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# Means to enable Enterprise Interoperation: CIMOSA Object Capability Profiles and CIMOSA Collaboration View

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Abstract: Collaboration between enterprises has moved from regional and national environments to a global one. This has tremendously increased the need for information exchange between collaborating partners. However, non-compatible (heterogeneous) ICT environments and inconsistent semantic and syntax of information to be exchanged are very often barriers in the interoperation process. Nevertheless, the relevant semantic information is usually collected in enterprise models. This information, amended by the corresponding syntax, can be collected in Object Capability Profiles that describe the required and provided information to be exchanged by the partners. An even more elaborate solution could be a new model view that collects all information needed to support intra- and inter-enterprise information exchanges. The authors first propose the exploration of object capability profiles for inter-organisational communication or interoperation applied to CIMOSA and the related international standard CEN/ISO 19440. Object Capability Profiles of objects potentially involved in information exchange will identify both semantic and syntax of the information to be exchanged. Comparison between required and provided information will detect any mismatch between the two and would allow automatic or manual corrections. In addition, collaboration aspects are proposed to be modelled in a specific modelling view called Collaboration View. After recalling elements of the CIMOSA modelling language, the paper presents a proposal for both the Object Capability Profiling and the Collaboration View. A simplified illustrative example demonstrates the applicability of the two proposals.

*Keywords:* Enterprise Modelling, Enterprise Interoperability, Object Capability Profiles, Collaborative Networked Organisations, Collaborative View, CIMOSA.

## 1. INTRODUCTION[1]

Collaboration is about working together in order to increase competitive advantages, benefits, competencies or capabilities. Collaboration between enterprises has been common practice in many industries for a long time. However, never in history has the need for collaboration among companies been so strong. Also, the role of the collaboration participants has changed. Suppliers have become real partners (i.e. trusted stakeholders) in product design, production and even distribution. Nowadays, this collaboration has been extended to the day to day operations and to the process level [1]. With the heavy automation of most enterprise processes, the need for computer-based intercompany information exchange has become paramount. However, incompatibilities between different ICT systems have been and still are a barrier for straightforward system interconnections and application interoperability while information exchange remains a severe barrier in such collaboration.

Early work in the area of enterprise modelling has characterised such incompatibilities and identified three types of solution for ICT based interoperation [2]:

1. Master models – from which all other models are derived and thereby leading to integrated environments

2. Unified models/meta-models – enabling translation between models and leading to unified environments

3. Federated models – that provide for loose coupling – late binding – as needed that support federated environments

CIMOSA (Computer-Integrated Manufacturing Open System Architecture) has been developed as an early Enterprise Architecture Framework (EAF) at a time when the focus was on Computer-Integrated Manufacturing [3]. However, the CIMOSA event-driven process-based concepts can be applied to any type of enterprise and in any environment (centralised or distributed). It has the potential to support information exchange in inter-organisational environments.

The original work on CIMOSA focussed on the master model solution. In the meantime, with the shift to very intensive collaboration, the focus in R&D has moved towards solutions for the federated environment. The international standard CEN/ISO 11354 [4] has identified three types of barriers that hinder inter-organisational information exchange in federated environments:

1. Conceptual barriers – difficulty in content understanding due to different semantic, semiotic and syntax of the information to be exchanged

2. Technological barriers – difficulty in information transfer due to different technology implementations

3. Organisational barriers – difficulty in problem solving due to organisational incompatibilities

[1] The CIMOSA Association is closed.

All three barriers require particular solutions and most of these may become rather time consuming and costly. But the most difficult type of barrier is the conceptual one with the potential misunderstanding of information content. The three causes of these misunderstandings are in information:

- Syntax: The arrangement of words and phrases to create well-formed sentences in a language [5]. In computer science, the syntax of a programming language is the set of rules that define the combinations of symbols that are considered to be correctly structured programs in that language [6].

- Semantics: The branch of linguistics and logic concerned with meaning. The two main areas are logical semantics, concerned with matters such as sense and reference and presupposition and implication, and lexical semantics, concerned with the analysis of word meanings and relations between them [5].

- Semiotics: The study of signs and symbols and their use or interpretation [5]. Semiotic engineering was originally proposed as a semiotic approach to designing user interface languages. Over the years, it has evolved into a semiotic theory of human-computer interaction (HCI) [7].

All this holds for enterprise models. However, differences in information syntax, semantics and semiotics are not only due to the various languages (natural and ICT oriented) or modelling formalisms themselves, but can often be due to their use in the different professions, industries or regions. To solve these differences may require not only technical but also cultural changes. Whereas the syntactical differences can be resolved relatively easy, the remaining two – semantic and semiotic – are rather difficult. Fortunately, both are related and may be solved altogether.

Numerous approaches can be used to address the problem of semantic incompatibilities in heterogeneous environments. Examples include semantic annotation, object capability profiling or ontology-based transaction. The aim of these approaches is to provide a priori information about the semantic characteristics of the information objects to be involved in the transaction.

Software capability profiling is the subject of ISO 16100 [8], an international standard that identifies software capabilities to enable selection of software packages needed in particular tasks. Capability profiling is about describing domain-specific attributes or rules that define operational abilities that an object must possess. Such types of profiles could also be used to describe the semantic and syntax of the attributes of information objects that are to be part of inter-operational exchanges in heterogeneous environments [9, 10].

Potential sources of information about these objects are enterprise models. Such models have captured all information needed to describe particular enterprise processes and objects and usually present those with their names. The models therefore already contain an important part of the information needed for Object Capability Profiles of these enterprise objects potentially to be exchanged. If this information could be amended by its related syntax and made available for such profiles it would be a significant step forward to enable interoperability in heterogeneous environments.

The following sections describe the selection of Object Capability Profile information relevant for inter-organisational communication in federated environments, illustrated with the CIMOSA modelling language [11] and the related international standard CEN/ISO 19440 [12]. They have been selected because of their generic nature and familiarity of authors to them. Furthermore, a Collaboration View, in the sense of the CIMOSA View concept, is proposed to collect all relevant collaboration information about the partners in a collaborative environment.

Starting with a short description of enterprise modelling according to CIMOSA, the most relevant language construct for the creation of Object Capability Profiles is that of Enterprise Activity. Its template is introduced in a summarised form. The object view items identified in the template are those that in the real case may either be available or may have to be stored in a foreign system or both. To use these information items in the Object Capability Profile, only the information about their syntax have to be added to enable either the matching between information origin and destination or at least the identification of mismatches.

## 2. ENTERPRISE MODELLING

Improving production processes and handling their complexity have been the driving force in production research throughout its existence. Process modelling [13] has been an important tool in this undertaking. But it was soon recognised that the timely behaviour of production processes is not only depending on execution of their own tasks, but is heavily influenced by the environment. Supporting functions such as production planning, purchasing and even administrative tasks play a role in the production processes as well. Therefore, process modelling has soon been extended to enterprise modelling by taking into account these processes as well [3, 12, 14].

The tasks in any enterprise process can be described as a sequence of activities that need inputs to produce results and require resources for the actions to take place. Control information represents the rules under which the actions are to be carried out by the resources. The dynamic behaviour of the process itself is described by a set of behavioural rules that describe the control flow under which actions (i.e. activities) will take place.

To describe all the different aspects of the enterprise in one coherent model is a rather ambitious and somehow unrealistic undertaking. Furthermore, working with such a large and complex model could even be more challenging. CIMOSA has therefore introduced the concept of modelling view that allows focussing on certain aspects of the enterprise while temporarily ignoring all others. Each model view will present only the modelling language building blocks to the user relevant for her/his particular interest. Four essential model views have been defined and standardised: Function/Process View, Information View, Resource View and Organisation View [3, 12]. This is not limitative and other views may be defined if needed.

## 3. CIMOSA MODELLING LANGUAGE

The most relevant building blocks of the CIMOSA modelling language which have been standardised as model language constructs in CEN/ISO 19440 are presented in Table 1 (herein, the term construct is used in the CEN/ISO 19440 sense). Other constructs exist and the content of a few additional building blocks defined by CIMOSA have been integrated in the constructs of the international standard CEN/ISO 19440. For details on these constructs, the reader is referred to the CIMOSA Formal Reference Base [11].

Table 1 lists the major enterprise modelling constructs with their basic elements (or information items). Constructs in parenthesis are either subsets or specialisations of the base constructs. Table 1 also shows the relation between these constructs and the four views mentioned earlier. The functionality of these constructs is described in Table 2.

Table 1: CIMOSA Modelling Language (extract)

| *Modelling Views* | | | | |
|---|---|---|---|---|
| Function/Process View | | Information View | Resource View | Organisation View |
| *Modelling Language Constructs* | | | | |
| Domain (DM), Business Process (BP), Event (EV) | Enterprise Activity (EA) | Enterprise Object (EO), Object View (OV) | Resource (RE) (Functional Entity), Capability Set (CS) | Organisation Unit (OU), Person Role (PR) (Organisational Role, Operational Role) |
| *Language Construct Elements* | | | | |
| Behavioural Rule | Functional Operation | Information Element | Capability Element | Organisation Element |

Table 2: Functionality of Modelling Constructs (Adapted from CEN/ISO 19440)

| *View Name* | *Modelling Language Constructs* |
|---|---|
| **Function/Process View** | **Domain:** Represents a functional subset of the enterprise (i.e. the universe of discourse) to be analysed and for which a CIMOSA compliant model will be created.<br>**Event:** Represents a change of state in the enterprise or its environment. Occurrences of events trigger business process occurrences.<br>**Business Process:** Represents a set of Business Processes and/or Enterprise Activities that can be executed to achieve some desired end-result.<br>*Procedural Rules:* Describe the behaviour of a Business Process controlling the sequence of execution of Enterprise Activities.<br>**Enterprise Activity:** Represents a part of the enterprise functionality and identifies the inputs needed for its execution and the outputs created as a result.<br>*Functional Operation:* Represents a part of the functionality of an Enterprise Activity. |
| **Information View** | **Enterprise Object:** Represents the set of information that describes a generalised or a real or an abstract entity.<br>**Object View:** Defines the object nature (material or information) and represents the object state by a subset of the Enterprise Object attributes relevant in a particular application.<br>*Information Element:* Descriptive properties of Enterprise Objects. |
| **Resource View** | **Resource:** Represents the provided capabilities required to execute an Enterprise Activity.<br>**(Functional Entity):** A specialisation of the Resource construct able to perform, completely on its own, a (class of) functional operation(s) required by an Enterprise Activity.<br>**Capability Set:** Represents the capability characteristics of either a Resource (its provided Capability) or an Enterprise Activity (its required Capability).<br>*Capability element:* Descriptive of capability properties. |
| **Organisation View** | **Organisation Unit:** Represents an entity of the organisational structure of an enterprise.<br>**Person Role:** Represents a set of personal capabilities, skills and responsibilities.<br>**(Organisational Role):** Specialisation of Person Role that represents organizationally relevant human skills and responsibilities.<br>**(Operational Role):** Specialisation of Person Role that represents relevant human skills and responsibilities. |

*Templates*

Modelling language constructs are formalised as templates that enable the capture of information needed in the description of the model in an implementation independent way. They can then easily be implemented as object classes and stored in any type of database. For instance, the Enterprise Activity template header provides information for construct identification, whereas the data to be captured are collected in the template body. The latter are categorised in three different sections:

- General information that describes the purpose and dynamic behaviour of the building block
- Required data needed for the execution of the activity, i.e. enterprise activity inputs
- Provided data produced during the execution of the activity, i.e. enterprise activity outputs

Both required and provided data are represented as Object Views that gather the information elements and are stated as particular items in the template.

The templates of Enterprise Activity (Table 3) and Object View (Table 4) are shown hereafter in a summarised form to

illustrate the use of such templates (For the complete set of templates, please see CEN/ISO 19440). The activity construct is expected to be the one mostly involved in enterprise interoperation since process activities are the locus of action, i.e. need and produce information and objects. Information exchange may be needed for other constructs as well.

Table 3: Enterprise Activity Template

| **Template Header** |
|---|
| Construct label, Identifier, Name, Design Authority |
| **Template Body** |
| ***General information***<br>Description, Activity Behaviour, Objectives, Constraints, Performance Indicators, Events<br>Where used, Consists of<br>*Operational Relationships:* Operation Responsibility, Operation Authority |
| ***Required data***<br>Function Inputs, Control Inputs, Resource Inputs, Operational Roles, Capabilities<br>***Provided data***<br>Function Outputs, Control Outputs, Resource Outputs, Operational Role Outputs, Ending Statuses, Duration |

Table 4: Object View Template

| **Template Header** |
|---|
| Construct label, Identifier, Name, Design Authority |
| **Template Body** |
| ***General information***<br>Description, Nature, Constraints, related Enterprise Objects, Associated Events<br>*Operational Relationships:* Operation Responsibility, Operation Authority |
| ***List of attributes:***<br>Attribute name: Property names and values |

## 4. OBJECT CAPABILITY PROFILING IN CIMOSA MODELS

The CIMOSA constructs have been widely used and demonstrated in various case studies dealing with manufacturing integration [14].

Nowadays, information exchange between organisations is needed if origin and destination of the information required and produced during process execution are located in different ICT system environments. To exchange such information, the ICT related characteristics of the data (i.e. meaning = attribute name, syntax = value format and arrangement of property elements) have to be matched between the requiring and providing partners. A priori information characteristics about the items that need to be exchanged are seen as a helpful means in the exchange. Such information enables the partners to test the potential transaction and identify corrective actions. These actions may be partly automatic, but most probably have to include human intervention.

Sources of a priori information are indeed enterprise models that have collected all relevant data about enterprise processes. Therefore, the data to be exchanged are part of the model and the content of the needed information exchange profile will be the list of relevant attributes identified in the enterprise model object templates. These attributes have to be amended with information about their syntax and format to support the matching between the partners of the exchange.

There are two ways of presenting the ICT characteristics of the data to be exchanged:

1. Amending the relevant construct templates of Table 1
2. Providing a special Object Capability Profile template

The two alternatives are shown in Tables 5 and 6, respectively. The Enterprise Activity template presented earlier has been chosen as an example for alternative 1. Here, the proposed profile for information exchange is added to the existing template to indicate the capability of CIMOSA or the international standard CEN/ISO 19440 to support enterprise interoperability. This profile would list all Object Views that could be needed in the execution of the activity as well as all of those produced during the execution.

The proposed Object Capability Profile will be a generally applicable language construct that will be associated with any object potentially involved in an information exchange. It will post the lists of attributes identified for the associated construct (e.g. Enterprise Object). The profile would therefore be applicable in enterprise environments that are not using templates to capture related information.

Table 7 shows the use of alternative 1 of the proposed profile on an illustrative example developed for the international standard CEN/ISO 19440. A ‘machine’ Enterprise Activity, that is part of a manufacturing process shown in Figure 1, has been chosen to demonstrate the expansion of the model information to the profile data. According to the CIMOSA concepts, all required and provided information are identified as Object Views. These Object Views represent special views or states on the different information objects that make up the information model of the manufacturing process. Therefore, the content of the identified Object Views has to be identified in the Enterprise Activity profile in Table 7. To enhance acceptance of interoperability in multi-lingual collaborations, attribute names may be expressed in national languages, provided that translation into a language common to all partners (e.g. through an ontology) is available.

Table 5: Enterprise Activity Template amended by Profile for Information Exchange

| **Template Header** |
|---|
| Construct label, Identifier, Name, Design Authority |
| **Template Body** |
| ***General information***<br>Description, Activity Behaviour, Objectives, Constraints, Performance Indicators, Events<br>Where used, Consists of<br>*Operational Relationships:* Operation Responsibility, Operation Authority |
| ***Required data***<br>Function Inputs, Control Inputs, Resource Inputs, Operational Roles, Capabilities<br>***Provided data***<br>Function Outputs, Control Outputs, Resource Outputs, Operational Role Outputs, Ending Statuses, Duration |
| **Profile for information exchange** |
| Identification of all Object View attributes in this activity to be potentially involved in information exchange<br>***Required data:*** See list in Template Body with representation of attribute name, value and syntax (format and structure)<br>***Provided data:*** See list in Template Body with representation of attribute name, value and syntax (format and structure) |

Table 6: Enterprise Object Capability Profile Template

| **Template Header** |
|---|
| Construct label, Identifier, Name, Design Authority |
| **Template Body** |
| ***General information***<br>*Applies to:* Enterprise Object<br>*Relationships:* associated Object Views, Events<br>List of Object View attributes to be involved in information exchange<br>***Required information:*** representation of attribute name, value and syntax (format and structure)<br>***Provided information:*** representation of attribute name, value and syntax (format and structure) |

Table 7: Illustrative Example of Enterprise Activity Template with Profile for Information Exchange

| **Template Header** |
|---|
| Construct label: ***EA***, Identifier: ***EA1***, Name: ***machine,*** Design Authority: ***Production Planning*** |
| **Template Body** |
| ***General information***<br>Description: *Identifies all inputs and outputs needed for the task of part machining starting with material handling and ending with part completion*, Activity Behaviour: *TBD (To Be Done)*, Objectives: *increase profitability*, Constraints: *Resource availability, Regulations (working time and environment)*, Performance Indicators: *TAT* (*Turn Around Time); Work in progress, machining cost*, Events: *Shop Floor Order a*<br>Where used: *BP Manufacturing*, Consists of: *NIL*<br>*Operational Relationships:* Operation Responsibility: *Dept. Mgr.*, Operation Authority: *Mfg. Engineering* |
| ***Required data***<br>Function Inputs: *OV Part Material,* Control Inputs: *OV Shop Floor Order a*, Resource Inputs: *OV Machining Resources,* Capabilities: *CS Machining Capabilities*, Person Profile Inputs: *OV Machining Operator*<br>***Provided data***<br>Function Outputs: *OV Part*, Control Outputs: *OV Performance Indicators*, Resource Outputs: *OV Resource Status Information*, Person Profile Outputs: *Operator Status Information*, Ending Statuses *{Part done}*, Duration: *OV Time* |
| **Profile for information exchange** |
| Identification of all Object View and Capability Set attributes in this activity to be involved in information exchange.<br>Representation of attribute name/value and syntax (format and structure)<br>**Required data:**<br>Function Inputs: *OV Part Material (Part Name=xyz, Part Id=123, Drawing nr=456, Part Material=A)*<br>Related Enterprise Object: *Parts Material*<br>Control Inputs: *OV Shop Floor Order a (Order nr.=789, Order type=shop floor, Order subject=part machining, Order volume={200, 300, 400}, Start date=current week; Finish date= current week +3)*<br>Related Enterprise Object: *Order Pool*<br>Resource Inputs: *OV Machining Resources (Machining Cell=Y)*<br>Related Enterprise Object: *Resource Pool*<br>Required Capabilities: *CS Machining Capabilities (Set-up, Handling, Positioning, machining)*<br>Related Enterprise Object:<br>Person Profile Inputs: *OV Machining Operator (Name=X*, P-Nr= 234, *Competencies: Resource Setup, Resource Operation,* Availability=1st shift)<br>Related Enterprise Object: *Operator Pool*<br>**Provided data:** |

| | |
|---|---|
| Function Outputs: | *OV Part (Part name=xyz, Part Id=123, Number of parts=200)*<br>Related Enterprise Object: *Collaboration Administration Pool* |
| Control Outputs: | *OV Performance Indicators (*TAT < 10 min)<br>Related Enterprise Object: *Collaboration Administration Pool* |
| Resource Outputs: | *OV Resource Status Information (Machining Cell=Y, usage time=10 hours)*<br>Related Enterprise Object: *Collaboration Administration Pool* |
| Person Profile Outputs: | *OV Operator Status Information (Name=X*, P-Nr= 234, Work time=12 hours)<br>Related Enterprise Object: *Collaboration Administration Pool* |
| Ending Statuses: | *{Part done}* |
| Duration: | *OV Time* |

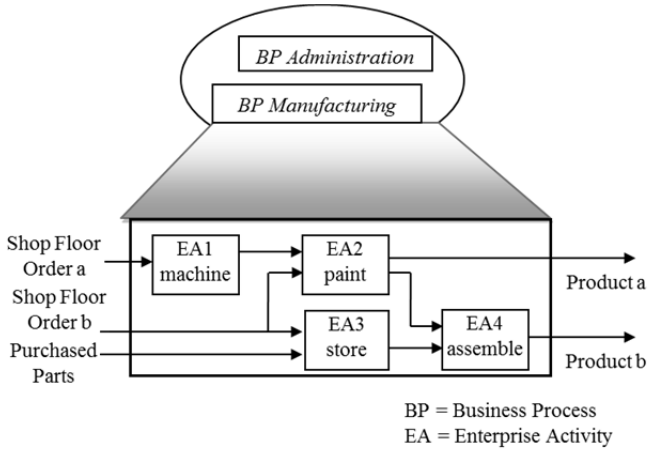


Figure 1: Simplified Illustrative Example on Manufacturing Processes[2]

## 5. COLLABORATION VIEW

Enterprise networks and Collaborative Networked Organisations (CNOs) are made of a finite set of collaborating entities from different partner companies working together. This implies among other things business process synchronisation, sending events, exchanging material or information objects and even, in some cases, sharing resources.

Whereas Object Capability Profiling has been proposed to syntactically and semantically define for each partner the information potentially to be exchanged between partners, a Collaboration View is proposed to describe the context and characteristics of the collaboration from the point of view of each partner. Indeed, the enterprise architecture of each partner belongs to this partner while the architecture of the whole network does not belong to any specific partner.

Following the model view concept of CIMOSA, this view identifies three new language constructs with their respective elements to globally describe collaboration as commonly depicted in the literature [1, 15, 17]. These are:

- Collaboration Domain: *Description, Collaborating Partners, Collaborating Entities*[3]*, Exchanged Object Views, Exchanged Events, Collaboration Points*
- Collaborating Partner: *Partner identification, Parent entity, Partner Role, Partner ICT Environment*
- Collaboration Point: *Partner entity, Collaboration type, Collaborating entities, Exchange flows, Exchange media*

The Collaboration Domain construct is used to describe a given collaboration area between the enterprise at hand (*Us*) and its partner companies identified as its Collaborating Partners. It indicates the collaboration entities (i.e. processes, activities, resources or organisation units described in the other modelling views of the enterprise architecture), the exchanged objects in terms of events and object views as well as the list of Collaboration Points, i.e. gateways supporting the various exchange flows with the different partners.

Collaborating Partners of the enterprise at hand are business entities involved in the collaborative exchanges with this enterprise. They are defined in terms of their role in the collaboration (e.g., supplier, provider, consumer or retailer). A description of their ICT environment can be made.

Collaboration Points, as defined by Li et al. [16], represent the collaboration interfaces between collaborating entities of an enterprise and those of one of its Collaborating Partners. The type of collaboration can be unidirectional or bidirectional, synchronous or asynchronous or based on mutual adjustment. The exchange media or transportation means supporting the exchange flows must be specified.

A partner enterprise, or one of its branches, can be involved in several Collaboration Domains. Each Collaboration Domain may comprise several Collaboration Points.

Table 8 shows the new Collaboration View and its content together with the other four views.

The use of the different language constructs enables the representation of a collaboration model from the point of view of a given partner company with reference to the models of the other individual enterprises by describing its collaboration domains and interacting partners. The three new templates of the Collaboration View are presented in Tables 9, 10 and 11.

## 6. ILLUSTRATIVE EXAMPLE OF A COLLABORATION DOMAIN

Let us assume that two companies are willing to cooperate by sharing resources in the production of mechanical products by splitting the production process into machining (EA1 machine) done in Company X and finishing (EA2 to EA4) done in Company Y. The collaboration domain of the two companies contains at least the two Business Processes as shown in Figure 2. The example only details the

[2] Adapted from CEN/ISO 19440.

[3] Namely, Processes, Activities, Resources or Organisation Units (usually organised in pairs - one from each partner).

manufacturing process and leaves out any details for the administration process. However, the latter is possibly involved in order processing, supplier and vendor relations, among others. The Collaboration Point (parts and data exchange) named CP1 is represented by the symbol "X" between activity EA1 and activity EA2 in Figure 2. Examples of Collaboration Domain and Collaboration Point constructs are given in Tables 12 and 13, respectively.

Table 8: Amended CIMOSA Modelling Language

| *Modelling Views* | | | | | |
|---|---|---|---|---|---|
| Function/Process View | | Information View | Resource View | Organisation View | Collaboration View |
| *Modelling Language Constructs* | | | | | |
| Domain (DM), Business Process (BP), Event (EV) | Enterprise Activity (EA) | Enterprise Object (EO), Object View (OV) | Resource (RE) (Functional Entity), Capability Set (CS) | Organisation Unit (OU), Person Role (PR) (Organisational Role Operational Role) | Collaboration Domain (CD), Collaborating Partner (PC), Collaboration Point (CP) |
| *Language Constructs Elements* | | | | | |
| Behavioural Rule | Functional Operation | Information Element | Capability Element | Organisation Element | Partner Element (Legal information, Trust...) |

Table 9: Collaboration Domain Template

| **Template Header** |
|---|
| Type, Identifier, Name, Design Authority |
| **Template Body** |
| ***General information***<br>Description<br>*Operational Relationships:* Operation Responsibility, Operation Authority: |
| ***Domain Components***<br>Collaborating Partners, Collaborating Entities, Exchanged Object Views, Collaboration Points |

Table 10: Collaboration Partner Template

| **Template Header** |
|---|
| Type, Identifier, Name, Design Authority |
| **Template Body** |
| ***Partner Information***<br>Partner identification (Legal Name, Legal status, Location), Parent entity (if any), Partner role (supplier, service provider, consumer, retailer, other), Partner ICT environment description |

Table 11: Collaboration Point Template

| **Template Header** |
|---|
| Type, Identifier, Name, Design Authority |
| **Template Body** |
| ***Collaboration Point Components***<br>Collaborating Partner, Collaboration type, Exchange flows (Sender, Receiver, Flow: list of Events and/or Object Views, Exchange media/means) |

Table 12: Example of Collaboration Domain Template

| **Template Header** |
|---|
| Construct label: ***CDM***, Identifier: ***CDM-01***, Name: ***Cooperation for mechanical part manufacturing,*** Design Authority: ***TBD*** |
| **Template Body** |
| ***General information***<br>Description: the cooperation aim is to share resources by splitting the part production process into a machining part (Company X) and a finishing part (Company Y). The two companies have modelled their processes and are using mostly compatible environments (case A) or not (case B)<br>Operational Relationships: Operation Responsibility: Dept. Mgr., Operation Authority: Mfg. Engineering |
| ***Domain Components***<br>Collaborating Partners: *Company X (Us)*, *Company Y*<br>Collaborating Entities: *Company X: EA-1 machine*<br>*Company Y: EA-2 paint*<br>Exchanged Object Views;<br>*OV Part (Part ID, Number of Parts, Date of Completion)* ,<br>Exchanged Events:<br>*EV Part Machining Completed (attached OV Part)*<br>Collaboration Points:<br>*CP1* |

Table 13: Example of Collaboration Point Template

| **Template Header** |
|---|
| Construct label: ***CP***, Identifier: ***CP1***, Name: ***Parts transfer,*** Design Authority: ***TBD*** |
| **Template Body** |
| ***Collaboration Point Components***<br>Collaborating Partner: *Company Y*<br>Collaboration type: *Batch transfer (unidirectional, asynchronous)*<br>Exchange flows*:*<br>*- Sender: Company X (Us): EA-1 machine*<br>*- Receiver: Company Y: EA-2 paint*<br>*- Flow: list of OV Part*<br>*- Exchange media/means: Transport by truck* |

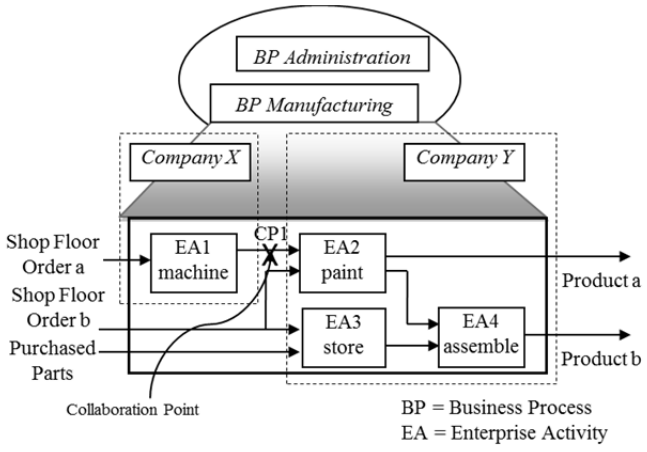


Figure 2: Example of Enterprise Collaboration

## 7. CONCLUSIONS AND FUTURE WORK

The spread of enterprise cooperation as well as collaborative organisation networks is intensifying in various business environments because ever more companies need to share capabilities, knowledge, competencies or know-how due to constantly increasing product or service complexity. Thus, information exchange between organisations has become a research item of high priority with emphasis on semantic, semiotic and syntactical incompatibilities between heterogeneous systems. The paper proposes the use of enterprise models as a source for a priori information about the information items involved in the exchange. Using the Object Capability Profiling concept, these information items only need to be amended by information about their syntax. The enterprise activity template can be extended as shown in the paper to represent both the original template as the source of the information and, added as its extension, the proposed profile for information exchange. Furthermore, the paper advocates that collaboration aspects of a networked organisation can be described by means of an additional Collaboration View in the architecture of each enterprise involved in the collaboration using three new constructs: Collaboration Domain, Collaborating Partners and Collaboration Points.

The proposal is being made as a contribution to the search for potential solutions in the area of ICT based information exchange in heterogeneous environments. The example provided remains academic and a real-world test scenario of this proposal is still outstanding. Also, the new constructs proposed apply at the requirements definition modelling level and should be specified for the design specification modelling level and the implementation description modelling level as well.

Although illustrated on CIMOSA and CEN/ISO 19440 modelling constructs, it is worth to mention that the proposed approach will remain valid for any other enterprise modelling formalism based on constructs.

One area for further research concerns the degree of formalisation, or formal specification language, for object capability or collaboration view templates to reduce risk of different interpretations by agents using them.

Finally, it should be noted that the minimum maturity level as defined by Chen [18] required by the approach is that the collaboration objects (enterprise activities and their object views) are fully described in the form of object templates or classes (level 3). For object capabilities, capability profiles describe what is provided or needed and in which format. Depending on the ICT environment, this may allow for automatic adaption, which would require level 4.

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