Research Article

Implementation of Haversine Algorithm in Web-Based Online Attendance Application

[1,*] Leon Fernando Wijaya, [2]Tony

[1,3] Department of Information Systems, Faculty of Information Technology, Universitas Tarumanagara, Jakarta, Indonesia

* Corresponding Author: leon.825210088@stu.untar.ac.id

Abstract: Attendance is an important aspect of the world of work. A manual attendance system is a conventional attendance recording method that is still widely used. However, with the rapid advancement of technology, digital attendance now allows recording attendance through software connected to the internet. PT Password Solusi Sistem, as an information technology solution provider and system integrator, already has an online attendance application, but its effectiveness is still limited, and feature customization is difficult because the application comes from an external service provider. This research aims to develop a web-based online attendance application with the implementation of the Haversine algorithm to calculate the distance between the user's location and the office location through geolocation technology during attendance so that the results of this calculation are used to provide information on attendance whether it is done outside or within the office radius. In addition, this study also compared the results of distance calculations between the Haversine algorithm and the Google Geometry Library in 20 different locations, which resulted in a difference of 0.0113. GPS Geolocation testing, conducted using a smartphone, showed 100% accuracy, with all test locations being valid. The results showed that the online attendance application with the Haversine algorithm was successfully implemented, and the accuracy comparison between the Haversine algorithm and Google Geometry Library showed almost similar results.

Keywords: Haversine algorithm, geolocation, Scrum, presence, attendance.

Citation: Wijaya, L. F., & Tony. (2024). Implementation of Haversine algorithm in web-based online attendance application. Iota, 4(4). ISSN 2774-4353. https://doi.org/10.31763/iota.v4i4.836

Academic Editor: Adi, P.D.P

Received: October 17, 2024

Accepted: November 18, 2024

Published: December 28, 2024

1. Introduction

In the context of the workplace, attendance refers to an employee's presence at work. Effective attendance management is essential to monitor employee productivity and discipline. A manual attendance system is one of the methods of recording attendance that is still used, but this method is often not efficient enough because it has several weaknesses, such as potential recording errors due to human error. Along with the development of technology, a digital attendance system emerged that utilizes software that can be accessed through devices connected to the internet.

PT Password Solusi Sistem aka MyPassword is a case study in this research. MyPassword is located at Wisma 77 Slipi, West Jakarta. MyPassword is an information technology solution provider and system integrator company consisting of several divisions, such as Business Applications, Infrastructure, Human Resources, and Business Support. The Infrastructure division has flexibility in working, as it can carry out tasks both in the office and outside the office. Currently, MyPassword already has a digital presence application that allows Infrastructure Staff to take attendance from anywhere. This digital attendance application is obtained through an external service provider. However, there are several obstacles, such as inefficient recording of overtime and limitations in feature customization, because the application only provides standard features.

Based on the above problems, the development of an online attendance application is proposed. Several previous studies are used as references in the development of this attendance system. The authors in [1], [2], and [3] researched the development of an attendance system using Radio Frequency Identification (RFID). This system works by bringing an RFID card or device close to the sensor, after which attendance is recorded. Although this attendance system is very fast and efficient, it has limitations in supporting remote attendance, as it requires specific hardware at certain locations.

Goyal et al. [4] and Adiono et al. [5] focus on attendance systems using fingerprint technology. This system operates by scanning an individual's fingerprint, which is then matched against stored data to record attendance. Similar to RFID-based systems, fingerprint attendance systems offer high accuracy and efficiency. However, they also have limitations, particularly in supporting remote attendance, as users must be physically present at designated devices to complete the attendance process. Additionally, these systems often require investment in specialized hardware, which can increase setup and maintenance costs.

Isnanto et al. [6], Khan et al. [7], and Jana [8] developed a mobile-based attendance application that records only the user's location at the time of attendance. However, this system lacks indicators to specify whether attendance was marked within or outside the office premises, meaning each location must be manually verified to determine the exact attendance point. This limitation poses challenges, as similar street names can lead to ambiguity, and certain streets cover a large area, making precise identification difficult. Additionally, Rexline and Nazrin [9] concluded that a geotagging-based attendance system using Google Maps API provides accurate and efficient tracking for remote employees. While it improves attendance accuracy and documentation, the system incurs costs due to Google Maps API usage, especially for frequent location checks or a large number of employees, which organizations must consider in its implementation.

Based on the references above, the attendance application will be developed with several adjustments, particularly in attendance recording. This application will include a feature that captures facial photos and records the user's location during attendance. The captured location will be calculated concerning the office location to determine whether the attendance is within or outside the office radius. In mathematics, various formulas can be used to calculate the distance between two points, one of which is the Haversine formula. Prasetya et al. [10] conducted research on the use of the Haversine algorithm to solve the shortest path problem, while Muttaqin et al. [11] used the algorithm to determine the closest distance to a supermarket. Both studies demonstrated the accuracy of these calculations. In the development of this application, the Haversine algorithm will be applied to provide real-time information on whether the attendance is within or outside the office radius. Unlike other systems that rely on geotagging or specialized hardware, this application offers a more flexible and cost-effective solution for remote attendance tracking. Additionally, Google provides the Geometry Library API to calculate the distance between two locations, and this research will compare the results of both the Haversine algorithm and Google Geometry Library to assess their relative accuracy and efficiency.

2. Method

2.1 The Scrum Method

In this chapter, we will explain the methods and algorithms used in the development of online attendance applications. The research flow is outlined in Figure 1, which is divided into eight stages. This structured approach ensures a systematic and comprehensive development process, allowing each phase to contribute to the overall functionality and effectiveness of the application. The eight stages serve as a guide, from initial planning to implementation and evaluation, ensuring all critical aspects are thoroughly addressed.

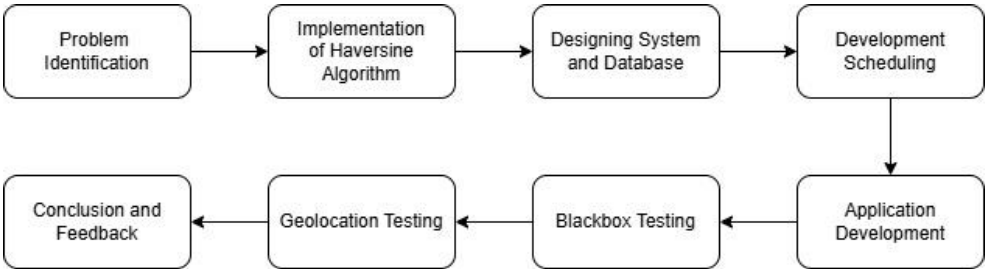

Figure 1. Research Flow

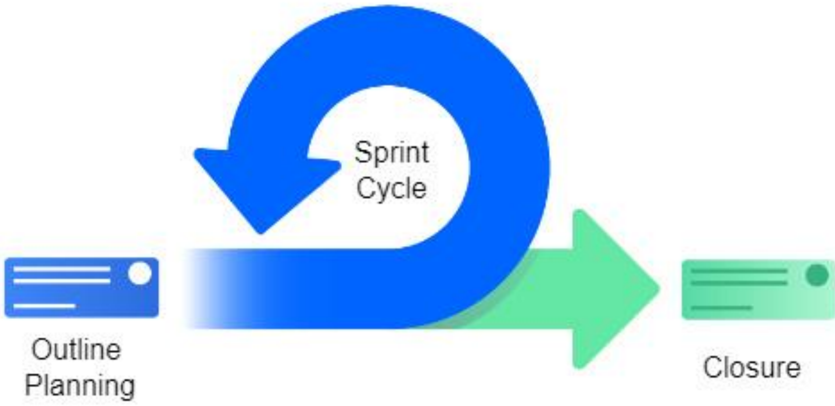

Figure 2. The Scrum Method

The method used in the development of this application is the Scrum method. Scrum is a lightweight framework that helps individuals, teams, and organizations create value through adaptive solutions to complex problems [12]. Scrum was chosen because it offers an iterative approach that supports continuous feedback and adaptation, unlike the traditional Waterfall method, which is rigid and involves long delays before coding and testing. This iterative nature is particularly important for this project, which involves multiple stakeholders [13]. Scrum consists of 3 main phases shown in Figure 2, including outline planning, sprint cycle, and closure [14].

In the initial stage of outline planning, the needs of the application are identified together with the user. Based on the identification of needs, a list of features will be compiled in order of priority, which is referred to as the product backlog [15]. The needs identification was conducted through an offline interview with the Human Resources Manager on July 26, 2024, at MyPassword. The interview produced information about the flow of attendance and overtime submissions. In addition, the outline planning stage will include creating a Gantt chart to map the development schedule, use case diagram, and logical database design.

The next stage is the sprint cycle, which involves multiple iterations. Each sprint lasts between 1 to 4 weeks. At the beginning of each sprint, sprint planning is conducted to determine which items from the product backlog will be worked on. A daily scrum, a brief 15-minute meeting, is held to review progress. At the end of the sprint, a sprint review presents the results to the product owner, followed by a sprint retrospective to evaluate and improve the work process [16].

At the sprint cycle stage, application development will be carried out based on the product backlog feature list. Application development will use JavaScript and PHP programming languages with the Laravel framework. The database that will be used is MySQL. Tailwind CSS framework will be used for styling the application. In addition, several libraries will be used in the development including JQuery, LeafletJS, and SweetAlert2. This application will also implement the geolocation technique, which is a technique to obtain coordinates (latitude and longitude) via IP address, Wi-fi connection, cell tower, or GPS on a smartphone, tablet, or computer [17]. The coordinates obtained will be calculated using the Haversine algorithm.

The last stage is closure, where UAT (User Acceptance Test) is carried out as the last test, as well as the delivery of the final product to the user. Testing will use the type of black box testing, which is testing done to observe the input and output results of the application without knowing the code structure of the application [18].

2.2 The Haversine Algorithm

In addition to applying the Scrum method in application development, the Haversine algorithm is also used. MyPassword, especially in the Infrastructure division, employees can take attendance both inside and outside the office. The use of the Haversine algorithm to calculate the distance between the user's coordinate point during the presence and the office coordinate point, and the results of this calculation are used to determine whether the presence is outside the office or still within the specified radius around the office.

Table 1. Comparison Haversine and Vincenty Algorithm [19]

Feature	Haversine	Vincenty
Earth Model	Spherical	Ellipsoid
Mathematical Complexity	Relatively simple to implement.	More complex and computationally intensive.
Performance	Faster, since it's computationally simpler.	Slower, due to the iterative process required for accuracy.
Accuracy	Provides a good approximation.	More accurate (much less in a meter)

The Haversine algorithm is the most popular method. It uses trigonometry to calculate great circle distances using coordinates defined in decimal degrees as input. Haversine is the most commonly used algorithm as it is relatively lightweight from a programming perspective and quite accurate in most cases [19]. In addition to the Haversine formula, there is a Vincenty formula, which is commonly applied in geodesy to determine the distance between two locations on the Earth's surface, assuming it is an ellipsoid [20]. Table I shows a comparison between the Haversine formula and the Vincenty formula. Next, several studies compare the results of the Haversine algorithm with other algorithms. Table II presents the findings of a study that compares Haversine with several other algorithms.

Table 2. Comparison of Algorithms in Related Research

Authors	Algorithm	Research Results
Syarifudin & Sari [21]	Euclidean	The Haversine algorithm has an accuracy of 99.71%, while the Euclidean algorithm has 99.65%, with Haversine being superior.
Abdulhameed *et al.* [22]	Vincenty	The accuracy is 3% higher, but it uses more memory and CPU, and the calculations are slower.
Hertaryawan *et al.* [23]	Euclidean	The Haversine algorithm achieves 91.95 % accuracy, slightly outperforming the Euclidean algorithm, which has an accuracy of 91.94 %.

There are several steps in the Haversine algorithm [24]. The first step is to convert both coordinate points (latitude and longitude) into radian units using Eq. (1). Next, we apply Eq. (2) and Eq. (3) to calculate the latitude and the longitude difference between the two points, respectively.

$$rad = degree \cdot (\pi/180) \quad (1)$$

$$\Delta lat = lat_2 - lat_1 \quad (2)$$

$$\Delta lon = lon_2 - lon_1 \quad (3)$$

We then use Eq. (4) to find the value of a or the distance between two points on the earth's surface using the coordinates (latitude and longitude) of the two locations that have been converted into radians and using the value of the difference in latitude and longitude.

$$a = \sin^2(\Delta lat/2) + \cos(lat_1) \cdot \cos(lat_2) \cdot \sin^2(\Delta lon / 2) \quad (4)$$

Finally, we use Eq. (5) to find the distance between the two points using the previously calculated value of a and the average radius of the earth of about 6371 km.

$$distance = 2R \cdot \arcsin(\min(1, \sqrt{a})) \quad (5)$$

3. Result and Discussion

This chapter discusses the implementation results of the online attendance application developed using the Scrum method and the Haversine algorithm. This section will explain how the two approaches contribute to achieving the development objectives, including the geolocation-based distance calculation process to support the presence feature, as well as the evaluation of application performance and functionality based on the tests that have been carried out.

3.1 Implementation of Haversine Algorithm

At this stage, the distance between the user's location when doing attendance and the office location will be calculated using the Haversine algorithm which will be applied to the application. The following is the pseudocode for the Haversine algorithm in the online attendance application. This algorithm requires input in the form of the user's coordinates, which will be automatically obtained through GPS geolocation. After that, both the user's and the office's coordinates will be converted to radians and then used in the Haversine algorithm to calculate the distance between the two points.

```
INPUT:
userLatitude, userLongitude (Latitude & Longitude of the user in degrees)

OUTPUT:
Distance (Distance between the user and the office in the same unit as R)

ALGORITHM:
1. Convert all degrees to radians:
lat_u = userLatitude * 3.14 / 180
lon_u = userLatitude * 3.14 / 180
lat_o = -6.19058187 * 3.14 / 180
lat_o = 106.79779495 * 3.14 / 180
```

```
2. Calculate the difference in latitude and longitude:
diffLat = lat_o - lat_u
diffLon = lon_o - lon_o

3. Calculate the value of a using the Haversine formula:
a = sin(diffLat/2) * sin(diffLat/2) + cos(lat_u) * cos(lat_o) *
sin(diffLon/2) * sin(diffLon/2)

4. Calculate the value of c:
c = 2 * asin(sqrt(a))

5. Calculate the distance:
distance = 6371 * c

6. RETURN distance
```

Next, the authors compared 20 location points with the MyPassword office location using the Haversine calculation implemented in the attendance application and the distance calculation provided by the Google Geometry Library. Table III shows the comparison results of the two distance calculation methods. The average calculation result of 20 location coordinates compared to MyPassword office coordinates using the Haversine algorithm in the attendance application is 10.004. However, when compared to the calculation using the Google Geometry Library, which averages 10.015, there is a difference of 0.011. This indicates a slight difference between the results of the Haversine algorithm and the Google Geometry Library in the application, but the difference remains within acceptable tolerance limits for most practical applications, including this attendance application.

Table 3. Distance Calculation Comparison

Location Name	Haversine Presence Application	Google Geometry Library
Universitas Tarumanagara	2.572	2.575
Gelora Bung Karno Stadium	3.152	3.155
Pasar Pecinan Glodok	5.615	5.621
Pasar Slipi Jaya	0.204	0.204
Pusat Jantung Nasional Harapan Kita	0.564	0.565
PIK Avenue	11.098	11.110
Thamrin City	2.058	2.060
Emporium Pluit	7.079	7.087
Menteng Park	4.689	4.694
Central Park Mall	1.519	1.520
Summarecon Mall Serpong	19.499	19.521
Vihara Mahavira Graha Pusat	7.371	7.379
Stadium Patriot Candrabhaga	22.106	22.131
Pondok Zidane	27.110	27.140
Universitas Indonesia	19.187	19.209
Grand Galaxy Mall	21.244	21.268
Museum Pancasila Sakti	16.473	16.491
Aeon Mall BSD City	21.319	21.343
Sarinah	2.868	2.871
Masjid Istiqlal	4.351	4.355
Average	**10.004**	**10.015**

3.2 *Presence Application Development*

The first phase in the development of the attendance application is outline planning. In this phase, needs identification is carried out through interviews with the Human Resources Manager. From the results of this interview, the information will then be processed into diagrams such as use case diagrams to describe the interaction between users and the system, ERD (Entity Relationship Diagram) to describe the required data structure, and Gantt chart used to map the system development schedule in detail. These diagrams will be the basis for the design and implementation of the attendance application.

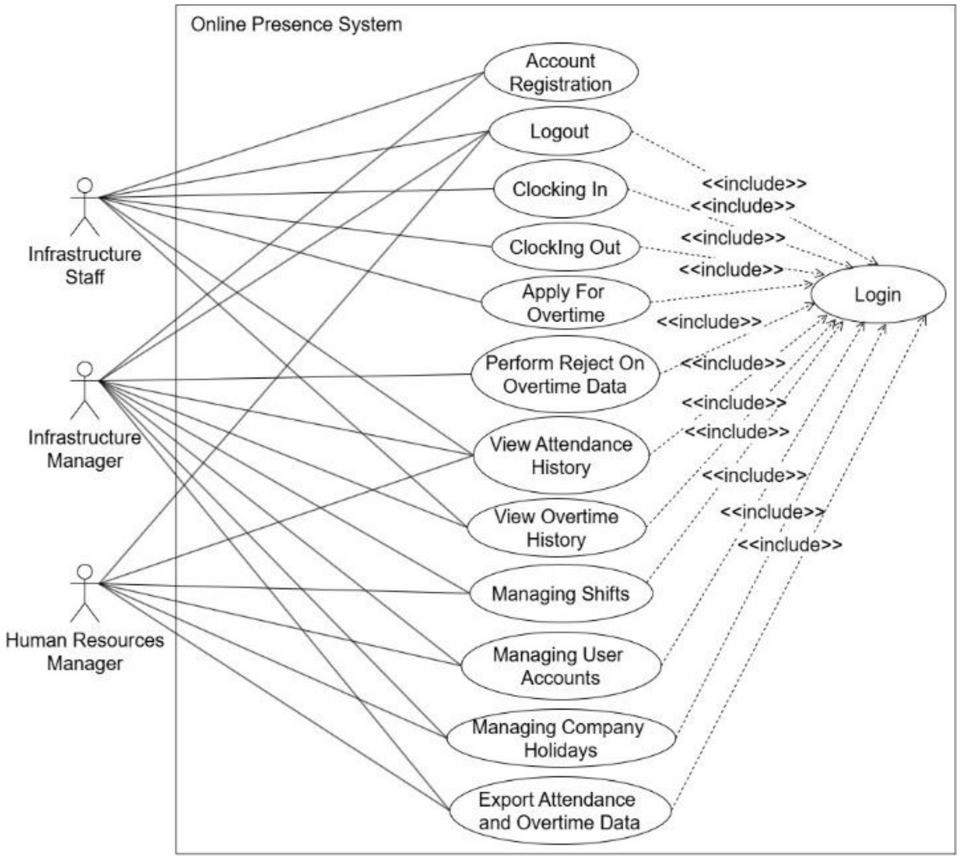

Figure 3. Use Case Online of Presence Application

UML (Unified Modeling Language) is a graphical language used to define, visualize, build, and document software system artifacts. One of the diagrams in UML is the use case diagram, which aims to summarize all functional requirements of the system [25]. Figure 3 shows the use case diagram for the online attendance application, which involves three actors: Infrastructure Staff, Infrastructure Manager, and Human Resources Manager. All roles must log in first before they can use the available features. Infrastructure Staff can perform registration, and attendance, submit overtime, and view attendance and overtime history. Meanwhile, the Infrastructure Manager and Human Resources Manager have the highest authority, where they can manage shifts, manage company holidays, and view and export attendance and overtime data. However, there is a difference in the Infrastructure Manager, which can reject invalid overtime data.

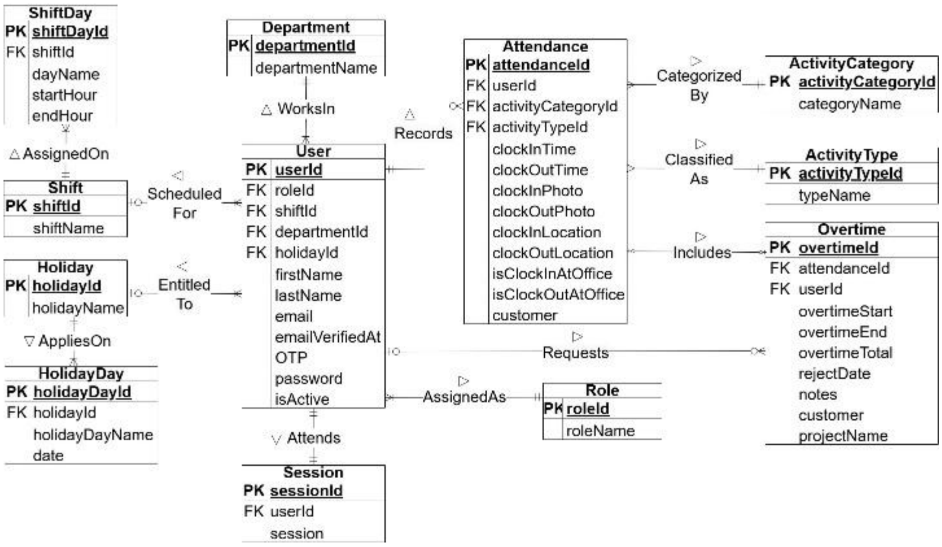

Figure 4. Logical Database Design of Online Presence Application

Furthermore, in the application design stage, an ERD (Entity Relationship Diagram) is also created. The creation of ERD aims to provide a clear visualization of how data will be organized, accessed, and managed in the system. Figure 4 shows the ERD design of the online attendance application, which is made in the form of a logical database design, representing the logical schema of the database before it is physically implemented.

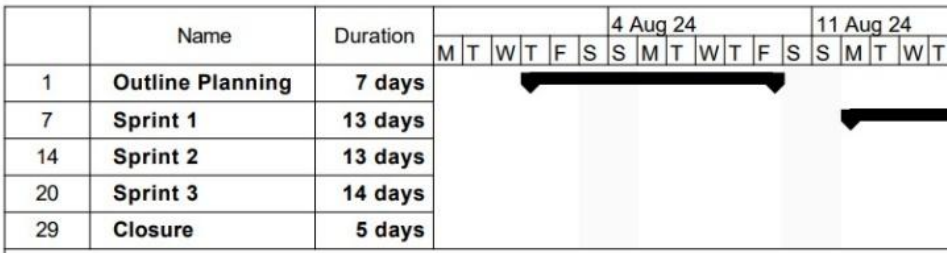

Figure 5. Scope of Project Stages

Application development scheduling will use a Gantt chart as a tool to visualize project stages, manage the timing of each task, and monitor overall project progress. Figure 5 shows the scope of the overall project stages presented in the form of a Gantt chart. The project stages consist of outline planning, three sprint iterations, and closure. Figure 6 shows the details of the tasks performed in sprint 1.

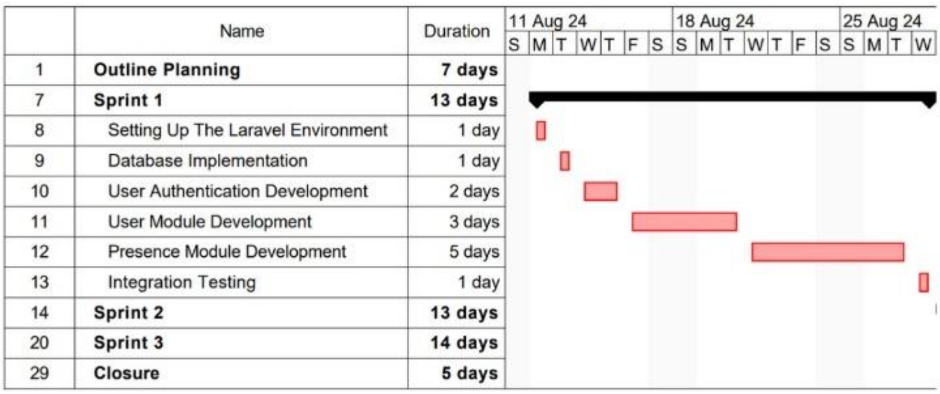

Figure 6. Sprint 1 Activities

In the sprint phase, the development of the attendance application will be carried out using the Laravel framework. Although Laravel is a backend framework, it also provides frontend development capabilities using Blade templating. The sprint phase will consist of 3 iterations, where each iteration will involve the implementation of all modules and features that have been compiled in the product backlog. Each iteration will also be accompanied by testing to ensure each feature functions as expected before proceeding to the next iteration, thereby minimizing potential errors and accelerating application refinement.

Figure 7 shows the results of development in the sprint phase, where the attendance page module has been implemented. The attendance page is the main page that will appear first after the Infrastructure Staff logs in. Through this page, Infrastructure Staff can clock in and out. Figure 8 shows the display of the clock in modal when the Infrastructure Staff wants to take attendance. In the modal, it displays a map with the user's location point, if the location is still not appropriate the user can press the "Get My Location" button to refresh the location. The user must also fill in the input form and take a face photo through the camera by pressing the "Get My Photo" button.

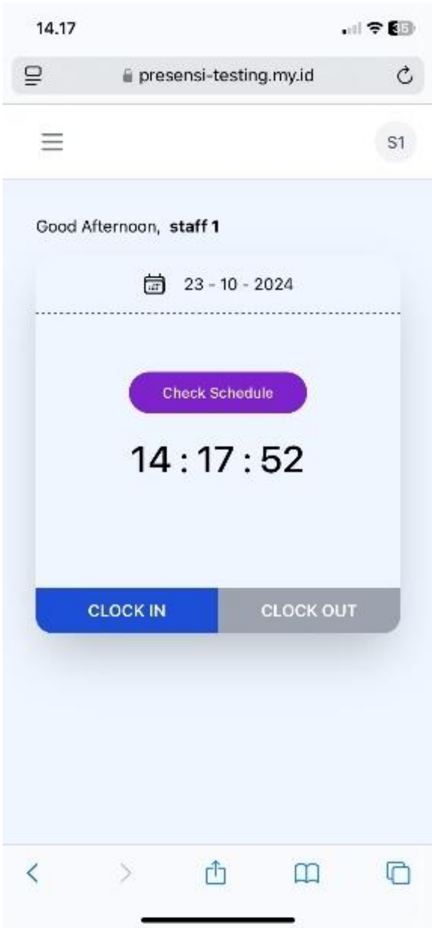

Figure 7. Presence Page

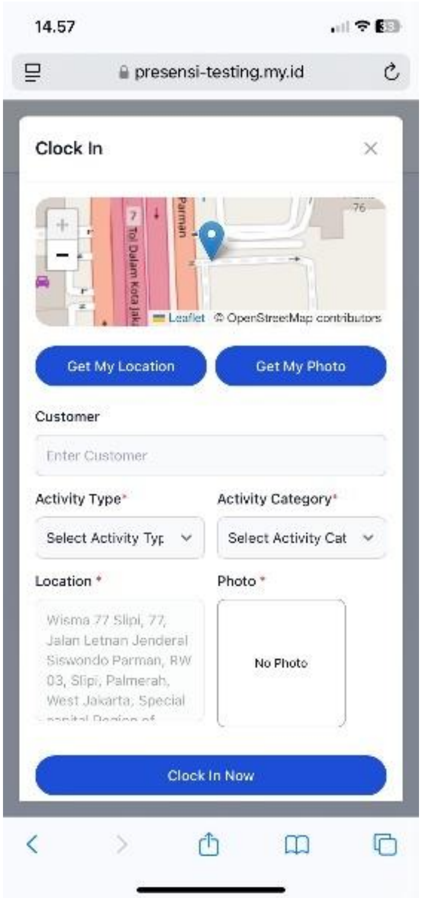

Figure 8. Clock In Modal

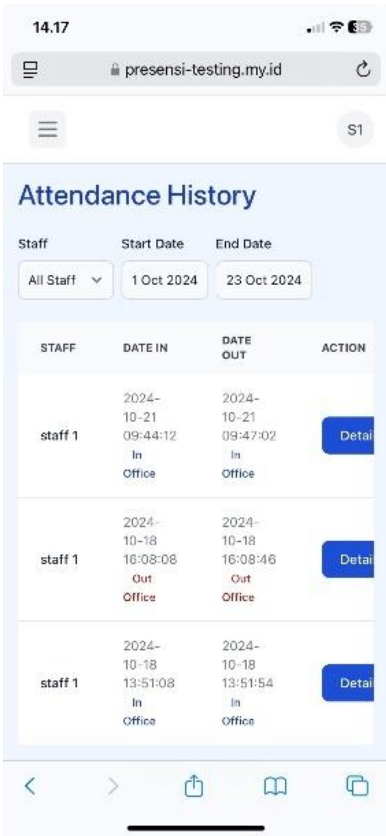

Figure 9. Presence History Page

Each attendance information will be stored, and the system will calculate the distance between the user's coordinates and the office coordinates using the Haversine algorithm. The user's coordinates are obtained through Geolocation technology, which utilizes GPS on the user's device. The results of this calculation will determine whether the attendance is done inside or outside the office radius, with a distance tolerance of 120 meters from the MyPassword office location. Figure 9 shows the appearance of the attendance history page, where the results of the Haversine algorithm calculation are displayed. This page describes "In Office" if the user is within the office radius, or "Out Office" if outside the radius.

In the final stage, closure is conducted, which includes the final User Acceptance Testing (UAT) using the black box testing method. This testing is performed for all actors, namely the Infrastructure Staff, Infrastructure Manager, and Human Resources Manager. Table IV presents the results of UAT using the black box testing method involving all actors in MyPassword. All test results are declared valid for every tested scenario. In addition to black box testing, Geolocation testing is conducted using GPS. The geolocation testing involves collecting data from 10 different locations through the online attendance application. All obtained coordinates are compared with the corresponding locations on Google Maps to ensure accuracy.

Table 4. Blackbox Testing

Features	**Scenarios**	**Expected Results**	**Test Results**
Register	Register with a company email	Shows a successful registration message	Valid
Login	Login using the correct account	Redirects to the main page	Valid
Logout	Logging out account	Redirects to login page	Valid
Presence	Taking attendance outside the office radius	Save attendance data with "Out Office" Information	Valid
	Taking attendance near the office radius	Save attendance data with "In Office" Information	Valid
	Taking attendance outside of shift hours or on company holidays	Save attendance and overtime data	Valid
	Taking attendance during shift hours	Save attendance data	Valid
Overtime Request	Fill out the overtime application form	Shows a successful overtime request message	Valid
Presence History	Display all presence history data	Display all presence history data	Valid
	Export attendance history data	Successfully download attendance history data	Valid
Overtime History	Display all overtime history data	Display all overtime history data	Valid
	Export overtime history data	Successfully downloaded overtime history data	Valid
Overtime Reject	Reject overtime data	Shows a successful rejection of over-data	Valid
Setting Holiday	Update holiday data	Shows a successful update of holiday data	Valid
	Delete holiday data	Shows a successful deletion of holiday data	Valid
	Create holiday data	Shows a successful create holiday data	Valid
Setting Shift	Update shift data	Shows a successful update shift data	Valid
	Delete shift data	Shows a successful delete shift data	Valid
	Create shift data	Shows a successful create shift data	Valid

In addition to black box testing, geolocation testing is conducted by the authors using GPS on a smartphone. The geolocation testing involves collecting data from 10 different locations through the online attendance application. All obtained coordinates are compared with the corresponding locations on Google Maps to ensure accuracy. Table V shows the results of Geolocation testing obtained through

GPS on a smartphone. The results show that all 10 locations tested are valid, achieving 100% accuracy.

Table 5. Result of Geolocation Testing using GPS

Location Name	Coordinate Points	Address Name	Results
MyPassword	-6.190578, 106.7978118	Wisma 77 Slipi, 77, Jalan Letnan Jenderal Siswondo Parman, RW 03, Slipi, Palmerah, West Jakarta, Spe- cial capital Region of Jakarta, Java, 11420, Indonesia	Valid
Universitas Tarumanagara	-6.1720398, 106.7897299	Jalan Taman S. Parman, RW 16, Tomang, Grogol Petamburan, West Jakarta, Special capital Region of Jakarta, Java, 11450, Indonesia	Valid
Mal Ciputra	-6.1683184, 106.7873051	Jalan Daan Mogot I, RW 01, Tanjung Duren Utara, Grogol Petamburan, West Jakarta, Special capital Region of Jakarta, Java, 11470, Indonesia	Valid
Apotek Nusantara Sehat	-6.1434918, 106.7931933	Jalan Profesor Dokter Latumeten, RW 09, Angke, Tambora, West Jakarta, Special capital Region of Jakarta, Java, 11330, Indonesia	Valid
Alfamart Lempuk	-6.1310003, 106.7768492	Jalan Lempuk, RW 13, Pejagalan, Penjaringan, North Jakarta, Spe- cial capital Region of Jakarta, Java, 14450, Indonesia	Valid
Apartemen Teluk Intan	-6.1286313, 106.77804	Jalan Moa, RW 13, Pejagalan, Pen- jaringan, North Jakarta, Special cap- ital Region of Jakarta, Java, 14450, Indonesia	Valid
Season City	-6.1520494, 106.7952633	RW 05, Jembatan Besi, Tambora, West Jakarta, Special capital Region of Jakarta, Java, 11320, Indonesia	Valid
Universitas Jakarta Internasional	-6.1812963, 106.7963873	Jalan Letnan Jenderal Siswondo Parman, RW 01, Kemanggisan, Palmerah, West Jakarta, Special capital Region of Jakarta, Java, 11420, Indonesia	Valid
Hariston Hotel	-6.1377053, 106.7879378	Jalan Teluk Gong Raya, RW 16, Pe- jagalan, Penjaringan, North Jakarta, Special capital Region of Jakarta, Java, 14450, Indonesia	Valid
Vihara Satria Dharma	-6.138157, 106.786245	Jalan Teluk Gong Raya, RW 09, Pe- jagalan, Penjaringan, North Jakarta, Special capital Region of Jakarta, Java, 14450, Indonesia	Valid

4. Conclusion

Based on this research, it can be concluded that the development of a web-based online attendance application with the implementation of the Haversine algorithm has been successful. This application was developed following the features desired by users, which previously did not exist in existing applications. In addition, this application applies Geolocation technology to obtain user coordinates when recording attendance, which is then calculated using the Haversine algorithm to provide an automatic label if the attendance is done outside or around the office radius. The comparison results between the Haversine algorithm and Google Geometry Library show that both have almost the same level of accuracy, with an average difference of only 0.011 from testing on 20 locations. Moreover, the GPS Geolocation testing, conducted using a smartphone, showed 100% accuracy, with all 10 test locations being valid. Looking ahead, it is important to consider the scalability of the application for use in multiple branches, integrate advanced technologies like machine learning for enhanced facial recognition, and address the challenges of managing storage due to the large file sizes generated by attendance photos.

Acknowledgments: The authors thank PT Password Solusi Sistem for providing the opportunity and information necessary for conducting this study.

Author contributions: The authors were responsible for building Conceptualization, Methodology, analysis, investigation, data curation, writing—original draft preparation, writing—review and editing, visualization, supervision of project administration, funding acquisition, and have read and agreed to the published version of the manuscript.

Funding: The study was conducted without any financial support from external sources.

Availability of data and Materials: All data are available from the authors.

Conflicts of Interest: The authors declare no conflict of interest.

Additional Information: No Additional Information from the authors.

References

1. K. Aravindhan, S. K. B. Sangeetha, K. Periyakaruppan, K. P. Keerthana, V. SanjayGiridhar and V. Shamaladevi, "Design of Attendance Monitoring System Using RFID," 2021 7th International Conference on Advanced Computing and Communication Systems (ICACCS), Coimbatore, India, 2021, pp. 1628-1631, doi: 10.1109/ICACCS51430.2021.9441704.
2. H. Jun Jie, H. Aysa Abdul Halim Sithiq and N. Azlina Abd Rahman, "Convergence of APCARD and RFID for Attendance System," 2022 IEEE International Conference on Distributed Computing and Electrical Circuits and Electronics (ICDCECE), Ballari, India, 2022, pp. 1-5, doi: 10.1109/ICDCECE53908.2022.9792991.
3. S. Sharma, S. Monika, S. V. S. Prasad, K. Dasari and S. Kamaganikuntla, "RFID Based Low Cost Attendance Recording and Proxy Avoidance System," 2022 International Conference on Advancements in Smart, Secure and Intelligent Computing (ASSIC), Bhubaneswar, India, 2022, pp. 1-5, doi: 10.1109/ASSIC55218.2022.10088295.
4. P. Goyal, V. Nigam, S. A. Khan and S. K. Singh, "Automated Attendance Management System," 2023 5th International Conference on Advances in Computing, Communication Control and Networking (ICAC3N), Greater Noida, India, 2023, pp. 452-455, doi: 10.1109/ICAC3N60023.2023.10541627.
5. T. Adiono, D. Setiawan, Maurizfa, J. William and N. Sutisna, "Cloud Based User Interface Design for Smart Student Attendance System," 2021 International Symposium on Electronics and Smart Devices (ISESD), Bandung, Indonesia, 2021, pp. 1-5, doi: 10.1109/ISESD53023.2021.9501878.
6. B. Isnanto, A. Amir Alkodri and Supardi, "Attendance Monitoring With GPS Tracking on HR Management," 2020 8th International Conference on Cyber and IT Service Management (CITSM), Pangkal, Indonesia, 2020, pp. 1-4, doi: 10.1109/CITSM50537.2020.9268915.
7. A. A. Khan, D. G. Purnama, and A. M. Kurniawan, "Development of mobile-based attendance management system applications," Jurnal Indonesia Sosial Teknologi, vol. 4, no. 12, pp. 2372-2384, 2023.
8. S. N. Jana, "Online presence system using geolocation and digital signature at the Rejang Regency Defense Office," Kreator, vol. 10, no. 2, pp. 24-35, 2023.
9. S. J. Rexline and S. Shameema Nazrin, "GeoTagging based Attendance System using Google Maps API," 2024 2nd International Conference on Advancement in Computation & Computer Technologies (InCACCT), Gharuan, India, 2024, pp. 894-898, doi: 10.1109/InCACCT61598.2024.10551178.
10. D. A. Prasetya, P. T. Nguyen, R. Faizullin, I. Iswanto, and E. F. Armay, "Resolving the shortest path problem using the haversine algorithm," Journal of Critical Reviews, vol. 7, no. 1, pp. 62-64, 2020.
11. A. Muttaqin, A. A. Murtopo, S. Syefudin, and G. Gunawan, "Application of the haversine formula method to determine the closest distance to a minimarket," Jurnal Mandiri IT, vol. 13, no. 1, pp. 72-80, 2024.
12. Jeff Sutherland and Ken Schwaber, “The Scrum Guides,” 2020. Accessed: Oct. 20, 2024. [Online]. Available: https://scrumguides.org/docs/scrumguide/v2020/2020-ScrumGuide-US.pdf.
13. Mark C. Layton, Scrum For Dummies. Wiley, 2022.
14. Susheela Hooda, Vandana Mohindru Sood, Yashwant Singh, Sandeep Dalal, and Manu Sood, Agile Software Development. Wiley-Scrivener, 2023.
15. Rod Stephens, Beginning Software Engineering. Wiley, 2023.
16. Josh Wright, Scrum: The Complete Guide to the Agile Project Management Framework that Helps the Software Development Lean Team to Efficiently. 2020.
17. Bradley A. Shellito, Introduction to Geospatial Technologies Fifth Edition, 5th ed. MacMillan Learning, W. H. Freeman and Company, 2019.
18. P. Leloudas, Introduction to Software Testing. Apress, 2023.
19. Joel. Lawhead, Learning Geospatial Analysis with Python: Unleash the power of Python 3 with practical techniques for learning GIS and remote sensing. Packt Publishing, 2023.
20. V. A. Windarni and A. Setiawan, "Comparative analysis of Vincenty and geodesic method approaches in measuring the distance between subdistrict offices in Salatiga City," BAREKENG: Jurnal Ilmu Matematika dan Terapan, vol. 16, no. 4, pp. 1207-1220, 2022.
21. M. K. Syarifudin and R. T. K. Sari, "Perbandingan metode Euclidean distance dan Haversine distance pada aplikasi sistem PPDB dan algoritma K-Means untuk menentukan kebijakan peraturan zonasi," faktor Exacta, vol. 15, no. 4, pp. 206-212, 2023.

22. A. A. Abdulhameed, D. A. Mokheef, M. A. Shanyoor, S. M. Abood, and N. R. Obeid, "Accurate determination of Qibla direction: A comparative study of Haversine, Vincenty, spherical trigonometry, great circle navigation, and equatorial oblique cylindrical projection algorithms using Python programming language," 2024.
23. R. M. P. Hertaryawan, D. I. Mulyana, and Y. Akbar, "Optimasi pemetaan ruang makan pada TPU di Jakarta menggunakan Quantum GIS dengan metode Haversine formula," TEKNIKA, vol. 18, no. 2, pp. 547-558, 2024.
24. William C. Bauldry, Computational Calculus: A Numerical Companion to Elementary Calculus (Synthesis Lectures on Mathematics & Statistics. Springer, 2023.
25. Suriya Sundaramoorthy, UML Diagramming: A Case Study Approach. CRC Press, 2022.