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Lora and IoT Based Device for Disaster and Fleet Management

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Abstract
Disaster management is essential for mitigating the widespread effects of natural and human-induced disasters, such as loss of life, property damage, and economic disruptions. Strategies including hazard assessments, preparedness, and international collaboration can help lessen their impact. Technology plays a pivotal role in disaster management, with innovations like the Internet of Things (IoT) enhancing situational awareness and response capabilities. This paper explores the application of LoRa low-power wide-area communication technology in disaster management and military operations, particularly for fleet management and emergency warfare. The device utilizes a LoRa-based transmitter and receiver system, enabling communication across different geographic locations through various frequencies. It operates within a specific frequency range and connects to a cloud-based interface, serving as an active IoT hub with secure communication channels. Real-time data, including analytics and emergency situations, are transmitted and displayed, with morse code used for specific indications. Government authorities oversee these channels, ensuring rapid response to emergencies. The device's compact design and secure communication capabilities make it an asset in military and disaster management contexts, offering server-less functionality and triggering alerts when necessary.

1. Introduction

Disaster management stands as an imperative field given the profound impact of both natural and human-induced catastrophes, resulting in loss of life, property damage, and significant economic disruptions. Although these events are inevitable, their repercussions can be alleviated through preemptive measures like hazard assessments, fostering awareness, preparedness initiatives, and global cooperation. The integration of technology-driven solutions are paramount across various disaster management phases—prediction, response, recovery, and learning—to effectively address the multifaceted challenges posed by such occurrences. The utilization of Internet of Things (IoT) technology plays a pivotal role in enhancing situational awareness within power grids by facilitating extensive sensor collaboration and robust information communication networks. This paper delves into the application of LoRa low-power wide-area communication technology in disaster management and military communication, particularly in fleet management and emergency warfare scenarios. The device, comprising LoRa-based transmitters and receivers operating across different frequencies, establishes communication across varied geographical locations. Acting as active receivers within specific areas, these devices transmit data to a master receiver linked to a cloud-based interface, functioning as an IoT hub with controlled access. In critical situations, these devices operate as serverless entities triggering alerts when needed, thus offering secured and compact communication mechanisms, poised to revolutionize military applications and disaster management strategies.

1.1 Advanced Disaster Management and Monitoring Devices

The paper outlines a framework deploying LoRaWAN for monitoring water quality in lakes/reservoirs. It connects multiple sensors to LoRa transceivers, transmitting data to a cloud server. A test established a LoRa gateway, linking a temperature sensor to monitor lake water. Data was relayed to the gateway, visualized on a centralized dashboard. The system's coverage test in an urban setting ranged from 150-2,500 m, affected by antenna placement and obstacles. Clear line of sight achieved a 2.5 km range. Keywords: Lake Monitoring, Water Quality, LoRaWAN [1]. LOCATE presents a pioneering Emergency Communication System (ECS) utilizing LoRa technology via a mobile app and BLE-connected transceiver. It addresses challenges in large-scale emergencies where cellular networks fail, ensuring long-range communication for survivors and rescue teams. The system's novelty lies in LoRa's extensive assessment, a multi-hop dissemination algorithm optimizing emergency delivery within set timeframes, and comprehensive evaluations showcasing superior performance over traditional D2D solutions. With minimized transmission and swift emergency handling, LOCATE surpasses other dissemination strategies, marking LoRa as a game-changer in ECS for its accuracy in GPS-free localization [2]. The study introduces secured bidirectional communication using LoRa for remote robot control. While LoRaWAN relies on standard networks, this proposes a LoRa-based secure device for scenarios like war zones where networks might fail. A cryptographic protocol ensures data confidentiality, authenticity, and integrity between base station and robot. Tested over 1.2 miles, this protocol effectively controls and monitors a Pioneer-P3Dx robot from a remote location, showcasing its robust security in operation sans network dependency [3]. The rise of IoT has propelled smart networks, notably LoRa, renowned for its long-range and low-power capabilities. Evaluating various factors like path loss, transmission power, and node deployment, our study modeled different environments to gauge LoRa network performances. Through simulations using FLoRa in OMNeT++, rural, urban, and parking area scenarios were tested. Findings underscored the substantial influence of optimizing parameters on energy consumption and data rates. This analysis emphasizes how tweaking key factors could significantly enhance the deployment of efficient smart networks [4]. The focus of disaster management is to minimize damage, offer immediate aid, and ensure swift recovery. Effective rescue operations post-disasters demand varied information about the disaster's impact. IoT technology, mature and versatile, holds immense potential in these scenarios. A proposed IoT-based solution addresses these needs, validated through the task-technology fit (TTF) approach. Results from exploratory studies establish crucial dimensions for task requirements and IoT TTF constructs. Confirmatory analyses affirm the substantial impact of both task needs and IoT tech on IoT TTF in disaster management. This work significantly contributes to modeling TTF for IoT in the realm of disaster management, refining constructs for optimal implementation [5].

1.2 Centralized Monitoring System

The paper introduces a sophisticated Fleet Monitoring System, surpassing basic telematics by automating data analysis from vehicles. It identifies discrepancies between planned and actual data, facilitating swift revisions and updates to the logistics system. This system minimizes manual intervention for dispatchers, enabling rapid response to transportation disruptions and ensuring precise records of arrival and departure times at customer locations [6]. Efficient resource management, especially of non-renewable resources like fuel, is crucial in daily life. To address this, effective control over transportation fleets is imperative. Our solution leverages IoT for secure, remote fleet management, curbing fuel wastage and ensuring vehicle upkeep. Fuel sensors and GPS-based Odometer constantly monitor vehicle status, empowering remote fleet control.

This IoT platform facilitates proactive maintenance, benefiting drivers and ensuring optimal vehicle condition [7]. The paper delves into Fleet Management Control Systems (FMCS), pivotal for real-time vehicle monitoring and schedule adherence. Improving transit services in developing nations requires enhanced route info, schedule compliance, and traffic rule adherence. Current FMCS systems face limitations in communication tech, costs, interoperability, and standardization. It proposes an Intelligent Transportation System (ITS) architecture and a prototype using Long Range communication for these countries. Successfully tested, the prototype identifies optimal communication parameters for better transit control. The FMCS offers solutions for compliance, safety, and cost reduction, vital for medium-sized cities, promoting interoperability and advanced communication tech for improved mobility services [8]. Advancements in IoT and compact sensor technology enable discreet data gathering for human activity recognition and behavior modeling. This innovation finds valuable application in ambient assisted living, particularly in enhancing the well-being and quality of life for older adults. Current solutions focus on individual monitoring, resulting in isolated management for each intelligent environment. To address this, a centralized system for collective monitoring within a community is proposed [9]. This approach utilizes a cloud-based solution, centralizing data collection and processing. By aggregating data from all residents, the system fosters social interaction among the community members. Moreover, it potentially reduces costs by necessitating only sensing devices for data collection, with processing handled by cloud infrastructure. This streamlines the setup of home monitoring systems and decreases associated labor. The study delves into the role of assistive robots, explores remote monitoring possibilities, and evaluates potential challenges inherent in this centralized approach. Ultimately, this paper highlights the transformative potential of a cloud-based, collective monitoring system in ambient assisted living for older adults while acknowledging its associated prospects and hurdles [10]. The Internet of Things (IoT) has transformed the conventional Internet landscape by extending connectivity beyond human-centric services to enable objects to communicate through the web. This paradigm shift has fostered diverse applications, including smart water management systems. However, these applications demand energy-efficient sensor nodes capable of long-distance communication. Consequently, the proliferation of Low-Power Wide Area Networks (LPWAN) technologies like LoRa has surged to meet these requisites. This paper conducts a comprehensive survey focusing on IoT devices and various applications utilizing LoRa and LoRaWAN, aiming to comprehend the current array of devices in use. The primary goal is to advance LoRa as a dependable communication technology for applications requiring extensive coverage and decentralized deployment. The study emphasizes the configuration of device parameters and presents the outcomes derived from each surveyed experiment. By exploring and assessing IoT devices operating on LoRa, this survey aims to contribute to the evolution and practical implementation of this technology in diverse settings requiring robust, long-range connectivity [11]. The paper explores IoT technology for rescue monitoring, comparing WiFi and LoRa as data transmission methods. Emphasizing battery efficiency, it advocates for low-power modules in IoT devices. Specifically focused on rescue monitoring, it aims to evaluate WiFi and emerging LoRa technologies for data transmission from IoT devices. Critical aspects during rescue monitoring involve identifying and rescuing vulnerable individuals or groups likely to be lost. Utilizing a LoRa-based gateway and WiFi Router, the study connects end-devices to the Internet. Data collected from IoT sensors is accessible to authorized users via web or mobile applications. Results from simulations and real-time experiments highlight LoRa as a promising option for rescue monitoring due to its performance. This research marks the initial phase in establishing a comprehensive ecosystem for rescue operations, integrating hardware and software reliant on LoRa technology for transmission. The implications suggest a potential shift towards LoRa-based solutions in future rescue monitoring systems, showcasing its viability and efficiency in this context [12]. The research investigates a novel model of LoRa technology operating in the 2.4GHz frequency, exploring its potential within an environment saturated with Wi-Fi and Bluetooth interference.

Deployed across a university campus, the study focuses on assessing transmission capabilities, packet delivery rates, and the range limitations of this LoRa variant. Placing the gateway strategically at the campus center, the team analyzes signal strength and connectivity by situating LoRa-based end-node devices at various locations. Results unveil that while the 2.4GHz LoRa model exhibits reduced effectiveness concerning distance compared to its sub-GHz counterparts, it still surpasses Wi-Fi and Bluetooth in range and remains cost-effective for IoT applications. The research highlights the importance of enhanced antennas and obstacle elimination to optimize LoRa's performance. Despite demonstrating lower power levels than anticipated based on device specifications, LoRa technology continues to offer greater coverage than competing protocols, indicating potential for improvement with technical enhancements. This study underscores LoRa's utility in IoT solutions, emphasizing avenues for maximizing its effectiveness within high-interference environments [13]. The modern landscape of transportation relies heavily on vehicle tracking systems for efficient operations. However, various sectors such as cab services, public transport, and school buses lack comprehensive security measures within their tracking systems. This project aims to address this gap by introducing a Real Time Vehicle Fleet Management and Security System. This innovative system integrates real-time vehicle tracking, online monitoring, dedicated remote server storage for fleet data, and robust security features into a unified platform. Developed on a Linux-based embedded microprocessor, the system utilizes a GPS receiver for precise vehicle location tracking, while communication occurs through a GSM-GPRS modem. To bolster security, physical panic buttons, biometric sensors, cameras, and speakers are incorporated. The data acquisition takes place on a dedicated server, and a user-friendly GUI renderer has been created for intuitive interaction. This graphical user interface dynamically presents real-time data, enabling users to monitor and visualize vehicle movements effectively. Ultimately, this project amalgamates technological advancements to enhance vehicle tracking, monitoring, and security within public and commercial transportation sectors [14]. The COVID-19 pandemic pushed businesses reliant on fleet vehicles to navigate challenges. Balancing profitability with safety and productivity emerged as a crucial hurdle. Addressing this, a focus on driver management within fleet operations took center stage. Recognizing the absence of real-time ride data studies, a cost-effective, reprogrammable Fleet Management System (FMS) was devised. This system, utilizing ESP32 SIM800L and data analytics, enables real-time monitoring of vehicle location, speed, distance, and ETA. Data is transmitted via GPS and GPRS to local SQL and cloud-based Firebase servers. A user-friendly web interface employs Google Maps for vehicle tracking, while real-time analytics on Firebase and SMS functionality for driver communication enhance the system's versatility [14].

2. Method

This multifunctional device serves as a linchpin in both disaster management and fleet operations, owing to its sophisticated long-range communication abilities. LoRa technology, renowned for its efficient long-range communication, functions as both the receiver and transmitter within this device. Comprised of several essential components, including a keypad for input, a LoRa transmitter and receiver, and a NodeMCU responsible for data collection and transmission, this device orchestrates a seamless flow of critical information. Operating as a conduit for data, the NodeMCU efficiently collects and transmits vital data from numerous transmitters to an array of diverse receivers, all interconnected through a centralized cloud-based infrastructure. The device operates on a meticulously designed system where specific conditions, vital for distinct emergency scenarios, are meticulously encoded into unique emergency codes. These codes serve as the digital language through which the device communicates, enabling swift identification and response to various critical situations. The synchronized encoding and decoding mechanisms embedded within both the transmitters and receivers ensure the secure transmission and reception of data, mitigating any potential breaches or interferences. Moreover, the interconnectedness of the transmitters and receivers is pivotal, each region utilizing its specific set to pinpoint the origin and nature of the emergency message within its designated area. This tailored approach not only facilitates precision in identifying the source of the distress signal but also ensures an efficient and targeted response strategy. As data travels between transmitters and receivers, the encoded information is seamlessly transmitted and received, reflecting the critical conditions in real-time on a sophisticated graphical user interface housed within the cloud-based system. This graphical interface serves as the nerve center, displaying crucial data and triggering a series of serverless APIs that, in turn, activate an array of responses and notifications. In the realm of disaster management, this device emerges as an indispensable tool. It effectively translates the complexities of various emergency situations into easily decipherable emergency codes, streamlining communication and expediting response times. Whether facing natural calamities, humanitarian crises, or unforeseen emergencies, the device stands ready to convey the urgency and specifics of the situation accurately. Furthermore, in the context of fleet management, the device becomes an invaluable asset, facilitating seamless coordination and communication across fleets navigating diverse and often challenging terrains. The device's robust long-range communication capabilities empower it to transcend geographic barriers, ensuring that crucial information reaches the right recipients swiftly and accurately. In regions prone to warfare or conflict, this device becomes a beacon of hope, enabling timely and strategic responses to supply needs, facilitating swift evacuations, and orchestrating intricate rescue operations. Its capacity to efficiently manage fleets within such volatile environments, where communication and coordination are often compromised, renders it an unparalleled asset in ensuring the safety and effectiveness of operations. Additionally, the device's incorporation of LoRa technology elevates its efficiency and reliability in adverse conditions where conventional communication methods may falter. LoRa's resilience to interference and its capacity to penetrate obstacles makes it an ideal choice for ensuring uninterrupted communication in scenarios where infrastructure may be compromised or nonexistent. In conclusion, this device stands at the forefront of modern technological innovation, bridging the gaps in communication and operational efficacy in disaster management and fleet operations. Its amalgamation of advanced components, sophisticated encoding mechanisms, and seamless cloud-based integration positions it as a transformative tool, heralding a new era in efficient and reliable emergency response and fleet management. The Hardware Design is shown in Figure 1.

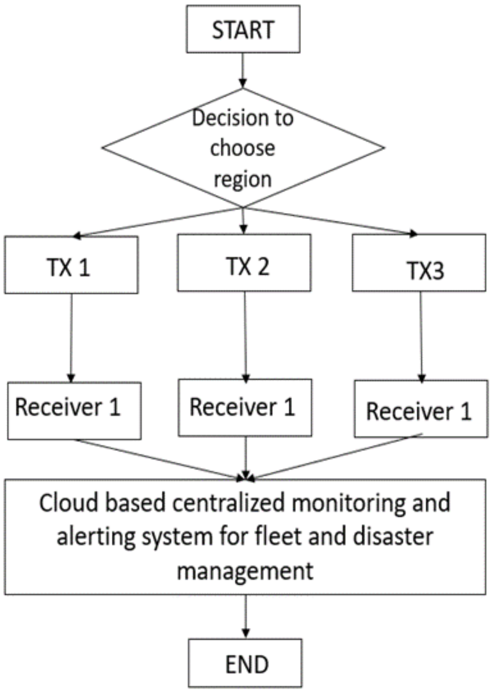

Figure 1 The Above Shown Device is a Hardware Design

It seems like you're looking to expand further on the functionality and significance of the device in managing emergency conditions and fleet operations. Here's a detailed paragraph: The device's versatility lies in its adaptability to diverse emergency conditions across regions, where specific transmitters correspond to distinct receivers, enabling targeted responses to crises within precise geographic areas. This regional mapping ensures that emergency messages are accurately pinpointed to their originating areas, allowing for swift and localized response measures. Encoded transmissions and receptions are a cornerstone of this device's operation, ensuring the secure and reliable transfer of critical data. Employing robust encoding and decoding processes at both the transmitter and receiver ends, the device guarantees the integrity of transmitted and received information. Through this meticulous encoding system, various fields of emergency conditions manifest distinctly on the graphical user interface of cloud devices. The interface serves as a visual representation of real-time data, highlighting different emergency scenarios, thereby facilitating prompt decision-making processes. Additionally, the device's integration with a range of serverless APIs enables automatic triggers upon receiving specific indications, swiftly disseminating crucial alerts to various governmental sectors. In the domain of fleet management, this system emerges as an indispensable tool. Its seamless orchestration of fleet operations streamlines supply management and rescue efforts in diverse warfare zones and regions, ensuring swift responses to evolving situations. Transmitter and Receiver Part of the Communication Device is shown in Figure 2.

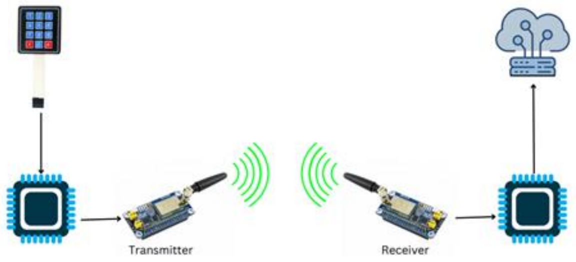

Figure 2 Transmitter and Receiver Part of the Communication Device

This device's ability to distinguish and respond to different emergencies across regions ensures a targeted and efficient approach to crisis management. By utilizing encoded transmissions specific to each region, it allows for a highly accurate identification of the source and nature of the emergency, aiding in prompt and precise responses. The encoding and decoding mechanisms integrated into both the transmitters and receivers safeguard the integrity and confidentiality of the transmitted data, ensuring its accuracy and reliability. This encoded data manifests in various fields on the graphical interface of cloud devices, providing a comprehensive overview of different emergency scenarios in real time. This visual representation is instrumental in aiding decision-making processes and expediting necessary actions. Moreover, the device's seamless integration with a range of serverless APIs serves as a catalyst for automatic triggers when specific emergency indications are received. This triggers a chain reaction, swiftly alerting and notifying various governmental entities responsible for emergency response and management. The device's efficacy is particularly pronounced in fleet management, where its capabilities enable streamlined coordination and management of fleet operations in challenging environments, such as warfare zones and regions grappling with crises. Its ability to facilitate the efficient deployment of supplies and swift rescue operations in such high-stakes scenarios underscores its significance and impact. In conclusion, this device stands as a testament to technological innovation in crisis management and fleet operations. Its ability to identify, encode, and decode emergency messages across regions ensures precise and targeted responses, while its seamless integration with cloud-based interfaces and serverless APIs expedites communication and action. In the context of fleet management, its role in orchestrating operations in challenging and high-risk environments underscores its indispensability, making it a pivotal tool for effective emergency response and fleet management.

3. Results and Discussion

3.1 Results

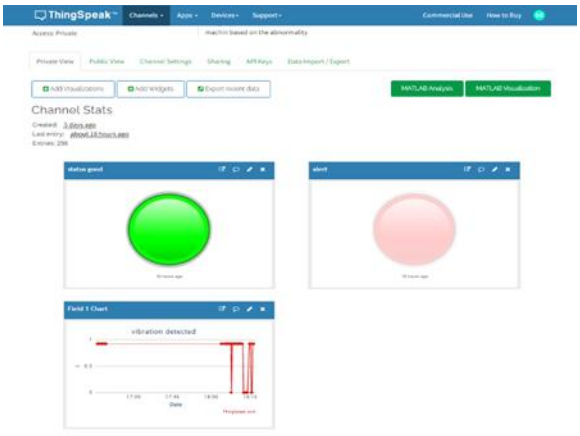

Figure 3 Safe Operation Proper Functioning Without No Disaster

The dashboard's green indication signifies that is Figure 3, a status where goods are not urgently required, conveying a sense of normalcy. Despite this, the system continually receives and updates data regarding the feed. However, when the dashboard indicator turns red, where in Figure 4, here this signal shows an immediate need for attention and action. The shift to red illuminates a spectrum of emergency scenarios, each denoted by different fields representing distinct requirements and alerts. These coded messages encapsulate various urgent needs and critical situations, serving as a prompt for specific actions or responses tailored to the indicated emergency. In essence, the change from green to red on the dashboard serves as a visual cue, prompting a shift in focus and response protocols from regular operations to urgent and targeted interventions based on the nature of the highlighted emergency field.

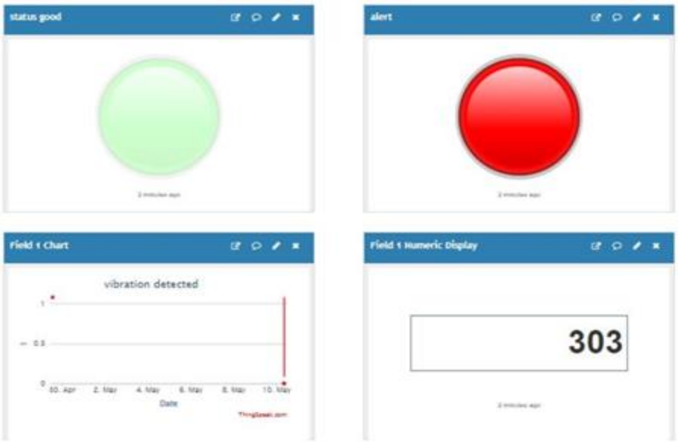

Figure 4 Emergency Code for Request of Fleet or Other

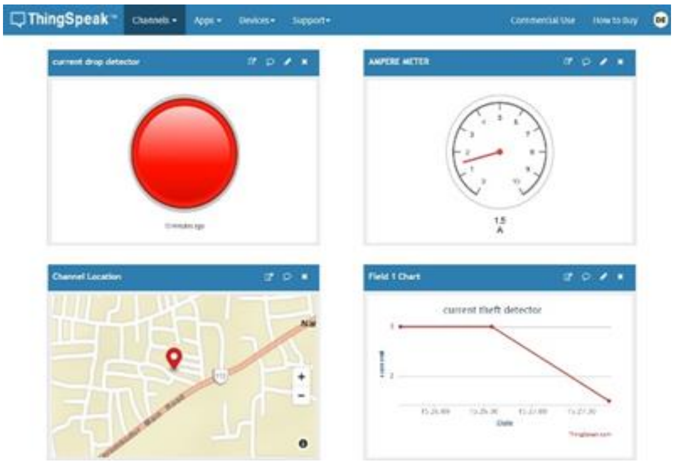

Figure 5 Emergency Situation Alert

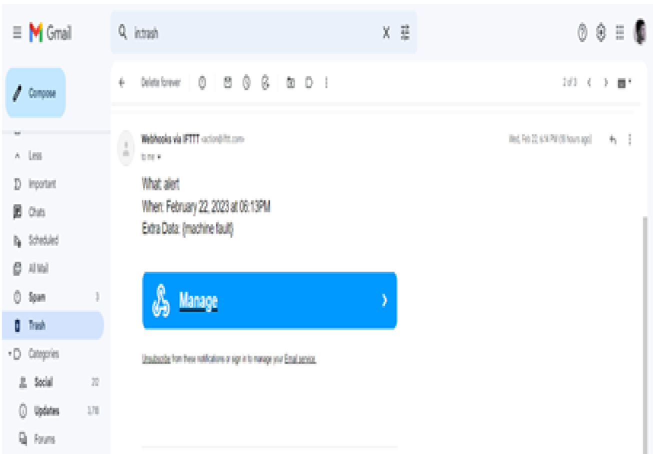

Figure 6 Data Reported And Alert Sent Through Mail

During any emergency Figure 5 and Figure 6, swift alerts and critical information dissemination are paramount. This crucial data is shared across different levels of government, spanning various departments dedicated to disaster management. In times of crises, whether it's a natural disaster or a requirement for fleet monitoring, the urgency of the situation dictates the need for prompt and coordinated responses. To ensure seamless communication and effective action, this information is relayed across governmental tiers and pertinent disaster management departments. The data is formatted and transmitted in various formats, aligning with the specific requirements and protocols of each level and department. This strategic dissemination ensures that the right information reaches the right authorities swiftly, enabling coordinated efforts and efficient deployment of resources in mitigating the emergency at hand. Whether it's alerts, resource requirements, or fleet management necessities, the interconnectedness and swift transmission of information among governmental entities stand as the cornerstone of an effective response mechanism during emergencies (Figure 7).

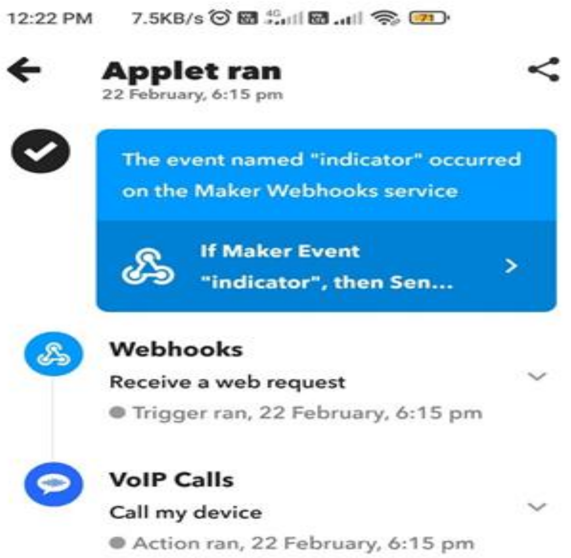

Figure 7 Alert Sent Through Message

3.2 Discussion

The outputs displayed below represent the comprehensive data outputs generated by the device, meticulously integrated from various fields within the receiver component. Each field corresponds to a specific aspect of the device's operation, intricately capturing diverse information pertinent to different emergency scenarios. The visual representation below showcases distinct fields for distinct regions, offering a clear and concise delineation of data for each geographical area. These fields encapsulate critical information, ranging from emergency codes and status indicators to location-specific details, enabling a detailed understanding of the nature and scope of emergencies in real-time. Through this graphical representation, users can swiftly grasp the unique emergency conditions prevailing in different regions, facilitating prompt and targeted responses. The clarity and specificity of the data fields enhance decision-making processes, empowering users to prioritize and strategize responses tailored to each area's requirements. This visual representation stands as a vital tool, providing a comprehensive overview of diverse emergency scenarios across regions, ensuring effective management and swift action in critical situations.

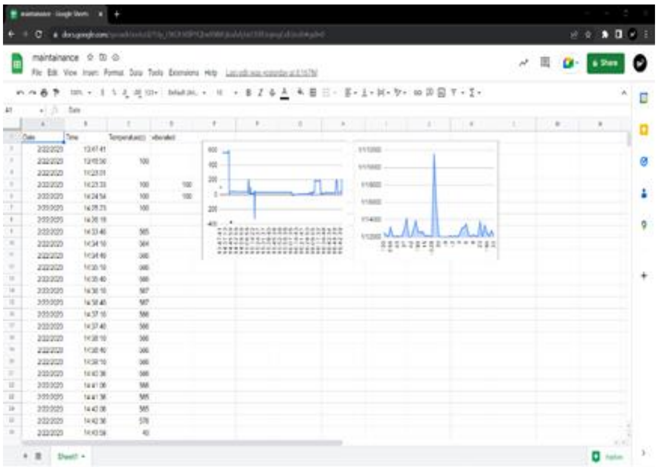

Figure 8. Data Logged About the History of the Fleet Management

The displayed output in figure 8, represents a comprehensive database housing a myriad of logged data encompassing diverse fields and various requests. Within this repository, an extensive array of fleet-related information is meticulously stored, awaiting analysis and interpretation. Each entry captures nuanced details pertaining to fleet operations, encompassing critical data that spans requests, performances, and operational intricacies. This reservoir of information serves as a treasure trove, encapsulating the multifaceted aspects of fleet management, including route optimizations, vehicle performance metrics, supply logistics, and response effectiveness. The data amassed within this database holds immense potential for in-depth analysis, enabling insightful assessments and informed decision-making processes. Its repository status ensures accessibility and utilization for ongoing and future analyses, providing a robust foundation for deriving actionable insights that drive enhanced operational efficiencies and strategic fleet management initiatives.

Conclusion

In navigating the complex landscape of disaster management, technological advancements like LoRa-based communication devices emerge as pivotal tools in mitigating the impacts of both natural and man-made disasters. These events, laden with widespread consequences, demand proactive measures and innovative solutions. Leveraging IoT technology, particularly LoRa's low-power wide-area connectivity, this device exemplifies a transformative approach in disaster management and military communications for fleet and emergency warfare needs. Operating on distinct frequencies across geological locations, these devices serve as active receivers, channeling crucial information to a cloud-based interface. Through a master receiver and IoT hub, this device ensures secure data transfer and real-time analytics, projecting critical requirements as Morse codes for swift indication and response. Governed by authorities, these devices serve as compact, secure, serverless communication hubs, triggering alerts as needed. This sophisticated yet compact system promises to revolutionize disaster response and military applications, showcasing the potential for enhanced situational awareness and precise, responsive actions in times of crises. As a game-changing technology, its integration signifies a leap forward in disaster management strategies, offering resilience and agility in the face of adversity.

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