

ORGANIZATION AND AUTOMATIC APPOINTMENT SCHEDULING IN MULTI DOCTOR/MULTI SERVICES ENVIRONMENT

Organizacija i automatsko zakazivanje termina u više liječničkom/više uslužnom okruženju

Professional paper

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Abstract

Appointment scheduling systems are used by all health care providers to manage access to their services. In this paper an algorithm and a web application for automatic appointment scheduling is presented. They are implemented through the concept of booking appointments for patients for a specific service offered by each doctor. The purpose of the application is to make signing up for a specific service easier for patients. Providers are added to the system, they add the services they provide, and each service offered has its own duration. Users register, search for services matching their parameters, and schedule an appointment for the requested service. Available appointments are generated through the algorithm, which is the main part of this project. The algorithm searches the database and returns an available appointment, before the previously existing appointment, between two appointments, or at the end of the last appointment.

Keywords: Algorithm for scheduling, Health tourism, Organization, Web application.

Sažetak

Sustave raspoređivanja termina koriste svi pružatelji zdravstvenih usluga za upravljanje pristupom njihovim uslugama. U ovom radu je predstavljen algoritam i web aplikacija za automatsko zakazivanje termina. Provode se kroz koncept rezerviranja termina za pacijente za određenu uslugu koju nudi svaki liječnik. Svrha aplikacije je olakšati prijavu za određenu uslugu pacijentima. Davatelji se dodaju u sustav, dodaju usluge koje pružaju i svaka ponuđena usluga ima svoje trajanje. Korisnici se registriraju, traže usluge koje odgovaraju njihovim parametrima i zakazuju sastanak za traženu uslugu. Dostupni se termini generiraju putem algoritma, što je glavni dio ovog projekta. Algoritam pretražuje bazu podataka i vraća raspoloživi termin, prije prethodno postojećeg termina, između dva termina ili na kraju posljednjeg termina.

Cljučne riječi: Algoritam za raspoređivanje, Zdravstveni turizam, Organizacija, Web aplikacija.

1. Introduction

Internet and mobile applications have become really popular and part of our every-day life. Their aim is to make life much more comfortable by providing users with information and services in a transparent and easy way as possible. Thus, users do not need to worry about complicated calculations, configuration and scheduling tasks to get appointment for services that they need.

Organization of an appointment scheduling systems is a core of efficiency and timely access to health services. Timely access is a key factor for achieving successful medical results. It is also an important determinant of patient satisfaction. For a lot's of people, the biggest burden is

making an appointment and going to doctor's office, because they know beforehand that they will be waiting, before the doctor will see them. On the other hand, the doctors are also very busy people. Every time that patient fails to come on time or just doesn't come doctors will run out of his schedule and have lot of idle or overtime time.

Organizing an appointment in one doctor office is a complex task. First, one of the patient scheduling models must be selected [1, 2, 3]. However, without additional information, such as the patient's medical history, the patient's condition, whether it is a first or follow up visit, or some different reason, it is difficult to determine the du-

ration of the examination. That's why organizing and ordering patients in a multi doctor/multi services environment is especially complicated.

The focus of this paper is to present algorithm for organization and automatic appointment scheduling of patients in multi doctor/multi services environment. It does not consider problems pertaining to the size of staff and facilities or with resource allocation in multiple-service-site systems like in [4].

2. Algorithm for scheduling

In this paper is presented algorithm for automatic appointment scheduling in multi doctor/multi service environment. We observed different approaches and combined them to get final algorithm which suits for multi doctor/multi services environment. Our algorithm uses the usual block schedule similarly as in [5, 6]. In these studies, authors use analytical methods instead of simulation to estimate performance. Some other studies use a dynamic programming approach to determine the optimal variable-sized multiple-block schedule approaches [7, 8, 9]. Another study [10] suggests heuristics approach in which service time depends on the relative position of the service in the schedule. In other study [2] simulation-based techniques are used to compare the performance Appointment scheduling in health care using variety of heuristic appointment rules. Another approaches use genetic algorithms and machine learning for patient scheduling in highly constrained situations [11].

Our algorithm is combination of heuristic, dynamic programming and genetic approach. The algorithm is presented using flowchart diagram which is consisted of a series of arrow-related symbols that define the flow and direction of program execution. This algorithm representation is simple, easy to review and easy to find. Problems can be easily analysed and compared to another problem, which shortens the time to find a solution. In order to find available appointment time, it is necessary to create

database for storing data. Database E-R diagram is shown in fig. 1.

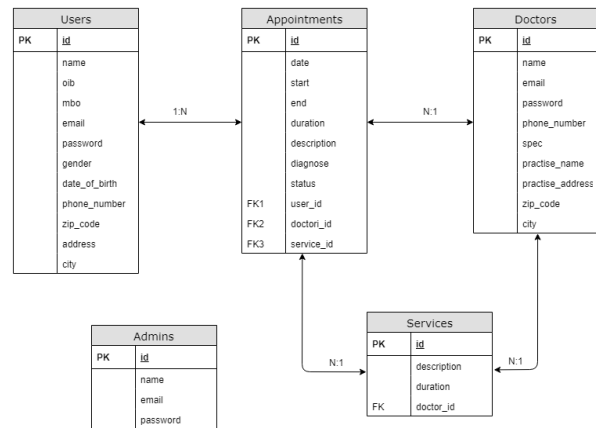


Figure 1. Database E-R diagram

As shown in fig. 1 database contains the following tables:

- Table Users represents the users (patients)
- Table Doctors represents the doctors
- Table Appointments represents the scheduled appointments of users with each doctor
- Table Admins contains information about the application administrators
- Table Services is providing all possible services offered by individual doctors

User and Appointments tables are related by a 1: N relation, which means that one user can have more than one appointment, while one appointment only applies to one user (patient). Further, the Appointments and Doctors tables are related by a N: 1 link, indicating that one appointment can only refer to one doctor, while one doctor may have multiple appointments. The Appointments and Services table are related by a N: 1 relation, since one appointment can have only one service, while the same service can belong to several different appointments. In addition, the Doctors and Services tables are related by a N: 1 relation, indicating that one doctor may offer multiple services while one service belongs to only one doctor. The Admins table is not related with other tables, but has a separate role. Application is made using PHP framework named Laravel which uses migration to create this tables.

The algorithm starts by looking for already reserved appointment to make it unavailable. When a user chooses the date range in which he or she would like to book an appointment, it is primarily followed by checking that the selected dates are valid. The user can set the start date as early as tomorrow, while the end date is unlimited.

The following is a check of whether there are already records in the table for the selected days. If there is no record for the selected day range, the user is offered an appointment at the beginning of the day at 08:00 for each selected business day. If there is a record in the database for the selected dates, it is checked when first appointment starts for that day. If the start of the first appointment is greater than 08:00, it means that there are empty time slots before the first appointment of the day, and it is checked can be offered for appointment. In order to be able to offered, it is necessary to check whether the appointment time fits in the empty space until the next reserved appointment. If the condition is fulfilled appointment is reserved for current user.

In case these conditions are not fulfilled, and there is no free time slot before first reserved appointment, it is followed by checking whether there is another free time slot for comparison in the database on the same day. If free time slot is found, it is checked whether the selected appointment ends until 16:00 hours, since it is the end of working hours. If the condition is fulfilled, appointment is reserved for current user, and if not, it means that the day has been filled and appointment checking will be moved to a next date selected by user.

In case there is a next date in the day for comparison, it is checked for free times slot same as first day in algorithm. After all days are checked and appointment is not reserved algorithm has failed, failure to meet this requirement means that there is not enough free time between start and end date, thus user is prompted to select another time period. Algorithm is shown in fig. 2.

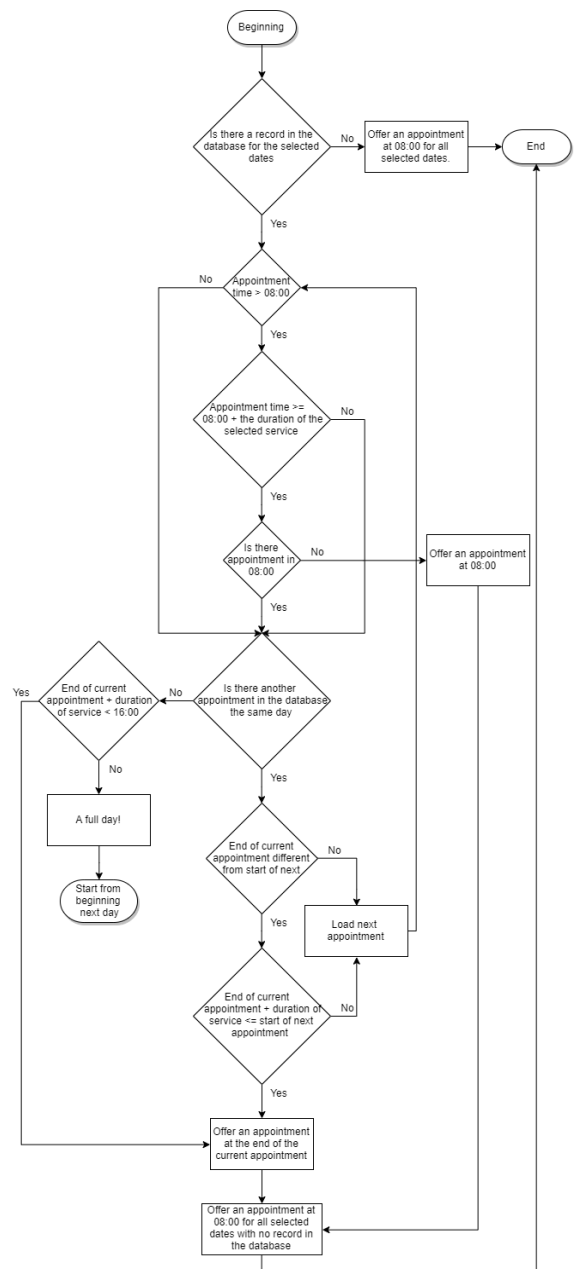


Figure 2. Block diagram for appointment scheduling

3. Application

The concept of the application is conceived so that the user selects the medical institute and the city in which he wants to make an appointment. After selection, all available doctors are shown to the user, and by selecting one, he or she reserves one of the available appointments that suits him best. In fig. 3 the homepage of the internet application is displayed.

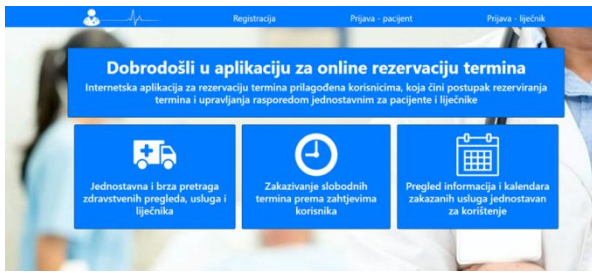


Figure 3. Home page of application

If a user wants to book an appointment, they need to log in with their user information. The patient is logged in by entering the Insured Identity Number (MBO) and password. In case the user does not have an account, registration is required. By choosing to register, the form shown in the fig. 4.

Figure 4. Registration form

After registration user is redirected to user profile as shown in fig.5.

Figure 5: 5. User profile

Logged user can search for the medical institution where the appointment (service) is scheduled. The first thing the user chooses is the medical institute and the city

where they want to book an appointment. In case the user's selection does not find any result, the user receives feedback and is offered a return to the homepage. In the next step all founded doctors are shown that fit the parameters and their basic information (first and last name, address, email, phone number, office address, etc.). The user selects the doctor who best suits his requirements. After the user has selected the doctor with whom he wants to request a service, then the service itself is selected. The user chooses the service for which he wants to book an appointment. Also, in this boo-king step you will see a map with the exact location where the examining office is located as shown in fig.6.

In the next step, it is necessary to select the date range for which the user wants to see the available appointments, and to choose the one that suits him best. The start date of the range must be one day longer than the current day, since it is not possible to book an appointment in the current day, but no earlier than the next day. In the event that this condition is not fulfilled, the same page is reloaded and the user is informed of an error he made. After selecting a valid date range, the algorithm performs its task and returns to the user the appointment information and process is over.

Figure 6. Information about doctor and his location on map

In addition to being able to sign up for patients, there is also the option to sign up for doctors who offer their services.

The doctor is not able to register himself, but the doctor is added to the system by the application administrator. When an administrator enters a new doctor into the system, the doctor receives a welcome message at the email address with the user name and password that he

logs in to. A password is randomly generated when creating a doctor, and only the created doctor has access to the password. When a doctor is logged in, a home page opens showing all the terms of the registered doctor. As with patients, a calendar view of the appointment schedule is set. Below the calendar view, all the appointments of the user are listed in card form, where it is possible to see the details of the appointments. In addition to scheduling details, below the calendar is a form to add services that the doctor offers. Selecting the "Add new service" option opens a page where the doctor fills in a description of the service offered and the duration of the service itself. Successful entry reloads the profile listing the services offered. Each enrolled service can also be removed by selecting the "Delete Service" option, located at the end of the name of each service. Doctor's profile with all appointments and services offered are shown in fig. 7.

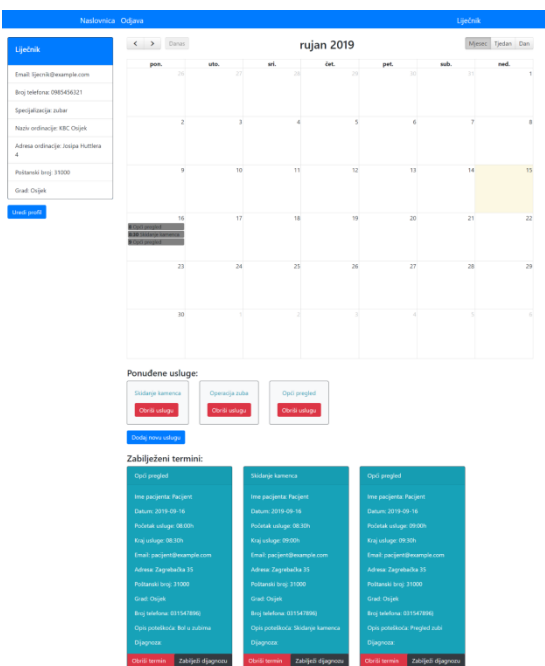


Figure 7. Doctor's profile

In addition to reporting patients and doctors, there is also a way to sign up for a site administrator. Once logged in administrator can see all the doctors in the database and their information. There are options for each doctor with which the administrator has the ability to edit information and remove the doctor from the database.

In addition to existing doctors, the administrator also has the option "Add a new doctor", since doctors do not have the option to register with the system. The admin dashboard layout is displayed in fig. 8.

ID	Ime i prezime	E-mail adresa	Broj telefona	Specijalizacija	Naziv ordinacije	Adresa ordinacije	Politički broj	Grad	Opcije
1	Matej Jukić	matej@example.com	0958748562	kirurg	KBC Osijek	Josipa Hutlera 4	31000	Osijek	Ukloni Ukloni
3	Petar Marković	petar@example.com	0912547856	infektolog	KBC Osijek	Josipa Hutlera 4	31000	Osijek	Ukloni Ukloni
4	Tin Marković	tin@example.com	0925478596	infektolog	KBC Osijek	Josipa Hutlera 4	31000	Osijek	Ukloni Ukloni
6	Miško Marković	misko@example.com	0957843214	infektolog	KBC Osijek	Josipa Hutlera 4	31000	Osijek	Ukloni Ukloni
7	Ivan Marković	ivan@example.com	25485784	pedijatar	KBC Osijek	Josipa Hutlera 4	31000	Osijek	Ukloni Ukloni
8	Dino Perkočić	dino@example.com	0954123457	neurokirurg	KBC Osijek	Josipa Hutlera 4	31000	Osijek	Ukloni Ukloni
9	Hrvanje Perkočić	hrvanje@example.com	0985456321	dermatolog	KBC Osijek	Josipa Hutlera 4	31000	Osijek	Ukloni Ukloni
10	Mate Horvat	mate@example.com	0985456321	ortoped	KBC Osijek	Josipa Hutlera 4	31000	Osijek	Ukloni Ukloni

Figure 8. Administrator's profile

4. Conclusion

In this paper is presented algorithm and online application for automatic appointment scheduling, which was implemented through the concept of booking patients' appointments for a specific service offered by individual doctors. Primarily plan was to improve health tourism in Croatia by developing algorithm which will maximize doctor's efficiency and minimize patient waiting time. By maximizing efficiency patients will be more satisfied and have more services by one visit. The algorithm is developed for that purpose and it allocates appointments to the data-base. The application itself is created in a Laravel which is used to build web applications based on MVC architecture. The layout scheme of the database was de-signed to contain all necessary data for the proper operation of the application. The main part of this paper is the development of the algorithm, with the focus on functionality and simple layout. The algorithm is designed to view the database and return an empty appointment which is appropriate for doctors and patients, remove overlaps and minimize waiting time. The application has two modes of user login, namely patients and doctors. Each has different functions and different views of the content, since they have different roles. Patients have been registered, logged in, selected, and scheduled appointments with the ability to edit their information, while

doctors have been disabled from registering and added by the application administrator. Doctors have the ability to view scheduled appointments, add and delete individual services they offer, and edit their information. The response of the application is relatively fast, but after a while the amount of data in the database would increase and the speed would depend on the strength of the ser-ver. The problem could be solved by storing data in another memory location after a certain amount of time has elapsed since the end of the term. In future work we plan different improvements based on practical experience by using this application. We plan to assess doctors and patients to get feedback and find out possible improvements.

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