BROKER AND MARKET OF RESOURCES AS ORGANIZATIONAL MECHANISMS FOR SUSTAINABILITY OF RESOURCES SELECTION PROCESSES IN AGILE / VIRTUAL ENTERPRISES

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Abstract: *Our Agile / Virtual Enterprises (A/V E) model, it is associated with the creation of temporary net of several physical organizations (or resources), with the intention to develop and produce one or more products/services, in the quantity and quality desirable, answering rapidly to a market solicitation. Our model has to satisfy four functional requirements: virtuality, distributivity, integrability and agility. The main mechanisms, or tools, for assuring satisfaction and implementation of these requirements, by the Virtual Enterprises Architecture Reference Model (BM_VEARM), are the Broker, the Market of Resources and the virtuality (as the specific organization architectural, or structural, pattern). In this paper, Broker and Market of Resources, and their roles and relationship within the process of resources selection, as one of the main processes of the A/V E as well as one of the "agility" processes, are considered. Both of them, Broker and Market of Resources, are independent physical entities, with own juridical identification, that inter-working between them and the Principal (the mentor of a business opportunity), could origin an A/V E creation.*

We will show in this article the main functions and its organizational position, associated to the triple Broker – Resources Market – Principal, for the A/V E configuration and operation. For the resources system selection those functions will be more detailed explained and identified its tools or type of tools, and its desired performance to assure the A /V E integrability and agility. One of these kinds of tools, are expected to be quality assurance tools, namely the value analyses.

Key words: *Agile/Virtual enterprise, Organizational Mechanisms, Resources selection.*

1. THE ORGANIZATIONAL MECHANISMS

Our Agile / Virtual Enterprises (A/V E) model has to satisfy four functional requirements: virtuality, distributivity, integrability and agility. The first one is related to the possibility of the creation and operation of an A/V E instance to be hidden for an upper level; the second, with the possibility of the resources to be separate geographically; the third with the necessity of integrating all the resources (physic (materials and information integration), organizational and cultural integration) that participate in an A/V E; and the last one with the importance of the system to act (and not to react) rapidly with the performance variations, i.e., dynamic reconfigurability.

All of them are supported by organizational mechanisms that should provide the tools needed to perform the configuration and operation of our A/V E model. By the Virtual Enterprise Architecture Reference Model (BM_VEARM) (defined in Putnik, G.[13]), these mechanisms are:

1. **Virtuality -** as the specific organization architectural, or structural, pattern, Putnik, G. et al. [14]

2. **Market of Resources -** an electronic and virtual market, subscribed by a subset of the universe of independent resources [6]
(validated in Cunha, M. [7])

3. **Broker -** Enterprise (A/V E) configuration manager [13]
(validated in Ávila, P. [3])

All of the three mechanisms, in an aggregate sense, contribute for all of the functional requirements. In spite of BM_VEARM consider all the four A/V E functional requirements and the three mechanisms referred, the Broker and the Market of Resources could exists and perform independently of the BM_VEARM framework, as it is shown in figure 1. The interpretation of the figure 1 could be as follows: the Broker and the Market of Resources are parts of the BM_VEARM (part of the Broker and Market of Resources concepts overlaps / belongs / is part of the BM_VEARM), but, also, could operate independently of the BM_VEARM (part of the Broker and Market of Resources concept outside of the BM_VEARM), The Broker and Market of Resources should satisfy all four functional requirements too, i.e. virtuality, distributivity, integrability and agility.

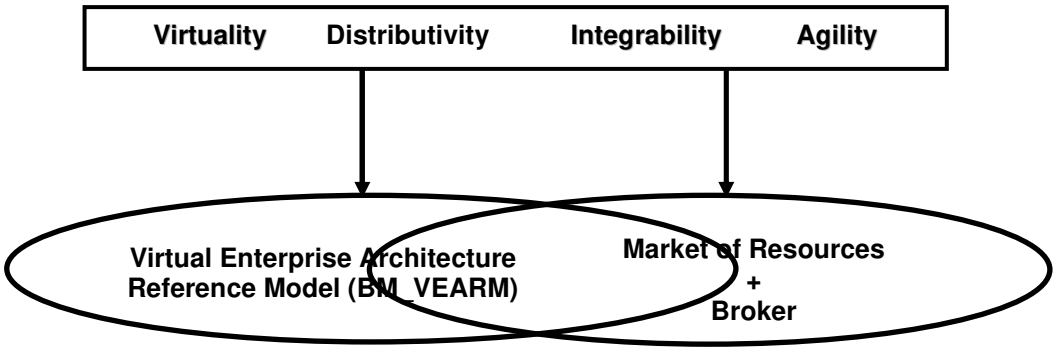

Figure 1 – Relation between organizational mechanisms and thel A/V E functional requirements.

The Market of Resources and the Broker are both independent physics entities, with own juridical identification, that interacting with one another and the A/V E owner or principal (business opportunity mentor) could originate the A/V E creation.

This paper considers the Market of Resources and Broker as organizational mechanisms, and their roles and relationship, for sustainability of the resources selection process, as one of the main processes of the A/V E as well as one of the "agility" processes.

2. THE RELATION BETWEEN THE TRIPLE: MARKET OF RESOURCES, BROKER AND PRINCIPAL

During the A/V E creation that triple interacts in the sense of the preparation and negotiation of the business conditions in order to prepare/create the A/V E to the operation phase. These relations can be designed as business relations. We should notice that the Principal may establish commercial relations with both the Broker and the Market of Resources and these may also establish the same relation between them with the purpose of satisfying the Principal requisites (requisites for the future A/V E) (see figure 2).

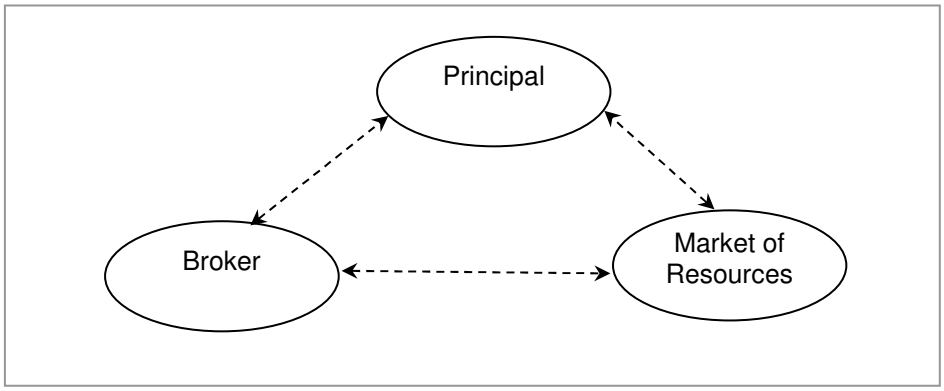

Figure 2 – Relation between the triple: Market of Resources, Broker and Principal (outside operation – during the A/V E creation).

In an operation phase, what occurs is similar with what is shown in figure 3. Now the A/V E is created and is constituted by the Principal, Broker and by the resources system, and operates inside the Market of Resources environment.

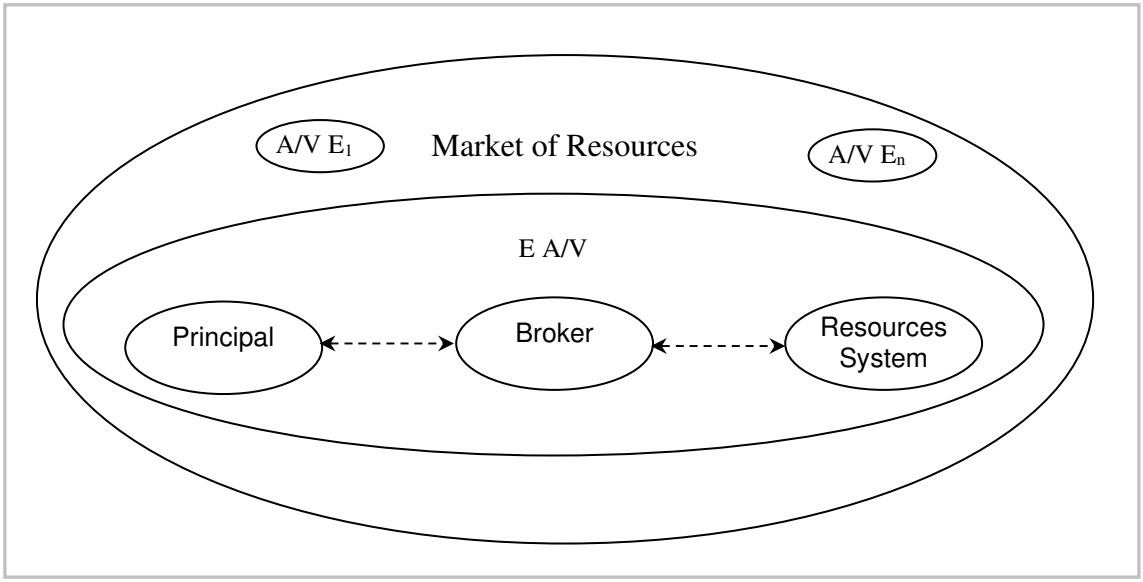

Figure 3 - Relation between the triple: Market of Resources, Broker and Principal (during A/V E operation).

3. THE RESOURCES SYSTEM SELECTION MODEL

We defend that the resources selection be performed with the broker and consequently this process should be seen as the broker model of the selection of resources. The Resources Selection Process decomposes in two main phases (see figure - 4), the resources pre-selection (Process A21), and the resources system selection (process A22). The performance of these two phases is critic for the project and the reconfiguration of the A/V E. However, the performance of the second process is influenced by the results of the first, namely by the "quality" of the pre-selected resources and by the quantity (dimension) of resources pre-selected per task. This last one affects the complexity of the resources system selection, which is exponential if the selection method is integral[1] [1].

[1] Integral Selection Method - is the selection method that defines the resources systems for the A/V E in function of its performance for the execution of the tasks plan considering parameters that reflect the distributiveness of the resources (e.g., transport time and cost).

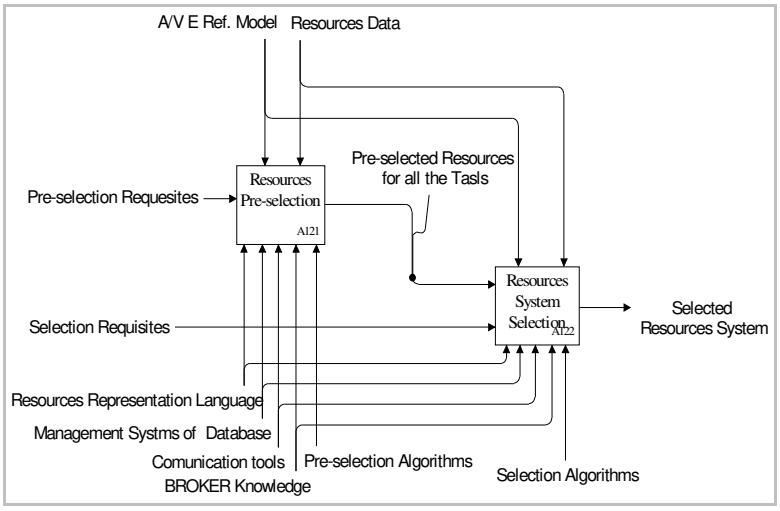

Figure 4 – IDEF0 representation of the process A12 – Resources Selection.

3.1. Resources Pre-selection

The resources pre-selection process, showed in figure 5, has two main phases, the resources search (process A1211) and the identification of the pre-selected resources (processes A1212, A1213 and A1214).

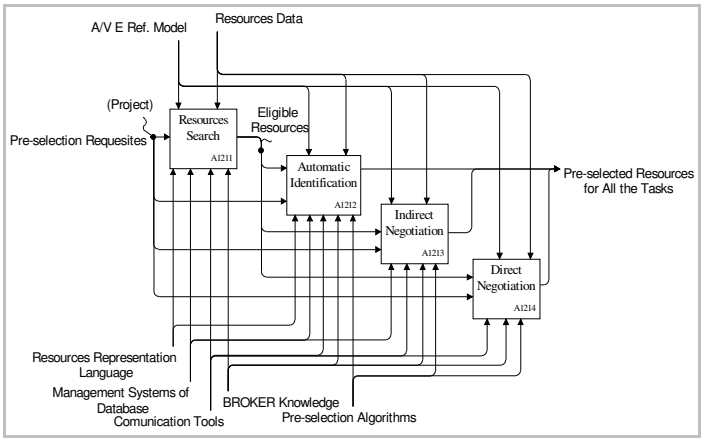

Figure 5 – IDEF0 representation of the process A121 – Resources Pre-selection.

Process A1211 – Resources Search
The resources search has the goal to identify the resources that have potential to be pre-selected, which we call eligible resources. Indeed it is an introductory process at the pre-selection properly so called. This search can be made over a mesh more or less tight bearing in mind the pre-selection requisites. But at least, the broker should search resources that have the capacity to provide tasks associated to the product project. For the broker performance, the search should begin inside his data bases, distributed or not, but with advantage if organized in a form of market of resources. In Cunha, M. [7] the project and operation of a market of resources integrated in our model of A/V E are explained and its importance in this context validated.

For the next step three processes are proposed: automatic search (process A1212), indirect negotiations (process A1213) and direct negotiation (process A1214). All of them could be (or not) necessary or complementary to each other, to perform the identification of the pre-selected resources, which depends on some factors associated with the tasks.

Process A1212 –Automatic Identification
The automatic identification consists in visiting all the eligible resources of the previous process, or else simultaneously with the process for the search of resources, and carries out in “real time” the comparison of the pre-selection requisites with the parameters of the resources and pre-selects the resources whose

parameters satisfy the requisites. In short let us say that this process shares analogies with the term "shopping from catalogue".

This process, the quickest of all, implicates that the parameters of the pre-selection of resources are available and up-to–date on a determined support (computerized or other) and lined up with the requisites of pre-selection so as to make the comparison possible. Because of this fact, this process will probably only occur if the resources are organized in a market of resources lined up with the product of the A/V E, if and/or the requisites of the pre-selection of the task in question are not very complex, they are of general magnitude or do not need further specification.

Process A1213 –Indirect Negotiation
Two steps characterize this process. In a first step the broker informs about the tasks and their requisites of pre-selection to the eligible resources, i.e., offers the tasks and later the interested resources make their proposals for each task. In a second step the proposals of resources are reviewed and accepted if they fit in the requisites of the offer. The management of the proposals from the resources can also be managed as an open[1] auction or sealed[2]. Bichler M. [5] refers in his work several kinds of open and sealed auctions, considering also the parameters which characterize them, such as the rules of the auction, how the winners are found, and the best strategies for the competitor resources.

This process is slower than the previous one but it can be necessary in case the automatic identification is not possible. Because this kind of negotiation doesn't place broker and resources face to face, but requisites and proposals, it is designated as indirect negotiation, although it is possible that no negotiation may take place.

Process A1214 – Direct Negotiation
The identification of the pre-selected resources through direct negotiation presupposes that the broker will need to negotiate his proposals directly with the eligible resources considering the pre-selection requisites. The success of this kind of negotiation depends on the agility and competence of the broker himself. It is the slowest process of all, but the most reliable one in terms of the participation of resources if it is well conducted. This process may be executed independently from the others, but it is surely a process that can be used as a complement of the two previous ones. If by any chance the resources for a specific task are not identified, or if the proposals that arrive are not the most satisfactory, this process is always the last resource to pre-selection. We would even say that if the pre-selection fails with resource to the direct negotiation, the project of the A/V E is compromised.

3.2. Resources System Selection

In the resources system selection we consider three processes: (see figure 6), space solutions valuation (Process A1221), selection and integration of selection algorithms (Process A1222), and final selection of the resources system (Process A1223).

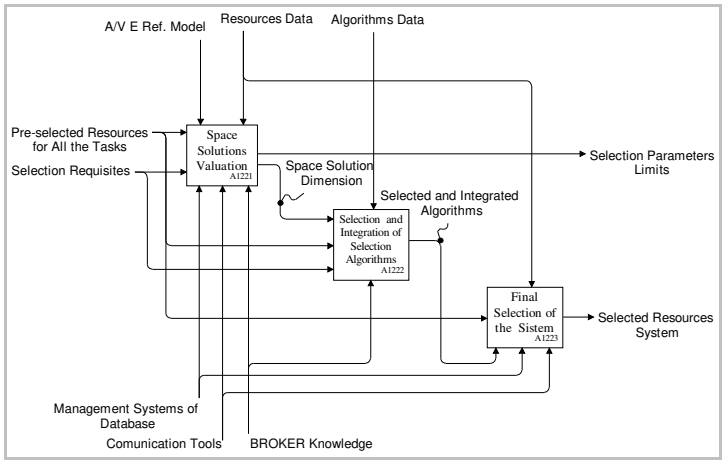

Figure 6 – IDEF0 representation of the process A122 – Resources System Selection.

[1] The resources in competition have access to some information about each other's proposals, such as the price and total number of proposals.
[2] The resources in competition don't have access to each other's proposals.

Process A1221 - Space Solutions Valuation
This process, the first of the resources system selection, receives two main inputs, one directly from the A/V E that is the selection requisites, and the other one from the last phase, resources pre-selection, and has two main goals according to its produced outputs. The first one, related with the limits of selection parameters, is the quantification of the limits of the selection system for which the resources system can tend, and can be calculated considering independent selection[1] (it is the limit of fractionated selection [1] for the resources system). These limits can function as a rude performance of the resources system (the best if possible to achieve), for the decision if the A/V E project is feasible, and then to continue the selection, or to compare these limits with the results of the final selection process. The other goal is related to the determination of the space solution dimension, whose results are important to analyze the complexity of the selection problem, and be one of the measures that will affect the selection of the algorithms in the next process. In reality the Space solution validation process is a process that makes the two participants, broker and A/V E to think and have a global idea of how difficult and/or feasible the project can be.

Process A1222 - Selection and Integration of Selection Algorithms
In this process the Broker projects the model of this phase, the resources systems selection. But to perform the final selection process efficiently it is necessary to select the most adequate selection algorithms for each task plan asked by the A/V E, because the problem of resources system selection is a combinatorial problem and with the growth of task number and pre selected resources to perform each task, the problem turns more complex. We use the plural because a single algorithm may not be enough to satisfy the requisites of selection. More than one algorithm can be applied if we consider the fractioned selection, or if we can apply different algorithms for each selection requisites, or if it is necessary firstly to consider time compatibility. To help the selection of algorithms selection, in [2] we create a base from some existing algorithms revised from literature, which could be helpful and used by the A/V E resources manager, or broker, to contribute to his performance. After the selection of the adequate algorithms they must be integrated, i.e., there are some necessary set ups to do, such as its ordering, and if necessary to adapt for the present selection.

Process A1223 – Final Selection of the System
This process corresponds to put running the algorithms to look for a desired resources system. It is important for the broker to make the control of the process according to time disposal and with limit parameters of the selection.

4. THE PRINCIPAL FUNCTIONS OF THE MARKET OF RESOURCES, BROKER AND THE PRINCIPAL FOR THE RESOURCES SELECTION PROCESS

In the last chapter we said that the resources system selection model could be seen as a broker selection model. Indeed, the Broker is the responsible for the management of all the activities proposed in that model and he takes for each activity the corresponding decision. However, he has to inter-act with the Principal and with the Market of Resources, as we said before in chapter 2.

The Broker relates with the Principal, mainly in order to define the pre-selection requisites (inputs of the pre-selection phase, see figure 5) and to define the selection requisites (inputs of the selections phase, see figure 6). Beside that, the Broker should perform other normal business relations with the Principal.

The Broker has to relate with the Market of Resources because it is inside the Market that the A/V E will be created and will operate. The Market of Resources is an institutionalised organisational framework and service, assuring the accomplishment of the competitiveness requirements for A/V E dynamic integration and business alignment [11, 12]. The operational aspect of the Market of Resources consists on an Internet-based intermediation service, mediating offer and demand of resources to dynamically integrate in a A/V E, assuring low transaction costs and reduced reconfiguration time (as demonstrated in [9, 10]) and the partners' knowledge preservation. In this environment, the Broker should find the best conditions to perform the resources system selection process, because the service provided by the Market of Resources is supported by [8, 11, 12]:

- A knowledge base of resources and results of the integration of resources in previous A/V E,
- A normalized representation of information,
- Computer aided tools and algorithms,

[1] 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.

- Regulation, i.e., management of negotiation and integration processes, as well as contract enforcement mechanisms.

The Market of Resources is able to offer [8, 11, 12]:

- Knowledge for selection of resources, negotiation, and its integration;
- Specific functions of A/V E operation management; and
- Contracts and formalizing procedures to assure the accomplishment of commitments, responsibility, trust, and deontological aspects, envisaging that the integrated A/V E accomplishes its objectives of answering to a market opportunity.

We can say that the principal function of the Market of Resources is to create the conditions to the resources system selection process, mostly during the pre-selection phase.

5. THE CHALLENGES OF THE MARKET OF RESOURCES AND BROKER FOR THE RESOURCES SELECTION PROCESS

According to [4], for the most precise selection method (*DSMW*[1]) we got the following effort expression for the pre-selection phase:

$$\textit{Total Effort of the Pre-selection}_{DSMW} \propto n(St + e * X) + n * X^2(St + e * X)$$

Considering:

e – Effort factor in the pre-selection of one resource and equal for any resource independently of the task;
X – Number of pre-selected resources;
n – Total number of processing tasks or transport tasks;
St – total set up for the pre-selection phase per each task;

It gives us the information that the pre-selection effort is polynomial and in maximum of degree two. However, considering some pre-selection experiments the coefficients e and St can be very high and interfere with the desired performance.

In order to perform the selection process, during the first phase (pre-selection) the conditions created by the Market of Resources are critical for its success, because the pre-selection effort depends principally on the parameters that characterize the tools offered by the Market. So the Market of Resources challenge is principally to reduce those coefficients for the pre-selection phase.

Again according to [4], for the most precise selection method we got the following effort expression for the resources system selection phase:

$$\textit{Maximal Effort of Resources System Selection}_{DSMW} \propto X^{2n}$$

So, in the resources system selection phase, the effort grows exponentially with the number of tasks and with the number of pre-selected resources.

In order to perform the selection process, during the second phase (resources system selection), the performance of the tools created by the Broker to execute the related activities is critical for the success of the above mentioned process, namely, the selection and integration of the algorithms and the final selection of the system.

6. CONCLUSIONS AND FURTHER WORK

To assure our A/V E requisites, principally integrability and agility, the performance of the resources systems selection process is very important in order to achieve those requisites. This performance depends on each

[1] Dependent Selection Method with Pre-selection of Transport Resources (DSMW).

A/V E case or instance, but the resources systems selection process should be prepared in order to have quality, be fast and with attractive costs for the Principal requisites.

In this work we have shown that for the global difficulties pointed for each of the selection phases, the Market of Resources and the Broker (organizational mechanisms) both have their challenges to overcome.

As far as the Market of Resources is concerned, we are developing tools that will allow the automatic identification to be easer, in order to decrease the coefficients e and St. As for the Broker we are developing a genetic based algorithm for the resources system selection problem, to deal with cases of resources system selection problem when the space solution dimension is high. Concerning both, the Market and the Broker, we also expect the positive contribute of the value analyses in the resources system selection problem, i.e., a tool that we hope will contribute to the A/V E sustainability.

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