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DEVELOPMENT OF REQUIREMENTS FOR THE BI SYSTEM FOR THE ANALYSIS OF KEY PERFORMANCE INDICATORS OF A MEDICAL ORGANISATION

Examiners: Associate Professor Jussi Kasurinen
Professor Igor V. Ilin

ABSTRACT

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Development of requirements for the BI system for the analysis of key performance indicators of a medical organization
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Improving medical and economic efficiency is an urgent task for top management of medical organizations. It is determined by the necessity to implement modern medical concepts of value and personalized medicine. The current development of digital technologies (IoT, Big Data, neurotechnology, block chain) allows the implementation of such medical concepts.
In this regard, new business models of medical organizations appear; the structure of valuable offers of medical services, distribution channels and the system of working with medical services consumers are changing. Understanding the development strategy of medical organizations requires monitoring activities. It is possible when forming a system of indicators of the medical organization, which will allow to evaluate the work results. In addition, tools visualizing these indicators are required to make management decisions based on the analysis.
Thus, the significance of this chosen research topic is confirmed.
The thesis presents the analysis of modern medical organization business processes for the implementation of an innovative business model that implements the value-based and

personalized medicine principles. The system of efficiency indicators of the medical organization has been formed. An overview of the tools for KPI system visualizing the scorecard and the subsequent assessment of the organization are presented. The requirements for BI-applications for visualizing the efficiency indicators of a medical organization have been shaped. A prototype of BI application has been developed that allows to visualize indicators and analyze activity based on the results.

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Victoriia Iliashenko

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LIST OF SYMBOLS AND ABBREVIATIONS

ABC	Activity Based Costing
AI	Artificial Intelligence
AR	Augmented Reality
ARIS	Architecture of Integrated Information Systems
BAPI	Business Application Programming Interface
BI	Business Intelligence
BPWin	AllFusion Process Modeler
CRM	Customer Relationship Management
CSV	Comma-Separated Values
DBMS	Database Management System
DFD	Data Flow Diagrams
DWH	Data Warehouse
ETL	Extract, Transform, Load
ERP	Enterprise Resource Planning
eEPC	Extended Event Driven Process Chain
ERD	Entity-Relationship Diagrams
FAD	Function Allocation Diagrams
GB	Gbyte
IDEF	Integrated Definition
IS	Information Systems
IIoT	Industrial Internet of Things
IoT	Internet of Things
IT	Information Technology
KPI	Key Performance Indicators
PDF	Portable Document Format
RAM	Random Access Memory
RIM	Research in Motion
RUP	Rational Unified Process
SADT	Structured Analysis and Design Technique
SQL	Structured Query Language
STD	State Transition Diagrams
UML	Unified Modeling Language

VR	Virtual Reality
XML	eXtensible Markup Language

1 INTRODUCTION

1.1 Background

Modern society trends, like population growth, increased life expectancy, implementation of modern medical and digital technologies require the adaptation of the medical services and products to new environment. The leadership of medical organizations is faced with the task of increasing the effectiveness of medical and economic efficiency. All this requires continuous monitoring of the activities of medical companies based on a system of performance indicators. This will allow companies to maintain their value in the healthcare services market. The solution to these problems requires a review of the entire management system of the medical organization: from business services and business processes to the IT infrastructure of a medical organization.

The key idea of medical organizations is to ensure the quality and accessibility of healthcare. at the lowest cost of resources. The main condition is an increase in the volume of medical services for the population. Sustainable development of the company can be achieved through organizational and innovative improvements. Such actions affect all the main areas of the medical organization:

- management of processes, resources;
- services;
- monitoring the performance of the medical organization;
- innovation and training.

Quick decision making in order to quickly respond to changing conditions is possible by automating business processes and analyzing the situation based on the dynamics of the performance of a medical organization.

To analyze the dynamics of performance indicators of any company, a class of information systems – Business Intelligence (BI) systems - is used. The term Business Intelligence was introduced by Gartner analysts as “a process that focuses on a business user and includes access and research of information, its analysis, development of intuition and understanding that lead to improved and informal decision-making” [1]. BI is a special software designed to help a manager analyze information about his company and its environment. BI-

technologies allow to analyze large amounts of information, focusing users only on key performance factors, simulating the results of various options for action, tracking the decisions results. Business Intelligence tools allow users to analyze a huge amount of different data and gain data-based knowledge. Moreover, such tools allow to see the process of creating and processing data, as well as support for data warehouse. Business intelligence platforms are a unique means of data visualization, which allowing to display analytics on the screen in a visual form for customers.

1.2 Goals and delimitations

The main goal of thesis is development of requirements for the BI system for the analysis of key performance indicators of a medical organization. Moreover, the master thesis has a number of other goals:

- analysis of current trends in the medical organization management;
- analysis of leading business intelligence systems;
- analysis of the medical organization business processes;
- formation the system of key performance indicators of a medical organization, based on modern medicine and IT trends;
- formation of BI systems requirements during the implementation in medical organization.

The object of research is medical organizations. The subject of research is the BI application for the analysis of the key performance indicators of a medical organization.

This paper has the following delimitations:

1. The business analysis system is not part of any solution and does not replace other already installed systems, but can receive data from any sources.
2. The thesis is based on the example of one area - the healthcare.
3. The research is conducted in terms of describing business models and business processes of medical organizations, technological architectures of BI platforms.
4. The thesis includes the creation of a dashboard and is not aimed at developing a complete set of BI applications.

1.3 Structure of the thesis

Section 2 includes a literature review: current trends in the management of a medical organization, which include new smart technologies; considered the business model of a medical organization; a graphical description of the business model of the medical organization according to the business model canvas is proposed; existing approaches to the analysis of business process models and to the formation of requirements for IT systems and overview of existing BI systems and practices of implementing BI systems in a medical service company

Section 3 is aimed at the formation of a system of key performance indicators of the medical organization; description of key performance indicators of a medical organization. This section has practical meaning and has no borrowing.

Section 4 is intended for the formation of a system of requirements for analytical reporting systems that monitor the activities of a medical organization; prototyping a BI application layout for analyzing the KPI system of a medical organization. This section has practical meaning and has no borrowing.

Section 5 is a discussion of the thesis. It carried out a brief summary for each part of the thesis and highlighted the results for them.

Sector 6 includes the conclusion of the thesis. Here the results of the thesis are summarized and ideas for future research are proposed.

2 LITERATURE REVIEW

2.1 Current trends in the medical organization management

The modern medical management system is influenced by modern medical concepts (value medicine, predictive medicine, personalized medicine), on the one hand, and technologies that provide the realization of medical concepts (IoT, Big Data, blockchain), on the other hand. The modern medical management system involves the implementation of fundamental changes in the activities of the organization using digital technology. At that time, medical organization development strategies, business models, business process systems, IT architecture, services architecture, data architecture change. To make timely decisions regarding the development of medical institutions at the strategic and operational levels, it is necessary to evaluate the performance of a medical organization using appropriate tools. Today, the main tools for monitoring the dynamics of enterprise performance indicators are BI systems.

The next part will be devoted to current medical trends in the field of medical organization management. The most significant are 4P medicine and the value-based medicine concept [2]. The 4P medicine concept includes four components:

- predictive medicine, based on data on the structure of the genome and its functions, genomic medicine that helps not only to make an accurate diagnosis, but also to determine the hereditary predisposition to the disease, prevent its development and choose the best option for drug therapy;
- preventative medicine, the main purpose of which is either to completely prevent or reduce the risk of developing a disease;
- participatory medicine, which based on patient involvement in the treatment process.;
- personalized medicine [3,4].

The term personalized medicine means «a set of methods for the prevention of a pathological condition, diagnosis and treatment in case of its occurrence, based on the individual characteristics of the patient». It can also be called precision or individual medicine. The goals of personalized medicine [5] are to provide opportunities for predicting a person's individual predisposition to diseases and to develop personal tactics for disease prevention;

an accurate diagnosis; the formation of the most effective treatment tactics, taking into account individual characteristics and effects of drugs.

Value-based medicine means special medical practice, including the highest level of processing evidence-based medicine in combination with assessing the effectiveness of treatment through the quality of life of the patient who received the service [6]. Moreover, the patient is involved in the system for evaluating the effectiveness of treatment. Valuable medicine is focused on the result achieved in the medical services provision.

The considered medical trends can be successfully implemented only on the basis of modern digital technologies [2]. Health 4.0 is a strategic healthcare intention based on Industry 4.0. The goal of this consept is to secure the implementation of the ideas of value-based and personalized medicine through the massive use of modern IT technologies: processing capabilities and the use of Big Data, cloud computing, machine learning, the Internet of things (IoT) and services, developed mobile networks (5G). All these technologies help to make the infrastructure of medical organizations “smart” by creating solutions based on Artifical Intelligence to ensure provide hugh level of knowledge and huge medical data analysis at a relatively low cost.

Description of digital technologies and the concept of «end-to-end digital technologies»

Digital conversion in companies is due to a significant increase in data volume that can be converted into information that is valuable for a specific business purpose. Digital technology, which is the main driver of digital transformation, affects business and enables consumers to provide unique value. The use of digital technologies provides organizational changes that can significantly enhance the productivity of companies. Digital transformation is the process of integrating digital technologies into various aspects of business activity, requiring fundamental changes in technology and the principles of creating new services and products [7].

The cross-cutting technologies of the digital economy are Big Data, blockchain, neurotechnologies, quantum technologies, artificial intelligence, new production technologies, the industrial Internet, virtual and augmented reality, robotics, sensorics, wireless communications [8].

Big Data

Big Data is a designation of structured and unstructured data of huge volumes and significant diversity, effectively handled by horizontally scaled (scale-out) software tools that appeared in the late 2000s and are alternative to traditional database management systems and Business Intelligence solutions [9]. In a broad sense, “big data” is spoken of as a socio-economic phenomenon associated with the advent of technological capabilities to analyze huge amounts of data, in some problematic areas - the entire world data volume, and the transformational consequences arising from this [10].

Big data involves more than just analyzing vast amounts of information. The problem is not that organizations create huge amounts of data, but that most of them are presented in a format that does not correspond well to the traditional structured database format — these are web magazines, video recordings, text documents, machine code or, for example, geospatial data [11]. All this is stored in a wide variety of repositories, sometimes even outside the organization. As a result, companies have access to their data, but do not have high-quality tools to establish the relationship between them. This can adversely affect data analysis findings. Now data is updated quickly and Big Data technologies are an advanced way to work with them. The use of Big Data technology is based on five basic principles: Velocity, Volume, Variety, Value, Veracity.

The concept of Big Data implies working with information of a huge volume and diverse composition, which is often updated and located in different sources in order to increase work efficiency, create new products and increase competitiveness [12]. The Forrester company gives a short wording: Big data allow to combine technologies and techniques that make sense from data at an extreme limit of practicality.

Neurotechnology

One of the definitions of neurotechnology is - the totality of technologies created on the basis of the principles of the functioning of the nervous system [13]:

1. Neurotechnologies consider the brain as a neural network, that is, a set of interconnected neurons. Neural networks can be divided into two types: “wet” and “dry”. “Wet” - biological neural networks that are in our heads, and “dry” -

artificial ones; mathematical models built on the principle of biological neural networks, capable of solving very complex problems and self-learning.

2. The most promising branches of neurotechnology:

- Neuropharmacology. The development of gene and cell therapy, early personalized diagnosis, treatment and prevention of neurodegenerative diseases, as well as improving mental abilities in healthy people [13].
- Neuromedtech. The development of neuro prosthetics of organs, including artificial sensory organs, the development of means for rehabilitation using neurotechnologies that help develop a limb that has lost mobility.
- Neuro-formation. The development of neural interfaces and virtual and augmented reality technologies in training, the development of educational programs and devices, the creation of devices to enhance memory and analyze the use of brain resources.
- Neuro-entertainment and sports. The development of brain-fitness - exercises for the brain, the creation of games using neurogadgets, including neuro-developing games [13].
- Neurocommunications and marketing. Development of neuro-marketing technologies (a set of methods for studying the behavior of buyers, the possibilities of influencing it, as well as reactions to similar effects using neurotechnologies), predicting behavior based on neuro- and biometric data.
- Neuroassistants. The development of natural language understanding technology, the development of deep machine learning (machine learning based on neural networks that help improve algorithms such as speech recognition, computer vision and natural language processing), the creation of personal electronic assistants (web services or applications that play the role of virtual secretary) and hybrid human-machine intelligence.

Artificial intelligence

Artificial intelligence (AI) is the science and technology of creating intelligent machines, particularly computer programs [14]. Nowadays AI includes a number of algorithms and software systems, the distinguishing feature of which is that they can solve some problems as a person who would think about their solution would do it [15]. The main AI properties are learning and the ability to think and act, language comprehension.

AI is a set of related technologies and processes developing rapidly and qualitatively, for instance:

- machine learning;
- virtual agents;
- recommendation systems;
- expert systems;
- natural language text processing.

This helps to build a qualitatively new customer experience and interaction process. Two areas of AI development can be distinguished:

- solving problems related to the approximation of specialized AI systems to human capabilities, and their integration, which is implemented by human nature;
- the creation of artificial intelligence is the process of integrating already created AI systems into a single whole. This allows to solve most of the world's problems.

The main areas of AI application are:

- Automatic translation
- Medical intelligent systems
- Getting business intelligence
- Visual recognition
- Expert systems
- Text recognition
- Information retrieval
- Understanding and analysis of natural language texts
- Image analysis
- Intelligent information security systems
- Speech recognition
- Robotics

Figure 1 presents a diagram of the existing technological areas of AI.

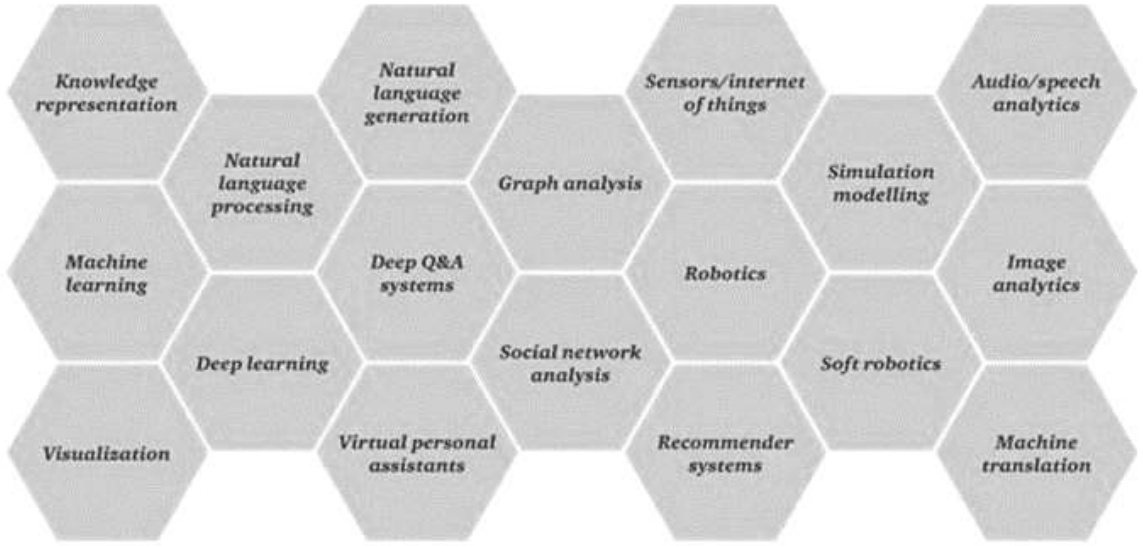

Fig. 1. Technological areas of development of AI [16]

Blockchain

Blockchain technology is considered as a decentralized, distributed ledger that records the source of a digital asset [17]. A special database has a set of records, which are called blocks. Each of these blocks has a specific time stamp and a link to the previous block. Blockchain is a record encryption technology. All users can only make changes to their blockchain. Each user has a private key, without which file writing is impossible. Moreover, encryption technology provides synchronization of a distributed block chain copies for all users.

Blockchain technology originally incorporated security at the database level [18]. Thanks to a decentralized server, blockchain technology has a high level of security. The server attaches timestamps and makes peer-to-peer connections over the network. As a result, a database with an autonomous control mode is formed. Due to this, blockchains are a convenient means for recording events (for example, creating medical records) and operations with a large data set.

Blockchain technology suggests a tempting capability to get rid of intermediaries. These technologies allow to perform three main actions that are usually performed by the financial services sector: registering transactions, verifying identity and concluding contracts.

In world practice, there is the use of distributed registry technology to increase the efficiency of various business processes in medical organizations. Most studies are conducted in the USA and are mainly devoted to the individual projects description and the experience of

introducing certain technologies into the medical organizations practice. For example, Change Healthcare offers software, analytics, services and network solutions based on innovative healthcare technologies. The company's mission is to modernize the American healthcare system in order to increase economic efficiency. The company has implemented a project to use blockchain technology to process hundreds of medical transactions per second. To achieve this goal, a technology implementation project was implemented on the Hyperledger Fabric platform. Blockchain technology has enabled the company to process 50 million transactions per day with a throughput of up to 550 transactions per second.

A McKinsey consulting company, after conducting a study, suggests that the US healthcare system can save up to $ 450 billion a year thanks to updated technologies [19]. Royal Philips, a technology company, has expanded the use of distributed ledger technology and launched Blockchain's research lab. In 2015, the company first conducted studies on the possibility of using Blockchain in healthcare, however, a report on practical application was not issued. The Estonian blockchain platform allows to view patient history in real time. Guardtime technology and the eHealth Foundation provide a high level of data security by protecting data from unforeseen changes or deletion as a result of hacker attacks, system crashes, and malware. Moreover, the transparency and integrity of medical information is maintained.

New production technologies

New production technologies are a complex of processes of designing and manufacturing at the modern technological level of custom-made material objects of varying complexity. The cost of such goods is comparable to the cost of mass-produced goods. They include new materials; digital design and modeling; supercomputer engineering; additive and hybrid technologies.

Industrial Internet of Things

Industrial Internet of Things (IIoT) is the special concept of building info-communications, which allows to form of new business models when creating goods and services, as well as their delivery to consumers.

The key driver for the implementation of the “Industrial Internet” concept is to rise the efficiency of existing production and technological processes, and reduce the need for capital

costs. The resources of companies released in this way form the demand for industrial Internet solutions.

Today, all the links necessary for its functioning are involved in the Internet of things system: manufacturers of sensors and other devices, software, system integrators and customer organizations (both B2B and B2C), communication operators.

The introduction of the industrial Internet has a significant impact on the economies of individual companies, contributes to increased labor productivity and the growth of gross national product, and has a positive effect on working conditions and professional employees [20]. The economy service model that is created during this transition is based on the digitalization of production and other traditional industries, the analysis of large amounts of data and the exchange of data between various actors in the production process.

Robotics

Robotics is an applied science aimed in the automated systems development. A robot is a programmable mechanical device capable of performing tasks and interacting with the external environment without human assistance. Robotics is based on such disciplines as computer science, radio engineering, electrical engineering, mechanics, electronics, mechatronics [21]. They distinguish building, industrial, domestic, medical, aviation and different extreme robotics.

Wireless communication

Wireless communication - communication that bypasses wires or other physical transmission media. For example, the Bluetooth wireless data protocol works “over the air” over a short distance. Wi-Fi is another way to transfer data (Internet) over the air. Cellular communication is also wireless. Although wireless protocols are improving from year to year, in terms of their basic indicators and transmission speed, they have not yet circumvented wired communications. Although high hopes in this field are shown by the LTE network and its latest iterations.

Virtual reality

Virtual reality (VR) — the world created by technical means (objects and subjects), transmitted to a person through his sensations: sight, hearing, smell, touch, and others [22].

Computer synthesis of properties allows to create a sense of reality over time. The user is able to act on virtual reality objects in accordance with all laws of physics. However, users are often allowed more in the virtual world than in reality (for example, creating additional objects, flying) [23].

"Virtual reality" systems are devices that more fully, in comparison with conventional computer systems, imitate interaction with the virtual environment, by affecting all five sensory organs that a person has.

Augmented reality

Augmented reality (AR) is a special technology for introducing sensory data into the field of human perception in order to complement environmental information and improve the perception of information [22]. Augmented reality - perceived mixed reality, created using additional computer elements of perceived reality.

Among the most common examples of complementing perceived reality is a parallel front colored line showing the location of the closest field player to the goal when watching football matches in television, arrows showing the distance from the penalty kick to the goal, a mixture of real and fictional objects in film films and computer, different gadget games. There are several definitions of augmented reality: Ronald Azuma researcher in 1997 considered it as a special system that can:

- mix real and virtual;
- work in 3D;
- interact in real time.

The implementation of these concepts allows to transform the work of the healthcare industry. In the next years, the widespread adoption of technologies that provide the implementation of the value-based and personalized medicine ideas can ensure the capability to introduce the management intention of medical organization.

According to the experts opinion, the concept of managing a modern medical organization is based on automated processes supported by modern IT technologies aimed at improving current processes and introducing new capabilties for patient care [24]. The implementation of management solutions for a modern medical organization is one of the priority areas for

big companies offering appropriate IT solutions. These actions can solve problems associated with reducing costs in the healthcare system during the supporting the required level of quality of care.

The management level of a medical organization must understand the company's development strategy and have a well-developed business model. This will allow the introduction of modern technological solutions. Successful business models rise customer loyalty and benefits and help to create a competitive cost structure, choosing the right option for automating and digitizing the processes of a medical organization into account.

A business model has certain features depending on the medical organization specifics, environmental conditions. The formation of customer-oriented business models allows to implement the concept of Smart Hospital. They extend the opportunities of drivers and analysis tools, modeling and implementation of innovative business models.

2.2 Business model of modern medical organization

Choosing the right vector for the development of a medical organization is important for company activity. For this it is necessary:

1. to formulate requirements for business services;
2. to analyze and reengineer the business process system of a medical organization;
3. to form following (based on the analysis of the business process system):
    - KPI system for measuring business processes;
    - IT service requirements;
    - requirements for IS and BI systems as a component of the enterprise IT architecture.
4. to formulate proposals for the development of a medical organization based on monitoring dynamics of indicators, formulate proposals for the development of a medical organization.

By a business model we mean an analytical tool for "... a description of the basic principles of the creation, development and successful operation of an organization" [25]. There are a large amount of approaches to the formation of a business model: the business model

of “closed innovation” (“Closed business model of R&D”), the business model of “open innovation” Henry Chesborough, model D. Debelac [26], the approach of A. Osterwalder and I. Pigne, the approach of L. Schwarzer [27], the concept of Chan Kim and Rene Moborn, who described the blue ocean strategy [28].

After analyzing all the above approaches to the formation of a business model, we can conclude that all the proposed options contain 4 key elements:

- an offer in the customers value form that the organization offers on the basis of manufactured products and services;
- interaction with the consumer such as suppliers and target customers, as well as value chains;
- the infrastructure that the enterprise uses to create value;
- financial performance of the organization.

The advantage organization’s actions and are aimed at making an earnings. Moreover, this business model has instrumental support and is widely used by a large number of corporations. Guided by these provisions, it is possible to carry out research based on the use of the business model template of A. Osterwalder and I. Pigne. Alexander Osterwalder, together with Yves Pinier, developed a business model methodology, which consists of nine structural blocks [29]:

- key partners;
- key activities;
- cost structure;
- value propositions;
- customer relations;
- sales channels;
- key resources;
- consumer segments;
- revenue streams.

Each block under consideration has its own structure. The practical approach proposed by A. Osterwalder to the formation of innovative business models is used in the TOGAF

standard of the Open Group, has instrumental support in Archi, and is used in many world industries [29].

Consider a service-oriented business model for the development of a medical organization planning to implement modern medical concepts based on digital technologies. A description of the reference business model of a modern medical organization is proposed in the article Igor Ilin, Oksana Iliyaschenko, Alexandra Konradi ”Business model for Smart Hospital health organization” [29]. The authors developed a business model within the framework of the methodology proposed by A. Osterwalder and I. Pigne:

1. Consumer segments. There are patients who can be classified for various reasons. Classification of patients will be the basis for the formation of consumer segments for a medical organization. A medical organization that implements the concept of Smart Hospital provides different types of medical care provided for by No. 323 Federal Law of 11/21/2011 "On the Basics of Protecting the Health of Citizens in the Russian Federation", 32 article 32 [30]. All patients can be divided due to the care they receive:
   - patients at risk;
   - patients who receive high-tech medical care;
   - primary care patients;
   - patients who receive a specialized ambulance medical care;
   - patients who require postoperative health monitoring (moreover, palliative care).

   Also, a medical organization can provide corporate clients by services and individuals. Patients can live in the region where the medical institution is located or can be located in remote regions, including remote ones.

   The next option for classifying patients is by source of funding for care:
   - compulsory medical insurance;
   - voluntary health insurance;
   - payment for services directly by the patient.
   - quotas of the Ministry of Health of the Russian Federation;
2. Value propositions. The identified consumer segments allow to formulate a set of value propositions supported by relevant medical and IT-technologies within the Health 4.0 concept framework.

- services for continuous monitoring of the health status of patients;
- services for early diseases diagnosis, which are extremely important for high mortality rate diseases;
- the choice of treatment methods taking into account various factors, for example, the patient's genome, environmental features;
- patient rehabilitation services;
- patient care services (anytime, anywhere);
- services for corporate clients;
- comprehensive services based on a combination of various value propositions;

3. Relations with the customer. A client-oriented approach to each recipient of the service, aimed at improving the duration and life quality. To develop the formed value propositions, a patient base should be created. It is also necessary to organize a patient feedback system through the use of modern technologies such as mobile applications, social networks. Patients should be part of the process of forming an assessment of satisfaction with the provided services. So, for instance, to implement services for patient rehabilitation, it is necessary to conduct online consultations with specialists. Early diagnosis involves the use of cloud services to download results when making appointments. Furthermore, it's advisable to establish a system for informing patients regarding online schedule of specialists, the possibility of making an appointment au automatically, conducting open lectures, events.
4. Distribution channels. There are partner and own channels for a medical organization. The own organization's website includes a site of a medical organization that provides information about the services provided, the possibility of online recording, as well as informing the patient about automatic recording to specialists when the regulated examination time is reached. Partner channels include the portal of the Ministry of Health of the Russian Federation, healthcare facilities portals in different regions, and insurance companies [29].
5. Key activities. Providing medical care (primary, specialized, high-tech medical care), preoperative monitoring, postoperative monitoring, disease cure, disease diagnosis, implementation of complex medical services.
6. Key partners. For a medical organization, two types of partnerships are highlighted:

- Strategic cooperation between non-competing companies. This type includes the Federal organizations of the healthcare system of the Russian Federation; funds; insurance companies; research universities; public organizations.
- Relations between suppliers and manufacturer, which can guarantee the receipt of high-quality components. Such relationships are supported by suppliers of IT solutions, pharmaceutical companies, suppliers of medical equipment.

7. Key resources. Highly qualified personnel, modern equipment, intellectual resources are a prerequisite for the functioning of medical centers that provide high tech medical care.
8. Revenue streams. Due to the large geographic coverage, an increase in the flow of patients through compulsory medical insurance, which will lead to an increase in budget funding on the one hand, and an increase in the flow of patients through voluntary medical insurance.
9. The cost structure. The main items of expenses in the framework of the provision of telemedicine services are payment to staff and the cost of maintaining IT infrastructure. In turn, due to the good quality of pre-hospital examination, the average duration of a patient's stay in a bed will decrease, which will allow overruns of funds allocated for the treatment of patients as part of the provision of high tech medical care, specialized medical care in compulsory medical insurance, compulsory medical insurance. Also, the released resources will increase the number of commercial services, including voluntary health insurance services.

The model proposed by the authors can be graphically represented as follows (Appendix 1). The use of digital technology is one of the conditions for the implementation of the concept of Value Based Medicine. This concept aims to:

- objective value (increasing life expectancy and / or quality of life),
- use of standards and best practices in building a service system,
- constant cost estimation and monitoring of cost effectiveness,
- receive data for analysis and improvement of the activity of a medical institution,
- orientation of medical care on personal parameters of patients associated with quantitative indicators.

By creating value for the patient is meant the provision of medical services for the shortest possible period of time at the appropriate price. Having determined the needs of the patient, the process steps can be divided into adding and not adding value to the final service.

The steps of the process have a positive effect on the creation of the service, and unreasonable activities should be minimized or eliminated. The goal of the Value Based Medicine concept is to provide a cost-effective, scientifically sound healthcare that will provide the patient with the best service quality. For the successful implementation of the concept of Value Based Medicine, it is necessary that the medical institution has a developed infrastructure. It assumes that a business process system has been developed and implemented, there is a KPI system for assessing the performance of employees, information systems provide IT support for the activities of a medical institution [31]. Figure 2 shows the stages of the development of value medicine.

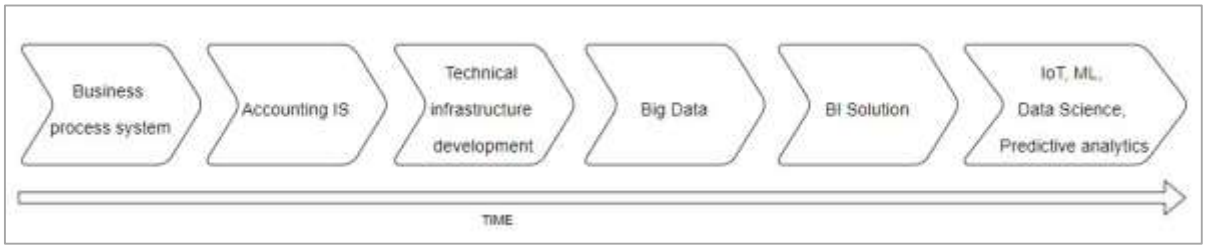

Fig. 2. The stages of the value medicine development for modern medical organization.

2.3 Description of existing approaches to the analysis of business process models

Business processes modeling includes a description, study and analysis of processes in order to improve, rationalize the methods of their construction, management and forecasting. Models can be classified according to some criteria:

- formal models, which using generally accepted rules, notations and informal;
- quantitative, which allowing for numerical evaluations and checks;
- quality which designed to understand behavior and structure systems;
- descriptive, which intended only for human perception;
- executable, which allowing you to examine their behavior and use obtained results for conclusions about the original object.

It is necessary to take the general principles and features into account when building any models [32]:

1. The feasibility principle. Achievement of goals should be provided by the created model. Before proceeding collecting information about the object, we need to clearly define the scopes of the modeling area, aims and quantitative indicators of their achievement.
2. The information sufficiency principle. In the complete absence of information about the investigated object, the construction of its model is impossible. Modeling does not make sense with full information. There is a certain critical level of a priori information about an object, upon reaching which it makes sense to move from the collecting information to the building model stage.
3. The principle of model multiplicity. The created model should reflect the properties of the real object, which affect the selected performance indicators. For a more complete study of a real object, a number of models are needed, allowing from different sides and with different details to reflect the process.
4. The aggregation principle. A complex system can be represented as a set of subsystems, for the description of which standard schemes are used.
5. The separation principle. The study area incorporates several isolated components. Their internal structure is not interesting for specific project goals. In this case, the model uses an empty block, for which the input and output information flows are determined.

The main goals of modeling business processes of an organization are:

- providing an understanding of the organization structure and the dynamics of the processes occurring in it;
- providing an understanding of the current problems of the organization and their solutions;
- systematization of knowledge about the company and its processes in the form of more convenient analytical processing of the information received.

There are four main stages of business process optimization:

1. Studying a business process and setting goals for modeling and optimization. This stage does not have a formal description and forms a general idea of the business process. Goals and objectives should be regulated and achievable.
2. Building an AS IS business process model (as is). The main task of this stage is to describe the existing structure of the organization, internal and external business processes.

3. Analysis of the main problems identified during the construction of the business model. The main objective of this stage is to identify key performance indicators and sources of problems.
4. Development of recommendations for solving the tasks posed before the analysis.

To solve the above problems, it is necessary to use various mathematical methods that will allow to analyze the business processes of the enterprise:

1. Functional cost analysis (FCA). It is a cost analysis by type of company activity. In Western practice, it is used in various modifications, such as value analysis, value engineering, value management [33]. As part of the process, we are dealing with three costs: the cost of raw materials at the input of the process, the cost process and the cost of the product at the output of the process. Moreover, the cost of the product is related to the cost functions by the following relation (1):

$$C_{product} = C_{process} + C_{raw\ materials}\ , \tag{1}$$

2. Activity Based Costing (ABC) method based on costing by type activities (functions). The author of the method is P.B.B. Thorns (USA), 80s of XX century. The main difference between the method is its emphasis on costs, and in the functional-cost analysis - on consumer cost [34]. ABC allows to transfer overhead costs to direct ones according to the sources of incurring costs. Therefore, these methods should be used together. The conceptual design of ABC is shown in Figure 2. An approach that is based on the use of the ABC method reverses focus primarily on activities (processes, procedures), which carried out within the organization, and only then - on objects costing.

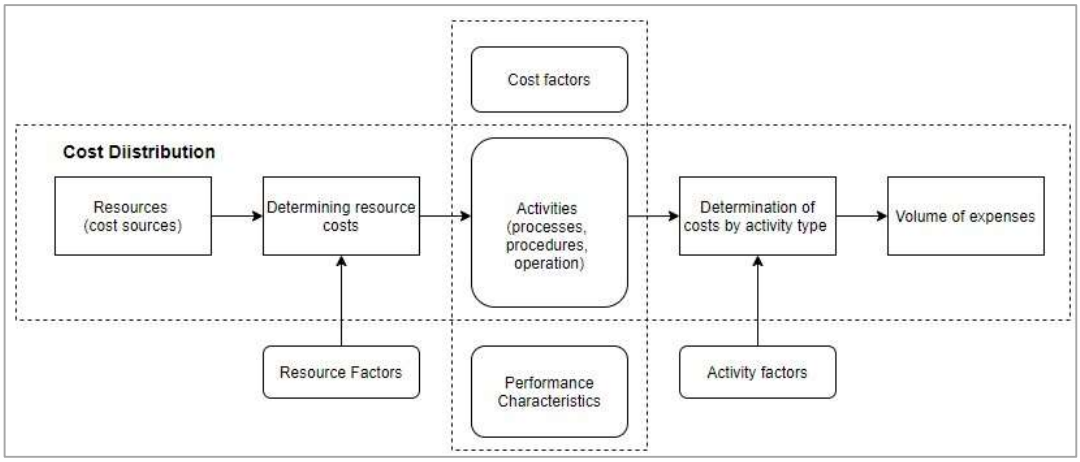

Fig. 1. Conceptual diagram of the ABC method

3. Simulation method on the development of information models of business processes using software to simulate the performance of business processes over time. This method is used if functional modeling is not enough for specific technological operations. Using simulation models allows us to solve the problems of production restructuring, improving product quality, reducing production and logistics costs, modeling the life cycle of new products. The main tasks in production are modeling the processes of adaptation of the enterprise to changing demand for products, the use of simulation methods to develop projects for the modernization of existing enterprises, modeling budgeting processes at an industrial enterprise [35]

   To solve this problem, several approaches have been formed in modern simulation modeling:

   - Discrete event modeling - reflects abstractions of low and medium level.
   - System dynamics, which suggests the maximum level of model abstraction. The system dynamics apparatus usually operates with continuous processes in time.
   - Agent-based modeling involves working with a decentralized model.
   - Queuing system - an object (enterprise, organization), the activity of which is associated with the multiple implementation of the execution of some similar tasks and operations.
   - Finite state machines are a mathematical abstraction that allows to describe ways of changing the object state depending on its state and input data.
   - Petri nets. The interpretation of Petri nets is based on the concepts of conditions and events. The state of the system is described by a set of conditions. The functioning of the system consists in the implementation of a sequence of events. For an event to occur, certain conditions, called preconditions, must be met. The occurrence of events can lead to the fulfillment of conditions called postconditions. In a Petri net, conditions are modeled by positions, events are modeled by transitions. Event preconditions are represented by the input positions of the corresponding transition, postconditions are represented by the output positions.

Consider the advantages and disadvantages of business process modeling methods. it is advisable to use the FCA technique in comparison with the ABC method Functional cost analysis has the following advantages compared to simulation:

- more accurate knowledge of the production cost, which allows to determine the optimal combination of products, choose a method of manufacturing products;
- clear functions performed, through which companies manage to pay more attention to management functions, to identify the volume of operations that do not add product value.

Simulation has the following advantages:

- more accurate results that are close to the real system;
- “compression” of time is possible: years of practical operation of a real system can be simulated for several seconds or minutes.

Modeling business processes is a tool to identify current problems in the company, to understand how the enterprise as a whole works, how it interacts with customers and suppliers, how activities are organized at each individual workplace, allows to give a valuation of each process in the company individually and all business processes together, anticipate and minimize risks.

2.4 Description of modern approaches to the formation of requirements for IT systems

When developing an information system (IS) at the initial stage, various approaches to the formation of system requirements are applied. In one of them, the requirements for IS are formed on the basis of the enterprise business model. In order to minimize the number of errors that analysts can make when moving from a business model to the formation of information system requirements, it is necessary to formalize and, if possible, automate this process. This approach allows to record, as well as analyze the current state of the organization. Building a business model is a collective process in which both IT specialists (consultants) and domain specialists, as well as management, take part company. This allows to develop a common understanding of the processes occurring in the organization and a common "language of communication". This is the key advantage of this approach. The main

question that arises with this approach is how, based on the constructed business model, it is possible to formulate requirements for the information system.

Classification of methods for generating IS requirements based on a business model

To describe the requirements for the developed IS, we usually use the same modeling tools as for building a business model. This allows to convey to the customer the functional specification of the IS in a clear and understandable way for him (since he already "imbued" this tool at the stage of building a business model). All modeling tools (or rather, not the tools themselves, but the modeling methodologies that these tools support) can be divided into three groups in terms of the approach to modeling IS requirements based on a business model. According to this classification, for modeling business processes and modeling requirements for an information system, the following can be used [36]:

- different types of diagrams;
- one and the same type of diagrams;
- intermediate variant (the same type of diagrams is used, but the elements of diagrams are different).

The use of various types of diagrams in modeling the business model and the model of IS requirements

This approach assumes that the methodology not only supports the modeling of business processes, but also has specialized tools for modeling information systems. A classic example of this approach is the Rational Unified Process (RUP), supported by Rational Rose [37].

As part of RUP technology, the first step in developing an information system is business modeling. The results of this step are the Business Analysis Model, the Business Use-Case Model, and the Business Use-Case Realizations model. Using these artifacts as part of the Explore Process Automation process, areas of business processes that are planned to be automated using the developed IS are allocated. Having selected the areas of automation, it is necessary to analyze the model of implementation of interaction scenarios (Business Use-Case Realizations) and based on them to form a model of interaction scenarios (System Use-Case Model) and a system analysis model (System Analysis Model) according to the

instruction "Transition from a business model to a system" (“Going from Business Model to Systems”).

The algorithm for the transition from a business model of interaction scenarios to a model of system interaction scenarios is as follows:

1. For each business worker, it is necessary to determine whether he will use the information system.
2. If so, then on the model of scenarios of system interaction it is necessary to determine the actor with such the same name as a business worker.
3. For each interaction-scenario (use-case) in which the given business worker participates, it’s necessary to create use case on the model of interaction scenarios.

If the IS completely automates the process, then the business actor will work directly with the IS and act as a system actor instead of a business worker. To form a system analysis model, the algorithm is as follows:

1. For each business entity, it is necessary to determine whether it will be managed by the information system. If yes, then we need to determine the corresponding entity in the system analysis model.
2. For each attribute of the entity, it is necessary to decide whether it should be modeled as a separate entity in the system analysis model or not.

In addition, it is necessary to identify all other potential sources of system requirements and analyze whether they have any effect on both functional and non-functional requirements for the system.

Using the same type of diagrams when modeling both a business model and an IS requirements model

This approach is implemented in tools that specialize in modeling business processes and were not originally intended for modeling requirements for information systems. The most representative representative is AllFusion Process Modeler (BPWin) - a widespread tool for visual modeling of business processes from Computer Associates, based on Integrated Definition (IDEF) technology. BPWin supports three modeling methodologies: IDEF0 (function diagrams), IDEF3 (process diagrams) and DFD (data flow diagrams). The main

idea embedded in the BPWin modeling mechanism in the framework of the IDEF0 methodology is to build a tree-like functional model of the enterprise. First, the functionality of the enterprise is described as a whole using the context diagram, and then the general functions are divided into large sub-functions, this is called functional decomposition. Large sub-functions, in turn, are divided into smaller sub-functions and so on [38]. The result is a set of hierarchically arranged diagrams. The result of modeling with this technology is the so-called AS-IS model, after which it is analyzed, there are weaknesses in it and the TO-BE model is already built on its basis. In this case, as a rule, several TO-BE models are built at once, the best one is selected from them and already it becomes the basis for the information system model.

Unlike RUP, IDEF doesn't spell out a clear technology for building an information system model based on a business model, but it is assumed that the sequence of actions should be as follows:

1. Highlight automated processes. For this, it is necessary to go from general to particular, that is, first consider the processes at level A0, determine which of them will be supported by the system, then analyze the processes at the next level (A1) and so on.
2. Transfer the indicated processes to the diagram A0 of the system. When transferring processes to the model of the information system, the following mapping is performed: - the process control changes (strategies, procedures are replaced by user control actions) - the process mechanisms change (executors, equipment are replaced by corresponding IS mechanisms) - except this may change the outputs of the process (for example, instead of a paper report, the output may be an electronic form).
3. Decompose the functions of the system model (build grams A1, A2)

As a result of applying the algorithm, a general functional model of the system will be obtained. To build a more detailed functional model of IS, IDEF3 (workflow diagramming) diagrams are used. Using diagrams of this type, you can either describe in detail the logic and sequence of the process (an analog of an activity diagram in Unified Modeling Language -UML), or describe the sequence of transition of an object from one state to another (an analog of a state diagram in UML).

To identify the entities with which the system will operate, it's necessary to analyze the inputs and outputs of the processes. Incoming and outgoing documents, information are candidates for the role of the essence of IS. To simulate IS entities, data flow diagrams are used. They allow to display the mechanisms of transmission and processing of information in the developed system. As for non-functional requirements for the system, the IDEF technology does not provide for the possibility of describing such requirements on the basis of a business model.

Intermediate business model and IS requirements model

This type of modeling tools assumes that the business model and the IP model are combined into a single model, that is, the same diagrams are used to describe them, but different types of "icons" (stereotypes). Typically, this approach is practiced by the so-called large integrated modeling tools that support more 20 types of methods and models, such as, for example, ARIS Toolset ("Integrated IC Architect") by IDS Sheer AG.

The ARIS (Architecture of Integrated Information Systems) methodology is a modern approach to a structured description of the organization's activities and its presentation in the form of interconnected and complementary graphic diagrams that are convenient for understanding and analysis. The ARIS methodology is based on the concept of integration, which offers a holistic view of the processes, and represents a lot of different techniques, combined in a single system approach [39].

The ARIS methodology implements the principles of systemic structural analysis, the basic concept of which is a structural element (object). Structural analysis is a methodological variety of system analysis. Structural analysis involves the use of a graphical representation to describe the structure and activities of an organization. In this case, the basic principles of structural analysis are implemented: dividing into levels of abstraction with a limitation of the number of elements at each level (usually from 3 to 9); limited context that includes only material details at each level; use of strict formal rules for records; sequential approach to the final result (depends on the goals of the simulation). The ARIS methodology also uses decomposition and allows to refine the subject of modeling using alternative or complementary models.

The ARIS methodology considers the enterprise as a set of four views:

- the organizational structure;
- the structure of processes.
- the structure of functions;
- the data structure;

Moreover, each of these views is divided into three sub-levels:

- a description of the requirements;
- a description of the specification;
- a description of implementation.

It is proposed to use 85 types of models to describe business processes; up to 90 types of objects can be used on each model (for example, “function”, “class”, “organizational unit”). Between different types of objects, various types of connections are possible (for example, “executes”, “is incoming,” “takes a position”). In addition, each type of model, object, or connection has a list of attribute types (for example, “name”, “costs”, “execution time”, “address”), the values of which are set by users and the system.

All these subsystems of the organization in reality and in models should be interconnected. The ARIS methodology makes it possible to describe rather heterogeneous subsystems in the form of an interconnected and mutually agreed set of different models that are stored in a single repository (Fig. 1). It is the interconnectedness and interoperability of models that are the hallmarks of the ARIS methodology.

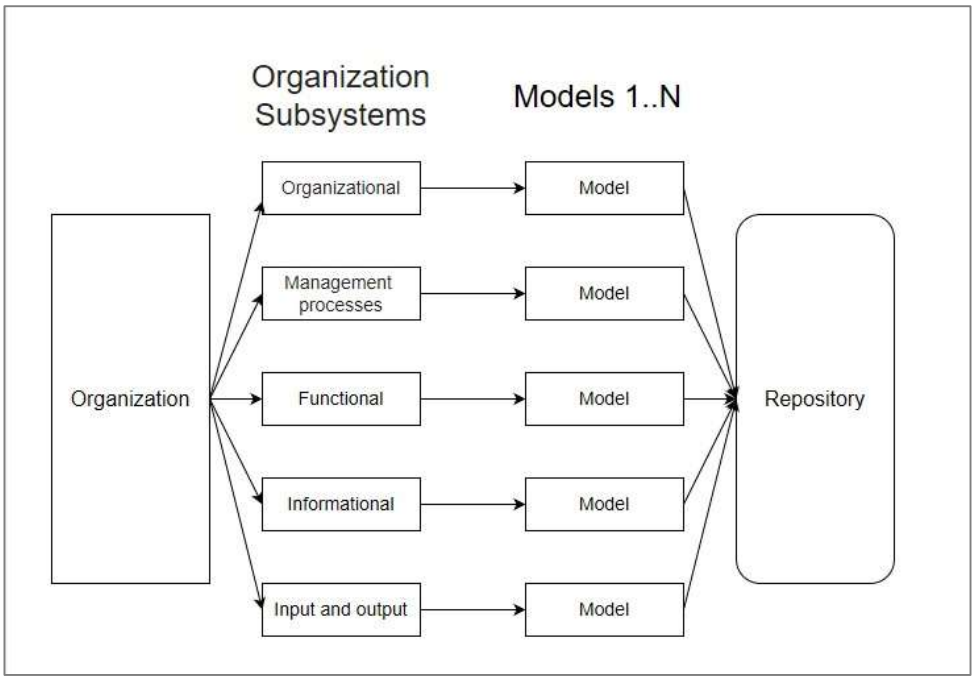

Fig. 1. Block diagram of repository formation

In accordance with the rules of structural analysis, each of these subsystems is divided into elementary blocks (modules), the totality of which is the notation of the structural model of a particular organization subsystem.

In this regard, the ARIS methodology identifies five types of representations of the main models that reflect the main aspects of the organization:

1. Organizational models describe the hierarchical system structure, i.e. the hierarchy of organizational units, positions, powers of specific individuals, the diversity of relations between them, as well as the territorial affiliation of structural units [40].
2. Functional models describing the functions (processes, operations) performed in the organization.
3. Information models, reflecting the structure of information necessary for the implementation of the totality of system functions.
4. Process or management models, representing a comprehensive view of the implementation of business processes within the system and combining other models together.
5. Inputs and outputs models - give a description of material and intangible flows.

Representation types are the first component of architecture. They allow to structure business processes and highlight their component parts, which makes consideration easier. The application of this principle allows, from different points of view, to describe the content of individual parts of the business process, using special methods that most closely match each point of view. This eliminates the need for the user to consider many relationships and connections.

To build models and conduct structural analysis in ARIS, the following methods and means of visual description are used [41]:

- DFD (Data Flow Diagrams) - data flow diagrams for the analysis and functional design of system models. Describe the sources and destinations of data, logical functions, data streams and data storages that are accessed;
- STD (State Transition Diagrams) - state transition diagrams for the design of real-time systems;
- ERD (Entity-Relationship Diagrams) - entity-relationship diagrams describing objects (entities), the properties of these objects (attributes) and their object relationships (relationships);

- SADT (Structured Analysis and Design Technique) - technology for structural analysis and modeling of hierarchical multi-level modular systems;
- IDEF0 (Integration Definition for Function Modeling) - a subset of SADT - a standard for describing business processes in the form of hierarchically related functions;
- IDEF1 - standard for the description of the movement of information; used to determine the structure of information flows, traffic rules, information management principles, flow relationships, identifying problems of poor-quality information management;
- IDEF1X - a standard for developing logical database schemes based on the concept of entity-relationship;
- IDEF3 is a script-based process description standard. A scenario is a description of the sequence of changes in the properties of an object within a certain process. The standard allows to describe the sequence of stages of changing the properties of an object (Process Flow Description Diagrams - PFDD) and the state of the object at the stages (Object State Transition Network - OSTN). The standard allows to solve the problems of documenting and optimizing processes;
- IDEF4 - a standard for describing the structure of objects and the inherent principles of their interaction; allows to analyze and optimize complex object-oriented systems;
- IDEF5 - a standard that allows to describe a set of terms, rules for combining terms into statements to describe the properties and relationships of objects, to build a model based on these statements. Such models make it possible to study the ontology of objects.
- UML (Unified Modeling Language) is an object-oriented unified visual modeling language. This type describes action diagrams, interaction diagrams, state diagrams, class diagrams, and components. It is used both for analysis and for designing models of information systems.

Another feature of the ARIS methodology, which ensures the integrity of the developed system, is the use of different levels of description, which supports the theory of the life cycle of a system existing in the information technology area.

The ARIS approach to the design of information systems is based on the so-called ARIS phase model, which characterizes the stages of creating an information system and the approaches applied to the description of business models. The model consists of the following levels of description:

1. Analysis of business problems.

   The starting point of modeling, models at this level are not very detailed semantic descriptions of business processes.
2. Definition of system requirements.

   At this level, the semantic requirements for the applied information system are described.
3. Project specification.

   At this level, not functions are already described, but user or modular transactions that perform these functions. This can be considered as a mapping of formulated requirements into categories and description methods related directly to information systems and expressed in terms of relevant technologies.
4. Description of implementation.

   At this level, the project specification is transformed into specific hardware and software components.

For modeling business processes in ARIS, the following tools (diagrams) are used, which are included in the so-called “simple methodological filter”:

1. Organizational chart (organizational chart) allows to simulate organizational structure of the enterprise for the purpose of subsequent analysis for double subordination, an unreasonable number of hierarchy levels.
2. Function Tree. A function is an element of work that forms one logical step within a process. The name speaks for itself - this type of diagram is designed to model the structure of business processes and reflect the relationships between them. At the highest level, the most complex functions are described (the business processes themselves), and then there is the granularity. Thus, a hierarchical structure of functions is obtained. Functions are combined into a tree according to 3 criteria:

   • Object-oriented Processing of the same object (for example, create an order - transfer order - print order).

- Process-oriented Ownership of the same process (order processing: accept order - check stock availability - check solvency - unsubscribe goods).
- Operations-oriented Performing the same operations (change order - change invoice - change sales plan).

3. Extended Event Driven Process Chain (eEPC). The diagram is intended for a detailed description of the processes carried out within a single unit, allows to identify the relationship between the organizational and functional models. It reflects the sequence of steps within a single business process that are performed by org. units, as well as time limits imposed on individual functions. For each function, the initial and final events, material and documentary flows can be determined, as well as decomposition to lower levels. Events - the state of the system, which is essential for business management purposes. For example: "order received." Events transfer control from one function to another, they occur instantly. One event can trigger the execution of several functions at the same time, a function can be the result of several events.

The following diagrams can serve as additional (auxiliary) tools for describing business processes:

1. Function Allocation Diagram. It is intended to describe the objects surrounding the function - executors, input and output information flows, documents, materials, equipment. The diagram is used to drill down functions from the eEPC model, and also reflects the relationship between the data model and the functional model. Included in the “simple methodological filter” [42].
2. Process Chain Diagram. The notation of this model is the same as the eEPC notation, but the model is more structured. This diagram allows to analyze the process and determine the reasons for its lack of effectiveness (information gaps, organizational gaps, extra inputs or outputs). The chart is drawn with a high degree of generalization, without detail, and is an alternative to eEPC.

A serious advantage of ARIS over other tools is that it has well-developed graphical tools for representing the formed models. ARIS allows to display in the reporting document any information contained in the project database, as well as receive analytical reports structured according to a number of criteria. ARIS is an appropriate tool for the detailed classification, structuring and visualization of operational risks.

Building a model of an information system based on a business model is carried out in stages.

Definition of automation plots.

To formulate functional requirements for IP, the first thing to do when building a TO-BE model is to analyze current business processes (for example, a tree of functions) and identify those work plots that you plan to automate using the system.

Modeling the functions and executors of the system.

After that, in diagrams with detailed descriptions of processes (for example, eEPC), we should:

- replace the current executors of functions with an information system (or add IP as another executor). It should be noted that the executor may not be the system itself, but some part of it (for example, the module for importing orders from a file);
- with full automation of the operation, the stereotype “function” should be replaced by the stereotype “IT function”.

Modeling system entities.

To determine the entities that the system will operate, you need to analyze diagrams with detailed process descriptions (eEPC), as well as environment diagrams (Function Allocation Diagrams) for all functions that the IP will perform. Objects such as documents, input / output information flows, information clusters, materials are potential applicants for the role of the essence of IP. Entities are modeled using the same function environment diagrams, but other specialized stereotypes are used, for example, “file”, “class”, “attributes”.

Definition of non-functional requirements.

Various patterns and stereotypes can be used to model such requirements. For example, other application systems available in the organization may have an impact on the designed system. To describe and reflect the relationship with business processes, an Application system type diagram is used.

The result of the analysis of the presented approaches

Each of the presented approaches has its advantages and disadvantages. The RUP approach (the use of various diagrams for the business model and the IP model) is the most flexible; it most fully spells out the technology for transition from a business to an information system

model. Therefore, the use of this methodology allows developers to clearly formulate requirements for the system according to the proposed algorithm, without imposing significant restrictions on the model.

A distinctive feature of the BPWin approach (as well as the IDEF methodology itself) is the simplicity of using this tool and rather strict regulation of the format for representing models (limiting the number of objects in one diagram, IDEF form for creating a diagram, required fields). From the one hand, this allows users to use BPWin who are not experts in modeling, and on the other hand, it limits the functionality of the tool. For example, in BPWin there are no visual means for modeling system executives (in particular, there is no way to visualize the procedure performed by one employee), limited possibilities for modeling system entities.

Methodology ARIS has a variety of modeling tools (95 types of objects, 90 types of models). Thanks to this, the models in ARIS are more detailed, more accurately it is possible to convey the essence of the simulated object. On the other hand, wide functionality is expressed in the complexity of using this tool, the absence of an algorithm for switching from a business model to an IS model, as a result of which the work on creating a model should be preceded by the development of complex, multi-aspect documentation.

The RUP methodology is the most effective means of modeling requirements for an information system based on a business model of an enterprise. It provides a universal transition technology, as well as a balance of simplicity and at the same time the functionality of models, which makes RUP applicable to projects of varying complexity. In turn, it is advisable to use BPWin only in small-scale and long-term projects where a relatively inexpensive tool with basic functionality is required. Using ARIS, on the contrary, will bring the greatest benefits on large-scale projects (detailed modeling of the activities of a large organization from various points of view). The rich functionality of ARIS will be required on such projects and due to this, the high costs associated with its operation will pay off.

2.5 Overview of existing BI systems

Today, there are a large number of software programs designed to help managers analyze information about their company and its environment. Most Business intelligence tools are used by end users to access, analyze, and generate reports on the data that is most often located in the data warehouse. This section provides an analysis of the most popular BI systems, highlighting their advantages and disadvantages.

At the present stage of information-analytical systems development, companies, in particular medical organizations, have an urgent need to introduce modern BI-platforms for the analysis of key performance indicators of their activities. Analytical solutions allow to perform data analysis in various sections in real time, build KPI systems for each of the company's departments, make a forecast based on current values of indicators. The ability to aggregate data of various formats from various sources of information that characterize the work of the organization as a whole is one the main advantages of analytical platform. Companies can build visual statistical and dynamic reports, graphs, charts, and other data visualization elements with business analysis systems. The basic component of business analysis technologies is the ability to analyze structured end data in a visual form to end users. This aspect is one of the main criteria for end users when working with analytical reporting systems.

The key advantages of implementing business analysis systems in enterprises are [43]:

- the accuracy of the performance indicators values of the company in reporting systems;
- real-time data analysis and forecasting;
- support for the development of enterprise business processes;
- support for the development of organization structural changes;
- ability to simulate various business situations in a single information environment;
- operational analysis of non-standard user requests;
- increasing the amount of time for deeper analytical work;
- decreasing the routine load on staff;
- stable operation with a large amount of data entering the system.

In addition to the key advantages described above for using BI systems, in particular in the healthcare sector, it should be noted that the developed analytical system should combine information from various sources in its database, including remote regional medical systems, information systems at the level of a medical organization, various data sources in electronic format.

Business analytics helps to extract knowledge from a large amount of data that allows to make managerial decisions based not only on intuition, but also on facts. Among the business intelligence scenarios:

- identification of unprofitable and profitable lines of business;
- sales planning, assessment of the implementation of plans in real time;
- budget planning, cash flow analysis;
- competition analysis, marketing research;
- production planning, operational management of supplies, stocks [44].

The benefits of professional business intelligence systems are based on the principles that are supported in all advanced BI applications:

1. Visibility. The main interface of any business analysis software should reflect the main indicators. Thanks to this, the manager will quickly be able to assess the state of affairs at the enterprise and begin to do something if necessary;
2. Customization. Each user should be able to customize the interface and function keys in the most convenient way;
3. Layering. Each data set should have several sections (layers) to provide the detailed information that is needed at a particular level;
4. Interactivity. Users should be able to collect information from all sources and in several directions at the same time. It is necessary that the system has the function of setting alerts for key parameters;
5. Multithreading and access control. In the BI system, the simultaneous operation of a large number of users should be implemented with the ability to set them different access levels.

Figure 2 shows the general scheme of work of business intelligence systems.

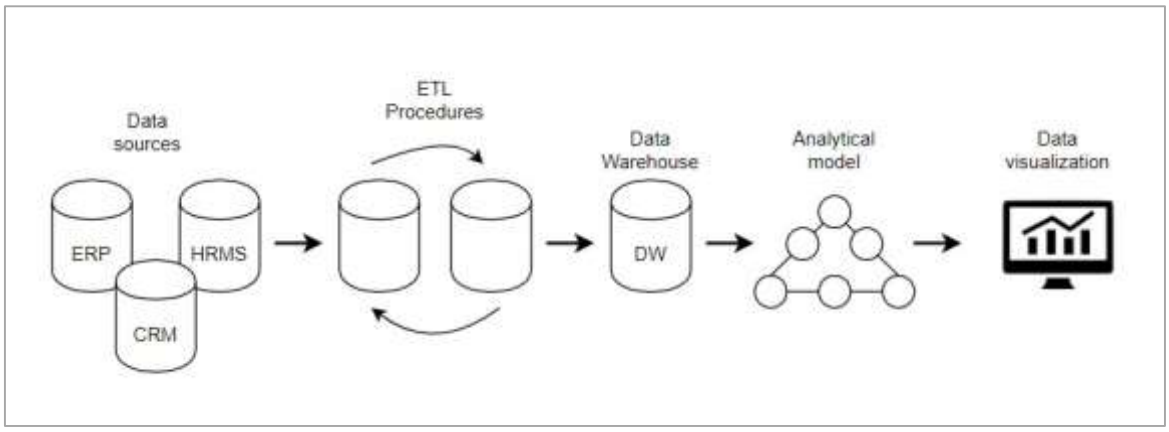

Fig. 2. Business Intelligence Platform Concept

The main components in the concept of analytical systems are:

1. Data sources can be different: ERP databases, CRM systems, Excel corporate portals, XML and Excel files.
2. ETL tools: programs that allow to load data into DWH from various accounting systems.
3. DWH repository: a complete SQL database for preparing and storing data for analytics.
4. Analytical model: data model that allows to effectively manage data in the program.
5. Data visualization is a presentation of data in the form of graphs, tables that provide the most effective work of a person to study them.

Before starting a project to introduce BI technology, a thorough analysis of the company's business processes and the principles of making managerial decisions are required. The main criteria for choosing a particular analytical reporting system are:

1. Goals and objectives of the implementation of BI systems.
2. Requirements for data storage and the ability to operate with them.
3. Data Integration Features. Without using data from all sources in the company, management will not be able to get a holistic picture of the situation.
4. Visualization features. For each person, ideal BI analytics looks different, and the system should satisfy the needs of each user.

5. Versatility or narrow specialization. In the world there are systems aimed at a specific industry, as well as universal solutions that allow to collect information in any context.
6. Demanding for resources and the price of a software product. The choice of a BI system, like any software, depends on the capabilities of the company [45].

Successful implementation of BI systems in any area is based on the following rules:

1. The correctness of the data. If the data for the analysis are incorrect, then there is the possibility of a serious system error.
2. Full training for each user.
3. Fast implementation. It is necessary to focus on the correct formation of the necessary reports at all key places, and not on the ideal service of one user.
4. Realize the return on investment in the BI system. The effect depends on many factors and in some cases is visible only after a few months.
5. Equipment should be designed not only for the current situation, but also for the near future.
6. Understand why the BI system was launched, and do not require the impossible from the software.

This chapter discusses the most widely used analytical platforms, such as QlikView/Sence, Tableau and Power BI. The comparison of key parameters such as usability, ease of installation and use, support, work with various data types was given.

QlikView Platform

This is an innovative business intelligence system, which allows to consolidate, visualize and analyze information from heterogeneous sources, and also has convenient and functional tools for conducting data analysis, including multivariate analysis, fragmentation and combining of information. QlikView provides quality and timely support in building effective corporate strategies.

Solutions on the Qlik platform are the most popular in the Russian Federation in various fields of activity - financial, industrial, oil and gas. Medical companies are no exception. The QlikView platform is one of the most powerful tools for data visualization, which does not require additional installation of a set of software products at a high price, as with traditional BI solutions. QlikView system allows to build business solutions based on a simple data

architecture, the integrity of which stabilizes the work of all components of the Qlik platform.

The flexibility of the platform allows to adjust the charts and dashboards for a specific task. QlikView has a built-in ETL that allows to perform basic cleaning and data processing operations.

The main plus of the platform is the opportunity to build an associative data model. The software is the most important data management tools on the internal platform level. QlikView platform stores data tables in RAM, and any value from one table is associated with all values from other tables [46].

Moreover, key platform features are:

- the ability to automatically determine the relationship between data without any user pre-configuration;
- data storage in RAM server, which significantly accelerate query execution and data analysis [47].

The platform is convenient in terms of use and is suitable for both beginners and advanced users of the SQL – language. In terms of price, QlikView is the most expensive platform on the market.

Table 1 presents the main pros and cons of the QlikView platform from two points of view.

Table 1. QlikView Pros&Cons.

	+ Pros	**-Cons**
From the user	• Attractive interface • Easy data filtering for visualization • The speed of creating graphs and tables • Sending reports in pdf format	• Combines some data types when filtering • There is no way to combine the results in bookmarks • Difficulty in working without technical knowledge
From the developer	• Import data from various sourses	• Difficulty writing function

Table 1 (continuation). QlikView Pros&Cons.

	+ Pros	**-Cons**
From the developer	• Convinience of creating graphs, tables, filters • High speed download and data processing • Possibilty of joint development	• Some basic functions are not implemented • Difficulty sending submitted reports • The complexity of using as a working tool for the entire company

Figure 3 shows the architecture of the QlikView platform. It includes three main blocks: QlikView Developer, QlikView Server, QlikView Publisher [48].

The QlikView Developer block includes tools for uploading, transforming, and loading data (ETL process), which allows to perform complex operations on data to load it from various sources of information: BW, ERP databases, data marts, corporate portals, XML and Excel files.

The QlikView Server block is responsible for the integrity of the data, ensures the security of its storage, and allows updating data in all reports of the QlikView system.

The QlikPublisher block is a specialized tool for administering data for analytical applications that are available to the end user. The advantage of this unit is the ability to split access to applications by categories of user groups, as well as the ability to deliver analytical reports to personal emails in PDF format.

Documents published on the QlikView server can be accessed through a variety of clients, including the Internet Explorer plug-in, AJAX Zero Footprint, and several mobile clients such as iPhone, iPad, as well as Android and RIM devices.

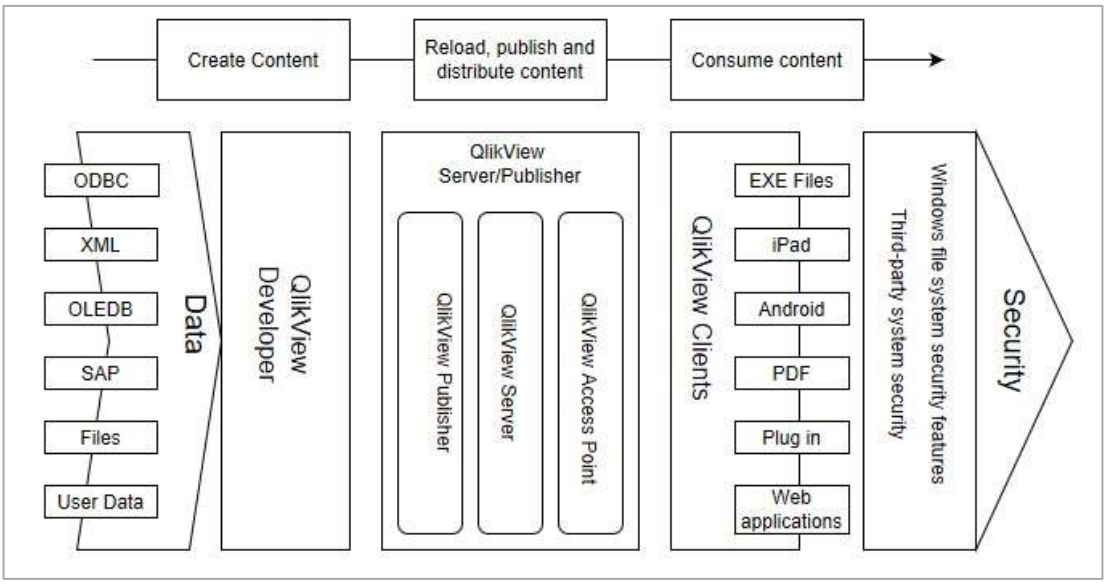

Fig. 3. Architecture of the QlikView platform.

Microsoft Power BI Platform

Power BI is a Microsoft integrated business analysis (BI) software, combining several software products with a common technological and visual design, connectors (gateways), as well as web services. The platform allows users to create customized visualizations. Moreover, this platform allows to standardize and clean up the data. Interestingly, clients can use a mobile version of platform, which available on different operating systems.

One of the advantages of the Power BI is the ability to support various ways to import data (for example, cloud services, streaming data, Excel documents and external applications). Power BI is associated with the company's core products: Cloud Service; MS Excel; SQL Server.

Key features of Power BI are [49]:

- a free version of product;
- supporting different ways to import data;
- creation of interactive dashboards with real time data reflection;
- platform integration with other systems;
- several different ways to share reports and dashboards;
- supporting for multiple platforms (Web, desktop or mobile application).

Microsoft Power BI is a quality business intelligence tool with affordable pricing.

The free version is available for any individual user and has the following characteristics: a memory limit of 1 GB, the processing speed of streaming data 10,000 lines / hour, along with restrictions on updating and collaboration on reports.

Power BI Pro costs $ 9.99 per user per month and increases the memory limit to 10 GB per person, along with a speed of 1 million lines / hour. There is also the possibility of accessing data sources directly, linking them to data companies through the Data Connectivity Gateway. Finally, advanced collaboration tools such as Office 365 Groups, Active Directory groups, and the data directory are available [50].

Table 2 presents the main pros and cons of the Power BI platform.

Table 2. Power BI Pros&Cons.

+ Pros	**-Cons**
• Availability of free version, easy accessibility of the platform • Integration with other Microsoft products • Built-in data visualization libraries	• Combines some data types when filtering • There is no way to combine the results in bookmarks • Difficulty in working without technical knowledge

The architecture of the Power BI platform is shown in Figure 4.

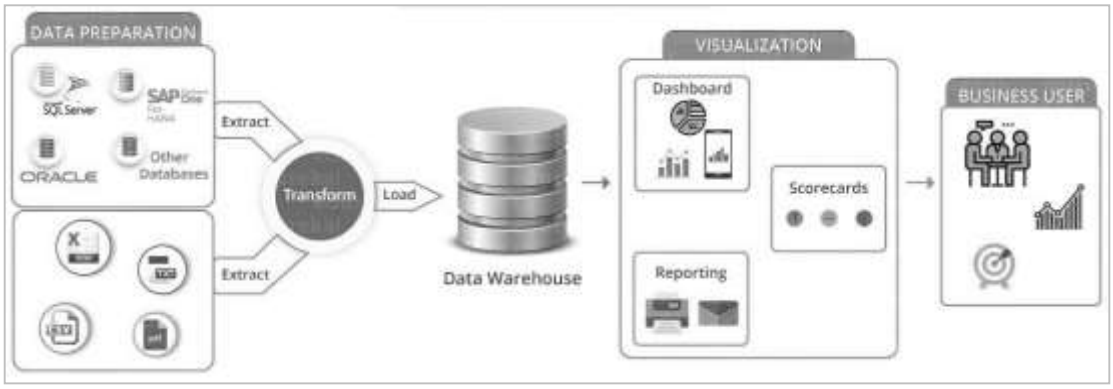

Fig. 4. Architecture of the Microsoft Power BI platform.

The Power BI architecture consists of three phases. The first two phases use ETL (extraction, transformation and loading) for data processing.

1. Data Integration. This phase includes the processing of data from various sources of information in order to further combine them into a standard format and save them in the intermediate area.
2. Data processing. The data processing phase includes the processing and purification of data, after which business rules are applied to them and they are converted into presentable data. Then the data is loaded into the data warehouse [50].
3. Data presentation. The phase of data presentation is necessary for data visualization using various interface toolbars for visual presentation of reports.

Tableau Platform

Tableau analytic platform is a fast and powerful data visualization tool that does not require training of business users and does not include costly implementation at the enterprise.

Tableau platform specializes in analyzing data through its visualization: interactive dashboards; effective charts. Tableau supports different data sources organized in file format (Excel, XML, CSV), relational and non-relational databases and cloud systems (Azure, Google BigQuery , AWS) [51].

The key difference between Tableau and its competitors is the ability to combine data drom different sources and databases. The platform allows multiple users to work simultaneously with one report in real time. Moreover, Tableau implements different ways of how to share reports:

- by publishing them on the Tableau server;
- through access by reference
- by Tableau Reader e-mail;

Tableau has the broadest visualization capabilities: the platform's rich library includes word clouds, tree and bubbles diagrams. The main functions of the service allow to incredibly place elements on a dashboard and combine and overlap them in any way [52]. Tableau platform has an intuitive interface that allows users to work without special technical skills. Designed dashboards make it easy to find filters for creating reports. Tableau is considered one of the easiest to learn BI services when analyzing structured information.

Key features of Tableau are:

- great opportunities to distribute reports and dashboards;
- support a lot of data types;
- wide library of guides;
- combining data from different sources;
- integration with R.

Tableau has three different products: Tableau Desktop, Tableau Online and Tableau Server. The first product is intended for individual users and costs $ 999 per year per person and $ 1.999 for corporate use, including support. In the first case, it is supposed to connect up to 6 data sources, and in the second - up to 44. Tableau Online is a web-based cloud platform that can be used for free if all solutions are stored on a shared server and published in the public domain. The private version costs $ 500 per year for one user. Tableau Server is a monolithic business tool for companies that manage their servers and want to have full control over data flows and their security [53]. The cost of such a service will be $ 10,000 per year for 10 users, and support will cost an additional 25% of this amount.

Table 3 presents the main pros and cons of the Tableau platform.

Table 3. Tableau Pros&Cons.

+ Pros	**- Cons**
• Intuitive interface • Integration with Big data platforms (Hadoop, Google BigQuery) • A large number of built-in tools to import data from various sources • Report collaboration • Regular release of platform updates with new features • Reliable customer support • Wide library of video materials, courses, manuals	• Mandatory data preprocessing (data must be structured) • Narrowly targeted functions • Not able to create financial reports • No Tableau server level change histories

The main advantage of the system is the opportunity to process data of any format together with a high speed of obtaining the result. Tableau is based on two main technologies:

- VizQL (allows to create high-level data visualizations);
- Data Engine (provides second analysis of a large number of rows).

Figure 4 shows the architecture of the Tableau interactive business intelligence system. It includes 5 main components:

- a data server that allows the Tableau system to connect to multiple data sources;
- data connector, which is an interface for connecting external data sources to the Tableau data server;
- Tableau server components;
- network gateway designed to send requests from users to Tableau components;
- platforms with which you can edit and view visualizations and dashboards on the Tableau server. The platforms are a web browser, mobile applications and a desktop version of Tableau.

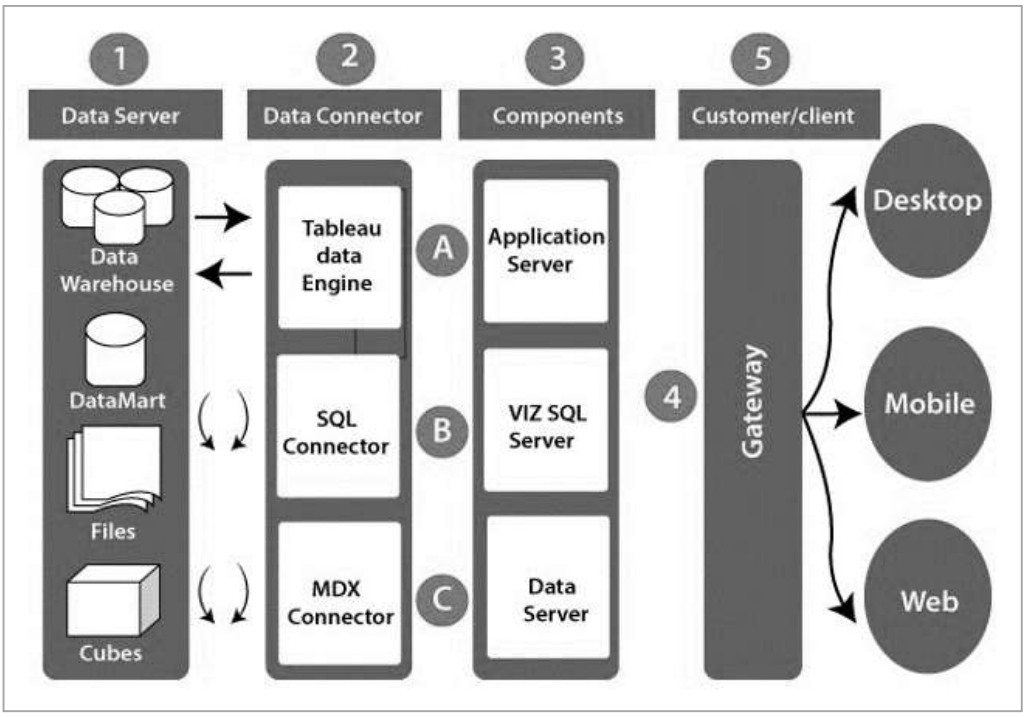

Fig. 5. Architecture of the Tableau platform [54].

2.6 Examples of implementing BI systems in a medical service company

World practice

The use of business analysis platforms as a tool for data analytics in medical companies is valuable in terms of studying clinical, financial and operational data. In turn, this helps to improve the quality of medical care and reduce costs. For example, the QlikView and QlikSence platforms allow hospitals to support three basic data types:

- clinical data;
- corporate data;
- transaction data.

In the United States, some medical organizations have up to fifty Qlik reports to visualize the necessary data. The main tasks that the Qlik platform helps hospitals cope with are:

- analysis of the use of operating rooms;
- quantitative analysis of ambulance calls;
- identification and elimination of bottlenecks;
- identification of clinical changes.

In the UK, one of the medical institutions using the analytical system helped to identify how an increase in the chamber load (by 1%) will increase the weekly income (up to $ 15,000). Moreover, in the UK, a government order has been issued that says that it takes less than four hours to examine and treat each patient. Qlik shows how often a medical institution violates this decree. Moreover, the system gives an idea of the peak time when the largest number of patients enters the emergency department. Also, the visualization panel shows the number of patients that goes to the hospital [55].

Atlanta hospitals, including Children's Healthsouth Rehabilitation and Allina Health, use analytical systems to measure HCAHPS, CGCAHPS, outpatient quality assurance, and the number of potentially preventable rehospitalizations. Business intelligence systems offer users to see visualized information on patients, their age, attending physicians, time of arrival at a medical institution.

Table 4 presents models of healthcare solutions using the Qlik platform as an example.

Table 4. Decision models in healthcare based on the Qlik platform

Value-Based Healthcare Delivery	Clinical Domain	Operating room	The ability to make decisions throughout the entire operational process
		Emergency Department	Real-time operational management of ambulance processes
		Clinical Benchmarking	Comparison of large volumes of diverse data for making decisions about the choice of treatment methods for patients
	Healthcare Operations	Workforce optimisation	Improving the efficiency of personnel management based on monitoring staff load
		Supply chain	Analysis of the results of the implementation of the end-to-end supply chain management process
	Corporate Domain	Financial Management	Compilation of comprehensive financial statements for various indicators
		Performance Visualization	Visualization of cross-system analysis of indicators on various aspects of the medical organization

Finland practice

Valvira company is the Valvira, the National Supervisory Authority for Welfare and Health in Finland. The company works with a large data set and uses a wide range of resources to maintain its infrastructure. The creation of analytical reports is an important part of Valvira's work to analyze economic indicators, the effectiveness and impact of various participants. Business analysis tools allow the company to manage internal processes. The main driver for introducing an analytics system within the company was the modernization of its own BI solution and information management.

One source of information is patient data from the National Institute of Health and Welfare.

The company's IT director says that «…patient information systems are mainly used in hospitals, but the idea is that Valvira will not receive personalized numerical data for its monitoring purposes as a by-product. Both internal and external systems were created from different starting points at different times, and they do not always work without problems. Valvira may not have access to certain information that it needs or the data it acquires is incompatible» [56].

BI systems are necessary for the company to create reporting for management, which displays the analyzed data from internal and external sources. The end user will see in the system the information that he needs according to his position. Role allocation is configured using sectional access. Valvira wants to use a system that is universal. This will allow to configure access for different groups of users: employees of their own organization, regional and state institutions. The main advantages of using BI systems for Valvira is the ability to work with raw, high-quality data for further correct processing. As a platform for creating reports, the company chose the QlikView solution. The platform is suitable for the company because of its economic efficiency, a wide range of capabilities, a set of functions and ease of use. Moreover, this solution does not depend on the supplier and has advanced functions from the point of view of the user and analyst.

3 ANALYSIS OF KEY PERFORMANCE INDICATORS OF MEDICAL ORGANIZATIONS

3.1 Key business functions of a medical organization

Business processes determine the enterprise organizational structure. The organizational structure is a stable set of interrelated and mutually subordinate organizational units for coordinating the enterprise workforce [57]. The project is traditionally defined as "a temporary organization created to solve unique problems / obtain unique results." As a temporary organization, the project does not have a permanent organizational structure - instead, there is a structure of roles and responsibilities that are implemented on a temporary, role basis by performers from the organizational structure of the company.

Business architecture involves a description of all groups of processes - main, managerial, supporting with an appropriate level of decomposition into subprocesses [58]. A business process model is a key element of business architecture for reengineering management system, because of:

- it provides an understanding of the company;
- it allows to make a visual model for analysis, benchmarking and identification of company's development;
- it defines the organizational structure and cash flows;
- it allows to identify the needs for IT support, the requirements formation for IT services and the subsequent formation of the IT architecture landscape.

Let's try to simulate a business architecture for a medical organization, but it is worth remembering that when modeling the activities of medical organizations, there are a number of specific features of this industry that affect the choice of approach to identifying processes:

- a patient-oriented approach that determines the cross-functionality of activities in business processes for patient care;
- a pronounced matrix management system on the grounds of functional and administrative subordination;

- the individual path of treatment of the patient, leading to a high degree of flexibility and variability of business processes for patient care;
- a high degree of regulation of the processes of medical care and related processes, including certain requirements for document management in healthcare.

In connection with the specified specifics, the main processes of medical activity were identified not by medical specialization, but by the form of medical care and services. Below is a detailed description of the typical functions of a medical organization (Fig. 6). This figure was implemented Archi 4.0 tool. ArchiMate is an open and independent enterprise architecture modeling language for supporting the description, analysis and visualization of architecture inside and outside business processes in a unique way [59]. The proposed models contain an exhaustive list of functions of medical organizations obtained in the course of analysis of existing practices of modeling the activities of medical organizations and in consultation with large medical organizations in Russia. Functional models in Fig. 6 can be considered as reference models and adapted to the conditions of implementation of the activities of a particular medical organization.

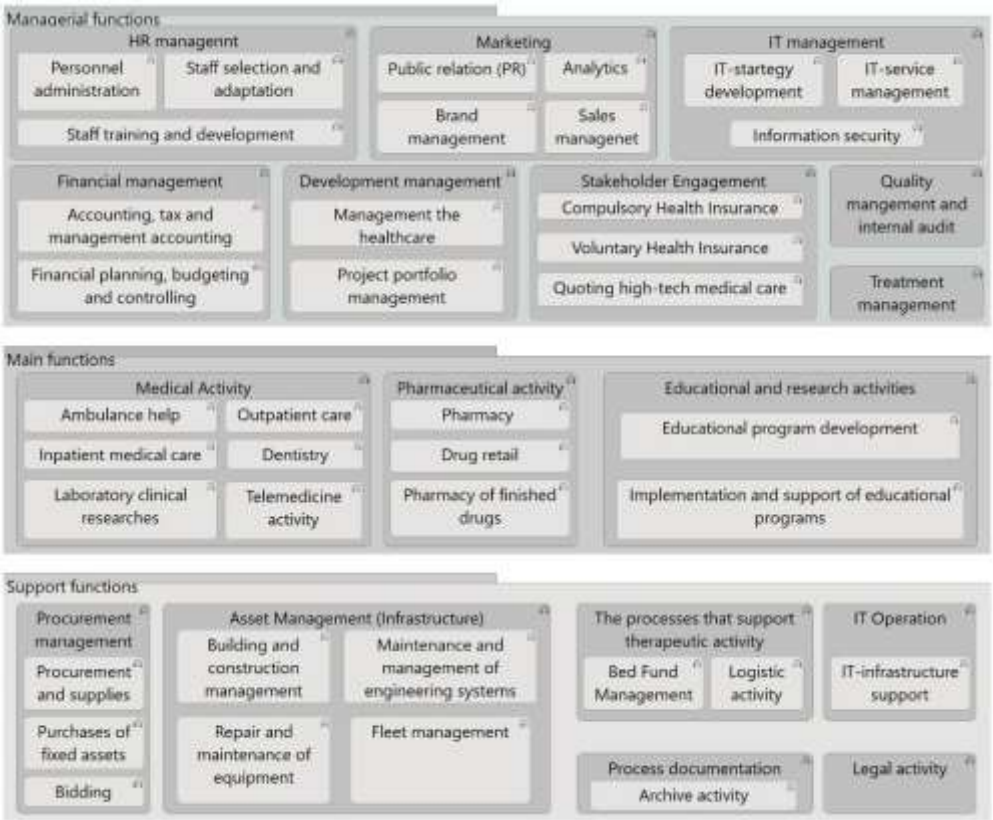

Fig. 6. Key business functions of medical organization

3.2 Description of key performance indicators of a medical organization

The practical implementation of BI systems in the activities of medical organizations involves the formation of a system of key indicators to assess its effectiveness and efficiency. In various sources, including regulatory documents, one can find approaches to the classification of indicators of efficiency and effectiveness of institutional units of the healthcare sector. Their use can serve as a basis for assessing the achievement of target values of effective indicators (criteria) in order to determine the effectiveness of the state task.

When choosing key indicators of the effectiveness and efficiency of medical organizations, the following basic criteria must be used:

- reliable assessment of the achievement of target values by a medical institution;
- the interconnection of indicators used to assess key aspects of the activities of medical organizations, and coordination with other lists of applicable indicators in accordance with information disclosure standards, industry management regulations, requirements of regulatory authorities and regulatory acts to ensure comparability and cost-effectiveness;
- maximum orientation to industry and regional medical and economic standards, as well as examples of best practices;
- reliability of information sources, quantitative measurability, ease of calculation of indicators and their economic feasibility.

As practice shows, the recommended indicators are not able to fully reflect the level of effectiveness of state regulation by control points. In this regard, there is a need for the development and implementation of additional indicators, and, above all, non-financial. Most of these key indicators are calculated on the basis of public information, thereby ensuring compliance with the principles of transparency and verifiability of reporting and, in general, the activities of medical organizations, and the use of which helps to achieve sustainable success and increase the socio-economic efficiency of medical services.

Evaluation of the effectiveness of the quality of medical care should be based on an analysis of indicators characterizing medical efficiency, social satisfaction of patients and the costs incurred. The table 5 shows the main indicators necessary for the analysis of the organization.

Table 5. Key performance indicators for the analysis of the organization activities

Key performance indicators	Description
Cost effectiveness	The cost of effectively treating a newly diagnosed patient / the cost of treating a newly diagnosed patient
Financial support in the form of subsidies for the fulfillment of a state task	It is determined based on the financial statements of a medical organization.
Financial support through targeted subsidies	It is determined based on the financial statements of a medical organization.
Financial support at the expense of compulsory medical insurance	It is determined based on the financial statements of a medical organization.
The level of consumer satisfaction with the quality of medical services	Determined by the results of a survey conducted in the form of a survey
The coefficient of medical effectiveness	The specific gravity of medical care cases during which the planned result is achieved. The target value of this coefficient is one.
The level of qualification of personnel of a medical organization	It is determined by monitoring personal files of employees
Proportion of employees of a medical organization with a degree	The number of employees of a medical organization with a degree / total number of employees of a medical organization
Complications during medical diagnostic procedures recorded in medical documentation	The indicator is considered fulfilled if there are no cases of complications.
Cases of violation of established sanitary rules and norms	The indicator is considered fulfilled if there are no cases of violation

Table 5 (continuation). Key performance indicators for the analysis of the organization activities

Key performance indicators	Description
The complexity of the work of doctors related to the main staff (hours)	Determined in accordance with approved standards
Labor intensity	The complexity of medical posts of the main staff / number of patients treated
Percentage of patients who complained of ethics and deontology of medical workers, in the total number of patients served	The number of patients who complained about ethics and deontology of medical workers / total number of patients of a medical organization
Labor productivity per patient treated	Number of patients treated / number of occupied medical positions of the main staff
Number of occupied medical positions of the main staff (abs.)	Determined by the data presented in the accounting and analytical documentation
Cost ratio	It depends on the ratio of normative and actual costs of treating patients in a particular department.
Performance ratio	Calculated as the ratio of the number of patients whose treatment achieved the planned result to the total number of treated patients.

Moreover, there are a number of indicators that will be reflected in the form of various types of data visualization: graphs, tables, charts, text fields, containers. Such indicators allow to analyze total costs and number of patient visits (encounters) by specialty; the billed amounts and insurance write-offs by charge department, and costs over time.

4 FORMATION OF A SYSTEM OF REQUIREMENTS FOR ANALYTICAL REPORTING SYSTEMS THAT MONITOR THE ACTIVITIES OF A MEDICAL ORGANIZATION

4.1 Development of a system of requirements for a BI solution for the analysis of key performance indicators of medical organization

The analytical reporting system is designed to provide information on the activities of the structural business units of a medical organization to interested parties involved in administrative activities. The main objectives of the system are:

- improving the quality and reliability of reporting for management decisions;
- increasing the capabilities of data analysis and forecasting for making managerial decisions;
- reducing the complexity and timelines for the process of preparing analytical reports;
- integration of various production and functional units into a common information model as users of management information.

The requirements for analytical reporting systems are functional and technical. All requirements were divided into seven groups (Figure 7).

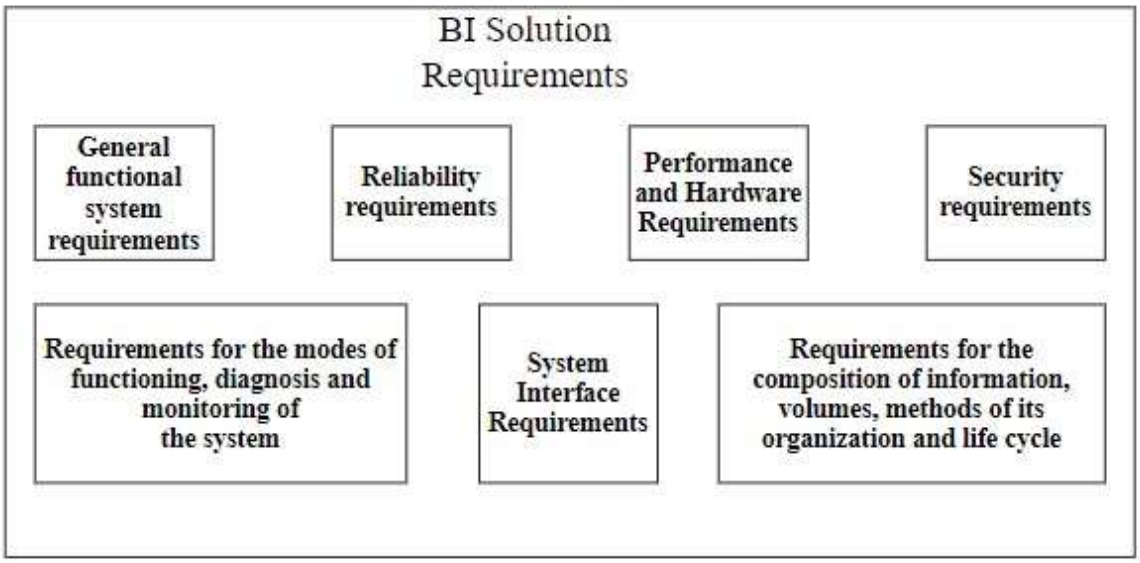

Fig. 7. BI System Requirements Map

General functional system requirements

The system should have three functional subsystems. The first subsystem is intended for collecting, processing and loading data, which is designed to implement the processes of collecting data from source systems, bringing these data to the form necessary to populate the data storage subsystem. The second data storage subsystem allows to store data in structures aimed at decision making. The last subsystem of reporting generation and visualization is intended for the formation of business-oriented data marts and reporting.

The system must provide the following general functions:

1. Automated data loading from information systems-sources in the established format. Then, need to set up and perform data normalization procedures: converting downloaded data to a single format, forming and storing relationships between data from various source systems.
2. Formation of performance, production and business indicators to assess the activities of the organization. Conducting financial and economic data analysis for the following types of analysis: plan-fact analysis, factor analysis, recalculation of the forecast for the actual volume (flexible forecast) and statistical analysis.
3. Supporting work with two types of reporting forms: fixed reporting forms and interactive reporting forms with the ability to use a graphical designer of report forms and analysis. Ability to export generated reports to MS Excel format files in manual and automatic mode. Moreover, the system should provide for the ability to supplement the data received from SAP BW with additional data from Excel tables (including additional indicators).
4. The main elements of the report must be interactive, must support the drill-down function, filtering in all elements and tabs of the report must be end-to-end. As part of navigation, the report should include the ability to add a specific set of data slices to favorites, for subsequent direct access to them and the possibility of full contextual search in the report.
5. The system should provide for the possibility of differentiating access by different users. At the same time, it should be possible to establish restrictions both for data slices and for a set of indicators.
6. The system must have the functionality for exchanging comments and the ability to attach a comment to a specific element of the report and / or slice data with

subsequent access to it by all users (if this does not contradict their access rights). The system should have functionality for automated sending of reports by e-mail.

7. The system interface should be created on the five main principles:
    - uniform stylistic design;
    - multilingualism;
    - use of preferred options for deriving the final information:
        - graphs and charts (columnar, linear, circular, "bubbles");
        - tables (no scrolling);
        - search for a solution (answer to a question) in 5 clicks.
    - intuitive interface designed for use on mobile devices and projectors (correct scalability when changing resolution). The project does not intend to develop separate reports for mobile devices;
    - all elements must support the conditional formatting function.
8. The availability of statistics on the use of reports by users.

Reliability requirements

The system should have a two-system landscape: test and productive environment. The system guarantees the receipt and sending of data. In the event of a failure, the data can be sent again. The ability to return the system to its original state after an unsuccessful change must be supported.

In the event of a system update or short-term operational disruptions of the state of any components, data loss should not occur. It should be possible to organize automatic and manual backup of system data with a frequency and storage period agreed upon with the customer using the DBMS system and software.

The system should ensure the correct handling of emergencies caused by incorrect user actions. In these cases, the user should receive the appropriate error messages from the system, and then return to the operating state that preceded the incorrect (invalid) command, group of commands or incorrect data entry. The software should automatically recover if the hardware restarts correctly after a failure, including a power outage.

The availability of the system should be at least 99.75%. The recovery time should not exceed more than 1 hour during working hours, during non-working hours - no more than the time before the start of the working day plus one hour.

Performance and Hardware Requirements

To ensure the performance requirements of a productive environment, it is necessary to provide at least 2 servers with 512 GB RAM.

The required response time of the system to user actions up to 5 seconds is provided due to the restrictions of the developed applications. Such limitations are presented in table 6.

Table 6. The performance and hardware restrictions of the developed applications

Name of restrictions	**Value**
The maximum number of lines	50 million lines
The maximum number of columns	40
The number of tabs in	No more than 10
The maximum number of visualization objects	No more than 100 (these are all objects, including static inscriptions and pictures)
The maximum number of calculation expressions	No more than 50
The maximum number of design measurements	No more than 5
The maximum number of simultaneously displayed visualization objects	No more than 10
The amount of data used to build visualization objects	up to 30% of the total application volume
The average number of requests per user	4 per minute
The maximum number of competitive users	50

Security requirements

Access to the system is available only to registered users. User registration is subject to approval by the employee controlling department. The system must have an audit function

(logging of work with the system). Moreover, the system should provide flexible user account management capabilities.

Various levels of access to the objects should be configured in the system: access prohibition, reading, reading and writing, administration. Furthermore, the system should allow flexible configuration of the rights and privileges of users of the system. The possibility of inheritance of rights in relation to objects that are hierarchically dependent should be realized. All administrator actions should be logged by system.

Transparent user authentication should be implemented in the existing corporate directory. Also, the client part must have the ability to encrypt traffic transmitted between the client and the server. In the case of security of user information, the system is openly allowed to store users and passwords in the code or system metadata in an open form

Requirements for the modes of functioning, diagnosis and monitoring of the system

One of the most important possibilities of the system is containing diagnostic and monitoring tools. Moreover, the system must be available to users 24/7. It is allowed to stop the system for scheduled preventive work on weekends and holidays for a time not exceeding the time before the start of the working day. If system has errors, they should be logged in the system log. In case of errors when processing the data array on one screen, they should be grouped and displayed in one window. Thus, the system should not have unhandled exceptions.

System Interface Requirements

The system should be fully functional on a PC running Windows 7, 8, 10 and IE 8,9,10, 11 and mobile devices. The system should provide a user-friendly interface that meets the following requirements:

- uniform design style for user interfaces;
- convenient, intuitive navigation in the user interface;
- multi-language interface;
- user interfaces of the system should be designed and developed using the same principles of graphical presentation of information and organization of access to functional capabilities and services.

Requirements for the composition of information, volumes, methods of its organization and life cycle

One of the important criteria for system quality is the correct archiving and storage of data. The system should have developed a unified approach to archiving obsolete data.

Tools should be provided for backing up and archiving stored information. The system administrator should be able to recover data for a certain elapsed period. It should be possible to back up the database manually and automatically. The system should allow to configure time periods for data storage. The system must work with virtualized disk storage

The database must be consistent, scalable, extensible, reliable, and resilient.

The data source is SAP BW. In order to minimize discrepancies in the data, all calculations, if it is technically possible and expedient, should be performed on the SAP BW side. The BI system should only perform standard transformations, such as: filtering, aggregation.

There are different ways of ways of ERP/ MIS and BI system integration. The main advantages and disadvantages of each integration technologies are highlighted.

Using the Excel upload reporting system [59].

Advantages: ease of use; low cost; no special skills required; ease of implementation; low participation of external experts.

Disadvantages: low data security; data loading process automation has low degree; high probability of system failures when creating new files (the result may be a loss of integrity and completeness of data); creating new queries to the ERP database depending on user requirements.

Making connection of BI system directly to DBMS using standard ODBC/OLE DB interface [59].

Advantages: support of external data sources such as ODBC; ability to work with 32/64 bit drivers (ODBC); low solution costs; no need to use additional modules; constant access to databases; no violation of data completeness and integrity.

Disadvantages: the presence of difficulties in creating DBMS queries when encrypting the names of tables and fields in the formation of the ERP database

Uploading data from ERP and MIS systems by software component Xtract BI [59].
Advantages: ability to extract data from ERP system tables; use special component to access data from BAPIs; ability to use dynamic SQL statements; processing retrieved Big Data; no significant effect on the production system.
Disadvantages: the cost of using additional modules is required.

The main functions of the connector are four points:

- data models generation;
- creating a direct sample from database;
- automating the assigning data fields process;
- connector is a help desk for data structures and ERP table relationships.

All requirements for the analytical reporting system should reflect both the technical component during the implementation of the system and describe the key points in data visualization.

4.2 IT-architecture of medical organization with BI systems integration

Figure 8 shows the model of uploading data from the ERP system to the BI system depending on the data source type [59]. Uploaded data are used for further aggregation. The diagram is drawn using tool Archi 4.0. The first layer is business layer, which describes the activities and development of the enterprise, as well as its environment; describes products and services for external consumers, the main business processes and services, business executives and business roles that perform these processes, as well as the information used (business objects).
The second is an application layer, which describes applications, their functionality, and the relationship between applications. It also describes application services that support the business layer and the main data objects used by applications.
The last technological layer is an infrastructure services (e.g. processing, storage, communication) necessary to support applications implemented using computer and communication equipment and system software [60].

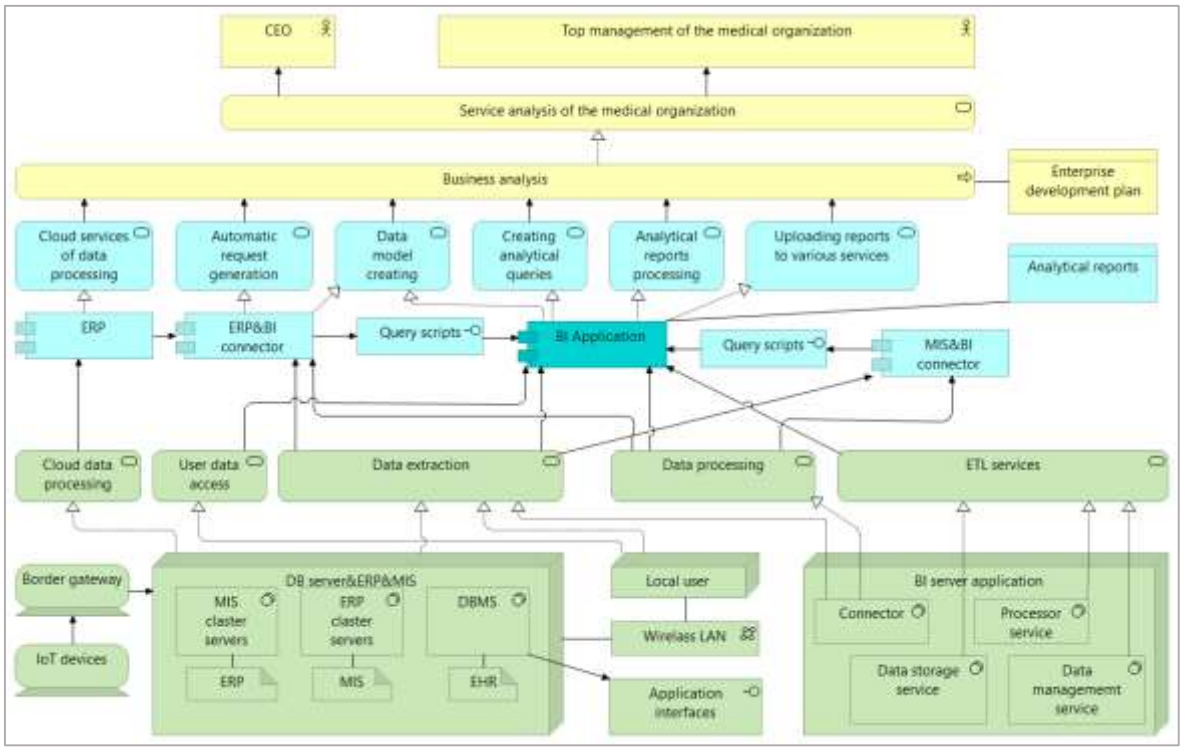

Fig.8. Referent architectural model with BI system integration

4.3 Prototyping BI application layout for analyzing the KPI system of a medical organization

QlikView platform was chosen as an analytical reporting system. The main advantages of this platform are:

- powerful analytics in a clear format;
- possibility of implementation based on the described requirements;
- quick analysis of information;
- instant consolidation;
- multi-platform;
- associative search.

QlikView platform system architecture

The system architecture should include the following components:

1. Sources - data objects from source systems that will be loaded for review in the analytical System.
2. Data and downloaders - the level of data storage and processing in the System.
3. Analytical applications implement the analytical subsystem and the information protection subsystem.
4. Hardware - hardware resources allocated for the implementation of the System.
5. Qlik software - essential software for setting up a QlikView server. Using the basic functions of Qlik software, an information protection subsystem is implemented.

To carry out the development, configuration and testing of System applications, a dedicated server and a set of software are allocated - the development and testing environment. This ensures the independence of the productive operating environment and the development and testing environment.

Data is transferred between the client’s Internet browser and the QlikView server through the open http protocol. The use of the productive environment of the system is supposed only in the secure perimeter of the company's internal network.

Administrators of QlikView production environments can additionally work with the system through a secure VPN / RDP connection. Administrators have full access to all servers in a productive environment.

The backup and recovery subsystem are implemented by external means.

Figure 9 shows the overall architecture of the development system.

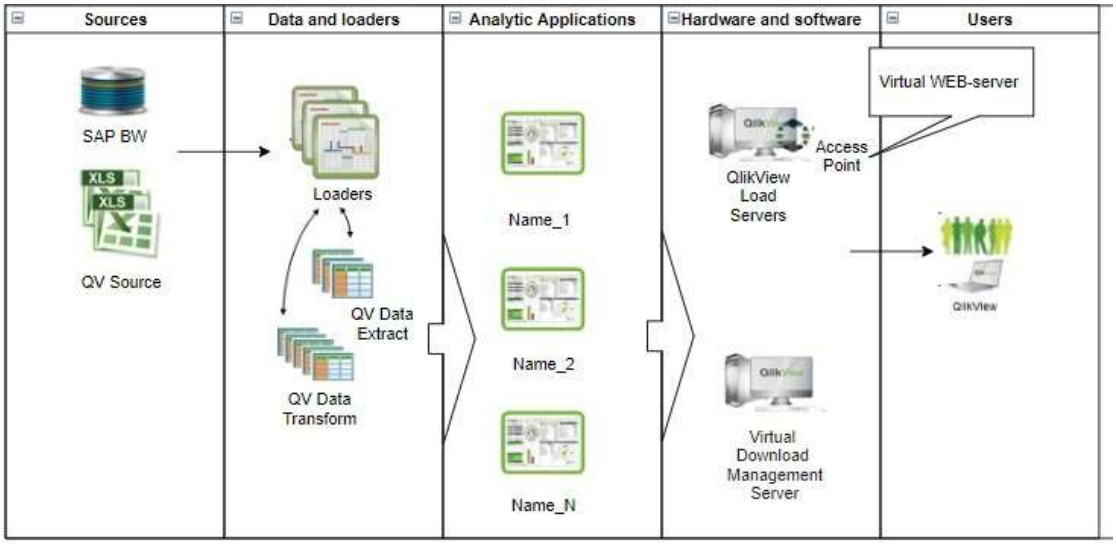

Fig.9. Development Environment System Architecture

List of indicators

Table 7 presents a list of basic and calculated indicators.

Table 7. List of indicators

№	The name of indicators	Unit of measurement	Description
1	Cost of services provided	$	The amount of services rendered reflected in information systems in accordance with accounting mechanisms
2	Number of visits	visits	The patient's appeal to a doctor or paramedical personnel for medical assistance, advice, and obtaining a medical opinion
3	Number of services	services	The number of services provided to the patient
4	Number of services per visit	services/ visits	The average number of services provided to the patient within one visit / one bed day
5	Count of patients	persons	The total number of unique patients seeking medical care in the planned or reporting period
6	Number of bed days	Bed days	Unit for recording time spent in a clinical hospital, sanatorium

Table 7 (continuation). List of indicators

№	The name of indicators	Unit of measurement	Description
7	Bed turnover	person	The indicator characterizes the number of patients in a hospital bed during the reporting or planned period. This ratio is the number of outpatients (discharged + deceased) / average annual number of beds.
9	Number of operations	operations	The number of operations performed during the reporting period
10	Number of applicants	persons	The number of patients admitted to the hospital
11	Number of dropouts (discharged, deceased)	persons	The number of discharged (deceased) from the hospital
12	The number of repeat patients	persons	The number of patients who applied repeatedly for the reporting period
13	Number of services per patient	services/ persons	Number of services provided to one patient
14	The number of visits per patient	visits/ patients	Number of visits per patient in the planning or reporting period
15	Revenue per patient	$	Revenue per unique patient
16	Average check	$	Average revenue per visit / average bed / average cost of surgery
17	Average cost of service	$	The average price of one service provided to a patient
18	Capacity utilization	%	Doctors Performance Indicator
19	Staff loading	%	Staff performance indicator
20	Staff power	visits/ bed days	The indicator reflecting the maximum ability of staff
21	Staff time fund	hour	Number of working hours for the reporting period according to the work schedule of the staff
22	Implementation of the bed work plan for the period	%	Percentage of bed utilization
23	The average duration (median) of the patient's stay in the department	days	The average amount of time that a patient is in the department
24	Bed Downtime	days	Time between discharge and hospitalization for bed
25	The number of complications by nosology	complications	The number of complications in patients after treatment in the context of nosologies

Table 7 (continuation). List of indicators

№	The name of indicators	Unit of measurement	Description
26	The proportion of patients with complications in nosology	%	Number of patients with complications / total number of patients
27	The proportion of patients with an unplanned return to the operating room (within 48, 72 hours)	%	Number of patients with unplanned return / total number of patients
28	The average duration of waiting from the moment of diagnosis to the first treatment by nosology	minute	The time that the patient expects to receive the first stage of treatment
29	Number of transfers to other departments	transfers	The number of times the patient was transferred to other departments
30	The load of the doctor in the department	beds	Number of beds per doctor
31	Hospitalization result	-	- recovered - dead - re-hospitalization
32	Frequency of rehospitalization	%	An indicator of how often the patient returns to the hospital after discharge

List of directories

It is necessary to load 4 basic directories into the system: patient reference; reference book for medical personnel; reference book on nosologies; the calendar.

Data model

Figure 10 shows the data model for the prototype BI application. The model includes the following tables:

- Encounter – fact table;
- Patient – contains patient information fields;
- Physician – contains medical staff information fields;
- Admission –contains information about admission of patients: type and results of it.
- Discharge - contains patient discharge information

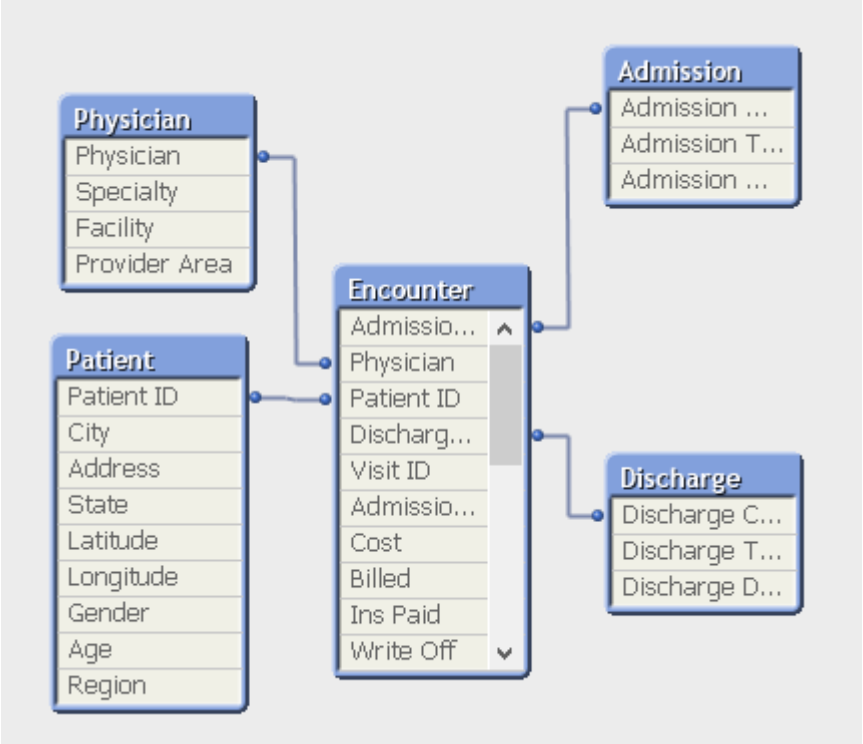

Fig.10. Data model

Appendix 2 presents a prototype of a BI application dashboard. It performed an analysis of the main indicators that reflect the activities of a medical organization. This prototype was made taking the above requirements for the BI system into account. On the dashboard, an analysis of the indicators prescribed in table 6 is performed.

5 DISCUSSION

5.1 Literature review

Current trends in the management of a medical organization were analyzed in this section. The use of modern technologies in organizations makes its changes to the strategy of company management. In this regard, new business models of medical organizations appear; the structure of value propositions of medical services, distribution channels and the system of working with consumers of medical services are changing.

The chapter describes the existing approaches for analyzing the company's business processes. The key approaches are functional cost analysis method, activity based costing (ABC) method and simulation method.

A description of modern approaches to the formation of requirements for IT systems was also given. Such approaches are:

- Rational Unified Process (RUP) - is the most effective means of modeling requirements for an information system based on a business model of an enterprise.
- BPWin - belongs to the CASE category of top-level funds. It supports three modeling methodologies: IDEF0 (function diagrams), IDEF3 (process diagrams) and DFD (data flow diagrams).
- Architecture of Integrated Information Systems (ARIS methodology). This uses foolowing methods and means of visual description such as: data flow diagrams (DFD), state transition diagrams (STD), entity-relationship diagrams (ERD), structured analysis and designed technique (SADT), unified model language (UML).

The last subsections of this chapter reflect the information about existing business analytics systems and examples of the implementation of BI systems in companies of medical sector. Leading systems such as QlikView, Tableau and Power BI were considered. The main advantages and disadvantages of each system in the form of tables were given. Information on modern practices of implementing BI systems was taken from various electronic resources, as well as from the websites of medical organizations in Finland and around the world.

5.2 Analysis of key performance indicators of medical organizations

This section describes the key business functions of a medical organization, which allows to define a system of processes that implement business functions, and a KPI system that provides the ability to monitor the medical and economic performance of an organization. Understanding business functions and their processes is the first step in implementing appropriate IT support. For ease of understanding, business functions are shown using the ArchiMate language.

Based on an analysis of the business functions of a medical organization focused on the implementation of the concepts of value and personalized medicine was formed a system of indicators. They allow to a certain extent to evaluate the activities of a medical organization in terms of the implementation of these concepts with on the one hand, and also from the point of view of solving problems of economic efficiency, with the other side.

The section presented key performance indicators of a medical organization. The practical implementation of BI systems in the activities of medical organizations involves the formation of a system of key indicators to assess its effectiveness and efficiency. The list of KPIs is presented in the form of a table with a brief description of each of them.

The indicators that allow us to make decisions about the level of implementation of the concepts of value and personalized medicine, we included: the level of consumer satisfaction with the quality of medical services; the coefficient of medical effectiveness; the level of qualification of personnel of a medical organization: complications during medical diagnostic procedures recorded in medical documentation; cases of violation of established sanitary rules and norms.

The following indicators can be used to evaluate the economic efficiency of a medical organization: labor productivity per patient treated; number of occupied medical positions of the main staff; cost ratio; performance ratio.

5.3 Formation of a system of requirements for analytical reporting system that monitor the activities of a medical organization

This section is one of the results of the study. It spells out the basic requirements for analytical reporting systems, which must be observed when implementing systems in a company. All requirements are divided into two types: functional and technical. General functional system requirements include requirements for the subsystem for collecting, storing and processing data, the subsystem for data storage and the subsystem of reporting generation and visualization.

As the main requirements were highlighted:

- Reliability requirements;
- Performance and Hardware Requirements;
- Security requirements;
- Requirements for the modes of functioning, diagnosis and monitoring of the system;
- System interface requirements;
- Requirements for the composition of information, volumes, methods of its organization and life cycle.

Based on a study of the processes of a medical organization, the IT-architecture of medical organization with BI systems integration was developed. When building the architectural solution, we used the TOGAF standard. This model is one of the possible options for integrating a BI application into a common architectural model. The relationship between different layers is shown: a business layer, a layer of information systems and a layer of IT infrastructure.

As a practical component, a prototype of BI application for the analysis of the KPI system of a medical organization was proposed. This prototype is made taking the formed requirements into account. The prototype allows to analyze the indicators needed to monitor the activity of a medical organization at various levels of its administration.

As mentioned earlier, all indicators allow to assess the level of medical effectiveness or economic efficiency. The indicators of the first group (medical effectiveness) include number of visits, service, operations; the number of complications by nosology; the

proportion of patients with complications in nosology; the proportion of patients with an unplanned return to the operating room (within 48, 72 hours); the average duration of waiting from the moment of diagnosis to the first treatment by nosology; number of transfers to other departments; hospitalization result; frequency of rehospitalization. The indicators allowing to draw a conclusion about the level of economic efficiency in the activities of a medical organization are number of bed days, bed turnover, average hospital stay, revenue per patient, average check, average cost of service, capacity utilization, staff loading, staff power, staff time fund, implementation of the bed work plan for the period, the average duration (median) of the patient's stay in the department, bed downtime.

The generated scorecard allowed us to develop a data model that is implemented using the QlikView BI tool. Designed dashboards allow visualization for easy analysis of the main indicators that reflect the activities of a medical organization. The developed application is one of the possible examples of solving the problems of analyzing the values of performance indicators of a medical organization. This application involves the use of data from accounting systems, as well as data from patients who provide feedback on the results of treatment. This is an important parameter for improving the provision of medical care, taking into account the implementation of the ideas of value and personalized medicine, for shaping the development strategy of a medical organization in the context of implementing innovative medical trends based on end-to-end digital technologies, such as Neurotechnology and Artificial Intelligence, Robotics and sensor components, Internet of Tings (IoT), Big Data, New manufacturing technologies, Quantum technology, Wireless technology.

6 CONCLUSIONS

The result of this thesis is the formation of a system of requirements for an analytical reporting system for the analysis of key performance indicators of a medical organization.

Throughout the research, an analysis of the business processes of a modern medical organization was carried out to implement an innovative business model that implements the principles of value and personalized medicine. A system of key performance indicators has been formed, which is aimed at monitoring the activity of the medical organization.

An overview of the tools for KPI system visualizing the scorecard and the subsequent assessment of the organization are presented. The requirements for BI-applications for visualizing the efficiency indicators of a medical organization have been shaped. A prototype of BI application has been developed that allows to visualize indicators and analyze activity based on the results.

As future studies, it is planned to form a holistic BI system that will allow monitoring the performance of various organizational units of companies in the medical sector.

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APPENDIX 1. Business model of modern medical organization

<table>
<tr><th>Key Partners</th><th>Key Activities</th><th>Value Propositions</th><th>Customer relationship</th><th>Customer segments</th></tr>
<tr>
<td>• Federal organizations
• Insurance companies
• Medical equipment suppliers
• Pharmaceutical companies
• IT providers for healthcare organizations
• Public organizations, funds
• Universities</td>
<td>• Providing medical care (primary, specialized, ...)
• Disease cure
• Disease diagnosis
• Patients monitoring, who have been given medical care
• Implementation of complex medical services
• Material resources
• Staff
• IT-recourses
• Intellectual resources
• Finance recourses</td>
<td>• Services for continuous monitoring of patients health
• Services for the early diagnosis of disease
• Selection of treatment methods taking the genome into account of patients, features of the external habitat
• Patient Rehabilitation Services
• Patient care services
• Services for corporate clients, depending on the specifics of their activities</td>
<td>• Formation of patient’s database
• Feedback system with pats using mobile apps and social media
• Access to all patient data in real time, including on mobile devices
<u>Affiliate channels</u>:
• Portal of the Health Ministry
• Portals of medical organization in other regions
• Insurance companies
<u>Own channel:</u>
• Informing about services through the website
• Online recording (website, mobile)
• Automatic recording of the patient to specialists upon reaching the regulated examination time</td>
<td><u>Patients</u>:
• Individuals
• Corporate clients
• Remote region patients
• Patients providing treatment based on different types of insurance</td>
</tr>
<tr><th colspan="3">Cost Structure</th><th colspan="2">Revenue Streams</th></tr>
<tr>
<td colspan="2"><u>Fixed costs</u>:
• the basic salary of all categories of personnel
• rent (land, buildings)
• costs of staff training and retraining
• costs of medical research and development
• IT support costs for a medical organization</td>
<td><u>Variable costs</u>:
• medicines;
• soft patient inventory;
• depreciation of the active part of fixed assets;
• expenses related to commercial activities (advertising, taxes)</td>
<td colspan="2">• various types of health insurance
• extrabudgetary activities of a medical organization (paid services system)</td>
</tr>
</table>

APPENDIX 2. BI Application Dashboard Prototype

Specialty	Cost	Count of visits
Итоги	**180 896 607,66**	**207239**
Anaesthetics	10 235 701,74	10907
Cardiology	13 116 780,47	18286
Dermatology	13 562 919,54	14304
Emergency medicine	14 641 929,55	15125
Gastroenterology	14 584 553,52	18179
General surgery	13 703 690,00	18365
Infectious Diseases	9 369 437,68	8986