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Disaster-Resilient Mesh Network with AI Load Balancing

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Abstract: Floods, earthquakes, cyclones and landslides commonly destroy essential communication facilities like mobile towers, fibre links and internet services. This breakdown prevents those who are in need from sending out an SOS or sharing their current location which greatly slows down the rescuers and causes more people to be killed. In order to solve these problems, I will use AI technology to design an emergency rescue communication system that can provide continuous, stable and reliable communication for both online and offline environments. When the network is available, it uses GPS and cloud to send exact location data along with structured emergency request types like Ambulance, Water Supply, Resources, General Help etc. Without Internet Services: In the absence of internet service, the system smartly forms a wireless mesh network among adjacent cell phones that enables multi-hop messages to travel over devices connected via a link in between. An integrated AI-based routing module considers battery level, RAM availability, storage space, and signal strength; selects the best & most energy-efficient communication path for sending a message, using ML algorithm to increase the reliability of delivering a message under harsh environment. A real-time rescue dashboard, with color codes of (Red, Yellow, Green) status, provides the rescue team members with better visibility and understanding for a faster interpretation and better coordination in times of emergency. The Proposed System increases Situational Awareness & Reduces Gaps on Communication, so it can give Timely help as a Scalable & Flexible Life Saver framework for Modern Disaster Management Operations

Keywords: Emergency Communication, Wireless Mesh Network, Disaster Management, Reinforcement Learning, AI Routing, Offline Communication, Rescue System.

I. INTRODUCTION

Natural disasters like flood, earthquakes, cyclones, tsunamis and landslides have been getting more frequent and severe because of the changes in climate and quick urban development These events destroy a lot of vital infrastructure like electricity networks, roads, etc., but even more so they destroy communication systems. The fall of mobile towers, fibre optic lines and internet backbones makes it hard for those affected to send out SOS signals, share their real-time location or tell the rescuers what they need urgently. The research, it shows that over 60% of disaster-related deaths are because of delayed communication and lack of information for a quick rescue. This is showing we need something more resilient, adaptable solution for how to talk with people during emergency times. Voice calls, internet-based messaging apps, SMS services, and emergency hotlines – these kinds of traditional communications mostly count on a centralised network. When there is network traffic congestion or failure of network devices, these systems become extremely slow or even paralysed. And like during big floods and big earthquakes, when millions are trying to call their families or the emergency services at once, all sorts of problems occur with everyone calling. And also, emergency responders may get unstructured, unclear information that makes it hard for them to sort out rescue priorities or distribute resources properly.

With the fast development of mobile computing, P2P connectivity and AI technologies, there are great opportunities to build disaster communication systems without just depending on traditional infrastructure. Wireless mesh networking can make smartphones communicate with each other directly, creating a decentralised network that is still functional even when mobile towers fail. Similarly, the use of AI routing will enable it to choose the most suitable communication channel according to device status, link quality and available resources, just as to ensure important information reaches the rescue centres in the correct manner.This work's AI-enabled Emergency Rescue Communication System tackles these pressing concerns through dual-mode communication—offering support for both internet-based and offline mesh-delivered messages. In case of having internet connectivity, it sends the exact GPS location of the victim to the rescue command centre. When offline, the system switches into a Mesh network so that the device can forward the message over more than one hop until reaches at a connected node. Hybrid Communications Architecture ensures the flow of uninterrupted messages in all disaster environments. Also, the citizens could send in their own emergency requests, like needing an

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ambulance or being short on drinking water and resources, or even just calling for help. Request sent with its correct geolocation & device metadata, which makes it easier for rescue teams to determine severity quickly & assist accordingly. A dedicated Rescue dashboard that gives Real-time information of all Emergency tasks, a colour-coded status (Red/Yellow/Green) so everyone involved knows what's going on at all times -Rescue Team, Volunteers & Government. The overall effect of the proposed system makes it more reliable and can decrease communication delays as well as improve situational awareness during life-or-death events. The combination of AI, mobile computing, mesh networking, and real-time visualisation results in a resilient and scalable solution that will change modern disaster management for the better and save thousands of lives.

II. PROBLEM STATEMENT

Natural Disasters often lead to the destruction of normal communication infrastructure, people can't send out SOS alerts or share their current positions in real time. There is no reliable means for communications and it slows down rescues which causes more death. We need a strong and AI aided hybrid communication system that will allow us to communicate our message when we do not have internet and mobile networks and it must select the best device on its own to forward the messages in mesh network.

III. EXISTING SYSTEM

In today's disaster communication ecosystem, most emergency response mechanism depends a lot on regular cell phones network SMS service and internet-based mobile apps. These systems work just fine when everything is normal, but they fail quickly as soon as disasters like floods, earthquakes or cyclones hit mobile towers, fibre cables and power facilities. Existing SOS application needs a stable Internet /Cellular connection for sending the location data and SOS information, which may not work in off offline/ crowded environment. There's neither smart route selection nor offline message relaying, so if the user is in a network-dark place, their SOS alert doesn't work at all. Also current system does not have real-time rescue status tracking, which leaves those impacted uncertain if their request has been heard or if assistance is coming. Limitations like these cause communication gaps between people, slower rescues, poor coordination among responders, and a greater risk to people's lives when emergencies happen.

- SOS apps require active connectivity or SMS networks.
- No support for offline communication
- No AI routing; messages can fail when the network is congested.
- The rescue team receives a message without a particular request category
- No real-time tracking of request status
- Leads to confusion and a lack of coordination, as well as slow rescue response times

IV. EXISTING SYSTEM DRAWBACKS

- Relies completely on cellular networks or the internet.
- There is no offline device-to-device multi-hop messaging available.
- No intelligent routing according to device resource status.
- Manual communication steps delay rescue. Dashboards don't provide live status visualisation.
- There's no decision-making using ML for choosing the best node.
- Can't manage heavy traffic in an emergency situation, poor scalability in remote areas.

V. PROPOSED SOLUTION AND KEY CONTRIBUTIONS

The proposed system introduces an AI-enabled Emergency Rescue Communication System to tackle the limitations of current disaster communication systems and maintain continuous message delivery both in online as well as offline environments. Unlike existing SOS apps which totally depend upon cellular or internet connectivity, the suggested solution uses dual communications. If the network is connected, it will send structured emergency requests like ambulance, water supply, resources, general help and accurate GPS coordinates to the centralized cloud for quick handling. If the communication facility is destroyed or not available in an offline environment, it will switch to a wireless mesh network and allow smartphones to directly connect with one another. It forwards messages over multiple hops until reaching a device that has connectivity. A big innovation that I'm proposing here is that the system has smart routing According to AI; this means it picks out the most reliable way of sending a message by looking at things like battery power left, free RAM space, how much room there is for storing information on the device, signal strength from nearby devices, and how close those devices are physically to each other. So that even if harsh circumstances exist, it will make sure important emergency messages can be delivered effectively. Also, the rescue authorities can get a special real-time

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monitoring dashboard showing citizens' requests by colours: Red - Waiting, Yellow - Being Handled, Green - Solved. This way, decisions are made quicker, work is given out better, and rescue teams work together better. In summary, I would say that the proposed system offers a strong, scalable and resilient solution to the disaster management problem. It significantly increases the speed of the rescue operation process, making it more reliable and transparent.

- Works both online (server) and offline (mesh network)
- Multi-hop D2D communication ensures connectivity without towers
- AI-based routing using DT, RF, SVM, XGB selects best node
- Best model integrated directly into Android app
- Real-time GPS tracking
- Colour-coded dashboard improves decision-making
- Energy-efficient and reliable routing
- Scalable, secure, and fault-tolerant
- Quicker rescue response, less communication gaps.

VI. LITERATURE SURVEY

A. WiMesh: Leveraging Mesh Networking for Disaster Communication in Resource-Constrained Settings

Authors: Usman Ashraf, Amir A. Khwaja, Junaid Qadir, Stefano Avallone, and Chau Yuen. (May 2021)

This paper proposes WiMesh, a practical wireless mesh network (WMN) solution to be used for communication during disasters in low-resource and rural areas. Authors explain about system design decisions and implementation details as well as field trials conducted in a remote mountainous village. WiMesh focuses on cheap hardware and uses power wisely; it should be easy to deploy so people can send/receive voice/text/multimedia over many hops if no cell towers are available. The article talks about lessons learned from actual deployment experiences, and shares open-sourced code of some parts. Advantages: realistic field evaluation; focus on low cost, low power tradeoff; practical guidance for real-world deployment; multiple hop connectivity provides extended coverage.Disadvantages: not looking at new routing algorithms, performance relies on density of devices and available power, scalability past small/medium requires more research.

B. BLUEMERGENCY: Mediating Post-Disaster Communication Using Bluetooth Mesh

Authors: F. Álvarez et al. (arXiv preprint, 2019).

This work proposes BLUEMERGENCY, a concept for an emergency network according to the Bluetooth Mesh standard. The paper shows how currently available Bluetooth and IoT sensors could be used to form a vendor-agnostic mesh capable of carrying emergency messages in the aftermath of disasters. It consists of an Android app proof-of-concept, a model design for vendors' interoperability, and tests within smart environments showing that it is feasible. Advantages: Leverages common Bluetooth hardware (compatible back to Bluetooth 4.0) - no new hardware required, many-to-many messaging supported, self-organisation.Disadvantages: Bluetooth Mesh range & throughput are limited in comparison with Wi-Fi, multi-hop latency might be large, energy usage needs consideration for dense network scenario.

C. Delay-Tolerant Networks (DTN) for Disaster Scenarios

Authors: Survey / research articles compiled on DTN applications (various authors; survey sources).

A collection of work on Delay Tolerant Networks DTN represents the concept of store, and forward where nodes buffer messages until they are able to forward them to other nodes that have a better chance of delivering those message The surveys discussed on DTN routing like epidemic spray and wait, PRoPHET, bridging disconnected partitions and practical applications in scenarios with intermittent or sparse connectivity. DTN is considered either alone or together with hybrid systems that hand over to backbones when available. Advantages: Can work under intermittent connection; Low infrastructure demand; tolerates high delays; suitable for sparse or mobile disaster environments.

Disadvantages: Delivery latency is very high; Delivery probability is variable; Buffer / storage overhead; Cannot be used when real-time / low-latency is required.

D. Crowdsourcing the Disaster Management Cycle

Authors: (Survey/characterisation) — examples and review of crowdsourcing in disaster response.

This line of research analyzes how crowd sourced information social media SMS volunteer mapping supports situation awareness needs assessment and resource allocation throughout the disaster management cycle Papers reviews empirical deployments, e.g., Haiti, Colorado classify crowdsourcing use case and discuss integration with official emergency management they talk about volunteer AI work flow, crisis map, digital volunteer and tool that process lots of noisy data. Advantages: quick situation information, cheap, it uses both humans and automation to scale up processing, helps discover otherwise invisible needs.

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Disadvantages: Information credibility, verifying the information, bias on what is covered and incomplete coverage of issues and problems. The contributors also depend on social media platforms and have power and connectivity.

E. Sensors in IoT Systems for Urban Disaster Management

Authors: F. Zeng et al., Sensors (MDPI), 2023 (systematic literature analysis).

This systematic review logs sensors and IoT setups for urban disaster management – seismic, flood gauge, air-quality, and human-centric. Data aggregation, edge/fog processing, early warning systems and integration with emergency response platforms are discussed. The paper emphasises design points (reliability, low-power sensing, data fusion) in robust IoT disaster solution. Advantages: sensor/architecture taxonomy; best practices for low latency & scalable detection. Disadvantages: IoT deployments depend on remaining power/comm infrastructure, may not work if the broad infrastructure collapses; security/privacy concerns.

F. Cloud-Based Solutions for Real-Time Crisis Management

Authors: (Research articles and recent 2024/2025 overviews).

These works consider how cloud platforms allow centralised ingestion, processing and visualizing of disaster data(sensor streams, citizen reports, maps). It benefits scalable compute / storage, ML pipelines for triage, and real-time dashboards for authorities. Use Cases: Multi-Agency Coordination & Data Driven Decision Support. Advantages: Scalable Processing Power, Centralised Analytics, Ease of Integration with ML for Triage/Prediction.

Disadvantages: Full dependence on internet/backhaul connectivity; single-point-of-failure concerns unless complemented by edge/fog or offline modes.

G. Reinforcement Learning & Learning-based Routing in Mobile Ad-Hoc Networks (MANETs)

Authors: Multiple (e.g., Li et al., MIT CSAIL; Q-routing papers; various survey articles on Q-Routing).

This research work makes use of reinforcement learning (RL), Q-learning and its variants for route choice in MANETs. RL agents learn to forward packages according to changing circumstances like mobility, congestion and energy limitations, usually giving better package delivery ratios and more stable links than static rules. The papers have simulations and small testbed tests that make networks more connected when things move around. People.

Advantages: Adaptive routing according to network dynamics; can be optimised for multiple objectives, including battery, delay, throughput. Disadvantages: Training overhead and convergence time; computation/energy cost on devices; potential safety issues if decisions need to be explained in critical systems.

H. Advanced SOS & Smartphone Emergency Apps (Design & Implementations)

Authors: Various case studies and implementations (e.g., "Advanced SOS App in Smartphone" — G. Shri Krishna, M.P. Lokesh; "Development of Smart SOS Application").

The applied papers, project reports describe smartphone SOS apps that take the GPS coordinates and send an alert to emergency contacts or a server, also do local storage/backup for offline working. UI/UX decision details are provided for SMS/HTTP fallback and integration with local authorities. Advantages: user-friendly, easy deployment on consumer phone; useful for individual alerts in the presence of connectivity. Disadvantages: most depend on SMS/internet for operation; little peer-to-peer/offline functionality; no link to a large response system.

I. Intelligent Dashboards for Emergency Management

Authors: Yaniv Mordecai, Boris Kantsepolsky et al. (ISCRAM 2018 paper) and related works.

The research is focused on the design, usability and intelligence of dashboards used by emergency managers. Real-time visualisation requirements for prioritising alerts and decision-making assistance; design pattern proposal for helping operators to make quick resource assessment and distribution. The article has an additional section about automation, which includes a discussion about how dashboard designers can utilise machine learning based triage but still maintain oversight from people who use them. Advantages: enhances situational awareness, provides organised prioritisation, and enables multi-agency collaboration. Disadvantages: depends on continuous data feed (internet/cloud), reliance on automatic sorting could be unsafe without human-in-the-loop validation.

J. An Overview of Emergency Communication Networks

Authors: Q. Wang et al. (2023 review) — comprehensive overview paper.

This overview paper provides an overview of the current landscape in emergency communication technologies—satellite, cellular, ad-hoc, mesh, DTN, and hybrid. Latency vs coverage vs cost vs resiliency tradeoffs are evaluated as well as integration approaches like edge/fog/cloud. The survey also points to open research topics like energy-aware routing, privacy, and resilient architectures. Advantages: A broad synthesis that is helpful for system architects, highlighting missing research areas and comparative evaluations. Disadvantages: high-level treatment; lack of new empirical results requires supplementing with focused experimental work

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VII. PROPOSED SYSTEM

The proposed system introduces an AI enabled Emergency Rescue Communication System to tackle the limitations of current disaster communication systems and maintain continuous message delivery both in online as well as offline environments Unlike existing SOS apps which totally depend upon cellular or internet connectivity, the suggested solution uses dual communications If network is connected, it will send structured emergency requests like ambulance water supply resources general help and accurate GPS coordinate to centralized cloud for quick handling. If the communication facility is destroyed or not available in an offline environment, it will switch to a wireless mesh network and allow smartphones to directly connect with one another. It forwards messages over multiple hops until reaching a device that has connectivity. A big innovation that I'm proposing here is that the system has smart routing According to AI; this means it picks out the most reliable way of sending a message by looking at things like battery power left, free RAM space, how much room there is for storing information on the device, signal strength from nearby devices, and how close those devices are physically to each other. So that even if harsh circumstances exist, it will ensure important emergency messages can be delivered effectively. Also, the rescue authorities can get a special real-time monitoring dashboard showing citizens' requests by colours: Red - Waiting, Yellow - Being Handled, Green - Solved. This way, decisions are made quicker, work is given out better, and rescue teams work together better. In summary, I would say that the proposed system offers a strong, scalable and resilient solution to the disaster management problem. It significantly increases the speed of the rescue operation process, making it more reliable and transparent. Communication system with AI supports dual-mode communication.

• **Online mode:** GPS-based tracking and cloud messaging.
• **Offline mode:** Wireless mesh networking for multi-hop transmission.
• AI Routing finds the best device path by using:
• Battery levels
• RAM and storage
• Signal strength
• Distance to other devices
• Citizens can send structured request types:
• Rescue team real-time status:
• **Red:** Waiting
• **Yellow:** Under way
• **Green:** Done
• Can guarantee reliable, transparent effective disaster rescue communications.

Proposed System Advantages
• Works both online (server) and offline (mesh network)
• Multi-hop D2D communication ensures connectivity without towers.
• AI-based routing using DT, RF, SVM, XGB selects best node
• Best model integrated directly into Android app
• Real-time GPS tracking
• Colour-coded dashboard improves decision-making
• Energy-efficient and reliable routing
• Scalable, secure, and fault-tolerant
• Quicker rescue response, less communication gaps.

VIII. SOFTWARE AND HARDWARE REQUIREMENTS

1) Software Requirements
• Android Studio (Java/XML)
• Python (for ML model training)
• Libraries: scikit-learn, XGBoost, pandas, numpy
• Mesh networking library (Wi-Fi Direct/Bluetooth LE)
• Apache Tomcat Server
• MySQL
2) Hardware Requirements
• Android Smartphones with Wi-Fi
• Laptop/Server for hosting

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• GPS sensor
• Internet modem (server side)
• Rescue team computer or tablet

3) Technologies used

• The Java Programming Language
• MySQL ("My Sequel")
• Navicat 8 lite
• Python
• Jupyter notebook

IX. FUNCTIONAL AND NON-FUNCTIONAL REQUIREMENTS

A. Functional Requirements:

1. User Registration Authentication: Users need to fill in some simple information, like name and phone number, to sign up. The system will ask the users for secure login details. The system stores user profiles safely, whether it be on local storage or a cloud server

2. Emergency Request Generation: Allow users to send emergency alerts by choosing from different help options: Ambulance, Water Supply, Rescue Resources, and General Help. Capture GPS coordinates automatically when an SOS signal is received. Let users write a short message about what's happening with them.

3. Online Communication Mode: When an internet mobile network is available, the system shall transmit Emergency type User ID, Exact location, latitude, longitude, and Timestamp. The system shall sync all data to the cloud server or Firebase. The system shall notify rescue teams via the dashboard

4 Offline Communication Mode: The Mesh Networking system shall automatically detect when no network is available. The system shall initiate Device-to-Device mesh communication using Wi Fi Direct Bluetooth. The system shall discover nearby mobile devices acting as nodes. The system shall forward emergency messages through multi-hop routing until an internet-enabled device is reached.

5. AI-Based Optimal Node Prediction Module: The system shall collect the device metrics like Battery Level RAM Available Storage Capacity Signal Strength (RSSI) System will run trained ML models(DT, RF, SVM, XGB) and compare its performance: Load best-performing model(XGBoost or highest Accuracy) into Android App The system predicts the best possible device to forward messages over the mesh network: System rejects nodes with battery levels too low or signal strength too weak.

6. Multi-Hop Message Forwarding: The system will forward the message by means of an intermediate device till a gateway which has internet or an alert is received at the rescue dashboard. The system should maintain message integrity when doing multi-hop transmission. The system needs to prevent messages from being lost with retry and ack packets.

7. Rescue Team Dashboard Functionality: Display the dashboard with real-time emergency messages:
Dashboard should show a map/marker for the location. The dashboard should use colour coding for classifying emergencies as follows:
Red - Critical
Yellow - Moderate
Green - General Help
Dashboard to have Activity log per SOS request: Rescue Operators shall be able to update case status (received, in progress, resolved).

8. Portability Requirements: The Android app has to run on Android 6.0 and above. Mesh Networking needs to work with different Smartphone brands; the AI Model and Codebase should be portable to iOS in future versions.

9. Notifications and Acknowledgements: The system shall send an acknowledgement to the user when the rescue team receives the alert. The system shall generate push notifications/update messages.

10. Admin and Rescue Team Controls: Admin shall manage user accounts and system logs. Rescue personnel shall update the emergency handling status from the dashboard.

B. Non-Functional Requirements:

1. Performance Requirements:

The system has to react to an emergency request initiation within 2 seconds. On mobile devices, AI-based node selection prediction should be done in <300 ms. Mesh discovery needs to find close by devices within 5 seconds. The system can have at least 10-20 hops over a mesh network without any considerable delay

2. Reliability Requirements: The system must achieve a>95% success rate of message delivery over the mesh network. The system will retry to forward messages if it fails. If unable to send, the system stores unsent messages locally.

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3 Availability Requirements: The system must work around the clock, both when online and offline. Dashboard should be available 99% during the rescue operation. When the network disconnects, it should switch to offline mode instantly.
4 Scalability requirements: Mesh network can support hundreds of nodes without degradation: Cloud backend scales to store tens of thousands of emergency alerts & logs. The system needs to support integration with external services like an SMS gateway and an IoT sensor.
5. Security Requirements: Online mode user data (location, emergency info) should be encrypted by AES or HTTPS. Authentication tokens have to be safeguarded. Unauthorised devices must not join the mesh network. App ML model should be protected against tampering.
6. Usability Requirements: The Mobile app will have a simple UI with easy access to the SOS button. Emergency requests should be able to trigger with one/two clicks. A Colour-coded dashboard can help make decisions quickly. UI is accessible for all ages.
7. Maintainability Requirements: System modules need to be updated with module coding standards. It is possible to change and upgrade the ML model without changing the whole app. Logs have to stay maintainable for debugging.
8. Portability Requirements: Android App needs to run on Android 6.0 +**.** Mesh networking should work across different smartphone brands. The AI model and codebase need to be able to port over to iOS in future versions.
9. Accuracy Requirements: ML models need to give more than 90% of correct node selection predictions. GPS tracking needs to be accurate between 5-10 meters.
10. Safety Requirements: The system should avoid false alarms and duplicate transmissions. The application has to protect sensitive emergency information, and battery and resource usage should be low.

X. METHODOLOGY

1. Emergency Request Creation:
The methodology starts when a person makes an emergency request using the mobile app. The citizens can choose from different type of assistance through the interface. like Ambulance, Water Resources and General Help. When choosing an option the system attaches important metadata like the user's GPS location time stamp, and unique request id automatically This structured request format brings clarity, minimizes confusion, and gives rescue teams precise details necessary for evaluating urgency and assigning proper resources.

2. Communication Mode Detection and Selection:
The system produces the request, then intelligently determines whether the device has internet access or not. When connected by mobile data/WiFi/broadband, it sends messages directly to the central cloud server through normal internet protocol transmission. If there is no connectivity due to infrastructure failure, the switch is done to offline mode seamlessly This automatic mode detection means that users do not have to toggle any settings themselves and will get continuous message delivery during disaster.

3. Offline Wireless Mesh Network Formation:
When offline, the mobile device will create a wireless mesh network by using technologies like Wi-Fi Direct or Bluetooth. Any nearby devices running the same app will automatically be added to the mesh and able to communicate directly with each other. Each device is both a source of data and a relay node; together they make up a decentralized, self-healing network. This means that emergency messages could travel over many hops before finally arriving at a gadget with an online connection or perhaps a rescue team's field unit with its own connectivity.

4. AI-Based Routing and Path Optimization:
A significant improvement to the system is the integration of an AI-based routing component that identifies the most dependable device-to-device communication route in the mesh network. The AI model considers real-time factors like battery percentage, RAM availability, storage space, processing power, node mobility, and signal strength. Taking all this into account, it gives preference to stable nodes rather than opting for weak or less powerful devices which might fall out of the network. This smart routing improves message delivery success rates and lowers latency during multi-hop messaging.

5. Rescue Response:
When a rescue team accepts the request, it will prompt an update on the dashboard and be relayed back to the person who requested help's phone. The user exchanges information with the system and the rescue team, as well as the server during the task. Once the emergency has been dealt with properly and the situation is under control, the status

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changes to green which represents closure of that particular incident. It is also a feedback for authorities to see if their disaster response plans are working and improve them in the future.

XI. IMPLEMENTATION

A. System Architecture and Deployment:

Fig. 1 presents he **overall working architecture** of the proposed AI-enabled emergency rescue communication system. The system is designed to ensure uninterrupted communication during disasters by intelligently switching between **online cloud communication** and **offline wireless mesh networking**.

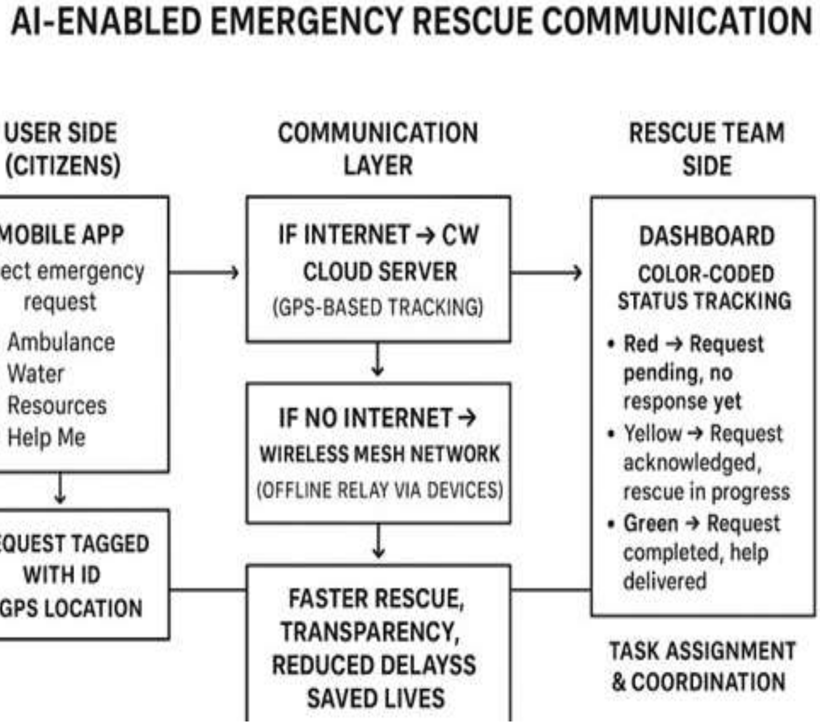

Fig. 1: System Architecture Diagram

1. User Side (Citizens)

- Citizens interact with the system through an **Android mobile application**.
- The app provides a simple interface where users can select the type of emergency:
  - Ambulance
  - Water Supply
  - Resources
  - Help Me (General Emergency)
- Once an emergency is selected:
  - The request is **tagged with a unique user ID**.
  - The user's **GPS location** is automatically captured.
- This ensures that every emergency request is **precise, identifiable, and traceable**.
- **Purpose:** To allow quick SOS generation with minimal user interaction during critical situations.

2. Communication Layer

The communication layer is the core of the system and operates in two intelligent modes:

a) Online Mode (Internet Available)

- If internet connectivity is detected:
  - Emergency requests are sent to the **cloud server**.
  - GPS-based real-time tracking ensures accurate victim location.
- The cloud server acts as a centralized hub that forwards data to rescue teams.

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Advantages:

- Fast transmission
- High reliability
- Centralized monitoring

b) Offline Mode (No Internet Available)

- When internet connectivity is unavailable:
  - The system automatically switches to a **wireless mesh network**.
  - Nearby smartphones form a **device-to-device (D2D) network**.
  - Emergency messages are relayed across multiple devices until a device with internet access is reached.
- AI-based routing selects the **best mobile node** for forwarding messages based on:
  - Battery level
  - RAM availability
  - Storage capacity
  - Signal strength

Advantages:

- Works without mobile towers or internet
- Ensures message delivery in disaster zones
- Reduces dependency on infrastructure

3. Rescue Team Side

- Emergency alerts are displayed on a **real-time rescue dashboard**.
- Requests are categorized using a **color-coded status mechanism**:
  - **Red** – Request pending, not yet responded
  - **Yellow** – Request acknowledged, rescue in progress
  - **Green** – Request completed, help delivered
- The dashboard enables:
  - Task assignment
  - Resource allocation
  - Coordination among rescue teams

Purpose:
To improve situational awareness, response speed, and operational efficiency.

4. System Outcome

- Faster rescue operations
- Improved transparency and coordination
- Reduced communication delays
- Increased survival rates during disasters

The system ensures that **no emergency request is lost**, even in the absence of conventional communication infrastructure.

This architecture combines **mobile technology, AI-based decision making, mesh networking, and cloud computing** into a unified framework. By seamlessly switching between online and offline communication modes, the system provides a **robust, scalable, and life-saving solution** for modern disaster management.

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XII. RESULTS AND OBSERVATION

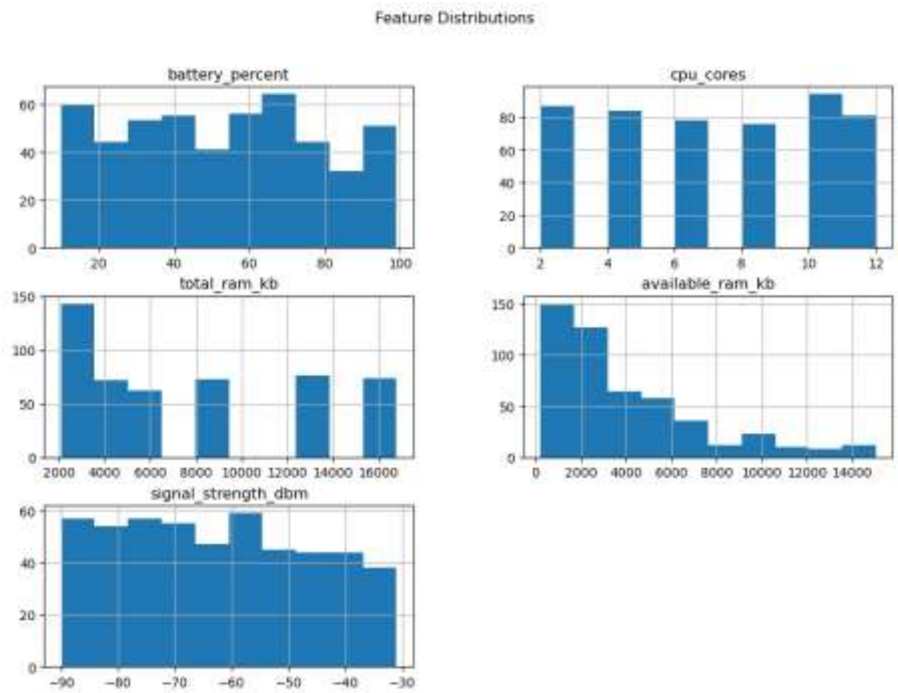

Fig. 2: Feature Distribution Graph

Fig. 2 illustrates the statistical distribution of key device-related features used for predicting the **optimal mobile node** in the AI-enabled mesh network for emergency communication. Understanding these distributions is essential to evaluate data quality, detect imbalance, and justify machine learning model selection.

1. Battery Percentage (battery_percent)

- This histogram shows battery levels ranging from **10% to 100%**.
- The distribution is relatively **uniform**, indicating that devices with both low and high battery levels are present.
- A good spread of values helps the ML model learn realistic routing decisions.
- Devices with **higher battery percentages** are generally more suitable for multi-hop message forwarding.
- This feature strongly influences **energy-efficient routing** in disaster scenarios.

Interpretation:
The dataset adequately represents devices in various battery conditions, enabling the model to avoid selecting nodes with critically low power.

2. CPU Cores (cpu_cores)

- Values range from **2 to 12 cores**, reflecting different smartphone hardware capabilities.
- The distribution shows multiple peaks, indicating common configurations (quad-core, octa-core).
- Devices with more CPU cores can handle **routing, encryption, and forwarding** efficiently.

Interpretation:
This feature helps the ML model distinguish between low-end and high-performance devices for reliable forwarding.

3. Total RAM (total_ram_kb)

- Total RAM ranges approximately from **2 GB to 16 GB** (converted into KB).
- The distribution is **right-skewed**, meaning more devices have lower RAM while fewer devices have high RAM.
- High-RAM devices are better suited for handling multiple forwarding requests simultaneously.

Interpretation:
Including this feature ensures that devices with insufficient memory are not overloaded during emergency communication.

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4. Available RAM (available_ram_kb)

- Available RAM ranges from **very low values up to ~14 GB**.
- The distribution is heavily **right-skewed**, indicating that many devices operate with limited free memory.
- This feature is more critical than total RAM because it reflects **real-time device load**.

Interpretation:
The ML model uses this feature to prevent selecting devices that may crash or slow down due to insufficient memory.

5. Signal Strength (signal_strength_dbm)

- Signal strength ranges from **–90 dBm (weak)** to **–30 dBm (strong)**.
- The distribution is nearly uniform, covering weak, moderate, and strong signals.
- Stronger signal strength ensures **stable and reliable message forwarding** with lower packet loss.

Interpretation:
This feature is essential for ensuring high delivery success rates in the mesh network.

Overall Observations

- All features show **sufficient variability**, which is ideal for training ML models.
- No extreme skewness or missing values are observed, indicating **good data quality**.
- The combination of **hardware (CPU, RAM), energy (battery), and connectivity (signal strength)** provides a holistic representation of device capability.
- These distributions justify the use of advanced ML models **Random Forest and XGBoost**, which handle non-linear relationships effectively.

The feature distributions confirm that the dataset realistically models heterogeneous mobile devices encountered in disaster scenarios. This diversity enables the trained ML models to accurately predict the **most reliable and energy-efficient mobile node** for message forwarding in the emergency mesh network, improving communication reliability and rescue response time.

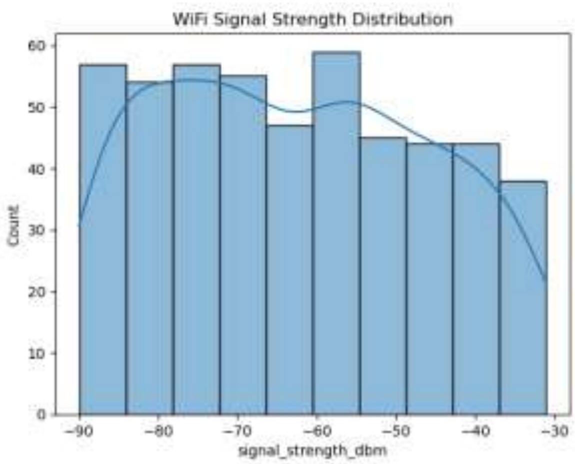

Fig. 3: Wi-Fi Signal Strength Distribution Graph

Fig. 3 illustrates the distribution of **Wi-Fi signal strength** values, measured in **decibel-milliwatts (dBm)**, which is a critical feature used for selecting the optimal mobile node in the emergency mesh communication network.

Understanding the X and Y Axes

- **X-axis(signal_strength_dbm):**
  Represents Wi-Fi signal strength ranging from **–90 dBm (very weak signal)** to **–30 dBm (very strong signal)**.
- **Y-axis(Count):**
  Indicates the number of devices (nodes) falling within each signal strength range.

Key Observations from the Distribution

1. **Wide Signal Coverage**
    - The distribution spans almost the entire operational Wi-Fi range.

- This shows that the dataset includes devices under **poor, moderate, and strong connectivity conditions**.

2. **Higher Density in Mid-Range Signals**
    - A significant number of devices fall between **–80 dBm and –50 dBm**.
    - These values correspond to **usable and stable connections**, suitable for mesh-based message forwarding.
3. **Low-Frequency Extremes**
    - Fewer devices exhibit extremely weak signals (**< –85 dBm**) or extremely strong signals (**> –40 dBm**).
    - This reflects real-world disaster environments where signal quality varies due to obstacles and mobility.
4. **Smooth KDE Curve (Trend Line)**
    - The kernel density estimation (KDE) curve highlights a **gradual rise and fall**, indicating no abrupt anomalies.
    - The peak around **–70 to –60 dBm** represents the most common operational signal range.

The Wi-Fi signal strength distribution confirms that the dataset realistically captures varying network conditions encountered during disaster scenarios. This variability is essential for training robust machine learning models that can accurately select the most reliable mobile node for message forwarding in a dynamic, infrastructure-less mesh network.

XIII. CONCLUSION

The AI-enabled Emergency Rescue Communication System ensures robust communication during disasters by combining mesh networking, GPS, and AI-based routing. Its structured emergency request system, real-time rescue dashboard, and dual mode operation significantly improve rescue response, transparency, and coordination. The solution effectively addresses the limitations of existing systems, offering a practical and life-saving technology for future disaster management. The proposed AI-enabled Emergency Rescue Communication System successfully addresses the communication challenges during natural disasters by offering a hybrid online/offline communication platform. By integrating mesh networking and machine learning–based routing, the system ensures reliable, energy-efficient, and continuous connectivity even in the absence of mobile networks. The inclusion of a real-time rescue dashboard enhances coordination and improves the efficiency of rescue teams. Experimental evaluation of ML models (DT, RF, SVM, XGB) identified the best-performing model, which was embedded into the Android app, enabling intelligent node selection. Overall, the system provides a scalable, robust, and life-saving solution for future disaster management frameworks.

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