Architecture of model parametric space: hierarchy in Simon's Architecture of Complexity

Y.R. Valkman, A.Y. Rykhalsky

The International Research and Training Center of Information Technologies and Systems Cybernetic Centre
40 Prospect Academica Glushkova, Kiev 22, Ukraine

yuri@valkman.kiev.ua

Abstract. *This work is devoted to the analysis of Simon's structure of complexity. The main goal of the study is to use the "near decomposability" principle in the architecture of model parametric space. This is necessitated by the fact that the <M,P> space is intended to represent knowledge of designers and researchers of new complex hardware.*

Keywords

Model, parameter, system, complexity, hierarchy, structure, technology, computer, research, study

1 Introduction

This work represents a continuation of the studies results of which can be found, particularly, in [1]. The general goal of these studies is to develop methods and ways of building knowledge bases for the purpose of modeling complex systems using the apparatus of model parametric (<M,P>) space. The authors discuss the issue of reflecting the structure of complexity of knowledge of designers and researchers modeled in <M,P> space.

2 Simon's structure of complexity

The main peculiarity of complex physical, social, biological, or technical systems per se is the fact that they have a clearly defined hierarchical organization. The occurring structure of multiple parts "nested" inside each other allows to describe these systems from the point of view of different levels (or modules) of organization, which leads to important consequences for the strategies of their study. Since separate parts located inside these levels interact among each other stronger than between the levels, when describing complex systems we may to a certain degree abstract away from their complexity and concentrate on the description of mechanisms of just one or two neighboring levels [2]. Simon calls these systems "nearly completely decomposable" or, to be short, "nearly decomposable" (ND) complex systems.

Everybody knows about Simon's "parable of the two watchmakers" which illustrates the usefulness of the ND principle. One of the watchmakers tries to assemble the watch outright from the tiniest details, which means that any serious malfunctioning of the watch makes him start all over again from the very beginning. The other watchmaker puts together intermediate modules, each of which has certain autonomy, first, and only after that he sets on assembling the whole watch. As a result, any problem sends him back to the certain already sufficiently advanced phase of work.

Structurally, complex systems are not homogeneous. They represent "interrelated islands" of more or less stable formations (modules). It reflects both the principles of self-organization in synergetic systems and certain approaches to the chaos theory. These general considerations lead Simon to the following two fundamental issues.

The first of them deals with the parameters of evolution processes related not to Charles Darwin's natural selection (or Adam Smith's "invisible hand of market") but to organisms and organizations built from the myriad of relatively autonomous and stable "functional blocks".

The second issue is the issue of applicability of logical and mathematical methods of describing complex systems and their behavior. As Simon noted in [3], "complexity of systems can easily exceed possibilities of their modeling using the most powerful computers, both present and future".

3 Architecture of model parametric space

Any model represents a system. Complex system may be represented only by complex system. The complexity of this model reflects in the need to support many models the structure of relations of which reflects the relations between components of the modeled object. The adequacy and stability (quality) of each local model reflects the level of our knowledge about modeled aspect of a designed or studied complex object. Therefore, the <M,P> space was initially built to support multi-model structures. In this case, models may be represented in different forms and formats: frames, products, via semantic networks, cognitive models, statistical polynomials, differential equations, tables, diagrams, on verbal level, etc.

Architecture of <M,P> space ensures that Simon's structure of complexity is reflected in the computer environment. The following levels of "knowledge" can be defined in the hierarchical structure of this space: *parameters, models, <M,P> neighborhoods, methods of calculating different integral and aggregated parameters, characteristics of new complex hardware, appearances (projections) of complex systems*. At the same time, certain <M,P> neighborhoods may become part of other <M,P> neighborhoods thus ensuring recursiveness. Levels of ND architecture of <M,P> space are limited only by the complexity of the problem.

Design and study of complex systems had always been the job of experts in various problem and application fields. Their knowledge represented using different models is integrated in <M,P> space. These models may come in form of generally accepted and tested laws. But <M,P> space may also include the models that only undergo the testing. Therefore, this space is *heterogeneous* from this point of view as well.

It is worth noting that the appearances are built for the purpose of modeling structures of different units, components, and subsystems of complex objects and processes of their functioning and behavior of the object in general in the outside environment.

[4] describers ideology of building hierarchical structures in <M,P> space. The appropriate methods are based on the use of a special model calculation apparatus (algebra and logic of model texts and contexts). We believe that the model located on the top level of hierarchy plays the role of context for the models lying below it. That's how the hierarchical structure of model contexts is formed. For the purpose of this work, context means formal representation of all aspects of adequate interpretation of the appropriate models.

4 Conclusion

Therefore, <M,P> space represents a balanced, interrelated, non-contradictory, integrated system of models of the created and/or studied complex object. The report cites the examples of building hierarchy of Simon's structure of complexity in <M,P> space for specific applications: tests and studies of aircraft, research and design of warships, megapolis development modeling.

References

[1] Рыхальский А. Ю. Модельно-параметрическое пространство – средство систематизации знаний исследователей сложных объектов. // Інститут проблем моделювання в енергетиці. Моделювання та інформаційні технології, Випуск 21 , 2003.

[2] Simon H. A., Ando A. Aggregation of variables in dynamic systems // Econometrica. 1961. Vo1. 29. P. 111-138.

[3] Simon H. A. The science of the artificial. 2d ed. Cambridge, MA: МГГ Ргess, 1996.

[4] Валькман Ю. Р., Рыхальский А. Ю. Иерархические структуры знаний в интеллектуальных системах: тексты и контексты // // Сборник трудов Международной конференции «Интеллектуальный анализ информации». Киев, Издательство «Просвіта», 2008 – с. 122 - 133.