An Alternative Approach to Identifying and Appraising Adaptive Loops in Complex Organizations

Amina Omarova\textsuperscript{a}, Vernon Ireland\textsuperscript{b}, Alex Gorod\textsuperscript{c}\textsuperscript{*}

\textsuperscript{a, b, c} Entrepreneurship, Commercialisation and Innovation Centre, Faculty of Engineering, Computer & Mathematics Sciences, The University of Adelaide, SA 5005, Australia

Abstract

This paper describes a research into the adaptation property of complex organizations. The research is focused on the development of a methodology for identifying and appraising loops that can allow for organizational adaptation. The proposed methodology draws a parallel between the nature of adaptation in complex organizations and the process of adaptive decision-making in human behavior. From this perspective, the adaptive loop in complex organizations can be divided into four steps adapted from the OODA loop (Observe-Orient-Decide-Act). The extension of the OODA loop to an organizational scale is incorporated with an assumption that flow of information, involved in adaptation processes, can be formed by different organizational components. Subsequently, the OODA loop can be presented as a chain of actions created by independent components of both the organization and its environment. Applying this approach to complex organizations necessitates mapping a functional definition of different organizational components within each step of the adaptive loop. Thus, while the functional definition of an organization can be done by using existing tools of organizational analysis (organizational structure, functional decomposition, architecture frameworks, etc.), the main goal of this proposed methodology is the determination of adaptive loops on an organizational scale.

Keywords: adaptation, adaptive loop, adaptivity framework, complex adaptive systems

1. Introduction

Acknowledgement of the present world’s complexity and its dynamic nature makes organizational adaptation a critical research area. Complex Adaptive Systems (CAS) theory includes the notion that adaptation is a very important internal property, which emerges from mutual nonlinear interactions among agents. Theorists and practitioners have been exploring organizational adaptation for decades. Organizational Change Theory (OCT) has been focusing on managing changes in organizations since the middle of the last century. The first period of the

* Corresponding author. Tel.: +61403439676.
E-mail address: amina.omarova@adelaide.edu.au.
OCT development was connected with an idea of “biological evolution, conceived as a cycle of variation, selection, and retention of species” [1]. Organizational adaptation was viewed at a macro level, with the “Darwinian theory of evolution” being taken as a theoretical base, where only successfully adapted organizations could survive in ever-changing environment. Since that time, many events have changed researcher’s perspectives on organizational adaptation and organizational change in general. For example, the first oil crisis as well as “economic globalisation of the world, the demographic shifts in the Western world’s population, technological opportunities, and upheaval and political uncertainties” [2]. Therefore, the modern world can be characterized by an “impression that this is not a period of crisis that will soon be replaced by stability, but that turmoil and unpredictability are here to stay”, where change is “something that the organization does itself” and it is “a never-ending, indeterminate process” [1]. Under these conditions, organizational adaptation, as an internal emergent property of organizations, attracts greater interest. There is a “wide range of specific tools are used to address adaptive issues in organizational change” while “complexity science can provide a more precise definition that supports both practical application and rigorous research of this unpredictable process of organizational change” [3].

Hence, the application of CAS theory to complex organizations opens up new horizons in investigating organizational adaptation. A brief summary of CAS characteristics is presented below.

2. Complex Adaptive Systems

The beginning of the CAS theory dates back to the late eighties and early nineties as “the study of chaotic systems” [4]. While there is still no common definition of CAS, the literature review demonstrates a number of the main properties of CAS, which can provide a good understanding of complex adaptive systems [4-13].

- **Agents and their interdependence, diversity, rule-based behavior and aggregation.** CAS consist of a number of agents. Each agent has its “own rules of behaviour” [11]. Agents are interconnected and there is “a variety of components [or agents] and interactions between components” [9]. CAS has also the ability of “less complex agents” to get aggregated into a group and “act as agents at a higher level – meta-agents” [6].

- **Nonlinearity.** CAS are “inherently nonlinear” [8]. Interdependence of CAS agents makes the reductionist rule of representing the whole as a sum of its parts unworkable. Thus, there are no clear cause-and-effect relations.

- **Openness and Dynamic.** CAS have boundaries that are “defined arbitrarily” [11]. A system is constantly exchanging energy and information with its environment, and is influenced by its environment. Moreover, changes in CAS are constant and non-continuous due to the number of agents and their properties such as openness, based-rule behavior and interdependence [11].

- **Emergence and Self-organization** relate to the unpredictable behavior of a system which results from simple rules of behavior of interconnected agents. While emergent properties can be simply viewed as unexpected behaviors, self-organization is characterized by macro-scale patterns of behaviour” [14]. Here, **Various attractors** represents “a variety of preferred states (Krohn, Küppers, and Novotny 1990) in which direction the system could move of its own accord” [9].

- **Sensitivity to initial conditions** – or “butterfly effect” – implies that “two complex systems that are initially very close together in terms of their various elements and dimensions can end up in distinctly different places” [14].

- **Adaptation** could be interpreted as – “an iterative process of generating change in the system, followed by a success-linked selection process to either retain or eliminate the change” [8].

- **Feedback loops** demonstrate the ability of a system to use its own output to control inputs or processes and they are an inherent part of the adaptation process.

The authors recognize that modern organizations can be viewed as complex adaptive systems. CAS theory and OCT pay great attention to the organizational adaptation. In discussing adaptation, G.H. Eyoang suggests that “Adaptation is familiar concept for scholars of organizational change” [3]. Indeed, reviewing the history of OCT, it is evident that the concept of adaptation occurred at the earliest stage of its development. For example, population ecology and life-cycle approaches are “based on ideas borrowed from biology” [1]. As a result, tracing the history of OCT development, it can be observed that the term adaptation is found in Evolutionary and Complexity approaches to organizational change management. This paper examines the ability of organizations to adapt as one of the key properties to successful operation. The review of organizations is based on complexity perspective, where organizations are reviewed as complex systems that are able to adapt.
3. Organizational Adaptation and Adaptivity Framework

The literature review reveals much research on the analysis of the adaptation property of systems [15-25]. Several works focus on the modeling of a particular complex dynamic system, while others take on a descriptive role. One of the descriptive frameworks of adaptation was created by the Defence Science and Technology Organisation (DSTO) in Australia and it is called Adaptivity Framework [22]. It is an explanation of “a generic model of adaptation, natural and hybrid types of adaptive mechanism, four classes of adaptation, five levels at which adaptation can be applied, and a discussion of the health of an adaptive mechanism, the levels of scale at which it can operate, and the factors that influence its effectiveness” [22]. The framework provides a comprehensive understanding of adaptation and represents “the conceptual framework for thinking about adaptivity and about how to apply it” [22].

CAS theory provides a majority of definitions of adaptation, where all of them use the same idea:
- Changes in the environment which are recognized by an organization.
- The process of information analysis and decision-making on subsequent behavior.
- Actions (changes) which are undertaken by an organization to achieve a new state in the changed environment.
- System of monitoring an organization’s position before and after changes to determine whether the implemented actions placed the organization in an advantageous position or not.

These points are linked with the OODA loop (Observe-Orient-Decide-Act). It was initially created by Boyd, who was attempting “to explain why American fighter pilots were more successful than their adversaries in the Korean war” [26]. The OODA loop represents four components linked between each other in the decision-making process [27]: observing the environment; orienting itself within in the environment to determine its own position; deciding on subsequent actions, and implementing those actions. Later, Boyd further developed the OODA loop into a number of multiple loops which include feedbacks as well as “a number of factors that affect the orientation achieved by the decision maker” [26]. These factors are composed of: “[g]enetic heritage, cultural traditions and previous experience, as well as the mental processes of analysis and synthesis” [26]. Today, various commercial companies such as “Intel, Nokia and other corporations [use the OODA loop] to produce a competitive advantage in the marketplace” [27]. Nevertheless, since the OODA loop is associated with the individual’s decision-making process, and it is believed that “Boyd’s model not only describes individual human behavior, but also mirrors organizational behavior as well [since] decisions are often the product of group interactions as well as individual behaviour” [28]. However, the OODA loop “is clearly the dominant model of C2 [command and control] today” [26], and its application is mainly related to decisions made at the top level of the organizational structure. In using the OODA approach to understanding how adaptive mechanism works it is clear that there are parallel lines of thought, such as Argyris’s double learning and from cybernetics. However, as a generic schema OODA loop represents an easy and practical way to proceed the theory-building process.

According to CAS theory, the adaptation of a complex system occurs because of interactions among agents at all levels, while the OODA loop is applied to decision makers at top levels. Grisogono provides a “generic model of adaptation” and shows that adaptive loops have the same components as the OODA loop [22], while her “generic model” gives more details of the adaptation process. Moreover, Adaptivity Framework provides a summary of five levels of adaptation: action, learning, learning-to-learn, defining success and co-adaptation [22]. It is assumed that adaptive loops are present at each level of adaptation. Here, the particular adaptive loops are informal, despite the hierarchical structure of organizations and the presence of formal processes of introducing organizational operations.

Grisogono also describes principles of designing systems. The first step there is “identifying the informal adaptive loops that arise spontaneously in any complex sociotechnical system, coexisting with, and often undermining the deliberate formal adaptive mechanisms” [22]. In this regard, reviewed frameworks and approaches are aimed to model or analyze the adaptation property [15-21, 23-25], although none of them are designed to identify adaptive loops inside complex organizations. One could argue that currently prominent agent-based modeling uses similar principles to describe agents’ behavior as an OODA loop. However, in this case only a bottom-up approach is used to show the emergent, self-organizing nature of a complex adaptive system. Another type of adaptability frameworks is to capture exclusively top-down relationships in organizations, recognizing the leaders whose behavior should be adaptive [21]. This paper proposes a method for identifying informal adaptive loops inside organizations, which represents the combination of top-down and bottom-up approaches. The functional decomposition of an organization and five levels of adaptation would capture both the hierarchical
distribution of processes and the involvement of different organizational levels in the adaptation process. The functional decomposition of an organization is to be done to determine a number of functional elements. These are elements of an organization, which specialize in performing a specific function. This approach would allow to distinguish one objective functions from another. An objective function is used to describe the main purpose of an organizational component. The list of objective functions can be defined by viewing organization from top to bottom. However, the identifying of adaptive loops in an organization requires in-depth understanding of formal and informal relationships among organizational components at all levels. This implies application of bottom-up approach to reviewing an organization. By viewing every step of the OODA loop separately, it is possible to observe that each step functions to transfer the results of its activity to the next step in the OODA loop. In general, four main categories of functions of the OODA loop can be identified: (1) collecting, processing and storing of data, (2) analyzing data, generating variations, (3) decision-making, (4) developing and implementation of functional change. From this perspective, the functional decomposition of an organization should be carried out in accordance with the classification of each function. This would allow the mapping of organizational functions within the OODA loop steps. In addition, the proposed approach could serve as a foundation for a practical methodology of identifying adaptive loops inside complex organizations.

4. Identifying Adaptive Loops

The following description of the proposed methodology for finding adaptive loops is based on a “generic model”, which besides other dimensions, includes “five levels of adaptivity” [22]. Adaptive loops can be organized formally by means of internal rules and procedures. However, as mentioned above, greater interest is shown towards informal adaptive loops, presented in an organization. In general, adaptive loops in organizations represent a collection of functions or processes, which influence “the behaviour that results is somehow better than what was available before the adaptation” [22]. The process of finding adaptive loops is a complex task, since it is necessary to determine informal multidimensional Observe-Orient-Decide-Act (OODA) sequences. According to Grisogono, an adaptive loop is “a closed loop”, where feedbacks are sensed by an organization and play important role. Feedbacks are involved in the process of the investigating success/failure of actions, which are performed by an organization in the environment. Consequently, the OODA loop can be presented as following – O(+F)ODA, which means that determination of feedback is a part of the Observe step. The term “OODA loop” is used as a pattern, which describes a sequence of actions/functions. This sequence in turn forms an adaptive cycle. The proposed methodology for investigating of adaptive loops in organizations requires determining every step of the O(+F)ODA loop. An adaptive loop should be closed, if it is to make a contribution to successful organizational adaptation. Overall, the process of finding adaptive loops can be started from any step of the O(+F)ODA loop. However, Observe, Orient and Decide are mainly associated with the collecting and processing of information. In this sense, any organization may have a huge number of elements or functions that perform these types of operations. It is therefore assumed that, from a practical viewpoint, it is more convenient to start searching for adaptive loops from the definition of Act step, since it performs a change in the system’s behavioral model. The definition of Act step is a search for functions and processes that can perform this change. Furthermore, the steps Decide-Orient-Observe can be found in reverse order – going from action to decision, from decision to orientation, and from orientation to observation. Every step of the O(+F)ODA loop uses results from the previous step as an input. Therefore, in order to determine the previous step of the O(+F)ODA loop in reverse order, it is necessary to apply some determinative questions to each input. This would help to identify source of input and therefore to determine the previous step of an adaptive loop. Table 1 shows steps of adaptive loop and corresponding determinative steps.

The finding of adaptive loops can provide a number of adaptive loops. The found loops can differ in scale. According to Grisogono, there are five levels of adaptation. Each level of adaptation is possibly presented in an organization and has its own adaptive loop [22]. Moreover, each level of adaptation can be characterized by specified properties that make it distinctive from other levels. The description of five levels of adaptation is presented below and is based on Grisogono’s Adaptivity Framework [22]:

- **Action-in-the-world** mechanism operates with determined parameters of objective function and makes data processing, variation and decision-making “within the constraints of existing sense, process and act capabilities”.
- **Learning** uses adaptive mechanism to create new behavior models (new objective functions and its variations). It aims to improve action-in-the-world level of adaptation.
• **Learning-to-learn** focuses on “aspects of how variations are created, evaluated, selected, and propagated or eliminated” at the learning level of adaptation. It also estimates the effectiveness of the learning level by means of collecting data about its activities, and generates new methods to create behavior models.

• **Defining success** is the “internalised success/failure proxy measures [which are] used for the lower three levels”. This is the reviewing of an organization from various perspectives over a long period of time.

• **Co-adaptation** is “addressing the interactions between multiple adaptive mechanisms and applying adaptation to the parameters describing the distribution of roles, resources, authorities and responsibilities between them”.

### Table 1. Steps of Adaptive Loop and Corresponding Determinative Steps

<table>
<thead>
<tr>
<th>Step of Adaptive Loop</th>
<th>Determinative Steps</th>
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<tbody>
<tr>
<td>Objective Function</td>
<td>1. Perform the top-down functional decomposition of the organization to identify an objective function</td>
</tr>
<tr>
<td></td>
<td>2. Choose an objective function for analysis</td>
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<tr>
<td>I. Act</td>
<td>3. Determine what can be changed in the chosen objective function (parameters or algorithms)</td>
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<td></td>
<td>4. Determine what parts of an organization can perform a change of parameters/algorithms of an objective function</td>
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<td></td>
<td>5. Determine method which is used to perform a change of an objective function</td>
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<tr>
<td>II. Decide</td>
<td>6. Determine who or what makes decision about change</td>
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<td></td>
<td>7. Determine how decision is made</td>
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<tr>
<td>III. Orient</td>
<td>8. Determine what type of information is used for decision-making. Determine where information for decision-making is coming from</td>
</tr>
<tr>
<td></td>
<td>9. Determine how variations of change are created. Determine how evaluation of variations is created. Determine how position of an organization is investigated in the parameter space</td>
</tr>
<tr>
<td>IV. Observe + Feedback</td>
<td>10. Determine where information for analysis of an organization’s position is coming from</td>
</tr>
<tr>
<td></td>
<td>11. Determine how collecting and processing of information is made</td>
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<tr>
<td></td>
<td>12. Feedback: Determine what parameters describe the result of an objective function’s action. Determine if information about changes in an objective function exists. Determine what data about an objective function is available in historical perspective</td>
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</table>

The Grisogono’s classification of adaptation levels provides a solid base for understanding various adaptive loops inside organizations. It can be seen that adaptation loops can be presented at various organizational parts and involve different hierarchical levels. Therefore, it is necessary to determine the level to which possible adaptive loop can relate. The proposed methodology for identifying adaptive loops, which is presented in the Table 1, assumes that determination of the O(+F)ODA loop should start from the Act step. The understanding of the main distinctive features of levels of adaptation would also be linked with that step. It is assumed that to determine the level of adaptation, it is necessary to identify the object a given adaptive loop aims – or the object of adaptation. Table 2 shows main characteristics of objective functions for each level of adaptation. An additional assumption is that determination of adaptive loops of various levels should be done from the bottom level of adaptation (Action-in-the-world) to the top level (Co-evolution). An adaptive loop of a lower level is considered as an object of adaptation of an adaptive loop of a higher level. Therefore, the object of adaptation of the bottom level needs to be found and then the ADOO(+F) steps should be defined in reverse order. Then it would be possible to determine higher levels of adaption. Figure 1 represents the interrelationship of five levels of adaptation and their objects.

### Table 2. Object of Levels of Adaptation

<table>
<thead>
<tr>
<th>Level of Adaptation</th>
<th>Object of Adaptation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action-in-the-world</td>
<td>Organization’s parameters, choose a behavioral algorithm from the existing set of behaviors</td>
</tr>
<tr>
<td>Learning</td>
<td>Model of behavior (“Parameters that characterise new capabilities for processing, sensing and action”)</td>
</tr>
<tr>
<td>Learning-to-learn</td>
<td>Ways of creating new models of behavior (“Parameters that characterise aspects of how variation is created, evaluated, selected and propagated or eliminated”)</td>
</tr>
<tr>
<td>Defining success</td>
<td>Methods and parameters of evaluating success/failure of the first three levels of adaptation</td>
</tr>
<tr>
<td>Co-adaptation</td>
<td>Functions/parameters of evaluating the success/failure of SoS, and ways of managing connections among subsystems</td>
</tr>
</tbody>
</table>

A complex organization presents a combination of components that forms a network of interconnected processes and information flows. Every component specializes in a number of functions, such as: management, production, finance, logistics, human resources and other internal and external services [29]. Information flows, which form the
adaptation cycle, are distributed over the components of an organization. Subsequently, the result of each step of adaptation process could depend not only on one component of the organization, but could be found in different components of the organization. Therefore, to analyze organizational adaptation, it is necessary to determine and evaluate the influence of different components of an organization at each step of adaptation. For this purpose, the proposed methodology implies a combination of top-down and bottom-up approaches, where reductionist and holistic methods can be applied. Glazner emphasizes that “some system decomposition is needed in order to understand the basic functions of the system, but must be done in a way that still permits analysis of a system such as a whole, accounting feedback and dynamics across the decomposition” [30]. In this case, the concept of near-decomposability can be used, which is “embracing both tree-like “pure” vertical hierarchies and lateral hierarchies with horizontal links at various levels” [30]. Thus, we assume that hierarchical structure of organization will be extended by horizontal links, where interconnectedness of components is to be determined by means of investigation of each step of adaptive loops. The combination of bottom-up and top-bottom approaches would open up a possibility to analyze various aspects of organizational operation. Therefore, success/failure of organizations can be analyzed not only from managerial and formal perspectives, but also from informal connections among people and departments. Organization theory and enterprise architecture methods and frameworks can provide various methods of reviewing an organization, where the goal of the proposed methodology is to provide a method of understanding components’ interconnectedness from an organizational adaptation viewpoint.

![Fig. 1. Levels of Adaptation and Objective Functions of Adaptation](image)

**5. Conclusion**

While much research has been conducted on understanding adaptation property of complex system, none of the works aim to determine adaptive loops. In this paper, we propose a methodology of finding adaptive loops in complex organizations. A method of decomposition of an organizational structure is being presented, which would allow for an effective search of adaptive loops inside complex organizations. As a next step, a method of qualitative evaluation of adaptive loops at various levels of organizations is being developed. This will help in determining the quality of adaptive loops. As part of the future research, the authors will test the described methodology against real life case studies. Further usage of the methodology could be linked with computational modeling of organizational adaptation, where it would be possible to test adaptive behavior of an organization under different environmental conditions. While current research focuses on qualitative analysis of adaptive loops, it still opens opportunities for mathematical modeling of organizational adaptation. In particular, numerical modeling can be used for analysis of characteristics of adaptive mechanism. However, at the first stage of reviewing organizational adaptation it is necessary to build a qualitative methodology for identifying and appraising adaptive loops in organizations.
References