Open data portal for audio files based on microservice architecture

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***Abstract* - Open data is a concept in which specific data should be freely available to all, for use and re-use, without copyright or other restrictions. The term open data most often refers to tabular and textual data, which state institutions create. This paper will describe an open data web portal developed at the School of Electrical Engineering - University of Belgrade (ETF), with the idea to help organize audio files of the Laboratory for Acoustics. The platform has developed in a modern microservice architecture, which is used in complex systems that contain a huge number of functionalities and big data. The initial goal of the platform was to facilitate the daily activities of employees within the laboratory, but it was later concluded that the addition of new microservices could develop a portal that could be used publicly for a very wide range of people, from researchers and engineers to musicians and students. This platform allows users to upload and download available audio files, to comment and rate other users' files, as well as exchange messages between users.**

***Keywords*: open data, big data, audio files, microservice architecture, instrument, impulse response, ambient noise**

I. INTRODUCTION

Open data is a significant way to spread knowledge today. The main characteristics of their openness are availability, reusability, and universal use. Open data portals are interfaces designed to make it easier to find information that can be reused. Like library catalogs, they contain metadata records of data sets published for reuse. The importance of the open data portal is reflected in the fact that in one place, there is a large database that can be searched by various parameters, with the ability to download data needed for private use or research purposes.

The authors created this portal primarily for research purposes. The Laboratory for Acoustics of the ETF needed this open data portal due to the easier search and processing of a large database of audio files. However, managing so many data sources without any application was difficult. The idea of this system is to group all this data in one place and through the simple graphical interface of the web portal, provide easy manipulation of this data. As the system needs to store large amounts of data, support various functionalities, and implement management of the portal users themselves, microservice architecture has been applied to solve this problem. It enabled the straightforward organization of data and tasks by division into several microservices, where each microservice stores a particular group of data and has a specific role.

Figure 1. The Open Data portal of the Republic of Serbia [3]

The concept of open data has been applied since 2008 and gained popularity after the initiative of some countries to open their data on portals such as: the United States open data portal [1], the UK open government data [2], Serbian open data portal [3], Open Data portal of the Statistical Office of the Republic of Serbia [4], etc. The importance of open data portals is growing, and the most popular are the open data portal of the World Health Organization [5], the World Bank portal with open data [6], the portal of open data of the European Union [7], and others. However, the question remains: Why is it important to open data? The answer lies in the enormous practical, economic, and creative potential of this information. Once opened and transformed into purposeful applications, the data makes everyday life easier for citizens, and business for members of the business sector. In order to discover, analyze data and draw conclusions from them, a very important branch is education and science. With this research, we want to contribute to the scientific research work of all persons involved in acoustics and analysis of audio files.

The system is designed to allow end users to search a large database of audio files, download those files and upload new audio files. The analysis concluded that three categories of these files are enough: instrument sounds, pulse response, and ambient noise. Each category of files has its own specific labels that better describe them, and a more detailed search can be obtained by these labels/criteria.

The second chapter describes the problem and motivation for creating such a specific open data portal. The third chapter gives an overview of the system architecture realized in the form of modern microservice architecture. The fourth chapter presents a description of using this system, and the fifth chapter provides a

conclusion and possible further directions for the development of this portal.

II. PROBLEM DESCRIPTION AND MOTIVATION

The research includes an analysis of existing open data portals (especially open data audio portals), analysis of the platform architecture and user interface principles necessary for the development of this type of portal, web portal development, data filling and testing.

In the field of audio files, there are a negligible number of such open data portals. The only publicly available portal with a similar topic is *Freesound* [8]. *Freesound* aims to create a huge collaborative database of audio snippets, samples, recordings, bleeps, etc., released under Creative Commons licenses that allow their reuse. Due to several key shortcomings that were noticed on that public portal, the authors decided to realize their portal, but also due to the large database that the laboratory already has.

Our research will answer the following questions:

- Does the portal need to implement predefined categories of audio files? For example: instruments, impulse response, ambient noise.
- Does the portal include pre-known labels, or can the user enter them?
- Does the administrator approve the audio file uploaded by end users?
- Does the end user have insight into the statistics and how to "reward" the end user who fills audio files in the database?
- Can additional information be saved for the audio file - about the type of instrument and the year (date) of recording, the location of the audio file recording, etc.?
- Is the option of commenting and rating files necessary?

III. THE SYSTEM ARCHITECTURE

The solution described in this research has realized in microservice architecture. Microservice architecture is based on the principle of loose coupling, i.e. the idea that microservices work with minimal knowledge of other microservices. Microservice architecture is an example of service-oriented architecture (SOA), as shown in Figure 2. The developed open data portal can be divided into two basic modules: the module for storing, processing, and organizing data and the module for interaction with users and presentation of data. The service part of the system is divided into two microservices. The service module of this system is realized in the Java programming language, and the user module of the system is developed in Angular. The microservice architecture has made this web portal easy to maintain and modular in design, so that new functionalities can be easily added. The development of such a system was a great challenge, and it was necessary to invest a lot of time in the design of the system, that the entire microservice communication functioned stably.

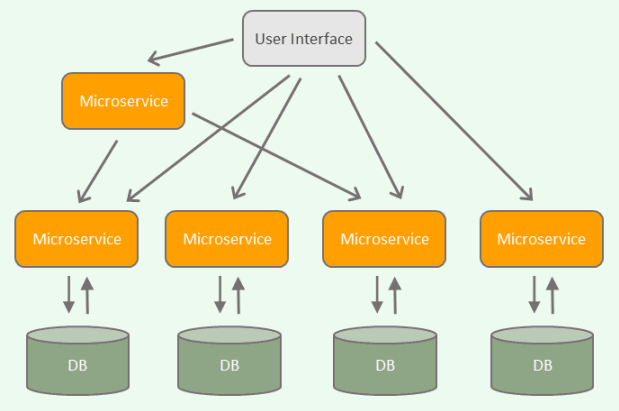

Figure 2. Example of microservice architecture

The microservice architecture of this open data portal is divided into the following layers (as shown in Fig. 3):

- The presentation layer is separated into a special frontend application written in the TypeScript programming language, i.e. the Angular 13 framework.
- The application layer represents all controllers, i.e. endpoints. Each endpoint has its own path and method. All standard HTTP methods (GET, POST, PUT…) are possible.
- The service layer contains the complete business logic of the application, and it is attached to the application layer in this application but can be easily separated.
- The data access layer is in charge of establishing a connection with the database and retrieving and manipulating the data stored in it. This layer accesses the data in the form in which it is stored in the database.

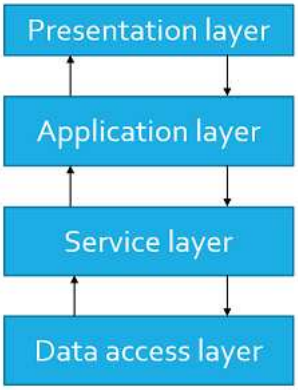

Figure 3. Layers of microservice architecture

A. *Microservice for working with user accounts*

A microservice that represents users is connected to a first *MySQL* database that has a user table. The user table contains basic information about the user and is designed to be able to increase very flexibly as desired. A complete view of the database model can be seen in Figure 4. The Spring implementation of the repository interface - JPARepository was used for the implementation of the data access layer. It allows easy retrieval of users using various parameters, as well as deleting, modifying and adding a new file to the database.

Figure 4. Table for user accounts

B. *Mikroservis za rad sa audio fajlovima*

The microservice that represents audio files is connected to a second *MySQL* database that has 3 tables for each category of audio files:

-instrument

-ambient noise

-pulse response

The table for each file category contains the name, author, file labels, the contents of the file itself in bytes to be played, and a parameter-approved based on which it is known whether the administrator approved the file and whether it is visible to all users in the system. A complete view of the database model can be seen in Figure 5. The Spring implementation of the Repository interface - JPARepository was used for the implementation of the data access layer. It allows you to easily retrieve files using various parameters, as well as delete, modify and add a new file to the database.

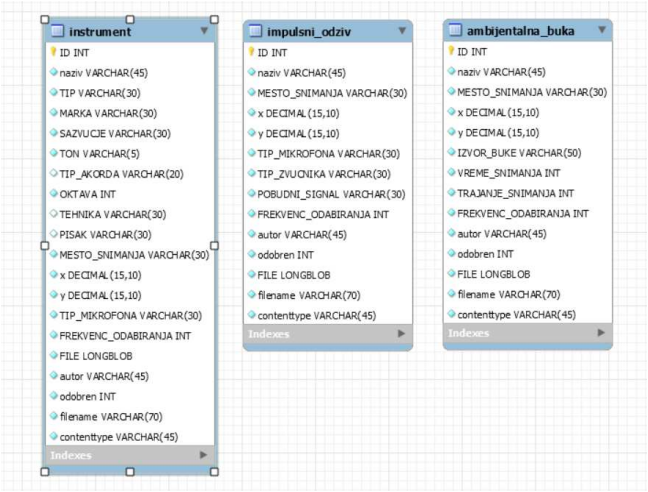

Figure 5. Tables for different types of audio files

IV. DESCRIPTION OF SOFTWARE SYSTEM USING

The portal is realized with 3 types of user accounts: unregistered user (guest), registered system user and system administrator. The home page of the unregistered user (guest) has a navigation bar, as shown in Figure 6, where the user can choose between the options instrument, ambient noise and impulse response. Also, the user can log in to the system. By simply clicking on the link for instruments, the guest will be taken to a page where he will be able to perform searches on various parameters.

A simple website designed to register a user requires the user to enter a first name, last name, email address and password. After that, the user will stay on the same page and receive a message whether he has successfully registered. During registration, by pressing the Register button, a call is sent to the system, which is redirected to the user's microservice.

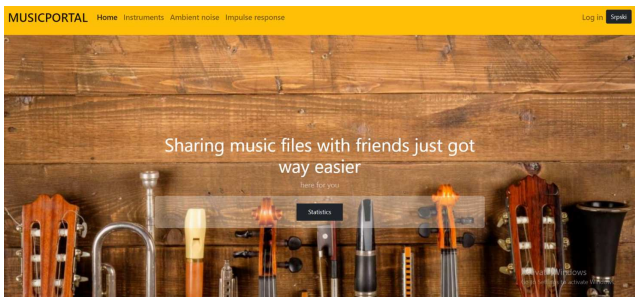

Figure 6. Home screen of the open audio files portal

Figure 7 clearly shows that some of the parameters in the search form have been selected and that pressing the Search button gives the result in the form of a table below the search form. As shown in Fig. 7, all its labels are presented for each file. The user can also see the Show on Map option, which leads to a new page where the location on the map where the given audio file was recorded will be displayed (Fig. 8). In the last column there is a part that serves to command the playback. It supports starting and stopping a song as well as increasing and decreasing the volume level. Very similar happens when ambient noise is chosen, as well as impulse response. Also, pagination was realized, in order to facilitate the viewing of a large number of audio files that are the result of the search.

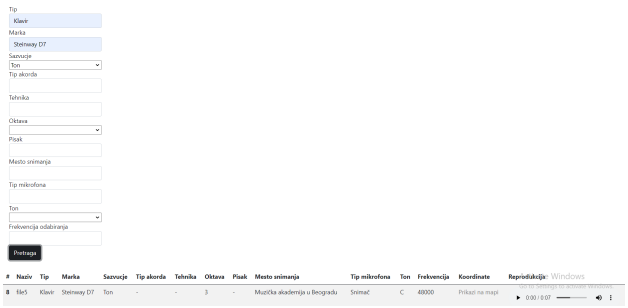

Figure 7. Web form for searching instruments and audio files

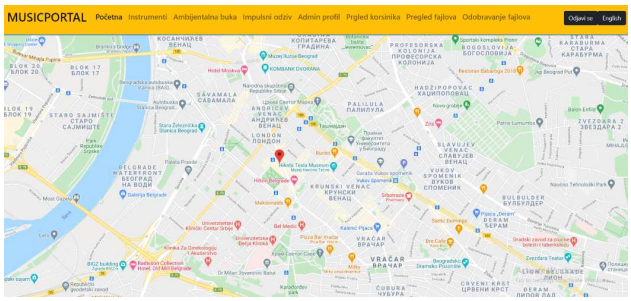

Figure 8. Web page that shows the location on the map where the audio file was recorded

The user profile will show all the audio files that the user has added. All added files are divided into three main categories (ambient noise, impulse response, instrument) for easy viewing. It is also noticeable that pagination is enabled for each part. All of these labels are listed for each file. In addition, for each file there is an option to delete, modify the file, as well as view the location of the file on the map, play audio and download the file. By deleting the

given file, it will be deleted from the database and will no longer be visible in any part of the system. When the edit file option is selected, the already filled form with the current labels of the given file will be displayed. Anything in the form can be changed and by clicking Save, changes to the database will be saved.

For each category there are links Add a new file, which goes to a page where you can add a new file (Fig. 9). The user must enter all the labels for the given file, as well as send the file to the server and select the location on the map where the given file was saved. By clicking the Add button, the file with the specified parameters will be saved in the database.

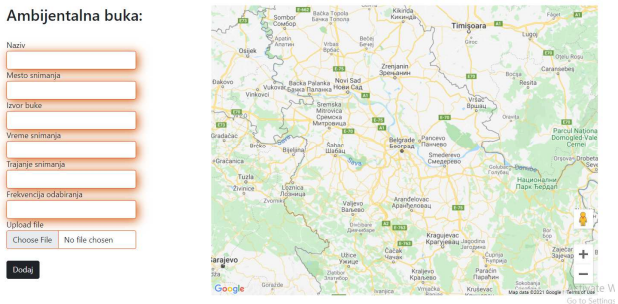

Figure 9. Web form for adding a new audio file

The administrator can additionally select the option to view all users, view files and approve files. Selecting the file approval option will display a page listing all files that have not yet been approved. The administrator has the option to reject or accept them. If it decides to approve the file, the file will become visible to all users of the system. In both cases, the user will be notified of the outcome, via the user's email address, which the user filled in during registration.

The portal currently supports Serbian and English language. Support for other languages can be easily added to the portal.

V. Conclusion

The implemented platform with open data was made with the idea to help organize data on audio files of the Laboratory for Acoustics of the School of Electrical Engineering (ETF) in Belgrade, but also so that other interested visitors of the platform could download files from it. The initial goal of the platform was to facilitate the daily activities of employees within the laboratory, but it was later concluded that the addition of new microservices could develop a portal that could be used publicly for a very wide range of people, from researchers and engineers to musicians and students. In the original planning, the goal was to allow users to comment and rate other users' files, as well as exchange messages between users. This web portal, like any application, is never finished, there is always the possibility to add new functionalities and the authors are working on that.

The microservice architecture has made the system of this work easy to maintain. All microservices are implemented keeping in mind all the good practices and are small enough for one developer to master each of them well. The advantage of the microservice approach is that for complex systems that contain a huge amount of data and operations, there is a precisely defined place where there are logically similar data that allows easier manipulation of them.

The development of such a system was a great challenge. It is necessary to invest a lot of time in the design of the system in order for the entire microservice communication to function stably and for the whole system to be divided into logical units or microservices. The experience that a developer gains during the development of such a system is very applicable in today's industry because most of today's companies use this architecture to develop their systems.

The entire microservice architecture could be metaphorically conceived as one orchestra. The orchestra consists of several people who play certain instruments. Each of these instruments can produce a perfect sound, but the whole orchestra can still play false and sound bad. The same situation can occur in microservice architecture. Any service can work perfectly but the system may still not be good enough. The reason why this situation arises when it comes to the orchestra is the need for a conductor who will know at what point which instrument should play a certain note. In microservice architecture, those moments are the demands that services send to each other, notes are operations, and conductors are system designers or developers. It is very important that, in addition to writing reliable and good individual services, their communication is harmonized and optimized so that the entire system works as needed.

Microservice architecture is currently at its peak. The community of people who use and develop it is growing every day, which means the desire to improve it. New techniques are being devised every day to improve it. With such community support, it is inevitable that microservice architecture is not only the present development of complex systems but also its future.

Acknowledgment

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