J. Basic. Appl. Sci. Res., 3(4)394-403, 2013
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ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

A Novel Reengineering Methodology for Organizations as Complex Adaptive Systems

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ABSTRACT

Establishing coherent relationship between an organization, its customers and suppliers needs structural and behavioral patterns within proper processes that make the interrelation with the environment possible and extend overall fitness. Regarding a living organ with several living agents that evolve over time, a solution is to take organizations as complex adaptive systems (CAS) with the ability to self-organizing the activities and processes. Besides, the coevolution that takes place between organization and environment can result in the dynamically formation of appropriate strategies that help organization reach to the desire fitness. During continuous adaptation and coevolution, the conflicts that emerge between the activities or processes of these CASs require an external control to expedite the formation of new schema or rectification of the existing ones, inherent for the existence of a CAS. The paper proposes a BPR methodology for these kind of complex adaptive systems to help them move in the predefined course. The implementation of reengineering results in the rectification of emergent schemas in CASs and as a result causes the survival of the CAS. Using the proposed methodology and taking under control the emergent behavior within the activities and sustaining the adaptability of these kinds of CASs could cause organization to agilely meet its defined strategies, get high fitness and survive in the competitive environment.

KEYWORDS: Business process reengineering, Complex Adaptive System (CAS), Fitness landscape theory, Coevolution, agents

1. INTRODUCTION

Organizations with given goals and strategies have processes that each satisfies one of the parameters of operational goals. Satisfying the process performance indicators guarantees the achievement of organizational grant goals. However when these processes cannot serve the goals or the customer satisfaction is far away, the reengineering or redesigning of the process would be a tool to solve the issue. (Anderson, 1999)

Nowadays, Market is full with BPR methodologies, and this makes the selection more difficult. Above all the similarities and usefulness of the different methodologies, criteria like the nature of the process or industries or the managerial priorities could be of hint selecting between the methodologies. Regarding organizations as CASs that coevolve with their environment mutually, our purpose in this article is to propose a BPR methodology in complexity context; an expression that has not been attended any more before.

The term “complex adaptive system” refers to a system that emerges over time into a coherent form, and adapts and organizes itself without any singular entity deliberately managing or controlling it (Holland, 1995). So, in order to have organizations as complex adaptive systems with high fitness and ability for self-organizing themselves, the adaptation process and coevolve of organization and its environment are a really noteworthy concern and is not addressed thoroughly in management literature.

This coevolve takes place in two levels. At the first level, adaptation process leads to appropriate strategies emergence. This formation can be shown in fitness landscape with the managerial concern like financial, customers, process and learning as the landscape axis. Selecting the point with high fitness in this landscape forms the strategies of a complex adaptive organization. In the second level, when organization strategies are in touch, processes should be managed or defined to make the strategic goals possible. In this path, use of businesses processes reengineering, at operational level, can result in rectification of emergent behavior and changes to sustain the adaptability and durability of these kinds of CASs and end in

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continuous improvement. This article has not got through the conventional literature in BPR. A BPR methodology that fits the characteristics of adaptive organizations is proposed. A process complexity measure as a prioritization criterion for redesign is also proposed. In fact, the proposed methodology runs disparate elements of an organization in a coherent, self-reinforcing direction that is defined with the strategies.

In this methodology, calculating organizational process complexity in stage 2 ends in the process redesign in stage 3. Outputs of this stage are improved processes with lower complexity that are used to perform business. The process complexity reduces to the point that while the process is capable in fulfilling the defined goals, is able to respond to unpredictable changes in the environment. Reaching the organization to this point, subsequently, increase the alertness of the organization and the organization would be more agile [Dooley 1996].

According to the methodology, the process with the highest complexity was selected for the reengineering. The complexity of the selected process reduced regarding the measure indices. Reducing the complexity would make the organization more agile [Arteta&Giachetti , 2004]. The hypothesis supporting this clam is that a less complex enterprise in terms of systems and processes is easier to change and consequently more agile. So the hypothesis that the proposed BPR methodology would help the coevolution of the organization with the environment, formation of the strategy and management of the operational process to reach to the defined goals would be proved. The contribution of this research is the quantification of complexity at the process level and description of a methodology for conducting reengineering project.

2- Earlier version of BPR methodology

The earlier version of proposed methodology is the one proposed by Kettingeret. al (1997). This methodology consists of six stages and twenty one activities.

In the following, the earlier version of the BPR methodology has been presented briefly (Kettinger, 1997).

2-1 ENVISION

This stage typically involves the project champion engendering the support to top management. a task force, including senior executives and individuals knowledgeable about a firm's processes, is authorized to target a business process for improvement based on a review of business strategy and IT opportunities in the hope of improving the firm overall performance.

2-2 INITIATE

This stage encompasses the assignment of reengineering project team, setting of performance goals, project planning, and stakeholder/employee notification and "buy-in".
This is frequently achieved by developing a business case for reengineering via bench-marking, identifying external customer needs, and cost benefit analysis.

2-3 DIAGNOSE

This stage is classified as the documentation of the current process and sub-processes in terms of process attributes such an activities, resources, communication, roles, IT, and cost in identifying process requirements and assigning customers value, root causes for problem are surfaced, and non-value-adding activities are identified.

2-4 REDESIGN

In the redesign stage a new process design is developed. This is alternatives through brainstorming and creativity techniques. The new design should meet strategic objectives and fit with the human resource and IT architectures .documentation and prototyping of the new process is typically conducted, and a design of new information systems to support the new process is completed.

2-5 RECONSTRUCT

This stage relies heavily on change management techniques to ensure smooth migration to new process responsibilities and human resource roles. During this stage, the IT platform and system are implemented, and the users go through training and transition.

2-6 EVALUATE

This last stage of a BPR methodology requires monitoring of the new process to determine if it met is goals and often involves linkage to a firm's total quality programs.

It was found that, while BPR methodologies, may vary based on philosophical differences, there is enough commonality among the practiced approaches to generally describe a prototypical BPR effort.

3- Organizations as Complex Adaptive Systems

Complex adaptive systems theory has enjoyed much interest in management and organizational circles during the last decade. Holland (1975) views CASs as systems composed of interacting agents described in terms of rules. These agents adapt by changing their rules as experience accumulates. In a CAS a major part of the environment of any given adaptive agent consists of other adaptive agents, so that a portion of any agent's efforts at adaptation is spent adapting to other adaptive agents. This one feature is a major source of the complex temporal patterns that a CAS generates (Holland, 1995). Brown and Eisenhardt (1997) describe complex adaptive systems as systems that exhibit complex, adaptive, and emergent behaviors; because they are made up of multiple interacting agents.

A CAS has the ability to learn and hence adapt to a new environment. The system is constantly revising and reorganizing its agents as experience is gained from past interactions. From this learning, the system will develop its strategies for the future by changing its schema. A complex adaptive system will sense changes and disruptions based on the internal and external assumptions of the agents relative to the environment. Kauffman (1995) stated that organizations are complex adaptive systems, as they learn, adapt and evolve over time. Subsequently this learning makes the agents more robust, more reliable and more capable in terms of their requisite variety (Dooley, 1996).

When organizations arrange themselves in ways that are consistent with the qualities of complex adaptive systems, successful coevolve and self-organizing is more likely (Ashmos et al, 2000).

As depicted in fig 1, three foci in a CAS are as: an internal mechanism, an environment, and coevolve [Choi et al., 2001]. The first two foci are the nature of environment and the organization, the last, is the result of the interrelation of those.

To investigate about the nature of a CAS coevolution and the interactions with the environment, many researchers utilize the fitness landscape theory (e.g., Choi et al., 2001; McCarthy et al., 2000; Kauffman, 1993; Beinhocker, 1999). Fitness landscape theory as mentioned by McCarthy and Tan (2000) can help the organization management obtain new insights and understanding about the interrelation between internal characteristics (such as strategy, technology, etc.) and external environment (competition, demand, market legislation, etc.).

In the next section, this theory with the view of process selection importance is introduce and getten through its application and instrumentality in CASs as a tool for sense and respond (adapt). As a matter of fact, this theory is used as a space to analyze organizations and could come to a decision for adaptation.

3-1 Adaptation Landscape and coevolution

Organizations as CASs are not controllable anytime; therefore it is essential to know the importance of self-organization and adaptation in the evolution process. The overall goal of adaptation in an organization is to increase the organization fitness. Subsequently one goal of the adaptation process in high level is strategies development for future and consequently related organizational configurations. These strategies shape in a manner to maintain survivability (based on adoptability and durability to the changing environment) and increase organization competitiveness. The second goal of adaptation occurs in operation level or in the management of organizational processes. Adaptation process causes schemas in process to be rectified and changed. This continuously reengineering makes the agents more robust (it can perform in light of increasing variation or variety), more reliable (it can perform more predictably), or more capable in terms of its requisite variety (in can adapt to a wider range of conditions) (Dooley, 1996).

There are two important points in coevolution analysis. First, organizational landscape should portray a positioning map, with attributes and elements affected in the configuration (elements of business strategy, its human resource policy, manufacturing system, and so on) on the axes and the density of consumers and suppliers' requirements (the density of satisfying their needs) determining the topography of the landscape or in other words, function $f(x)$. In this manner, the goal is to identify the peaks that satisfy the most requirements of consumers and suppliers and are not already crowded or satisfied by competing products/ services. Second, the landscape is not necessarily fixed, but there may be interactions between customers/ suppliers' preferences on one side and organizational configuration, processes, density and variety of

interactions between process agents (process complexity) on the other side. As a result, there is some coevolve in organizational configuration and preferences. Therefore, over time there is an increasing degree of interdependence between organization and environment.

The organizational landscape according to different configurations becomes quite rugged. This ruggedness occurs due to the large number of peaks mirroring the amount of consumers/ suppliers' needs satisfaction. Potentially, this increased complexity of organizational landscape would overwhelm the capacity of processes to manage such complexity and satisfy the consumers/ suppliers' requirements. The solution to such a problem is to reduce the linkage between products and the production process. For example, by using 'differentiation strategy' suggested by porter or by using a complexity absorption response to environmental changes (Boisot and Child, 1999). Another solution for this problem is to reduce process complexity while is placed at the edge of chaos. Levinthal and Warglien (1999) stated that this reduced linkage would not achieve via buffering. However they suggest using the modularization of the production process. By solving this problem, interdependencies are increased for organization-environment linkages, while interdependencies are reduced internally, or at least not increased proportionately with greater configurations diversity; so, can say that the organization has been more agile than before.

One of the assumption of this paper is that strategy landscape has been designed and grant strategies of the organization has been emerged by considering the coadaptation of consumers/ suppliers' requirements with organization missions and grant goals (see reference Levinthal and Warglien 1999; Beinhocker, 1999). Our main objective in this paper is to manage the adaptation process in operational level. So a process selection priority in a methodology for reengineering projects, redesign projects or enterprise engineering projects is proposed in order to align the organizational processes to its given goals and strategies. Thus since organization as a CAS has the ability to sense and respond (adapt) and coevolve with its environment by developing appropriate strategies (high level adaptation), it can also satisfy its strategies, in low levels, by managing the processes.

4- BPR in complex environment

This section, first of all, has gotten through more explanation about CASs, schemas and their roles in emergent behavior and structures. Then, to propose a process selection or prioritization criterion, the process in a CAS is defined and the role of schemas and process complexity in the process performance is determined. At the end, the effect of reengineering of the most complex process on the performance of the process and overall organizational fitness will be described.

Agents are the basic elements of a CAS. Agents are semi-autonomous units that seek to maximize their fitness by evolving over time. Agents scan their environment and develop schema. Schema refers to norms, values, beliefs, and assumptions that are shared among the collective (Schein, 1997 in Choi et al., 2001). These agents behave in a manner so as to increase "fitness" of the system that they belong to either locally or globally. Schema are mental templates that define how reality is interpreted and what are appropriate response for a given stimuli. These Schemas differ across agents. Within an agent, schemas exist in multitudes and compete for survival via a selection-enactment-retention process (Dooley, 1996). Schema can change through random or purposeful mutation, and/or combination with other schema. The fitness of the agent is a complex aggregate of many factors, both local and global. Unfit agents are more likely to instigate schema change (Dooley, 1996). Schemas define how a given agent interacts with other agents surrounding it. These interaction between agents involve the exchange of information and resources. These activities together shape a process. So a process in a CAS could be defined as "a collection of actions done by one or a group of agents and leads to either flow of information and resources between agents or changes in the schemas in order to be able to heighten the organizational fitness". An organization as a collection of a number of processes, and each with several interacting agents has some defined goals. These processes are shaped and correlated to an operational objective, corresponding to a grant goal in higher level. In other words, an organization is a collection of processes that by satisfying their performance indicators, the organization can reach its goals. The most fundamental property of these processes, in accord with proposed complexity definition, is their complexity property. Without processes complexity, the information and resource flows in organization would cease. Thus the process can't get its performance or satisfy its performance evaluation indicators. Also without this property, agents will miss their improvement opportunities for revising and reorganizing as experience gain from past interactions, and thus the system is likely to face extinction.

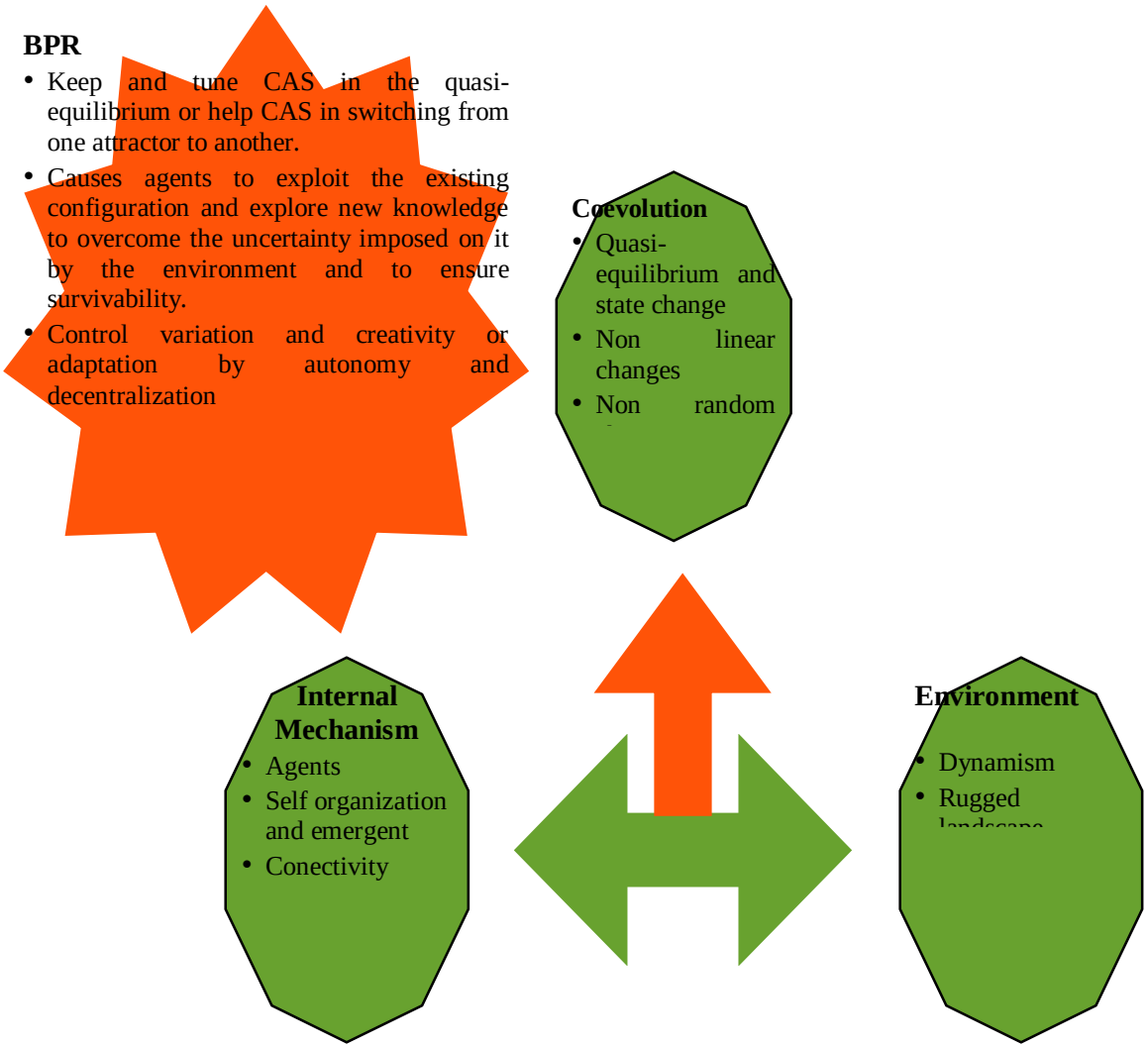

Fig. 1.The effect of BPR on a complex adaptive system.

Looking at the organization as a CAS that a few dominant schemas dictate the vast majority of behavior (e.g., Lewin, 1993; Choi et al., 2001; Holland, 1975), needs to delve into the nature of the process complexity. It is the nature of interaction between components of a system, and the density of connectedness, and not essentially constituent number, that determines whether the resulting behavior is complex or not. Therefore process complexity is defined as “t the amount of differentiation in the agents or in the interconnections”. In other words, accepting this definition, in connection with Kauffman NK model means that N factor doesn’t have so much consequent on resulting complexity. Contrarily, K factor result in complexity behaviors that are observed in a process. N factor only has result in complex behaviors when leads to diversity within interactions. Existence of agents without interaction density or diversity would not result in complexity behaviors. Complexity increase leads to increase in mutual interdependency between agents and causes to emergent structures and behavior in a process. That is, processes with higher complexity have been affected by higher emergent patterns. Thus, it is necessary to revise and re-organize schemas that have changed in the process.

Therefore the processes as the basis of managerial decisions should be analyzed and their complexity should be measured and tuned in the manner to be able to handle the mutual interdependencies of internal or external agents and subsequently the causal emergent behaviors. This management on one hand ought to satisfy diversity in organization while sustaining some complexity (Backlund, 2002), and on the other hands, the amount of complexity should be reduced for organizations to be able to meet every situation that might arise, and also be more flexible. Therefore, to get high fitness and performance improvement, complexity reduction combined with readiness to change might be preferable. So being at the edge of chaos

and process complexity reduction could be a criterion for process selection or prioritization for reengineering.

5- Revised methodology for BPR

The revised version of BPR methodology, with a distinctive criterion for process selection or prioritization in complex environment is presented below. The purpose of this methodology is engineering the processes constitute an organization as a CAS. This reengineering declines the process complexity and leads in reduction or control of emergent behavior in the processes. Moreover, this methodology guides to explore organizational landscape and find customers and suppliers' needs that have not been satisfied yet. After investigating the landscape, it is time to do the required changes in organizational processes in order to get high organizational fitness and coadaptation with the environment. So the organization will be able to answer to customers and suppliers' needs and goals constantly.

5-1 ENVISION

For performing an operational configuration and designing a space for further investigation, fitness landscape concepts are used. In fitness landscape theory, organizational landscape as a starting pointis studied and analyzed. As a starting point, the existing configuration (point in the landscape), its fitness and value of the elements that influence current fitness and the amount of expectation that has been satisfied with current configuration should be studied in order to get direction across BPR project. Furthermore in this stage, by means of analyzing the new customers and suppliers' needs, the evolution trajectory in landscape (adaptive search process) should be determined and therefore the elements of new strategy will be realized.

Sub-activities of this stage are as below.

- Secure top management sponsorship.
- Analyze organizational strategy plan.
- Analyze current organization landscape, the existing point, and its element value.
- Determine the elements that affect the organizational strategy and design organizational strategy landscape.
- Determine customers and suppliers' requirements and corresponding organizational goals in order to shape fitness function.
    - Identify internal / external customers and suppliers and prioritize them.
    - Identify internal / external customers suppliers' needs and prioritize them.
- Determine optimum configuration (point in landscape) and find strategy configuration (strategy element value).

Landscape topography in this stage is continuously updating based on environmental turbulent condition and its effects on organizational configuration. In other words, due to the effect of C factor in NK(C) model, we can see coupled landscape.

For more information on how to design the organizational landscape to respond to complexity see (Dooley, 2002; Simon,1993)and to reduce this complexity on manufacturing system see (Meijer, 2002).

5-2 INITIATE

Considering the strategies recognized in previous stage, the consequent landscape, its peaks (solutions) and their fitness, the project team should analyze customers and suppliers' requirements; meanwhile, the project team should identify and model existing processes. Thus the requirements that could not satisfy with current processes could be defined. After that, new processes or strategic activities for compensating these new requirements should be supplemented. Then the team use predetermined performance indicators to measure the performance of modeled processes.

A major task in this stage is to measure processes complexity. This measurement is used as a basis for process selection and implementation prioritization.

Complexity measuring leads to reengineer those processes that are more complex than the others. To have an organization with high fitness that evolves with the environment, it is necessary to accommodate agents and schemas with environment, by reengineering. As a result, howsoever a process get engineering it will be more adaptable and would be able to coevolve with the CAS environment and therefore would be more agile and could sensitively respond to environmental changes.

Output of this stage is a processes priority set for BPR project. The sub-activities of this stage are as follows.

- Assignment of reengineering project team
- Identify processes that are needed to satisfy customers and suppliers' needs.
- Measure the complexity of these processes.
- Arrange processes by the complexity.
- Measure processes performance.

5-3 COMPLEXITY MEAURE

Complexity science offers that all organizations are relatively complex, and the complexity that arises is not necessarily the result of various agents interacting in a complex way; rather, complex behavior of the whole can be the result of both the number of coupled agents and the diversity of interaction of these interconnection. So, to calculate the organization complexity, we define the process complexity as "the amount of differentiation in the agents or in the interconnections." The diversity of the interaction causes the emergence of new schemas in the agents. This reduces the CAS ability in cooperation of the agents and in coevolution. Besides, the diversity of the agents influence in the complexity, because needs more and more relation among the agents for the CAS to operate. Accordingly, we look at the process complexity from two approaches suggested by Max Boisot and Join Child (1999). The first focuses on the content of information and resources flows among agents and the second on the structure of the interactions that such flows allow among agents. The first, in effect, measures cognitive complexity, whereas the second measures what they call relational complexity. As Boisot and Child shows, the two approaches complement each other in a way that a low degree of cognitive complexity allows organization to handle a higher degree of relational complexity and vice versa without undergoing a phase transition into chaos. In other words, in an organization with less diversity and content of information, there is more orderly processing of connections among larger numbers of interacting agents.

Now, to measure the cognitive and relational complexity in an organization as a CAS we used the categories of Ashmos et. Al. (2000). Strategic and goal complexity are two types of cognitive complexity, and centralization, formalization and interaction complexity as the types of relational complexity in a process. Hage and Aiken(1967) article about scales of centralization, formalization, and task routines was used to develop the measure.

According to Ashmoset. Al. (2000), goal complexity is achieved when organizations pursue many different kinds of goals.

Strategic complexity is achieved when the organization simultaneously pursues a variety of strategic activities. Structural complexity as the group of centralization and formalization complexity is achieved when there is greater internal variety in the organization. This means that structural complexity is greater in organizations that are relatively decentralized and less formalized.

Interaction complexity is achieved when there are high levels of participation by multiple stakeholder groups in strategic decision making. To measure the process complexity, the portion of each process in each type of the complexity should be calculated. In other words, the questions in the questionnaire are asked regarding the scope of a process to measure each type the complexity of each process. At the end, the values for each process could be summed to calculate the process overall complexity.

5-4 DIAGNOSE

This stage is classified as the documentation of the current process and sub-processes in terms of process attributes such an activities, resources, communication, roles, IT, and cost in identifying process requirements and assigning customers value, root causes for problem are surfaced, and non-value-adding activities are identified.

For the sake of well redesigning, BPR project team should investigate the hardware and software infrastructures, information systems capabilities and also benchmarking in similar processes of other organizations or even other industries.

In this stage according to new organization state in landscape (new configuration), the indicators that affect process complexity, BPR team should get through redesigning of the processes. Outputs of this stage are improved processes with lower complexity that are used to perform business. As a result, new organization, as a CAS, is one with higher fitness, more agile and more capable in surviving or being pursued with its competitors.

Sub-activities of this stage are as follow.

- Identify infrastructures and opportunities for IT.
- Benchmarking.
- Identify the indicators that affect processes complexity (according to proposed measure).
- Draw up and perform improvement process.
    - Determine fundamental reasons of problematic factors, according to determined indicators.
    - Implement improvement solution.
- Collect processes performance measurement information.

5-5 REDESIGN

In the redesign stage a new process design is developed. This is alternatives through brainstorming and creativity techniques. The new design should meet strategic objectives and fit with the human resource and IT architectures .documentation and prototyping of the new process is typically conducted, and a design of new information systems to support the new process is completed.

To fulfill the performed changes, the project team should exert methods of change management in both cultural and tactical dimensions.

In order to implement the exerted changes, it is vital using the methods of change management. Change is not an event, despite our many attempts to call folks together and have a meeting to make change happen. Change management is the discipline of managing change as a process, with due consideration that we are people, not programmable machines. It is about leadership with open, honest and frequent communication. These methods are in two dimensions, tactical and cultural. Sub-processes of this stage are as follow.

- Change management
    - With tactical methods
        - Develop cross functional teams for planning and implementing BPR project.
        - A state transition team, to manage BPR plans.
        - A coordination team to coordinate the necessary operations and set the necessary connections.
    - With cultural methods
        - Frustrate the resistance to change by appropriate incentives.
        - Overemphasize the discontent with current situation.
        - Stimulate for getting desired results.
        - Use prototype implementation.
        - Develop staff training course for new professions.
- Implementation.

5-6 RECONSTRUCT

In this stage BPR project team should evaluate improved processes and assess their effects on organization dimensionality (as a CAS), its landscape and also on customer/ supplier needs. For doing so, use a landscape. Landscape axes determine processes performance indicators. Landscape fitness function (topography of landscape) determines organizational agility in satisfying customers suppliers' needs and also the amount of organizational goals have been obtained, to assess the amount of satisfied customer/ supplier requirements. The outputs or results of processes improvement (changes) and subsequently change in organization cause to environmental changes or competitor reactions. These environment or competitors' actions, again, lead to changes in organization landscape topography, the interdependencies of actors in landscape and the current organizational fitness. Subsequently these alterations cause process agents to search for improved fitness by taking action in order to better fit the observation, and it is when the reengineering is needed. In fact, C factor of NK(C) model causes to have coupled landscapes.

Sub-processes of this stage are as follows.

- Evaluate the effects of process improvement.
- Acquire feedback from customers, suppliers, external environment, and competitors in periods of implementation, by means of designed landscape.
- Survey, determine and investigate.

5-7 EVALUATE AND IMPROVEMENT

Revise the improvement and changes in processes if necessary. On account of changes in customers and suppliers' needs and turbulence in environment, it is necessary to modify processes that satisfy goals of organization and customers' requirements.

- Define projects and activities for performance improvement

6- Conclusion

This paper is gotten through a methodology for BPR projects that consider organizations as systems that learn, adapt and evolve according to their environment circumstances, over time. These systems have known as CAS. In order to have an organization with high fitness and co-adaptability with the environment, this paper starts looking at coevolution in two levels, strategic level and operational level. Our main objective is to manage the adaptation process in operational level. So a process selection criterion in our methodology is proposed in order to align the organizational processes with the given goals and strategies. Thus since organization as a CAS has the ability to sense and respond and therefore coevolve with its environment by developing appropriate strategies in high level adaptation, it can also satisfy its strategies, in operational levels, by managing the processes.

Because of interactions between agents and therefore organizational complexity, so many schemas appear or change. Subsequently, these alterations cause agents to search for improved fitness by taking action in order to better fit the observation, and it is when the reengineering is needed. This management on one hand ought to satisfy diversity in organization while sustaining some complexity and on the other hands, by increasing the amount of complexity, organizations still could not meet every situation that might arise, and they might also be less flexible. Therefore, it is not necessarily the best course to strive for greater and greater complexity. Complexity reduction while being at the edge of chaos might be preferable. Process prioritization for reengineering defined in this manner that the most complex process should be reengineered first and so on for other processes. At the end, by using organizational landscape, the amount of satisfaction in customers and suppliers' requirements will be assessed. Then organizational future strategies develop to resolve for future processes improvement. By continuous monitoring the organization using proposed methodology, organization could be more agile and could survive in competitive environments.

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