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FinSafe: Revolutionizing Communication For Safer Seas

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ABSTRACT

The FinSafe system is an innovative and cost-effective solution designed to enhance the safety, communication, and efficiency of fishermen operating in remote and challenging maritime environments. Leveraging the power of LoRa (Long Range) communication technology, FinSafe provides a robust network comprising three interconnected components: the Sender Device, Mouth Device, and Mother Device.

The Sender Device, mounted on fishing vessels, facilitates real-time location tracking and communication. The Mouth Device amplifies signals to extend the communication range, ensuring seamless connectivity even in vast oceanic regions. The Mother Device, connected to the cloud, acts as a central hub enabling long-distance communication and data synchronization.

To further enhance safety, the system integrates AI-powered emergency response capabilities, providing intelligent solutions during critical situations. Bluetooth and WiFi modules complement the system for short-range manual communication, offering flexibility and reliability.

FinSafe is designed with a focus on affordability, ease of production, and maintenance, ensuring accessibility to local fishing communities. By addressing the crucial challenges of communication and safety at sea, FinSafe contributes to reducing risks for fishermen, improving their working conditions, and fostering sustainable fishing practices.

This project showcases a practical and scalable approach to leveraging modern technology for the betterment of traditional industries, setting a benchmark for innovation in maritime safety.

INDEX TERMS

Fishermen Safety, LoRa Communication Maritime ,Communication System, Real-Time Location, Tracking AI-Powered Emergency Response, Bluetooth Connectivity, WiFi Communication ,Signal Amplification ,Cloud Integration ,Affordable Technology Solutions Sustainable Fishing Practices Maritime Connectivity, Low-Power Communication ,Emergency Management Systems Fishing Vessel Monitoring.

1. INTRODUCTION

Fishing is one of the oldest and most vital occupations, providing sustenance and economic stability for millions worldwide. However, it remains one of the most dangerous professions due to the inherent risks of operating in unpredictable and often harsh maritime environments. Challenges such as limited communication, difficulty in tracking location, and delayed emergency responses significantly impact the safety and efficiency of fishermen. These issues underscore the need for innovative technological solutions that can mitigate risks and improve connectivity in maritime settings.

The **FinSafe system** emerges as a transformative solution to address these challenges. Combining modern communication technologies like **LoRa (Long Range) communication**, **AI-driven emergency response mechanisms**, and **cloud integration**, FinSafe aims to provide a comprehensive safety and communication framework tailored for the unique needs of fishermen. Its modular architecture, consisting of the **Sender Device**, **Mouth Device**, and **Mother Device**, enables seamless communication, location tracking, and signal amplification over vast oceanic distances.

Traditional communication systems, while effective on land, often fail in remote maritime regions due to their reliance on cellular networks or satellite connectivity, which can be costly and inaccessible for local fishing communities. FinSafe bridges this gap by leveraging LoRa technology, a low-power, long-range communication protocol that is both affordable and reliable. Additionally, the integration of **Bluetooth** and **WiFi** ensures adaptability for short-range communication when necessary.

One of the standout features of FinSafe is its **AI-powered emergency response capability**, which intelligently detects emergencies such as adverse weather, equipment failures, or accidents and promptly notifies relevant authorities. This proactive approach significantly reduces response times and enhances safety measures.

The design of FinSafe emphasizes affordability, ease of production, and maintenance, making it accessible even to small-scale fishermen. By focusing on practical and scalable solutions, the system not only addresses immediate safety concerns but also contributes to sustainable fishing practices by improving operational efficiency and reducing risks.

This review paper explores the technological foundations, operational principles, and potential impact of the FinSafe system. It highlights its role in bridging the gap between traditional fishing practices and modern technological advancements, offering a safer, more connected future for fishermen worldwide.

2. LITERATURE SURVEY

Dynamic Secure Access Control and Data Sharing Through Trusted Delegation and Revocation in a Blockchain-Enabled Cloud-IoT Environment

Suhair Alshehri , Omaimah Bamasaq , Daniyal Alghazzawi [1], "Dynamic Secure Access Control and Data Sharing Through Trusted Delegation and Revocation in a Blockchain" explores leveraging blockchain technology to enhance security and efficiency in data access management. In this approach, blockchain's decentralized nature ensures transparency, immutability, and trust for managing user permissions. The system allows for dynamic access control, where permissions can be granted or revoked in real-time, ensuring that only authorized individuals or entities can access sensitive data.

A key feature of this system is the trusted delegation mechanism, enabling users to delegate access rights to others securely. This delegation is recorded on the blockchain, providing an auditable trail for accountability. Additionally, the revocation process is seamlessly integrated, allowing immediate termination of access when necessary, further strengthening data security.

By utilizing smart contracts, the system automates permission assignments and ensures that they remain tamper-proof. Blockchain's transparent and immutable properties make it an ideal foundation for creating a trusted environment where both access and data-sharing policies are dynamically enforced and verifiable, reducing the risk of unauthorized access or data breaches. This innovation has vast potential in fields requiring high-security data sharing, such as healthcare, finance, and government.

Employing Remote Sensing, Data Communication Networks, AI, and Optimization Methodologies in Seismology

Mohamed S. Abdalzaher , Senior Member, IEEE, Hussein A. Elsayed, Member, IEEE, and Mostafa M. Fouda , Senior Member, IEEE [2], "Employing Remote Sensing, Data Communication Networks, AI, and Optimization Methodologies in Seismology" explores the integration of cutting-edge technologies to enhance seismic monitoring and prediction. Remote sensing techniques enable real-time collection of seismic data from various sources, which is then transmitted through advanced data communication networks for immediate processing. Artificial Intelligence (AI) and machine learning algorithms play a crucial role in analyzing large datasets, identifying patterns, and making predictions about seismic activities. These AI-driven models help to forecast seismic events with higher accuracy, enabling better preparedness and response.

Optimization methodologies further enhance the system's efficiency by optimizing resource allocation, improving sensor placement, and fine-tuning the data analysis process. By combining these technologies, the system provides a more effective approach to monitoring and predicting earthquakes, minimizing risks, and improving safety measures. This integrated approach has great potential in fields like disaster management, urban planning, and early warning systems, offering a smarter, data-driven way to address seismic challenges and mitigate their impact on society.

Vector Tracking Based on Factor Graph Optimization for GNSS NLOS Bias Estimation and Correction

Changhui Jiang , Yuwei Chen , Bing Xu , Member, IEEE, Jianxin Jia , Haibin Sun, Chen Chen , Zhiyong Duan, Yuming Bo, and Juha Hyyppä [3], Vector Tracking Based on Factor Graph Optimization for GNSS NLOS Bias Estimation and Correction This technique addresses the challenge of Non-Line-of-Sight (NLOS) signal-induced bias in Global Navigation Satellite System (GNSS) pseudorange measurements, particularly in dense urban areas. The conventional Vector Tracking (VT) method using a Kalman Filter (KF) has been investigated for NLOS detection, but the estimation of NLOS-induced bias within the VT framework has not been thoroughly explored.

To address this limitation, the proposed approach incorporates Factor Graph Optimization (GO) with VT, instead of a KF, to optimize the estimation of navigation solutions. The NLOS-induced bias is added to the VT state vector as a variable for real-time estimation. In the GO-VT framework, the state transformation and measurement model are treated as constraints to optimize the state vector estimation, making it more flexible than the KF approach in handling state vector changes.

An iterative process is employed to solve for the optimization results, and a multiple-correlator scheme is used to provide initial values for the NLOS-induced bias. The proposed method is evaluated using three collected GPS L1 data sets (static and dynamic), and the statistical results demonstrate that GO-VT with state augmentation achieves superior position estimation in urban areas compared to the conventional KF-VT method.

A Review on Electromagnetic, Acoustic, and New Emerging Technologies for Submarine Communication

ZIHAN QU AND MENGQIN LAI [4], "A Review on Electromagnetic, Acoustic, and New Emerging Technologies for Submarine Communication" provides a comprehensive overview of the existing technologies used in underwater communication and the challenges faced in achieving reliable communication for submarines. The review covers traditional electromagnetic and acoustic methods, highlighting their limitations, such as short range, signal attenuation, and susceptibility to environmental factors. It further explores recent advancements in electromagnetic and acoustic technologies, as well as emerging methods that aim to improve communication capabilities, such as optical and underwater wireless communication systems. The paper emphasizes the need for innovative solutions to overcome the constraints of current technologies, focusing on improving the speed, range, stability, and energy efficiency of underwater communication systems. The review also discusses the potential

applications of these technologies in military, scientific, and commercial sectors, underscoring their significance for future submarine communication systems.

An Experimental Dataset for Search and Rescue Operations in Avalanche Scenarios Based on LoRa Technology

MICHELE GIROLAMI 1 , FABIO MAVILIA 1 , ANDREA BERTON 2 , GAETANO MARROCCO 3 , (Senior Member, IEEE), AND GIULIO MARIA BIANCO 3 , (Member, IEEE) [5], An Experimental Dataset for Search and Rescue Operations in Avalanche Scenarios Based on LoRa Technology **aims to evaluate the effectiveness of Long Range (LoRa) Low-Power Wide-Area Network (LPWAN) technology for mountain search and rescue (SaR) operations**. The dataset comprises experimental results from various studies, including numerical and experimental characterizations of LoRa-based helmet-to-UAV links on flat lands, multipath effects, and path loss models. The research focuses on the use of LoRa radios worn by search parties and installed in unmanned aerial vehicles (UAVs) to accelerate the localization of targets, likely unconscious victims, in avalanche scenarios. The dataset includes measurements of range, battery life, and communication link robustness to shadowing, as well as comparisons with standard Wireless Local Area Networks (WLAN) and current avalanche beacons. The results demonstrate that LoRa outperforms the considered technologies, offering extended range and low power consumption, making it a viable solution for SaR applications. Additionally, the dataset presents a convolutional neural network (CNN) approach for assisting avalanche SaR operations with UAV imagery, utilizing pre-trained CNNs to extract discriminative features and trained linear support vector machines (SVMs) to detect objects of interest. The experimental results show improved detection performance with increasing resolution, although computation time increases accordingly. This comprehensive dataset provides valuable insights for the development of LoRa-based SaR systems, enabling more efficient and effective search operations in avalanche scenarios..

Blockchain-enabled wireless communications: a new paradigm towards 6G

Jiaheng Wang, Xintong Ling, Yuwei Le, Yongming Huang, Xiaohu You [6], The convergence of blockchain and wireless communications is poised to revolutionize the next-generation network, 6G. By integrating blockchain’s decentralized, transparent, and secure features with wireless networks, a new paradigm emerges, promising enhanced trust, efficiency, and security. This fusion enables secure and trustworthy resource and service exchange among diverse communication systems, addressing the lack of established trust relationships in symbiotic communication frameworks. Blockchain’s consensus mechanisms, such as proof-of-work or proof-of-stake, can be adapted for wireless networks, ensuring secure and efficient data transmission. Furthermore, blockchain-based sharding schemes, like Green Sharding, can optimize energy consumption and reduce processing latency in 6G networks. As 6G networks integrate blockchain, they will provide a seamless global connectivity infrastructure,

enabling efficient interconnection of all devices and systems. This synergy will deliver more efficient, secure, and reliable communication services, paving the way for a sustainable and trustworthy 6G wireless network.

Blockchain Security and Privacy for the Internet of Things

Marco Picone [1], Simone Cirani [2,3], Luca Veltri [3] [7], Blockchain technology has emerged as a promising solution to address the pressing security and privacy concerns in the Internet of Things (IoT). By leveraging its decentralized, immutable, and transparent nature, blockchain can fortify IoT security infrastructure and protect user data. For instance, blockchain-based trust management systems can ensure secure data transmission and storage, while smart contracts can automate and verify interactions between devices, eliminating the need for centralized authorities. Additionally, blockchain's decentralized identity management capabilities can provide secure and private identification for IoT devices, preventing unauthorized access and data breaches. Furthermore, the use of blockchain in IoT can enable secure and transparent data sharing, ensuring that only authorized parties can access and manipulate data. Moreover, blockchain's immutability feature can provide a tamper-proof record of all transactions and interactions, allowing for auditing and forensic analysis in case of security incidents. Overall, the integration of blockchain with IoT can significantly enhance the security and privacy of IoT systems, enabling the widespread adoption of IoT technologies while mitigating the risks associated with data breaches and unauthorized access.

Blockchain for Internet of Underwater Things: State-of-the-Art, Applications, Challenges, and Future Directions

Sweta Bhattacharya[1]Nancy Victor[1]Rajeswari Chengoden[1]Murugan Ramalingam[1]Govardanan Chemmalar Selvi[1]Praveen Kumar Reddy Maddikunta[1]PraveenKumar Donta[2]Schahram DustdarRutvij H. Jhaveri and Thippa Reddy Gadekallu [1,4,*] [8], Blockchain for Internet of Underwater Things (IoUT): The integration of blockchain technology with IoUT has gained significant attention in recent years due to its potential to address security, privacy, and transparency challenges in underwater applications such as environmental monitoring, disaster management, and underwater exploration. The use of blockchain in IoUT enables secure data transmission, storage, and sharing, and provides a decentralized and tamper-proof platform for various underwater applications. However, the implementation of blockchain in IoUT also poses several challenges, including limited communication bandwidth, energy constraints, and high latency, which need to be addressed through the development of lightweight consensus mechanisms, edge and fog computing, and other innovative solutions. Despite these challenges, the future of blockchain in IoUT looks promising, with potential applications in areas such as oceanographic monitoring, naval defense, and underwater communication, and researchers are expected to continue exploring new ways to improve the scalability, performance, and security of blockchain-enabled IoUT systems.

3. COMPARITATIVE ANALYSIS OF LITERATURE REVIEWS

Table 1: Comparison Study of Papers

Paper Title	Authors	Comparative Study
Dynamic Secure Access Control and Data Sharing Through Trusted Delegation and Revocation in a Blockchain-Enabled Cloud-IoT Environment.	Suhair Alshehri , Omaimah Bamasaq , Daniyal Alghazzawi	"Dynamic Secure Access Control and Data Sharing Through Trusted Delegation and Revocation in a Blockchain" uses blockchain to improve data security by enabling real-time access control, trusted delegation, and instant revocation. Blockchain's transparency and immutability ensure secure, auditable management of permissions. Smart contracts automate and protect permissions, making it ideal for high-security fields like healthcare, finance, and government. 4o mini
Employing Remote Sensing, Data Communication Networks, AI, and Optimization Methodologies in Seismology	Mohamed S. Abdalzaher , Senior Member, IEEE, Hussein A. Elsayed, Member, IEEE, and Mostafa M. Fouda , Senior Member, IEEE	"Employing Remote Sensing, Data Communication Networks, AI, and Optimization in Seismology" integrates advanced technologies to improve seismic monitoring and prediction. Remote sensing collects real-time data, transmitted through communication networks for analysis. AI and machine learning analyze large datasets to predict seismic events more accurately. Optimization enhances resource allocation, sensor placement, and data analysis. This approach improves earthquake forecasting, safety measures,

		and disaster response, with potential applications in disaster management, urban planning, and early warning systems.
Vector Tracking Based on Factor Graph Optimization for GNSS NLOS Bias Estimation and Correction	Changhui Jiang , Yuwei Chen , Bing Xu , Member, IEEE, Jianxin Jia , Haibin Sun, Chen Chen , Zhiyong Duan, Yuming Bo, and Juha Hyyppä	The Vector Tracking (VT) based on Factor Graph Optimization (GO) addresses the challenge of Non-Line-of-Sight (NLOS) signal bias in GNSS measurements, particularly in urban areas. Unlike the Kalman Filter (KF) approach, which has limited NLOS bias estimation, the GO-VT method integrates NLOS bias into the VT state vector for real-time estimation. This approach uses an iterative optimization process and a multiple-correlator scheme for initial bias values, improving position estimation. Testing on GPS L1 data sets shows that GO-VT outperforms the conventional KF-VT method in urban environments.
A Review on Electromagnetic, Acoustic, and New Emerging Technologies for Submarine Communication	Chuanqi Zheng, Siddharth Sane, Kangneoung Lee, Vishnu Kalyanram, and Kiju Lee	"A Review on Electromagnetic, Acoustic, and Emerging Technologies for Submarine Communication" explores current underwater communication methods and their limitations, including short range and signal attenuation. It covers advancements in electromagnetic, acoustic, and emerging technologies like optical and wireless systems aimed at enhancing communication speed, range, stability, and energy efficiency. The review highlights the need for innovative solutions to overcome these challenges, with potential applications in military, scientific, and commercial sectors, emphasizing their importance for future submarine communication systems.

An Experimental Dataset for Search and Rescue Operations in Avalanche Scenarios Based on LoRa Technology	ZIHAN QU AND MENGQIN LAI	"An Experimental Dataset for Search and Rescue Operations in Avalanche Scenarios Based on LoRa Technology evaluates the use of LoRa LPWAN for mountain SaR operations. The dataset includes experimental results on LoRa-based helmet-to-UAV links, path loss models, range, battery life, and communication robustness. Compared to WLAN and avalanche beacons, LoRa offers extended range and low power consumption, making it ideal for SaR. It also incorporates a CNN approach using UAV imagery for better object detection in avalanche scenarios. The dataset provides valuable insights for developing LoRa-based SaR systems for more efficient search operations.
Blockchain-enabled wireless communications: a new paradigm towards 6G	Jiaheng Wang, Xintong Ling, Yuwei Le, Yongming Huang, Xiaohu You	The convergence of blockchain and wireless communications is set to transform 6G networks by integrating blockchain's decentralized, secure, and transparent features with wireless systems. This fusion ensures secure resource exchange, addresses trust issues, and enables efficient data transmission using blockchain's consensus mechanisms. Blockchain-based sharding, like Green Sharding, optimizes energy use and reduces latency in 6G networks. This integration will provide seamless global connectivity, delivering secure, reliable, and sustainable communication services for 6G.
Blockchain Security and Privacy for the Internet of Things	Marco Picone [1], Simone Cirani [2,3], Luca Veltri [3]	Blockchain technology offers a robust solution to security and privacy concerns in the Internet of Things (IoT). Its decentralized, immutable, and transparent nature strengthens IoT security by ensuring secure

		data transmission, automating interactions with smart contracts, and providing decentralized identity management. Blockchain also enables secure data sharing, preventing unauthorized access, and offers a tamper-proof record for auditing. Overall, integrating blockchain with IoT enhances security and privacy, mitigating risks of data breaches and unauthorized access, and supporting broader IoT adoption.
Blockchain for Internet of Underwater Things: State-of-the-Art, Applications, Challenges, and Future Directions	**Sweta Bhattacharya[1]Nancy Victor[1]Rajeswari Chengoden[1]Murugan Ramalingam[1]Govardanan Chemmalar Selvi[1]Praveen Kumar Reddy Maddikunta[1]PraveenKumar Donta[2]Schahram DustdarRutvij H. Jhaveri and Thippa Reddy Gadekallu [1,4,*]**	The integration of blockchain with the Internet of Underwater Things (IoUT) addresses security, privacy, and transparency challenges in applications like environmental monitoring and underwater exploration. Blockchain enables secure data transmission and decentralized storage. However, challenges like limited bandwidth, energy constraints, and high latency need solutions such as lightweight consensus mechanisms and edge computing. Despite these challenges, blockchain's future in IoUT looks promising, with potential applications in oceanography, naval defense, and underwater communication, as researchers continue to improve scalability, performance, and security.

4. CONCLUSION

The development of the **Finsafe** system marks a significant advancement in the domain of communication and tracking technology for fishermen, offering a comprehensive solution for enhancing safety, efficiency, and operational effectiveness in remote maritime environments. By leveraging **LoRa communication** technology, **AI-powered emergency response**, and multi-connectivity features such as **Bluetooth** and **WiFi**, **Finsafe** enables reliable communication and location tracking, even in challenging conditions where traditional systems struggle.

Despite the progress made in its design and functionality, several challenges persist in ensuring the robustness and scalability of such systems. Key considerations include improving the **energy efficiency** of the devices, optimizing the **range and signal stability** in remote or obstructed areas, and ensuring the **reliability of AI systems** during emergency situations. Additionally, the integration of cost-effective production and maintenance strategies remains essential for **Finsafe**'s widespread adoption among fishermen, particularly in developing regions.

As **Finsafe** continues to evolve, addressing these challenges while enhancing the system's ease of use and performance will be critical for its success. The potential impact of **Finsafe** in revolutionizing maritime safety and communication holds significant promise, not only for fishermen but also for the broader maritime industry. Future research and development efforts should focus on refining these technological aspects, further improving system reliability, and exploring new ways to reduce operational costs, thus contributing to the broader vision of safer, more efficient maritime operations.

5. STATEMENTS AND DECLARATIONS

Author contributions: Every author contributed to the development of the **Finsafe** project by conducting an extensive review of relevant literature and research papers. The tasks of data collection, system design, and analysis were carried out by **AL-AMEEN S**, **G AKSHAY, ABHIKRISHNAN U**, and **ANEESH A**, under the supervision and guidance of **MS DIVYA MADHU (ASSISTANT PROFESSOR)**. The first draft of the manuscript was written by

AL-AMEEN S, **G AKSHAY, ABHIKRISHNAN U**, and **ANEESH A**, with contributions and revisions provided by all authors. All authors read and approved the final manuscript.

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