Holonic Handling the Unexpected in Project Management

Levente BAKOS

1Lucian Blaga University of Sibiu, Sibiu, Romania
2Sapientia Hungarian University of Cluj Napoca,
levente.bakos@ulbsibiu.ro

Dănuț DUMITRAȘCU

Lucian Blaga University of Sibiu, Sibiu, Romania
dan.dumitrascu@ulbsibiu.ro

ABSTRACT

Risk assessment is one of the key activities of any project. The unexpected situations can have catastrophic consequences. Risk assessment tries to estimate to potential known unknowns, but there is no guarantee to foresee all circumstances around a project. In this situation the project team must be adaptive and find solutions by cooperation, creativity and abductive reasoning. In the paper we tried to analyse on what extent a project and a project team can be handled as a complex adaptive system. More precisely, how the scientific and practical achievements of the theory of complex adaptive systems (CAS) can be used in project management. More exactly, we analyse the applicability of the Holonic Multi-Agent Systems in risk management of the projects. We consider the way in which holons handle the unexpected situations can be a model in project management.

Keywords: risk management, project management, holonic manufacturing, complex systems

INTRODUCTION

The curiosity to see the future has the same age as mankind. It’s written in our genetic code to be anxious about to future. Wizards, predictors, prophets, mages, fortune-tellers made, and still make, big business about this. In state affairs and public administration, almost any scientific field, in the business environment and engineering to get ready what will happen in the future is extremely important. Planning, designing, trend and tendency analysis, evaluating the risks and many other scientific reasoning has as goal to be prepared to the future. Sometimes the future is predictable, known and it is easy to foresee what will happen. But in the most of the cases we must deal with “known” and “unknown” unknowns. We use this term after a famous quote of the former American state secretary Donald Rumsfeld, when he was referring some national security issues at the White House. The most difficult events are the totally unexpected “unknown unknowns”. Some of these events are named Black Swan events, after N.N.Taleb’s well-known book. (Taleb, 2007). The metaphor comes from a phrase in which black swan was presumed not to exist, till somewhere in the Southern Hemisphere someone saw it. The importance of the metaphor lies in the fragility of any system of thought. “One single observation can invalidate a general statement derived from millennia of confirmatory sightings of millions of white swans. All you need is one single (and, I am told, quite ugly) black bird”. (Taleb, 2007). Initially Taleb, analysed events from financial markets (beside being a scholar, he is an experienced trader, too), and later tried to give Black Swan examples from many other fields (unpredicted scientific discoveries and historical events like World War I, New York 9/11, etc.). In fact, he states Black Swans can explain almost anything. A Black Swan an event with the following characteristics:

- it is a surprise, lies outside the realm of regular expectations,
- it has an extreme impact.
- after its occurrence it is explainable and retrospective predictable.

From the perspective of our proposed theme, new possibilities in project management in risk assessment the Black Swans have the further important characteristics:
- they are not accounted in any risk mitigation programs.
- they are mostly the result of imperfect automation
- they can be related to bounded rationality

Taleb states the rare event equals uncertainty. These rare events could be seen in advance, but we are blind to them. We are blind with respect to randomness, and particularly with respect to the large deviations. The extreme effects, the unexpected failures, caused by Black Swans usually are the result of the fact that we excessive rely on what we know, what we see on the television or Internet and we overlook what is contradiction with our previous finding, even if there are obvious evidences. Figure 1 shows an unexpected value in a extremely simple situation, when we represent a single variable’s variation.

![Figure 1: Unexpected situation in the case of single variable problem](image)

Having the given variable’s previous values the whole the system was designed based on these values. The point here is, not the encourage to over-design even the simple systems, but to be prepared for the unexpected.

The behaviour of simple systems is quite well predictable. Even in the case of complicated systems we can speak about a predictable behaviour, because there are fixed rules how these systems work. For example, to make an ocean-liner is complicated. But if the workers follow the prescriptions of the designers and they are properly managed, the results are predictable. The elements of the system are known, the evolution stages (technological process) of the system are also known, and the interconnections among the components are well defined and fixed. The things get more, far more complicated, in the case of complex systems.

The study of complex systems is a multidisciplinary science related to many traditional sciences such as engineering, management, social sciences and medicine. Complexity theory is a mix of theories from evolutionary theory and cybernetics to general systems theory. Complex systems are somewhere in the middle among simple ordered systems (for example airplane, the law system, mathematics) and chaotic systems (for example the atmosphere, the movement of molecules, the stock market). We must mention there is a difference between complex and complicated systems, too. If a system, regardless of its size, can be described by its individual components can be considered a complicated system. One of the most common examples might be an airplane, computer or a building. In the case of complex systems knowing the constituents it is not sufficient condition to describe how the system works or how it will behave. In Figure 2 we briefly present how complexity evolves in the case of different type of systems.

**COMPLEX ADAPTIVE SYSTEMS IN FACING THE UNEXPECTED**

A specific category of complex systems represents the complex adaptive systems (CAS). In these adaptive systems the constituent entities communicate each other, they have unpredictable behaviour and they are adoptive. We will not propose to present the rich literature of defining what they are the CASs. From the multitude of definitions we chose one given by John H. Holland, the founder of the domain of genetic algorithms. He defined CAS as “systems that have a large numbers of components, often called agents, that interact and adapt or learn.” (Holland, 2006). Also he states, “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”.
It is difficult to depict the variety of such systems, but it can be considered as a complex adaptive system the Internet, the cities, organizations, companies, but also the families, our brain, intelligent power-grids and even the world economy. In order to survive and face the unexpected these systems must adopt their behaviour to change and must communicate to the environment.

In a larger research the authors analyse to what extent a project and a project team can be handled as a complex adaptive system, more precisely, how the scientific and practical achievements of the CAS can be used in project management. In this paper we’ll present some solutions how theoretical achievements of the study of complex adaptive systems can be applied in project management.

We had as starting point the observation that in project management is really usual that unexpected situations arise, and the project team must handle this previously known or unknown state, whether they are prepared for that or not. In these, sometimes crisis situations, the disturbance handling procedure relies on effective communication and how the team members behave. That is the case when the lessons learnt from the analysis of the complex adaptive systems come into sight. A substantial literature of CAS analysis focuses on questions about parts, wholes and the relationships among them, how parts of a system influence the collective behaviour of the system, and how the system interacts with its environment. “To understand the behaviour of a complex system we must understand not only the behaviour of the parts but how they act together to form the whole” (Bar-Yam, 1997). The unexpected collective behaviour of such systems is called emergent. The study of this emergent behaviour of the complex systems mostly is done through so-called agent-based modelling methods. Among these concepts the Multi-Agent Systems (MAS) represent a top research topic. The MASs are computerized systems with interacting components, called agents. The agents are autonomous entities, which allow to explicitly replicate - using a computer software - the interactions inside the system and emergent properties can be observed. Usually the agents are software agents, but in many cases agents are considered physical entities like robots and humans too. In the holonic concept presented in the next paragraph the agents (holons), if they are part of a Holonic Manufacturing Systems, can have a processing component and human operators are considered holons, as well. In MAS the agents try to find solutions for their problems themselves, being able to negotiate and they are fault tolerant. They main characteristic of the MAS systems is their flexibility and adaptability in changing environments. This ability allows the MAS to handle the unpredictable situations and that is why we decided to analyse if the functioning mechanism of these systems can have applicability in project management. Among the multiple MAS concepts we chose the holonic system concept, being one of the most developed in industrial context. Holonic Manufacturing Systems, are already performing well in large-scale applications, and also the concept has its extents to logistics, supply chain management and other non-industrial field.
HOLONIC MULTI-AGENT SYSTEMS AND THE RULES OF UNEXPECTED

Behind the holonic concept we can find two important figures: Arthur Koestler, a British-Hungarian author and the Nobel price winner economist Herbert Simon. The term holon was proposed by Koestler to describe an entity that is a “whole” and a “part” at the same time. The word holon was formed by adding to the Greek word holos (means “whole”) the suffix –on (meaning a “particle” like in proton, neutron, etc.). The holons being part and whole at the same time, are building blocks of a larger system, called holarchy by Koestler, which presents stability in changing environments. The secret of this stability relies on the observation that complex systems evolve better if their components are stable entities. The holons are autonomous self-reliant units and may act without the permission or instructions of higher authorities. The holonic concept proved it’s efficiency in practical applications, there are already mature holonic reference architectures for Holonic Manufacturing Systems. The most known reference architecture is PROSA presented in (Van Brussel et al., 1998). The holonic systems perform better in practical applications comparatively to the most of other multi-agent concepts, because of the existence in the model of the flexible rules. In the majority of other multi-agent systems, the agents are totally autonomous and independent entities. These properties offer them high adaptability in changing environments, but sometimes also unpredictable behaviour. In the case of holonic systems because of the flexible rules there is a decentralization and a certain degree of independence. This way this concept tries to combine the predictable behaviour of the classical (industrial) systems with the agility of the multi-agent systems. This way, the holonic systems are more likely to emerge and survive in dynamic environments, but also they are more reliable than other artificial CAS.

In holonic systems we have loosely coupled networks with a well-developed system of communication and control. Fault tolerance, capability to respond in real-time to disturbances, reconfigurability are the most important characteristics of these architectures. Figure 3 shows the position of the holonic systems between the traditional hierarchical systems and the multi-agent system model.

The holonic concept, and its developed applications in industry, shows the robustness against disturbances of these systems. Recent developments of the concept show its applicability outside the industrial development. In fact, based on the holonic concept Paul Valckenaers and Hendrik Van Brussel in their book “Design for the unexpected. From holonic manufacturing systems towards a humane mechatronics society” (Valckenaers -Van Brussel, 2015) develop a framework to extend the concept almost to any type of complex adaptive system. The new concept D4U (designed for unexpected) is useful mostly to software designers and process engineers to design or model complex adaptive systems. Although, the developed framework can provide ideas for many other scholars and practitioners from different domains. In D4U concept developed by Valckenaers and Van Brussel there are 2 principles and 4 laws of the artificial (here artificial means manmade system). These findings represent the latest achievements in holonics, as scientific philosophy.
Table 1 we present our findings about the novel principles and laws from the D4U concept related to project management.

| P/L | D4U concept | Risk management |
|-----|--------------|-----------------|
| P1  | designers must prefer stable design decisions | unstable project decisions, including those with regarding severe risks, shall be decided as later it is possible |
| P2  | earlier unstable design decisions are no justification for later decisions imposing the same constraint(s) | in stakeholder management in order to avoid risks never shall be assumed their support as granted |
| L1  | flexible hierarchies will dominate under bounded rationality and dynamic /competitive environment | As part of the risk mitigation process a special measure is to clarify the risk ownership issues, to define who is responsible for what risk. |
| L2  | members of strong autocatalytic sets have decisive competitive advantages over nonmembers. | in stakeholder management it is necessary to identify a relevant set of stakeholders in order to overcome opposition to change |
| L3  | when competition favors larger systems, the top levels of competitive systems cannot be effectively controlled in a centralized manner. | risk avoidance requires steering without centralization; in crisis situations down-flowing information shall be disregarded if there is a loss of information in the upward flow |
| L4  | effective proactiveness requires the ability to imagine what will happen. Accounting for future interactions requires a collective imagination. | dealing with the unexpected risk requires cooperation, self-control, multi-tasking, abductive thinking. |

P= Principle, L=law

It is out of the scope of this paper to present and analyse these principles and laws, we’ll make some as follows regarding the findings presented in Table 1. The P1 principle refers to pass up those assumptions (harmful constrains), which might be wrong in the future. A harmful constraint here means, an unstable constrain, which might be no longer valid in time. This principle is more challenging in project management, where in contradiction with other forms of the activities, in project management we can identify a totally apart dynamics of risks. We present this evolution in Figure 4. The refers to both the variation of the intensity of a certain risk type, both to variation of risk categories. Starting from the phase of planning till the closing activities there are specific risks that may arise. Figure 4 shows that during the execution process uncertainty and the level of risks decrease in time, but at the same time the impact of risk rises because the exponentially increasing costs related to changes. Related to P2 we’d like to give an example in order to explain our proposal. If we apply this principle in a business project having as goal to set the location of a warehouse, a stable constraint it is can be it’s location; unstable constraint might be set the relationship with one of the neighbours. This principle translated in our example: the good relationship with our neighbours in present, should not let us assume that good relationship is granted forever. For example, it would be a mistake to ignore them as a critical stakeholder when we decide to change our business profile (let’s assume a shift from a car spare-part warehouse to a warehouse for flammable chemical materials).
The third law’s (L3) statement translated in the risk management of projects means in order to face risks and unpredictable events in the case of larger projects the steering structure of the project mustn’t be centralized. In holonic systems, same as in project management, the hierarchical coordination and control is loosely coupled. The novelty, and a new stage in the development of project management techniques, would be if in certain circumstances (for example crisis situations) should be possible the give up the centralized control. It is a usual procedure for holons to create or break up hierarchies; according to the holonic concept holons can create holarchies (temporary hierarchical structures) if this fits their interest. Under certain circumstances, for example in the case emergencies, the situation might be handled by creative, specially trained and disciplined professionals. They may act with or without the knowledge of the project manager or the sponsors. There are already such procedures, because time is essential in handling major incidents and failures. The major task for scholars and practitioners might be to see on what extent this procedures can be used in other cases, creating a holonic-like project management.

The fourth law (L4) of D4U concept posits: “the effective proactiveness – and its benefits – requires the ability to imagine what will happen when selecting a course of action. This imagination must include the significant impact of future interactions. Accounting for such future interactions requires a collective imagination. This includes the impact of the accessibility of this imagination, collective or otherwise.” This statement is total compliance with statement of Guy Boy (scholar and practitioner in some large NASA projects), who recently stated “dealing with the unexpected requires accurate and effective situation awareness, synthetic mind, decision making capability, self-control, multi-tasking, stress management and cooperation (team spirit)”. (Boy, 2017).

**CONCLUSIONS**

We live in a complex world, nature itself is complex. In the case of complex systems even if we know the constituents it is not sufficient to describe how the system works or how it will behave in future. The unexpected situations can have catastrophic consequences. Black Swans, even later we recognise they were predictable, can ruin even countries or have major impact on the World economy. In smaller scale, unforeseen events can stop running project, can have major impact of the cost. Risk assessment tries to estimate to potential known unknowns, but there is no guarantee to foresee all circumstances around a project. In this situation the project team must be adaptive and find solutions by cooperation, creativity and abductive reasoning. Abductive reasoning means here a goal-driven behaviour, which delivers a possible option out of many, decided in most cases by consensus. Abductive reasoning is about foreseen the future. The complex adaptive systems being characterized by an emergent behaviour must deal on regular basis with unexpected situations. In the paper we tried to analyse on what extent a project and a project team can be handled as a complex adaptive system. More precisely, how the scientific and practical achievements of the theory of complex adaptive systems can be used in project management. We did not proposed to find the answer for this question, but we raised further questions and presented some solutions in which theoretical achievements of the study of complex adaptive systems can be applied in risk assessment used in project management. The unexpected situations, taking in account the
particularities of the project management, are quite often present and project team must handle this previously known or unknown state. We have found that the recent developments of the Holonic Multi-Agent Systems can have applicability in risk management of the projects. The way that holons handle the unexpected situations can be a model in project management. The collective imagination, cooperation and the steering without centralisation are strong arguments to test these principles in real projects, in real testbeds. The authors propose, as further work, to evaluate the theoretical findings of this paper.

REFERENCES

Bar-Yam, Y. (1997). Dynamics of Complex Systems, Reading, Mass: Addison-Wesley, Perseus Books, Massachusetts, ISBN: 978-020155748

Boy G.A. (2013): Dealing with the Unexpected in our Complex Socio-Technical World, 12th IFAC Symposium on Analysis, Design, and Evaluation of Human-Machine Systems, August 11-15, 2013. Las Vegas, NV, USA

Holland J. H (2006). Studying Complex Adaptive Systems Journal of Systems Science and Complexity. 19 (1): 1–8. doi:10.1007/s11424-006-0001-z

Hordijk, W., 2013. Autocatalytic sets: from the origin of life to the economy. BioScience 63, 877–881

Muriana, C., Vizzini G., (2017) Project risk management: A deterministic quantitative technique for assessment and mitigation, International Journal of Project Management, Volume 35, Issue 3, April 2017, Pages 320–340

Taleb, N. N. (2010), The Black Swan: the impact of the highly improbable (2nd ed.), London: Penguin, ISBN978-0-14103459-1

Shin, J. & Milkman K.L.(2016). How backup plans can harm goal pursuit: The unexpected downside of being prepared for failure. Organizational Behavior and Human Decision Processes 135 (2016) 1–9,

Valckenaers, P., Van Brussel H.,(2015): Design for the unexpected. From holonic manufacturing systems towards a humane mechatronics society, Butterworth-Heinemann, ISBN: 978-0-12-803662-4, http://doi.org/10.1016/B978-0-12-803662-4.00015-1

Van Brussel, H., Wyns, J., Valckenaers, P., Bongaerts, L., Peeters, P., (1998). Reference architecture for holonic manufacturing systems: PROSA. Computers in Industry. 37, 255–274

PMI, 2013. A Guide to the Project Management Body of Knowledge: (PMBOK® Guide). fifth ed.

PMI, Project Management Institute, NewtownSquare, PA.