TÉCNICO LISBOA

The Future of Radio - Combining Music Streaming With Traditional Terrestrial Radio Services

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Acknowledgments

When I have to write this part I’ll definitly cry.

Abstract

Audio streaming services are used daily by millions worldwide, enabling on-demand listening and the discovery of songs, artists and podcasts that closely align with the listener's preferences. Meanwhile, traditional terrestrial radio persists as another ubiquitous and still viable mode of accessing more pre-programmed music and news content, including traffic reports and weather information. While both media services offer listeners a distinct set of value propositions, efforts to combine the 'best of both worlds' have been few and far between. Towards this objective, we describe our preliminary efforts to understand audio media consumers' music streaming and traditional radio listening habits and preferences as part of a project aimed at creating an integrated experience for individual listeners and their close networks of family and friends. Through rapid prototyping, and the speed dating method, we explore the design implications for creating and validating radio-like experiences that are at once personal, customizable and shareable.

Keywords

Music; Music Streaming Services; Music Technology; Terrestrial Radio; Interactive Radio; User-Centered Design; Human-Computer Interaction

Resumo

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Palavras Chave

Música; Serviços de Streaming de Música; Tecnologia Musical; Rádio; Rádio Interativa; Conceção Centrada no Utilizador; Interação Pessoa-Máquina

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Listings

Acronyms

API	Application Program Interface
UI	User Interface
MBaaS	Mobile Backend as a Service
SDK	Software Development Kit
URI	Uniform Resource Identifier
RTA	Retrospective Think Aloud
RP	Retrospective Probing
SUS	System Usability Scale

1

Introduction

Contents

At the start of the millennium, Coats et. al [1] predicted that streaming would become the future of audio media consumption. With respect to music streaming services and corresponding developments around related technologies and the internet, early studies anticipated the stagnation and ultimate demise of traditional media, such as terrestrial radio [2]. More recent research, however, appears to contradict these predictions, revealing the sustained popularity of traditional radio broadcasting. [3, 4]. Indeed, in large parts of the world, traditional radio remains strong and continues to co-exist alongside newer streaming services, albeit with the important caveat that younger audiences are diminishing [5].

Streaming has rapidly become the standard delivery method for digital entertainment content [6], with the music industry forming an integral part of this interactive mode of media conveyance. In recent years, platforms such as Spotify, Apple Music, and Tidal have emerged as some of the more predominant and thriving services for on-demand media consumption, offering users new and easier ways to access, listen to, and discover songs, artists [7] and, more recently, podcasts to match their tastes. Specifically, audio streaming services enable listeners to access and discover an almost limitless selection of content [8]. With their ubiquity and large catalogues of recorded music and podcasts, along with social functions - such as the ability to create and collaborate on playlists, group listening, and shared activity notifications - audio streaming services offer listeners an enticing array of experiences, resulting in the widespread adoption of these services. [9]

Traditional radio, on the other hand, delivers a connection to the outside world through the disclosure of important information in a succinct way. More importantly, and in contrast to music streaming services, it is difficult for radio stations to make their song selection appealing to every listener, which in return makes them get worn-out and tired of tuning in to radio stations.

Yet, traditional terrestrial radio's popularity has remained very strong in recent years. [5] This is, in part, due to the human connection this medium provides, and which other modern solutions are taking away [4]. The 'social presence element', described by Short et. al [10] as "the degree to which a particular medium allows communicators to feel other people as being present psychologically", is lacking in music streaming services. The authors state that, in conjunction with the lack of nonverbal cues — which makes the communication quite limited — there is a direct and indirect impact on users' behavioral intention or actual use of technological platforms, such as music streaming services [11].

From the beginning of its adoption, terrestrial radio's strengths were ubiquity of access, ease of use, and the local nature of its content, as stated by the North American Broadcasters Association (NABA) [1]. Furthermore, according do Priestman et. al [12], one of the most compelling reasons for people to listen to it is because of the intimacy of audio - a person listening to radio is alone with the announcer or artist, even if other people are physically present, and much of the fascination of audio is the imagination it requires on the part of the listener to actively visualize. Waits et. al [4] also states that listening to the

[1] The Value Proposition Of Radio In A Connected World — NABA Next Generation Radio Working Group, 2019

radio, though experienced individually, is often a communal act, which sets our relationship to traditional radio to be determined by a certain expectation that it will be authentic and sociable.

Bringing all together, we can conclude that there is a lack of solutions that aim to improve the audio media consumers' experience. Music streaming services are convenient and highly popular because they allow listeners to not only enjoy their favorite songs on demand, but also to discover brand new artists that match their music taste. On the downside, they eliminate the human connection that traditional terrestrial radio stations provide, as there isn't someone on the other side of the line interacting with the listener, nor communicating information such as news, weather, or traffic information. Therefore, listeners loose their connection to the outside world while pivoting themselves on music streaming services. To try to improve this experience, we have started by asking ourselves: how can audio media consumers' music streaming and traditional terrestrial radio habits be best represented in an integrated and personalized experience that may be shared within small networks of friends and family?

In this work, we describe our efforts in designing and conceiving a solution, dubbed 'Sterio', that aims to answer our hunt statement, by developing a platform that is user-focused from its inception. Through rapid prototyping and the speed dating method, we explore the design implications for creating and validating such radio-like experiences that are at once personal, customizable, and shareable.

1.1 Goals

The objective of this work is to develop a general purpose platform that creates a novel radio-like listening experience, that aims to be personal, yet personalized and social. In order to achieve this goal, we defined some sub-objectives:

- Identify the most and least valued user features of both music streaming services and traditional terrestrial radio;
- Study and analyze the currently available platforms and mediums, as well as their most recent augmentations;
- Explore, develop, and reflect on the stature of a set of concepts and prototypes that aim to tailor users' needs and desires into an audio-listening experience of the context of this work;
- Design and develop a solid, appealing, consistent, and user-focused high-fidelity prototype of a general-purpose platform, that creates a novel and enticing radio-like listening experience;
- Evaluate the high-fidelity prototype in order to understand what type of experience is created within its users, as well as its usability, viability, and likability.

1.2 Document Structure

In Chapter 2 we present and discuss related work, focusing on the currently available music streaming services, how traditional terrestrial radio still plays an important role in audio media conveyance, and how the concept of interactive radio can be further augmented. At the end of such a chapter, we define the requirements for our solution. Chapter 3 is dedicated to describing the preliminary user research we conducted, and Chapter 4 presents the results of applying the speed-dating methodology to our concept. Chapter 5 describes the implemented solution, and chapter 6 shows the evaluation conducted on prototypes and its results. Finally, in Chapter 7 we expose our conclusions on this work and reflect on future work.

2

Related Work

Contents

In this section, we start by describing and analyzing the most popular music streaming services and the value they add to its millions of users. Then, we study how traditional terrestrial radio has kept up the pace and, despite its competition in the digital era, remained an important and prominent medium.

Finally, we outline the concept of interactive radio by presenting several important projects that apply and augment this concept, followed by a discussion regarding the most attractive and less compelling features of these three audio listening experiences.

2.1 Music Streaming Services

Music streaming services allow user access to millions of musical content from any web-connected computer, legally and free or with a low charge [13]. This kind of service marked an important cultural shift from old to new media [14]. But what attracts listeners to these services?

Various studies have explored the factors that determine consumers' decisions about adopting digital music streaming services. Vlachos et. al [15] identified content and convenience attributes as key indicators of consumers' willingness to use music streaming services. According to Weijters et. al [7], there are eight main factors that drive users to adopt these services: audio quality, business model, legality, ethicality, video capability, search/suggest features, connection to social media, and delivery mode (download vs. streaming). Furthermore, Stark et. al [16] have concluded that listeners rely on streaming services primarily for recreation and relaxation and that their listening sessions can happen over an entire day. Glantz et. al [14] has studied how streaming music services create and embrace opportunities to fit themselves into the lives of music fans while comparing them with terrestrial radio, while Swanson [13] has studied what users expect from listening to streaming services as an interactive medium, and what are the gratifications sought when tuning into them, also in comparison to terrestrial radio. Finally, Datta et. al [17] have studied how the adoption of music streaming services affects listening behavior of users.

Spotify, Apple Music, and Pandora Radio are the most used streaming services in the world [1]. To understand what are the best functionalities of each platform, we have conducted a study where we analyzed these three platforms with their top-tier plan, for an entire week as our main music listening source. In the ambit of our work, we have focused our analysis on two main aspects of each service: radio and sociability. We have reported our opinions, desires, and aspirations while using each service, so we could analyze their main strong features. The following subsections summarize our conclusions and combine them with researched information about each service.

[1] As of February 2020, according to Statista.

2.1.1 Spotify

The Sweden-born Spotify[2] is the most used streaming service in the world. In this service, music can be browsed using a search tool by track name, artist, or album. Users have the option of registering for a free account, supported by visual and radio-style advertising, or for one of two paid subscription models, which are ad-free and offer a range of additional features, such as higher bit rate streams and offline access to music. [13]

Nowadays, the platform incorporates highly advanced technologies, such as artificial intelligence and machine learning algorithms, in order to be a powerful tool for discovering new music according to the users' tastes. Furthermore, Spotify also provides its users many types of content, such as podcasts and even videos submitted by artists.

One of the main features available on this platform is the 'Radio' section. When using it, Spotify will suggest the user a number of playlists (called 'radio stations') based on their listening habits (favorite genres, artists, albums, or songs). A user is able to create a radio station based on a choice of a song, album, artist, or playlist, and the service will generate a 'radio station' with songs that are similar to the ones selected. As we'll discuss later, many music streaming services, including Spotify, want customers to know that they are similar to, but ultimately different from, or better than, traditional terrestrial radio [14].

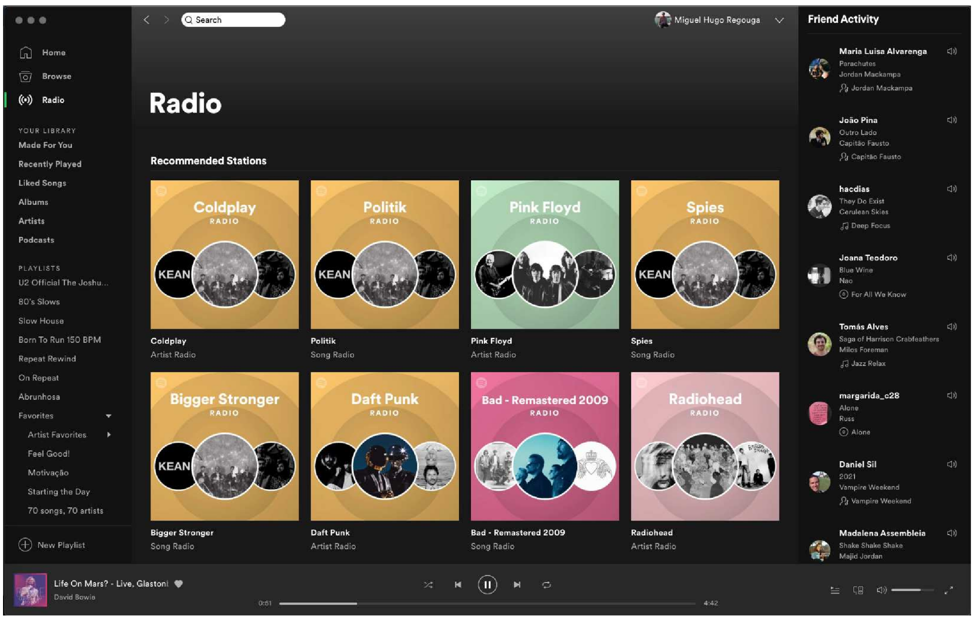


Figure 2.1: Spotify 'Radio' discovery features on its desktop application

Ultimately, the most relevant aspect in the context of our research was Spotify's sociability features. Users can choose from a wide range of playlists created by the Spotify community with hand-picked

[2] Spotify website.

songs, and not by an algorithm. Furthermore, it is possible to see what friends and family are currently listening to. As Wang et. al [11] described, users of these platforms can be driven by a sense of online community and may be willing to have more interaction with others, and this emphasis on sociability from the inception of the platform might be one of the reasons why it is so popular.

In the context of this project, we consider Spotify as a solid starting point for further analysis and study. It is, according to our criteria, the most solid and robust streaming service available, but has its flaws. As Gunawardena et. al [18] mentions, users can perceive a feeling of warmth and human contact by means of social presence, and although they exist, we find the social features of Spotify quite limited and not enough to provide users a well founded human connection. We'll explore this matter in section **??**, when we discuss the conducted user research.

2.1.2 Apple Music

In spite of Spotify being currently the most used music streaming service in the world, Apple Music is growing at a fast pace, as it is now the most used streaming service in the United States.[3] The service was born in 2015 after the company Beats was bought by Apple.

When this service was released to the public, its main selling point was that it was bringing a strong human element to these on-demand services, arguing that "algorithms can't do it alone – you need a human touch" [4]. Thus, the core features of the service were curated playlists, hand-picked by music experts, and recommendations tailored to the users' music preference, not resorting to algorithms (as Spotify does) [5].

Apple Music was also focused to emphasize on traditional terrestrial radio. Along with the introduction of this service, Apple announced they would be launching the Beats 1 radio station (now renamed to Apple Music 1), which broadcasts live to over 100 countries 24 hours a day, and would feature 'real' radio hosts, such as DJ Zane Lowe [6]. In 2020, Apple expanded this section of the service by adding three more 'real' radio stations that offer not only daily curated playlists of music, but also artist interviews, global exclusives and premieres, and other breaking music news. The idea behind these streaming radio stations is to cater to people who, sometimes, just want to turn on music without having to think about what they want to hear or dig around for a favorite playlist. That was the original promise of terrestrial radio, and Apple believes the formula can still work on modern-day streaming services, as well [7].

Building on that premise, Apple has also added to the service the ability to search for 'real' radio stations from around the world, allowing users to dial in local broadcast stations by call sign, name,

[3] As of September 2019, reported by Statista.
[4] Apple Music interview: 'Algorithms can't do it alone – you need a human touch' — The Guardian, 2015
[5] Apple unveils streaming service Apple Music and 24-hour radio stations — The Guardian, 2015
[6] Zane Lowe on Apple, the BBC and why he'll miss London — The Guardian, 2015
[7] Apple launches Apple Music Radio with a rebranded Beats 1, plus two more stations — TechCrunch, 2020

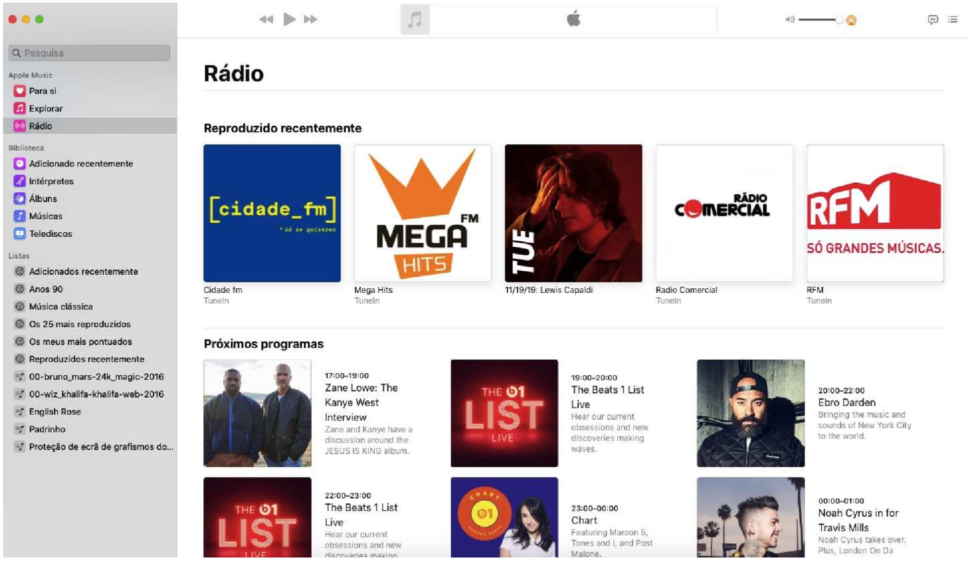


Figure 2.2: Local radio stations and discovery features on the Apple Music 'Radio' tab

or frequency [8]. Furthermore, the "Radio" tab also incorporates the before-mentioned Apple Music 1 station, as well as other radio stations that play genre-specific or artist-related music, depending on the user's preference. Unlike traditional radio services, the radio feature in Apple Music allows users to skip songs, view previously played tracks on the station, as well as to know what songs are playing next.

In terms of sociability, Apple Music is lacking in features, specially in comparison with Spotify. Although its original release included a 'Connect' screen aimed at creating a social experience between listeners and artists, such feature was later removed due to its low usage [9]. Nevertheless, until 2018, a truly social experience between the platform's users never existed. The ability for users to share what they're listening with their friends was later added [10], yet it is not as developed nor integrated in the platform as Spotify's matching features are.

The approach Apple Music takes on traditional terrestrial radio is very interesting in the ambit of this project. The addition of 'real' radio stations to the service and the commitment to add the option to listen to terrestrial radio stations may prove that users still want to indulge on this medium, despite the convenience that on-demand music selection provides them. Later on the study, we'll analyze the possible reasons why this is happening.

2.1.3 Pandora Radio

The Pandora Radio project was born in 2000, and it is considered one of the oldest streaming services available. The platform is widely popular in the United States, which is the only country it operates in.

[8] TuneIn brings over 100,000 radio stations to Apple Music — Broadband TV News, 2019
[9] Apple is shutting down Apple Music's rarely-used Connect feature — The Verge, 2018
[10] Apple Music will let you share what you're listening to with your friends — The Verge, 2017

Pandora takes on a different approach than the one from Spotify and Apple Music. While both these services were built on an on-demand philosophy, allowing the user to select their desired musical content to play, Pandora wasn't. Pandora enables the creation of 'personal radio stations', in which the user is prompted to choose a song, artist, or album, and a radio station is generated based on that choice (much like the Spotify's own 'radio' feature). [19] In short, listeners can tune into established genre stations, other users' stations, or create their own stations based on their musical interests. It functions in a similar way to a traditional radio station except that users select a song or artist they want to hear and a station is generated based upon such selection. [13]

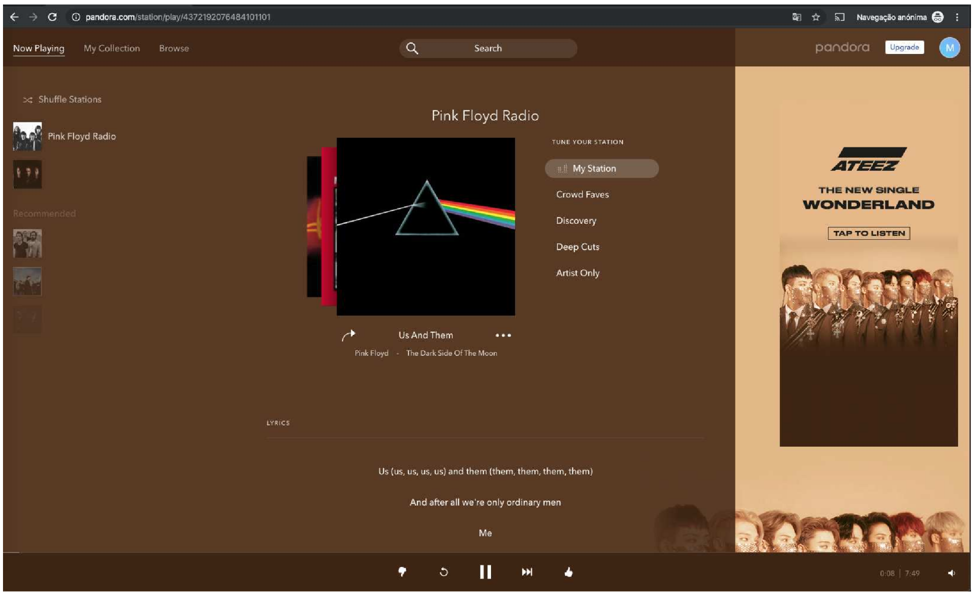


Figure 2.3: Pandora Radio web interface

While listening, users can rate positively or negatively the songs that are being played, and such feedback is taken into account in the subsequent selection of other songs to play, tuning in each station to the users' taste. Furthermore, users may even tailor their station to specific tendencies, such as 'Discovery', 'Crowd Faves', or 'Deep Cuts'.

When talking sociability, Pandora offers the same basic social functionalities as Apple Music — it is possible to follow users, see what they are listening to, and share stations with the community, but the platform isn't as community-centered as Spotify is.

One of the reasons Pandora may be so widely used is the fact that users don't want to choose what they want to listen to all the time. As Meneses mentioned [19], having millions of songs available is perfect when users want to listen to the music they are already familiar with, but most users don't want to listen to the same music constantly - hence the creation of discovery features on Spotify and Apple Music. On the other hand, if traditional radio is the main information source on new music, that happens because users want to uncover new material from artists or genres.

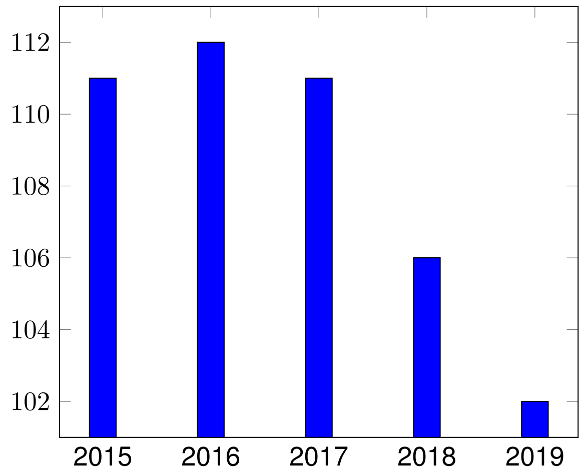


Figure 2.4: Average daily time spent listening to the radio per adult in the United States (in minutes) — Statista

2.2 Traditional Terrestrial Radio

Radio is the first mass medium that enables the instant dissemination of information from one to many, and it is often described as a "local" and "personable" medium to its audience [20]. It is largely a one-way communication system that allows individual listeners to passively consume radio content provided by radio broadcasters without any interaction or participation [21]. From its inception, traditional terrestrial radio has been challenged by several innovative technologies, each drawing listeners and forcing radio to update its programming to remain a competitive media option [5].

Although music plays a vital role in radio diffusion, traditional terrestrial radio also provides its listeners with useful information, such as news, weather, and traffic reports. A study conducted by Albarran et. al [5] has shown that, when taking all other audible mediums available into account (including music streaming services), traditional radio is still ranked as the first go-to solution when a user wants to access news and other types of information.

Waits et. al [4] states that traditional radio still features one of the things that on-demand streaming services may arguably be taking away from its users — a human connection, stating that the users' relationship to this medium is determined by a certain expectation that it will be authentic, sociable, and display intentionally and sincerity. Priestman et. al [12] argues that the same cannot be said about music streaming services, naming these platforms as 'automated music channels' or 'automated web jukeboxes', due to the absence of the sociable component in conjunction with the emphasis on the listener's music selection. The researchers' approach on traditional radio can be defined as a 'human communication', where one senses that the voice of an announcer creating the threads between various other broadcast elements becomes a key point.

A different study, conducted by Glantz et. al [14], states that, as advanced as music streaming platforms can be, they still anchor themselves in traditional radio. Many of these services market themselves as a ”personalized radio”, ”your radio station”, or as far as ”radio reimagined”. They want their users to believe that they are similar to, but ultimately different from, or better than, traditional terrestrial radio. In contrast, Priestman et. al [12] describe streaming services as a contradictory phenomenon to define in radio terms, since ”it is quite clearly an extension of music format radio but, in doing away with any form of presenter or news or indeed any kind of radio studio at all, it removes the essential element of broadcast communication: one human person talking directly to another or sharing with them some form of entertainment.”

In a study conducted in 2008 by Ala-Fossi et. al [2]. a group of users predicted that that the numbers of FM radio stations and their listeners would be decreasing by 2015, due to the impact of the emerging internet services, such as music streaming platforms. Yet, in defiance of the competition, traditional radio remains the biggest mass-reach medium in the United States, with more than 90% of consumers listening on a weekly basis [11]. The main thesis on why this is happening has to do with the conjunction of two concepts: passive listening, to which traditional terrestrial radio is built upon on; and tyranny of choice. [12] According to Miller, “the availability of so much music has led to what some academics and analysts call the tyranny of choice”. Users of music streaming platforms are often hit by this tyranny of choice, where the amount of selection available makes them unable to decide what to listen to, tuning to a ’traditional’ radio station where a radio host interacts passively with its listeners. [22].

In short, terrestrial radio still remains with a strong adoption, in spite of the rise of on-demand services. The disclosure of information, the passive audio listening experience, the sense of community, or the human connection that terrestrial radio stations provide may be some of the reasons why users still indulge heavily on this traditional medium. Nevertheless, music streaming services are still rising in popularity, which proves that the convenience of on-demand listening is evident among its users. The concept of interactive radio, which will be discussed in the following section, may provide a hint at a solution that aims to pick on the passive experience of traditional radio and merge it with the on-demand music selection that streaming services provide.

2.3 Interactive Radio

2.3.1 Calm Computing

In 1991, Weiser and Brown suggested that “if computers are everywhere they better stay out of the way, and that means designing them so that the people being shared by the computers remain serene and in control.” [23] Weiser and Brown’s vision was not realised, as nowadays computers are everywhere, but they do not stay out of our way. Mobile computing is predominantly stop-and-interact and the web

[11] The remarkable resilience of old-fashioned radio in the US — Quartz, 2014

[12] Radio survived the tape, CD, and iPod. In the age of Spotify, it’s more popular than ever. — Quartz, 2017

demands our constant engagement. Yet, there might be a platform available for a pervasive service that could advance Weiser and Brown's vision of calm computing: the format of radio.

Audio is an example of content which we can selectively attend to. Many times users listen to music while they do something else: work, run, drive, etc. Vazquez-Alvarez et. al [24] showed that, when designing audio interfaces, there was a significant difference between the user experience of selective attention (where audio was in the background and not requiring the full attention of the user) and divided attention (when two audio streams where competing for the user's attention). This ability for audio to shift between the center of our attention and its periphery fulfills a key element of Weiser and Brown's vision of calm computing. [23] Calm computing argues that systems should remain in the periphery of our attention until we require their services, at which point they would move to the center of our attention for direct interaction.

Radio is so common as a passive medium that it requires a conceptual leap to regard radio as a possible platform for eyes-free interaction. Yet, similar to interactive television, the concept of interactive radio is not a recent one. Although radio is considered to be a one-way communication channel from station to listener, many radio hosts try to mitigate this by asking listeners to interact with them — either through more analog types of communication, such as phone calls, or using modern platforms such as WhatsApp, enabling the listener to interact more easily with radio stations, potentially augmenting the overall experience of the listener. [20, 25] Yet, in the prime age of social interaction, many researchers have studied how this concept may be taken even further.

2.3.2 Nomadic Radio

One of the first approaches to this concept was presented by Sawhney et. al [26] in 1999. The researchers developed a system called *Nomadic Radio* in which scaleable auditory techniques and contextual notification modules for providing timely information were applied, while minimizing interruptions.

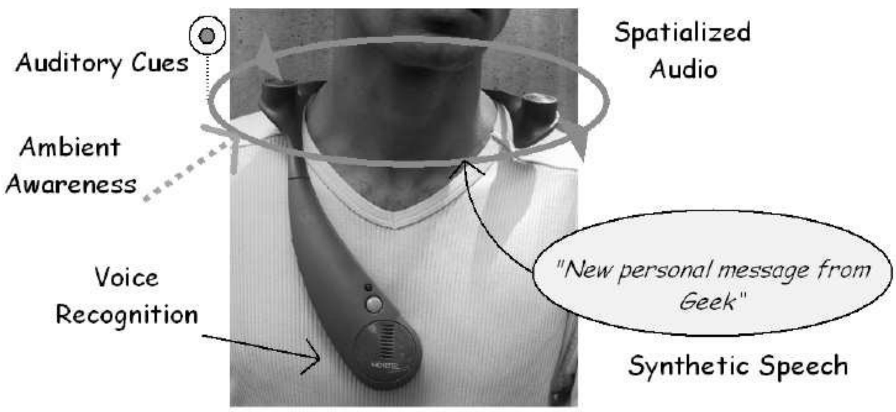


Figure 2.5: Description of the Nomadic Radio system with the SoundBeam Neckset audio device

Nomadic Radio is a wearable computing platform that provided a unified audio-only interface to remote services and messages such as email, voice mail, hourly news broadcasts, and personal calendar events. These messages are automatically downloaded to the device throughout the day and users can browse through them using voice commands and tactile input. This first attempt was, however, targeted at mobile workers rather than at the general audio media consumer.

2.3.3 AudioFeeds

Dingler et. al [27] built on the *Nomadic Radio* concept and took a more user-centered approach by proposing a mobile auditory display application, called *AudioFeeds*, that allowed users to maintain an overview of activities in different social feeds. The application runs on a mobile device and enables users to get an overview of their social networks and spot peaks in activity by sonifying social feeds and creating a spatialised soundscape around the user's head. By using this solution, users could stay informed about current issues and spot 'hot topics' while on the go.

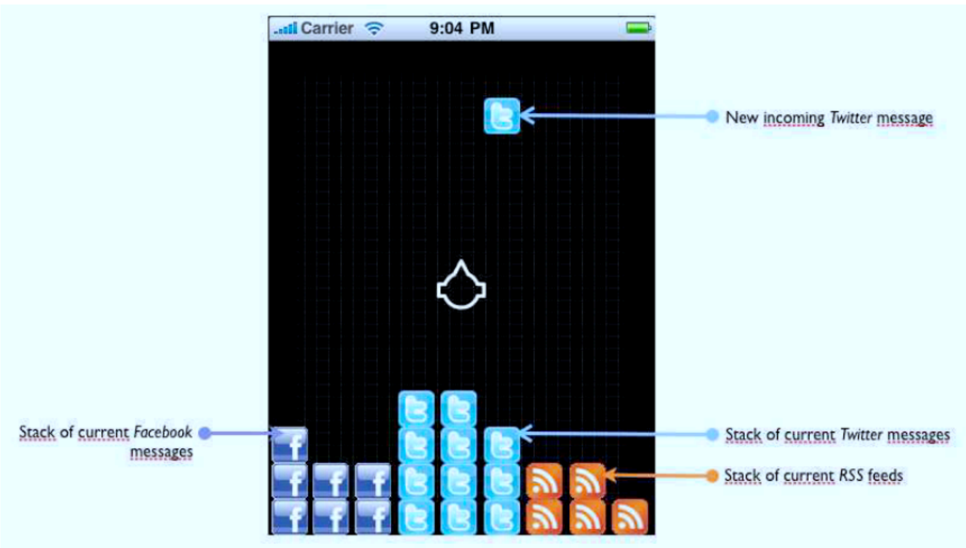


Figure 2.6: AudioFeeds GUI, where incoming messages are represented by icons that are dropped from the top

AudioFeeds adapted the idea of adaptive notifications that *Nomadic Radio* introduced and applied it to social feeds and their activity levels. The system enabled users to easily make out interesting social feed activities while maintaining an overview even in complex streams of information, thus fulfilling Weiser's vision of calm computing [23] and forming a close approximation of a truly interactive radio platform.

2.3.4 Radialize

More recently, Pereira et. al [28] created a platform for listening to music and radio programs through the Web, allowing the discovery of the content being played by radio stations on the Web, either by managing explicit information made available by those stations or by means of our technology for automatic recognition of audio content in a stream. Users can search, receive recommendations, and provide feedback on artists and songs being played in traditional radio stations, either explicitly or implicitly, in order to compose an individual profile.

Radialize utilizes every user interaction as a data source, as well as the similarity abstraction extracted out of the radios' musical programs, making use of the wisdom of crowds implicitly present in the radio programs. The system was one of the first user-available platforms that introduced a novel social listening experience based on the radio format, aiming to "be responsible for the transition of radio stations as a kind of mass media to a kind of social network". [28]

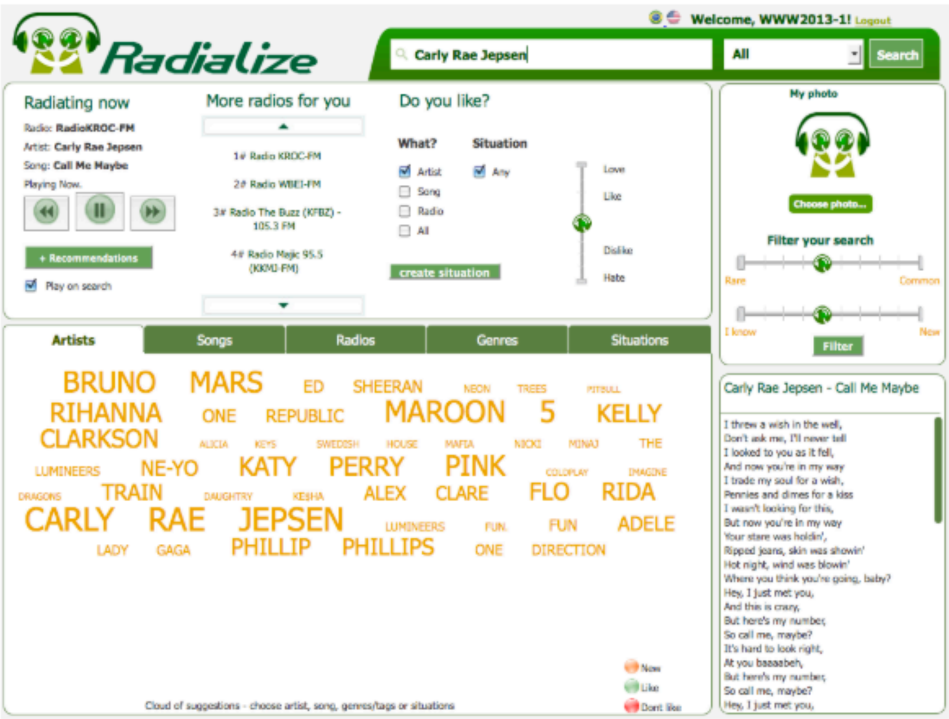


Figure 2.7: Screenshot of the Radialize system

2.3.5 MyMyRadio

Finally, and most importantly, the CereProc team created a platform which takes updates from a user's Facebook or Twitter accounts, and RSS feeds, and synthesizes them using CereProc's own text to speech technology, slotting these spoken updates into a playlist of your own music periodically. [13] Aylett et. al [29] have presented a case study on this platform, in which they highlight the potential and challenges of an interactive radio approach, which are of interest to the development of this project.

The MyMyRadio project was developed as a 'cure' to the constant engagement demanded by social networks, enabling content to be delivered in the background while users listened to music and carried out other activities. When a news or a social media was of interest to the user, the user could embrace a more direct and interactive approach with said content, allowing from an active listening experience. If a social, or news headline was of interest, the user would attend to it more closely and could interact directly with the content, moving from a passive or push-down consumption of content to an active or pull-down consumption.

This is in contrast with systems which use audio as notification of content, such as the previously discussed *Nomadic Radio* and *AudioFeeds*, where an audio notification interrupts the current activity. Instead, MyMyRadio inserts content naturally between music tracks to allow continued attention in the periphery. Furthermore, an audio notification system typically does not render the actual information, whereas MyMyRadio uses speech synthesis to render the headline so that only content which is of interest to users is brought to their attention. According to the testing results, the concept of this platform was well received and considered 'desirable' by its users.

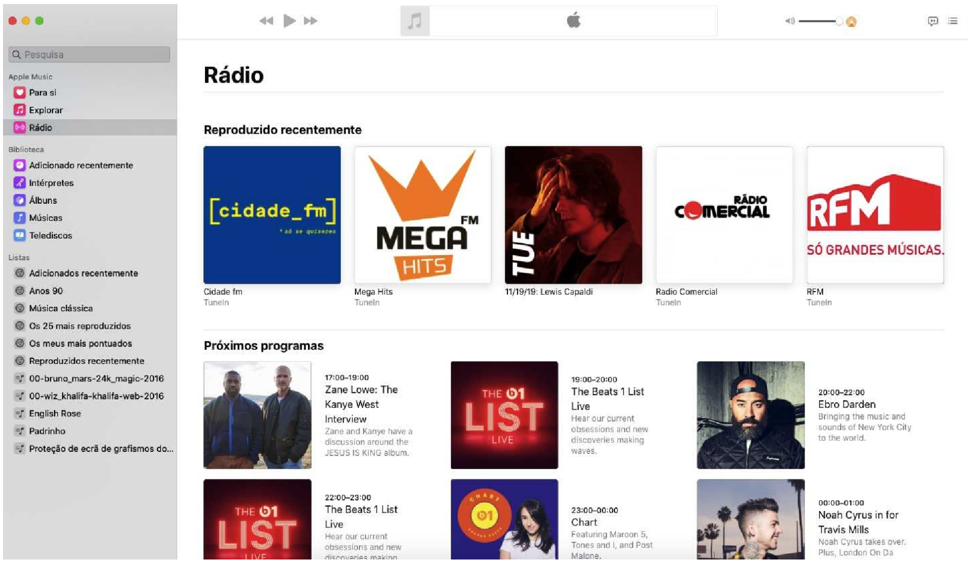


Figure 2.8: MyMyRadio mobile interface

In the ambit of such case study, the researchers concluded that *'a more developed interactive radio platform could contain localization information and allow a mixture of localized content, speech synthesis and pre-recorded audio, as well as personalized music streams such as Spotify (...) and offer integration with social media and new digital services.*'

[13] MyMyRadio (https://www.cereproc.com/en/mymyradio)

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Nomadic Radio	Yes	No	No	No	No	No	No	No	No
AudioFeeds	Yes	Yes	No	No	No	No	No	No	No
Radialize	No	No	No	No	No	No	No	Yes	Yes
MyMyRadio	No	Yes	Yes	No	Yes	Yes	Yes	No	No

Table 2.1: Summary of the analyzed interactive radio and calm computing platforms

2.3.6 Analysis

To facilitate the comparison between the mentioned platforms that implement and augment the interactive radio concept, Table 2.1 was created, with lines representing a given platform and columns showing some common and relevant features. We selected these features because we consider them to be the most important in the ambit of our case study. The mentioned features are:

(a) Audio notifications (interrupts current activity);

(b) News and social feeds (RSS, Facebook, Twitter);

(c) Integration with local (offline) music library;

(d) Integration with music streaming services;

(e) Speech synthesis of information (text-to-speech);

(f) On-site information rendering;

(g) Audio effects (adverts, jingles, background music);

(h) Social network/community features;

(i) Customization and recommendations;

The first feature determines if the system uses audio as notification of content, which interrupts the current activity of the listener [27]. The MyMyRadio system inserts content naturally between music tracks to allow continued attention in the periphery, which can result in an improved experience for the user.

Regarding the more social features, AudioFeeds and MyMyRadio provide integration with various social networks and news aggregation services, but AudioFeeds does not render the information locally as MyMyRadio does. This gives an advantage to the latter platform, which uses speech synthesis to render the headline so that only content which is of interest to users is brought to their attention. [29] However, although it aggregates displays content from social networks, MyMyRadio doesn't offer a truly social experience between users of the platform, and this is where Radialize has an advantage over the studied platforms.

By analyzing the table, we can observe that MyMyRadio is the most feature-packed platform, closely aligning with the scope of our project. It features a radio-like experience for its users by including audio dynamically created from news and social media sources, integration with the users' local music library, non-speech audio sound effects, and background music.

Yet, we can observe that none of the studied platforms offer integration with music streaming services, which, as we discussed in section 2.1, are now one of the preferred mediums for consuming audio content. Furthermore, only one platform offers a truly customizable experience tailored to each individual user, while also indulging them in a social-network like atmosphere. Identifying this will be important for defining our window of opportunity and to determine out how we can create a novel listening experience.

In conclusion, the concept of interactive radio can be further augmented, as, at first sight, there is both a user impulse for this to happen, and an opportunity that we can approach and tackle. Based on our research, this may be achieved by merging the strengths of both traditional terrestrial radio and music streaming services into a personal, yet sharable and customizable platform that aims to improve audio media consumers' listening experience. To assure this need, we'll conduct in-depth user research, aiming at understanding if users find such concept enticing.

3

Preliminary User Research

Contents

Before proposing a solution that aims at taking the concept of interactive radio further, we need to assess the need and desirability for such a solution. The before-presented literature identifies a demand; yet, as audio consuming mediums are very user-focused, there is a need to conduct a detailed investigation among these users' habits.

Furthermore, the foundation of this research project is a user-centered design development approach [30], as we want our hypothetical solution to suit the user, rather than making the user suit our solution. This is accomplished by employing techniques, processes, and methods, throughout the product life cycle that focus on the user. [31]

In a user-centered design approach, there are three main principles: an **early focus on users and tasks**, **empirical measurement of usage**, and **iterative design**. In this first stage of the project, we'll focus on the first principle — we want a systematic and structured collection of users' experiences so that we can maximize the quality of the user experience of our developed solution. By collecting user experiences, we can gain an understanding of what users want and need, how they currently work or how they would like to work, as well as the mental representations of their domain.

To best understand our users' habits and to have them into account from the very early stages, we have used three different user experience research activities: **survey**, **diary study**, and **interviews**. In this section, we describe the conducted procedures and efforts of each applied method, and we conduct a brief analysis of all the gathered data.

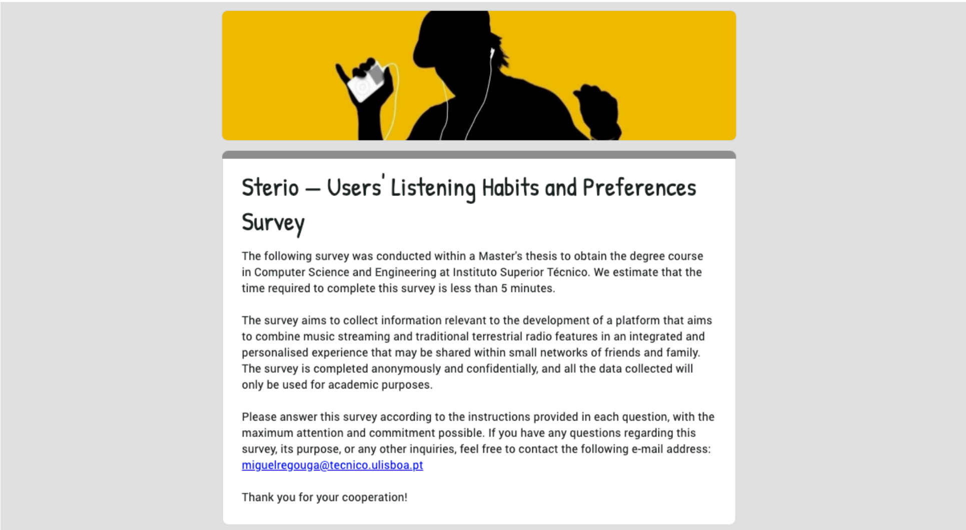
3.1 Survey

Surveys can be a viable approach to gathering data from a large sample in a moderately brief time frame. [31] They can help identify a target user population, current pain points, and opportunities that a solution could fulfill, and find out at a high level how users are currently accomplishing their tasks. Surveys ask every user the same questions in a structured manner, and participants can complete them in their own time and from the comfort of their home.

In this first stage, we wanted to reach a large number of people, and, according to Courage et. al [31], surveys are the indicated user research method to fulfill this requirement. Thus, we have conducted a survey using the online tool Google Forms [1]. We started by sharing it among our university's social groups to obtain a younger age range of respondents. Conversely, to get a set of participants from older age ranges and different socio-economical backgrounds, we also shared the survey among local general-themed social groups. The use of these different channels resulted in a broad set of respondents with distinct ages, occupations, backgrounds, and audio media consuming habits. Over one week, we have gathered **195 responses**, where 58.8% of them come from respondents with ages

[1] Google Forms

30 or below. Corroborating with this age range, half of the respondents are mostly students; the other half are employed.



Sterio – Users' Listening Habits and Preferences Survey

The following survey was conducted within a Master's thesis to obtain the degree course in Computer Science and Engineering at Instituto Superior Técnico. We estimate that the time required to complete this survey is less than 5 minutes.

The survey aims to collect information relevant to the development of a platform that aims to combine music streaming and traditional terrestrial radio features in an integrated and personalised experience that may be shared within small networks of friends and family. The survey is completed anonymously and confidentially, and all the data collected will only be used for academic purposes.

Please answer this survey according to the instructions provided in each question, with the maximum attention and commitment possible. If you have any questions regarding this survey, its purpose, or any other inquiries, feel free to contact the following e-mail address: miguelregouga@tecnico.ulisboa.pt

Thank you for your cooperation!

Figure 3.1: Homepage and introduction to the conducted survey

Among demographic and other miscellaneous user characterization questions, the following set of queries were asked:

- How often do you listen to music?
- Which mediums do you use regularly to listen to music?
- How often do you use streaming services?
- Which music streaming service is your most used one?
- On average, how long do you use streaming services in a listening session?
- Which of these factors do you consider more relevant when using a streaming service?
- What are the factors that stop you from using streaming services on a more regular basis?
- Do you listen regularly to podcasts?
- How often do you listen to traditional radio stations?
- On average, how long do you typically listen to radio?
- Where do you usually listen to radio?
- What are the main reasons that make you listen to radio stations?

Figure 3.2: Which of these factors do you consider more relevant when using a music streaming service?

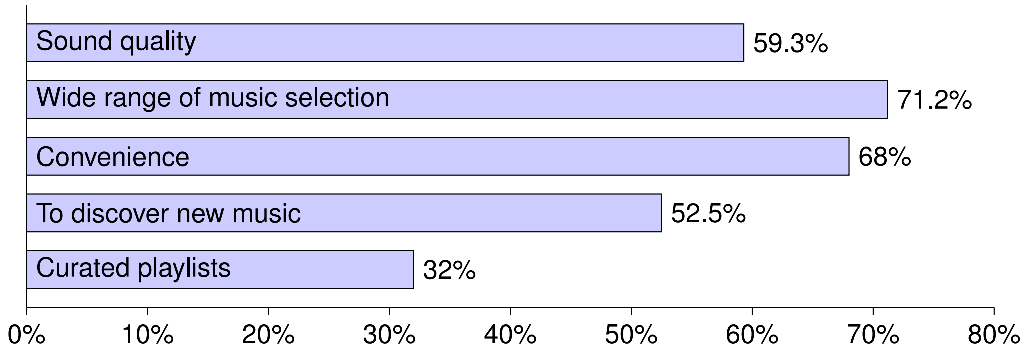
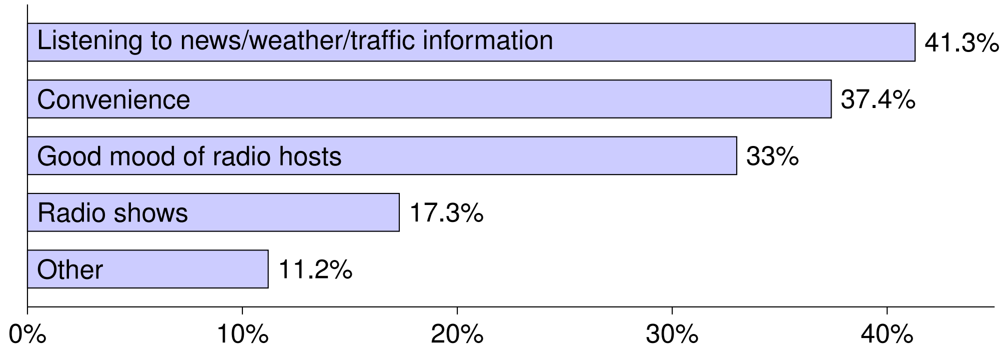


Figure 3.3: What are the main reasons that make you listen to radio stations?



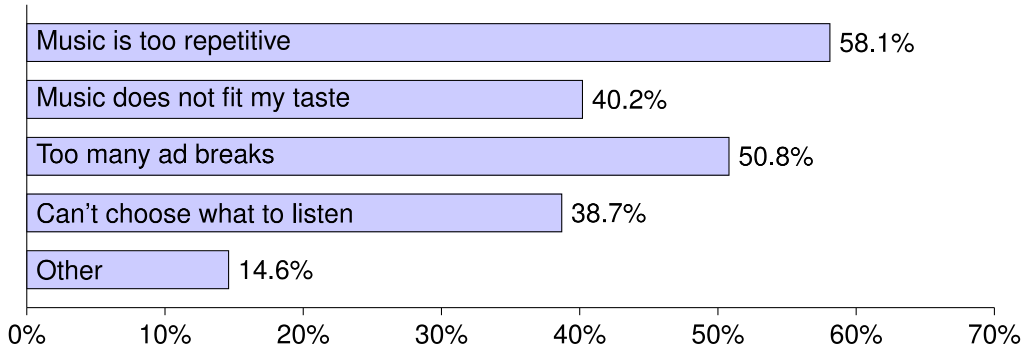
- What are the factors that stop you from listening to radio stations on a more regular basis?

When asked how often they use music streaming services, only 7% replied that they don't use them, and **almost 60% use them every day**. **Spotify** is the most used streaming service amongst them, while YouTube (which many use as a means of a streaming service) comes in second place. Users value these services' **wide range of music selection**, **sound quality**, and **low price**, but 16.7% of them still prefer to use another medium.

Regarding traditional terrestrial radio stations, 40.6% of the inquired listen to them daily, with 5.9% not listening to this medium at all. Almost half of the inquirers state that the main reason that makes them listen to radio stations is the **disclosure of news, weather, and traffic information**, with **convenience** and the **good mood of the radio hosts** following in second and third places respectively. On the downside, users don't listen to radio more frequently since they believe the music selection is too repetitive (58.2%) or doesn't fit their taste (40.1%); due to the high rate of advertisement breaks (50.8%); and because they can't choose what they want to listen to (38.4%).

From this first set of gathered data, we can arrive at some early conclusions. The first one is that music streaming services are really popular among this set of users, mainly because they see the advantage of having the possibility on-demand selection of music artists, songs, and genres. However,

Figure 3.4: What are the factors that stop you from listening to radio stations on a more regular basis?



when regarding radio stations, users enjoy the role of the radio host and the disclosure of information this medium provides, but often don't enjoy the music selection nor the long advertisement breaks.

As surveys allow us to reach a larger number of people, the use of this user research method may be a favorable first-step to start user research procedures. To obtain more detailed data about the users' audio media consumption habits, we have also conducted a diary study and interviews, so we could gather qualitative data and cross-reference it with the information obtained through surveying.

3.2 Diary study

To take a deeper look into audio media users' music streaming and traditional terrestrial radio habits, we have conducted a diary study, which asks participants to capture information about their activities, habits, thoughts, or opinions as they go about their daily activities. [31] This method allows the collection of typically longitudinal data *in situ*.

In order to obtain more raw and personal details regarding their audio consuming habits, we involved our own family and friends circle from the very beginning of the project, so we could understand how we can target and improve their experience. As we'll further discuss, we also want to understand how our solution could tackle the social presence and online community concepts, as described by Wang et. al [11].

We've selected 11 close friends and family to conduct a diary study over one week (the participating users on all user research activities are reported in table 4.1). From these users, 9 are paid subscribers of a music streaming service, while the other 2 use the free tier plan (if available). Users were asked to fill out a template spreadsheet on the Google Sheets [2] platform at the end of each day. The template, shown in fig. 3.5, had a set of pre-specified questions or probes for users to respond to, making this a structured diary study. Users were asked to sign an informed consent form, informing them how their data would be used and the importance of it in regards to the development of our platform.

[2] Google Sheets

Days	Radio stations					
	Estimated time of listening	Which radio station(s) did you listened?	What kind of content did you listened to during that session?	Where did this listening session took place?	Name 2 GOOD aspects you enjoyed on your listening session	Name 2 BAD aspects you disliked on your listening session
(Example)	*15 minutes*	*Rádio Comercial, RFM*	*Music, news, weather, traffic*	*Commuting on public transportations and at home*	*Radio hosts gave a nice company; hourly news are helpful*	*Too many ad breaks; music is quite repetitive*
Thursday (7/11)	2 hours	Cidade FM, Megahits, RFM	Music, news	At home and on public transportations	The type of music; And the range of musical styles	Too many ad breaks; Sometimes the hosts talked too much
Friday (8/11)	3 hours	Cidade FM, Megahits, RFM, Comercial	Music	Home and on private car	Not so many ad breaks (night time); Not a lot of interventions by the host (night time)	Quality of the sound (in the car); The search between different stations to find music I like
Saturday (9/11)	0	-	-	-	-	-
Sunday (10/11)	2 hours	Cidade FM, Megahits	Music, news, weather	At home and on private car	Good resume of news; Type of music	Quality of the sound (in the car); Hosts talked too much
Monday (11/11)	5 hours	Cidade FM	Music, news, weather, morning show	At home	Nice guest on the morning show; Good music	Repetition of some musics; Repetition of the same advertisment
Tuesday (12/11)	6 hours	Cidade FM, Megahits	Music, news, weather, morning show	At university and at home	Some new songs; The range of musical styles	Not so good guest on morning show; A lot of advertisment during morning show
Wednesday (13/11)	2 hours	Cidade FM	Music, news	At home	Good resume of news; Type of music	A lot of ads; Repetition of some musics

Days	Streaming services & Podcasts (Spotify, Apple Music...)				
	Estimated time of listening	Which streaming service(s) have you used?	What kind of content did you listened to during that session?	Where did this listening session took place?	Name 2 GOOD a you enjoyed o listening ses
(Example)	*2 hours*	*Spotify*	*Albums, podcasts*	*At home*	*Good shuffeling sug sound qualit*
Thursday (7/11)	3 hours	Apple Music	My own playlists	At home and outdoors	Sound quality; breaks!
Friday (8/11)	2 hours	Apple Music	Albums, my own playlists	At home	Sound quality; breaks!
Saturday (9/11)	1 hour	Apple Music	My own playlists	Home	Sound quality; The I can listen to it
Sunday (10/11)	0	-	-	-	-
Monday (11/11)	2 hours	Apple Music	My own playlists; Albums	At home	Sound quality; breaks!
Tuesday (12/11)	2 hours	Apple Music	Albums	At home	Sound quality; breaks!
Wednesday (13/11)	2 hours	Apple Music	My own playlists	At home and outdoors	Sound quality; breaks!

Figure 3.5: Diary study spreadsheet template filled by one user

The diary study focused on four main audio listening mediums: traditional terrestrial radio stations, music streaming services, music videos, and physical format. Each medium had the following questions:

- Estimated time of listening (in minutes);
- What kind of content did you listened to during that session?
- Where did this listening session took place?
- Name two good aspects you enjoyed on your listening session;
- Name two bad aspects you disliked on your listening session.

From this study, we can analyze both quantitative and qualitative data. Regarding the first, we have concluded that, on average, every user spends more than 3 hours per day listening to various audio content; streaming services count for about 62% of that, while traditional radio stations count for 21%. From the 11 users, 2 didn't use music streaming services during that week and are non-paid subscribers, and 3 didn't listen to traditional radio stations in the same period.

The main outcome of this diary study was, however, qualitative data. For the analysis of such data, we used an **affinity diagram** [32]. In an affinity diagram, researchers extract the data from each participant, pulling out key points, and write each note individually on an index card or sticky note. [31] Similar findings or concepts are then grouped to identify themes or trends in the data.

Affinity diagrams can add structure to a large or complicated issue, as they can break it down either into broader categories or more specific, focused categories. This assists and guides designers in the process of identifying issues that affect multiple areas, making affinity diagrams a crucial tool for organizing qualitative data into themes that may offer insights for the design and testing. [33] Figure 3.6 illustrates the first iteration of the affinity diagram created based on this study's participants' data.

From the analysis of this data, some conclusions emerge. Regarding traditional terrestrial radio, users enjoy the human connection it provides and the dynamics of the radio hosts. The disclosure of

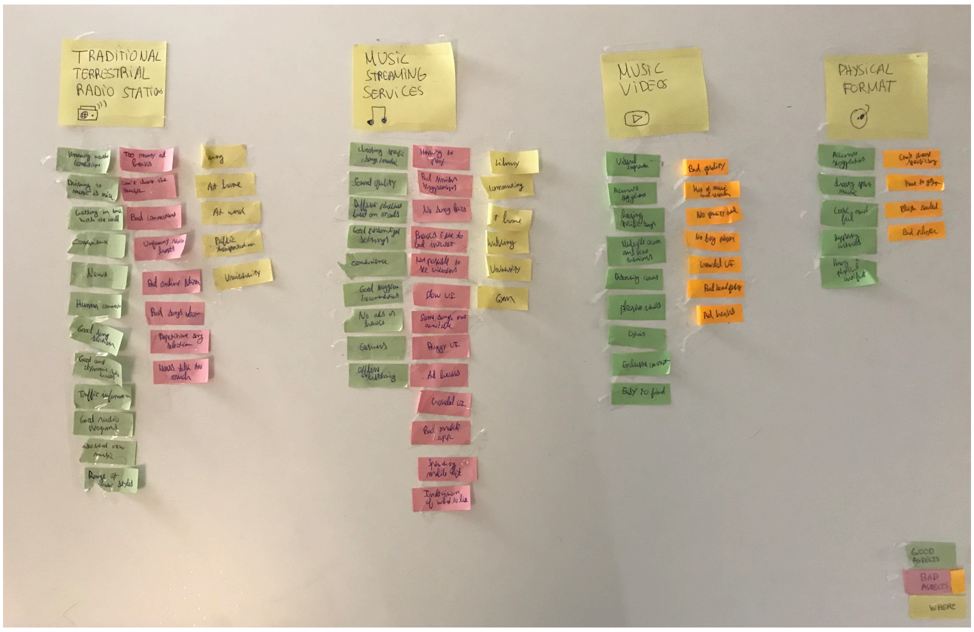


Figure 3.6: Affinity diagram with the gathered data from the diary study

information such as news, weather, and traffic reports is also very important when it comes to listening to radio, as well as the diversity of radio shows that are broadcast. On the downside, most radio listeners of this study don't like the song selection of the stations, as they find them very repetitive, always of the same genre, or simply not matching their musical taste. Not being able to choose what they want to listen to on the radio is something that frustrates them, as well as the amount of radio advertisement breaks.

In contrast, users value the **freedom of music choice** in music streaming services, as well as its overall **sound quality** and **convenience**. They appreciate the **automatically generated playlists** based on their mood or even their taste. The added freedom that music streaming services provide sometimes isn't a great feature to some users, as they sometimes have indecision of what to listen to (corroborating the tyranny of choice concept discussed in chapter 2.2).

The diary study has proven to be a great method to gather detailed information about audio media consumers' music streaming and traditional terrestrial radio habits — in conjunction with surveys, a broader dataset is obtained. To finish our preliminary user research, we have conducted interviews, to complement our dataset with information and empathy from our users.

3.3 Interviews

Interviews consist of a guided conversation in which one person seeks information from another. This method is considered flexible and can be conducted as a solo activity or in conjunction with another user experience activity. The result of a set of interviews is an integration of perspectives from multiple users. [31]

We conducted **semi-structured, in-person** interviews with the 11 participants of the diary study, as a **follow-up to this method** (the participating users on all user research activities are reported in table 4.1). We prepared a plan which subdivided the interview into five main sections: **introduction**, where we encouraged participants to answer honestly and to warn us whenever they couldn't answer one of the questions; **warm-up**, where the interviewees were asked easy, non-threatening questions in order to get positive answers to ease the participant into the interview; **body of the session**, where the main questions were asked; **cooling-off**, asking more general questions to summarize the interview; and **wrap-up**, where we thanked the interviewees for the time spent with all three user research methods by giving them a small gift.

The main objective of the study was not only to have more detailed information on users' audio media-consuming habits, but also to understand **how they feel** and **their opinions** on terrestrial radio and music streaming services. As a semi-structured interview, we begun each section with a set of questions to answer (closed-ended and open-ended), but we also deviated from the order and the set of questions from time to time. Among the planned questions, the following were asked:

- What do you enjoy about music streaming services?
- What's your opinion on streaming services' social capabilities?
- When it comes to your music habits, what would you like to share with your friends?
- What does music mean to you?
- What's the role of music in in your social life?
- What's your general opinion on traditional radio stations?
- Why don't you listen more often to traditional radio stations?
- Which radio stations do you like the most? Why?
- What's your opinion on the role of the radio host?
- What do you think about traditional radio stations' role in news, traffic, or weather disclosure?

As with the diary study, we obtained qualitative data from the interviews, which was added (and adapted, when appropriately) it to the previously created affinity diagram (fig. 3.6). The final affinity diagram, with the gathered data from both the diary study and interviews, is shown in Figure 3.7.

The interviewees have given us important and detailed information regarding their audio consuming habits — how and why they listen to music and other audio content, which factors they value the most

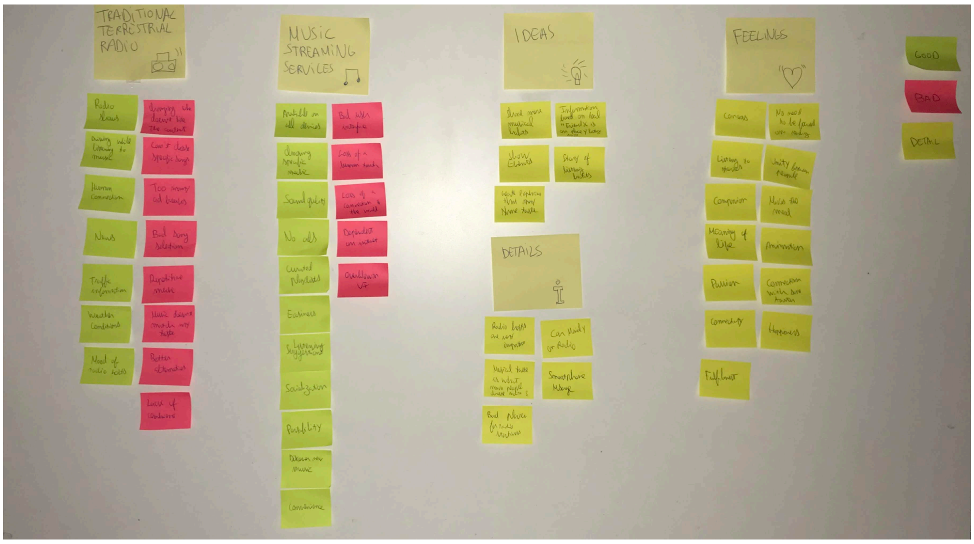


Figure 3.7: Final affinity diagram with the gathered data from the diary study and interviews

and the least in a listening session, and even some ideas and suggestions to implement and take into account when designing our solution. For instance, they noted that the social aspects of music streaming services and terrestrial radio are one of the most important aspects in their listening experience. The expressed empathy will be taken into account when developing the final solution, as all the interviewees expressed that music plays an extremely important role in their routines, and the way they experience it is a pivotal attribute.

To help us explore a diverse group of early-stage concepts, and to reflect on their stature, we will use the speed dating methodology, as proposed by Davidoff et. al [34]. Speed dating supports low-cost rapid comparison of design opportunities and situated applications by creating structured, bounded, serial engagements, based on the preliminary user research we delineated in this section. In return, by structuring a comparison of concepts, this method will assist us on the contextualization of multiple applications, as well as of critical aspects of individual applications, helping us in the identification and understanding of contextual risk factors, and how we can develop approaches to address them. Section 4 will describe the developed work in the ambit of this concept.

4

Speed Dating

Contents

Speed Dating is a design method for rapidly exploring application concepts, their interactions, and contextual dimensions, requiring no technology implementation. It was developed at Carnegie Mellon University for accessing finer-grained insights into user needs, and identifying critical contextual dimensions for the design space [34]. The main drive for developing such methodology was the lack of availability of methods that help design teams transition from ideation to iteration. Moreover, the authors state that, in ubiquitous computing, important design and contextual risk factors are not discovered before the deployment of a system, which can have a significant negative impact on the course or viability of a given project.

Aiming at solving these issues, speed dating supports low-cost rapid comparison of design opportunities and situated applications by creating structured, bounded, serial engagements. In addition, it helps teams contextualize multiple implementations, as well as critical aspects of individual applications, quickly foregrounding potential precarious issues before any implementation. It tests the researcher's initial ideas of problem definition and scope against user needs and the contextual factors that underlie them, while minimizing costs and time demands. Speed dating enables the researcher to explore the outermost frontiers of the design space, "presenting users with scenarios that push social boundaries to uncover where these boundaries actually lie" [34].

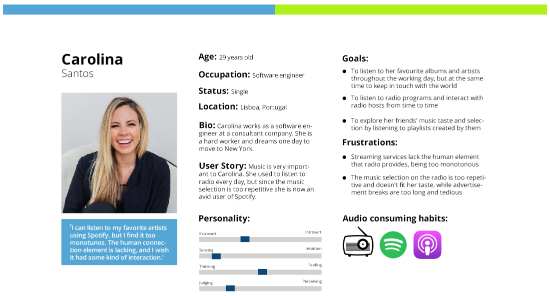
This method consists of a two-stage process, settling between sketching and prototyping. The first stage, named ***need validation***, involves the use of personas, scenarios, and storyboards in a process aimed at exposing and validating user needs. The second stage, labeled ***user enactments***, combines experience prototyping strategies and key concepts from the speed dating method within the elicitation of a second round of feedback pointed at finding a more full run of conceivable outcomes for the design.

We chose to apply the speed dating methodology since it allowed us to get a deeper understanding of our users' needs, while at the same time increasing our design effectiveness and efficiency. This approach was essential in exploring the complex set of factors, contextual dimensions, and design considerations that characterize a diverse and ambitious project such as this one. In this section, we describe the work we have conducted in each of the stages of this methodology.

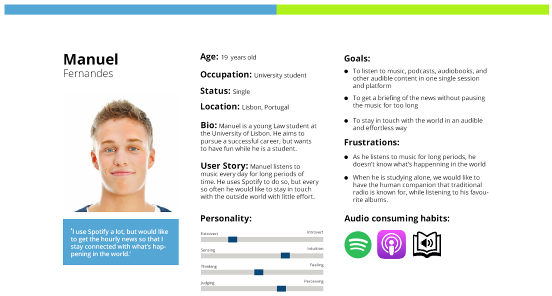
4.1 Need Validation

The need validation stage of speed dating consists of presenting a set of storyboards to a group of target users, to synchronize the design opportunities researchers found with the needs users perceive. These storyboards help designers prioritize user demands, map areas for innovation more clearly, and use that focus to narrow the design space for implied implementations. [34]

The first step of this phase is to focus concepts on user needs, where teams generate and cluster concepts around the needs identified in the conducted research. [34] This is achieved by creating a collection of personas and scenarios that fall on both sides of boundaries the design team has speculated on.



(a) "Carolina Santos" persona



(b) "Manuel Fernandes" persona

(c) "Rita Silva" persona

(d) "Tomás Ventura" persona

Figure 4.1: Created personas for the 'need validation' phase of speed dating

To do so, we have produced a set of four personas, based on four different potential users of this solution, represented in Figure 4.1. To make them feel as real as possible, each persona was attributed an age, occupation, status, location, biography, user story, goals, frustrations, personality traits, and audio media consuming habits. The latter attribute is the main characteristic that differentiates the created personas from each other, so that we can understand if the portrayed functionalities of this platform would appeal to all ranges of potential users, even those that don't have very substantial audio listening habits on their routines. A summary of each persona is presented in the following list:

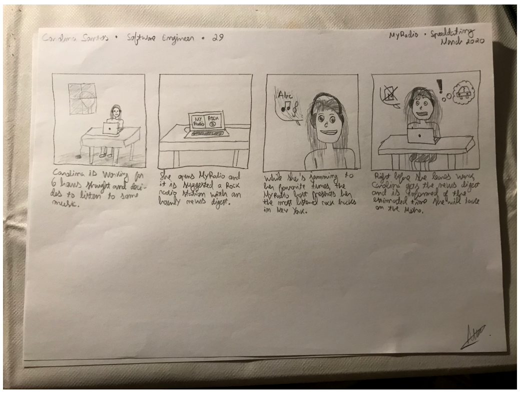
- Manuel Fernandes, an university student that is a power-user of Spotify, who feels 'disconnected' from the world while indulging in all-day music listening sessions using the on-demand service;
- Carolina Santos, a software engineer that enjoys the interactivity of traditional terrestrial radio stations, but also enjoys the on-demand selection of her favorite songs that a music streaming service provides;
- Rita Silva, a middle-aged school teacher whose audio listening habits consist of a few minutes per

day, tuning into her favorite radio station to listen to the news;

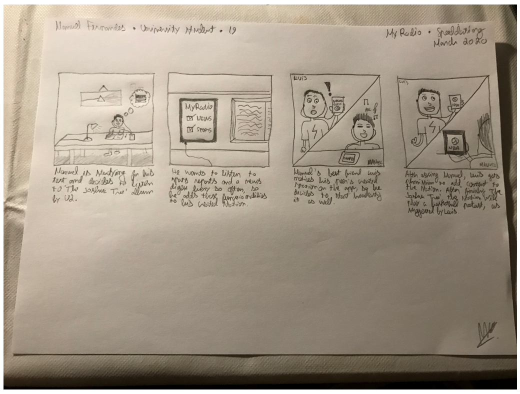
- Tomás Ventura, a truck driver that relies heavily on radio stations for his entertainment, but is getting tired of the repetitive music choice.

A subsequent set of scenarios was attributed to each of these four personas. Each scenario represents a distinct use case of this platform, focusing on situations where it is easy for participants to imagine themselves performing the mentioned activities.

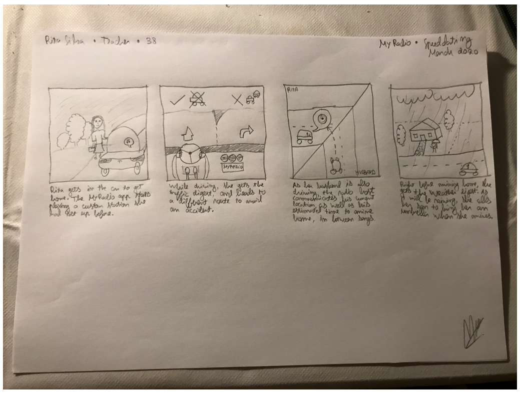
We have represented these personas and their respective scenarios in a set of storyboards that document how each need arises in daily life, and how the concept intervenes to improve the quality of life. To develop such materials, we have begun by using the traditional sketching method by drawing these storyboards on paper, represented in Figure 4.2.



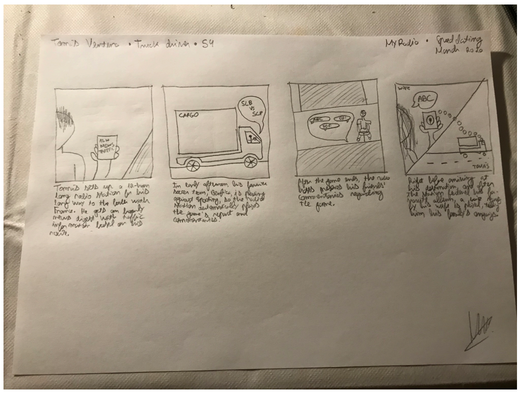
(a) ”Carolina Santos” storyboard on paper



(b) ”Manuel Fernandes” storyboard on paper



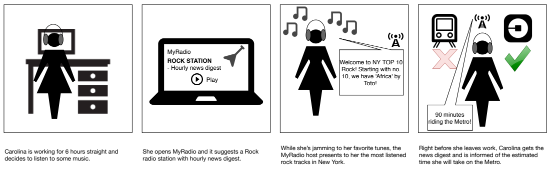
(c) ”Rita Silva” storyboard on paper



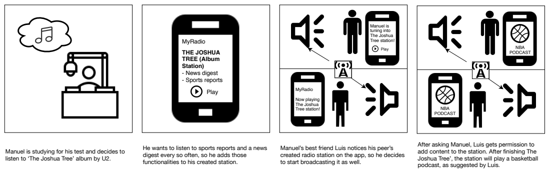
(d) ”Tomás Ventura” storyboard on paper

Figure 4.2: Created paper storyboards and scenarios for each persona

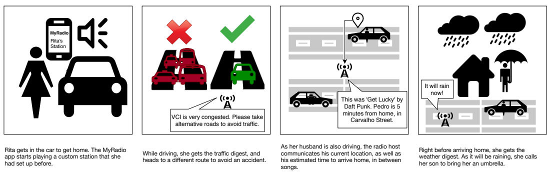
The next step was to conduct a session where we presented this set of storyboards to small groups of target users. The original guidelines of the speed dating methodology state that these sessions should



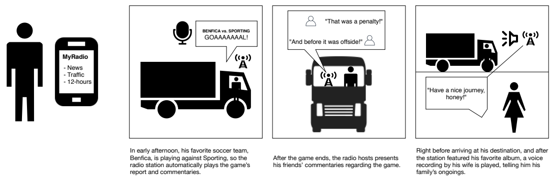
(a) ”Carolina Santos” digital storyboard



(b) ”Manuel Fernandes” digital storyboard



(c) ”Rita Silva” digital storyboard



(d) ”Tomás Ventura” digital storyboard

Figure 4.3: Created storyboards and scenarios for each persona on digital format

happen in a physical location; yet, as our study was conducted amid the 2020 COVID-19 pandemic, we had to circumvent this challenge, to comply with social distancing measures imposed by our country. Thus, we have conducted a total of **five remote sessions**, via the Google Meets [1] platform: three of them with users ranging from 18 to 24 years old; one with ages ranging from 25 to 35 years old; and a final session with ages ranging from 35 to 55 years old. The participating users are reported in table 4.1. The duration of each session ranged from **30 to 45 minutes**. The audio of the session was recorded with the consent of all participating users, in order to facilitate the note-taking and analyzing processes. A consent form was digitally signed by all participating users.

The sessions started with a brief description of the project and the goals of the discussion. Then, the developed personas and storyboards were shown digitally by sharing the screen and providing the link to the folder containing the files. To facilitate the understanding of these materials, we have transmuted the hand drawings into a digital representation, represented in Figure 4.3; nevertheless, we presented both and asked users to try to focus on the hand drawings.

After presenting a given storyboard, users were asked to **put themselves in the shoes of the correlated persona**, and, with that in mind, they were encouraged to express comments, opinions, and comparisons. The discussion of each scenario was facilitated by a researcher that had the main goal of steering the dialogue to elicit user needs. **Storyboard discussions were lively and focused on participants’ reactions to the scenarios.** When appropriate, participants were asked: ”Would you do something like that?” or ”What would you do differently?” and were encouraged to elaborate on their responses. The researcher also regularly asked participants for their feedback in identifying positive and negative aspects, what would they find useful in their own lives, and what would they change.

[1] Google Meets

Age	Preliminary User Research		Speed Dating	
	Diary Study	Interview	Need Validation	User Enactments
18	✓	✓	✓	✓
18			✓	✓
18			✓	✓
19				✓
19			✓	✓
20			✓	✓
21	✓	✓		
22	✓	✓	✓	✓
22	✓	✓	✓	✓
22	✓	✓		
22	✓	✓		
22	✓	✓		
22	✓	✓		
22			✓	✓
22			✓	✓
22			✓	✓
22			✓	✓
22				✓
22				✓
24			✓	✓
27	✓	✓		
32				✓
33				✓
36			✓	✓
38				✓
43			✓	✓
43			✓	✓
46				✓
49			✓	✓
50	✓	✓	✓	✓
51			✓	✓
55	✓	✓	✓	✓
61				✓
62				✓

Table 4.1: Participating users in the preliminary user research and speed dating activities.

The received feedback was very positive. Most users identified themselves with the younger developed personas (Manuel Fernandes and Carolina Santos), stating that this 'interactive radio' approach would significantly enhance their audio listening experience in their daily routines. As they use on-demand music streaming services for long periods of time, their listening experience becomes dreary and not interactive, generating a sense of disconnection to the outside world. Yet, as they embraced these personas, users stated that this feeling could be practically nonexistent. Finally, the social and community features described in Manuel's storyboard were very well received, which proves the user demand for more social and community features to arise in modern audio consuming mediums. Conversely, users didn't see the advantage of incorporating more personal tidbits of information into personalized radio stations, such as location sharing or voice messages from their friends, as described in the older personas (Rita Silva and Tomás Ventura). Instead, users stated that they would prefer to have their social feeds to be delivered, rather than more personal, decontextualized, and sensible types of information.

After conducting the sessions, we extracted the most relevant statements that were recorded, which helped us reveal new design opportunities, while at the same time recognizing the ones that don't consist of a general user need or demand. We have discussed the users' reactions to concepts, prioritizing needs that emerge strongly in both user research and validation sessions. With the received feedback, we were able to reduce our design dimensions by three main extents, which will be further employed in the second phase of the speed dating methodology.

4.2 User Enactments

The second and final phase of the speed dating methodology, labeled ***user enactments***, consists of creating a matrix of critical design issues, triggering the writing of dramatic scenarios that address the permutations of these issues. Researchers then ask participants to enact a specific role they regularly play as they walk through the scenarios, within an inexpensive, low-fidelity simulation of the target environment. [34]

As a result of the need validation process, we were able to reduce our design dimensions by three main dimensions: '**Create**', '**Listen**', and '**Share**'. These represent the three primary types of interactions with the system. 'Create' refers to the creation of a personalized station, where the user selects their desired audible content, as well as the station's schedule and preferences. 'Listen' invokes the actual listening experience of these stations, whether created by a given user or otherwise, in the context of the users' daily routines. Finally, 'Share' addresses the shareability and the community features of the system, such as simultaneous listening or station sharing.

We further identified an additional set of time-based dimensions through this process: **'Initiate'**,

'Employ', and **'Explore & Customize'**. 'Initiate' refers to a novel user interaction. 'Employ' refers to a response from the system, from which the user can interact with it. 'Explore & Customize' refers to the users' probing and engagement of the available personalization features on the platform, from within a certain interaction or otherwise.

Using the above described design dimensions, we generated a matrix for carrying out speed enactments, shown in table 4.2. The first set of dimensions ('Create', 'Listen', and 'Share') align along the vertical axis, while the second set ('Initiate', 'Employ', and 'Explore & Customize') align along the horizontal axis. The cells contain fictional scenarios that capture the intersection of types of interactions with stages of a system event. In the interest of keeping participants engaged and avoiding redundancy, we chose not to fill all of the cells in the matrix.

Based on the presented table, we developed a medium fidelity prototype aimed at showcasing a preliminary concept of the Sterio platform to the common user, shown in Figures 5.15, 4.5, and 4.6. The prototype focused on merging a users' music streaming service library and audio dynamically generated from news, social networks, or even personal sources, with non-speech audio sound effects and background music. In this first stage, we focused on the 'create' and 'listen' design dimensions, which resulted in the creation of a set of dummy and non-technical screens to avoid possible distractions concerning superficial design considerations.

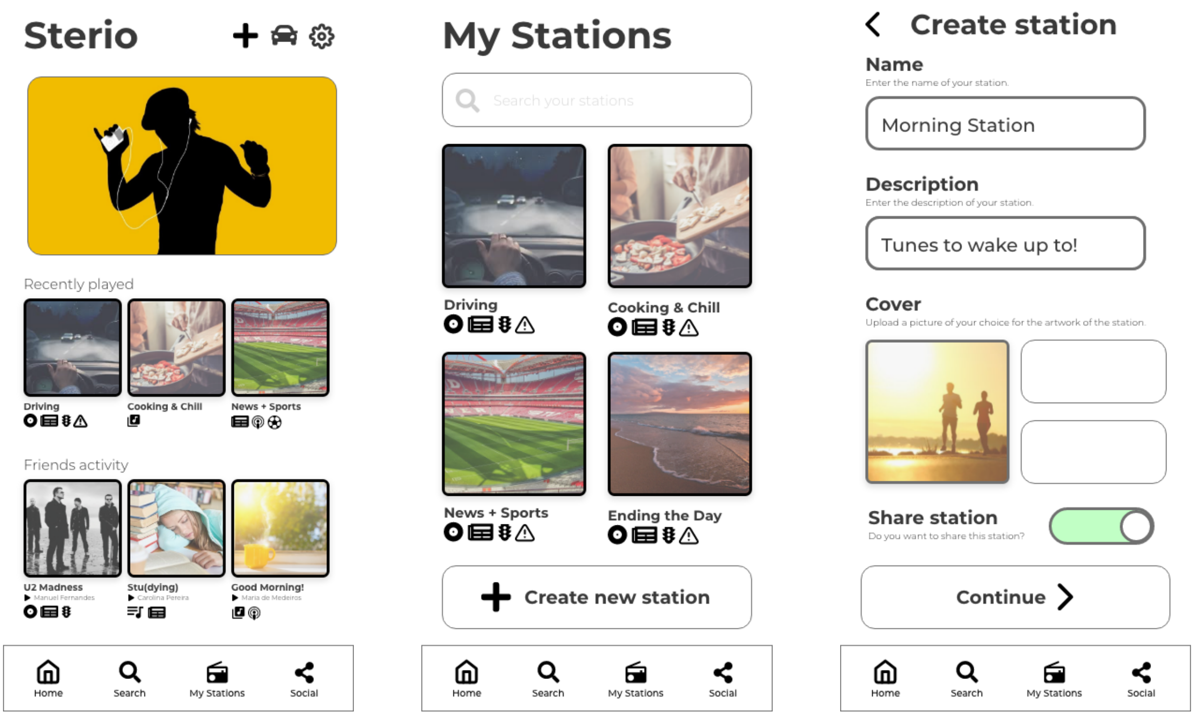
Users were guided through this set of dummy screens that enabled them to create and listen to a personalized radio station. This dummy station included a playlist from Spotify, breaking news about the COVID-19 topic, and weather information based on a given location — the latter two were synthesized and processed with a text-to-speech voice. When reaching the final screen of the prototype, an audio file that contained the 'selected' items was played. To keep users focused, the audio had a small duration of two and half minutes. The audio file also included snippets of two songs (from the 'selected' playlist) and radio-like transitions and sound effects, so that the station would feel as natural as possible to the user. Users were encouraged to try the prototype either on their desktop computers or on their smartphones, as the platform on which the prototype was built allowed both mediums.

Given the before-mentioned COVID-19 pandemic we faced during the development of this study, the diffusion of the prototype was conducted using the WhatsApp social network, complying with social distancing restrictions. **Groups with 4 users** were created (larger numbers were avoided in order to make the discussion easier). In total, 7 groups of 4 people were created, totaling **28 participants** in this study. 15 users were of ages ranging from 18 to 25, whilst the remaining 13 were of ages ranging from 26 to 62. The participating users are reported in table 4.1.

Since the discussion of this prototype was conducted using an instant messaging service, users were encouraged to share their opinions and engage in discussion with each other, providing useful feedback that will be taken into account when developing the final platform. From the 28 users, 19 have

	Initiate	Employ	Explore & Customize
Create	You create a radio station with a Spotify playlist, news about COVID-19, and weather information in Beja.	The radio station is created and added to your stations' library. A virtual radio host is assigned to your station. The schedule for your station is created automatically.	You further add radio blocks, such as a Twitter feed, and change the virtual radio host to a female Portuguese voice. You also tailor the schedule to your taste.
	You create a radio station that is more news-focused, based on a library of pre-created stations that are suggested to you.		
Listen	You start listening to the 'Morning Station' from your station library.	The radio station is played with its specified settings.	While listening, you choose to skip to a certain point of the station's schedule. You also add a 'Sports' news block, as suggested by the player.
	Before you start driving, you switch the 'car' mode and start playing to your 'Driving' station.		
Share	You check the station your friend is listening to, and you decide to start listening to it as well.	You start listening to the same radio station, at the same point the participating users were listening.	You suggest the addition of a sports podcast radio block, to which your friend (the station creator) gives you permission to add.
	You share one of your created stations with a small group of your friends, giving them the ability to edit the contents of the station.	Your friends can now start listening to your station.	A friend of yours adds a custom radio block, which enunciates the voice messages from their WhatsApp group.
	You choose to share one of your created stations with the whole platform's community, being publicly available to anyone.	Your station is now available to all users, ready to be played, and it has 226 followers now.	

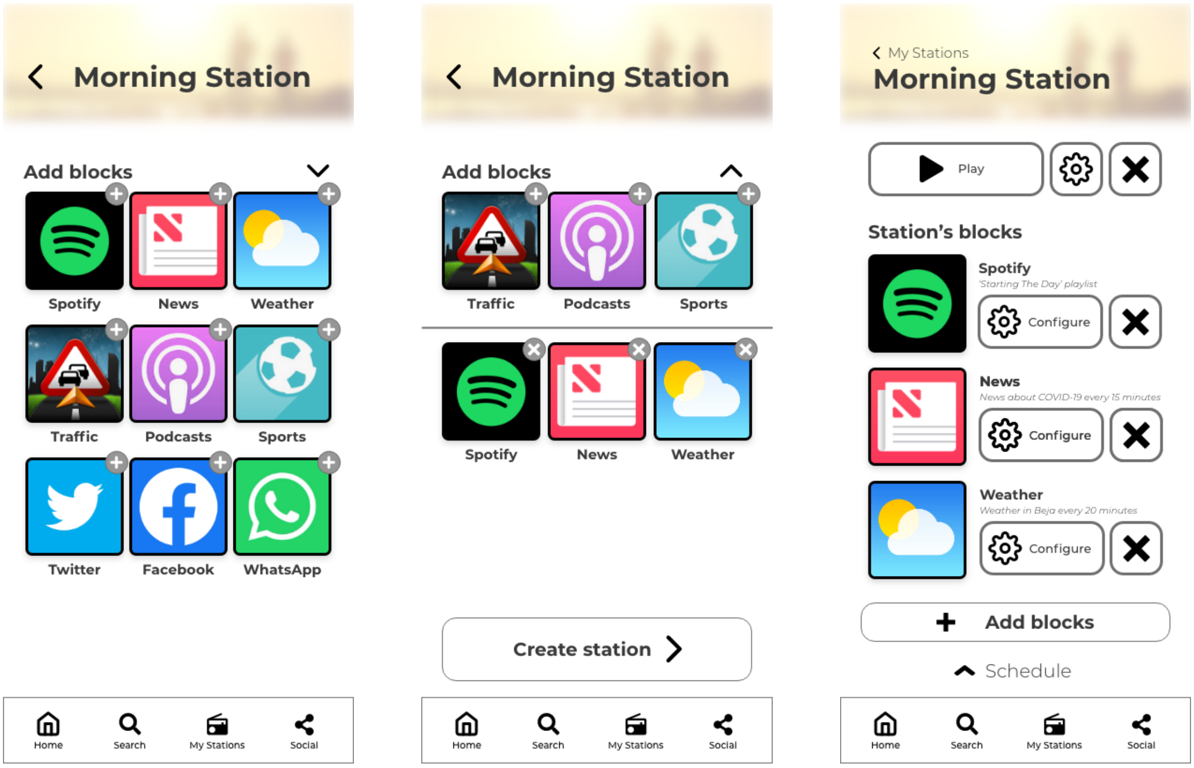
Table 4.2: Speed matrix generated for user enactments



(a) Home screen **(b)** ”My Stations” screen **(c)** ”Create station” screen

Figure 4.4: Screenshots of the medium fidelity prototype (1)

participated in the need validation activity of the speed dating method, thus an introduction to the general concept of the platform wasn't necessary. The remaining 9 users were introduced to the main abstract of the project and were asked to sign a virtual consent form. Users were informed that the displayed interface was created for demonstration purposes only, and that it didn't match the final product, shifting away their attention to the general concept of the system and not its usability.



(a) "Add blocks" screen

(b) "Add blocks" screen with added blocks

(c) Main screen of the "Morning Station" station

Figure 4.5: Screenshots of the medium fidelity prototype (2)

The middle-fidelity prototype was created using three main tools: Adobe XD [2], Audacity [3], and macOS Text To Speech voices.

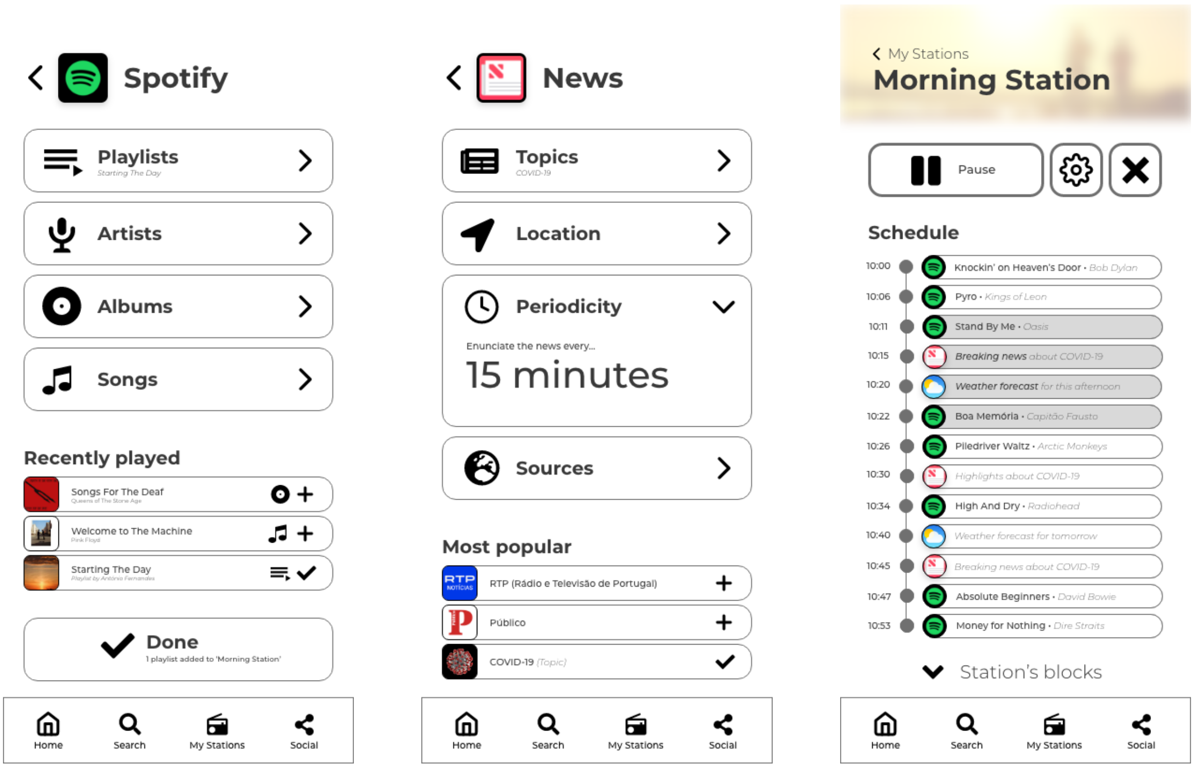
Adobe XD was used for the development of the dummy interface. This platform allows playback of an audio file, which was convenient to showcase the final concept of the platform. The app also allows an easy sharing of the prototype, guiding users through the set of dummy screens of the prototype.

Audacity was used to create the radio station audible file. The app allowed the editing of the audio file, making easy to expose how a created radio station would sound by gathered all the various audible elements (text-to-speech, music, and transitions) and inserting such content naturally between music

[2]Adobe XD
[3]Audacity

tracks to allow continued attention in the periphery.

Finally, macOS' built-in text-to-speech software was used to synthesize into speech the content that the 'dummy' user would provide (in this case, news and weather information). We opted for this solution since the operating system has a built-in European Portuguese voice (Catarina) that sounded very reliable and natural, making the development of the prototype a simpler task.



(a) Spotify block configuration screen

(b) News block configuration screen

(c) Station's schedule screen

Figure 4.6: Screenshots of the medium fidelity prototype (3)

Corroborating with the first step of the method, the received feedback was very positive. All users clearly understood the main concept of the platform. Some of them mentioned that, in a first stage, they didn't understand the conceptualization on paper, but the prototype did enlighten them by showing in a visual and practical way how the platform would work.

Regarding the text-to-speech usage on the prototype, the feedback received was better than expected. The majority of users thought that the text-to-speech voice mimicking a radio host was more natural than what they were expecting. When asked if they entangled a human element, and/or a connection with them in a similar way that traditional radio stations provide, all users replied affirmatively. In particular, older users accepted the text-to-speech functionalities quite well, with some mentioning that their original perception of this software (such as GPS turn-by-turn instructions) was out-blown with the use of this particular voice. Some younger users noted that the pronunciation of a small set of words was not clear or sounded unnatural, mainly new words (such as 'COVID-19') or foreignisms. Nevertheless, most of them noted that the advantages of using this technology outweigh the drawbacks.

Most users noted that they would use the platform on a daily basis, while others said it would be particularly interesting to use on specific occasions (such as driving or cooking). Some suggestions for future implementation on the system were also given by the users, such as the possibility for selecting their desired voice in their language, or a 'quick station' feature for the times when they would like to listen to a personalized radio based on their taste without a higher level of customization.

5

Sterio System

Contents

To understand the tasks that our platform must fulfill, the first steps we have taken were an investigation and analysis of the currently available music streaming platforms and terrestrial radio stations, identifying the strengths, weaknesses, and opportunities of each. At the same time, we have conducted a study on the available literature that addresses these mediums and the vital concept of interactive radio. Further, we have overseen a thorough user research study by conducting a survey, a diary study, and interviews, and, most importantly, by applying the speed dating method. As we're applying user-centered design and human-computer interaction principles and methodologies, our users must be involved in the development of the project from the very early stages. This will maximize the quality of the user experience of the solution, and the earlier the user is involved, the less repair work needs to be done at the final stages of the project's life cycles. [31]

After the presented research, we can identify our opportunity and act upon it. As such, in the first stage, we need to determine our requirements and accordingly plan the features and tasks that are going to be made available on the platform to fulfill our users' desires. The gathered datasets from sections 2, 3, and 4 provided pivotal information that helped fulfill this task. Then, after we've outlined the goals that our platform must satisfy, we can outset the development of a functional prototype with a working feature set and near ready for general-purpose usage.

In this section, we explain in greater detail the development process that led us to the final Sterio platform. We begin by outlining the requirements and goals that our solution must fulfill. Afterward, we discuss and examine the adopted technologies and services, as well as the overall architecture of the system. Finally, we present a complete overhaul of the crafted features by describing the methods, technical facets, and reasoning behind all components of the application.

5.1 Requirements

Taking into account all the conducted research regarding previous work, and by identifying and understanding our users' needs, we were able to identify a concrete set of features that we expect our solution to tackle. These features can be described as followed:

- Creation of personalized radio stations, allowing users to select their desired audio content (by songs, albums, artists, playlists or others) using an on-demand music streaming service, or even add to the station other audio media content such as podcasts or audiobooks;

- A 'virtual radio host' based on text-to-speech technology is attributed to a given station, allowing content to be delivered in the periphery during that session (news, weather, traffic, social feeds, information about friends and family, and other types of readable information);

- A high level of customization of such radio stations and of its content must be available, allowing users to choose how often they would like to listen to each sort of content, the specific topics or themes of each audible content, the voice of the 'virtual radio-host' from the selection of the available text-to-speech voices, among other functionalities;

- The 'virtual radio host' mimics as best as possible a 'real' radio host, promoting interaction, human connection, and empathy between the listeners and their 'own radio host'. Plus, audible divisors and elements, as well as other radio-familiar components are introduced along the session, so that these personal radio stations are as natural as possible, reassembling a 'real' radio station;

- A high level of shareability of the created radio stations, social/informative content, and other elements, allowing a simultaneous listening experience of radio stations among the platform's users, reproducing the same community feeling as traditional terrestrial radio, while at the same time indulging audio listeners in a social-network like atmosphere.

In the end, a general-purpose platform will emerge that creates a novel listening experience by merging the best functionalities of both music streaming services and traditional terrestrial radio in a personalized, integrated and social experience that may be shared with users' friends and family.

5.2 Architecture

The Sterio platform was developed following a layered architecture, which not only supports the incremental development of systems, but also provides a changeable structure so that an equivalent layer can replace another one. Moreover, when a given layer is changed or updated, only its adjacent layer is affected. [35] Every layer of the Sterio system can be used individually with other similar applications or can be easily changed without compromising the other layers.

The three main layers that compose our system are the Presentation, Business, and Database Layer, represented in Figure 5.1. In the following subsections, we explain in greater detail the role of each layer, as well as the reasoning and advantages of the used frameworks and technologies.

5.2.1 Database Layer

The Database Layer is responsible for managing and storing all the data that it is used in the system. It receives information entered by the application's users and answers accordingly with the requested information from the Business Layer. [35]

The first development step of the platform was the creation of an entity-relationship model so that we can model the database and determine which entities we need based on the medium-fidelity prototype described in section 4.2. The representation of this model, shown in Figure 5.2, will help us visualize

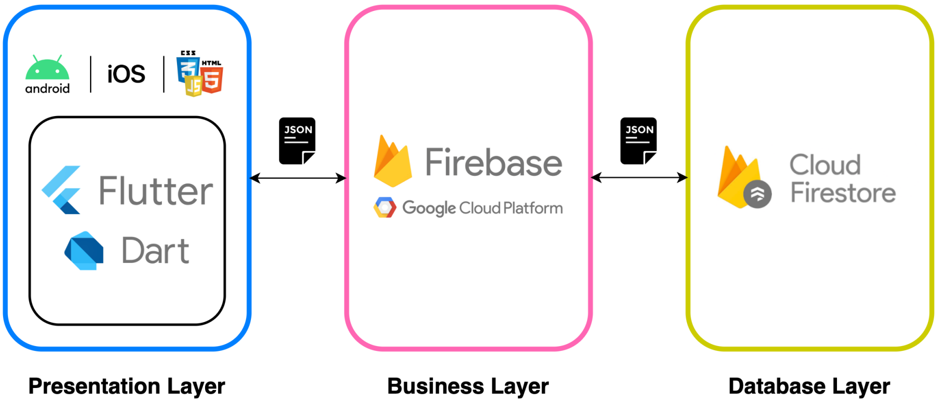


Figure 5.1: Architecture of the Sterio system

and conceptualize the system in the first stage, which will soothe the development difficulty and discard preliminary oversights.

The implementation of the database was conducted using Google's Cloud Firestore [1], which is a NoSQL, document-oriented database. Being a NoSQL database, it provides several advantages, such as a non-relational and schema-less data model, low latency and high performance, highly scalable, and object-oriented programming that is easy and flexible to use. [36] Each document contains a set of key-value pairs, being optimized for storing sizable collections of small documents. It is a serverless document database that effortlessly scales to meet any demand, with no maintenance required, which accelerates the development of native cloud applications and lets developers focus their efforts on the most foreground layers of a system.

We chose to use Cloud Firestore due to its lean learning curve, ease-of-use, good performance, reliability, high scalability, and deep integration with other Google services that will also be used in the development of the platform. Furthermore, by using this technology, the system is prepared to be easily customized and to receive new data if the project has any changes in the way we approach some of its features.

5.2.2 Business Layer

The Business Layer is responsible to encode the real-world business rules that determine how data can be created, stored, and changed. It contrasts with the remainder of the software that might be concerned with lower-level details of managing a database or displaying the user interface, system infrastructure, or generally connecting various parts of the program. [35]

For the Sterio platform, we chose to use Google's Firebase [2] business logic features. Firebase

[1] Detailed information available on the platform's official website.
[2] For more information on Google's Firebase and Cloud Platform services, visit its official website.

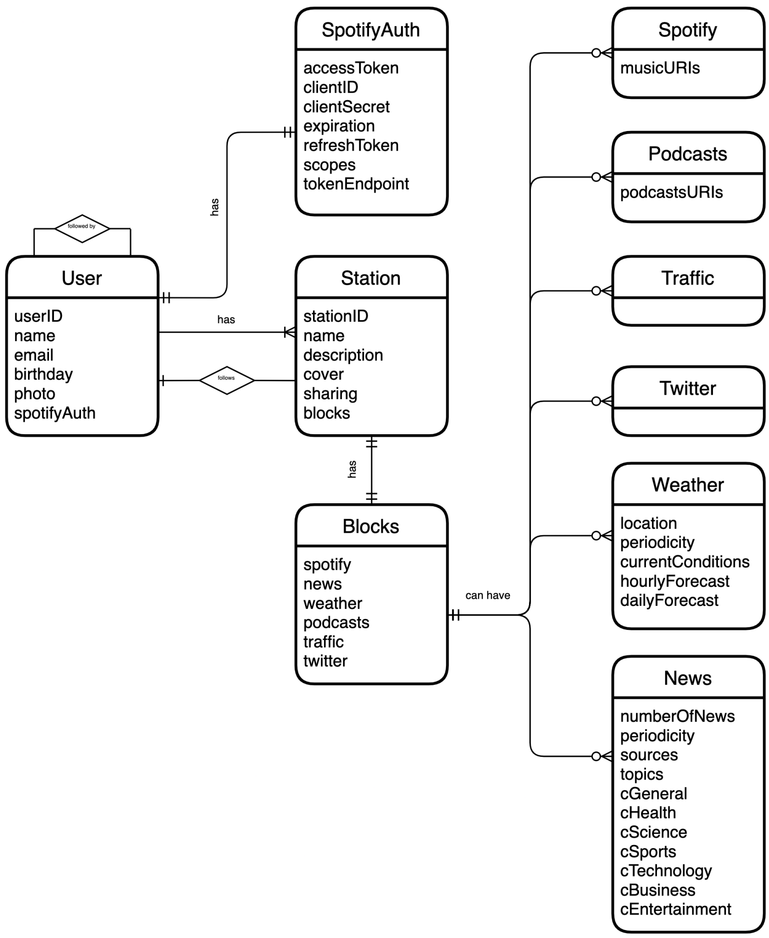
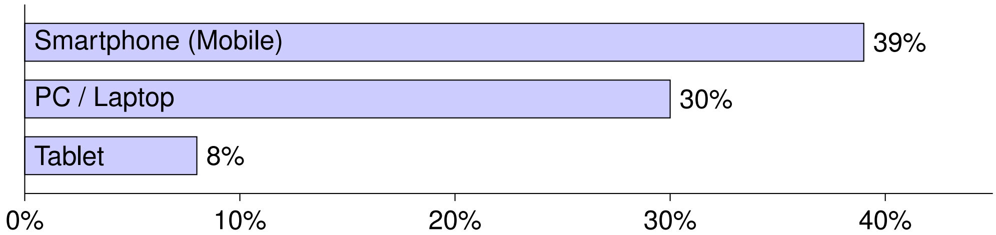


Figure 5.2: Entity – Relationship Model of the Sterio system

is a Mobile Backend as a Service (MBaaS), which is a model for providing web app and mobile app developers with a way to link their applications to backend cloud storage and Application Program Interfaces (APIs) exposed by back end applications while also providing features such as user management, push notifications, and integration with social networking services.

Firebase provides several pre-developed, robust, and reliable Software Development Kits (SDKs) — such as authentication, hosting, storage, and app indexing — that helped us steer the focus of our development efforts to the design and conceiving of the user experience and interface. As with Cloud Firestore, it integrates thoroughly with other Google services — including the Google Cloud Platform, which will be used for the process and synthesizing of the text-to-speech technology — while also allowing the configuration of third-party APIs that will be used in the context of our project.

Figure 5.3: Share of internet users who have used a music streaming services in the last month worldwide in 2nd quarter 2017, by device (Statista / GlobalWebIndex)



5.2.3 Presentation Layer

The third and final layer of the system is the Presentation Layer, which is responsible for the interaction between the user and the system. [35] This layer will interact with the business layer through calls to the Firebase service.

Based on the preliminary user research presented in Section 3, and corroborating with the data shown in Figure 5.3, most users listen to music streaming services on their smartphone. Furthermore, as we want our platform to be easily accessible on the go, we focused our efforts on analyzing the most popular mobile development frameworks to develop our platform on.

We chose to develop the Sterio platform using Flutter [3], which is an User Interface (UI) toolkit for building natively compiled applications for mobile, web, and desktop from a single codebase. Flutter apps are written in the Dart [4] programming language and make use of many of the language's more advanced features. [37]

In the context of our project, Flutter has some key advantages over other technologies. To start, although it has been built as a mobile-first toolkit in the first stage, Flutter is now a cross-platform development tool that allows the development of mobile (on the Android and iOS operating systems) and desktop apps without compounding changes to the codebase. This ensures that our platform renders well on a variety of devices and windows or screen sizes, without limiting our endeavors. [38] Secondly, in comparison with other mobile frameworks, Flutter reduces the code development time by a wide margin. In a large and complex project such as ours, this is a crucial advantage that will lead us to a robust final product without the need for allocating umpteen resources. Finally, Flutter offers a variety of advanced tools that allow us to achieve a great user experience and interface design, which will help us achieve our goals. [37]

[3] To learn more about the Flutter framework, consult the official website.
[4] For more information on the Dart programming language, visit its official website.

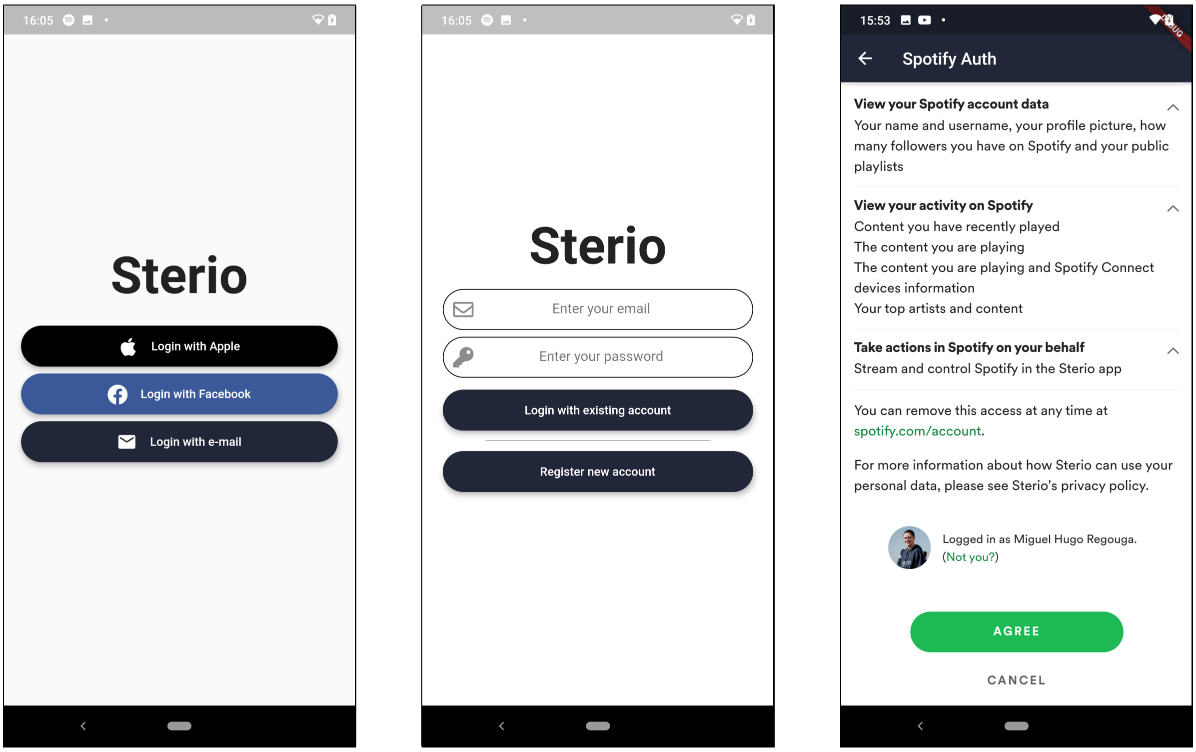
5.3 Functional Prototype

Based on the medium-fidelity prototype presented in Section 4.2, the last — and most important — step of the development cycle was to construct a functional prototype with a fully-working set of features. This prototype should resemble as close as possible to the final representation of the system.

In the following subsections, we describe in detail all functionalities, components, screens, implementations, and technical facets of the Sterio system, as well as the design implications and limitations faced during the development of the prototype. We begin by examining the four main screens of the application — 'Home', 'Search', 'Social', and 'My Stations' — followed by an analysis of the technical reasoning behind the creation, playback, and sharing of stations.

5.3.1 Login, Signup, and Authentication

The first interaction the user has with the Sterio platform is the login/signup screen, shown in Figure 5.4(a). There, the user can choose to login with an Apple or Facebook account, or with an e-mail. If the user chooses to use one of the first two methods, an in-app browser window is shown so that the user can enter the required credentials. If the user chooses to use an e-mail as a signup method, the screen is shown in 5.4(b) is presented.

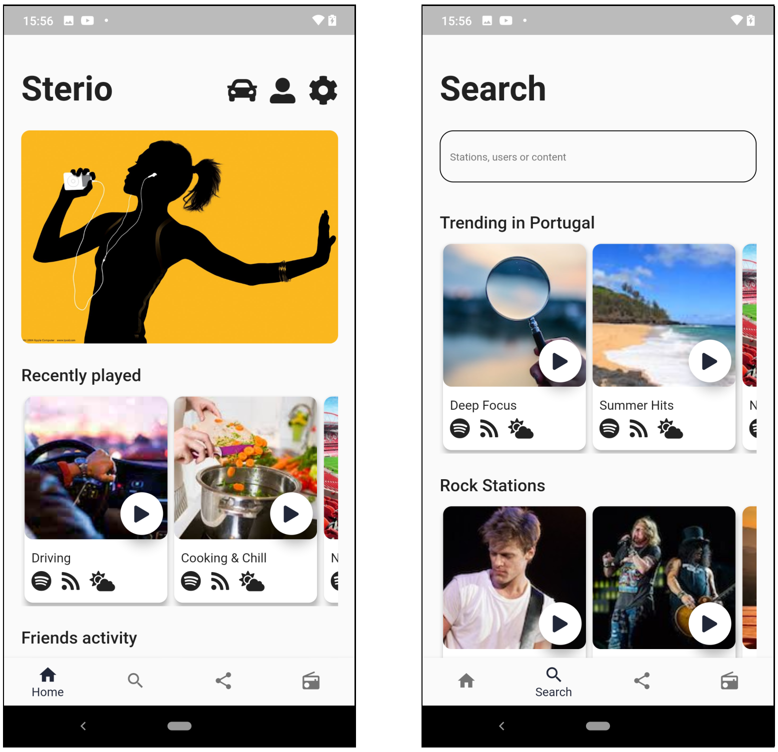


(a) Login / Signup screen **(b)** Login with e-mail **(c)** Spotify authentication

Figure 5.4: Login, Signup, and Spotify authentication screens

As the system integrates with a Spotify Premium account, it is also necessary that the user authenticates with the music streaming service, so that we can take advantage of its API. To do so, an in-app browser window, shown in Figure 5.4(c), is also presented to the user. This is a one-time step, as the system stores the necessary API parameters in the database and automatically logs in the user in future usages.

5.3.2 'Home' and 'Search' Screens



(a) 'Home' screen **(b)** 'Search' screen

Figure 5.5: 'Home' and 'Search' screens

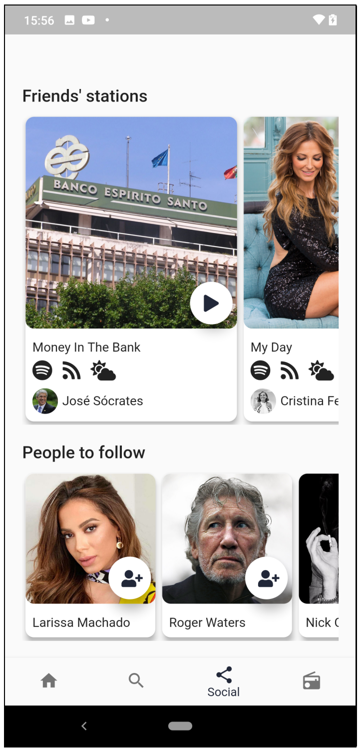
After logging in, the user is prompted with the 'Home' screen, shown in Figure 5.5(a), which is the first and most foregrounding screen of the platform. In this screen, the user can quickly play a station based on recent activity, friends activity, top charts, or other relevant information tailored to the user's taste and usability history. In this screen, the user can also change the settings and preferences of the app, as well as of the signed-in account. Finally, the user can also enter the "Car Mode" of the system, which transforms the UI in a stripped-down, non-distracting, and easy way for the user to control playback while driving.

In the 'Search' screen, shown in Figure 5.5(b), the user can search for a specific station, content, or even other users to follow and check their profiles. In the same screen, some listening suggestions are also shown, based on the most searched items and trending stations in a given location.

5.3.3 'Social' Screen

The 'Social' screen aggregates all the social activity of the profiles that a given user follows. From there, users can explore what stations their followers are currently listening to, as well as to listen along to such stations (mimicking the experience of a traditional terrestrial radio station). In Section 5.3.7, we explain in greater detail the technical background of this functionality.

(a) Social screen showing friends that are playing a station



(b) Social screen with following suggestions

Figure 5.6: 'Social' screen

From the same screen, users can also delve into the shared stations of their friends and family and get recommendations of profiles to follow based on their taste and friends' circle. Coinciding with a news feed of a traditional social network, users can also share and interact with shared media posts, creating a very integrated and cohesive social experience between the users of the platform.

5.3.4 'My Stations' Screen

The last of the four main screens of the platform is the 'My Stations' screen, shown in Figure 5.14, where the user can find their own created stations or saved stations created by other users of the platform. It acts as a 'library' of saved stations, making it easy for users to find their desired content. On the same screen, users can press the '+' red button and start the process of creating a new station, which will be added automatically to their library.

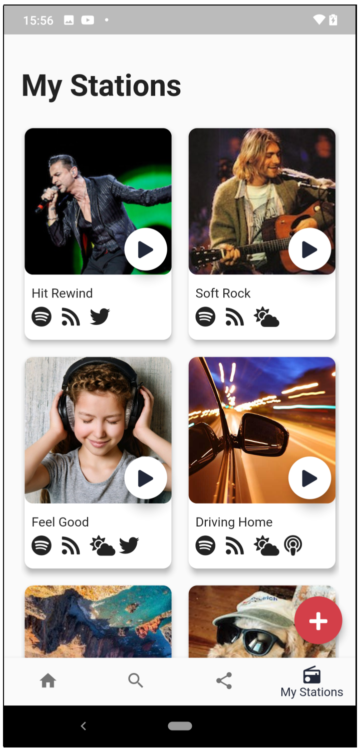
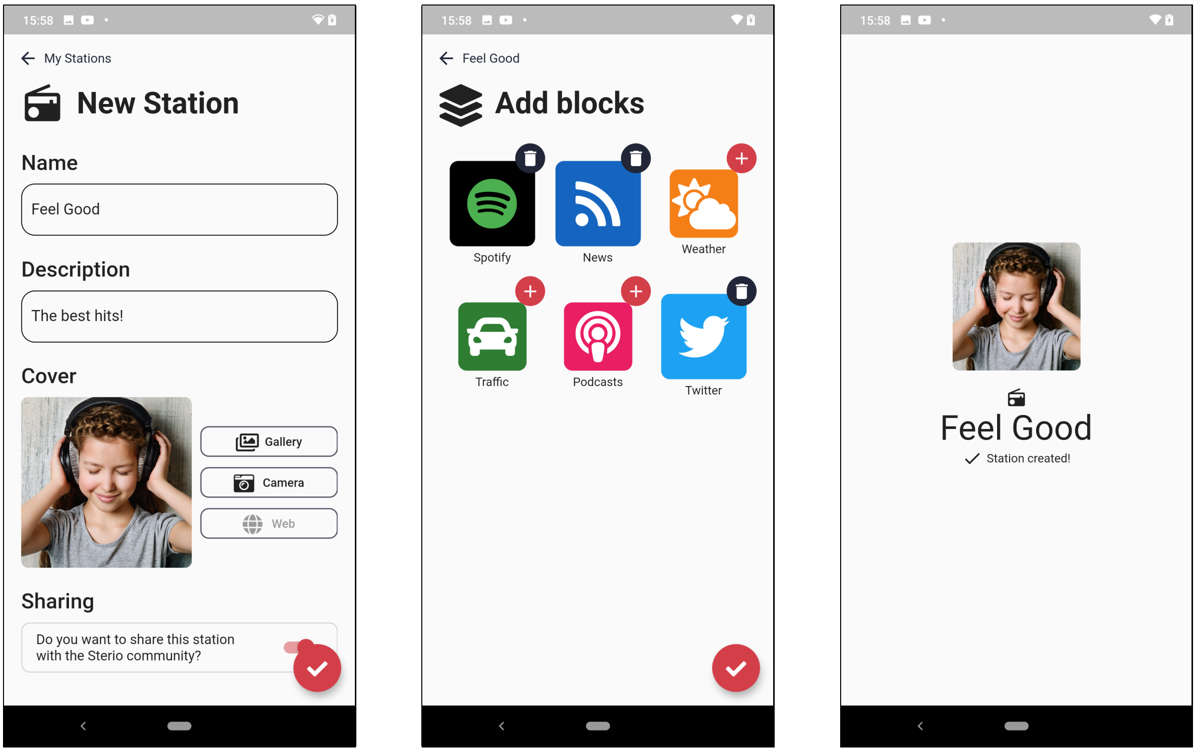


Figure 5.7: 'My Stations' screen

Each station is represented by a 'card' that displays its basic information — name, blocks, and artwork/cover. This configuration allows the user to have a glimpse of what are the contents of a given station without even entering the station's page. Furthermore, a convenient 'play' button is exposed so that users can effortlessly start playing a given station. This design is carried out across the platform's screens, creating a broad, cohesive, and consistent user experience.

All the station information is stored and loaded from the database on-demand, thus minimizing cache and offline efforts. Nevertheless, in case the user doesn't have a connection to the internet, it is possible to download and locally store a given station.

5.3.5 Creating a New Station



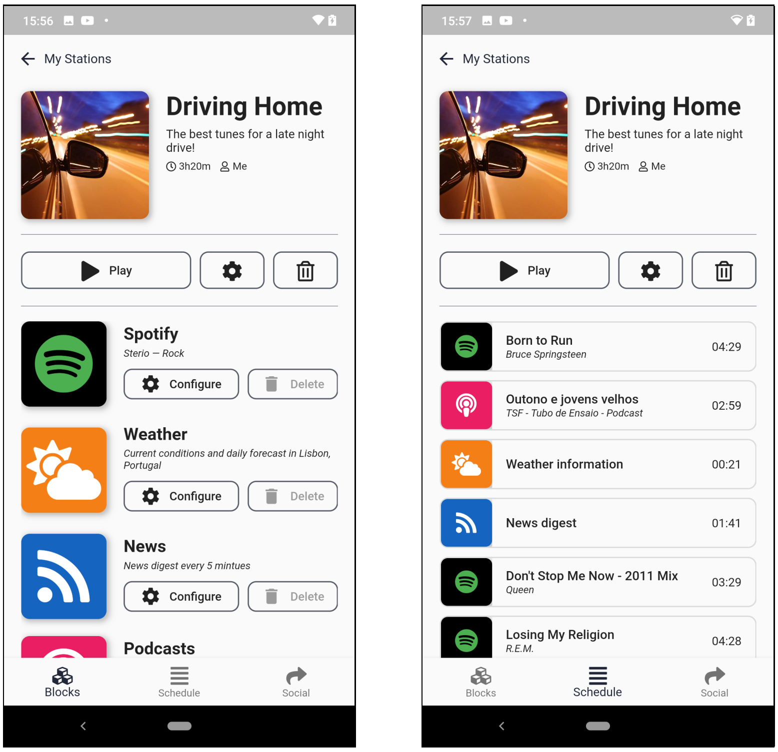
(a) Step 1 (stations' details) **(b)** Step 2 (adding blocks) **(c)** Success screen

Figure 5.8: Screenshots of the process of creating a new station

From the 'My Stations' screen, users can create their custom stations. This is a simple two-step process — first, users are requested to enter the name of the station, a brief description, a cover artwork (which can be selected from the local photo gallery, from a web search, or even from taking a picture in real-time), and a sharing option. The latter determines if the station will be kept private to the user (other users can't see the station contents nor play it), or if it is shared with the community of the platform's users. The screen where the user is prompted to enter this information is shown in Figure 5.8(a).

The second and final step of the creation process of a new station is the selection of 'blocks'. Each 'block' represents a service or source of information that can be added to the station playback. A simple screen, represented in Figure 5.8(b), is shown to the user so that they can select the desired blocks simply and intuitively. After the user is elated with their choices, the created station information is stored in the database, and if such a process is successful, a confirmation screen (represented in Figure 5.8(c)) is shown to the user. Finally, the user is redirected to the 'My Stations' screen (Figure 5.14), where the newly created station is now listed.

5.3.6 Configuring and Customizing a Station



(a) Blocks screen **(b)** Schedule screen screen

Figure 5.9: 'Driving Home' station screens

Each station has its dedicated page, where the user can explore and customize all aspects and features of it. This screen is divided into three sub-screens that fill the latter half of the canvas — the 'blocks', 'schedule', and 'social' screen.

The 'blocks' screen showcases all the added blocks of the station. In this sub-screen, it is possible to configure, add, or remove individual blocks. The 'schedule' screen presents visually the order in which the content inserted from each block will be played. The user can fully customize the order and also remove individual elements. Finally, in the 'search' screen — which is only displayed if the creator of the station allowed its sharing with the community — users can see the profiles that follow the station, as well to accept or decline any changes that other users have suggested.

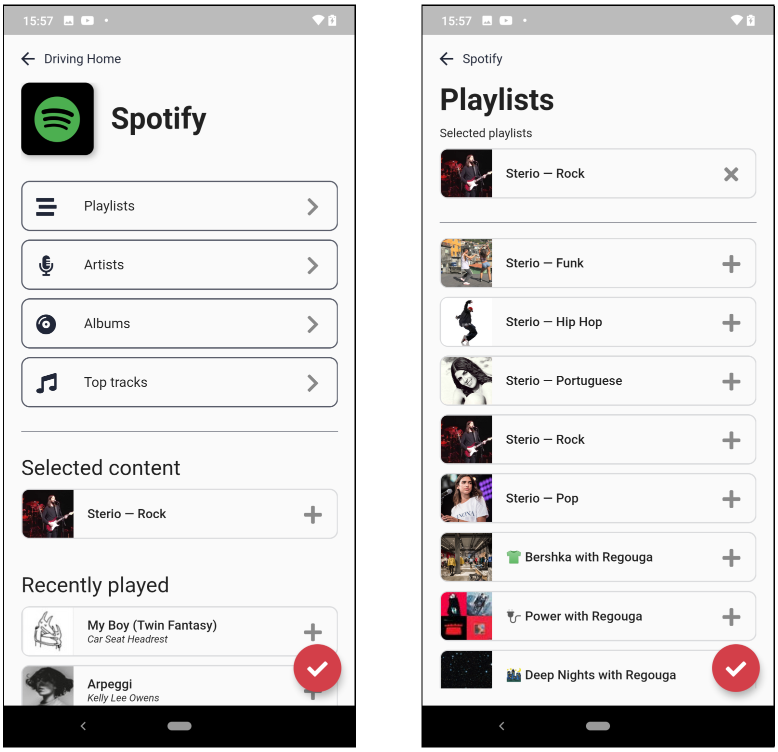
On the first half of the screen, users can examine the station's name, description, artwork cover, duration, and creator (or creators). There, users can also start playing the station, enter its settings screen (where it is possible to adjust some configurations, such as the used text-to-speech voice), or delete the given station.

In the following subsections, we explain in greater detail the logical and technical implementations of three of the available station blocks — Spotify, Podcasts, Weather, and News.

5.3.6.A Spotify and Podcasts

The Spotify block serves as the main connection to the music streaming service. From there, users can explore their music library and select their desired content (that could be represented in the form of a single song, artist, album, or even full playlists). To make it easier for users to add content, the recently played songs from Spotify are also displayed. Users can select an unlimited number of items, which are added to the station schedule automatically and in the order of their choice.

As mentioned in Section 2, Spotify also provides access to a growing library of podcasts, which the user can also add to their stations. Nevertheless, although the provider of both music and podcasts is the mentioned music streaming service, a separate block dedicated to Podcasts was created.



(a) Spotify main configuration screen

(b) Playlists selection screen

Figure 5.10: Spotify block configuration screens

Each item (song, album, playlist, artist, or podcast) is represented by a unique Uniform Resource Identifier (URI), which are obtained with the resource to the Spotify Web API [5]. The credentials entered by the user (described in Section 5.3.1) are used to authenticate and make an API call requesting the

[5] For more information on the development resources provided by Spotify, visit the Spotify Developers website.

desired information. A response JSON file is sent to the backend, where it is processed and, afterward, the information is presented to the user, where they can add the desired content to the station.

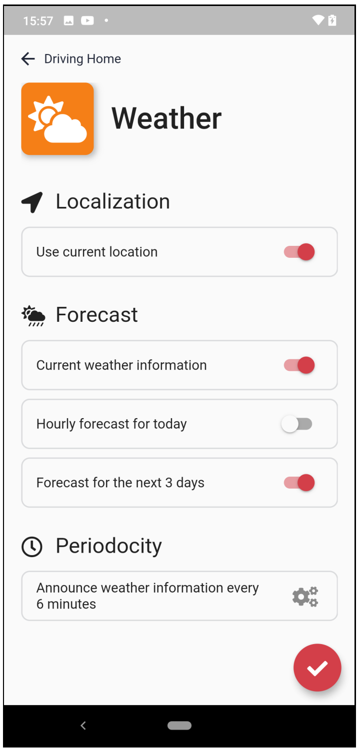

```json
{
    "collaborative": false,
    "description": null,
    "external_urls": {
        "spotify": "http://open.spotify.com/user/thelinmichael/playlist/7d2D2S200NyUE5KYs80PwO"
    },
    "followers": {
        "href": null,
        "total": 0
    },
    "href": "https://api.spotify.com/v1/users/thelinmichael/playlists/7d2D2S200NyUE5KYs80PwO",
    "id": "7d2D2S200NyUE5KYs80PwO",
    "images": [],
    "name": "A New Playlist",
    "owner": {
        "external_urls": {
            "spotify": "http://open.spotify.com/user/thelinmichael"
        },
        "href": "https://api.spotify.com/v1/users/thelinmichael",
        "id": "thelinmichael",
        "type": "user",
        "uri": "spotify:user:thelinmichael"
    },
    "public": false,
    "snapshot_id": "s0o3TSuYnRLl2jch+oA4OEbKwq/fNxhGBkSPnvhZdmWjNV0q3uCAWuGIhEx8SHIx",
    "tracks": {
        "href": "https://api.spotify.com/v1/users/thelinmichael/playlists/7d2D2S200NyUE5KYs80PwO/tracks",
        "items": [],
        "limit": 100,
        "next": null,
        "offset": 0,
        "previous": null,
        "total": 0
    },
    "type": "playlist",
    "uri": "spotify:user:thelinmichael:playlist:7d2D2S200NyUE5KYs80PwO"
}
```


Figure 5.11: Response JSON file of a call to the playlist library of Spotify's Web API

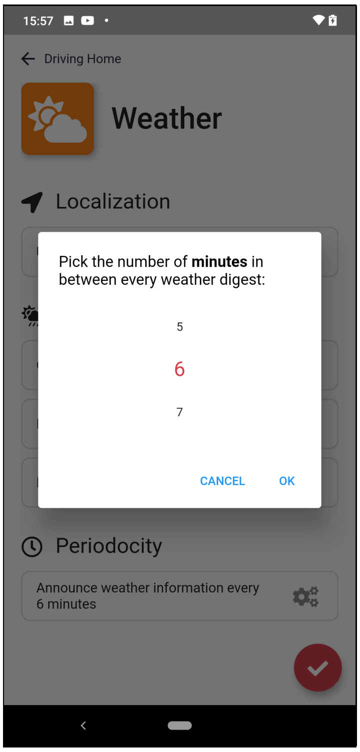
The Spotify Web API provides several useful features in the context of our project. For instance, it is possible to search the entire Spotify catalog for a specific element, get curated playlists created by Spotify's editorial team, based on popularity, mood, international events, and genres, or even present the best content recommendations based on a variety of terms such as market, seeds (artists, genres, tracks), ranged audio features (danceability, valence, tempo, liveness) and popularity. In the end, this creates a very integrated and personalized experience for the platform's users.

The selected URIs are linked to the matching station and stored in the database, so that when a user plays a station, Spotify can gather this information and use it to play an individual item. This algorithm — that uses Spotify's Playback API, rather than the Web API — is further explained in detail in Section 5.3.7.

5.3.6.B Weather



(a) Main configuration screen



(b) Dial selector of weather periodicity

Figure 5.12: Weather block configuration screens

The Weather block provides real-time and updated climate information to a given station. Users can choose to listen to the current weather information, hourly forecast for the current day, and/or forecast for the following three days. It is also possible to customize the periodicity of when this information is played in the station, which will change its matching schedule. Finally, users can also set the location from which they want to receive weather information — by default, this is attributed to the user's current location. These settings set by the user are stored in the database.

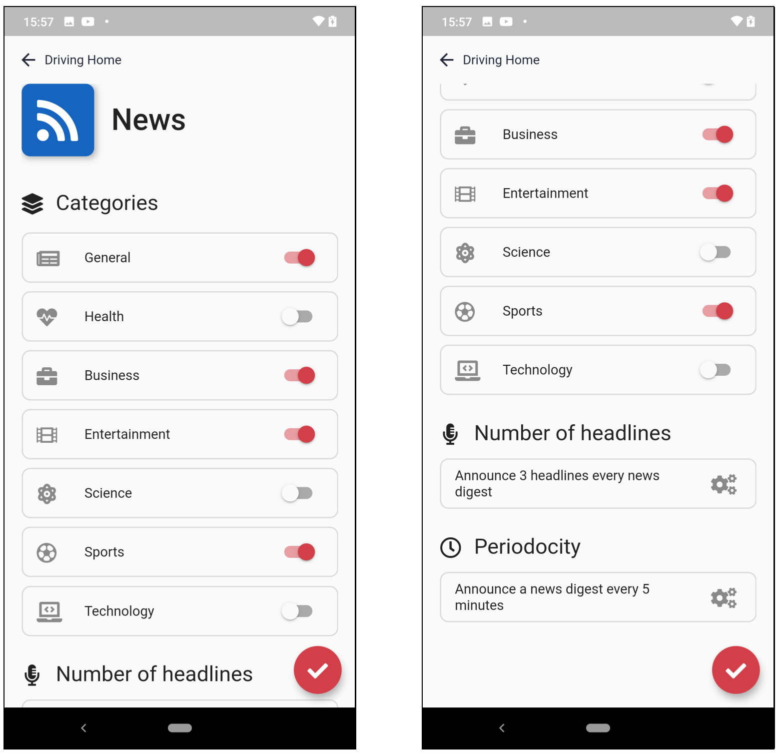
To gather meteorology information, we rely on the OpenWeather Map API [6], which provides the required information reliably and effortlessly. A 'get' request is made to the API, which response is a JSON file containing all the necessary information.

[6] Weather API

5.3.6.C News

The News block provides a digest of the top headlines to a given station. Users can select the categories of news they wish to listen to, the number of headlines, and the periodicity of the digest. It is also possible to select a specific keyword to fetch news from (e.g. ”COVID-19”), or even select the sources from where the headlines are retrieved. These settings set by the user are also stored in the database.

We used the News API to fetch this information, which delivers breaking news headlines, and allows the search for articles from news sources and blogs all over the web [7]. Just like on the Weather block, a ’get’ request is made to the API, which response is a JSON file containing all the requested information by the user.



(a) News categories selection

(b) Number of headlines and periodocity

Figure 5.13: News block configuration screens

When the News block is played in the station, each headline is synthesized and announced by the text-to-speech software, just like any other block containing readable information. To each headline, a small block of text is added to provide more context on the news. Then, an audio separator is played, so that the user knows when the announcement of the next headline begun.

[7] Text

The headlines are obtained based on the country and language selected by the user in the signup process. Nevertheless, the user has full control over this matter and can choose to obtain news headlines from a variety of search terms, topics, countries, languages, and categories.

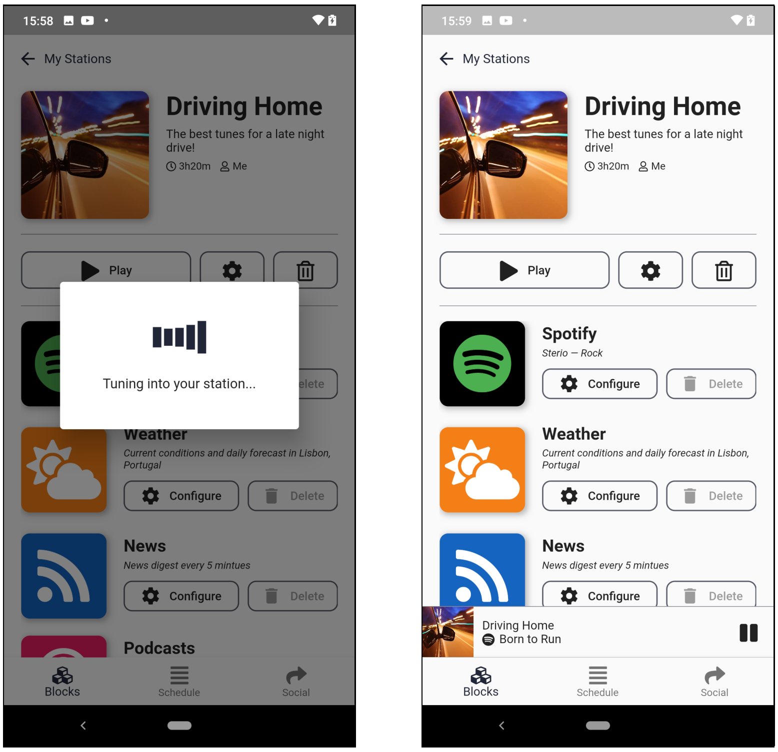

```json
{
    "status": "ok",
    "totalResults": 38,
    "articles": [
        {
            "source": {
                "id": "independent",
                "name": "Independent"
            },
            "author": "Oliver O'Connell",
            "title": "SNL skewers Trump for Supreme Court Covid superspreader event as Jim Carrey
                joins cast as Biden – The Independent",
            "description": "<p>Carrey’s Biden mutes Alec Baldwin’s Trump, says ‘I think we all need a
                break’</p>",
            "url": "https://www.independent.co.uk/arts-entertainment/tv/news/
                snl-trump-biden-chris-rock-carrey-baldwin-debate-b769792.html",
            "urlToImage": "https://static.independent.co.uk/2020/10/
                04/06/Screen%20Shot%202020-10-03%20at%2011.22.18%20PM.png",
            "publishedAt": "2020-10-04T07:21:00Z",
            "content": "Saturday Night Live is back in its famed studio for the first time since 7
                March, with a cold open sketch recreating Tuesdays presidential debate.\r\nTowards
                the end of the sketch, to applause from the… [+1807 chars]"
        }
    ]
```


Figure 5.14: Response JSON file of a call to the News API

5.3.7 Playing a Station

When the station is fully customized to the user's taste, it is then possible to play it. To do so, the user simply needs to tap the 'play' button, located either at the station information screen or at the preview card displayed on the 'My Stations' screen.

After tapping the 'Play' button, a modal, represented in Figure 5.15(a) is shown to the user, which acts as a 'loading' screen while the backend of the platform performs the necessary tasks to allow the playing of the station. To give a radio-like experience, it is played an audio track that mimics the sounds of tuning into a traditional terrestrial radio station, which automatically stops when all loading processes are complete.

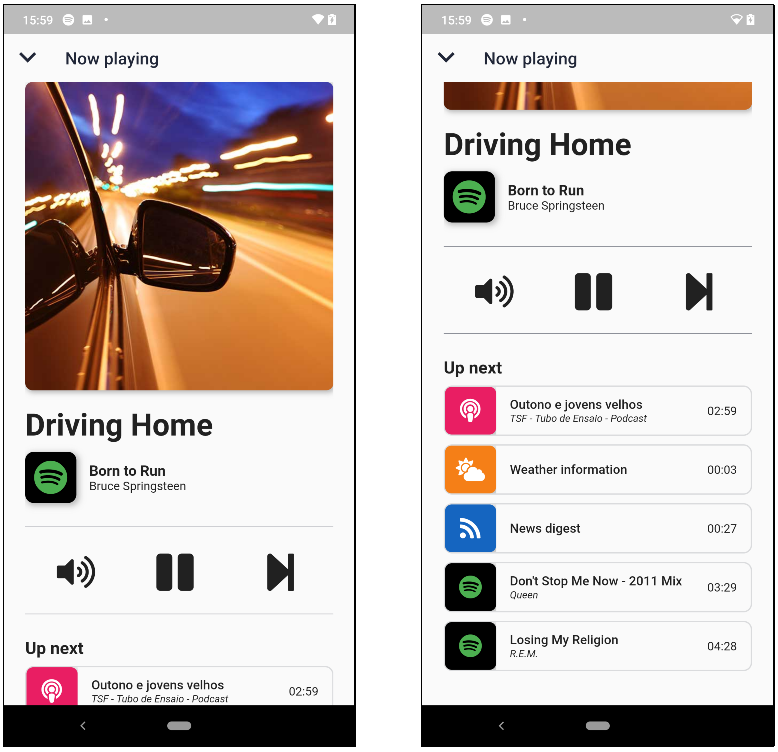


(a) Loading ("tuning") screen

(b) "Now Playing" controller bottom bar

Figure 5.15: Playing a station

Finally, the station starts playing, and a 'now playing' controller bar, shown in Figure 5.15(b), is displayed. This bar provides quick and easy information to the user regarding what's currently playing, as well as a play/pause button to stop playback when needed. If the user taps this bar, the 'Now Playing' screen, showcased in Figure 5.16 is shown, which provides more playback controls and information regarding the currently playing station, including the content that will be played next in the schedule.



(a) Now playing screen **(b)** Up next content

Figure 5.16: "Now Playing" screen

To play the station, a 5-step algorithm is performed before entering the main playing loop. This algorithm is represented in Figure 5.17.

After pressing the play button, the first step of the algorithm is to check if the user has changed the configurations of any of the selected blocks, or if the schedule playing order has been modified. If it is the case, the algorithm updates and processes the schedule so that it is performed on the most recent configurations of the station.

Following this process, the platform will connect to the Spotify Controller, which is a dedicated component of the code that connects to the Spotify Playback API. As mentioned in Section 5.3.6.A, this is a different API library from the one used to select the desired content from the music streaming service.

To control a user's Spotify playback, the API requires that the Spotify application is installed on the user's device and that it is opened in the background so that it can receive requests. This is a limitation set by the Spotify API that we can't bypass. After the connection to the Spotify Controller is successful, then all the selected content (URIs) is added to the user's Spotify listening queue.

After the Spotify connection is handled, all the information from the remaining station's blocks is fetched, so that it is as updated as possible. The responses are then processed into a natural spoken text, which is then sent as a GET request to the Google Cloud Text-to-Speech API. The API responds with a set of encoded information containing the synthesized sound bytes, which are locally converted into audio files. These audio files are then stored in the cache of the platform which, after playing the station, are discarded to save storage space.

Then, if Spotify successfully connected to the platform, and if all the requested information from the blocks is synthesized into text-to-speech audio files, the last step before entering the main playing loop is to set the now playing station as the current 'state' of the platform. This allows the access and control of the currently playing station throughout the interface, as shown in Figures 5.15(b) and 5.16.

Finally, the station enters its main playing loop. Every station begins with a radio transition jingle or audio effect that serves as a separator between content, mimicking a traditional terrestrial radio station, and granting a more cohesive and integrated experience to the user. This transition is naturally between music tracks or other content to allow continued attention in the periphery.

Following this introductory audio effect, the algorithm checks whether the next item of the schedule is a Spotify URI or not. If it is, it plays it by simply calling a 'play' function provided by the Spotify controller, and sets the now playing state of the application. Then, the algorithm checks if the current Spotify content has finished playing, and, if so, it plays an audio transition and another iteration of the loop is processed.

The most difficult challenge we faced while coding this algorithm was the process of determining whether the Spotify content has finished playing or not. The Spotify Playback API does not provide an easy way of accessing this information, allowing only the access of a limited set of playback information, such as the current position of a content's playback. To bypass this limitation, we crafted a sub-algorithm that checks second by second this information, and when the current position of a content's playback matches the total length of such content, an alert is sent to indicate that the content has finished playing. This approach adds complexity in terms of performance and resource usage, but it was the only way we found to bypass this limitation set by the Spotify Playback API.

Conversely, if the next item on the schedule is not a Spotify URI, then the algorithm picks up the matching synthesized audio file and plays it. At the same time, matching background music is added while the text-to-speech audio file is played, so that the user creates more empathy while listening to the information. The now playing state of the application is also set, and if the algorithm checks if the current content has finished playing, it plays an audio transition, and another iteration of the loop is processed. As we're processing local files, we didn't face the same issues in determining if the currently playing content has finished playing, unlike we had with Spotify playback.

When the station finishes playing its matching schedule, the playback is stopped and all the local cached files are deleted. Nevertheless, the user can choose to loop or repeat the station, allowing a non-stop playback of content.

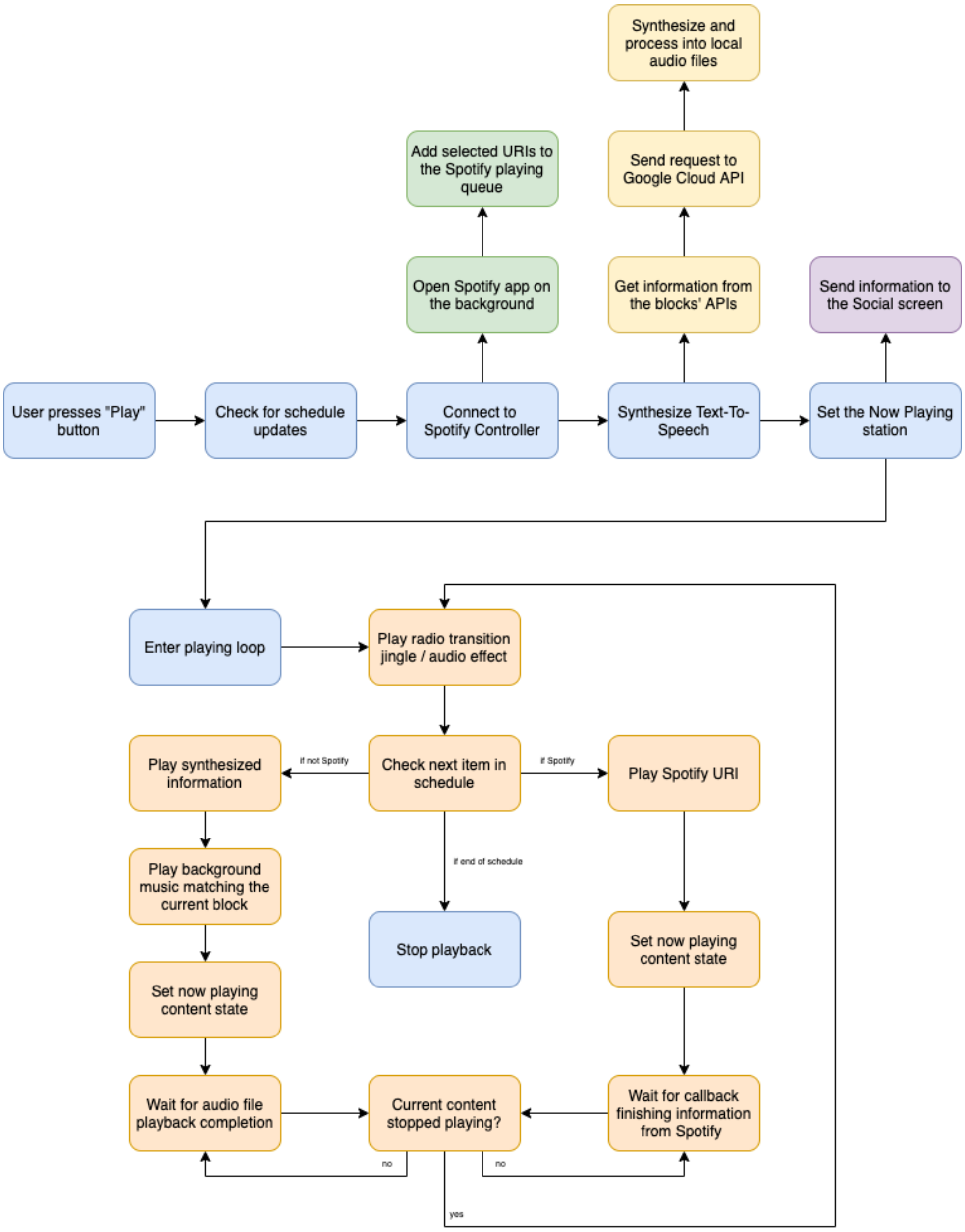


Figure 5.17: Algorithm for playing a given station

6

Evaluation

Contents

After completing the last cycle of development, a set of users tested the Sterio system, in order to gather quantitative and qualitative usability metrics to assure that our platform meets both users' needs and our set goals. We start by presenting the methodology used, followed by the description of the tasks defined for the test sessions, justifying, for each, what we want to conclude by asking users to do it. We finally present the analysis of the test results and the workload estimated for the prototype, as well as the conclusions that we were able to get from the results.

6.1 Methodology

When a final functional prototype of the platform with a working set of features was completed, a group of 26 potential users tested the system. This set of users were of distinct ages, occupations, socio-economical backgrounds, and audio media consuming habits. From these users, 21 haven't participated in either of the previously-mentioned user research (described in Chapter 3) and speed dating activities (examined in Chapter 4), while the remaining 5 have participated in these ventures.

This evaluation was conducted to assess the success of the final prototype and to check that a standard was upheld, which is a process known as summative evaluation. [31, 39] The same list of tasks and protocols were presented to each user, and their performance was evaluated mainly through qualitative measures, as we want to deeply understand the type of experience that is created while users indulge in the platform, as well as insights, findings, and anecdotes about the experience of the user.

To help us steer the session, and to keep all gatherings as cohesive and alike as possible, the first step was to write a protocol guide, shown in Appendix CENAS. All sessions were conducted in a physical location, where several measures were taken to comply with health and safety guidelines as a response to the COVID-19 pandemic. For instance, the researcher and the user were seated at least 2 meters apart from each other, complying with the social distancing rules. All surfaces — including the provided smartphone on where the prototype was tested — were disinfected before and after the session. Users were required to utilize hand sanitizer when entering and leaving the room and were also asked to bring their smartphone so that they could fill out the necessary survey forms.

We planned each testing session to be divided into 3 distinct segments, which we will describe in the following subsections.

6.1.1 Introduction, Informed Consent Form, and Initial Survey

After the user's arrival to the testing room, the facilitator invited them to sit in a comfortable way. In front of them, three items were displayed: a smartphone with the loaded Sterio system; a sheet containing a set of QR codes that redirects users to the necessary survey forms; and a helping sheet that contains extra information regarding the tasks.

In order to contextualize each user on what the purposes of the testing were, an introduction was read by the research. Then, users were asked to carefully read and sign an informed consent form (presented in Appendix CENAS. Finally, by presenting them an initial survey (showcased in Appendix CENAS), we collected demographic information and other relevant details of the user, such as if they had any visual or hearing conditions, as well as their general audio media consumption habits.

6.1.2 User Training and Task Protocol

After the initial remarks, the user was allowed a maximum of five minutes to explore freely the platform's four main screens. The remaining screens were not available for the users to explore in the first stage, as this could interfere with the testing results. During this period, the user could ask any questions. After they felt ready to do so, we began the testing session.

The core testing session consisted of 4 different tasks, that are further described in Section **??**. Each task followed a specific protocol that was transversal to all tasks. First, the researcher presented the task and gave space for the user to clarify any questions related to the disclosure of the task.

Then, after the consent of the user, the researcher started a stopwatch timer to count the time the user took to perform the task. Furthermore, the screen of the used smartphone was also recorded, to help later in the protocol. At the same time, the facilitator was paying attention to the user's actions, taking relevant notes about the usability when appropriate, and counting the number of errors (if any occurred). Beforehand, it was communicated to the user that it was not possible to express any comments nor ask any questions unless a very high level of difficulty whilst performing the task was detected.

Right after the conclusion of the task, the user is asked to fill out a post-task survey that evaluates quantitatively the general experience, usability, and difficulties felt by the user. This survey is showcased in Appendix CENAS.

To gather a broad dataset of qualitative data, two types of moderation to encourage each tester to share their thought process were applied: Retrospective Think Aloud (RTA), where the moderator asks participants to retrace their steps when the session is complete, and Retrospective Probing (RP), where the researcher asks detailed and relevant questions after the fact.

Regarding RTA, a video replay of the user's actions was shown, so that it was easier for them to recall and express their line of thought as they performed the task. The researcher took relevant notes as the user expressed their reasoning.

Lastly, users were asked specific questions about their thoughts and action, such as "What would you do differently?" and were encouraged to elaborate on their responses. As the user was expressing comments, the researcher took relevant notes.

Each of the four tasks followed this protocol, whose duration was an average of 5 minutes per item.

6.1.3 Final Debrief

After the conclusion of the four tasks, users were redirected to a final survey, presented in Appendix CENAS, which was subdivided into two sections.

The first half consisted of a System Usability Scale (SUS), which is a simple, ten-item scale giving a global view of subjective assessments of usability [28] about the user experience with the Sterio system. We followed the guidelines established by Brooke [28]: each question had a degree of disagreement or agreement, with a range from Strongly Disagree (1) to Strongly Agree (5) respectively, from which the user could choose. Users were asked to answer each question honestly, but not too attentively.

The latter half of the final survey consisted of Microsoft's Product Reaction Cards method, which consists of a list of 118 words that might be used to describe a product. The list includes positive words like 'Useful' and 'Engaging', together with negative words, such as 'Frustrating' and 'Ineffective'. Users were asked to choose up to 5 of these words, which were sorted randomly to avoid any bias.

Finally, to close the session, a short final interview with the user was conducted. These interviews allowed the participants to shed light on their experience without extra prompting. A semi-structured approach using a few predetermined questions was applied in the first stage, but afterward, the interviews took their own direction, which uncovered some very useful insights regarding our platform. As the interview was unrolled, the researcher took note of relevant aspects and observations.

6.2 Tasks

The core evaluation session consisted of 4 different tasks that allowed us to understand if our platform met our established usability goals. These tasks should not be too complex, but should be able to explore the full capabilities and features of our prototype, so that we can uncover as much detail as possible regarding the user's experience.

The complete set of four tasks is:

1. Create a new station *(Create)*
2. Configure the station's blocks *(Create)*
3. Play the created station *(Listen)*
4. Share the created station *(Share)*

These tasks are focused on the defined three main user enactments on Section 4.2 — tasks 1 and 2 for the 'Create' enactment, task 3 for the 'Listen' enactment, and task 4 for the 'Share' enactment. This setting allowed us to better understand and organize the session, as well as to steer our results and compare them with the previously discussed matter.

In the first task, users were asked to create a new station with a given name ('Feel Good'), description ('The best hits!'), cover (the first image on the gallery of the smartphone), and blocks (Spotify, Weather, and News). This was a simple task that evaluated the ease of use of the platform, as well as how quickly the user can create a fully tailored and customized station.

The second task was the most complex, as it required a lot of input from the user. Users were asked to configure the three added blocks (Spotify, Weather, and News). For the Spotify block, they were asked to select one of the 5 available playlists, which had identical duration but with a distinct set of songs to match the user's taste. In the Weather block, users were asked to select the current location, current conditions, hourly forecast, and 3-day forecast, with the periodicity set to 5 minutes. Finally, in the News block, users were asked to select the 'General', 'Health', and 'Entertainment' categories, with 6 as the number of headlines and periodicity of 5 minutes. One of our established goals was to make as simple as possible for the user to tailor and customize the station to their taste, and this task let us uncover helpful insights in this matter.

The third task was the most simple one for the user to perform but was the most critical for our study. Users were asked to play their created station and to listen carefully to its content. Then, they were asked to enter in the 'Schedule' screen of the station, as well as to find and enter the 'Now Playing' screen whilst the station was playing. Ultimately, this task gave us really important feedback on the experiences the users felt while indulging in this new listening model.

Finally, the fourth task tested our platform's social capabilities. Users were asked to enter in the 'Social' screen and follow the 'Roger Waters' profile. Then, it was simulated that such a profile was listening to a shared station, and users were asked to listen along (testing the simultaneous listening experience). Afterward, users were asked to enter the "My Day" shared station, and change the News periodicity to 4 minutes. This task allowed users to experience the social counterpart of the platform, giving us important feedback on their experience.

The execution of each of the four tasks followed the same protocol, described previously in Section 6.1.2. Each task didn't surpass 5 minutes in performing them, which allowed us to maintain our goal of keeping the total duration of the sessions in the window of 30 to 35 minutes.

6.3 Results

In this section, we present the results obtained from the execution of the test sessions. We start by presenting the users' characterization (sub-section 5.3.1), followed by a statistical analysis we made to compare results between tasks (sub-section 5.3.2). Then, we examine and review all the gathered qualitative data (sub-section 5.3.3). Finally, in sub-section 5.3.4, we present some conclusions regarding suggestions gathered and notes taken by observation during the test sessions with the users.

6.3.1 Users' Characterization

A total of 26 users participated in the test sessions. From those, 15 were of ages ranging from 18 to 30, while the remaining 11 refer to ages 31 to 60. A majority of the participants were female (16 users). Aproximmatelly 54% were employed, while the remaining 46% were students. None of these users had a visual or hearing condition that cloud affect their performance on the testing sessions.

As for audio media consuming habits, 76.5% of the users use a music streaming service on a daily basis, with only 5.9% using them 'rarely'. With 81%, Spotify is the most used streaming service, followed by YouTube which counts for 5.9%. As for traditional terrestrial radio stations, 41.2% of the users state that they listen to it on a weekly basis, while 17.6% listen to them daily and just 5.9% not listening to them at all.

6.3.2 Statistical Analysis

In this sub-section, we present the results of the statistical analysis performed over the test results. This analysis was conducted with the goal of understanding, in raw metrics, the usability of our system. We evaluated success, time taken to answer, and difficulty evaluated by the users.

6.3.2.A Duration and Number of Errors

Table 6.1 presents the duration it took each user to perform each task, as well as the number of errors. In the same table, some statistics about those values are also presented, which show the values referring to the minimum, maximum, and average time spent executing each task, the value of the standard deviation, and the confidence interval with the confidence level of 95%.

We decided not to count nor analyze the time the users took to perform tasks 3 and 4. These tasks involved playing a station, in which the total time of listening would depend on a variety of factors. As such, this wouldn't be an indicative value to study and take into consideration in our analysis.

By analyzing the table, we can reach some conclusions. First and foremost, we can conclude that the user can create and fully customize a station on an average of 2:30 minutes, which is a good indicator that the platform is fast and intuitive to interact with. Nevertheless, as expected, task 2 was the one who took the most time to complete.

All tasks had a very low number of committed errors. This indicates that users were able to perform the requested tasks in the platform without much complication nor issues. Most of the committed errors

Table 6.1: Statistical Analysis — Duration and Number of Errors

	Duration (seconds)		Number of Errors			
	Tasks					
Users	**T1**	**T2**	**T1**	**T2**	**T3**	**T4**
U01	49	76	0	0	0	0
U02	97	182	1	0	0	1
U03	50	74	0	0	0	0
U04	42	57	0	1	0	0
U05	64	120	0	0	0	0
U06	46	104	0	0	0	0
U07	41	81	0	0	0	0
U08	35	75	0	1	0	0
U09	57	151	0	0	0	0
U10	38	88	0	0	0	0
U11	31	105	0	0	0	0
U12	68	110	0	0	0	0
U13	38	108	0	1	0	0
U14	52	98	0	0	0	0
U15	39	80	0	0	0	0
U16	38	78	0	0	0	0
U17	40	83	0	0	0	0
U18	51	114	1	0	0	0
U19	29	55	0	2	0	0
U20	45	107	0	0	0	0
U21	36	65	0	0	0	0
U22	32	116	0	1	0	0
U23	69	128	0	0	0	0
U24	37	58	0	0	0	0
U25	42	87	0	0	0	0
U26	36	94	0	0	0	0
Statistics						
Min	29	55	0	0	0	0
Max	97	182	1	2	1	1
Mean	46,23	95,92	0,07	0,23	0,11	0,03
Standard Deviation	14,95	29,26	0,27	0,51	0,32	0,19
Confidence Interval (95%)	18,39	35,98	0,3	0,6	0,4	0,2

were, however, mainly caused by a misplace or opalescent element of the user interface, which we will further analyze in Section **??**.

6.3.2.B Task Satisfaction

As mentioned in Section 6.1.2, users were asked to respond to a quick, post-task survey that evaluates the degree of satisfaction felt while performing such task in a quantitative way. This survey had a set of 3 questions, whose answers were on a scale from 0 to 10:

- Rate the ease or difficulty of performing this task, on a scale from 'very difficult' (0) to 'very easy' (10);
- Rate the time it took to complete this task, on a scale from 'less time than expected' (0) to 'more time than expected' (10);
- Rate the likelihood that you would use this feature or task (on a scale from 'not likely at all' (0) to 'very likely' (10).

Regarding the first question, users found all tasks to be very easy to perform, with task 2 being the most difficult (average of 8.23), and task 3 being the easiest (9.7). The overall difficulty average was 9.17, which indicates that users felt no big difficulties whilst interacting with the system. As for the time it took to complete the tasks, in general users thought that it took less time than expected to perform the tasks, with an average of 3.7 per task. Finally, users were found of wanting to use the tested features very frequently. In particular, task 3 (matching the listening of the station) had an average rating of 9.8, meaning that the platform matches users' expectations and desires.

6.3.2.C System Usability Score (SUS)

In the final survey, users were asked to fill out a SUS survey. We grouped the user's questionnaires and for each one of these the SUS was calculated following the guidelines provided on the works of Brooke [28].

The mean rating of our system was 92.94 points, based on Bangor et al. [29]. With this average score, we could make a comparison to understand if our platform is considered 'Worst Imaginable', 'Awful', 'Poor', 'OK', 'Good', or 'Excellent'. By correlating our system, with the adjacent metrics, we conclude that the achieved score falls into the range of what is considered 'Excellent', indicating that users really enjoyed the system and its functionalities.

6.3.3 Qualitative Analysis

In this subsection, we analyze the qualitative data we gathered, which helped us understand the overall experience of the user, as well as what pleased them and the nature of the problems they experienced.

Two very importance sources of feedback were the RTA and RP conducted after the conclusion of a given task. The first one provided a handful interpertation of the line of thought of the user whilst performing the task, allowing us to uncover usability issues. For instance, we were able to detect two misplaced buttons that the user was expecting to be on another part of the interface, as well as an unclear item that users misinterpreted. As for RP, users provided pivotal feedback on their experience while performing the tasks, suggesting some changes or implementations when asked. The "Would tou do something different?" question, asked in the ambit of this moderation acitivity, proved to motivate users to express their comments and suggestions.

In the final survey, before ending the session, users were shown a set of 118 words that could be used to describe a system, as explained in Section 6.1.3. The most used words to describe the Sterio platform are shown as a form of a word cloud in Figure 6.1. From its analysis, we can conclude that no negative word was used to describe the system, and that users found it very easy to use, organized, and innovative, meeting our set goals.

Finally, and most importantly, a final short interview was conducted with all participating users, which provided another way for the participants to share their experience in their own words, thus giving us more detailed and complete insight on their experience.

Most users noted that they would use the platform on a daily basis, while others said it would be particularly interesting to use on specific occasions (such as driving or cooking). They noted that the overall interface was very easy and quick to use, making the platform a very compelling complement to their audio media consuming routines.

A vast majority of users felt they were listening to a 'real' radio station, noting also that they felt a connection in some way. When asked if they entangled a human element, and/or a connection with them in a similar way that traditional radio stations provide, all users replied affirmatively. One user pointed out that, by using the system, it could the weariness felt whilst using a music streaming service for a long periods of time.

Regarding the used text-to-speech, the majority of users thought it was more natural and human-like than what they were expecting, but it still had some flaws when pronnouncing more complex words.

As for the social component of the platform, most users thought it was very well integrated and developed. They noted that they would like to expand their audio consuming social sharing habits, and that the currently available music streaming services are lacking this facet. One particular user suggested the integration of this social component with real radio stations, providing them a way to create and share pre-customized stations with real radio hosts interacting with the listener, but by combining a

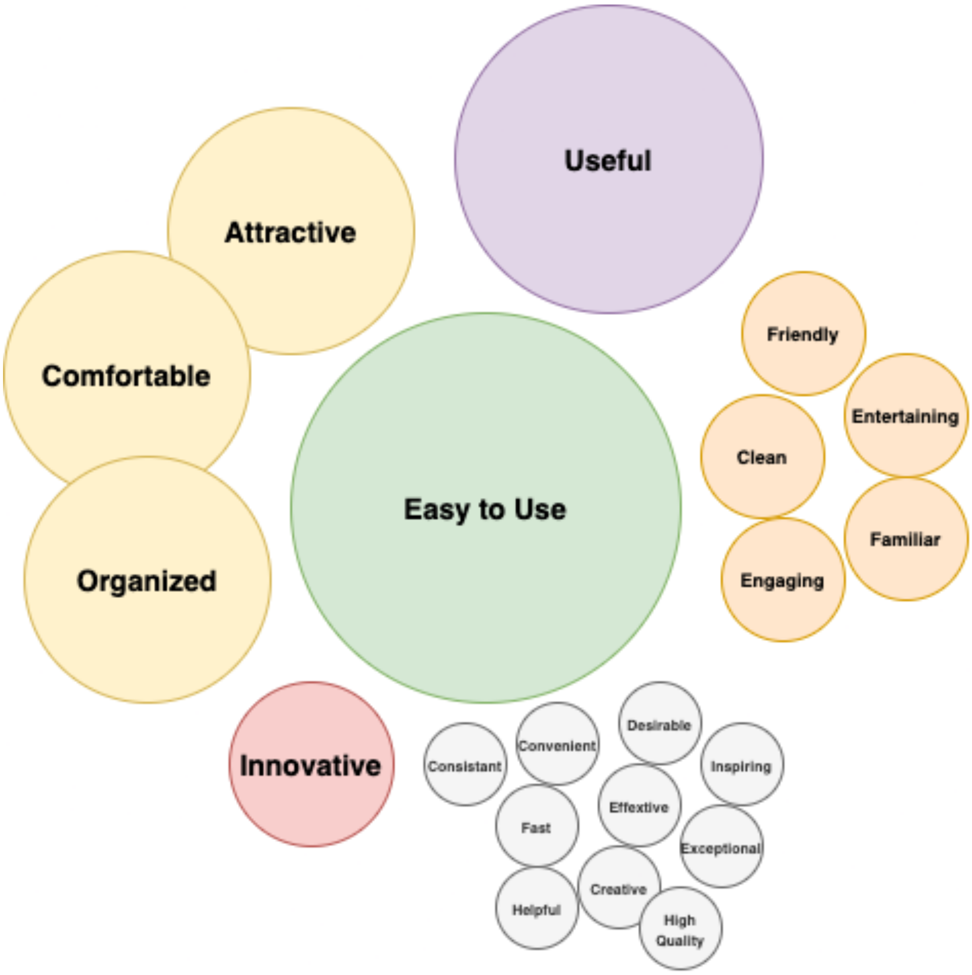


Figure 6.1: Generated word cloud from the most used terms to describe the Sterio system

user's selection of music library, without compromising the customizable capabilities.

Finally, most users believed that this platform could be widley adopted by the community, as they found it very unique and desirable. In conjunction with the analyzed feedback, this assures that our goals were met successfully.

6.4 Discussion

Audio streaming services are used daily by millions worldwide, enabling on-demand listening and the discovery of songs, artists, and podcasts that closely align with the listener's preferences. Meanwhile, traditional terrestrial radio persists as another ubiquitous and still viable mode of accessing more pre-programmed music and news content, including traffic reports and weather information. While both media services offer listeners a distinct set of value propositions, efforts to combine the 'best of both worlds' have been few and far between. After a background analysis in Chapters 2, we set the goal of this project to answer to the question: "How can audio media consumers' music streaming and traditional terrestrial radio habits be best represented in an integrated and personalized experience that may be shared within small networks of friends and family?"

With both our user studies conducted in Chapters 3 and 4, and with our hunt statement in mind, we described in Section 5.1 the requirements that a platform of this scope should have. In short, our ultimate goal was to design and develop a novel listening experience, dubbed Sterio, aimed at merging the best of both worlds — i.e. music streaming services and traditional terrestrial radio — in an interactive, user-centered, appealing, engaging, and innovative platform.

The future of radio has to blend the convenience and viability of music streaming services with the human touch and connection to the world that terrestrial radio stations provide. Sharing this personalized experience with friends and family is a must-have functionality, as the music plays a key role in users' lives and we're living in a social age where users want to be connected with each other. By merging a users' music streaming service library and audio dynamically generated from news, social networks, or even personal sources, with non-speech audio sound effects and background music, into a radio-like integrated, interactive and social experience, Sterio forms a new approach to ubiquitous audio consuming platforms.

From the analysis of the results of the usability testing, we can conclude that our system had a phenomenal user acceptance and usability. This indicates that our platform has not only met user's needs and expectations but exceeded them. Thus, taking all into account, we consider that we've successfully met our goals, proving that the concept of interactive radio can indeed be further augmented into a novel, integrated experience for individual listeners and their close networks of family and friends.

7

Conclusion

Contents

Rui Cruz
You should always start a Chapter with an introductory text

Pellentesque vel dui sed orci faucibus iaculis. Suspendisse dictum magna id purus tincidunt rutrum. Nulla congue. Vivamus sit amet lorem posuere dui vulputate ornare. Phasellus mattis sollicitudin ligula. Duis dignissim felis et urna. Integer adipiscing congue metus.

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7.1 Future Work

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A

Code of Project

Nulla dui purus, eleifend vel, consequat non, dictum porta, nulla. Duis ante mi, laoreet ut, commodo eleifend, cursus nec, lorem. Aenean eu est. Etiam imperdiet turpis. Praesent nec augue. Curabitur ligula quam, rutrum id, tempor sed, consequat ac, dui. Vestibulum accumsan eros nec magna. Vestibulum vitae dui. Vestibulum nec ligula et lorem consequat ullamcorper.

Listing A.1: Example of a XML file.

```
<?xml version=”1.0” encoding=”UTF-8”?>
<StreamInfo version=”2.0”>
    <Clip duration=”PT01M0.00S”>
        <BaseURL>videos/</BaseURL>
        <Description>svc_1</Description>
        <Representation mimeType=”video/SVC” codecs=”svc” frameRate=”30.00” bandwidth=”401.90”
            width=”176” height=”144” id=”L0”>
            <BaseURL>svc_1/</BaseURL>
            <SegmentInfo from=”0” to=”11” duration=”PT5.00S”>
```

```
                <BaseURL>svc_1-L0-</BaseURL>
            </SegmentInfo>
        </Representation>
        <Representation mimeType="video/SVC" codecs="svc" frameRate="30.00" bandwidth="1322.60"
            width="352" height="288" id="L1">
            <BaseURL>svc_1/</BaseURL>
            <SegmentInfo from="0" to="11" duration="PT5.00S">
                <BaseURL>svc_1-L1-</BaseURL>
            </SegmentInfo>
        </Representation>
    </Clip>
</StreamInfo>
```

Etiam imperdiet turpis. Praesent nec augue. Curabitur ligula quam, rutrum id, tempor sed, consequat ac, dui. Maecenas tincidunt velit quis orci. Sed in dui. Nullam ut mauris eu mi mollis luctus. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Sed cursus cursus velit. Sed a massa. Duis dignissim euismod quam.

Listing A.2: Assembler Main Code.

```
; **********************************************************************
; * Constantes
; **********************************************************************

ON     EQU  1 ; contagem ligada
OFF    EQU  0 ; contagem desligada
INPUT  EQU  8000H ; endereço do porto de entrada
          ;(bit 0 = RTC; bit 1 = botão)
OUTPUT   EQU  8000H ; endereço do porto de saída.


; **********************************************************************
; * Stack
; **********************************************************************

PLACE    1000H
pilha:     TABLE  100H   ; espaço reservado para a pilha
fim_pilha:

; **********************************************************************

PLACE    2000H

; Tabela de vectores de interrupção

tab:     WORD   rot0

; **********************************************************************
; * Programa Principal
; **********************************************************************

PLACE    0

inicio:
  MOV BTE, tab      ; incializa BTE
  MOV R9, INPUT     ; endereço do porto de entrada
  MOV R10, OUTPUT     ; endereço do porto de Ìsada
  MOV SP, fim_pilha
  MOV R5, 1       ; inicializa estado do processo P1
  MOV R6, 1       ; inicializa estado do processo P2
  MOV R4, OFF       ; inicializa controle de RTC
  MOV R8, 0       ; inicializa contador
  MOV R7, OFF       ; inicialmente não permite contagem
  EI0          ; permite interrupções tipo 0
```

```
  EI             ; activa interrupções

ciclo:
  CALL  P1       ; invoca processo P1
  CALL  P2       ; invoca processo P2
  JMP   ciclo    ; repete ciclo

; ***********************************************************************
;* ROTINAS
; ***********************************************************************

P1:
  CMP R5, 1    ; se estado = 1
  JZ  P1_1
  CMP R5, 2    ; se estado = 2
  JZ  P1_2
sai_P1:
  RET        ; sai do processo.


P1_1:
  MOVB  R0, [R9]  ; lê porto de entrada
  BIT R0, 1
  JZ  sai_P1     ; se botão não carregado, sai do processo
  MOV R7, ON     ; permite contagem do display
  MOV R5, 2    ; passa ao estado 2 do P1
  JMP sai_P1

P1_2:
  MOVB  R0, [R9]  ; lê porto de entrada
  BIT R0, 1
  JNZ sai_P1     ; se botão continua carregado, sai do processo
  MOV R7, OFF    ; caso contrário, desliga contagem do display
  MOV R5, 1    ; passa ao estado 1 do P1
  JMP sai_P1
```

Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Phasellus eget nisl ut elit porta ullamcorper. Maecenas tincidunt velit quis orci. Sed in dui. Nullam ut mauris eu mi mollis luctus. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos.

This inline MATLAB code `for i=1:3, disp('cool'); end;` uses the `\mcode{}` command.[1]

Nullam ut mauris eu mi mollis luctus. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Sed cursus cursus velit. Sed a massa. Duis dignissim euismod quam. Nullam euismod metus ut orci.

Listing A.3: `Matlab Function`

```
for i = 1:3
    if i >= 5 && a ~= b       % literate programming replacement
        disp('cool');         % comment with some LaTeXin it:  πx^2
    end
    [:,ind] = max(vec);
    x_last = x(1,end) - 1;
    v(end);
    ylabel('Voltage (µV)');
end
```

[1] MATLAB Works also in footnotes: `for i=1:3, disp('cool'); end;`

Nullam ut mauris eu mi mollis luctus. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Sed cursus cursus velit. Sed a massa. Duis dignissim euismod quam. Nullam euismod metus ut orci.

Listing A.4: `function.m`

```
%   Copyright 2010 The MathWorks, Inc.
function ObjTrack(position)
% #codegen
% First, setup the figure
numPts = 300;               % Process and plot 300 samples
figure;hold;grid;           % Prepare plot window
% Main loop
for idx = 1: numPts
    z = position(:,idx);    % Get the input data
    y = kalmanfilter(z);    % Call Kalman filter to estimate the position
    plot_trajectory(z,y);   % Plot the results
end
hold;
end   % of the function
```

Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Phasellus eget nisl ut elit porta ullamcorper. Maecenas tincidunt velit quis orci. Sed in dui. Nullam ut mauris eu mi mollis luctus. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Sed cursus cursus velit. Sed a massa. Duis dignissim euismod quam. Nullam euismod metus ut orci. Vestibulum erat libero, scelerisque et, porttitor et, varius a, leo.

Listing A.5: HTML with CSS Code

```
<!DOCTYPE html>
<html>
  <head>
    <title>Listings Style Test</title>
    <meta charset="UTF-8">
    <style>
      /* CSS Test */
      * {
        padding: 0;
        border: 0;
```

```
        margin: 0;
      }
    </style>
    <link rel="stylesheet" href="css/style.css" />
  </head>
  <header> hey </header>
  <article> this is a article </article>
  <body>
    <!-- Paragraphs are fine -->
    <div id="box">
      <p>
        Hello World
      </p>
      <p>Hello World</p>
      <p id="test">Hello World</p>
      <p></p>
    </div>
    <div>Test</div>
    <!-- HTML script is not consistent -->
    <script src="js/benchmark.js"></script>
    <script>
      function createSquare(x, y) {
        // This is a comment.
        var square = document.createElement('div');
        square.style.width = square.style.height = '50px';
        square.style.backgroundColor = 'blue';

        /*
         * This is another comment.
         */
        square.style.position = 'absolute';
        square.style.left = x + 'px';
        square.style.top = y + 'px';

        var body = document.getElementsByTagName('body')[0];
        body.appendChild(square);
      };

```

```
        // Please take a look at +=
        window.addEventListener('mousedown', function(event) {
          // German umlaut test: Berührungspunkt ermitteln
          var x = event.touches[0].pageX;
          var y = event.touches[0].pageY;
          var lookAtThis += 1;
        });
      </script>
    </body>
  </html>
```

Nulla dui purus, eleifend vel, consequat non, dictum porta, nulla. Duis ante mi, laoreet ut, commodo eleifend, cursus nec, lorem. Aenean eu est. Etiam imperdiet turpis. Praesent nec augue. Curabitur ligula quam, rutrum id, tempor sed, consequat ac, dui. Vestibulum accumsan eros nec magna. Vestibulum vitae dui. Vestibulum nec ligula et lorem consequat ullamcorper.

Listing A.6: HTML CSS Javascript Code

```

@media only screen and (min-width: 768px) and (max-width: 991px) {

  #main {
    width: 712px;
    padding: 100px 28px 120px;
  }

  /* .mono {
    font-size: 90%;
  } */

  .cssbtn a {
    margin-top: 10px;
    margin-bottom: 10px;
    width: 60px;
    height: 60px;
    font-size: 28px;
    line-height: 62px;
  }
```

Nulla dui purus, eleifend vel, consequat non, dictum porta, nulla. Duis ante mi, laoreet ut, commodo eleifend, cursus nec, lorem. Aenean eu est. Etiam imperdiet turpis. Praesent nec augue. Curabitur ligula quam, rutrum id, tempor sed, consequat ac, dui. Vestibulum accumsan eros nec magna. Vestibulum vitae dui. Vestibulum nec ligula et lorem consequat ullamcorper.

Listing A.7: PYTHON Code

```python
class TelgramRequestHandler(object):
    def handle(self):
        addr = self.client_address[0]          # Client IP-adress
        telgram = self.request.recv(1024)      # Recieve telgram
        print "From: %s, Received: %s" % (addr, telgram)
        return
```

B

A Large Table

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Table B.1: Example table

Benchmark: ANN	#Layers (1)	#Nets (2)	#Nodes* $(3) = 8 \cdot (1) \cdot (2)$	Critical path $(4) = 4 \cdot (1)$	Latency (T_{iter}) (5)
A1	**3–1501**	1	**24–12008**	**12–6004**	4
A2	501	1	4008	2004	**2–2000**
A3	10	**2–1024**	**160–81920**	40	60†
A4	10	50	4000	40	**80–1200**
Benchmark: FFT	FFT size‡ (1)	*#Inputs* $(2) = 2^{(1)}$	*#Nodes** $(3) = 10 \cdot (1) \cdot (2)$	*Critical path* $(4) = 4 \cdot (1)$	Latency (T_{iter}) (5)
F1	**1–10**	2–1024	**20–102400**	4–40	6–60†
F2	**5**	32	1600	20	**40 – 1500**
Benchmark: Random networks	#Types (1)	#Nodes (2)	*#Networks* (3)	*Critical path* (4)	Latency (T_{iter}) (5)
R1	3	10–2000	500	*variable*	(4)
R2	3	50	500	*variable*	$(4) \times [1; \cdots; 20]$

* *Excluding constant nodes.*
† *Value kept proportional to the critical path:* $(5) = (4) * 1.5$.
‡ *A size of* x *corresponds to a* 2^x *point FFT.*
Values in bold indicate the parameter being varied.

As Table B.1 shows, the data can be inserted from a file, in the case of a somehow complex structure. Notice the Table footnotes.

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And now an example (Table B.2) of a table that extends to more than one page. Notice the repetition of the Caption (with indication that is continued) and of the Header, as well as the continuation text at the bottom.

Table B.2: Example of a very long table spreading in several pages

Time (s)	Triple chosen	Other feasible triples
0	(1, 11, 13725)	(1, 12, 10980), (1, 13, 8235), (2, 2, 0), (3, 1, 0)
2745	(1, 12, 10980)	(1, 13, 8235), (2, 2, 0), (2, 3, 0), (3, 1, 0)
5490	(1, 12, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
8235	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
10980	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
13725	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
16470	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
19215	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
21960	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
24705	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
27450	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
30195	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
32940	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
35685	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
38430	(1, 13, 10980)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
41175	(1, 12, 13725)	(1, 13, 10980), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
43920	(1, 13, 10980)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
46665	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
49410	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
52155	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
54900	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
57645	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
60390	(1, 12, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
63135	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
65880	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
68625	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
71370	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
74115	(1, 12, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
76860	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
79605	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
82350	(1, 12, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
85095	(1, 12, 13725)	(1, 13, 10980), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
87840	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
90585	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
93330	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
96075	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
98820	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
101565	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
104310	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
107055	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)

Continued on next page

Table B.2 – continued from previous page

Time (s)	Triple chosen	Other feasible triples
109800	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
112545	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
115290	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
118035	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
120780	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
123525	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
126270	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
129015	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
131760	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
134505	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
137250	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
139995	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
142740	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
145485	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
148230	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
150975	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
153720	(1, 12, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
156465	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
159210	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
161955	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
164700	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)