

A model for the suggestion of logistics partners for virtual organizations

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Abstract: In a Virtual Organization (VO) scenario the difficult to select the most appropriate logistic providers is even higher. Part of this is due to the intrinsic nature of a VO, which is a temporary and dynamic alliance of autonomous, heterogeneous and geographically dispersed companies (often small and medium enterprises) created to attend to very particular business opportunities, sharing costs, benefits and risks, and acting as it was one single enterprise. In the literature review the specification of the methodology for selecting logistics partners to compose virtual organizations using key performance indicators has not yet been adequately explored. This work proposes a methodological support, to be called as a framework for suggesting of logistics partners for virtual organizations (VOs) based on performance indicators analysis.

Keywords: Logistic Partner, Virtual Organization, Methodology, Performance Measurement, Performance Indicators

1. Introduction

The globalization of markets is a trend that favors the expansion of logistics partners. New markets and new products have been increasingly created all over the world and proper logistic providers should be contracted. The cleverer this activity is done the greater flexibility, improved customer service and cost savings will be provided (Mentzer and Konrad, 1991).

In a Virtual Organization (VO) scenario the difficult to select the most appropriate logistic providers is even higher. Part of this is due to the intrinsic nature of a VO, which is a temporary and dynamic alliance of autonomous,

heterogeneous and geographically dispersed companies (often SMEs) created to attend to very particular business opportunities (Camarinha-Matos and Afsarmanesh, 2005), (Mowshowitz, 1997), (Katzy, 1998), sharing costs, benefits and risks, and acting as it was one single enterprise (Sandberg, 2007), (Camarinha-Matos and Afsarmanesh, 2008). After ending all legal obligations a VO is dismissed. This means that, differently from traditional supply chains, logistics providers (the ones responsible for handling material and cargo transportation) are not known in advance, as this depends on the business, on the client, on the country or region's regulations, on the place client is, etc. Therefore, the collaboration among involved industrial partners (the ones who produces some part of the good) and logistic providers are crucial to be augmented (Skjoett-Larsen, 2003), (Whipple and Russell, 2007) as a way to fulfill temporal and quality requirements of this unique business opportunity as well as to differentiate in the market as long as they create value in this chain (Rafele, 2004), (Esper and Williams, 2003).

This higher level of collaborative alliance is actually a trend, where organizations can structure themselves in business networks, interconnected through multilateral interests, where market competition occurs between networks of companies and not only between individual companies (Provan, Fish et al., 2007). Considering this tighter collaboration, in this work logistics providers are treated as logistics partners (LP) and a business opportunity is treated as a collaboration opportunity (CO).

Most of the works found out in the literature tackled this general problem usually calling it as partner's search and selection. However, very few of them deal with the logistics issue, but rather concentrating efforts on how to select industrial partners. Besides that, current works on logistics in VOs mostly covers performance evaluation models and with a focus at a too operational level, neglecting tactile and strategic levels. Yet, they do not consider other relevant dimensions when autonomous and collaborative companies do business together, such as governance and trust. Finally, the large majority of the works try to apply an automatic approach when selecting partners. We argue that the selection of logistics partners in a VO scenario is so complex and full of particularities that making this automatically can become it unrealistic as well as prevent involved companies' managers from putting in practice their experience.

In this sense, this ongoing and partially exploratory work proposes a novel model that complements other contributions, suggesting the most adequate logistic partners to cope with the VO specifications, integrated to a comprehensive performance evaluation model and assisting managers in the

final selection so that a VO can be created.

This paper is organized as following: section I introduced the problem; section II details the problem and contextualizes it within the collaborative networks area; section III presents the supporting methodology for LP suggestion; section IV introduces the performance evaluation model; section V provides an example of the model usage; and section VI provides some preliminary conclusions about the model.

2. Problem

A VO is just one type of a diversity of Collaborative Network Organizations (CNO). However, a key aspect when considering VOs is that all of its members come from another type of CNO, which is the so-called Virtual organization Breeding Environment (VBE). A VBE is a long-term alliance of (mono or multi-sector) companies whose ultimate goal is to be the basis for the creation of VOs. Likely VOs, VBE members are composed of autonomous, heterogeneous and geographically dispersed companies. Regarding that they share principles (such as trust building and governance) and working methods (such as information sharing and minimum IT tools and platform), the creation of VOs from a VBE becomes much faster, more effective and less complex to manage (Rabelo, Baldo et al., 2004), (Afsarmanesh and CamarinhaMatos, 2005). A typical VO is hence generally composed of logistics partners (LPs) and industrial partners (IPs), as illustrated in Figure 1.

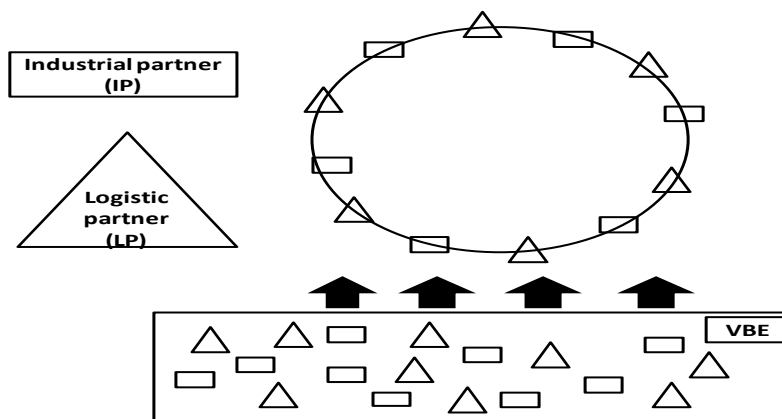


Figure 1: VO composed of LPs and IPs

The reference process for VO creation consists of seven steps, as outlined in Figure 2 (CamarinhaMatos, Silveri et al., 2005). Adopting a performance measurement approach, in (Baldo, Rabelo et al., 2008b) partners' search and

selection step is extended with the introduction of a sub step in which key performance indicators (KPI) are firstly set up to better filter industrial partners. The work presented in this paper follows the same approach, adapting it to logistics partners' (LP) and restricting the model's scope to the suggestion stage.

This is a complex task because LPs will work collaboratively in a VO and their selection should also consider particular aspects of the VO and VBE, such as:

The environment is dynamic, where LPs can only be identified after knowing the CO in details;

A repeated CO will be rarely composed with the same set VBE members;

VO's LPs and IPs not necessarily will have worked together in some previous CO;

Several COs are unique or one-of-a-kind;

KPI (key performance indicators) and/or their weights vary from one CO to another;

LPs usually have difference information system, semantics and different performance measures;

The final handshake among IPs and LPs should be carried out as fast as possible;

Each VBE has its particular governance model.

A literature survey about this showed that there are several approaches based on performance measurement and KPIs for evaluating companies (Seifert 2009). However, quite few of them address the problem of KPI models for LPs in VOs. . For example, in (Westphal, Thoben et al., 2007) a generic methodology based on balanced Scorecard (BSC) indicators is proposed, but without any support for governance and trust issues. The methodology proposed by (Bititci, Mendibil et al., 2005) assigns performance indicators for each partner but does not provide criteria for analyzing the collaboration level of partners to compose VOs. In (Sarkis, Talluri et al., 2007) the complexity of structuring a methodology for VO partners' selection is identified and a hierarchical methodology based on multiple attribute decision making is proposed. However this work has focused only on intra-organizational performance indicators.

One of the most relevant contributions of this proposed model is a supporting methodology. The suggestion process is a rational model of decision making based on a set of characteristics and criteria that can be changed depending on the resources availability.

3. Proposed Methodology

The methodology for LPs suggestion for VOs is generally illustrated in Figure 3. Two important assumptions are considered. The first one is that all LPs are members of a VBE. The second one is that there is a global coordinator of the process, which is the so-called VO Coordinator. Typically, it is represented by the company’s manager who got the CO. An additional role is taken by the VO specialist, who permanently audits the LPs’ KPI values.

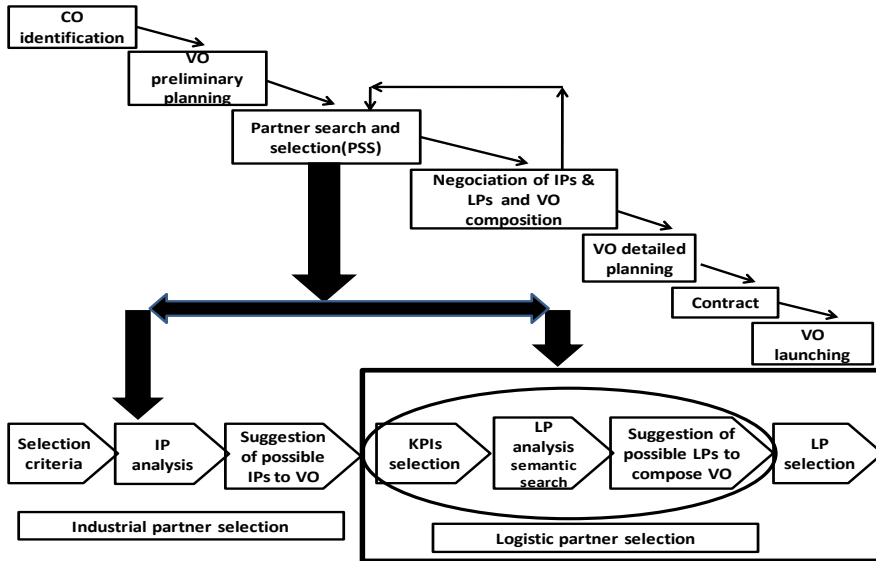


Figure 2: Extended framework for the VO creation

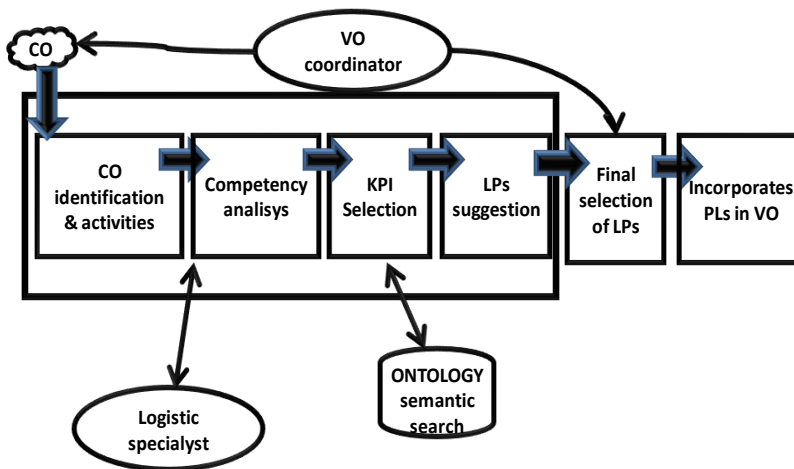


Figure 3: LP selection steps

3.1. CO Identification

In this first methodology stage the CO is verified in order to identify the logistics activities that have to be carried out. A CO, besides other information, is composed of the following logistics-related data:

Place of origin (e.g. Paris);

Place of destination (e.g. Chicago);

Departure Date: date that the cargo should be loaded;

Delivery Date: date that the cargo should be delivered to the end user;

Service Modal: the requested modal type, which may involve different options (e.g. plane or ship);

Cargo Type: cargo to be transported (e.g. parts, wood);

Quantity: the amount (e.g. in tons) to be transported;

Route: the whole path, including intermediate nodes (e.g. Route: Paris-Chicago, intermediate nodes: Paris-TO-Amsterdam; Amsterdam-TO-New York; New York-TO-Chicago);

CO activities: The methodology is prepared to suggest one LP per activity. In the case of intermediate nodes other LPs will be suggested for each way (i.e. sub activities). By coincidence or VO manager preference or optimization options, a single LP can get responsible for a whole activity. (e.g. according to route information there are 03 activities: activity_1: Paris-Amsterdam; activity_2: Amsterdam-New York; activity_3: New York-Chicago)

Technical skills: One per each activity and requests LP technical competence and provides the technical description of how and what should be shipped (e.g. see section B).

Level of Collaboration (LC): minimum requested value for the given CO (e.g. see section D).

This set of information was based on a VO information reference model (Oliveira, Camarinha-Matos et al., 2007) and extended for this work. This extension, in turn, took into consideration a literature overview and opinions from a group of logistic operators.

3.2. LP Competency Skills Analysis

In a first round of analysis the methodology checks the technical LP competences (based on KPIs) against to every single (sub) activity. If a given

LP is pre-selected then it is moved to a suggested list for further VO manager decision.

After an analysis on the logistics discipline (Gunasekaran, Patel et al., 2001), six attributes were elicited to represent LP competences:

Geographic coverage at source: (e.g. Paris area);

Geographic coverage at the destination: (e.g. Amsterdam area);

Transportation of different type of loads: e.g. oil, gas;

Modal options: (e.g. train, truck, plane);

Realization of consolidated shipments; (e.g. if the LP does the load consolidation, means low cost of transportation);

Response time: (e.g. 3 days).

The formal competency skills analysis is performed using the set theory. Two sets are considered: R and M. R represents the whole set of specific CO requirements ($R=\{1,\dots,r\}$). M represents the set of LP's competencies ($M=\{1,\dots,m\}$), which are expressed in KPI terms. The problem is to find a match between R and M, which will then define the pre-selected PLs for the given CO (Figure 4). This is provided by the function $G(i,j)$, which represents the intersection of R and M sets:

$$G(i,j)=|R_i \cap M_j|, \forall i \in R \square \forall j \in M \quad (1)$$

3.3. Identification and Selection Of KPIS

This third step of the methodology aims at selecting the most appropriate KPIs that will be applied over every CO's activity to filter the pre-selected LPs. This process is aided by an ontology, which considers and links the semantic of the CO' attributes with the developed KPI model (Figure 4).

The purpose of ontology is to provide a formal knowledge representation that can be used and reused to facilitate understanding of concepts and relationships between them in a specific domain (Berners-Lee, Hendler et al., 2001).

The developed KPI model comprises fifteen KPIs (see section IV). There may be more than one KPI associated to a given CO activity. LPs will be selected after this set of KPI evaluation. This strategy has been inspired from (Baldo, Rabelo et al., 2008).

With the list of KPIs and LPs that were selected in the previous phases, the methodology determines the level of collaboration (LC) (see Section D) of each pre-selected LP for each (sub) activity. The LP to be finally suggested is the one with the highest LC value. The VO managers evaluate the suggested list and

assign one LP to the (sub) activity then becoming member of the VO. The method repeats until the end of the CO activities, i.e. when there is one or a set of LPs selected to link all the involved (and previously defined) VO's industrial partners.

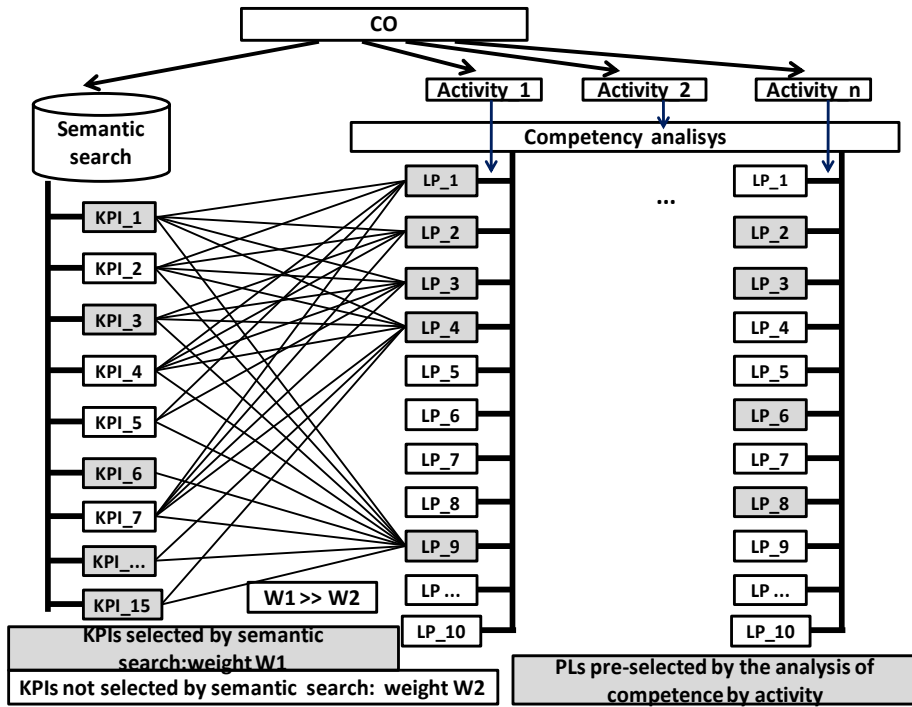


Figure 4: KPI and LP competency analysis

3.4. Level of Collaboration (LC)

The final decision about which LPs will compose a VO is determined by a last filter, which is the level of collaboration (LC). It is a value calculated for each selected LP that was selected by the competence analysis, and it is represented by a vector of collaboration (VC), which is formed by the historical collaboration of each pre-selected LP in past VOs (Figure 5). It is composed of fifteen positions/KPIs, where each position is calculated multiplying the average of the historical values of each KPI by its respective weight. The determination of the LC is applied to all LPs, as follows:

Set the past KPI values (from the VBE database) from each pre-selected LP, associated to their previous participations in VOs;

Determine the time horizon to be applied upon the LPs. Depending on the OV or the VBE policy, this can vary from a number of past OVs (e.g. the last ten participations) or period of time (e.g. the participations in the last two years);

Calculates VC, where each vector field is the arithmetic average of the last values multiplied by the respective KPI's weight. The weight is represented by the variable $W_{i,j,k}$, and it is calculated using the AHP method (explained later);

Determines the total LC for each LP by the sum of the indices of the respective KPI vectors of collaboration;

Suggests that the PL with the highest LC for each CO's (sub) activity.

The formula for VC and LC calculation is given by:

$$VC(i,j,k) = AA_KPI(i,j,k) * W(i,j,k) \quad (2)$$

Where:

i = amount of KPIs;

j = number of LPs per activity;

k = number of activities within a CO;

AA_KPI = arithmetic average of historical values of the KPI i , referring to PL j , which is associated with the activity k ;

$W(i,j,k)$ = weight assigned to KPI by AHP;

$$LC(j,k) = \sum_{I=1}^{15} VC(I,j,k) \quad (3)$$

Where:

I = number of KPIs;

J = number of LPs by activity;

K = number of activities of the OC;

$VC(i,j,k)$ = vector of collaboration from KPI i to partner j , related to activity k ;

$LC(j,k)$ = level of collaboration of the PL j to activity k ;

$$LC(k) = (Max(NC(j, k))) \tag{4}$$

Where:

LC(k):represents the greatest value for the LC to activity k.

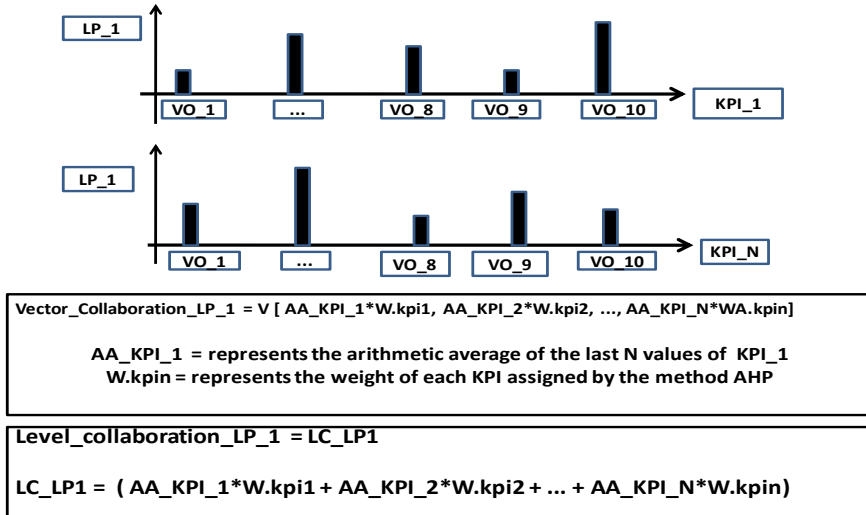


Figure 5: Value of KPIs and historical metrics on LPs

4. KPI Model

A crucial element of the proposed model for suggesting LPs to VOs is the KPI model. Regarding this goal, two general requirements were necessary to be coped with in order to conceive this model. Firstly, the set of KPIs should consider both intra and inter organizational perspectives. Secondly, they should consider indicators at strategic level.

After a literature review, several KPI models were found out (e.g. (Saiz, Bas et al., 2007), (Westphal, Thoben et al., 2007), (Kim and Kim, 2009), (Seifert, Wiesner et al., 2008)). However, none of them were either comprehensive enough to cope with those requirements or were devoted to logistics in dynamic and alliances, which is the case of VOs and their life cycle.

Trying to take advantage of existing models (e.g. SCOR (Supply-Chain Council, 2006)) and based on a literature overview, a KPI model has been conceived. It is composed of fifteen KPIs (Figure 6):

ROE (return-on-equity): The amount of net income returned as a percentage of shareholders equity;

Cash flow: focusing on the cash being generated related to how much is being generated and the safety net it provides to the LP;

Cost Control: controls the cost reduction of LPs;

Customer satisfaction: measures the customer perception related to delivered services;

Susceptibility: measures the elapsed time between the customer purchase order and product(s) delivery;

Commitment: measures the level of commitment between the LPs;

Collaboration: measures the LPs level of collaboration;

IT maturity: measures if the LP's IT objectives are aligned to its business strategies;

Governance: measures how is the code of conduct (ethical) and cultural issues of each LPs;

Flexibility: measures the LP flexibility level to be adapted to changes occurred at VO operation phase;

Environmental performance: measures how the LP is compliant with environmental best practices;

Availability: measures the level of LP availability;

Effectiveness: measures if resources (e.g. labor) are properly allocated;

Trust: measures the level of trust between the LPs;

Communication: measure the level of effective communication among LPs' members.

Each KPI is seen as a strategic dimension, which is divided into a subset of individual and operational/lower level performance indicators (PIs). When computed as a whole, they provide the value of the KPI itself. For example, KPI Cost Control is calculated considering the PIs cost of warehousing, reverse cost and labor cost.

4.1. Assigning Weights to KPIs

The methodology applies the AHP method to assign weights to the fifteen KPIs. The AHP was proposed in (Saaty, 1990) to solve multiple criteria problems in a hierarchical structure. In AHP, the criteria related to the goal are distributed at lower levels from the top of the structure.

The VC calculation uses this hierarchical structure to distribute the weights (i.e. the degree of importance) of KPIs and hence to suggest the best LPs

(Figure 7). All KPIs will receive a given weight. By default, the methodology assigns the higher weights to KPIs with a semantics match with the CO, whereas lower weights are assigned to those without matching. The VO coordinator is in charge of weights assignment to all KPIs, and if necessary can redefine the weights distribution along the KPIs.

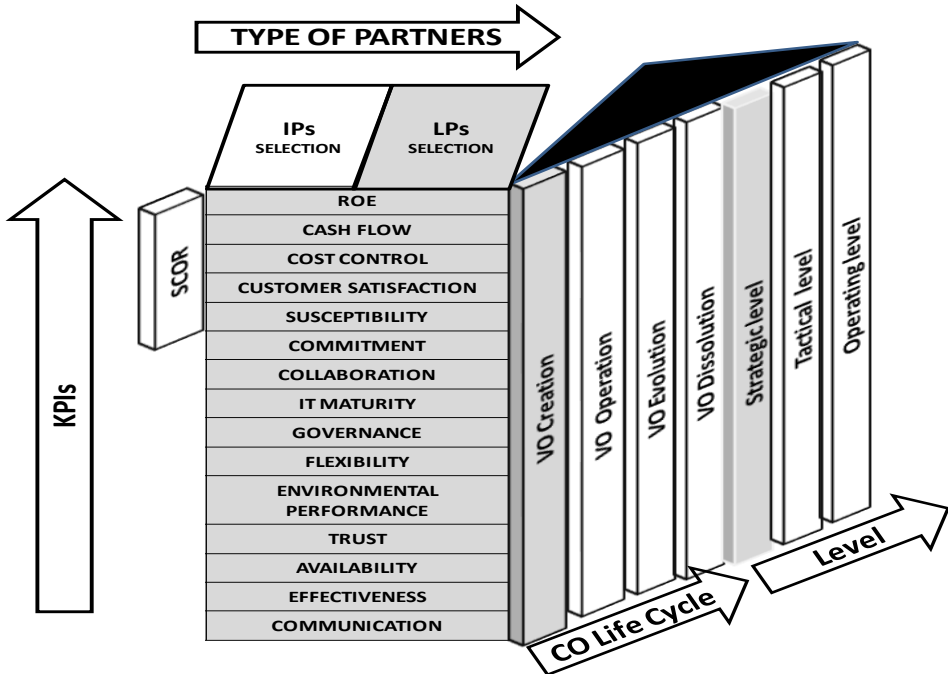


Figure 6: Developed KPI model

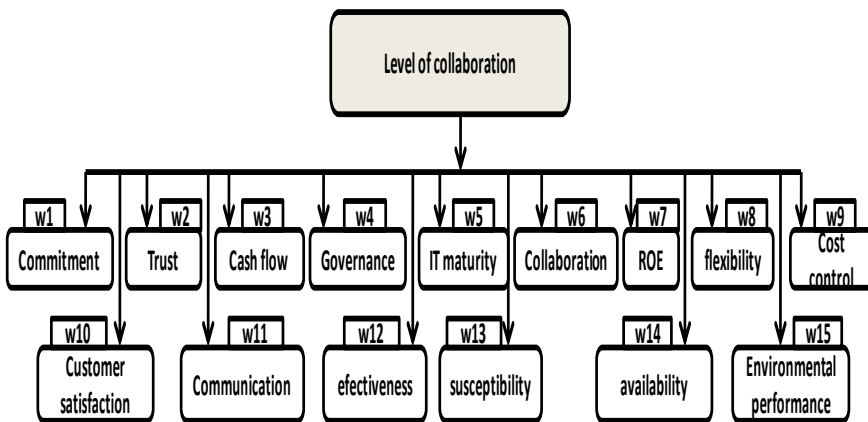


Figure 7: Using AHP with the KPIs

4.2. Assigning Values to KPIS

As the system works is also based on historical data, the VBE database should be updated after the VO dissolution with the applied KPIs values. This is done by all the involved VO's companies via electronic questionnaires. In order to normalize the KPI values the Likert scale (Linacre, 2002) is used, defining values from zero to five. These values are calculated from the set of operational PIs that composes each KPI, which are calculated by the arithmetic mean of the individual PI values.

5. Example of Methodology Usage

Figure 8 generally illustrates a resumed example on how the proposed model and methodology are used. The given CO refers to transport of some good from location A to B, with three legs in between: A-C, C-D and D-B. Each leg is represented by a CO's activity and they require up to three LPs. A LP may even get all the three activities, depending on its LC. Following the CO:

Place of origin: A;

Place of destination: B;

Departure Date: 01-31-2011;

Delivery Date: 02-04-2011;

Service Modal: plane and train;

Cargo Type: shoes;

Quantity: 1, 20 tons;

Route: AC, CD, DB;

CO activities: activity_1: AC; activity_2: CD; activity_3: DB)

Technical skills for activity_01;

Geographic coverage at source: A;

Geographic coverage at the destination: C;

Transportation of different types of loads: not considered;

Modal: plane;

Realization consolidated shipments: mandatory;

Response time: 12 hours;

Technical skills for activity_02;

Geographic coverage at source: C;

Geographic coverage at the destination: D;

Transportation of different types of loads: not considered;

Modal: plane;

Realization consolidated shipments: mandatory;

Response time: 1day;

Technical skills for activity_03;

Geographic coverage at source: D;

Geographic coverage at the destination: B;

Transportation of different type of loads: mandatory;

Modal: train;

Realization consolidated shipments: mandatory;

Response time: 1 day;

-Level of Collaboration (LC): 5, 1.

As explained in Section 3, the selection of the set of PLs to be suggested to VO managers to compose the VO related to the given CO is carried out along five phases:

Phase 1: the actor who gets the CO (e.g. the VBE coordinator, a VBE broker or the industrial partner who was directly contacted by the customer, depending on the VBE operating rules) checks the activities associated with the CO.

Phase 2: for each CO's activity the VBE database is consulted and LPs are pre-selected via the analysis of their competencies. In the example, Activity_1 was detailed and LP_1, LP_4 and LP_10 were pre-selected;

Phase 3: Semantic search selects KPIs which are related to the OC, and weights are assigned to them (using AHP method);

Phase 4: calculation of: the arithmetic average for each KPI; the VC for each LP; and the final LC for all LPs previously selected;

Phase 5: For each activity the LP with the highest LC is suggested to compose the VO. For example, LP_1 was selected for Activity_1 with the score 5.4;

The process repeats for OC's activities 2 and 3 until there are the required LPs for the entire OC.

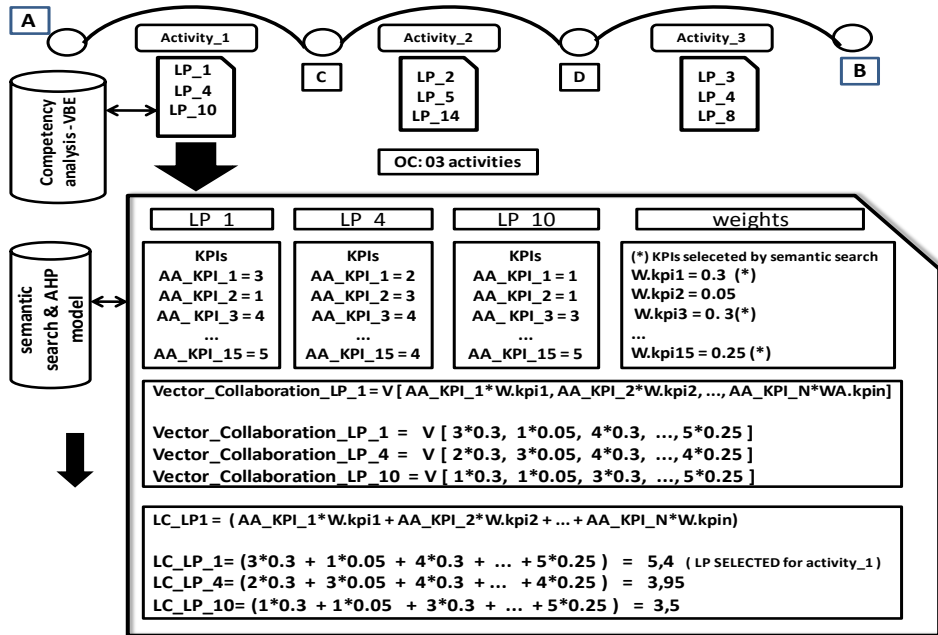


Figure 8: Example of LP selection

6. Conclusion

This paper has presented a novel model for supporting the selection of logistics partners to compose virtual organizations. It corresponds to an ongoing PhD thesis of an essentially exploratory and qualitative work.

The essential of the novelty refers to the intrinsic dynamics, temporality and autonomy of virtual organizations, whose partners (including logistics ones) can only be identified when the usually unique business opportunity is gathered. Therefore, it is of extreme importance to not only make this process faster but also with more quality and confidence. As a contribution to this problem, a model and supporting methodology are proposed to assist the so-called virtual organization managers in deciding for the most adequate logistics partners for the whole value chain.

A new performance model is also presented and it is devoted to cope with the singularities of virtual organizations. It is composed of 15 KPIs and it is used to compare companies' competences, regarding that their weights of importance can be flexibly assigned (applying AHP method) depending on the business opportunity requirements. A formal ontology to establish the relation among requirements, KPIs and competences was specially conceived so mitigating

semantic problems. After all, the set of logistics partners are selected based on their level of collaboration, also considering their past performance.

So far the model has been only verified in a controlled environment and close to a very small group of logistics operators in the form of a general questionnaire. Next main steps will go for the implementation of the whole model and methodology as a decision support software prototype and testing the whole framework in near real scenarios.

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