An Intelligent System for Generating End-User Symptom Recommendations Based on Machine Learning Technology

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Abstract. The purpose of the study is to develop an intelligent system with the ability to work with the symptoms of users, through which one could obtain sufficiently complete information about the choice and purchase of medicines. The main objectives of the study:
1. To analyze known literary sources, subject area of pharmacy , known algorithms for medicine selection and intellectual formation of recommendations.
2. Carry out a systematic analysis of the object of study, using preliminary means of structural and object notation.
3. To build a comparative description of possible software alternatives of the developing intelligent system, separately highlighting the disadvantages and advantages, as well as user feedback. Use the analyzed data to further build the intelligent design system. Describe many requirements, including technological requirements, for the system under study, algorithms and technological processes for processing information.
4. Using the previously analyzed data and the designed system, to select and justify methods and tools for the subsequent realization of the solution of the previously set task.
5. Write a software tool to automate the processes of solving the tasks set when performing this work. Give a reference example of the use of the developed software to confirm the performance of the system.

Keywords. Intelligent system, symptom, recommendations system, generating end-user symptom recommendations

1 Introduction

The pharmacy business has been considered one of the most profitable in recent years. We can see that it is attractive because of the number of pharmacies that is constantly growing. They are being opened more and more - large and small, independent or included in large pharmacy retail chains [1-3]. Every mall has a pharmacy kiosk or shop today, and sometimes several - and they all look different, have different prices, which are often very different. Not so long ago, only a few decades ago, pharmacies were a rather unpleasant place. It is obsolete interior, unwelcoming sellers, constant queues, persistent odor of medicines. The assortment was also not distinguished by the variet, there were often medicines that were in constant "scarcity".

Statistics also say that only a third of pharmacy customers know exactly what medicine they came to the pharmacy for. It is worth noting that, according to polls, about ten percent of shoppers have learned about advertising and about forty percent through doctor's recommendations, and the rest through tips from acquaintances or sellers of the same pharmacies [4-9].

Based on the statistical behaviour of the clients of the points of sale of medicines, it can be noted that the average person needs information resources that can provide the necessary information and support for the purchase of medicines. People often have to look for medicines without planning this in advance, and often there are situations when it is impossible to use the full version of the pharmacy network site. Not to mention finding cheaper and closer options across multiple sales networks. It is also difficult to notice that in today's world, people are increasingly using "big" computers and increasingly moving to mobility. This trend is also supported by the medicine market, whose system in our country is long outdated and needs innovations [10-16].

The object of study is the process of information support for pharmacy customers. The subject of the study is the automation of the process of information support for pharmacy customers and the formation of recommendations for the purchase of symptomatic medicines. An intelligent recommendation system for pharmacy customers will enable users to:

1. Search for the right medicine.
2. Form pharmacy lists by location and price.
3. View relevant pharmacy or medication information in an understandable manner.
4. Look for alternatives to well-known medicines.
5. View information about selected medicines without connecting to the WAN.
6. Determine the recommended medication by symptomatology.
7. To supplement and develop an intelligent system for the selection of medicines.

2 Methodological Principles of the Study

Medicines are a major component of health care services, and their use has grown tremendously in the last century with the advent of effective antibiotics, anesthetics, painkillers, antiretroviral medicines and many other medicines. Medication can cure, relieve symptoms and prevent complications. Proper (rational) use of medicines

means delivering the right medication at the right doses and when necessary and avoiding unnecessary medicines or the use of which is unlikely to lead to health benefits. This means choosing the treatment with the best efficacy and safety options from all available alternatives and the least costly equivalent treatment option [17-23].

These decisions require knowledge of the patient's health, life situation and preferences, access to objective, comparative benefit information, and adverse effects of all available treatment options.

The international pharmaceutical industry plays an important role in the development, manufacture and distribution of medicines. In many countries, the pharmaceutical industry has also become a major sponsor of specialist training, postgraduate medical education, and research. However, there is a contradiction between increased sales incentives in the competitive pharmaceutical market and patient health concerns. The World Health Organization (WHO) described the "imminent conflict of interest between the legitimate commercial goals of manufacturers and the social, medical and economic needs of health and public health professionals to choose and use the medicine in the most rational way." (Euro-WHO, 1993).

In order to announce new medicines in the market , the company must provide proof and efficiency, safety and quality of production. Evidence of effectiveness and safety include laboratory, animal and clinical research. The largest are randomized controlled trials ('phase III') conducted on patients with the condition for which the test medicine is being prescribed. Most of these studies compare new medicines with placebo. Many people do not imagine that manufacturers do not have to prove that new medicines are better than existing treatments. New medicines should have a claimed beneficial effect of an acceptable magnitude when compared to placebo and be reasonably safe. To test the efficacy of the medicine, the manufacturer conducts randomized controlled trials involving patients with the disease to be treated with new medicines. This is usually for short-term studies lasting from a few weeks to several months, even when the medication is intended to treat a chronic condition. For some serious illnesses where placebo treatment would be ethically unacceptable, new medicines are compared to existing treatments. However, these studies aim to show that new medicines are as effective as alternatives, or less effective; new medicines do not need to be better. When new medicines appear on the market, they are only tested on carefully selected clinical trial participants. For example, the elderly and those with concomitant chronic conditions are usually excluded. Too few people have been exposed to new medicines to evaluate the possibility of rare adverse effects - usually between 3,000 and 5,000. In view of such an inevitably inadequate safety study, reasonable, from the point of view of both public health and the individual patient, there is a cautious, slow approach to the introduction of new medicines into practice.

2.1 Relationships between Healthcare Professionals and the Pharmaceutical Industry

The links between healthcare professionals and the pharmaceutical industry have grown tremendously in the 20 m and early 21st century, leading to a call by teachers to create powerful barriers - firewalls - to protect the independence of medical academic centres (Brennan, 2006). As part of a large survey conducted in the United

States (Campbell, 2007), over 90% of physicians reported relationships with the pharmaceutical industry:

- 8 out of 10 doctors received gifts, usually in the form of free meals at their workplace;
- 8 out of 10 doctors received free samples of medicines;
- 4 out of 10 doctors were paid for attending conferences and meetings;
- 3 out of 10 doctors were paid consultants in the company lecturer team or on the advisory board.

Studies in many industrialized countries have shown that, on average, doctors meet with one sales representative a week (Wazana, 2000). In Turkey, however, more than half of the city doctors working in the third largest city, Izmir, met with at least one sales representative every day and one third of the doctors spent more than 30 minutes with them daily (Guldal, 2000). Although two-thirds of surveyed physicians believed that sales reps did not influence their prescribing, the majority noted the use of advertising brochures as sources of information. A relatively small number of studies have been conducted on the interaction of pharmacists / pharmacists with the pharmaceutical industry. In one national study, the United States examined attitudes to the pharmaceutical industry and the promotion of medicines (Farthing-Papineau, 2005). Two-thirds of this random sample of 1,640 pharmacist pharmacists and pharmacy practitioners noted that sales reps offer gifts to non-patient pharmacists.

2.2 Activities Aimed at Increasing Sales

Recently, several lawsuits in the United States have led to the publication of internal documents highlighting the variety of activities used to increase medicine sales. Gabapentin (Nerontin) has been approved in the United States as a second-line treatment for epilepsy. Soon, large quantities of gabapentin recipes appeared for non-approval of off-label. It is illegal to promote a medicine testimony in the United States, where it has been tried in any country. The problem with the promotion of over-the-counter medicines is that the company has failed to provide national regulatory authorities with systematic evidence of the efficacy or safety of medicines in this category of patients. In many cases, the medication is under-researched and the potential beneficial properties may not outweigh the potential harm. This is also the case with many of the evidences that Gabapentin has promoted (Steinman, 2006).

The nature of the appointments of gabapentin (Nerontin), is fully consistent with the promotion steps described in the Nerontin trial (Steinman, 2006). However, according to surveys, doctors usually report that promotion activities have little effect on their medication decisions. For example, a study of novice physicians in the field of internal medicine (interns, interns) found that only 1% of them believed that the promotion had a serious impact on their prescribing decisions, and most believed that the promotion of medicines did not have them no effect (Steinman, 2001). If medication promotion did not influence treatment decisions, would pharmaceutical companies pour billions of dollars annually into marketing aimed at healthcare professionals? Given that companies need to show steady profits to their shareholders, this seems unlikely. Companies that market research calculated the average return in the

form of increased sales for every dollar invested in the promotion of medicines in 2004, amounting to 8.34 dollars US (Arnold, 2005). Fortune 500 ratings also ranked the pharmaceutical industry consistently in the ranking, with the highest investment returns among all industries: in 2006, it ranked second after the oil industry, with revenue at 19.6% as a percentage of total revenue (Fortune, 2007).. These scientific studies confirm that the promotion of medicines really affects professional activity. In parallel with the lack of priority in regulating these issues, medicine promotion has received relatively little coverage in medical and pharmaceutical education (Mintzes, 2005). This lack of attention is in stark contrast to the billions of dollars spent annually on medicine promotion. Often, medical professionals believe that the promotion of medicines does not affect them themselves, and may have insufficient training to distinguish between ethical and unethical practices. Interactions between healthcare professionals and the pharmaceutical industry often begin early in the training stages. Discussing these interactions can help distinguish between ethical and unethical interactions, distinguish displaced information from accurate scientific information. Teaching clinical pharmacology and pharmacotherapy is an important part of professional education. It is also very important to understand the context in which therapeutic decisions are made about the use of medicines. The purpose of this guide is to create awareness among medical students and pharmacists of the broader context of medicine use; provide background information on the types and extent of promotion and the scientific evidence of its impact; and to help develop practical skills that need to be guided when interacting with the pharmaceutical industry in their professional practice. The goal, after all, is to improve patient care.

2.3 Analysis of the Level and Dynamics of Prices in the Pharmaceutical Market of Ukraine

One of the most important and socially acute problems in the development of the pharmaceutical market in Ukraine is the problem of pricing medicines. This is due to the fact that, in the pharmaceutical sector, prices, in addition to purely economic content, have a significant social role, because they determine the availability and level of satisfaction of the need of society and health care institutions for medicines related to socially important goods. In this regard, in Ukraine, as in many other countries, state control over prices in the pharmaceutical market is exercised.

2.4 Purpose and Subject of Activity of Pharmacies

The pharmacy is created to provide the population and the medical establishment with medicines and medical products, the production of dosage forms, the provision of services, as well as at the expense of the achievement of meeting the needs of the workforce. The subject of pharmacy activity is:

- Production, storage and sale of medicines according to the prescriptions of doctors and requirements of medical establishments of Ukraine;
- Intra-pharmacy quality control of manufactured medicines and their design;

- Dispensing of finished medicines according to prescriptions written by doctors, requirements of medical establishments;
- Over-the-counter sale of medicines and medical products;
- Harvesting, collecting and processing medicinal plants made from plants;
- Wholesale implementation of medicines (under special conditions);
- Incoming quality control of medicines;
- Identifying demand and establishing the need for medicines.

2.5 Functions of Pharmacies

The pharmacy performs a social, industrial, commercial, financial and economic function. However, the implementation of medicines is still problematic due to the low interest of people in pharmaceuticals and biology, which is why it is difficult for medicinestore chains in Ukraine to introduce new medicines and have little effective replacement. Software systems that can provide the user with comprehensive information about pharmacies and medicines can solve this problem.

2.6 State and Prospects of Research

Pharmacy activities around the world show general trends in the development of medical services: provision of information on medicines, participation in quality control of medicines and cost of care, closer attention to the patient, assistance to pharmacists in the further management of patients. Pharmacies in Europe are making sure that the use of medicines in hospitals becomes safe, effective and, of course, cost-effective.

2.7 Establishment of Various Medical and Medicine Committees by Specialists

This began with the creation of experts from various medicine and therapy committees to develop medicine policies that save money and ensure their safety and effectiveness. The next step that influenced the use of medicines across the pharmacy and hospital sectors was the creation of prescriptions directories. Due to the activity of pharmacies in hospitals, the length of hospitalization of the patient is reduced, the optimal use of medicines is ensured, professional advice is given, pharmacovigilance and prescription errors are identified. Due to the rapid development of pharmacotherapy, there was a need for information services for medicines: first, inpatients, who then joined local and national groups to respond to requests, create specialized databases and collaborate with governmental and industry organizations [24-27]. At the same time, the pharmaceutical market in Ukraine continues to grow. As of 2019, consumption has rebounded to pre-war rates. Market growth in dollar terms was 16.5%. The number of pharmacies has remained virtually unchanged in recent years. The consolidation of the retail segment is emphasized. Today, market leaders are pharmacy discounters. The number is projected to continue to grow. But it is not necessary to rely only on such players.

Among the most important factors that will affect the development of the market, it is important to highlight the introduction of a compensation system; implementation of medical reform in the country; introduction of electronic recipes; import licensing; VAT change for medicines. Above this factors will change the structure of consumption of medicines in general. Thus, it is projected to increase the share of prescription medicines, generics, domestic medicines and medicines included in the reimbursement system. Sales of medicines with unproven or contradictory efficacy (homeopathy, "function enhancers", metabolism, influenza preventive agents, immunomodulators, probiotics) are also expected to decline, and subsequently the sale of antibiotics may be reduced. The pressing topic of discussion today is the legalization of online pharmacies. Retailers and consumers are already ready for the emergence of such an instrument, and Ukraine has every opportunity to do so, however, as long as the issue is not regulated by law. It also raises patient concerns about unskilled consumption, the complexity of counterfeiting and fiscal controls. Discussions are being conducted around the online trade in medicines. Medicines, cosmetics and dietary supplements have already been successfully marketed over the Internet. As a result, selling medicines over the Internet is only a matter of time, so there is a need to address and regulate the issue of such activity [28-35].

2.8 Analysis of Known Systems

Considering the basic principles of functioning of pharmacies and the principles of pharmacy, it can be concluded that for these institutions it is quite difficult to introduce a system of information exchange about the necessary medicines and their availability in the selected pharmacy for a potential client, and even more so a system with the function of forming recommendations on symptoms. The latter is only implemented in a few websites, such as mobile applications; during the course of this qualification work could not be found. Also, the problem is often a lack of understanding by the user of the general information about what should or should be contraindicated in his / her probable symptoms or the doctor's diagnosis, whether there are analogues available, at a more affordable price, and how effective they are.

Therefore, the user of the intellectual system should obtain information on the price of the medicinal product, possible analogues, the main active substance, the availability of pharmacies, the need to present a prescription for the purchase and access to the contact details of the selected point of sale of medicines. In addition, in the projected program, you need to create a medication selection page for selected symptoms to further recommend medications to users. It should also be noted that it is important for the clients of these institutions to read the medication instructions before taking them. Based on the above requirements for pharmacy systems, the following systems have been identified:

- *GeoApteka.* The application is a free adaptation to the Android operating system of a well-known website, which is positioned as a medicine search service in pharmacies in Ukraine [1]. The adaptation has been installed on more than 50 thousand devices, which indicates its popularity in comparison with other similar services.

The interface is user-friendly and intuitive. A good colour palette was applied. Window transition animation is present, smooth and unobtrusive. It is also worth noting the choice of Ukrainian, although Russian is standard after installation (as in all analogues below). The search for medicines is simple; the input box is noticeable enough in the main window of the program. The pharmacy list you find is sorted by approximate location or price. The benefits of search are relevant to account for the information, mobility and clarity of release of found trading networks. It is also advisable to find out the pharmacy's contact details and the availability of medicines at its warehouses.

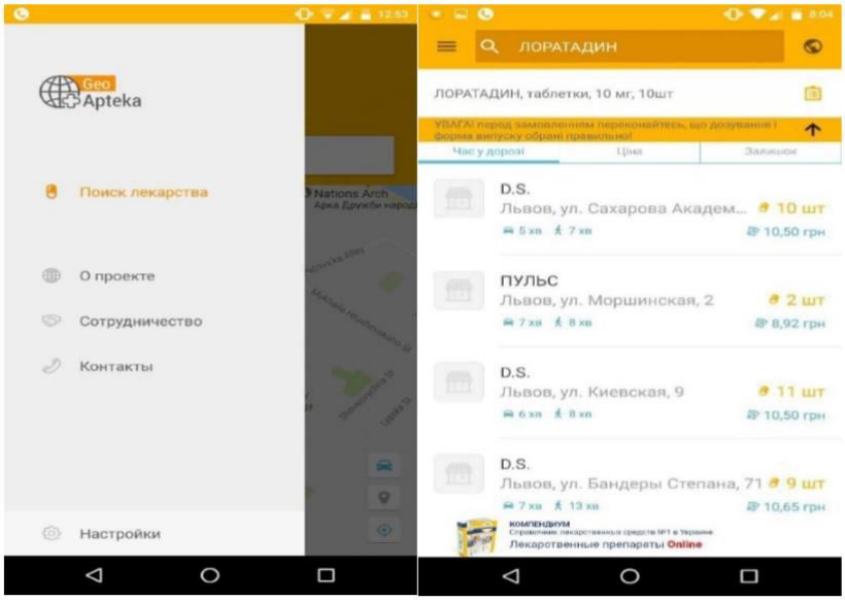

Fig. 1. GeoAptek program

However, there are some drawbacks to using the program that you can quickly notice. This is especially true of the relatively small database of searchable pharmacies, the inability to view analogues of medicines, and, importantly, the instructions to them. The final but not least significant step in the analysis of the program is the evaluation of the client. The average rating is 4.0, 260 users have voted. While this is considered high, it is also advisable to pay attention to reviews on the Google Play site: most reviews are negative, the drawbacks are the lack of many pharmacies, medicines and the unreliability of these prices.

- *Finding medicines in pharmacies.* Like the previous app, the program is free and designed for users from all over Ukraine and contains information on various pharmacies across the country [1]. Of all the analogues discussed in this section, this program has the largest number of installations; the number of its users is approximately 50-100 thousand. The program fully justifies its relatively high popularity with good functionality, but because of this the *interface of the* program is

difficult to understand, difficult to use the program for the first time. The previous window system blends in perfectly with the nice colour palette you choose and the thoughtful size of the buttons and input windows.

The advantages of the analogue are the definition of a large database of pharmacies in major cities of Ukraine; the ability to view instructions for the use of medicines; sort by name and price; constant informing of clients about new discounts in shopping centres; a system of searching for analogues and comparing their prices is implemented. The list of points of sale found immediately shows a contact number, which is quite convenient. Another benefit of the program is the automatic display of the message that the pharmacy is closed or opened according to their work schedule.

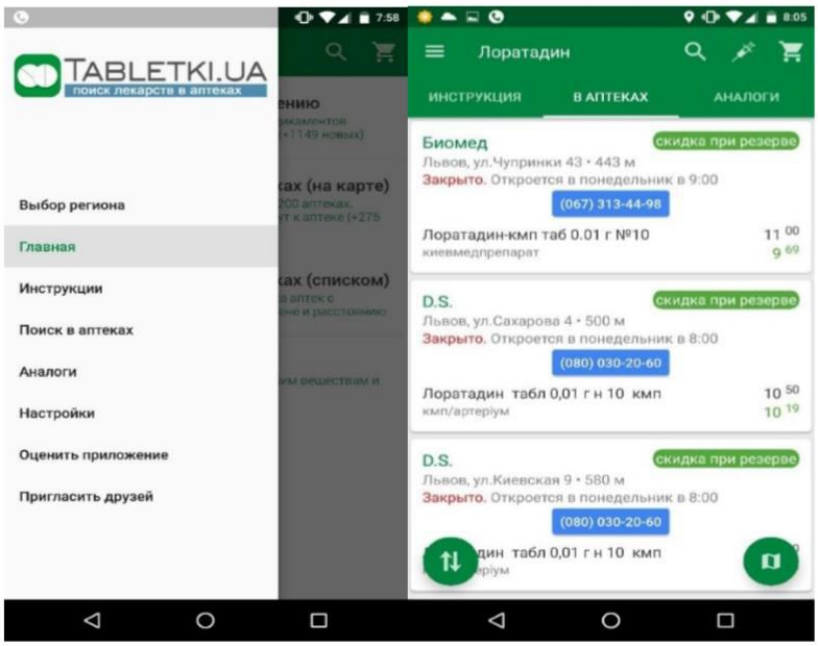

Fig. 2. Software from Tabletki.ua

The disadvantages of the program include the relative complexity of the interface, not always an obvious way to find the desired function in the windows of the application. This minus is quite significant and may be critical for some users. One of the drawbacks is the lack of information about some unpopular pharmacy chains and low project support, which is not often the result of updates. Compared to the previous analogue, the program from "Tabletki.ua" has a relatively high rating for programs of this kind: 4.4. However, most reviews are positive, and the only common problem clients face is the inability to change the search city at times [1].

- *DS Pharmacy Network.* Unlike the above examples of applications for pharmacy clients, this system is aimed at customers of one pharmacy network - the DS pharmacy network, and therefore provides information only on the points of sale that

are part of it [1]. The number of users of this app is insufficient due to the relatively smaller number of potential customers. The number of installations does not exceed 5 thousand.

The application's *interface* is user-friendly and easy to use, which supports a rather old version of Android 2.33. The colour palette is more varied than its counterparts, making the design less harmonious and appropriate. The difference between an application and its counterparts in the form of support for only one pharmacy network allows you to highlight some advantages that are not found in the analogues. For example, this includes extended project support from developers, the ability to go into your own office and view pre-orders, work with the account with the bonus funds provided by the network, and always relevant information about the availability of goods, its price, working hours of the selected department. One of the advantages is to mention the possibility of setting certain search criteria and having an article section where you can read about the latest news in the world of pharmacology, medicine and pharmacy. It is possible to review the instructions for use of the medicine before buying it.

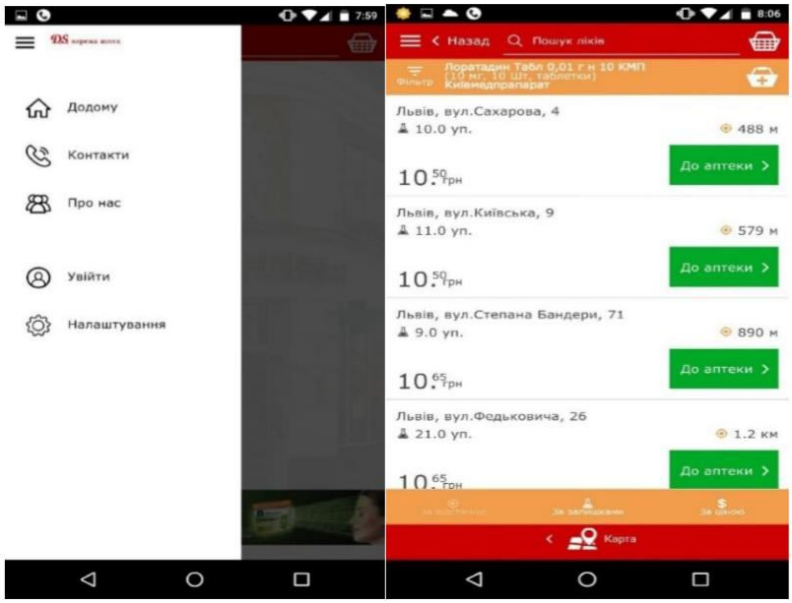

Fig. 3. D.S. network pharmacy program

Of course, the drawback of a system that is immediately noticeable to the potential user who is looking for a medicine search program and wants to get as many good pharmacy choices as possible is the limited use of only one medicine sales network. Along with this drawback is the lack of a search function for possible medicine analogues. The program is well received by users, its average rating is 4.3, there are almost no negative reviews, and most of the shortcomings listed in the reviews are corrected in the updates of the application [1].

- *Pharmacy 911.* The only system found to support the formation of symptomatic recommendations. Also supports pharmacy medicine search. However, this is not a mobile application but a website, so mobile compatibility is low. Although the mobile version is, but not very different from the full, the *interface is* not clear, you need to spend a considerable amount of time to find the right medication.

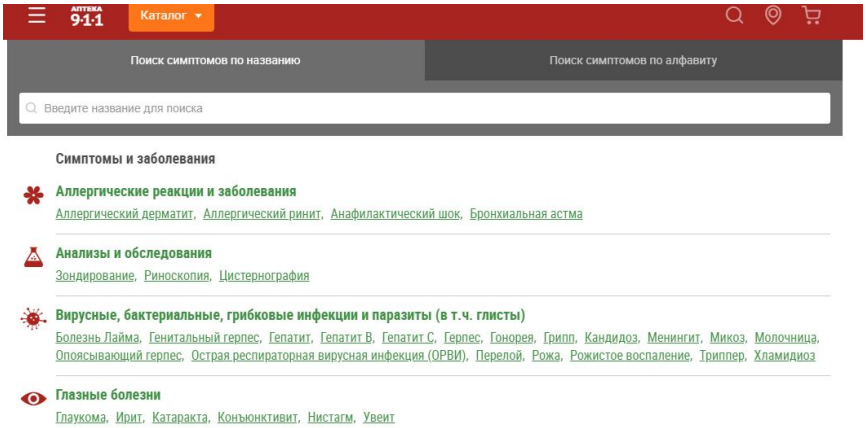

Fig. 4. Forming a recommendation from Pharmacy 911

Although the resource supports the drawing up of recommendations, it works only through lists, and therefore no "intellectual" component has been applied. It is also noticeable due to the small popularity of the site [1].

3 System Analysis of the Research Object and Subject area

Defining and justifying the ultimate goal that must be achieved to accomplish a specific task plays a significant role in system analysis. In most cases, a goal tree is used - a graphically structured view of goals in the form of a hierarchy, the main goal of which is to accomplish the sub-goals of the lower levels [36-42].

When creating a goal tree, you first need to formulate a common goal - the top of the tree that reflects what you need to achieve as a result. Given that the fulfilment of the primary objective is quite difficult, it is broken down into secondary goals or subgoals, the aggregate achievement of which contributes to the achievement of the main objective. The decomposition process takes place for each purpose until they are sufficiently specific, achievable and easy to implement [43-47].

In Fig. 5 depicts the purpose tree of the future designed system. Its main purpose is to create an intelligent medicine recommendation system that needs to achieve three goals, namely: "System design", "Gathering relevant data" and "Customer support". Then, for the details in the figure, smaller sub-goals are shown.

"System design" can be divided in detail into the following sub-goals: "Database design" - necessary to describe the real entities in the implementation of software; "Application of modern technologies" - will allow in the future to add

new functionality and increase productivity; "Writing modules" is a necessary goal of achieving an object-oriented software structure that simplifies its creation and perception of code, "Designing the server and client part, their interaction" - a necessary goal for client-server architecture, which is the dominant concept.

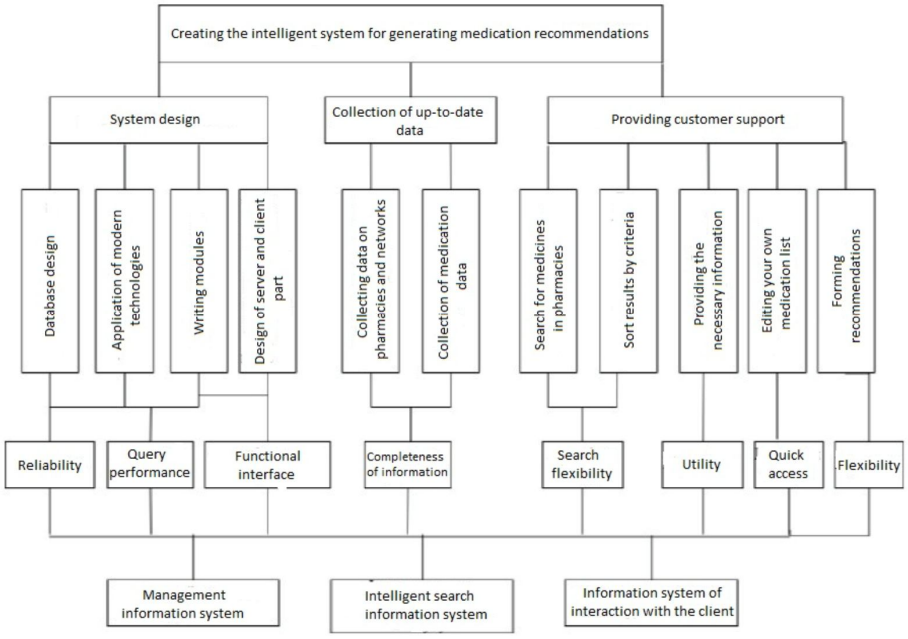

Fig. 5. Goal tree

The next goal responsible for collecting and accumulating relevant data can be divided into the following two: “Collection of data on pharmacies and their networks” and “Collection of data on medicines”, which respectively provide the developed system of medicines. The primary goal of Customer Support is to provide the information system with the utility to meet and work with users' information needs. Achieving the goals of this goal allows pharmacy customers to use search features with additional criteria such as price and location to view pre-selected information by users without an Internet connection.

It should also be noted the sub-objective "Formation of Recommendations", the task of which is to formulate recommendations of medicines based on the symptoms of users. For this purpose, the criterion "Flexibility" is added to the tree, which is necessary for the operation of the machine learning system for work with different users, and accordingly different symptoms, preferences and financial possibilities.

In addition, several criteria have been added to the goal tree that determines the ranking of vertices according to their importance. "Reliability" - allows the system to perform functions consistently in the event of errors; Query Speed - allows the server to generate requests relatively quickly and to receive responses using modern technologies; "Functional interface" - provides functional interaction between client and server parts; "Completeness of information" is sufficient data

to solve problems; "Search Flexibility" - the ability of the system to provide a smooth change of functionality for the user according to changes of parameters; "Utility" - the ability to meet the needs of the user to the tasks assigned to them; "Fast access" - provides the speed of information output, saving it on the user's device. The following alternative design options for the system were also identified:

- "Management Information System" is used to provide management functions such as decision making, dissemination and dissemination of information;
- "Search Engine Information" is used to store and search data in databases; "Customer interaction information system" - used to enable the user to functionally interact with the system interface of the developed application.

Visual modelling in UML can be represented as a certain process of comparative descent from the most general and abstract conceptual model of the source system to the logical and then to the physical model of the corresponding software system. To achieve these goals, we first build a model in the form of a so-called use case diagram, which describes the functional purpose of the system or, in other words, what the system will do in the course of its operation. The use case diagram is the original conceptual representation or conceptual model of the system in the process of its design and development [48-56]. Developing a use case diagram aims to:

- Define the general boundaries and context of the simulated subject area in the initial stages of system design.
- Formulate general requirements for the functional behaviour of the designed system.
- Develop an initial conceptual model of the system to further detail it in the form of logical and physical models.
- Prepare source documentation for interaction of system developers with its customers and users.

Below, in Fig. 6, presents a conceptual model of the developed system (mobile application). Through this diagram you can trace the basic functionality of the future intelligent system, as well as the potential of the potential user when working with it. The diagram shown is used to show the relationship between the actor, in our case the user, and the group of use cases. The following several types of standard relationships were used for design: association relation, extension ratio (on the chart labelled "extend") and inclusion ratio (on the diagram labelled "include"). The actor gets the initial use after successful launch of the program. Extensions are also included for each variant, giving the actor additional options to use the system. Once logged in, the user has the ability to navigate to three uses: "Find a cure" - search for a medicine by name or part of the name, "Work with the list of favourites" - use the features of the list of favourites and "Find by symptoms" - an intellectual component of the system that responsible for formulating recommendations. While searching for medicines, the user can also add the medication to the list of favourites (expressed in the "extend" ratio on the chart), open the medication manual, and find its analogues. After performing a search for a medication by their name, the user can go to their search in pharmacies ("Search in pharmacies"), also this includes, of course, a list of found points of sale of a medicinal product. In addition, the user can sort the list of

pharmacies by price and distance; view the contact information of the selected pharmacy. If the user chooses to work with the list of favourites, it includes viewing the list and editing it. The most important function of the system is to formulate recommendations. To do this, the user needs to select symptoms that match his or her own, then, by selecting all the necessary ones and having received the result, he can go to a medicine search in pharmacies or if he is not satisfied with the recommendation, choose his own medicine option.

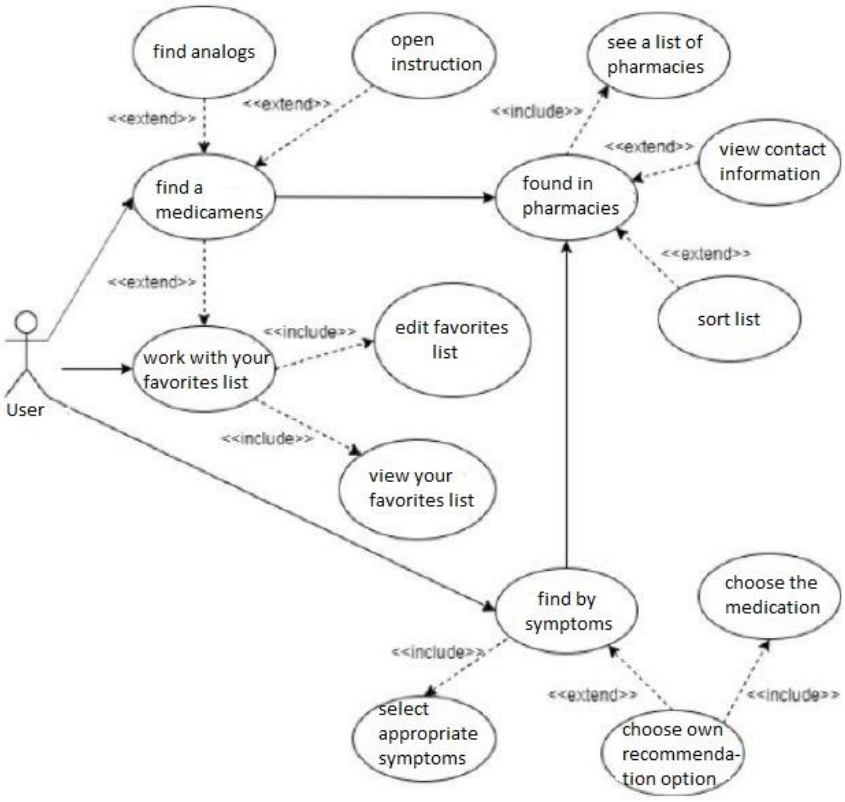

Fig. 6. Use case diagram

State Diagrams are used to describe the behaviour of complex systems. They identify all the possible states in which an object may be located, as well as the process of changing the states of an object as a result of certain events. These charts are commonly used to describe the behaviour of one object in several precedents. The status hierarchy is displayed by the inclusion of one state in other directed arrows, and signatures to the arrows are descriptions of events that symbolize the transition between states. Because state diagrams describe system states, events, and transitions between system states, this makes them suitable for modelling systems [57-62]. In the status diagram you can trace the transition between the states of the developed application

system from its launch to its exit from the user. First, when you start it, "Go to the home screen", that is, the user is in the main menu, and then, after selecting the following action, you go to the selected screen: "Go to the screen of the medicine selection", "Go to the search screen" or "Go to Favourites screen ».

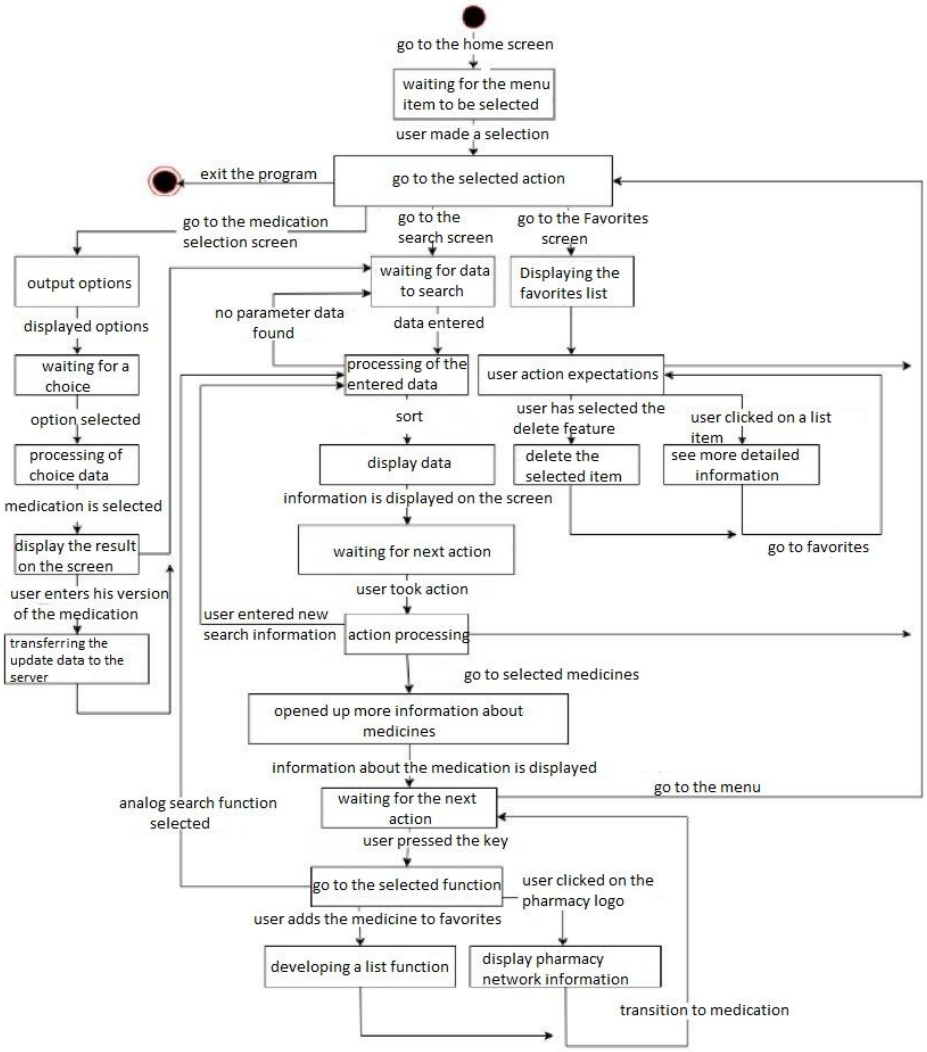

Fig. 7. State diagram

After going to the symptom selection screen, the user is presented with variants of the symptoms. To do this, the system accesses the remote database and waits for a list of symptoms, as this list is not permanent and may change quite often as the database of medicines is filled, after which the "Derived Options" event occurs. Then, after waiting for the selection to complete, these symptoms are processed and the medica-

tion selected. The user may decide that the recommended medication is worse, in his opinion, than another, so he has the opportunity to choose his version of medication, after which the system updates the relevant data on the remote server. The system then proceeds to search for recommended medicines by name.

In order to find a medical device, the user enters the name of the medicine or part of the name, after which the system requests data from the server and if successful, displays a list of medicines on the screen. The user can then return to the main menu, work with a list of favourites, find an analogue of the selected medication, or go to his search in pharmacies. Also, when searching for medicines, the user can enter on the same screen new text for search, which is shown in the diagram by going from the status "Action processing" to "Processing the entered data" as a result of the action "User entered new data for search". When performing actions on the Favourites list, the system is working on changes to the local database.

It is also possible to display detailed information on medicines and point of sale on the relevant pages of the mobile application. There are no cases where the system cannot find data by search criteria, in such cases the event "Parameter data not found" occurs and the system switches to "Pending data for search".

The Favourites list allows the user to edit the list, view the instructions (saved for offline reading), and go to a quick medicinestore search. It is worth noting that the diagram provides a transition from any page of the mobile application to the initial one, which shows the main functions of the system (in the diagram "Go to menu").

The class diagram is the central link in the methodology of object-oriented analysis and design. The class diagram shows the classes and their relationships, thus representing the logical aspect of the project. A separate class diagram represents a certain perspective of the class structure. In the analysis stage, class diagrams are used to highlight the general roles and responsibilities of the entities that provide the necessary behaviour for the system. At the design stage, class diagrams are used to convey the structure of the classes that shape the system architecture [63-67]. Below, in Fig. 8, shows a general UML diagram of system classes that can easily trace the relationships between the package entities: : «package entity», «package dao», «package service» and «package controller».

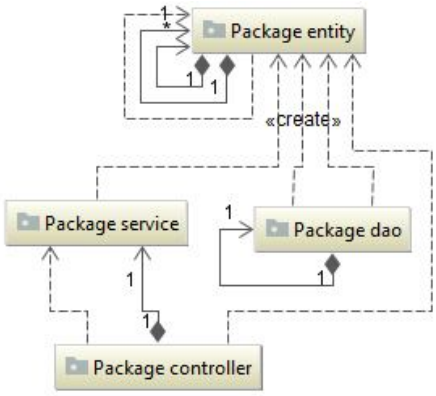

Fig. 8. Top-level UML diagram

The entity package (Fig. 9) contains model classes that also reflect the structure of the database, and therefore its essence.

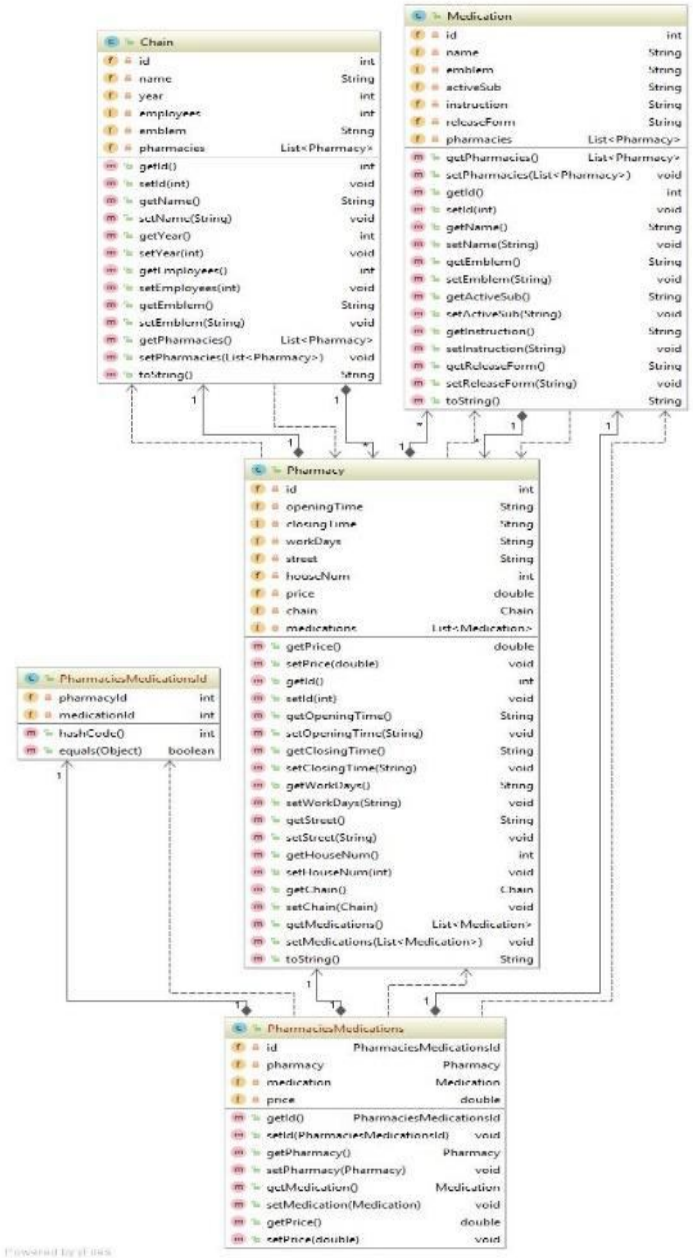

Fig. 9. UML diagram at the model level

The diagram contains five main classes: Pharmacy, Network, Drug, Pharmacy, Symptom, Symptom, and two auxiliaries: Pharmacy ID and Drug-Symptom. Auxiliary classes are required for key generation and, consequently, indexing in complex classes. All class models contain standard methods: writing methods and reading methods for class variables, as well as constructors.

An equally important package of classes in the developed intellectual system is the "dao" package (Fig. 10), which is responsible for working with the database, transmitting requests and receiving responses from it. The DAO layer abstracts the entities of the system (entity model level) and displays it on the database. That is, it can be called a certain intermediate module between the data and the system.

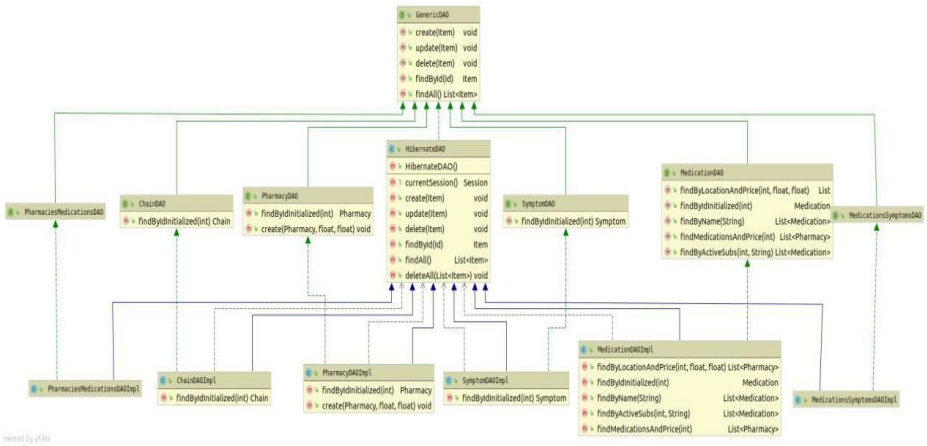

Fig. 10. DAO level UML diagram

The central components of the DAO level are the «GenericDAO» interface and the «HibernateDAO» abstract class. The first specifies the standard database queries: «create», «update», «delete», «findById» and «findAll», and the second implements them using the «Hibernate» library connected to the project. The rest of the classes implement the interface specified via «GenericDAO» and inherit «HibernateDAO». This allows you to separate the description from the implementation, which greatly simplifies support and perception of the code. The «PharmacyDAO» class contains the implementation of the overloaded create method, which, when entering a new pharmacy in the database, sets its coordinates on the map, which allows further use of quick sorting of the pharmacy list by distance to the user's device.

It is also necessary to describe the methods that implement the «MedicationDAO» class - the main complex database queries are executed through it:

- «findByLocationAndPrice» is search of pharmacies with the necessary medical preparation with sorting by distance to the user;
- «findByIdInitialized» is search for a medicinal product by identification number;
- «findByName» is search for a medicinal product by part of the name;
- «findMedicationsAndPrice» is search for pharmacies with the right medication with sorting by price;

- «findByActiveSubs» is search for medicines by active substance.

Another important component of the system is the level of services (Fig. 11), in which all work is done on the business logic of the system. This layer is important for achieving SOLID principles in program architecture design and greatly facilitates interaction between controller levels and «dao». It is also worth noting that it is in this part of the system that the sessions, the maximum value of which is extracted by the system from the resource files, are distributed.

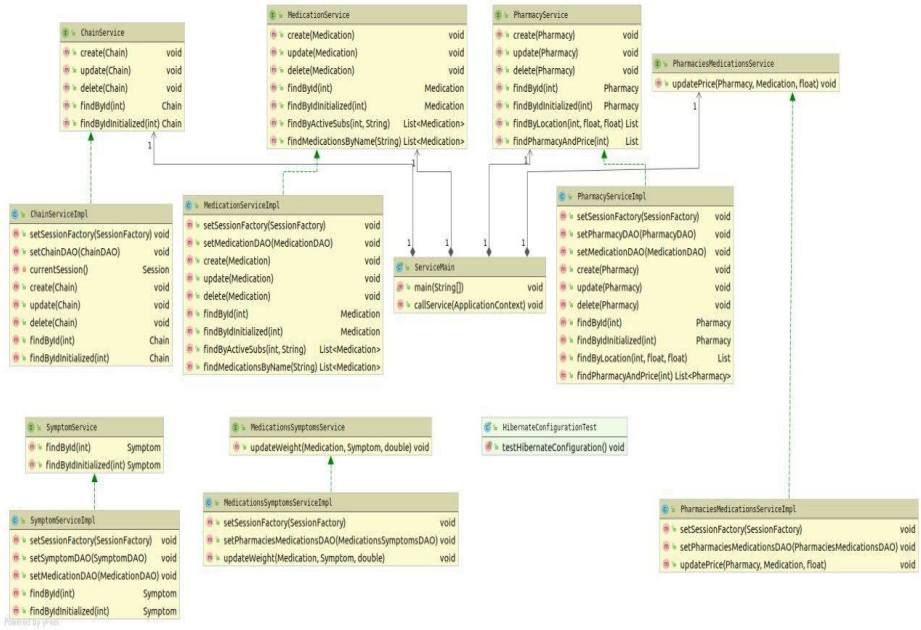

Fig. 11. UML diagram of service level classes

The physical representation of the software system may not be complete if the information is unavailable, if there is no information on which platform and on which computing tools it is implemented [68-74]. The deployment diagram is for visualizing elements and components of a program that only exist at runtime. Only instances of programs that are executable files or dynamic libraries are submitted. Those components that are not used at runtime are not displayed in the deployment chart. Yes, components with source programs can only be present on the component diagram. They are not listed on the deployment schedule [75-79].

The Deployment diagram contains graphical representations of processors, devices, processes, and links between them. Unlike logical representation diagrams, the deployment scheme is unique to the system as a whole, since it must fully reflect the features of its implementation. This diagram essentially completes the OOP process for a particular software system, and its development is usually the last step in the model specification [80-86]. In Fig. 12 shows the deployment diagram for the designed software solution. As you can see from the diagram, three devices are required

for the system to function fully: a device on the Android mobile platform (Android-MobileDevice), a web server (WebServer), and a database server (DBServer).

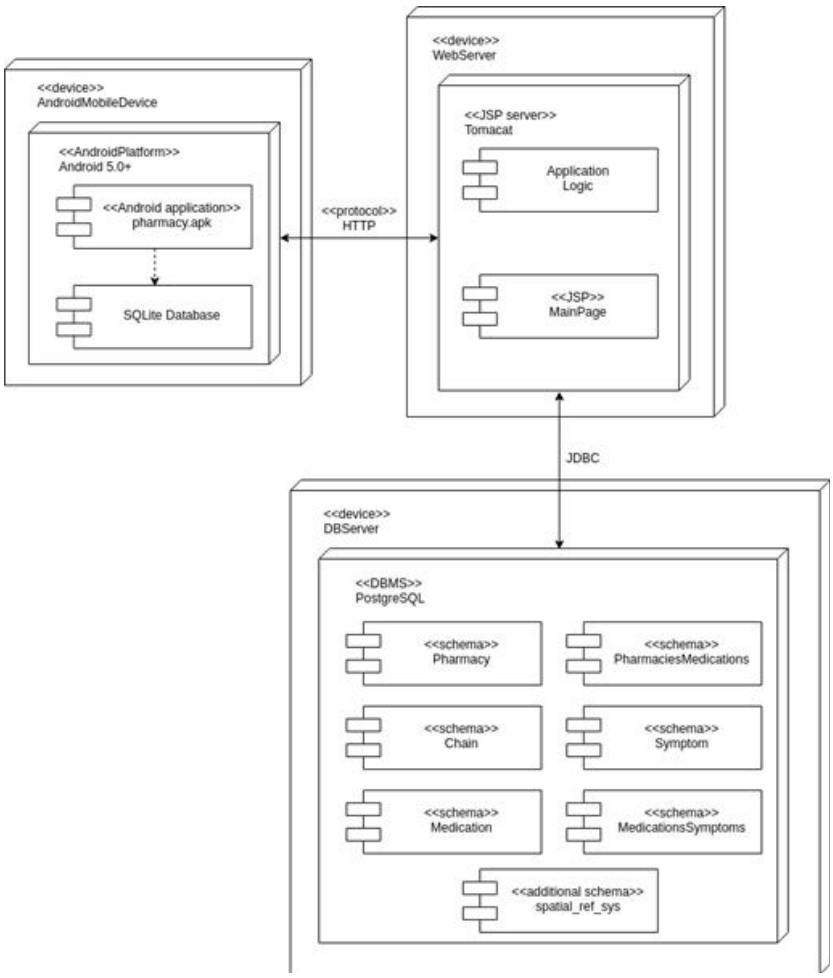

Fig. 12. Deployment diagram

Your mobile device must run on Android (AndroidPlatform) at least a fifth version. The device stores an apk file of the application, which contains all the resources and code of the application. It should also be noted that the code in the file (pharmacy.apk) has already been compiled. In addition, the local database is stored on the mobile device using SQLite (SQLite Database) technology. The WebServer and the user's mobile device use HTTP to transmit data. The web server uses JSP technology to dynamically generate web pages. The web services server uses a Tomcat container capable of handling servlets. Using JSP, the server generates a main webpage (MainPage) that is referenced by the client side of the system when it requests. The main part of the logic of the web server is contained in a java program (ApplicationLogic in

the diagram). The web server accesses the database server (DBServer) according to the JDBC standard, which provides methods and tools for interaction between java applications and the DBMS (PostgreSQL is selected in the diagram). The database consists of six basic diagrams and one additional scheme for the implementation of quick and accurate geographical data of the location of pharmacies and users, as well as the distances between them.

4 Formulation and Justification of the Problem

The purpose of developing an intelligent symptomatic recommendation formulation system is to create a software product that will enable pharmacy customers in Ukraine to obtain the necessary information about medicines, places of sale, possible analogues, and to receive recommendations for their purchase. Given the trends in the pharmacy market in Ukraine, as well as the lack of modern analogues, there is a significant need for a designed solution in the mobile application market.

In addition, it should be noted that the country is currently poorly developed high-speed Internet, and therefore an important requirement for the designed intelligent system of recommendation (namely its client) is the ability to work in conditions of insufficient coverage of the Internet. To describe the capabilities of the developed system with a certain level of abstraction in the table 1 describes its functionality.

Table 1. Functionality of the system

N	Function name	Priority	Working hours	Risk	Stability	Appointment
1	Information input and output data	Critical	Average	High	Low	Provides communication with the user
2	Graphic interface	Critical	High	Average	Average	Helps the user quickly and do the job effectively
3	Finding a cure	Critical	High	High	Average	Finding a cure
4	Audit network	Important	Low	High	Average	Checking your network connection
5	Searching for pharmacies	Critical	High	High	Average	Finding a cure in pharmacies
6	Audit availability of medicines	Important	Low	Average	Average	Checking the existence of drugs in the database
7	Revision instructions	Critical	Average	Average	Low	View instructions
8	Local database medication	Critical	High	Average	Average	Database of selected medicines
9	Interaction with server	Important	High	High	Average	Interaction of the custom part with the server
10	Add to Favourites	Important	Average	Average	High	Adding medication
11	Remove from Favourites	Important	Average	Average	High	Removing drugs from a local database

N	Function name	Priority	Working hours	Risk	Stability	Appointment
12	Quick review of the instructions	Important	Average	Average	High	View medication instructions
13	Quick search of pharmacies	Important	High	High	Average	Finding a cure from a local database at pharmacies
14	Search for analogues	Important	Average	Average	Low	Searching for analogues by active substance
15	Sorting by price	Critical	Low	Average	Low	Sorting a list of pharmacies by price
16	Search for a location	Critical	Average	Average	Low	Search for finding a user's device
17	Sort by location	Important	High	Average	Average	Sort the list of pharmacies by distance to the user
18	Multithreading	Important	High	High	High	The system performs several functions
19	Contacts	Useful	Average	Average	High	Provision of contact information of pharmacies
20	Condition of the pharmacy	Useful	Average	Low	High	Automatically update pharmacy status (open / closed)
21	Formation of recommendations for symptomatology	Critical	High	High	Average	Selection of the drug with user-selected symptoms
22	Machine Training Recommendation Selection	Important	High	High	High	Allowing users to influence medical selection drug on symptomatology

Regarding the effects of the implementation of the developed software solution, it is expected that the pharmacy clients will become more aware of the purchase and choice of medicines, reduce the impact of advertising and acquaintances before acquiring medicines.

5 Choosing and Justifying the Means of Solving the Problem

For the purpose of software implementation of the intelligent system, a comparison and selection of already known technological means were carried out and optimal software solutions were selected. In order to reach the maximum number of potential users, the software should not be high specification to the client side, and therefore it is necessary to choose the client server architecture. In addition, this will allow further development of client applications for other platforms, since this will eliminate the need to rewrite the server part code for individual devices.

The most accessible and commonly used operating system on mobile devices is Android OS, an operating system and mobile platform created by Google based on Linux kernel. As of 2019, it is the most popular (over 75% of the mobile OS market]). This mobile platform is an open platform that distinguishes it from its closest competitor and provides developers with advanced methods and software solutions to create various software products without undue effort and search. Therefore, the client side of the designed solution will be in the form of an application and will be developed within this mobile platform. The development language for both the client and server side of the software solution will be Java programming language (object-oriented programming language, released in 1995), since it can be used for both server logic and application for Android. Considering the platform and programming language you choose, it is advisable to select the Android SDK to develop this software. The application will be developed in Android Studio, a free, IntelliJ IDEA-based development environment that provides tools for creating and debugging mobile applications on Android devices.

Android Studio also includes: Android SDK; design and interface solutions, debugging; different versions of the Android compilation platform, the most up-to-date version of Android OS to prepare your applications for launch on new devices.

For the server side, the server development environment must meet the following requirements: the ability to quickly debug the program and support the code autogeneration feature. The most popular Java IDEs are the following: Intellij IDEA and Eclipse, the listed criteria is the first of these development environments. IntelliJ IDEA is a Java application development environment. IDEA is now one of the most popular environments in the industry. This is due to its high comfort and ease of use, as well as compatibility with popular tools used in software development (for example, Maven, Junit, CVS). We use an advanced XML mark-up language to design the UI. The advantage of having a UI ad in an XML file is that it can more effectively separate the appearance of the application from the code that controls its behaviour. User interface descriptions are outside the application code. This means that you can modify or adapt the interface without having to make changes to the source code and re-compile it. In addition, XML layout ad simplifies the visualization of the UI structure, making it easier to debug. You must use the XML Extended Markup Language to design the client application interface. The advantage of having a program interface in an XML file is to more effectively separate the appearance of the program from the components of the business logic that controls its behavior. User interface descriptions are outside the application code. That is, you can modify or adapt the solution design without having to make changes to the code and re-debug. It is also worth noting that the interface declaration in XML files simplifies the structure of the interface, making it easier to understand the principles of the system for other developers, and therefore generally the code. Selecting a system architecture template is an important step. To develop the system, you need to choose an approach that allows you to independently develop modules, which, in turn, facilitates the improvement of individual pieces of software. The most common template that meets these requirements is MVC, or more precisely its implementation in the Spring MVC Framework, which can significantly reduce the number of lines of code and make it easier to read.

Spring MVC is a technology that supports the Model - View - Controller template architecture with tightly coupled prefabricated components, which is an important advantage when writing and maintaining system software.

Considering the two principles of creating web services as a clear favourite, it is possible to recognize the principle of REST, since it already implemented the methods GET, PUT, POST, DELETE and others in itself, there is no need to write a special code to end the calls, its closest competitor - SOAP does not contain provide similar functionality. Volley and Retrofit help libraries should choose the second option, because this library requests the REST API we chose to create client-server communication architecture. Retrofit reports in JSON format and converts it to an object in Java programming language. REST is the general principles for organizing an application / site interaction with an HTTP server. The peculiarity of REST is that the server does not memorize the user so much between requests - each request transmits information identifying the device as a user (for example, a token obtained through OAuth authorization) and all the parameters necessary to perform the operation. Each piece of information is identified by a global identifier, such as a URL that has a clear and consistent format. Retrofit [1] is a library that simplifies network interaction, some even consider it a standard. The reason why this popularity is the mass library has excellent support for the REST API, is easy to test and configure, and network requests are easily and quickly executed.

The speed and smoothness of downloading and displaying images is acquired by pre-hashing them into the internal or external memory of the device. To implement this, we use Picasso technology, which automatically caches images and retrieves them from a hash when used. It should be added that the tool notices and works with any errors related to downloading images or problems with the Internet connection.

Picasso is one of the most popular and convenient solutions for downloading and hashing images on Android OS.

To choose the database management system for the designed solution, let's look at the most popular such systems: MySQL, MariaDB, Firebird and PostgreSQL. Among the databases listed, it is wise to choose PostgreSQL, which includes a wide list of supported data types. The technology also allows you to work with reasonably large geographic and temporal data capabilities, as well as the ability to create your own data type. In addition, the popular lightweight relational database engine for Android - SQLight - has been selected to store and manage local values.

PostgreSQL is one of the most popular database management systems. The postgresql project itself evolved from another project called Ingres. The system also includes many additional subsystems that provide additional capabilities for working with databases, such as PostGIS. PostGIS is software that supports working with geographic features in a PostgreSQL relational database.

It is also necessary to emphasize the need for this technology in the developed system to accurately determine the distance to the nearest pharmacies from the location of the user, which is realized through the use of additional spatial IDs GiST.

Google Maps Geocoding API is a library that contains a geocoder class capable of dynamically geocoding data used by the system.

In addition, this technology is required to automatically populate tables with geographic data types used to find the location of an object by its address.

SQLite is a compact, built-in relational database that uses the client-server paradigm, that is, the SQLite engine is not a separate process that the program interacts with, but rather provides a library from which the program compiles and becomes an integral part of the program. Thus, the SQLite library's function calls (APIs) are used as the exchange protocol. This approach reduces overhead, response time and simplifies the program. The system allows you to save the relational database in a single file on the device or external device, and thus create a local database. To easily relate to the server-side code of the system and an external database, you can use the Hibernate library, which is designed to solve object-relational mapping (ORM) problems. This library provides an easy-to-use framework for displaying an object-oriented data model in traditional relational databases. The purpose of Hibernate is to free the developer from a significant amount of relatively low-level programming to ensure that objects are stored in a relational database. It is also worth noting that the automatic assembly of the system uses the Gradle system, built on the example of Apache Ant and Apache Maven, but uses a significantly modified order of tasks, built on an anti-cyclic graph. Gradle is convenient to use in complex design solutions, such as those developed in this work, because the system automatically detects any changes in the build tree and whether to restart the build of the software solution.

6 Description of the Implementation of the Task

6.1 Description of the Developed Application Software

The role of the DBMS is performed by PostgreSQL tools, the schema of the remote database is shown in Figure 13.
The public.chain diagram contains:

- - Name;
- - Year;
- - Number of employees;
- - The emblem.

The public.pharmacy diagram contains:

- - Opening time;
- - Closing time;
- - Working days;
- - Street;
- - House number;
- - Location.

The public.medication diagram will contain:

- - Name;
- - Photo of the medicinal product;
- - The main active substance;
- - Instruction;

- - Release form.

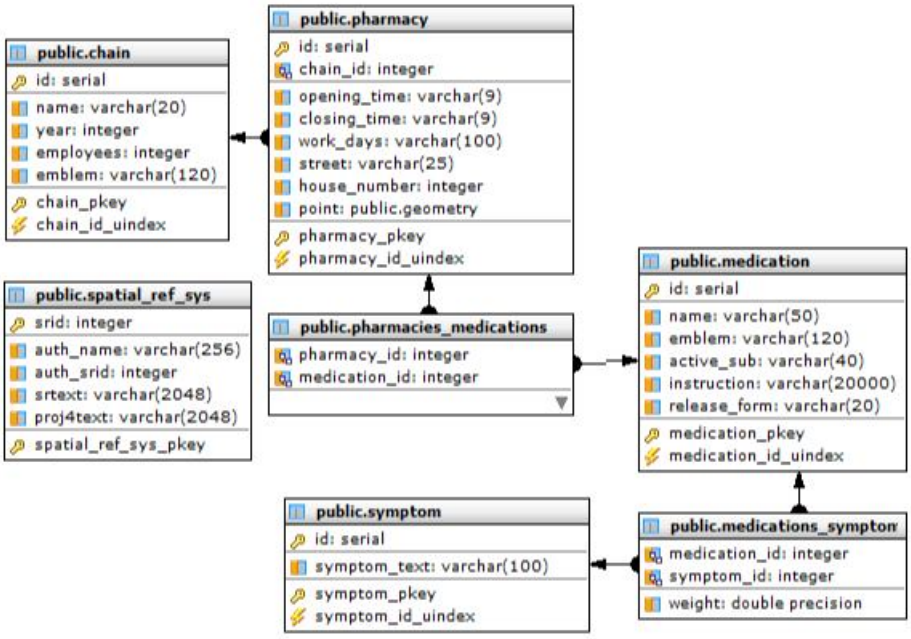

Fig. 13. PostgreSQL remote database diagram

The public.symptom schema will contain:

- - The name.

The additional public.pharmacies_medications diagram contains:

- - Price.

The additional public.medications_symptoms diagram contains:

- - Weight.

Weight is needed in the latter scheme to mathematically indicate the importance of a symptom in the formulation of a drug recommendation. That is, the greater the weight of a given symptom in combination with the medication, the higher the chance of their recommendation to the user. The spatial_ref_sys scheme is required to store pharmacy location data (using the PostGIS library), and then in the process the client application uses it to calculate the distance between the user and the point of sale of medicines.

The software product has a client-server architecture (Fig. 14). The server in this connection is always an abstract service on a reduced network, a workable HTTP based host, the server and the client communicate (in JSON format). The client in this

connection is an Android application. The REST interface is used to manage data and generate queries, as well as receive appropriate responses in the selected format [1].

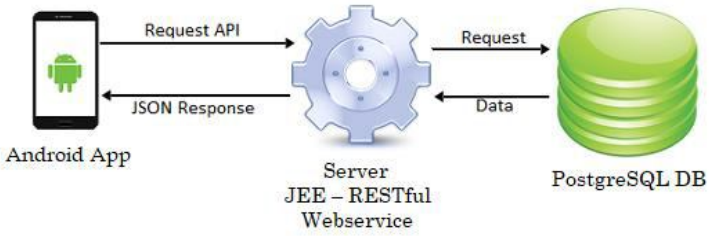

Fig. 14. Scheme of communication between server and client parts, as well as with the database

In order to detail the structure of the server part of the intelligent system, Figure 15 shows the scheme of interaction of three main software components: Controller, Service and DAO (levels: Spring Controller, Service Layer and Data Access Layer), as well as their implementation. The controller examines the request from the client part, builds the desired model, for which reason go to the Services field, which in turn invokes the methods of the DAO module, whose main function is to work with the database. Then the data is returned in the form of a response in the same way to the client part. Also for a more detailed understanding of the implementation of the Controller level using the IDEA software environment methods in Fig. 16 is formed part of the scheme of interaction between them. With regard to the formulation of a medication recommendation, the system shall take into account the weight of each symptom in combination with the appropriate medication. To do this, the sum of the respective weights of each of the selected symptoms is calculated, and the user with the highest total weight is recommended.

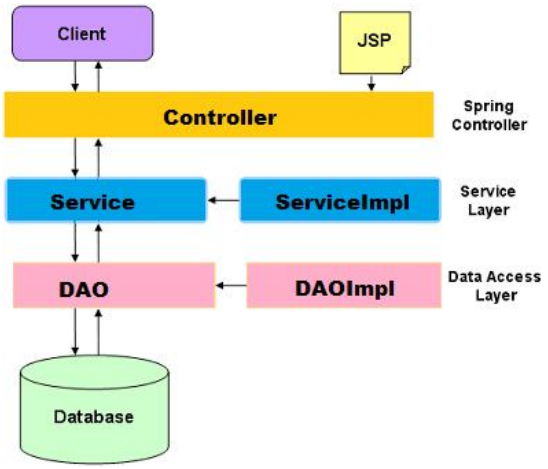

Fig. 15. Scheme of interaction between levels of the server part

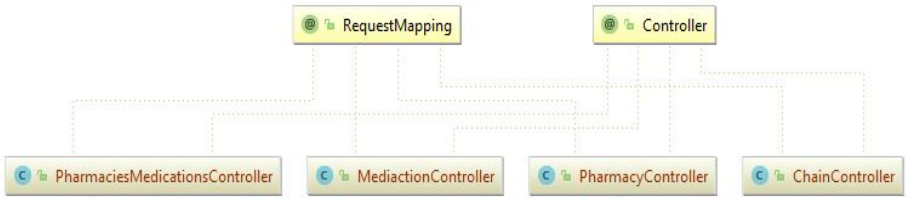

Fig. 16. Part of the scheme of interaction between levels of the server part

It is also advisable to specify functional restrictions on the use of the client application. Therefore, in order for the software to work properly, the user must provide the projected application with the following permissions to use:

- Internet connection.
- Internet connection information.
- Geographic location (GPS) data.

In addition, the user's device must be running Android with a minimum version 5.0.

6.2 Description of Requests

The server side of the program uses SQL queries to enter and retrieve data from a remote database. The data is then transformed into a format in which the client and server part "communicate" according to the requests / responses.

Basic SQL queries used by the developed system:

- - Location data entry in the database:

UPDATE Pharmacy set point = ST_GeomFromEWKT ('SRID = 4326; POINT (longitude latitude)) where id = pharmacy_id)

- - Search for medicines by name:

SELECT * from Medication where lower (name) like lower ('% name%)

- - Search for medicines for the main active substance:

SELECT distinct m from Medication m inner join m.pharmacies p where nameSubstance like m.activeSub and m.id! = Id

- - Search for medicines in pharmacies sorted by price:

SELECT pm.pharmacy, pm.price from Medication m inner join PharmaciesMedications pm on m.id = pm.medication.id where m.id = id order by pm.price

- - Search medicines in a pharmacy sorted by distance to the user:

SELECT * from pharmacy as p INNER join pharmacies_medications as pm on pm.pharmacy_id = p.id WHERE pm.medication_id = id order by ST_DistanceSphere (p.point, ST_GeomFromEWKT ('SRID = 4326; POINT (lng lat ")) limit 20

- - Finding medicines for the user-selected symptoms:

SELECT pm.price from pharmacy as p INNER join pharmacies_medications as pm on pm.pharmacy_id = p.id WHERE pm.medication_id = id order by ST_DistanceSphere (p.point, ST_GeomFromEWKT ('SRID = 4326; POINT (lng lat)) limit 20

7 Analysis of the Results

In order to demonstrate the compliance of the developed system with the requirements, the results of the creation of an intelligent system in the form of a software product are given. On all desktop screens of the client application there is a window at the bottom of the screen with a Google advertising banner - Google AdMob [1]. The advertising box is small in size and should not interfere with users without interference with the basic features of the application. As soon as the application is started the user meets the main window of the program (Fig. 7).

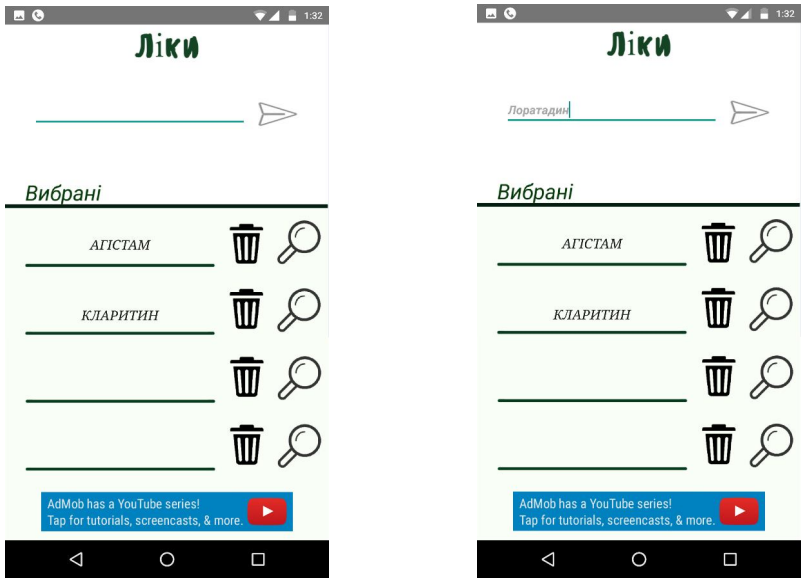

Fig. 17. Home page of the application

When you click the button field in the upper corner of the main program screen, the system transfers the user to the symptom selection page (Fig. 18). The task of the user is to choose the symptoms that the friend he wants to find. The selected symptom from the list box changes from green to light red for clarity.

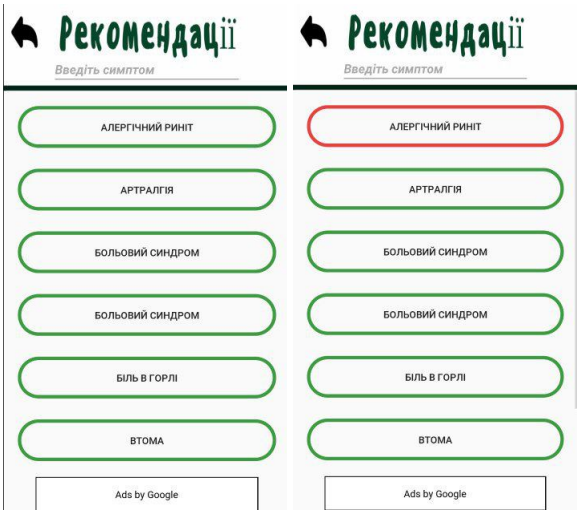

Fig. 18. Symptom Selection Page

Fig. 19. Recommend Page

Also, given that the number of symptoms is quite large above them, there is a search box that can help you find the symptom you are looking for. In addition, for the convenience of users, the symptoms are arranged alphabetically.

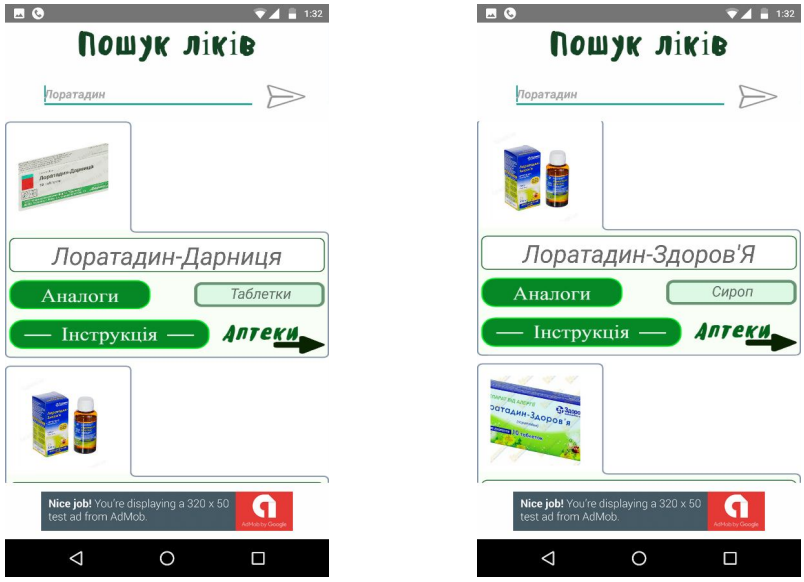

Fig. 20. Medicines Search Page

When all the necessary symptoms are selected, the system displays a drug on the recommendation page (Fig. 19), the indications of which coincide with the selected symptoms. If the user is dissatisfied with the results of forming a symptomatic rec-

ommendation, a button on the result page is available to select another variant of the ones that also coincided with the symptoms. After clicking, the user enters the list of medicines (Fig. 20) and in case of selecting one of them the system transmits data about the choice of another medication to the server and adjusts the value of the weights for symptoms and medicines. The user navigates to the same page after clicking on the search button on the start page of the application and having the text in the input box at the top of the same screen called the page. On the new page, the search box is still at the top of the window, allowing the user to modify the text he previously typed and search for medication by part of its name again. Below is a scrollable list containing medicines that are found according to a part of the name entered by the user (for example, to list allergy medications, enter "Loratadine", and the system will list the medications that have the word entered). In the field of found drugs there are buttons by which you can respectively find analogs of a medicinal product, read the instructions (Fig. 21) and go to its search in pharmacies.

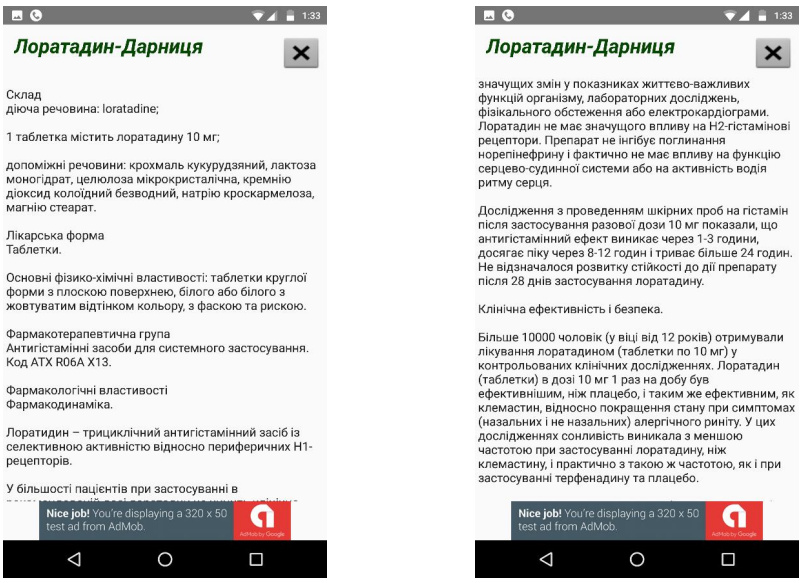

Fig. 21. Instruction window

The system searches for analogues by searching for drugs with the same basic active substance (Fig. 22). Also, from the list of similar medicines, the drug from which the transition to analogise is made is precluded. The system searches for analogues, using the main active substance to search, so it selects the drugs in which this substance coincides (Fig. 22). Also from the list of such medicines is excluded the drug from which the transition to the page with analogues. After selecting the required drug, the user clicks on the pharmacy search button, and the system goes to the drugstore search page (Fig. 23). By default, the app sorts this list according to the price of the drug at the pharmacy, but the user can use the special slider button above the list to change the sort type to sort by distance, and then the system sorts the list accordingly.

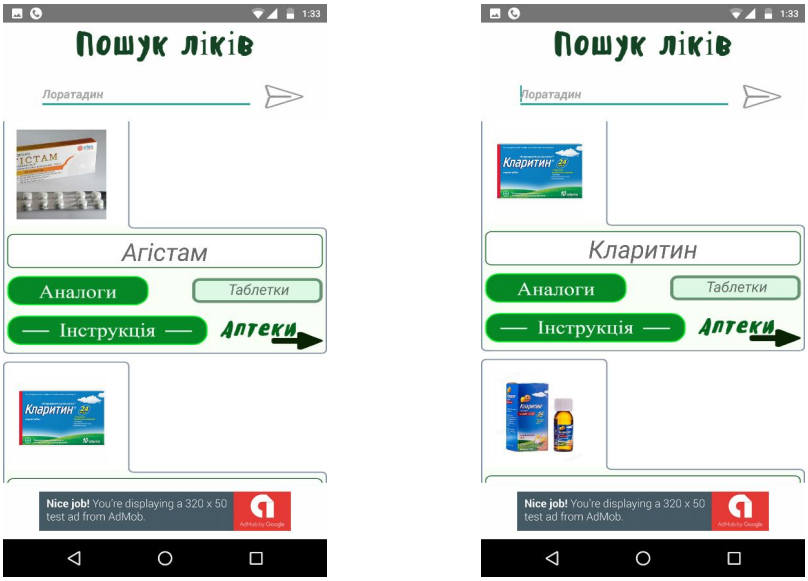

Fig. 22. Analogous search page

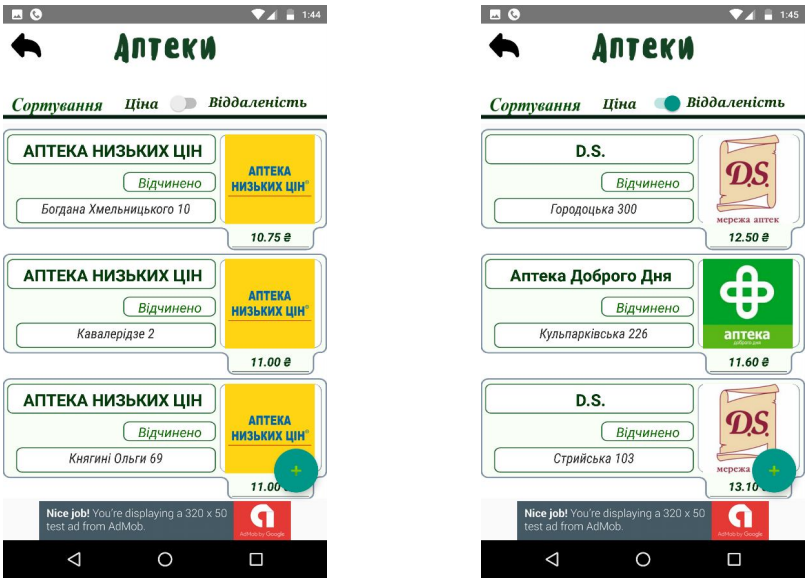

Fig. 23. Pharmacy drug search page

Also, as you can see from the previous picture, there is a "+" button on the pharmacy search page, which is responsible for adding the wanted drug to your favorites list. It's just worth noting that this button only appears in the absence of medication in this list.

By clicking on the pharmacy network logo, the program displays additional information about the selected pharmacy network (Fig. 24) as a dialog.

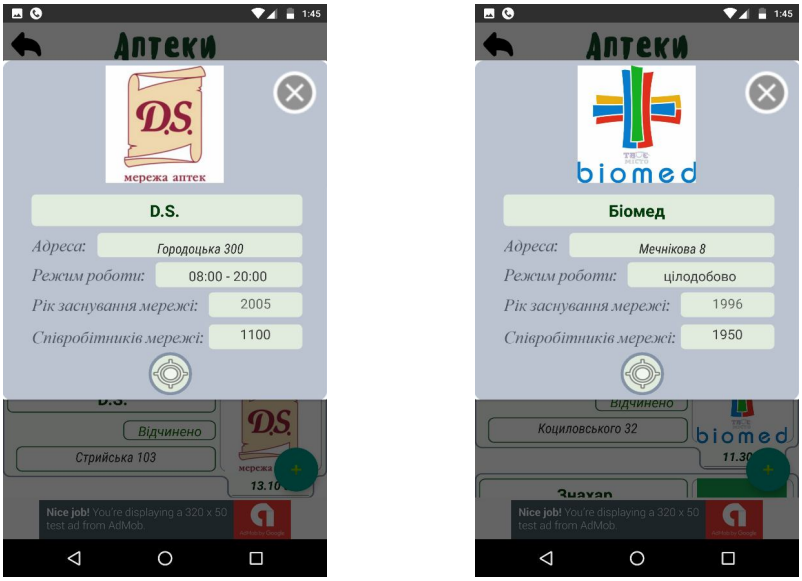

Fig. 24. Point of sale information in a special window

With the two buttons on this special window, you can: close the window and go to the Google Maps navigation app built into every Android smartphone, this app automatically outlines the user's route and location of the selected drug selling point on the interactive map (Fig. 25).

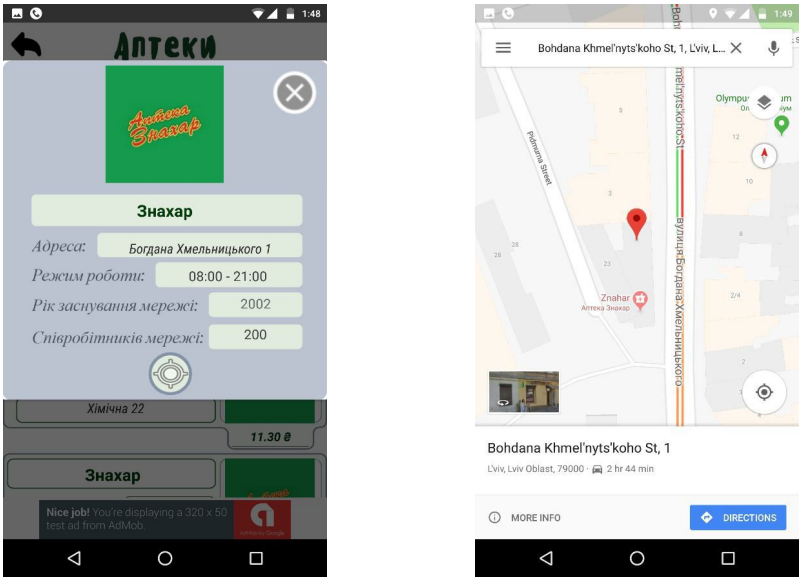

Fig. 25. Navigation

Additional functionality of the developed system, in the form of local database support, can be seen in displaying instructions for user-selected medicines without Internet connection (Fig. 26), although such a scenario also excludes the possibility of placing an advertising banner, but it should be noted that this is normal behaviour ads across all Android apps.

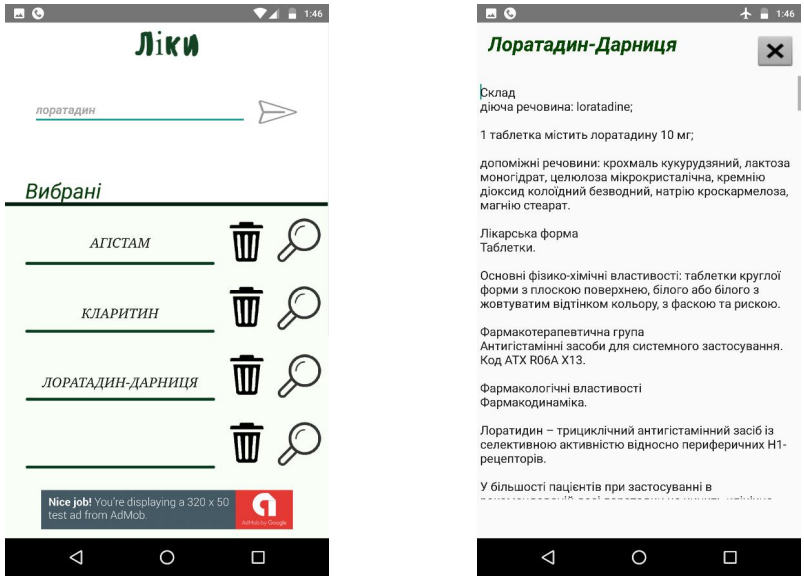

Fig. 26. Instructions for medicines without an Internet connection

8 Conclusions

Comparing the main advantages and disadvantages of similar applications and reviews of their users, we can conclude that the need for modern mobile applications for pharmacy customers is significant and requires urgent solution. Therefore, the purpose of my research is to create an intelligent system that contains up-to-date, proven information on medicines and will enable them to be searched in pharmacies, as well as able to formulate appropriate recommendations for their purchase.

In the article, a systematic analysis of the object of study: an intelligent system of generating symptomatic recommendations based on machine learning technology. The purpose tree method is used to detail the purpose of the system. Using the diagram of use cases, a comparative descent from the most general and abstract conceptual model is started, the basic process of system functioning is determined. The following describes all the possible states of the system in the state diagram as well as the events that provoke their change to describe the behaviour of the system being developed. The class diagram is used to depict the classes of the projected software solution and to share common roles and responsibilities between them. The final step in designing the software system and specification of its model was to use a deployment diagram, which made it possible to visualize the program elements, platforms

and computing tools on which it was implemented. In addition, at the end of the section the task of this work is set and substantiated.

The paper analyzes software and system tools that could be part of the solution when developing a mobile application and server part of the projected system. Smartphone operating systems, design development tools, architectural templates for software design and creation, local database and remote database management systems, as well as assistive technologies and libraries that can be implemented and updated using common modern design technologies are analyzed. In the end, to solve the problem of writing an application on the Android platform, selected development in the Android Studio environment, the application will connect to a server developed by Intellij IDEA. MVC template has been selected for the server system architecture of the developed system software. Data transmission between client and server parts will be done in accordance with the REST API and with compatible Retrofit technology. For work with both types of databases: remote and local, it is decided to use two DBMS: PostgreSQL and SQLight.

This article analyzes and tests the developed software solution and describes the features of its use. Also, the purpose of the designed system was considered, the PostgreSQL database management schemas, client and server components were described, the use and choice of templates for the architecture of the system components and their connections. With regard to the example of the client application, for example, the search for the drug "Loratadine" was carried out, and the work of the intellectual functions of the system was tested on the example of the same medical device.

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