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NOOKHATHA

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Abstract

The "NOOKHATHA" application is a technology-driven platform designed to support Bahraini fishermen by simplifying administrative processes, improving their quality of life, and aligning with Bahrain's Vision 2030. It streamlines fishing license applications, eliminates paper-based procedures, and includes a real-time safety tracking system to monitor fishermen's safety during maritime trips. The app also features a direct sales platform, boosting fishermen's income by reducing reliance on intermediaries. As a multi-stakeholder platform serving Bahrain's fishing industry, "NOOKHATHA" provides essential information on maritime laws, weather updates, and geographical boundaries, promoting awareness of marine resource conservation and sustainability. By integrating technology with tradition, the platform preserves Bahrain's maritime heritage while addressing global challenges and transforming traditional industries through digital innovation. This research examines the development, implementation, and societal impact of "NOOKHATHA" in safety, sustainability, and economic empowerment, aiming to inspire new digital initiatives and inform best practices for e-government transformation.

Keywords

Bahraini Fishermen, Vision 2030, Safety, Maritime Laws, Sustainability, Fishing License, Geographical Boundaries .

I. INTRODUCTION

Today, technology can reach and affect nearly all areas of our lives, from our daily routines to complex professional undertakings. Most fast-tracking toward digital solutions happened post the outbreak of the COVID-19 pandemic, under the pressure of efficiency and safety. Given the might of this churning, government and ministries of the Kingdom of Bahrain adopted several digital tools to ensure their ease and smoothness in operations toward service delivery to its citizens. A great example is the "NOOKHATHA" application and website, where a specially designed virtual assistant is introduced into the traditional fishing sector.

"NOOKHATHA" is a comprehensive digital platform designed to revolutionize Bahrain's fishing sector by providing tailored solutions for Bahraini fishermen and streamlining administrative processes for governmental authorities. The platform consists of two integrated components: a mobile application for fishermen and citizens, and a website for relevant ministries and authorities to manage and monitor all operations. This seamless integration ensures that every aspect of the fishing industry is efficiently linked, creating a cohesive system that benefits all stakeholders.

The mobile application simplifies traditionally complex procedures, such as obtaining fishing licenses and managing direct sales. By automating these processes, "NOOKHATHA" eliminates the burdensome paperwork and in-person administrative tasks, allowing fishermen to focus on their craft, thereby boosting their economic productivity. Additionally, the app provides critical features like real-time navigation and an SOS emergency system, ensuring the safety of fishermen and enhancing the efficiency of their maritime activities. It also offers access to updated information on marine laws and regulations, empowering fishermen to adopt sustainable practices and contribute to the conservation of marine resources.

On the other hand, the website serves as a management and monitoring tool for governmental bodies and ministries. It allows authorities to oversee operations, track compliance, and ensure alignment with Bahrain's maritime policies. This dual-platform approach facilitates improved communication between fishermen and authorities, creating a well-governed, eco-interactive fishing culture.

"NOOKHATHA" is more than just a technological innovation; it is a milestone in Bahrain's journey toward a sustainable, profitable, and environmentally conscious maritime industry. By empowering Bahraini fishermen, securing sea travel, and fostering collaboration between citizens and authorities, the platform aligns with Bahrain's Vision 2030 and sets the stage for a brighter future for the nation's maritime communities.

II. RELATED WORK

Marine operations have been progressing over the years, with major advances made within the framework. The integration of progressed advances into the system, with strides made in terms of mapping, compliance, security, and most importantly, proficiency, has given the framework of NOOKHATHA major improvements. The framework tends to oversee all marine-related exercises and needs such as route, compliance, authorizing, and crisis reaction. As such, these improvements lead to a smoother user experience and aid the user to easily be able to navigate the app and its perks.

A. Mapping and Route Innovations

Mapping apparatuses play a crucial part in marine operations, giving exact and real-time geospatial information for routes. These routes are extremely important for marine users as they play a crucial part in their livelihood and aid in navigating an often dangerous terrain [1]. Smith et al. illustrated that coordination of Geographic Data Frameworks (GIS) with portable applications upgrades decision-making in marine settings by advertising exact course arranging and

visualization [2]. NOOKHATHA's intelligently mapping highlight embraces comparable standards to help clients differentiate angling zones and secure courses [3]. Therefore, such changes aid in preventing any mistakes, or illegal activity, and most importantly, allow the user to safely navigate the provided areas with no doubts or fears [3].

B. *Compliance and Permitting Frameworks*

Advanced Advanced compliance frameworks have moved forward the proficiency of implementing marine controls and authorizing. They have led to a smooth transition of authorization into an effective and safe online system, which is accessible through a mobile application rather than a long process that occurs in person [4], [10], [11]. Brown et al. emphasized the significance of robotized cautions and detailing frameworks in guaranteeing compliance with universal marine laws [2], [3]. It also noted that such compliance aids in creating an accessible environment for such laws and preparing a user-friendly process that can be used by anyone at any time [4]. The NOOKHATHA framework coordinates compliance administration and authorizing functionalities to streamline administrative forms for marine administrators.

C. *Climate and Security Frameworks*

Real-time climate upgrades are fundamental for secure marine operations [1]. This will lead marines to be prepared for all weather conditions and expectations at the sea and may even cancel some operations due to the dangerous terrains ahead [5], [7]. Jones and Taylor highlighted the effect of coordination climate determining APIs into marine stages to decrease dangers and upgrade safety [8]. NOOKHATHA joins these highlights to supply real-time climate data and crisis cautions, guaranteeing client security amid angling and other sea exercises. Therefore, the overall safety risks will be decreased due to the notification of user of changes in the terrain and the dangerous routes that may occur during their journey.

D. *Shop and Item Administration in Marine Applications*

The advanced change of item and stock administration inside the marine division has streamlined operations for businesses. They aid in creating a one-step process and streamline the marine's needs. Garcia et al. illustrated how deal analytics and stock following frameworks contribute to operational productivity and decision-making in marine e-commerce platforms [9]. They aid in the choices made by business owners, especially small businesses, in terms of stock, the time consumed, and the deficiency that needs to be fulfilled in the market [11]. This leads to a higher likelihood of success, which in terms leads to a positive cashflow improvement for the business [10]. NOOKHATHA's shop administration framework adjusts with this approach, advertising devices for item administration and deals investigation.

E. *User-Centric Plan in Marine Applications*

User-centric plan standards are basic for moving forward in terms of user ease in usage of the app and client fulfillment in specialized frameworks. Anderson and Lee explored versatile interfacing custom-made client parts, highlighting their effect on client engagement [11]. It indicated that client engagement tends to be higher in clear, easily accessible, and readable frameworks. It makes the client feel safe and therefore, will easily use the features of the app and increases user interaction [11]. NOOKHATHA utilizes this methodology to guarantee the interface is instinctive and meets the differing needs of its clients, including admins and administrators.

F. *Crisis Security Frameworks*

Crisis readiness in marine situations requires coordinated frameworks for opportune cautions and communication. Green et al. investigated the utilization of robotized caution frameworks that use real-time information and mapping instruments to upgrade safety [6]. This means that data is used to create an algorithm that may aid in defining crises and dangerous situations to be avoided by the user. This will in the long-term decrease accidents, and risks, and increase the safety of all users. NOOKHATHA is coordinating these experiences into its crisis safety system to supply dependable caution and progress reaction times amid basic episodes.

These progressions in marine-related innovations have altogether affected the plan and functionalities of the "NOOKHATHA" framework. By embracing these demonstrated approaches, "NOOKHATHA" points to provide a comprehensive arrangement for overseeing marine exercises viably.

III. PROJECT MANAGEMENT

Effective project management is crucial for the successful execution of any project, All project activities shall be designed, organized and supervised in order to meet the needs and constraints of interested parties. Different types of project, not just software projects, are subject to the Project Management Principles which cover phases such as Initiation, Planning, Execution, Monitoring, Controlling and Closure. In this section, project management aspects of the "NOOKHATHA" application development will be discussed and the overall management approach employed throughout the project lifecycle.

A. *Process Model*

In the development of the "NOOKHATHA" application, the Agile methodology was adopted to ensure adaptability and collaboration with stakeholders for the continuous improvement of the product. As shown in Figure 1 This iterative and flexible approach provides key benefits, including enhanced responsiveness to dynamic user requirements and market conditions, fostering relevance and effectiveness. Regular stakeholder interaction ensures that development aligns with user needs and expectations, increasing satisfaction. Incremental delivery allows the project to generate value early while enabling continuous improvement over time. Additionally, frequent iterations and early testing help identify and resolve issues promptly, significantly reducing project risks.

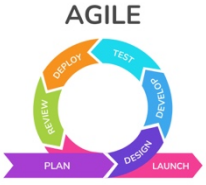

Figure 1: The Agile Development Process

B. *Agile Aproach in the Development of "NOOKHATHA":*

The development of the "NOOKHATHA" application follows a structured Agile approach, starting with Phase 1: Requirement Gathering, where the project team collaborates closely with stakeholders, including fishermen in Bahrain and

government regulatory bodies, to identify and document needs as user stories from an end-user perspective. In Phase 2: Sprint Planning, these user stories are detailed, prioritized, and organized into timeboxed sprints, typically 2–4 weeks long, each focused on delivering specific features. Phase 3: Iterative Development involves implementing these user stories through collaborative efforts, daily stand-ups, and adaptive adjustments to ensure progress aligns with project needs. Phase 4: Testing and Quality Assurance is integrated within the sprints, incorporating unit testing, integration testing, and user acceptance to maintain predefined quality standards. In Phase 5: Review and Feedback, sprint reviews allow the team to demonstrate functionalities to stakeholders and gather feedback, ensuring the product evolves in line with expectations. Finally, Phase 6: Release and Iterative Enhancements delivers completed product increments to users while enabling continuous improvement and adaptation based on evolving user and market requirements. This cohesive process ensures that the application remains relevant, effective, and aligned with stakeholder needs.

V. REQUIREMENTS COLLECTION AND ANALYSIS

This section details the rigorous requirement gathering process undertaken for the "NOOKHATHA" application, a pivotal component in the project's management. The process was conducted in active partnership with key stakeholders. This collaborative approach ensured a comprehensive understanding of the needs and expectations across the spectrum of users and regulatory bodies involved in the maritime and fishing industries.

A. Methodology

To ensure the "NOOKHATHA" project was grounded in real-world needs, a hands-on approach was taken to understand the lives and challenges of Bahraini fishermen and the roles of key government entities like the Ministry of Interior (Coast Guard), the Ministry of Municipalities Affairs and Agriculture (Agriculture & Marine Resources Affairs), and the Ministry of Transportation.

- **Observation**: Direct observation was conducted to understand the daily operations, challenges, and interactions of fishermen with their environment and existing services.
- **Questionnaire**: Electronic questionnaires were distributed, addressing various aspects of fishermen's daily activities and their interactions with government services. The responses helped quantify the frequency and impact of issues observed in their routines.
- **Interviews**: Structured interviews were conducted with representatives from the Ministry of Interior (Coast Guard), the Ministry of Municipalities Affairs and Agriculture (Agriculture & Marine Resources Affairs), and directly with fishermen. These interviews were instrumental in identifying existing services, uncovering gaps, and exploring how "NOOKHATHA" could effectively bridge these gaps.

These interactions were intended to collect important data regarding the regulatory landscape, present marine operations, and the daily struggles of fishermen. This information was essential for discovering service gaps and opportunities where "NOOKHATHA" could significantly improve the fishing community's operational effectiveness, safety, and profitability. Through these efforts, a user-centred application that supports the overall objectives of efficiency and sustainability, conforms with regulatory standards, and meets stakeholder needs was developed.

B. System Requirements

The findings from the requirement collection process, which encompassed observations, questionnaires, and interviews, provided a comprehensive understanding of stakeholder needs and challenges. This detailed analysis facilitated the identification of both functional and non-functional requirements for the "NOOKHATHA" application. The functional requirements shown in Table 1 and Table 2 define the specific features and capabilities necessary to address the operational needs of the fishing community, while the non-functional requirements shown on Table 3 outline the quality attributes essential for ensuring the system's effectiveness, reliability, and compliance with regulatory standards. These requirements form the basis for designing a robust and user-centered solution.

- **Application Functional Requirements**

ID	Use Case/Title	Description
NO-01	Fisher Registration	Fisher registers by providing Name, CPR, Email/password
NO -02	Fisher Login	Fisher log in using their registered email and password.
NO -03	Password Reset	Fisher can reset their password by receiving a reset link via email.
NO -04	Submit request	Fisher can send a services or report request
NO -05	Request Approval/Rejection	Fisher receives approval or rejection from the admin after submit the request
NO -06	View Services	Fisher can access all service categories
NO -07	View Previous Requests	Fisher can view all previous requests they finish or reject.
NO -08	Interact with map	Fisher can view their location and zoom in and out
NO -09	View map	Fisher can access and view the map
NO -10	Report a problem	Fisher can send description and upload photo
NO -11	Edit Profile	Fisher can create and update their profiles, including personal information.
NO -12	Edit shop	Fisher can create and update their shops.
NO -13	View sales	Fisher can view and see total sales of his shop
NO -14	license	Fisher can do all license services new /renew /transfer
NO -15	ships	Fisher can do all ship services register /renew /transfer
NO -16	View contraventions	Fisher can view all his contraventions
NO -17	payment	Fisher can pay for his contraventions
NO-18	Safety system	Fisher can use the safety system
NO-19	View weather	Fisher can view and see the current weather and sea conditions
NO-20	View laws	Fisher can see and read all the laws
NO-21	Citizen login	Citizen can login to the app using email and password
NO-22	Citizen register	Citizen can register to the app using their information

Table 1: NOOKHATHA Application Functional Requirements

- **Website Functional Requirements**

ID	Use Case/Title	Description
NO-25	Admin Login	Admins can login to website using their emails and passwords.
NO-26	Admin Registration	Admins can register to website using their information.
NO-27	Reset password	Admins can reset their password if they forget it.
NO-28	Insert contraventions	Admin can view and insert contraventions
NO-29	Approve or Reject request	Admins can approve or reject requests (ships/ license/ reports)
NO-30	View fisherman	Admins can view all information about fisherman by search
NO-31	Edit laws	Admins can add, edit, and delete laws
NO-32	View shops	Admins can view all information about the shops
NO-33	View problems	Admins can view all problems
NO-34	View hathra	Admins can view all hathra info
NO-35	Upload report	Admins can upload report to fishers
NO-36	Safety System	Admins can check the safety of the fishermen, if the fishermen do not sign out after 5 minutes from the sign-out time, an alert will be shown for the admin to track them.

Table 2: NOOKHATHA Website Functional Requirements

- **Non Functional Requirements**

Non-function Requirements	Description
Usability	User friendly system and easy to learn, easy to use and remember
Security	The system should provide security to all user's (fisher, buyer, admin) personal information
Availability	The system should be available and operable whenever needed at any time
Maintainability	The system design must be easy to maintain and modify regarding information and marine laws
Accuracy	The system must be able to provide the user with accurate and correct information that are related to laws and contraventions
Reliability	The system should ensure high reliability by consistently performing its intended functions under specified conditions without failure. This includes robust error handling and fault tolerance capabilities to maintain consistent operation and minimize disruptions during critical processes.
Safety	The application must prioritize user safety by incorporating features that users to potential dangers and ensure compliance with all maritime safety regulations. This includes providing real-time updates on prohibited fishing areas, weather conditions, and emergency response features to enhance the safety of fishermen while at sea.

Table 3: NOOKHATHA Non-Functional Requirements

C. System Models

System models play a critical role in illustrating the architecture and functionality of a system, providing a structured representation of how different components interact. These models are essential for documenting the behavior and design of the system, offering clarity on how it operates and meets the requirements of its users. For the "NOOKHATHA" application, the system models demonstrate the interactions between various stakeholders, such as government officials and fishermen, with the system. By clearly defining these relationships and processes, the models ensure that the system is developed in accordance with both user needs and regulatory standards, while facilitating the efficient and sustainable operation of the fishing community.

- **Fishermen's Use Case Diagram**

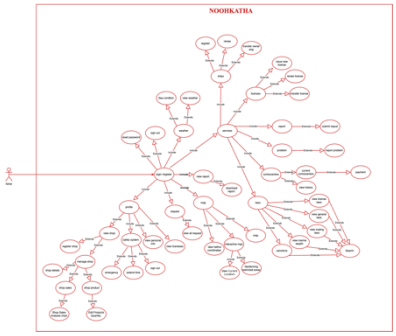

Figure 2: "NOOKHATHA" Fishermen Use Case Diagram

Figure 2 shows main actor of the application and can perform functions such as conducting and processing license and Ship transactions online, selling his catch, accessing weather information, using his current location to know the restricted areas around, requesting reports, and others.

Figure 5: "NOOKHATHA" UML Class Diagram

- **Authorities' Use Case Diagram**

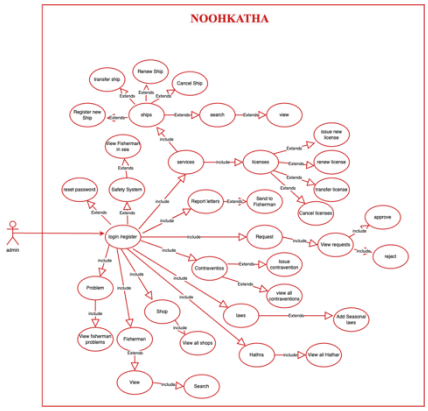

Figure 3: "NOOKHATHA" Authorities Use Case Diagram

Figure 3 shows Employee (Government Official): Managing and clearing marine and vessel licensing transactions, obtaining information for fishermen at sea, recording violations, adding laws, receiving complaints, seeing all registered bans, and sending reports to fishermen.

- **Citizens' Use Case Diagram**

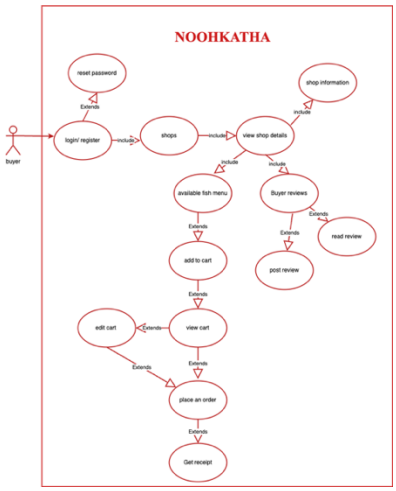

Figure 4: "NOOKHATHA" Citizens' Use Case Diagram

Figure 4 shows Citizen can see the stores that sell fresh fish and order from them easily and quickly

- **UML Class Diagram**

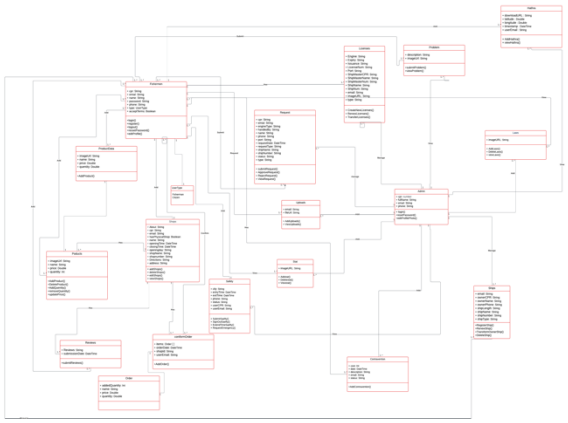

Figure 5: "NOOKHATHA" UML Class Diagram

As shown in Figure 5 the class diagram for the "NOOKHATHA" system provides a complete structural view of the application architecture. The class diagram gives static relationships between some important classes: Fisherman, Government Official, Regulatory Information, Transaction, and Emergency Services. The diagram during coding efforts is valuable because it specifies attributes in a class, and their interrelations, explicitly. In other words, this leads to a very methodical and efficient workflow of development.

- **Entities and Relationships**: The diagram clearly represents the entities with their attributes that would define the role a class would be responsible for the system. For instance, it shows the manner in which actions by government officials would affect control and access to regulatory information and fishing licenses.
- **Data Flow and Management:** The class diagram comes in rather handy in understanding in much detail about the data flow and dependencies. It is the manner in which the data will be stored, managed, and retrieved. In that sense, data flow is, on the other hand, a necessity in developing the back end and designing databases so that data may be handled in the application effectively and securely.

VI. System Design

System Design System Design is a critical stage in software development projects, involving the detailed planning and structuring of the system to ensure it meets the specified requirements. For the "NOOKHATHA" project, thorough planning was undertaken to utilize a combination of modern technologies and frameworks to cater to the unique needs of Bahraini fishermen. The system was designed with a strong emphasis on Human-Computer Interaction (HCI) principles, ensuring that the user interface is intuitive and accessible, particularly for elderly users who may not be as familiar with technology. This consideration led to a design that is easy to use, easy to remember, and visually clear, with a focus on large, easily identifiable icons and simple navigation. The system also emphasizes minimizing cognitive load by presenting information in a straightforward, user-friendly manner. This section delves into an exhaustive analysis and discussion of the different technology stacks employed, including mobile and web development platforms. The primary goal is to construct a robustly architected system that adheres to the project's objectives and proficiently addresses the functional demands of its users while ensuring accessibility and usability for all.

A. Software Architecture

The software architecture of the "NOOKHATHA" application is designed to be robust, scalable, and flexible, enabling efficient handling of the various needs of Bahraini fishermen. This section outlines the architecture's primary components and describes how these components interact to provide a seamless user experience while ensuring system reliability and security.

- **Architectural overview:** " NOOKHATHA" employs a layered architectural style, which is pivotal in separating concerns and allowing independent management of each functional area:
  - Presentation Layer: This layer is responsible for handling all user interface and browser communication logic. It serves as the front end of the application, providing an interactive and intuitive interface that fishermen can use to access various services such as license applications, trip tracking, and direct sales management.
  - Business Logic Layer: At the core of "NOOKHATHA" is the business logic layer, which processes data input from the presentation layer and enforces the application's operational rules. This layer coordinates complex operations such as transaction processing, navigation data interpretation, and emergency responses.
  - Data Access Layer: This layer serves as the bridge to the databases. It provides mechanisms for data storage and retrieval, ensuring data integrity and optimal access patterns for performance efficiency.
  - Data Layer: Comprising databases and data storage solutions, this layer stores essential user and application data securely, including user profiles, license records, sales data, and historical navigation routes.

- **Technology Stack:** To support this architecture, "NOOKHATHA" utilizes a modern technology stack that enhances the application's responsiveness and scalability. To support this architecture, "NOOKHATHA" utilizes a modern and effective technology stack:
    - Frontend: Angular is used for crafting dynamic user interfaces, coupled with Ionic for cross-platform mobile app development, ensuring consistent user experience across web and mobile platforms.
    - Backend: Firebase is employed to manage backend services and database needs, leveraging its real-time database features, authentication services, and easy integration with various cloud functions. TypeScript is used to write scalable and maintainable code, enhancing development efficiency and system reliability.
    - Database: Firebase also serves as the database solution, providing a flexible, scalable, and performance-efficient environment for managing large volumes of structured and unstructured data.

This architecture supports "NOOKHATHA" in meeting its goals of operational efficiency, user-friendliness, and security, making it a pivotal tool in modernizing Bahrain's fishing industry while ensuring sustainability and compliance with regulatory standards.

VII. System Implementation

A. Application Development

For "NOOKHATHA" application, the frontend was developed using the Ionic framework integrated with Angular, which provided a rich set of functionalities tailored for mobile interfaces. This combination allowed for the creation of a responsive and user-friendly interface optimized for mobile platforms. Angular's powerful data-binding and modular capabilities, along with Ionic's native-like app experience, facilitated an interactive user experience. The backend of the application was handled using TypeScript, which added strong typing and object-oriented features to JavaScript, enhancing code reliability and maintainability. TypeScript's compilation into JavaScript ensured seamless backend integration and efficient handling of asynchronous calls, database operations, and server-side logic.

B. Website Development

For "NOOKHATHA" website, HTML and CSS were employed to craft the frontend, ensuring a visually appealing and intuitive user interface that is consistent with the mobile application. HTML provided the structure of the website, while CSS was used to refine the styling, accommodating different screen sizes and devices. The backend of the website was developed using JavaScript, leveraging its dynamic scripting capabilities to handle server-side interactions, data retrieval, and database management efficiently. JavaScript's event-driven nature was crucial for implementing interactive features on the website, providing a smooth and engaging user experience.

C. Algorithms

For "NOOKHATHA" application, two specific algorithms were developed to enhance the functionality of the system for both citizens and administrators. The first algorithm used for sorting the product listings on the citizen-facing page of the "NOOKHATHA" application. The algorithm enables users to sort the list of products featuring details like price and quantity according to their preferences. This sorting algorithm is particularly useful for enhancing user experience by providing flexible viewing options, allowing citizens to easily navigate and make purchasing decisions based on their preferences. The second algorithm the search functionality in the admin section of the "NOOKHATHA" website allows administrators to quickly find specific fishermen by their CPR numbers. This algorithm facilitates efficient retrieval of fisherman profiles, streamlining administrative tasks and ensuring timely management actions.

D. Backend Components

Firebase Firestore was chosen as the backend for "NOOKHATHA" Application and Website, a NoSQL database, to manage and synchronize our data effectively across fishermen, citizens and administrator interfaces. Firestore's scalable, cloud-native architecture is essential to meet the high demands of "NOOKHATHA" broad user base and ensures "NOOKHATHA" remains efficient and responsive, even under high user loads. Its schema-less design adapts easily to changing data needs, eliminating the need for extensive restructuring. The database's structure of documents and collections provides a flexible yet organized data hierarchy. Additionally, Firestore's advanced querying capabilities allow for complex data searches, significantly enhancing user and administrative interactions with the app.

E. Testing Strategies

The testing strategies for the " NOOKHATHA" application include a comprehensive approach, covering unit testing, integration testing, functional testing, and system testing, to ensure the system's functionality, reliability, and performance. Unit testing focuses on validating the core functionalities of the application, with each test carefully designed and documented to confirm the application behaves as expected. Following unit testing, integration testing ensures that various components and modules of the application collaborate seamlessly, including interactions with the Firebase backend and external services such as call gateways. System testing then evaluates the entire application in an environment that simulates real-world operating conditions, validating both functional and non-functional requirements. This phase ensures the application meets all specified criteria, including performance, usability, security, and regulatory compliance. By employing these rigorous testing methodologies, "NOOKHATHA" is thoroughly evaluated to minimize defects, enhance system performance, and deliver a robust and dependable application that ensures user satisfaction and trust.

VIII. Results and Discussion

Implementation and testing of the "NOOKHATHA" system brought forth many important developments in trying to solve major challenges for Bahraini fishermen. This section assesses the results against three key elements, namely operational efficiency, safety, and compliance. Preliminary tests and simulations conducted were very useful to understand how this system works and would usher in a paradigm shift in the Bahrain fisheries sector.

A. *Operational Efficiency*

The system automates the management of administrative matters that are of utmost importance, such as license renewals, ship registrations, and direct sales procedures, and it is performed by an integrated digital platform. With the presence of automation systems, the manual and paper-based procedures of administrative work are diminished, thus, the administrative workforce and the utilization of resources are also reduced. The functionality of direct sales, which is enabling the fishermen to connect to both businesses and consumers, is likely to cut out intermediaries and thus benefit the local economic development. In preliminary simulations, there was up to 50% less time used in administrative processes.

B. *Safety Enhancement*

The implementation of a real-time SOS system will allow the direct communication with the Coast Guard, and therefore it enables them to respond within some minutes to the emergency cases. Through an integration of weather updates and geofencing technologies, the system is conveying real-time data to users about the prevailing maritime conditions and restricted zones. The testing demonstrated the system's capabilities to deliver correct navigation alerts, hence, enhancing safety during maritime operations.

C. *Regulatory Compliance*

A central platform for the distribution of maritime laws, seasonal restrictions and beyond the requirements, has been created, that sends the updates directly to the users. The main benefit of the system is that it will minimize the number of incidents related to non-compliance and therefore fines. The platform also provides regulators with improved monitoring tools for their job, cutting down the complications of maritime regulations. The results of testing underline the fact that these features will significantly enhance compliance with conservation and operation standards.

IX. Challenges Identified

Developmental problems are associated with various issues, such as, stable internet connectivity, and the varying user experience involving digital platforms. To cope with these problems in upcoming software updates will make the system more accessible and the adoption of users will be enhanced. However, "NOOKHATHA" is a transformational solution that could modernize the fishing industry of Bahrain. It provides functionalities for solving existing problems but at the same time opens opportunities toward sustainable growth, safety, and compliance. Future versions are planned to develop system capabilities further.

X. Future Directions

To further expand the impact and usability of the "NOOKHATHA" system, future iterations will focus on the following enhancements:

A. *Advanced Predictive Features:*

1) Integrate machine learning models to give personalized recommendations of fishing zones and the best times for fishing.

2) Incorporate predictive analytics to reduce risk where Enable proactive alerts about potential threats.

B. *Integration with Government Systems:*

Enables seamless communication between authorities for faster decision making and better service delivery which will streamline administrative procedures and improve compliance tracking.

C. *User-Centric Enhancement:*

Increase the functionalities of the system by expanding the system features.

D. *Scalability and Regional Adaptation:*

Adapt the "NOOKHATHA" system for deployment in other GCC countries, customizing features to align with local regulations and fishing practices.

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