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Optimized Pharmaceutical & Hospital System

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Abstract: Admin Dashboards and Salesman Dashboards offer real-time storage, syncing, and support for access with ease for convenient usage with Firebase integration. Use of Firebase real-time database or Firestore can be applied for updating and storage of confidential data such as Order Management records (medical medicine orders from doctors), Punch-In & GPS Tracking logs (work hours and location marks), and Inventory Check data (amounts). Assigned Doctor & Chemist Lists are displayed to salesmen in real-time, and Sales Reports are automatically calculated by Firebase cloud functions to compute daily/monthly/yearly amounts. Leave Management requests are centralized and visible to admins using the Admin Dashboard. For admins, Firebase drives Total Sales Overview with real-time sales trends, Salesman Management monitoring (orders, GPS traces, and performance reports), and real-time Leave Request approval in real-time. Real-time tracking employs Firebase live update capabilities to monitor system activity, and Inventory Update capabilities employ Firebase for secure batch number recording, expiry, and stock number recording. Firebase authentication facilitates role-based access (salesman/admin), and Firebase cloud-based infrastructure scalability facilitates guaranteed data storage, regulatory compliance, and synchronization to all devices in real time for effective automation of the selling processes of pharmaceuticals. The platform is complemented by a medical delivery and hospital inventory management robot. The robot is manually teleoperated remotely through teleoperation for remote operation, allowing precise navigation and task performance. The solution provides flexibility in dynamic conditions to enable human operators to exert control over robot movement as needed.

Index Terms - Firebase Realtime Database, Firestore, GPS, Cloud-Based, Teleoperation Control Systems, Role-Based Access Control (RBAC), Automated Sales Analytics, Secure Batch-Level Inventory Tracking, Firebase Cloud Functions.

I. INTRODUCTION

Integration of web development and robotics has revolutionized inventory management and sales automation in pharma logistics. Easy solutions require real-time data, secure storage, and role-based access to manage sensitive medical data, e.g., batch-level inventory management, GPS histories, and order history. Firebase platforms, Firestore, and Realtime Database are essential tools to enable scalable, low-latency synchronization of dynamic data sets [1]. The systems enable real-time updation of sales dashboards, inventory queries, and leave management to enable coordination among administrators and field sales personnel [3]. Teleoperation platforms rely on the seamless integration of multiple sensing technologies to ensure precise collision detection, environmental perception, and accurate localization. [2]. This platforms increase logistics agility through remote control of medical delivery robots in changing environments. This highlights the need for teleoperation platforms to enable smooth cooperation between humans and software-based systems [4]. The systems depend on manual input, but the underlying infrastructure is built to be flexible, allowing for future updates that will focus on autonomy. These developments fit into the broader trend of improving human-robot teamwork using adaptable software tools like Gazebo and RViz2 [7].

II. LITERATURE SURVEY

Web integration of teleoperated robots into dashboards has turned drug logistics into a real-time analytics, secure storage of data, and remote control operations. This overview pinpoints some of the most significant breakthroughs and vulnerabilities in these areas on the basis of some of the most recent studies.

2.1. Pharmaceutical Logistics Dashboard Systems

Pharmaceutical Logistics Dashboard Systems Dashboards built using web development tools can leverage cloud platforms to bring together real-time data streams, helping businesses make smarter decisions. According to Kumar and Michael (2021), Firebase—a popular cloud service—can be used to sync important data like sales records and inventory levels in real time with minimal delays. This makes sure that all the devices, whether for field sales or admins, show equal and updated information [1]. For health care companies, Wang and Liu (2022) recommend how secure cloud infrastructure can deal with sensitive inventory data, such as batch numbers and expiration dates. They propose encryption and role-based access control (RBAC) to ensure such data is not misused [3]. Zhang and Qiu (2022) also propose the application of RBAC in health care databases, proposing Firebase's security rules as a means to achieve high levels of privacy like HIPAA compliance [8]. For purposes of improving sales performance, Chen and Zhang (2020) recommend the adoption of GPS tracking on dashboards. This will enable organizations to monitor routes covered by field sales staff in an effort to improve resource utilization and greater coordination with Punch-In systems for attendance and task assignment purposes [12].

2.2. Robotics and Teleoperation in Medical Logistics

Teleoperation systems enable remote control of robots in sophisticated scenarios like hospitals. According to Siciliano and Khatib (2016), basic frameworks for robot modelling and control are essential for designing teleoperated platforms [2]. Nir and Shvalb (2023) highlight the role of teleoperation in medical logistics, emphasizing its adaptability in unstable situations, such as dynamic hospital layouts [5]. Latency, a critical challenge in teleoperation, is addressed by Al-Fuqaha and Guizani (2019), who propose edge computing as a solution to minimize delays in command transmission, ensuring real-time responsiveness [6]. Fink and Kumar (2021) advocate for hybrid systems that combine manual teleoperation with future autonomous capabilities, such as semi-autonomous stock restocking [11]. Rausch and Koubek (2021) connect teleoperation to human-robot collaboration, proposing analytics-based task prioritization to optimize stock control processes [7].

2.3. Predictive Analytics and Machine Learning Platforms

Machine learning (ML) enhances in-store sales forecasting and inventory management within cloud systems. According to Kim and Lee (2023), integrating ML with Firebase can forecast sales trends, automate reporting, and minimize human oversight [10]. Cloud computing's scalability, as highlighted by Smith et al. (2024), supports resource-intensive predictive analytics by providing on-demand processing capabilities. This is consistent with Firebase Cloud Functions, which enable automated inventory alerts, such as stockouts or expiry notifications, based on historical patterns [12].

2.4. Security and Compliance in Healthcare Cloud System

The care logistics demand the highest level of data protection to cater to regulatory requirements like GDPR. Encryption and audit trails for medicine are necessary in stock systems to protect sensitive data [3]. Furthermore, Role-Based Access Control (RBAC) deployments in Firebase have been seen to deny unauthorized staff from accessing sensitive datasets, like doctor's orders [8]. Such practices are needed to provide data integrity in multi-user systems where administrators and salespeople work simultaneously [3]. Furthermore, RBAC provides effective collaboration while protecting sensitive healthcare information [8].

2.5. Web Development & Robotics Integration with Firebase

Cloud platforms are supplemented by edge computing, which minimizes latency in communication among robots. Al-Fuqaha and Guizani (2019) illustrate how edge nodes process data from sensors locally before sending critical updates to the cloud, conserving bandwidth usage [6]. Teleoperation systems benefit from this architecture, as it enables low-latency command execution, while Firebase supports centralized data storage and analytics for such systems [11].

III. PROPOSED SYSTEM

The proposed system offers a web-based teleoperated robotics solution to propel pharmaceutical logistics optimization based on real-time data synchronization, secure inventory management, and responsive remote control. Conventional autonomous systems for tracking independent sales and inventory management fall short. Meanwhile, the offered platform combines Firebase Cloud Infrastructure and ROS2-web-based teleoperation platforms to implement dynamic workflows, regulatory adherence, and future autonomy [1].

System Purposes:

3.1. Real-Time Dashboard Coordination: An integrated dashboard collects robot activity, stock, and sales data in real-time. This is achieved through cloud-based data streaming concepts [1]. Edge computing is also employed to minimize data processing and communication latency [6]. GPS tracking also enables coordination among field sales teams and inventory systems [12].

3.2. Secure Teleoperation of Inventory Robots: Secure interfaces allow robots to be remote teleoperated for inventory stocking and scanning. Role-based access control (RBAC) guarantees that only the correct users with the correct rights are allowed to ensure safe operation [3].

3.3. Regulatory-Compliant Data Management: Regulations like HIPAA and GDPR in the healthcare sector are complied with by the system. Secure cloud-based databases store individual medical inventory information [3]. Traceability and integrity of data are ensured by encryption techniques and audit trails [5].

3.4. ROS2-Gazebo Simulation to Test Task: ROS2-Gazebo simulations allow robot movements to be tested, e.g., path planning and collision avoidance, in virtual environments before deployment [2]. Simulations allow the performance of the task to be optimized and reduce the risks of operations [9]. The simulations also confirm human-robot collaboration to facilitate easy integration into workflows [7].

3.5. Scalable Firebase Integration: The Firebase Platform is capable of scaling resources elastically and enable low-latency communication among distributed inventory systems, sales teams, and robots [4]. Predictive inventory optimization and sales analytics are enabled with machine learning models integrated into the platform [10].

IV. System Architecture:

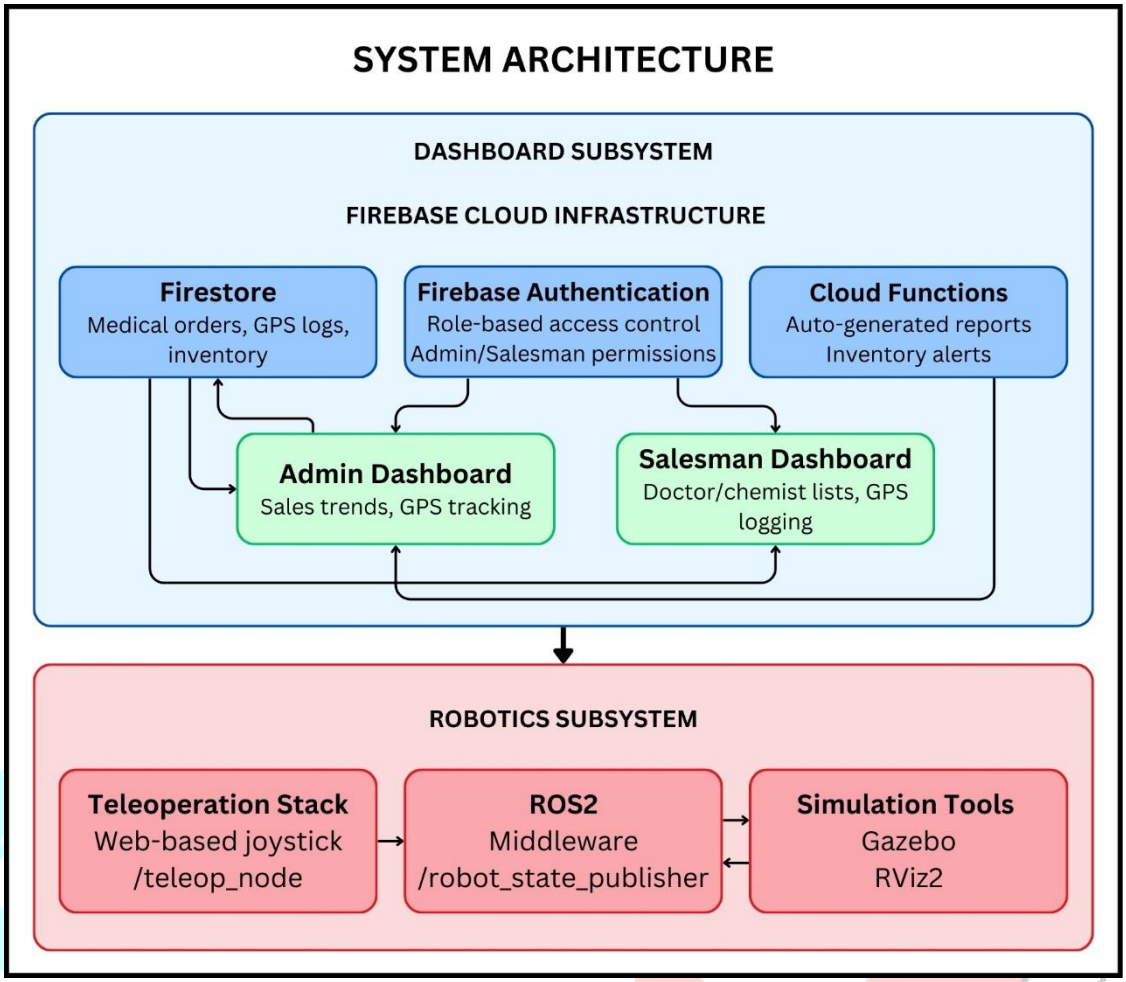

Fig. 1. System Architecture

The design of the system consists of two interdependent subsystems: the Dashboard Subsystem and the Robotics Subsystem, and are constructed to be modular and scalable. The System Objectives are:

4.1 Dashboard Subsystem

The Dashboard offers a full interface to track sales trends, leave request approval, and salesman performance tracking through GPS analytics. The Salesman Dashboard provides role-restricted visibility to assigned doctor/chemist lists and inventory statuses. Firebase Authentication offers role-based access control (RBAC) support for secure access to data using email/password or OAuth [8]. Cloud Functions trigger activities like creating sales reports (daily/monthly/yearly) and stock alerts (stockouts, expiry) by incorporating Firestore data [3].

4.2 Robotics Subsystem

The simulation and teleoperation are emphasized by the robotics subsystem. An Internet-based teleoperation interface provides commands (e.g., velocity, waypoints) to ROS2 Nodes, which are combined with physics simulation using Gazebo and RViz2 for real-time representation of robot status (position, task progress) [11]. That is, ROS2 data (e.g., sensor logs, simulation results) are stored on the local machine running the robotics stack and not propagated to Firestore, and thus latency does not depend on the cloud [6].

4.3 Data Flow

- **Dashboard Workflow:** Admin/salesman inputs are retained in Firestore and subsequently invoke Cloud Functions to update dashboards and generate analytics. Successfully updated [1].
- **Robotics Workflow:** Operator instructions are resolved through ROS2 nodes to Gazebo/RViz2, and telemetry information (such as robot location) is returned to the teleoperation control interface for closed-loop control [11].

4.4 Security Scalability

Firestore security rules and Firestore RBAC separate sensitive health information from unauthorized users, and offline capability brings resiliency [8]. Decoupling makes for future upgradation, i.e., implementation of autonomous path planning to the robot subsystem without interrupting dashboard workflows [7].

V. METHODOLOGY

5.1 System Design

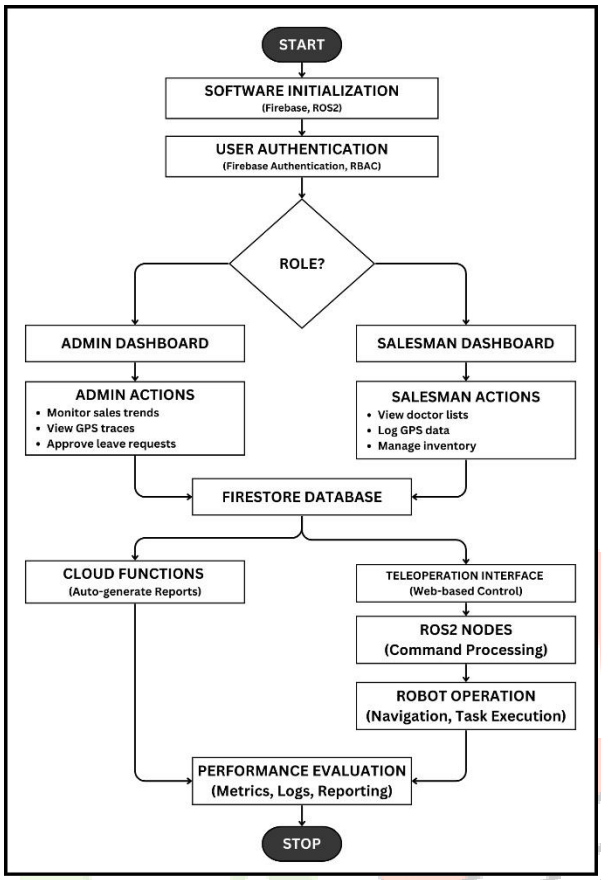

Fig. 2. Flowchart

The system starts by combining Firebase, ROS2, and ROS to enable real-time communication between software components using client-server principles [1]. Firebase Authentication ensures secure login for admins and salesmen through email/password or OAuth, following role-based access control (RBAC) for better security [8]. Firestore Database stores important data like medical orders, GPS logs, and inventory details, keeping all devices updated in real-time [3]. Admins use a React.js dashboard to monitor sales trends, approve leave requests, and track GPS histories, while salesmen use dashboard to view doctor lists and inventory statuses [5]. Cloud Functions automate tasks like generating sales reports and sending inventory alerts by responding to changes in Firestore data [6].

For robots, a web portal allows users to send commands (like navigation instructions) to ROS2 nodes, which work with simulation tools like Gazebo and visualization software like RViz2 [2]. Performance metrics such as GPS accuracy and task duration are saved in Firestore for analysis, while ROS2 data is stored locally to reduce delays [12]. The system is designed to be modular, making it easy to add autonomous features to the current teleoperation processes in the future [11].

5.2 Dashboard Development

The dashboard is user-need-centered. Firebase Authentication is utilized for implementing role-based access control (RBAC) in such a manner that only registered users such as admins and salesmen can update authorized datasets [8]. Firestore is utilized to maintain dynamic data like medical orders, GPS coordinates, and inventory data, and security rules are implemented for following HIPAA rules [3].

The Admin Dashboard is created using React.js, which listens to Firestore to show real-time updates on sales trends and leave requests [1]. The Salesman Dashboard is built with Flutter, providing a mobile-friendly view of doctor lists and inventory status [3]. Cloud Functions are used to automatically generate sales reports and send inventory alerts, such as stockouts, reducing the need for manual work [4]. Feedback from stakeholders and mock designs help improve the dashboard's design until it is easy to use and works well on all devices [7].

5.3 Robotics Simulation Configuration

The robotics system uses ROS2 for flexible and modular control [2]. A web-based joystick interface sends commands to ROS2 nodes, which connect to Gazebo for physics simulations and RViz2 for visualizing the robot's real-time status [4]. The simulation environments mimic hospital floor plans, allowing operators to practice tasks like stock delivery in a safe virtual setup [5]. ROS2 nodes are designed to support future upgrades, with placeholders for advanced path planning algorithms like A* [2]. This approach allows workflows to be tested in simulations first and then applied in real-world settings [9].

5.4 Security Implementation

Firebase builds security into design. Firestore Security Rules determine data access based on roles such as admin or salesman [8]. Firebase Authentication allows for secure sign-in using mechanisms like email-password and OAuth, with encryption securing user credentials [8]. Patient medical data like batch numbers and dates of expiration are encrypted in motion and at rest to ensure compliance [3]. Auditing access logs and test data on a regular basis ensures ongoing compliance and prevent accidental inventory modification [6].

5.5 Testing and Validation

- **Dashboard Testing:** Unit testing ensures that Firestore Data, e.g., GPS traces, are precise and reliable [1]. Useracceptance testing (UAT) to ensure dashboards are functioning smoothly, respond quickly, and utilize role-based access control (RBAC) rules [7].

- **Robotics Testing:** Teleoperation tests are conducted to observe how robots respond to commands and navigate without delay [5] and task completion times are recorded for future references [9].

Feedback from both the test stages helps to make the system more reliable for actual application in pharmaceutical supply
chain [11].

5.6. Future Scalability

The above system gives pharmaceutical logistics a platform that incorporates teleoperated robots and cloud integration. Future research will focus on enhancing autonomous navigation with machine learning models for real-time obstacle detection, reducing the requirement for human control [2]. The platform can also be extended to surgical robots, i.e., neurosurgery or dental surgery, through cloud infrastructure to enable remote collaboration between experts [5].Future development will investigate applying edge computing to reduce teleoperation latency, particularly in applications such as robotic inventory picking [6]. Scaling the platform to accommodate groups in healthcare settings using ROS2 swarm algorithms will boost large-scale inventory management productivity [4]. Adding wearable sensors to track the health of field salespeople in real time will extend the platform's capabilities to end-to-end healthcare staffing management [9].

VII. RESULT AND CONCLUSION

6.1 RESULT

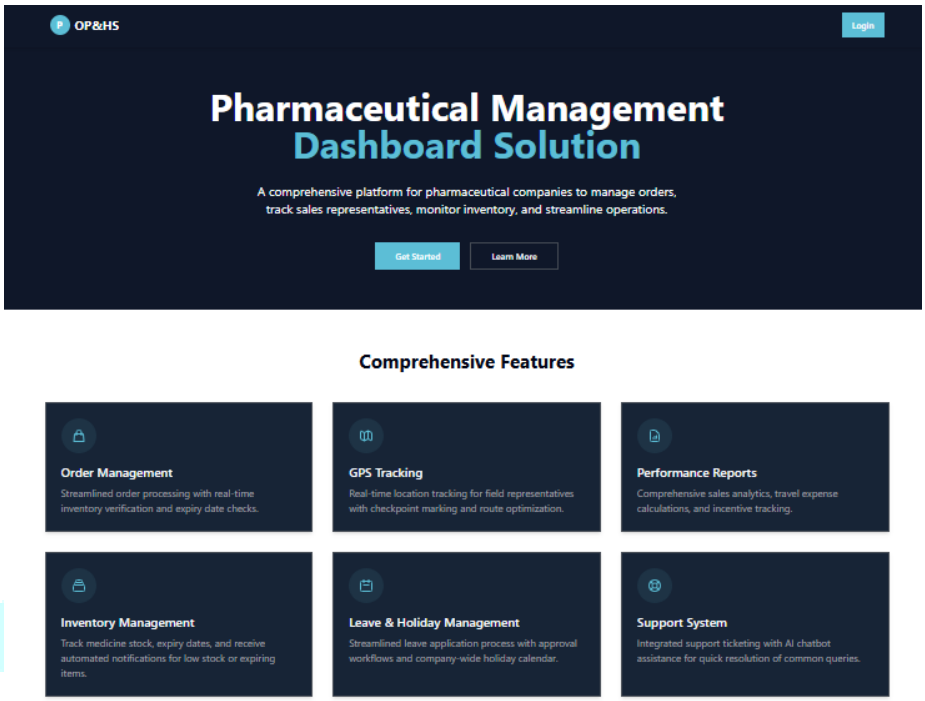

Fig. 3. Landing page

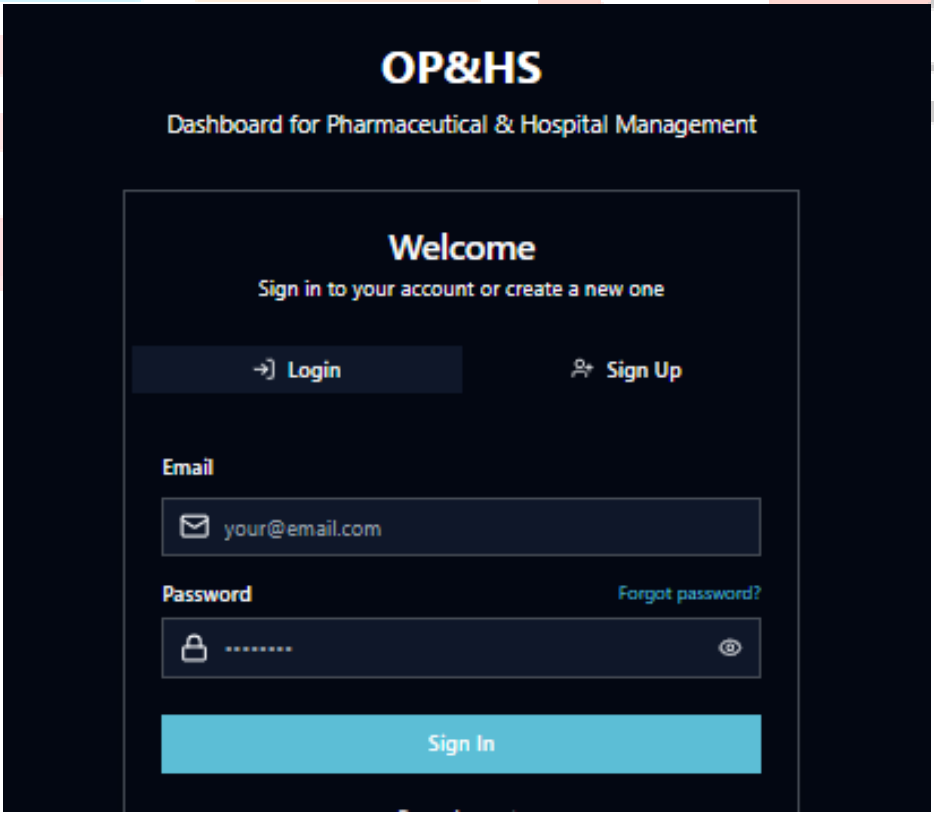

Fig. 3. Login & Sign Up page

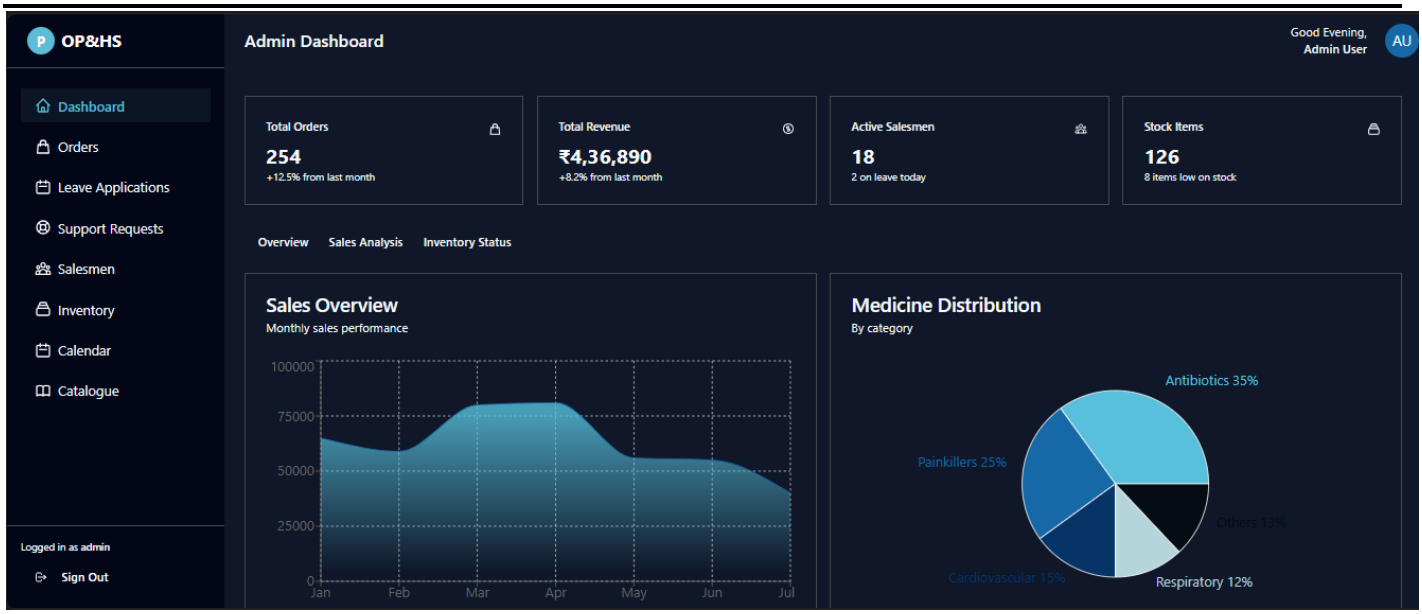

Fig. 5. Admin panel (Dashboard)

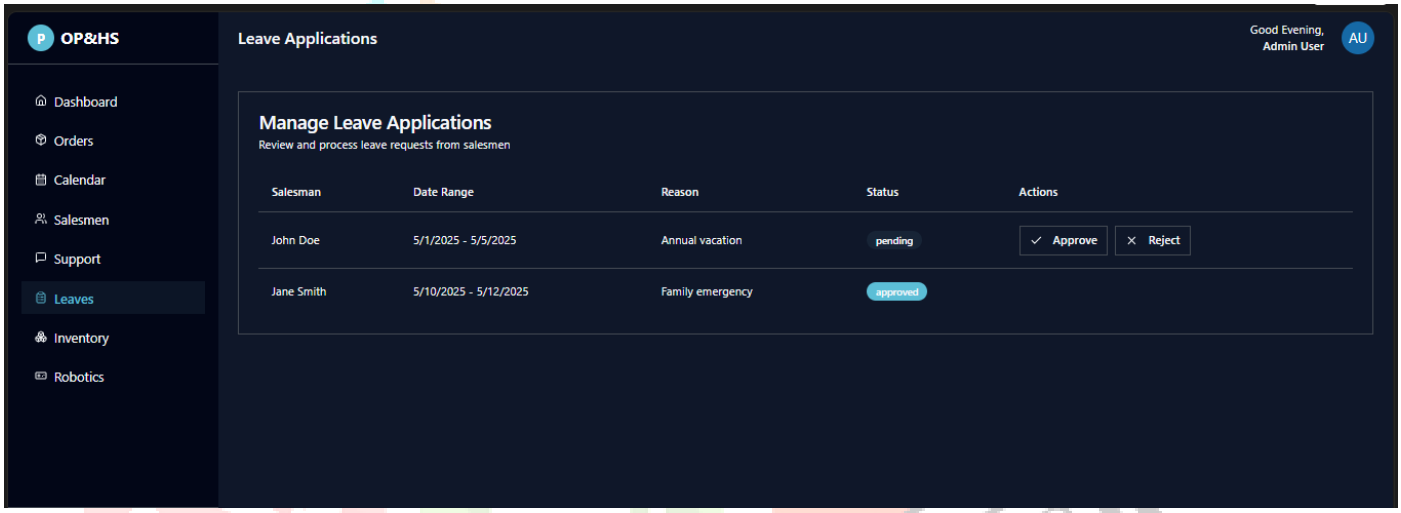

Fig. 6. Admin panel (Leave)

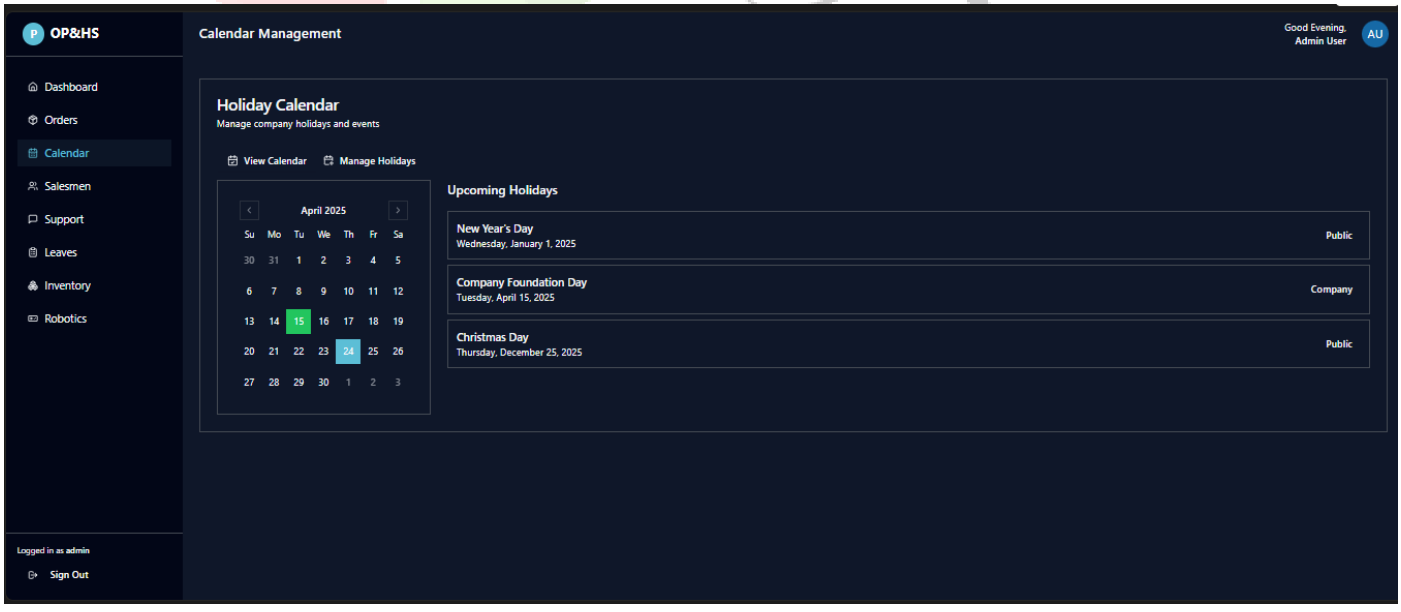

Fig. 7. Admin panel (Holiday Calendar)

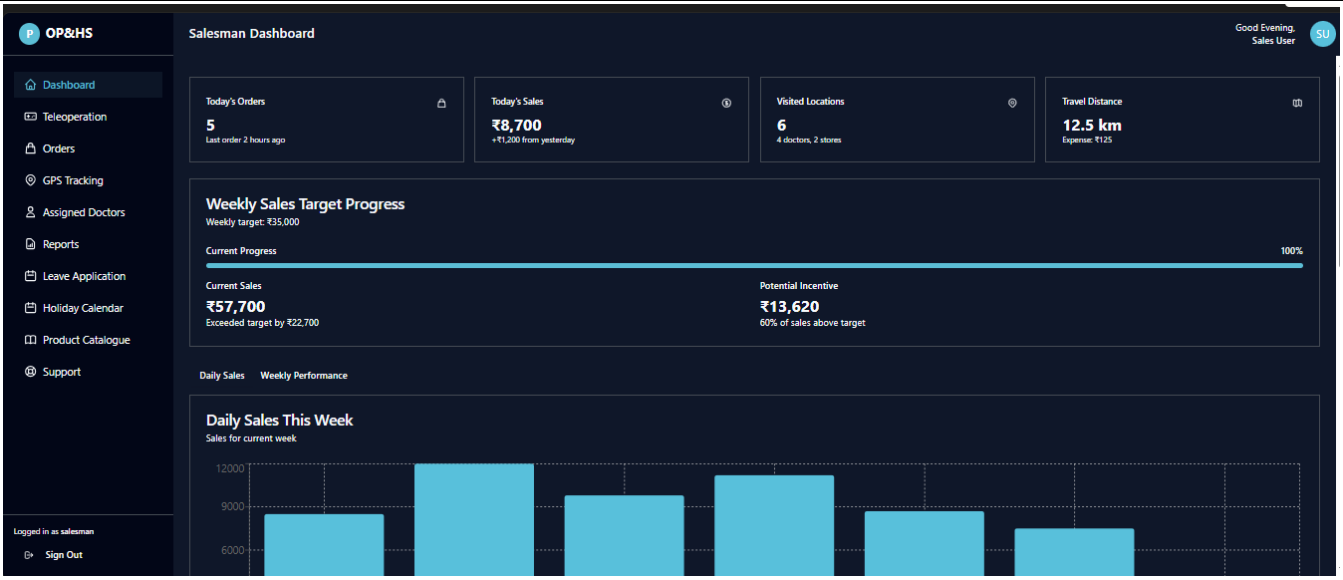

Fig. 9. Salesman panel (Dashboard)

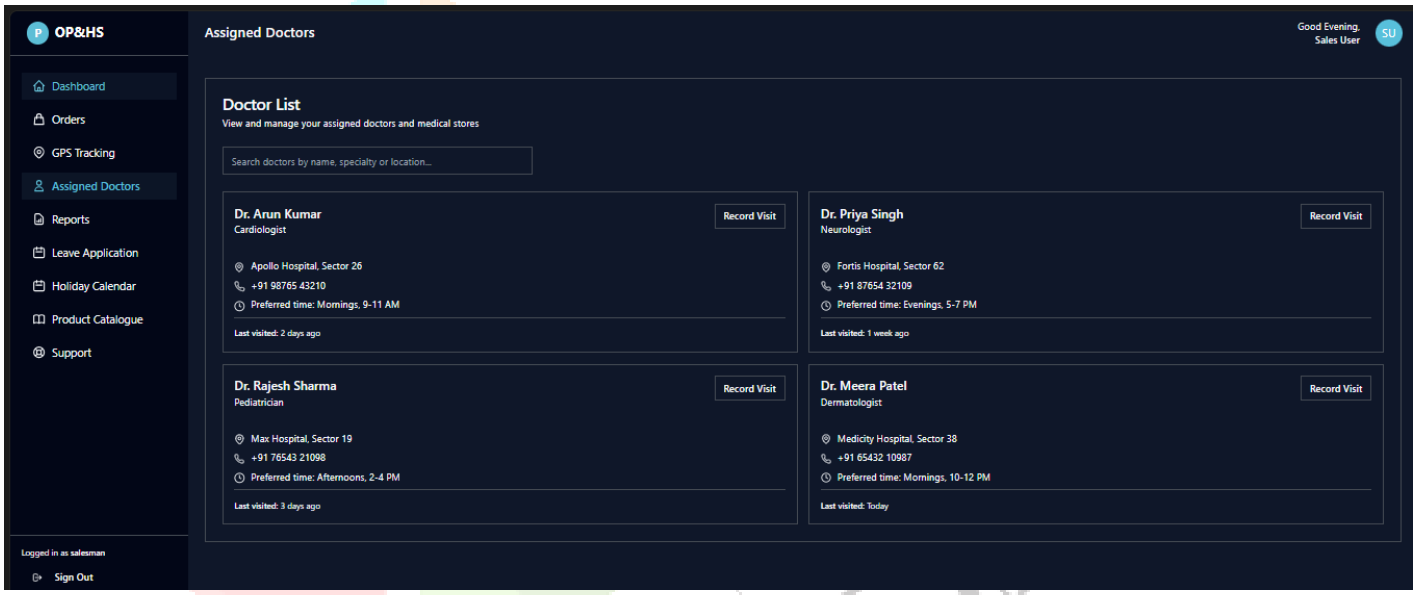

Fig. 10. Salesman panel (Assigned Doctors)

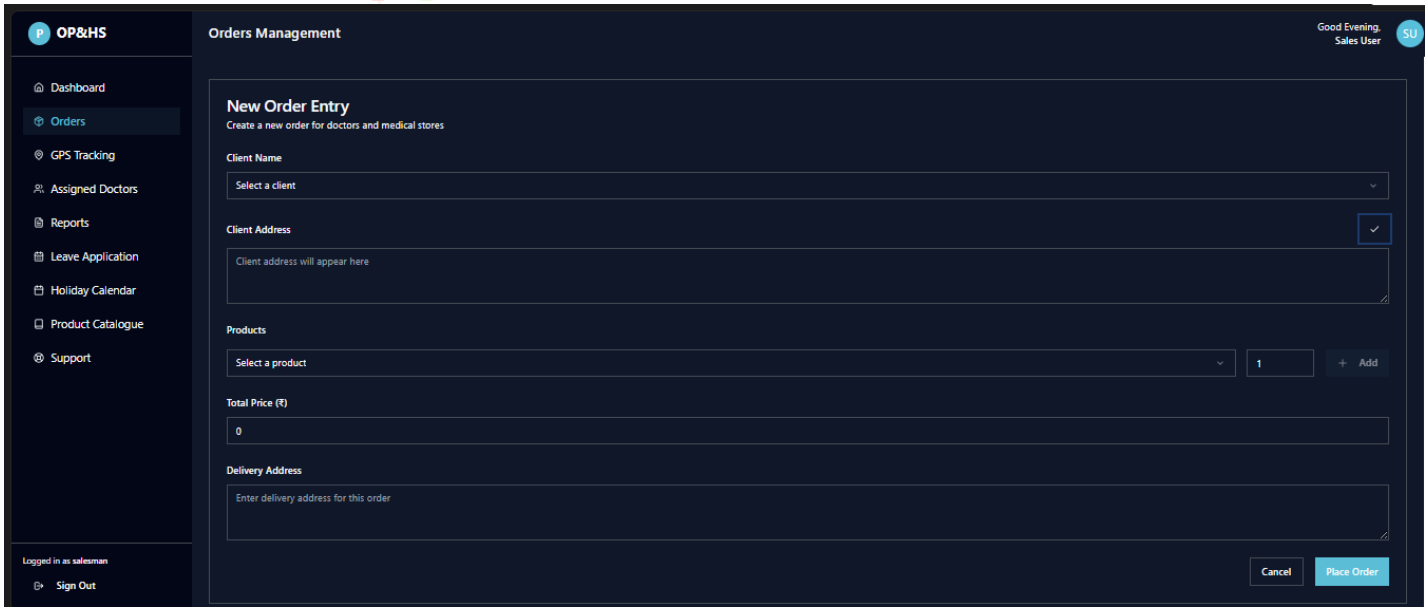

Fig. 11. Salesman panel (Orders Management)

6.2 CONCLUSION

The web-robot system detailed here solves the core problems of pharmaceutical logistics such as real-time inventory management, regulatory compliance, and remote handling [1]. With Firebase Cloud, the system enables fast, secure sharing of medical information (e.g., batch records, GPS logs), and dynamic stock tracking and sales analysis dashboards [4]. The system additionally uses ROS2 and Gazebo simulations for robot navigation within dense hospital environments and identifying areas of potential logistial malfunction [9].

This article highlights how integration with web development and robots can further boost the efficiency of pharmaceutical logistics, particularly through functionality such as role-based access control (RBAC) and report automation [8]. Technologies such as autonomous navigation can reduce delays and enable more complex operations, like surgical robotics [6]. By leveraging advancements in secure data processing and scalable cloud platforms, this system provides a roadmap for next-generation pharmaceutical logistics solutions [5].

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