standardized. OMG is also discussing ODM (Ontology Definition Metamodel).

Then following issues are considered to keep this part consistent with them..

(1) This part does not provide any contents of ontology.

(2) This part does provide a facility to register administrative information of ontologies in order to make them sharable and reusable.

(3) This part provide a facility to develop an ontology referring a pre-existing reference (Upper) ontology.

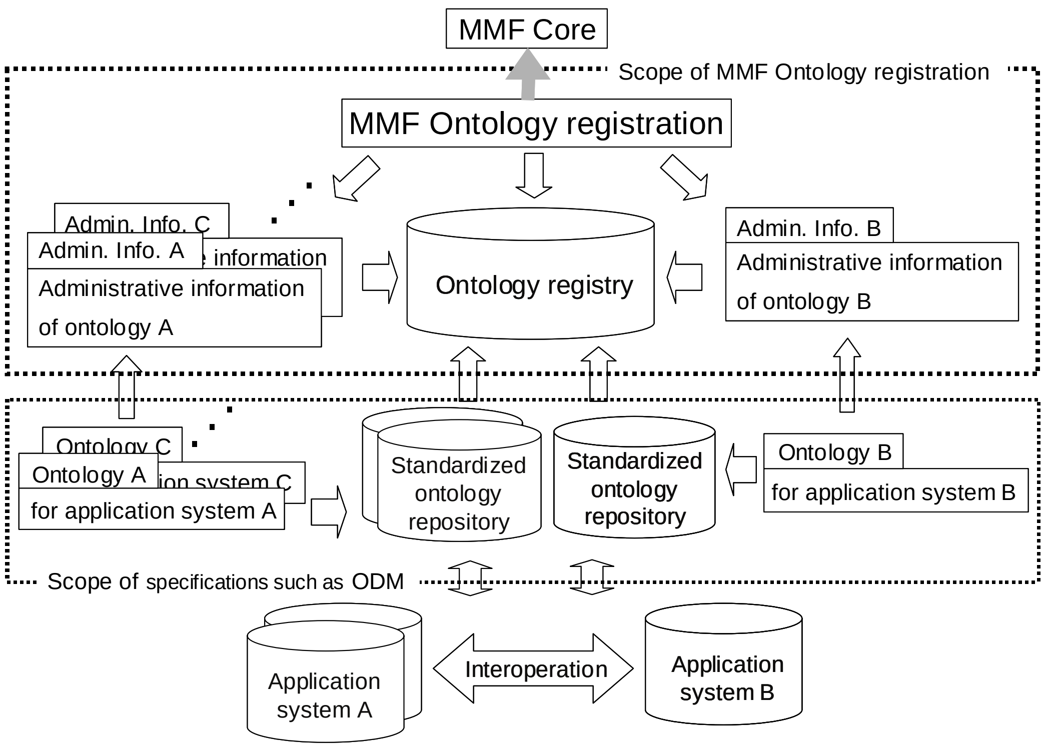

Figure 18 - Metamodel for ontology registration

4.4 Metamodel for Model mapping

This standard is a part of the metamodel framework family of standards (Part-4). It is based on inheritance of the core model.

This standard provides solutions to resolve problems typically found in a heterogeneous environment which consists of different software platforms and middleware. Even in a single environment which consists of similar platforms, a business object might be implemented or installed in different formats or syntaxes.

The metamodel framework for model mapping provides a normative metamodel which allows the describing of differences regarding formats and types of objects to be exchanged or shared. This metamodel framework also provides a capability for describing transformation rules between different objects in term of a metamodel instance.

Figure 17 illustrates the basic structure of the MMF for Model mapping which could be minimal set of metamodel for representing both mapping targets and mapping rules.

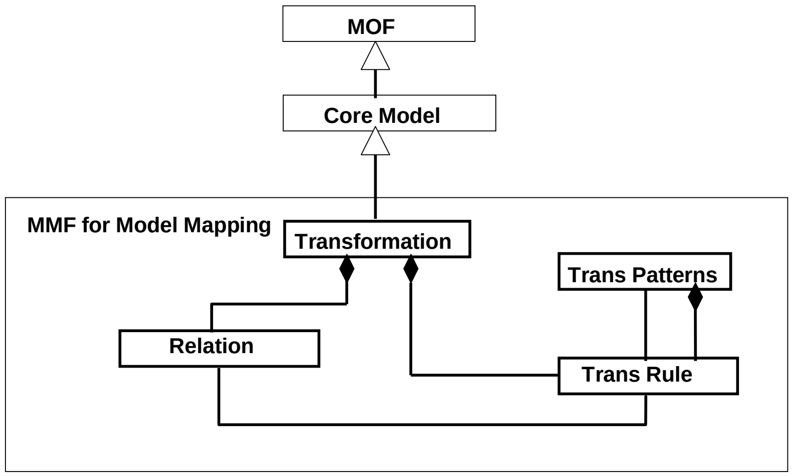

Figure 18 - Metamodel for model mapping

In the development of MMF for model mapping, following issues should be concerned.

(1) Discussions which are taking places in the standard organizations such as OMG, should be watched

(2) Actual implementation of those scheme, i.e. CWM (Common Warehouse Metamodel) or some other commercial products for the data warehouse should be investigated

(3) The mapping between models or model elements which were defined with different modeling facilities, such as UML or IDEF1X should be investigated and some sort of the transform metamodel framework should be provided in this standard.

[NOTE:]
The mapping rule between models defined by different modeling facilities might be a hard trial in the development of the MMF for model mapping. However, a place holder for this sort of framework should be prepared in the standard.

4.5 Metamodel for model constructs

This standard supports the registration of various types of model constructs and their reuse. Typical model constructs could be;

a) Data elements

b) Data base records

c) Object patterns

d) Object definition templates

e) Message format

etc.

[NOTE]

At the moment, no sub project to a metamodel framework for modeling constructs has been initiated.

5 Conformance

ISO/IEC19763-1 specifies no conformance requirement. Other parts of this family of standards specify their own conformance requirements as appropriate.

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TR 9007 provides information on conceptual modelling.

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ISO/IEC 10027 describes the concept of levels of modelling.

[3] ISO/IEC TR 15452:2000, *Information technology – Specification of data value domains*
TR 15452 describes the specification of value domains. It is expected to be replaced by ISO/IEC TR 20943-3.

[4] ISO/IEC TR 20943-1:200n, *Information technology – Achieving metadata registry content consistency – Part 1:Data elements*
TR 20943-1, which is under development at the time of publication of ISO/IEC 11179-3, will provide guidelines for recording data elements in a 11179-3 metadata registry.

[5] ISO/IEC TR 20943-3:200n, *Information technology – Achieving metadata registry content consistency – Part 3:Value domains*
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