Workshop: NGEBIS 2014 - New Generation Enterprise And Business Innovation Systems

Cooperative Decision Making in Virtual Enterprises

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Cooperative Decision Making in Virtual Enterprises

- Cooperative Decision Making

  Cooperative Decision …. involves multiple agents that operate under uncertainty on the basis of different streams of observations. Cooperative Decision Making unfolds over … sequence of steps. At each step, every agent chooses an action based purely on its local observation, …

  Cooperative Decision Making. Christopher Amato. To appear in Decision Making Under Uncertainty: Theory and Application edited by Mykel J. Kochenderfer. MIT Press, 2014

- Virtual Enterprises

  A virtual enterprise can be defined as an organization form in which a collection of legally independent enterprises, institutions, or single persons come together quickly to cooperate for a particular mission

  D. Arnold, W. Faisst, M. Haertling, P. Sieber, Virtuelle Unternehmen als Unternehmenstyp der Zukunft? HMD} Theorie und Praxis der Wirtschaftsinformatik 32 (185) (1995) 8}23.
  Kanet, J. J., Faisst, W., Mertens, P.: Application of information technology to a virtual enterprise broker: The case of Bill Epstein. International Journal of Production Economics, 62, (1999) 23-32

- Conceptual Modelling

  Models are *"a **representation of either reality or vision**"* (Whitten, 2004) that are created *"for some certain purpose"* (OMG, 2003) *"with an intended goal in mind"* (Bézivin, 2001). The reality or vision that a model is representing is sometimes also referred to as "***system under study***" *(SUS)* (Seidewitz, 2003)

  Karagiannis D., Grossmann W., Höfferer P., (2008) Open Model Initiative: A Feasibility Study, retrieved, June 24, 2013, from http://cms.dke.univie.ac.at/uploads/media/Open_Models_Feasibility_Study_SEPT_2008.pdf

Requirements

- **Use Case:**
  Chair production of „ Muebles Romero“
- **Challenge:**
  In case a Virtual Enterprise is designed in a cooperative way, the challenge is make the modelling method aware of “cooperative decision making”
- **Requirement:**
  Enable cooperative decision making for relevant model information such as KPI thresholds, on quality criteria in thread models

Requirement on Conceptual Modelling

1. **Development of modelling method** that enables to describe the thread models.
2. **Selection of mathematical model** that realizes “Cooperative Decision Making” to find a consensus among preferences.
3. **Develop a mechanism** that realizes cooperative decision making based on selected mathematical model in the aforementioned modelling method describes thread models

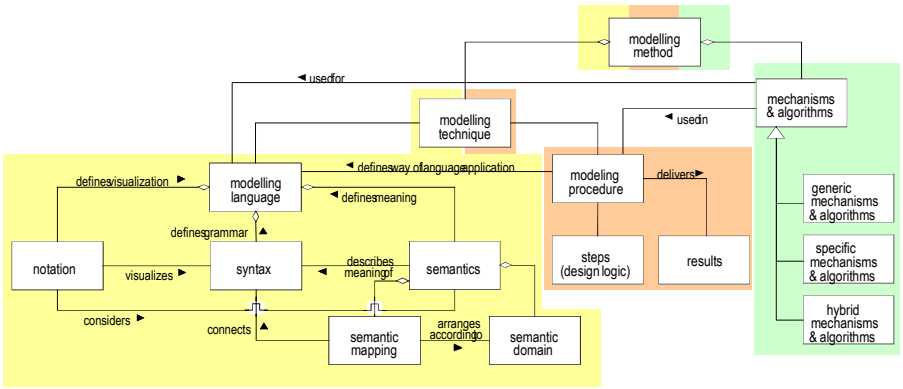
Solution with Conceptual Modelling

1. Development of a **modelling method in ADOxx** for Virtual Enterprises including a model type „thread model“.
2. Selection of **mathematical model** that is considered as a **black-box**.
3. Development of „**Cooperative Decision**“ **mechanisms in ADOxx** enables modelling „thread models“ with making decisions on the relevant information of the models cooperatively, with AdoScript, Expression or Cooperative Attribute Type.

Development of a **modelling method in ADOxx** for Virtual Enterprises including a model type „thread model“.

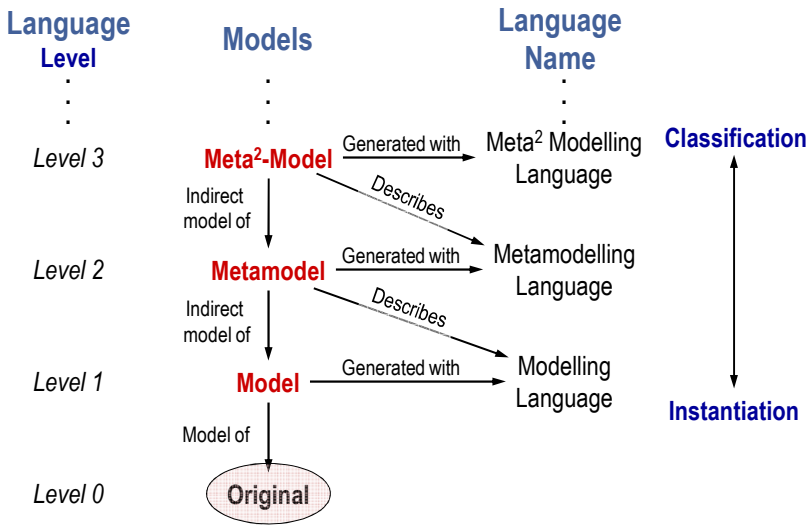
META MODELLING AS A CONCEPT

Generic Modelling

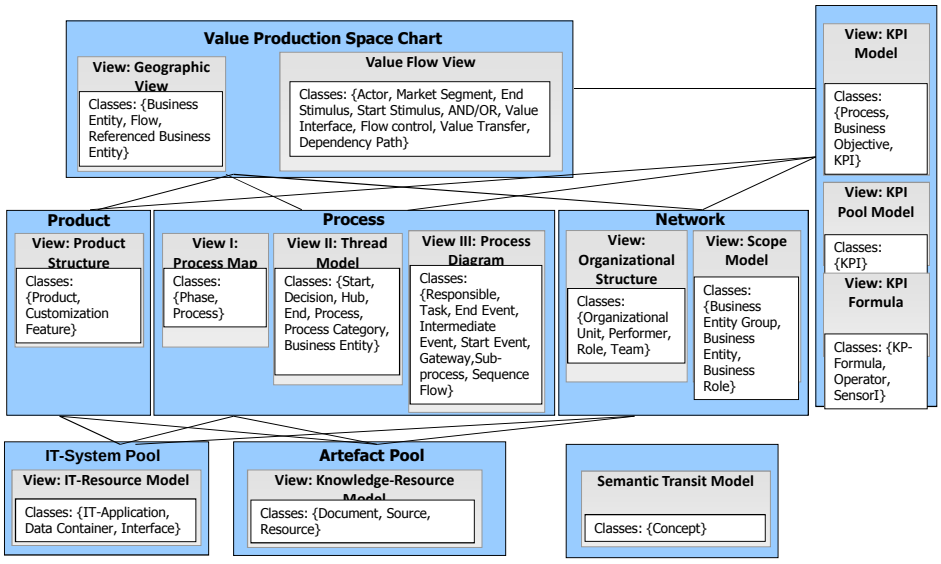


Karagiannis, D., Kühn, H.: „Metamodelling Platforms". In Bauknecht, K., Min Tjoa, A., Quirchmayer, G. (Eds.): Proceedings of the Third International Conference EC-Web 2002 – Dexa 2002, Aix-en-Provence, France, September 2002, LNCS 2455, Springer, Berlin/Heidelberg, p. 182 ff.

META MODELLING AS A CONCEPT



OVERVIEW OF BIVEE META MODEL



Modelling Method is to be find in ALL Repository in Adoxx.org

INPUT:

SELECTED MATHEMATICAL MODEL

Correlation as Selected Mathematical Model

Given that concepts process owner, preference and correlation vector are object types of a conceptual model;

$$ProcessOwner,\ Preference,\ CorrelationVector \in O_{MT}^{T}$$

There can be multiple owner of a process (given A and B) and each process owner can have one to many preferences;

$$A, B \in ProcessOwner,\ pAi, pBi \in Preference$$
$$domain(Preference) = \{ProcessOwner\}$$
$$card(ProcessOwner, Preference) = \{1,n\}$$

Each preference has a weight assigned with a value from predefined range of values

$Weight_i$ where $Weight_i \in A_{MT}$

$$domain\ (Weight_i) = \{Preference\},$$
$$range\ (Weight_i) = \{Enumeration_{weight}\}$$
$$card\ (Preference, Weight_i) = \{1,1\}$$
$$Enumeration_{weight} = \{-w_i, -w_i + 1, \dots, -1, (0), 1, \dots, w_i - 1, w_i\}$$,with $w_i \in \mathbb{N}$ $(i = 1, 2, \dots, N)$

Correlation as Selected Mathematical Model

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

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

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

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

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

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:

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

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 $c_{AB}^i \in \left[L_{Process}^i, U_{Process}^i\right]$ for all $i \in \{1, \dots, N\}$.

Development of „**Cooperative Decision**“ mechanisms to model „thread model“ with making decisions cooperatively.

COOPERATIVE DECISION MAKING APPROACH

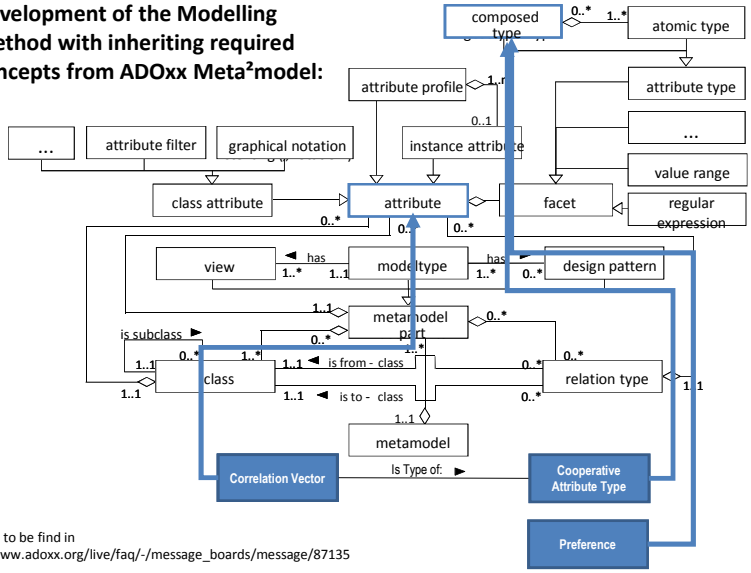
Cooperative Decision Making Solution developed in ADOxx

Cooperative Attribute:

1. Scripted
2. Expression
3. as an Attribute Type

Cooperative Attribute **Scripted**- Description

Development of the Modelling Method with inheriting required concepts from ADOxx Meta²model:



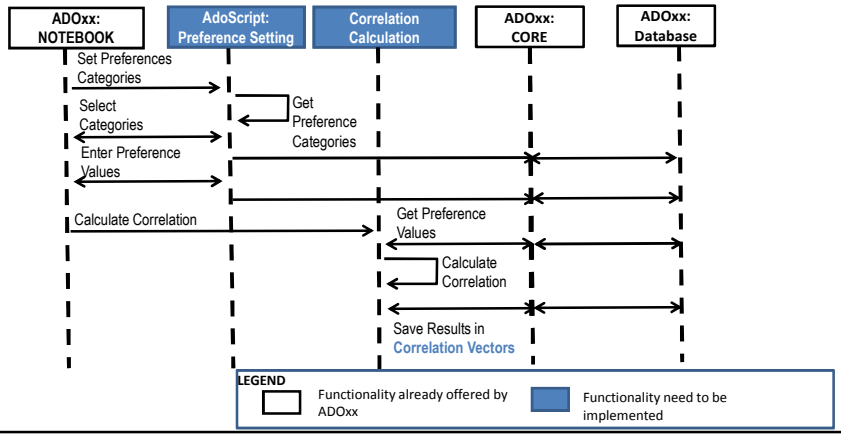
Scenario to be find in
http://www.adoxx.org/live/faq/-/message_boards/message/87135

Extension of: Kühn et al. (1999a), S. 79

Cooperative Attribute **Scripted** - Description

Description of Algortihm:

- A mechanism has been implemented with using AdoScript, which enables selection of dimensions, collection of values from preferences according to dimensions and calculates correlation according to selected mathematical model



Cooperative Attribute **Scripted**– Realization (1/2)

AdoScript Code:

```
GET_PREFERENCE_VALUES intproc_objid:(VAL s_intprocess_objid)
pref_attrid:(n_intproc_outspacepref_attrid) answers:a_answers_to_space
...
CALCULATE_CORRELATION a_answers_1_array:(a_answers_from_space)
a_answers_2_array:(a_answers_to_space) max_w_1:(3) max_w_2:(3)
a_prefandcorranddim_array:a_correlation_results
...
PROCEDURE GET_PREFERENCE_VALUES intproc_objid:integer pref_attrid:integer answers: reference
{
    CC "Core" GET_REC_ATTR_ROW_COUNT objid:(intproc_objid) attrid:(pref_attrid)
    SET n_numberof_pref_space:(count)
    SET answers:(array(n_numberof_pref_space))
    FOR i from:0 to:(n_numberof_pref_space-1)
    {
       CC "Core" GET_REC_ATTR_ROW_ID objid:(intproc_objid) attrid:(pref_attrid) index:(i+1)
       SET n_rec_pref_rowid:(rowid)
       SET n_preferences_objid:(tobjid)
       CC "Core" GET_ATTR_VAL objid:(n_rec_pref_rowid) attrname:("Preference")
       SETL s_temp_pref:(val)
       CC "Core" GET_ATTR_VAL objid:(n_rec_pref_rowid) attrname:("Weight") as-string
       SETL s_temp_weight:(val)
       CC "Core" GET_ATTR_VAL objid:(n_rec_pref_rowid) attrname:("Dimension") as-string
       SETL s_temp_dimension:(val)
       SET answers[i]:(s_temp_pref+"@"+s_temp_weight+"@"+s_temp_dimension)
    }
}
```

Retrieve each preference from each agents

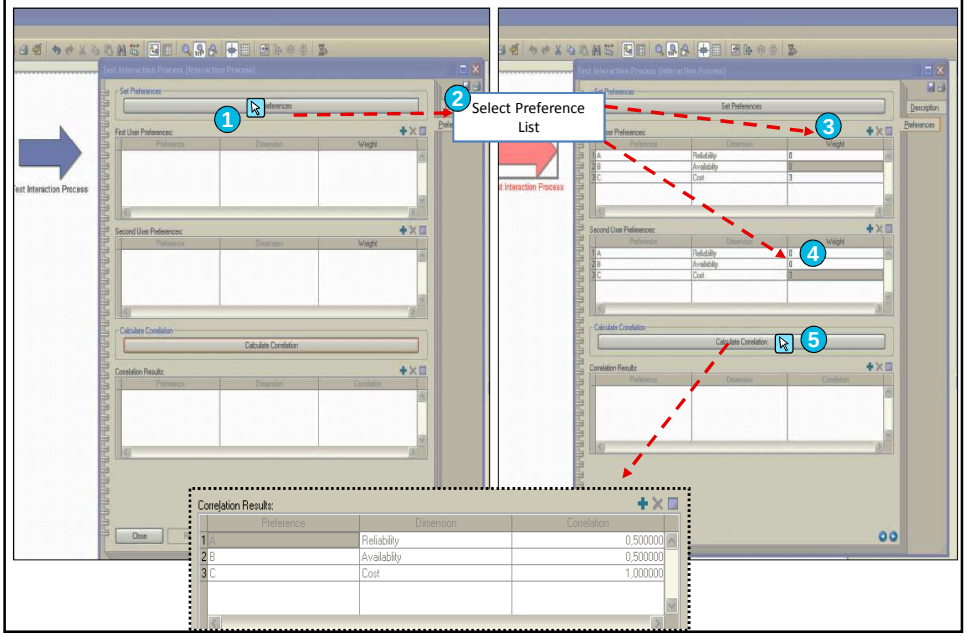
Cooperative Attribute **Scripted**– Realization (2/2)

AdoScript Code:

```
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
{
    SET co:(1/(2*max_w_1*max_w_2))
    SET n_answer_1_value:0
    SET n_answer_2_value:0
    SET n_questions_count:(a_answers_1_array.length)
    SET flag:1
    SET a_product_s_array:(array(n_questions_count))
    SET a_prefandcorranddim_array:(array(n_questions_count))
    FOR i from:0 to:((n_questions_count-1))
    {
       SETL temp_prefandweight:(a_answers_1_array[i])
       SETL temp_pref:(token(temp_prefandweight , 0 , "@"))
       SET n_weight_1:(VAL token (temp_prefandweight , 1 , "@"))
       SETL temp_dim:(token(temp_prefandweight , 2 , "@"))
       FIND_SAME_PREF pref:(temp_pref) a_pref2:(a_answers_2_array) weight:n_weight_2
       IF ((n_weight_1<=0) AND (n_weight_2<=0))
       {
          SET flag:(-1)
       }
       SET a_product_s_array[i]:(((1/2)+(flag*co*(n_weight_1*n_weight_2))))
       SETL s_help_string:(STR (a_product_s_array[i]))
       SET a_prefandcorranddim_array[i]:(temp_pref+"@"+s_help_string+"@"+temp_dim)
       SET flag:(1)
    }
}
```

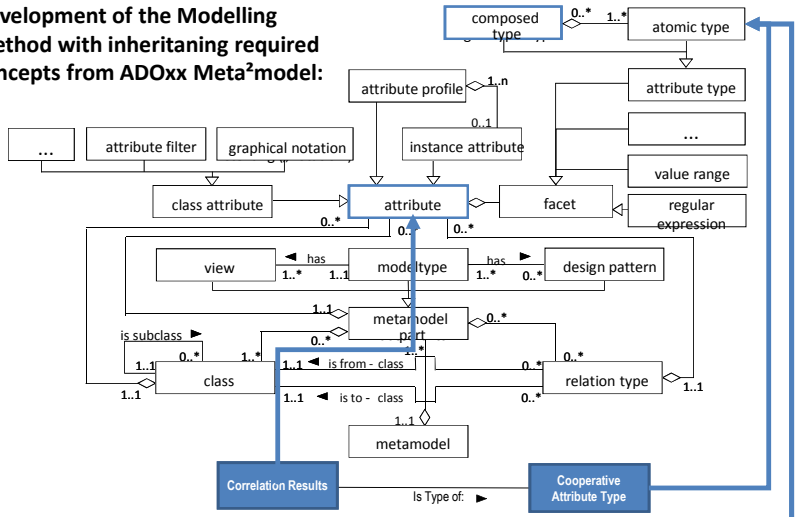
Calculate Correlation between each preference pairs

Cooperative Attribute **Scripted** - Screen Shot



Cooperative Attribute **Expression**- Description

Development of the Modelling Method with inheritaning required concepts from ADOxx Meta²model:



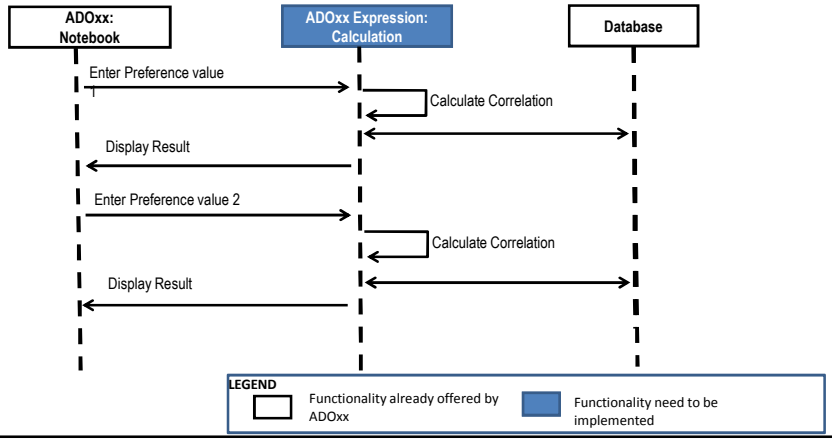
Scenario to be find in
http://www.adoxx.org/live/faq/-/message_boards/message/87131

Extension of: Kühn et al. (1999a), S. 79

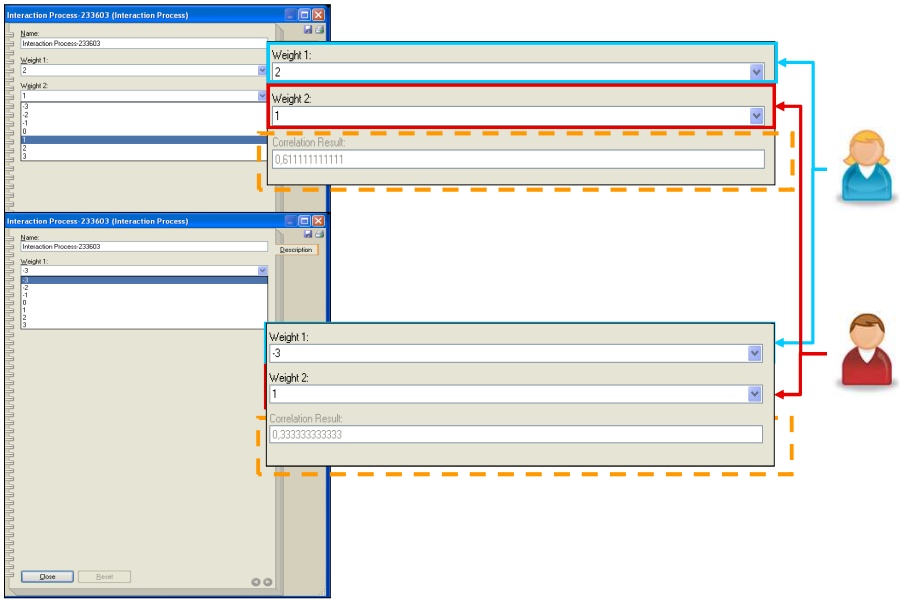
Cooperative Attribute **Expression**- - Description

Description of Algorithm:

- A expression based on selected mathematical model has been implemented. The expression listens entries of preferences and each time a preference is entered, it re-calculates correlation automatically.



Cooperative Attribute **Expression**- - Screen Shot



Cooperative Attribute **as an Attribute Type** - Description

- Enabling entry of preferences and calculation of correlation between preferences within an attribute that type of cooperative attribute which is defined in the meta²model.
- It is the best solution scenario. Since "Cooperative Attribute" has not been implemented in Meta²-model, this scenario could be implemented in ADOxx.

Pro and Contra

	Solution	Pro	Contra
1:	Cooperative Attribute Scripted	• User friendly • Flexible • Arbitrary Preferences	• Redundant preference concepts
2:	Cooperative Attribute Expression	• User friendly • Only entry of values	• Inflexible • Fix defined preferences
3:	Cooperative Attribute as Attribute Type	• User friendly • Flexible • Arbitrary Preferences	• Inflexible until its implemented in Meta²-model

Summary and Outlook

- Cooperative decision making can be applied on relevant information of conceptual models by modellers from different parties who design a Virtual Enterprise.
- Implementation of several alternatives enable a huge flexibility of the developed modelling tools.
- Definition of “Cooperative Attribute” in the Meta²model and implementation of the scenario with “Cooperative Attribute as a Attribute Type” are open research questions like;
- Consideration of conflicting preferences in the mathematical model

Download and Use the Solutions

1. Join ADOxx.org and download development platform
   www.adoxx.org/live/download
2. Implement your modelling tool
   www.adoxx.org/live/video-helloworld
3. Download implemented solutions and join into discussions about them
   www.adoxx.org/live/faq/-/message_boards/message/87135
   www.adoxx.org/live/faq/-/message_boards/message/87131
4. Download cooperative decision making solution package
   www.adoxx.org/live/tutorial -> NGEBIS 2014
5. Integrate cooperative decision making solution into your modelling tool and get help from the OMiLAB community
   www.omilab.org

RELATED WORK: REFERENCES (1/2)

1) Adla, A; Zarate, P, A Cooperative Intelligent Decision Support System , International Conference on Service Systems and Service Management, 2006, pp763-769
2) Kanet, J; Faisst, W; Mertens, P., Application of information technology to a virtual enterprise broker: The case of Bill Epstein, in International Journal of Production Economics 62, 1999, p 23-32
3) Qin, X; Li, P. Adjallah, K; Eynard, B; Lee, J, Cooperative Decision Making for Diagnosis of Complex System based on Game Theory: Survey and an Alternative Scheme, IEEE International Conference on Industrial Informatics, 2006, pp 725-730
4) Sakava, M.; Nishizaki, I., Cooperative Decision Making in Hierarchical Organizations, in Cooperative and Noncooperative Multi-Level Programming, 2009, p 83-179
5) Shahrivar, E.; Moshiri, B.; Rezagholizadeh, M., Decision Concensus in Cooperative Fuzzy Decision Making, 19th Iranian Conference on Electrical Engineering (ICEE), 2011, pp 1-6
6) Kwon, Y.; Lee, H.; Lee, J., The Virtual Enterprise: Redefining the Concept, in Web and Communication Technologies and Internet-Related Social Issues – HIS, 2003, pp 249-258
7) 2Woitsch, Robert. "Hybrid Modeling: An Instrument for Conceptual Interoperability." Revolutionizing Enterprise Interoperability through Scientific Foundations. IGI Global, 97-118, 2014.
8) Fraunhofer IAO, Industrie 4.0, http://www.iao.fraunhofer.de/lang-de/geschaeftsfelder/unternehmensentwicklung-und-arbeitsgestaltung/1009-industrie-40.html (accessed, February 17, 2014)
9) FInES Cluster (2010), FInES Research Roadmap, ,http://cordis.europa.eu/fp7/ict/enet/documents/fines-researchroadmap-final-report.pdf (accessed February 17, 2014)
10) Fill, H-G., Redmond, T. ,Karagiannis, D.: FDMM: A Formalism for Describing ADOxx Meta Models and Models. ICEIS, 2012.
11) ADOxx.org, www.adoxx.org (accessed, February 28, 2014)
12) Karagiannis, D., Buchmann, R., Burzynski, P., Brakmic, J.,"Specification of Modelling Method Including Conceptualisation Outline" ComVantage Project Deliverable D3.1.1, 2012
13) Hrgovcic, V.,Efendioglu, N., Woitsch, R., Quirchmayr, R., Popescu, S., "Mobile and Community aspects of the eHealthMonitor Knowledge Space", eHealth Monitor Pro-ject Deliverable D3.3, 2013
14) Popplewell K., Lampathaki F., Koussouris S., Mouzakitis S., Charalabidis Y., Gon-calves R., Agostinho C. (2012) EISB State of Play Report, Deliverable D2.1 ENSEMBLE, retrieved, June 24, 2013 from http://www.fines-cluster.eu/fines/jm/Publications/Download-document/339-ENSEMBLE_D2.1_EISB_State_of_Play_Report-v2.00.html
15) Karagiannis, D., Hrgovcic, V. and Woitsch, R. , "Model driven design for e-applications: the meta model approach". iiWAS, IEEE, 2011
16) Hrgovcic, V., Karagiannis D. and Woitsch, R., Conceptual Modeling of the Organisa-tional Aspects for Distributed Applications: The Semantic Lifting Approach, COMPSACW, IEEE, 2013
17) ADOxx.org, Homepage, http://www.adoxx.org/live/home (accessed February 21, 2014)
18) Woitsch, Robert, Hybrid Modeling with ADOxx: Virtual Enterprise Interoperability using Meta Models
19) 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
20) Kühn, Harald, Methodenintegration im Business Engineering, PhD Thesis, 2004.

RELATED WORK: REFERENCES (2/2)

21) PlugIT, Overview of Modelling Languages, http://plug-it.org/plugITwiki/index.php5/Main_Page (accessed February 21, 2014)
22) Karagiannis, D, Kühn, H. Metamodelling Platforms In: Bauknecht, K.; Min Tjoa, A.; Quirchmayer, G. (Eds.) Proceedings of the Third International Conference EC-Web 2002 – Dexa 2002, (p. 182) Aix-en-Provence, France, LNCS 2455, Springer-Verlag, Berlin, Heidelberg, 2002
23) BIVEE EU Project, http://bivee.eu/ (accessed February 21, 2014)
24) e3Value , "e3Value Methodology:Exploring innovative e-business ideas", http://e3value.few.vu.nl/e3family/e3value/ (accessed February 21, 2014)
25) Supply Chain Council, "SCOR", https://supply-chain.org/scor , (accessed February 21, 2014)
26) Adoxx.org, "Cooperative Attribute Scripted" http://www.adoxx.org/live/faq/-/message_boards/message/87135 (accessed March 25, 2014)

THANK YOU FOR YOUR ATTENTION!

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