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# An Intelligent Cloud System for Disaster Communication and Management Involving IoT Mesh Networks

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***Abstract***

*Disaster coordination and communication are key areas of rescue. Nevertheless, the frequent interruptions in old communication channels underscore the need for alternative approaches. Modern communication technologies play a critical role in enhancing disaster management. This study proposed an effective approach wherein a local communication network is created which will aid emergency responders in responding to disasters, with the aim of improving their ability to handle emergencies quickly and efficiently. Advanced technologies such as network connectivity, LoRa, Mesh networking, IoT GSM and advanced security measures are utilised for this purpose. Additionally, this network unites all these technologies to produce a highly efficient communication system that can function effectively even in the most challenging circumstances. This study discusses how these technologies can be utilised to overcome the limitations of conventional communication methods in times of disaster.*

**Keywords:** Mesh networking, LoRa (Long Range), IoT GSM, GPS, disaster communication

## INTRODUCTION

The impact of natural or man-made disasters on communities can be significant, resulting in loss of life, property damage, and disruption of essential services. Effective communication is crucial for coordinating rescue operations, providing updates, and ensuring the safety and well-being of those affected in such situations. Nevertheless, in times of disaster, traditional communications systems are often at risk of failure or damage, which can hinder response time and cause significant harm.

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Increasingly in recent years, there has been the need to consider alternative communication methods that are capable of working well in case of disaster. Consequently, new technologies have been introduced to enhance communication capabilities in such scenarios. Networking is a technique that allows devices to communicate with each other without any interference, for instance [1, 2]. LoRa technology is the ideal choice for long-distance communication and can be used to reach remote areas where traditional communication methods have failed.

Additionally, the Internet of Things (IoT) has enabled the deployment of sensors and devices that can collect and transmit data in real-time, providing valuable insights for disaster response teams. However, these advancements also bring new challenges, such as ensuring the security and integrity of the communication network against potential cyber threats. In our proposal, we will use a model of mesh networking that is very decentralized: each node in the network acts as re-entrant for other nodes in an interconnected peer to peer communication system. Despite the challenges of network failures, mesh networks are still highly capable and resilient to disaster-stricken environments that are shown in Figure 1, we can imagine as 'REAL LIFE SCENERIO'. The strength and dependability of a mesh network are maintained by the ability to establish communication between nodes, even in areas where none is accessible or susceptible to failure.

## LITERATURE SURVEY

The research work on communication skills for disaster coordination and communication covers many topics related to the use of technology in crisis management. Its main focus is on research on disaster communication [3], including networking, LoRa, IoT GSM and GPS, and their applications in disaster management. Mesh networking has emerged as an effective way to communicate effectively in disaster areas. Research shows that mesh networks can provide reliable communications even in the event of infrastructure damage or network congestion. For example, Wang *et al*. 2022 [4] demonstrated the effectiveness of mesh networks in providing communication support to problem-solving teams in remote areas. LoRa technology provides long-distance communication, making it ideal for reaching remote areas where traditional communication is not possible. Many studies have demonstrated the potential of LoRa networks for disaster management, noting their ability to provide wide coverage and low energy consumption (Borgia, 2016) [5]. Additionally, the LoRa network is easy to deploy and configure, making it suitable for emergencies. IoT GSM can provide better information to disaster response teams by deploying sensors and devices that instantly collect and transmit data. Research shows that IoT GSM can improve situational awareness and decision-making in disaster situations (Bakar et al., 2019) [6]. By integrating IoT GSM into communications, emergency responders can access critical information quickly and efficiently. GPS technology plays an important role in disaster management by providing accurate location information to emergency responders and affected individuals. Research shows that GPS can increase the effectiveness of search and rescue operations during disasters. Integrating GPS with communications can help emergency responders better navigate disaster areas and coordinate more effectively. In summary, case studies demonstrate the importance of technology in collaboration and communication.

By leveraging mesh networking, LoRa, IoT GSM and GPS, we communications network has the potential to improve disaster response, ultimately saving lives and reducing the impact of disasters on this community [4].

## PROPOSED WORK

The proposed work plans include the development of social networks that will facilitate cooperation and communication for empowerment, efficiency and adaptation in difficult regions. The network should include technologies such as networking, LoRa, IoT GSM and GPS to provide more ways to solve the complex problems of disasters. The basis of the project is defined in the careful design of the communication network architecture. The architecture will be carefully designed to integrate various technologies and enable coordination and integration of different products.

**Figure 1.** Real Life Scenario.

 

The communication network will serve as the basis to facilitate communication between the elements of the system. This approach reduces interference by allowing communications to continue without interference, making it especially suitable for disaster areas where normal communications would be disrupted. The integration of LoRa technology further increases the reliability of the network and enables communication in the field with low power consumption [7]. LoRa’s ability to overcome obstacles and cover large areas makes it useful in reaching remote or hard-to-reach areas where traditional communication is not possible. Additionally, LoRa's low power consumption ensures the long service life necessary for continuous communication during a disaster. IoT GSM adds another layer of functionality to communications by supporting the deployment of sensors and devices for immediate response to collect and send information. These IoT devices can provide information regarding disaster situations, including environmental conditions, infrastructure damage, and the location of affected individuals. Using IoT GSM, emergency responders can receive timely and effective information, allowing them to make more informed decisions and allocate resources. The addition of GPS technology can increase the effectiveness of communications by providing accurate location information to rescuers [8]. GPS provides precise navigation in disaster areas, facilitates search and rescue, and facilitates coordination of response efforts. By integrating GPS into communications, emergency responders can improve their routes, reduce response times, and maximize efficiency. The proposed project also includes the development of advanced software systems and processes to manage communications, manage data transmission and ensure network security. These software products designed to be lightweight, efficient and functional and able to run on unlimited devices when necessary. Best security measures, including encryption and authentication methods, used to protect the integrity and confidentiality of network communications and reduce network threats and unauthorized access. Overall, the proposed work is an effort to create effective and efficient communication for problem-solving situations. Using technology and effective safety measures, the network can improve disaster coordination and communication, ultimately saving lives and reducing the harmful impact to society.

## CHAT COMMUNICATION ACTIVITY OVER TIME

Communication in computer networks differs in determining how devices (or nodes) are connected to each other. The three types of topologies used are mesh, linear, and tree, and each has different characteristics that affect real-time communication as we can see in Figures 2 and 3. The mesh network topology is characterized by the connection of each node with the other node, creating an incredible and dynamic structure. This redundancy ensures that communications are still available even if one or more nodes fail, thus increasing reliability. In terms of communication games over time, mesh networks can well control the amount of traffic because the message can be sent over different channels. However, as the number of nodes increases, the complexity of managing the network also increases, leading to more interference and overhead. In contrast, a linear network topology connects nodes in a linear fashion; each node connects to exactly two nodes in addition to the last one. This simple model is easy to use, but communication may take less time than a mesh network. Communication in line topology is limited by the number of lines in the connections and there is no redundancy in the connection, making it vulnerable to failure. Multi-network topology organizes nodes in a hierarchical structure; There is a base at the top and sub-nodes branching from the base. This topology is ideal for situations where there is central control or coordination. The message can be organized from root to leaf, and the hierarchy ensures clear communication.

However, tree topology may be less robust than network topology because failure of the root node can disrupt communication with all other nodes (Figure 3). Many factors come into play when comparing network topologies over time. Mesh networking provides reliability and redundancy, making it suitable for applications that require continuous communication. Although line networks are simple, they can suffer from scalability and violation issues, making them unsuitable for complex networks. Tree networks provide a communication mechanism that can be useful for some hierarchical networks [9], but they may not have the flexibility and redundancy of mesh networks. In summary, the choice of network topology for communication depends on the specific requirements of the application at that time. Mesh networks are superior in terms of reliability and repeatability, wired networks are simple but not inefficient, and tree networks provide a layered structure suitable for some applications. Understanding these topologies helps design and implement effective networks according to features and needs.

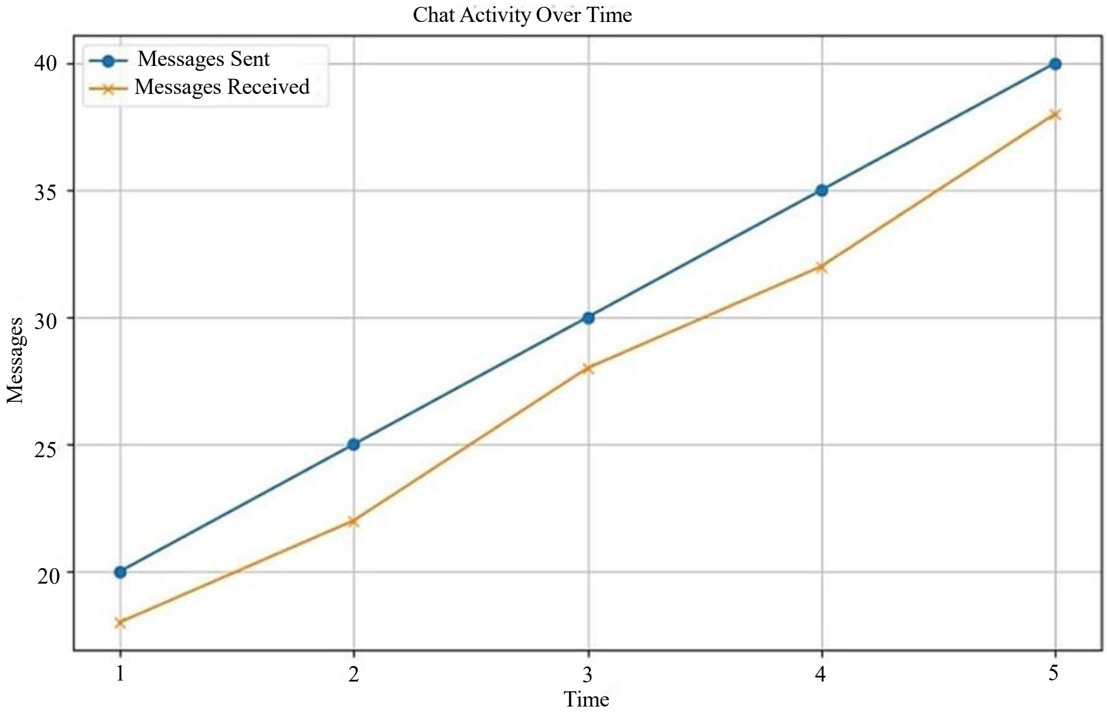


**Figure 2.** Chat activity over time.

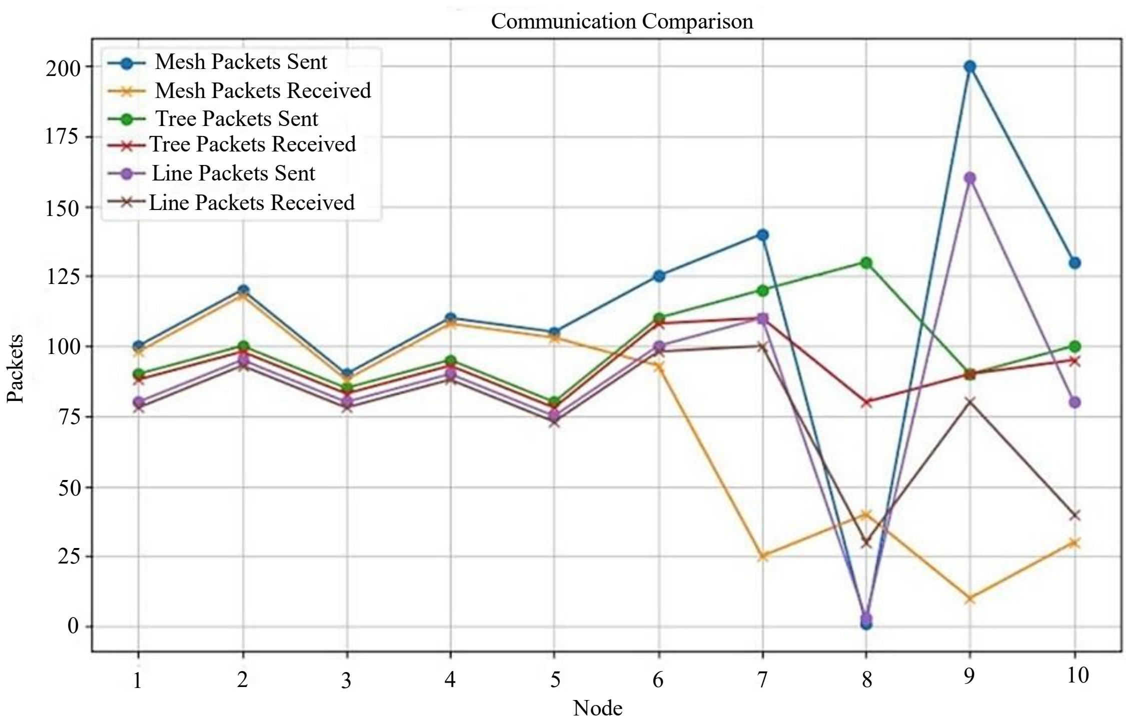


**Figure 3.** Chat communication comparison.

 

## NODE'S LOCATIONS

Node location in communications networks (such as those used in drones and robots) refers to the physical location of each part of the network (Figure 4). Each node represents a device, such as a drone, robot, or sensor, that can send, receive, or transmit data in the network. Understanding and managing node locations is critical to optimizing communication, ensuring reliable communication, and ensuring efficient data transfer. In a normal network, nodes are distributed in an area and their location plays an important role in determining network performance. How is data routed between nodes? The placement of nodes may vary depending on the specific requirements of the network topology. For example, in a mesh network, nodes are often placed in a grid-like pattern and each node is connected to several adjacent nodes. This allows for effective communication because items can be sent via multiple paths if one path is blocked or unavailable. In a tree network, nodes are arranged in a hierarchical structure with a central node at the top (root) and branches at lower levels. This topology is often used in situations where nodes need to report information to a central authority or where information needs to be collected and sent to higher levels. In a linear network, nodes are positioned in a linear manner, each connected to the next node. This topology is simple and useful for situations where nodes need to communicate in a race, such as pipes or roads. The location of the node also affects signal strength and communication quality [10]. Nodes that are closer together will generally have stronger, more reliable communications, while nodes further away will see weaker signals and be more likely to interfere. Checking node location involves determining the best placement of nodes to maximize network performance. This may include considerations such as communication between nodes, terrain and surrounding obstacles, and the power required at each node. By placing nodes and adjusting their locations as needed, network operators can ensure efficient and reliable communication and data transfer in the network.

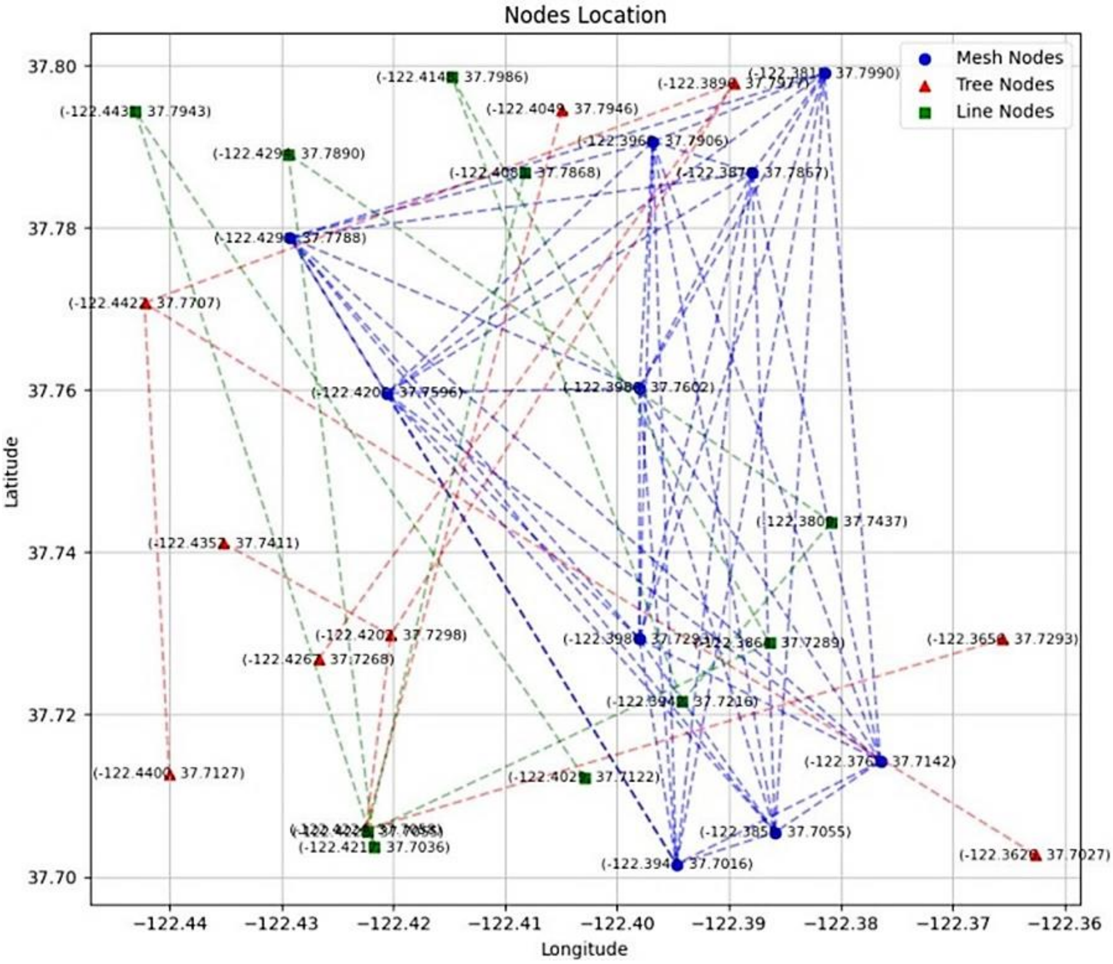


**Figure 4.** Node's location.

## BRIEF SCENARIO

In a simple scenario where nodes such as drones and robots communicate using the ESP32 chat server in different network topologies such as line, mesh and tree, if a message is dropped by one node and needs to connect to another node in a different topology, the system will find a way to deliver a message. In routing, if a message is dropped, the sender or another node may be frustrated until it reaches a gateway node connected to another topology. This gateway then forwards the message to the token key, which can then send the message to the ESP32 chat server for storage in the database. In the network, if a message is dropped, the neighbouring node can reroute it until it reaches the gateway node, and then forward it to the destination node in a different TOPOLOGY. Similarly, in tree construction, if the message has been dropped, it can be routed through other points in the hierarchy until it reaches the gateway point which is a bridge in another topology. After the message reaches the gateway, it is sent to the destination node for storage in the database. Therefore, regardless of the topology, the network ensures efficient communication between the node and the ESP32 chat server [9], ensuring successful message delivery even if one node fails. Also, when sending location data for military rescue operations, the process is the same. Location information is included in the message and passed over the network up to the gateway node which forwards it to the database server. Military personnel can then use this information to plan and coordinate rescue operations.

## ADVANCEMENTS IN RELIABLE COMMUNICATION SYSTEMS

As the frequency and severity of natural and man-made disasters around the world has increased in recent years, the importance of effective disaster coordination and communication has increased. These incidents often result in significant loss of life, property damage, and disruption of critical services, highlighting the critical need for reliable communications systems to facilitate timely and coordinated response activities.

Traditional communication systems are often vulnerable to failure or damage during disasters, hampering response time and exacerbating the impact of such events. To address these challenges, there is a need to explore communication methods that can be used effectively in disaster-affected areas.

One of the upcoming approaches is to develop local communication networks for emergency response using advanced technologies such as mesh connectivity, LoRa [10], Mesh networks, IoT GSM and advanced security measures [11, 12]. This network will provide an efficient and resilient communication system that can operate even in the most challenging conditions.

For example, a network is a decentralised communication model where each node in the network acts as a relay for other nodes, allowing peer-to-peer communication without the need for a centralised infrastructure. This approach improves network resilience by allowing communication to continue even if multiple nodes are down or unavailable.

LoRa technology, which enables long-distance communication over low-power networks, can be very useful for reaching remote areas where conventional communication methods may fail. By connecting LoRa to the communication network, emergency responders can communicate over long distances, ensuring they reach those in need.

IoT GSM expands network capabilities by deploying sensors and devices that can collect and transmit data in real time. This information can provide valuable insight to disaster response teams, allowing them to make informed decisions and allocate resources more effectively.

Advanced security measures must be implemented to ensure the security and integrity of the communication system. It includes secure encryption and authentication mechanisms to protect against cyber threats and unauthorised access.

 

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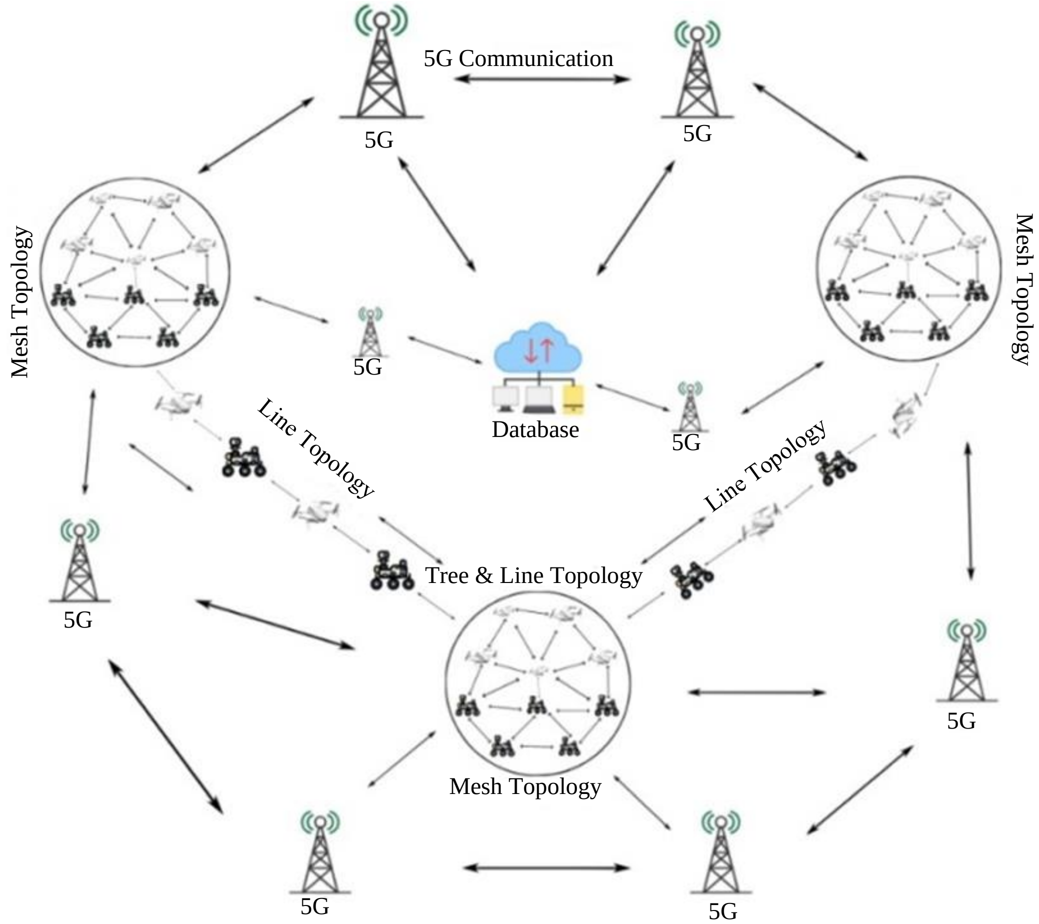


**Figure 5.** Communication between multiple devices.

In summary, the proposed local communication system for emergency responders represents a significant advance in disaster coordination and communication. By using advanced technology and implementing robust security measures, this system has the potential to significantly improve the effectiveness and resilience of disaster response efforts, ultimately saving lives and reducing the impact of disasters on society.

On the receiving side, nodes can be displayed on a map, allowing the user to see the sender's location. This tracking capability now improves coordination and situational awareness, especially in applications such as search and rescue, surveillance and environmental monitoring. Users can track the movement and location of the drone or robot in real time by adding location information to the message. This feature allows for better coordination among team members because they can monitor each other on-site and respond quickly to changing situations. Overall, the integration of the location tracking module with the ESP32 communication server provides a powerful means of communication using drones and robotics. It allows users to send location-aware messages, thus promoting better collaboration, improved situational awareness and better communication between multiple applications that are shown in Figure 5.

## CONCLUSION

Integrating location data into messages sent by drones and robots using the ESP32 communication server involves integrating GPS or similar location into the drone or robot. These modules determine the exact location of each device and then add it to the message along with the text. When users send messages, location information is added to the message or included in a separate location. The combined message is then entered into a format suitable for transmission over the network. When the ESP32 chat server receives a message, it extracts the target data and sends the message along with the target data to the appropriate destination. Nodes in the network. If the application needs to store location information in a database, the ESP32 server can interact with the database to store this information in message.

In summary, the use of ESP32 chat servers and different network topologies offers a reliable and flexible communication solution for drones, robots and other devices. This technology enables efficient routing and delivery of messages even in scenarios where nodes fail, or messages must traverse multiple topologies. Long-distance communication capabilities are developed using LoRa technology, which enables communication over long distances or in remote areas with limited infrastructure. This technology has applications in various fields such as search and rescue, environmental monitoring and control. In general, the combination of the ESP32 chat server, different network topologies and LoRa technology provide a reliable and effective communication foundation for various applications, contributing to the development of communication and coordination in complex environments.

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