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

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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 efforts to understand audio media consumers' music streaming and traditional radio listening habits and preferences, in order to develop a platform, dubbed *Sterio*, that creates a novel and 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 Streaming Services; Music Technology; Terrestrial Radio; Interactive Radio; User-Centered Design; Human-Computer Interaction

1 INTRODUCTION

Streaming has rapidly become the standard delivery method for digital entertainment content [13], 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, and artists. 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. [10]

Traditional radio, on the other hand, delivers a connection to the outside world, curating and presenting a daily diet of up-to-the-minute news and entertainment content. And yet, as people become more familiar with on-demand media services, radio stations risk losing their listening audiences, who prefer more dynamic and nuanced audio entertainment experiences. [2]

Music streaming services offer listeners the convenience of enjoying their favorite songs and podcasts, on-demand, while enabling the active discovery of artists and content that align with their tastes. However, these services typically lack the human and place-based connection that traditional terrestrial radio stations provide, since there is no on-air presence for actively engaging with listeners, e.g. via call-in shows. Thus, as more and more people gravitate away from traditional radio and towards streaming services, individuals and communities risk losing a certain degree of connection to the outside world.

In this work, we describe our efforts 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 and user centered platform.

2 INTERACTIVE RADIO

Although traditional 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, applying an interactive radio approach that enables a dynamic interaction between radio hosts and listeners.

One of the first augmentations to this concept is the 'Nomadic Radio' system [12], in which scaleable auditory techniques and contextual notification modules for providing timely information were applied. Dingler et. al [6] built on that concept and took a more user-centered approach by proposing a radio-like mobile auditory display application that allowed users to maintain an overview of activities in different social feeds.

Finally, and most importantly, the CereProc team created a platform, called MyMyRadio, which takes updates from a user's Facebook or Twitter accounts, and RSS feeds, and synthesizes them using CereProc's text to speech technology,

slotting these spoken updates into a playlist of a selected periodically. Aylett et. al [3] have presented a case study on this platform, in which it is highlighted the potential and challenges of an interactive radio approach, which are of interest to the development of this project. In the ambit of such case study, the researchers state that 'a more developed interactive radio platform could 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.'

Thus, the concept of 'interactive radio' can be further augmented as there is a user impulse for this to happen. Based on our research, this may be achieved by combining the strengths of both terrestrial radio and streaming services into a personal, yet social platform.

3 USER RESEARCH

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. As we want our solution to suit the user, rather than making the user suit our solution, we need to understand users' habits and to have them into account from the very early stages. Thus, our efforts began by conducting a survey, a diary study, and interviews.

Survey

To better identify a target user population, current pain points, and opportunities that our solution could fulfill, we conducted a survey using the online tool Google Forms. In this first stage, as the goal was to reach a large number of individuals, we used Facebook and WhatsApp social networks to ensure its wide diffusion. 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 gathered 198 responses, where 58.8% of them came from respondents with ages ranging 18 to 30, while the remaining 41.2% refer to ages 31 to 60. A majority of the participants were female (60%) and 40% were male. 50% of them were employed, while 42% were students, and the remaining 8% were unemployed or retired. The questions on the survey were of multiple-choice with single or multiple responses.

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, with Spotify being the most used one. 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. 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 in second and third places respectively. 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%).

Diary study

To obtain a more raw and personal set of data regarding users' audio consuming habits, we conducted a diary study, which asks participants to capture information about their activities, habits, thoughts, or opinions as they go about their daily activities.

The author's personal network of 11 close friends and family members were recruited to participate over the course of one week. Participants were asked to complete a spreadsheet template on the Google Sheets platform at the end of each day. The template had a set of pre-specified questions for users to respond to, including: "What type of content did you listen to during that session?", "Where did this listening session take place?" and "Name two aspects you enjoyed and disliked on your listening session".

The main outcome of this diary study was qualitative data. For its analysis, we used an affinity diagram, where we extracted the data from each participant, pulling out key points, and wrote each note individually on a sticky note. Similar findings or concepts were then grouped to distinguish themes or trends in the data. Specifically, the sticky notes were assorted by listening medium and then subdivided into 3 distinct colors: green to showcase the positive aspects of a listening medium, red for the negative, and yellow for the places the listening session took place. The first iteration of the affinity diagram is shown in figure 1.

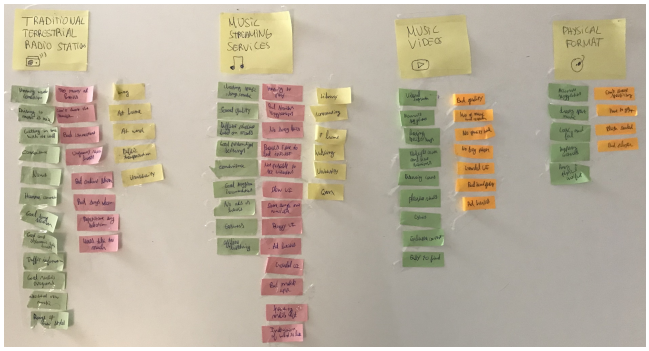

Figure 1: Affinity diagram with the gathered data from the diary study.

From its analysis, some conclusions emerged. Regarding traditional terrestrial radio, users enjoy the human connection it provides, as well as the disclosure of information such as news, weather, and traffic reports. On the downside, most respondents don't like the song selection of stations, as they find them repetitive or not matching their musical taste. Not being able to choose what to listen to on the radio is something that also frustrates them. Conversely, users value the freedom of music choice in streaming services, as well as its overall sound quality and convenience.

Interviews

We conducted semi-structured in-person interviews with the 11 participants of the diary study as a follow-up to this method. The main goal 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 empathy on terrestrial radio and music streaming services. As with the diary study, the main outcome was qualitative data, which was added and organized in the previously created affinity diagram, shown in fig. 1.

The resulting feedback on the affinity diagram gave us important information regarding audio media consumers' streaming and radio listening habits and preferences. Specifically, we learned the users' most and least valued aspects of said mediums, as well as their general consumption habits and desires, which helped us determine what features to focus on towards our final goal.

4 CONCEPT VALIDATION

To help us explore a diverse group of early-stage concepts, and to reflect on their stature, we have used the speed dating methodology [5]. This method consists of a two-stage process: need validation and user enactments.

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. [5]

To do so, we have crafted a set of four personas, based on four different potential users of this solution. To make them feel as real as possible, each persona was attributed a set of personality traits. A subsequent set of scenarios was attributed to each of the 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.

The next step was to conduct sessions where we presented this set of storyboards to small groups of target users. We have conducted a total of five remote sessions that started with a brief description of the project and the goals of the discussion. Then, the developed personas and storyboards were presented. After presenting a given storyboard, users were asked to put themselves in the shoes of the correlated persona and were then 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. 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.

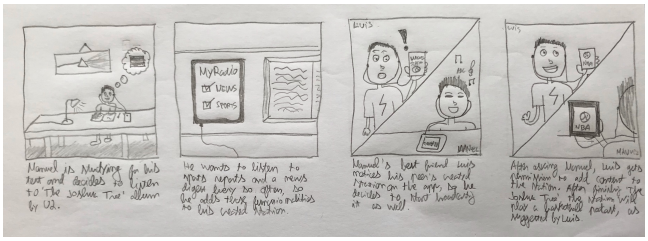

Figure 2: Example of one of the created storyboards.

The received feedback was very positive. Most users stated that this 'interactive radio' approach would significantly enhance their audio listening experience in their daily routines. The social and community features were very well received, which assesses the user demand for more social and community features to arise in modern audio consuming mediums.

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. [5]

As a result of the need validation process, we were able to reduce our design dimensions by three main dimensions: 'Create', 'Listen', and 'Share'. 'Create' refers to the creation of a personalized station, where the user selects their desired audible content. 'Listen' invokes the actual listening experience of these stations. Finally, 'Share' addresses the shareability and the community features of the system.

Based on this information, we developed a medium fidelity prototype aimed at showcasing a preliminary concept of the *Sterio* platform to the common user. The prototype focused on merging a users' music streaming service library and audio dynamically generated from news and social networks with non-speech audio sound effects and background music.

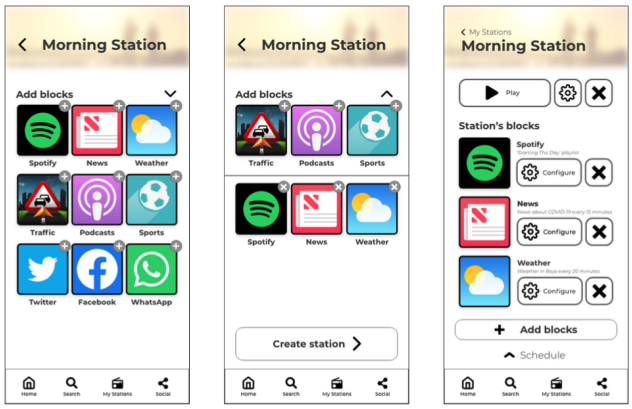

Figure 3: Medium-fidelity prototype of the *Sterio* system.

The diffusion of the prototype was conducted using the WhatsApp social network. 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 product.

Corroborating with the first step of the method, the received feedback was very positive. All users clearly understood the main concept of the platform. Regarding the text-to-speech usage on the prototype, the feedback received was better than expected, as the majority of users considered the text-to-speech voice more natural than what they were foreseeing. Most users noted that they would use the platform on a daily basis.

5 STERIO SYSTEM

Requirements

Based on the conducted research, some basic functionalities that the platform should perform emerged.

The first and most important is the creation of personalized radio stations that allow users to select their desired music using a streaming service or other audio media content such as podcasts or audiobooks. A high level of shareability and sociability must be offered, 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. To each station, a 'virtual radio host' based on text-to-speech technology is attributed, allowing content to be delivered in the periphery during that session. This host mimics as best as possible a 'real' radio host, promoting interaction, human connection, and empathy between the listeners and their 'own radio host'. 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.

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. [1] The three main layers that compose our system are the Presentation, Business, and Database Layer.

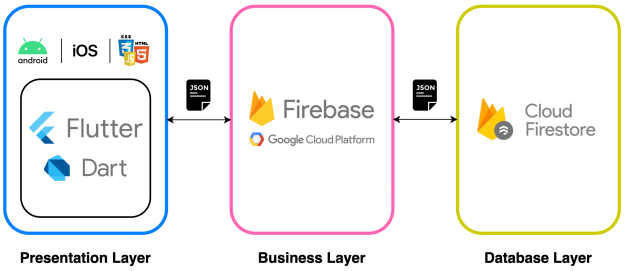

Figure 4: Architecture of the *Sterio* system.

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. [1] 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. The implementation of the database was conducted using Google's Cloud Firestore, which is a NoSQL, document-oriented database. 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.

Business Layer. The Business Layer is responsible for encoding the real-world business rules that determine how data can be created, stored, and changed. [1] For the *Sterio* platform, we chose to use Google's Firebase business logic features. Firebase is a 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 API exposed by backend applications while also providing features such as user management, push notifications, and integration with social networking services.

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. [1] This layer will interact with the business layer through calls to the Firebase service. We chose to develop the *Sterio* platform using Flutter, which is an UI toolkit for building natively compiled applications for mobile, web, and desktop from a single codebase. [11] In the context of our project, Flutter has some key advantages over other technologies. To start, Flutter is 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. [9] Secondly, 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. [11]

Functional Prototype

Based on the medium-fidelity prototype presented in Section 4, the last — and most crucial — 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.

'Home' and 'Search' Screens. After logging in, the user is prompted with the 'Home' screen, shown in Figure 5, 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. In the 'Search' screen, the user can search for a specific station, content, or even other users to follow and check their profiles. In the same screen, listening suggestions are also shown, based on the most searched items and trending stations in a given location.

'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). From the same screen, users can also delve into the shared

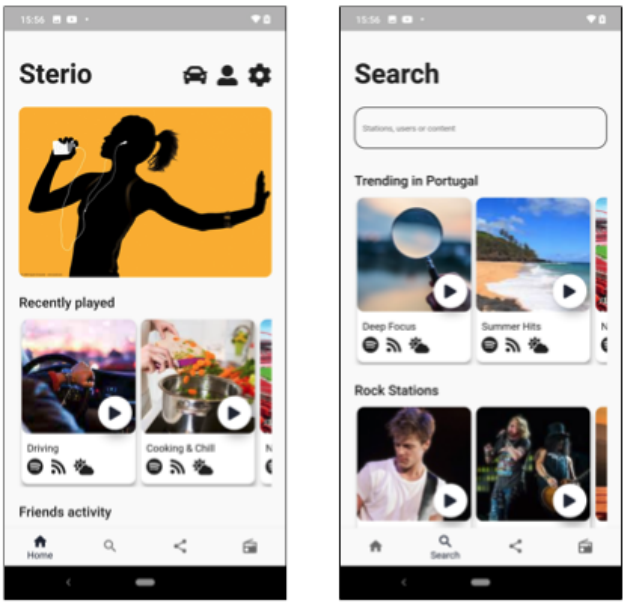

Figure 5: 'Home' and 'Search' screens.

stations of their friends and family and get recommendations of profiles to follow based on their taste and friends' circle.

'My Stations' Screen. The last of the four main screens of the platform is the 'My Stations' screen, 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.

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, 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 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 is shown to the user so that they can select the desired blocks simply and intuitively. After being elated with their choices, the user is redirected to the 'My Stations' screen, where the newly created station is now listed.

Configuring and Customizing a Station. Each station has its dedicated page, where the user can explore and customize

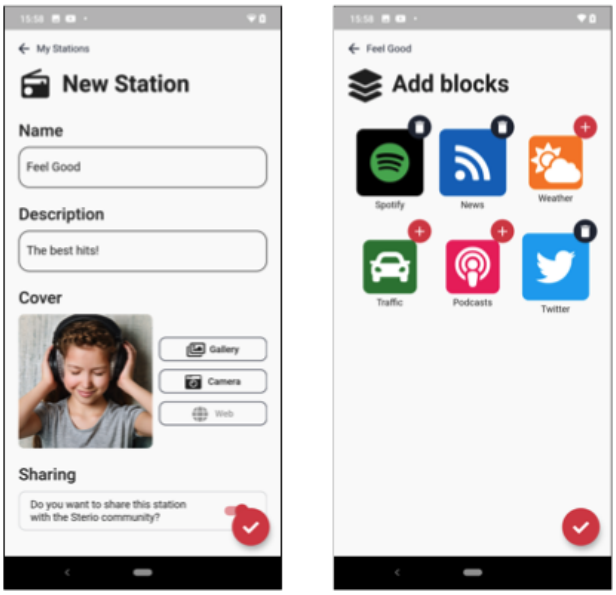

Figure 6: Process of creating a new station.

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 remove individual elements. Finally, in the 'social' 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 to the station's content.

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

Spotify and Podcasts. The Spotify block acts as the main connection to the music streaming service. From there, users can explore their music library and select their desired content. They 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. Each item (song, album, playlist, artist, or podcast) is represented by a unique URI, which are obtained with the resource to the Spotify Web API. The credentials entered by the user are used to authenticate and make an API call requesting the 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.

Weather. 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, 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.

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 select the sources from where the headlines are retrieved. 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. 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. 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, descriptive 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.

Playing a Station.

When the station is fully customized to the user's taste, it is then possible to play it. After tapping the 'Play' button, a modal screen 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.

Finally, the station starts playing, and a 'Now Playing' controller bar 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 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.

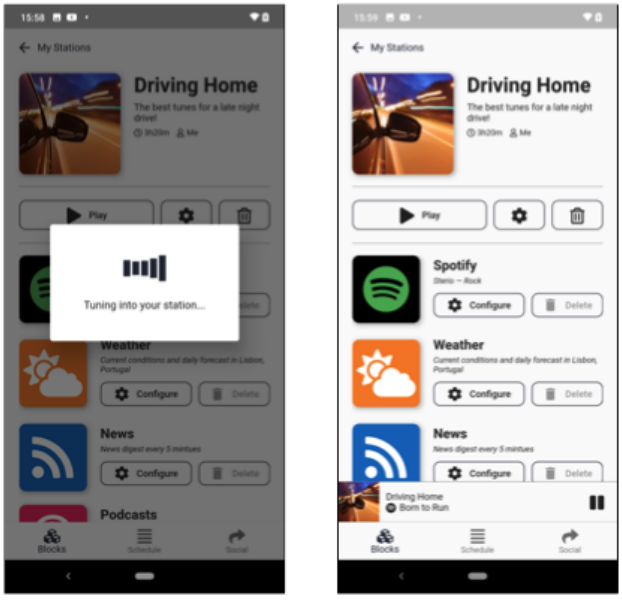

Figure 7: Interface displayed when playing a station.

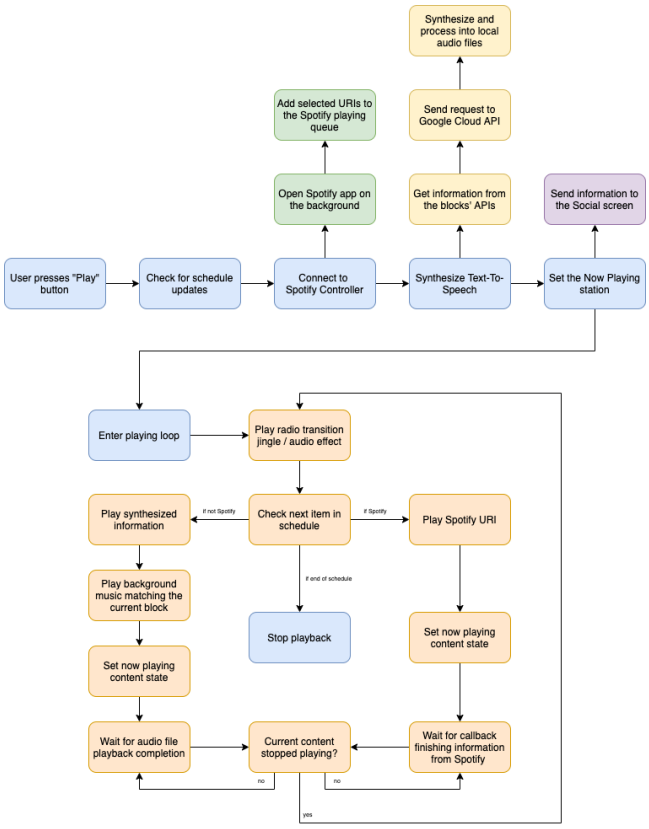

Figure 8: Algorithm for playing a station.

To play the station, a 5-step algorithm is performed before entering the main playing loop. This algorithm is represented in Figure 8.

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 accordingly, 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.

After the Spotify connection is handled, all the information from the remaining station's blocks is fetched, so that it is as updated and real-time 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. Then, 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.

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 inserted 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. 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. 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.

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.

6 EVALUATION

Methodology

When a final functional prototype of the platform with a working set of features was completed, a group of 26 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 Section 3) and speed dating activities (examined in Chapter 4), while the remaining 5 have participated in these ventures. 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, dividing each session in three distinct segments.

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 order to contextualize each user on what the purposes of the testing were, an introduction was read by the researcher. Then, users were asked to carefully read and sign an informed consent form. By presenting them an initial survey, 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.

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. 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 four different tasks:

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

Each task followed a specific protocol. 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. 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). Right after the conclusion of the task, the user was asked to fill a post-task survey that evaluates quantitatively the general experience, usability, and difficulties felt by the user. To gather a broader 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. [8] As the user was expressing comments, the researcher took relevant notes.

Final Debrief. After the conclusion of the four tasks, users were redirected to a final survey. The first half of it consisted of a System Usability Scale (SUS), which is a simple, ten-item scale giving a global view of subjective assessments of usability [4] about the user experience with the *Sterio* system. 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 [8]. 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.

Results

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). Approximately 54% were employed, while the remaining 46% were students. As for audio media-consuming habits, 76.5% of the users use a music streaming service daily, 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 them every week, while 17.6% listen to them daily, and just 5.9% not listening to them at all.

Statistical Analysis.

Duration and Number of Errors. We recorded the duration it took each user to perform each task, as well as the respective number of errors. By analyzing our results, we could 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, due to its added complexity. All tasks had a very low number of committed errors, indicating that users were able to perform the requested tasks in the platform without much complication nor issues.

Task Satisfaction. As mentioned in Section 6, users were asked to respond to a quick, post-task survey that evaluates the degree of satisfaction felt while performing such a 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 difficulty or ease of performing this task;
- Rate the time it took to complete this task;
- Rate the likelihood that you would use this feature or task.

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.

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 [4]. The mean rating of our system was 92.94 points. With this average score, we could make a comparison to understand if our platform is considered 'Worst Imaginable', 'Awful', 'Poor', 'OK', 'Good', 'Excellent', or 'Best Imaginable'. By correlating our system with the adjacent metrics, and based on the scale set by Bangor et. al [7], we concluded that the achieved score falls into the range of what is considered 'Best Imaginable', indicating that users enjoyed the system and its functionalities.

Qualitative Analysis. Two crucial sources of qualitative feedback were the RTA and RP conducted after the conclusion of a given task. The first provided a handful of interpretations 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 you do something different?" question, asked in the ambit of this moderation activity, 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. The most used words to describe the *Sterio* platform are shown as a form of a word cloud in Figure 9. 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.

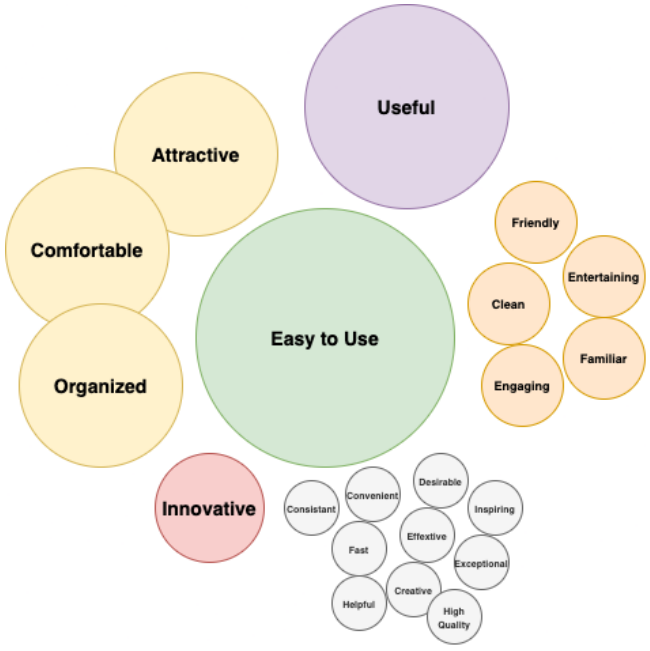

Figure 9: Generated word cloud from the most used terms to describe the *Sterio* system.

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 daily, 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 human 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.

Regarding the used text-to-speech voice, the majority of users thought it was more natural and human-like than what they were expecting, but it still had some flaws when pronouncing more complex or recently-created words. As for the social component of the platform, most users thought it was very well integrated and developed. 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, while also combining a user's selection of music library, without compromising the customizable capabilities that makes this platform unique. Finally, most users believed that *Sterio* could be widely 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.

7 CONCLUSION

In an age where on-demand streaming services are the preferred way for users to consume audio media content, the human connection that makes these experiences so enjoyable in the first place is lacking more than ever. Conversely, traditional mediums, such as terrestrial radio, are still thriving by keeping their listeners 'connected to the world' through the dissemination of information, such as news, 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 investigated how we can develop a platform aimed at best representing audio media consumers' music streaming and traditional terrestrial radio habits into an integrated and personalized experience, that may be shared within small networks of friends and family.

We started by studying the currently available mediums and the concept of interactive radio. Next, we conducted preliminary user research activities that gave us an insight into users' listening habits and desires. To understand how these habits can be constituted in a new platform that aims to create a novel listening experience while applying the interactive radio approach, we used the speed dating methodology, which validated users' needs, reduced the design dimensions of the platform, and generated a medium-fidelity prototype that was used as the foundation for the development of the platform.

Finally, we presented our value proposition, which consists of the *Sterio* platform, that was developed with a sturdy focus on the user. The system allows the creation of personalized radio stations that yields users to select their desired music using a streaming service or other audio media content such as podcasts or audiobooks. A high level of shareability and sociability is offered, 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. To each station, a 'virtual radio host' based on text-to-speech technology is attributed, allowing content to be delivered in the periphery during that session. This 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 with the session, so that these personal radio stations reassemble a 'real' radio station.

After describing in detail the final crafted solution, as well as our efforts, technologies, and methodologies used in the context of the development of the platform, we presented an in-depth analysis of our evaluation methodology and its results. By interpreting them, we concluded that all our objectives were achieved, meaning we successfully created and validated a novel radio-like experience that is at once personal, customizable, and shareable.

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