Team 26 | Adio: Location-based Advertising for Rideshare

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Abstract

Adio is a location-based audio advertising platform for rideshare drivers that intersperses geographically targeted audio advertisements between music played during rides and provides a portion of the advertisement revenue to the rideshare drivers. There are two main components to the product: a cross-platform mobile application that rideshare drivers can use to play advertisements between music and a web application that advertisers can use to create geographically targeted audio advertising campaigns. Adio enables advertisers to target specific geographic customer segments, drivers to earn passive income, and riders to learn about businesses and offerings nearby. Adio aims to revolutionize the worlds of audio and rideshare advertising.

1 Motivation

1.1 Problem Overview and Need

Advertisers, especially small businesses, want and need innovative and cost-effective ways to reach high-potential consumers. Moreover, consumers want and need relevant and effectual methods to discover and connect with businesses that are easily accessible to them. Rideshare companies, such as Uber and Lyft, provide an important service and a unique medium for novel, location-based advertising that provides supplemental income to rideshare drivers.

1.2 Market Opportunity and Customer Segments

Audio advertisements have been shown to be one of the most effective mediums of advertisement. According to a study conducted by Nielsen Catalina Solutions, radio advertisements had a higher ROI than other forms of advertising, including Facebook and other digital media. The average ROI on radio advertisements was more than $6 for every $1 spent, which is double even the best results from studies of digital or TV media advertisements [13]. However, radio advertisements are always broadcast to a large area, making them both expensive and less valuable to smaller or local businesses who may want to reach only a particular, fine-grained location segment. Additionally, Uber and Lyft drivers do not benefit at all from playing radio advertisements. Our solution is to take advantage of the immense ROI that audio advertisements provide and further increase their their value by providing fine-grained location targeting, while also providing an additional source of income for our rideshare driver-partners.

Rideshare drivers comprise a very large population but are paid very little compared to those in other professions in the United States. According to the Economic Policy Institute, there are around 833,000 Uber driver participants in a year, and after deducting Uber fees and driver vehicle expenses from passenger fares, the average compensation that goes to the driver is only $11.77 an hour [2]. This is substantially less than the $32.06 average hourly compensation of private-sector workers and the $14.99 average hourly compensation of workers in the lowest-paid major occupation (service occupation workers) [2]. After adjusting for benefits and payroll taxes, the official "wage" for Uber drivers averages $9.21 an hour, which is less than what 90 percent of all workers in the United States earn. This wage falls below the mandated minimum wage in 13 of 20 major Uber urban markets. We see that rideshare drivers have a clear need for additional sources of income; we believe that Adio is an excellent solution for this as it provides supplemental income with minimal effort on the part of drivers [1].

When we were gauging potential interest in our product, we received positive feedback, especially from current Uber and Lyft drivers. Drivers emphasized that they appreciated the minimal setup required to use our platform, which sets Adio apart from many of the aforementioned rideshare advertising opportunities. Many drivers cited their current experiences playing music through the radio during their rides and expressed excitement over the possibility that audio advertisements could provide them passive income. The primary concern for drivers was that the passenger experience may be worsened due to advertisements, which could potentially affect their rideshare driver rating. However, Adio plays one or two short advertisements at regular intervals, which is more pleasant than traditional bulk radio advertising. Furthermore, we expect these advertisements to be more relevant to riders as they are geographically targeted. Finally, we allow driver-partners to control advertisement frequency and provide an easy interface to turn Adio on and off, in case a particular rider has a strong aversion to advertisements or does not want to listen to music. We also polled several regular rideshare riders, who told us that audio advertisements would be an unlikely reason for them to reduce a driver's rating, especially since the advertisements broadcasted by Adio will likely be helpful to the riders.
When interviewing rideshare riders about our product, we received positive feedback and interest. Given that students on campus frequently use rideshare services to travel to Center City, Philadelphia, many felt that location-based advertisements would inform them of activities and offerings in the area and would definitely be an improvement over traditional radio advertisements. Adults also expressed an interest in this idea, citing business travel to new cities as one of their primary uses for rideshare services. Relevant advertisements would allow them to cost-effectively explore the area around them during their free time.

1.3 Market Size and Growth

In 2019, spending on radio advertisements in the United States was roughly $17.9 billion. This amount is projected to grow to $18.4 billion by 2023 [13].

Rideshare itself is an incredibly prominent business with global reach; Uber alone is spread throughout 600 cities across 65 countries. In 2019, there were approximately 75 million Uber passengers worldwide who were served by around 3.9 million drivers. The United States comprises Uber's largest market, with about 41.8 million users in March 2018 [3]. In the Philadelphia area, these numbers have been increasing at an astronomical rate. The number of yearly Uber and Lyft trips in Philadelphia increased by about 13 million from 2016 to 2018, according to the Philadelphia Parking Authority. There were about 36 million Uber and Lyft trips starting in Philadelphia from July 2017 to June 2018. These rides alone earned about $376 million in revenue, which was a 62% increase from the previous year [2].

Similarly, small businesses have grown in size and number throughout recent years. According to the United States' 2018 Small Business Profile, there were about 30.2 million small businesses in the United States (which account for 47.5% of the country's private workforce) [10].

In terms of advertising, small businesses have some hurdles to overcome. According to Blue Corona, a study done by Business Insider demonstrated that 46% of small businesses see great value in advertising, but 72% of them prioritize increasing revenue before budgeting for marketing. In 2019, Vivial showed that advertisers are more interested in audiences than anything else – quality over quantity has reached a new level of importance. Thus, we believe small businesses will find value in Adio's innovative advertising that aligns with this interest. We believe small businesses have great potential to comprise a large portion of the advertisers on our platform, especially since it is cost-effective and enables fine-grained geographical targeting.

1.4 Value Proposition

Our goal is to provide a platform, Adio, for location-based audio advertising in rideshare vehicles that delivers relevant and effective advertisements between songs played by our rideshare driver-partners. Our driver-partners are able to download our mobile application, select the frequency of advertisements they wish to play – perhaps one every 5, 10, or 15 minutes – and begin playing music from their personal libraries, online audio distribution platforms (e.g. SoundCloud), or music streaming services (e.g. Spotify or Ap-

ple Music). Based on the advertisement frequency chosen, our driver-partners' music will automatically be interspersed with advertisements from our advertiser-partners. Using the current location of our driver-partners (and potentially rideshare trip data), Adio will play geographically relevant advertisements based on target regions selected by our advertiser-partners for their respective advertisement campaigns.

1.5 Stakeholders

Our advertiser-partners, many of whom we expect will be small businesses, are able to use audio advertisements to target geographically relevant customers. The value of each advertisement is greater than that of a comparable radio advertisement since businesses can broadcast their advertisements through Adio to a specific geographic region. This means that the cost of advertising through this novel medium is affordable and practical for a larger group of businesses as compared to that of radio advertisements. Advertiser-partners are also able to flexibly create, monitor, and remove advertisement campaigns at any time. If needed, existing campaigns can be easily modified to change the target region, impression limit, or the advertisement itself.

Rideshare passengers who engage with advertisements through our platform will discover businesses that are relevant and easily accessible to them due to the location-based targeting of our advertiser-partners' advertisement campaigns.

Our driver-partners are able to supplement their income through Adio as a portion of the advertisement revenue that we generate is paid to our driver-partners based on the quantity of advertisements they broadcast to passengers. It is also incredibly easy for driver-partners to begin using Adio, as there is little initial setup or cost required on their part.

1.6 High-level Functionality

There are two main components to Adio: a web application and a mobile application. Each one caters to one of our primary stakeholders and serves a unique purpose.

At a high level, the web application is designed for advertiser-partners to easily create audio advertising campaigns that are seamlessly delivered to consumers via our driver-partners. The website allows advertiser-partners to sign up and sign in, upload audio advertisements, and set a rectangular geographic area in which their advertisements will be broadcast using our drag-and-drop map interface or using latitude and longitude coordinates. In addition to creating advertisement campaigns, advertiser-partners can also monitor and adjust their existing campaigns.

The mobile application allows driver-partners to sign in, start or stop usage of Adio, set various parameters regarding the advertisements that they wish to broadcast, such as volume and frequency, and view their earning history. In order to play advertisements interspersed between music, we have currently implemented audio ducking. In other words, based on the frequency that the driver-partner sets, at regular intervals the application will reduce the volume of the music currently playing on the driver-partner's phone to a minimal level and play an advertisement that has been queued.

1.7 Demos

Our web application is hosted on Amazon Elastic Beanstalk and can be accessed at `http://adio.us-east-1.elasticbeanstalk.com/`. We were not able to deploy the mobile application publicly at this time, as this requires registering for an Apple or Android Developer account with a subscription fee. Instead, we have deployed our application to our personal phones and included a screen recording in our demo video linked below.

Video demos of our web application and mobile application can be found at `http://tiny.cc/adio-web-demo/` and `http://tiny.cc/adio-mobile-demo/`.

2 Competition and Related Work

We completed thorough market research to better understand the existing market, learn about competitors, identify important differentiating factors, and realize what does and does not work. We categorized the existing landscape and competitors as follows:

Tablet-based Rideshare Advertising

(1) Octopus (playoctopus.com) provides free tablets to rideshare drivers for passenger use

that have trivia games and location-based video advertisements. Octopus pays drivers up to $100 per month.

(2) Vugo (govugo.com) provides in-car tablet-based entertainment for rideshare passengers in the form of video games, applications, film shorts, sports, and news. Vugo pays drivers $100–$200 per month.

(3) Surf (ridewithsurf.com) provides tablet-based entertainment for rideshare passengers that includes videos, podcasts, and live radio. Surf pays drivers $0.35 per four-minute advertisement interaction session.

Rideshare Billboard Advertising

(1) Firefly (fireflyon.com) provides electronic screens that are placed on top of rideshare vehicles and cycle through different geo-targeted advertisements. Firefly pays drivers about $300 per month.

(2) Halo Cars (www.halocars.co) also provides electronic screens that are placed on top of rideshare vehicles and cycle through different geo-targeted advertisements. Halo Cars pays drivers about $400 per month.

Music Promotion

(1) Steereo (steereo.com) creates playlists for drivers with sponsored music from independent artists paying to promote their songs. Steereo pays drivers once they have reached a minimum of $100 in earnings.

Our solution is similar to those of competitors in the market in that it also provides rideshare drivers with a way to supplement their income while driving. However, Adio differs from the competition in several ways that we feel benefit driver-partners, advertiser-partners, and riders. First, our product is purely software-based and thus avoids any hassle that may come with hardware-based solutions, such as billboards. Second, our product delivers advertisements in between music chosen by our driver-partners, allowing for a higher level of personalization. Finally, our product is particularly useful for smaller businesses who typically do not get the exposure that larger companies receive and for those who it is not practical to advertise via traditional radio. This is because our audio advertisements are cost-effective due to their geographic targeting and advertisement campaigns are able to be easily produced and monitored.

3 Technical Approach

Our web application is developed with JavaScript, Node.js, EJS, HTML, and CSS. It uses Amazon DynamoDB and Amazon S3 for storage and Amazon Elastic Beanstalk for hosting. Our mobile application is developed with React Native and Expo and uses AWS Amplify, Amazon Cognito, Amazon DynamoDB, and Amazon S3 for secure communication with our databases, authentication, and storage. Both platforms use several relevant APIs, such as the Google Maps API, to enhance user experience and functionality.

3.1 Web Application

The web application uses Amazon S3 to store the actual audio files submitted by our advertiser-partners. We also utilize Amazon DynamoDB to store all advertiser-partner account information and advertisement campaign information, such as advertisement metadata and geographic bounds. This separation is useful for quick retrieval of information and data about advertisements without needing to retrieve actual advertisement files. The server side of the web application is built using Node.js and the ExpressJS framework to create a reliable, scalable, and simple back-end for the advertiser-partner interface. Finally, the client side of the application is built using EJS, which allows us to dynamically generate HTML markup using JavaScript. We also utilized secure hashing algorithms and the Google Maps API to provide a very secure and seamless experience for advertiser-partners. The web application is currently hosted on Amazon Elastic Beanstalk and can be viewed at `http://adio.us-east-1.elasticbeanstalk.com/`.

When advertiser-partners visit our site, they first view the home page, in which they can sign in or sign up with their email, company name, and a password. Our platform uses a SHA-512 hashing scheme with a randomized salt to store – when an account is created – and verify – during sign in – advertiser-partner passwords on the back-end. Once logged in, they will see their account page, which displays all of the advertisement campaigns they have submitted with all relevant details. This

page is dynamically rendered using EJS on the front-end and pulls advertisement metadata from DynamoDB to ensure quick load time. Advertiser-partners have the ability to edit their campaigns and change the geographic reach of their advertisements, campaign name, and description; they can also upload new advertisements to an existing campaign as well as delete advertisements from a campaign. When this is done, we make sure to delete the metadata stored in DynamoDB as well as the actual audio file in S3. If advertiser-partners want to submit a new campaign, they can navigate to the "Submit my Ads" page, where they can provide a campaign name, latitude and longitude coordinates, description, and audio file(s). We used the Google Maps API to render a map that allows users to visualize and select their targeted geographic reach by denoting the selected region with a draggable and resizable box. The minimum and maximum latitude and longitude coordinates will then be auto-generated as the bounds for the advertisement(s). Upon submission, the files will be uploaded to our S3 bucket and the advertisement metadata will be written to our DynamoDB table.

3.2 Mobile Application

Our mobile application was made with our driver-partners kept in mind. We first began developing an iOS application using Swift but we quickly switched to building a React Native application instead for a number of reasons. A core requirement of ours was that the application should be able to handle high user traffic and be usable by as many drivers as possible. Building the application with React Native using Expo gave us the option to launch simultaneously on both iOS and Android devices, the two major operating systems used by 99.8% of cellular devices in America[1]. We also ensured that React Native allows us to run our application in the background since most rideshare drivers use other applications in the foreground while driving. Most of all, React Native's modular architecture and large user community allowed us to use many external libraries easily, improving the functionality and quality of the application.

Amongst the many external libraries we used is Amazon Cognito. Cognito issues each user temporary, limited-privilege credentials at the start of their session and allows the ability to create user pools to ensure only authenticated users get access to specified data. This level of security was of the utmost importance since we store information about earnings and usage history. Once logged in, the primary functionality provided by the application allows the driver-partner to start Adio and automatically play advertisements between their music. To connect to our databases, we used Amazon Amplify. The use of Amplify provided us with an easy-to-use development platform that ensures a secure connection to our databases and lossless fetching of advertisement information and metadata.

At the core of Adio is its advertisement-fetching algorithm. This is the logic behind the primary value Adio provides to our advertiser-partners and riders. Advertisements are fetched based solely on the GPS location of the mobile device the driver-partner is using and the mobile application asks the driver-partner for access to this location data prior to the driver-partner's first session driving with Adio. It is important to note that no driver-partner or rider demographics are used as an input to the algorithm. Once the current location of the ride is obtained, we use GraphQL to query advertisements whose geographic bounds contain the current location of the ride. To improve the speed and efficiency of this query, we created a secondary index for our DynamoDB table, which stores metadata about the minimum and maximum latitude and longitude coordinates for each advertisement. Once our application fetches a pool of advertisements that can be played at the current location, the algorithm caches the metadata for these advertisements. When it is time to play an advertisement, the algorithm will queue from the cached advertisements for quick playback. Before advertisement playback, an additional check is made to ensure that the device's current location still remains within the advertisement's geographic region. This improvement to the algorithm allows us to guarantee to our advertiser-partners that any advertisement played by Adio has been targeted to the device's current location. Furthermore, to provide quick advertisement fetching and processing, the algorithm first only fetches metadata about advertisements from DynamoDB; the advertisement audio file is only fetched from the Amazon S3 bucket after it has been confirmed to be played. This algorithm proves to be

efficient and accurate while also protecting all of our stakeholders and maximizing the value of Adio.

Our mobile application also implements an impression logging system to track the usage of Adio and performance of advertisement campaigns. After an advertisement finishes playing through the mobile application, an entry is added using GraphQL to a separate DynamoDB logging table that stores the dates and number of impressions for each advertisement and all driver-partners every day. Additionally, we update the DynamoDB table containing advertisement metadata to update the number of impressions for the particular advertisement that was played. This logging system allows us to display in real time the number of impressions for each advertisement in our advertiser-partners' web application dashboard and provide insights into driver-partner earnings over time in our mobile application dashboard.

The final technical component of the Adio mobile application is the user interface. When creating the user interface, the goal was to make it simple but functional, especially since driver-partner interactions with the application are inherently limited due to them driving during the majority of their use of Adio. To accomplish this, we created three pages in the application: the home page, the profile page, and the settings page. The home page simply shows an intuitive "play" button that begins the use of Adio, along with volume and advertisement frequency sliders that allows the driver-partner to control the volume of advertisements and how many minutes they would like in between advertisements. If driver-partners pickup a rider who prefers music without advertisements, they can also easily stop the use of Adio with the "pause" button and begin again at any time they wish. The profile page allows the driver-partner to view information like their email, total earnings to date, and daily earnings over a specified number of days. The application uses APIs like React Native Chart Kit to provide a clean and functional visual representation of their earning history. Finally, the settings page allows the driver-partner to also control advertisement playback settings and enable night mode, which changes the entire mobile application user interface to a darker color scheme, making the application more conducive to safe nighttime driving. APIs like Stack Navigator and Switch Selector were used to implement these features.

3.3 Code Repository

Additional low-level details of our work can be seen in our code repository on GitHub, linked here: https://github.com/sneharampalli/Adio.

4 Evaluation

4.1 Manual Testing for Correctness and Security

To evaluate the correctness of the functionality in our web and mobile applications, we conducted manual testing through simulations of the applications. For the web application, we hosted the website locally and for the mobile application, we used the Expo phone simulator.

For the web application, we tested that a user can submit, delete, and modify advertisements and that these changes get stored and properly updated in the Amazon Web Services back-end. We tested uploading audio files of various lengths, sizes, and types. This also involved ensuring that users can input a location for an advertisement campaign and that these coordinates are stored in our database. We performed manual testing of the database upload process by uploading ten dummy advertisements each for fifteen dummy companies and then inspecting our database for the correct *(advertisement, company, location)* triplets. We saw 0 errors in the triplets over these 150 uploads.

For the mobile application, we ensured that the geographically-targeted advertisements are played in their selected locations by electronically spoofing different GPS locations in the phone simulator and checking that geographically correct audio files from the aforementioned 150 advertisements were selected and played by our algorithm. We also ensured that updated audio files are correctly pulled from the database as changes are made via the web application. In addition, we manually ensured that playing and pausing yields the desired behavior while an advertisement is playing, while background music is playing, and when play or pause is clicked multiple times by the user (with fifteen test runs per scenario). Moreover, we determined that the frequency settings achieve their desired behavior by measuring the number of advertisements played across certain time periods and comparing the long term averages with our

desired benchmarks (all of them successfully aligned for target frequencies of one, three, five, and ten minutes). For advertisement playback, we checked that background music is correctly ducked while an advertisement is playing and the application works with multiple music sources (Spotify, Apple Music, locally downloaded music, etc.). We also tested that the driver-partner dashboard displays the correct earning history for the past seven, thirty, and 365 days based on impressions logged in our database and ensured that faulty numbers (negative earnings, earnings with excess decimal places, etc.) are never shown.

For both the web application and mobile application, we rigorously tested account sign in and sign up. Specifically, for the web application, we tested security against invalid account creation by attempting to sign up twenty fake accounts with malicious usernames (such as cross-site scripting usernames with the intent of manipulating the website) or duplicate accounts (with the same email address as a currently registered user); all account creations were rejected in these cases. We also tested that account creation did not occur with invalid inputs (such as if the email is not a valid email address, the password does not meet security standards, there are empty fields, or the two-factor authentication code incorrect) with five dummy accounts per each scenario. For both platforms, we tested that faulty or unregistered accounts are not able to use our service and that correct accounts are always able to sign in by testing with ten dummy accounts that had sign in credentials similar to those already stored in our database.

4.2 Automated Testing and Simulations

We ran several automated tests so that we could draw conclusions from a larger pool of test cases. We first ran penetration tests on the sign in components of both our web and mobile applications, using mock route handlers for the former and JavaScript to automate entry and submission of the sign in form for the latter. We attempted to breach our system using sign in credentials that were slight variations of credentials already registered with Adio. We also ran these same tests using malicious usernames, as mentioned above with our manual testing. Doing so (across ~ 5000 test cases) allowed us to see that none of these faulty username and password combinations were validated, instilling 100% confidence in our sign in systems.

We also ran automated tests to simulate high user traffic for both the uploading of advertisements through our web interface and the retrieval of advertisements through our mobile interface in order to see if high user traffic would hurt our upload or retrieval times and if information would not be stored properly. For both, we ran tests that featured hundreds of simultaneous uploads and retrievals. Ultimately, we found that the upload and retrieval times under high load were very similar to what we had discovered during manual testing with much lower demand, as the manual testing averages of 8.27 seconds and 2.294 seconds lined up with our automated testing averages of 8.52 seconds and 2.45 seconds. These new times were within the 10% bound we set as a benchmark. Furthermore, all data was correctly uploaded, ensuring zero loss of data, as we had hoped.

4.3 Speed of Database Queries

One of the main empirical metrics we used to evaluate our application is the time required for uploading and retrieving items from our databases. A very slow runtime would lead to a poor user experience and may also invalidate the advertisements that are fetched from the database if the device moves outside of the advertisement's target region in that time.

For our Amazon DynamoDB database, the minimum latency for processing requests is 12.6 ms and the maximum is 20 ms. The average latency is 16.8 ms. These runtimes are very quick as they are simply retrieving user sign in information from an optimized database system. For our Amazon S3 database that stores audio files, see Table 1 below, which contains timing information for advertisement uploads and retrievals. We want to especially take note of the retrieval times, as these must be optimized to play in real time as driver-partners use Adio. We determined that these upload and retrieval times were sufficient for our intended user experience, as advertiser-partners would be willing to wait about 8 seconds for their advertisement campaign to be created and an average retrieval time below 3 seconds should not affect a driver-partner's advertisement playback experience, given that advertisements are played once every few min-

utes.

	Upload Time	Retrieval Time
Min (s)	6.461	1.333
Max (s)	9.673	3.268
Average (s)	8.2736	2.294

Table 1: Table 1. Minimum, maximum, and average times (in seconds) to upload and retrieve audio files from our Amazon S3 database.

4.4 Accuracy of Advertisement Retrieval Algorithm

A key component of our product is the advertisement retrieval algorithm. With an inaccurate algorithm, advertisements would not be played at the correct times and advertiser-partners would not see the full benefit of our location-based advertisement platform.

To evaluate accuracy of our algorithm, we define false positives to be instances in which advertisements that should not have been retrieved (because they are not targeted towards the current GPS location) were retrieved and played. We define false negatives to be instances in which an advertisement should have been retrieved and was not. On our first iteration of the advertisement retrieval algorithm, we found a small number of false positives. This was because we were retrieving and caching advertisements too early from our DynamoDB database in an attempt to improve the efficiency of our algorithm. We found that this caused advertisements that had been cached very early and were no longer targeted towards the current location to still be played. However, we updated our algorithm to include an additional check for validity directly before an advertisement is played. This reduced our false positive rate to 0%. We also had a 0% false negative rate due to the accuracy of our GraphQL query. Thus, advertiser-partners can be confident that their advertisements will always play in the targeted regions and riders will benefit from always hearing advertisements relevant to their current location.

4.5 Qualitative Evaluation Metrics

In addition to our empirical evaluation metrics, we performed some qualitative evaluation to ensure that our application is intuitive and our product is useful. We conducted user-centered testing of the user interfaces of our mobile and web applications and found that the experience was seamless and intuitive. We also conducted a survey of about fifty West Philadelphia rideshare riders aged 18 to 26 and asked them how they felt about audio & radio advertisements in rideshare. In particular, we asked whether such advertisements have the potential to impact how they rate drivers. We found that 80% of riders indicated little to no aversion to audio advertisements and 100% of responses indicated no potential detriment to driver ratings. We do note here that our survey subjects were from a similar age group and the scope of the survey was limited. Future surveys were planned to broaden the demographics of our respondents but they had to be placed on hold due to the COVID-19 quarantine.

We also held interviews with West Philadelphia rideshare drivers and potential advertisers to gauge their interest in an application like Adio. We asked drivers, who ranged from ages 22-64, questions regarding interest in additional, passive income and found that there was an overwhelming positive response. Similarly, we asked potential local advertisers how much they believed they would benefit from location-based audio advertising and discovered that they also had a good amount of curiosity and interest.

We initially planned to quantitatively evaluate advertiser-partner satisfaction with our application after the launch of our pilot but this was not be possible due to the COVID-19 quarantine and other time restrictions. In the future, we plan to launch a pilot by giving local, small businesses free Adio advertisement credits to create audio advertisements on our platform. We would also have specific promotion codes mentioned in these advertisements so that businesses could measure how many customers were redeeming these codes and provide both themselves and us with metrics on the effectiveness of Adio. Comparing these numbers to the number of impressions for each advertisement, we would be able to quantitatively show advertiser-partners the value of our service. We also planned to implement a rider feedback system, through which driver-partners would place a small feedback card in the backseat of their vehicle encouraging riders to complete a quick survey regarding their experience during the ride, especially with regard to the relevance of the audio advertisements that were

played. This would give us more quantitative feedback regarding the benefit of Adio to our riders and the impact of Adio on the overall rideshare experience. We could also use this pilot program to conduct A/B testing to improve our UI in both the web and mobile applications.

5 Societal Impact

5.1 System Security and Data Collection

Our web application uses a SHA-512 hashing scheme with a randomized salt to store and verify advertiser-partner passwords on the back-end. Additionally, our use of Amazon Web Services, specifically S3 and DynamoDB, guarantees scalability, robustness, and security. For the mobile application, we have created a two-factor sign up protocol using Amazon Amplify and Cognito for exceptional security. When users create an account, they will receive a confirmation code in their email to verify their account and will be asked to verify their mobile phone number. Using the Amazon Amplify framework, we are also able to securely communicate with our databases, fetch advertisements on-demand, and record impressions. Using Amazon Web Services helps ensure driver-partner data is secure and cannot be manipulated.

5.2 Positive Societal Impact

Adio benefits advertisers, rideshare passengers, and rideshare drivers, as discussed above in our Value Proposition. In addition, to prevent monopolization of our platform by larger companies, we plan to play advertisements from campaigns of all sizes at equal frequencies so as to not discriminate. For example, if we have multiple advertisements targeted to the current GPS location, then we will choose one that has fewer advertisement impressions and ensure that all advertisements reach their targeted number of impressions over time.

5.3 Privacy Risks

Adio was designed to provide minimal privacy risk to its stakeholders. We recognize that we are advertising to riders in rideshare vehicles based on the location of their ride (which is the only audience-specific datapoint that we collect). This could be seen as a privacy risk as the advertising is location-based. However, unlike modern advertising methods used by websites, social media, and even music streaming services, such as Spotify and Pandora, Adio does not capture any personal information about consumers. Rather than seeking to understand consumer preferences by tracking their personal data, we look to market to consumers in the target locations of businesses, with the hypothesis that location-based targeting based on the specific, traveling, and live locations of consumers will provide high-value advertising opportunities. Furthermore, location-based advertising itself is not novel. We see it daily in varying levels with billboards, radio advertisements, and the other mediums mentioned above that also utilize many other forms of personal information as well. In this manner, we seek to minimize the privacy risk to riders.

In order to provide this unique passive income opportunity to our driver-partners, we must periodically request their location and monitor audio levels, driving habits, and the number of advertisements played. However, we look to minimize the amount of data monitored and stored to only what is absolutely necessary in order to ensure that driver-partners are compensated fairly and that we can avoid manipulation of our platform. For advertiser-partners, we ask for information related to the advertisement campaigns they wish to create and provide information to them about the number and costs of their advertisement impressions. This allows us to create value for them and charge them fairly. Of course, driver-partners and advertiser-partners can always opt into and out of partnership with Adio.

5.4 Vulnerable Groups and Long-term Unintended Consequences from System Adoption

Based on the detailed privacy risks above, we do not find that there are any significant vulnerable groups with regard to Adio. This is firstly because driver-partners and advertiser-partners choose to opt into a partnership with Adio. In addition, we do not store any information about consumers and only use the location of the ride to play geographically relevant advertisements, which is far less intrusive and involves far less data collection that other modern forms of advertisement. Note that we also look to provide value to consumers by informing them of opportunities in their vicinity.

While we do not believe that there are any groups being negatively impacted or marginalized as a

result of Adio and that we are empowering and creating value for all of our stakeholders, there may be certain aspects of Adio that impact our stakeholders in unintended ways. One unintended consequence from adopting this system could be that driver-partners' ratings could decrease, as the rider experience may reduce in quality with interspersed advertisements. However, echoing what is discussed in our Evaluation section, 80% of riders indicated little to no aversion to audio advertisements. More importantly, 100% of responses indicated no potential detriment to driver-partners' ratings.

5.5 Cybersecurity Risk

For our web application, in order to ensure advertiser-partners are logged in before submitting advertisements and viewing their accounts, we used a secure account management and creation system. In terms of storing their passwords, we used a SHA-512 hashing scheme with a random salt to prevent hackers from accessing passwords. In terms of storage of advertiser-partner data, such as their advertisement audio files and metadata about the advertisement, we used Amazon Web Services, specifically S3 and DynamoDB. As one of the most secure data storage management systems, Amazon Web Services allowed us to secure the audio files we are storing in S3 as well as the metadata we store about the advertisements in DynamoDB.

For our mobile application, we use Amazon Amplify to handle authentication and retrieval of advertisements from S3 and DynamoDB. Firstly, we created a two-factor sign up protocol. When users create an account, they will receive a confirmation code to their email to verify their account and will be asked to verify their mobile phone number. Additionally, to perform our queries to fetch advertisements based on the current location of the ride, we perform queries using GraphQL Transform. We carefully defined our data schema and requests to ensure that malicious code cannot be injected into our queries.

5.6 Manipulation and Deception

Several advisors have raised concerns regarding improper use of Adio by driver-partners. For example, driver-partners could leave Adio on even if they are not on a ride, meaning that they could collect payment for advertisements not being heard by any riders. To combat this, as a first measure, we plan on ensuring the vehicle is moving before broadcasting any advertisement. As a more complete check, we plan to integrate with the Uber and Lyft Driver APIs, to ensure the driver-partner is currently on a ride when broadcasting advertisements. Another concern that was raised was that advertisements may be muted or not played at an audible level. To combat this, we will monitor the audio level of advertisements in the vehicle using the driver-partner's phone's microphone only when an advertisement is being played. Only if an advertisement is played above a certain threshold volume will the driver-partner receive payment. We would like to note that we only plan to use microphone data to monitor advertisement volume to ensure proper usage, without recording the sound data or storing any additional audio information in our databases. Finally, we plan to protect against improper usage of Adio by advertiser-partners by reviewing each advertisement manually to ensure all advertisements are appropriate and of high-quality. Eventually, we could transcribe advertisements and use machine learning methods to identify negative or offensive advertisement content, rather than only manually reviewing them. This could be done by comparing transcriptions to a official corpus of offensive words and checking for the appearance of offensive words as well as general syntax that may be inappropriate. If an advertisement is flagged via this process, it would be sent to us so that we could conduct a manual review.

6 Cost and Revenue Model

We plan to begin with a $40 per 1000 impressions charge for advertisement campaigns. While the cost of an average radio advertisement is around $12-$16 for 1000 impressions, we hypothesize that the value of each Adio advertisement will be far greater than that of a traditional radio advertisement, since businesses can broadcast their advertisements through Adio to a specific geographic region. The cost of advertising through this novel medium will be affordable and practical for a larger group of businesses as compared to that of radio advertisements, especially because each impression will be geographically targeted and the total number of impressions can be limited.

Our primary costs include paying driver-partners, database and other technical costs, employee

costs, and marketing costs to reach advertisers. Our driver-partner payment model is based on the number of advertisements broadcasted by the driver-partner each month. As an example, a full-time rideshare driver located in an urban area who partners with us could drive for 20 days a month and earn upwards of $20 a month of passive income at our starting rate for advertiser-partners. This figure will only increase as we continue to adjust our pricing and platform, which currently does not include the second-price auction model, does not take into account that the average Uber or Lyft ride has more than one passenger, and only allows for one advertisement to be played at every set interval. Adjusting for these factors, our ideal target would be to pay our driver-partners up to $50 or more per month. Finally, these transactions (both advertiser-partner to Adio and Adio to driver-partner) will take place via wire transfers, collecting driver-partner and advertiser-partner bank information in a secure manner.

7 Discussion and Lessons Learned

This was an incredibly interesting and fulfilling project to work on and we are truly thankful to finish our time at Penn with such an experience. We believe that we were able to create an effective workflow and stick to it throughout the past several months. Specifically, we identified our key stakeholders and what issues or features might be most important to them. Through quantitative and qualitative research, we were able to maximize Adio's usefulness while ensuring that all stakeholders would be using a platform that guaranteed usability, efficiency, and security. Furthermore, by repeatedly iterating on previous versions of our product and incorporating feedback from class used to narrow and strengthen the scope of our work, we have built a product that is both seamless and robust. Adio provides a service that allows rideshare riders to learn more about opportunities around them, rideshare drivers to earn a passive income in addition to their current earnings, and advertisers, especially small businesses, to have their messages heard in a geographically-targeted and sophisticated manner.

The biggest challenge we faced in the development of Adio was the transition from iOS to React Native. Because we had run into issues with playing audio in our original iOS application (due to a bug in iOS13 that prevented connection to the Spotify API), we decided to re-build and improve the application in React Native, which also gave us the additional benefits of compatibility with Android and flexibility with APIs used. In addition to familiarizing ourselves with an entirely new application framework, this pivot involved completely restyling our mobile application and developing a new approach to storing our data. After overcoming these technical challenges and transitioning to React Native, we were able to create a mobile application that was even more intuitive, secure, and cross-platform than before.

Continuing our work would first involve more in-depth feedback from users regarding their experiences. Specifically, we would quantitatively evaluate advertiser-partner satisfaction with a pilot launch that gauges customer conversion rates. Similarly, to measure the effectiveness of Adio compared to other mediums through which customers are sourced, we would like to model customer lifetime values for customers acquired through Adio and determine what types of companies could benefit more from Adio and strengthen our value for them.

Additionally, future work would focus on application integrity, integration, and maximization of advertisement value. Specifically, as mentioned earlier, we want to ensure fraud is prevented at scale by integrating with the Uber and Lyft Driver APIs to verify driver-partner identities, ensure that driver-partners are on a ride before playing advertisements, and use the microphone to safely ensure that advertisements are audible. We also want to integrate with different APIs provided by music services to play advertisements in between songs rather than ducking. Finally, our ultimate goal would be to develop a second-price auction format similar to that of Google AdWords to allow for maximized advertisement value in high-demand geographic regions.

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