

**Short Paper\***

# **Development of a Tourism Mobile Application Using Linear Search Algorithm Linked to Cloud-based NoSQL Document Database**

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## **Abstract**

*Purpose* – The researchers planned to develop a secure tourism mobile application that acts as a digital guide to help tourists navigate the city. It has features that answer frequently asked questions by tourists while traveling, as well as security features that are required.

*Method* – The JavaScript and React Native framework platforms were used to create the mobile application. The application is designed to protect user information and itself by utilizing Firestore and NoSQL Realtime databases. It is also capable of restricting access to unregistered accounts via Firebase authentication, verifying real users via OTPs, masking critical data via obfuscation, and detecting or blocking devices with an unusual number of requests.

*Results* – The testing results showed that the system was fully functional, with a score of 100% when the major modules were tested. Similarly, after passing all security tests, the application received a 100% system security rating and an average of 4.63 in user-friendliness surveys.

*Conclusion* – The developed system is a fully functional where all necessary functions are met. In terms of system security, the system passed test cases pertaining to malicious access or attacks. The developed system is simple to use, with a user-friendliness rating of 4.63. The identified rating was based on a survey of people in cities surrounding Makati.

*Recommendations* –Some aspects of the project that could be improved is the inclusion of travel planner and weather forecast to provide more control over tour customization, considering interactive and embedded map when doing the route-mapping for a specific accommodation or historical site, and adding a hotline for tourism office without any charges.

*Research Implications* – This application can be cascaded to all Local Government Unit to promote tourism. This application benefits the Tourism Office in the Local Government Unit by providing a new and convenient approach to tourism. As a result, the city's tourist-worthy locations and activities received the exposure and recognition and generated more revenue.

*Keywords* – Tourism Mobile Application, React Native Framework, Firestore, NoSQL Realtime Database, Obfuscation

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## **INTRODUCTION**

Tourism is defined as the movement of people from one location to another in search of enjoyment, relaxation, and recreation. Even before the term "tourist" was coined, this practice of exploration was observed in ancient Greece and Rome, with an emphasis on nature, infrastructure, and other notable destinations (Walton, n.d.).

Tours have a positive impact on people as they provide unique and different life experience that cannot be found in one's home country. Exposure to different people and cultures promotes learning and growth, while straying from stressful situations improves a person's mental and physical health. In a broader context, tourism is critical to achieving social and economic gains. Socially, having tourists empowers locals to discover and be cognizant of other people's behavior and culture. Similarly, cultural preservation through local government and citizen effort is observed; as such, community strengthening through involvement in local events and festivals. Meanwhile, tourism prompts and encourages people to spend money, which has a significant impact on the host country in terms of revenue, development, and opportunities. With many tourists, the host will be able to gain direct contributions from tourism taxes and income, as well as indirect contributions from goods and services purchased by the tourists. Furthermore, this will pave the way for infrastructure and service development on tourist hotspots. Tourism-related service and infrastructure improvements also generate new business and job opportunities (Stainton, 2020).

"It's More Fun in the Philippines" is the tourism slogan of the Philippines, which offers a wide range of enjoyable and fun activities. With a summer-like climate almost all year and being one of the world's largest archipelagic nations, the country is appealing to people who want to experience perpetual summer and crystal-clear waters. Boracay and Palawan are two of the most popular tourist destinations in the Philippines because they have fine white sand, clear water, good accommodations, and an overall enjoyable experience (MAKATI, 2021).

Tourism is increasingly embracing technology, as evidenced by the availability of travel-related mobile applications such as LoungeBuddy, AirHelp, and Airbnb. LoungeBuddy specializes in tourist lodging. After entering information such as a credit card number, airline status, and lounge memberships, it returns a list of lounges. AirHelp, on the other hand, assists individuals in enforcing their passenger rights, assists during delayed or canceled flights, and offers payouts and perks. Airbnb allows tourists to book and rent individual rooms and apartments from locals, which is beneficial for those on a tight budget (Leong, 2021).

Thus, it can be stated that the available travel applications nowadays only focus on a single aspect of travel, such as accommodation, food, or transportation. More specifically, travel and touring applications in Metro Manila are severely limited, with none encompassing all essential aspects of travel on a single app. Having a dedicated application can be beneficial to a city or county tourism because it enables tourists to get to know the city better by compiling the notable spots and locations into a single platform. Considering this, the research and development of a tourism mobile application can be beneficial (Hyun, 2019).

Makati is a city that can accommodate a variety of lifestyles. It can provide modern and urban living while also having historical and cultural sites. With such amenities, the city hopes to highlight its less popular half. Aside from its elegant infrastructures, Makati wishes to highlight its food strips, museums, parks, and churches to boost tourism in the city. As part of its adaptation to the technological world, the local government has launched Makatizen App, a mobile application that delivers critical information such as accidents, floods, fires, and other announcements. Similarly, social media pages and accounts were established for the dissemination of the same information.

## ***Background of the Study***

Makati's mobile app and social media platforms are focused on news and community updates, and the city has determined that this current approach is not necessarily beneficial to Makati tourism as it does not directly cater to tourists. When traveling, most people require places to stay, food and beverages, entertainment such as shopping and sightseeing, and directions. The concern is that Makati lacks a platform to address these needs. While searching the web can be beneficial, it can also be inconvenient, especially

when dealing with multiple tourists' needs. Similarly, it may cause a tourist to have an incomplete experience in Makati because web results frequently feature common locations and activities rather than unique places that the city can also offer. On a different note, cyberattacks are steadily increasing, rising from 61% in 2014 to 86% of organizations worldwide in 2021. Furthermore, high-risk vulnerabilities were discovered in 38% of iOS mobile applications and 43% of Android mobile applications. Given that over 205 billion mobile applications have been downloaded, mobile security is crucial. The city of Makati requires a dedicated and secure tourism application (Leong, 2021)

With this information, the researchers created a secure Android-based tourism application that is linked to a real-time database via the Firebase platform and served as a digital guide to assist tourists in navigating the city. It has features that answer frequently asked questions by tourists when traveling, such as what to see and do, where to shop, where to stay, and where to eat, along with security features such as access restriction, user verification, encryption, and spam protection (Xiaojun Fan, 2022).

## ***Design Objectives and Constraints***

### ***Design Objectives***

The research developed a mobile application that will suggest tourist location or itinerary within the city of Makati using linear search algorithm and geo-mapping. In addition, the mobile application has addressed the following:

1. To develop a highly functional system for addressing the common tourist needs
2. To develop a secured tourism mobile application
3. To develop a user-friendly tourism mobile application

### ***Design Constraints***

Based on the identified needs of Makati City Tourism Office, the system has considered the following:

1. The mobile application must provide a list of suggested tourist locations and activities with the map details of the suggested locations.
2. The mobile application must abide and operate under the implementing rules and regulations of the Tourism Act of 2009 (Republic Act No. 9593) to promote the development of Philippine tourism that is for and by the Filipino people.
3. The mobile application must abide to the Data Privacy Act of 2012 (Republic Act No. 10173) in handling the user's information.
4. The mobile application must list and suggest only legal and registered activities and businesses in the city.

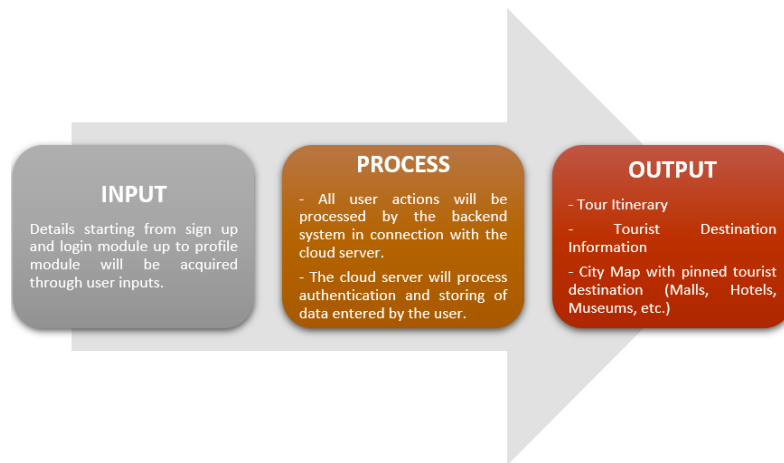


Figure 1. Conceptual Framework

Figure 1 depicts the system's input, process, and output. The system enables users to find the best travel, accommodation, route mapping, and other services in Makati, as well as travel updates, picture galleries, and location information. All these details were determined after the user creates an account and logs on to the app successfully. All user inputs will be handled by the backend system, which will process everything by the cloud server, including application authentication and storage of all data registered by the user in the application. The backend-server connection will send all requests made to the cloud server back to the mobile application. As a result, all user actions will act on their own functions and properly display the required output based on the user's query.

## METHODOLOGY

### *Project Design*

The project concept is a developed mobile application for Android. The mobile application was created using JavaScript and React Native framework platforms. It is an open-source user interface software framework used to create hybrid native Android and iOS applications (A. J. Irawan, 2021). Because the framework allows the same code for deployment in Android and iOS used, the app can easily be expanded. All the functions that were visible from the proposed UI were designed and integrated using React Native (Pedro Palos-Sanchez, 2021).

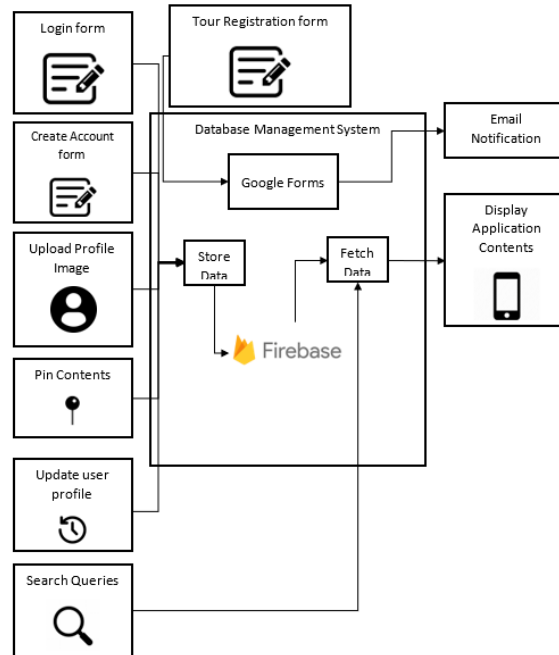


Figure 2. System Block Diagram

Figure 2 depicts the flow of each system function using a block diagram. Login, sign-up, tour registration, uploading of profile, pinning of items, updating of user profile, and search queries are all possible inputs into the system. Inputs are determined by how the user interacts with the device. Meanwhile, all data-requiring inputs were directly stored in their respective packages on the Firebase platform. When you register for a tour, it is saved in the Google Forms database and an automatic registration notification is sent out.

The team also used the software Visual Studio Code in addition to React Native (VS Code). VS code is a code editor that has been redesigned and optimized for building and debugging applications. Developers can modify the code from React Native directly on the VS Code platform in this application. The editor supports IntelliSense and code navigation native to React. IntelliSense is a feature that allows the code to be edited with code completion, parameter information, quick info, and other features. This helps to make code writing more efficient and allows proponents to track what has been done to minimize development errors (Yang, 2021).

The backend system was built using Firebase platform packages. It offers Realtime Database, Cloud Firestore, Firebase Authentication, and Cloud Storage services. Because of its scalability, it can easily be handled by the system as the number of users grows (Rosmansyah, 2021). The Firebase Realtime Database is a NoSQL database hosted in the cloud that allows you to store and sync data between your users in real-time. It comes with mobile SDKs, allowing supporters to create apps without the need for servers. Researchers can also run backend code that responds to database-triggered events (al, 2019).

Cloud Firestore is a NoSQL document database that allows you to easily store, sync, and query data for your mobile devices, and - on a global scale, data structure can be easily done with collections and documents. This allows creation of hierarchies to store related data and easily retrieve it using expressive queries. (Pundir, 2019) Firebase Authentication was used for login and sign up to simplify secure authentication systems while improving end user sign-in and onboarding. Cloud storage is used to support mobile applications store and serve user-generated content such as photos and videos quickly and easily.

## Software Design

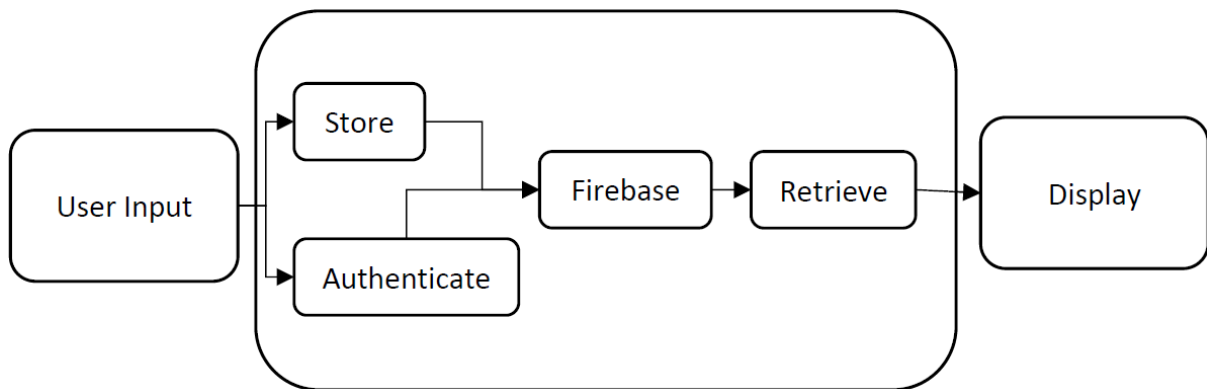


Figure 3. System Block Diagram

Figure 3 depicts the process of the back-end system's block diagram in the application. All interactions that used Firebase services in the end-device were sent to each in accordance with the user inputs. The firebase platform handled everything, including storing and authenticating. All data retrieved from Firebase would simply display or provide information to the user.

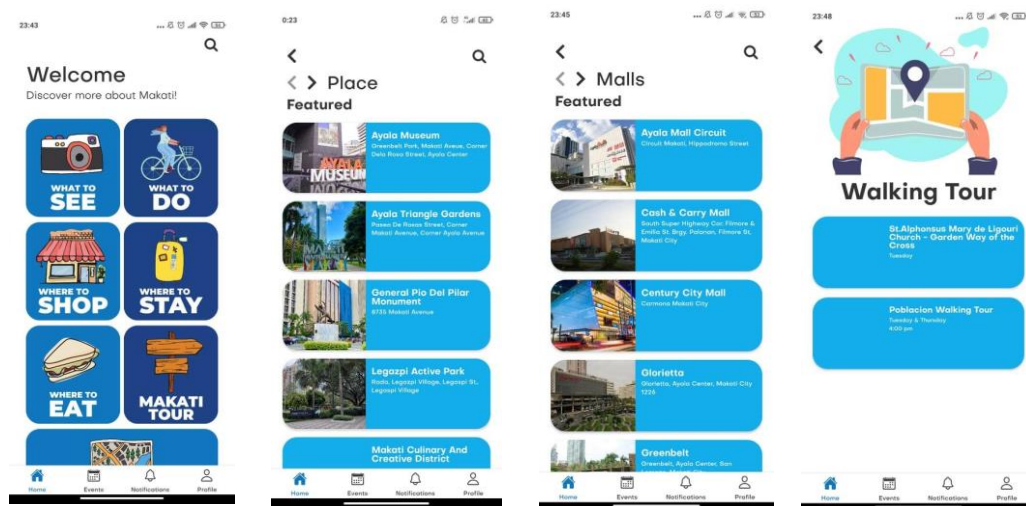


Figure 4. Sample Mobile Graphical User Interface



Figure 4 depicts an example of the developed mobile application's graphical interface. This is the homepage of the mobile application, where the user can choose from seven categories such as what to see, what to do, where to shop, where to stay, where to eat, Makati tour, and the tourist information center. A sample page for the "what to see" category, displaying the various places and landmarks available in Makati City. When a user clicks on an item, it displays a more detailed description and allows the user to pin the location or navigate Google Maps for directions (Adu-Gyamfi, 2020). Another sample GUI for the "where to shop" category, which allows the user to view the various registered malls and shops. Similarly, the landing page for the "walking tour" category, where various walking tours are available. This allows the user to click on an item to see a detailed description of the tour and register for a tour by clicking the "Register using Google Forms" button or scanning a QR code.

## **Mathematical Models – Search Query Function**

### **Linear Search**

The application has a search function, which means that all the places in the database are queried to see if their names or descriptions contain the string that the user has typed, and if so, they are returned. The time complexity of the linear search for traversing each location in the database is  $O(n)$ . It then performs another linear search on the string itself, with a time complexity of  $O(n)$ . In total, the time complexity of the place-search algorithm used by the researchers to find relevant places based on the user's input is  $O(2n)$  (A. E. Jacob, 2017).

In a linear search algorithm, the best case is when the element to search for is the first element in the array; this has a time complexity of  $O(1)$ . The worst-case scenario on the other hand is when the element to search for is the last element in the array, which has a time complexity of  $O(n)$ . If the element to search for occurs  $k$  times in the list, and all orderings of the list are equally likely, the expected number of comparisons is (Equation 1)

$$\begin{cases} n & \text{if } k = 0 \\ \frac{n+1}{k+1} & \text{if } 1 \leq k \leq n. \end{cases} \quad \text{Equation 1}$$

In this case, if the desired value appears only once in the list and all orderings are equally likely, the expected number of comparisons is  $(n+1) / 2$ . However, if it is known that it occurs only once, then  $n - 1$  comparisons are required, with the expected number of comparisons being (Equation 2):

$$\frac{(n+2)(n-1)}{2n} \quad \text{Equation 2}$$

## Merge Sort

On the application's home page, there are various categories that separate various types of places, for example, tours, shops, restaurants, and so on. The researchers used Merge sort, which has a time complexity of  $O(n \log n)$ .

Merge sort has an average and worst-case performance of  $O(n \log n)$  when sorting  $n$  objects. The recurrence relation  $T(n) = 2T(n/2) + n$  follows from the definition of the algorithm, which applies the algorithm to two lists half the size of the original list and adds the  $n$  steps taken to merge the resulting two lists. The master theorem for divide-and-conquer recurrences leads to the closed form (Kuwelkar, 2020).

For large  $n$  and a randomly ordered input list, merge sort's expected (average) number of comparisons approaches  $\alpha \cdot n$  fewer than the worst case, where (Equation 3):

$$\alpha = -1 + \sum_{k=0}^{\infty} \frac{1}{2^k + 1} \approx 0.2645. \quad \text{Equation 3}$$

Merge sort uses approximately 39% fewer comparisons than quicksort does in its average case, and its worst-case complexity in terms of moves is " $O(n \log n)$ ," which is the same complexity as quicksort's best case (M. Marcellino, 2021).

## RESULTS

The team intended to create a prototype of a tourism mobile application that provides useful information about a tourist's needs. The researchers have specified that the designed project must adhere to the research objectives: fully functional, secure, and user-friendly mobile application.

### ***Fully Functional Testing***

The purpose of the test determined whether the proposed system is fully functional. This can be determined by adding the scores of each major module together. A module's score is calculated by dividing the number of passed tests in a module by the total number of tests in a single module.

As presented in Table 1, the signup module has the highest score of 20.00, the login module has a score of 17.14, the home module has a score of 25.72, the events module has a score of 14.29, the notifications module has a score of 5.72, and the profile module has a score of 17.14.

Table 1. Fully Functional Testing Result

No.	Application Modules	Fully Functional Checklist		Score (%)
		Success	Fail	
1	Signup Module	Passed 7 test cases		20.00
2	Login Module	Passed 6 test cases		17.14
3	Home Module	Passed 9 test cases		25.72
4	Events Module	Passed 5 test cases		14.29
5	Notifications Module	Passed 2 test cases		5.72
6	Profile Module	Passed 6 test cases		17.14

### System Security Testing

The purpose of the test was to determine the application's security. The test was carried out by multiplying the average of each security feature by 25%. The average for each module was determined by dividing the number of successful security tests by the total number of tests in a security feature. While the constant of 25% was chosen because each security feature is treated equally. When the results for each feature were added together, the total value is 100%.

Table 2. System Security Testing Result

No.	Application Modules	Testing Result		Score (%)
		Success	Fail	
1	Mobile application can restrict access from unregistered accounts (Login)	Passed 5 trials for the 2 test cases		100
2	Mobile application can verify users by implementing a mobile number verification by sending an OTP	Passed 5 trials for the 3 test cases		100
3	Mobile application is capable of masking critical data through obfuscation	Passed 5 trials for the 5 test cases		100
4	Mobile application can protect itself from DDoS attacks	Passed 5 trials for the 2 test cases		100

Table 2 demonstrated that the system is secure against unregistered account access, capable of sending OTP as user verification, capable of masking data, as well as capable of defending itself against DDoS attacks.

## User-Friendliness Testing

A survey was created using Google Forms to test the application's usability. Further, the survey was given to 20 people from Makati and nearby cities like Pasay, Mandaluyong, Taguig, and Manila. As an alternative, a demo video, and a collage of pictures of the user interface are placed inside the form so that respondents can see and experience the application despite Makati City Government restrictions. The rating would range from "1" to "5", with "5" being considered as excellent.

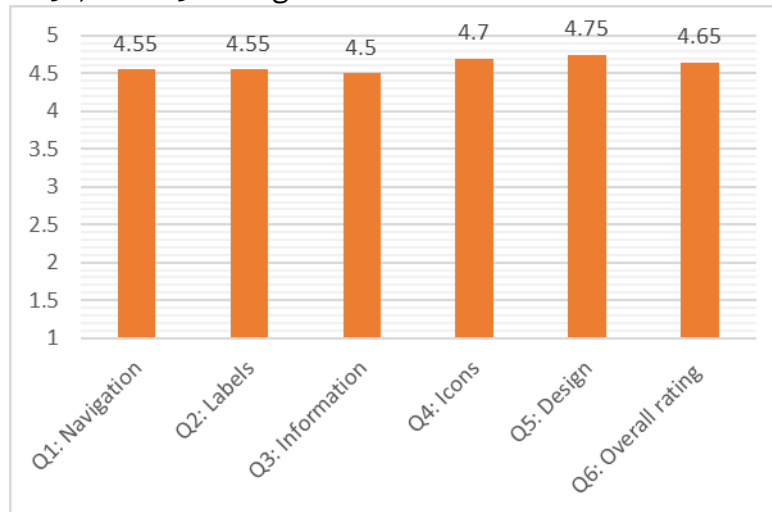


Figure 4. User-Friendliness Survey Result

As presented in Figure 4, the survey is composed of six questions about the application's usability. The first question inquires about the application's simplicity and ease of use. The second question concerns the application's labels' relevance and clarity. The third question concerns the application's information organization. The fourth question inquires whether the application's icons are properly represented. The fifth question is about the appearance and usability of the user interface. The sixth question concerns the overall usability of the application. Based on the result, the system met the set criteria of a user-friendly system.

## DISCUSSION

According to the fully functional testing results shown in the table, the Signup Module Score (SMS) is 20.00, the Login Module Score (LMS) is 17.14, the Home Module Score (HMS) is 25.72, the Events Module Score (EMS) is 14.29, the Notifications Module Score (NMS) is 5.72, and the Profile Module Score (PMS) is 17.14. By adding all the module scores, the goal for fully functional achieved a 100% rating.

As shown in the table system security testing results, five trials are performed per test case. The average of security features one to four resulted in a 100% secureness rating.

Based on the user-friendliness testing results, the question with the lowest average rating was about the application's organized and uncluttered information, which received 4.50. Questions about the application's ease of navigation and clear labels rank slightly higher, with a 4.55 average rating. The overall rating for the application's user-friendliness is 4.65; while the question about proper icon representation in the application received an average of 4.70. The question with the highest rating is about the appearance of the application's user interface and how simple it is to use.

## **CONCLUSIONS AND RECOMMENDATIONS**

In relation to the study's objectives, the design functions implemented in the development of the tourism mobile application performed appropriately and yielded satisfactory results during testing. The project is made up of various functions, the most important of which is the application's ability to store data in a database. The system's ability to store data has a significant impact on the project's functionality because it connects every function in the application, in the sense that the acquired data from the user must be stored before it can be used and displayed on the application.

Even though issues and problems arose during the system's development, the results significantly satisfied the study's objectives. Furthermore, the system could deliver a highly functional, secure, and user-friendly application. After developing the system and analyzing the results, the researchers came to the following conclusions:

- The developed system is fully functional where all necessary functions are met.
- In terms of system security, the system passed test cases pertaining to malicious access or attacks.
- The developed system is simple to use, with a user-friendliness rating of 4.63. The identified rating was based on a survey of people in cities surrounding Makati.

During the development and testing phases, the project's proponents were able to observe some aspects of the project that could be improved. The following are the group's recommendations, that may be useful to future researchers.

- In addition to location pinning, features such as travel planner and weather forecast may be considered to provide more control over tour customization.
- Add ratings and reviews about a specific location to help other tourists.
- Add filters to the content suggestions, such as rating or distance-based suggestions, to assist tourists in selecting their next destination.
- When route-mapping a specific accommodation or historical site, include an interactive and embedded map.
- Include interactive features, such as videos, on event pages to give visitors a better idea of what to expect at a specific event.
- Think about adding offline functionality to the application.

- Allow phone numbers to be used as a login method for easy access to the application.
- Add a filter to each module or when searching for an item to make it easier to access the application's contents.
- Make a "no-load" call to the Makati emergency hotline.
- Include a booking option for specific hotels.

## **IMPLICATIONS**

This developed system greatly assisted tourists in navigating the city of Makati. It allows them to have a pocket tour guide that includes basic tourists' needs such as activities, hotel accommodations, and a place to eat. Furthermore, the application was used to search for community events and register for walking tours for itinerary. Similarly, this app served as a platform for various businesses to gain more public exposure. People can identify and easily locate a specific shop or facility based on the application suggestions, and allowed improvement of their market visibility and, ultimately, revenue.

This application benefited the Makati Tourism Office in the Local Government Unit by providing a new and convenient approach to tourism. As a result, the city's tourist-worthy locations and activities received the exposure and recognition. Consequently, this application aided in increasing the number of tourist transactions in the city, allowed Makati businesses to thrive, and Makati in generating more revenue.

## **ACKNOWLEDGEMENT**

The researchers would like to express their deepest gratitude to city of Makati for the opportunity to do this project. Asia Pacific College, for trusting us to do the research and develop this project.

## **DECLARATIONS**

### ***Conflict of Interest***

All authors declare that they have no conflicts of interest.

### ***Informed Consent***

When completing the survey questionnaire, all study participants were informed of the study's purpose and the data that would be collected. The respondents' identities were not obtained during data collection.

### ***Ethics Approval***

The conducted research presented user information, and other confidential information; hence, it does not violate any ethical issues.

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