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A COLLABORATION READINESS ASSESSMENT APPROACH

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Collaboration readiness depends on "hard" factors such as competency fitness or technological preparedness, but also on several other factors of a "soft" nature such as organization's character, willingness to collaborate, or affectivity / empathy relationships. A modeling approach to assess how prepared is an enterprise to join a collaborative network is proposed. The approach is based on a notion of "character" of the organization and the use of belief networks. An example illustrates the proposal.

1. INTRODUCTION

In collaborative networks, members work together towards the achievement of common or compatible goals. As collaboration goes on, they adopt patterns of behavior according to the situations they are involved in. While most of these patterns are both acceptable and desirable, some others might not be. Naturally, undesirable behaviors should be avoided, as they affect collaboration and may lead to conflicts. The act of working in collaboration is by itself considered challenging and risky. Many times, an organization works successfully alone, but poorly in collaboration. This means that before joining networks, organizations should be adequately prepared for collaboration.

This research proposes the elaboration of an approach for performing assessment of the collaboration readiness of members or candidates for collaborative networks. This assessment is mostly based on the concept of organization's character, as described in section 2. The Bayesian Belief Network will be used to make predictions on collaboration preparedness based on organization's character, as described in section 3. The approach is then illustrated with a small example.

2. COLLABORATION READINESS ASSESSMENT

2.1. The character of an organization

Organizations inside networks work and interact with each other towards the achievement of common or compatible goals. They typically manifest a variety of behaviors, according to the peers and situations they are involved in. In this sense, behavior can be understood as anything that an organization does involving pro-active actions and responses to external events/requests. These behaviors typically tend to show some repetition through time, mainly those that appear to be positive for collaboration or achievement of the goals. This repetition usually leads to the formation of behavioral patterns. These patterns can be associated to a set of identifiable *traits*. A trait represents a relatively stable predisposition

to act in a certain way or, in other words, the preponderance for the occurrence of a certain behavioral pattern. These traits, together, form what is referred to as *character*. An organization's character can therefore be seen as a composition of a set of traits that determine the behavior or nature of the organization. This underlying mapping between character traits and behavior can be used to perform behavior prediction. This means, in turn, that collaboration readiness assessments can be performed using the concept of organization's character. Basically if the predictable behavior is positive towards collaboration, then the readiness increases, otherwise it decreases. This is the approach suggested in this paper for collaboration readiness assessment. It shall be noted that the intrinsic connection between character traits and behavior has traditionally been an extensive research topic in Psychology, as expressed in (Goldie 2004) and (Webber, 2006).

Examples of research that address the behavioral aspects of collaboration can be found in (Camarinha-Matos & Macedo, 2007), which establishes a dependency of the joint behavior and the underlying value systems. In (Westphal et al, 2007) the problem of collaboration performance is addressed, using aspects, such as flexibility, reliability and commitment.. In (Romero et al, 2007) the definition of guidelines for governance rules and bylaws for behavior regulation is attempted. The idea of an organization having a character is not a completely new concept. For instance, in (Gothlich, 2003) a model for collaborative business ecosystems is presented taking some metaphors from biology, in which the behavioral patterns are described through a small number of classification traits, namely resilience and responsiveness. In (Wilkinson et al, 2005) an analogy is made between the idea of mating and sexual appealing and the idea of business mating. They describe matching factors for engaging in long term partnerships. These factors were grouped in financial issues, organizational (and strategic issues), and technological issues. In (Chun, 2005) a "virtuous ethical character" scale, composed of 6 dimensions (integrity, empathy, courage, warmth, zeal, conscientiousness) and 24 items, is described to enable an assessment of the link between organizational level *virtue* and organization's financial or non-financial performance.

2.2. Towards a collaboration readiness assessment model

The word readiness, according to the Oxford Dictionary of English (Oxford, 2003), refers (1) to the state of having been made ready or prepared for something; (2) the willingness to do something; (3) and the quality of being immediate, quick and prompt. Following this definition, an organization could be considered ready to collaborate if it is prepared and willing to work in collaboration for the achievement of common goals, performing tasks in an accurate and reliable way. This readiness concept should cover several aspects, ranging from technological and economical to behavioral and social ones. In this research, however, the emphasis is put more on aspects related to organization's behavior. Since traits represent predispositions to act in a certain way, an organization can be considered prepared to collaborate if its character traits have values that favor the predisposition of occurrence of behaviors that are desirable in a collaboration context.

In this section a number of concepts are defined in order to better understand the context and suggested approach. In the used notation it is assumed that all single attributes are named in small letters, while sets are named in capital letters. At the base, let us consider the following sets:

- $O=\{o_1, o_2, \dots\}$ – the set of organizations of a virtual organization breeding environment (VBE) (Afsarmanesh, Camarinha-Matos, 2005).
- $T=\{t_1, t_2, \dots\}$ – the set of trait identifiers that can be used to characterize an organization's character.

- V_i={$v_{i,1}$, $v_{i,2}$,…} –the set of values that trait t_i can assume.
- E={e_1, e_2, …} – the set of empathy, affectivity or attitudes assumed by one organization toward others.
- OP={op_1, op_2, … } – the set of comparison operators. The operator op_i performs comparisons between the values of the set V_i (e.g. 'near(v_1,v_2)').
- C={c_1, c_2,…} –the set of competences required for the achievement of a collaboration opportunity.

Just as an example, these sets can be instantiated with the following values: O={net1, org2, university3}, T={flexibility, creativity, reliability}, E={trusts, distrusts, respects, relies, dislikes, … }, $V_{reliability}$={low, fair, high}, C={DBA, logistics, ICT, CAD},and OP={'<', '>', '=', about, near, reliability_op, prestige_op}.

Definition 1 **(Organization's Behavior)** – The way in which an organization acts or conducts itself and toward others; the way it behaves in response to a particular event or situation.

Definition 2 **(organization's behavioral patterns)** – The regularities of behaviors that are observable or discernible in the behaviors of an organization.

Definition 3 **(Organization's Character)** – An organization's character can be seen as a composition of a set of traits that determine the way it behaves. It can be modeled as a tuple OC=(o, TV), in which

- o - is the organization being characterized.
- TV = {(t_i, $v_{i,k}$) | $t_i \in T$, $v_{i,k} \in V_i$} – is the trait set constituted of tuples, each one composed of a trait and a corresponding trait value.

As an example, the character of a hypothetical organization org_1, using the above definition, could be specified by the tuple (org_1, {(*reliability*, high), (*creativity*, fair), (*honesty*, high}).

Definition 4 **(Willingness to collaborate)** – An organization is willing to collaborate whenever it perceives that (a subset of) its interests can be better satisfied in collaboration with other organizations.

These interests can include the access to new markets, access to resources, complementing its competences and skills, sharing of market risks, or increasing its own benefits. Sometimes this willingness can be negative; for instance, whenever an organization feels uneasy or when perceives important concerns in the *VO* or in the *collaboration opportunity (CO)* achievement (e.g., when it does not believe that the CO will provide the expected benefits).

Definition 5 **(Character-related Preparedness Conditions)** – The preparedness conditions related to the organization's character are represented by a set CP of preparedness items. Each item is a tuple that specifies the condition or value required for a given character trait of an organization. The preparedness conditions' set is formally defined as:

CP = { (t_i, $v_{i,k}$, op_i, p_i) | $t_i \in T$, $v_{i,k} \in V_i$, $p_i \in [0,1]$, $op_i \in OP$ }, in which

- t_i - is the trait name
- $v_{i,k}$ - is the trait value, such that $v_{i,k} \in V_i$.
- op_i - is the operator used for comparing the values of probability p_i.
- p_i - expresses the desired probability/likelihood of the trait t_i having the value $v_{i,k}$.

As an example, a preparedness pattern would be represented by the following set CP = {(reliability, high, '>=', 0.7), (creativity, fair, 'about', 0.8)}.

Definition 6 **(Competences fitness)** – An organization fits in some collaboration scenario if it possesses adequate (or required) competences.

The competences' adequacy depends on whether the context is either a *VBE* (bringing competences that fit the general scope of the VBE) or a virtual organization (*VO*) (providing or complementing required competences for the achievement of the *VO goals*) (Camarinha-Matos, Afsarmanesh, 2006).

Definition 7 **(Preparedness for collaboration)** – An organization is considered prepared to collaborate if it can satisfy a set of character's conditions (definition 5) and possesses adequate competences (definition 6).

Definition 8 **(Affectivity/Empathy relationships)** – It is a set composed of elements that specify empathic relationships between organizations. It is formally specified as $A=\{(o_i, o_j, e_l, level)| o_i, o_j \in O, e_l \in E, level \in [-1,1], \}$. Each tuple represents a "feeling" between one organization o_i, and a peer o_j. The *level* parameter specifies the intensity of the feeling. Empathy relationships can be negative (e.g., when an organization distrusts another).

Definition 9 **(Readiness to collaborate) -** is a concept that combines the organization's preparedness (definition 7), willingness to collaborate given a concrete *CO* (definition 4), and the affective/empathic relationships (definition 8) between this organization and the other entities to participate in the CO.

Figure 1. Collaboration readiness concept

Contrary to preparedness, the concept of readiness is applied to a specific collaboration opportunity and typically defined for a short time window. Preparedness, on the other hand, is more long-term oriented.

Specific cases of readiness can be defined, e.g. Readiness to join a *VBE*, Readiness to join a VO. Past research has put considerable effort in the area of "competence fitness" (e.g. matching algorithms for partner selection). However, the other elements of Fig. 1 have received little attention so far, and yet they are important for the success of a collaboration process. In the remaining of this paper we will focus on the issue of character's related preparedness. The other aspects will be subject of future research. For this purpose, let us make the following assumption:

Assumptions **– Organization's behavior predictability**

An organization performs actions or behaviors that tend to repeat through time, leading to the formation of behavioral patterns. These patterns can be associated to a set of identifiable traits. Given the underlying correspondence between traits and behaviors, then the organization's character can be used in behaviors' prediction. Thus, the character of an organization can be used to perform collaboration preparedness assessment, in the following way:

- If the predicted patterns are seen as favorable to collaboration, then the collaboration preparedness increases.
- If these patterns are mostly positive, then in terms of its character the organization is considered prepared to collaborate.
- On the opposite side, if these patterns are considered undesirable or unfavorable to collaboration, then the collaboration preparedness decreases.
- If these patterns are mostly negative, then in terms of its character the organization is considered not prepared to collaborate.

With the above definitions together with these assumptions, it is possible to formulate the following two axioms of collaboration preparedness.

Axiom 1 - An organization *org* is prepared according to a given set of character-related preparedness conditions *PC* if for each preparedness item $p \in PC$, there is a corresponding belief *b*, such that *org*'s character complies with the preparedness item *p*.

$$\forall_{org}\forall_{PC}((is\_prepared(org, PC) \leftarrow \forall_{p}\exists_{b}((\text{belongs}(p, PC) \wedge belief(org, p, b)) \rightarrow c\text{omplies}(p, b)))$$

The predicate 'belief' estimates the probability or likelihood of a given trait to have a value *b*. The 'complies' predicate verifies whether this likelihood meets the condition *p* specified in *PC*. The 'belief' predicate uses a belief network for its functionality as described in section 3.

Axiom 2 – A *VO* satisfies a given set of preparedness conditions *PC* if all its members are prepared according to *PC*.

$$\forall_{VO}\forall_{PC}((preparedness(VO, PC) \leftarrow \forall org((belongs(org, VO) \rightarrow is\_prepared(org, PC)))$$

It shall be noted that often there is not enough information to perceive and characterize an organization's character. This results in traits that are unknown or specified with imprecision. This increases the uncertainty regarding behavior's prediction and, consequently, limits the collaboration readiness assessment. Therefore, the output of the assessment process should be of probabilistic nature.

3. A MODELING EXPERIMENT

3.1. Belief networks basics

A Bayesian belief network is a kind of probabilistic model that represents causal relationships on a set of variables (Fig. 2). It is composed of two parts: the structural part, which consists of a direct acyclic graph, in which nodes stand for random variables and edges for direct conditional dependence between them; and the probabilistic part that quantifies the conditional dependence between these variables. Each variable can have state values (such as, 'no', 'yes' or 'low', 'high'). If the value of a variable in a node is known, then that node is said to be an evidence node. More on belief networks can be found in (Jensen, 1996). For instance, in Fig. 2, the arc pointing from node C to node E can be perceived as C causing or influencing E. Each of the child nodes have a conditional probability table that quantifies the effects that the parents have on them. For the nodes without parents, the corresponding table only contains prior probabilities. Due to these conditional dependences, if a node becomes an evidence node, then the probabilities (or likelihood) of the other nodes change.

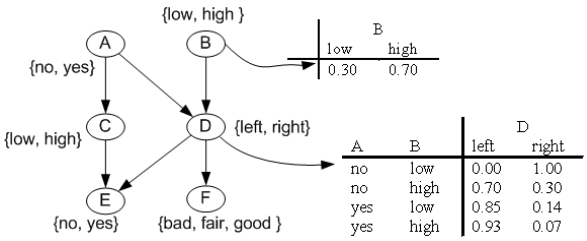

Figure 2. An example of a Bayesian belief network

For any node of the network, the computation of conditional probabilities is done using the Bayes' rule, exemplified in the next section. For the above example, the probability of variable *E* being in state *yes* or *no* is conditioned by its parent C being in state *low* or *high* and its parent *D* in state *left* or *right*. Belief networks can be used to perform queries in distinct ways:

- To perform predictions. This is useful whenever some causes are known and it is necessary to determine the probability of possible effects/consequences. For instance, when B=low and C=high, the probability of E=yes is given by the query P(E=yes | B=low, C=high).
- To perform diagnostics. For instance, when the fact F=bad is known, it is necessary to determine the likelihood of eventual causes: P(A=yes| F=bad).
- It is also possible to make queries on the joint distributions, without providing evidences. For instance, the probability of F=fair, without further evidence, is given by P(F=fair).

3.2. Modeling the predictor

In simple situations a Bayesian network can be specified by an expert and used to perform inferences, as illustrated in Fig. 3. In many cases this task is too complex to be done by hand. Alternatively, both the structure (nodes and arcs) and parameters of the local distributions can be learned from historic data, using Machine Learning techniques (Pearl, 1996), (Cheng et al, 1997), (Cheng, Greiner, 2001) and (Friedman, 1997).

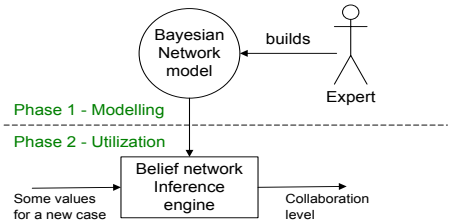

Figure 3. Belief Network modeling and utilization

In order to guide the belief network design process for this experiment, we selected a few assumptions related to members' behavior, among potential many others, which should be taken as merely illustrative. Therefore, for building a modeling example, we conjecture that:

- An organization of fragile economical condition, in order to benefit from others' competences (that usually it cannot afford to own), is more willing to accept the risks of collaboration. On the other hand, due to its fragile condition, it tends to be less reliable.

- An organization in good economical condition might be more reliable, but does not feel the same pressure, as the previous case, to collaborate and therefore tend to be more risk conservative considering collaboration/partnerships.
- A small size organization (e.g. a SME) might possess fewer competences and, with the goal of complementing them, accepts to be more exposed to the risks of collaborating with other organizations.
- The prestige of an organization, which is an attribute that is perceived by its peers, is fundamental in collaboration and adds directly to the preparedness level.
- The creativity of an organization, which can be roughly estimated by evaluating its rate of generated innovations, might also be important for collaboration, and adds directly to the preparedness level.

Certainly, these conjectures are arguable, but they are considered here only for the elaboration of an illustration. An example belief network, modeled using the above guidelines, for the inference of the organization's preparedness levels is shown in Fig. 4, using (Netica, 1997).

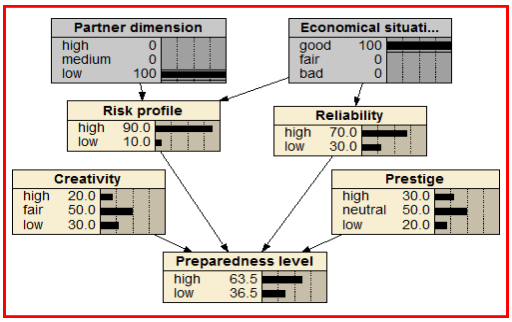

Figure 4. A Bayesian network example to assess the preparedness level

For this belief network, the joint probability distribution, from which the predictions and diagnostics can be made, is the following (showing only the initials for the nodes names):

$$P(PD,ES,RP,R,C,P,PL) = P(PD) \times P(ES|PD) \times P(RP|PD,ES) \times P(R|PD,ES,RP) \times P(C|PD,ES,RP,R) \times P(P|PD,ES,RP,R,C) \times P(PL|PD,ES,RP,R,C,P)$$

This function can be simplified by considering the conditional independence statements implied in the belief network. For instance, the 'partner dimension' variable does not directly influence the 'preparedness level', as 'reliability' does. This is because $P(PL|PD,R)=P(PL|R)$, so PD can be removed from the above expression. In other words, PL and PD are conditionally independent given R. The same approach can be applied to the other conditional probabilities, which helps removing more variables (the shaded ones) from the above expression. This results in the expression:

$$P(PD,ES,RP,R,C,P,PL) = P(PD) \times P(ES) \times P(RP|PD,ES) \times P(R|ES) \times P(C) \times P(P) \times P(PL|RP,R,C,P)$$

As an illustration for the given problem, and assuming most of the nodes as evidences (to reduce calculations), the probability of preparedness level PL=high, given that PD=high, ES=fair, C=high, and P=high is given by:

$$P(PL_{high} \mid PD_{high}, ES_{fair}, C_{high}, P_{high}) = \frac{P(PL_{high}, PD_{high}, ES_{fair}, C_{high}, P_{high})}{P(PD_{high}, ES_{fair}, C_{high}, P_{high})} = 0.815$$

After the belief network description, it is now possible to give more explanations about the behavior of the 'belief' predicate, used in axiom 1. This predicate, through the belief network, provides the likelihood that, for a given character, the trait t_i specified in preparedness item t (definition 6) has the value $v_{i,k}$ also specified in that item. As an illustration, let us consider the preparedness item t = (reliability, high, '>', 70) and observe the vbe_1 in table 1. This predicate would provide the values for belief b (see axiom 1 for 'b'), using the belief network, as illustrated by the following cases:

- For organization *o_1*, the belief that reliability=*high* is b=100%, because *o_1* has the trait 'reliability' defined with value high in its character profile. It would be represented by an evidence node in the belief network of Fig. 4.
- For organization *o_3*, the belief that reliability=*high* is *b*=0%, because *o_3* has low reliability in its character profile. It would be represented by an evidence node in the belief network of Fig. 4, but with different evidence (low reliability).
- For organization *o_2*, the belief is *b*=53.6%. This is because, the reliability of this organization is unknown and, therefore, this value is obtained using the query b=P('reliability=high'| known_traits(*o_2*)) on the belief network of Fig. 4. The predicate '*known_traits*(*org*)', provides the known values of an organization's traits.

3.3. An example

The example described below illustrates the estimation of collaboration preparedness based on organizations' characters, which, as mentioned before, is one of the aspects considered in the readiness assessment approach being researched.

Let us consider the existence of a virtual breeding environment composed of a group of organizations. These organizations, together with corresponding competences and character traits, are defined as shown in table 1. For illustrative purposes, the traits used in this example are the ones defined in the belief network of Fig. 4 in section 3.2. Aspects related to the orthogonality of these traits are yet to be considered in future research. As illustrated in Table 1, one important aspect to emphasize here is that, for the given organizations, some traits are unknown.

Table 1. Competences and traits of the VBE's members

VBE_1 composition							
		Organization traits					
Organization	***Competences***	***PD***	***ES***	***RP***	***R***	***C***	***P***
o_1	*c1, c2*	high	good	?	high	high	high
o_2	*c4, c6*	med	?	high	?	low	high
o_3	*c2, c5*	med	fair	high	low	high	high
o_4	*c1, c2*	?	good	high	low	?	?
o_5	*c1, c3, c4*	high	bad	high	high	high	low
o_6	*c2, c3*	low	good	high	?	high	high

(PD: partners dimension; ES: economical situation; RP: risk profile; R: reliability; C: creativity; P: prestige).

Fig. 5 illustrates two distinct cases of network joining. In the first case, organization *o_12* is a candidate to join the *VBE*. In the second, organization *o_6*, already a member of the *VBE*, is being considered to join an existing virtual organization (*VO*), namely *vo_1*.

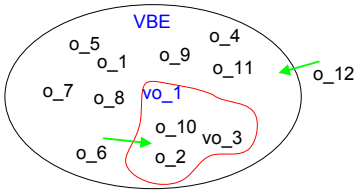

Figure 5. A Virtual breeding environment with an existing VO

As a newcomer, little information is known about o_12's character. The only known evidences about this candidate are that it is in good economical situation and is of low dimension (as illustrated in the belief network of figure 4). We can query the belief network about the probability of this organization to express a high preparedness level, using the conditional probability

P("preparedness level"=high| "partner dimension"=low, "economical situation"=good)=60.1%.

For the second case, candidate *o_6* is already a member of the VBE and, as such, there is more information about its character, so its classification's certainty should increase. Taking the known traits of o_6 from table 1, the probability of this organization having a high preparedness level is obtained by the query:

P("preparedness level"=high| "partner dimension"=low, "economical situation"=good, "prestige"=high, "creativity"=high)=90.5%.

If we want to assess whether the virtual organization vo_1 is composed of members that are prepared to collaborate, we can define some preparedness conditions, supposedly adequate for a given situation or context, and run the predicate "preparedness" specified in the axiom 2. We would invoke the following query

"preparedness(vo_1, {(reliability, high, '>=', 0.7), (creativity, fair,'about',80)})"

In this case *vo_1* is not prepared according to the specified preparedness conditions, because organization *o_2* does not comply with the preparedness conditions. This organization has reliability P(reliability=high, know_traits(o_2))=0.63, which is less than 0.7, as specified in the conditions. It also fails in terms of creativity, because P(creativity=fair, know_traits(o_2))=0. In other words, its creativity level is *low* and the conditions of the query require it to be *fair*.

4. CONCLUSIONS

Collaboration can be highly beneficial and even a survival factor for industrial companies. But it can also be risky, being important to assess the readiness of potential partners. Although most works in the past were focused on "hard" factors such as competency matching or technological preparedness, the success of a collaborative process depends on several other factors of a "soft" nature such as organization's character, willingness to collaborate, or the affectivity / empathy relationships. A preliminary approach to handle

such elements was introduced.

The preliminary results show that this assessment approach is feasible and promising. Nevertheless, further research is needed towards the development of a full assessment model for collaboration readiness, which is the subject of our ongoing research.

4.1. Acknowledgements

This work was funded in part by the European Commission through the ECOLEAD project.

5. REFERENCES

1. Afsarmanesh H, Camarinha-Matos LM. "A framework for management of virtual organization breeding environments". In Collaborative Networks and their Breeding Environments; eds. Camarinha-Matos, L., Afsarmanesh, Ortiz, A.; Springer, 2005, pp. 35-48.
2. Camarinha-Matos LM, Afsarmanesh H. "Creation of Virtual Organizations in a Breeding Environment". In Proceedings of INCOM'06 - St. Etienne, France - 17-19 May 2006.
3. Camarinha-Matos LM, Macedo P. "Towards a Conceptual Model of Value Systems in Collaborative Networks". In Establishing the Foundation of Collaborative Networks; eds. Camarinha-Matos, L., Afsarmanesh, H., Novais, P., Analide, C.; Boston: Springer, 2007, pp. 53–64.
4. Chun R. "Ethical Character and Virtue of Organizations: An Empirical Assessment and Strategic Implications". Journal of Business Ethics, V57, 2005, pp. 269-284.
5. Goldie P. What people will do: personality and prediction. Richmond. Journal of Philosophy 2004; 7: 11-18
6. Gothlich SE. "From Loosely Coupled Systems to Collaborative Business Ecosystems". Paper No. 573, University of Kiel (Germany), May 2003, from http://www.bwl.uni-kiel.de/grad-kolleg/de/kollegiaten/goethlich/Business%20Ecosystems%204b%201,5Z.pdf
7. Netica Application for Belief Networks and Influence Diagrams Users Guide, Norsys Software Group, 1997,http://www.norsys.com.
8. Oxford Dictionary of English. Catherine Soanes, Angus Stevenson (Ed.), Second Edition, ISBN 0-19-8613474, Oxford University Press, Oxford, UK, 2003.
9. Romero D, Giraldo J, Galeano N, Molina A. "Towards Governance Rules and Bylaws for Virtual Breeding environments". In Establishing the Foundation of Collaborative Networks; eds. Camarinha-Matos, L., Afsarmanesh, H., Novais, P., Analide, C.; Boston: Springer, 2007, pp. 93–102
10. Webber J. Virtue, Character and Situation. Journal of Moral Philosophy 2006; 3 (2): 193-213.
11. Westphal I, Thoben KD, Seifert M. "Measuring Collaboration Performance in Virtual Organizations". In Establishing the Foundation of Collaborative Networks; eds. Camarinha-Matos, L., Afsarmanesh, H., Novais, P., Analide, C.; Boston: Springer, 2007, pp. 33–42
12. Wilkinson IF, Freytag P, Young L. Business Mating: Who Chooses Whom and Gets Chosen?. Industrial Marketing Management 2005, Vol. 34: 669-80.