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Study Period Report on the Feasibility of Mapping Modelling Languages for Analysis & Design

25th October 1998

1. Summary

This is the report of a study period conducted by ISO/IEC JTC1/SC7/WG11 that has focussed on mapping the following modelling languages:
- CDIF meta-meta-model with
- STEP EXPRESS, and with
- OMG's Unified Modeling Language (UML) and Meta Object Facility (MOF)

The objectives of this study period were:
- to establish a proof of concept for the feasibility of mapping between modelling languages;
- to establish the basic elements of this mapping process;
- to prepare the plan for follow-on work in the relevant JTC1 committees, e.g. SC7, SC32, TC184/SC4, and liaison groups, e.g. EIA CDIF, OMG.

The study period has met its objectives as follows.
- The mapping between CDIF and EXPRESS [CDIF-EXP] has established a proof of concept for the feasibility of mapping between modelling languages by defining a general correspondence between CDIF and EXPRESS and specific transformations from CDIF to EXPRESS and from EXPRESS to CDIF.
- These mappings provide a format that can be followed by other mappings and thus they have established the basic elements of this mapping process.
- Outline mappings between CDIF and MOF [SMIF-CDIF] confirm the results from EXPRESS and provide a foundation for complete mappings
- This report makes recommendations for further work. Although the study period has been successful in meeting its objectives and makes recommendations on potential future standards for mappings between modelling languages, it does not propose that any further standardisation should be pursued urgently because of the state of flux in standards for model engineering.

The report describes:
- the background to the study period: the underlying problems, and the prior work that led to initiation of the study period (section 2);
- the activities that have been carried out during the study period in separate streams for CDIF-UML and CDIF-EXPRESS (section 3);
- results of the study period for these two streams (section 4);
- the conclusions and recommendations of the study period (section 5);
- and the primary references for the report (section 6).
- Annex A contains a description of the architecture and terminology used in systems for specifying and exchanging models.
- Annex B contains an outline transformation of the MOF to CDIF, based on work in [SMIF-CDIF].

2. Background

The problems that give rise to the subject of the study period are as follows (see [ToR]).

- There are many groups (formal standards, industry consortia) defining *models* (sometimes referred to as *metadata*).
- Although there are signs of convergence on some of the modelling languages (e.g. CDIF-OMG), there will never be agreement on a single approach.
- Therefore the ability to map between different modelling languages is a firm requirement, and a common (potentially standardised) mapping approach needs to be investigated and developed.
- The ability to exchange models is a prerequisite for communication between system designers (and others), sharing and exchange of data and interoperability of system components.

This problem was studied at a JTC1 workshop (see [JWKS]) in September 1996. One of the workshop resolutions, later accepted by JTC1, was directed at SC7:

JWS R2.3: The Joint Workshop requests that JTC1 recommend that JTC1/SC7 conduct a study period to establish the technical basis for a program of work leading to the standardization for the mapping of modelling languages.

Given these terms of reference, SC7/WG11 proposed an initial study period focussed specifically on mapping the following modelling languages:

- CDIF meta-meta-model,
- STEP EXPRESS, and
- OMG Unified Modeling Language (UML)

The objectives of this study period were:

- to establish a proof of concept for the feasibility of mapping between modelling languages;
- to establish the basic elements of this mapping process;
- to prepare the plan for follow-on work in the relevant JTC1 committees, e.g. SC7, SC32, SC33, TC184/SC4, and liaison groups, e.g. EIA CDIF, OMG.

SC7 approved the study period and this report describes the activities, results and proposals from the study period.

3. Activities

The main activity began on 5th and 6th November 1997 during the WG11 meeting in London, hosted by BSI. Experts from JTC1/SC32 (SQL, CSMF, IRDS), JTC1/SC33 (ODP) and TC184/SC4 (STEP) attended.

There were presentations of mapping projects (CDIF to PCTE; ANSI IRDS and ISO IRDS; NIAM to SQL; various tool-supported mappings). A STEP expert gave a tutorial on STEP and introduced a NWI on systems engineering which has a similar scope to CDIF.

The scope, objectives and method of the study period were discussed (e.g. whether a mapping should be defined as a correspondence between similar elements or as a transformation from one system to another; whether the mappings should be defined directly or in terms of a general reference model) without reaching complete agreement. Some elements of the business requirements for defining mappings were noted. It was suggested that the mappings should be applied to a common, simple example. Detailed processes for mapping between CDIF and UML and between CDIF and STEP were defined. These were to be carried out for the two mappings separately outside meetings. Details of the activities for each mapping are given in the following sub-sections.

The outline plan in the Terms of Reference was expanded to a detailed plan which was later published in revised Terms of Reference SC7/WG11 N224R3. Administrative actions were taken such as the assignment of roles and adoption of communication via email and the web.

The **second meeting** was held on 10th-11th February 1998, hosted by EIA CDIF and collocated with the OMG's meeting at Salt Lake City.

Drafts of the two mappings and a comparison of the architectures (see Annex A) were reviewed and actions were assigned to maintain progress according to the study period plan.

An outline of the study period report, previously distributed by email, was reviewed and accepted in Salt Lake City. A draft of this interim report was distributed by email at the beginning of April 1998. It reported complete results of the CDIF-EXPRESS mapping and partial results of the CDIF-UML mapping.

The **third meeting** was held in Johannesburg during the SC7 plenary meetings from 25th-29th May 1998.

An interim report, previously distributed by email, was reviewed by WG11 and SC7 resolved to forward the revised version to other committees. SC7 also resolved to circulate the CDIF-EXPRESS mapping, a draft British Standard, for comment with the intent that the standard be fast-tracked through JTC1.

The study period was extended to enable it to take account of responses to the OMG Request for Proposal for a Stream-based Model Interchange Facility [SMIF], which were not expected until July.

The report, amended as agreed in Johannesburg and with additional material about the results of the OMG's process for adoption of SMIF, was reviewed at the **final meeting**, held during the SC7/WG11 meeting in Kumamoto from 26th-30th October 1998.

~~1.1~~3.1 CDIF-EXPRESS

During the study period different type of mappings have been carried out for CDIF and EXPRESS under a UK BSI/DTI contract. Three versions were distributed to the study period email list and review and discussion outside the meetings was conducted mainly through that email list. These mappings are all included in a draft British Standard or Technical Report [CDIF-EXP].

Version 1, a nearly complete mapping of CDIF to EXPRESS, was reviewed and the accompanying editor's questions were answered in Salt Lake City . It was agreed that

- a general mapping of the CDIF and STEP architectures should be added, based on material already submitted to the study period;

- a mapping of EXPRESS to CDIF should be added;
- the next version should be based on the balloted versions of CDIF, and should anticipate likely changes for comments that are being submitted in the ballot;

The only contentious technical point was whether the mapping should preserve all semantics faithfully or should conform to the style of the target modelling language. For example should CDIF meta-relationships be mapped to EXPRESS explicit and inverse attributes or to associative entity types.

After the meeting further comments were received by email, some of them about the issues raised in the meeting. There was discussion and agreement on how to resolve them. The editor of the mapping consulted a standard text book [EXPIM] about EXPRESS style and comments were received from EXPRESS experts including one of the authors of the book.

Version 2 was a complete mapping of CDIF to EXPRESS with changes for the mapping of CDIF meta-relationships and was based on the balloted versions of CDIF. The EXPRESS schemas had been checked with a tool. This version also generated a spate of email discussion, including substantial technical comments.

Version 3 was included the general mapping of CDIF and STEP architectures and the mapping of CDIF to EXPRESS as requested in Salt Lake City.

During the study period, the following mappings of CDIF and EXPRESS have been carried out:

- a correspondence between the CDIF meta-meta-model and EXPRESS, which is the basis for
- a transformation from the CDIF meta-meta-model and EXPRESS, and
- a transformation from EXPRESS to the CDIF meta-meta-model;
- EXPRESS schemas derived from CDIF subject areas via the former transformation.

3.2 CDIF-UML and CDIF-MOF

At the outset, the question was raised as to which of two closely related OMG specifications should be used: UML, for analysis and design, or the MOF, for repository access. Although both specifications state that the MOF is the meta-meta-model for the UML meta-model, this is untrue (although it could have been made true). UML is defined using a simple subset of UML, not the more complex MOF. Since the goal was a mapping of the CDIF and OMG modelling languages for analysis and design, UML was chosen.

An outline CDIF-UML mapping from EIA CDIF was input to the London meeting. This consisted of outline mappings of the UML Core package to the CDIF meta-meta-model and of UML to the CDIF semantic meta-model. The mapping was reviewed briefly in Salt Lake City. The purpose of the mapping is that a CDIF subject area may be derived for UML and the CDIF transfer format may then be used for data interchange of UML models. The experience from this would be valuable in determining how successfully a CDIF tool can integrate UML models and other models by implementing a translator of UML to CDIF. It was recognised that it is essential that a derived collectable meta-object which is semantically equivalent to a collectable meta-object in the CDIF semantic meta-model be assigned the same value of CDIFMetaIdentifier, and a new value otherwise.

It was agreed that further work would be carried out as part of a submission in response to an OMG RFP (Request for Product) for a Stream-based Model Interchange Facility [SMIF]. OMG had had a long-standing liaison with EIA CDIF and a more recent C liaison with SC7, instigated by WG11.

Experts of EIA CDIF and SC7/WG11 who are representatives of OMG member companies submitted a response [SMIF-CDIF] that uses the CDIF Transfer Format. In discussion prior to submission, it was found necessary for acceptability to base the submission on the MOF rather than UML. This entailed the definition of a simple subset of the MOF, the MOF static kernel, as the MOF meta-meta-model. Annex B contains an outline transformation of the MOF static kernel to the CDIF meta-meta-model, based on [SMIF-CDIF], that could be developed in detail in the same way as the CDIF-EXPRESS mappings.

The specification [XMI] likely to be adopted by OMG for [SMIF] uses XML as a transfer format, in preference to CDIF. This meets the need for publication of models on the Web.

4. Results

Although the study period focussed on mapping CDIF, OMG and STEP modelling languages, some work was done to place them in the context of the architectures of CDIF, OMG and STEP. These architectures and their main components are listed in a comparative table in Annex A. Section 1 of Annex A describes the general structure of these architectures and defines the main terms used in this report.

This section discusses general lessons for mapping modelling languages that have been learned from the study period, concerning e.g. the objectives of the exercise, the different types of mapping and whether there is a need for a reference model.

4.1 Scope and purpose of the mapping exercise

Many of the results relate to topics discussed in London [LONMIN], section 7.1. Various judgements are coloured by the objectives of a mapping. The most important distinction is whether the work is intended

- to be about modelling languages in *general* (or all modelling languages), and to aid understanding of the principles of modelling and modelling languages; or
- to be centred on one modelling language and to aid harmonisation of *one particular* modelling language with others.

The study period (as defined by SC7/WG11 and as carried out) has taken the latter position, with CDIF as the particular modelling language, because:

(a) there are insufficient resources and support for a general, long-term activity;
(b) the results of such an activity would probably become just another modelling language and would be accepted as neither general nor global;
(c) useful results can be achieved in the short term with specific CDIF mappings;
(d) a few specific CDIF mappings will enable us to make statements about CDIF mappings in general and even about mappings between general pairs of modelling languages.

In London we also noted, [LONMIN] section 7.1, the distinction between

- a mapping as a <u>correspondence</u> or <u>comparison</u> of two systems
- a mapping as a <u>transformation</u> from one system to another system

Those taking a more general position on the aims of the exercise tended to prefer the former choice; those taking the CDIF-centred position preferred the latter.

The work on the CDIF-EXPRESS mapping clarified the distinction and the respective strengths and weaknesses (see section 4.2). This in turn shed light on the question of reference models (section 4.3).

4.2 Correspondence *versus* transformation

It is clear from the work on mappings between CDIF and EXPRESS that both correspondences and transformations are required.

- A *correspondence*, i.e. a symmetrical mapping of nearly equivalent systems, is useful for discussing where the equivalence is inexact or where one system lacks an equivalent feature of the other system.
- A *transformation*, an asymmetrical mapping from a source system to a target system, is necessary for generating new features in the target system that are precisely equivalent in function and meaning to features in the source system. Definition of a transformation encourages more thorough work on difficult differences between the two systems.

Disagreement over some technical details in Version 1 resulted in prolonged discussion of the design criteria for transformations. One criterion that was generally agreed is that the transformation can be automatically applied by a computer program. This may produce somewhat unfriendly results and so is in conflict with another criterion: that the results should be in the style of the target system and acceptable to its users. The conflict was resolved in [CDIF-EXP] by defining a transformation (called *mechanical)* that meets the first criterion and defining differences for the transformation (called *natural*) to meet the second criterion. It was pointed out by EXPRESS experts that there are different views on what is good style and that it may depend on what the EXPRESS schema is to be used for.

A further criterion that was recognised is that the mapping should be as simple and uniform as possible and omit unnecessary detail, including detail that can be included in separate general rules. The aim of this criterion is to simplify implementation by tools and use by people.

4.3 Use of a reference model

In London we discussed, [LONMIN] section 11.2, whether the mapping should be structured according to CDIF concepts, as in [CDIF-PCTE], or an independent reference model. There were strong reservations about the latter choice among those making the detailed investigation, because:

(a) there is no such independent reference model already available;
(b) a new reference model would be seen, judged and rejected as a proposal for the basis for a new, ultimate, general modelling language;
(c) the reference model would simply add to the variety of alternative terms and concepts;
(d) CDIF, intended as a neutral architecture and information model, should serve adequately as a reference model.

In fact, most of [CDIF-EXP] is structured as corresponding statements about CDIF and EXPRESS (or STEP) concepts, each using the native terms, in adjacent entries of a table. CDIF and EXPRESS terms are both used in clause headings. There are also places where general terms are used, such as "module", "type" and "subject area" – some of which may also be special CDIF or EXPRESS terms – e.g. in clause headings and preambles. All this was done to avoid "CDIF-centricity" and encourage acceptance and joint ownership by both CDIF and STEP communities. Whilst the mapping is specific it is not too specific to CDIF and the same approach could be used with other pairs of modelling languages.

The correspondence between CDIF and EXPRESS in [CDIF-EXP] may be said to use an implicit reference model: writing it required a lot of thought on the separation and classification of concepts. So the CDIF-EXPRESS mapping provides a format for mappings which can be used (possibly with extensions and modifications) as an implicit reference model.

The format of the transformations from CDIF to EXPRESS and from EXPRESS to CDIF in [CDIF-EXP] provide a suitable structure for defining other transformations from CDIF, EXPRESS and other modelling languages. The ordering of such transformations should be based on the ordering used in the definition of the source language, since the writers of that specification have already worked out a suitable structure.

4.4 Use of existing mappings

Version 1 of the CDIF-EXPRESS mapping was based on [CDIF-PCTE], but took account of the observation made in London that clause 8, Issues for the Mapping, would be clearer if formatted like the transformation in clause 9. Acting on this helped to elucidate the nature of mappings and in creating suitable formats for correspondences and transformations.

The form of the transformation from CDIF to PCTE has remained with little change for the transformation from CDIF to EXPRESS. Some technical details of the transformation were questioned and changed considerably after prolonged discussion by email. Although this may demonstrate the main risk of re-use – copying with insufficient thought about changed circumstances – the advantages of having previous work for comparison far outweigh the disadvantages. (The comparative approach also showed deficiencies in the original CDIF-PCTE mapping.)

5. Recommendations

~~1.1~~5.1 General applicability

The study period has produced specific results that can also be applied in other mappings of CDIF and in the mapping of modelling languages more generally. Taken together, such mappings provide a basis for interoperability between a range of systems.

R1. It is recommended that SC7/WG11 informs the SC7 Secretariat of the following change:
Renaming ISO/IEC 15478, and the corresponding projects, to "CDIF Mappings", so that CDIF mappings be parts of a separate multi-part standard.

The correspondence between CDIF and EXPRESS and the transformations from CDIF to EXPRESS and from EXPRESS to CDIF in [CDIF-EXP] provides a suitable basic format and style, or reference model, for defining correspondences and transformations of modelling languages.

R2. It is recommended that editors of future CDIF mappings follow the format and style of the CDIF-EXPRESS mapping, once it becomes an ISO/IEC document.

The experience from this study period can be used to provide general guidelines for CDIF mappings.

R3. It is recommended that the title of Part 1 of 15478 CDIF Mappings be "Guidelines for CDIF Mappings", and that the SC7 Secretariat be informed of such change. (see R1).

Producing a CDIF-EXPRESS mapping structured like the CDIF-PCTE mapping [CDIF-PCTE] not only provided a good starting point for the CDIF-EXPRESS mapping, but also shed light on both mappings. Future CDIF mappings should be compared with existing CDIF mappings.

5.2 Quality

The use of compilers for the EXPRESS modelling language has made a vital contribution to the quality of the CDIF-EXPRESS mapping. It is regrettable that the primary format for the CDIF modelling language does not lend itself to automatic parsing of the CDIF standards.

R4. It is recommended that SC7/WG11 investigate the requirements and level of interest for proposals for a simple parsable syntax for the CDIF meta-meta-model that can be used in CDIF standards, so as to allow CDIF standards to be parsed and checked by software.

The use of tools for one modelling language (EXPRESS) has shown up differences between the modelling languages. For complete validation of mappings and other interoperability specifications it is necessary to prototype the whole system. Complete prototyping of any mapping is to be encouraged.

5.3 Future standards

The CDIF-EXPRESS mapping has been received with interest in both CDIF and EXPRESS communities.

R5. It is recommended that BSI asks SC7 to distribute [CDIF-EXP] to ISO/IEC JTC1/SC7 and ISO TC184/SC4 for comment on its suitability for submission to JTC1 through the fast-track procedure.

The specification [XMI] likely to be adopted by OMG for [SMIF] is disappointing since it does not support the interchange of UML models with other models, e.g. STEP product data models.

R6. It is recommended that SC7/WG11, via the C liaison, request the OMG's Analysis & Design Task Force to issue an RFP for interchange of models defined by different modelling languages.

6. References

[CDIF1] ISO/IEC FCD 15474-1, Information Technology — CDIF Framework — Part 1: Overview.

[CDIF2] ISO/IEC FCD 15474-2, Information Technology — CDIF Framework — Part 2: Modelling and Extensibility.

[CDIF-EXP] Mappings of CDIF and EXPRESS, version 3, BSI

[CDIF-PCTE] ISO/IEC CD 15474-3, Information Technology — CDIF Framework — Part 3: Mapping to PCTE.

[EXPIM] Information Modeling the EXPRESS Way, D.A. Schenck and P.R. Wilson, OUP 1994.

[EXPLRM] ISO 10303-11:1994, Industrial automation systems and integration — Product data representation and exchange — Part 11: Description methods: The EXPRESS language reference manual.

[JWKS] Report of the Joint Workshop on Standards for the Use of Models that Define Data and Processes of Information Systems http://www.nist.gov/workshop/jtc1-96/report.htm

[LONMIN] London Meeting Note – SP Mapping Modeling Language (SP-MML), Jean Bérubé

[MOF] Meta Object Facility (MOF) Specification, OMG ad/97-10-02

[SMIF] Stream-based Model Interchange Format, Request for Proposal, OMG ad/97-12-03

[SMIF-CDIF] Stream-based Model Interchange Format, Version 1.0 beta, OMG ad/98-07-09

[STEP] ISO 10303-1:1994, Industrial automation systems and integration — Product data representation and exchange — Part 1: Overview and fundamental principles.

[ToR] Terms of Reference for an Initial Study Period Report in Mapping Modeling Languages for Analysis & Design, SC7/WG11 N224R3

[UML] UML Semantics, version 1.1, OMG ad/97-08-04

[XMI] XML Metadata Interchange (XMI), OMG ad/98-10-05 XMI Specification, ad/98-10-06 XMI Appendices (Includes UML 1.1 and MOF 1.1 DTDs)

Annex A. Comparison of CDIF, OMG and STEP architectures

1. Architecture and terms

An information model comprises different *types of model*, such as data models, data flow models and state transition models. These describe different aspects of an information system from abstract models for the definition and analysis of requirements through to models that determine the design and implementation of system components, preferably by automatic generation, otherwise by manual programming.

An information model may be thought of as a program description (source program) that has two special characteristics:

- it is a model, i.e. is a representation (often with a graphical view), of the system it describes;
- it is abstract, i.e. it only represents certain characteristics of the system it describes.

So an information model is a special kind of program and is described in a modelling language, a special kind of programming language, one of whose special characteristics is that it can itself be defined as a model. Such a model, used to define types of models, is called a *meta-model*. A meta-model, being a model, can also be defined using a modelling language, called a *meta-meta-model*. The relationship of model, meta-model and meta-meta-model is shown in Figure A1.

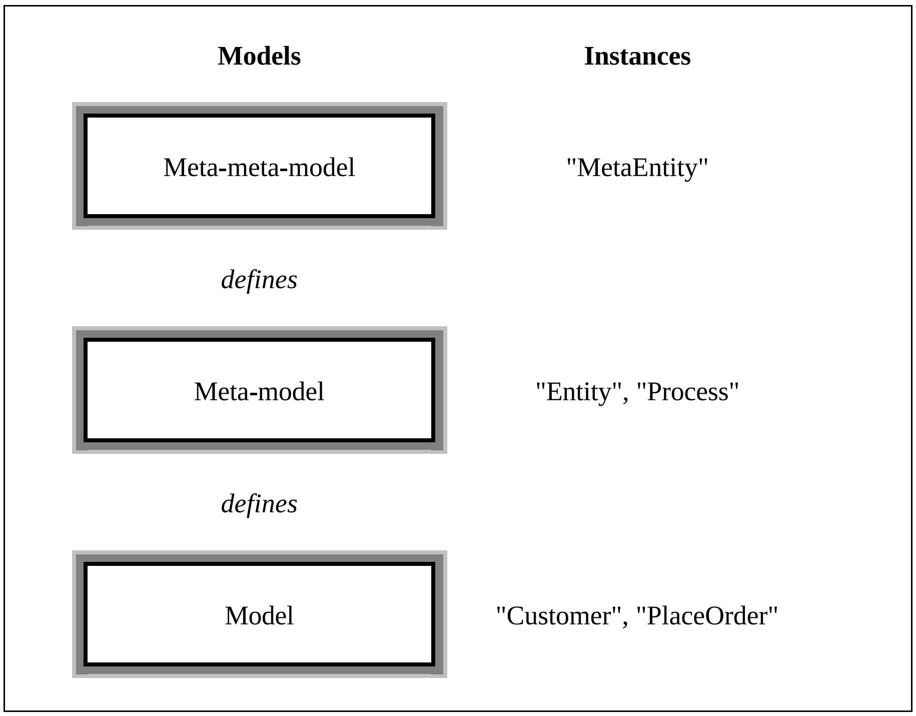


Figure A1. Layered architecture

The reason for including the meta-meta-model (which is a continual source of confusion) is as follows. The likelihood of having a single standard meta-model is as remote as of having a single programming language: software engineering and systems engineering are not yet fully mature disciplines so the requirements for process and data models are not stable. The business requirements in the previous section for transforming and integrating information models can be supported with a generic *transfer format*, i.e. a representation of the model and its meta-model that is suitable for stream or file-based transfer, for *exchanging* models. This requires a language for defining a meta-model, i.e. a meta-meta-model, and a transfer format based on the meta-meta-model.

A further advantage of defining the transfer format in terms of the meta-meta-model is that it supports user extensions to the meta-model or even a whole different meta-model.

Any pair of tools will probably have different internal meta-models, e.g. the types of data model they support will differ syntactically and semantically in detail. So model exchange between these tools will require transformation of the model and its meta-model for one or both tools. Models can be exchanged between any pair of tools which provide transformation to and from the same standard meta-model, so one is included in most implementations of the architecture described in this section.

The next sections describe some standards for representing and exchanging information models in terms of this architecture.

2. Comparison of architectures

The following tables summarise the corresponding architectural features of CDIF, STEP and the modelling and data exchange specifications of OMG.

The comparison is separated into

- references to where the architecture is defined,

and correspondences between

- the modelling languages that are used to define other architectural elements,
- other architectural elements at the meta-meta-model level, i.e. elements that can be applied generically to any instance of an element at the meta-model level, and
- architectural elements at the meta-model level.

Transformations defined between corresponding elements at the meta-meta-model level are generic transformations of elements at the meta-model level that can be applied to one system to derive elements that are semantically equivalent in the other system.

For full references of CDIF standards, see [CDIF1]. All the references for STEP are to parts of ISO 10303; for full references, see [STEP]. References to OMG UML can be found in [UML].

Architecture

OMG	CDIF	STEP
OMG (Object Management Group) is an industry consortium that adopts specifications for distributed object-oriented systems. The architecture of OMG specifications referred to here is described in ad/97-08-04	*Architecture* CDIF (originally for CASE Data Interchange Format) is a set of multi-part ISO/IEC draft standards whose architecture is described in FCD 15474-1. These are based on earlier EIA (Electronic Industries Association) interim standards.	STEP (STandard for Exchange of Product model data) is a multi-part standard ISO 10303 whose architecture is described in Part 1

Modelling Languages

OMG	CDIF	STEP
A subset (the Core package), ad/97-08-04, of UML (Unified Modeling Language), a (visual) modelling language with a graphical representation for defining meta-models, including UML itself	*Modelling Language* The Meta-meta-model, FCD 15474-2, a modelling language for defining meta-models (types of model), with textual and graphical representations	EXPRESS, Part 11, a modelling language for defining product data models, with a textual representation, and a graphical representation for a subset EXPRESS-G

Meta-meta-model Level

OMG	CDIF	STEP
	Semantic Constraint Language	
OCL (Object Constraint Language), ad/97-08-08, is used for the definition of semantic constraints of UML itself.	CDIF only supports the definition of semantic constraints through unstructured text (or a separate language).	EXPRESS, but not EXPRESS-G, supports the definition of semantic constraints
	Mapping Language	
No equivalent for UML models	*No equivalent for CDIF*	Mapping Language EXPRESS-X for defining mappings between EXPRESS schemas, *under development*
	Transfer Format	
Stream-based Model Interchange Format (SMIF), RFP ad/97-12-03, for exchanging models and meta-models between tools	Transfer Format, parts of 15475, for exchanging models and meta-models between tools	Clear Text Encoding, Part 21, for exchanging models between tools
	Model and Meta-model Access	
IDL bindings of MOF, ad/97-10-2, and UML, ad/97-08-09, for accessing object instances of meta-models and models, respectively	IDL binding of Meta-meta-model and Meta-model, EIA/IS-734, for accessing object instances of meta-models and models	Standard Data Access Interface (SDAI) for accessing object instances of models, Part 22 (abstract specification) with bindings in parts 23 (C++), 24 (C), 26 (IDL), etc.
	Repository Access	
Meta Object Facility (MOF), ad/97-10-2 and ad/97-10-03	Provided through mappings of CDIF to repositories, e.g. PCTE, CD 15474-3	Available through SDAI
	Conformance Testing Methodology	
No equivalent for OMG specifications	Conformance is defined generically in each part	Conformance is defined generically in each part. The Conformance Testing Methodology, Parts 31 and 32, specifies how to define specific conformance test suites for each AP
	Branding	
There is an OMG programme for CORBA branding	There is an EIA "CDIF enabled" programme for self-certification.	*not investigated at this time*

Meta-model Level

OMG	CDIF	STEP
UML, ad/97-08-02 to ad/97-08-09, for defining object analysis and design models, possibly with future extensions, e.g. for business process modelling	*Meta-model* The Semantic Meta-model, parts of 15476, for defining the types of data and process models used in software engineering. This harmonises the concepts of different methods and viewpoints, making CDIF independent of particular methods and tools	Application Protocols (AP), Part 2xy, provide product data models for some phase of product life in a particular field of engineering. An AP comprises • Application Interpreted Model (AIM), in EXPRESS, for data exchange, c.f. physical schema (normative) • Application Reference Model (ARM), optionally in EXPRESS, for application view, c.f. external schema (informative) • Application Activity Model (AAM), optionally in EXPRESS, for business process context (informative) Note. EXPRESS and EXPRESS-G are also used as a meta-model for defining application data models
UML provides a means of sharing elements between Packages. UML comprises a structure of inter-dependent packages for sharing and reusing elements of the meta-model	*Integration Mechanisms* CDIF provides a means of sharing elements between Subject Areas. The Semantic Meta-model includes subject areas specifically for integrating other subject areas: • Foundation subject area, FCD 15476-1, contains the roots of the meta-entity and meta-relationship hierarchies. • Common subject area, FCD 15476-2, contains constructs used in several subject areas	EXPRESS provides a means of sharing elements between Schemas. STEP includes schemas specifically for integrating APs: • Integrated Generic Resources, Part 4x, which contain constructs used in many APs, e.g. Part 42, Geometric and topological representations • Integrated Application Resources, Part 1xy, which contain constructs used in a particular application domain, e.g. Part 101, Draughting • Application Integrated Constructs, Part 5xy, which provide another means of sharing APs
No equivalent for UML unless SMIF enables use of CDIF Presentation Meta-model	*Presentation* Presentation Meta-model, CD 15477-2, for defining the graphical presentation of models described by the Semantic Meta-model	Integrated Generic Resource, Visual Presentation, in Part 46, for defining the graphical presentation of models described by Application Protocols
No equivalent for UML models	*Conformance Test Suites* *No equivalent for CDIF*	Abstract Test Suites, Part 3xy for AP Part 2xy

Transformations

OMG	CDIF	STEP
Transformation of UML Core to the CDIF Meta-meta-model, *under development in SMIF submission*	<u>*Modelling Language Mappings*</u> Transformations of the Meta-meta-model to other modelling languages, parts of 15474, that each enable the derivation of transformations to the target modelling language of parts of the CDIF Semantic Meta-model: • PCTE, CD 15474-3 • EXPRESS, *under development in study period*	Transformation of EXPRESS to the CDIF Meta-meta-model, *under development in study period* Non-standard mappings exist for EXPRESS to KIF and IDEF
Derived transformations of UML packages that are semantically equivalent to the UML definition: • CDIF subject areas, *under development in SMIF submission*	<u>*Meta-model Mappings*</u> Derived transformations of Semantic Meta-model subject areas that are semantically equivalent to the CDIF definition: • PCTE schema definition sets, CD 15474-3 • EXPRESS schemas, *under development in study period*	*There is a requirement for derived transformation of EXPRESS to CDIF subject areas that are semantically equivalent to the EXPRESS definition.*

Annex B. Transformation of MOF to CDIF

1. MOF Static Kernel

The MOF static kernel, which is a proper subset of the MOF meta-meta-model specified in [MOF] is shown in Figure B1. Further details of the definition of the MOF static kernel and of the transformation are given in [SMIF-CDIF].

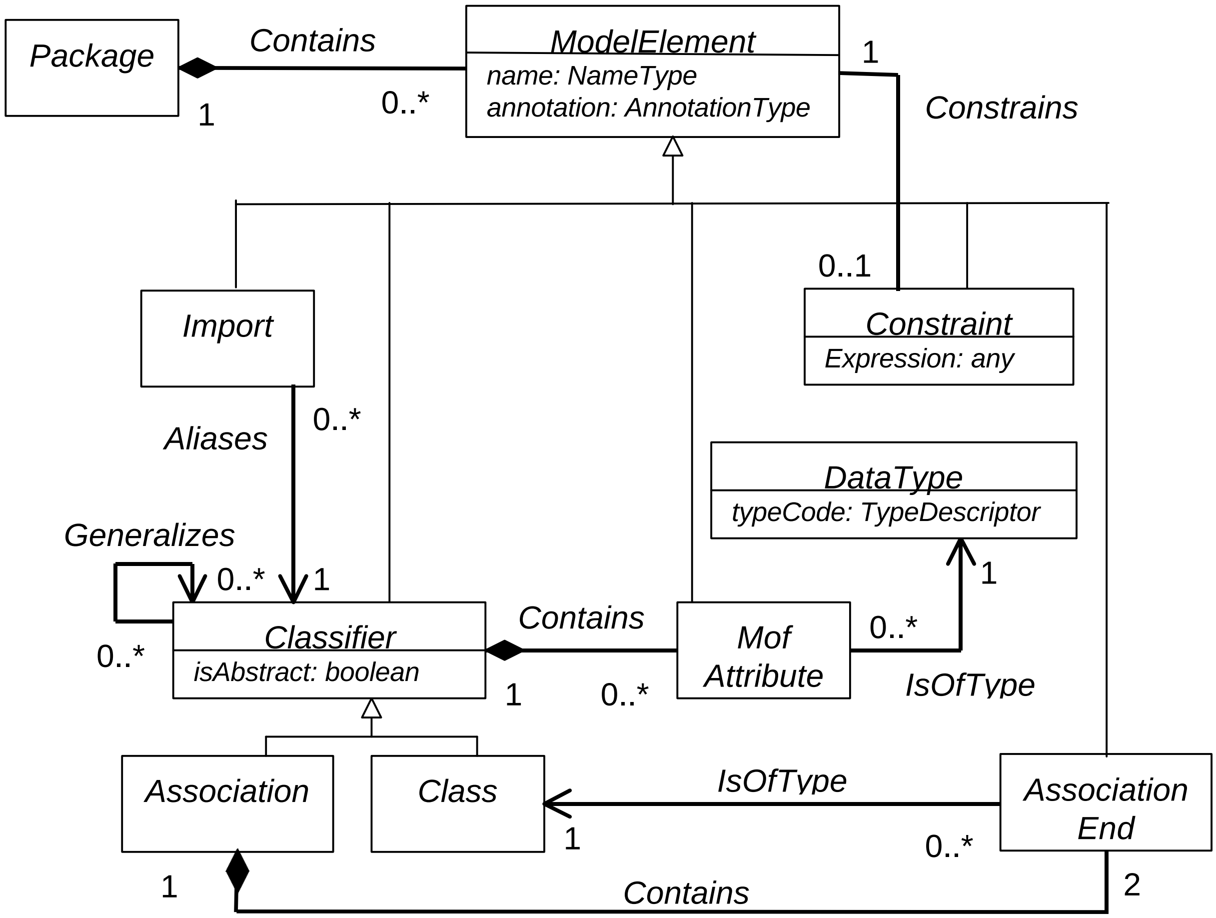


Figure B1 MOF static kernel

This diagram uses the UML notation described in the UML Notation Guide (OMG AD/97-08-05)

2. Transformation of MOF static kernel to CDIF meta-meta-model

An outline transformation of the MOF static kernel to the CDIF Meta-meta-model is defined below. At this level of detail the transformation is isomorphic.

~~1.1~~2.1 Direct transformations

Part of the transformation consists of the direct transformation of a MOF static kernel element to a CDIF meta-meta-model element. These transformations that are listed in Table B1. Elements of the MOF static kernel are referred to here as (metameta)Classes, (metameta)Associations and (metameta)Attributes.

Table B1 Direct transformations

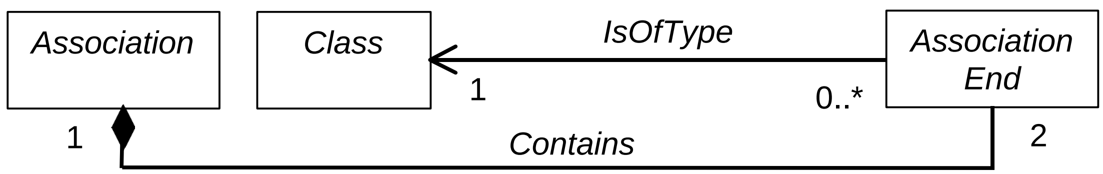
MOF Static Kernel Elements	CDIF Meta-meta-model Elements
(metameta)Classes	**Meta-meta-entities**
Package	*SubjectArea*
Class	*MetaEntity*
Association	*MetaRelationship*
MofAttribute	*MetaAttribute*
Classifier	*AttributableMetaObject*
(metameta)Associations	**Meta-meta-relationships**
Package-Contains-ModelElement	*CollectibleMetaObject.DefinedIn.SubjectArea*
Classifier-Generalizes-Classifier	*AttributableMetaObject.HasSubtype. AttributableMetaObject*
Classifier-Contains-MofAttribute	*MetaAtttribute.IsLocalMetaAttributeOf. AttributableMetaObject*
(metameta)Attributes	**Meta-meta-attributes**
Classifier.isAbstract	*AttributableMetaObject.IsAbstract*
ModelElement.name	*MetaObject.Name*
ModelElement.annotation	*MetaObject.Description*

Other parts of the transformation are defined below as transformations of the MOF static kernel which can then be directly transformed to CDIF meta-meta-model elements according to Table B1.

2.2 Transformation of Classes into Associations

Two (metameta)Classes transform into (metameta)Associations:

- *AssociationEnd* becomes two separate associations
- *Import* becomes a many-to-many association



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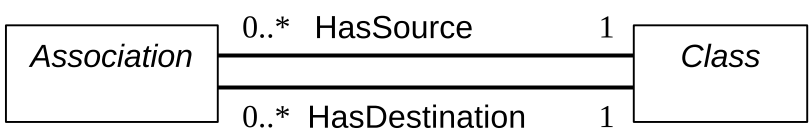
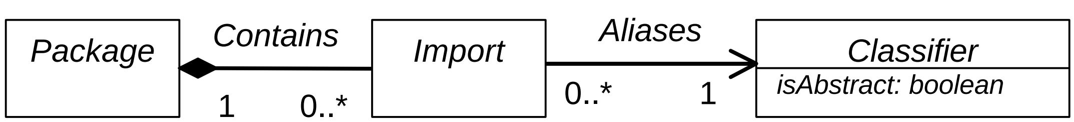


Figure B2 *AssociationEnd* transformation



Transforms into:

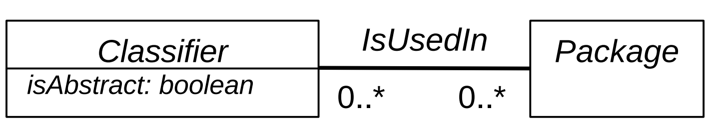
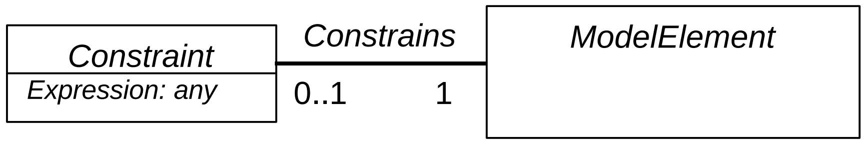


Figure B3 *Import* transformation

2.3 Transformation of Classes into Attributes

Two (metameta)Classes transform into (metameta)Attributes:

- *Constraint* becomes an optional attribute on *ModelElement*
- *DataType* becomes a mandatory attribute on *MofAttribute*



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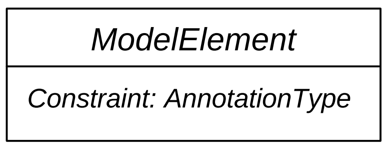
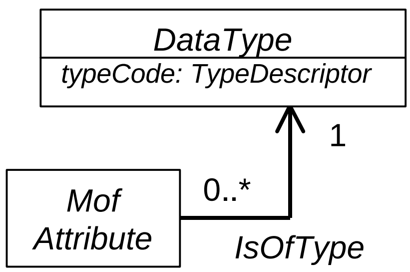


Figure B4 *Constraint* transformation



Transforms into:

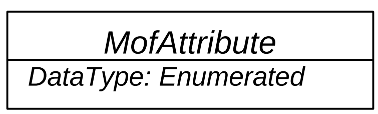


Figure B5 *DataType* transformation