THESIS

Application-Website for Sports Performance Testing

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To my dearest family, my father George, and my mother Evangelia, to my siblings and my husband, John, who have supported my aspirations every step of the way, and from whom I am certain I will always find inspiration and motivation towards pursuing higher things in life. I would like to also extend my thanks to close friends and colleagues who have undoubtedly been the most motivating individuals during this period through words of encouragement and support.

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ABSTRACT

The purpose of this thesis is the designing and development of an application for physiotherapists, doctors, and coaches, which will help to quickly gather all the necessary information they need without losing time on testing or the analysis video. Hylyght clients spend a lot of time on testing and gathering data. The analysis takes too much time and there are a lot of open-source options to assess these tests automatically. This holds them back, it's always an effort to test and screen; even though objective data are more and more important. We want to help them by automating some of the tests and offer a user-friendly web-based app, which is linked to their cloud platform. In this thesis we are going to examine the problems that they are facing and our solutions as a team.

The project consists of website development, a mobile version, and a tablet, where in each of them we have to:

1. Add more options such as sort or filter by test/Athlete, Add a new test/Athlete,

2. It has to be a user-Friendly Interface,

3. Adding new Features such as QR-Code, Video Analysis,

4. Keep the existing Design Language (Vue) so team of Hylyght can do easily changes

ΣΥΝΟΨΗ

Σκοπός της παρούσας εργασίας είναι ο σχεδιασμός και η ανάπτυξη μιας εφαρμογής για φυσιοθεραπευτές, γιατρούς, προπονητές, η οποία θα τους βοηθήσει να συγκεντρώνουν γρήγορα όλες τις απαραίτητες πληροφορίες που χρειάζονται χωρίς να χάσουν χρόνο στις δοκιμές ή στην ανάλυση βίντεο. Οι πελάτες αφιερώνουν πολύ χρόνο σε δοκιμές και συλλογή δεδομένων. Αυτό τους κρατά πίσω, είναι πάντα μια προσπάθεια δοκιμής και προβολής. παρόλο που τα αντικειμενικά δεδομένα είναι όλο και πιο σημαντικά. Θέλουμε να τους βοηθήσουμε αυτοματοποιώντας ορισμένες από τις δοκιμές και να προσφέρουμε μια φιλική προς τον χρήστη εφαρμογή βασισμένη στον ιστό, η οποία συνδέεται με την πλατφόρμα cloud τους. Στην παρούσα πτυχιακή θα εξετάσουμε τα προβλήματα που αντιμετωπίζουν και τις λύσεις μας ως ομάδα. Το έργο αποτελείται από ανάπτυξη website, έκδοση για κινητά και έκδοση tablet, όπου σε καθένα από αυτά πρέπει να:

1. Να υπάρχουν περισσότερες επιλογές, όπως ταξινόμηση ή φιλτράρισμα ανά δοκιμή/αθλητή, προσθήκη νέας δοκιμής/αθλητή,
2. Πρέπει να είναι μια φιλική προς το χρήστη διεπαφή ,
3. Προσθήκη νέων λειτουργιών όπως QR-Code, Video Analysis,
4. Διατηρήστε την υπάρχουσα γλώσσα σχεδίασης, ώστε η ομάδα του Hylyght να μπορεί να κάνει εύκολα αλλαγές.

Table of Contents

List of Figures

Table Index

Notation and Glossary

CSS	Cascading Style Sheets
DOM	Document Object Model
HTML	Hyper Text Markup Language
MVVM	Model-View-ViewModel

1. INTRODUCTION

This thesis is part of an international Erasmus+ project named Blended-AIM (Academic International Mobility) (*Mobility, n.d.*), where students from Educational Institutes around Europe formed a team to develop an application requested by a company. A student takes part in a traineeship advertised by a private company. The company offers flexible working conditions for their employees and does not require their trainees to be present at physically all the time. The trainee takes part in virtual team meetings and their attendance could be part of the evaluation criteria. This thesis aims to document the work developed within the scope of the curricular unit Project/Internship, of the Degree in Informatics Engineering of the HMU (Hellenic Mediterranean University) Heraklion, Crete. Its main objective is to consolidate the skills acquired during the course, in a real work environment, in order to prepare the participant for their integration in a professional context. This Project/Internship was carried out at Hylyght, which is a Startup of the Interuniversity Microelectronics Center (IMEC). The project consists of the implementation of a website, to be used by therapists, which will allow them to speed up the exercise of their functions, since it allows them to observe the results obtained in loco. Using this website, therapists will be able to carry out a detailed analysis of the exercises applied to the athletes, obtaining an immediate record of the values achieved. This project emerged as a great challenge, as well as a great opportunity since it brings together two very distinct and essential aspects nowadays: one multicultural and the other multidisciplinary. The team was composed of 7 students, all of them from different countries, namely Portugal, Scotland, France, Germany, Luxembourg and Greece. The students also belonged to different areas, such as design, marketing, sports and programming. In this way, it becomes possible to acquire a wide range of skills, both at an academic and personal level. In this way, it becomes possible to acquire a vast set of skills, both at an academic and personal level.

1.1. Outine

Health informatics is a multidisciplinary area that aims to apply information and communication technologies in health care, to improve quality and increase the expanding of these services, reducing costs and increase availability and accessibility. The “Hylyght” company (*Hylyght, 2023*) produces software aimed at physical therapists, primarily for injury prevention, athlete rehabilitation, talent identification and the growth of young athletes. Thus, the need arose to create a website that would accompany the daily work performed by physical therapists. Therapists increasingly value the time they need to perform a certain task because the more time they spend with an athlete, the less time they will have to dedicate to others, needing support in their daily tasks. It would, therefore, be convenient to have a digital tool that would speed up part of the work and even perform some of the tasks, such as certain measurements or analyzes of the human body.

1.2. Aims & Objectives

According to the needs presented in the description of the problem, it was intended to develop a solution that would allow accelerating the efficiency of the tasks to be performed by the therapists. The objective of the internship is to implement a website in VueJS that accompanies therapists in their daily tasks, in particular, integrating physiological tests in order to accelerate their application. This website should incorporate a user-friendly interface, so that it is commonly used by therapists. These will start the process by creating the athletes' profiles. Each profile can contain several data items such as personal data (Name, Age, Height, Weight, Sex) or notes (Day, Process, etc.). Everyone can be placed in one or more groups or subgroups. Then comes the process of selecting the athlete(s) and choosing the test (or choosing to perform the screening of a set of tests) that you want to be executed. At the same time, there is also the possibility for the therapist to upload a video and receive the results of it automatically. Through artificial intelligence mechanisms, the analysis of videos will present results with increasing reliability.

1.3. Blended AIM (Academic International Mobility)

Blended AIM (Academic International Mobility) (Mobility, n.d.) is an Erasmus+ funded project made to promote students' employability and support companies hosting internships. Every year 10 educational institutes from European countries, like Portugal, Greece, Belgium, United Kingdom, Germany, France, and Austria send up to 4 students each to form a team. The purpose of that is to support the students develop soft skills in an international environment by means of blended mobility. At this moment, a student's professional career depends on mobility and demands certain intercultural skills. However, most institutes don't have courses that provide international exposure.

Blended mobility helps the students adapt and learn but it's hardly considered, let alone as used, a solution to international mobility's problems. Blended Aim sets the foundation to promote and test blended mobility by providing the resources, training, supporting tools, and information to the students and the companies that host internships. Every student who takes part in blended brings knowledge and skills so that he can develop not only as a student but also as a person since we had the opportunity to meet people from all over Europe. Undoubtedly the blended aim is an unforgettable experience.

1.3.1. How Blended Works

Every year at its beginning students from 10 educational gather to take up a project given by a company. That project is considered as a course and each student gets ECTS after the project's completion. The students are from different study fields such as computer informatics, graphic design and business management so that the project can be completed. The project is usually product that helps solve some of the company's problems. During

the time of the entire project there are two important meetings. In the first one the students meet with each other, their professors and the company's representatives to discuss how to approach the project and how to work on it effectively (Kick-off Meeting). In the second one the students present the product to the teachers and the company's representatives and after that they get appraised by the teachers (Final Meeting). During the time between the two meetings, the students perform online meetings to showcase their work and discuss with each other their ongoing work and the problems that they may be facing.

1.3.2. The History of Blended Mobility

Blended Mobility is the sequel of former collaborations between several European universities. One of the most valuable predecessors is the MUTW project (Multinational Undergraduate Teamwork - funded by ERASMUS KA2 - 2009). This Erasmus project's main goal was to strengthen the students' communication skills by organizing them in an international, multicultural team. In the very first phase, we simply had an international team of IT students working together on a common project, collaborating mainly online. As a second step, we extended the student team with members from other study areas. Next to IT students, designers got involved, as well as students from Business Development and Management. The technical outcome was enriched with design and the resulting product was accompanied by a real business plan. Students learned to communicate throughout the borders of their own discipline. In between the former MUTW project (2009-2011) and the new Blended Mobility project (2016-2018) we ran several editions on our own. During this period, we extended our goals by involving companies as providers for real project proposals. With this professional involvement the students get a context which is international, multicultural, multidisciplinary, and professional. Today some of the partner universities integrated Blended mobility as a course unit in their curricula.

1.4. International Symposium on Ambient Intelligence & Embedded Systems (AmiES)

The International Symposium (*International Symposium , 2023*) has been held for almost 20 years. What is an international symposium? The International Symposium is organized by the Office of International Programs and highlights the ways CSU students, faculty, staff, and partners add global dimensions to their teaching and learning, research, and community engagement. What is the purpose of symposium? The purpose of a symposium is to typically allow experts in a given field to meet, discuss papers/topics in question, and examine the issues and trends associated with the topic. The findings from a symposium can be used to help others within the field of research and can endure testing if applicable. The aim of this is to give and receive knowledge and experiences in the fields of Ambient Intelligence, Embedded Systems, Internet Programming, and Information Technology.

In the context of the International Symposium (AmiES, 2022), our application was described and presented by Dr. George Papadourakis. Additionally, the corresponding paper was written for the application. (*Giorgos M. Papadourakis, Blended Mobility Project, 12th Edition 2022: Application for Sports Performance Testing, an Interior Design Application and a Hospitality Management System", 19th International Symposium on Ambient Intelligence and Embedded Systems – AMIES 2022, 2022*)

1.5. Structure of Thesis

In addition to the introduction, this thesis contains 4 more chapters. As already seen, in the introduction chapter, a brief presentation of the project is made, referring to the context in which it is inserted, the description of the problem, its objective, the approach used during the work, the contributions that it has in the society, the importance in the company and the planning defined in the execution of the project. In general, this chapter aims to make the reader aware of the context of the project.

In Chapter 2, Fundamentals are described, which includes the Agile methodology and the Analysis & Development Tools that we used for the implementation.

In Chapter 3, the state of the art is described, which includes a summary of related work and existing technologies, with a focus on objectives and contributions to the problem to be solved.

In Chapter 4, the analysis and design of the solution appears, where the problem domain, functional and non-functional requirements, as well as the project design are presented.

In Chapter 5, the implementation of the solution is described and is mainly dedicated to the presentation of details related to the framing and implementation of the solutions recommended in the previous chapter.

In Chapter 6 comes the conclusion, in which the analysis of the results obtained, objectives achieved, limitations and future work to be carried out in the application and, finally, a final appreciation of the work carried out.

2. FUNDAMENTALS

For the development of the project, a sequential approach was adopted, using an iterative and incremental methodology. As far as the website is concerned, we split with my team our tasks, so I took the test's part, and one of team's member took the athlete's part. I started by trying to write various messages in my code and then depicting them on the site. Later, I started making my own methods always with the help of Vue's documentation. The Agile methodology (*Agile, n.d.*), illustrated in Figure 1, is characterized by the division of the project into small parts, thus making it simpler to understand priorities and introduce changes in the development of the same, if necessary. In a first phase, the required functionalities were defined, and they were prioritized. Then, the design phase began, where the necessary documentation was prepared in order to carry out the development of the project. Subsequently, several essential decisions were taken, from the implementation mode to the workflow. In a second phase, the development of the project began, where all the steps outlined in the design phase were followed. Later, the testing phase began, that is, all the features developed were tested and the irrefutability of their implementation was evaluated. Finally, the submission and feedback phases were carried out, that is, the phase in which all progress was demonstrated and in which aspects to improve were agreed. After the completion of these phases and given that the Agile methodology is iterative and incremental, the initial phase was returned, and new tasks were defined.

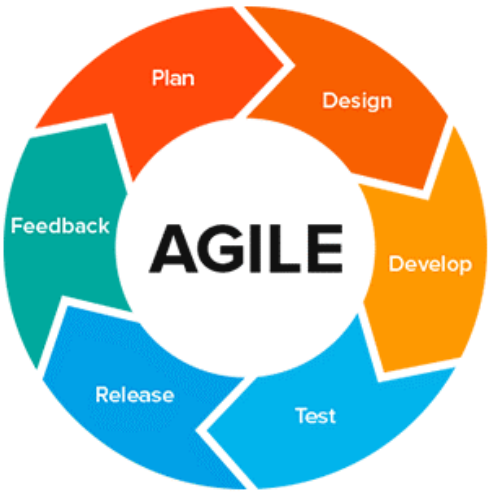

Figure 1-Agile Methodology

2.1. Analysis & Development Methods

2.1.1. Microsoft Teams

Microsoft Teams (*Microsoft, 2017*) is an open application where you can receive and send messages at no cost. It is an online workspace for real-time collaboration and communication. In addition, you can have meetings, sharing files and folders and applications. So, everything is in one place, all accessible to everyone. As a team we used the teams for the intermediate communication all the time we worked, as well as the meetings with the client (This is illustrated in Figure 2).

In addition, we have integrated the Trello platform into the Microsoft Teams so that we have a program for our goals. Throughout the coronavirus pandemic, Teams, along with the zoom platform, received a particularly high level of interest as several meetings were now transferred to a virtual environment because all schools and universities had to teach via tele-conferencing. Even most employees worked from home through the team's platform.

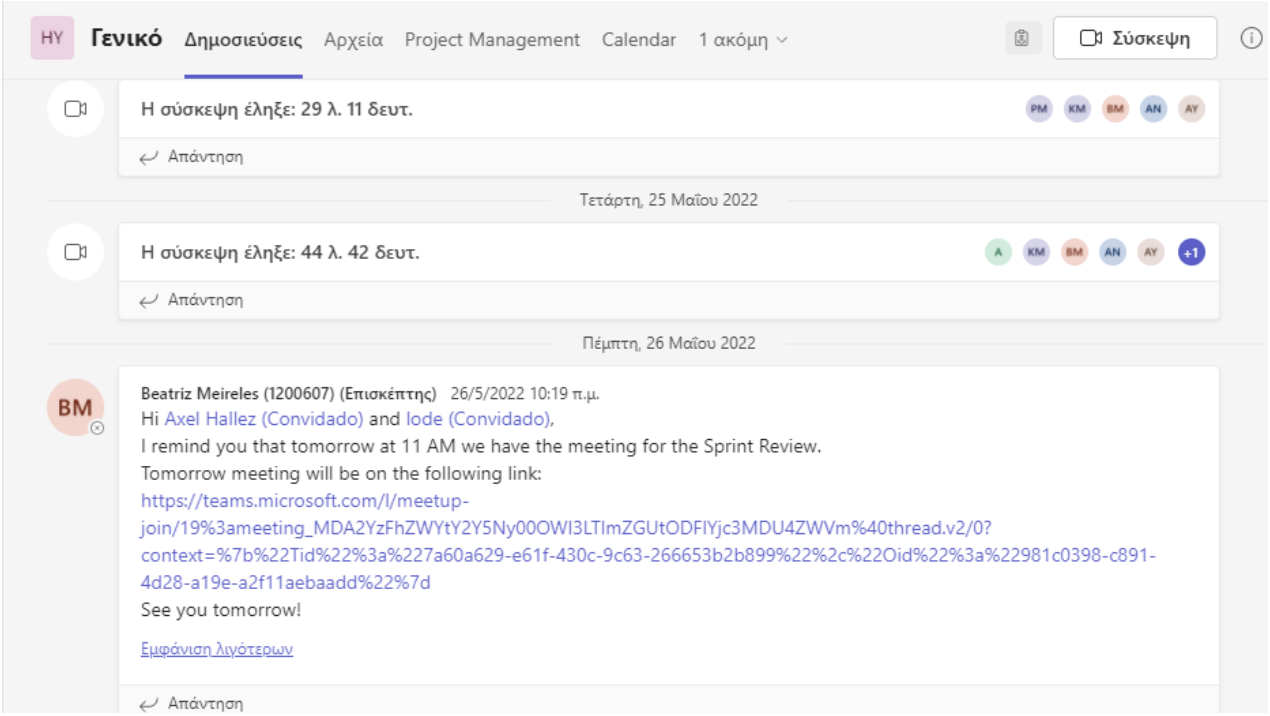

Figure 2-Microsoft Team's Meeting

2.1.2. Trello

What is Trello? Trello is a platform which we can use for organizing our tasks. We can add files, checklists or even automation: adapts it all to how the team works best. The only step is to register, create a table and that was it. Trello is like an electronic agenda. It has "To Do" list, where you can write your plans for the next days. In addition, it has an "In progress" card where you can set the goals where you currently work. It has a "Done" list, where you can put the things you finished, as well as a "Blocked" list to set goals that are difficult for you and cannot be solved. In that way, we all know about our progress, and we managed to have everything organized and planned (This is illustrated in Figure 3). In Trello, clients had access too, so they could know about our progress, what we were going to do, and what goals had been achieved. (*Joel Spolsky, 2011*).

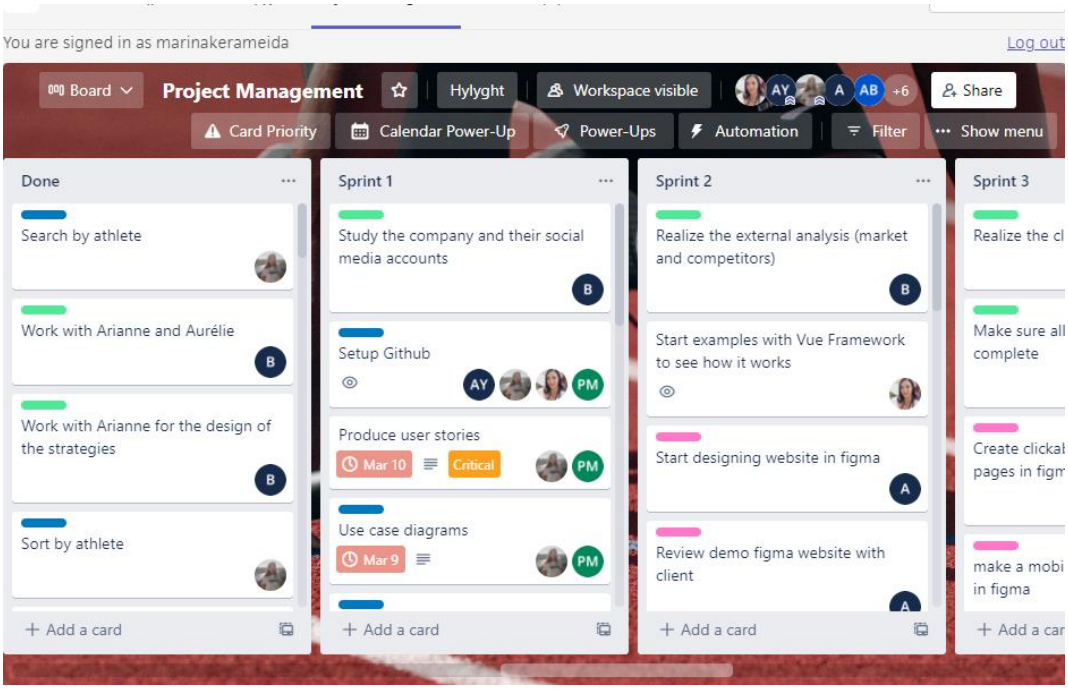

Figure 3-Trello Platform

2.1.3. Task Scheduling

Initially, the duration of the Sprints was defined, being these two weeks, as illustrated in Figure 4. Next, a schedule was drawn up and it was defined that the main meetings would take place fortnightly. In this way, on Mondays, the team met with the aim of carrying out the Sprint Planning and on Fridays, also fortnightly, the Sprint Review was carried out in meetings with the client and with the internship supervisor. Finally, the Sprint Retrospective was held, with only the team members, also biweekly, on Fridays, where the positive and negative aspects of the course of the Sprint. In addition to the above, the team held Daily Meetings on Mondays, Wednesdays, and Fridays, in order to find out about each one's progress throughout the project. All the students of the team were always cooperative and willing to help each other so in each sprint we could record the

improvement and development. As a team we were totally understanding if someone couldn't attend our daily meetings due to course load, since it was exam period, so we made sure that they were always informed about our discussions and the improvement of the project. Additionally, apart from the scheduled meetings with the clients, when we needed them urgently for a problem there was always time for a quick meeting in order to quickly find a solution.

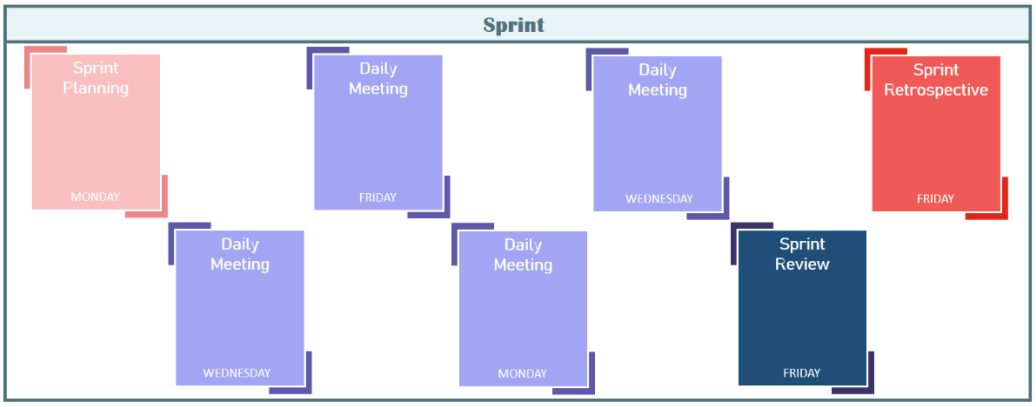

Figure 4-Planning a Sprint

As we can see in Figure 5, the planning of the work carried out. The graph represents the various stages of the project and their respective duration in weeks. The duration of the goals and the stages of the project were jointly decided by the team.

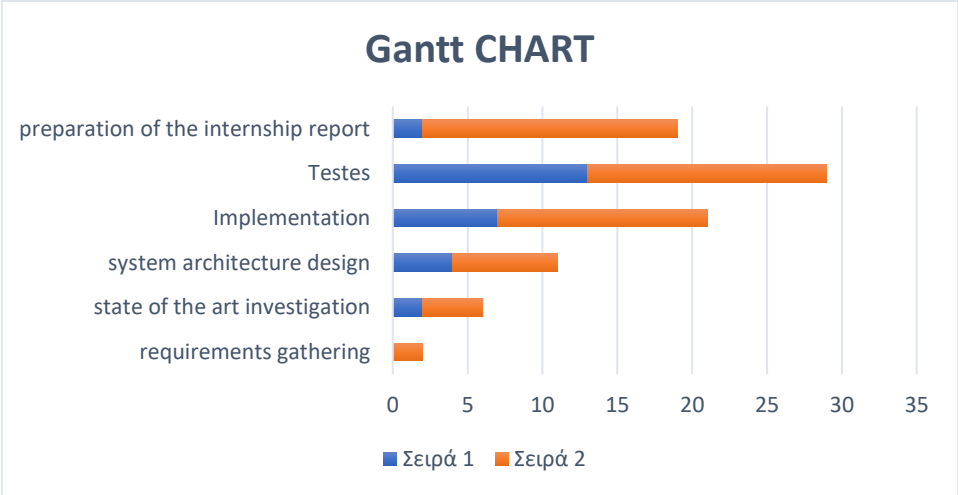

Figure 5-Gantt Chart

Through the chart, in the first two weeks, a requirements survey was carried out so that we could learn the programming language and its documentation, the methodology we would use, the search for the necessary skills that we would have to develop for the project, and then a study on the state of the art, also lasting two weeks. In the following three weeks, the system architecture design was elaborated so that, later, the solution could be implemented, which took seven weeks. Finally, we moved on to the testing phase, which lasted two weeks. In addition to the above, this report was also being carried out at the same time.

3. WORK PLAN

3.1. State of the Art

Over the years, technology has evolved rapidly, thus helping to solve various problems in the field of health, industry, etc. This chapter presents an approach to the present, from a technology, with an introduction to related works and technologies already that had the purpose of identifying the problems to which it is intended to address answer.

3.2. Related Works

In the study area of the project, based on software for therapists, it was found that this is a rapidly growing area that has proven its ability to increase the quality, scope and effectiveness of services, with a number of considerable amount of studies and application proposals, both mobile and web-based, to offer possible solutions for monitoring the physical condition of athletes. Next, we analyze some of these applications.

3.2.1. Optojump

The Optojump (*OptoJump, n.d.*) is an optical measuring system composed of a transmitting bar and a recipient ,as illustrated in Figure 6. The transmitter bus LEDs communicate continuously with those on the bus. recipient. The system detects any interruptions in communication between the buses and calculates its duration. This makes it possible to measure flight and contact times during the execution of a series of hops with an accuracy of 1/1000 of a second. From these basic data fundamentals, the dedicated software makes it possible to obtain a series of parameters linked to the athlete performance with maximum precision and in real time. the absence of parts moving mechanics guarantees precision and great reliability. Optojump Next goes beyond the acquisition of numerical data: thanks to small cameras that can be positioned as desired, allows the recording of images of the tests performed, synchronizing them perfectly with the measured events. This allows take advantage of the cross between data and images and those arising from of a more detailed video analysis by exploring the possibilities offered by the dedicated utility. Movie sequences and all other data are stored in the database. That allows you to consult them at any time and, as with numerical data, make comparisons between the performances of different athletes or the same athlete in different moments.

Figure 6-Optojump Test

Optojump has several similarities with Hylyght, namely regarding to the introduction of the athlete's data, the performance of the tests and the respective results. Nonetheless, it was found that the Optojump user, during the test, receives three types of real-time feedback: numerical, graphic and video (from one or two webcams), unlike Hylyght which only returns numerical feedback. However, there is always the possibility for the therapist to upload a video and receive the results of the even immediately. Once the test is confirmed, the three types of Optojump data are saved and remain available for immediate review or future reference. As with Hylyght, there is also the possibility of recovering tests performed previously to any time. Unlike Hylyght, the speed of the video displayed by Optojump can be reduced to "frame by frame" or still image.

3.2.2. My Jump

The My Jump application was the first to appear on the market and that allowed to know, in real time, the value of the jumps, namely: the height of the jump, the execution speed, the impact force and which is the best jump. Given the high sensitivity of My Sensors Jump, the application allows you to calculate jumps even a few centimeters. It also gives the opportunity to choose between two units of measurement (meters and centimeters). After the jump, a voice automatically transmits the height of all jumps performed. The vertical jump is important in many sports and discovering this through an application has become an asset for physical therapists. (*Robert Stanton, 2015*).

3.2.3. My Jump 2

My Jump 2 is the only software that calculates the force-speed profile using the Samozino's innovative method. Through this application, the physiotherapist can know the strength theoretical maximum, speed, power and how far the athlete is from their ability's ideals. It can also obtain information about which quality (strength or speed) should work to

increase maximum performance. In addition, it provides the contact, the vertical stiffness and the reactive force index of the jumps.

With an excellent design, and validated by sports scientists, My Jump 2 provides advanced jump information using the smartphone or tablet camera and analyzes the evolution of the athlete's performance over time. This software also calculates different types of jump: jump with counter-movement (CMJ), squat jump (SJ), drop jump (DJ) and free arms (CMJ). My Jump 2 has been scientifically validated using devices with camera video slowly for the most accurate results. On other older devices, such as the My Jump, measurements are less accurate but still reliable. (*Balsalobre, 2021*).

3.2.4. HUDL Technology

The HUDL Technique is a very useful tool for the physical therapist, a since it allows you to analyze videos in detail through the following resources: videos in slow motion, compare two videos side by side, use a drawing tool, and measure or highlight something in the video. It is primarily marketed as a training tool to help improve athlete performance by perfecting technique and movement through analysis of them, during training, competition or game and allows comparison with athletes of elite and professionals. However, biomechanical analysis remains quite subjective, regardless of the analysis technique. In turn, the ability to analyze the race, or any sporting movement in a controlled manner (for example, in an office) or during training, it can have many additional benefits in sports medicine. Despite the benefits, the author states that the application should be used with caution, due to the subjectivity of interpretation. Furthermore, the validity of biomechanical changes is still unclear and may increase the risk of sports injuries. The evaluation of standards spatiotemporal gait provides essential information about functional capacity, stability, risk of falling, selection of therapeutic intervention, assessment of progress and patient mortality. The application allows different forms of evaluation of different aspects of gait, including visual observation, functional assessments, recorded measurements by video and three-dimensional motion analysis software. (*Collins, 2017*).

3.2.5. iClinic

This application consists of a software to perform clinical management and presents. various features such as:

- Patient List – to add, edit and delete patient information;
- Medical agenda – to view the list with all the patients that will be attended in day;
- Alerts – to receive alerts whenever appointments are rescheduled or canceled;
- Patient Call – to call the patient directly from the iClinic App without the need to store the patient's number on the personal cell phone;
- Electronic Inventory – to create and customize the inventory in the way that most please and perform patient care;

- Images and Attachments – to send multiple photos, videos, or PDFs from the gallery of the phone or capture directly from the device's camera.

iClinic also has a Marketing component, as it sends information by e-mail, namely regarding treatments and procedures. In addition, it analyzes the financial situation by recording expenses, income, as well as transfers made. (*iClinic, 2019*).

3.2.6. Comparative Analysis

The performance of IT in the health sector is expanding more and more with evolution of technology. For this reason, there is a growing availability as well variability of smartphone applications that can be used to evaluate it movement in clinical practice. Most of the tested applications were approved for iPhones, due to the better image quality and ease of software development. Most of the studies were performed in the laboratory, which may mean different results if tested in a place open, such as sports practice. Regarding applications that are only used to manage athletes, as well as to record some data, it was found that there is greater competition. The developed website presents something more innovative, since it manages to join the two aspects, that is, in addition to managing a group of athletes and keeping their data, it also performs video analysis to obtain certain results. There is, however, one application that stands out from the others for giving the possibility of performing practically the same actions, Optojump. This one also has video analysis tools and gives the possibility to store the data obtained in the course of the tests. However, Hylyght's advantage lies in the fact that it is only necessary to use a cell phone to record videos, while Optojump uses transmitter bars.

3.3. Technologies

As previously mentioned, the main objective of this project was to develop a website and integrate the video analytics component. Since I am part of a team in this project, it was necessary to divide task. Therefore, I was responsible for the front-end development.

The front-end consists of three essential elements, HTML (*html, 1993*), where the structure of the web page, the CSS, through which the appearance of the elements is formatted structures and JavaScript, which is a programming language that describes the functionality and is responsible for the dynamic elements on the web page. In order to facilitate the development, there are frameworks. its use presents several advantages, namely a greater speed in the development of the website, as it is not necessary to write so many lines of code due to the existence of some functions already done. Some of the most used frameworks are Angular, React and, the most recent, the Vuejs. For the website development, Hylyght suggested using the Vue framework, since they already had some experience in using it and, in this way, were able to help with work more easily. Next, we analyze the three main frameworks.

3.3.1. GitHub

GitHub (*Tom Preston-Werner, 2008*) is an online platform where one can upload/store one's code with specific commands. Anyone can view the code or even download it. The common use is to store open-source software development projects. For version control, Git (and by extension GitHub.com) allows pull requests for any change to the source code. Users who can review the proposed changes can view a diff of the requested changes and approve them. In Git terminology, this action is called "committing" and an instance is "commit". Also, there is always a change history, where anyone can see the changes that have been made previously.

As a team we used GitHub, so we stored our project there, and every time we made changes to our code, we updated the existing file. The company also had access, so they could know what was going on. The most common commands that were used were (*Commands for using git, 2015*):

•git clone (your repo URL)

Copy repository locally to your computer.

•git status

If we change some files, it shows us which files have been changed.

•git diff

It shows us in detail what was changed in each file.

•git add -A

When something changes, we want to add it to the repository so that it exists as history and can be reverted.

•git commit -m "Your message"

With this command we create a location in the repository where we can reset it at every time.

•git push

This command sends the changes to the remote repository.

•git pulls

With this command we delete any change we have made to any file locally that has not already been committed or added.

3.3.2. Angular

Angular is a platform and framework for creating a single-page application (SPA) that uses HTML and TypeScript. As a platform, Angular includes a component-based framework for building web applications, a collection of well-integrated libraries that cover a wide range of features, and a set of tools to help you develop, build, test, and update code. Angular was developed by Google, so it is a strong advantage, as it is easy to find many useful development tools, plugins and packages, and when a problem arises, it is easy to find a solution by searching. Another advantage is the fact that Angular is very flexible and independent, that is, the code is reusable, and the concepts are very similar on practically all platforms (web applications, mobile applications or desktop applications). In this way, their development is faster. In addition, Angular is a complete framework with built-in resources, which means that no external libraries or tools are needed, which is why it is considered the most robust framework. Another positive point is the fact that it is possible to involve several programmers in the same project, as its architecture makes the code very readable and consistent.

Despite the positive aspects presented, there are also some negative aspects. One of the negative aspects of Angular is the learning curve. To use this framework, a complete reading of the documentation is necessary in order to understand the set of rules that apply. In addition, it is essential to learn the syntax, components, Angular-exclusive directives, bidirectional binding, among others. Despite the above, it is simple to find documentation related to the framework in question, which appears in a clear and concise way for each aspect. However, the biggest disadvantage of Angular is the size of the applications and, consequently, the page speed. This difference is more noticeable in small applications. Finally, when compared to React and Vue, Angular takes up much more space. (*Gajewska, 2021*).

Figure 7-Angular Features

3.3.3. Vue

Vue (*Gajewska, 2021*) is a JavaScript framework based on the MVVM (Model-View View-Model) pattern used in front-end development. Like React, Vue's main goal is to create dynamic, interactive user interfaces and a single-page application (SPA). Vue, having a simple structure and well-defined architecture, has several advantages. The development process is easier, faster and more efficient and does not require much preparation for the start of the project. Vue is extremely adaptable, offering programmers a lot of freedom, that is, they are not restricted to one way of doing things, as they can use available resources and create new solutions. Also, Vue is easy to integrate, as seen in Figure 8, with other libraries or existing projects as it is only focused on the visualization layer. Another important factor is that any web application made with Vue will be lightweight. As a result, you get fast loading and great startup and memory allocation times. In addition, Vue optimizes the web application as it only re-renders components that have had a state change. One of the biggest advantages of Vue is that it offers a wide variety of tools and libraries that facilitate the development process. As Vue is progressive, they can all be added to the project gradually, whenever necessary.

In Vue's tools and libraries, the most important are Vuex (*Vuex, n.d.*), which is used to centrally manage the state of components, Vue Test Utils, thanks to which it is possible to test the developed components, Vue Router, which manages the application routes and, finally, the Vue Cli, used to generate the application/project. We use Vuex to share information between every component. So, on our file store.js we have all arrays data that we need, and we also have some methods to mutate those arrays. We use Axios to store all website data so, by this way we can do gets and posts to obtain all and add new data. We also have a file style.css where we have all CSS things, and a folder asset with all images and logos that we need. Vue works with components. When we open the website, we do a scanning to obtain all the athletes and all tests that already exist (ListAthletes and ListTests, respectively). Then we store that data in our store.js arrays, so as not to do a lot of consultations to database. When we want to sort, search or filter athletes/tests we just do an update to store.js arrays, because athletes and test lists are based on those arrays. When we add an athlete or a test (NewAthlete and NewTest, respectively), we do a post to our database and, at the same time, we push that information to store.js arrays.

We can select some athletes and some tests, and we save those selected athletes and tests in another store.js array. After that, when we click on the start button, we can select what athlete we want to test first and what test we want to do. Input boxes appear on the screen according to the number of repetitions the test requires. And finally, we save the information on the database. Another important factor inherent in Vue is the fact that when there are updates, it offers as much compatibility with previous versions as possible. Vue was the last framework to appear, for that reason, it presents common aspects, both to Angular and to React, respectively, directive syntax and Virtual DOM.

Figure 8-Vue Features

3.3.4. React

Despite being on this list, "React" (*Gajewska, 2021*) is not a framework, but a JavaScript library. The main purpose of React is to create dynamic and interactive user interfaces, being, in most cases, a single-page application (SPA). Its main strengths lie in the fact that it is quite light on the use of components and extremely fast development. React has an architecture based on components, however, each of them is independent and has its own logic, thus encouraging programmers to reuse as much code as possible and thus speeding up the development process. In addition, the component-based architecture facilitates cohesive design, ensuring a reduced amount of discrepancies throughout the project. Another advantage presented by React is the fact that it is unnecessary to write the exact steps regarding the behavior of the component. The reason that React performs fast is because of the use of the Virtual DOM (Document Object Model)(This is illustrated in Figure 9).

The DOM is a representation of the web page that presents its structure, as well as all its content. However, the DOM was created to serve static UI pages, that is, whenever the page is refreshed, all the elements of its structure are also updated, which ends up decreasing performance. Virtual DOM solves this problem by ensuring that no changes will be made before calculating the best and most efficient way to do so. Until then, all changes are stored in Virtual DOM memory. In this way, the number of necessary updates decreases, improving the performance of the website. React uses the unidirectional link between the components, that is, the information passes from the parent component to the child component and not the other way around.Finally, React is used by several programmers and, therefore, has a wide availability of tutorials or clarification forums. Although React has the various tools mentioned above, it also has disadvantages, because to use them it is necessary to install them, no matter how small the project is. Also, the plethora of different tools can lead to less clean and consistent code compared to Angular. In this way, due to the huge amount of tools that React has, and with the constant updates on them, it becomes difficult to find the adequate and

complete documentation regarding each one of them, causing, in this way, programmers to lose some time looking for the proper use of the respective tools.

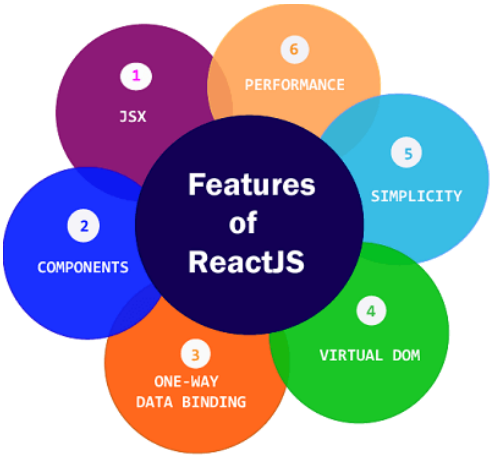

Figure 9-React Features

3.3.5. Comparison Table

In order to facilitate the comparison between Angular, React and Vue, the following comparative table was created:

Table 1-Comparison Angular, React and Vue

	Angular	React	Vue
Creator	Google	Jordan Walke	Evan You
Year of Creation	2010	2011	2014
Support	Google	Facebook	Community
Type	framework	Library	framework
Language	TypeScript	JavaScript	JavaScript
Flexibility	Low	High	Very tall
SUN	Regular	Virtual	Virtual
Data Binding	Both	Unidirectional	bidirectional
rendering	client side	server side	server side
time to start	Slow	Fast	Fast
extra tools	Not necessary	Required	Required
Documentation	Detailed	scarce	Detailed
Learning Curve	Difficult	moderate	Easy

After this analysis, I concluded that Vue has an excellent performance and, in my opinion, is the framework that best suits the realization of this project. As it is the most recent, it combines the best of Angular with the best of React, being also very

accessible, since with a basic knowledge of HTML, CSS and JavaScript, you can build a basic application. In addition, Vue is very versatile, as it offers ready-made and standardized solutions for the vast majority of situations. Another advantage that I appreciate in Vue is also the fact that it is progressive, because if we already have a server-side application, for example, we can use Vue only in part of the application, using only the modules that are necessary. Last but not least, it is worth remembering that there is no “the best framework”, since this choice will certainly vary greatly according to each project to be developed. For certain projects Vue may be the best solution, as for other projects maybe Angular or React are better choices. There is no “best” or “worst” framework, but the one that best suits the needs of each project.

4. MAIN PART

This chapter presents the problem domain, functional and non-functional requirements, and project design. This chapter is essential because it is where a detailed description of the project is made so that, in the future, it can be understood and reproduced by other people.

4.1. Problem Domain

The domain model is a system of abstractions that describes selected aspects of a sphere of knowledge, influence, or activity (a domain) (illustrated in Figure 10). The domain model is the most important artifact as it serves as a reference to resolve ambiguities that may arise in development. The following figure represents the universe of discourse, relative to the domain in question. (*Domain model, 2023*)

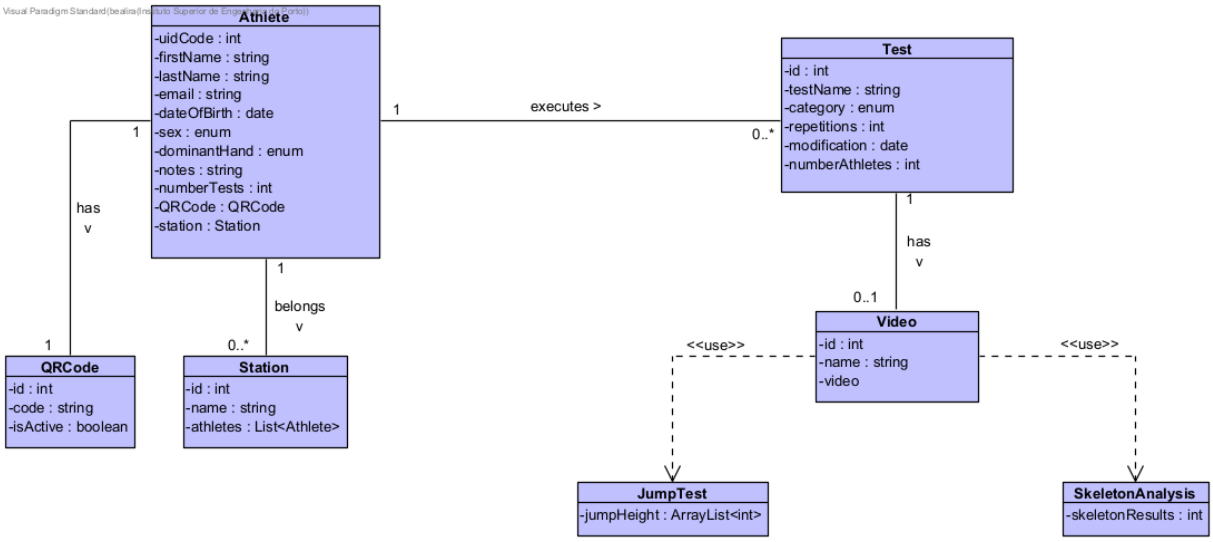

Figure 10-Domain Model

In the present domain model, it is verified that the athlete's class has several attributes in order to identify it. Additionally, it can be seen that it has three associations, namely with the QR code class, with the station class and, finally, with the test class. Regarding the QR code, it is known that each athlete only has one, since it is one of the identification attributes of the same. Regarding the station class, the issue of multiplicity is already different because each athlete does not necessarily need to belong to one station but can also belong to several. As for the association of the athlete class with the test class, it can be seen that the multiplicity goes back to 1 to 0 or more, as each athlete can perform several tests or none at all. Regarding the test class, it is noted that there is a 1 to 0 or 1 association with the video class, since the tests have or do not have an alternative for video analysis. This video analysis depends on the jump test and skeleton analysis classes, since it is through them that the video will be analyzed, and the results obtained.

4.2. Functional and non-functional requirements

The Use Case diagram, illustrated in Figure 11, (*Use case diagram, n.d.*) describes the proposed functionalities for the new system that will be developed and is a good tool for gathering its functional requirements.

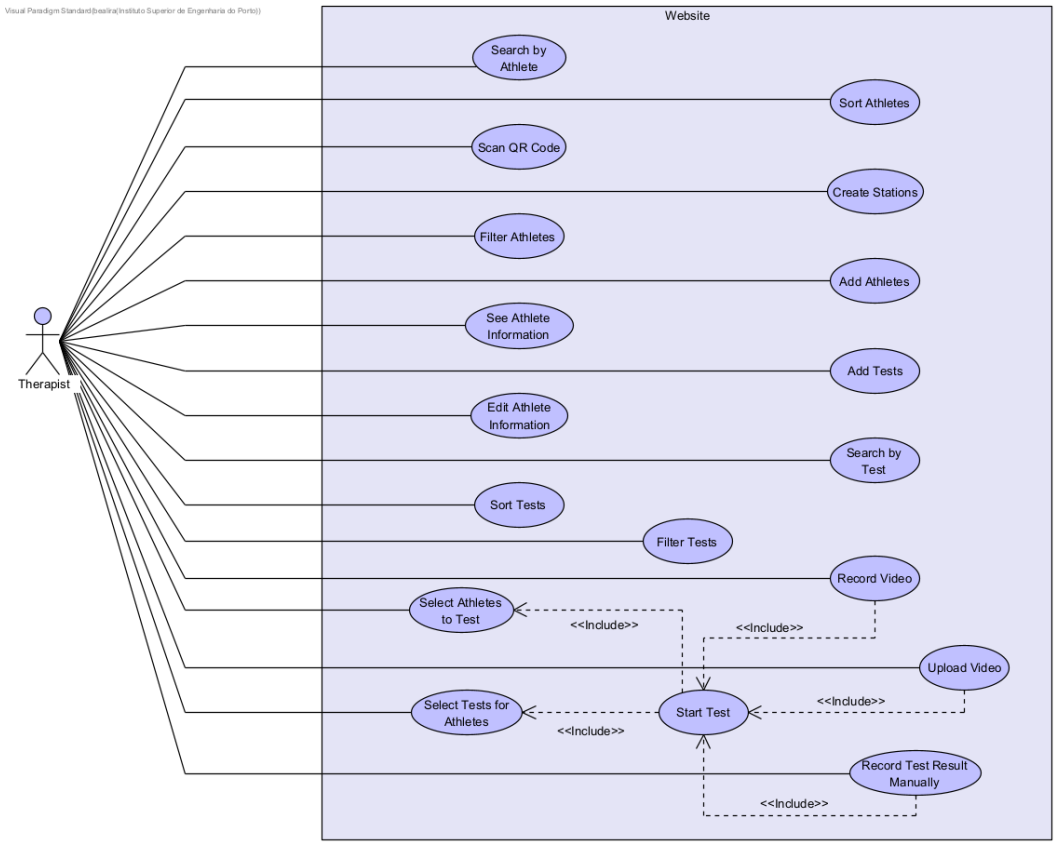

Figure 11-Use Case Diagram

Functional requirements describe how the product or service satisfies customer needs. These include features and functionality in use cases that document how users will interact with the product or service. In this way, it is possible to identify them through the presented use case diagram. The following table presents the functional requirements obtained through the use cases.

Table 2-Functional requirements

1	Search for an athlete by their name
2	Sort the list of athletes alphabetically or by the number of tests
3	Filter athletes according to their age and/or gender
4	add athletes
5	Scan QR code to identify athletes
6	View information about a particular athlete
7	Edit information about a particular athlete
8	add tests

9	Search for a test by name
10	Sort tests alphabetically or by the number of tests performed
11	Filter tests by category and/or season
12	Create stations to group tests
13	Select athletes and tests
14	run a test
15	Record a video for analysis
16	Upload a video for review
17	Submit test results manually

Regarding to non-functional requirements, it is known that they are related to the use of the application in terms of performance, simplicity, reliability, security, availability, maintenance and technologies involved, that is, they are requirements that are not directly related to a functionality of the system. The non-functional requirements are as follows:

Table 3-non-functional requirements

1	Fast auto video analysis runtime
2	Easy-to-understand and quick-to-learn design for the user
3	Data storage must be secure in order to respect athletes' privacy policies
4	Integration of video analytics components with the website

4.3. Implementation

To design the solution, a combination of two architectural representation models, C4 and 4+1, was adopted (*4+1 architectural view model, 2023*). The 4+1 View Model proposes the description of the system through complementary views, thus allowing to separately analyze the requirements of the various stakeholders of the software, such as users, system administrators, project managers, architects, and programmers. Views are defined as follows:

- Logical View: relating to aspects of the software aiming to respond to business challenges;
- Process View: relative to the flow of processes or interactions in the system;
- Development View: relative to the organization of the software in its development environment;
- Physical View: relating to the mapping of the various software components into hardware;
- Scenario View: relating to the association of business processes with actors capable of triggering them.

The C4 Model advocates the description of software through four levels of abstraction: system, container, component and code. Each level adopts a finer granularity than the level before it, thus giving access to more detail in a smaller part of the system. The levels are defined as follows:

- Level 1: Description (framework) of the system as a whole;
- Level 2: Description of system containers;
- Level 3: Description of container components;

- Level 4: Description of code or smaller parts of components.

It can be said that these two models expand along different axes, with the C4 model presenting the system with different levels of detail and the 4+1 View Model presenting the system from different perspectives. By combining the two models, it becomes possible to represent the system from different perspectives, each with different levels of detail.

To visually model/represent both what was implemented, and the ideas and alternatives considered, the Unified Modeling Language (UML) is used.

4.3.1. Level 1

4.3.1.1. Logical View

Regarding the logical level 1 view, it is known that the therapist interacts with the developed system, as seen in the following figure.

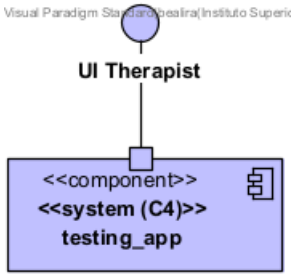

Figure 12-Logical View Level 1

4.3.1.2. Process View

This topic covers the process view for the two most important ones, namely, the process of adding an athlete and the process of starting a test run for several athletes.

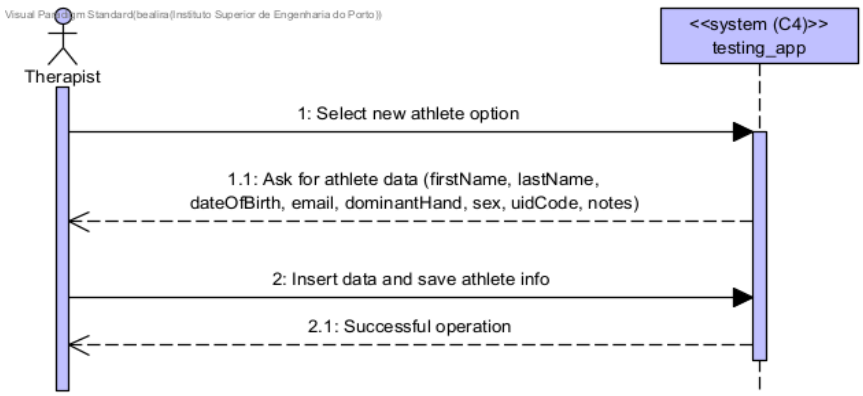

Figure 13-View Process of Adding Level 1 Athlete

The diagram shows that when the therapist wants to add an athlete, he has to select the appropriate option and, later, enter the data related to him. After submission, the athlete is saved in the system. Regarding the process of starting the execution of a test for several athletes, we have:

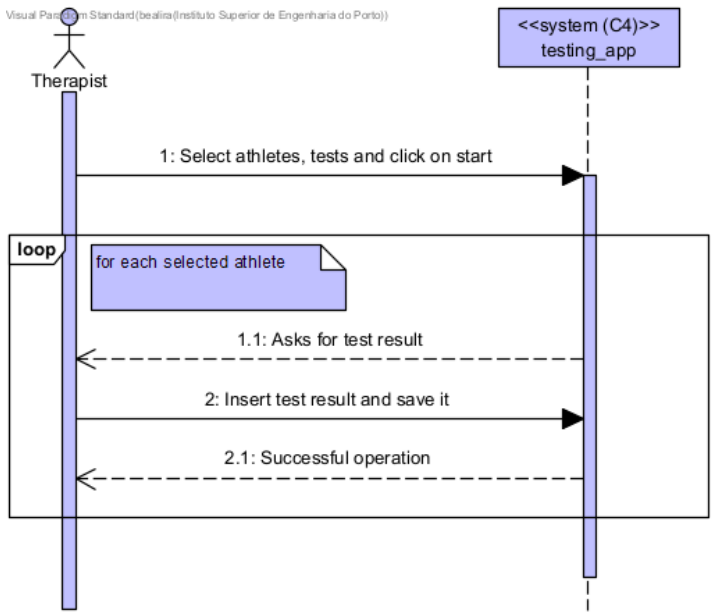

Figure 14-View Process of Conducting Test Level 1

In this diagram, it can be seen that it is necessary to select both athletes and tests by the therapist, and then start recording the results. This record belongs to a cycle as it depends on the number of athletes selected to test.

4.3.2. Level 2

4.3.2.1. Logical View

Regarding the logical level 2 view, we have:

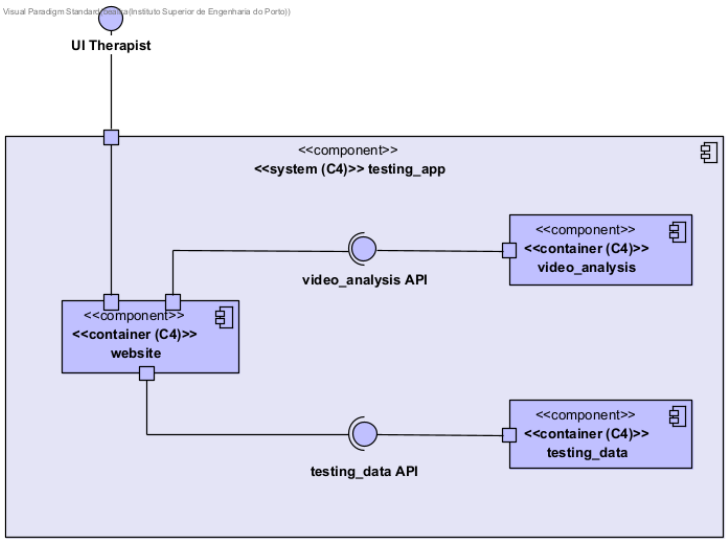

Figure 15-Logical View Level 2

It can be seen that the website component consumes both the video analysis component and the test data, as the website needs the data provided by both components. The video analysis component returns the results according to the videos submitted, while the test data component consists of the management of both athletes and tests.

4.3.2.2. Development View

The level 2 development view can be found in Appendix A. This diagram refers to the organization of the software in your development environment. It can be seen from the same that the website has two dependency links, one for the test data and the other for the video analysis.

4.3.2.3. Physical View

The following figure shows the physical view of level 2.

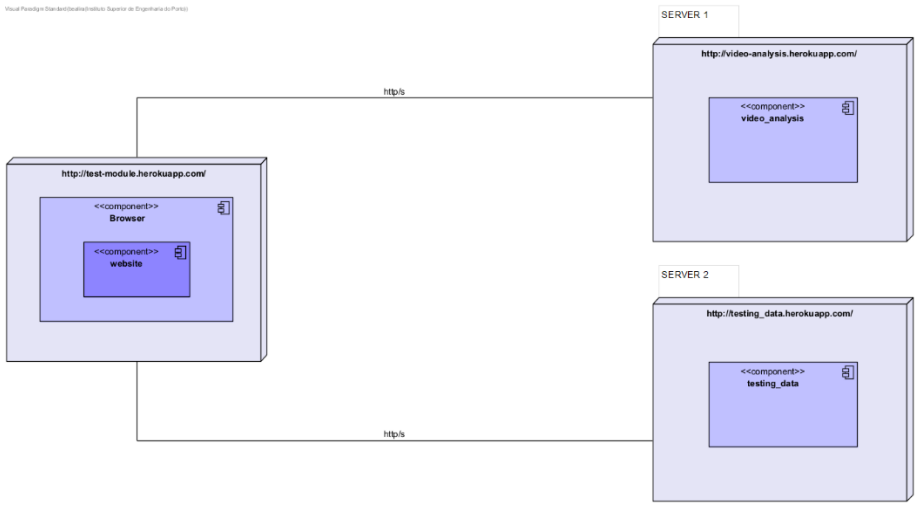

Figure 16-Level 2 Physical View

The deployment plan refers to configuring and installing the system on three different physical nodes, one for the website, one for the video analytics, and one for the test data. This deployment plan was adopted, since the video analysis and test data were already implemented in Heroku and, therefore, it was chosen to follow the same for the website.

4.3.2.4. Process View

This topic addresses the process view, related to the two previously mentioned, namely the process of adding an athlete and the process of starting a test execution for several athletes. For the process of adding an athlete we have:

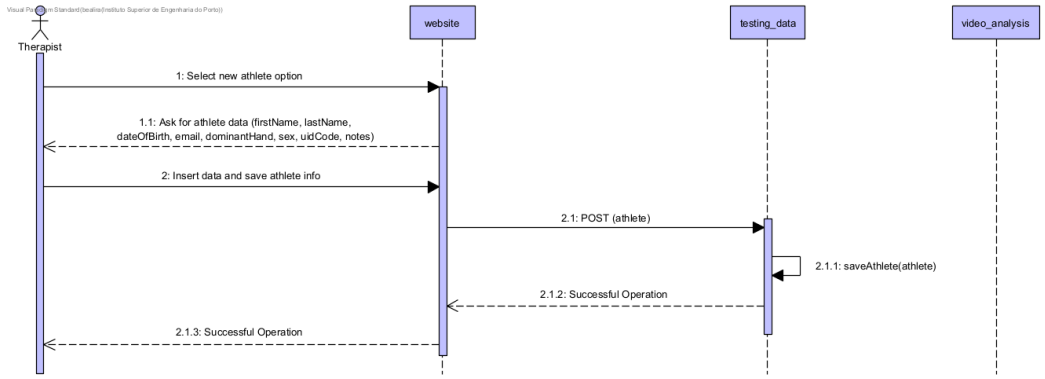

Figure 17-View Process of Adding Athlete Level 2

As seen before, it appears that when the therapist intends to add an athlete, he has to select the appropriate option and, later, enter the data related to him. After submission, the athlete's data is sent from the website to the test data component through a POST performed with the submitted information. In this last component there is a method that will store the information received. Regarding the process of starting the execution of a test for several athletes, we have:

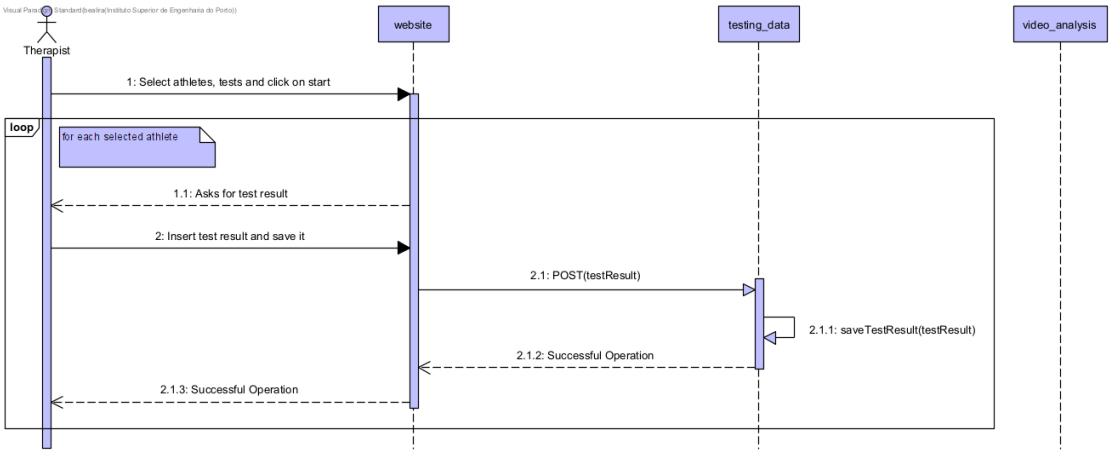

Figure 18-View Process of Performing Level 2 Test

As already mentioned, in this diagram it is clear that it is necessary to select both athletes and tests by the therapist, to then start recording the results. This record belongs to a cycle as it depends on the number of athletes selected to test. For each test recorded by the therapist, a POST is made with the information of the same, which is then saved through a method in the test data component.

4.3.3. Level 3

4.3.3.1. Logical View

In the following diagram, only the logical view, level 3, for the website component is shown.

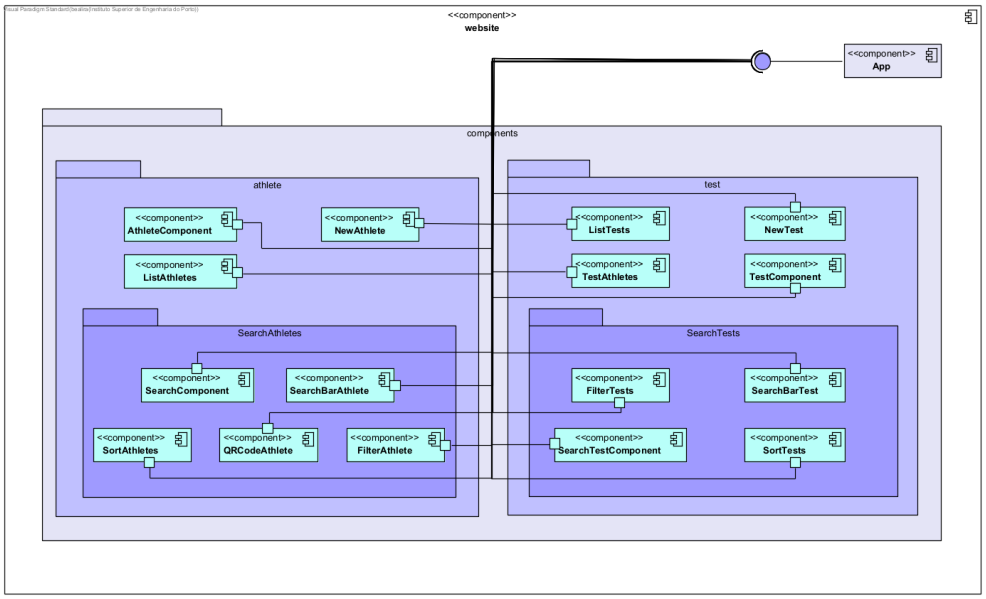

Figure 19-Logical View Level 3

As you can see, the website has an App component that is directly related to all other components. Initially, a division is made between the components belonging to the athletes and the components belonging to the tests. Subsequently, within each of these divisions there is still a folder that contains only the components referring to filter methods, such as the search, the sort, the filter and, in the athlete, the QR code as well.

4.3.3.2. Development View

The level 3 development view can be found in Appendix A. Only the level 3 development view for the website component is shown. From the attached diagram, it can be seen that the website has a paste source and, within this, there are three others, one for assets, one for components and one for the store. The component-related folder has dependency links to the other two folders.

4.3.3.3. Physical View

The physical view of level 3 can be found in Annex A. This diagram is practically the same as that of level 2, only a few notes for each server are added.

4.3.3.4. Process View

This topic addresses the level 3 process view, related to the process of adding an athlete.

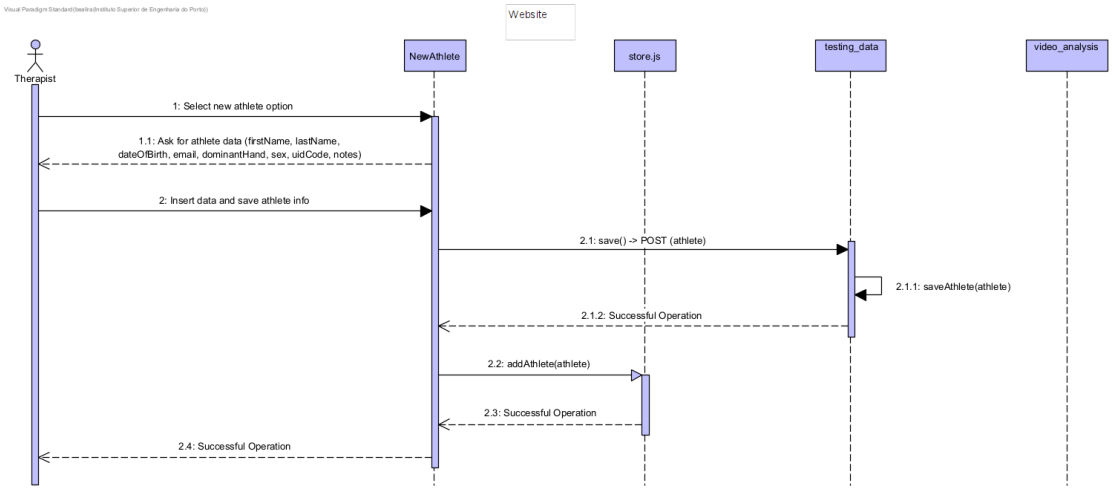

Figure 20-Add Athlete level 3 process view

As seen before, it appears that when the therapist intends to add an athlete, he has to select the appropriate option and, later, enter the data related to him. After their submission, in the NewAthlete component, the athlete's data is sent from the test data component through a POST performed with the submitted information. In this last component there is a method that will store the information received. The athlete's information is also stored in the store, which is a file that allows the sharing of variables.

4.4. Conclusion

For the design and architecture of the solution to the problem, fundamentals acquired during the Degree were used, namely the combination of two models of architectural representation, C4 and 4+1. The use of these representations had a positive impact on the development of the solution, starting with the explanation of the architecture in general and, later, moving on to more technical and specific subjects, thus increasing the granularity. In this way, the design and architecture of the solution became simpler to execute.

5. IMPLEMENTATION

This chapter presents the details related to the framing and implementation of the solutions recommended in the previous chapter. In addition, an approach to related tests and a description is also made to evaluate the developed solution.

5.1. Description of Methodologies

As mentioned in previous chapters, the project brings together two strands, one multicultural and the other multidisciplinary. The team was composed of 7 elements, all of them from different countries, namely Portugal, Scotland, France, Germany, Luxembourg, and Greece. The elements also belonged to different areas, such as design, marketing, sports, and programming. Communication between the team started 15 days before the meeting in Gent, since it was important to know not only the area of all the elements, but also the time that each one could spend on the project. Later, in Gent, the first contact was made with the team and with the company Hylyght. During this week it was possible to clarify most of the doubts regarding the requirements intended by the company. In addition, there were workshops alluding to team dynamics and cultural awareness, as well as training with an introduction to SCRUM (*What is Scrum, n.d.*)given by Wouter Vandenbosch from Imec. During the week, in Gent, it was defined how the work would go during the semester, from the daily meetings to the meetings with the company and the working method. Regarding the project to be carried out during the semester in a remote environment, everything went according to plan; brief meetings were held between the team on Monday, Wednesday and Friday and meetings with the company took place every 15 days on Friday. At the beginning of each Sprint, the tasks to be carried out during the two weeks were defined and, in this way, the team was constantly updated on the project in general. In addition to the above, there was also a presentation in the middle of the semester where the project developed so far was presented and discussed its positive and negative points. Finally, there was also a final meeting, but this time in the city of Porto. That week, a presentation of the final product and the method used to achieve it was prepared.

5.2. Description of Technologies

As mentioned in previous chapters, the framework used to develop the project was Vue. It is common for applications that use Vue to be organized in a component tree. (*Vue, Components Basics, n.d.*)

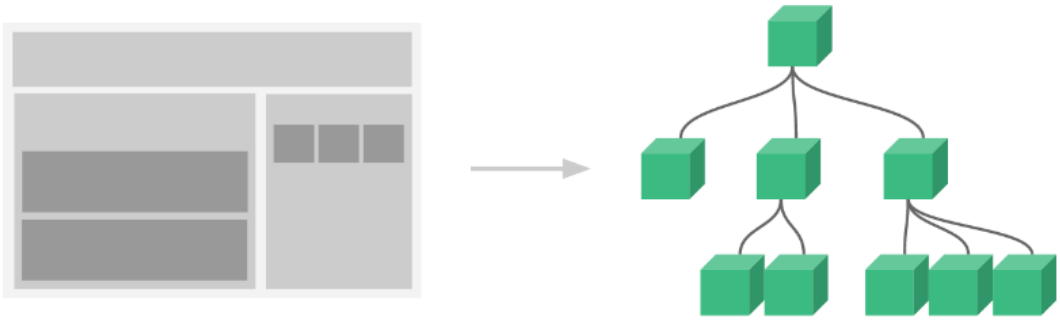

Figure 21-Organization of Components

Typically, there is, for example, a component for the header, another for a content area, and so on. Furthermore, each component may further contain one or more components. For the development of this project, it became necessary to create several components, and they needed the same variables and to communicate with each other. In this way, it was necessary to resort to the VueX library, since it serves as a store for all components in an application, ensuring that the state can only be changed in a predictable way. VueX contains a section for state, another for getters, one for mutations and one for actions. For example, in the status of the developed project we have:

```
state: {
    results:[],
    // -----------
    id:[],
    athletes:[],
    original:[],
    selectedAthletes:[],
    // -----------
    tests:[],
    testsOriginal:[],
    selectedTests:[],
    testsStation:[],
    selectedTestsStation:[],
    // ---------
    recordedVideo: null
 }
```

It is in this section that all variables that need to be shared between components are stored. In turn, the mutations section is where there is a change in the current value of the variable present in the state, and these changes are all made with rules. In the project in question one of the mutations present is:

```
mutations: {
    addresults(state, results){
        state.results.push(results)
    }
}
```

As you can see, this mutation will change the value of the results array, which was initially empty, to the results variable that it receives.

In addition to VueX, another technology was also used, Axios. Axios is a Promise based HTTP client for making requests. It can be used either in the browser or in Node.js or in any API service. In addition to the above, Axios makes Ajax requests in the browser via XMLHttpRequests, intercepts requests and responses and automatically transforms the data into JSON. In order to instantiate Axios, an axios.js file was created with the following instructions:

```
Vue.use({
   install(Vue){
       Vue.prototype.$http=axios.create({
          baseURL: 'https://hylyght-5d758-default-rtdb.firebaseio.com/'
       })
   }
})
```

Later, when it was necessary to make a POST, for example, the name of the table where the information was to be stored was indicated and the same was sent to be stored, as can be seen in the following code excerpt.

```
this.$http.post('athletes.json',this.athlete).then(
            this.$store.commit('addAthlete',this.athlete)
)
```

The aforementioned technology was used in order to simulate requests and responses from the company's API. In this way, to have the website communicate with the company's API, they only need to change the URL to the desired one.

5.2.1. Implementation of the Proposed Solution

As mentioned above, the application was divided into several components, and this can also be seen in the diagram of the logical view.

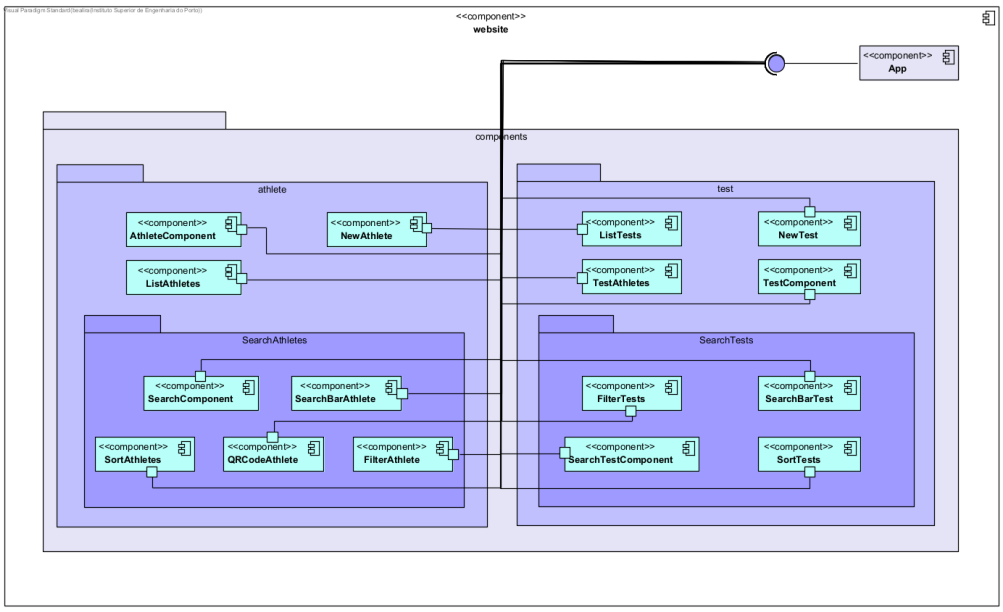

Figure 22-Diagram of divided several components

The main component of the application is divided into two others, the **AthleteComponent** and the **TestComponent**, and these also have other components according to the following structure:

- AthleteComponent
    - NewAthlete
    - SearchComponent
        - SearchBarAthlete
        - QRCode
        - FilterAthletes
        - SortAthletes
    - ListAthletes
- TestComponent
    - NewTest
    - SearchTestComponent
        - SearchBarTest

        - FilterTests
        - SortTests
    - ListTests
    - TestAthletes

Likewise, it is also possible to check some components to show how they are nested. First, in the main component, as already mentioned, we have:

```
<div class="column_athlete">
      <AthleteComponent></AthleteComponent>
</div>
<div class="column_test">
      <TestComponent></TestComponent>
</div>
```

Then, in the AthleteComponent there is the call of 3 other components, NewAthlete, SearchComponent and ListAthletes:

```
<div class="grid-item-athlete">
      <h6 class="mt-5 subtitle">first select your:</h6>
      <h2 class="title">Athlete(s)</h2>
      <NewAthlete style="float:right"></NewAthlete>
</div>
<div class="grid-item-athlete">
      <SearchComponent></SearchComponent>
</div>
<div class="grid-item-athlete" style="overflow-y:scroll;height:400px;">
      <ListAthletes></ListAthletes>
</div>
```

Finally, the SearchComponent contains the SearchBarAthlete, QRCode, FilterAthletes and SortAthletes components.

```
<div class="grid-item-athlete">
      <SearchBarAthlete></SearchBarAthlete>
</div>
<div class="grid-item-athlete">
      <QRCode></QRCode>
</div>
<div class="grid-item-athlete">
      <FilterAthletes></FilterAthletes>
</div>
<div class="grid-item-athlete">
      <SortAthletes></SortAthletes>
</div>
```

In this way, it becomes easier to understand why the components needed to communicate with each other. For example, regarding the component of ranking athletes, he needed to know which athletes were on the list, in order to be able to sort them later.

In this situation, the method for the necessary mutation of the array was called in the sort component.

```
methods:{
    sortByAlphabet(){
      this.$store.commit('sortAthletesByAlphabet')
    }
}
```

Then, within the invoked method, the necessary changes were made, according to the defined rules, and, finally, the variable present in the state was changed.

```
mutations: {
    sortAthletesByAlphabet(state){
        const athletes = this.state.athletes
        athletes.sort((a, b) => a.firstName.localeCompare(b.firstName))

        state.athletes=athletes
    }
}
```

In addition to the above, it is also possible to verify the use of the store in the method of adding an athlete to the application. The following figure shows the diagram referring to the level 3 process view of the use case of adding an athlete.

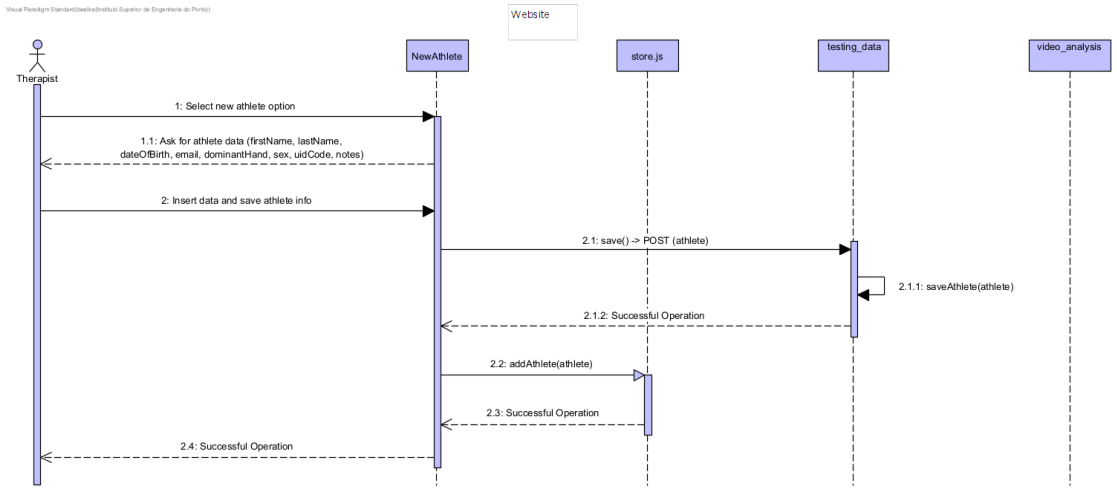

Figure 23-Add Athlete level 3 Process View

It is possible to verify that after the physical therapist presses the save button, the POST is performed and the information is properly stored, the addAthlete function is called in order to send the athlete's data to the store, so that it is possible to save it in the array assigned to it. It is also possible to confirm the above through the following code snippets:

```
<div class="buttons">

            <button @click="save" class="save-button"
type="submit">SAVE</button>

            <button @click="cancel" class="cancel-
button">CANCEL</button></div>

methods:{

      save(){

          this.$http.post('athletes.json',this.athlete).then(

          this.$store.commit('addAthlete',this.athlete)

          )

      }

}

  }

}
```

```
mutations: {
    addAthlete(state, athlete){
        state.athletes.push(athlete)
    }
}
```

5.3. Website Interface Design

The website interface was designed by our team's designer, Ariane. During our first Sprint, back in Ghent, the designer had to select the colors, the fonts and the app icons were going to use. The designer discussed with the clients and what they are want for the website. The final selection from the company was to keep the colors from their website. In addition, we use "Lato" as the font-family for the website (*Lato-Light, Lato -Medium, Lato-Regular*).

About the colors are the following:

Orange: #FF9800

Blue: #3C84F0

Green: #00C28F

Grey: #F4F5F7

Black: #000000

The second approach had totally different colors with the main colors being purple, gray, cyan and white. The icon of the app stayed the same as company's logo. The final selection from the company was to keep the colors from their website and use the" Lato" font that we suggested for our texts. After selecting the colors and font of the application layouts for each page, the designer used the Figma platform to design the website. We talked about evolution in each Sprint, we made changes and there was an improvement. In each Sprint the models were checked by the company and helpful comments were made about what needed to be changed. Having so many repetitions in the design definitely affected the growth rate. However, the final design was exactly what the company wanted.

5.3.1. Figma

The Figma prototype allows you to develop functional flows that explore how a user can interact with your designs. Primitives are a great for previewing user feedback. Figma is a powerful web-based design tool that assists you in designing anything from websites to apps, logos and more. We can actually use it to do all kinds of graphic design work, designing mobile app interfaces, building designs, wireframing websites, creating prototype designs, styling social media posts etc. All the front-end team had access on Figma so we can see the designs and try to do the same on the website. The designer of our team made changes after each of our meetings, always after consultation with the clients and finally based on the Figma designs, we tried to do exactly the same with code. (*Figma, 2016*). About the Figma designs:

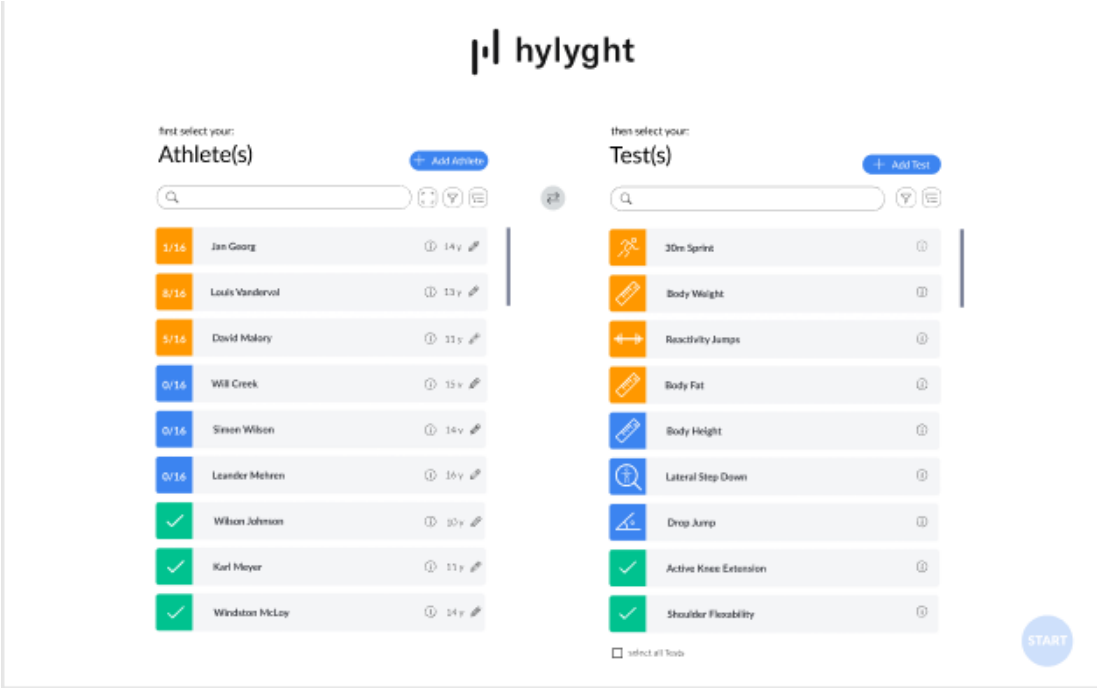

Figure 24-Home page on Figma

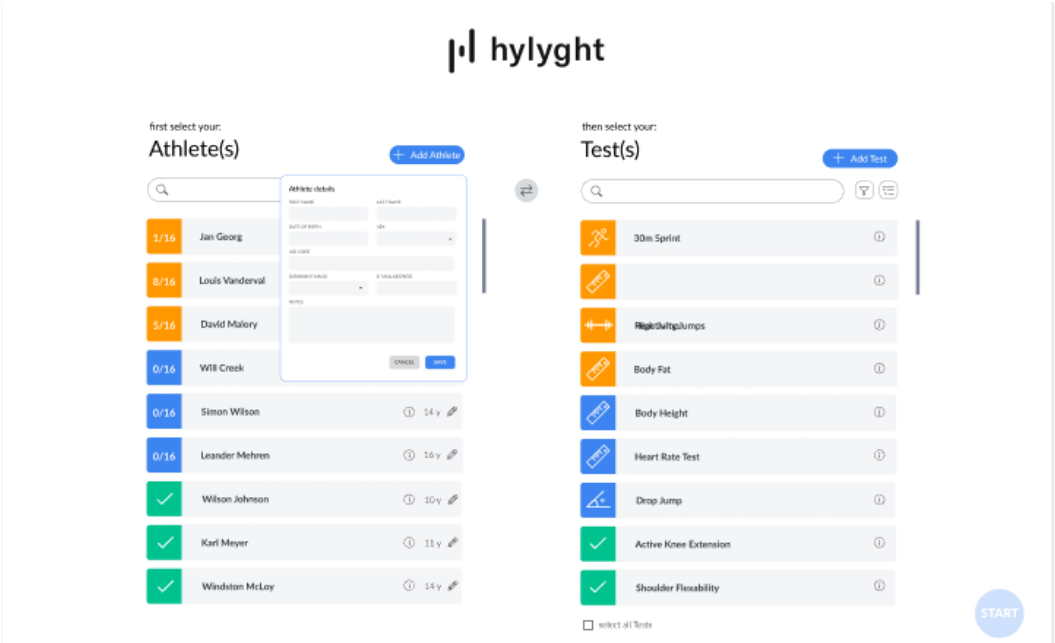

Figure 25-Add Athlete Option

Figure 26-Add Test Option

In addition, in Figures 27 and 28 we can see the options of Sort by & Filter by, that we added:

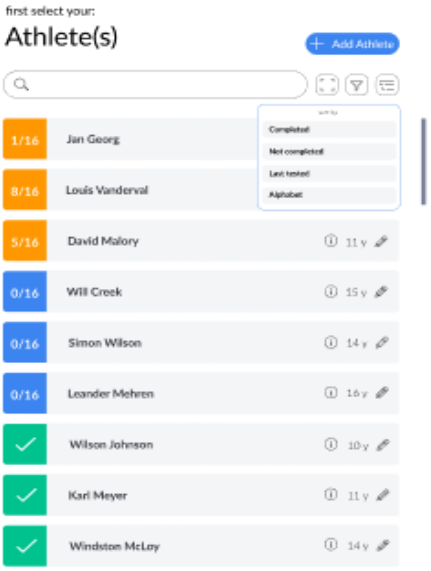

Figure 27-Sort Athlete By

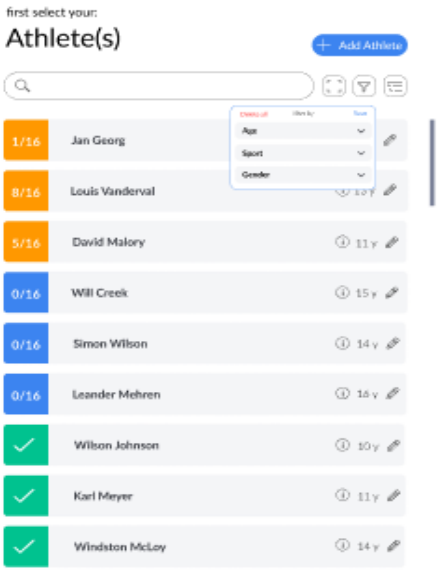

Figure 28-Filter Athlete By

In addition, there were also the same options for the Tests.

5.3.2. Newest Website

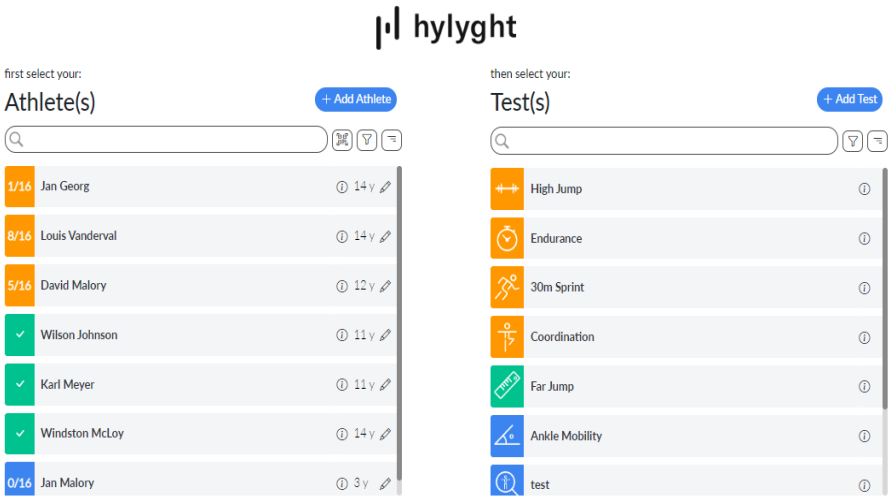

Figure 29-Home Page of the new website

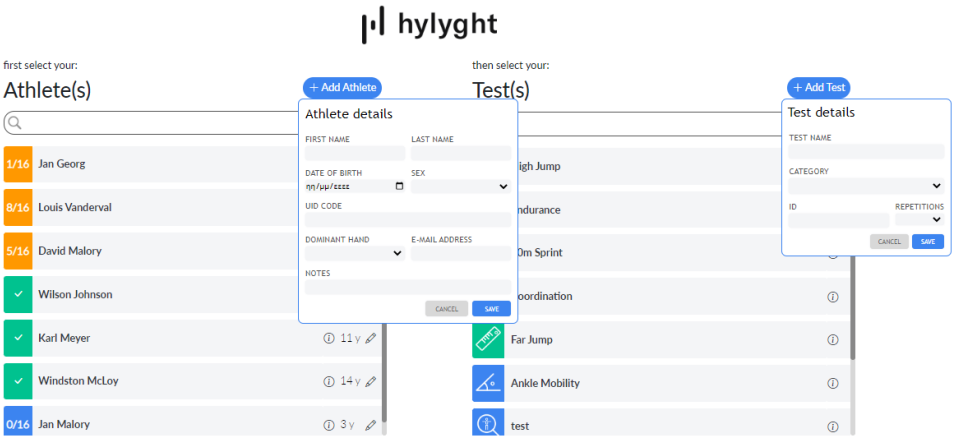

Figure 30-Add Athlete & Test

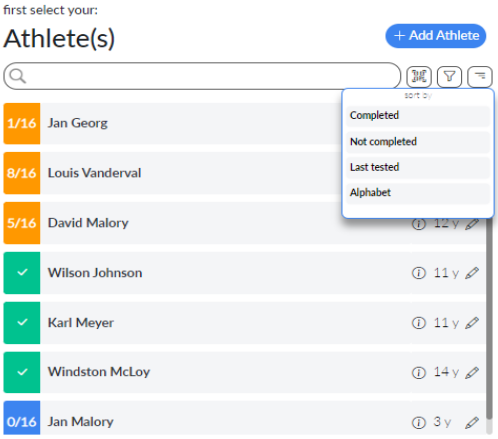

Figure 31-Sort Athlete By

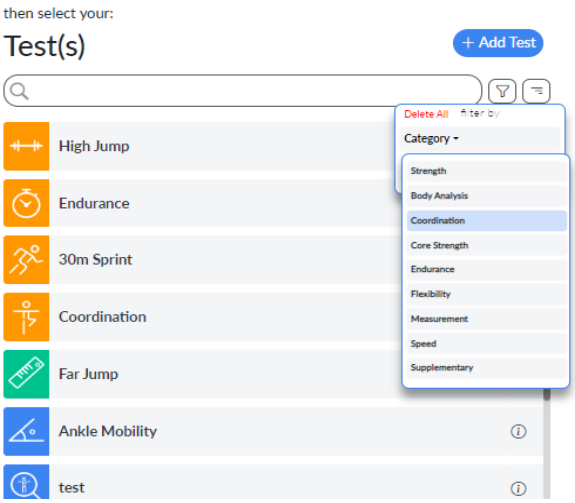

Figure 32-Filter Test By

5.4. Implementation Specifics

The Vue framework has some rules that can be divided into categories. Priority A are the essential rules that help prevent errors and priority B are the highly recommended rules that are used to improve code readability. In addition to those mentioned, there are also priorities C, recommended rules, and D, resources to use cautiously. In priority A, one of the rules is due to the fact that component names must always be multi-word, except for the App component, main component. Also, the data option in the components must be a function. Another rule is that you must use the key attribute when using v-for. In priority B, one of the rules is that there should only be one component per file and always use the same naming convention, one of the conventions being the word order in the component name, starting with the highest level. (*Vue, Style Guide, n.d.*). These rules must be used as they help the programmer to interpret the code and also by any programmers who need to adapt the code or improve it.

5.5. Tests

During this project, unit tests and component tests were carried out.To carry out the tests, the test framework Jest was used. Below are some examples of tests performed for the SearchBarAthlete component:

```
const factory = (values = {}) => {
  return mount(SearchBarAthlete, {
    data () {
      return {
        ...values
      }
    }
  })
}
describe('search-input-athlete - Unit', () => {
  it('should be a vue instance', () => {
    const wrapper = factory()


    expect(wrapper.vm).toBeDefined()
  }),
  it('check elements', () => {
```

```
    const wrapper = factory()


    const div = wrapper.find('div')
    expect(div.exists()).toBe(true)


    const input = wrapper.find('input')
    expect(input.exists()).toBe(true)
  }),
  it('check empty variable', () => {
    const wrapper = factory()


    expect(wrapper.find('.text').exists()).toBeFalsy()
  }),
  it('check variable with more than 10 characters', () => {
    const wrapper = factory({text: '12345678910'})


    expect(wrapper.find('.error').exists()).toBeTruthy()
  })
})
```

First, it is necessary to assemble the component and, only after that, the implementation of the tests begins. Then, in the first test, it is verified if the component was, in fact, well instantiated. In the second, the presence of the appropriate elements in the component is verified. In the third test, it is verified that there is still no String since no search has yet been carried out. Finally, in the fourth test, it is verified that when the text entered has more than 10 characters, an error occurs, as the maximum limit is 10.

5.6. Evaluation of Solution

In order to evaluate the developed solution, one of our team's members organized a few sessions in order to evaluate our application. 8 physiotherapists tested, in terms of usability, both the website that the company already had and the one that was developed during the project (illustrated in Figure34). In order to obtain quantitative ratings, they

were given a numerical scale from 0 (minimum value) to 10 (maximum value) so that they could evaluate the old website and, later, the new one. The result obtained was the following:

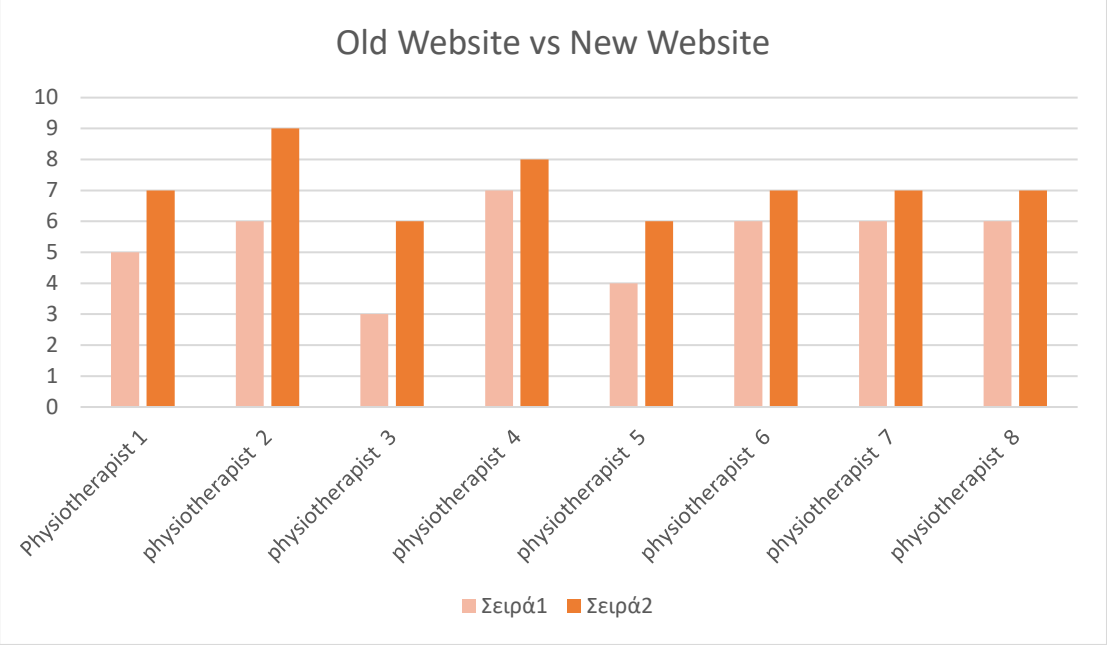

Figure 33-Graph of the old and new website

After observing the graph, the first conclusion that was drawn was the fact that the website developed had a superior evaluation in all cases. The average rating of the previous website is 5.25, while that of the new website is 7.125, that is, practically 2 values higher.

Through the results obtained, it is possible to affirm that the main objective of the project was achieved, that is, to make the website user-friendly. However, the website can still be improved in order to satisfy the physiotherapists more.

5.7. Conclusions

The implementation of the solution became challenging, since it was necessary to acquire skills related to a new framework so that, later, it was possible to build a solid and flawless application, so that the final product could be used. Although it is still possible to add more features to the product, all the aforementioned requirements were met, which reveals that what the company requested was fully implemented.

6. CONCLUSIONS

In this chapter, the conclusion of the elaborated project is carried out, starting with the achieved objectives, followed by an approach to limitations and future work and, later, a final assessment.

6.1. Goals Achieved

The objective of the project was to implement a website in VueJS to accompany therapists in their daily tasks. This website should incorporate a user-friendly interface, in order to be commonly used by therapists. These will start the process by creating the athletes' profile. Each profile can contain several data items (personal data, notes, etc…). Each individual can be placed in one or more groups or subgroups. Athlete data is therefore fully open to modification as needed.

Then came the process of selecting the athlete(s) and choosing the test (or choosing to perform the screening of a set of tests) that is intended to be performed. At the same time, there is also the possibility for the therapist to upload a video and receive the results of it automatically. Through artificial intelligence mechanisms, the analysis of videos will present results with increasing reliability. The aforementioned objectives were all successfully completed and, in addition to the above, the website was deployed, as the company requested it at the end of the project.

6.2. Limitations & Future Work

Throughout the development of the project, some setbacks emerged, however, these were overcome. Although the main objective has been achieved, the website could present other features in order to make the work of physiotherapists even easier. In addition, there is also a need to improve the integration of video analysis with the website, so that it is more easily understood and used by physical therapists.

6.3. Final Approach

Upon completion of the project, I can say that the levels of motivation were maintained during all phases of the work in view of the dynamics of the team that prepared it and the area in which it was inserted. The fact that the project privileges contact with different nationalities, cultures and areas made it more interesting, enabling the development of various soft-skills throughout the execution of the work. Furthermore, integration in a professional context was of great importance, as it was possible to understand how a project should be guided from start to finish. During the internship, I recognized the importance of good practices taught during the three academic years of the Degree, both in terms of planning and work methodologies that allowed the project to be carried out progressively. The realization of the project required a significant commitment on the part of all those involved, but the collaboration and contribution of each one, whether in terms of overcoming or in terms of effort, was extremely productive so that the intended project could be completed, within of the deadline. In short, the internship helped to increase my skills and complement the academic evolution, as well as the introduction to the world of work. I also hope that the project developed will bring several contributions to the company, so that it can continue to expand.

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APPENDIX A: SOLUTION DESIGN

Development View - Level 2

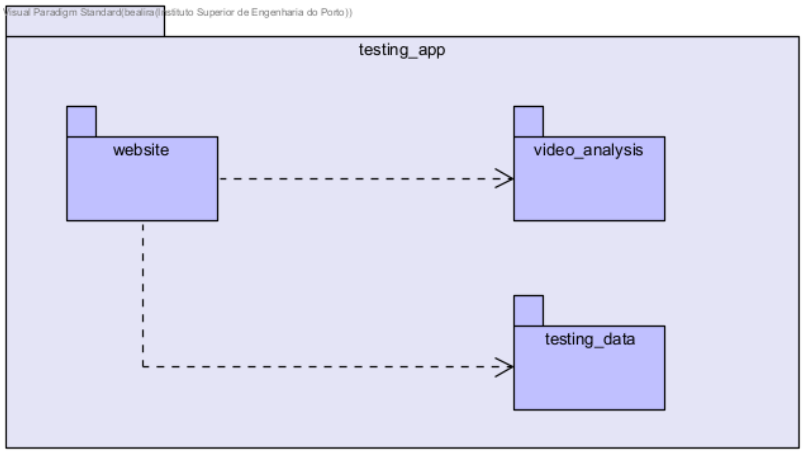


Figure 34-Level 2 Development View

Development View - Level 3

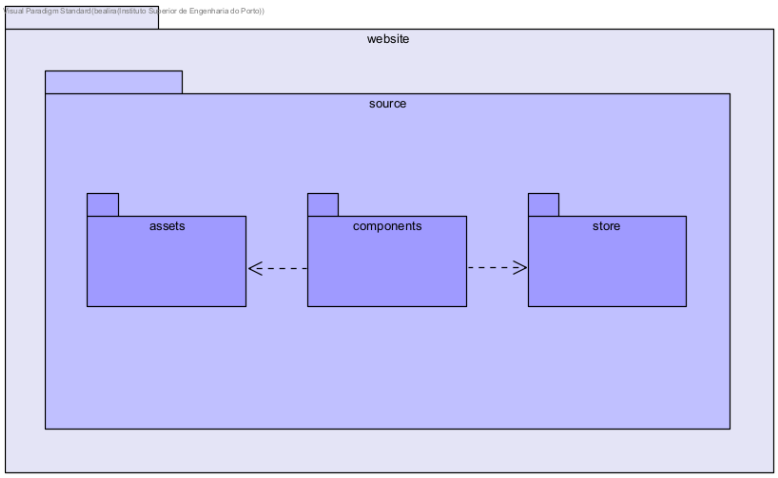


Figure 35-Level 3 Development View

Physical View - Level 3

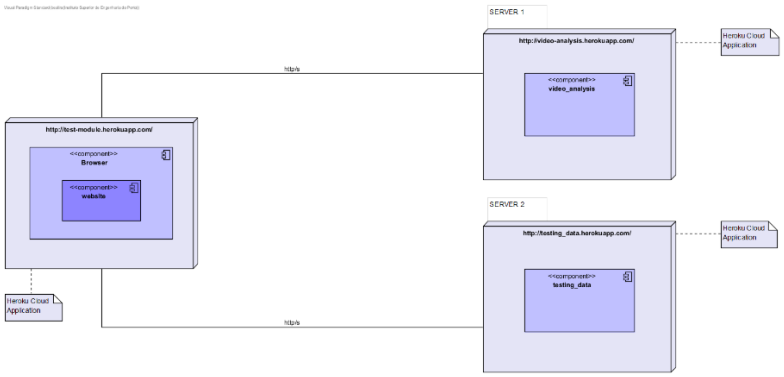


Figure 36-Physical View Level 3

APPENDIX B: ABSTRACT OF PAPER

Giorgos M. Papadourakis, Marina Kerameida, Sofoklis-Evangelos Tsiakalos, Maria Eleni Tzagkaraki, Nuno Escudeiro, "Blended Mobility Project, 12th Edition 2022: Application for Sports Performance Testing, an Interior Design Application and a Hospitality Management System", 19th International Symposium on Ambient Intelligence and Embedded Systems – AMIES 2022, Antwerp, Belgium, September, 2022.

Blended Mobility Project methodology is devoted to create and manage international multidisciplinary teams of students who will collaborate in order to develop a solution for an engineering problem. These teams are set up for a semester with the purpose of developing and presenting a prototype or a proof of concept for a given challenge.

Blended Mobility Project in the academic year 2021/22, completed its 12th edition which started in the academic year 2009/10. Altogether HIEs from 11 countries were participating including Portugal, Belgium, Germany, the UK, Greece, Italy, Kurdistan - Iraq, Slovenia, Nigeria, France and Lithuania. Information Technology companies provide real project proposals. With this professional involvement, students got a context which is international, multicultural, multidisciplinary and professional.

The preparation of the course starts at the beginning of the first semester in October. At this stage the teachers collect challenges from companies and select the most interesting with regards to its pedagogical potential. Initially 13 projects were selected. The selected challenges are presented to final-year-undergraduate or master students. Each project is implemented by a team of about 10 students which are mainly from Information Technology and Software Engineering disciplines but students from other fields of study, such as: Business Development, Management, Electronics, IT & Design participate. Applicants are selected based on a set of criteria defined by each partner university and the teams for each challenge are setup. In 2021/22 edition, more than 53 students were involved actively, as well as 14 teachers from the 11 participating HEIs. Allocating 7-9 students per team the most 7 popular projects among the students were chosen to be implemented. This process was concluded by the end of January and the first face-to-face meeting that runs at the beginning of the second semester, took place at Ghent, Belgium, 21-25 February, 2022. At this first face-to-face meeting, students get to know each other, the company offering the challenge and its details. The challenge is provided to the students by the company but no specifications are given concerning the solution to develop; that is the students task. Students have to interact and cooperate during the semester in order to agree on the necessary specifications and on how to integrate all the elements of the solution from a technical, marketing and business point of view. The first face-to-face meeting runs for five working days during which students design a first draft of the solution for the challenge at hand organize

themselves to work as a team during the semester and assign responsibilities to each team member according to the number of ECTS credits they get for their work. At the end of the week the envisaged solution by each team is discussed with the company, the teachers and the students so all agree on a definite proposal. After this first meeting, students work at their home institution working at a distance through online groupware platforms. At the end of the project all modules are integrated and the fully operational system, a unique product, is presented by the students as a team. The second and final meeting took place in Porto, Portugal 20-24 June 2002, students get together face-to-face again to finalize their solution, their final presentation and to discuss the delivered product with the client company and the teachers. The team as a whole must guarantee that all parts integrate well to produce a unique solution for the problem and present the full solution to the project jury. The project jury was composed by a teacher from each partner institution and a representative from the client company.

In total there were 7 projects implemented in the academic year 2021/22 and 3 of them will be presented where HMU students participated. The first project was suggested by Hylyght, a Belgian startup company. The challenge was the designing and development of a user friendly web-based application for physiotherapists, doctors, and coaches, which will help to quickly gather all the necessary information they need without losing time on testing or the analysis video. Company's clients spend a lot of time on testing and gathering data. The analysis takes too much time and there are a lot of open-source options to assess these tests automatically. This holds them back, it's always an effort to test and screen; even though objective data are more and more important. This application will help them by automating some of the tests and offer a user-friendly web-based app, which is linked to their cloud platform. The team was separate into the groups of marketing, design, and development under Scrum framework. For the organization and management of the groups tools like Trello, Microsoft Teams, Dropbox, and GIT were used. The IT group divided the requirements in smaller tasks in order to work on them separately. For the development of the website the JavaScript framework "Vue" and Vue's tools "Vuex", Python, and HTML we used.

The second project was introduced by Epam Systems an American company that specializes in product development digital platform engineering, and digital product design and its branches are represented in more than 35 countries. The challenge was to create an interior design application, named "DecoratAR", to allow people worldwide to visualize furniture in their living spaces more easily. This application is intended to be used both for professional and private use. The aim of the team was to combine all the features from similar applications on the market into one application for easier and more practical use. For the development of the application Unity3D was used for the code (with C#) and Blender for the models. The team stayed in touch through various platforms and programs like Microsoft Teams, Whatsapp and Zoom. The presentations were made with Canva and the mockups with Figma.

The third project was addressed by Expect Me is a Belgian hospitality tech startup that focuses on the international hotel industry. They provide hotels with a unique software that will allow their guests to select and guarantee a specific room based on a clear floor plan and room overview, as convenient as selecting your seat on a plane. The challenge was to develop an integrated plan for an automated onboarding process to activate those

hotels on Expect Me, named “Onboard Me”. This project required building a dedicated onboarding platform, either custom-made or (partially) integrating open-source tools, considering a service approach, proper communication, marketing, and design to reflect Expect Me hospitality values. The team was divided into four departments: marketing, hospitality, design and development. The marketing department helped with the “Onboard Me” platform providing a mission, vision and values statements, a description of the platform and their benefits. The hospitality team was asked to create a data base with the over 600 hotels that the company provided and establish direct contact with some hotels located in Portugal that were on the data base. Moreover, the hospitality team helped with the making of the marketing action plan. The design team focused on corporate identity, flow diagrams, wireframes and website design. The development team implemented the “Onboard Me” application by developing and integrating three portals: Admin Portal, Company Portal and Customer Portal.

APPENDIX C: PRESENTATION OF PAPER

Blended Mobility Project Organization

- HIEs from 11 countries participating:
  - Portugal, Belgium, Germany, UK, Greece, Italy, Kurdistan - Iraq, Slovenia, Nigeria, France and Lithuania.
- Information Technology companies provide real project proposals.
  - With this professional involvement, students got a context which is international, multicultural, multidisciplinary and professional.

- Preparation starts in **October**.
  - ❑ Teachers collect challenges from companies.
  - ❑ Initially 13 projects were selected.
  - ✓ Projects are presented to students (final year BS - Masters).
    - ✓ Each project is implemented by a team of about 10 students.
    - ✓ Information Technology and Software Engineering disciplines
    - ✓ other fields: Business Development, Management, Electronics, IT & Design

Blended Mobility Project Organization

- 2021/22 edition: 53 students, 14 teachers, 11 HEIs
  - ❑ 7-9 students per team.
  - ❑ 7 popular projects (among the students) from 13 selected.
- ✓ Process was concluded **end January, 2022.**

- First face-to-face meeting Ghent, Belgium, **21-25 February, 2022**. beginning of the second semester
  - Students get to know each other, the company project details.
  - Students have to interact, cooperate organize themselves to work as a team during the semester and assign responsibilities
  - Students design a first draft of the solution for the challenge.

❑ At the end of the week the envisaged solution by each team is discussed with the company, the teachers and the students.

Blended Mobility Project Organization

- After this first meeting, students work at their home institution working at a distance through online groupware platforms.

- Second and final meeting Porto, Portugal, **20-24 June 2002**
  - Students get together to finalize solution, final presentation, discuss product with company and the teachers.
  - The team must guarantee to produce a solution for the problem and present the full solution to the project jury.
  - Project jury was composed by a teacher from each HEI and representative from company.

Blended Mobility Project Challenges

- 7 projects implemented academic year 2021/22
  - 3 of them will be presented, HMU students participated.

1. Hylyght, a Belgian startup company.
   - Designing and development of web-based application for physiotherapists, doctors, coaches, data gathering, quick analysis of video.
2. The second project was introduced by Epam Systems
   - American company that specializes in product development digital platform engineering, and digital product design
   - The challenge was to create an interior design application, named "DecoratAR", to allow people worldwide to visualize furniture in their living spaces more easily.

Blended Mobility Project Challenges

3. Expect Me a Belgian hospitality tech startup that focuses on the international hotel industry.

❖ The challenge was to develop an integrated plan for an automated onboarding process to activate hotels on Expect Me, named “Onboard Me”.

Website-Application for sports performance testing

➢ **WHAT IS HYLYGHT? WHAT DO THEY DO?**

Website-Application for sports performance testing

- **Designing and development** of a user friendly web-based application for physiotherapists, doctors, and coaches which will help to quickly gather all the necessary information they need without losing time on testing or the analysis video.

- ❑ Company's clients spend a lot of time on testing and gathering data.
- ❑ The analysis takes too much time
- ❑ There are a lot of open-source to access
- ❑ The interface must be more user-friendly

Website-Application for sports performance testing

Website-Application for sports performance testing

About the Product?

- An improvement of the existing version of the application for Desktop, Mobile and the Tablet version.
- **Main objective:** help physiotherapists analyze their athletes, based on some tests such as: coordination, strength, endurance, speed, flexibility, body analysis, anthropometric, among others.
- The application will be available in all mobile versions, in order to facilitate the analysis and study of athletes for better treatment, rehabilitation and injury prevention.
- In addition, a video analysis of "Jump Height" and "Skeleton" will be integrated, which basically helps, both physical therapists and athletes themselves, to analyze and study their efficiency and effectiveness in the appropriate treatment.
- Ability for athletes or physiotherapists to film the training, so that it can then be evaluated in more detail. This evaluation will be carried out by the application automatically, which will make the analysis much faster.

Website-Application for sports performance testing

Goals

1. More Options (sort by, filter, Add test/Athlete…)
2. User Friendly Interface
3. Adding new Features (QR-Code, Video Analysis..)
4. Keeping the existing Design Language

Website-Application for sports performance testing

HMU involvement in project

- Website in VueJS to accompany therapists in their daily tasks.
- Start the process by creating athletes' profile.
  - Each profile can contain several data items (personal data, notes).
  - Athlete data is fully open to modification as needed.
- Selecting the athlete(s) and choosing the test intended to be performed.
- Ability for the therapist to upload a video and receive the results automatically.

Website-Application for sports performance testing

Website-Application for sports performance testing

Development

1. Learn Vue Framework
2. Use Agile Methodology
3. Develop the website following the design
4. Deploy the website

Interior Design application

Epam Systems

- Create an interior design application, named "DecoratAR", to allow people worldwide to visualize furniture in their living spaces

Interior Design application

Segmentation, Targeting, Position (STP) Analysis

Looking at the world around us there's no doubt that the use of interacting apps and technology is increasing more than ever.

Interior Design application

Differences from existing applications

- Searched for existing similar apps to see what they offer and how similar or not they were with the proposed idea.
- Some of them had similar functions,
  - none of them implemented the proposed ideas

Interior Design application

Differences from existing applications

	Planner 5D	Ikea Place	DecoratAR
Scan the room	✗	✓	✓
Place Furniture	✓	✓	✓
Resize Furniture	✗	✗	✓
AR technology implemented	✗	✓	✓
Share on social media	✓	✗	✓
Buy Furniture	✗	✓	✓

Interior Design application

User Interface and Design

- After having a clear vision of the functionalities

- designing team:
  - ✓ to start designing how it would look like,
  - ✓ to make mockups for the developers to implement
  - ✓ to create the application's logo.

Interior Design application

APPLICATION DESIGN: How it should look like?

- Minimalistic
- Clean
- Intuitive

Interior Design application

10

COLORS

- Grey
- Beau Blue
- Off-White

DECORATAR

Application Logo

We want our logo to reflect a strong desire for new achievements and innovations. That's why we use colors that will show the vision of our application itself.

- Off-White is associated with new beginnings
- Blue is associated with inspiration
- Grey is associated with neutrality

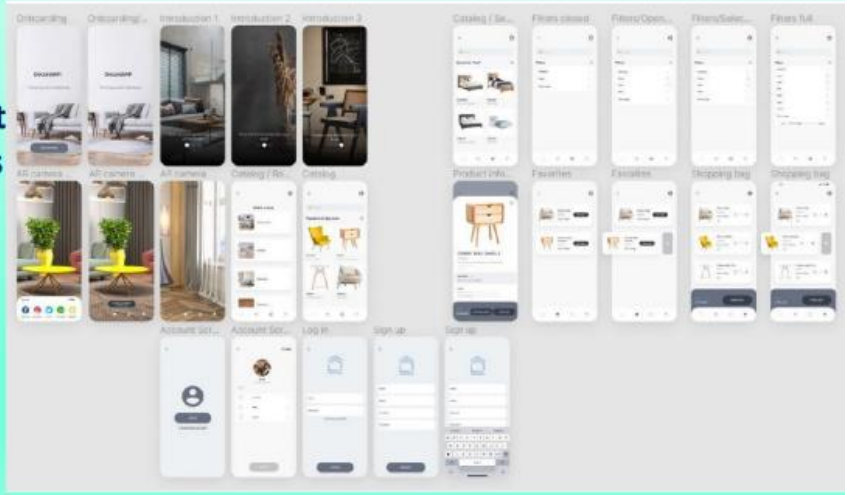
Blended Mobility

Interior Design application

HMU involvement in project

Development

Used Unity3D (With C#) to implement part of the mockups created with Figma.



Blended Mobility

ONBOARDME

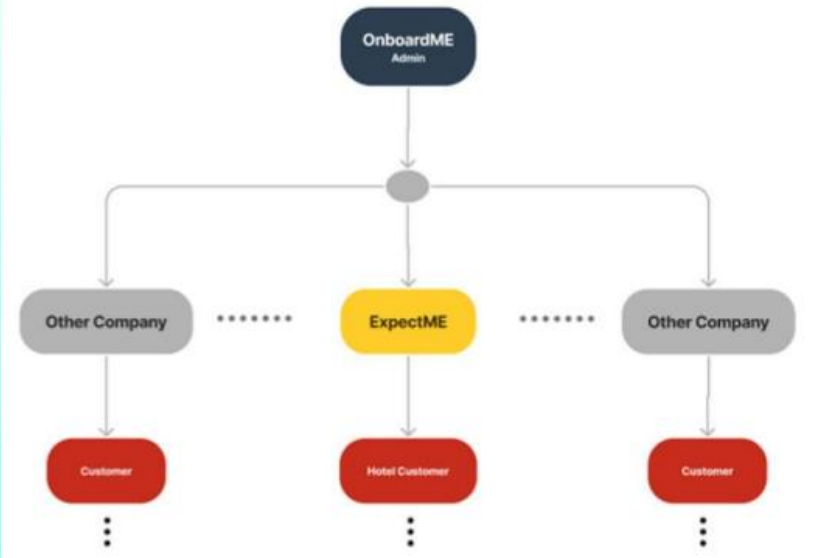
Expect Me

- Their mission is to help hotels and their guests achieve the ultimate hospitality experience.

Expect Me

- They provide hotels with a unique software that will allow their guests to select and guarantee a specific room based on a clear floor plan and room overview, as convenient as selecting your seat on a plane.
- **The challenge** was to develop an integrated plan for an automated onboarding process to activate those hotels on Expect Me, named **ONBOARDME**.
- This project requires building a dedicated onboarding platform, either custom-made or (partially) integrating open-source tools, considering a service approach, proper communication, marketing, and design to reflect Expect Me hospitality values.

ONBOARDME
3 layers of users,
so 3 portals:
~~Onboardme~~
admin
Companies
Customers



USED TOOLS

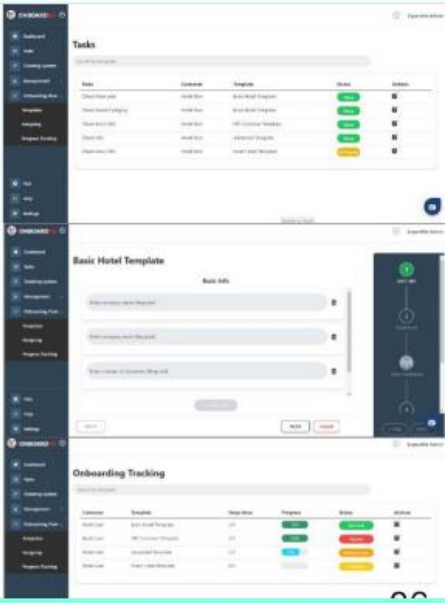
Jira
Figma
Microsoft Teams
node.js
Azure
React
mongoDB
GitHub
Bootstrap

DESIGN

- Corporate Identity
- Flow Diagrams
- Three portals
  - Admin portal
  - Company portal
  - Customer portal

COMPANY PORTAL

- Dashboard
- **Onboarding Flow**
  - Templates
  - Assigning
  - Progress tracking
- **Tasks**
- Management
  - Customers
  - Roles
  - Users
- Wiki
- Contact Details



CUSTOMER PORTAL

- Dashboard
- **Onboarding Flow**
- Wiki
- Contact Details