



DADIVA IPO

Digital Aid and Donor Information Verification Application for IPO

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Relatório do projeto realizado no âmbito de Projecto e Seminário
Licenciatura em Engenharia Informática e de Computadores

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INSTITUTO SUPERIOR DE ENGENHARIA DE LISBOA

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Resumo

Texto do resumo. Breve descrição do projeto, dos resultados importantes e das conclusões: o objetivo é dar ao leitor uma visão global do projeto (não deve exceder uma página).

Abstract

The Instituto Português de Oncologia (IPO) in Lisbon currently employs a manual system for managing blood donor information. This involves donors completing a pre-donation form on paper, followed by a medical interview where a doctor assesses eligibility based on the form and additional verbal questions. This manual process of handling and verifying medical and medication details is prone to errors and inefficiency.

The proposed project aims to digitalize the blood donation process at IPO. This includes creating a digital version of the pre-donation form and developing a system to manage and cross-reference medication and pathology data. The digital system will allow for easy updating, customization, and retrieval of information. By automating the form and data handling, the project seeks to reduce errors associated with manual data management and decrease the overall time required for the donation process, thereby streamlining both donor signup and triage procedures.

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Chapter 1

Introduction

Blood donation services play a vital role in the healthcare systems of nations worldwide, serving as a cornerstone of public health initiatives. In Portugal, the establishment of the Blood National Institute (Instituto Nacional do Sangue) in 1958 marked the inception of formal coordination of transfusion medicine. This institution, evolving over more than five decades, culminated in the establishment of the Portuguese Blood and Transplantation Institute (Instituto Português do Sangue e da Transplantação, IPST) in 2012 [1].

Throughout this historical trajectory, blood donation services have undergone substantial organizational reforms aimed at ensuring the safety of both donors and recipients. However, the donor screening process has seen limited evolution despite these systemic changes.

The "Council Recommendation of 29 June 1998 on the suitability of blood and plasma donors and the screening of donated blood in the European Community" underscores the importance of gathering information from potential donors through written questionnaires. Although the specifics of these questionnaires may vary among Member States, their primary objective remains consistent: to identify common risk behaviors and diseases.

According to the 2022 Transfusion Activity and the Portuguese Hemovigilance System Report [2], Portugal recorded 306,796 blood donations from 203,287 donors, with 373,209 donor registrations during the same period. Notably, the main reason for temporary suspension of blood donations is low hemoglobin levels, followed by recent travel to high-risk regions and engagement in behaviors associated with increased health risks.

Institutions like the Portuguese Oncology Institute (Instituto Português de Oncologia, IPO) in Lisbon, which contributed 1.88% of total blood donations in 2022, still rely on traditional, paper-based questionnaires for donor screening. However, this manual process, coupled with the need for cross-referencing against guidelines provided by IPST, is susceptible to inefficiencies and errors. Such inefficiencies may contribute to reduced donor adherence and suboptimal health outcomes.

In partnership with Lisbon's IPO this project endeavors to address these challenges by developing a digital platform. The platform aims to provide donors with a comprehensive digital questionnaire encompassing both standard and relevant sub-questions pertinent to the

screening process. For healthcare professionals, the platform will offer streamlined access to donor responses alongside information regarding potential health risks. Additionally, administrators will have tools to manage user accounts, questionnaire structures, and information regarding drug/disease interactions with blood donation.

By reducing the need for additional questions during screening consultations, this platform seeks to enhance donor participation. This is particularly crucial given the observed decline in donor numbers and donations from 2013 to 2022, amounting to a decrease of over 30,000 donors and 50,000 donations. Through these efforts, we aim to foster greater engagement with blood donation initiatives, thus contributing to the broader health and well-being of our community.

The main challenge with this project is regulatory compliance, particularly given our team's limited expertise in this domain and, to confront this challenge, our development strategy prioritizes the creation of adaptable functionalities designed to meet a broad range of regulatory requirements. Additionally, maintaining close collaboration with Lisbon's IPO will afford us invaluable guidance, ensuring our platform aligns with established frameworks and standards. By taking these proactive measures, we aim to navigate regulatory complexities effectively and develop a robust, compliant solution that can be tailored to the needs of blood donation services.

Chapter 2

Problem Description

Current blood donation workflow faces a set of challenges like screening time for more complex cases can be time consuming, as well as cross checking information about drug and pathology interaction, and printed forms need to be disregarded when legislation or the form's structure is changed.

Screening time can be reduced by employing a dynamic form, in digital format, that shows relevant follow up questions according to the potential donor's answers, thus collecting relevant information, that would otherwise need to be obtained during the medical screening. This solution raises a set of questions such as:

- What data structure is appropriate to describe the form's structure and flow/logic - the questions order, possible answer values, what answers trigger or suppress follow-up questions;
- How will the form's rule be enforced in a way that doesn't mix domain and rules - the front-end should be able to show and compute various forms and a form change shouldn't need to be accompanied by changes to the front-end implementation.

Upon form submission the information supplied by the potential donor, or automatically obtained, can be automatically cross checked against IPST guidelines for drug and pathology interaction with blood donation. This solution raises a set of questions such as:

- How are the potential donor's drug and disease information validated - the number of available drugs and possible diseases might be too great for real time validation, when the user is inputting that information into the form;
- Are the IPST guidelines available in a machine readable format that make it feasible to be cross checked against the form's answers - currently the guidelines are available in pdf and printed format, sometimes drugs/pathologies are individually mentioned and sometimes grouped in a family (ie there's no mention of aspirin in the 2022 manual, instead the term Non Steroidal Anti Inflammatory medication is used).

The digital form structure and flow, pathology/drug interaction and terms of service information should be update-able in the back-office. This solution raises a set of question such as:

- How can the form structure and flow be visualized in an intuitive way - the user changing the form shouldn't need to know anything about it's implementation but still be able to identify it's flow;
- How will the drug/pathology interaction be updated - will a user manually insert information in the back-office or are can it be requested from a web-service.

Beyond these specific challenges the platform will have to employ three types of users, donors, that can access the form and submit form responses, doctors, who can view donors form answers and pathology/drug interactions, and administrators, who can manage users, form structures, drug/disease and regulatory compliance interaction information.

2.1 Proposed Solution

In order to solve the challenges listed above, we have developed DADIVA IPO.

DADIVA IPO is a web platform that allows blood donation services to decrease the screening time of blood donation candidates via an update-able dynamic form and automatic interaction verification.

It is intended as an alternative to the current, and less versatile, paper form used by blood donation services in Portugal, such as Lisbon's IPO.

2.1.1 Functional Requirements

- Donors should be able to quickly fill out a digital pre-donation form. The form should be adequate according to the current law, adaptable, and depend on the donor's answers.
- Doctors should be able to find all relevant data on pathology and/or medication interactions with the donation in a digital format.
- Doctors and administrators should be able to access a back office used for customizing the pre-donation form and for updating the pathology and/or medication interaction information. The back office should also allow for user management.
- Google-like search and results by relevance - Search should be as simple as possible. There may be a need to increase the number of filters, but this complexity should be hidden. The results returned should be sorted based on relevance.

2.1.2 Non-Functional Requirements

- Intuitive user experience through a simple and practical user interface.
- Responsive design that ensures a good user experience both on desktop and mobile.
- Complete and thorough documentation.
- Unit and integration testing with sufficient coverage to ensure confidence that the system is working without flaws.
- Good software engineering practices to ensure the fast development of the system.

2.1.3 Optional Features

- After filling out the pre-donation form, the system could automatically check if the donor had any vaccinations and/or prescriptions that could be medically relevant. It would require integration with the SNS, and/or Infarmed systems.
- The medical interview may be based on a pre-analysis, with the system having already identified possible risk vectors and logical incongruencies that better assist the doctor when deciding on accepting or refusing the donor.
- It is possible that the IPST has already implemented a digital system to maintain pathology and medication interaction information. If so, it would be possible to integrate this into our system, so that this information does not have to be manually updated.
- Users can authenticate using the Digital Mobile Key (CMD). It would require integration with the AMA (Administrative Modernization Agency) systems.

2.1.4 Use Cases

With the requirements listed above, we have identified the use cases that the platform shall support. A use case is a written description of how users will perform tasks on a system. It outlines, from the user perspective, the behavior of the system as it responds to a request. The use cases identified shall allow to reason about who are the users of the platform, their objectives, the actions they are able to perform, and how the platform shall respond to each action. The use cases are divided into three categories, each representing one type of user. The Donor use case is presented in Figure 2.1. The donor user can request the current form and can submit their form responses.

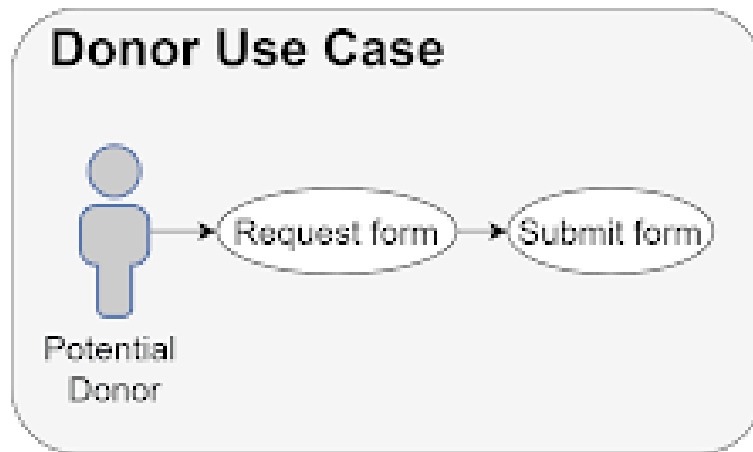


Figure 2.1: Donor use case.

After a donor submits their form responses a doctor user will be able to access their answers by searching by the user's unique id as presented in Figure 2.2.

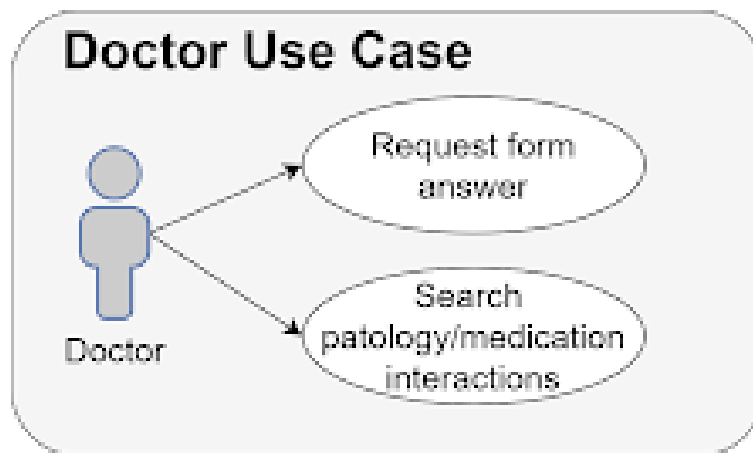


Figure 2.2: Doctor use case.

Furthermore the doctor user is able to search for pathology/medication interactions to resolve any inquiries that might appear during the screening.

Finally the administrator user can update the form structure and flow, update the interaction information and manage the platform's users. The administrator use case is presented in Figure 2.3.

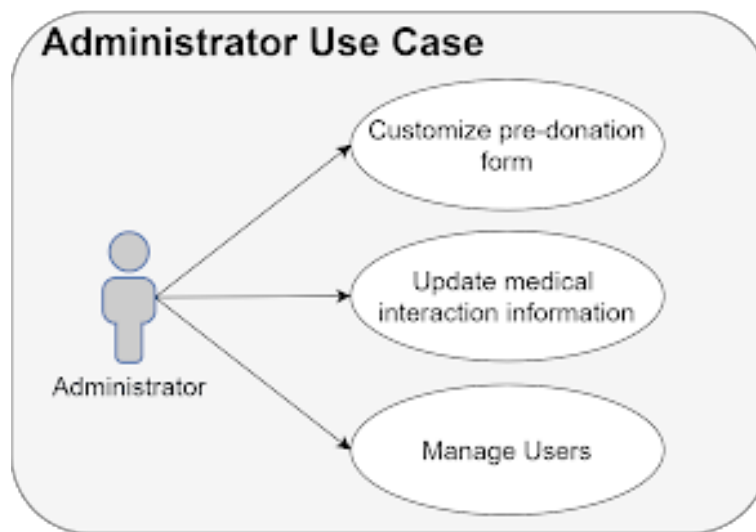


Figure 2.3: Administrator use case.

Chapter 3

Technologies

In this chapter we introduce the most relevant technologies that support the different components of the DADIVA IPO Platform, explaining what they are and why they are being used in the context of our project. We will start by introducing the technologies that are used in the backend, then we will introduce the technologies that are used in the frontend, and finally we will present the tools that enable version control. We obtained experience in some of these throughout the several courses of our bachelor's degree in computer science, which highly influenced us in choosing them in our project:

- Introduction to Web Programming (Introdução á Programação na Web) - Express.js;
- WebApplication Development (Desenvolvimento de Aplicações Web)- Docker, React, Material-UI, Webpack;
- Systems Virtualization Techniques (Técnicas de Virtualização de Sistema) - Docker;
- Software Laboratory (Laboratório de Software) - Docker;
- Informatic Security (Segurança Informática) - RBAC;
- Git and Github where used during most of the course.

3.1 Backend Technologies

The backend technologies used in the DADIVA IPO are similar, at least conceptually, to those used in Software Laboratory and Introduction to Web Programming. These technologies encompass the server-side components that handle data processing, database management, and API integrations. In this section, we will explore the key backend technologies employed in our project, providing a comprehensive overview of their functionalities, benefits, and relevance to our system. We will explore how these technologies work together to support the seamless operation and performance of the DADIVA IPO platform.

The programming language used in the backend was C#, which is a general purpose, object-oriented programming language. C# was chosen since it is part of the technology

stack at Cofidis, the employer of João Pereira, and it presented a opportunity to use a new, industry prevalent, language in a large project that would prepare us for possible development environments upon course conclusion.

Other options where Kotlin, which was extensively used during our course and Java, which, much like C#, is already a staple language for backend development. However C# presented an interesting novelty challenge that wasn't as present in these alternatives.

3.1.1 .NET

.NET is a comprehensive development framework created by Microsoft. It serves as the backbone for building a variety of applications, including web, mobile, desktop, gaming, and Internet of Things (IoT) applications.

.NET provides a built-in dependency injection container that is straightforward to use. This container is integrated into various application types, including ASP.NET Core, and is conceptually similar to Spring, as well as a Role Based Access Control(RBAC). This framework also allows to create Minimal API's which are controller free API's similar to the Express.js API created during Introduction to Web Programming.

3.1.2 Docker

Docker is an open-source project which wraps and extends Linux containers technology to create a complete solution for the creation and distribution of containers. The Docker platform provides a vast number of commands to conveniently manipulate containers.

A container is an isolated, yet interactive, environment configured with all the dependencies necessary to execute an application. The use of containers brings advantages such as:

- Having little to no overhead compared to running an application natively, as it interacts directly with the host OS kernel and no layer exists between the application running and the OS;
- Providing high portability since the application runs in the environment provided by the container; bugs related to runtime environment configurations will almost certainly not occur;
- Running dozens of containers at the same time, thanks to their lightweight nature;
- Executing an application by downloading the container and running it, avoiding going through possible complex installations and setup.

To easily configure the virtual environment that the container hosts, Docker provides Docker images. Images are snapshots of all the necessary tools and files to execute an application. Containers can be started from images, the same way virtual machines run snapshots.

To effortlessly distribute images, Docker provides registries. These are public or private stores where users may upload or download images. Docker provides a cloud-based registry service called DockerHub.

In addition to the Docker platform, we use Docker Compose to orchestrate the containers. Docker Compose is a tool for defining and running multi-container Docker applications. With Compose, we can define a multi-container application in a single file, then spin it up in a single command which does everything that needs to be done to get it running. Compose is especially useful in development environments, testing environments, and CI workflows.

We use Docker as an alternative for software containerization because it is the most well known, actively developed and supported in the area. Many frameworks already support it or are starting to support it.

3.2 Frontend Technologies

3.2.1 React

React is a JavaScript library for building user interfaces. It is maintained by Facebook and a community of individual developers and companies. React can be used as a base in the development of single-page or mobile applications.

React is a component-based library, which means that the application is built by assembling components. Each component is a small piece of code that can be reused in different parts of the application. React is also declarative, which means that it is possible to describe the user interface without specifying how the user interface should be updated.

In DADIVA IPO, we use React to create the user interface. We also use React Router to manage the routing of the application. React Router is a collection of navigational components that compose declaratively with your application.

3.2.2 JSON-Rules-Engine

JSON-Rules-Engine is a library that enables the evaluation of business rules based on data inputs, providing a way to separate business logic from the core application code. Rules are defined in JSON format, making them easy to read, write, and maintain. The engine evaluates these rules against provided facts (data inputs) and triggers actions based on the results.

3.2.3 Material-UI

In addition to React, we also use Material-UI to create the user interface. Material-UI is a React component library that implements Google's Material Design, which is a design language that combines the classic principles of successful design along with innovation and technology. Material-UI provides a set of components that can be used to create a user

interface that follows the Material Design guidelines, such as buttons, cards, and tables. This makes it easier to create a consistent user interface.

3.2.4 Webpack

Webpack is a module bundler. It takes modules with dependencies and generates static assets representing those modules. Webpack is used to bundle JavaScript files for usage in a browser. It also provides a set of plugins that can be used to optimize the application, such as minification and code splitting.

In DADIVA IPO, we use Webpack to bundle the JavaScript files of the application, optimizing them for production. The technology also provides a development server, which is used to serve the application during development. We also use ts-loader to compile TypeScript files into JavaScript.

3.3 DevOps Technologies

3.3.1 Git and GitHub

Git and GitHub are widely used version control tools that play a critical role in modern DevOps practices. Git is a distributed version control system that allows teams to efficiently manage changes to source code, track them over time and streamlines developer collaboration. GitHub, on the other hand, is a web-based hosting service for Git repositories that provides additional collaboration and project management features. Both of these technologies were extensively used throughout our course.

Chapter 4

Architecture

This chapter provides an overview of the system’s components and their interactions. It outlines the capabilities of the project and presents the architecture, entities, and implementation blueprint that have been designed and developed.

4.1 Overview

Figure 4.1 presents a diagram illustrating the main components of the system and their interactions. The system consists of a backend application (server-side) and a frontend application (client-side). The backend comprises a collection of services, responsible for data manipulation and storage database. The frontend is composed of a web application, that facilitates user interaction. Communication between the frontend and the backend is achieved through a REST API, utilizing the HTTP protocol [24].

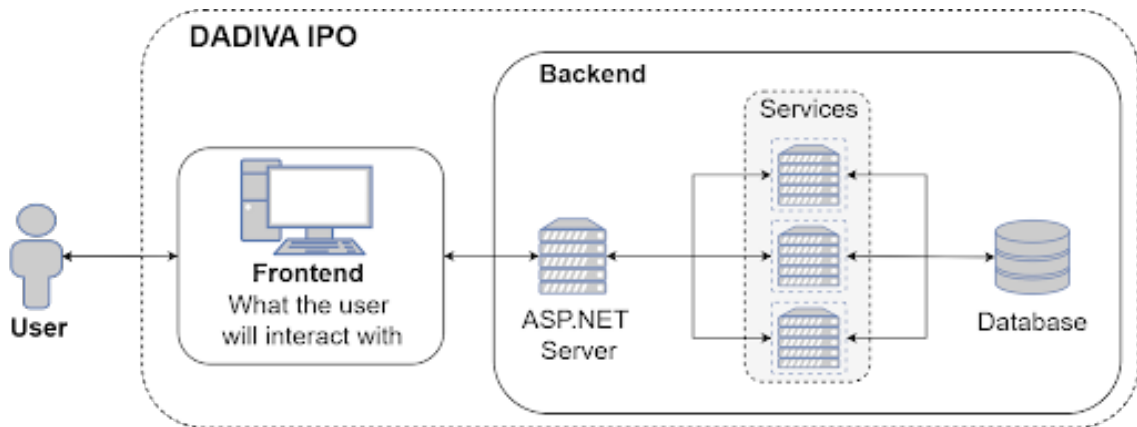
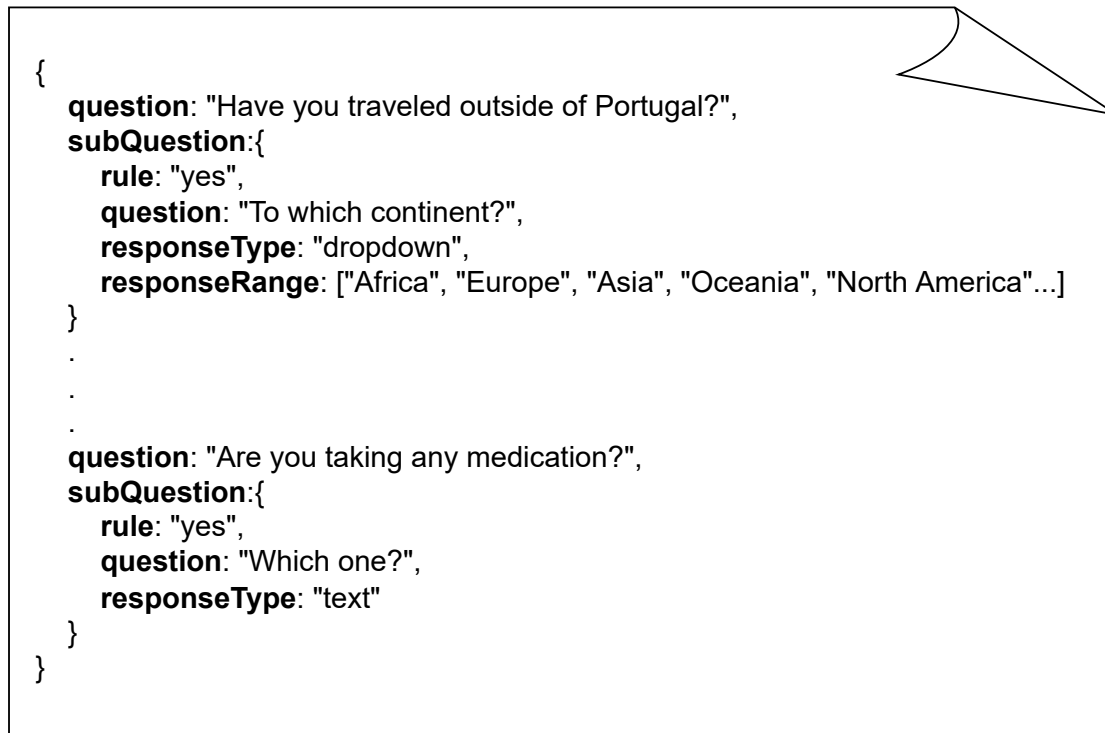


Figure 4.1: Application Architecture.

4.2 Form Data Model

The first approach to solve the dynamic form challenge was to use a data structure formed by main questions and sub-questions, example presented in Figure 4.2, where a main question

can only be answered with boolean values, and one of those values triggers the display of a sub-question which has a certain type of response, such as boolean, dropdown for known multiple answers, and text to accept user text input.



```
{
  question: "Have you traveled outside of Portugal?",
  subQuestion:{
    rule: "yes",
    question: "To which continent?",
    responseType: "dropdown",
    responseRange: ["Africa", "Europe", "Asia", "Oceania", "North America"...]
  }
  .
  .
  .
  question: "Are you taking any medication?",
  subQuestion:{
    rule: "yes",
    question: "Which one?",
    responseType: "text"
  }
}
```

Figure 4.2: First Form Data Structure.

This approach has some drawbacks, such as the fact that it disables the possibility of suppressing further questions, hence not adhering to the principle of creating a generic and adaptable solution, and mixes questions and rules in the sub-question.

Upon further discussion we settled on using a more complex data structure, exemplified in Figure 4.3, composed by a list of questions and a list of rules.

Each question has an id, the text that composes it, the type of response (boolean, text and dropdown) and can have options that lists all the possible values for a multiple(dropdown) response.

Each rule has conditions, which can be "any", "all" or "not", so that, when any, all or none of the conditions are met an event is triggered, which can be to show or hide a question, the question targeted by the event is identified by the id, supplied via the params field.


```

{
  "questions": [
    {
      "id": "0",
      "text": "Have you traveled outside of Portugal?",
      "type": "boolean"
    },
    {
      "id": "1",
      "text": "To which continent?",
      "type": "dropdown"
      "options" : ["Europe", "Asia", "Africa", "South America"...]
    }
  ]
  "rules": [
    {
      "conditions": {
        "any": [{
          "fact": "0",
          "operator": "equal",
          "value" : "true"
        }]
      },
      "event": {
        "type": "showQuestion",
        "params": {
          "id": "1"
        }
      }
    }
  ]
}

```

Figure 4.3: Final Form Data Structure.

4.3 Frontend Application

The frontend application is composed of a web application, which is responsible for the interaction between the users and the backend. This application provides a simple and intuitive interface for the user to interact with the system, allowing donor users to fill out the current form, doctor users to search for pathology and medication interaction with blood donation and request form answers of a given user and administrator users to customize the current form, update the pathology and medication interaction information and manage the user. This application is divided into multiple pages and components, and has a service layer that is responsible for communicating with the backend application through the REST API.

4.4 Services

The backend application is composed of a set of services, responsible for data manipulation and storage. Each service is associated with a given domain and is independent from the remaining services, allowing for ease of future updates. The services communicate with the database, in which the various data models are divided into specific indexes, such as:

- /form: stores all the forms ;
- /submissions: stores all the user form responses ;
- /users: stores all the users.

The system is composed of the following services:

- form: responsible for form management, such as, creation, requests, submission, editing and deletion;
- search: responsible for medication and pathology interaction information management;
- users: responsible for user management, such as, registration, login, deletion and role management.

4.4.1 Form Services

The form service is responsible for managing the form resources. Figure 4.4 is a diagram that shows the architecture of the form services.

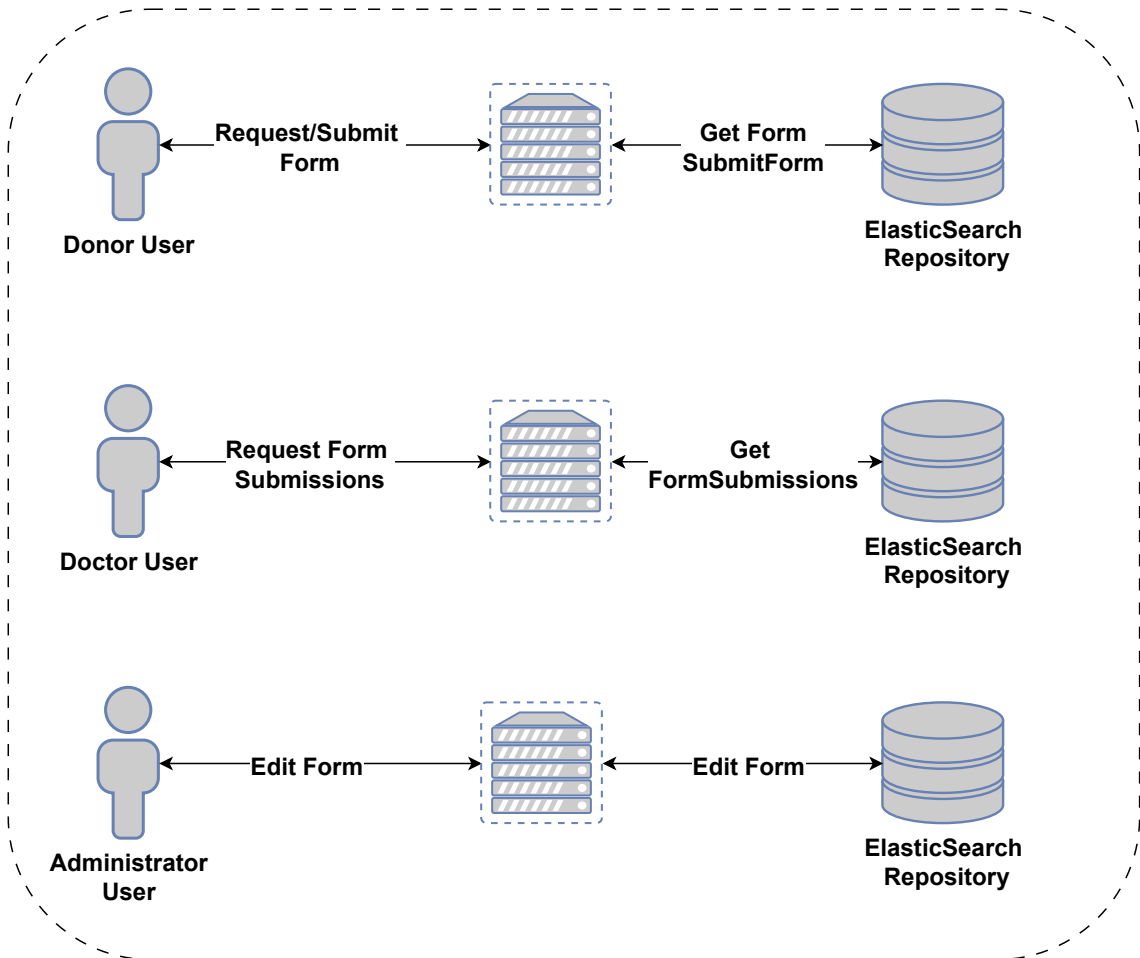


Figure 4.4: Final Form Data Structure.

Chapter 5

Exemplos

A nossa solução é apresentada neste capítulo. A solução consiste em grandes ideias, desenvolvidas e testadas.

Exemplo de indentação do segundo parágrafo.

5.1 Nome da primeira secção deste capítulo

Texto da secção. Seguem-se exemplos de vários parágrafos.

Esta unidade curricular funciona no semestre de Verão de cada ano letivo. Nos casos de impedimento prolongado justificado (designadamente por doença ou por motivos profissionais no caso dos trabalhadores-estudantes), poderá ser prolongada, havendo lugar à elaboração de outro relatório de progresso e a nova inscrição se o prolongamento for além do período de época especial desse semestre. A entrega da justificação e a sua apreciação deverão ocorrer antes do final do prazo estabelecido para a entrega final.

O estudante só poderá frequentar Projecto e Seminário se, em conjunto com as restantes unidades curriculares em que se inscreve nesse semestre isso corresponder, no máximo, a 44 créditos ECTS, tendo acumulado, pelo menos, 138 créditos. No caso de estudantes em regime de tempo parcial, o valor máximo está limitado a 30 créditos no ano letivo. Não são admitidas inscrições como unidade curricular isolada.

Anualmente é divulgada a lista de ideias para projetos e respetivos orientadores. Os estudantes poderão propor outras ideias identificando os orientadores. A escolha da ideia de projeto é feita no período de interrupção letiva após o semestre de Inverno. As propostas de projeto são registadas no início do período letivo do semestre de Verão, verificado que os estudantes reúnem as condições de frequência. O projeto deve ser realizado em grupo de dois estudantes (excecionalmente um ou três). Cada elemento do grupo tem tarefas específicas pelas quais é responsável. Esta situação deve ficar clara desde o início do projeto.

A orientação dos projetos é feita por docentes da área departamental onde o curso está ancorado ou por especialistas externos, podendo haver coorientadores, mas sendo obrigatória a coorientação por docente da área departamental no caso de orientação externa. O desenvolvi-

mento do projeto é acompanhado de reuniões periódicas do orientador (ou coorientadores) com o grupo. A informação referente ao projeto é mantida em formato eletrónico em local acessível pelos elementos do grupo, pelos orientadores e pelos docentes de Projecto e Seminário.

A avaliação de Projecto e Seminário envolve:

1. proposta do projeto;
2. relatório de progresso;
3. apresentação individual;
4. cartaz e versão beta do projeto;
5. relatório de projeto e discussão pública final.

A avaliação incide sobre o trabalho planeado e desenvolvido pelos estudantes, com restrições de tempo e prazos previamente estabelecidos. Se durante a realização do projeto for considerado que este está em risco, ouvidos os estudantes envolvidos, o orientador e o docente da unidade curricular decidem se o projeto continua. Em caso de desistência do estudante, esta deve ser comunicada ao orientador do projeto e ao regente da unidade curricular.

5.2 A segunda secção deste capítulo

Na segunda secção deste capítulo, vamos abordar o enquadramento, o contexto e as funcionalidades.

5.2.1 A primeira sub-secção desta secção

As sub-secções são úteis para mostrar determinados conteúdos de forma organizada. Contudo, o seu uso excessivo dificulta a leitura do documento.

5.2.2 A segunda sub-secção desta secção

Esta é a segunda sub-secção desta secção, a qual termina aqui.

5.3 Descrição detalhada da solução

A solução proposta assenta nas seguintes ideias. O algoritmo 1 apresenta as ações de pesquisa de um elemento E sobre um grafo G .

Algoritmo 1 Algoritmo de pesquisa em grafo.

Dados: Grafo G , Elemento E

Resultado: Localização de E em G

1. Para todos os vértices v em G
 2. Pesquisar e obter a localização de E
 - (a) Iniciar a lista de pontos, P
 - (b) Ordenar P
-

Nalgumas situações, é necessário apresentar excertos de código que ilustrem aspetos relevantes da implementação.

```
namespace ps;
public static void main() {
    System.out.println("PS - Projecto e Seminário");
}
```


Chapter 6

Testes

Este é o capítulo de testes. É possível forçar a inclusão de todas as referências com [].

Modo de matemática em texto $x = ma^2$ e em equação (duas formas):

$$x = ma^2$$

$$x = ma^2 \tag{6.1}$$

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Appendix A

Exemplo de apêndice

Este é o primeiro parágrafo do apêndice.

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