EasyChair Preprint

№ 9424

Hierarchy of Concepts and Models for Creating and Maintaining Software Throughout the Life Cycle

Valery Khranilov, Pavel Misevich, Elena Pankratova and Andry Ermilov

December 7, 2022

Hierarchy of concepts and models for creating and maintaining software throughout the life cycle

ValeryKhranilov[1], PavelMisevich[1],ElenaPankratova[1]and AndreyErmilov[1]

[1] *NNSTU n.a.R.E.Alekseev, Minina 24 str., N.Novgorod 603000, Russia*

Abstract

The article is devoted to the classification of concepts and information models in the light of the construction of automated systems. Hierarchies ofconcepts and models are considered.

Keywords

Automated systems, concept hierarchies, information models

1. Introduction

The field of Automated systems is now being actively developed. It influences all spheres of human life.Moreover, it initiates the development of the theoretical foundations of designing and supporting automated systems during the life cycle. Today we have a set of concepts and models in the scientific field of designing and supporting automated systems. In this paper we analyze the set in order to find the causal factors which ensure the success of using the concepts and models.

It should be noted, that every classification system of concepts and models has a bit of subjectivism.However, the development of classification systems is a well-known research method. The use of the research method often produces good and interesting results.In this paper, the authors describe a classification system of concepts and methods for building and maintaining automated systems.

2. Hierarchy of concepts

In this paper, the authors propose to decompose the set of concepts into three levels. The first or top level (Figure 1) includes concepts that are used for describing the greatest trends in IT field. The concept are the following:

- using artificial intelligence in modern automated systems;
- globalization and integration of IT systems;
- applying the system approach for building modern and complex IT systems [1];
- supporting information and automated systems during their lifecycle [2];
- open systems [3];
- object-oriented approach [4] etc.

GraphiCon 2021: 31th International Conference on Computer Graphics and Vision, September 27-30, 2021, Nizhny Novgorod, Russia
EMAIL: hranilov@nntu.ru (V.P.Khranilov); p_misevich@mail.ru (P.V.Misevich); inyaz@nntu.ru (E.N.Pankratova); aermilov09@mail.ru (A.E.Ermilov)

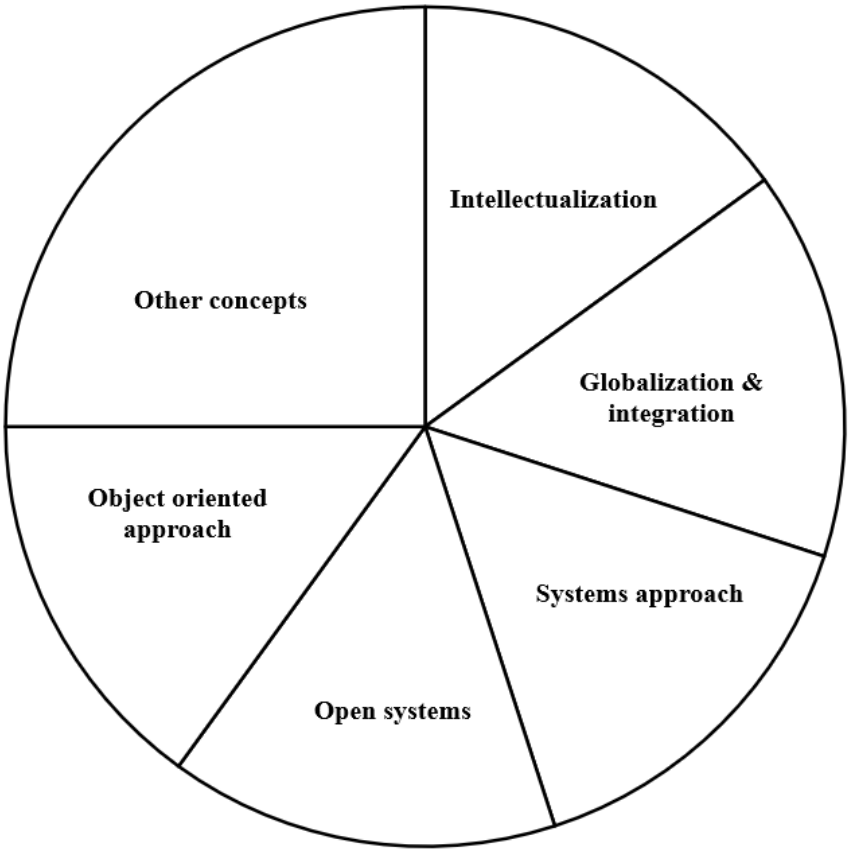

Figure 1: Concepts of the first level of the hierarchy

The second level (Figure 2) includes concepts for supporting the design process of hardware and software systems. The concepts are the following:

- situational approach [5];
- scenario approach [5];
- scenario-situational approach [5];
- logistics approach (every fact, every given in the right format, in the right place and at the right time) [6];
- agent-based approach [7] and etc.

The third or bottom level of the hierarchy consists of concepts that are used to (interpret) as practical guides. There are concepts for designing software and information system. There are concepts for designing software and information systems.

The design of information systems usually is based on a set of concepts. They are the following:

- hierarchies of abstractions (DB scientific fields) [8, 9];
- aggregation [8, 9];
- generalizations [8, 9];
- normalization [8, 9];
- semantic networks (artificial intellect, open systems, etc.) [10];
- frame networks (artificial intellect, CAD, decision support systems etc.) [11, 12];
- multimedia frame networks (remote control and monitoring systems) [13];
- networks of frames with fuzzy logic (monitoring systems etc.) [14].

The design of software is usually based on a set of concepts. They are the following:

- object-oriented programming [4] ;
- procedure-oriented programming [15];
- structured programming [16];
- modular programming [17];
- etc.

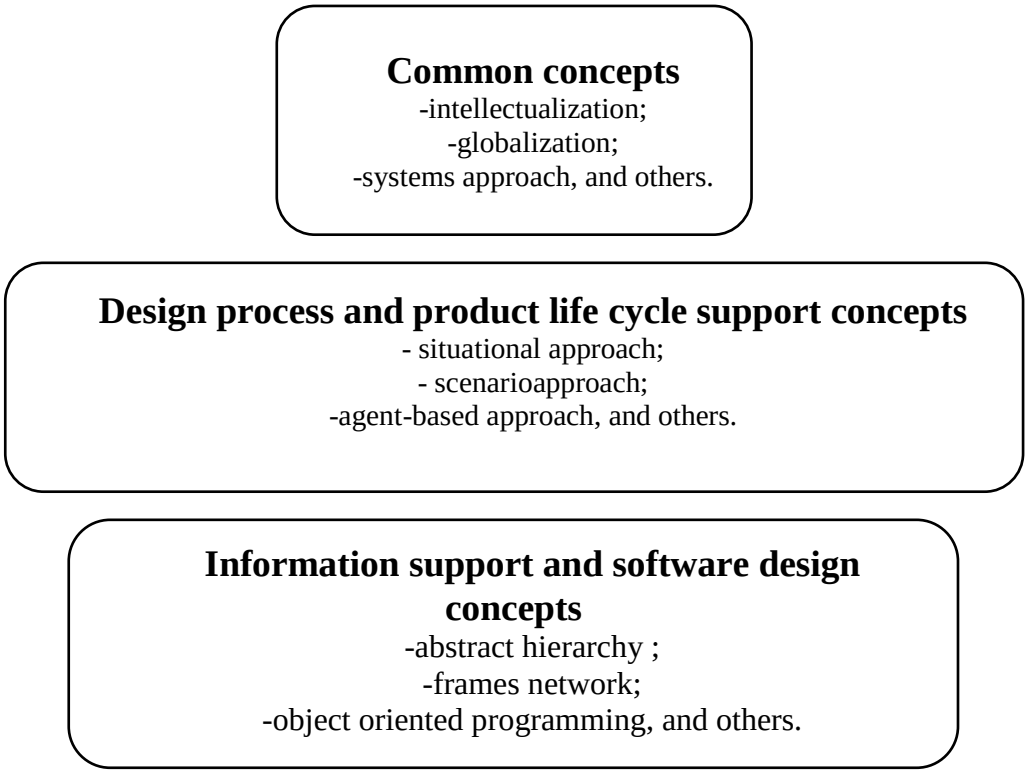

Figure 2: Hierarchy of concepts for designing automated systems

It's imported to note, that the classification criterion is not fully defined yet. For example, the situational approach has to be attributed to the top of the classification system because it is one of the main concepts for building IT systems. The first situational management center appeared in the 1970s. The market segment of this class of systems is actively expanding now. However, the situational approach has also to be attributed to the bottom of the hierarchy because it is actively used for designing automated systems (CAD, systems of remote control and monitoring systems, situational monitoring systems).

The hierarchy of concepts is based on a simple principle. The level of the concept is related to the degree of its universality. If the concept is more universal, then its level is higher and it applies to a larger number of subject areas. Note, that designers of the systems have a lot of freedom when they use high-level concepts. The concepts do not offer specific strategies for designing systems, because high-level concepts are based on the philosophy of developing programs and hardware.

Consider the following example. Let us focus our attention on the concept of using artificial intellect in modern automated systems. There are not certain technologies or specific tools for solving the problem of using artificial intellect in the concept. If a designer develops a modern software or computer system, then he has a problem of choice. The problem consists of choosing an element from a set of alternatives. They are the following:

-to use business intelligence;
-to develop a system of intelligent support for users or business processes;
-to use artificial intelligence data models for building information support;
-to apply different algorithms for logical conclusions;
-to use hybrid knowledge to solve engineering tasks etc.

3. Model hierarchy

Let us analyze the models for supporting and designing automated systems during their life cycle. We have to select two classes.

At the top level (first class), we will place the set of models. They are the following:

- models - descriptions of the processes of design and support of automated systems during the life cycle (cascade model, spiral model, etc.) [18];
- dynamic models of supporting the processes of resources selected for the designing system [19];
- the dynamic model for describing the process of operating scenarios in automated systems [20].

The bottom-level models have engineering orientation. They are the following:
- frame model for describing the design process of objects [12];
- frame model with multimedia frames [13];
- frame model with fuzzy logic procedures [14];
- hybrid frame-production model for the representation design processes of automated systems with multimedia [21];
- hybrid situational models [22] etc.

Thus, if we focus attention on the models for supporting the design process and lifecycle, we can formalize only two levels of the hierarchy (Figure 3).

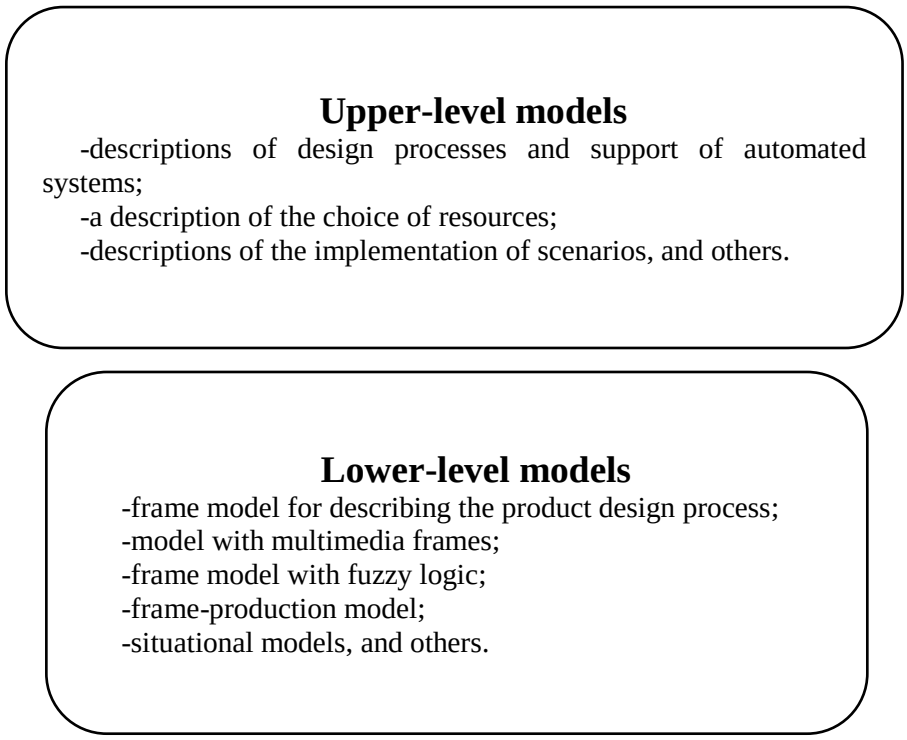

Figure 3: Hierarchy of models describing the design processes and support of automated systems throughout the entire life cycle

Note, that the classification of concepts has three levels, and the classification of models consists of two levels of hierarchy. This fact is determined by tradition: there are three levels of abstraction in the scientific field of design. There are on the top-level cybernetic concepts. At the top level there are cybernetic concepts which are used to describe global processes in the subject area.

At the middle-level there are machine-independent concepts and conceptual models that make possible to implement a project using several alternative platforms (or tool complexes, for example, if one creates DB systems, it possible to use ORACLE, SQL Server or other DBMS).

The lowest level contains machine-oriented concepts and models for supporting the implementation of the project using specific tools such as C#, ADO.NET etc.

4. References

[1] Igor Klimenko: Systems theory and systems analysis. Tutorial. Knorus, 2021.264 p.
[2] Yurchik, Golubkova: Application of CALS technologies at the enterprise. Study Guide / Doe, 2020 - 92 C.
[3] Gulyaev Yu. V., Zhuravlev EE, Oleinikov A. Ya. Methodology of standardization to ensure the interoperability of information systems of a wide class. Radioelectronics, N3, 2012, pp. 1-12.
[4] Booch G. Object-oriented analysis and design with examples of applications 3rd edition, -M .: ID Williams, 2008. - 720 p .: ill.
[5] Pospelov D.A. Situational management: theory and practice. Moscow: Nauka, 1986 .-- 288 p.
[6] Misevich, P.V. Logistic approach to the design of object systems and the formation of scenarios for software operation // Control systems and information technologies. 2007. No 4.1 (30). - S. 169-174.
[7] Russell, Stewart. Artificial Intelligence: A Modern Approach (AIMA) / Stuart Russell, Peter Norvig. - M .: Williams, 2007 .-- 1424 p.
[8] Tiori, T. Designing database structures. In 2 books / T. Tiori, D. Fry - M .: Mir, 1985. 1. - 287 p. Book. 2. - 320 p.
[9] Paklin N.B., Oreshkov V.I. Business Intelligence: From Data to Knowledge. Tutorial. - 2nd ed., Rev. - SPb .: Peter, 2013 .-- 704 p.
[10] Osipov, GS Methods of artificial intelligence / Osipov GS - Moscow: FIZMATLIT, 2011. - 296 p.
[11] Minsky, M. Frames for knowledge representation / M. Minsky. - M: Energy, 1979 .-- 151 p.
[12] Semyonov V.V. The principles of formation and fragments of the knowledge base of control theory, in the collection "General software for computer-aided design systems", Moscow, MAI, 1981.
[13] Belov, D.A. Problem-oriented automated system for monitoring the movement of a railway train / D.A. Belov, P.V. Misevich, V.P. Khranilov // Automation in industry. 2009. No. 2. S.49-51.
[14] Ermilov A.E., Misevich PV Application of a frame model and fuzzy logic in the basis of building tools for automated monitoring systems. // Proceedings of the Nizhny Novgorod State Technical University. R. E. Alekseeva, 2015, No. 1 (108), Nizhegor. state tech. Unt.-N. Novgorod, pp. 71-76.
[15] Boris Oleinikov Programming. procedural programming building: Siberian Federal University 2016 92 p.
[16] 16. Tatiana Pavlovskaya, Yuri Shchupak C / C ++. Structural and Object-Oriented Programming: Workshop SPb .: Peter, 2011. - 352 p.
[17] 17. Titovskaya NV, Titovsky SN Modular programming: textbook. allowance / N.V. Titovskaya; S.N. Titovsky, Krasnoyar. state agrarian un-t. -Krasnoyarsk
[18] Solnitsev, R.I. Automation of design of automatic control systems / R.I. Solnitsev - M., Higher School, 1991. - 335s.
[19] Khranilov, V.P. Fuzzy dynamic model of interactivedistribution of computing resources / V.P. Khranilov, D.V. Prokhorov // Control systems and information technologies. 2006. No. 4.1 (26). S. 189-12020
[20] Misevich, P.V. Dynamic model of functioning of an automated system // Control systems and information technologies, 2008, 3.1 (33). - S. 175-179.
[21] Basalin P.D. Construction of a CAD system based on a frame - production model / P.D. Basalin, P.V. Misevich // Information processing and control systems: interuniversity. Sat. scientific. tr. / N. Novgorod: publishing house of NSTU, 1995.- pp. 106 - 112.
[22] Polevaya OM Mathematical support for the synthesis of the formulations of strategic goals and objectives in the information system for supporting strategic management processes // Information systems and technologies, No. 3, 2016, pp. 81-91.