LAUTECH Journal of Engineering and Technology 18 (3) 2024: 80-87
10.36108/laujet/4202.81.0390

Development of a customer feedback-enhanced ATM locator using Dijkstra's algorithm and the Haversine formula

[1]Meeting P. E., [2]Afolorunso A. A., and [3]Onanuga A. G.

[1]Department of ICT, Ogun State Polytechnic of Health and Allied Sciences, Nigeria
[2]Department of Computer Science, National Open University of Nigeria, Abuja, 900001, Nigeria
[3]Department of Computer Science, Ogun State Polytechnic of Health and Allied Sciences, Nigeria

Article Info

Article history:

Received: June 14, 2024
Revised: Sept 4, 2024
Accepted: Sept 10, 2024

Keywords:

ATM Locations,
Banking Technology,
Dijkstra's Algorithm,
Digital Mapping,
Feedback Integration

Corresponding Author:
paulemittin@gmail.com

ABSTRACT

Automated teller machines (ATMs) allow customers to perform financial transactions without visiting a bank branch. ATM locators help users find the nearest ATMs based on their location. Customer satisfaction, heavily influenced by service quality, is crucial for banks. Hence, banks should actively seek customer feedback to improve services. Existing ATM locators lack features for communicating customer feedback to banks. This study aimed to enhance the ATM location experience with an Android-based ATM Locator application. The application was developed using C# for the server backend and Java for the mobile app. It allows users to find ATMs, get detailed information, and provide feedback sent via email to participating banks. The app's effectiveness was measured using accuracy (precision & recall), user satisfaction, and response time. User feedback improved the system's strength. The application was tested by 200 students from Ogun State Polytechnic of Health and Allied Sciences. Analysis of the results showed that 81% of recommended ATM locations were relevant, and 84% of these were recognized by users. The average service rating was 4 out of 5, indicating positive feedback. However, some reviews pointed out issues with cash replenishment processes, highlighting areas for further improvement.

INTRODUCTION

With the advancement in technology, transactions are mostly done by the financial system through remote access. Automated teller machines have made banking very convenient since they offer an opportunity for customers to retrieve money at any time. It is a thing of the past for a customer to go about with a pocket full of money, as ATMs can help withdraw money within close distances.

An automated teller is a telecommunication device used by customers of financial institutions to carry on different financial transactions as described by (Bennett, 2023). Such transactions are in the form of cash withdrawals, deposits, funds transfers, and checks, and also for inquiries about one's balances within an account as well as the account's information. It is interesting that these services are effected around the clock and do not require direct communication with a bank's employee.

To operate an ATM, customers insert their card into the machine or use a cardless procedure and enter their password or Personal Identification Number (PIN). If the PIN is correct, the ATM allows customers to make desired transactions. Once the transaction is complete, the customer's card is returned. ATMs offer round-the-clock convenience, enabling customers to access their funds at any time within the limits set by their bank. ATMs are now conveniently located not only at bank branches but also at places like airports and

railway stations, providing easy access for customers. With ATM cards, customers can even deposit money swiftly.

But in Nigeria, there are a lot of ATMs from different banks that are not properly recorded throughout the nation. At the moment, only Google Maps and specific bank applications may be used to locate branch and ATM locations. Customers cannot find local banks or ATMs to make deposits or withdraw cash without these applications. According to Das, Purohit, Alam, and Chowdhury (2014), this ignorance about ATM locations may make it impossible to obtain essential financial services in an emergency. Furthermore, because they are unfamiliar with the country, visitors and newcomers to Nigeria have compounded difficulties. The simple fact that there are ATMs does not suffice if there is no trustworthy way to find them when needed. To address these issues, it is essential to create a digital map of ATM locations across the country, which would also integrate modern location-based services provided by smartphones for easy access to ATM points nationwide.

Another crucial consideration is ensuring both customer satisfaction and productivity. The satisfaction of customers holds significant importance in retaining their loyalty. According to Guido (2015), customer satisfaction is defined as an individual's assessment of their contentment with the choices they make regarding products and services. Notably, the quality of service emerges as a pivotal factor influencing both customer satisfaction and delight. Desiyanti, Sudja and Martini (2018) discovered a positive correlation between service quality and customer satisfaction, as well as customer delight. To enhance overall performance, businesses including banks, must consistently elevate the standard of their services. An effective approach to achieving this is by actively seeking feedback from customers, as it contributes to the improvement of brand perception, the performance of service teams, and the handling of customer inquiries.

To address these concerns, the study proposed the development of an ATM point locator software enhanced with customer feedback. The software is a hybrid application designed for smartphones, allowing users to locate nearby ATMs and access detailed information along with previous user reviews. Users can submit their feedback, and the software will send these reviews to participating banks via an electronic mailing system. This aims to assist banks in improving the quality of their services and ultimately enhance customer satisfaction.

With advanced customer feedback systems that include ratings and reviews, our proposed system improves the accuracy of ATM information. Customers engage actively by providing the bank with feedback that leads to the creation of a community banking model in which the ecosystem of the bank is built by the community.

The research by Oyafisegbe (2021) deals with the creation of an ATM service centre locator using geographical positioning technology. The study aimed to develop a mobile web application which is capable of locating ATM centres and providing information about their status conveniently. Moreover, it includes the development of a device capable to capture and identify nearby ATM centre locations with the help of GPS. The research stresses the fact that GPS is no longer solely a military application; rather it is integrated into the daily life of people with thousands of applications such as navigation and localization. However, it could not provide a means of communicating customer feedback to the participating banks.

The paper by Bharath and Vamsi (2015) addressed an ATM with a locator device. The system helps users find nearby ATMs offering surcharge-free cash withdrawals for Money Pass network cards, especially when a particular ATM is not working. It uses in-built GPS technology to supply accurate directions to nearby ATMs. The study was able to improve user satisfaction by providing a convenient means of locating functional ATMs. However, there was no means of communicating user feedback to the participating bank.

In their work, Das et al (2014) designed an application that runs on Android smartphones to provide ATM location data using OpenStreetMap (OSM) in a particular area of Bangladesh. The application presented ATM locations on a map, which would enable users to check the distance to the nearest ATM booth or fast track and find the shortest path between their current location and the desired ATM using the Haversine formula and Dijkstra's algorithm. However, these devices were restricted because they did not have the list of all the banks and could not make thorough searches over long distances. Furthermore, it was not a cross-platform app so it could only work on the Android operating system.

Mohsin and Aldabbagh (2014) introduced an Android mobile application that enabled users to add, remove, and review specific locations on an online map. Using Google Maps APIs, Google Direction APIs, PHP, JSON, and MySQL, the application provided basic navigation features, such as displaying directions between source and destination, calculating distances, and estimating driving times.

Problem Statement

Current ATM locators are missing real-time user feedback, which can lead to inaccurate information regarding the location and operation status of an ATM. This leads to dissatisfaction among users and difficulties in identifying the available and functioning ones.

METHODOLOGY

To achieve the goals of this study, the Android platform was selected due to its widespread adoption and significant market share. As of April 2024, Android OS commands approximately 70.87% of the global market and 86.92% within Nigeria. This widespread usage makes it an ideal choice for reaching a large user base. Additionally, a hybrid version of the application was developed to support users on non-Android platforms, ensuring broader accessibility and flexibility.

The geographic coordinates for various ATM locations across Nigeria were meticulously gathered using a GPS tracker and Google Maps. This data was crucial for determining the precise locations of ATMs. Once collected, the coordinates, along with pertinent details such as the bank’s name, specific ATM locations, and customer feedback, were systematically imported into a central Microsoft SQL Server database. This centralization facilitates efficient management and retrieval of the data.

To calculate distances between the user's current location and various ATM points, the Haversine formula was employed. This mathematical formula computes the shortest distance between two points on the Earth's surface, given their latitude and longitude in decimal degrees. It is particularly effective for calculating great-circle distances, which represent the shortest path between two points on the surface of a sphere, such as the Earth.

In conjunction with the Haversine formula, Dijkstra's algorithm was utilized to determine the shortest path from the user's current location to the desired ATM points. Dijkstra's algorithm is well-

suited for this task, as it calculates the shortest path in graphs with nonnegative distances, using the distances computed by the Haversine formula to ensure accuracy.

The Haversine formula is expressed as:

$$a = sin^2\left(\frac{\Delta lat}{2}\right) \text{Cos(lat1) x Cos(lat2) x Sin2}\left(\frac{\Delta long}{2}\right) \quad (1)$$

$$c = 2 \text{ x atan}^2(\sqrt{a}, \sqrt{1-a}) \quad (2)$$

$$d = R \text{ x } c \quad (3)$$

where:

- Δlat is the difference between the latitudes of the two points,
- Δlong is the difference between the longitudes of the two points,
- lat_1 and lat_2 are the latitudes of the two points,
- R is the radius of the Earth (meaning radius measures 6,371km or 3,959 miles),
- a is the square of the Haversine of half the angular distance between the two points,
- c is the angular distance in radians,
- d is the distance between the two points (along the surface of the sphere)

To facilitate the transmission of customer feedback to participating banks, email addresses of bank support teams were retrieved from the banks' official websites. This step was essential to ensure that feedback could be communicated effectively to the relevant institutions, enhancing the overall user experience and responsiveness.

The dataset used in this study was sourced from GPS tracking and Google Maps for geographic coordinates, while customer feedback and bank details were obtained through direct interactions with the banks and online research. This comprehensive approach ensures the reliability and effectiveness of the ATM locator system.

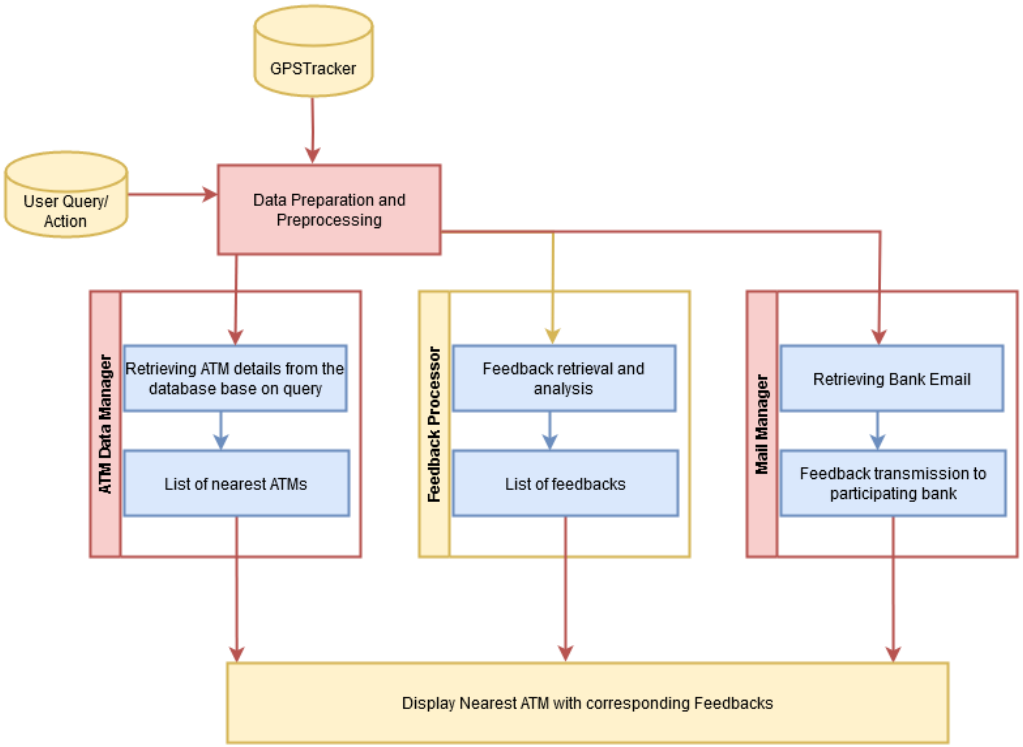

Figure 1: Model Architecture

Model Architecture

The study applied the Model-View-Controller (MVC) architectural pattern in developing the application as depicted by Figure 1. This technique is like a schema for scribing the code to logically organize it in a way that separates and organizes different parts of the application. Think of it as dividing responsibilities among three main components: the Model, the View, and the Controller are the key components. The Model encompasses all the data and the logic that steers the functional operations of the application. It is like the engine of the application; it controls tasks like where to locate ATMs and it handles feedback from the users.

The View is the part where the users interact. It provides the interface, which displays the information and accepts user inputs, for example, a screen and buttons you see on your device when running the app. The Controller represents the link between the Model and the View in this case. The View is the interface where the user sends the request for any kind of interaction with the ATM, like when a user searches for an ATM location or provides feedback. Then, the View sends the request to the Model to make things happen as required. It performs the job of conveying or moving the data and commands to and from the Model and the View.

With the use of MVC, the structure of the code was made in such a way that the understandability and the maintenance of it, is simple. Each component plays a separate role, hence modifying or repairing a particular part of the application does not affect other components.

Model: The dynamic data structure of your application is represented by the Model. It includes entities such as ATM locations, feedback, and associated data. The AtmManager is part of the Model, responsible for handling ATM-related data and database interactions. The Feedback Processing Module is also part of the Model, handling feedback data and analysis.

The User Interface (UI) serves as the View in the MVC pattern. Users interact with the application through the UI when searching for ATM locations or providing feedback. The UI receives input from the user, such as bank name, sort direction, and location coordinates from the GPSTracker. GPSTracker – using Geolocation Services: This component interacts with the UI by providing location information from the Geolocation Services of the Android Device.

The Controller manages the flow of data between the View and the Model. AtmManager acts as the Controller for ATM-related functionalities. The Feedback Processing Module acts as the Controller for feedback-related functionalities. The Controller receives user input from the UI, processes it, and interacts with the Model components accordingly. The Controller is responsible for issuing SQL queries to the database, calculating distances using the Harvesian Formula, and sorting data based on user preferences. MailManager: Responsible for handling the communication of feedback to the appropriate bank email address. It receives input from the Feedback Processing Module.

RESULTS AND DISCUSSION

The system “ATM locator enhanced by customer feedback” was successfully developed as outlined in the goal of this study. The system was then subjected to a rigorous test involving 200 students of the Ogun State Polytechnic of Health and Allied Sciences, which exhibited great accuracy- 81% of the ATM locations, suggested by the system, were corroborated to be relevant by the users. Additionally, regarding service, the app was marked as on average 4 out of 5, which highlights a

rather high level of user satisfaction. The results of the evaluation are presented in this section; the researchers evaluated the precision & recall, user satisfaction level based on feedback and system response time. Table 1 is the number of ATMs locations returned based on user query. Table 2 presents the formula and results obtained from applying the formula to determine the performance of the system;

Table 1: ATM Locations Returned and Users/Ratings

Variables	**Value**
Total number of ATM location recommendations (A)	109
Number of relevant ATM locations recognized by users (B)	92
Number of irrelevant ATM locations recognized by users (C)	17
Number of relevant ATM locations recommended by the system (D)	88
Number of irrelevant ATM locations recommended by the system (E)	21
Number of Users Tested With	200
Sum of Ratings	800

Table 2: **Metrics and Results**

Metric	**Calculation**	**Result**
Accuracy (Precision)	D/A = 88/109 ≈ 0.81 * 100	81%
Accuracy (Recall)	B/A = 92/109 ≈ 0.84 * 100	84%
User Satisfaction	Sum of ratings/Number of Users = 800/200	4
Response Time	Average Response Time	2.5 seconds

Application Screenshots

Figures 2 through 5 provide key insights into the user experience of the ATM Locator system. Specifically, Figure 2 illustrates the Search Screen, where users can input specific criteria to locate nearby ATMs. Figure 3 showcases the ATM Detail Screen, offering detailed information about the selected ATM. Figure 4 highlights the Reviews and Ratings Screen, featuring customer feedback on ATM performance. Lastly, Figure 5 demonstrates the Feedback Submission Screen, enabling users to provide their reviews and ratings based on their experiences.

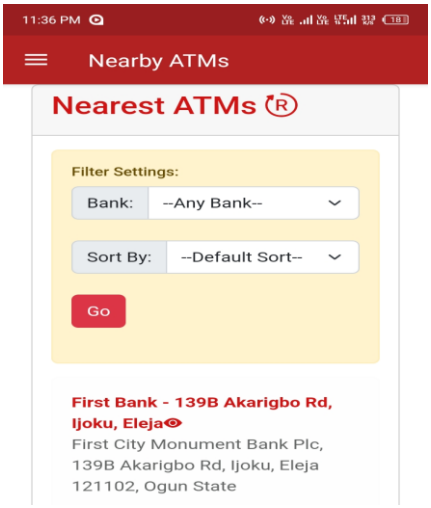

Figure 2: Search Screen

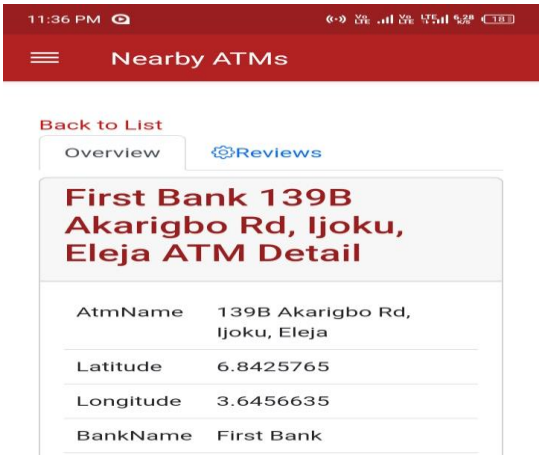

Figure 3: ATM Detail Screen

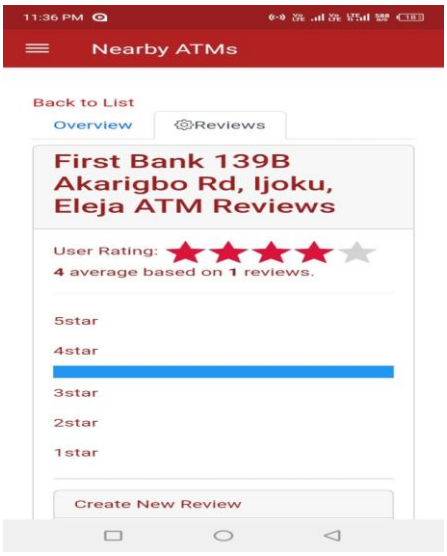

Figure 4: ATM Reviews/Ratings

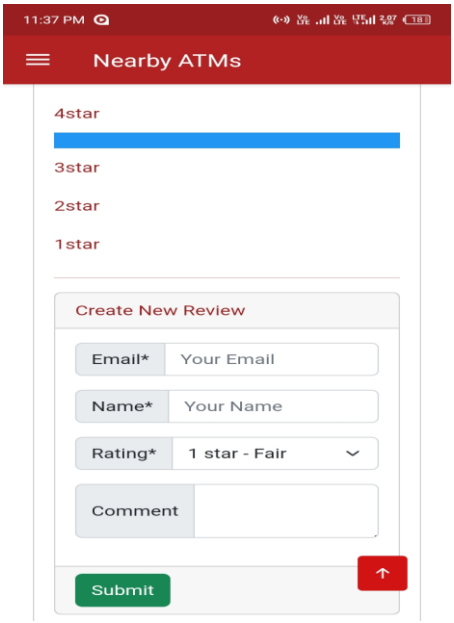

Figure 5: Feedback Submission Screen

Discussion

The ATM locator app is aimed at being a customer's loyal friend who is ready to help them when in need of cash. The app is user-friendly and users can rely on it to provide them with the most accurate and up-to-date information on ATM locations.

Results from Table 2 show that 81% of the recommended ATM locations were relevant to users. It goes further to reveal that the app successfully recommended 84% of the relevant ATM locations recognized by users. Table 2 goes further to reveal the average ATM service rating of the locations by the customers to be 4 out of 5. This is positive feedback. Nevertheless, the customer comments/reviews highlight some weak points in the process of cash replenishment, especially in the area of allocating cash to different ATM locations to keep the machines reliable and running.

Customer satisfaction is the app's priority. That is why everything is made easy and user-friendly. Thus, the app is always assessing user feedback about their ATM experience, regardless of whether it is about the condition of the machine, the availability of currency, or any other aspect, there is room to mention this. The app is designed in such a way that all the user feedback will be transmitted to the banks via the electronic mail system; this is to enable them to immediately respond to any issues that arise and improve the banking experience for all customers. In a few words, the ATM locator app is put here to make life simpler. This has been made possible by its accuracy and user-friendly interface, which is now more convenient than ever.

The mean time consumed to update ATM data is 12 sec, while the average time for user query response is 4 sec. By having these relatively short timescales, the system is showing that the decision-making process is prompt and the information and assistance are provided quickly to the users.

CONCLUSIONS

The ATM Locator Enhanced by the Customer Feedback just came forward as a potential solution: it enables users not only to find ATMs nearby with ease but also to leave feedback to participating banks quickly, thus prompting banks to work

together in service improvement through a cooperative approach.

The implementation of the ATM Locator Software, plus the incorporation of User Satisfaction metrics, has produced the following positive results: enough effectiveness and efficiency. Although there are more positive things than others, the reviews of users still pointed out the areas that needed to be improved upon, particularly with the replenishing of cash. In the future, it will be necessary to work on getting rid of these weaknesses and improve the ATM Locator Assisted by Customer Feedback system to ensure that customers will be satisfied with the banking service offered.

REFERENCES

Bennett, K. (2023). *Automated teller machine (ATM): What it is and how to use one*. Bankrate. https://www.bankrate.com/banking/what-is-an-atm/ (Accessed March 30, 2024)

Bharath, S., & Vamsi, S. (2015). ATM locator. *International Journal of Students' Research in Technology & Management, 3*(4), 330–332. https://doi.org/10.18510/ijsrtm.2015.345

Das, R., Purohit, P., Alam, T., & Chowdhury, M. (2014). Location-based ATM locator system using OpenStreetMap. In *Proceedings of the 2014 IEEE Symposium on Knowledge and Information Management* (pp. 1-6). https://doi.org/10.1109/SKIMA.2014.7083518

Desiyanti, N., Sudja, I., & Martini, L. (2018). Effect of service quality on customer satisfaction, customer delight and customer loyalty (Study on LPD Desa Adat Sembung and LPD Desa Adat Seseh). *International Journal of Contemporary Research and Review, 9*, 20660-20668. https://doi.org/10.15520/ijcrr/2018/9/03/483

Dijkstra's algorithm. (2022). In *Wikipedia*. Retrieved October 2022, from https://en.wikipedia.org/wiki/Dijkstra%27s_algorithm

Google Maps metrics and infographics - Google Maps for iPhone. (n.d.). *sites.google.com*. Archived from the original on March 21, 2022.

Guido, G. (2015). *Customer Satisfaction*. In C.L. Cooper, N. Lee, & A.M. Farrell (Eds.), *Wiley Encyclopedia of Management.* https://doi.org/10.1002/9781118785317.weom090287

KPMG. (2021). *Changing customer, changing priorities: 2021 Nigeria banking industry customer experience survey*. https://assets.kpmg/content/dam/kpmg/ng/pdf/2021-kpmg-nigeria-banking-industry-cx-survey-v2.pdf (Retrieved October 7, 2022)

Mohsin, K., & Aldabbagh, O. (2014). Design and implementation of an online location-based service using Google Maps for Android mobile. *International Journal of Computer Networks and Communications Security, 2*(3), 113–118. Available online at: www.ijcncs.org

Movable Type Ltd. (2023). Calculate distance, bearing and more between latitude/longitude points. *Movable Type*. https://www.movable-type.co.uk/scripts/latlong.html (Retrieved October 7, 2023)

Oyafisegbe, F. (2021). *ATM service centre location using GPS*. Retrieved April 17, 2024, from https://repository.mouau.edu.ng/work/view/atm-service-centre-location-using-gps-7-2.