Cooperative Decision Making in Virtual Enterprises

Nesat Efendioglu, Vedran Hrgovcic, Ronald Quirchmayr, and Robert Woitsch

BOC Asset Management, Operngasse 20b,
1040 Vienna, Austria
firstname.lastname@boc-eu.com

Abstract. Virtual enterprises provide an environment where flexible production and corresponding service delivery is cooperatively and efficiently carried out by involved stakeholders focused on utilizing their core competences. This unarguably promising approach raises many challenges – in this paper we focus on two. First we investigate how hybrid modelling approach can be applied to design amalgamated meta models covering artefacts required by the stakeholders within such a distributed environment – e.g. to design a distributed value chain. Second we propose how insights from other domains such as eHealth can be applied to solve the cooperative decision making challenge – e.g. fundamental due to having more than one process owner. We elaborate on three possible realization scenarios and select one to investigate how the previously designed meta model has to be extended to apply the proposed solution.

Keywords: Cooperative Decision Making, Meta-models, Conceptual Model, Conceptual Integration, Virtual Enterprise.

1 Introduction

In the conjunction with activities concerned with raising the flexibility level of small to medium enterprises by shifting production towards distributed networks (e.g. Virtual Enterprises) [3] a set of enterprise interoperability related challenges [9] can be identified. These challenges include: (1) description of such complex and distributed systems; (2) interoperability between enterprises comprising such systems and their monitoring; (3) based on the dynamic changes of short-term objectives/preferences the dynamic re-arrangement; (4) finding cooperative consensus about long and short-term objectives. They impose the necessity to provide tools and methods capable of conceptualizing the distributed networks [11] and enabling collaboration of involved stakeholders on the appropriate level of detail to allow efficient management of such networks. According to authors in [11] the application scenario for such tools and corresponding methods is identified as a requirement at the design phase of Virtual Enterprises. The design phase consists of several tasks: integrating organizational aspects of each stakeholder, selecting appropriate services, skills and tools, etc. Given the assumption that each involved stakeholder is likely to utilize a different description language and different modelling procedures for specific enterprise interoperability dimensions – as introduced in [9] – during the design phase, the reduction of the complexity on the virtual enterprise level, becomes indispensable.

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As elaborated in [2], [13] and practically applied and evaluated the in EU-projects: BIVEE[1], ComVantage[7] and e-SAVE [14], hybrid modelling represents an appropriate approach in order to overcome the aforementioned challenges by using meta-modelling platforms such as ADOxx [12]. Such meta-modelling platforms are capable of supporting dynamic adaptation of the conceptual base structure typically found in distributed networks.

This paper proposes a set of realization scenarios and integration of a cooperative decision making mechanisms into a modelling language based on the hybrid modelling approach. This enables cooperative design of distributed networks based on automatically calculated consensus by considering individual preferences of each involved stakeholder. In order to ensure completeness, we summarized the hybrid modelling approach as solution toward specific enterprise interoperability challenges in section two, also we revisit the Virtual Production Space (VPS) Modelling Language realized in [1] following the hybrid modelling approach.. In section three we present cooperative decision mechanism in virtual enterprises and in section four we investigate and formalize relevant meta model parts of the VPS Modelling Language, where mechanisms, such as cooperative decision making can be integrated and then we elaborate on three possible realization scenarios and present one implemented sample. Section five finalizes the paper with a conclusion and outlook on future work.

2 Hybrid Modelling as Enterprise Interoperability Solution

The conceptual models are knowledge representation of real world, where each observes relevant part of the real world. Hybrid modelling is an approach that aims to create one holistic conceptual model, therefore aiming to merge several meta models in order to enable merging of different viewpoints of the real world [2]. In order to apply the approach in the first step all relevant meta models (within a specified Virtual Enterprise) are differentiated and classified according to (1) their domain, (2) the level of technical granularity , (3) the degree of formalization and (4) the cultural dependencies of the applying community.

The second step is the composition of the meta models – so called meta model merging. According to [2] we distinguish between meta model merging techniques: (1) loose integration of meta models, (2) strong integration of meta models and (3) hybrid integration of meta models. Additionally in [15] we may find the meta model merging patterns that may range from loosely coupled to fix coupled meta models. While loose coupling is very flexible, fixed coupling enables the realization of additional functionality.

An important task for the integration is the correct formalization of the meta models – Generic Meta Modelling Specification Framework (GMMSF) based on [17] is one prominent sample. The FDMM (A Formalism for Describing ADOxx® Meta Models and Models) [5] which follows the GMMSF proposes a formalization approach for meta models realized on the ADOxx®. In the following paragraphs a brief introduction to simplified version of FDMM is provided as it is used to formalize the Value Production Space Modelling Language presented in the next sub-section. As specified in [5] the FDMM defines a meta-model of modelling language as a tuple:

$$\text{MM: <MT, } \preccurlyeq \text{, domain, range, card>} \tag{1}$$

where MT is a set of Model Types:

$$\text{MT: } \{MT_1, MT_2, \ldots, MT_n\} \tag{2}$$

and where each MTi is defined as a tuple:

$$MT_i\text{: } <O^T_i, D^T_i, A_i> \tag{3}$$

MT_i consists of O^T_i, which represent a set of object types, D^T_i, which represents a set of data types, and A_i, which represents set of attributes. The relation $\preccurlyeq$ defines an ordering on the set of object types O^T. It can be used to express inheritance of classes defined in MT (e.g. $o^T{}_A \preccurlyeq o^T{}_B$ means $o^T{}_A$ is a subtype of the object type $o^T{}_B$).

The domain function is used to map the set of attributes A to a specific set of objects OT.

$$\text{domain: } \mathbf{A} \rightarrow \mathcal{P}\left(\bigcup_j \mathbf{O}_j^T\right) \tag{4}$$

The range function is used to map an attribute to the set of all pairs of object types and model types:

$$\text{range: } \mathbf{A} \rightarrow \mathcal{P}(\bigcup_j (\mathbf{O}_j^T \times \{\mathbf{MT}_j\}) \cup \mathbf{D}^T \cup \mathbf{MT}) \tag{5}$$

The card function maps attributes and object types to a set of integers – e.g. to define cardinality of relation classes.

$$\text{card: } \boldsymbol{O}^T \times \mathbf{A} \rightarrow \mathcal{P}(\mathbb{N} \times (\mathbb{N} \cup \{\infty\})) \tag{6}$$

In the next sub-section we revisit VPS Modelling Language, and we apply the FDMM notation to formalize it.

2.1 Value Production Space Modelling Language

The EU research project BIVEE [18] introduces the notion of a Value Production Space (VPS), which considers the different viewpoints of involved stakeholders in order to enable management of the virtual enterprise by a collaborative means [1]. The VPS modelling stack – identifying and orchestrating the different meta models within VPS Modelling Language- is depicted in Fig. 1. It identifies relevant meta models applied to describe the Virtual Enterprise from VPS point of view (for details on state-of-the-art analysis and specification of VPS Modelling Language see [1]). The meta models within VPS modelling stacks include:

(1) Value Production Space Chart, which represents geographical scope models and value flow models based on e3 value methodology [19], (2) Product, which defines products, their components, as and their sub-components,(3) Process, which represents processes in phases and levels comparable to SCOR (Supply Chain Operations Reference Model)[20], (4) Network, which represents organizational structures and roles within the network of the participating enterprises in the distributed network), (5) Key Performance Indicator (KPI), which enables conceptualization of

relevant parts of the concrete instances of the production processes, (6) IT-System Pool, which describes relevant IT-systems where user interaction or computation is significant to the designed processes, (7) Artefact Pool, which represents a reference pool to the relevant documents and (8) Semantic Transit Model, which is used to enable semantic lifting of the VPS Modelling Language (for more details on semantic lifting see [11]).

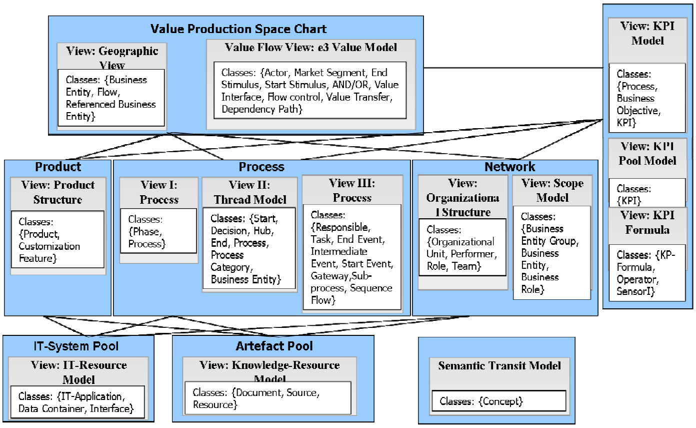

Fig. 1. VPS Meta-model (simplified excerpt)

Having defined VPS Modelling Language and corresponding requirements imposed by the enterprise interoperability within Virtual Enterprise a challenging application scenario is to define objectives of a business process. This is challenging due to fact that it involves a large number of stakeholders, hence requiring a collaborative definition of objectives of the business process. In this context, a question on "How to collect preferences from multiple stakeholders and calculate joint preferences" arises. We provide an answer to this question in section four by introducing possible realization scenarios and by presenting an implemented solution. These scenarios are adapted from eHealth domain, which has the similar challenges like VE in context of decision making. In the eHealth domain, different actors, such as patient, medical doctors with different proficiency, family and professional caregivers, administrative personnel, etc, are involved in the decision making process, similar to heterogeneous stakeholders involved in the processes executed within Virtual Enterprises. Starting from this in the next section we elaborate on the challenges related with cooperative decision making in Virtual Enterprises.

3 Cooperative Decision Making in Virtual Enterprises

Distributed networks such as Virtual Enterprises bring new challenges and enforce adaptations to the "Decision Making" process. We can identify a subset of relevant challenges for the decision making context by comparing the situation within a single enterprise with requirements to complete such an activity in a conglomerate of separate entities usually found in Virtual Enterprises.

In the single enterprise dimension there exists one process owner, responsible for defining the goals of the delegated business process. Given that complexity of the business process may be high, depending on the specifics of the scenario and relevant aspects like IT-systems, knowledge resources, the question “what shall be monitored and what are the KPIs to be utilized for monitoring” may be loosely linked to the process, it is enough to consider only the goal of process owner. The cooperation may take place during the design time, the cooperative settings are considered during execution time.

In the Virtual Enterprises, there are many process owners – the so-called process owner crowd. Each process owner in the crowd defines several goals for the business process. Hence to define the aim of the business process complying with each process owner’s goal, cooperative decision making is required. During the definition of the “best-fit” for the aforementioned aspects the preferences of each process owner need to be considered, which requires a common preference to be defined or calculated automatically based on the individual preferences. Collaboration may take place during design time but also may take place during the execution time by changing preferences and hence changing the process aim. In the following we will define a mechanism capable of addressing the abovementioned issue of cooperative decision making in Virtual Enterprises. The calculation of correlation of preferences related to criteria such as cost, quality, reliability etc. is one of the possible approaches in order to find a common preference.

In the next paragraphs we describe an approach on how to generate a set of correlated preference values depending on two sets of values provided by two different process owners. Thereby the correlation takes both sets of preference values equally into account. Correlation values are normalized, i.e. between zero and one. High positively agreeing preference values yield a high correlation value. The case that one process owner sets a positive preference value and the other one sets a negative value results in a low correlation value. The same is true if both define negative values. In the following we describe the details of this approach.

Given process owners in a Virtual Enterprise can be represented with object type $o^T_{ProcessOwner}$ And given two process owners having N number of preferences represented with the object type

$$ProcessOwner, \quad Preference, \quad CorrelationVector \in OMTT \tag{7}$$

$$A, B \in \quad ProcessOwner, \quad pAi, pBi \in Preference \tag{8}$$

$$domain(Preference) = \{ProcessOwner\} \tag{9}$$

$$card\ (ProcessOwner, Preference) = \{1, n\} \tag{10}$$

Each preference has a weight assigned with a value from predefined range of values represented by $Weight_i$ where $Weight_i \in A_{MT}$

$$domain\ (Weight_i) = \{Preference\}, \tag{11}$$

$$range\ (Weight_i) = \{Enumeration_{weight}\} \tag{12}$$

$$card\ (Preference, Weight_i) = \{1,1\} \quad (13)$$

$Enumeration_{weight} = \{-w_i, -w_i + 1, \dots, -1, (0), 1, \dots, w_i - 1, w_i\}$, with $w_i \in \mathbb{N}$ $(i = 1, 2, \dots, N)$ (14)

The weighting of preferences results in two preference vectors, one for each process owner:

$$P_A = (p_A^1, p_A^2, \dots, p_A^N) \quad \text{and} \quad P_B = (p_B^1, p_B^2 \dots, p_B^N). \quad (15)$$

In order to calculate correlation between A and B's preferences we define a vector

$CorrelationVector_{AB} = (c_{AB}^1, c_{AB}^2, \dots, c_{AB}^N)$ given by

$$c_{AB}^i = \begin{cases} \frac{1}{2} + \frac{(-1)P_A^i P_B^i}{2m_i^2} & \text{if } P_A^i < 0 \text{ and } P_B^i < 0 \\ \frac{1}{2} + \frac{P_A^i P_B^i}{2m_i^2} & \text{else.} \end{cases} \quad (16)$$

Due to the above scaling, $c^i \in [0,1]$.

Example. Let $N = 2$,

$$Enumerationweight1 = -1, 1 \sim \text{"no","yes"} \quad (17)$$

$$Enumertation_{weight2} = \{-3, -2, -1, 0, 1, 2, 3\} \sim \{\text{"verylow", .. ,"very high"}\} \quad (18)$$

$$p_A^1 = 2 \sim \text{"high"} p_A^2 = -1 \sim \text{"no"}, pB1 = 3 \sim \text{"very high"},\ p_B^2 = -1 \sim \text{"no"} \quad (19)$$

$$CorrelationVector_{AB} \approx (0.83, 0.00) \sim (\text{"high", "no"}). \quad (20)$$

Processes are annotated with thresholds for preference values: lower and upper bounds. A process is selected by the mechanism, if all preference values of the correlation vector are within the corresponding lower and upper bound: Let

$$([L_{Process}^1, U_{Process}^1], [L_{Process}^2, U_{Process}^2], \dots, [L_{Process}^N, U_{Process}^N]) \quad (21)$$

be the vector of thresholds for Process with $L_{Process}^i$ being lower bounds and $U_{Process}^i$ being upper bounds $(i = 1, \dots, N)$. Then $Process$ is selected, if $c_{AB}^i \in [L_{Process}^i, U_{Process}^i]$ for all $i \in \{1, \dots, N\}$.

4 Realization of Cooperative Decision Making

In order to enable cooperative decision making in hybrid modelling,-as mentioned before- we have investigated approaches utilized in the EU-project eHealthMonitor[8]. Following the results of the project we propose integration of the so-called "Cooperative Attribute" concept in the meta-model of a VPS Modelling Language following the hybrid modelling approach. The "Cooperative Attribute" enables users to enter their own preferences for the criteria (such as technology, trust, localization, cost, time, reliability, quality, and environment) and contains correlation vectors.

With regard to adapt these scenarios, we need to identify the appropriate meta-model part in VPS Modelling Language and required concepts in order to plug-in cooperative decision mechanism into the VPS Modelling Language. For that concern we investigated applicability of the e3 Value Model Type, Product Structure Model Type and Thread Model Type as possible candidates. In order to test the applicability the first step is the formalization by applying FDMM on the object type level.

Model Type: e3 Value Model; e3 Value Model is utilized to provide detailed view of interactions between production units, such as information or material flow [1]. Object Types of e3 Value Model:

O^T_{E3}:{Actor, Market Segment, Value Interface, Flow control, Value Transfer, End Stimulus, Start Stimulus, AND/OR, Dependency path, Referenced Business Entity, Referenced Concept}

Since investigation focuses on object type level, formalization of attributes and data types are not included in the paper.

Model Type: Product Structure: Product structure models are utilized, to model product structure conceptually [1]. Object Types of Product Structure Model:

O^T_{PSM}:{Product, Customization Feature, Includes, Referenced thread model}

Model Type: Thread Model; Thread model is utilized to conceptualize the actual supply chain for a specific product configuration. It is based on a set of processes where the flow of material or information indicates the sequence of execution [1]. Object Types of Thread Model:

O^T_{TM}:{Business Entity, Process, Process Category, Start, End, Decision, Hub, Assigned Processes, Described by, Enabled by, Flow, KPI Cockpit, Planed by, Responsible}

In order to integrate a “Cooperative Attribute” into candidate model types of VPS Modelling Language we need to extend it. This is possible using any of the following extension scenarios (ES);

ES 1: Integration into Model Type: e³Value Model;

As we defined in section 3 $Actor \in O^T_{E3}, Actor \equiv ProcessOwner$,

$$domain(Preference) = \{Actor\}$$

$$domain\ CorrelationVector = \{CooperativeAttribute\} \quad (22)$$

$$CooperativeAttribute \in O^T_{E3} \quad (23)$$

$$domain\ (CorrelationVector) = \{CooperativeAttribute\} \quad (24)$$

$$domain\ (CooperativeAttribute) = \{MT_{E3}\} \quad (25)$$

ES 2: Integration into Model Type: Thread Model;

$$Business\ Entity \in OTMT, Business\ Entity \equiv ProcessOwner \quad (26)$$

$$domain(Preference) = \{Business\ Entity\} \quad (27)$$

$$CooperativeAttribute \in O_{TM}^{T} \quad (28)$$

$$domain\ (CorrelationVector) = \{CooperativeAttribute\} \quad (29)$$

$$domain\ (CooperativeAttribute) = \{Process\} \quad (30)$$

ES3: Integration into Model Type: Product Structure Model; Although in this model type there is no concepts semantically equivalent with ProcessOwner –since the preferences on criteria are related with customization feature of product we can integrate $CooperativeAttribute$ as following;

As we defined in section 4 $Customization\ Feature \in O_{PSM}^{T}$, add new object type Actor in the model type

$$Actor \in O_{PSM}^{T},\ Actor\ \equiv ProcessOwner,\ CooperativeAttribute \in O_{PSM}^{T} \quad (31)$$

$$domain\ (CorrelationVector) = \{CooperativeAttribute\} \quad (32)$$

$$domain\ (CooperativeAttribute) = \{Customization\ Feature\} \quad (33)$$

We propose to integrate lower- and upper-bound $\mathrm{L}_{\mathrm{Process}}^{\mathrm{i}}, \mathrm{U}_{\mathrm{Process}}^{\mathrm{i}}$ into the model type: Process Model as following; $L_{Process}^{i}, U_{Process}^{i} \in A_{PrcM}$, and assign these attributes to the model type itself;

$$domain\ \left(L_{Process}^{i}, U_{Process}^{i}\right) = \{MT_{PrcM}\} \quad (34)$$

Moreover we propose an additional model type so-called "Preference Pool Model", which contains preference objects for each criterion

$$MT_{PrfM}\!:< O_{PrfM}^{T}, A_{PrfM}, D_{PrfM}^{T} > \quad (35)$$

$$O_{PrfM}^{T}\!:\{Preference, Criteria, InterrefReferencedCriteria\} \quad (36)$$

$$A_{PrfM}\!:\left\{PreferenceName, CriteriaName, Weight_{i}\ \right\} \quad (37)$$

$$D_{PrfM}^{T}\!:\left\{String, Enummeration_{weight}\right\} \quad (38)$$

$$domain\ \left(PreferenceName, Weight_{i}\ \right) = \{Preference\} \quad (39)$$

$$range\ (PreferenceName) = \{String\} \quad (40)$$

$$range\ \left(Weight_{i}\ \right) = \left\{Enummeration_{weight}\right\} \quad (41)$$

There exist three realization scenarios to realize the "Cooperative Attribute". As a sample we took model type "Product Structure Model" from the candidate model types as sample to demonstrate the realization of the CooperativeAttribute

Given that $domain\ (CooperativeAttribute) = \{Customization\ Feature\}$

- **RS1:** "Cooperative Attribute" as type of Expression: In this scenario the values of the $CooperativeAttribute$are calculated via expressions, which reacts to changes of preferences of any user and re-calculates correlations automatically.

$$range\ (CooperativeAttribute)=\{Expression\}$$
$$card\ (CooperativeAttribute, CustomizationFeature) = \{1,1\} \quad (42)$$

- **RS2:** "Cooperative Attribute" is self is an Attribute Type

$$CooperativeAttribute\ \in D^{T}_{PSM} \quad (43)$$

- **RS3:** Preferences are taken and correlation among them are calculated by script and saved in the "Cooperative Attribute". In this scenario the values of the cooperative attribute calculated via execution of a script, which considers preference of two users for selected dimensions.

$$range\ (CooperativeAttribute) = \{Record\}$$
$$card\ (CooperativeAttribute, CustomizationFeature) = \{1,1\} \quad (44)$$

- A solution based on RS3 has been implemented within the project eHealthMonitor [8] and has been reviewed and approved by external experts during the project review.

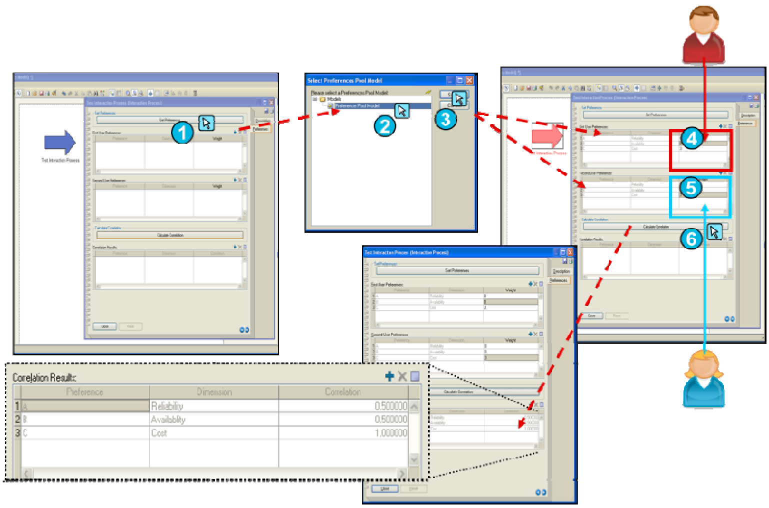

Fig. 2. ADOxx® based realization of RS3 (based on figure from [21])

Fig. 2 depicts implemented solution within the project eHealthMonitor. In the first step by execution of an ADOscript (for details see [6]), relevant criteria are selected and set, so that both users can define their preferences. In following step two users may enter their preferences for each of the selected criteria. Finally by execution of an ADOscript (as shown in the code snippet below), pairs of preferences entered by two different users are retrieved. For each preference pair the corresponding correlation is calculated and saved in the attribute "CooperativeAttribute" for further processing such as selection of concrete business process. Relevant part of the ADOscript code is presented below (to see realization discussion please refer to [21]).

```
"…
PROCEDURE GET_PREFERENCE_VALUES intproc_objid:integer
pref_attrid:integer answers: reference
{
…
FOR i from:0 to:(n_numberof_pref_space-1)
{
…
CC "Core"    GET_ATTR_VAL objid:(n_rec_pref_rowid)
attrname:("Preference")
CC "Core"    GET_ATTR_VAL objid:(n_rec_pref_rowid)
attrname:("Weight") as-string
SETL s_temp_weight:(val)
…
PROCEDURE CALCULATE_CORRELATION a_answers_1_array: array
a_answers_2_array: array max_w_1:integer max_w_2:integer
a_prefandcorranddim_array: reference
{
…
FOR i from:0 to:((n_questions_count-1))
{
…
SET a_product_s_array[i]:
(((1/2)+(flg*co*(n_weight_1*n_weight_2))))
…
}…"
```

5 Conclusion and Outlook

This paper followed two goals. First goal was to identify the challenges that arise when moving away from single to multi and virtual enterprises. Second, starting from identified challenges, to evaluate and select the prominent ones and to apply the proposed solution. These challenges included the necessity to establish a common means of understanding between the involved stakeholders and their enterprises. To achieve this we have applied the hybrid modelling approach to structure and design the amalgamated VPS Modelling Language– covering the full cycle of production and delivery in virtual enterprises – building on top of the vast literature and practical research performed in the BIVEE project. And second to address the challenge of cooperative decision making – raising from the one-to-many process owners transition we (1) formalized both the VPS Modelling Language and the proposed extensions using FDMM, and (2) performed a research on appropriate solutions in other domains. The identified solution – in the eHealth domain - was then evaluated in the eHealthMonitor project and accepted by experts in an EC review and it's applicability within Virtual Enterprises has been elaborated with the experts from the BIVEE project.

Open research questions include the adaptation of the VPS meta model to include extensions needed to efficiently use and apply the introduced consensus mechanism and it's testing, evaluation and approval in the real life test cases with end users in the BIVEE project.

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References

1. Woitsch, R., Efendioglu, N., Knoke, B., Verdu, J.H.: State of the Art and Mission Control Room Specification, BIVEE Project Delivaerable D3.1, http://wordpress.bivee.eu/wp-con-tent/uploads/2013/07/D3.1_State_of_the_Art_and_Mission_Control_v1.1_pub.pdf (accessed February 17, 2012)
2. Woitsch, R.: Hybrid Modeling: An Instrument for Conceptual Interoperability. In: Revolutionizing Enterprise Interoperability Through Scientific Foundations, pp. 97–118. IGI Global (2014)
3. Fraunhofer IAO, Industrie 4.0, http://www.iao.fraunhofer.de/lang-de/geschaeftsfelder/unternehmensentwicklung-und-arbeitsgestaltung/1009-industrie-40.html (accessed, February 17, 2014)
4. FInES Cluster, FInES Research Roadmap, http://cordis.europa.eu/fp7/ict/enet/documents/fines-researchroadmap-final-report.pdf (accessed February 17, 2010)
5. Fill, H.-G., Redmond, T., Karagiannis, D.: FDMM: A Formalism for Describing ADOxx Meta Models and Models. In: ICEIS (2012)
6. ADOxx.org, http://www.adoxx.org (accessed February 28, 2014)
7. Karagiannis, D., Buchmann, R., Burzynski, P., Brakmic, J.: Specification of Modelling Method Including Conceptualisation Outline. ComVantage Project Deliverable D3.1.1 (2012)
8. Hrgovcic, V., Efendioglu, N., Woitsch, R., Quirchmayr, R., Popescu, S.: Mobile and Community aspects of the eHealthMonitor Knowledge Space. eHealth Monitor Project Deliverable D3.3 (2013)
9. Popplewell, K., Lampathaki, F., Koussouris, S., Mouzakitis, S., Charalabidis, Y., Goncalves, R., Agostinho, C. (2012) EISB State of Play Report, Deliverable D2.1 ENSEMBLE, http://www.fines-cluster.eu/fines/jm/Publications/Download-document/339-ENSEMBLE_D2.1_EISB_State_of_Play_Report-v2.00.html (retrieved June 24, 2013)
10. Karagiannis, D., Hrgovcic, V., Woitsch, R.: Model driven design for e-applications: The meta model approach. IEEE iiWAS (2011)
11. Hrgovcic, V., Karagiannis, D., Woitsch, R.: Conceptual Modeling of the Organisational Aspects for Distributed Applications: The Semantic Lifting Approach. In: COMPSACW. IEEE (2013)
12. ADOxx.org, Homepage, http://www.adoxx.org/live/home (accessed February 21, 2014)

13. Woitsch, R.: Hybrid Modelling with ADOxx: Virtual Enterprise Interoperability Using Meta Models. In: Franch, X., Soffer, P. (eds.) CAiSE Workshops 2013. LNBIP, vol. 148, pp. 298–303. Springer, Heidelberg (2013)
14. Utz, W., Hrgovcic, V., Woitsch, R., Pramatari, K., Tarantilis, C., Zachariadis, M., Zampou, E.: Operations and Supply Chain Management Tools Description – Initial Version. e-SAVE Project Deliveralbe D3.1 (2013)
15. Kühn, H.: Methodenintegration im Business Engineering, PhD Thesis (2004)
16. PlugIT, Overview of Modelling Languages, http://plug-it.org/plugITwiki/index.php5/Main_Page (accessed February 21, 2014)
17. Karagiannis, D., Kühn, H.: Metamodelling Platforms. In: Bauknecht, K., Tjoa, A.M., Quirchmayr, G. (eds.) EC-Web 2002. LNCS, vol. 2455, p. 182. Springer, Heidelberg (2002)
18. BIVEE EU Project, http://bivee.eu/ (accessed February 21, 2014)
19. e3Value, e3Value Methodology:Exploring innovative e-business ideas, http://e3value.few.vu.nl/e3family/e3value/ (accessed February 21, 2014)
20. Supply Chain Council, SCOR, https://supply-chain.org/scor (accessed February 21, 2014)
21. Adoxx.org, Cooperative Attribute Scripted, http://www.adoxx.org/live/faq/-/message_boards/message/87135 (accessed March 25, 2014)