MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

Sumy State University

Academic and Research Institute of Business, Economics and Management
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____ _____ 2024

QUALIFICATION WORK
towards attaining a Master's Degree

specialty *073 Management*,
(code and title)
educational-professional program *Business Administration*
(educational-professional / educational-scientific) (program)

Topic: Modern Techniques of Business Processes Modeling

_____

Student ___БА.м-22ан___ _____Yuwei Jiang_____
(group code) (surname, name)

The qualification work contains the results of own research. The use of ideas, results and texts of other authors are linked to the corresponding source.

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Supervisor senior lecturer, PhD, Associate Professor Yurii Derevianko _____
(position, academic degree, academic title, Name and SURNAME) (signature)

Sumy – 2024

Ministry of Education and Science of Ukraine
Sumy State University

DEPARTMENT OF ECONOMICS, ENTREPRENEURSHIP AND BUSINESS ADMINISTRATION

APPROVED
Head of the Department
of Economics, Entrepreneurship and
Business Administration
_____Oleksandra Karintseva
“___” _____ 20___ .

ASSIGNMENT
for the qualification work
towards attaining a Master’s Degree

Student of group _БА.м-22ан____, 2 year of study___ARIBiEM_____
(Institute)
Specialty 073 “Management”
Study program 8.073.00.09 “Business Administration”
_____Jiang Yuwei_____
(full name)
Topic of the qualification work: _____
Modern Techniques of Business Processes Modeling_____

Enacted by the SSU order №_____from “___”_____2024.
Date of finalized Thesis submission: “21” June 2024.

Initial data for research:_____
textbooks, monographs, articles, enterprises’ reports_____
_____

Content of the main part of the qualification work (list of questions to be considered) _____
The essence and description of the business process. Basic approaches to modelling in business. Notations for describing business models

List of illustrations (should be presented during the defense)

- Structure of the business process
- Basic characteristics of business processes
- Business analysis techniques used in modeling
- General comparative characteristics of IDEF0, BPMN, EPC notations
- General diagram of business process description using BPMN notation

Date of receiving the assignment: “06” May 2024 .

Master Thesis supervisor _____As. Prof. Yurii Derevianko_____
(academic title, Name, and SURNAME)

Assignment is accepted for completion: “06” May 2024. _____
Student signature

Notes:

1. This assignment constitutes a crucial component of the qualification work required for the attainment of an educational degree and is positioned immediately following its title page.
2. Upon task completion, students are expected to acquaint themselves with the following:

- A calendar schedule delineating the preparation stages of the qualification work, inclusive of specified deadlines for each stage's implementation.
- The procedural guidelines for assessing the qualification work to identify any indications of academic plagiarism.
- The criteria and requirements governing the evaluation of the qualification work, providing a clear understanding of the expectations and standards to be met.

ABSTRACT

for qualification work on the topic:

“Modern Techniques of Business Processes Modeling”

Structure and scope of qualification work. The total volume of the qualification work is 46 pages, including 4 tables, 5 figures, and 22 used references.

The purpose of the work. The purpose of the qualification work is to analyze modern methods and techniques in business analysis at the current stage of economic development and to study their strengths and weaknesses, advantages and disadvantages.

In accordance with the set goal, the following *tasks* were solved:

1) analyze the essence and description of business analysis and its features;

2) investigate the essence and components of the business process;

3) study and describe the main approaches to modeling in business;

4) investigate the essence and role of notations in various business analysis techniques;

5) consider and define the key features of the use of IDEF, BPMN, eEPC notations.

The subject of research theoretical, methodological and practical aspects of applying modern techniques in business analysis.

Object of study – business process analysis models used in business analysis of various types of notations of modern analysis techniques.

In the first chapter "The essence and description of the business process" considered the concept of the business process and the basic components of the business process.

In the second chapter, “Basic approaches to modelling in business” the essence of modeling in business and key types of modeling in business are considered.

In the third chapter, “Notations for describing business models” the essence of notations was studied, and the essence of IDEF, BPMN and eEPC notations was considered in detail.

Based on the results of the research, conclusions are formulated regarding the features of the use of various business analysis techniques at the current stage of economic development, and their strengths and weaknesses, advantages and disadvantages are outlined.

The main scientific result (scientific novelty) of the qualification work consists in a detailed consideration of the most modern techniques in business analysis, their strengths and weaknesses, advantages and disadvantages are outlined.

Keywords: analysis, business process, notation, model, modelling, management.

CONTENT

INTRODUCTION

Actuality of the topic. The relevance of the topic of qualification work is determined by the fact that the most effective way to improve the efficiency of enterprise processes is undoubtedly the automation of business processes. Such modernization of activities allows the company to increase the efficiency of the work performed, minimize the impact of the human factor and, ultimately, bring more profit.

The modernization of business processes provides a certain "transparency" of the company's activities, while the possibility of improving productivity, staff efficiency and the payment process appears. The manageability of the enterprise increases; thus, employees will be able to better understand the tasks and goals of the organization. The company's profit and financial results are affected by the conscious choice of processes to be automated. With the help of modelling business processes, the quality of final products is also improved.

Modern ideas about company management are based on the fact that business needs to be clearly defined, measured, analyzed and improved. Improving business processes is of primary importance for enterprises that wish to remain competitive in the market. Companies are forced to improve their business processes because customers demand better and better products and services.

The subject *of the study* is the theoretical, methodological and practical aspects of the application of modern techniques in business analysis.

The object *of research* is business process analysis models used in business analysis of various types of notations of modern analysis techniques.

The goal of the work. The qualification work aims to analyze modern methods and techniques in business analysis at the current stage of economic development and to study their strengths and weaknesses, advantages and disadvantages.

In accordance with the set goal, the following **tasks** were solved:

1) analyze the essence and description of business analysis and its features;

2) investigate the essence and components of the business process;

3) study and describe the main approaches to modeling in business;

4) investigate the essence and role of notations in various business analysis techniques;

5) consider and define the key features of the use of IDEF, BPMN, eEPC notations.

To solve the tasks in the work, the following methods were used:

— economic analysis, comparison;

— horizontal and vertical analysis;

— the method of analogy - to evaluate the effectiveness of existing business process management methods;

— logical analysis - to study existing in theory and in practice methods of assessing the effectiveness of modern techniques of business analysis;

— graphical and tabular methods.

The total volume of the work is 49 pages, including 4 tables and 5 figures.

Scientific and methodological materials related to the management of business processes of enterprises and organizations were used as an information base when writing the work.

Chapter 1. The essence and description of the business process

1.1 Concept of business process

There are several options for defining the concept of "business process". A business process is a set of interconnected or interacting types of activities that transform inputs into outputs (ISO 9000-2011).

A business process is a sequence of logically connected operations (functions, activities, works), at the output of which some result is formed. Operation (function) - the simplest action, indecomposable into components, at the output of which a certain result is formed.

In a simplified form, a business process is any logical sequence of actions that is regularly repeated and leads to a result that is individual for each type of activity (Fig. 1.1). For example, business processes are: the process of selling goods/services; service process; procurement process for needs; production process; delivery process. Examples of business processes, in addition, can be internal processes of employee interaction - hiring/dismissal, leave, translation, internship, the process of training and retraining of personnel, etc.

The implementation mechanism is directly a process that includes the entire set of operations, events, subprocesses, and other components necessary to obtain a process product. This is a certain sequence of actions that must be performed in order to receive the product.

Inputs are what goes into a process and is transformed into an output.

Output is the result of a business process, a created product, which can be the main (usually one) and auxiliary (there can be several).

Resources are what must be used in order for the process to be completed (software, equipment, raw materials, materials, tools, information, financial resources, etc.). At the same time, people do not belong to resources, but to participants in the business process.

Control flow – documents, information, direct orders that determine how the process is carried out.

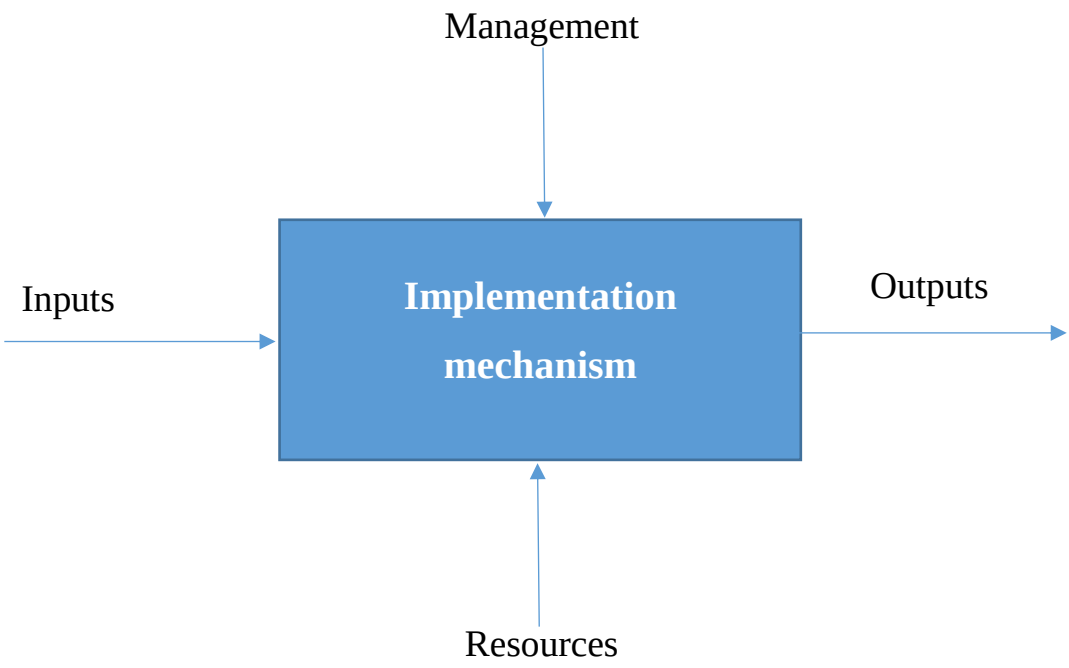


Fig. 1.1 Structure of the business process

A business process can consist of the following elements.

- subprocesses;
- events;
- operations;
- tools and equipment;
- raw materials and materials;
- work streams;
- information flows;
- participants (roles);
- documents;
- databases and software;
- Indexes.

1.2 Components of the business process

Each business process has the following main components:

- *customers* - those who use the product of the process. They can be internal (processes, organizational units and specific people) and external (organizations, groups that are not part of this organization and use the products of its processes);
- *the owner* is the one who is responsible for the process, its products, and the satisfaction of the process's customers. The process owner has the authority to manage the process and change it in order to improve its efficiency, ensure product quality and customer satisfaction;
- *participants* are people, organizational units (organizations) that perform some actions in the process (for example, transfer something within the process or receive from it). Suppliers and clients of the process are also its participants;
- *events* are the fact that an information object (document, e-mail, etc.) related to a business process receives a status (received, sent, entered, etc.), which controls the further course of the business process or affects it. Events transfer control from one function to another and occur as a result of certain actions of process participants. They can be the result of performing functions. Unlike functions that have a certain duration, events take place instantly and are a statement of the fact that happened. When defining an event, it includes the object whose state describes the event and the description of the state itself. The following examples of events can be given: "Order received", "Fax sent", "Goods delivered". Any process always begins and ends with an event;
- process boundaries - events that start and end the process, i.e., determining when it begins and determining conditions under which the process is considered complete. There can be several starter and finish events in the process. For example, the process can start with receiving an order or complaint. To determine where the boundaries of a particular process are, it is necessary to compare the

purpose of the process with the possibilities of influencing it in cases where it exceeds the boundaries of the organization. If there is an opportunity to coordinate the process with suppliers/consumers and to influence the course of the process outside the organization, then the boundary of the process goes beyond its boundaries. Process boundaries set the boundaries of responsibility for outcomes.

The business process necessarily takes place with the participation of a person (in an explicit or implicit form). If the actions are performed by an automatic system or program, it is a business process. A business process should always have a description (model) ("Process Modeling" technique). The description must be detailed and can be presented in graphic and (or) textual form for the purpose of regulation, further analysis and its optimization, i.e. to improve the business process itself. When describing business processes, emphasis is often placed on information (used documents, reports), which is necessary for the implementation of any process action or is the result of its implementation. This is important for its analysis, optimization and automation. In addition, the description is the basis for designing the business process of the interface.

According to one of the classifications, **three types of business processes are distinguished** (Table 1.1).

The business process has three *main characteristics* - cost, duration, level of consumer satisfaction (Table 1.2).

There is a difference between a business process and a technological process, despite the fact that they are sometimes presented as identical processes. *A technological process* is a part of the production process that contains purposeful actions to change and (or) determine the state of the subject of work.

Unlike a business process, the "presence" of people in it is not necessary. Almost any technological process is a part of a more complex process and at the same time a collection of simple technological processes (technological operations). ***A technological operation*** is the smallest part of a technological process that has all its properties. It is often performed by one employee at one workplace.

Table 1.1 Types of Business Processes

Managers (management)	Operational	Supporting
Processes related to system operation management - risk management, strategic management, corporate management	Processes related to sales, marketing, service, supply, production, other business processes that determine the main activity of the organization	Processes related to the support of the organization's activities - accounting, recruitment and work with personnel, administrative part, technical support, etc.

Table 1.2 Basic characteristics of business processes

Duration	Cost	satisfaction
The faster the process, the higher the productivity of the organization. At the same time, the quality of the result should not decrease due to the reduction of time. Various technical and IT resources capable of speeding up business are used to shorten the process execution time	The cost of performing a business process should always strive for minimal indicators. This approach applies both to the production process and to the provision of services. An organization that optimizes and reduces cost has more profit and therefore, grows faster	The result of a business process is a product. The success of the organization and customer loyalty largely depends on the quality of the final result. It is important to collect feedback from customers to improve processes, as well as to conduct your own quality control

The following types of technological processes are distinguished:

• single technological process - a technological process of manufacturing or repairing a product of the same name, regardless of the type of production;

- typical technological process - the technological process of manufacturing a group of products with common structural and technological characteristics;
- group technological process — a technological process of manufacturing a group of products with different structural but common technological features.

The technological process involves a clearly regulated sequence of actions determined by standards or technical conditions. And if it would be more useful for the business to change the established sequence, then it is very difficult to change the technological process (for example, you cannot first polish a part and then grind it). Doesn't mean technology can't be changed. It changes relatively rarely, and its changes must go through certain regulated procedures, such as certification, etc. Business processes, on the other hand, can change as often as business conditions require. At the same time, the search for new solutions contributes to increasing their effectiveness.

A business process is a broader concept than a technical process. Technological processes are often considered as an integral part of business processes, but they are not directly related to customers. However, in any definition of a business process, the customer and the added value of the output product are mentioned in one way or another. For example, the customer will not want to receive a part of a certain size and shape instead of another, of a smaller size and a changed shape, but if the ordered part is delivered without waiting and installed immediately, he will be satisfied.

Chapter 2. Basic approaches to modeling in business

2.1 The essence of modeling in business

The more clearly the information is presented and transmitted, the faster and more accurately it will be perceived by the person for whom it is intended.

Currently, there is practically no field of human activity where modeling is not applied. In business analysis, it is used very widely, since a significant amount of work falls on working with interested parties, and modeling allows you to visualize and present the necessary information to them more clearly and clearly. In addition, many works are related to the description of business processes in order to improve them. Some types of models developed in different notations are usually used to describe business processes.

> **Notation** - Description format, system of conventional signs (graphic objects) and rules for their use to describe various categories of the modeled system, such as objects, processes, relationships, etc. There are many different notations. The main reason for such diversity is that one notation cannot solve all tasks for describing business processes at once, and the use of each of them is convenient in one case or another.

The concept of "model" in science and technology is not clearly defined, therefore there is no single classification of types of modeling. Classification can be carried out according to the nature of the models, the nature of the objects being modeled, the areas of application of modeling, etc. Next, several classification options will be considered.

A model is a physical or symbolic system that has an objective similarity with the studied system, which is the subject of research. This is a conventional image of the research object, designed to simplify it. In the process of research, it replaces the original object, preserving its specific features that are important for

this research. Therefore, by the properties of the model, we can judge not about all the properties of the object, but only about those that are similar both in the model and in the object. To build any model, abstraction is needed and any language can be used — natural, algorithmic, graphical, mathematical.

Practice shows that the best means of determining the properties of an object is a natural experiment, i.e., study of the properties and behavior of the object itself under the necessary conditions. However, in many cases, a full-scale experiment is impossible. For example, it is impossible to: conduct an experiment with the past; to test new drugs, because at the initial stage it can be dangerous for a person's life; conduct an experiment with the elements of space stations, which can also cause the death of people, etc.

In ***business analysis, a model*** is a descriptive and visual way of communicating information to specific stakeholders for analysis, communication support, and understanding. Models cover many aspects of business analysis and allow:

- describe groups of interested parties, their roles, relationships between them within the organization, as well as their relationships in relation to the solution;
- show justification of the reasons for the changes;
- characterize business processes, flows of sequence of actions;
- characterize the available opportunity in relation to the decision or the organization in general;
- present the characteristics of information and its flows within the organization or solution.

Modeling is the process of creating a model of some phenomenon in the form of its conceptual representation and further research of the object of knowledge. It allows a better understanding of phenomena, and also helps to predict phenomena of interest to researchers. Usually, the models reflect only some aspects of the analyzed phenomenon, therefore, for example, two models of the same phenomenon can differ significantly from each other. Such differences may

be due to different requirements of end users of this model, conceptual preferences of model creators, goals of model creation, decisions made during modeling, etc.

Modeling formats in business analysis are matrices and diagrams. Modeling is characterized by the use of certain techniques (Table 2.1), which allow you to get an idea of the subject area from different angles. Any combination of these techniques when conducting a business analysis can be any, while they should ensure the satisfaction of stakeholders' needs as best as possible.

Table 2.1 Business analysis techniques used in modeling

People/roles	Justification	Activity streams	Opportunities	Data and information
Matrix of roles and rights Organizational modeling. Map of interested parties parties	Canvas business models. Modeling solutions Modeling borders. Root cause analysis (Ishikawa model). Analysis business rules	Process modeling. Use cases and scenarios. Custom stories	Analysis of opportunities business Functional decomposition. Prototyping	Data dictionary. Data flow diagrams. Data modeling. Glossary. State modeling. Analysis of interfaces

In general, the modeling process consists of several stages. The division into stages mainly depends on the level of detail. So, a less detailed approach involves the allocation of the following stages:

- The first stage of model building involves *obtaining some knowledge about the original object.* The model should be constructed on the basis of a deep study of the essence of the process. Only in this case the model is adequate to the economic process and will objectively reflect it. Ensuring the necessary and sufficient similarity of the original and the model is decided depending on the research objectives. The model loses its meaning both in the case of identity with

the original (in which case it ceases to be a model), and in the case of a significant deviation from the original in all essential aspects.

- At the second stage, the model is an independent object with which *research is being conducted*. The end result of this step is knowledge about the model.
- At the third stage *transfer of knowledge from the model to the original is carried out* - the formation of a lot of knowledge. At the same time, knowledge about the model must be adjusted taking into account those properties of the original object that are not displayed or were changed during the construction of the model.
- The fourth stage is *the practical verification of the knowledge obtained with the help of the model and its further use*, for example, to change or manage the original object.

Modeling is a cyclical process, which assumes that the first considered cycle can be followed by a second, third, etc. Knowledge about the object under investigation will be expanded and refined, and the original model can be gradually improved. Deficiencies discovered after the first cycle of modeling, due to insufficient knowledge of the object or errors in the construction of the model, can be corrected in subsequent cycles.

Depending on the range of problems, modeling can have different orientations. If you include everyone involved in this process in the model, then such redundancy can significantly complicate the model, so modeling is divided by species. The division by types allows to simplify the model, to focus attention on some characteristics of the process. Different types of modeling can be used for the same business process, and the models will differ accordingly. Different types of models allow you to work with it independently of each other.

Different modeling languages are used to describe models. **A modeling language** is any artificial language that can be used to express information, knowledge, or a system in a structure defined by an agreed set of rules. The

modeling language can be graphical or textual. Their difference lies mainly in the purpose.

Graphical modeling languages (business modeling languages) use the technique of diagrams and are represented by different notations. Business modeling languages consider the sequence of actions (process) precisely from the point of view of business. They may include the work of employees, movement of products, IT systems, etc. That is, they directly cover the work of the business as such as much as possible, and it is not always possible to describe the aspects of algorithmization of systems and their automation in them with a sufficient degree of detail. An example of such a language is BPMN. This notation is intended to describe the subject area of business and is not a language for describing IT systems. At the same time, both software systems and interested parties (employees, customers, suppliers) can be involved in the formation of models using BPMN. This is the main difference between this notation and graphical tools for describing programs.

Text modeling (design) languages can use standardized keywords accompanied by parameters or natural language terms and phrases to create computer-interpretable expressions.

Design languages of IT systems consider business processes from the point of view of the possibility of their automation. They do not have elements that allow to fully describe the actions of employees, units, their interaction with each other, work with customers and suppliers, etc. The tools of this group of languages allow you to automate those business processes that are possible. All other processes will not be considered. An example of IT system design languages is the UML language family.

2.2 Types of modelling in business

There are several options for classifying modelling. One of them is the selection of such types of modelling of business processes (approaches) as structural, object-oriented (object) and integrated.

Structural modeling is an area of systems analysis, modeling used for research and development of systems. It reflects (and allows you to study) the structure of the system from the composition of elements and subsystems and the relationships between them (structure), and even from the properties of the system that allow you to achieve a given goal (function). Models are schemes (block diagrams), graphs, drawings, diagrams, tables, drawings. Such modeling has several subtypes: functional modeling, simulation modeling, information modeling.

Functional modeling involves a hierarchical, sequential description of processes as interdependent, clearly structured business functions, actions, operations. That is, it is a diagram of a business process, presented in the form of a sequence of its business functions, in relation to material and informational objects, used resources, organizational units, etc. At the same time, it is not necessary to adhere to the strict temporal sequence of these functions in the form in which it exists in real processes. The advantage of the functional approach is the logic of operations, and the disadvantage is subjectivity in their detailing. It is convenient to use the IDEF0 notation for building functional models. In addition, notations of Gane-Sarson (Gane/Sarson), Jordan-De Marko (Yourdon/DeMarko), IDEF3, eEPC, BPMN can be used.

Simulation modeling (behavior modeling) - This is a representation of the behavior of the system over time, a description of the behavior of business processes in various internal and external conditions with an analysis of the distribution of resources and dynamic characteristics of processes. Simulation models allow you to evaluate how the process will be performed with input data that have not yet been encountered in the real work of the organization. For this type of modeling, you can use CPN (color Petri nets), IDEF3 (OSTN), GPSS, SIMAN notations.

Information modeling. An information model is a description of an object as a text in some coding language, containing all the necessary information about the object, i.e. various information aspects such as signs, symbols, words, theoretical (abstract) constructions, theories, studies, tables, algorithms are used to describe the object. Examples of an information model can be a geographic map, a library catalog, a diagram of bus routes, any drawing or mathematical formula, etc. This type of modeling is also used in building modeling (from the English Building Information Modeling (BIM), building information modeling) - the development of a model of a building (structure), in which each stage corresponds to a certain model that reflects the amount of currently processed information (economic, design), architectural, technological) about the building or structure. ERD, P. Chena, Barker, IE, IDEF1 and IDEF1X notations can be used for description.

Object modeling. This type of modeling involves the description of processes as a set of interacting objects (production units), without detailing the performed operations, but with a description of conditions and events. First, the objects are selected, then the actions in which they participate are determined. Objects can be specific objects or entities: client, order, service, and others. An object is characterized by a set of attributes that determine its state, and a set of operations to check it and change it. Objects can be passive (objects on which actions are performed — equipment, materials, documents) and active (objects that perform actions — specific performers, organizational units, software). That is, the static structure of the model is described by the objects, and the behavior of the model is the messages exchanged between the objects. This type of modeling makes it possible to more objectively distinguish operations performed on objects and to understand the expediency of using certain objects. The disadvantage is less visibility of the analyzed business processes. The notation used is UML.

Integrated modeling combines different types of models - structural analysis models, object models, simulation models, etc. This is a collection of several different models, each of which describes separate structures of the modeled

object, and together they form a complete and comprehensive picture of it. The notation used is eEPC.

Another variant of the classification provides for the selection of three main approaches depending on the principle of operation:

- functional;
- procedural;
- mental (using mental cards). Let's consider the main characteristics of these models.

Process modeling (modeling of business processes). A process from the point of view of a business model is a sequence of any events, actions that must be performed in order to obtain a certain result. It has a beginning and an end point.

The main difference between process modeling and functional modeling is that functional modeling considers the business model from the point of view of input and output (existing resources and the desired result), while process modeling is based on a sequence of actions within certain limits. In process modeling, the main focus is on what we want to get, on what needs to be done to get the result, i.e. not the results of one or another activity, but the very sequence of actions. All processes can be broken down into sub-processes down to the level of tasks, i.e. actions, further detailing of which is impossible. In the business model as a process, the result may be implicit, unlike the functional model.

Another important difference between a functional model and a process model is its purpose. Yes, the functional model can be used only for the design of the system as a whole, and not for its implementation. The process approach allows you to create "executed" models, i.e. description of the sequence of actions before creating the system.

Despite the differences, the functional and process approach to modeling are interrelated. As a result of detailing each function, there is a transition from a functional approach to a process approach. That is, the consideration of the model begins with the view of opportunities and the desired result, and when moving to the decisions of each function, a process approach is needed, i.e. a step-by-step

algorithm of actions to achieve a result. For example, a function model has a Get Order function. When decomposing, this position is considered not as a function, but as a process, and the sequence of actions upon receiving an order is a process approach.

The BPMN notation is the most commonly used (one might say, the standard for process modeling). However, these models can be constructed using almost any notation.

Mental approach (mental maps). When creating mental models, modeling is approached not as a process or a set of functions, but as a set of interrelated concepts. This type of approach is most often used at the initial stage to understand the received information and systematize it in a free form. In addition, mental maps help to find a solution that will be further implemented according to stricter rules for building process or functional models.

Mind maps are convenient for interaction with interested parties, because they are simple and visual: they do not use special languages, there are no strict frameworks and restrictions when creating a scheme, in most cases, this map is intuitive and easy to create. At the same time, the lack of a standardized methodology is also a disadvantage. To understand the model, comments from its developer are often needed, and there is a possibility of different readings, which should not be the case when describing business processes, since unambiguous decisions are important.

The main **principles of modeling business processes** are:

1. *The principle of decomposition*. Each process can be represented by a set of hierarchically constructed elements. That is, the process must be detailed into its elements.

2. *The principle of focus*. To develop a model, it is necessary to focus on key aspects and abstract from many other parameters of the process. Each model may have its own key aspects.

3. *Principle of documentation*. The elements included in the process must be fixed in the model in a formalized form. Each element has its own designation. Fixation of elements in the model depends on the type of modeling and the notation used.

4. *The principle of non-contradiction.* All elements included in the model should not contradict each other, should have an unambiguous understanding and interpretation.

5. *The principle of completeness and sufficiency*. The model should include those elements that have an impact on the entire process. If the effect of an element is small, it should not be included in the model, because it will unnecessarily complicate it.

In general, the advantages of developing business models can be considered:

- high-quality transmission of information. When transmitting information about a business process, you can use a mental approach, but the standards and rules of development languages help, due to their universality, to increase the ease of perception when transmitting information, and therefore, the quality;
- increasing the speed of processing models. Languages (notations) contain all the necessary tools and graphic blocks for describing a business process;
- reducing the number of errors during model development. The existing elements of the system already contain a list of necessary and possible actions;
- convenience in identifying problems of business processes and "bottlenecks", since an understanding of all stages of the process appears;
- convenience when interacting with interested parties and reducing the time for them to understand information related to the description of processes. For example, often ordinary text or speech is not enough to describe a business process, because the business process is complex, and the use of visual business

models allows you to quickly understand a particular business process and options for its improvement;

• the possibility of using the business model by technical specialists if it is necessary to automate this process, to create an automated business management system. A business process model built in one of the modeling languages can be used as a guide for the further design of IT systems.

As mentioned, a special language — modeling notation — is used to describe business processes as visual models. The methodology (notation) of creating a model (description) of a business process is understood as a set of ways in which objects of the real world and the connection between them are represented as models. Each object and relationship is characterized by a number of parameters or attributes that reflect certain characteristics of a real object (object number, name, description, duration of execution (for functions), cost, etc.). That is, notations consist of designations of various component processes and rules for their use. The main methodologies (notations) for describing business processes are ARIS, DFD, IDEF0, IDEF3, BPMN, eEPC, FlowChart, etc.

To describe complex business processes with different levels of nesting (decomposition), it is advisable to use several notations. For example, the IDEF0 notation should be used to describe high-level processes (it displays the structure and functions of the system, uses information flows and material objects), the FlowChart, eEPC notations should be used to model the procedures of the lower operational level. Regardless of the business process description methodologies used, the main thing is to get a complete understanding of the business process.

Chapter 3. Notations for describing business models

3.1 The essence of notations. IDEF notation

Notation is a specialized graphic language that allows you to visually describe business processes, the organization's activities, and the interaction between different departments. Notations can be used for process or functional modeling. In business analysis, they can be called a programming language.

The first IDEF0 notation was developed in 1981 by the US Department of the Air Force for the automation and optimization of industrial enterprises producing military products.

The second notation - EPC (*Event-driven Process Chain)*, appeared 10 years later. In accordance with its name, "chain of event processes" the emphasis is on the event itself.

The BPMN notation is part of the BPM (business process management) concept. It was created in 2004 (version 1.0) and has been modernized several times.

In general, the characteristics of these notations are presented in the table. 3.1.

Let's consider the given notations in more detail.

IDEF notation. IDEF (I-CAM DEFinition or Integrated DEFinition) is a methodology of the ICAM (*Integrated Computer-Aided Manufacturing*) family for functional modeling of complex systems. They allow displaying and analyzing activity patterns of a wide range of complex systems from different perspectives. The IDEF methodology includes the following private modeling methodologies for graphical representation of systems:

- IDEF0 - notation for describing the functional model. The model allows you to display the structure and functions of the system, information flows and material objects transformed by its functions (for example, a description of the

top level of the business process). This notation is one of the world's recognized modeling standards;

Table 3.1. General comparative characteristics of IDEF0, BPMN, EPC notations

Characteristics of the notation	IDEF0	BPMN	EPC
Allows to display	The structure and functions of the system	Work flow, action algorithm	Flow of events and functions
Basic elements	Rectangles (functions, processes), arrows (flows)	Objects, events (initial, final, intermediate), rectangles (actions in the process), arrows (flows), gateways	Events (initial, final), functions, flows (material, documentary), participants, performers
Level of use	Upper level	Usually for modeling the lower levels of the process, for decomposition	For modeling the lower levels of the process, for decomposition
Can be decomposed in notations	IDEF0, BPMN, EPC	BPMN, EPC	BPMN, EPC

- IDEF1 — notation for building an information model, for displaying the structure and content of information flows within the system, which are necessary to support its functions;
- IDEF2 - building a dynamic model of information, system resources, behavior of functions that change over time. Since the analysis of dynamic systems poses significant difficulties, this standard has now been practically abandoned;
- IDEF3 - the notation is intended for documenting the processes taking place in the system (for example, for the study of technological processes in the organization). The notation allows you to describe the scenario and sequence of operations for each process. IDEF3 is directly interconnected with IDEF0 - each functional block can be represented as a separate process using IDEF3;

- IDEF4 - the notation is convenient for modeling object-oriented systems for the purpose of their analysis and optimization. It allows you to visualize the structure of objects and the principles of their interaction with each other;
- IDEF5 - Ontological study of complex systems. The ontology of the system can be described taking into account a special dictionary of rules and terms, which allows for a certain time to form reliable statements about the state of the analyzed system. The conclusions formed on the basis of the statements made allow judging the further development of the system and its optimization.

IDEF0 is a notation intended for formalization and description of business processes. Modeling with IDEF0 is the first stage of studying any system and its structure. A characteristic feature of IDEF0 is its emphasis on the subordination of objects. The IDEF0 standard considers logical relationships between jobs, and not their temporal sequence (work flow). The model is intended to define the boundaries of the process, including indicating the problems that may be discovered during its analysis. The main advantage of IDEF0 is the ability to focus on how a process or function interacts with its environment.

The IDEF0 notation is a fairly strict methodology, originally developed, like technical design standards, for manual modeling. Therefore, it includes requirements for the placement of arrows, the format of all elements, the content of the information frame, etc. Features of the IDEF0 language are also the use of the natural language of experts (interested parties) as a basis and its structuring using graphical means. This enables the interested party to easily describe the functioning of the system using familiar and convenient terminology, and the business analyst (model developer) to easily "transfer" the description in natural language to a graphical representation of the IDEF0 language.

An IDEF0 model is a collection of functional blocks (a set of hierarchically related diagrams representing a process or activity), each of which is a "black box" with inputs and outputs, as well as controls and mechanisms, which are detailed

(decomposed) to the required equal. This model allows you to describe all the main types of processes: administrative and organizational.

Thus, the features of the IDEF0 model are:

- subcontracting of objects;
- use of context diagram;
- support for decomposition;
- dominance;
- mandatory presence of interface arcs that control.

The IDEF0 model unfolds simultaneously to the left and from top to bottom, diagonally. The most important functions (block, process) are located in the upper left corner, which dominate the rest (give more influence). Dominant objects can include dependent objects (for example, order delivery is an element that is part of a larger order management process). Dominant objects can also be preliminary stages for dependent ones: receiving an application - agreeing an application. There should be no less than three and no more than six to seven blocks on the diagram. This limitation keeps the complexity of the diagram at a level that is easy to read, understand, and use.

In a functional block, each side has a certain purpose: the left side is for inputs, the right side is for outputs, the upper side is for control, and the lower side is for mechanisms. This reflects system principles: inputs are transformed into outputs, mechanisms show how and what a function does, and control dictates or limits the conditions under which transformations are performed.

Functions are interconnected by arrows and descriptions of functional blocks. Each type of arrow (or activity) has a meaning. Interface arcs (flows, arrows) display various objects that determine the processes occurring in the system. The interface arc shows the element of the system that is processed by the function block or otherwise affects the function displayed in the given block. Such objects can be various elements of the process - machines, parts, workers, information, data flows, etc. The model can have the following types of arrows:

1. Input - arrows that set a certain task. A job can have no entry arrow. The entry arrow is depicted as entering the left face of the work.

2. Output - arrows characterizing the result of the process. Each job must have at least one exit arrow.

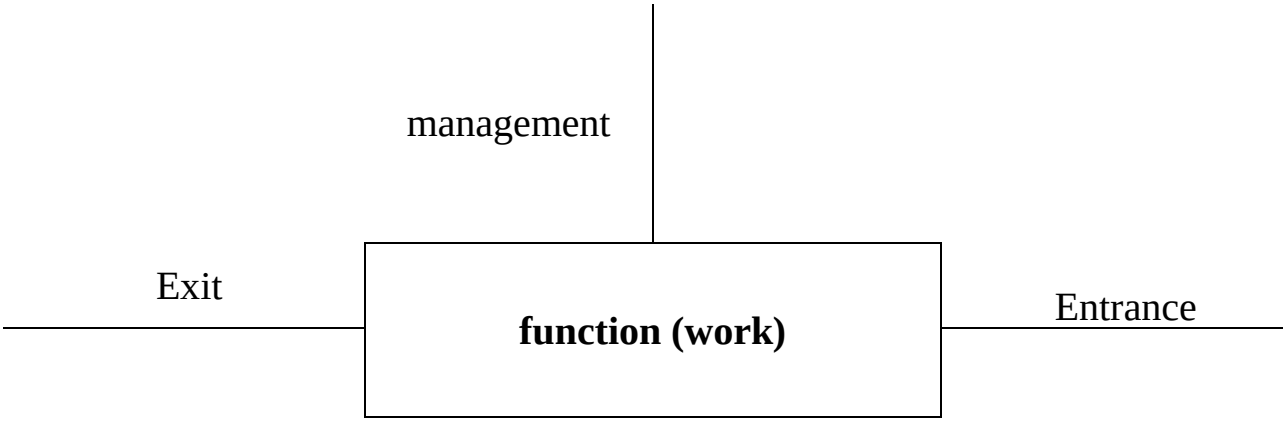
3. Management (from top to bottom) - information that controls work actions (regulations, instructions, etc.). These arrows define the conditions required by the process to make the correct exit, ie. the control arrows carry information that indicates what the function is supposed to do. Each job must have at least one control arrow.

4. Mechanism (from bottom to top) — resources that perform work. They use it to perform the necessary work. Arrows identify the means that support the execution of the process. At the discretion of the model developer, these arrows may not appear on the model.

5. Call - a special arrow that indicates that some work is done outside the system being modeled. The call arrows draw the original from the bottom of the work.

Arrows are signed with nouns (work, plan, rules), and blocks with verbs, i.e. they describe actions (for example, conclude a contract, create a product, make a shipment).

The principle of building a process model is presented in fig. 3.1.



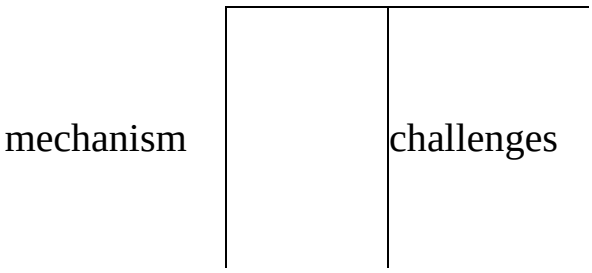


Fig. 3.1 The principle of IDEF0 model construction

Thus, in general, the main requirements of the **IDEF0 standard when building a model** can be imagined as follows:

1. The main element is always located in the upper left corner.

2. All elements of the model must have arrows (input and/or output), because in order to perform the process, you need to receive something at the input (task, order), and after processing at the output, you need to transfer the finished product. Output arrows are always located to the right, input to the left of the block.

3. The control elements are shown on top, and the mechanisms necessary for the process are shown on the bottom.

4. If one letter has several blocks, each subsequent one is located to the right and below the previous one.

5. It is necessary to strive to create schemes in such a way that the intersection of arrows is minimal, but sufficient.

6. A functional block can be decomposed and presented separately as a set of other interconnected blocks that describe the source block in detail.

Building the IDEF0 model always begins with the representation of the system as a whole, i.e. from the construction of a context diagram (one functional block with interface arcs), which is denoted by A-0 (A minus zero). The context diagram belongs to the category of diagrams that describe the system only at the "black box" level (ie. only the external properties, and not the content of the system). This diagram allows you to define the boundaries of the simulation. It shows only one block (Fig. 3.2).

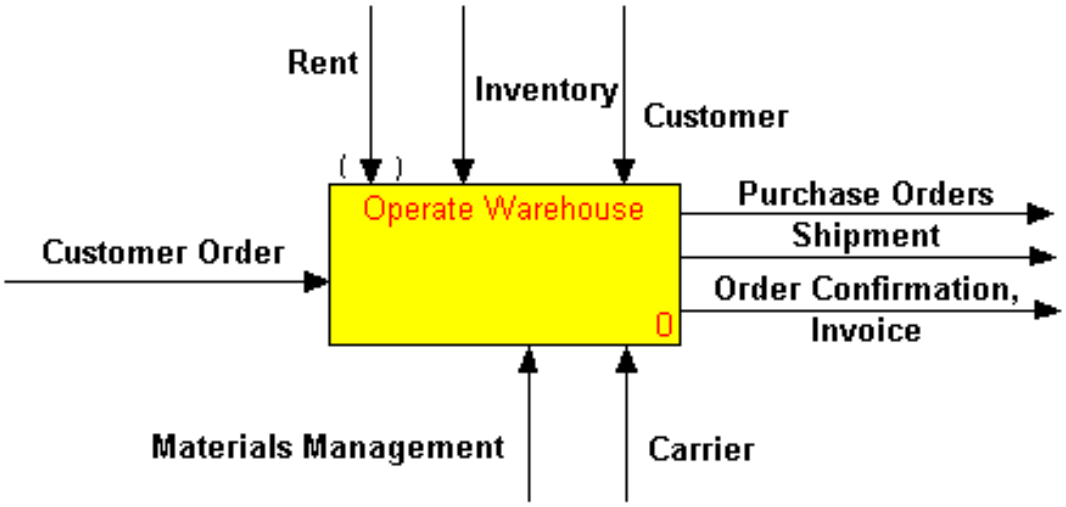


Fig. 3.2 Example of a context diagram

The main purpose of the context diagram is to identify the main function (task) before the execution of the business process. In addition, the main characteristics of the entire model are displayed on the context diagram:

1. Purpose - a specific formulation, a brief description of the purpose of the model for further verification of the accuracy of the model construction.

2. Position — determination of the main direction of model development and the level of necessary detail. The correct description of the view allows you to significantly reduce the time spent on building the final model, to "unload" it, avoiding excessive detailing of those elements that are necessary for this system. It is formulated on behalf of the model developer (or key stakeholder) and depends on the focus of attention. For example, if a general model of the organization is being built, it is often presented from the point of view of its director. The point of view is most important when forming a common view of the task to be solved: what and in what quantity will be needed, what will be obtained at the exit, who is involved in this business process, what documents are needed to solve this task.

3. Model type - an indication of exactly what information is displayed in it "as is" ("as it is") or "to be" ("as it should be"). This division is necessary because the model can be built both for the analysis of current activity and its changes.

A context diagram does not give a complete view of the process, only a "general view". Then, to describe the process in more detail, this diagram must be decomposed.

To *typical errors of the functional approach IDEF0* can be attributed to modeling that:

- models are created with the help of various tools, including those not designed for modeling, while checking for errors and limitations of the standard is not carried out;
- different colors are used (the most common mistake). The use of multi-colored arrows and blocks introduces confusion and distorts the perception of the scheme. The use of color is necessary in mental modeling, which is not standardized;
- the most significant elements of the model are highlighted. There are no more or less important elements in functional modeling. In the diagram, they are equally important, because if any one of them is taken away, the whole process will be disturbed;
- too many blocks are used, reflecting all the details of the organization's work. This unnecessarily complicates the model and reduces its readability. The best option is detail sufficient to understand the issue;
- the structure of the process is violated and the symbols described in the standard for building the model are used incorrectly. All elements should have input and output arrows, other important attributes. It should have elements that are of significant importance to the model. For example, if the client does not directly affect the process of obtaining a result described in the model, then it should not include elements related to him. Conversely, adding an important element to a model causes all of its necessary attributes to be included.

Positive aspects of using IDEF0 is:

- clarity and ease of identifying "bottlenecks". The standard is universal and convenient for designing at the upper level;

- high speed of model creation with a sufficient level of mastery of this standard;
- absence of errors. The IDEF0 standard has strict frameworks and rules for building models;
- possible exchange of information between developers and interested parties (consultants, users, etc.);
- the possibility of use in project management, when it is necessary to connect different projects or processes with visual flows.

The *disadvantages of notation* include:

- applicability only for the upper level of modeling;
- limitation on the number of elements (6-7), which forces excessive "fragmentation" of schemes;
- the fact that the notation was created a long time ago and has not been developed, so some developers believe that it is functionally obsolete;
- the fact that it does not contain specification of process start and stop events, conditions of transition from one action to another;
- lack of ability to visually display all resources and performers without overloading the scheme with arrows;
- the lack of an opportunity to reflect the reaction of process participants to events in the external environment, which does not allow assessing the risks associated with changes in the external environment.

3.2 BPMN notation

BPMN notation. The "BPM" part of this acronym has two interpretations: Business Process Modeling and Business Process Management. The first reflects the direct modeling of the business process, and the second - the management of business processes, i.e. it is a general system of which Business Process Modeling is a part. There is another abbreviation - BPMS (Business Process Modeling System) - a description of management systems in which business processes are

modeled and executed. It is convenient to use for decomposition, description of the lower levels of business processes, when it is necessary to show the actions of process participants.

BPMN (Business Process Model and Notation) is one of the most common and best business process modeling languages. It is standard for creating models in the field of business management. The BPMS 2.0 notation, developed by the Object Management Group, formed the basis of the ISO/IEC 19510:2013 international business process modeling standard. It is one of the few globally accepted modeling standards.

The BPMN notation is intended to describe:

- order of performance of works forming a business process;
- data flows between process operations;
- message flows between processes;
- associations of processed data objects with process operations.

At the same time, it does not allow modeling such aspects of the business process model as:

- organizational structure of the business entity;
- functional (structural) decomposition of works;
- data model;
- business rules;
- business strategies of the organization.

The BPMN notation is based on the Workflow methodology. Not only the structure of the process, its functions, but also the algorithm, a clear sequence of actions performed by specific participants.

Conventional designations of this notation are presented in the form of diagrams and block diagrams, so even a non-specialist can build a business process using the elements and rules used in it (see appendix 4 of the textbook). The following basic graphic categories of elements that determine the course of a business process are used as designations in BPMN:

1. Flow Objects (Flow Objects).

- events (Events);
- activities (Activities),
- Gateways.

2. Data (data objects and databases):

- data object (Data Objects),
- data inputs (Data Inputs),
- data outputs (Data Outputs),
- data stores (Data Stores).

3. Connecting Objects (Connecting Objects) that connect with each other and other elements:

- flow of operations (Sequence Flow),
- message flow (Message Flow),
- association (Association),
- data association (Data Association),

4. Areas of responsibility (Swimlanes)

- Pool
- lane (Lane) ("swimming lane"),

5. Artifacts – footnotes for adding additional information about the described process. Any number of artifacts can be used, but two typical types are usually used:

- group (Group)
- text annotation (Text Annotation).

The general diagram of the description of the business process using the BPMN notation is shown in Fig. 3.3.

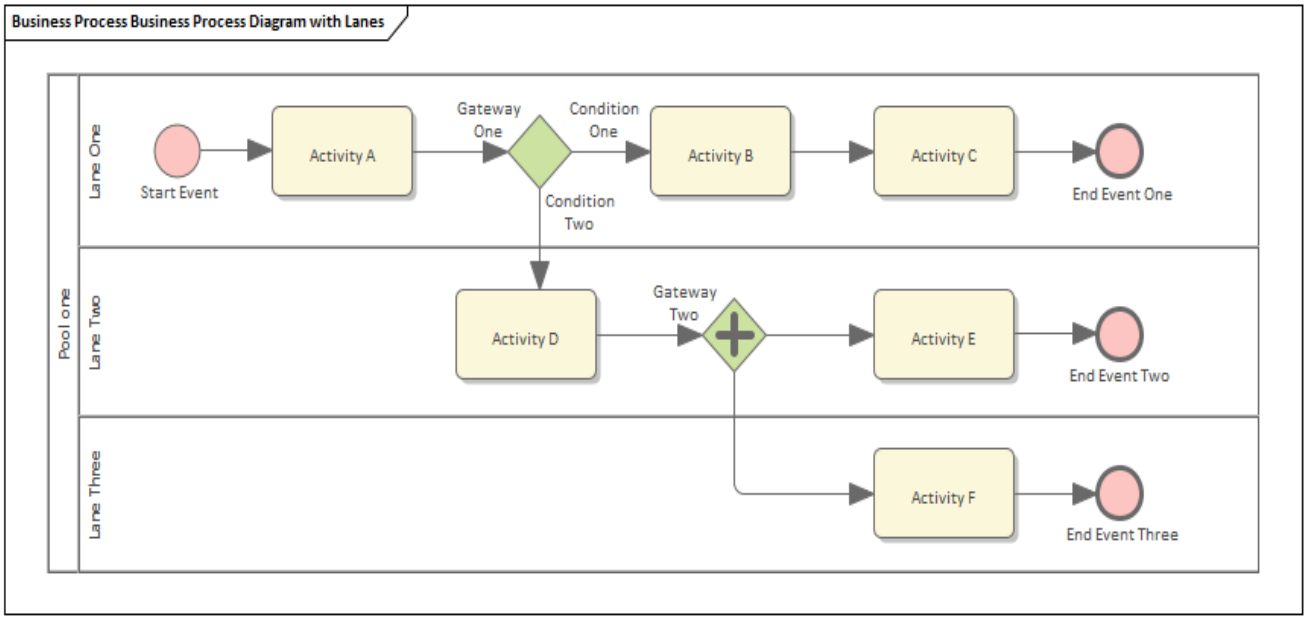


Fig. 3.3 General diagram of business process description using BPMN notation

A key feature of the BPMN notation is the use of pools and tracks to reflect the interaction of process participants during its implementation and the division of their actions. A pool is a self-regulated (separate) entity of a business (usually an organization or system), a collection of all process operations and persons responsible for their execution. It is intended to mark the boundaries of the process. Typically, a process includes one pool for the customer and a second pool for the organization being analyzed, although the process can contain any number of pools.

The track element is used to display responsible performers (roles in the process). Tracks are part of a pool, and multiple tracks can exist within a single pool. When the flow of work crosses the track boundary, the responsibility of the work moves to another role in the organization.

Advantages is the considered notation has simplicity, widespread use and ease of perception, clarity and flexibility. In addition, it is one of the most powerful and flexible notations for identifying process constraints.

The following disadvantages can also be identified:

- training and work experience are required for the correct use of the full set of symbols;
- it is difficult to see the relationships between different levels of the process;
- depending on the simulation tools, different subsets of the notation can be supported.

3.3 eEPC Notation

eEPC notation. Event-driven Process Chain, the letter "e" at the beginning of the abbreviation means extended) was developed in the early 1990s during the development of the ARIS methodology. Modeling in this notation is centered around the events that determine the development of the process. That is, it is an extended notation for describing an event-driven process chain.

This notation is based on the IDEF3 notation. At the same time, the eEPC notation is more functional and visual. It represents the business process as a graph consisting of vertices - model objects, arcs (directed connection) and edges (undirected connection) - connections between them that connect model objects and serve to determine the relationship between them.

The eEPC model allows you to display the order of executed processes, events that control process development, documents, information systems, resources, personnel, etc., which is convenient for further analysis. eEPC refers to notations of the Workflow type. Its characteristic feature is the principle of eventness - a description of the sequence of functions (actions) in the order of execution. In the eEPC model, the actual duration of the procedures (process) can be displayed visually, which is a limitation of eEPC schemes. Therefore, on the e EPC diagram, for example, it is not possible to show that an employee must perform several jobs at the same time, or to show the entire amount of work offered to him in a working day. If you need to indicate the duration of the process, you can use a Gantt chart.

This notation is characterized by the following elements: "event", "function", the presence of logic operators: "and", "does not exclude or", "which excludes".

The main objects in the e EPC notation are:

- an event is the fact of doing something, or more precisely the definition: an event is a state of the process in which an action is to be performed. In other words, an event is a necessary and sufficient condition for the performance of a certain action. Examples of events: "customer call", " 5 minutes have passed since the start of the technical operation", etc.):
    a) "necessary" - if this event has not occurred, then the function (user action) cannot be performed;
    b) "sufficient" - if this event has occurred, then nothing else is needed to start performing the function (action);
- function - performed work;
- organizational unit - organizational units of the enterprise;
- application system - a system that is used within the framework of the technology of performance of the function;
- cluster of information - data considered as a set of entities and relationships between them;
- document – an object that displays some information carrier (for example, a paper document);
- arrow – a type of relationship between other objects;
- logical operators (symbols of logic), which define connections between events and functions within the framework of the process, allow the display of branching and merging of the business process.

When building the model, each block is distinguished by shape and colour (Fig. 3.4). The colour palette in different software products used for this usually coincides. Using colour and shape allows you to highlight performers, necessary materials, a list of functions performed during the process, and possible system states.

The main colors are:

- pink – events;
- green - functions (actions);
- yellow - performers;
- gray - resources;
- orange - information systems.

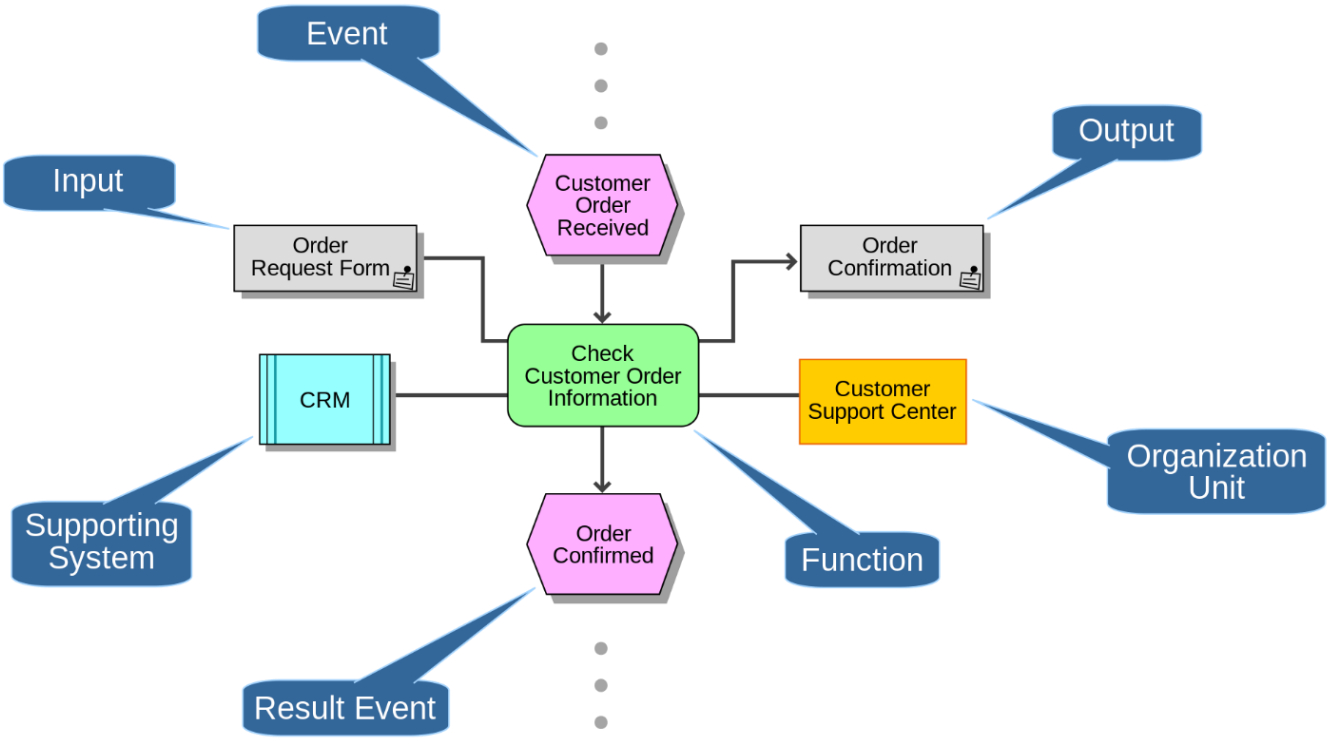


Fig. 3.4. Basic process description chain

The notation has a very large list of notations. The model unfolds from top to bottom, with higher-level elements preceding lower-level elements. In addition to arrows, separators "and", "or", "which excludes or" are used as connecting elements. This makes EEPC most suitable for business processes that have branches. When building a scheme, the start/final event is first determined, then the intermediate events, the necessary performers and the resources necessary for them.

The basic construction rules are as follows:

- every function must be initiated by an event and terminated by an event. For example, an e-mail arrived, and an employee opened the letter to reply.

In this case, "mail received" is an event, and "reply to a mail" is a function. The letter has been sent - another event. That is, a chain of events is observed: letter - reply - sending. After sending the letter, it is possible to perform a new function: entering the letter into the Register, etc.;

- each function cannot include more than one arrow that "starts" its execution and cannot have more than one exit arrow that describes the completion of the function's execution.

Common modelling *errors* in eEPC ARIS notation are:

- confusion of the state of the system after the execution of the function and the original document. The source document is declared an event and vice versa;
- enumeration of one function of several actions;
- the presence of two mutually exclusive or mutually exclusive functions to which the event leads. The event (state) itself decides which action is performed;
- two (or more) inputs to one function. For example, in the circular execution of functions.

Positive aspects should include:

- simple and clear construction logic;
- the possibility to add "own" elements in addition to the existing basis for rules and markings;
- the ability to display all significant organizational elements in one diagram (as opposed to simple block diagrams);
- the possibility of using different levels of the description model and global processes, and detailed instructions with the help of the fact that each functional block can become a subprocess;
- easy description of complex process parallelization, because any number of events can be entered in one row;
- the possibility to specify the performer for each stage;

• the ability to specify input and output data for each function and trace the logic of moving input and output data from block to block;

• notation support by many modern automated means of modeling business processes, primarily the ARIS system, and even Visio, Business Studio.

There are also the following *disadvantages of eEPC notation:*

- it is impossible to display the process as a transitional flow of work with the roles of a business process, i.e. it is not obvious how the process participants interact;
- not intended to describe "automatically executed" processes;
- it is necessary to create events for any, even the most insignificant stages, since the structural unit is the event. This leads to the creation of tautological elements: the task "agree the contract" - the event "the contract is agreed", the task "determine the executors" - the event "the executors are determined";
- the complexity of the model, which appears as a result of the description of many ramifications that occur during the execution of the process. In addition, it is difficult to display performers when jobs are parallelized (for example, if one worker performs several functions).

CONCLUSIONS

A business process is a regularly repeated sequence of interdependent measures (operations, procedures, actions), in the execution of which environmental resources are used, consumer value is created and a result is given to him.

Modeling of business processes is carried out in two ways [7]:

1) "as is" (reflects existing business processes in the organization);

2) "as it should be" (reflects the necessary changes in business processes taking into account the implementation of the projected information system).

The main purpose of process modeling is their documentation and further implementation of functional analysis for the purpose of finding process "bottlenecks" and opportunities for their improvement. BPMN, UML, IDEF, EEPC, BPMN (Business Process Model and Notation) are the main notations/methodologies of business process modeling – a system of conventional notations (notation) for modeling business processes.

The main goal of BPMN is to create a standard set of conventions that are understandable to all business users. Business users include business analysts who create and improve processes, technical developers responsible for implementing processes, and managers who monitor and manage processes. Therefore, BPMN is designed to serve as a link between the design phase of a business process and the phase of its implementation.

IDEF (Icam (Integrated computeraided manufacturing) DEFinition for functional modeling) is a family of standards for describing and displaying business processes, which has the following structure:

1) IDEF0, which displays the process at the function level;

2) IDEF1, which focuses on information flows; IDEF1X for developing relational databases;

3) IDEF2 for dynamic modeling of systems;

4) IDEF3, which models technological processes as the next level after IDEF0;

5) IDEF4 for building object-oriented systems;

6) IDEF5 for ontological research of complex systems.

There are many notations that are used to model business processes, for example:

BPMN - functional sequence of works;

EPC - event sequence of works;

IDEF0 - logical sequence of works.

The purpose of modeling is to systematize knowledge about the company and its business processes in a visual graphic form that is more convenient for analytical processing of the received information.

Currently, the computer technology market offers many special programs that allow you to survey the enterprise and build a model. The choice of methodology and tools, which are used to model business processes, is not of primary importance. There are standardized, time-tested methodologies and tools that can be used to survey an enterprise and build its model. Their key advantage is simplicity and accessibility.

Modeling business processes allows you to analyze not only how the enterprise works as a whole, how it interacts with external organizations, customers and suppliers, but also how activities are organized at each individual workplace.

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