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# Towards a Modeling Framework for Service-Oriented Digital Ecosystems

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**Abstract.** Reference modeling for collaborative networks has been identified as a key topic in consolidating this new scientific discipline. Earlier contributions on this field have provided a solid initial framework and they are considered starting points for this work. Based on two well-known approaches, the CIMOSA and ARCON modeling frameworks, what this work proposes is a set of modeling constructs for CNO modeling under a service-orientation perspective. Service Entities are incorporated as a third approach that may be considered if service ecosystems are being modeled.

**Keywords:** Collaborative Networks Reference Modeling, Service Ecosystems, Service Oriented Architectures.

## 1 Introduction

Considered as a commonly-agreed framework for understanding the significant concepts, entities, and relationships of some domain, Reference Modeling in the Collaborative Networks domain has been identified as a research topic that needs to be further developed [1].

Reference models are intended to provide a conceptual basis on top of which systems designers and implementers may build robust solutions for specific domains.

The main goal of this paper is to provide an initial set of modeling constructs for CNO modeling if service-orientation is being also considered.

The work has been structured in four sections. Besides this introduction, Section 2 reviews three complementary approaches that will be adopted, are introduced. Section 3 describes the approach and, finally, Section 4 briefly discusses the need, expected contribution and further research steps.

## 2 CNO Reference Modeling

Developing reference models is a complex task which requires a lot of effort. Actually, most well-recognized initiatives come from heavily-contributed large research projects. Both the AMICE [2] and ECOLEAD [3] consortiums involved several worldwide partners in developing CIMOSA and ARCON proposals, respectively. Being considered inspirational sources of this work, next sections will briefly describe both initiatives in order to better focus the contribution.

### 2.1 ARCON Reference Modeling Framework

In [4] a comprehensive modeling framework is introduced. A Reference Modeling Framework for Collaborative Networks (ARCON) is the result of developing a solid conceptual base intended to support different modeling levels ranging from General Representations of CNO up to detailed and concrete manifestations as Professional Virtual Communities or Virtual Labs.

Based on information collected from previous initiatives and developments of ECOLEAD project, proponents combine three main dimensions which are supposed to cover CNO (specifically its manifestations) modeling needs.

As it was mentioned earlier, developing a reference model for a specific domain may involve several people and take several years to reach its mature stage. Actually, in [], authors argue that ARCON represents just a first step in that direction and more research contributions will be needed.

What this work is providing is just a minor step in that way. Specifically, in Section 3, a set of building blocks is provided for each modeling intent layer (GR, SM and IM) but this proposal is only considering the CNO modeling from its Endogenous perspective.

### 2.2 CIMOSA Building Blocks for CIM Modeling

The Open Systems Architecture for CIM (Computer Integrated Manufacturing), initiative carried out by the AMICE consortium, perhaps it may be considered one of the most influential works of the Enterprise Engineering body of knowledge.

Initially conceived as an open architecture for manufacturing systems, its main concepts have influenced many other works. Specifically, the Virtual Enterprise Reference Architecture (VERAM) [5] and more recently ARCON, included implicit or explicit references to some of its underlying concepts.

The CIMOSA modeling framework is also characterized by three dimensions:

- **Genericity dimension:** related to the degree or particularization of created models. It goes from generic building blocks, intended for general purpose models, to specific company-wide ones.
- **Modeling dimension:** provides modeling support from a systemic perspective, going from requirements up to the description of system implementation.
- **View dimension:** this dimension provides users with different perspectives intended to model near-orthogonal abstractions of the system being modeled.

In terms of building blocks, a comprehensive list has been provided. Main CIMOSA building blocks are detailed in [6]

### 2.3 Service Entities for CNO Reference Modeling

Service Entities paradigm has been proposed as a complementary approach of Virtual Breeding Environments (VBE) and Virtual Organizations (VO) management practices and they are considered a key component of the next generation of VBE Management Systems [6].

In their simplest form, Service Entities represent abstracted specifications of actual entities existing in some specific domain, in terms of its attributes and methods (business services) needed to define their behavior. In [7], has been discussed how SE may be used to support CNO reference modeling, mainly from their Functional, Structural and Informational perspectives.

## 3 A Modeling Framework for Service-oriented Digital Ecosystems

Based on the above mentioned approaches, next sections will describe a three-layered approach for the identification of the main building blocks in CNO reference modeling. First, a description of building blocks for CNO General Representation is introduced. This layer considers generic building blocks that may be used to describe many CNO manifestations.

Next, Specific Modeling (SM) building blocks are introduced. Most of constructs are derived from GR layer and, complementarily, two service-oriented specific ones are given:

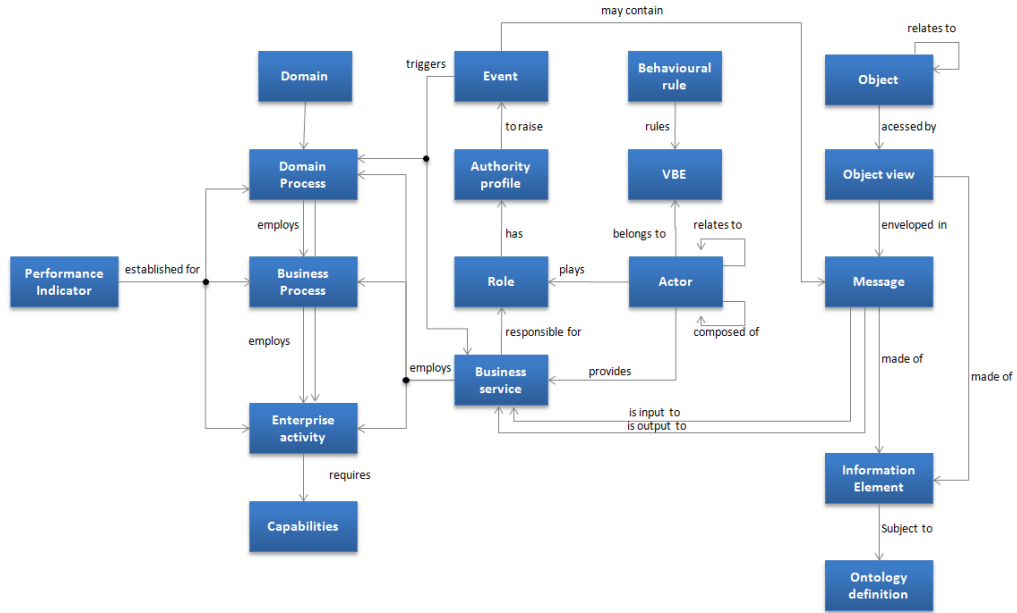
- **Digital business service interface**: which is intended to support the definition of business services that CNO members may need to define in order to properly support CNO service-orientation approach
- **Abstract Service Entity**: this construct will be used to represent actors (i.e. resources) of the CNO which will be providing such business service interfaces.

At the Implementation level, main contribution includes two related constructs which can be used to describe their implementation details: **Web Services** and **Concrete Service Entity**.

### 3.1 General Representation (GR) Modeling Constructs

General Representation modeling constructs are intended to provide a common understanding framework for modeling generic descriptions and requirements of collaborative networks despite their nature and specific class.

Figure 1 provides an overview of main constructs and their relationships. Complementarily, Table 1 includes a brief description of such constructs. Previous contributions are *indicated*.



**Fig. 1.** CNO General Representation building blocks

**Table 1.** Main modeling constructs for CNO General Representation (GR).

| Construct             | Description   | Dimension           |
|-----------------------|---|---------------------|
| Domain                | Defines the functional areas subject to system analysis and implementation.   | <i>Functional</i>   |
| Domain processes      | DPs are stand-alone processes triggered by nothing but Events and producing defined end results. They encapsulate a well-defined set of (network) functionality and behavior. | <i>Functional</i>   |
| Business processes    | BPs are user-defined sub-processes of Domain Processes defining pieces of network behavior. They are made of other Business Processes and/or Enterprise Activities.           | <i>Functional</i>   |
| Enterprise activities | Define the network functionality as elementary tasks defined by their inputs, their outputs, their function and their required capabilities.                                  | <i>Functional</i>   |
| Events                | Describe real-world happenings, timers or requests to do something in the network. They activate the processing of the DP (and possibly the BP) of the network.               | <i>Functional</i>   |
| Performance indicator | Performance Indicators are related to specific DP, BP or EA of the network and their definition includes both target goals and constrained limits.                            | <b>Functional</b>   |
| Business service      | A business service represents a “business interface” that any member of the network makes available to third parties by means of an interface specification                   | <b>Functional</b>   |
| Actor                 | Each individual network member (or candidate). They may represent organizations, individuals, systems or machines being able to provide business services.                    | <b>Organization</b> |

|                      |   |                     |
|----------------------|---|---------------------|
| Role                 | Roles are played by actors and, depending on the network type, they may assume several roles along their life-cycle.        | <b>Organization</b> |
| VBE                  | Virtual Breeding Environments represent containers where specific CNO instances may be launched and where actors belong to. | Organization        |
| Behavioral rule      | Behavioral rules constrain in the sense that is described in E4 ARCON's perspective.  | <b>Organization</b> |
| Object               | Describe generalised entities (or objects) of the network which can thought as a whole.                                     | Information         |
| Message              | Represent the basic exchange mechanism used for processes activation and events generation.                                 | <b>Information</b>  |
| Information elements | Describe elementary, i.e. atomic, pieces of information as perceived by users.  | Information         |
| Ontology definition  | Express constraints on Information Elements to ensure their consistency.  | <b>Information</b>  |

### 3.2 Specific Modeling (SM) Constructs

Specific Modeling Constructs refer to a set of building blocks that can be used to model specific types of CNO. Their specification will serve as base for modeling specific types of CNO and they may be based on currently available GR building blocks.

Figure 2 shows the constructs of this layer and their main relationships. Complementarily, Table 2 includes a brief description of them where previous contributions are *highlighted*.

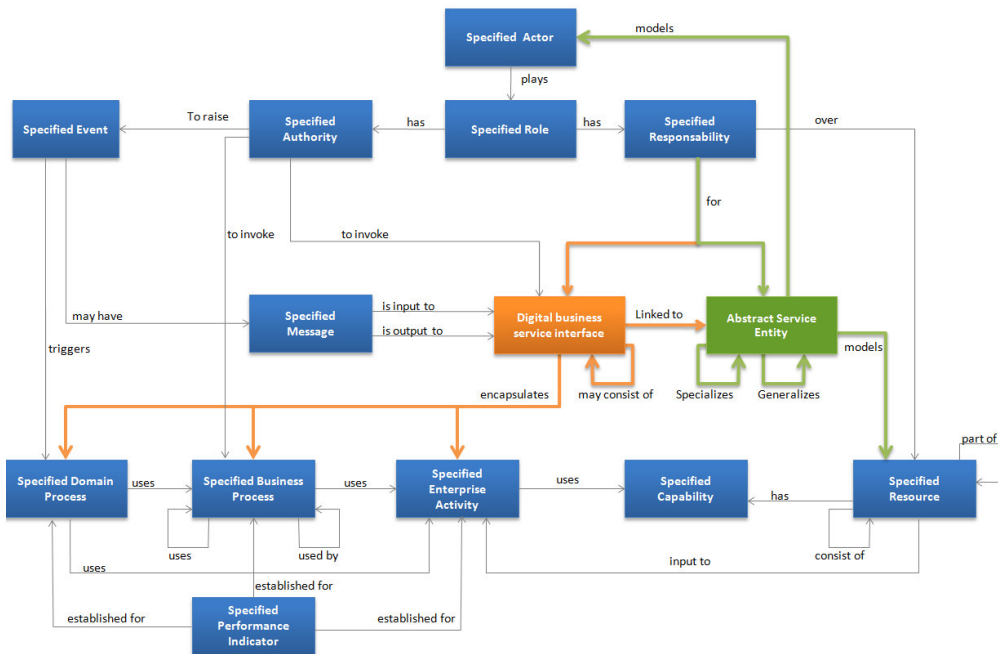


Fig. 2. CNO Specific Modeling building blocks

**Table 2.** Modeling constructs for CNO Specific Modeling (SM).

| Construct                          | Description  | Dimension           |
|------------------------------------|--|---------------------|
| Specified Domain Process           | Formal specifications of Domain Processes.   | <i>Functional</i>   |
| Specified Business Process         | Formally defined specifications of Collaborative Business Processes. They are defined by their triggering condition and Process Behaviour  | <i>Functional</i>   |
| Specified Enterprise Activity      | Specification of Enterprise Activities defined by their Inputs, Control, Resources, Outputs and Resources.   | <i>Functional</i>   |
| Specified Performance Indicator    | Formal definition of Performance Indicators linked to operational processes and resources.   | <b>Functional</b>   |
| Digital business service interface | Linked to GR-Business Services, they represent the formal definition of a business service interface (mainly in terms of inputs, outputs and expected functionality) that will be provided by means of digital networks. | <b>Functional</b>   |
| Abstract Service Entity            | Representing a type of Actor, they provide functional capabilities by means of their abstract digital service definitions.   | <b>Organization</b> |
| Specified Message                  | Formal definition of messages to be exchanged inside the network when DP and BP are executed.  | <b>Functional</b>   |
| Specified Event                    | Formally defined specifications of both external and internal Events   | <i>Functional</i>   |
| Specified Resource                 | They provide the specified Capabilities which meet or exceed the required Capabilities defined at the GR definition level  | <i>Resource</i>     |
| Specified Capability               | Provided by specified Resources, meet or exceed the required Capabilities defined at the GR Modeling Level   | <i>Resource</i>     |
| Specified Responsibility           | Formally defined engineering responsibilities for the creation, and maintenance of specific modeling activities  | <i>Organization</i> |
| Specified Actor                    | Formal identification of entities involved in the CNO. At this modeling level they only are identified as classes or types.  | <b>Organization</b> |
| Specified Role                     | Directly linked to actors, a role is assumed by one or more actors, depending on network specific constrains.  | <b>Organization</b> |
| Specified Authority                | are formally assigned engineering responsibilities for the creation, and maintenance of specific modeling activities   | <i>Organization</i> |

### 3.3 Implementation Modeling (IM) Constructs

Implementation Modeling Constructs refer to a set of building blocks that can be used to model specific instances of specific CNO models. They may be based on currently available SM building blocks. Figure 3 shows the constructs of this layer and their main relationships. Complementarily, Table 3 includes a brief description of them where previous contributions are *highlighted*.

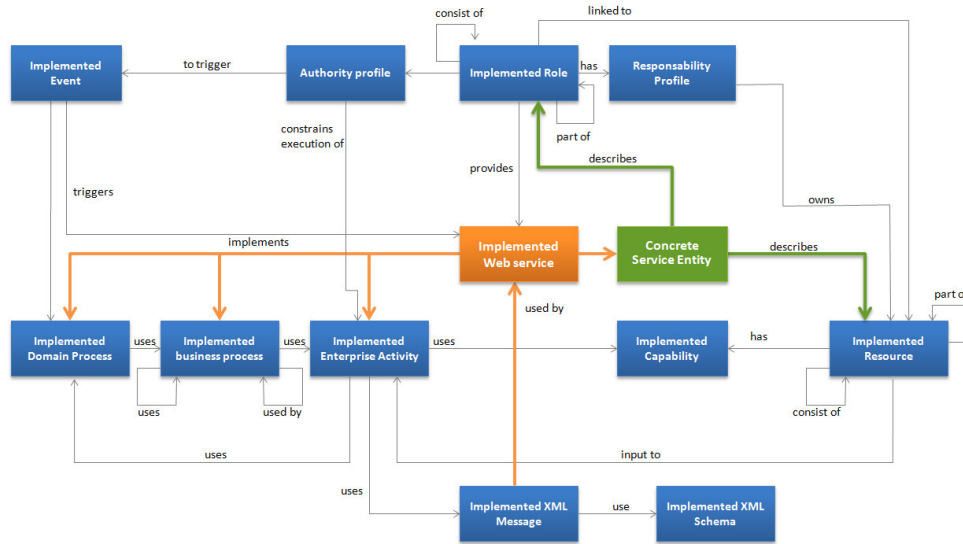


Fig. 3. CNO Implementation Modeling building blocks

Table 3. Modeling constructs for CNO Implementation Modeling (IM).

| Construct                          | Description   | Dimension           |
|------------------------------------|---|---------------------|
| Implemented Domain Process         | Describe the implemented Domain behavior  | <i>Functional</i>   |
| Implemented business process       | Describe the implemented flow of control for a part of a DP.  | <i>Functional</i>   |
| Implemented Enterprise Activity    | Describe the implemented functionality and indicate resources needed to execute it.   | <i>Functional</i>   |
| Implemented Event                  | Describe how enterprise events initiate action by the physical system of the enterprise   | <i>Functional</i>   |
| Implemented Resource               | Describe resources which are derived from Specified Resources.  | <i>Resource</i>     |
| Implemented Capability             | Describe capabilities which are provided by Implemented Resources and which comply with Specified Capabilities defined at the Design Specification Modelling Level. | <i>Resource</i>     |
| Implemented authority profile      | Define engineering and operational responsibilities   | <i>Organization</i> |
| Implemented role                   | CNO Specific roles that may be assumed by Implemented resources and Concrete Service Entities   | <b>Organization</b> |
| Implemented responsibility profile | Assign engineering and operational responsibilities   | <i>Organization</i> |
| Web                                | Implemented digital business service interface which  | <b>Information</b>  |



|                         |  |                     |
|-------------------------|--|---------------------|
| service                 | constitutes the expected digital functionality provided by them  |                     |
| Implemented XML Message | Describe XML-based messages that are going to be used for CNO information sharing and coordination mechanism.                  | <b>Information</b>  |
| Implemented XML Schema  | Describe implemented XML-schemas that will be used to validate messages and ontological validation.                            | <b>Information</b>  |
| Concrete Service Entity | Actual instances of Abstract Services Entities linked to implemented resources and able to provide their expected capabilities | <b>Organization</b> |

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#### 4 Brief Discussion

Reference modeling in the Collaborative Networks domain has been identified as a key research topic that needs to be further addressed.

Earlier contributions in this field have provided solid initial foundations and this work has introduced a first attempt to provide a set of modeling constructs for CNO, based on three converging research streams: the CIMOSA Modeling Framework, ARCON Modeling Framework and Service Entities approach.

As a result, an overall framework has been made available for systems architects and developers.

We are aware that developing this kind of models requires deep research community consensus. Cause of that, next research steps will include its submission to public bodies as the Society for Collaborative Networks (SOCOLNET) for further enrichment and validation.

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