Smart Hospital Architecture: IT and Digital Aspects

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Abstract. The paper proposes to consider the IT and Digital concepts of Smart Hospital. Today, smart clinics are a healthcare facility that uses the latest digital technologies to improve the quality of healthcare services, simplify healthcare workflows, reduce the burden on clinic staff, and ultimately increase patient satisfaction. Therefore, the relevance of this article is clear. The analysis of world experience in terms of digital technologies and making smart hospitals is presented. A detailed analysis of modern digital technologies used in medical institutions has been carried out. The architecture of Smart Hospital was proposed. The purpose of research is formation of the top level of IT architecture of a smart hospital and presentation of requirements for complex architecture of smart hospital. The methodological basis of the paper is the analysis of open sources.

Keywords: Smart Hospital, Digital Technologies, Reference Model, IT-architecture.

1 Introduction

In medicine, as in other industries, digitalization has penetrated, and it is here that it works most noticeably: the effectiveness of treatment is growing even for the most severe diseases, diagnostics predicts problems at the very beginning or even before they arise. In addition, service has received a special role in healthcare today. Smart hospitals are being created all over the world, or old hospitals are being transformed into them. In such a "smart" hospital, the patient is comfortable, calm [1].

Smart hospitals, as they are commonly called, are built on technologies that automate not only many "manual" tasks, but also communication and interaction with patients, that is, they digitize most of the processes. These hospitals are generally paperless. They usually purchase and / or develop modern equipment, work professional doctors and scientists, conduct clinical research [2].

"IoT" (Internet of Things) - technology, permissive or implicit possibility connecting to the global data network of any devices that are not originally IT equipment (servers, personal computers, smartphones). "Big Data" - the term adopted for descriptions of modern volumes of information related with a digital society, digital economy.

Term “Big data” characterizes data sets with possible exponential growth that is too large, too unformatted, or too unstructured for analysis by traditional methods [3-4].

The main goal of this article is making an overview of IT and Digital concepts of Smart Hospital; to make an overview of the world's leading clinics using advanced digital technologies, consider their structure and the interaction of the main components of the hospital. Moreover, the article suggests the architecture of the upper level of interaction of the components of a smart clinic.

As a result of the research, the authors of the article want to get a set of requirements to smart hospital. Moreover, the result of research is formation of the top level of IT architecture of a smart hospital and presentation of requirements for complex architecture of Smart hospital, which takes all blocks as building, digital technologies, smart wards into account.

2 Materials and Methods

2.1 Johns Hopkins Hospital

Johns Hopkins Hospital is the most famous medical institution in the United States, which is at the same time a training base for the Johns Hopkins Medicine educational complex, Baltimore, Maryland, USA [5].

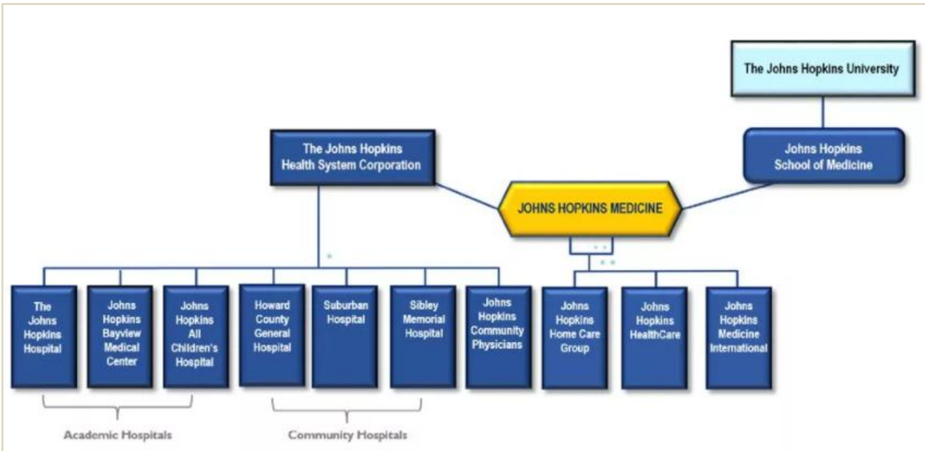

Fig. 1. Johns Hopkins Medicine Organizational Chart.

In terms of innovation, the clinic can be distinguished:

– Enhanced filtered air circulation system to prevent the spread of germs and reduce respiratory complications.

- The latest surgical technologies in 33 operating rooms, including intraoperative MRI. Innovative patient ward layout to ensure the best possible care and collaboration between your medical team.
- A real-time positioning system that instantly tracks equipment anywhere in the hospital and can locate staff in inpatient wards.
- Radiological imaging packages with the most advanced diagnostic and radiological services in the country.
- An automated underground system that delivers materials and waste through a tunnel and to a hospital loading bay, a quarter mile from patient service areas.
- High-tech computer systems to help your healthcare team respond to problems.

The Hopkins Hospital Health System includes the following units (Fig.2):

- Johns Hopkins University is necessary for laboratory and fundamental research, staff formation.
- Johns Hopkins Health system which is necessary for which is necessary for carrying out the key functions of the clinic - medical activity.
- Care management includes supervision and educational activities conducted by healthcare professionals to help patients with chronic conditions.
- The operations block includes one of the key processes of the clinic - surgical treatment.

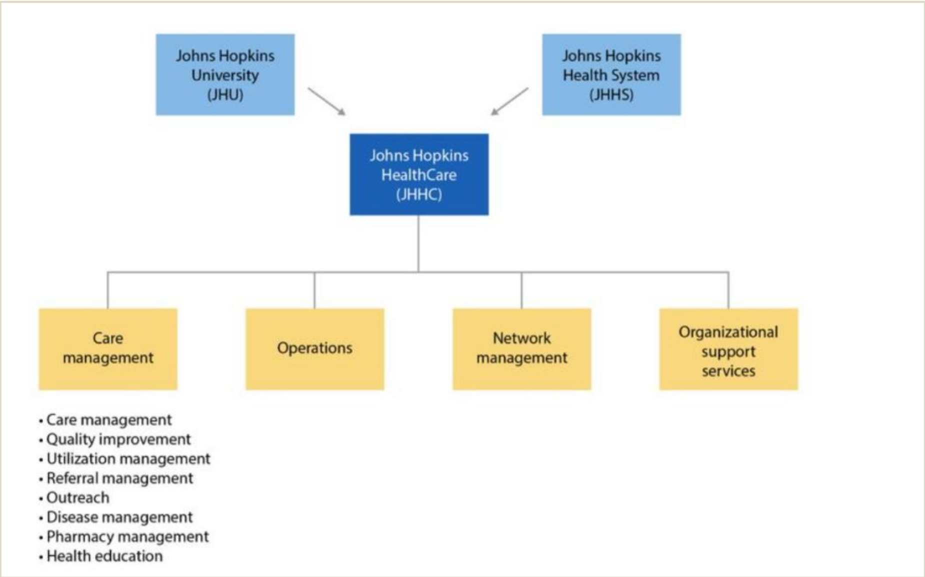

Fig. 2. Johns Hopkins Healthcare: interaction with other blocks.

2.2 Breakthrough R&D

"Smart" hospitals also often appear on the basis of university clinics that conduct research and train doctors. For example, Stanford Medical Complex is famous for the world's first heart, lung transplants and other surgeries. The hospital also has the world's first hybrid ward that diagnoses and treats vascular disease using stereoscopic digital subtraction angiography. In Germany, Asklepios Barmbek has such a scientific fame, a clinic where doctors take on the most difficult cases in gynecology, urology, and neurology. Sometimes smart clinics have narrow specializations. For example, the world-famous Mayo Cancer Center in the United States. This clinic is engaged in research, including unique ones, in the field of oncology. For example, it was Dr. Mayo who performed the neurological examination of the rugby team after the game with the V-Go remote robot. Indian research center Fortis also pays great attention to research, in particular, there is a stem cell laboratory [6-7].

Ideally, a smart hospital is a combination of smart components, such as the Bundang Hospital of Seoul National University. Bundan is a multidisciplinary medical center that uses the latest technology and methods to treat serious illnesses. There is the BestCare information system with an electronic dossier, a biometric data transfer system, "smart" systems for making clinical decisions and resource management. BestCare maintains digital communication with the patient, stores all the data on incoming and outgoing people in a digital environment, in addition, it automates internal processes. The patient is aware of what manipulations are carried out with him, how he is being treated, even if the doctor is not nearby. There are also various pleasant things that complement the system and make your stay in the clinic more enjoyable. For example, a smart bed can maintain individual light and temperature levels. Such hospitals exist not only in Korea. For example, in El Camino, California, together with Silicon Valley-based IT startup Lockheed, they created a similar system that controls all processes in the clinic. The hospital has achieved particular success in the treatment of oncology. Also, a similar system operates at Anadolu Medical Center in Turkey. The institution does not have a single paper card - all information is stored in computers and smartphones, and telemedicine is the main way of communicating with patients. In the Palomar medical center, together with the "smart" system of organization of the clinic, biometric identification works, which further increases the convenience of patients and doctors [8].

Digitalization has become the basis of many modern clinics, including the oldest ones, which simply invested in the modernization of medical facilities. For example, the Thai hospital Bumrungrad, established in 1980 in Bangkok. Today it is the largest clinic in Asia, which every year purchases the latest equipment - digital PET-CT scanners, drug dosing and distribution systems, mammography. Ramkamhang Hospital, also a Thai medical institution, has digitized the entire process of interaction with patients: at the reception, everyone is given a digital hospital card - a guide card, which stores all information about him. Doctors only need to scan the card code, and they see the medical history on a computer or tablet. All diagnoses are stored electronically, and prescriptions are sent to a digital pharmaceutical system that dispenses the required amount of drugs by itself [9].

There are also relatively new medical organizations that have begun to emerge on the basis of modern IT solutions, which is called "from scratch." In 2010, Vail Hospital was opened in the small town of Hensol in the UK. The hospital has digital operating theaters, the design and layout of which changes depending on the operation. In 2013, the Nuffield Health Clinic was launched in Bristol. It is believed to be the first fully digital hospital in England. Such technologies include a digital communication system and the latest technology (MR, CT scanners, PET, 3D mammography, equipment for endoscopy). Of course, such high-tech clinics require large investments - tens of millions of dollars.

2.3 SunCom Smart Clinic

The Digital Clinic provides real-time communication between doctors. Communication can take place through a secure messenger, as well as using audio and video communication channels using telemedicine complexes installed in operating units. The combination of Avaya technologies and Sun Com developments allow for emergency consultations from the doctor's office and from the operating room. In addition, the Digital Clinic increases the availability of medical personnel and the efficiency of decision-making by displaying the employment and location of employees in a medical institution. A complete record of what is happening in the operating room and the indications of medical devices is also available. This provides objectification of the course of operations, including the possibility of using the accumulated content for the analysis and training of the clinic staff [10].

"Digital Clinic" solves not only the internal tasks of the clinic, but is also a convenient tool for patient communication. The solution improves the quality of service and provides additional opportunities to contact the clinic remotely.

In particular, it is possible to receive research results and provide remote rehabilitation and monitoring of the patient's health status. Also, this solution provides integration with e-mail and the patient's busy calendar.

Grand Medica is considered the largest smart hospital in Siberia and the Far East region. On 19,000 sq. m contains special equipment and a highly efficient EcoStruxure platform from Schneider Electric, which allows you to manage the devices connected to it, carrying out monitoring and local control. The technology is flexible: as the facility grows and develops, it can be easily scaled, modernizing the clinic to further improve the productivity and quality of patient care.

Remote management of power grids and medical equipment has reduced operating costs by 20%, according to Grand Medica. Heat consumption has dropped by almost a third. Thanks to Schneider Electric product compatibility, the medical center saved approximately $ 176,000 in capital expenditure [11].

At the heart of the Grand Medica Smart Hospital is Schneider Electric's EcoStruxure healthcare platform. It combines three layers of unique IoT solutions: connected devices, local management and data collection, analytics and services. These solutions support hospitals and clinics at all levels - from emergency departments to executive offices.

3 Results

3.1 Integration of digital platforms in medical centers

There is a growing awareness in the healthcare system of the need to involve patients in the treatment process. An important aspect for restructuring the industry is the ability to leverage the continuous flow of health data from wearable devices, sensors and other similar systems and devices. Such technology, in particular remote monitoring systems and mobile applications, will be able to provide a closer contact between patients and their doctor and open up new opportunities for patients to exchange data with doctors. This makes it possible for doctors to gain a more complete picture of patients, especially how patients behave in between appointments at the clinic, which can significantly improve the results of treatment of chronic diseases [12]. Note that the patient's personal data is not only clinical data, but also data that determine the social lifestyle, which allows the doctor to get a holistic view of the patient. But today, doctors tend to resist adopting such technologies and using them in their diagnostic and treatment decisions. There are many reasons: information and emotional overload, incomplete or unreliable data, privacy and security issues, and so on. Nevertheless, this technology must be present in the clinical workflow as it is critical to the success of treatment, given the workload that most physicians face today. But it should not increase the burden on doctors, but, on the contrary, provide them with information in a revised form, ready for clinical use. To do this, these data must be collected from different sources, accumulated and analyzed.

Today there is no easy way to move data between systems, such technologies are just being created. Data interoperability remains an issue as much of EHR data is tied to manufacturers' own platforms. But the implementation of information exchange standards such as Fast Healthcare Interoperability Resources (FHIR) is expected to improve data interoperability in the near term. Collecting patient data will help develop predictive analytics models based on advanced algorithms, artificial intelligence and historical data. Moving from inpatient care to remote patient care is opening up new opportunities that can help identify, treat, and prevent disease. But for this, it is necessary to expand the capabilities of collecting and analyzing data using complex algorithms. To do this, wearable and home sensors and systems must be combined into a simplified and easily integrated platform so that developers can focus on the application. Today, such platforms are already being developed by several developers who create systems that can take information from many different sensors with the ability to transmit data for almost any type of application. These solutions separate wearable sensors, network, and data infrastructure from end-use applications, allowing developers to focus on their specific area, be it detecting congestive heart failure, monitoring infections during chemotherapy, or monitoring bedside deterioration in bedridden patients. Sensors are abstracted from the application using a common protocol, making it easy to integrate multiple data sources at once. In addition, the provision of reliable data transmission, for example, in the event of a network failure, between the sensor and the application is carried out within the framework of the protocol, instead of requiring the developer to install the application itself.

Validic

This integration system, which was launched back in 2013, allows you to access and improve the quality of data generated by patients and medical organizations on a daily basis. The platform and associated mobile solutions provide continuous access to personal health data from more than 350 medical devices, mobile applications and wearable sensors in the home. The platform can transmit all these data in the form of a single stream of information to any medical information system. In this case, the data is checked for correctness before being transferred to a medical or other system [13].

Validic has a rich set of tools for administering and maintaining services, improving the quality of critical data, registering and maintaining users, and managing device connections. Patients receive periodic reports in the form of so-called. a dashboard containing their health data. Physicians, in turn, receive more complete information on their dashboard with expanded interpretations of the same data, which allows for a richer discussion with patients about their treatment. Providing information to the patient in such a visual form was noted by experts as the most important incentive for patients to take care of their own health. Connecting to the platform is very easy and takes only a few hours as data from all mHealth applications is standardized within Validic. At the same time, all security requirements for the storage and transfer of protected health information are taken into account, which comply with the "Safe Harbor" de-identification standard in accordance with the US Health Insurance Portability and Accountability Act (HIPAA). The system is used today in more than 50 countries.

Capsule Tech

This platform is a secure, comprehensive, technology-independent cloud service that connects medical devices (more than 875 different types of sensors and devices) for the free exchange of data between users of such devices and medical institutions. This service has received approval for use from the FDA and, accordingly, can be used by medical institutions. The Qualcomm 2net network is based on open standards, and the platform itself is integrated with electronic health record systems from 50 different manufacturers, as well as a number of other technology companies. 2net consists of two main modules.

The first is 2net Core, which interacts with sensors and devices for collecting health data and collects information from them, performing the function of a "library" of data, transferring them to the second module - 2net Application, which contains the user interface. The modules are self-contained, which allows customers to create their own applications based on 2net Core, with their own set of capabilities and functions. An add-on to the Clinical Observation platform can provide clinicians with contextual information about a patient's condition in real time, which can facilitate early intervention, improve patient safety and improve clinical outcomes. The system can analyze data and provide actionable guidance to help clinicians make informed decisions quickly. The 2net SDK is available to developers of mobile applications on the Android platform. Developers will be able to offer automated connectivity to the open ecosystem of biometric sensors supported by 2net through their applications [14].

TactioRPM

TactioRPM remote patient monitoring platform, developed in Canada, includes a mobile application, browser tools, a secure cloud service, and a vendor-agnostic medical device integration system. In total, the system currently supports more than 150 medical devices for various purposes (thermometers, pressure meters, glucometers, scales, oximeters, heart rate meters and activity trackers). The TactioRPM platform brings together mobile patient apps, clinical portals, integrated healthcare systems (including Garmin, A&D Medical, BÜHLMANN Laboratories, Fitbit, Roche, Nonin, Omron, MIR & Welch Allyn), patient profiles, digital training programs. The system allows doctors to remotely view the data generated by the patient's devices and devices, provide the latter with educational materials and involve patients in new mobile-based relationships with medical professionals. In addition, TactioRPM provides a rich set of APIs for medical organizations, which allows the latter to organize additional data integration, automate their processes and connect special applications [15].

Having analyzed the current world experience in creating smart solutions for clinics, the authors of the article propose the following scheme for the interaction of the key blocks of a smart hospital (Fig.3).

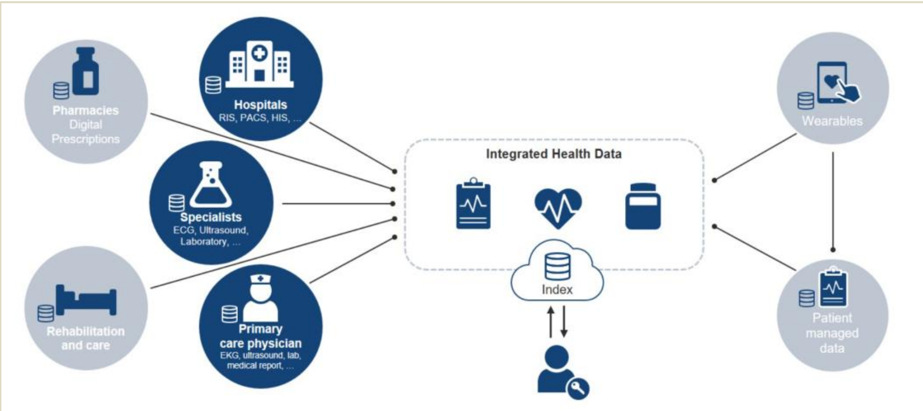

Fig. 3. Smart Hospital data integration architecture.

We can also highlight the key points that a smart clinic should include:

1. Intelligent building.
   Through the introduction of an automation system, it is possible to maintain a favorable climate in all rooms of the building, conveniently control lighting, and ensure visitor awareness. Thanks to the introduction of fire and security systems, video surveillance and access control systems, the level of security is increased. The output of information on the operation of all engineering systems to a single

dispatch center allows to reduce the number of maintenance personnel. The automated system is created in order to provide centralized monitoring and control of critical systems, increase the comfort and safety of operation, and reduce the cost of maintaining engineering equipment and consumed energy resources. The purpose of the system is a high level of awareness of the operation of systems, critical parameters of the facility, continuous quality control with a high level of reliability of data on the state of the facility and the ability to respond quickly in emergency situations.

2. Integrated automation and dispatching system for building engineering systems (BMS).
   It is envisaged to install a decentralized control system, which provides a high level of reliability, fault tolerance and autonomy. The main information buses of the control system are KNX and Ethernet TCP / IP buses. Automation cabinets are distributed throughout the building, which ensures high safety, reliability and fault tolerance of the system. To ensure the uninterrupted operation of terminal and panel equipment, uninterruptible power supply units are used. Provides software and hardware for self-diagnostics and equipment condition monitoring. Provides the ability to send SMS and e-mail messages in emergency situations, with the ability to set mailing groups depending on the type of accident.
   A BMS system is envisaged with a remote operator's workplace and access via a web browser. The BMS system allows monitoring and control of all engineering systems from a single dispatching point or remotely from mobile devices. Information on the BMS screen is displayed in the form of tables and mnemonic diagrams, including floor plans, individual rooms, general screens with the most important information.
3. Integrated building security system
   To ensure sufficient safety, the following items must be installed:

- access control system (ACS) to restrict access to an object or to individual rooms. Fencing means (electromechanical and electromagnetic locks on doors, barriers, turnstiles, etc.) are used, as well as an access system, input devices for identification (fingerprint scanner, iris scanner, RFID tag) and a control device with protection against unauthorized access;
- alarm system and security video surveillance. These include video cameras, motion and window break sensors, perimeter security sensors, "panic buttons", fire alarms, aspiration systems, a situation center;
- fire protection system. The main task of such complexes is to inform people about an emergency and assist in coordinating actions when leaving a dangerous facility.

4. Multimedia systems
   The ability to connect mobile devices to the room's audio system and play music through the built-in ceiling speakers. Possibility of playing Internet radio in the room is supposed.
5. Smart-ward

- Lighting control. Each room provides for light control via relays / dimmers using the KNX protocol. The light is controlled using an LCD wall panel, keypads and mobile devices. The ability to create lighting scenarios is provided. Information about the operation of the lighting system is transmitted to a single control center. It is possible to control the light from the control room.
- Climate control. Provide for the installation of a climate control system to maintain the specified air temperature in the ward. The climate control system regulates the operation of local air conditioners, underfloor heating and heating convectors.
- Safety. Integration of comfort systems with security systems is envisaged. On a signal from the ACS system, a signal is received about the presence of people. Depending on who is in the ward, the patient or the service staff, they will have different levels of access to the systems. If full access is provided for patients, then access to certain subsystems can be restricted for service personnel.

3.2 Methodology for the formation of an integrated architecture of a medical organization

Building an architectural model - an architectural process - follows certain principles. The most important of them are:

- The principle of gradual detailing. One should start by looking at the enterprise from a great height (the “owner” perspective in the Zachman model or the business architecture in the TOGAF model, etc.), rather than with a detailed description of one or more underlying elements. This is due to the fact that, describing any of the underlying elements of the general enterprise model, we will not get a single systemic view of the enterprise, which its architectural model is designed to give. The detailing can be deepened as needed, but this should be determined by how the architectural model is used.
- The principle of consistency of layers. If the basis is the most popular view of enterprise architecture as a "layer cake" (four levels in the TOGAF model or "perspective" in the Zachman model) [16,17], it is necessary to achieve consistency of the layers. After all, the goal of building an architectural model is to get a unified and interconnected picture of the enterprise. Therefore, you should not describe the layers separately, entrusting this work to various departments. It is better to single out a process, or, at first - a project - describing the enterprise architecture, and create a single team.
- The principle of the independence of layers. At the same time, the layers (levels, "perspectives") must be independent. It is possible to select any necessary layers or levels (for example, an integration architecture that defines the principles of interaction and integration of applications, data and business processes in a distributed company environment in the Frameworx model (formerly NGOSS), or a security architecture). Therefore, when isolating them, the following conditions are applied: • if the lower layer is out of order, the upper one cannot work; • inoperability of the upper layer does not affect the performance of the lower one; • the performance of

elements within one layer may or may not affect the performance of other elements of the same layer [18].

- The principle of completeness. The enterprise architecture model should describe the enterprise with the required completeness. At the same time, one should not get carried away with a large number of architectures and levels, as this complicates the model. The number of architectures and levels should be determined by specific tasks for the solution of which the architectural model is built.
- The principle of consistency. Elements of the architectural model should not contradict each other.
- The principle of no duplication. Elements of the architectural model should not duplicate each other [19-20].
- The principle of continuous transformation of the current enterprise architecture. It should not be forgotten that any enterprise is in constant development. This means that its architectural model is useful only when it is relevant and constantly brought in line with the real state of the enterprise.

Based on the global experience of introducing digital technologies in medical institutions and describing the key steps in building an integrated enterprise architecture, the authors propose the following development roadmap for creating a smart clinic [21]. It includes 9 stages that cover both technical and financial aspects of the project. Particular attention should be paid to the formation of the IT landscape, service architecture and information systems integration (Fig. 4).

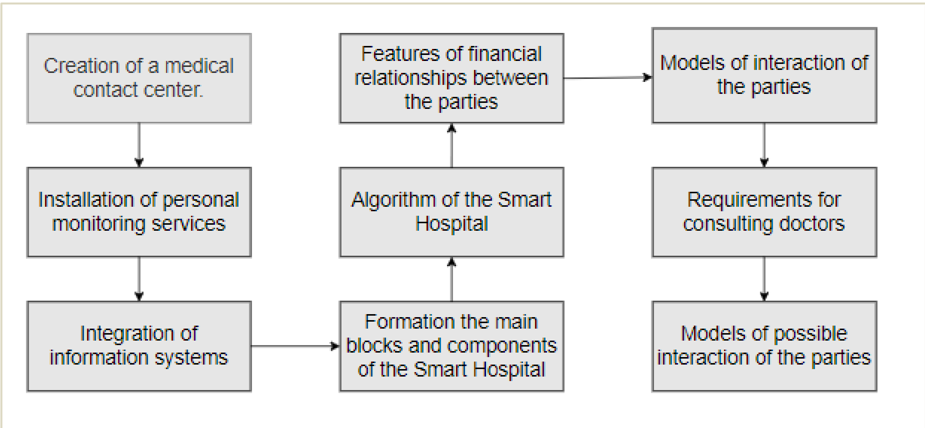

Fig. 4. Stages of the Smart Hospital concept creation.

4 Discussion

The results of such studies will serve as a basis for creation complex IT-architecture of Smart Hospital considering all the technological features of modern trends. Based on the described requirements for the integrated architecture of a medical organization that implements the principles of value-based and personalized medicine, the authors plan to form a comprehensive architecture of a digital clinic within the framework of scientific research based on the federal medical center.

5 Conclusions

In this paper, the IT and Digital concepts of Smart Hospital were considered. The analysis of world experience in terms of digital technologies and making smart hospitals was presented.

An in-depth analysis of the world's experience in creating smart clinics and digital platforms that support the development of the organization's digital resources was carried out.

Based on it, the authors suggested top level of IT architecture of a smart hospital and presentation of requirements for complex architecture of smart hospital. As a result, the paper suggests steps to form Smart Hospital considering different aspects as technical and financial.

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References

1. Ilin, I., Levina, A., Borremans, A., Kalyazina, S. Enterprise architecture modeling in digital transformation era (2021) Advances in Intelligent Systems and Computing, 1259 AISC, pp. 124-142..
2. Digital business: 3 requirements to make it real, https://inform.tmforum.org/features-and-analysis/2017/01/digital-business-3-requirements-make-real/, last accessed 02 February 2021.
3. Ilin, I.V., Iliashenko, O.Yu., Iliashenko, V.M. Architectural approach to the digital transformation of the modern medical organization // Proceedings of the 33rd International Business Information Management Association Conference, IBIMA 2019: Education Excellence and Innovation Management through Vision 2020, 2019, стр. 5058–5067.
4. Dubgorn A., Ilin I., Levina A., Borremans A. Reference model of healthcare company functional structure // Proceedings of the 33rd International Business Information Management Association Conference, IBIMA 2019: Education Excellence and Innovation Management through Vision 2020. 33, Education Excellence and Innovation Management through Vision 2020. 2019. С. 5129-5137.
5. Johns Hopkins University Organizational Chart - Organizational Structure Finance And Administration, https://mumbai.org/johns-hopkins-univehttps://darda.sssrsity organizational-chart/, last accessed 03 May 2021.
6. Smart Medicine: what makes a hospital "smart" https://rb.ru/opinion/smart-medicine/, last accessed 03 May 2021.

7. Digital medicine in Russia: how new technologies are applied in practice https://supermed.pro/digital-med.html, last accessed 03 May 2021.
8. Smart hospitals and digital transformation, https://www.unity.de/en/industry-solutions/healthcare/smart-hospitals-and-digitalization/, last accessed 03 May 2021.
9. What is a smart hospital? https://healthcareglobal.com/hospitals/what-smart-hospital, last accessed 03 May 2021.
10. Abdumanonov A. A., Karabaev M. K. Computerization medical institutions for the organization and optimization of clinical processes, 2016.
11. GrandMedica, https://gm.clinic, last accessed 03 May 2021.
12. Mirsaidova M. H. The use of modern information and communication technologies into diagnostic practice // Medical Science, №3, 2020.
13. Digital platforms for collecting medical data, https://evercare.ru/tsifrovye-platformy-dlya-sbora-meditsinskikh-danny, last accessed 03 May 2021.
14. Medical Device Integration, https://capsuletech.com/, last accessed 06 May 2021.
15. Digital platforms for collecting medical data, https://evercare.ru/tsifrovye-platformy-dlya-sbora-meditsinskikh-danny, last accessed 06 May 2021.
16. Q. Neo Bui, Evaluate Enterprise Architecture Frameworks Using Essential Elements // Communications of the Association for Information Systems 41(1):121-149, DOI:10.17705/1CAIS.04106, 2018.
17. Mogilko, D.Y., Ilin, I.V., Iliashenko, V.M., Svetunkov, S.G. BI Capabilities in a Digital Enterprise Business Process Management System (2020) Lecture Notes in Networks and Systems, 95, pp. 701-708.
18. Moreira, M.W.L., Rodrigues, J.J.P.C., Kumar, N., Saleem, K., Illin, I.V. Postpartum depression prediction through pregnancy data analysis for emotion-aware smart systems (2019) Information Fusion, 47, pp. 23-31.
19. Anisiforov, A., Dubgorn, A., Lepekhin, A. Organizational and economic changes in the development of enterprise architecture (2019) E3S Web of Conferences, 110, № 02051
20. TOGAF, sewiki.ru/TOGAF, last accessed 03 May 2021.
21. IT-director book, https://book4cio.ru, last accessed 06 May 2021.