КОМП'ЮТЕРНІ НАУКИ

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Improved Model and Software of the Digital Information Service of the Municipal Health Care Institutions

Today, state and municipal services are being actively digitized in Ukraine. In particular, the Kropyvnytskyi city authorities initiated the creation of several information systems (IS) necessary for the development of various spheres of activity based on public needs for municipal services. Among these are IS of medical services provided by the city's health care institutions. Thus, the scientific and technical task of implementing the software for the municipal medical services information system in the city of Kropyvnytskyi is relevant. The work aims to implement access to information about medical services of health care institutions in the city of Kropyvnytskyi by creating municipal information systems with iOS-client.

The scientific novelty of the obtained results is to improve the model of municipal information systems of medical services through the implementation of the offline mode of system operation, which in contrast to existing models of similar municipal systems provides access to IP data in the absence of Internet connection. The practical value of the results of scientific work is determined by the developed algorithms of the system, non-creation, work with the map and collection center of analytical, mobile iOS-application of the municipal medical services information system for the city of Kropyvnytskyi, published in the "App Store".

digitalization, digitalization, information system, medical service, software

Introduction. Modern technologies have made it possible to place large capacities on small devices, which has led to the popularization of smartphones. Mobile applications have become full-fledged analogs of PC applications and web services. Therefore, it's logical that the authorities want to use this tool to improve the mechanism of the state.

Based on the public need, the city authorities of Kropyvnytskyi initiated the creation of several information systems for municipal services, which are necessary for the development of various activity spheres. Their initiative is to create IS medical services. The municipal government is interested in a service that will provide access to up-to-date data about the medical equipment of all hospitals in the city by mobile application. Thus, the work aims to give access to information about health care institutions' medical services in the city of Kropyvnytskyi through the implementation of municipal IS with an iOS-client. The expected result is an iOS application that will meet the needs of the local community in free access to information about medical services in Kropyvnytskyi.

The object of the study is the process of providing access to information about medical services of municipal health care facilities by using the Internet, information and telecommunications technologies, and the subject is the technology of creation of IS medical services at the municipal level based on software application for mobile operating system iOS.

Achieving the goal of work will ensure the solution of the following tasks:

1) to analyze existing systems analogs and technical solutions of municipal information systems;

2) to develop a conceptual model of IS of medical services;

3) to improve the model of the municipal medical services information system to ensure access to IS data in the absence of the Internet;

4) to develop functioning algorithms for the client of municipal information systems of medical services on a mobile platform;

5) to implement client software IS medical services for mobile operating systems iOS and perform its qualified testing.

Analysis of recent research and publications. The analysis of analog systems [1, 3, 5, 9, 10] and municipal information resource www.kr-rada.gov.ua/elektronni-servisi revealed the activity of local governments in creating and promoting information systems, as well as examples of already implemented services for the community of Kropyvnytskyi: "Green Kropyvnytskyi", "Public Budget" and "Educational Map of Kropyvnytskyi"; all of them in some way facilitate the community's access to some information, but none of them provides access to information about health services, so the municipal health information system will be unique and relevant.

The application, which is the project's end product, is part of the municipal health information system. The purpose of IS is to describe an object or group of objects, states, and interactions, which are expressed through certain indicators. The main tasks include [4]: identifying sources of information; collection, registration, processing, and issuance of information; distribution of information between users.

The scope of municipal IS of medical services follows from the purpose: municipal - for all residents of Kropyvnytskyi; medical - for all individuals involved in the medical field: doctors and patients.

At the initiative of local governments, all medical institutions of the city provide complete information about medical services and the state of medical equipment, and with the help of IS this information is processed and made available to all residents. Therefore, the area of application of the software to be developed is the sphere of medical services in the city.

The purpose. It's needed to improve the model of municipal medical information system in order to implement the offline mode of system operation, which is based on different models of similar municipal systems that provide access to IS data during Internet connection. The object of research is the process of providing access to information about municipal health care institutions' medical services using Internet information and telecommunication technologies. The subject of research is the technology of synthesis of the medical services information system at the municipal level based on the software application for the mobile operating system iOS.

Research methods. The methodological and informational basis of the work is the methods of information systems theory, algorithm theory, analysis and synthesis methods, process and system modeling methods, information systems design methods, algorithm design methods, software implementation methods, qualified software testing methods.

Results. The municipal health information system will be based on a client-server architecture. The client will communicate with the server via the Internet. The client will be a mobile application for iPhone, and the server will be a group of several service elements. So, each of the service elements will have an independent channel for exchanging data with the client.

The service elements will be responsible for the construction of routes to hospitals with the current user position, analysis of analytical data, construction of statistical graphs, and communication with the database of medical services. The most important role is played by the server, which will interact with the database and send the client information about hospitals and medical services of the city.

The mobile application will use a graphical interface to interact with the user. If necessary, the user must send or receive information from the server part, as well as work with maps, build routes and collect data for statistics.

The conceptual model of the municipal medical services information system is presented in [7, 8, 11, 12].

Development of an improved model of municipal information systems of medical services. The development of an advanced IS model is based on the use of a conceptual model. It helps easily identify main components of the system, and then it remains to determine only their main functions and types of relationships between them.

It is proposed to improve the model of municipal information systems of medical services by implementing the process of offline mode of system operation, which, unlike existing models of municipal systems provides access to IS data without the Internet.

The first large block is divided into three parts: View Controller, View Model, and Coordinator (Fig. 1). Combining of these three elements into one block is justified by the architecture of the application, in which each screen is represented by three given elements.
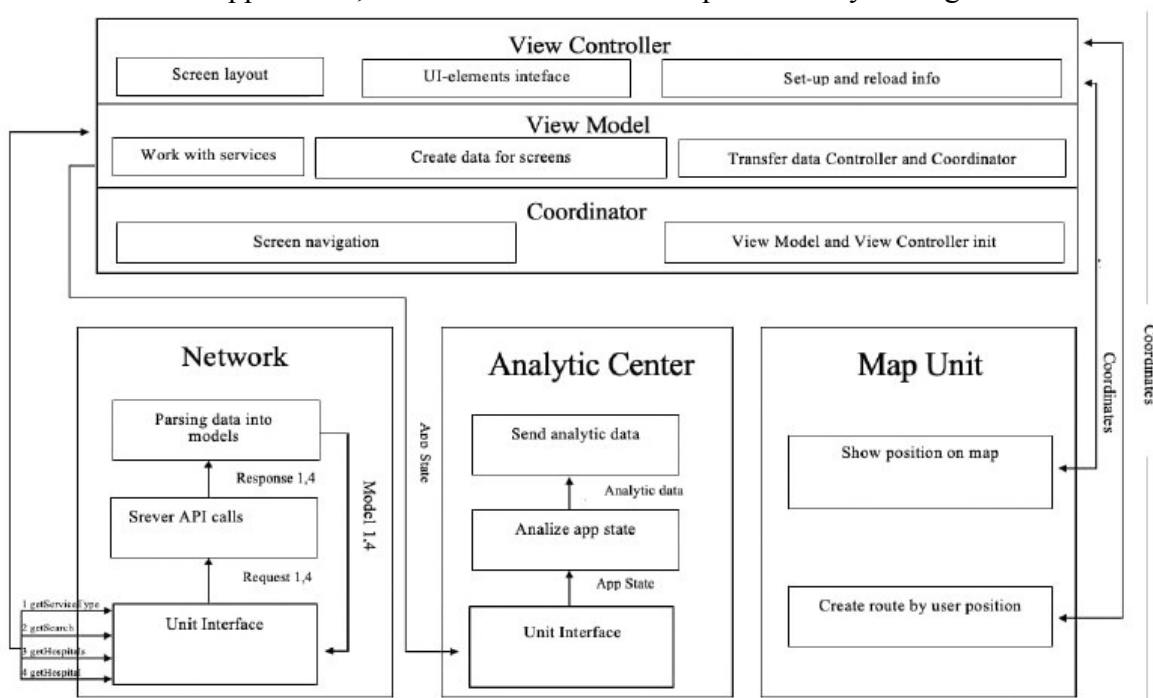

Figure 1 – Improved model of municipal health services IS

Source: compiled by the authors

The View Controller element is responsible for building screens and interacting with UI elements. The screen can be built only with the help of code, or you can use files to build graphic elements: * .xib or * .storyboard. All screens in the project must be created in * .storyboard, their graphical representations are built using built-in or special graphic elements, and then the correspondence between them and the controllers is written. If View has a graphical representation in another file, you need to create links between the elements and the code responsible for their configuration. After completing all the settings, the View Controller can populate and update the data displayed on the screen. Data for the screen is obtained from the View Model.

View Model is responsible for all the business logic of the screen. It creates data packets for the screen, receives all the necessary information, and formats it to the desired appearance. To receive or transmit information View Model communicates with services. Thus, all work with services is done only through the View Model. It is important to

emphasize that it is the View Model that implements the data transfer between the View Controller and the Coordinator. The most common example of such transfer is navigation between screens. View Controller receives the information that the user clicked on the button, passes it to the View Model, and the last passes it to the Coordinator, which performs the process of switching to another screen.

As described above, the Coordinator is the element responsible for navigating between screens. However, another important feature of this class is the creation of the View Model and View Controller. During initialization, communication with the Coordinator retains only the View Model, so communication with the View Controller is shown one-way.

In addition to the first large block, the chart shows three more blocks. Two of them are connected only with the View Model, these are services, and one is with the View Controller, which is a generalization of the process of working with the map.

The first of the two services is Network (work with the server part). It contains some additions that allow it to work with the Internet. The interface for interaction with this unit has four functions: getServiceType - initiates a request for all types of medical services; getSearch - initiates a search query; getHospitals - initiates a request to receive all hospitals that provide a particular medical service; getHospital - initiates a request for detailed information about a particular hospital.

After creation, the request is sent to the server and according to API, the answer is arrived. The resulting data is converted from the JSON format to special models, which are then returned to the View Model. There are several types of answers. Some of them can be considered valid and some of them are errors. However, the only thing left is to spread the answer and pass it on.

The second service is the analytical data collection center. Its interface is quite simple; it expects the state of the application from View Model. The center analyzes this state and generates a special message that is sent to Firebase.

The map unit, as described above, is a generalization for the two main tasks, displaying the location and construction of the route. Both tasks are performed independently, but the View Controller starts working by transmitting coordinates. The positioning of a specific location on the map is displayed using a native UI element that contains its logic, so View Controller only transmits coordinates and changes some of its configurations. A third-party service Google Maps provide construction of the routes. View Model generates a link and passes it to the View Controller, which opens a link to Google Maps using a browser.

As a result of the development of the improved model based on the conceptual model, the functions and connections for all software components of the client of the municipal medical services information system are defined. With the help of these data, an improved model was built.

The authors developed models of algorithms for the operation of an automated information service. During the planning and description of design decisions, the functionality of the IS is determined, based on which the client-server architecture for project implementation is selected and the main components are identified: the client and the group of server elements. During the development of the conceptual model of IS all structural elements of the system (for the client: UI, business logic, navigation, analytics, Network and work with maps; for the server: Google Maps, Firebase, and server that accesses the database of medical services) and connections between them are identified, after which in the development of an improved model based on the structural elements of the client their main functions, detailed their relationships were justified.

Therefore, this section proposes models for municipal IS of medical services, and the described elements, connections, functionality of IS, and algorithms are the basis for design decisions.

Software implementation of the app for the municipal medical services information system. The mobile software, which is developed in this study, is designed for use under the iOS, operating system (OS) developed by Apple for mobile devices, tablets, etc. The main feature of this OS is that it can only be used on devices manufactured by Apple. It uses the XNU core (Match microkernel), which stores closed source code.

Since the mobile application will be created only for iOS devices, the easiest to use is Xcode. At the same time, this choice affects the choice of programming language. Xcode supports two programming languages: Swift and Objective-C. The first is the primary development language for iOS, the syntax is derived from C and SmallTalk. Although Swift has recently been introduced, many advanced projects are still implemented on Objective-C [6]. Swift is a new programming language (2014), created by Apple specifically for software development for the company's devices. It is intuitive, easy to read, strictly typed, but quite resistant to program errors. It should be noted that Apple has implemented mechanisms to integrate both Swift in Objective-C and vice versa. Swift will use the programming language as the basis for this project.

Discussion. After the completion of the project, an application was implemented, which is a client of the municipal medical services information system. During its testing, the operation of the main modules of the application was tested: Network, work with the map, and the center for collecting analytical data.

During the qualified testing of the compiled IS application, the correctness of downloading information from the server and the correctness of the display on the user's screen were checked. An example of the program code for requesting detailed information about the hospital is as follows:

```
getHospital (id: "472cf05208fcf4c9f1cf473de68904db")
networkService.hospitalObserver.subscribe (onNext: {[weak self] result in
        switch result {
        case .success (flightmodel ):
            self? .update (model: model)
            print ("Hospital response received with id =", model.id)
            self? .isHUD = false
            self? .didLoadData? ()
        case .failure (error: let error):
            self? .didLoadFailed? (error)
            print ("Error received", error.description)
        }
}). disposed (by: disposeBag)
```

Output to the terminal:

```
Received    a    response    about    the    hospital    with    id    =
472cf05208fcf4c9f1cf473de68904db
```

A test route was developed to test the map using the same hospital. It is the browser that completely coincides with the one received during the experimental test and confirms the correctness of the service. And Debug View was used to test the work of the analytical data collection center. This tool is useful for validation during the development phase and helps to identify errors in the implementation of analytics. For testing purposes the software is compiled on a built-in IDE simulator that connects to Debug View via the Internet. The test result confirmed that all events and properties are recorded correctly (Fig. 2).
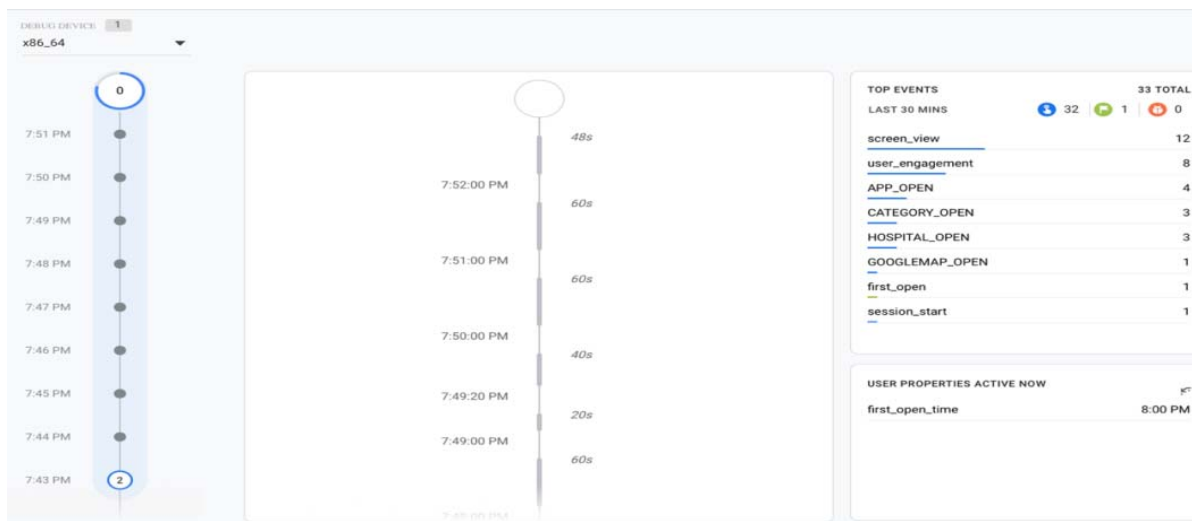
Figure 2 – Debug View screenshot

Source: compiled by the authors

Conclusions. The initiative of the local self-government authorities of the city of Kropyvnytskyi and the need to digitalize the sphere of medical services were reasons for the creation of a municipal medical services information system as a topical issue. The implementation of the software is a part of a program aimed at information resources creation for the city community. In general, this is a unique IS. Its purpose is to inform the community about medical services and the work of medical institutions, and the area of application in the field of medical services in the city of Kropyvnytskyi.

In the process of planning and describing project solutions, the functionality of the municipal medical services information system was determined, based on which the chosen client-server architecture for project implementation was substantiated and the main components - client and group of server elements were identified. Based on the structural elements of the client, their main functions are substantiated, their relationships are detailed, and algorithms for the operation of IS software are developed and described: a generalized application algorithm and algorithms for running the services are defined in the project.

During the research, the work on the necessary calculations (GoogleMaps) was performed and the functioning of the client-server architecture was experimentally tested. In addition, according to the defined architecture of the application, the classes View Controller, Coordinator, and ViewModel were developed and the interaction of system components was configured. According to the proposed algorithms classes of services were created, and according to the conceptual and improved models some coherent, system, and software interfaces were implemented that ensure the successful layout of all components and elements of the IS.

The program is implemented in the high-level Swift language and the Xcode software environment. Their use during the creation of the application allowed to minimize the time of software development, and, as a consequence, to reduce the cost (resources) for its implementation. The quality of the developed software product is confirmed by qualified testing.

The tested software for the municipal medical services information system has been put into operation. An analysis of the tools available to perform this task showed that there is only one platform for publishing applications for iOS devices: "AppStore" (https://www.apple.com/ua/app-store/). After investigating this platform and getting acquainted with its usage rules, the developed application was published. In general, the created software confirms the correctness of the proposed design solutions and meets the established requirements. The software has a simple and user-friendly interface, and provides

easy access to information, which is its main purpose. Implemented software has the potential to further improvement and usage of the developed software code in creating analog systems.

The obtained results of the research contain the scientific novelty, consisting in the improvement of the model of municipal medical information system by the implementation of the offline mode of system operation, that provides access to IS data during Internet connection, unlike other existing models of similar municipal systems.

The solution of the tasks of the work, in particular the offered software of the mobile iOS-client, provides access to information about the health care institutions' medical services in the city of Kropyvnytskyi and evidence of the achievement of the goal of the work.

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Удосконалена модель та програмне забезпечення цифровізованого інфосервісу муніципальних закладів охорони здоров'я

В Україні активно цифровізуються державні й муніципальні послуги. Зокрема органи управління міста Кропивницького за суспільною потребою на муніципальні сервіси ініціювали створення декількох інформаційних систем (ІС), які необхідні для розвитку різних сфер діяльності. Серед них – ІС медичних послуг, які надаються закладами охорони здоров'я міста. Отже, науково-технічна задача реалізації програмного засобу муніципальної інформаційної системи медичних послуг Кропивницького є актуальною. Тож слід діджиталізувати доступ до інформації про медичні послуги установ сфери охорони здоров'я м. Кропивницького шляхом створення муніципальної інформаційної системи з мобільним клієнтом.

У процесі досягнення мети дослідження розв'язані такі науково-технічні задачі: 1) виконано аналіз існуючих систем - аналогів та технічних рішень муніципальних інформаційних систем – цифровізованих інфосервісів в Україні; 2) розроблено концептуальну модель інформаційної системи медичних послуг; 3) удосконалено модель муніципальної інформаційної системи медичних послуг для забезпечення доступу до даних ІС при відсутності інтернету; 4) програмно реалізовано функціонування клієнта муніципальної інформаційної систем медичних послуг на мобільній платформі; 5) розроблено клієнтське програмне забезпечення ІС медичних послуг для мобільних операційних систем iOS та виконати його кваліфіковане тестування. У роботі застосовані методи теорії інформаційних систем, теорії алгоритмів, методи аналізу й синтезу, метод моделювання процесів і систем, методи проектування інформаційних систем, методи проектування алгоритмів, метод реалізації програмних засобів, метод кваліфікованого тестування програмного забезпечення.

Наукова новизна отриманих результатів полягає в удосконаленні моделі муніципальної інформаційної систем медичних послуг за рахунок реалізації процесу офлайнового режиму функціонування системи, що на відміну від існуючих моделей аналогічних муніципальних систем забезпечує доступ до даних ІС у період відсутності зв'язку з Інтернетом. Практична цінність роботи визначається розробленим програмним забезпечення функціонування системи, нетворку, роботи з мапою і центру збору аналітичних, а також мобільним iOS-застосунком муніципальної інформаційної системи медичних послуг міста Кропивницького, який опублікований в «App Store».

цифровізація, діджиталізація, інформаційна система, медичний сервіс, програмне забезпечення