Yabi - Yet Another Business Inteligence

Vitório Miguel Prieto Cilia - 40920

Dissertação apresentada à Escola Superior de Tecnologia e de Gestão de Bragança para obtenção do Grau de Mestre em Sistemas de Informação.

Trabalho orientado por:

Prof. Albano Alves

Prof. Lúcio Valentin

Esta dissertação não inclui as críticas e sugestões feitas pelo Júri.

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Dedicatória

(Facultativo) Dedico este trabalho a ...

Agradecimentos

(Facultativo) Agradeço a ...

Resumo

O resumo (no máximo com 250 palavras), permite a avaliação do interesse de um documento e facilita a sua identificação na pesquisa bibliográfica em bases de dados onde o documento se encontre referenciado.

É recomendável que o resumo aborde, de forma sumária:

- Objetivos principais e tema ou motivações para o trabalho;
- Metodologia usada (quando necessário para a compreensão do relatório);
- Resultados, analisados de um ponto de vista global;
- Conclusões e consequências dos resultados, e ligação aos objetivos do trabalho.

Como este modelo de relatório se dirige a trabalhos cujo foco incide, maioritariamente, no desenvolvimento de software, algumas destas componentes podem ser menos enfatizadas, e acrescentada informação sobre análise, projeto e implementação do trabalho.

O resumo não deve conter referências bibliográficas.

Palavras-chave: termos (no máximo 4), que descrevem o trabalho.

Abstract

Direct translation (maximum of 250 words) to English of the section “Resumo”.

Keywords: direct translation of “Palavras-chave”

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Chapter 1

Introduction

Chapter 2

Context

TODO: Isso parece mais como uma introducao

As companies and institutions develop, they tend to implement and depend on digital systems [1]. Generally speaking, solutions involve the deployment of a information center such as a relational database or a directory service, Relational Database Management System (RDBMS) being the most common [2]. Once the information center is made available, it is frequently updated with new information that, if not properly processed and made available, does not generate any meaningful insight.

It is not a hard task to give access to the raw information contained within a RDBMS but because of how it is split in logical relations to avoid unnecessary data repetition [3, Part V], technical knowledge is required to harness its potential into a tangible understanding that can help in the decision-making process.

A good system would enable anyone, expert in computational systems or not, to co-relate and extract the information held in their institution, however this is too broad of a scope. Therefore, an approximation of such system that is able to give meaningful insights and handle the most frequent cases is considered good enough even if it requires some manual work by an administrator.

TODO: Acho que esse eh um contexto melhor

With more than 8,500 students and professors, Instituto Politécnico de Bragança (IPB) is composed of 5 schools that span diverse fields of study including but not limited to Education, Administration, Chemistry, Health, Tourism, Biology and Engineering.

Towards the beginning and the end of the semester and during student registration time, professors often need some insights on their educational affairs. To do so, they get reach out to the Academic System department and request in broad terms what they need, the technician then stop his current task, write a Structured Query Language (SQL) script, run it and email back the results as an spreadsheet file.

With time, the technician built a list of about 40 common requests and their respective scripts so that this process takes less of his time, which in turn enables him to further develop IPB's in-house software. However, interruptions still happen often enough that an automated system is still needed.

`TODO:` acho que isso nao precisa vvv Talvez vira intrtoducao

On a daily basis, a lot new information is generated from its many In-house and third-party software. Their custom administrative portal, `On-Line`[1], alone is able to handle many aspects of an student's interaction with the institution, for example, it can manage student balance, internship application, document request, submission of final thesis and reports, reserving meals and managing an electric bicycle rental subsystem called `IPBike`[2]. More specific features are available in function of user roles so that professors, researchers, employees, and course coordinators spend less time and resources into administrative tasks.

[1] https://apps2.ipb.pt/online
[2] http://ipbike.ipb.pt

Chapter 3

Objective

To develop a web platform that exposes SQL scripts to IPB's employees in a convenient way that does not require expert knowledge of the underlying system architecture and eases the technician workload during the institution's critical moments.

Such platform will be maintained by an administrator that is responsible for registering the desired SQL scripts.

Based on their role in the institution, professors and other employees are presented to a list of queries coupled with meaningful title and description in which they can run, see the resulting table and download an spreadsheet file.

As a non-functional objective, the system should be easily maintained by the current Academic Systems department team and therefore should comply to their current technologies.

Following is a translation of the original proposal found in Appendix A:

> Proposal nº 2
>
> To architect and construct from scratch a "business intelligence" system with emphasis on education management. Now a days we know how valuable and important information is for those who manage institutions and the impact that data analysis tools have in the decision-making process. At the time writing, IPB is already provided of a centralized database through which a

large number of SQL of many diverse purposes queries are run. The intention is that, based on certain criteria, provide access to information without having to manually write queries that are often more than 30 lines long.

The proposed system would be fed with "clusters" of queries and provide a way to easily insert and validate individual or group of queries depending on the currently logged-in user's profile.

Keywords are reuse and automatic parameterization of queries that are supported by an automatic web search interface based on the current query.

All in all, its about deploying a intelligent search system that is able to adapt to the necessities and profile of each user. The end result will always be tables of data that can be exported to many different formats

Chapter 4

Concepts and Technologies

Throughout the development of this project quite a few tools and technologies were employed. To address them all, this chapter was broken in three sections; Front-end in Section 4.1, that is focused mainly in user-facing web technologies; Back-end in Section 4.2, which is concerned with the developed Web Application Programming Interface (API) and lastly; Development in Section 4.3, with the tools used to write, build and test this project.

4.1 Front-end

This section is concerned with the description of technologies used to assemble the human-interactive part of this project.

4.1.1 Typescript

" A super-set of JavaScript that compiles to plain JavaScript " [4], Typescript is a language maintained by Microsoft and developed by *Anders Hejlsberg* in 2012 with the goal of improving the quality and manageability of JavaScript code bases with features such as static typing and object-orientated qualities [5]. Ultimately, Typescript must be compiled

to JavaScript before being executed, for compatibility reasons, the default JavaScript target is version ES3 but newer back-ends are also available.

4.1.2 HTML

The Hypertext Markup Language (HTML), the " World Wide Web's core markup language " [6] is a declarative language through which the vast majority of online content is structured, shared and accessed. It is a specification of elements that can be used to structure the content of web pages, such as headings, images, link to other documents, buttons and many others [7].

4.1.3 CSS

Cascading Style Sheet (CSS) is another declarative language that pairs with HTML. Its purpose is to describe how the elements present in a web page are presented. Some of definitions handle colors, fonts, element arranging, visibility, interaction and many others aspects [7].

4.1.4 SASS

Syntactically Awesome Style Sheets (SASS) is a augmentation of CSS with features that are similar to a object-oriented languages, with loops, variables, functions and rule nesting [8]. SASS files need to be compiled into plain CSS before deployment, there are many of such compilers, some re-generate CSS files upon file changes.

4.1.5 Angular

Front-end web framework developed as a side project at Google that proved itself as a valuable tool for modern application development. The core idea is that HTML faults when it comes to declare dynamic content [9], therefore a new middle-ware is introduced between the rendered page and the underling code so that all the elements and events in

the HTML document are captured and made available to its components. Such binding goes both ways, so if the state of the underling code changes, the document is re-rendered to reflect the new state.

The first version of Angular is now called AngularJs and can be included in a HTML document just like any other JavaScript library. This version proved it's value but was considered confusing and some times, slow. Since then it entered Long Term Support (LTS) stage and no features are added. Angular version 2 and up is a Typescript re-write that includes some new features that aid in the architecture and development of scalable and reusable code, namely, the introduction of Components, Router, Ahead-of-Time compilation and Observables [10].

An overview of key Angular elements follows:

Module Internally referenced as a `NgModule`, these are the basic elements through which an Angular application is structured[11]. They declare the elements that will be provided to its child Modules, Services and Components.

Component Binds a Template to behavior and data. Components are the elements that directly interact with the information perceived by an user. They typically rely on Services to acquire information and on Modules to fulfill their dependencies.

Router A special kind of service that is responsible for managing the navigation through an application, mapping Universal Resource Locator (URL)s to Components.

Service Akin to a library, a Service have methods that can be used by multiple Components and other Services to provide some functionality. They are commonly implemented to act as the means of interaction to a remote API.

Template An augmented HTML file that is bound to a Component. Effectively, they are medium through which information is displayed and interacted with. Among other things, Templates can have elements that are dependent of some expression, values that are provided by a Component and events that notify the underlying Component.

The relationship between such elements is that a Component may be dependent on Services, Components and Templates form what is called a View; Views and Routers are exposed to the application under a Module; which in turn forms a tree with a root Module. Other important features include the dependency injection mechanism, template directives and directional data binding. Through these features Angular aims to be a highly modular framework capable of fast development.

4.1.6 Angular Material

Material Design is a set of guidelines and principles made by Google for designing User Interface (UI) that aims to bring natural and consistent interactions between users and computers. The guiding principle is based on paper and ink but it is not limited to what they can do in the physical world [12].

Angular Material [13] is the implementation made by Google of components like buttons, text input and separators that follow the Material Design guidelines to be used by Angular applications, providing a consistent look across devices.

4.1.7 Sb-Admin-Material

To accelerate the development speed and have faster working prototypes, many web-based projects begin form a ready-made template. This saves time by keeping developers from re-writing common pieces of code commonly referred as “boilerplate”.

SB Angular Material is a re-write of the famous SB Admin template [14], a free and open source template developed by Start Bootstrap [15] in Angular using components developed in the previously discussed Angular Material project.

As the name implies this template tries to assess the need for an administrator panel, and in doing so it provides a few ready-made components, to name a few, a login component as seen in figure 4.1; the main screen with a top and a collapsible side navigation components, seen in figure 4.2 and 4.3. This template already encompass some amount

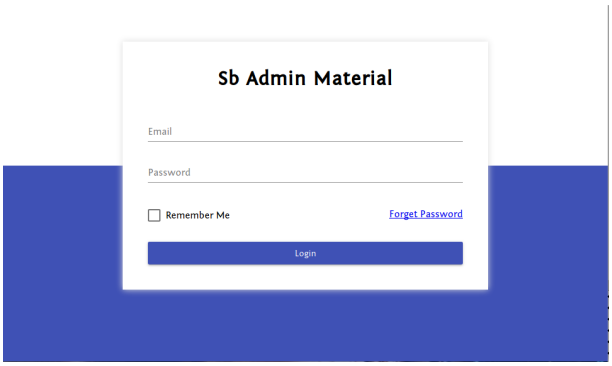

Figure 4.1: Login Screen

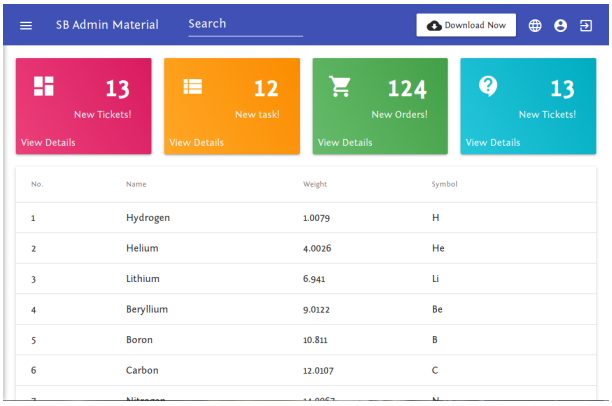

Figure 4.2: Dashboard with collapsed side menu

of responsive design by toggling the ability of said side navigational panel to be collapsed depending on the user's screen width.

In the following subsection this template's folder structure will be explained so that one can understand where what are the main parts in which it can be extended to fit any particular project.

Project Structure

SB Admin Angular was written with the intention of being modified and extended by other developers. Because the team did not express any guidelines towards how it should be further developed, it is important to give an overview of the current project structure so that the changes made to accommodate the topic of this project are better understood.

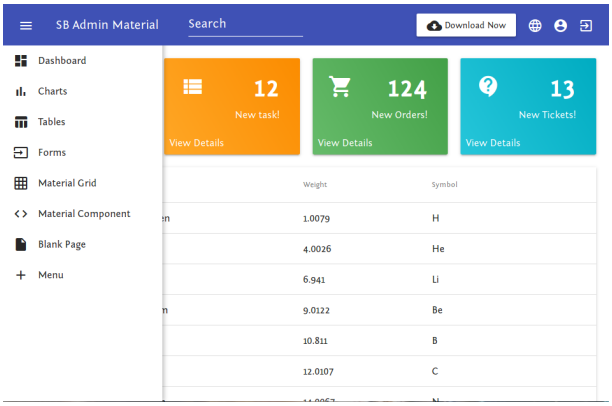

Figure 4.3: Dashboard with visible side menu

- **root** This item is not a folder but the root of the project. In here there are configurations for code linter, JavaScript dependency descriptor and the license statement.
- **dist** Once the project is built for deployment, this directory will hold all the assets and optimized code ready for production, including the main `index.html` file that bootstraps the whole project.
- **e2e** This holds the source code for End-to-End test cases, hence the name.
- **src** This is the heart of this template, a directory that holds all the structure, content and behavior needed per application.
    - **app** The Angular entry-point and application wide router module.
        - ➛ **layout** All the components used to compose the navigational elements and menus and their subsequent pages plus some example pages.
            - **black-page** A inaccessible component that does nothing, probably unfinished.
            - **blank-page** An example component that is white.
            - **charts** A component that display chart capabilities of the integrated JavaScript module chartjs[1].

[1] Available at https://www.chartjs.org/

        - **components** Omnipresent page elements such as the Topbar and the collapsible Sidebar.
            - **topnav** The blue navigation top bar as seen on Figure 4.2.
            - **sidebar** The Menu on the left side of the screen as seen on Figure 4.3.
        - **dashboard** The page in which the user is redirected after logging in.
        - **forms** Demonstration of the many different input methods such as Auto Complete text input, Date picker, Text Area and others.
        - **grid** A demo of the available page subdivisions.
        - **material-components** An example page displaying the main components of Angular Material such as buttons, Dialog and Notifications.
        - **nav** Unused component, deprecated by the side bar component.
        - **tables** A example component displaying Angular Material's table mechanisms.
    - **login** This is the Login component as see on Figure 4.1
    - **shared** Code that can be used in a application wide manner so that higher abstractions and code reuse can be achieved.
- **assets** Static content directory. Images, fonts, and i18n translations.
- **environments** Depending on how the project is run, either in development or in production mode, a the respective configuration file that holds environment constants is used, allowing developers to use the same reference name throughout the code base no matter the environment.
- **styles** SASS files that define the look and feel.

After this overview, it is interesting to note the following:

- The Layout folder hosts, for the most part, Components and Modules that are listed in the sidebar.

- There are some unused components that were probably left over from design changes and were not deleted, which is the case of black-page and the nav component.
- There are many examples that proved as a handy reference during development, namely the forms and material-components.

4.2 Back-end

The tools and concepts described in this section refer to the server-side of this project. It manages the authenticated and authorized data access as well as business-specific functionalities.

4.2.1 Java

Given how ubiquitous it is, there is not much to be said. Java is a Object-Oriented programming language firstly developed by James Gosling at Sun Microsystems, it is statically and explicitly typed and gets compiled to a machine-independent byte code that is then interpreted by the Java Virtual Machine (JVM) [16].

Because of its high adoption, many concepts were developed to accommodate its deficiencies and improve the development cycle. In fact, because of the recurring solutions for recurring situations in software design, a group of skilled professionals got together to discuss and write a book entitled "Design Patterns: Elements of Reusable Object-Oriented Software" [17], bringing the concept of repeatable ways to some problem.

This leads to the next topic, View Model, which was used throughout the development of this project to filter the information that is sent to a non-administrator user, removing from the role of filtering sensitive information to the insecure front-end application.

View Model

The ViewModel is a piece of a bigger pattern called Model View ViewlModel (MVVM) created by John Gossman to address the scenario in which a model as described in the

Model View Controller (MVC) pattern can't be completely mapped to a View [18], therefore it is sensible to specify another model that partially reflects the original model but is able to be completely bound to user interface elements.

During the implementation of this project, the ViewModel pattern was used out of the MVVM pattern, however the goal of decoupling code the same. More precisely, some models can not have all of its attributes serialized back to a View or they expose different attributes depending on the user who is requesting it; ViewModel classes were implemented in such cases.

4.2.2 Spring

Developed by Pivotal Software in 2002, the Spring Framework provides most of the "plumbing" necessary for fast development and deployment of enterprise Java applications [19], some of the main features include: Dependency Injection, a Inversion of Control (IoC) mechanism; Spring Data, a set of tools for information access such as Object-Relational Mapping (ORM) configurations; Spring Security, a application-wide security mechanisms and configurations.

One of the strongest design philosophies of the Spring Framework is the following:

> "Provide choice at every level. Spring lets you defer design decisions as late as possible. For example, you can switch persistence providers through configuration without changing your code. The same is true for many other infrastructure concerns and integration with third-party APIs." [19]

This leads to a feature-centered development model that is able to quickly deliver prototypes and changes on-demand.

Dependency Injection

Conceptually, Dependency Injection is a implementation of the IoC principle, abdicating any given class class from managing its own dependencies; leaving them to a overseer object that knows how to create and inject dependencies to each class[20].

In practical terms, when writing a new class the programmer declare its dependencies through some mechanism in which the framework is able to reason about. Later in the run-time when a such dependent class is about to be instantiated, its dependencies are made available and injected into the new instance.

The key idea is that for the most part an application does not need to know which specific class is provided as long as it implements some given interface. It is the Framework's job to choose which class is injected. The programmer, however, is able to tailor the Framework's behavior to their liking.

When using Spring, one can express dependencies by declaring them in the class's constructor or by annotating an attribute using the Autowired annotation[21].

Data

When developing a enterprise-level application, often times there is the need of a database management system, an authentication provider and other information-centered services. To address this heterogeneous information storages the Spring Data module was developed that bases itself in a single interface named Repository, through which data is accessed[22].

For the general case the following modules cover the requirements of many applications:

- Spring Data Java Database Connectivity (JDBC).
- Spring Data Java Persistence API (JPA).
- Spring Data Lightweight Directory Access Protocol (LDAP).
- Spring Data Represnetational State Transfer (REST)

Note that these libraries are included with the bigger, Spring Data Project.

Hypermedia As The Engine Of Application State (HATEOAS)

REST, according to its creator:

> "REST is a coordinated set of architectural constraints that attempts to minimize latency and network communication, while at the same time maximizing the independence and scalability of component implementations. This is achieved by placing constraints on connector semantics, where other styles have focused on component semantics. REST enables the caching and reuse of interactions, dynamic substitutability of components, and processing of actions by intermediaries, in order to meet the needs of an Internet-scale distributed hypermedia system." [23]

In other words, this "new" architecture expresses requests and responses as the application state itself being transmitted in the client and server approach. There are a few ways in which the state can be communicated and structured, one of which is the subject of this section.

HATEOAS is a response structure that enables a client to discover and navigate related information for that resource[23]. Mainly it is able to specify what are the related information, where it is located and how to interact with it. This is accomplished by including some meta-data in the response in which the client can parse, present to the user and issue proper requests.

In the context of Spring Framework, `CrudRepository` is a interface which can be extended for each class with Entity annotation that needs integration with some kind of persistence mechanism. In its default implementation there is a REST service that is coherent with HATEOAS, providing Create Retrieve Update Delete (CRUD) capabilities; indexing as in listing all entries and internal resource linking, which give the ability to retrieve a resource's related resource (think of if like a RDBMS table relation).

Security

This spring project aims to provide both authentication and authorization mechanisms throughout the application's components, exposing implementable interfaces that enable developers to override necessary parts for their specific needs.

It is important to clarify the distinction between Authentication and Authorization because they have their respective software counterpart that play important roles in Spring Framework.

Authentication, in by definition means "To prove real or genuine" [24]. In Spring this translates to a custom extension of the `WebSecurityConfigurerAdapter` abstract class that defines how to verify that a given user exists and is allowed access the resources. There are a few ways to achieve this, two of the most common are: JDBC authentication, though which credentials are queried and matched from a RDBMS and LDAP authentication, that binds to some remote directory for the given user and password pair. Note that it does not define *what* may be accessed by such user, only if the used has access to the system as a whole.

Authorization, "the act of endorsing, or permitting by some recognized authority" [24]. Similarly to Authentication can also be specified via a custom extension of `WebSecurityConfigurerAdapte` and they can co-exist in the same extension. Authorization mechanisms are usually related to some attribute of the current authenticated user, in Spring, the `GrantedAuthority` interface is the central piece that unifies *what* the user has access to. Authorization points can be defined at the global level by the `WebSecurityConfigurerAdapter`, at the controller level or at the method level though proper annotations.

Boot

Although Spring Framework is a marvelous piece of software for its malleability and wide range of available features, for a while it was considered a *Configuration Hell* because of its eXtensive Markup Language (XML) configuration that would require a lot of expertise into writing [25] [26] [27] [28] [29]. In face of this, the Spring Team came up with Spring Boot, a dependency that can be inserted into a project and provides sane, already-configured Spring packages to accelerate development and keep code organized.

4.2.3 MariaDB

Due to legal concerns Michael Monty Widenius founded Monty Program AB, whose main product, MariaDB, started as a fork of his previous work, the MySQL RDBMS [30]. Such relational databases allow the user to define data structures and perform operations such as inserts, retrievals, updates and removals through a language known as SQL

MariaDB is an open source project licensed under the GNU General Public License (GPL) and its current stable version is 5.2. Its SQL dialect is and configuration files are either identical or very similar to those of MySQL. One of the main goals of MariaDB is to keep enhancing its performance [31]

MariaDB server is said to properly execute in many operating systems, namely Microsoft Windows, Solaris, Linux, MacOS and Free BSD. There are many packages that handle connections to MariaDB, graphically like DBeaver or phpMyAdmin, textually like mycli and not further than that, programming language connectors such as Java's JDBC [32].

4.2.4 Apache Directory Studio

LDAP in its core is a protocol defined by Internet Engineering Task Force (IETF)'s Request For Comments (RFC) number 4511 [33] that defines access to X.500 compliant directory services. A Directory is an agglomerations of cooperative systems that serve structured information about the real world [34]. Different from a traditional RDBMS, directory services are expected to be automatically accessed by other interconnected systems, therefore they are better optimized for frequent queries and fewer updates.

Alex Karasulu, founder of the Apache Directory Project, was right when he stated that the need for interconnected systems grew alongside the expansion of the Internet but unlike his expectation, Directory services were replaced with RDBMS systems that don't exactly address the same goals and further complicate interconnected systems[2].

Given this situation, his project have the goal to modernize the tooling and functionalities of Directory systems and in doing so, two main sub-projects were created: Apache

Directory Service [35], a modern, LDAPv3 compatible, Java based implementation of a Directory Service that introduces triggers, stored procedures, view and queues; Apache Directory Studio [36], a complete LDAP tool developed as an Eclipse Rich Client Platform (RCP) extension that offers a more friendly user experience with visual elements for LDAP Data Interchange Format (LDIF) editor, tree explorer and permission management.

4.3 Development

This section cover the tools used during the development phase of this project. The tools in question do not only satisfy the coding needs but also mimics the production environment through which the application interacts with so that no sensitive information was touched by a potentially insecure, unfinished application.

In general, there was a need to comfortably edit Java and Angular projects, with code completion and refactoring support; a project manager that automatically downloads dependencies; a container tool to quickly deploy an environment with databases and directory services, without the need of editing non-functional configurations and lastly, a browser to access the system as the end-user would.

4.3.1 Apache NetBeans

One of the Duke's Choice Award winner [37], NetBeans is a general-purpose, cross-platform Integrated Development Environment (IDE) mainly focused for Java development with the goal to maximize productivity. In 2016 NetBeans was added to the Apache Incubator so that it could be further developed by the community [38], as of 2019 it became one of Apache's Top Level project [39] and is expected to attract a even bigger community.

Because Java was the main focus of NetBeans during its first few years, support for the language is very broad in features. Developers can easily operate code with context-sensitive refactoring; mark line, method, expression and class breakpoints; step through paused code; automatic JavaDoc generation; semantic code completion and more [40].

Through its module system, support for other languages and resources were introduced, namely source code management with Git, Mercurial and Subversion, database management with support for viewing data and running SQL queries, unit testing, PHP, HTML, JavaScript and CSS [41].

4.3.2 Maven

Maven is a Build System for mainly used for Java applications, that is: Through a the `pom.xml` file, developers declare their project's attributes and dependencies file and if needed, tweak the building process; from there on, Maven is capable of downloading dependencies from a remote repository, compiling them if necessary and generate an executable Java ARchive (JAR) file or loadable library [42].

The project goal is to unify the project structure so that there is less time spent by the developer to understand how the a given application code is arranged and to centralize common project actions such as previouly mentioned dependency resolution, run unit and integration tests and generate packages that are able to be distributed [43].

4.3.3 Lombok

This plugin offers an annotation-based code-scaffolding tool for class definitions. Give the right annotations, common methods like getters, setters and no attribute constructor are automatically generated in build or compile-time [44]. This tool consists of a two-part system that includes the integration with the compiler/build-system and another one that interacts with the developer's IDE so that the completion system is able to recognize the implicitly generated methods.

Some of the notable annotations include:

- `@Data`, useful for Plain Old Java Object (POJO) classes, this annotation generates getters, setters, a string converter and equality methods.

- `@NoArgsConstructor` and `@AllArgsConstructor`, as the name implies, one generates a constructor that takes no arguments and the other, a constructor that generates all arguments.

At first glance this might not be a necessary tool given that most IDEs often have support for a similar form of code refactoring but the key difference is that lombok does not clutter the classes with generated implementation therefore it reduces the project's Line of Code (LoC) count.

4.3.4 Visual Studio Code

Microsoft's take on open-source, this code editor gained traction among developers as one of the most used code editors [45]. Like any other modern code editor, it offers syntax highlight; auto-completion, though Microsoft's *IntelliSense* integration and a plugin system that enables users to add custom behavior and further develop the editor's support for programming languages [46].

One of the acclaimed features that arose with Visual Studio Code was the open source specification of Language Server Protocol (LSP) [47]. This specification aims to define a communication protocol that is used between a code editor, referred as a LSP client and a editor-independent program referred as a LSP server, that takes care of features such as code completion, highlight, error detection, contextual variable renaming and jumping to definition [48]. This decoupling reduces the amount of code needed to develop a highly capable editor because language-dependent support is now transferred to said LSP server.

4.3.5 Docker

Akin to a Virtual Machine (VM), containers provides a way to have a different computing environment than the active running in the hardware. The key difference is that instead of emulating the whole computing stack, from processor to applicaion, a container system shares the core host resources with its guests and thus is generally less resource-hungry.

One downside of a container is that the guest operating system must share the same kernel with the host.

In the other hand, Docker is more than just the sandboxing of processes, handling image building through a `Dockerfile` specification, containers that can be shared among different machines, a online registry of extendable containers, a command line interface that downloads, builds and manages containers [49].

Core Docker definitions are brought up [50]:

Dockerfile A file that declares the steps taken to build an Image [51].

Image A blueprint of a container generated once a `Dockerfile` is built.

Container If an image is an compiled binary, a container is the running process.

Volume Is a shared folder between the host Operating System (OS) and a running container.

4.3.6 Docker-compose

The flexibility offered by the Docker ecosystem is of great use for moderate applications. Define a `Dockerfile`, build it into an image and create a running container. However, not all solutions require a single image, in fact, most of them are composed of independently working pieces that are tailored together and bundling all pieces in a single image is not considered good practice [49].

Distributed with Docker, this tool provides a way to define a multi-container applications, their virtual connections and manage all containers as one single entity. Such separation of concerns enable the tool to take smarter choices when starting a solution that includes a modified image, preserving volume data between solution runs and on the development side, it makes a local instance of a solution to be quickly deployed to testing purposes [52].

4.3.7 Chinook Database

This is a single-script data-set. Structured in many SQL dialects, it represents a digital media store and in total it contains 11 tables, 11 constraints, 66 columns and 15607 rows [53]. The data used for this project was generated from a real iTunes library, sales information was randomly generated and customer and employee were manually inserted [54].

List of Available dialects:

- MySQL
- SQL Server
- SQL Server Compact
- SQLite
- PostgreSQL
- Oracle
- DB2

Such diversity in dialects, structural complexity and amount of information makes the Chinook Database a good sample for database-generic applications.

4.3.8 Angular CLI

Angular applications have a basic directory for its components. Often times a directory contains most of the code for a specific piece of an application, such as a Component definition, a Service, a Template, a Style definition, a Class definition and lastly, these related pieces are then declared in a Module definition.

Managing this volume of files and relations can sometimes lead to confusion. Angular Command Line Interface (CLI) was developed to make this task more manageable. With it a developer can quickly initialize a new application skeleton, generate Components and

Modules, build a deployment-ready applicaion and run a testing server that re-compile with code changes [55].

4.3.9 Firefox

From the downfall of Netscape browser and the release of its source code, the Mozilla project started with the mission to ensure the Internet to be a global public place, open and accessible to all [56]. Its main product is the open source web browser, Firefox.

Firefox comes bundled with plenty of tools that facilitate web development, considered as the most valuable are the following:

Source Mapping Is the ability to map some generated code back to its source. Some web frameworks like Angular4.1.5 generate applications that are not developed in JavaScript itself but compiled to JavaScript in order to be executed [57]. In the beginning this led to great confusion because the browser's built-in debugger would display not the original source but the generated code.

Debugger Support for breakpoints, conditional breakpoints, expression stepping and variable lookup. Even better with the previous element [58].

Network Monitor Often times it is needed to inspect the outgoing requests and their responses. The integrated monitor is able to expose all elements of the communication exchange and measure the different attributes of a network operations [59].

Storage Inspector Provides access to the information storage that is managed by the browser for each page [60], namely:

- Cache Storage
- Cookies
- Indexed Database (DB)
- Local Storage
- Session Storage

Console Enables the input of expressions in the page context and output information associated to the current page, including explicit calls for the `console.log` function.

Page Inspector Examine the page's HTML structure and CSS rules [61]. Developers can quickly experiment new possibilities by temporarily altering CSS rules and the page's structure.

4.3.10 Webpack

With the growing complexity of web applications, websites got slower and development, trickier. Webpack was developed to generate a optimized, ready to run, package that can be deployed in production [62]. Such packages are not meant for code only, they may contain images, CSS rules and anything else. It offers an API that can transform the contents of a package before it is bundled, for example, Typescript sources and its compiled counterpart or extracting inline CSS from a HTML document into a separate file.

In the context of Firefox's debugger and an angular 2+ applications, when serving the application using Angular CLI, discussed in Section 4.3.8, it automatically bundles Typescript source code so that it can be instrumented and debugged inside the browser by accessing the Webpack element under the debugging tab.

4.3.11 Postman

As programs grew larger and were split into smaller pieces, it is now a common practice to have a API that concentrate on the business logic and a Graphical User Interface (GUI)s that consume them; Such separation of concerns got even more pronounced when Web systems popularized, web browsers acting as GUI and interacting with remote Hypertext Transfer Protocol (HTTP) servers as their source of information.

As with any software, APIs need to be tested and validated in order to provide a good quality product. In this context Postman was developed to be a Web API suite, offering a nice user interface through which developers can not only send, receive and

analyze HTTP requests but also generate and manage documentation so that front-end and back-end teams have a single source of truth, manage test cases for remote HTTP APIs, mock API that are still under development and more [63].

Chapter 5

Project

5.1 Requirements

Permissions is a central piece of this system. It's what associates users with information. Permissions follow a hierarchy. There is a root Permission whose path is simply "/"

There are two roles that any given user may be assigned to, either Administrator or User.

Users can only access information in which they are given permission to.

Administrators may aceess all information.

5.1.1 Use-cases

5.2 Class Diagram

5.3 Template Sb-Admin-Material

5.4 Multi-Database Support

Chapter 6

Implementation and Results

6.1 Front-end

6.1.1 Component Structure

Services

Modules

Dialogs

6.1.2 Generic Form Control Builder

6.1.3 Spring HATEOAS Classes

Entity Class

Acessor Class

Repository Class

Repository Service Class

6.1.4 Temporal Caching Repository

6.1.5 Error Handler

6.1.6 Database Reader

Chapter 7

Conclusion

Chapter 8

Future Work

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Appendix A

Proposta Original do Projeto

A.1 Proposta nº 2

Pretende-se desenhar e construir de raíz um sistema de "business inteligence" aplicado à gestão letiva. Sabemos bem o valor e a importância que a informação tem hoje em dia para quem gere instituições e as mais valias que as ferramentas de análise de dados trazem para a tomada de medidas e decisões. O IPB tem já uma base de dados centralizada à qual é aplicado diariamente um grande número de queries em SQL para os mais diversos fins. Pretende-se abrir o acesso a esta informação de forma criteriosa mas sem implicar a escrita manual de queries muitas delas com mais de 30 linhas de código.

O sistema seria pré-alimentado com "clusters" de queries mas teria uma característica evolutiva que daria a possibilidade de introduzir de forma fácil, suportada e validada novas queries ou novos grupos de queries, dependendo do perfil do utilizador.

As palavras chave serão a reutilização e a parametrização automática desses grupos de queries suportadas pela geração automática de interfaces web de pesquisa de informação, tendo por base o tipo de query a implementar.

Trata-se da disponibilização de um sistema de consulta inteligente no sentido em que se adapta às necessidades e ao perfil de cada utilizador. O resultado final serão sempre tabelas exportáveis para os mais variados formatos.