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Secure Disaster Relief Donation Platform With Beneficiary Distribution Monitoring

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ABSTRACT

Effective Disaster Relief Management (DRM) requires timely coordination, secure communication, and transparent management of donations and resource distribution among government authorities, donors, volunteers, and beneficiaries. Conventional disaster relief systems primarily depend on manual documentation, disconnected digital platforms, and informal communication channels, resulting in delayed response times, poor coordination, limited accountability, and inefficient resource utilization. The absence of centralized monitoring and secure information management often leads to duplication of efforts, inaccurate record maintenance, and difficulties in tracking donations and beneficiary requests. Additionally, inadequate authentication and security mechanisms expose sensitive disaster-related information to unauthorized access, reducing stakeholder trust and operational reliability. To address these challenges, this research introduces a secure web-based platform developed using the Flask framework. The system implements role-based access control for government authorities, collectors, and receivers, enabling secure management of disaster events, donation campaigns, inventory, aid requests, and resource distribution through a unified interface. TinyDB is utilized as a lightweight NoSQL database for storing user records, donations, campaigns, requests, and distribution details. To ensure confidentiality, the platform incorporates Vigenère cipher encryption for secure messaging and file sharing, with user-provided encryption keys protecting sensitive information during communication. Flask supports modular routing, session management, and secure authentication throughout the application. The proposed system enhances transparency, improves coordination, strengthens data security, automates disaster relief workflows, and provides a scalable digital platform that supports efficient, accountable, and well-organized disaster response and donation management.

Key words: Disaster Relief Management, Flask Framework, Role-Based Access Control, Secure Communication, TinyDB.

1. INTRODUCTION

Natural catastrophes such as earthquakes, tsunamis, floods, forest fires, plane crashes, and viruses are becoming more common, posing major challenges not just for the public but for government organizations in charge of disaster management and preparedness. Recent failures to respond to natural disasters, such as the H1N1 pandemic (i.e., the management of the swine flu), which arrived on Australian shores through the cruise ship industry in 2009 [1], and the earthquake in Haiti, have sparked concern. In Victoria, Australia, bushfires have been a recurring challenge, often exacerbated by a lack of timely availability of skilled resources and a failure to harness the potential for skill reuse. Such shortcomings in disaster management can lead to catastrophic outcomes [2]. Frequently, the potential for skill reuse is neglected with disastrous consequences. Therefore, utilizing the disaster management metamodel, in this work we suggest a method for integrating disaster management

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information to develop a flood and disaster support system that incorporates several disaster management (DM) operations tailored to a particular disaster. This strategy is inspired by method engineering, a knowledge management practice in software engineering. DM manages disaster risks and effects. DM covers mitigation, readiness, response, and recovery. DM involves organizing, directing, and using counter-disaster resources. This domain's practitioners attempt to decrease or prevent natural disasters, assist disaster victims, and recover quickly. Operationalizing this domain involves many difficult activities. Risk evaluations, readiness, emergency responses, rescue, relief distribution, and reconstruction are all included. Data modelling and communication are difficult. Instead of attempting a comprehensive model, this work suggests a metamodel that can link various imperfect models that try to systematically convey DM knowledge.



Fig. 1: Disaster relief donation.

This approach allows us to set up a hypothesis of general notions that affect how we perceive reality [3]. Reality ought to be influenced by models. They must be true or faithful representations to ensure that the model can be used to answer questions about the world or predictably change the world. A metamodel that explains what can be articulated in legitimate knowledge domain models is the result of metamodeling. The metamodel provides information about models. In this case, a model means the DM solution model, which shows how DM activities and their parts (such as people, resources, and plans) should be coordinated for a given disaster. Failures typically emerge from the accumulation of a complicated chain of events, and are frequently accompanied by changes in environmental factors [4,5].

1.1 Research Motivation

In modern disaster management and humanitarian sectors, organizations such as the Red Cross, UNICEF, World Food Programme, and logistics partners like DHL Disaster Response increasingly depend on digital platforms to manage large-scale relief operations. These organizations handle massive volumes of real-time data related to donations, supply inventories, beneficiary records, transportation schedules, and campaign performance. Effective data analysis helps them monitor fund utilization, predict resource shortages, identify distribution delays, and ensure that assistance reaches affected communities efficiently. Without analytical support, manual reporting systems often lead to data inconsistency, delayed decision-making, and poor coordination among stakeholders. Moreover, donors and regulatory bodies now demand transparent and auditable digital records to maintain trust and accountability. The growing complexity of humanitarian operations and the need for secure, data-driven coordination strongly motivate the development of integrated digital monitoring and analysis frameworks for DRM.

2. LITERATURE SURVEY

Ayoub Ghani, et al. [6] presented Eghatha, a blockchain-based decentralized platform developed to improve the efficiency, transparency, and security of humanitarian aid distribution during disasters and emergency situations. The proposed system enabled secure transfer of donations from donors to beneficiaries by recording every transaction on

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an immutable blockchain ledger, thereby minimizing fraud, duplication, and misuse of relief resources. The platform was designed to operate through collaboration among volunteers, civil society organizations, and government agencies, ensuring coordinated disaster response while adapting to local community requirements. Ankit K. C., et al. [7] proposed an Ethereum blockchain-based disaster donation management system that utilized smart contracts to automate donation transactions and maintain transparent financial records. The implementation ensured traceability, accountability, and tamper-resistant management of donations, allowing donors to verify how their contributions were utilized while improving trust among all participating stakeholders. Istiaque Ahmed, et al. [8] enhanced traditional charity management systems by integrating electronic Know Your Customer (eKYC) authentication and cryptographic hash functions to strengthen user verification and secure data exchange. The proposed framework employed smart contract filters to preserve information privacy while introducing random time delays and coin-toss-based data selection techniques to protect against guessing attacks and improve communication security.

Hanyang Wu, et al. [9] proposed a comprehensive donation service management system that addressed the functional requirements of donors, beneficiaries, and administrative authorities within a unified platform. The study described the overall system architecture, service workflow, and operational mechanisms required to support efficient donation collection, request management, resource allocation, and administrative monitoring. The proposed framework emphasized coordinated management and streamlined communication among all participants involved in disaster relief operations. Eun Jung Kim, et al. [10] investigated the influence of workplace disability facilities on job retention among physically disabled employees in South Korea. Using data collected from the 2018 Panel Survey of Employment for the Disabled, the study analyzed the mediating roles of workplace safety perception and job satisfaction in supporting long-term employment. The findings demonstrated that improved workplace accessibility and safety positively influenced employee satisfaction and increased job retention, highlighting the importance of supportive working environments for individuals with disabilities. Deserina Sulaeman, et al. [11] examined the influence of social media on household donations during natural disaster relief campaigns conducted through online crowdfunding platforms. The research identified demographic and inter-ethnic patterns affecting donation behavior, revealing that fundraising campaigns initiated by Hispanic organizers received comparatively fewer donations from non-Hispanic contributors. The study emphasized the significant role of social media platforms in shaping public participation, donation visibility, and fundraising outcomes during humanitarian crises.

Saad Mazhar Khan, et al. [12] explored the application of Internet of Things (IoT) technologies, sensor networks, and model-driven engineering for improving disaster preparedness and flood management. The proposed approach utilized real-time environmental data collected from flood-prone regions to enhance situational awareness, support early warning systems, and improve disaster response planning. The study demonstrated that integrating IoT technologies with predictive modeling significantly improves decision-making during emergency situations. Muhammad Khan, et al. [13] emphasized the importance of fast, fair, and secure humanitarian logistics in minimizing disaster impacts and supporting sustainable

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disaster management. The study highlighted that digital transformation of humanitarian logistics enhances resource allocation, improves coordination among relief organizations, and enables timely delivery of essential supplies to affected populations. The findings suggested that efficient logistics systems not only reduce human suffering but also contribute to long-term disaster resilience and sustainable development. Sheikh Kamran Abid, et al. [14] reviewed the application of Artificial Intelligence (AI) across all phases of disaster management, including preparedness, mitigation, response, and recovery. The study demonstrated that AI technologies significantly improve disaster prediction, resource planning, emergency response, and post-disaster recovery through intelligent decision support systems. Furthermore, the integration of Geographic Information Systems (GIS) and Remote Sensing (RS) technologies enhanced situational awareness, spatial analysis, and damage assessment, enabling authorities to perform more effective planning and disaster management operations.

3. PROPOSED SYSTEM

This research presents a structured and secure digital framework for managing disaster relief donations and monitoring beneficiary distributions in a coordinated and transparent manner. The study follows a modular architecture that integrates user interaction, authentication control, data management, encrypted communication, and operational monitoring into a unified workflow. The methodology begins with user registration and role verification, followed by controlled access to donation management, inventory handling, beneficiary requests, and distribution tracking. A centralized data repository ensures consistent storage and retrieval of operational records, while secure encryption mechanisms protect sensitive files and communications. Analytical aggregation and reporting modules support real-time monitoring of campaigns, inventory levels, and fulfillment status, as shown in Fig. 1. Through continuous data synchronization and role-based coordination, the methodology improves accountability, operational efficiency, and reliability in humanitarian relief management environments.



Fig. 1: System architecture for disaster relief monitoring system.

User Roles and Access: The system begins by defining three primary user roles: government authorities, collectors, and beneficiaries. Each role is assigned specific permissions that control access to disaster management, donation handling, and beneficiary request functions. This role separation ensures accountability and prevents unauthorized operations.

Web Application Layer: All user interactions are processed through a centralized web application built using the Flask framework and TinyDB database. The application handles authentication, request routing, data storage, and communication between modules. It acts as the control hub that coordinates secure and reliable system operations.

Disaster Management Module: Government users create and manage disaster events and associated campaigns through this module. Disaster details, severity levels, and campaign schedules are recorded and updated in real time. This module enables structured planning and monitoring of relief activities.

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Donation Management Module: Collectors record both monetary and material donations using standardized digital forms. The system tracks campaign-wise collections, donor information, and donation types for transparent monitoring. Aggregated donation data supports real-time fundraising analysis and reporting.

Beneficiary Request and Distribution Module: Beneficiaries submit aid requests specifying urgency, category, and quantity requirements. Authorized collectors review, approve, and fulfill these requests based on inventory availability. Distribution records are maintained to ensure accurate tracking of delivered resources.

Security and Encryption Module: User credentials are protected using password hashing and session management mechanisms. Text messages and sensitive information are encrypted using the Vigenere cipher before storage or transmission. This module ensures confidentiality, integrity, and controlled access throughout system operations.

Secure File Transfer Module: Files uploaded by collectors are encrypted at the byte level before being stored on the server. Only authorized receivers with valid decryption keys can download and access original file contents. This process safeguards operational documents and sensitive reports from unauthorized exposure.

Messaging System: Users communicate through an internal messaging interface with optional encryption support. Encrypted messages are stored securely and decrypted only after valid keys are provided. Message status tracking improves coordination and ensures reliable communication among stakeholders.

Audit and Reporting Module: System activities are continuously logged and aggregated into analytical reports and dashboards. Real-time statistics on donations, campaigns, inventory, and distributions support monitoring and performance evaluation. This module strengthens transparency, auditing, and decision-making during disaster relief operations.

3.1 VIGENERE ENCRYPTION

Vigenere encryption is a symmetric key technique used to protect sensitive information by applying a repeating keyword to transform the original data into an unreadable format. Instead of using a single fixed substitution, this method applies multiple shifting values derived from the secret key, making pattern detection more difficult. The encryption process works on both textual and binary data, allowing secure handling of messages and files. Each data unit is combined with a corresponding key unit to generate encrypted output as shown in Fig, 2. Non-alphabetic data is preserved without alteration to maintain formatting integrity. This approach provides lightweight yet effective confidentiality for secure communication and storage systems.

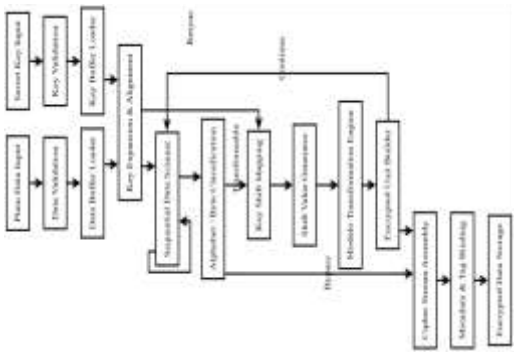


Fig. 2: Internal workflow of Vigenere Encryption.

Input Acquisition and Validation: The system first accepts the plaintext data and secret key from the user interface. Both inputs are validated to ensure the presence of a valid key and acceptable data format. Invalid inputs are rejected before entering the encryption pipeline.

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Key Expansion and Synchronization: The secret key is repeated and aligned with the length of the input data stream. Each data unit is paired with a corresponding key unit to maintain the correct shifting order. Synchronization logic ensures accurate mapping across the entire encryption process.

Data Scanning and Classification: The input stream is scanned sequentially to identify each character or byte. Alphabetic and binary units are marked for transformation, while special symbols and control characters are optionally bypassed. This classification preserves non-encryptable content.

Shift Value Computation: For each valid data unit, a numerical shift value is derived from the aligned key character. The shift magnitude determines how much the data unit will be rotated within its valid range. This step forms the cryptographic core of the transformation.

Modulo Transformation and Encryption: The system applies modular arithmetic to shift each data unit within its character set or byte range. The transformed value produces a single encrypted unit. These encrypted units are sequentially appended to form the cipher stream.

Cipher Stream Assembly and Storage: All encrypted units are combined into a continuous encrypted output stream. Metadata such as file identifiers and ownership information may be attached. The encrypted data is then securely stored or transmitted, completing the encryption workflow.

4.3.2 VIGENERE DECRYPTION

Vigenere decryption is the reverse cryptographic process used to recover original data from an encrypted message using the same secret key. It applies inverse shifting operations to undo the transformations introduced during encryption. The repeating key is aligned with the encrypted input to ensure accurate reversal of each character or byte. Modular subtraction is used to compute the original values while preserving data boundaries.

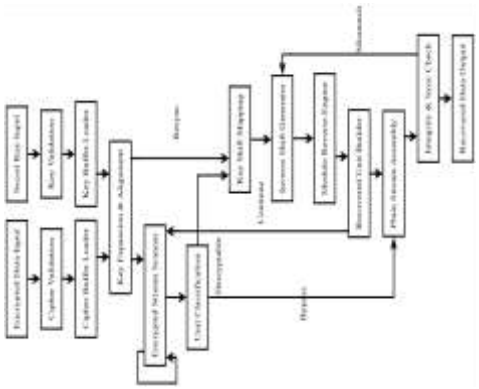


Fig. 3: Internal workflow of Vigenere Decryption.

Non-alphabetic symbols and control bytes are maintained without modification to preserve data integrity as illustrated in Fig. 3. This technique guarantees controlled data recovery while maintaining confidentiality and key-based access control.

Encrypted Input and Key Validation: The system first receives the encrypted data and the secret decryption key from the user interface. Both inputs are verified for correctness and access permissions. Invalid keys or corrupted data are rejected before further processing.

Key Reloading and Alignment: The secret key is repeated and aligned with the encrypted data stream length. Each encrypted unit is paired with a corresponding key unit for accurate reversal. Synchronization ensures consistent decryption across the entire data sequence.

Encrypted Stream Scanning and Classification: The encrypted stream is scanned sequentially to identify each character or byte unit. Units eligible for decryption are separated from symbols that must be bypassed. This preserves formatting and non-transformable elements.

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Inverse Shift Value Computation: For each encrypted unit, the numeric value of the aligned key character is computed. This value determines how much reverse shifting must be applied. The shift magnitude forms the basis of the inverse cryptographic operation.

Modulo Reverse Transformation: The system applies modular subtraction to reverse the encryption shift within valid character or byte limits. Each transformed unit reconstructs the corresponding plaintext element. This step gradually rebuilds the original data content.

Plain Stream Assembly and Integrity Validation: All recovered units are combined into a continuous output stream. Internal verification checks confirm correct synchronization and valid reconstruction. The final plaintext or binary file is released to the authorized user.

4. RESULTS AND DISCUSSION

Fig. 4 illustrates the Disaster Management Screen, which enables structured creation and monitoring of disaster events within the platform. The screen depicts systematic handling of disaster-related information, including classification, severity assessment, and status tracking. It demonstrates how disaster records form the foundation for campaign initiation and resource allocation. The figure highlights-controlled lifecycle management to avoid inconsistencies and unauthorized modifications. This component ensures accurate representation of disaster scenarios throughout the relief process.



Fig. 4: Disaster Management Screen



Fig. 5: Campaign Oversight Screen

Fig. 5 illustrates the Campaign Oversight Screen, which supports the creation and supervision of donation campaigns associated with registered disasters. The screen depicts goal-driven fundraising management with progress evaluation and time-bound execution. It reflects the system's emphasis on transparency, traceability, and controlled campaign activation. The figure demonstrates how financial resources are aligned with specific disaster needs. This screen plays a critical role in ensuring accountable and effective mobilization of relief funds.

Fig. 6 illustrates the Collector Verification Screen, which represents the authorization process for entities responsible for collecting disaster donations. The screen depicts a verification workflow that distinguishes approved collectors from pending or unverified participants. It highlights mechanisms designed to prevent fraud, impersonation, and unauthorized fund handling. The figure demonstrates the role of administrative validation in establishing trust.



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Fig. 6: Collector Verification Screen

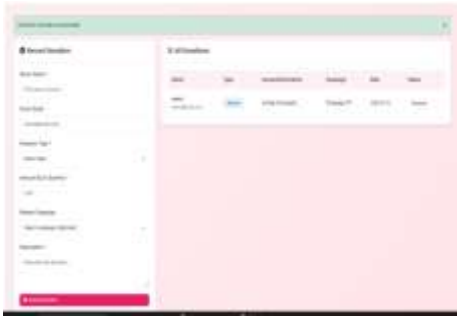


Fig. 7: Donation Screen

Fig. 7 illustrates the Donation Screen, which enables structured recording and tracking of monetary and material donations. The screen depicts standardized capture of donor details, donation type, associated campaign, and transaction status. It emphasizes traceability of donations from submission to acknowledgment within the system. The figure reflects mechanisms designed to ensure accountability and prevent untracked contributions. This screen forms a critical link between donors, campaigns, and downstream distribution processes.

Fig. 8 illustrates the Inventory Management Screen, which supports systematic tracking of physical relief resources. The screen depicts inventory categorization, quantity management, and update mechanisms to maintain accurate stock records. It reflects the system's capability to align material availability with beneficiary needs. The figure highlights-controlled inventory operations to reduce wastage and misallocation. This screen plays a key role in ensuring efficient utilization of donated resources.

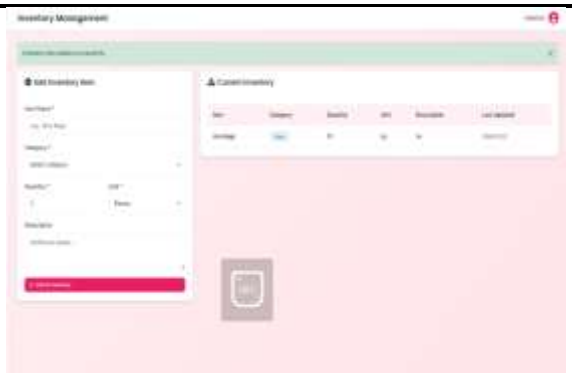


Fig. 8: Inventory Management Screen

Fig. 9 illustrates the Needs Tracking Screen, which provides beneficiaries with visibility into the progress of their submitted requests. The screen depicts request status monitoring and fulfillment progression in a structured manner. It reflects transparency in aid processing and reduces uncertainty for affected individuals. The figure highlights continuous tracking to ensure responsiveness and accountability. This component strengthens trust between beneficiaries and the relief distribution system.



Fig. 9: Needs Tracking Screen

5. CONCLUSION

This research successfully presents a secure and transparent disaster relief donation platform that effectively integrates role-based management, encrypted communication, and persistent data tracking to support reliable humanitarian operations. The implementation demonstrates improved performance through lightweight Flask routing, efficient TinyDB storage, and optimized backend workflows

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that reduce response latency during donation recording, request processing, and file transfers. Automated campaign updates and synchronized inventory management enhance transaction accuracy and minimize manual intervention. The use of symmetric encryption strengthens confidentiality while maintaining low computational overhead, ensuring faster file handling compared to heavyweight cryptographic frameworks. Real-time dashboards and analytical summaries improve monitoring efficiency and support timely administrative decisions. Modular system design enhances scalability and maintainability, enabling the platform to handle increasing users, disasters, and records with consistent performance. Controlled workflow execution and validation mechanisms reduce data inconsistencies and prevent unauthorized access. Persistent logging and traceable transaction histories further strengthen reliability and audit readiness.

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