Automated Attendance Tracking System Using Geolocation Technologies: A Hybrid Solution for Onsite and Offsite Employees

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Abstract

Attendance is an important aspect of any workplace as it talks about how regular its employees are coming to the office. Hence attendance records need to be accurate and tamper proof. Previous methods like manual entry records, RFID scanners, QR code scanners and other methods are prone to multiple discrepancies like proxy attendance, system failure and much more which can lead to errors in attendance records which can be detrimental for any company. Thus, in this paper a new hybrid method for automated tracking attendance using a smartphone is presented. It uses modern technologies like geofencing, reverse geocoding, and facial recognition, to accurately track attendance and store the data in a secure tamper proof cloud database being managed by the company administrator through an administrative dashboard.

Keywords: Automated attendance tracking, geolocation, Wi-Fi verification.

1. Introduction

In modern workplaces like school, colleges and office which has large number of employees, there is a need for a well-organized and errorless attendance tracking system to ensure productivity, save time of employees and make it easier for the administrative department to manage attendance records. Traditional methods like manual register records, RFID scanner and QR code scanners, are not effective anymore because these methods can be easily exploited like human errors, proxy attendance and hardware limitations, which can lead to inaccurate records. To overcome these issues, we present the design of a mobile application that leverage geolocation technologies to have separate functionalities for both onsite employees whose attendance will be marked automatically when he enters or exits a geofence, and for offsite employees the attendance will be marked using reverse geocoding when they reach within a close proximity of the predefined offsite location. Facial recognition will ensure that proxy attendance can be avoided. Buffer zone will make sure that employees don't go on regular breaks in the working hour. Leaves will also be managed through the application itself. Wi-Fi in the office will be a crucial marker to ensure the employee's physical presence in the office, as they have to be connected to it all the time. A separate administrative dashboard will be present alongside the application to manage any errors that may creep in through, or if some data that is being displayed is incorrect.

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2. Literature Review

2.1 Problems faced by previous attendance systems

The RFID based attendance system is a very simple system in which every employee is assigned a RFID tag which they have to scan in a RFID scanner while entering and exiting the office to mark the attendance. Each tag has a unique number which is matched against the database when the tag is scanned by the scanner. A major issue in this system is that employees can share their RFID cards with other colleagues which can mark a proxy attendance for them. So, it is a fast way but still not very effective [1]. The QR Code based attendance system is a similar system to this as in this case students can mark their attendance by scanning a QR code which can be generated by the instructor dynamically but this system has a similar issue that is if one person shares the QR code with another then they can also mark their attendance easily while still being away from the workplace or college [2]. Fingerprint system is one of the main common methods that is used in biometric field which used to identify the individual uniquely. To enhance accuracy fingerprint-based attendance systems were introduced, but there are certain challenges. As fingerprint scanners is placed at fixed location which is not helpful for offsite work. Other challenges include failure of fingerprint recognition, which makes the system less reliable [3].

2.2 Previous systems using Geolocation Technology and their Flaws

University Smart Attendance Tracking System is an attendance tracking system using both geolocation services and IoT. In this system a geofence is created along the coordinates of the classroom, and when the student is in the classroom then only their attendance can be marked, and then for secondary verification a RFID card is used which ensures the physical presence of the student. All the attendance data is stored in a secure encrypted database. The only drawback in this system is that if students share both their phones and RFID cards with another student then they can mark proxy attendance on their behalf [4]. Teacher attendance monitoring system teaching with QR-Code and Geo Location using Android Platform is another attendance tracking system for teachers which uses geofencing and QR code to mark attendance using their mobile phones. Each teacher is assigned a unique QR code that remains constant and they have to scan this QR code while being in the predefined geofence. This system is a good effective way to ensure physical presence but it requires a internet connection every time when marking attendance. Also, there is a slight chance that some teachers may share their QR code with other to bypass this system. Or sometimes a teacher may use a fake GPS location application to spoof his location into the coordinates of the school and mark attendance [5].

Mobile Based Student Attendance System Using Geofencing with Timing and Face Recognition is a more advanced attendance tracking system that uses geofencing and face recognition for marking attendance of students. In this paper geofencing helps in verifying the physical presence of students and only marks their attendance when they are inside the geofence for at least 90% of the time, to prevent late check in or early check out, and they use live facial recognition to make sure that no proxy attendance can be marked. But this paper also does not consider the scenario where students can use a fake GPS location application to bypass the system and be inside the geofence and mark their attendance [6].

3. Methodology

3.1 Geolocation Technologies

GPS (Global Positioning System): Geolocation based attendance systems commonly uses GPS stands for Global positioning System. GPS often used for real time tracking of attendance. GPS technology works by using a receiver to gather location and time information from satellites. When a device has an unobstructed connection to at least four GPS satellites, it can determine its location with high accuracy

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anywhere on Earth [7]. In recent years, smartphones have made it easier to access GPS data, which has also helped in the development of indoor positioning systems. For example, an app called Travel Portal uses GPS and geotagging to help users plan and manage their trips in coordination with travel agencies. It also allows them to receive real time travel updates and responses to their queries [8].

Assisted GPS: Assisted GPS is an advanced version of simple GPS as assisted GPS basically uses both GPS signal and cellular network signal to accurately track a person's location up to 15 meters outside and up to 50 meters inside a building or a closed space [9].

Wi-Fi Verification: Wi-Fi stands for Wireless fidelity is basically a wireless networking technology, that allows users to connect to the internet without using any physical cables. It is commonly used in households, offices, universities and public places for easier connectivity to the internet within a certain limited area generally ranging from 100-300 feet. To connect to the internet, people need to connect to the access points which are also called Wi-Fi routers. It is a physical device which is connected to a broadband internet source using an internet fibre cable. Our phones have a Wi-Fi receiver that communicate to these routers through radio waves and hence are able to connect and use the internet [10]. Each Wi-Fi router has a specific name which is also known as the SSID of the Wi-Fi router. There is also a Basic Service Set Identifier of each router. This BSSID is unique for each router as it has the MAC (media access control) address of that router. Thus, the SSID is human readable name of that router while the BSSID is the machine-readable unique address identifier for each router. Although SSID for two devices can be same but BSSID cannot be same for any two routers. This can help us in uniquely identify each router or access point in an office or a university [11].

3.2 Tracking Techniques

Geofencing: It is a location-based technology in which a virtual fence or boundary is created around a real-world geographic area. It is useful in tracking a person's movement but with minimal interaction. When a user enters or exits this pre-defined area an event can be triggered which can be used notify that the person is in the fence. This technique can be useful in monitoring employee attendance [12].

Reverse Geocoding: It is the process of converting GPS coordinates into human readable address or place names. In this process for a specific set of coordinates, from the database a readable address is generated by checking the nearby areas and point of interests corresponding to those coordinates. Mengyu Ma in his paper suggests a method using the Global Subdivision Model called Geohash based reverse geocoding to improve the process of reverse geocoding by dividing earth into a multi grid system and each grid is assigned a geohash code. These geohash codes act as an identifier and improve the searching. Whenever a coordinate is searched it is first checked which grid it belongs to using its geohash coding and then searching is done in that grid and from the database the place whose coordinates are being checked can be found more efficiently. This method is useful when doing real time searching of address like in our case [13].

Point Clipping Algorithm: Clipping algorithm is a computational technique used to check if a certain pre-defined area is containing a given set of lines or not. If used for points then it becomes point clipping algorithm which will check if a given set of points lie in a certain area. This when combined with geolocation technologies and location-based systems in phones can be useful in marking attendance. The area will be defined using set of coordinates taken from google maps which will cover the area of the office and if the employee comes in the area, his attendance can be marked. For a pair pf coordinates (X, Y), to lie inside the perimeter it has to lie between at least ($X_{min} < X < X_{max)}$ and ($Y_{min} < Y < Y_{max}$) [14].

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3.3 Application Design

The goal is to design a mobile-based application which can automate the process of attendance tracking. In the previously presented papers geofencing is used to mark the attendance of an employee along with other supporting verification methods. But there is one consistent major flaw in them is that no system actually uses marks the physical presence of an employee, like in case of QR code-based system, the

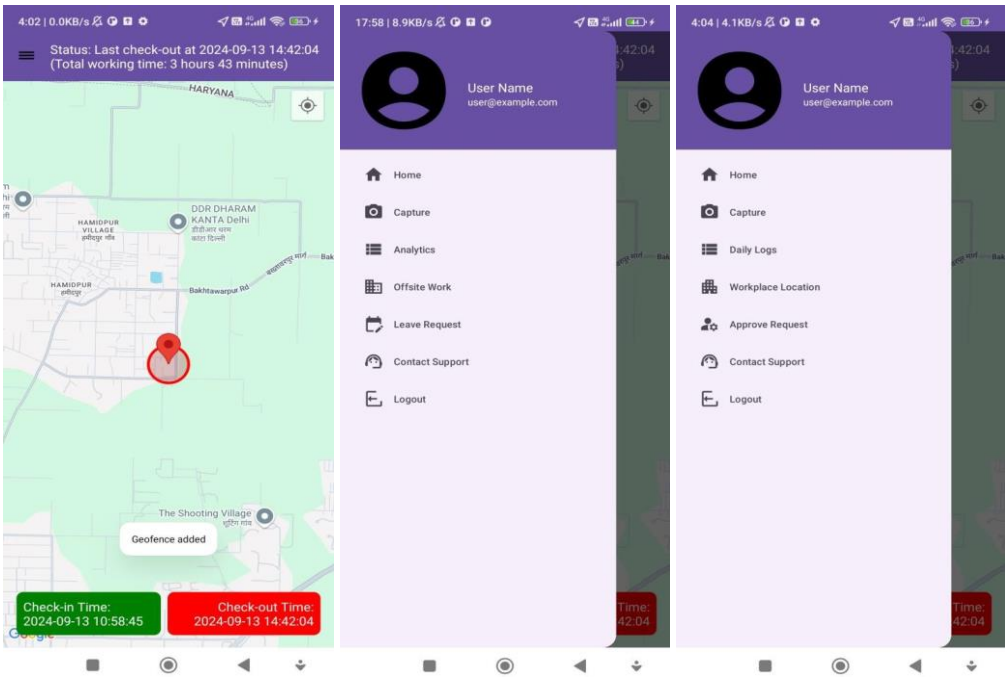

Fig.1. Interface of the application showing the geofence, employee's view and HR's view respectively

QR codes can be shared or in the RFID card system the RFID card itself can be transferred, or even when it uses facial recognition it can still be bypassed by using a fake GPS location application.

Onsite Employees: To overcome this, we have come up with the idea of using a triple parameter based system which considers all the scenarios of bypassing the system, which is using geofence as the first parameter to confirm his initial presence inside the office and then face verification to make sure the employees is not trying to mark a proxy attendance, and then third which is connecting to the office's Wi-Fi network to confirm physical presence all the time inside the office. The third layer of using the office's Wi-Fi as a parameter is simple yet effective for physical presence because to connect to any Wi-Fi router in the office, they have to be present in the range of any of the office's Wi-Fi, and thus be present in the office. The list of all the Wi-Fi routers along with their information will be stored in the form of a SSID (name) and BSSID (router's MAC address) pairs. When an employee connects to the office's Wi-Fi, the application will check if the connected Wi-Fi details are stored in the local database or not. After Cross checking if the details are matched then the third parameter will also be satisfied. This way using the Wi-Fi, we can make sure that even if someone tries to use a fake GPS location application, he cannot be successful in marking the attendance. Also, the application features a buffer zone, which is an outer layer to the main geofence that allows employee to go outside the range of Wi-Fi for a short break, which will still mark attendance without a Wi-Fi connection but only for a short period of a time, and if they remain in the buffer zone for a time longer than the allowed time, then their attendance will be cut-off. There will be a cooldown period too for staying in the buffer zone, so that the employee cannot exploit this feature by staying in the buffer zone and returning inside the geofence just before the allowed period time ends and then go back into the buffer zone again. To construct this buffer zone, we will use point clipping algorithm, which a simplified version of a geofence as it will

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only send data on basis of the polling rate, we set on it, which means the times we want it to scan for employee presence, and can be manually adjusted to our preferences.

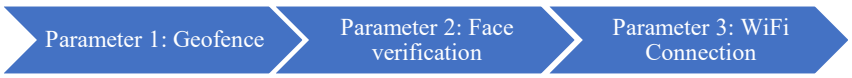

Fig.2. Triple parameter system for onsite employees

Offsite Employees: For offsite workers, we will use reverse geocoding to mark their attendance. When an employee is going for an offsite job, first of all they have to take approval from their human resource (HR) manager. They can do this from the application itself as it will have both the option to apply for offsite work and the HR manager can approve it from the application too. This is made possible with the help of a routing mechanism using an API server, which will take requests from the employee and route it to HR. Then the approval status is sent back to the employee using the similar process. After getting the allowance, they will report to the designated offsite location from where they will have to manually check in. Once they press the check in button, their coordinates will be converted into readable human addresses using reverse geocoding. This address which is being derived from the reverse geocoding algorithm will be compared against the predefined designated address, if they match their attendance will start getting marked. Further they will have to also do face verification to avoid proxy attendance.

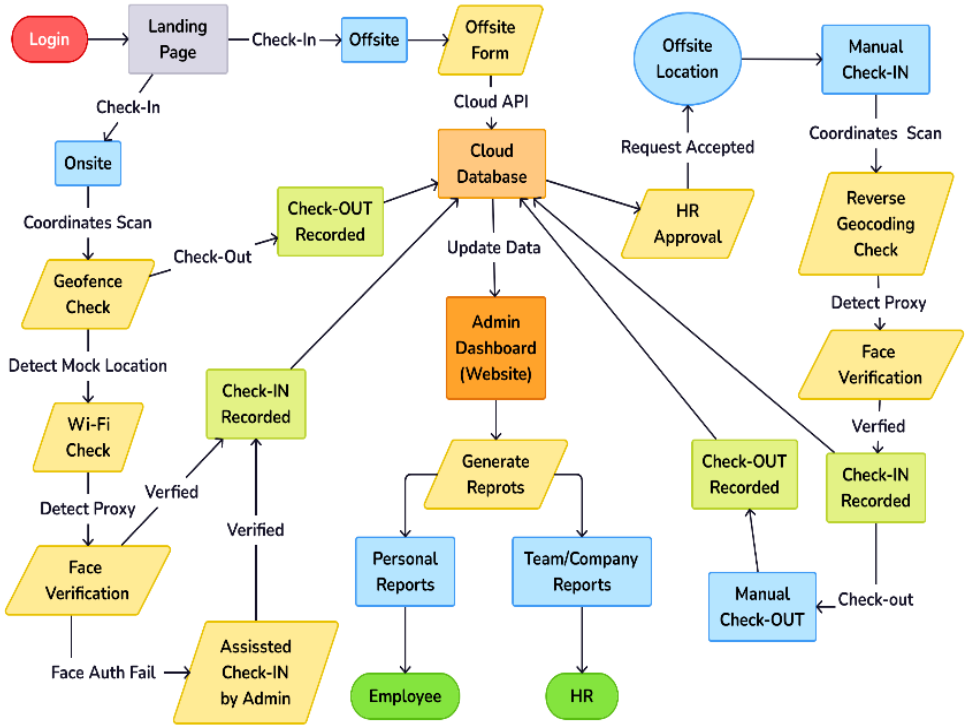

Fig.3. User Flow of how the attendance system works for both onsite and offsite employees.

3.4 System Architecture

The whole attendance system can be divided into five separate layers which are the application layer, API server layer, database layer, admin dashboard layer and external services. The application layer consists of three major sections the user interface, the main features of geolocation services and lastly the requests section. The user interface consists of two branches the employee interface and the HR interface. Both these interfaces can be accessed from the same login page depending upon the user permissions. They allow the main access of services and provide control to the users. They also provide the analytics of the attendance of users. The geolocation services which is the second section consists of the geofencing service, buffer zone service, face recognition and Wi-Fi checking. The data generated

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from all these tracking services are sent to the database via APIs. Finally, the third section which is the requests section, has two main branches, the offsite request section used by the respective field employees and the leave section which help in applying for leaves from the app itself.

The API server layer has majorly three functions which are request handling, real-time attendance services, and HR request processing. The request handling section helps in dividing the user interface of the app into employees and HR based on the login credentials. The real time attendance helps in the tracking the attendance of employees either onsite or offsite by tracking the check-in/out times, validates whether they have validated the Wi-Fi and face recognition, enquires about the employees in buffer zones, sends push alerts wherever needed and finally send all the information that is coming from the application to the online database. Finally, the HR request processing section is useful in routing the request generated by the employee and send it to the respective HRs, and the re-routing the information provided by the HRs, back to the employees. The database layer contains all the records of different kinds including employees, their information, their attendance records. They also have the records of the requests and their current status. It also includes all the records of the different geofence's and buffer zone coordinates. The details of all the Wi-Fi router are stored in the database too. The online database helps in keeping the records tamper proof and safe. A separate administrative dashboard managed by the super admin will be provided which will manage the database of the whole workplace and will be responsible if there are any errors within the application. They will be responsible for new user enrolment, handles geofences, Wi-Fi details, and generate reports of the whole company. They will also manage manual over rides and view audit reports.

For creating the android application, we will use Java as the backbone language for the application, its user interface will be designed using XML, and for geofencing we will use Google Maps cloud and its API too. For areas with lower internet connectivity, we will use offline database to store data and for that we will use SQLite to connect the backend to the local database and for cloud storage we will use Firebase which will provide secure and tamper proof records. We will use React.js to build the frontend and node.js for backend for both the admin dashboard and the API server. Firestore authentication will be used for authentication for both website and android application.

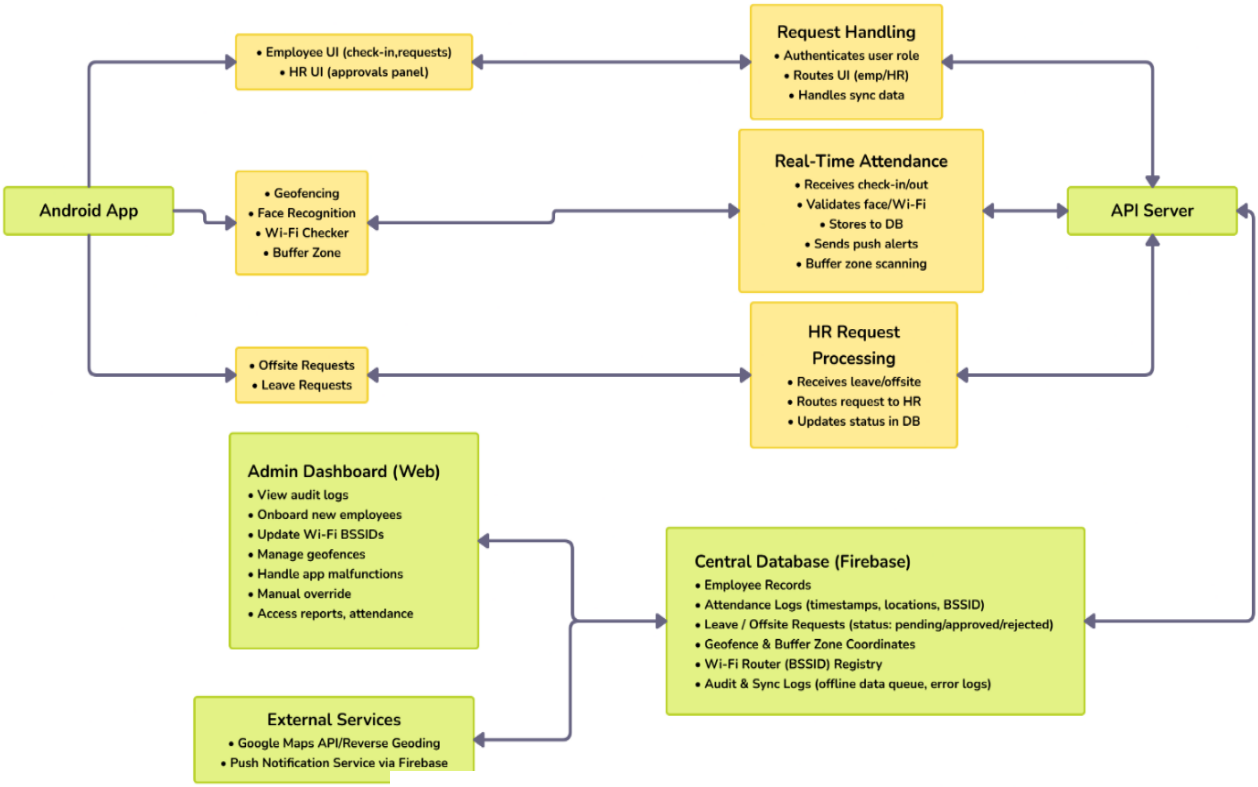

Fig.4. System Architecture Diagram

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3.5 Privacy, Security, and Network Dependency Considerations

3.5.1 Privacy Considerations

The application collects sensitive data from the employees such as facial data, coordinates data and also Wi-Fi data. Thus, to preserve employee privacy we will implement the following measures:

Data Minimization: The app only collects necessary data required for attendance tracking, and no extra data will be tracked.

Local Face Recognition: Face recognition is performed using a local module bundled inside the app itself, and the data collected is not sent to any online database. This avoids facial data leak.

Anonymization and Hashing: The necessary details of employees and Wi-Fi routers and even coordinates will always be hashed and encrypted before being transmitted online.

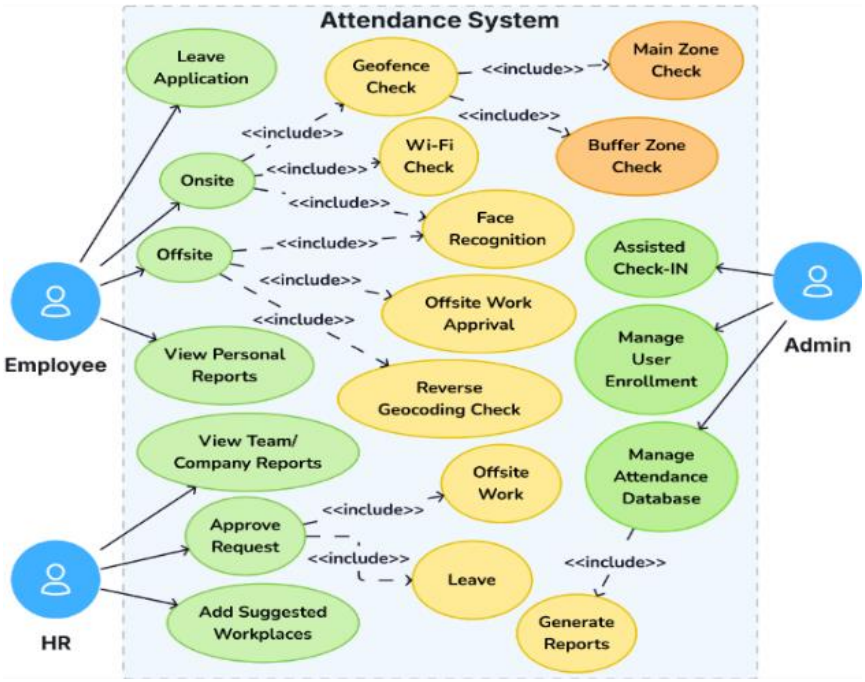

Fig.5. Use cases describing how the employees, the HR manager and the super admin will use the whole system.

Transparency and Consent: The application will show clear prompts explaining the use of location and facial data. A privacy policy is made available within the application itself to highlight data usage, retention, and user rights.

3.5.2 Security Considerations

For data protection and security of employees the following measures are taken:

Authentication and Authorization: Firebase authentication service is used for login into both the application, server and the web dashboard. Access control defined on the basis of roles restricts functionalities between employees, HR, and administrators.

Data Encryption: All the data is encrypted while being sent to the database using HTTPS.

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3.5.3 Network Dependency Considerations

Locally working geofence and face recognition: The geofence will be handled using predefined coordinates, enabling the tracking system to track check in/out time entirely offline, and the face recognition module bundled within the app itself helps in local verification.

Offline Attendance Mode: Attendance check-in/out data is cached locally using SQLite and when internet connectivity is unavailable and synced online when internet is available.

4. Conclusion

The proposed Automated attendance tracking system effectively addresses the challenges faced by traditional methods by making use of geolocation technologies, AI powered facial recognition and cloud storage. Through geofencing the process of marking attendance is automated, using facial recognition proxy attendance is prevented, using Wi-Fi physical presence of the employee can be confirmed and using reverse geocoding offsite work attendance can be verified. All the records of attendance are being monitored by the super administrator having access to the administrative dashboard. Thus, this application and website dashboard ecosystem enhances efficiency, transparency, and security in attendance management making it convenient for both employees and HR personnel. The application also streamlines the process of getting approval for both offsite work and leaves from the HR thus saving time of both parties. This system is also beneficial to the environment as it requires no additional physical device like a scanner, thus reducing electrical waste. Future prospects for this system could include using of the office's cameras to randomly check for employee presence, while machine learning algorithms can also be integrated which can track patterns in attendance records and analyse them to provide useful insights.

References

1. Joshi, A., Ahmad, A., Saxena, A. and Juneja, P., 2021. RFID based attendance system. *Int. J. Modern Trends Sci. Tech*, *7*, pp.40-43.
2. Patel, A., Joseph, A., Survase, S. and Nair, R., 2019, April. Smart student attendance system using QR code. In *2nd International Conference on Advances in Science & Technology (ICAST)*.
3. Chandramohan, J., Nagarajan, R., Dineshkumar, T., Kannan, G. and Prakash, R., 2017. Attendance monitoring system of students based on biometric and gps tracking system. *International Journal of Advanced engineering, Management and Science*, *3*(3), p.239799.
4. Fischer, G.A., Ojong, V. and Inametic, E., DESIGN AND IMPLEMENTATION OF A UNIVERSITY SMART ATTENDANCE TRACKING SYSTEM USING GEO-LOCATION AND IOT.
5. Amirulloh, I., d Iskandar, I., Apriyani, Y., Warnilah, A.I., Purnia, D.S. and Surahman, M., 2020, November. Teacher Attendance Monitoring System Teaching with QR-Code and Geo Location using Android Platform. In *Journal of Physics: Conference Series* (Vol. 1641, No. 1, p. 012030). IOP Publishing.
6. Babatunde, A.N., Oke, A.A., Babatunde, R.S., Ibitoye, O. and Jimoh, E.R., 2022. Mobile based student attendance system using geo-fencing with timing and face recognition. *J. Adv. Math. Comput. Sci*.
7. Bajaj, R., Ranaweera, S.L. and Agrawal, D.P., 2002. GPS: location-tracking technology. *Computer*, *35*(4), pp.92-94.
8. Maryam, A., Siddiqui, N., Qadeer, M.A. and Umar, M.S., 2016, July. Travel management system using GPS & geo tagging on Android platform. In *2016 Thirteenth International Conference on Wireless and Optical Communications Networks (WOCN)* (pp. 1-6). IEEE.
9. Djuknic, G.M. and Richton, R.E., 2001. Geolocation and assisted GPS. *Computer*, *34*(2), pp.123-125.
10. Al-Alawi, A.I., 2006. WiFi technology: Future market challenges and opportunities. *Journal of computer science*, *2*(1), pp.13-18.
11. Mwinuka, L., 2022. *User-side wi-fi hotspot spoofing detection on android-based devices* (Doctoral dissertation, NM-AIST).
12. Küpper, A., Bareth, U. and Freese, B., 2011, October. Geofencing and background tracking–the next features in LBSs. In *Proceedings of the 41th Annual Conference of the Gesellschaft für Informatik eV* (pp. 5-9).

13. Ma, M., Zhong, Z., Guo, N., Jing, N. and Xiong, W., 2016, August. An efficient reverse geocoding method based on global subdivision model. In *2016 24th International Conference on Geoinformatics* (pp. 1-9). IEEE.
14. Rahmatulloh, A., Rianto, R. and Shihab, M.Q., 2019. Point Clipping Algorithm on Employee Presence Application for Geolocation of Employee Position. *Kinetik: Game Technology, Information System, Computer Network, Computing, Electronics, and Control*, pp.345-356.

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