

AN ANALYSIS ABOUT THE RESOURCES SELECTION PROCESS IN AGILE/VIRTUAL ENTERPRISES

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Abstract: We intend in the context of this work, to do an analysis on studies, literary revisions and mainly on existent models, in the universe of virtual enterprises resources selection, in order to allow us to put on perspective, in a sustainable way, new slopes to be incorporated that contributes to an improvement of the whole global process. This analysis for the A/VE was focused in several areas and basic slopes for the whole global process of the problem in question, namely in terms of the pre-selection phases and requisites; selection phases, requisites and methods; mathematical models, used tools and other important areas.

There were incorporated the decision process of create an A/VE project and the requisites of the process principal phases. We approach the essential aspects for the work that is intended to develop, such as the integration of the existent models with the tasks plan (PT) of the product, namely if there are contemplated the reformulation and evaluation of the PT, and other important characteristics such as the weighting of resources and the incorporation of the value concept in the existent models, being that in our opinion an integration of a methodology of the type of Value Analysis will be able to incorporate surplus values in all this process. Conclusions were withdrawn on the whole global process, pointing to gaps and limitations and trying to do an approach which allows to synthetize and put in perspective an efficient analysis of the whole extent of the problem in question.

Keywords: Agile/Virtual Enterprises, Resources Selection, Value Chain, Integration

1. INTRODUCTION

Since thousands of years ago, namely in military campaigns, the supply chain and the resources selection always has assumed basic importance. For example, Sun Tzu [1] in its classic "The Art of War" has already emphasized the relevance of this question. It can also be understood as a form of contribution between suppliers, customers and consumers for the value creation. It is then, all the global process of the customer satisfaction through the creation of a value chain that integrates, in an optimizing form, all the intervening ones that are in the origin of a product or family of products execution. It is necessary to implement a global management based in the added value creation of a product, since the raw materials production phase until the distribution of the final product, in order to improve the quality of the global product performance that is proposal to the final consumer.

The technological development and the information technologies (IT) have evolved extremely fast, which originated a bigger attention to the area of the selection of resources. These more and more dynamic and complex chains provoked a strong increment of the investigation in these thematic of the resources selection. In this work the resources selection process is

considered in the form of A/VE projects to frame all this thematic in a global perspective of all problematic inherent to the resources selection.

2. SELECTION OF RESOURCES IN AGILE/VIRTUAL ENTERPRISES

In the context of the intense bibliographical review and in the revision of the literature found on this theme, which sometimes is not linear and comprises other vectors and different extents, there were considered for analysis the models to be next referred, being that they all treat the problem of resources selection in organizations designated by virtual enterprises, or according to our model, agile/virtual enterprises.

The models analyzed are presented in the following table:

MODEL	Year
Sluga et al [2]	2001
Ko et al [3]	2001
Chu et al [4]	2002
Ávila [5]	2004

Fischer et al [6]	2004
Huang et al [7]	2004
Wu et al [8]	2005
Sha et al [9]	2005
Zeng et al [10]	2006
Jarimo et al [11]	2007
Chen et al [12]	2007

Table 1 Resources / Partners Selection Models in Agile/Virtual Enterprises

In this listing we tried to have an approach that was as exhaustive as possible on this theme, which has been a target of intense investigation, not intending to effectuate a "complete" literary revision, but a exhaustive and careful analysis in order to match the main objectives of the present work being of giving particular emphasis to Ávila model [5], which is interconnected in the context of the BM_VEARM agile/virtual enterprise model [13], in which the present work is inserted.

2.1.1. Requisites of Pre-Selection Resources

The pre-selection requisites, that were considered in the analysis of the existent models are those identified in previous underlying works to our A/VE model [13], and they are: **Product/Task, Product/Task Project, Production Process, Production Planning and Others** (it includes quality management systems, geographical location, financial situation, cultural aspects, organizational factors, history of collaborations and others).

2.1.2. Phases of Pre-Selection Resources

The resources pre-selection process, in our A/VE model, has two principal phases [5]: the **Resources Search** and the identification of the pre-selected resources (**Automatic Identification, Indirect Negotiation** and **Direct Negotiation**).

In the next table (table 2) it is presented the main conclusions of the pre-selection requisites and phases.

2.1. Pre-Selection Phase in the Resources Selection Models in Agile/Virtual Enterprises

Models	Resources Pre-Selection Phases				Consider Pre-Selection	Pre-Selection Requisites				
	Resources Search	Automatic Identification	Indirect Negotiation	Direct Negotiation		Product /Task	Product / Task Project	Production Process	Production Planning	Others
Sluga	Net Diffusion	N	Y	N	Y / NE	Y	N	N	Y	N
Ko	Net Diffusion	N	N	N	Y	Y	Y	Y	N	Y
Chu	Data Bases, Group Tecn.	Y	N	Y	Y	Y	Y	Y	ND	Y
Ávila	Y / NE	Y / NE	Y / NE	Y / NE	Y	Y	Y	Y	Y	Y
Fischer	Data Bases	N	N	N	Y / NE	Y	Y	Y	Y	N
Huang	Data Bases	N	Y	Y	ND	N	N	N	N	N
Wu	Net Diffusion	N	Y	Y	Y	Y	Y	Y	Y	Y
Sha	ND	N	Y	Y	Y	N	N	N	Y	N
Zeng	ND	Y / NE	ND	ND	N	N	N	N	N	N
Jarimo	ND	N	Y	ND	ND	Y	Y	ND	ND	N
Chen	Data Bases	Y / NE	N	N	ND	Y	Y	N	N	N

Legend: Y – Yes

ND – No Determined

N – No

NE – No Explicit

Table 2 Analysis of the Resources Pre-Selection Phase

Of the analysis of the previous table it emphasizes the fact that most of the models do not contemplate this phase of pre-selection formally and even those who consider this phase, they just attend to some of the requisites associated to this phase. We consider that this is an important limitation because this is a fundamental phase to the success of an A/VE project, and which we intend to develop in our future work. Of this table we can also withdraw conclusions that in what respects to the considered phases of pre-selection, the resources search is the one where the existent models that consider this phase intervene. This phase is approached in different forms, since the models in which this phase are characterized by not defined, they effectuate obviously this resource search, not with the intention of pre-selection, but already incorporated in the phase of final selection. In what it concerns to the identification of the resources (phases of automatic identification, indirect negotiation and straight negotiation) only some of the models that consider the resource pre-selection attend these phases, a great deal of the times in a not formal or not explicit way. This is a subject that is more deepened [14] in investigation connected with the technologies of information (IT) for A/VE and is less referred in the relative literature to the models of selection that we are analyzing, nevertheless its incorporation seemed to us relevant in this analysis.

2.2. Selection Phase in the Resources Selection Models in Agile/Virtual Enterprises

2.2.1 – Requisites of Selection Resources

The selection requisites, that were considered in the analysis of the existent models are those identified in previous underlying works to our model of A/VE, and they are: **Number of Enterprises, Production Time, Transport Time, Production Cost, Transport Cost, Resources Quality, Earliest Date and Others.**

2.2.2. Phases and Methods of Selection

The resource selection process, in our A/VE model, has three principal phases (**Space Solutions Evaluation, Selection and Integration**

of the Selection Algorithms and System Final Selection and we also distinguish two methods of selection of the resources (**Independent Selection Method and Dependent Selection Method**) [5]. These phases and methods of selection are next described, in a succinct form.

Space Solutions Evaluation: This phase has two principal objectives: the limits of selection parameters, in other words, the quantification of the limits of the resource systems performance which these systems can tend and the determination of the space of solutions dimension, in order to analyze how complex and / or feasible the project can be.

Selection and Integration of the Selection Algorithms: In this phase there is planned the model of selection that is going to be applied in the selection of the resource system. Besides the selection of the algorithms is necessary his integration, in other words, to adapt them to the problem in question and to integrate them.

System Final Selection: This phase consists in executing the algorithms of selection in the search of the best system of resources.

Independent Selection Method: Method of selection that defines the resource system in order that integrates the A/VE project in function of his performance in the total execution of all the tasks of the task plan of the product cycle of production. It means that each resource is selected for each task without considering its affection for the rest of the resources system, e.g., in time and transportation cost.

Dependent Selection Method: Method of selection that defines the resource system in order that integrates the A/VE project in function of his performance in the execution of the task plan considering parameters that reflect the distributiveness of the resources (e.g., transport time and cost) of the product cycle of production.

In the next table (table 3) it is presented the main conclusions of the selection requisites phases and methods.

Models	Phases			Selection Method	Requisites							Model Type	Mathematic Model	Final Selection Tools	
	Space Solutions Evaluation	Selection and Integration of Selection Algorithms	System Final Selection		N° Ent.	Prod. Time	Transp Time	Prod. Cost	Transp Cost	Res. Quality	Earliest date				Others
Sluga	Y	N	Y	Dependent / Independent	N	Y	N	Y	N	Y	N	Y	Quantitative	Constraint Logic Programming	B&B
Ko	ND	N	Y	Dependent / Independent	N	N	N	Y	N	N	N	N	Quantitative	Integer programming	Tabu Search
Chu	ND	N	Y	Independent	ND	Y	ND	Y	Y	ND	Y	ND	Qualitative / Quantitative	Goal Programming / ND	AHP, MADM
Ávila	Y	Y	Y	Dependent / Independent	ND	Y	Y	Y	ND	ND	ND	ND	Quantitative / Qualitative	Goal Programming / ND	
Fischer	Y	N	Y	Independent	ND	Y	ND	Y	Y	ND	Y	ND	Qualitative	Goal Programming / ND	AHP, ACO
Huang	ND	N	Y	Independent	ND	Y	ND	Y	ND	Y	Y	Y	Qualitative / Quantitative	Goal Programming / ND	Taguchi Functions
Wu	Y	N	Y	Dependent / Independent	ND	Y	Y	Y	Y	Y	ND	Y	Quantitative	Integer programming	ECT
Sha	Y	N	Y	Independent	ND	ND	ND	Y	ND	ND	Y	ND	Qualitative / Quantitative	Integer programming	AHP, MAUT
Zeng	Y	N	Y	Independent	ND	Y	ND	Y	ND	Y	ND	Y	Quantitative	Integer programming, NP complete	B&B
Jarimo	Y	N	Y	Dependent / Independent	ND	Y	Y	Y	Y	Y	ND	Y	Qualitative / Quantitative	Mixed integer programming	EDR
Chen	Y	N	Y	Dependent / Independent	Y	ND	ND	ND	ND	ND	ND	ND	Qualitative / Quantitative	Polynomial	AHP, MADM, MAUT, EDA, Fuzzy

Y – Yes ND – No Determined N – No NE – No Explicit

Table 3 Analysis of the Resources Selection Phase

Of the previous table analysis we can note that the models treat the requisites of this phase in different forms. For example one of the vectors crucial to the resource selection process for an A/VE project is related with the questions inherent of the product transport from a task to the next task, in other words must attend not only to the costs but also to the transport times. The models that consider in some form, these requisites and that treat them in accordance to its particular importance, are focused more in the question of the costs and less in the times. Obviously these factors affect, in different ways, the complexity and resolution time of the selection algorithms inherent to the models as well as its performance. The analysis of these transport requisites stipulates also the type of mathematical formulation presented by the models reviewed. The requisite earliest date is also not attended in all the models, when actually this is a more and more essential requisite where factors as delivery time and flexibility assume primordial relevance. Also the remaining requisites of this phase are treated in a different form by the considered models, being that none considers all the considered requisites. We can note also that only one of the models [12] attends in the formal way to the aspect of the number of potential resources / partners of the project, being that in this model the objective is minimize the number of enterprises participants. Some of the models incorporate in this phase other requisites besides the defined ones and these can be visualized in the final column of the table (column "others").

In our opinion one of the gaps of some of these models is that they do not contemplate the requisite resource quality. This requisite assumes nowadays particular relevance since the quality factor is more and more crucial for any project success.

It is also relevant, the fact that in the space solutions evaluation phase of the models that contemplate it, they do not quantify the performance limits of the resource systems for which these systems can tend towards but only the determination of the space of solutions dimension, in order to analyze if the project can be feasible, in other words they attend only to the second factor of what it was defined previously as the objectives of this phase. The only model that contemplates a selection and integration of the selection algorithms is the Ávila model, because it is the only that comprise the whole type of problems, it leaves opened which algorithm is selected to treat a determined problem. The remainder models specifies the respective problems and proposes a decision model/algorithm(s), in other words, they boards what we define for the resource system final

selection. The tools/methods used for the resource system selection attending to the respective requisites, are of several types (AHP, Fuzzy, EDR, BB, MAUT, MADM, etc.) and they can be characterized as support techniques to the decision process and jointly with the mathematical models of the selection models, already analyzed previously, allow, according to the respective authors, the resolution of the selection process of the inherent resources systems.

Models	Task Plan (TP) Integration		Decision Taking A/VE	Other Characteristics	
	TP Ref.	TP Eval.		Resources Weighting	Value Concept
Sluga	Y	N	ND	N	N
Ko	N	N	ND	N	N
Chu	Y	Y	ND	Y	N
Ávila	Y	N	ND	N	N
Fischer	Y	Y	ND	Y / ND	N
Huang	N	N	ND	Y	N
Wu	Y	Y	Y	N	N
Sha	Y	ND	ND	Y	N
Zeng	Y	ND	Y	N	N
Jarimo	Y	Y	ND	Y	Y
Chen	N	ND	N	N	N

Legend: Y--Yes ND--No Determined N--No

Table 4 Global Table of Resources Selection Models in A/VE

In the previous table, there were represented slopes that we intend to deepen in the course of this work: the integration of the existent models with the product tasks plan (TP), namely if they contemplate the reformulation and evaluation of the TP, and other important characteristics such as if the models incorporate the weighting of the resources candidates and if they do any type of reference to the value concept.

Of these slopes analysis we can conclude that in what it concerns to the models integration with the TP, this is not contemplated by all the models. As a matter of fact there is a myriad of approaches, so it is possible to state that each model treats this question in a more or less different way from the remainder. As for the decision process of create an A/VE, the models do

not contemplate the phase of decision taking of A/VE through a comparative analysis with a conventional process, the references to this decision [8, 10] have to see with the determination of the project exequibility face to the selected resources and eventual constraints of the model. In what it respects to the resources weighting there are several models that incorporate this weighting what goes towards the approach that we intend to use in our work.

3. ANALYSIS OF THE GLOBAL PROCESS OF RESOURCES/PARTNERS SELECTION

There was presented a revision of the existent literature and state of the art in this selection of resources process comprising to the A/VE universe. In what it respects to the selection models for A/VE, the majority is not associated in explicit form to A/VE reference models, in other words, there has not been defined the type of A/VE which the model is associated.

Most of the models do not contemplate the pre-selection phase in a formal way, they just attend to some of the requisites associated to this phase. In what it concerns to the considered phases of pre-selection, the resource search is the one where the existent models more intervene. This phase is approached in different forms, sometimes, not with the intention of resources pre-selection, but already incorporated in the final selection phase. In what it concerns to the identification of the pre-selected resources only some of the models attend to these phases.

The resources system selection is the principal motivation of the presented models. The models treat the requisites of this selection phase in different forms. For example one of the crucial vectors to the resource selection process for an A/VE project is connected with the issues inherent to the product transport from a task to the next task, e.g. we must attend not only to the costs but also to the transport times. These requisites not always are considered explicitly what constitutes an important gap since they affect the complexity and time of resolution of the selection algorithms inherent to the models as well as its performance. Also the remaining requisites of this phase are treated in different forms by the considered models. The models do not attend in a formal way to the number of resources/partners of the project, being that, this requisite is basic for the creation of synergies, relations of partnership/confidence and inter-organizations relations. The requisite earliest date is not always attended, when this is actually a more and more essential requisite when factors as delivery time and flexibility assume primordial relevance. Another limitation of some of these models is that they do not contemplate the

resources quality requisite. This assumes, at present, particular relevance since the factor quality is fundamental for the success of any project.

The models specify the respective problems and propose a decision model/algorithm(s) which approach mainly the final selection of the resource system. The space of solutions evaluation phase is not attended by the presented models. They do not quantify the limits of the resources system performance for which these systems can tend towards. Only some models determine the space of solutions dimension, in order to analyze if the project can be feasible. The methods of selection that have to see with the problem specification are varied and the tools/methods used for the final selection of the resources system are of several types, namely support tools of the decision process and together with the mathematical models allow the resolution of the selection process of the inherent systems of resources. These are methods, per excellence, for use in multi-criteria type of problems and they contain aspects that go towards the methodology that contemplate the value concept. Almost all the mathematical models, propose the problem resolution of the resources selection with support of complete enumeration algorithms, or define goal functions for the considered variables.

4. CONCLUSIONS

An important aspect for our future work and which regards of the considered models analysis for A/VE has to see with the reference and incorporation of the value concept in the existing models. None of the models found and analyzed in the existent literature incorporates formally the value concept, which indicates that there is a whole basic slope, that is a paradigm actually, the value creation, which is not treated, not even analyzed, and not integrated in the aspects inherent to the resource selection process. It is our objective the integration of this concept through the application of the Value Analysis, where we expect that this application provides an important surplus value for an A/VE project [15, 16]. In what it respects to the resources/requisites weighting this is an area that has been developed and which several of the models consider. This consideration goes towards the methodology used in the Value Analysis and we intend to incorporate these weighting in the model to develop.

The existent models do not contemplate the decision process of creating an A/VE, through a comparative analysis with a conventional process. When the selection process is finished and even perhaps in intermediate phases, there must be done an evaluation of the same process. This

evaluation will have to attend, as it is obvious, to the costs but also to other factors such as the project quality, the synergies and partnerships advantages that will develop with the A/VE project and others. This comparison decision is considered very important in our work, attending to all the previous and different considerations, the creation of an A/VE or the possibility to develop the project through a conventional process, eventually resorting to an outsourcing. It is based in this comparison decision that will take into account criteria of several types, quantitative and qualitative, that an effective decision of creating an A/VE must be taken.

Another slope of interest, in the context of the work, is related with the existent interconnection between the resources selection process and the tasks plan (TP) defined for a determined product. This is an issue that, in spite of joining some consensus of its importance, is not contemplated by all the models. There are models that contemplate the reformulation and evaluation of the TP while others do not attend to this situation. Also this aspect of the evaluation does not appear generally with a final evaluation, of the TP performance itself, but as a sequential and iterative evaluation task by task. As a matter of fact there is a myriad of approaches, so it is possible to state that each model treats this question of a more or less different way from the remainder. We think that in this area there will be space and relevance for a more deep and efficient investigation that leads to a better integration of the TP in the whole process of the resource selection of an A/VE project.

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