

Ministry of Education and Science of Ukraine

# ODESA NATIONAL UNIVERSITY OF TECHNOLOGY

International Competition of  
Student Scientific Works

# BLACK SEA SCIENCE 2023

## PROCEEDINGS



ODESA, ONUT 2023

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# **BLACK SEA SCIENCE 2023**

**Proceedings**

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## DEVELOPMENT OF AN INFORMATION AND TECHNICAL SYSTEM FOR THE EXCHANGE OF MEDICAL DATA WITHIN A MEDICAL INSTITUTION

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***Abstract.** The work is devoted to the development of an information and technical system for the exchange of medical data within a medical institution. Such systems help to automate administrative and medical processes and increase the information security of the enterprise. In turn, this increases the quality of patient care and reduces the likelihood of medical errors.*

*During engineering, the main problems of modern medicine in the information technologies and of the technical equipment of medical institutions were identified. The object for which the system is being developed has been researched and the task of qualification work has been set.*

*Modern methods of enterprise organization are analyzed. The main attention was paid to: methods of building small corporate networks, information security and the process of automation of administration.*

*The process of developing an information and technical system was also described, which includes: the choice of network architecture, software, server and network equipment, and the process of setting up the system.*

*The result of the work is the developed and implemented information and technical system for the medical institution of KPN "Odesa Regional Clinical Hospital".*

***Keywords:** corporate network, information security, medicine, automation, software, server and network equipment.*

### I. INTRODUCTION

Nowadays, nearly any enterprise uses computer technology in its activities. It can be keeping computer accounting, presenting the company in the form of a website on the Internet, contacting partners using electronic means of communication (e-mail, chat, messengers), automating routine elements of work processes, etc. This thesis also applies to modern medical institutions that produce and accumulate huge amounts of data. The quality of medical care, the general standard of living of the population, and the level of development, in general, depend on how effectively these data are used by medical workers.

There was a need to use large volumes of information when solving medical tasks (diagnostic, therapeutic, statistical, managerial and other). Currently, this determines the creation of information and technical systems in medical and preventive institutions. Until recently, there used to be almost no signs of automation in the health care system of Ukraine. Maps, bulletins, procedural reports, records of patients, medicines - the entire document flow was carried out on paper. It affected the speed and, therefore, the quality

of patient care, complicated the work of medical staff, which led to errors in work, time-consuming filling of cards, and preparation of reports. This complicated the work of the management of the medical and preventive institution.

Therefore, on April 1, 2020, the second stage of the medical reform in Ukraine began. This stage emphasized that all state medical institutions must be connected to the electronic health care system (eHealth) - this is a two-component system that provides the ability to create, review, exchange information and documents between registers, state electronic information resources, and electronic medical information systems.

For this, medical institutions should be carried out with autonomization and computerization. Without this, they will not be able to receive funding from the National Health Service of Ukraine, and this is the most important aspect in the further existence of the medical institution. Consequently, the goal of this project is to develop an information and technical system for the medical institution "Odesa Regional Clinical Hospital". The development and implementation of this project will allow the institution to receive the following benefits:

- Connection to the eHealth system;
- Centralized access to information within the institution;
- Centralized and secure data storage;
- Significant reduction in search time for necessary data;
- Improving the quality and speed of patient care;
- Effective administrative management of the medical facility;
- Transition to electronic document management.

## II. LITERATURE ANALYSIS

### 2.1 Problems of the information and technical component of medical institutions

Modern trends in the market of medical services around the world are closely related to the new opportunities that the progress of information technology provides us. Today, it is difficult to find a modern hospital or medical center that does not use hospital information systems, electronic medical records and, in general, electronic document management for its needs. But, unfortunately, we are talking about modern medical institutions in the West, not in Ukraine. For Ukrainian medicine, it is a common phenomenon when computers, if they are at all in the hospital, are used as typewriters. Needless to say, most specialists have never heard of hospital information systems. It should be noted that the greatest economic and social success is characteristic of those enterprises that actively use modern means of communications, information technologies and their network applications: e-mail, visualization, modeling, computer graphics. But all these applications and related applied tasks require the appropriate qualification of employees, the creation of a new class of telecommunication networks and information resource management systems. Databases, computers, fiber-optic communication lines, personal computers are all components or elements of information systems.

The majority of medical institutions that switched to a new type of financing found themselves in a very difficult situation, their information and technical component was not ready for reform, and had the following problems:

- Outdated technical equipment;
- Insufficient qualified personnel;
- Absence of centralized data exchange;
- Lack of possibility of modernization;
- Absence of information backup regulations;
- Inadequacy of the comprehensive information protection system.

## **2.2 Analysis of the existing network of the medical institution**

Odesa Regional Clinical Hospital has three main buildings: Inpatient Department, Polyclinic and Maternity Hospital. They are combined into one local network using Ethernet and Fast Ethernet technology, data transfer speed in the network is from 10 to 100 Mbit/s. The department of the hospital has a dedicated room for the server (server room).

The local network in these buildings is built using the following network equipment: Медиаконвертори Telstream MC-118/320

- Telstream MC-118/320 media converters
- a PC on which a network OS (RouterOS) is installed;
- D-link dgs-3000-28sc switch in the server room;
- D-Link DGS-1210-28 switch in the server room;
- Switch in the server room TP-Link TL-SG1024;
- Chassis for GateRay media converters;
- Repotec RP switch.

This project will consider the modernization of the LCM of one of the OOKL buildings, namely the building of the polyclinic and the server room. More than 122 medical and administrative personnel work in this unit. But to date, there are only 30 computers in the medical center of the polyclinic, and most of them are not owned by the company.

Most medical staff do not have the ability to exchange information with medical staff in other buildings. All PCs are connected to the Internet through various providers, using outdated network equipment, and Fast Ethernet with a speed of up to 100 Mbit/s is used as a data transmission technology.

The software used by the medical institution mainly consists of operating systems, office packages, tools (antiviruses, disk management, etc.), accounting programs (all together up to 60%), and other (specialized medical software).

## **2.3 Methods of access to information and its protection**

### **Microsoft Active Directory**

Active Directory technology in Windows Server is used to store and organize network objects into a hierarchical, secure logical structure, such as users, computers, or other

physical resources. Active Directory services significantly increase the protection of the corporate network. Yes, all data, such as accounts, are stored on domain controllers that are protected from external access. In addition, the Kerberos protocol is used for authentication in Active Directory services.

### **Terminal access technology**

With the development of local networks for the exchange of information between computers, terminal access was organized, capable of serving several computing processes at the same time. Terminal access - access to the information system, organized so that the local terminal machine does not perform computing work, but only redirects the entered information (from the mouse and keyboard) to the central machine (terminal server) and displays graphic information on the monitor

### **Virtualization of servers based on hypervisor**

Virtualization technologies allow the computing power of the physical server that hosts the virtual machines to be distributed among the virtual machines based on their load. The most common method of implementing virtualization is the use of a hypervisor.

### **Monitoring of server and network equipment**

Modern system administration is ineffective without automated monitoring tools that allow timely response to emergency situations and monitor network dynamics. One of the ways to solve this problem is to implement a system of automated monitoring of network equipment with further analysis of the results obtained during operation.

## **III. OBJECT, SUBJECT AND DESIGN METHODS**

### **3.1 MODERN METHODS OF ORGANIZING THE ENTERPRISE**

#### **3.3.1 Choosing an architecture model**

To solve the problem of centralized management and protection of the company's local network, there is a sufficient number of solutions that have different implementations, approaches and different methods of use. In modern realities, the choice of a method for solving this problem depends only on the preferences of the enterprise and the tasks it performs. The administration of the local network can be conducted from a separate cluster of the structural unit of the enterprise, and the entire corporate network can be administered using ready-made solutions for building centralized network management. Despite all the variety of specific implementations of modern information networks, the absolute majority of them have one or another typical architecture as their basis. It is accepted to define several typical architectures for building information networks:

- terminal-main computer architecture;
- peer-to-peer architecture;
- client-server architecture;
- cloud architecture.

To choose the necessary architecture, it was necessary to analyze the two most common architectures, peer-to-peer and client-server. After analyzing the two architectures, and taking into account all the wishes of the owner of the medical institution, a three-level client-server architecture was chosen, the shortcomings of which are not critical for this institution.

### 3.3.2 Selection of software

**A medical information system** - is a document flow automation system for medical institutions, which combines a medical decision support system, electronic medical records of patients, medical research data in digital form, patient condition monitoring data from medical devices, means of communication between employees, financial and administrative information. During the analysis of the market of medical information systems, several leaders were singled out, namely: Health24, Helsi, SimplexMed, Kashtan, Dr. Eleks. Certain criteria were also identified by which MIS should be selected, namely:

- Integration with the eHealth electronic healthcare system;
- Personal doctor's office;
- Connecting DICOM equipment;
- Integration with other MIS;
- Own laboratory subsystems;
- Telemedicine support;
- Availability of the medical statistics module;
- The presence of a warehouse accounting module;
- Availability of the personnel accounting module;
- Electronic document flow;
- Online appointment;
- Type of data storage;
- The cost of purchasing a license.

The results of the comparison of medical information systems for medical institutions according to generally accepted criteria are shown in the table.

Table 3.1

The name of the characteristic	The name of the software product				
	Health24	Helsi	SimplexMed	Chestnut	Dr. Alex
Integration with the electronic healthcare system eHealth	+	+	+	-	+
The patient's office	+	+	-	-	+

Connecting DICOM equipment	+	-	+	-	+
Integration with other MIS	-	-	+	+	+
Own laboratory subsystems	-	-	+	-	-
Telemedicine support	-	-	+	-	-
Medical statistics module	+	+	+	+	+
Accounting of storage facilities	+	-	+	-	+
Accounting module	-	-	+	-	+
Personnel accounting module	-	-	+	-	+
Electronic document management	+	-	+	+	+
Online appointment	+	+	+	+	+
Type of data storage	Cloud storage		Centralized data storage on the enterprise server		
The cost of purchasing a license (one workplace) per month	350 UAH	350 UAH	650 UAH, or 10,000 unlimited	450 UAH	750 UAH

So, after considering the available analogs of MIS, the characteristics of which were given in table 3.1, we can say that the project will be built using the software product "SimplexMed", so it has the following and key advantages over competitors:

- Integration with the eHealth electronic healthcare system;
- Connecting DICOM equipment;
- Centralized data storage on the enterprise server;
- Availability of the medical statistics module;
- Telemedicine support;
- The presence of a warehouse accounting module;
- Own laboratory subsystems

**Operating Systems.** Different types of operating systems can be seen today on any device that has applications installed, from phones and game consoles to supercomputers

and web servers. Examples of popular operating systems today include Android, BSD, IOS, GNU/Linux, OS X, and Microsoft Windows.

Since the technical requirements of MIS, which support two processors and the Windows family OS, are taken into account during the construction of the ITS, the Windows Server 2022 OS of the Datacenter edition was chosen, it has updated security protocols, support for modern processors and a set of modern modules (RDS, Hyper-V, Active Directory) that will be used in this project.

Given that the client-server architecture, based on RDS, will be used, workstations can use any OS that allows connecting to the central server using the RDP protocol. Since Windows is a paid OS, Linux OS was chosen for the workstations.

**Monitoring system.** For this project, the Zabbix monitoring system was chosen, which combines modern monitoring methods, a large number of notification methods, and a convenient interface.

### 3.3.3 Selection of equipment configuration

**Server.** The choice of technical characteristics of the server depends on the tasks it will perform. It is necessary to highlight the following main tasks:

- RDS support for 500 users;
- MIS support for up to 200 users;
- Deployment of Active Directory.

Let's highlight the critical modules for building a terminal server:

- Number of RAM;
- Number of CPU cores;
- Storage size.

The requirements for the server on which RDS will work were identified through research. A system with one user (administrator) needs:

- 1 CPU core is loaded at 4%;
- 1 GB of RAM;
- 23.2 GB HDD.

Each subsequent user consumes 200 MB of RAM and 300 MB of HDD space, and when the user starts, another 100 MB of RAM is required. MIS consumes approximately 150 MB of RAM during load. Also, users need a place to store work documents.

Thus, taking into account the minimum requirements for the server, and a certain supply of allocated resources per user, for 10 users working at the same time, you need:

- 4.5 GB of RAM;
- 1 CPU core;
- 503 GB (3 GB for system and 50 GB for user files).

So, for 122 users you need:

- 54 GB of RAM;
- 12 CPU cores;
- 6 TB of storage.

Basic minimum hardware and software requirements for deploying Active Directory:

- Availability of at least one node (hardware or virtual) running MS Windows Server;
- 64-bit processor with a clock frequency of at least 1.4 GHz;
- RAM of at least 512 MB;
- System disk at least 40 GB.

Based on the requirements of MIS, RDS service and Active Directory, we will build a table of requirements for the hardware part of the server.

Table 3.2

Parameters	Consumer				In total
	MIS	RDS	Active Directory	Zabbix	
Processor	2 x Intel Xeon 2 ГГц,	12	x64 1.4 ГГц	2	21
RAM	40 Гб	54 Гб	512 Мб	2 Гб	96.5 Гб
HDD/SDD	2x6TB HDD	6 Тб	40 Гб	20Гб	18.6 Тб HDD
RAID controller	0 ,1, 5, 6, 10	-	-		-

So, taking into account all these factors, as well as the software requirements, and the availability of a separate room for the server room at the enterprise, a 1U server of the Fujitsu company was chosen, namely: Primergy rx2530 m5 in the amount of two pieces to build a fault-tolerant cluster.



Picture 3.1- Server Fujitsu Primergy rx2530 m5

**Data storage system.** Medical organizations have to work with ever-increasing volumes of data and a heterogeneous structure. Therefore, in large medical complexes and regional hospitals, classic data storage systems (SDS) of medium or high level SAN/NAS are usually needed. The IBM FlashSystem 5010 data storage system with a total memory capacity of 105.6 TB was selected for this project.



Picture. 3.2 - IBM FlashSystem 5010

**Workstations.** Since the ITS will be built on a client-server architecture, "Thin clients" will be used as workstations. After analyzing the "Thin Client" market, one of the leaders of this market was chosen, it is the Dell Wyse 3040. The Dell Wyse 3040 thin client is an effective solution made in a compact case.



Picture. 3.3 - Thin client Dell Wyse 3040

**Choosing network equipment** The main criteria for choosing network equipment are price, scalability, security, bandwidth, centralized network management, support for modern technologies, and fault tolerance. Therefore, it was necessary to make technical decisions for the construction of Gigabit Ethernet and 10 Gigabit Ethernet networks in a high-rise building, in which a data transmission network is partially mounted. At the same time, the possibility of connecting to the network of several communication operators was ensured. Taking into account all these parameters, MikroTik CSS326-24G-2S+RM was chosen as a switch, and MikroTik CCR1016-12S-1S+ and CCR 2004-1G-12S+2XS as a router.

## V. CONCLUSIONS

During the implementation of this project, all tasks were implemented, which in turn provide the following advantages for the medical institution:

1. Connecting to the eHealth system. This is the most important component in the work of medical institutions. Institutions that are connected to the electronic health care system get the opportunity to participate in the medical reform, which in turn gives the institution the opportunity to receive funding.

2. Eliminates filling out papers. There is no need to duplicate records and enter information into other documents: doctors and staff who have access to the patient's card can get acquainted with the history of his illness, the course of treatment, and the results of research from a single database.

3. Improving the quality of service and reducing the influence of the human factor. Automated document flow allows you to reduce the amount of paper work, successfully

maintain a customer base, relying on current information about research and services.

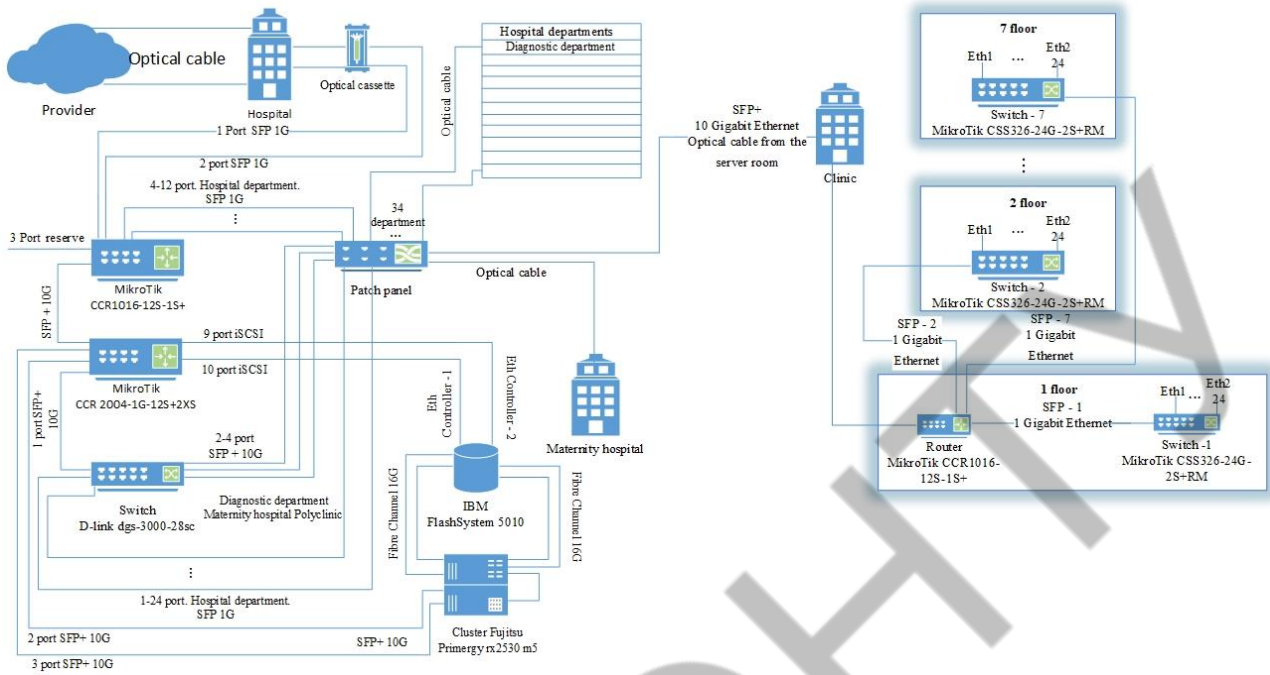
4. Advantage for patients. Thanks to MIS, patients get access to their data, quickly receive the results of laboratory tests and take them with the doctor. The probability of forgery and loss of medical data is reduced.

5. Reduction of costs for service personnel. Thanks to the implementation of a modern network architecture and the use of a monitoring system, the IT system requires less attention and effort from system administrators. This project was implemented using modern approaches in the field of information technologies, which in turn allows to implement this project in other medical institutions.

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### Structural diagram of the projected network



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