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Scan2Save: A QR Code-Based Digital Emergency Medical Information System for Enhanced Patient Safety

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Abstract - In medical emergencies, the lack of instant access to a patient's health history creates a serious risk, commonly resulting in treatment delays or negative outcomes. Traditional approaches such as engraved jewelry or wallet cards are grossly restrictive regarding the quantity and adaptability of information conveyed. This article presents Scan2Save, a contemporary, web- based electronic emergency medical ID system capable of filling this critical information gap. The system leverages QR code technology to give first responders and medical staff immediate, secure access to a patient's critical health information through any smartphone. The platform includes a secure user registration and profile management system, dynamic generation of QR codes, a dedicated emergency access portal with capabilities such as one-tap calling and voice alerts, and user-driven controls for privacy. Based on a scalable design with a React/TypeScript frontend and a Node.js backend, the system provides a holistic, globally accessible, and timely solution to enhance emergency response outcome and maximize patient safety.

Key Words: QR Code, Emergency Medical Information, Patient Safety, Digital Medical ID, First Responders, Web-Based Application.

1. INTRODUCTION

In the critical seconds of a medical crisis, first responders are often confronted with patients who cannot communicate because they are disoriented, unconscious, or otherwise incapacitated. This creates a perilous information void, as medical professionals do not have access to essential information such as pre-existing conditions, allergies, or medications. This information shortage can cause serious consequences, including drug reactions, misreadings of symptoms, and critical delays in treatment. For instance, giving a patient a usual medication when they have a life- threatening allergy may cause an allergic reaction.

Current solutions to this issue have serious drawbacks. Older methods like medical alert jewelry are only capable of containing a few words of data, not being able to convey the richness of a patient's health record. Wallet cards filled in by hand, more detailed than the former, can be lost, ruined, or forgotten during an emergency. Current digital innovations, such as medical ID options on smartphone lock screens, are a step up but lack standardization between devices and rely on the patient's phone being charged and functional.

This Scan2Save project addresses this enduring information deficit head-on by developing a universal, web-based solution independent of a particular device or app. With a straightforward and robust QR code as the key, Scan2Save offers an access point to detailed, user-managed health data, making it accessible to save lives when most needed.

2. ANALYSIS OF EXISTING SYSTEM

To establish the need for the Scan2Save system, it is essential to analyze the limitations of current methods for conveying emergency health information.

2.1 TRADITIONAL METHODS

Medical Alert Jewelry: Though well known, these necklaces and bracelets have an extremely limited surface area that acutely limits information storage. They are usually able to include only a first condition, with no room for medications, dosages, or more than one contact. In addition, the information that is engraved is not dynamic; any variation in a patient's status necessitates an expensive replacement of the entire device.

Wallet Cards: These plastic or paper cards can store more information but are very vulnerable. They can get lost, water-damaged, or left behind during an accident. First responders might not have time to rummage through a victim's belongings, and handwritten details may be poorly readable.

2.2 BASIC DIGITAL METHODS

• **Smartphone Lock Screen IDs:** New operating systems enable users to save basic medical information viewable from the lock screen. The method of access, though, varies greatly between devices and operating system revisions, potentially perplexing a first responder. This method is totally contingent on the patient's phone remaining charged, unbroken, and accessible following an accident. Numerous users are also not cognizant of this feature or do not update the information.

• **Third-Party Apps with Specialization:** Such apps tend to create an access barrier by asking the first responder to have the same app installed. They also raise issues concerning privacy or a subscription fee for the user.

The common weakness across all these systems is the failure to provide a comprehensive, easily accessible, and up-to-date source of health information in a standardized format.

3. THE PROPOSED SCAN2SAVE SYSTEM

The general weakness of all these systems is the inability to generate a standard, universally accessible, and current source of health information in an easily formatted manner. Scan2Save is an internet-based system set up to overcome these limitations through the provision of a centralized, secure, and immediately

available emergency medical information service based on QR code technology.

3.1 SYSTEM ARCHITECTURE

The system is built using a modern technology stack designed for scalability and maintainability.

• **Frontend:** A responsive Single-Page Application (SPA) developed with React and TypeScript supports a quick and engaging user interface. The UI is designed with Tailwind CSS for uniformity and quick development.

• **Backend:** A strong and fast RESTful API is developed on Node.js utilizing the Express.js framework. TypeScript is also utilized at the backend for type safety and code consistency.

• **Database:** The design supports smooth migration to a persistent PostgreSQL database to support data integrity and scalability, although the prototype version uses in-memory storage. The database schema and data validation constraints are common to both client and server to avoid integration bugs.

3.2 CORE MODULES AND FUNCTIONALITY

The system is composed of several interconnected modules:

User and Profile Management: This is the core module in which users are able to safely register and establish a full medical profile. The profile consists of fields for personal information, existing conditions, allergies, current medications, and emergency contacts.

Dynamic QR Code Generation: The system generates a dynamic QR code for every user profile. The QR code has a secure link to the emergency data of the user. Users can download the QR code as an image or print it on a physical wallet card.

Emergency Access Portal: A dedicated, public-access web portal for first responders. Scanning a QR code launches this portal to reveal the patient's medical information in easy-to-read, clear format. This is a read-only portal with no login required.

The main features are:

• **Tap-Once Calling:** The emergency contact's phone number is a tap-once click as an immediate dial.

• **Voice Alert System**: An automatic text-to-speech function recites the patient's critical data to responders, enabling them to take in information hands-free.

• **Granular Privacy Controls:** In acknowledging that medical information is particularly sensitive, users have complete control over which types of information appear on their public profile. Users can toggle individually the visibility of their conditions, allergies, and medications.
• **Administrative Dashboard:** An admin-only, secure section enables system administrators to delete user profiles when needed, view system statistics, and control the user base.

3.3 DATABASE DESIGN

The database utilizes a relational model implemented in PostgreSQL, with schemas defined using the Drizzle ORM to ensure type safety.

• **users Table:** This main table holds all account and user profile information, such as hashed passwords, medical information, personal information, and the privacy- controlling boolean flags.

• **Emergency_scans Table:** This is an audit table that tracks every time a QR code is scanned and connects the scan event to a particular user as well as captures the access time.

Fig – 1: Database Design

4. SYSTEM IMPLEMENTATION AND TESTING

4.1 IMPLEMENTATION STRATEGY

A phased implementation approach was used to ensure a controlled and manageable workflow.

Phase 1: Development and Setup: This entailed setting up the development environment and building the separate backend and frontend parts. The initial development utilized an in-memory database to enable quick API development and testing.

Phase 2: Integration and Testing: The Node.js backend API was integrated with the React frontend, then thoroughly end-to-end tested to validate all user flows worked flawlessly.

Phase 3: Deployment: This is a key phase that entails moving from in-memory storage to a production-level PostgreSQL database. It also entails security hardening practices such as adding password hashing and enabling HTTPS to encrypt all data in transit.

Phase 4: Post-Launch Monitoring: Once deployed, the system is monitored strictly for its performance and runtime errors and channels opened for user feedback.

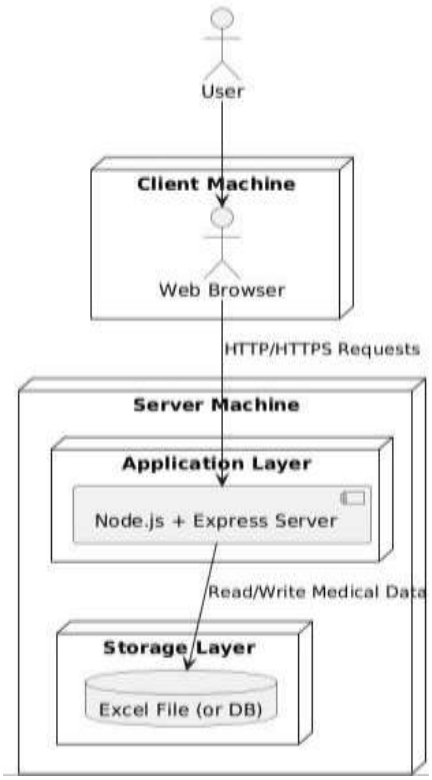

Fig -2: Hardware Architecture

4.2 TESTING METHODOLOGY

A multi-layered testing strategy was adopted to ensure comprehensive quality assurance.

• **Unit and Integration Testing:** Unit tests confirmed single components independently, while integration tests concerned the communication between modules, for example, the frontend talking to the backend API.

• **End-to-End (E2E) Testing:** These tests replicated real-user workflows from beginning to end, like a new user registering, creating a QR code, and the first responder successfully viewing the emergency profile.

• **Usability and Security Testing:** Usability testing collected user feedback regarding the ease of use of the platform. Security testing prioritized common web vulnerabilities and validating that privacy controls effectively filtered data on the emergency portal.

5. RESULTS AND DISCUSSION

The Scan2Save system's implementation is effective in addressing the main goals established at the time of its development. The system presents a viable and efficient solution to the issue of delayed patient data access in emergency situations. The main strengths of the suggested system in comparison with traditional approaches are:

• **Large Amount of Information:** The system has a virtually limitless capacity for medical detail, much more than can be accommodated in standard jewelry or cards.
• **Dynamic and Current:** Users can log on and change their details at any time, so that first responders will always have access to the latest information.

• **Universal Accessibility:** The QR code is readable by any smartphone camera, with no need for a special app for the respondent. The data is accessed through a standard web browser.

• **Improved Privacy and Security:** End users have precise control of what data is exposed, much better than methods in which sensitive information is always on display.

• **Redundancy and Robustness:** The QR code may be stored in various forms (printed card, sticker, digital image), thus offering redundancy.

• **Sophisticated Features:** Useful features such as the one-tap call button and voice-driven alerts provide substantial benefits in a stressful emergency situation.

The system is a useful tool that has the potential to greatly enhance patient safety and emergency response results.

6. CONCLUSION AND FUTURE WORK

This work has successfully provided a strong, user-friendly platform that fills the vital information gap in emergency medical response. Scan2Save provides a contemporary and more dependable solution to conventional medical alert methods, giving users control over their emergency readiness. The architecture creates a solid platform for many future improvements that could further extend the platform's potential. Potential areas for future development are:

• **Full Database Implementation:** Moving from in-memory storage to a completely persistent PostgreSQL database to support durability and scalability for a large number of users.

• **Native Mobile Applications:** Building native iOS and Android apps to provide a better user experience and deeper integration with platform features such as biometric authentication.

• **Family Account Management:** Adding a feature to enable a primary user to manage multiple family members' profiles, e.g., children or older relatives.

• **Real-time Scan Notification:** Developing a feature to trigger an automatic SMS or push notification to a user's emergency contact as soon as their QR code is scanned.

• **Wearable Technology Integration:** Investigating integration with wearables and smartwatches so the emergency QR code can be shown directly on a watch face to provide even quicker access.

• **Multi-Language Support:** Adding internationalization to enable the platform to reach a global user base.

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