Several years ago, the digital matatus team helped put Nairobi’s complex and dynamic matatu system on a map, improving navigation and accessibility of the system. However, we have received feedback that some of the routes have changed since route data was last collected. In order for navigation data to be useful, it must be up-to-date and reliable. The goal of the project is to crowdsource updates by tapping into the expertise of riders, driver, and others who use the system everyday. MA3TYCOON is a prototype app developed by three MIT graduate students in collaboration with ma3route, Kenya’s go-to source for traffic and commuting information.
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Like many developing cities, Nairobi, Kenya is connected by a semi-formal network of buses and minibuses run by hundreds of different operators. There are roughly 15,000 buses, or *matatus* as they are known locally, running the 100 routes that serve the city’s 3.3 million residents. While legislation in the last decade has begun to regulate these vehicles, there is not a single entity responsible for network planning and information provision. It wasn’t until 2012-2013 when a team of researchers from the University of Nairobi, MIT, and Columbia University embarked on an effort to formally collect digital route and stop information through the use of mobile phones. In 2014, this effort culminated in the development of 1) a stylized map depicting the complex network and 2) transit data in the standard GTFS format. The second outcome was particularly significant as it allowed for use of *matatu* data in trip routing software such as Google Maps and Open Trip Planner and has improved the navigation and accessibility of the system.

Despite the lack of a central administrator, the system is highly responsive. *Matatu* drivers fluctuate their fares throughout the day as a response to factors like demand to maximize their profits and are able to do this synchronously. Drivers and vehicle owners will also provide different amenities in an effort to develop and maintain a loyal client base. Thus not surprisingly, the digital matatus team has received feedback that some of the routes and stops have changed since data was last collected prompting a need to update this data.

In the Spring of 2016, a team of MIT urban planning students, working in collaboration with ma3route, Kenya’s go-to-source for traffic and commuting information, set out to develop an app to tap into the expertise of ma3route’s 500k+ users. After 16 weeks of research including two trips to Nairobi, learning multiple programming languages, presentations, and focus groups, we have created MA3TYCOON.
Crowdsourcing involves obtaining information, services, or ideas, from a large group of people, typically ordinary citizens rather than from employees. In the realm of information gathering, the separate contributions from a vast number of citizens create a significantly more comprehensive and fine-grained understanding of the problem. In particular, crowdsourcing has been used extensively and very successfully in mapping. From Open Street Maps to mapping areas of need during crises, people on the ground are intimately familiar with the area and possess an unrivaled amount of expertise.

In the case of mapping the matatu network, crowdsourcing this information makes sense. The matatu network is large and complex and it is responsive to changes to demand. Not surprisingly then, routes and stops will also change over time as drivers and matatus seek to meet passengers’ needs and maximize their profits. For a single entity to manage these changes over time can be overwhelming but there is also no need to obtain this information in a top-down way. Nearly half of the city’s population take a matatu every day and no one is more familiar with the routes then those who make that commute day after day.

ma3route, the client of this project, is a mobile/web/SMS platform for traffic and commuting information in Kenya and the principle way it obtains this information is through crowdsourcing. ma3route (pronounced “ma”, “3” as in the number, “route”) is a Sheng (a mixed language consisting mainly of Swahili and English) word for matatu as 3 in Swahili is “tatu”. ma3route filters and aggregates tweets about local road conditions, providing real-time transport information that did not previously exist. Recently, it integrated Google Maps route planning functionality and has over half a million users and continues to grow. We want to capitalize on their users’ wealth of expertise and provide a new way for them to engage with ma3route and perhaps have fun in the process.

Not surprisingly, traditional approaches to mapping involve GPS on mobile devices. Through focus groups and discussions with stakeholders, we learned that Kenyans are wary of turning on GPS on their phones due to privacy and battery concerns and a belief that it incurs data usage thus we wanted to avoid GPS if possible. Additionally, we wanted to reduce the effort and barriers to participation. How can we make it very simple for someone to tell us where stops and routes are wrong, in a way that is bite-sized and immediately gratifying?

We quickly thought of trivia games, like QuizUp, Trivia Crack, and BrainWars, that are fast-paced, competitive, and addictive, and encourage multiple, short sessions of gameplay throughout the day. Through this model, we created a web-based app called MA3TYCOON.
The Solution

**MA3TYCOON** is a rapid-fire trivia game that consists of a mix of matatu route questions and local Kenyan trivia questions. The goal is to earn MA3TOKENS, increase one’s ranking within the matatu hierarchy (crew driver, tout, full-time driver, matatu owner, sacco president), and build up their matatu tycoon (MA3TYCOON). Without having to download an app or go through a burdensome registration process, users can simply visit the webpage via their phones or computers and begin playing.

1. Users select the routes with which they are familiar.
2. Users can challenge their friends to a match or play against a random player. Each match consists of 10 questions, featuring a 70/30 mix of matatu route questions and random trivia questions. Route questions will ask if a set of 4 consecutive stops on a selected route is correct and users can answer yes, no, or skip. Random trivia questions will be multiple choice-based.
3. Each correct response to random trivia questions is worth 10 points, any response to the matatu questions is also worth 10 points. Users receive 2 tokens for each round they win and users can see their ranking relative to that of their friends and all other users.
4. After a critical number of users have answered a particular route question, users that have answered with the majority of other users (e.g., they are among the 75% of users who selected “yes” on that route question), then they will receive a bonus of 5 tokens.
The Solution

Additionally, users can also cash in their tokens to redeem credits at local partner retailers. To develop a core user group, we recommend offering more incentives at initial launch and creating weekly opportunities for users to win more prizes. For example, we can offer prizes for the 1000th user who joins or randomly select a winner from players who have logged-on and played that week. Such opportunities will encourage users to play regularly.
Benefits to ma3route

The primary outcome will be a heatmap highlighting routes or portions of routes that are inaccurately mapped. With such a map, we can deploy staff only to problematic portions for remapping, eliminating the need to remap the entire system and enabling digital matatus to efficiently (in terms of cost, time, and effort) bring the GTFS data up to date. In turn, the navigation data provided through ma3route’s app will be accurate, reaffirming ma3route’s reputation as the go-to provider of transport information.
Benefits to ma3route

Add value to the client’s existing app. Our app, as an extension of ma3route’s role as an aggregator of crowdsourced transport information, can be integrated into the existing app as a function in their menu. An interactive feature such as MA3TYCOON will increase the time a user spends on ma3route, which can translate to an increase in advertising revenue.

Expand the client’s userbase. Humans are competitive beings and currently, no other app exists that allow Kenyans to compete with other Kenyans on local trivia and matatu trivia. Individuals who do not currently use ma3route as they do not find the information relevant, may join as they are interested in the new feature or as a result of a recommendation from a friend. The incentives of retailer credits will also lure in more users.
**Benefits to ma3route**

**Increase advertising revenue.** MA3TYCOON creates the opportunity for user-specific advertising through the user route selection process. From a user’s routes we can infer places of live, work, and play without the use of GPS, and display advertisements that are relevant only to those specific neighborhoods. User-specific advertising can increase the effectiveness of advertising and efficiency of advertisers’ budgets. Both of which will increase the number of companies that will want to advertise through ma3route.

**Establish a model** for the future collection/verification of civic information. Matatu route information is only one possibility for MA3TYCOON. Using the same model, the client can verify or collect a variety of key public information, including locations of health centers, translations, and accuracy of street signs to name a few examples. This creates more opportunities for ma3route to partner with public agencies and nonprofit organizations.
Prototype

The decision to develop a web-based app as the prototype was intentional. The ultimate goal was a feature that can be fully integrated with ma3route’s existing mobile-based app thus we did not want to create a separate mobile-based app. A web-based app is also practical for testing purposes as it reduces the barriers to entry. Users do not have to go through the steps of downloading the app which can significantly impede uptake. A web-based app on the other hand, can be accessed on all devices and users can quickly begin using the app through their browsers.
Prototype

In this prototype, we have built the core function of the full concept - the route segments verification, including the development of the route question database, randomizing route segments, routes registration for users, storage of user inputs, and visualization of user’s responses. The screenshots on the right illustrate how the prototype works. The prototype is live and can be accessed via [http://ma3tycoon.webfactional.com/](http://ma3tycoon.webfactional.com/).

1) Home page of the project. It describes the goals, the full concept of the game, the business strategy, the client, and the project team.

2) The log-in module of the game. Individuals can either enter the game as a guest (one-time player) or log-in with a chosen username. Players who enter through their username can track their responses from previous visits in the results map.

3) The route selection module of the game page. Players are asked to choose three routes they are most familiar with by typing the route short name (e.g., 11A). The subsequent questions will be based on their selections. The text box has a autocomplete function. Players can also pick random routes to explore new areas. By clicking on the Twitter icon, people can share our app with their friends.
4) Route verification module of the game page. Randomly selected route segments are shown on the map. The player can choose “yes”, “no”, or “skip” to verify the accuracy of the segments.

5) Each round contains three questions and this is the second question of the round. The player can click on the stop to get more detailed information (e.g., stop name, route direction, etc).

6) After one round of the game, the game end module will appear, showing responses from other users as well as the player’s contributions. The module also summarizes the total submissions of the player. The player can opt to play another round or select different routes to play.

7) People can also directly access the results map through the menu.
Prototype

The web-app is also compatible with mobile phone and tablet browsers. Depending on the browser of the device, some of the styling may display differently.
Technology in The Prototype: Project Structure
Technology in The Prototype: Project Structure

We use a combination of HTML/CSS/JavaScript/SQL/Bootstrap for programming and styling and CartoDB for database storage and mapping. This project has three web pages: home page (description of the app, the client and the team), game page (the interactive element for matatu route verification), and the results page (matatu network heatmap showing all users’ inputs and the player’s contributions). On the game page, different modules display on a trigger while others remain hidden. When the player enters the page, a log-in module appears first. S/he is asked to log-in either with a username or play as a guest. If the player chooses to play as a guest, a temporary timestamp will be generated as his/her username. After log-in, the log-in module is hidden and the routes selection module appears. The player will choose three routes s/he is most familiar with. Then the app will search the database to find those routes, randomly select a route segment consisting of four consecutive stops on those selected routes, and return the properly centered and zoomed map with the route segment on the screen to the player. This is the route verification module. The player can select “yes”, “no”, or “skip” to verify the segment. When the player submits the answer, one entry consisting of the player’s username, feedback (e.g., “yes”), time elapsed, and other basic information will be sent to the user feedback table in the database. The submission will also trigger a new random route segment and updates the map. After each round of three questions, a game end module appears. The module has the result map, feedback summary, and the options of playing the game again as well as re-selecting routes. The feedback summary is determined based on the count of each feedback type this player has submitted to the user feedback table in the database. If the player clicks on those options, the corresponding module will appear and other modules will become hidden.

The results map on the results page and game end module of the game page are programmed in a similar way. JavaScript will call the CartoDB database to show all the routes, all segment buffers with players’ feedback, and the segments this particular player has verified. The colors range from green to orange and shows the percentage of all players who submitted “yes” answers for the segment (buffer). The routes and segment buffer location data are pre-set tables in CartoDB. The accuracy is calculated based on the user feedback table in CartoDB. The historical contributions of this player also come from the user feedback table queried by SQL.
Technology in The Prototype: Backend Database

Original route info

routes
- Matatu routes
  - Route_id
  - Route_short_name
  - The_geom
  - ...

stops
- Stop_routes2
  - Stop_id
  - Stop_lat
  - Stop_lon
  - ...
  - Route_id
  - Route_short_name
  - ...
  - groups

Stop groups
- Stop_group_1d
  - groups
  - Center_lat
  - Center_lon

- Num_stop_1g
  - groups
  - Num_stop

Point layer

Buffer layer

User_feedback2
- username
- groupid
- Feedback_no
- Feedback_yes
- ...

Stop_group_1d_copy
- groups
- Center_lat
- Center_lon

Result map
Technology in The Prototype: Backend Database

We use CartoDB as our back-end database for the prototype. Tables in CartoDB are easier to call and write to than other widely-used databases like PostgreSQL or MySQL. The web app can access the CartoDB database purely through JavaScript, while PostgreSQL and MySQL require Javascript and PHP, a server script language, to do the same. In addition, CartoDB works very well with mapping and spatial visualization, which satisfies our needs in this prototype. However, CartoDB has limitations as well. First, the tables in CartoDB are public if you use a basic account. It means that anyone can access your table if they have your username and table name which is unsafe and even dangerous if you have sensitive information stored in CartoDB. Second, CartoDB is slow in querying a large dataset which may affect loading speed. Therefore, we highly recommend future transfer of this prototype to safer databases or use a premium CartoDB account with private table function, if sensitive information (like passwords) needs to be stored. Our prototype uses a CartoDB basic account given the limited time frame and relatively low number of users' submissions.

The database contains three major parts: original route information, users' verifications, and segment buffers for the results map. The original route information uses the GTFS and GIS data of Nairobi’s matatu system created by digital matatus, which is freely available from their website. The GTFS data consists of tables of routes, trips, stops, stop sequences with identifiers with which to join the tables. The Stop routes2 table is the joined table of stop and route and contains the geographic location of all stops generated in CartoDB. JavaScript can call the location to visualize stop locations on the map. The Matatu routes table is the route shapefile from the GIS data and includes the geometry information of each line, route id, route short name, etc. Stop group 1d and Num stop 1g are generated by our offline programming endeavor. We grouped every four consecutive stops from the same route and labeled each of the ID the “groups” column (i.e. groupid.) We calculated the average latitude and longitude of the four stops, “center_lat” and “center_lon”, for each group. The center location is to determine the center of the map in each game question. The “num_stop” is the number of stops in each group. The total number of stops of many routes are not integer multiple of four, and thus the last group of those routes may contain stops less than four. The “num_stop” will be used to calculate map accuracy.

The table of user’s verification is the User_feedback2 table, which stores information of each submission, including device type (“device” as the column name), feedback type (“feedback_yes”, “feedback_no”, “feedback_skip”), groupid of the route segment (“groupid”), ip address (“ip_add”), loading time (“t_load”) and playing time (“t_round”) of each question, and username.

The segment buffers table (stop group 1d_copy) is generated using the stop group table (stop group 1d). The only difference is the geometry: stop group 1d_copy contains polygons while stop group 1d contains point information. We used a buffer to better visualize the segment range. In the results map, we joined ser_feedback2 and stop group 1d on groupid/groups, and color coded the buffer based on the accuracy or the percentage of all players who submitted “yes” for the segment.
The data points collected by our app continue to grow. Until the day of this writing (May 10, 2016), namely 11 days after the beta release, our app collected 194 responses to route questions, among which 151 are effective answers with either “yes” or “no” responses (the remaining were “skip”). 58 unique users have played our game and each user played 1.11 rounds of the game on average, suggesting that people are interested in our game and want to play it multiple times. Players spent 35.2 seconds on average answering each route segment question. The reasonable time length implies that people put thought into their responses rather than just click mindlessly.

The map on the right displays all users’ inputs. The data points are well-distributed across Nairobi. The map likely does not reflect reality yet, because each segment only has 1-2 responses. However, as time goes by, our app will certainly collect more responses and ultimately result in an informative heat map of matatu route accuracy. The team can then deploy staff to the problematic segments and remap those areas. In that way, we are able to keep update the map efficiently and provide Nairobi residents and visitors accurate travel information.
User Analysis

Launch Plan

We released MA3TYCOON beta on April 29th, 2016 and used a mix of promotion strategies to publicize the app. Marketing strategies included:

1. Email outreach: We sent direct emails to University of Nairobi students and faculty, ma3route and its networks in the tech industry, as well as interested groups we were able to connect with through Twitter interactions.

2. Social media: We shared MA3TYCOON at reddit.com (via the Nairobi subreddit and transit subreddit) and via digital matatus Facebook page.

3. Twitter interactions: We set-up a Twitter account, @MA3TYCOON, for more frequent interactions with potential users. In addition to regular tweets about the app and replies to interested Twitter users, we devised scripts to search for tweets that mention particular keywords (“route”, “matatus”, “ma3route” and the likes) and post new tweets to these users. Ten days after the launch, we were able to connected with keen groups such as @iAfrikan, @MyRideKenya and @BonnieG434.

4. Game design: We used prominent website real estate to emphasize the importance of the project. Additionally, we embedded “Tweet” button at the top of the pay so that players can easily share this game with their networks.
User Analysis

User behavior

The following user behavior analysis was conducted on May 10, 2016, 11 days after beta release, using a sample of 228 total sessions from 154 visitors. The number of visitors significantly exceeded our expectations, as we did not have any funds for marketing and our efforts were restricted to primarily digital means and the networks of the University of Nairobi and our client, ma3route.

Among the 154 visitors, 55 of them were from Kenya, accounting for 35.7%. The ratio has been increasing steadily which was initially 0% on the first day, probably due to our networks and the influence of reddit. However, the ratio quickly rose and remained stable at about 50% since May 3rd, thanks to our outreach to local Kenyan groups as well as increased publicity via Twitter. Notably, in the later phase of the 11-day period, we were also able to attract traffic from South Africa, Uganda, etc.

82 of these visitors used a desktop to access the website, showing desktop is still a preferred choice. 43 visitors used mobile devices, emphasizing the importance of an app that works on multiple platforms.
User Analysis

User behavior

Looking at the sources of these users, direct users from Kenya rank the highest, which are likely from direct email outreach (University of Nairobi students, networks of ma3route and groups like @iAfrikan). This category was followed by reddit referrals and direct traffic from the US, showing the influence of reddit in the US. This was followed by visitors from Twitter referrals, which we expect to continue to grow if Twitter activity is maintained.

The average session duration is 02:25, but the variance is large. This may be because some visitors left the page immediately and some stayed for more than five minutes. We expect the number of drop-offs to decrease if the log-in functions is made more user-friendly.
Survey results

Surveys were distributed to focus group members and available through a “feedback” link at the top of our website. The number of the responses was relatively low compared with the number of site visits, which is not surprising because surveys are understandably less interesting. From a total of 19 responses, we are able to derive the following insights:

1. Most respondents said “not sure” when asked whether the game was fun. This is understandable as the proposed gamification elements were not included in the beta version. We expect these users to be easily swayed once such features are built in the game.

2. Despite the low ratio of users who found the game “fun”, a lot of them would recommend MA3TYCOON to others. This suggests that MA3TYCOON offers additional value beyond the “fun” aspect.

3. Most respondents said that the feature would make them more likely to use ma3route. This is strong evidence to support the inclusion of MA3TYCOON as part of ma3route.
Transfer Plan

Based on the user feedback and user activity during the 10 days of launch, which surpassed all expectations, the app as it currently stands is ready for implementation under the condition that prizes are procured to offer to users as an incentive. We recommend that the client add a link to MA3TYCOON in the menu on the web platform. Additionally, they should integrate a Twitter sign-in feature on MA3TYCOON to facilitate the storage of responses from users, many of whom are already Twitter users. For prizes, we recommend the purchase of $200 in value of credits/gift cards to popular local retailers like Safaricom, Nakumatt, or Jumia. Through the established twitter account, @MA3TYCOON, the client would announce the opportunity for users to help ma3route and digital matatus update the matatu map and win weekly raffle prizes consisting of gift cards worth $25usd or KSH equivalent over a period of four weeks. We expect that within four weeks, the entire matatu network will be verified with a clear heatmap illustrating problematic portions of the map. At which point ma3route should work with students within the Computing and Informatics Department at University of Nairobi to conduct the remapping effort.

In the long term, a developer team should fully develop the MA3TYCOON game as a feature in ma3route’s mobile-based app exclusively which we estimate will take roughly 100 developer hours. The game will be an incentive for users to convert to the app to continue using MA3TYCOON. As the prototype only consisted of matatu route trivia questions, full development would include the proposed game features like creation of a large database of random trivia questions with varying levels of difficulty, real-time challenges with other players, challenges with friends, and the points (tokens) and ranking system. Further enhancements include ability for users to submit their own questions and themed weekly quizzes based on current pop culture. We are confident that this is a worthy investment and will further expand ma3route’s role in crowdsourcing key public information in Kenya and beyond.

As the model of MA3TYCOON is intentionally designed to avoid the use of GPS, the collected data poses minimal risk of misuse. In the case of matatu route verification data for example, the only information collected about a user is the routes he/she selects as part of gameplay. From this, we can only infer the general areas of live and work. This will certainly vary on a case by case basis depending on the type of information being crowdsourced through this model. Thus we do recommend that data management is evaluated at the onset of every new crowdsourcing effort. All data should be securely stored by ma3route and the client should only share the data after all personal identifiers have been removed (i.e., usernames or email addresses).
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