Chapter 6
Features and Aspects of Functional Modeling

ABSTRACT

The chapter discusses the possibilities for functional modeling of systems and processes, presenting the features of the used tools. It is indicated that this is an important element of the conceptual analysis of behavior performed in system design. The objects of discussion are functional modeling of system resources, study of algorithmic structures and information processes. The first part is based on the understanding that the structure of a computer device or system can be represented as a functional diagram (synchronous or asynchronous network of functional blocks). Functional modeling of algorithmic structures is based on the study of the logical scheme of an algorithm and its transformation into an ordered form. In addition, the application of D-cards proposed by Dijkstra, and discrete and stochastic graph description are presented. The third part deals with functional modeling of information processes and structures and discusses the opportunities of IDEF technology, data flow diagrams, dialog transition networks, generalized net, and UML apparatus.

1. FUNCTIONAL MODELING IN SYSTEM RESOURCE INVESTIGATION

Functional modeling is an important element of the conceptual analysis of the behavior of systems and processes. It is related to the representation of the general architecture (the static structure of the object) and the dynamics of the developing processes, the flows of information objects and the events that occur. In this sense, functional modeling is related to the study of the functional behavior of the object, considering it as a set of actions. It is accepted that this is necessary to ensure that the design process is carried out correctly (McIntire et al., 2016). The formalism in the description of the action implies the definition of basic structural elements (functional blocks) through which the descriptive functional diagram is built. The latter graphically represents the functional behavior of the object through functional blocks connected by pointed arrows. This is especially useful when designing a new object for which many of the features are a process of refinement and development.

DOI: 10.4018/978-1-6684-8947-5.ch006

The main tasks facing functional modeling are in two directions. The first is related to the study of the system computer resource as an interconnected set of hardware components. The second is the functional study of computer processing, i.e., of algorithmic and program components for organization and management of data processing. In essence, these are tasks of system analysis, considering the mutual influence of individual subsystems and devices. As a stage of the design of a system or a technological process, in the functional modeling it is necessary to reflect mainly the significant characteristics and regularities of the behavior, while idealizing others considered secondary. The rationale for this approach lies in the purpose of the research itself – to confirm the correct functionality of the object being developed.

The consideration of two main directions in functional modeling is also confirmed in (McIntire et al., 2016), where a behavioral model and a functional model are defined and an explanation of the relationship between them is given. The behavioral model describes the behavior of specific system components relative to functions in the functional model. On each structural element of the functional flow, a behavior is defined according to the investigated operating modes. A functional model is viewed as a graph in which each functional element is a state machine. The ability to construct a custom functional model with consistent behavior as graphical Python NetworkX description objects is indicated.

To provide a common mechanism and its easy application, a functional modeling framework has been defined (Williams, 2020). Complex systems research and software engineering techniques were used in the development, with the goal being to reflect the full range of important site functions. The goal is to be able to represent even functions for which the implementation mechanisms are not known. The paper discusses the application of the framework for modeling biological functionality that can be assumed to be dynamically stable. This assumption makes it possible to formulate a set of characteristics by which to determine the commonality between functional components in a wide range with other, including non-biological, systems. The discovery of such similarity allows physical and mathematical means to be applied to represent a research model.

The functional study of computer processing is discussed in (Atoum, 2019), where it is specified that successful software development depends on the adequacy and capabilities of the defined requirements. It is emphasized that the latter is a voluminous process, especially for complex software applications, which takes considerable time and can lead to error-prone solutions. In order to overcome this problem, the article proposes "*a scalable operational framework to learn, predict, and recognize requirements defects using semantic similarity models and the Integration Functional Definition methods*". The framework enables automation of the model validation process and ensures better performance of the software engineering solution. The development of IT in the direction of artificial intelligence requires an extension of the notion of functional modeling, which was done in (Rao & Reimherr, 2023) with the introduction of a new class of nonlinear models for functional data. Neural networks have been used, stating that deep learning is also very successful in non-linear modeling. Two variants of a functional neural network framework are proposed – with continuous hidden layers and with base extensions of hidden layers. Both frameworks for oriented cam structures using functional data, with functional gradient based optimization algorithm used for verification.

Structurally, a computer device or system can be represented as a functional diagram built as a synchronous or asynchronous network of basic functional blocks. Each block operates with input and output variables of two types - information and control, which can be represented as Boolean vectors. Blocks can perform: ✓ transfer – input information vectors and output information vectors; ✓ processing / storage – input information and control vectors and output information vectors; ✓ control – input information and control vectors and output control vectors.

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