Reference Digital Model of the IT-Architecture of A Medical Organization

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Abstract

At the present stage of modern technologies development, many companies are focusing on using end-to-end digital technologies (Internet of things, blockchain, big data, machine learning, etc.) to implement their IT strategy. Digitalization is changing the way business is conducted as part of the production of an end product or service based on the use of Internet of Things (IoT) technologies, intensive data exchange and analytical systems. However, the technological application of end-to-end digital technologies alone is not enough. To profit from digitalization, it is necessary to introduce innovative business models, for example, the transition to business models with advanced services. Medical organizations are no exception. The main problems in the digital transformation of medical organizations are the company's unpreparedness for organizational changes, as well as an insufficiently well-developed IT strategy and business model that should precede the start of the implementation of digital projects. Reforming the activities of medical organizations, caused by the need to introduce end-to-end digital technologies, requires analysis and reengineering of the business process system and the formation of the company's IT strategy. To solve these problems, it is necessary to form a reference model of the IT architecture of a medical organization. The methodological basis of the study is an analysis of the literature on the research problem, generalization and systematization of data, and an architectural approach. The result is the construction of a reference model of the IT architecture of a medical organization, taking into account modern digital technologies.

Keywords: IT-architecture, reference digital model, medical organization, digital transformation

Introduction

The digital economy is positioned as a "system of economic, social and cultural relations based on the use of digital information and communication technologies"[1]. Countries that are world economic leaders are actively using digital technology to increase productivity and efficiency of the economy as a whole and individual enterprises. Digitalization is becoming an integral part of all processes of social life. The digital economy, being the basis of the fourth industrial revolution, determines a change in basic technologies and, as a result, a change in the technical and economic paradigm.

Gradually, digital technologies become a reality in the economies of countries, everyday life, in various spheres of economic activity, in international relations (examples are in the studies of the authors [2-5]). The widespread adoption of digital technologies (the Internet of things, the industrial Internet, big data, blockchain, cloud computing, machine learning, artificial intelligence, mobile communications, etc.) is one of the most important conditions for the development of national economies of all countries [6,7].

Studying the experience of the development of the digital economy in Europe, the USA, China and other countries is of great importance for the development of the digital economy in Russia

The federal project “Digital Technologies” of the state program “Digital Economy of the Russian Federation” (until 2024) [8], adopted in the Russian Federation, and the state program “Development of Health Care” (until 2020) [9] determine the development and process of digital transformation of priority sectors of the economy based on end-to-end digital technology stack. The base objectives of “Digital Technologies” project are:

- support of leading Russian high tech companies, which are develope products, services and platform solutions based on end-to-end digital technologies for digital transformation of priority economy sectors and social sphere mainly based on domestic developments;
- support for projects to scale technological solutions based on “end-to-end” digital technologies in a high degree of readiness in priority economy sectors and social sphere”

One of the way of improvement of health care system is implementation of modern management technologies based on end-to-end digital technologies (service-oriented architecture, process management, e-health) into practical healthcare.

Digital technologies have a significant impact on the quality and cost-effectiveness of medical care into sphere of healthcare. This premise, in particular, underlies in the base of the project in the Russian Federation for the development and implementation of a unified state information system in the field of healthcare in accordance with the Russian Federation government resolution No №555 by 05.05.2018. In modern world, where new technologies are dynamically developing, the focus of enterprises has shifted from the sphere of technologies for the implementation of core activities to the sphere of management technologies. For example, the more quickly and flexible management system responds to external challenges, the more effective the whole enterprise is. At the same time, the business model of the company, the value-oriented and functional models of the company, and the system of business processes are primarily affected by changes. The reengineering of a business process system based on the use of end-to-end digital technologies allows us to further formulate the IT architecture requirements and determine the program of development projects.

Methods

The methodological component of this article is based on the following approaches.

1. Analysis. The article analyzes the current interest of medical companies in the transition to an IT business strategy. Also, the article analyzed existing medical concepts taking into account the introduction of modern digital technologies, for example, IoT, BigData. Moreover, the influence of end-to-end technologies, which are of key importance in the implementation of digital transformation in the medical sector companies, was noted.
2. Architectural approach. The methodological basis of the study is the architectural approach to the design of reference digital model of the IT-architecture of a medical organization. This approach allows to make an alignment between the business and IT development strategies of medical companies. The use of this approach is relevant in connection with the rapidly growing dependence of doing business with implemented IT support. The architectural approach allows us to reflect in detail various elements such as business processes, functional and organizational structure, the level of information services and applications, as well as the technological layer. At the present stage of development of approaches to designing enterprise architecture, four main approaches are distinguished: Federal Enterprise Architecture Framework [10], Gartner [11], Zashman Framework [12], TOGAF [13, 14]. After analyzing all the main advantages and disadvantages of each of the above incomes, the focus fell on the TOGAF method (Open Group Architecture Framework) [15]. The architecture description standard TOGAF was positioned by developers as a "tool for the development of architectural information systems." Based on version 8, the TOGAF standard is based on the principle and method of developing traditional architectures (“Enterprise Edition”). Within the framework of the TOGAF ideology, corporate architecture has the following main components: Framework Capability Framework, Architecture Development Method, Architecture Content Framework and

Enterprise Continuum. The choice of the method substantiated the possibility of its application to focus on the process of managing architectural changes in medical companies, taking into account the introduction of modern digital technologies. There is instrumental support for modeling architecture using TOGAF. The standard allows you to consider the architecture "as is", formulate, with the help of motivational expansion, the requirements for the target architecture, develop the target model of the corporate architecture of the medical organization taking into account medical and IT trends and create a plan for the transition to the target architecture.Moreover, this approach is flexible in relation to changes in the external and internal business environment. According to our study, we applied this approach to build a reference digital model of the It-architecture of a medical organization.

Results and Discussion

Digital technologies have infiltrated and changed the balance of power in most business areas, and the healthcare industry is no exception. Experts predict that soon the way we, the society, provide and consume medical services will change significantly [16,17]. Breakthrough technologies, such as Internet of Things (IoT), Artificial Intelligence (AI), Blockchain and Cloud Computing, have reached a certain level of maturity and are widely used in the world of healthcare. Today, the attention of investors and corporations is occupied by advances in medical technologies: inventions in the field of genomics, wearable devices for tracking health indicators and telemedicine, as well as inventions associated with various types of sensors. Researches in nanomedicine, robotics, and medical 3D printing is also not neglected and is aimed at helping medical organizations provide targeted, accurate and timely medical services.

Practices for Using End-To-End Digital Technologies in Medicine

Artificial intelligence, wearable devices, drones, robots are gradually becoming the usual health care tools. Modern technologies are used to diagnose diseases, treat, monitor, conduct operations, transport medicines and blood. Consider some of the possibilities of using artificial intelligence and the Internet of Things in healthcare. Let's consider examples of the introduction of end-to-end information technologies in various areas of medical activity [18].

Diagnostics

The most advanced diagnostic methods are the use of artificial intelligence. In December 2016, Don Woodlock, senior vice president of GE Healthcare, said that radiography would not require the use of films: images would be sent directly to radiologists via modern communication channels.

Making a diagnosis automatically using machine learning technologies will be the next step in medical transformation. Machine learning will not replace radiologists, but will make their work more efficient.

Also, artificial intelligence technologies will support the work of ophthalmologists. AI can detect eye damage in patients with diabetes. At present, a machine learning algorithm has been developed and passed its first tests, which is able to detect eye damage from photographs of the fundus.

To train the mechanism, it was necessary to use 130 thousand images of the retina. To participate in the project, images of both a perfectly healthy retina and images of diseases were used. Fifty experienced ophthalmologists previously evaluated the quality of the images, the presence and degree of retinopathy.

In September 2016, the Israeli company Beyond Verbal introduced a project of a system based on artificial intelligence. The task of the system is to diagnose diseases by voice. It is about recognizing intonation and other nuances that a person can't recognize by ear. To train the system, the developers proposed AI to analyze more than 2.5 million audio recordings with voices in 40 different languages.

In February 2017, experts at the American University of North Carolina developed a miniature wireless device. The device is able to remotely diagnose the physical condition of soldiers and athletes. A sensor made of elastic polymer material is attached to the wrist or chest. The device controls the electrical properties of the skin. These properties change depending on the level of perspiration of a person. The received data is sent to the tablet or smartphone of the owner. Scientists said that the sensor controls skin hydration, which means it will protect people working in hot conditions, improve the physical fitness of athletes, etc.

In May 2017, Perm scientists announced the creation of a system for the diagnosis of cardiovascular diseases based on a neural network and the method of mathematical freezing. For efficient operation and training of the system, a database was provided from the emergency cardiology department of the local hospital. The network is self-learning and successfully diagnoses. She uses data on previously transferred diseases of patients, medical history of relatives, data on pulse, pressure. The system takes into account 69 indicators.

In August 2017, an AI-based assistive system was presented in China for making a clinical diagnosis. To analyze 100 case histories, the system requires 4.8 seconds or 0.05 seconds for each history. The diagnoses of AI are 98% the same as those made by qualified medical staff. Millions of patient records have been used to create the system. The accuracy of the machine diagnosis is 20% higher than that set by the doctor.

Treatment

In December 2016, a prototype bracelet with an NFC chip was introduced in Israel, which will provide emergency assistance to soldiers wounded in battles. The device stores data on the patient's health, information about the treatment already carried out, photographs of the patient's wounds and GPS coordinates of the places where the soldier was injured. Developers are testing the bracelet to see if mass production is worth it.

Smart shoes are used to help travelers navigate and improve athletes' performance. In November 2016, ABI Research analysts reported that sensors embedded in the shoes themselves, in the insole or socks will be able to improve the condition of patients, and some can be literally put on their feet without the need for regular visits to doctors.

Monitoring

Wearable devices are already tracking physical activity indicators. For example, the Sensor Dot device developed by UCB and Byteflies will notify patients of an impending epileptic seizure. The sensor makes several different measurements to accurately predict the time of an impending attack.

Another device is a patch, a coin-sized one, presented in August 2017, released by Band-Aid. The wireless patch can be connected to the network and attached to the human body. First of all, patches will allow qualified doctors to obtain data on the health status of people in rural and mountainous areas, where, as a rule, medicine is poorly developed.

In May 2017, Apple CEO Tim Cook was spotted testing a device that looked like a blood glucose meter. Now, in order to measure the level of sugar in measles, people with diabetes need to pierce a finger. Wearable devices, if their error in determining blood sugar levels will be minimal, can also be used for monitoring, without having to take a blood sample.

Transportation of medicines and blood

Drones are indispensable for the delivery of medicines and donated blood to remote areas. For example, in Rwanda, Zipline (California) has been supplying blood and medicine with unmanned aerial vehicles since the fall of 2016.

Drivers of medical organizations development

Various studies [19-22] identify three main drivers that push medical organizations to begin the process of digital transformation to increase the value and quality of provided medical services:

- increase of costs and chronic diseases of patients;
- high expectations of digital patients for the quality of medical services provided;
- emergence of digital technologies and modern medical equipment, sensors and wearable devices enabling expansion of the boundaries of decision support systems.

In order to meet these challenges and take advantage of the opportunities that digital transformation provides, healthcare providers must rethink their traditional value chain and consider the possibilities of joining or organizing a Digital Healthcare Network. The goal of such a network is to bring together patients, specialists and suppliers to provide the most efficient and patient-oriented medical service possible. The Digital Healthcare Network is the foundation of a new consumer-oriented healthcare system in which stakeholders are trying to solve common problems through ongoing and continuous collaboration. From an architectural point of view, such a network is an open integrated platform that provides tools for exchange of information within a single network, as well as tools for access management based on the pre-configured rights and roles of users (network participants).
The transition to digital healthcare offers many opportunities for both market leaders and niche companies. However, organizations must adhere to a number of rules and concepts when developing medical services:

- focus on meeting the needs of patients at the lowest possible cost;
- establishment of the maximum possible number of touchpoints between the client and the service as well as the personification of offers and user experience;
- collaboration within the medical network: collaborative research and clinical trials, etc.;
- balancing supply and demand through advanced real-time analysis technologies and predictive analytics.

Reference Digital Model Of IT-Architecture of Medical Organization

Medical organizations investing in digital technologies need an IT architecture that will support the implementation of key business processes and, at the same time, provide an opportunity for the development and integration of innovative scenarios, such as: digital diagnostics, digital boardroom, clinical decision support, patient involvement and many others.

Figure 1 shows a conceptual (reference) model of the IT architecture of a medical organization.

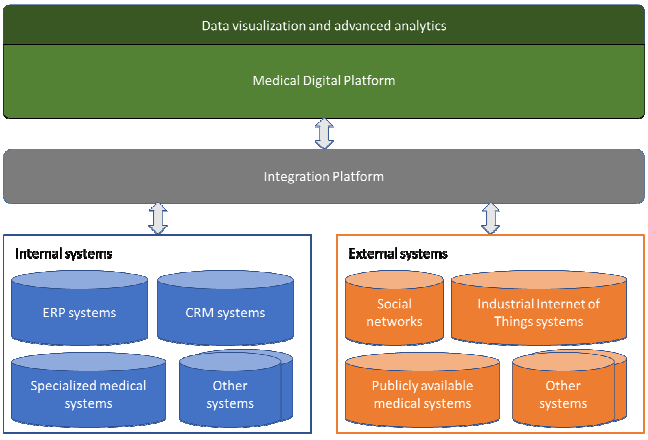

Figure 1 : Conceptual (reference) model of IT architecture of a medical organization

Let us consider in more detail each of the presented layers of the conceptual model of the IT architecture of a medical organization. Often in large medical organizations there is a "zoo" of IT systems of various classes. This is mainly due to the large number of specialized medical systems, but sometimes it is caused by the lack of a well-described IT strategy of the organization. In addition, with the growth of digitalization, medical organizations are forced to collect data from various external systems outside the enterprise's IT landscape: social networks, Industrial Internet of Things (IIoT) systems, various publicly available medical systems and catalogues, etc.

In this regard, in medical organizations the problem of integrating data from disparate sources is especially acute. The architectural solution (proposed within the framework of the reference model) is a comprehensive integration platform that would have functional and technical capabilities for setting up data exchange between all open integrated systems of the organization. Moreover, such an integration platform must be deployed in a cloud or hybrid environment in order to support the integration of cloud and on-premise systems.

The basis of this model is a Medical Digital Platform, which should provide functionality for aggregating heterogeneous data, as well as provide convenient and scalable services used by various applications located inside the platform. In addition, it is desirable that this system would support embedding (as an extension or add-in) of visualization dashboards (created by means of BI-systems), as well as libraries for Machine Learning and predictive and advanced analytics.

Figure 2 shows a conceptual (reference) model of the architecture of a Medical Digital Platform.

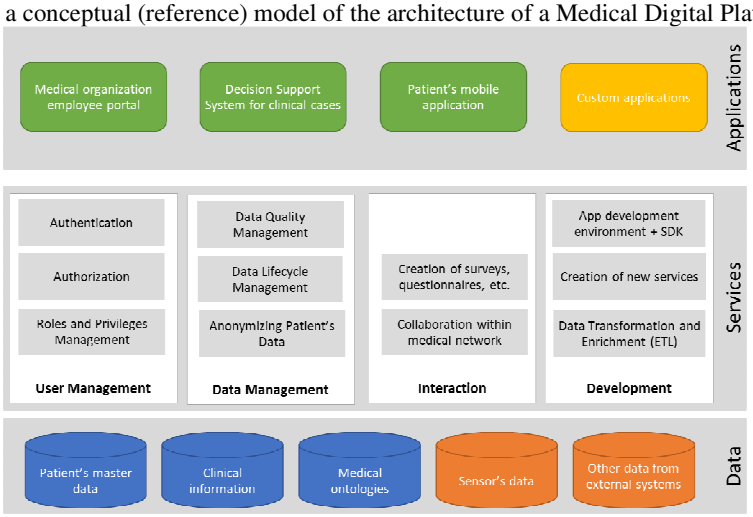

Figure 2 : Conceptual (reference) model of the architecture of a Medical Digital Platform

Digital Medical Platform should have technological capabilities for storing and processing large amounts of data. Patient's master data, data sets with clinical information and medical ontologies, data from medical devices and sensors, as well as other relevant data from external sources should be replicated to the medical platform to speed up the processing and visualization of this data.
Four key groups of services have been identified that, from our point of view, should be provided by a Medical Digital Platform:

- **User Management.** This group includes services for managing authentication, authorization, user's roles and privileges. When it comes to personal medical information of patients, it is extremely important to make sure that only attending physicians of patients themselves have access to it by providing protection against unauthorized access.
- **Data Management.** This group includes data quality and life cycle management services, as well as services for anonymizing patient data, which is a prerequisite for subsequent statistical analysis of such data arrays.

- **Interaction.** This group includes services responsible for interaction with the "external world": collaboration within the medical network, creation and automatic distribution of surveys, questionnaires, etc.
- **Development.** This group includes all services for custom development and refinement of the platform: tools for transforming and saturating data, tools for creating new unique client services (Platform SDK), and an integrated development environment for unique web and mobile applications (Mobile SDK).

Platform can be delivered with out-of-the-box boxed applications for solving various business problems. For example: a portal of an employee of a medical organization, a decision support system for clinical cases, a mobile application for a patient, etc.

Conclusions

1. Conceptual model of IT architecture of a medical organization, using IoT tehnologies, has been developed
2. Conceptual (reference) model of the architecture of a Medical Digital Platform has been developed.
3. Four key groups of services have been identified that, from our point of view, should be provided by a Medical Digital Platform.
4. The proposed reference model of IT architecture will allow in the future to formulate a program of projects for the development of IT architecture of medical organizations based on end-to-end digital technologies.

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