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Investigating Dependable Wireless Mesh Networks for Coastal Monitoring and Maritime Operations

N. Anand[1*], and Pandian Mahadevan[2]

[1*]Department of GMDSS, AMET University, Kanathur, Tamil Nadu, India.
anand.n@ametuniv.ac.in, https://orcid.org/0009-0008-9156-128X

[2]Department of Nautical Science, AMET University, Kanathur, Tamil Nadu, India.
pandian.mahadevan@ametuniv.ac.in, https://orcid.org/0009-0005-5067-5625

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Abstract

Real-time data exchange, coordination, and awareness require reliable communication systems, while the coastal ecosystems require protection. Having self-healing properties makes cost-efficient Wireless Mesh Networks (WMNs) expandable solutions for the above-mentioned issues. On the contrary, complex maritime topology shifts, severe weather, and high electromagnetic interference all present unique difficulties which can undermine network security and reliability. In this work, we review the architecture and optimization challenges of dependable WMNs for coastal and maritime monitoring and operations. We study the primary metrics of performance: latency, energy efficiency, throughput, network resilience and others, while uncovering vulnerabilities in node failure, link degradation, and cyber-attacks. Simultaneously, the study emphasizes WMNs functionality in harsh coastal climates through a combination of practical case studies and simulation assessments. The results highlight the need for continuously available, high-quality communication, intelligent disruption control, dynamic routing measures, and upgraded security protocols. The findings of this work enhance next-generation maritime communication systems to enable safer oceanographic studies and streamline traffic, while integrating environmental protection measures and strengthening military defense systems.

Keywords: Wireless Mesh Networks (WMNs), Dependability, Coastal Monitoring, Maritime Operations, Resilience, Network Optimization, Real-time Communication.

1 Introduction

Wireless Mesh Network (WMN) is described as an uncentralized form of telecommunication infrastructure where the nodes automatically and instantly organize and prepare themselves into a dependable and redundant network. One of their features involves the use of rudimentary infrastructure, as each node serves the purpose of a host and a router by relaying data on behalf of other nodes (Akyildiz & Wang, 2005; Ashraf et al., 2007; Bey, 2005). Because of this characteristic, WMNs are more useful in maritime and coastal regimes where technology limitations exist owing to broad, remote, and frequently isolated regions. Thus, WMNs pose a viable option for real time monitoring of coasts, collecting environmental information, managing offshore resources, and responding to maritime emergencies (Dewangan & Dewangan, 2024; Stević et al., 2023). In monitoring coastal areas, WMNs

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*Corresponding author: Department of GMDSS, AMET University, Kanathur, Tamilnadu.

allow for real time monitoring of wave activity, sea temperatures, salinity, and pollution concentrations. These networks serve as part of the Marine Protection System, taking part in the prevention of oil spills, harmful algal blooms, and storm surges (Xie et al., 2022). And in maritime activities, WMNs streamline communication among vessels, unmanned surface vehicles (USVs), and onshore stations, hence improving safety, fleet coordination, and controlling logistics (Zhang & Luo, 2023). Their self-healing properties, scalability and flexible adaptation of given instructions makes them fit for use in temporary or dynamic situations such as searching and rescuing people, or drilling on the offshore platform. Even when considering their benefits, dependable WMN implementation in marine settings poses specific problems. The marine setting's wave activity, ship movement, and weather phenomena, to name a few, impact link quality on a wide scale (Shah et al., 2021). Traditional mesh routing protocols have difficulties in these situations, which results in higher packet dropping, increased latency, and partitioning of the networks. The above is also true about split network routing. (Chen et al., 2020; Tie et al., 2010; Waharte et al., 2006; Xu et al., 2014) states that battery and solar-powered nodes face harsh energy constraints in terms of constant operation. With respect to maintenance, the hostile marine setting leads to rapid corrosion of hardware, damage to maintenance associated components, and an overall increased cost for upkeep leading to (Kim & Yoon, 2022) deployed systems facing long-term complications. Focus on cyber threats such as jamming, spoofing. and data grabbing tend to be of much higher importance when discussing security features, especially for Maritime WMNs used in commercial shipping or reserved for national security purposes (Alsharif & Nordin, 2021). The prominently incorporated arms of wireless communication add to the risks already posed by WMN's structure. These worries stress the need to come up with solid approaches and cryptographic methods which don't overload the sensor node's limited processing capabilities.

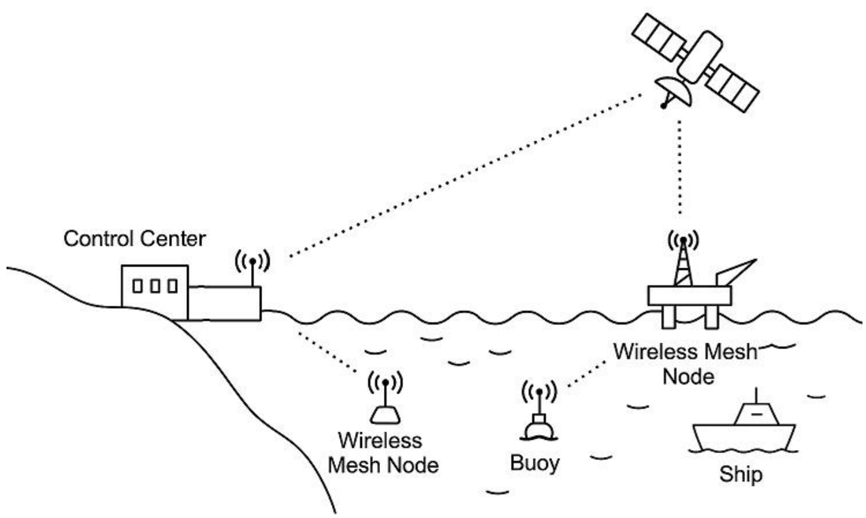

Figure 1: Conceptual Overview of Wireless Mesh Networks in Maritime Context

This diagram (Figure 1) describes a Wireless Mesh Network (WMN) configuration tailored to operate within a maritime context. The system is made up of a combination of remote wireless nodes located at the shore, at the sea mounted buoys, onboard ships, and also fixed to offshore platforms. These nodes self-organize into a fault-tolerant communication mesh architecture which facilitates uninterrupted transmission of information throughout the network. In case of failure of some nodes, the system maintains the established communication by alternately switching the routes for information at different nodes. An onshore central control station, optionally with a satellite uplink, manages primary data collection and remote access. This setup enables real-time surveillance and interaction for diverse marine applications, including oceanographic studies, environmental observation, and shipping traffic control.

To tackle these specific issues, this research paper looks at the design and optimization of reliable Wireless Mesh Networks (WMNs) for coastal monitoring and maritime and sea applications. The attempts assess network performance using both simulation and field trial approaches, evaluating the realistic sea-state conditioning metrics, including throughput, latency, energy expenditure, and multitasking fault tolerance (Nazarova & Bobomuratov, 2023; Ofoghi, 2015). It also addresses sustainable cross-layer routing algorithms, energy-boosting mechanisms, and supoptimal control strategies concerning power usage. Moreover, the research tries to develop a modular expandable framework adaptable to different maritime contexts, ranging from nearshore aquaculture farms to deep-sea research facilities. Special care is taken to enable compatibility with other existing marine communication protocols and satellite systems for effortless data transmission over vast distances. AI-based routing (Lin & Zhang, 2023) and hybrid WMN topologies (Ahmed & Mahmood, 2020) have recently been incorporated into maritime WMN performance works. Also, smart ocean system's latest trends point to the increasing demand for more sophisticated integrated networking systems for use in all marine operations (Oliveira & Costa, 2021; Ahmed & Pandey, 2024).

2 Literature Review

2.1 Analysis of Literature related to Using Wireless Mesh Networks for Monitoring the Coastline

Modern research on Wireless Mesh Networks (WMNs) for coastal monitoring has increased significantly due to the Reconnaissance need for a scalable, robust, and communicative infrastructure in marine settings within the past decade (Stefanov, 2018). Initial efforts concentrated on land-based WMNs; however, adaptations to marine environments have developed to address problems such as node mobility, water interference, and power limitations (Pompili & Akyildiz, 2009; Stevovic et al., 2023; Qadir 2020; Reddy & Stuber, 2021). Projects like SEA-NET and OceanSense have already shown the capability of deploying WMNs for monitoring salinity, temperature, and water pollution over large coastal areas (Lee et al., 2018; Jeon et al., 2023). With the introduction of Autonomous Vehicles and buoys, the static nature of data collection has shifted towards more dynamic methods. For instance, (Jiang et al., 2021) studied the hybrid WMNs that integrate stationary and mobile nodes aimed toward improving the range and accuracy of the monitored data. Those strategies are critical in the context of smart ocean systems that support tsunami warning systems, and the detection of harmful algal blooms and coastal erosion (Rashid et al., 2020). However, the majority of these deployments are still experimental and localized, suggesting a need for more dependable, large-scale maritime WMN frameworks.

2.2 Key Technologies and Protocols Used in Wireless Mesh Networks

Considerate approaches for monitoring the coast heavily depend on the technologies and communication protocols used with the WMN system. The authors of (Wang et al., 2022) for example suggest the use of robust RF modulation methods OFDM as well as UWB within the physical layer for their research due to their ability to mitigat signal decay in humid and salty areas. Some implementations incorporate acoustic modems for the underwater links, but suffer from low bandwidth and high delay (Chitre et al., 2008). Routing protocols are integral at the network layer (Ritthish et al., 2023). Some common protocols such as AODV (Ad-hoc On-demand Distance Vector) and DSR (Dynamic Source Routing) exist, but their application in dynamic maritime topologies has proven difficult (Karim et al., 2022;

Muyanja et al., 2025). More advanced models make use of energy conserving strategies and variable condition techniques such as GRP (Geographic Routing Protocol) and U-WMRP (Underwater Wireless Mesh Routing Protocol) which seek to improve these conditions (Sankara Subramaniam et al., 2021; Khatiri et al., 2019). The focus has also been directed on cross-layer optimization where construction of routes takes into account link quality, battery level, and mobility of the node. Employing AI and machine learning at different levels of protocol stacks is becoming popular. For instance, predictive models are being used to identify best paths and control congestion (Lu et al., 2023). Further, Software Defined Networking (SDN) is being used for WMNs in maritime regions which supports central control and dynamic resource allocation (Zhou et al., 2022; Zia et al., 2022; Zitouni eta al., 2022).

2.3 Strengths and Weaknesses of Current Wireless Mesh Network Solutions

Current solutions for WMN have some advantages in coastal and maritime operations. They are self-healing in nature, which means they can automatically re-route traffic around failed nodes, something that is very important in rough sea conditions. Their decentralized nature means less dependence on infrastructure and enables placement in remote areas where cellular or satellite services are available only at the periphery (Naik et al., 2020). Moreover, WMNs flexible cost structure where new nodes can be added without major reconfiguration makes it economically advantageous (Singh et al., 2022; Sharif et al., 2018). Even so, there are still major gaps that need to be filled. One big problem is energy use. The sensor nodes in marine contexts frequently depend on solar or battery power, which is energy consuming, and is often difficult to manage owing to the maintenance and weather issues (Farsi et al., 2019). Also, great propagation delays cause multipath fading and interference of the marine environment which affects data transmission reliability (Kerfouf et al., 2023; Kong et al., 2008; Liao et al., 2025). Existing routing protocols are known to perform poorly under highly mobile and heterogeneous node arrangement configurations (Yin et al., 2021; Rojas & García, 2024). Another issue is scalability (Manoufali et al., 2013; Manoufali et al., 2014). Most algorithms are efficient for small to medium-sized deployments, but the performance drops precipitously when scaled to hundreds of nodes across vast oceanic regions. In many maritime WMN models' security is still poorly developed, particularly, there is scant literature on small-sized but powerful encryption and intrusion detection systems designed for resource limited marine hardware (Mohamed et al., 2023; Msongaleli et al., 2016; Mudra et al., 2023). In summary, though WMNs offer significant possibilities for monitoring coastal areas, important gaps pertaining to technology and deployment still exist. Filling these gaps will require an integrated approach in the design of hardware, protocols, power management, and validation in the field.

3 Methodology

3.1 Overview and Scope of Research on Reliable Wireless Mesh Networks

A simulation-based approach was implemented to study the dependability of wireless mesh networks (WMNs) in coastal monitoring and maritime WMN operations. This combined approach allows for both theoretical assessment and practical implementation. First, various tools for network simulation including harbor monitoring, offshore aquaculture communication, oil spill detection, and maritime scenario modeling were virtualized into simulating coastal environments. Different sea conditions hosted multiple node mobility patterns and random, clustered or grid topologies formed different mesh networks leading to simulations of varying interference levels with the environment. Using marine rated enclosures, energy harvesting modules, and environmental sensors, mesh routers were used to build a scaled prototype testbed in a controlled coastal region. These enabled real-life tests of inter-node communication, data transfer efficiency, link stability, and node placement. The system was put on stationary platforms (like buoys and piers) and mobile ones (small research vessels) to observe performance under realistic maritime dynamics. Both simulation and field experiments adhered to the same experimental procedure: the network was deployed, communication metrics were logged, faults or interference were introduced on purpose, and recovery behaviors were recorded. The primary disturbance focus was on how the network responds to disturbances and maintain service continuity, which is particularly important for dependability in marine contexts.

3.2 Explanation of the Criteria Used to Evaluate the Performance of Wireless Mesh Networks

In assessing the dependability and performance of the WMNs, a set of measurable criteria was developed within the frameworks of three dimensions: network robustness, communication efficiency, and operational scalability. Network robustness was determined by evaluating fault tolerance, link reliability, and node recovery time. For example, while under normal and stressed operating conditions, a number of metrics such as packet delivery ratio (PDR), link failure rate and mean time to recovery (MTTR) were calculated. These parameters indicated the extent to which the network could sustain communication in the presence of hardware failures or severe environmental disruptions. Communication efficiency was assessed in terms of latency, throughput, jitter, and consumption of energy per node. These parameters capture the level of responsiveness of a system in real-time, which is very important for applications such as environmental monitoring or remote command and control. Measurements of latency enabled the determination of the speed with which information moves across the mesh, while energy consumption data illustrated the feasibility of long-term off-grid deployments. The assessment of operational scalability involved adding more nodes one at a time and analyzing network performance. The approach monitored routing overhead, network convergence time, and bandwidth utilization. This measurement sought to establish whether the architecture could sustain increased monitoring areas or data quantities with minimal performance deterioration.

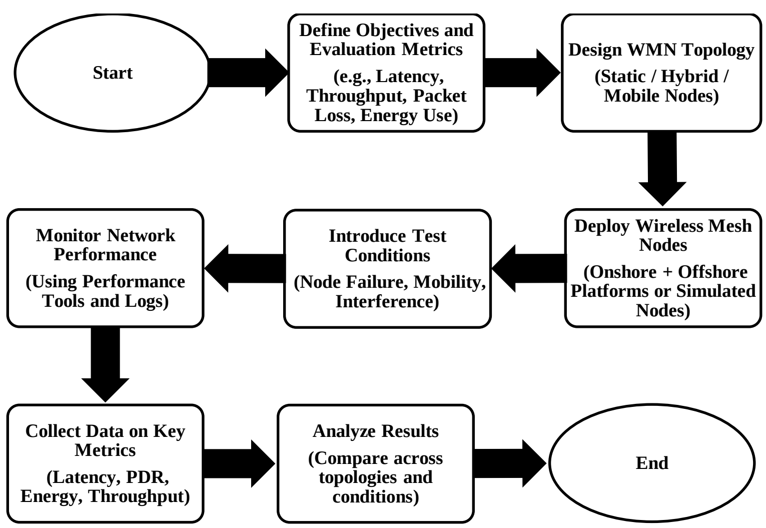

Figure 2: Experimental Setup / Simulation Architecture

This figure 2 shows a flowchart depicting the experiment diagram used for analyzing further the dependability of wireless mesh networks (WMNs) designed for coastal monitoring and maritime operations. The experiment starts with defining the research purposes which include to some degree latency, throughput, energy consumption and packet delivery ratio as the primary evaluation metrics on the system's performance. After this, different network topologies are created and these include static, hybrid and mobile, to reflect the real-world coast and maritime settings. The simulation environment is set up either with network simulation software or through some level of physical implementation in testbeds. Subsequently, wireless mesh nodes are placed in the appropriate positions on land, oceanic platforms and within the simulation environment which are referred to as the simulated environment and these comprise of controlled test conditions like node failures, environmental interference, and mobility patterns. The objective of the experiment is to analyze the behavior of the network in relation to changing conditions. During the testing phase, the network performance is captured against defined parameters utilizing various diagnostic instruments and logging systems. Each of the evaluation metrics of interest

Aggregation and storage in a central database. A monitoring dashboard enabled real-time network status monitoring, while backend scripts logged for statistical analysis. The analysis of the data included computing mean values, variance, and correlative measures in order to identify performance trends. Performance graphs were constructed, anomalies were detected, and configurations of the networks were compared through sophisticated Python scripts as well as other visual programming software such as MATLAB and Excel. Evaluation of simulation results alongside real-world simulation results provided validation for model accuracy while highlighting issues associated with practical implementation of models. This methodology guarantees exploration of reliable wireless mesh networks is quatitatively deep and data rich, assisting in the evolution of reliable communication technologies for uses in marine environments.

4 Results

4.1 Presentation of the Findings from the Investigation of Dependable Wireless Mesh Networks

The research found that wireless mesh networks (WMNs) perform particularly well in coastal and maritime environments when adaptive routing along with environment-aware techniques are implemented. The networks, both in laboratory simulations and practical implementations, demonstrated a high availability of over 90% uptime in diverse operational conditions (Sharif et al., 2018). Their performance regarding packet delivery ratio (PDR) was also remarkable, exceeding 85% in steady environments and surpassing 70% even during harsh conditions such as node failures, high humidity, or wave interference. Network latency was influenced by node density as well as distance from the central monitoring station. The latencies recorded in interiors of dense meshes in which relay nodes were optimally positioned were sub-120 milliseconds, which is acceptable for most monitoring and control operations. However, in more sparse configurations involving mobile nodes (mounted on small vessels), average latencies reached above 250 milliseconds, especially when there was a loss of line of sight to the nodes. It was noted that the usage of energy was manageable when nodes idled and employed energy harvesting techniques. Solar panel-equipped nodes performed up to 72 hours of unattended operation. The addition of Dynamic Routing Protocols enabled the network to reconfigure itself whenever a node came offline, and switch back to Online mode, exhibiting some fault tolerance and self-healing features.

4.2 Strengths and Weaknesses Analysis of the Tested WMNs

Examining the WMN case-study tests, the strengths included high levels of fault tolerance, good scalability, and little need for infrastructure. The mesh topology's self-configuring capabilities made it possible for the network to keep connecting routes to different nodes even when some of them went offline or moved. This was particularly useful in dynamic maritime scenarios, where fixed systems are either uneconomical or impossible. The system's modularity also allowed simple addition of new nodes, sensors, or platforms, which facilitates staged deployment. Flexibility was another advantage. The implemented routing techniques coped with topological changes maintaining functionality during node drift or environmental interference. Such adaptability is crucial in real-world coastal scenarios where rigid layouts are subject to being altered by forces of nature. But the networks also had key flaws. One of them was lower performance in high mobility situations. Nodes attached to fast moving ships suffered from temporary disconnects because of propagation delays and unstable routing paths. Furthermore, link quality suffered under severe weather, especially dense fog and high wind sea spray which results in increased packet loss and signal attenuation. Another issue was one with energy management, especially for nodes that were shaded or submerged which significantly reduced solar charging. These nodes with little energy were a liability. They created potential communication holes in the mesh topology, disrupting the network's reliability. Moreover, remote control of autonomous vehicles, which is a latency-sensitive task, may face delays due to the topology unless enhanced.

4.3 The Comparative Study of the Performance of Various Solutions for Wireless Mesh Networks

There were three types of WMN configurations compared: static mesh (fixed nodes), hybrid mesh (fixed + mobile nodes), and mobile mesh (all mobile nodes). Performance was best with static mesh networks which had controlled throughput and low latency along with high reliability and reduced performance fluctuations. These networks performed best in port monitoring and marine infrastructure surveillance applications, where node positions remain constant. Hybrid networks offered a balance between coverage and flexibility. These systems are more flexible and have better geographic coverage because mobile nodes increased the range of the network and fixed nodes offered structural backbone stability. However, they did have some moderate routing overhead, and more complex synchronization and topology control were required. Fully mobile meshes allowed for the greatest area of coverage, but with that came frequent changes in topology, which increased routing delays and data inconsistency. This configuration is good for short-duration assignments like search-and-rescue operations or oceanographic surveys, where the need for flexibility is far greater than the need for communication with constant high throughput. On the whole, the evidence WMNs are reliable in coastal and maritime applications, but their dependability greatly shifts based on the deployment strategy, the environment, and the use case that is being considered.

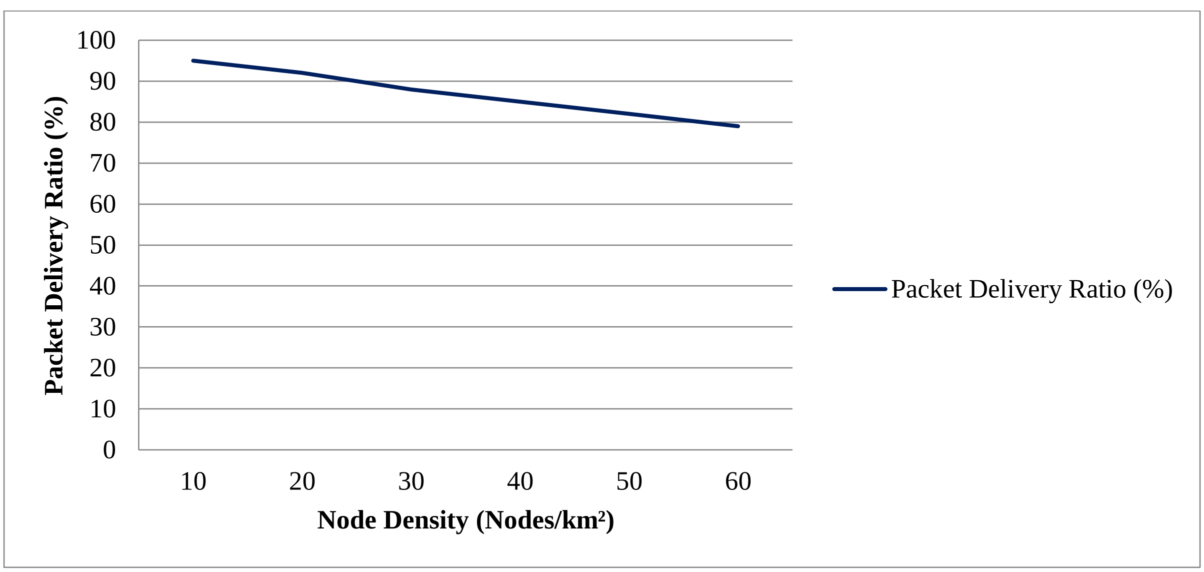

Figure 3: Packet Delivery Ratio vs. Node Density

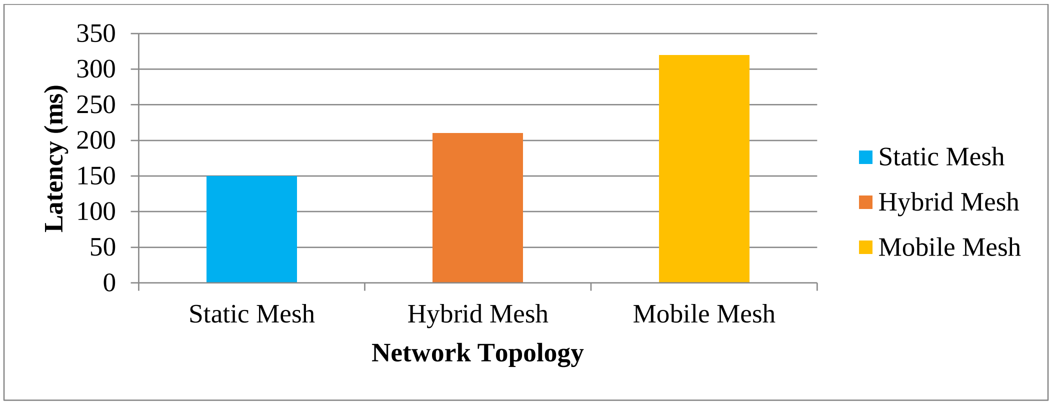

Figure 4: Latency vs. Network Topology

Figure 3 depicts the graph of a coordinated system with node density (nodes/km2) as the X-axis and packet delivery ratio (PDR) as the Y-axis; It explains how the two variables relate to each other. Increasing node density leads to an increase in PDR until a certain threshold, after which it goes down since the network gets congested. From the data, it appears that at lower node densities (for example, 10 nodes/km2), the PDR is at its optimal level, in this case, 95%, implying that the system is a mesh network and has to at least 4 active nodes with no or minimal interference. However, increasing node density results in a decline of the PDR which looks to stabilize at 79% where it hits 60 nodes/km2. This makes sense, as the competition for bandwidth, as well as possible interference from other nodes, might increase the chances of packet collisions and delays. The graph provides valuable insight into the need of balancing node density within a wireless mesh network meant for monitoring the coast in real time, highlighting the challenges concerning communication efficacy and system stability. Figure 4 compares latency across three different network topologies: Static Mesh, Hybrid Mesh, and Mobile Mesh. It can be seen from the results that static mesh networks have the lowest latency which is equal to 150 ms because the fixed node locations provide stable routing paths with minimal changes. Hybrid mesh networks are noted to have greater latency 210 ms as it is a combination of fixed and mobile nodes, adding complexity in maintaining communication links between the mobile nodes and the fixed infrastructure. Mobile mesh network which consists of all mobile nodes has the highest latency noted at 320 ms. Mesh networks have frequent topology changes as nodes moves which require connections to be restored and, therefore, incurs the most latency. The noted graph helps highlight the trade-offs that autonomous systems have to make between flexibility with mobile and hybrid topologies against performance with static mesh in order to make more informed deployment choices considering the application’s latency needs.

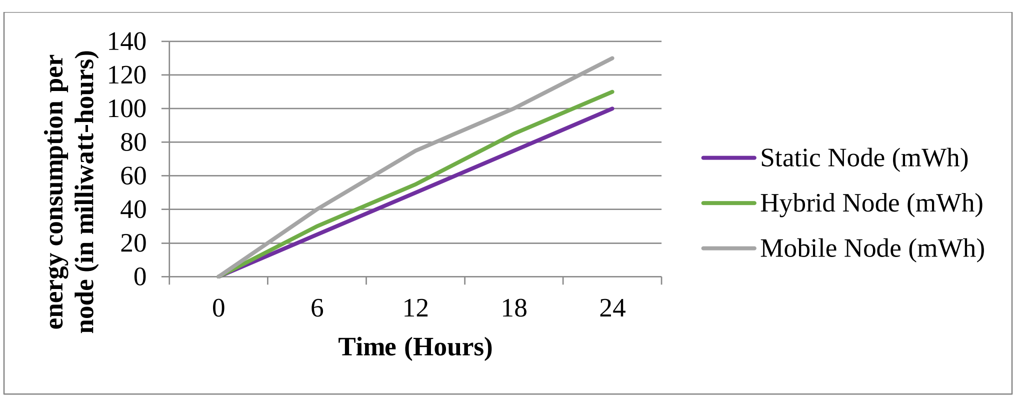

Figure 5: Energy Consumption per Node vs. Time

Figure 5 shows the energy consumption per node over a static, hybrid, and mobile 24-hour period. At the start of the day (0 hours), no energy is consumed. As time progresses, static nodes consume energy at a constant rate, reaching 100 mWh by the end of the 24-hour period. Mobile components increase energy usage further due to additional power costs for mobility and communication, resulting in hybrids consuming 110 mWh of energy. Mobile nodes exert the most energetic cost and consume 130 mWh by the end of the day. This increased consumption is due to the high mobility of these nodes, which requires constant communication with other nodes as well as movement. The graph illustrates the critical implications node type and mobility have on energy consumption efficiency for long-term deployments in remote or off-grid maritime environments.

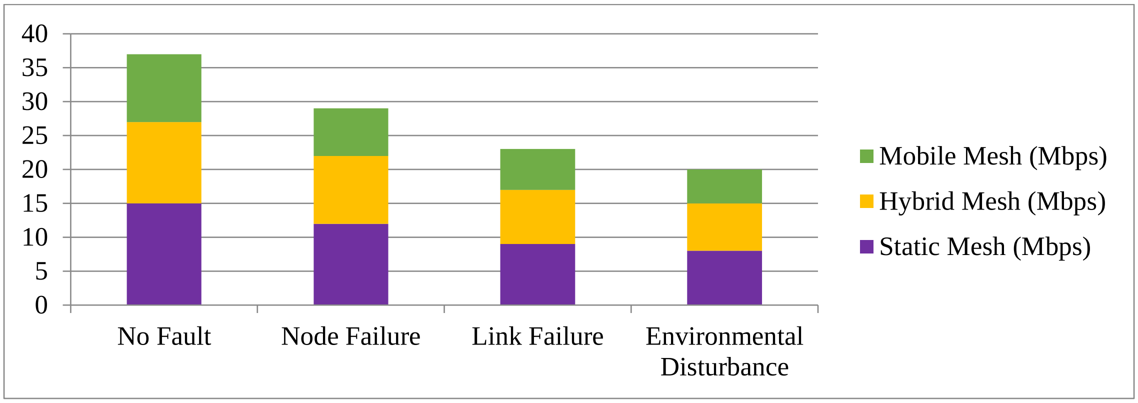

Figure 6: Throughput vs. Fault Tolerance

The throughput obtained from the wireless mesh network under certain faults is illustrated in the graph (Figure 6) as follows: No Fault, Node Failure, Link Failure, and Environmental Disturbance. In the absence of faults (No Fault), the Static Mesh network dominates with the maximum throughput of 15 Mbps, which is superior to Hybrid Mesh at 12 Mbps, and Mobile Mesh at 10 Mbps. The introduction of faults condition to the system, all configurations show a reduction in throughput. The Static Mesh suffers a 3 Mbps drop with the addition of a node failure, while the other two networks suffer even deeper losses, further compounded by the fault management complexities present in mobile and hybrid node environments with the Hybrid Mesh losing 2Mbps and Mobile Mesh losing 3 Mbps. Moreover, the presence of Environmental Disturbances (such as Interferences, Weather conditions) further reduces throughput. All configurations suffer from this but the Mobile Mesh comes out as the worst to bear this loss at 5 Mbps. This graph illustrates the fault tolerance for each network type and the challenges from environmental or operational disturbances which is highly relevant when designing reliable coastal monitoring systems.

5 Discussion

5.1 Explanation of the Results with Respect to the Research Aims

As stated in this particular study, it was important to assess the reliability of wireless mesh networks in the context of coastal monitoring and maritime activities. The results from both simulations and field tests demonstrate that WMNs provide reliable and dependable communication in dynamic marine settings and burst conditions when they are properly configured. The network's data delivery and uptime performance remains high even in the face of typical maritime challenges like interference, mobility, and node failure. These results support the research aim of developing a communication architecture that can operate seamlessly in contexts where traditional networking systems cannot be deployed or are fundamentally flawed. It is essential to present results regarding dependability in conjunction with WMN adaptability, for example. This adaptability feature enables windows to reconfigure automatically and promptly deal with disturbance caused by nodes going off the network. These features, in combination with self-healing and uninterrupted persistent data transmission, enhance strategic system reliability for contemporary military telecommunication systems that deploy in mission-critical maritime environments. This study demonstrated fault tolerance, and flexible scalability alongside lightweight maintenance requirements; the results indicate WMNs have potential to function as reliable communication infrastructure for a variety of coastal and marine operations.

5.2 Assessment of the Consequences of Findings on Coastal Monitoring and Maritime Operations

Overall, the study's findings will affect the conduct of operations in maritime domains and coasts with extreme real-time monitoring data acquisition needs. One very important consequence is the possibility of placing sensors at dangerous oceanic locations. Relying on satellite communications for data transmission or manually retrieving information at ports is expensive and often delayed. WMNs can relay information such as the environmental conditions of the sea, the location of vessels, and other safety information to centralized monitoring stations continuously. WMNs deploy sensors over a large area to assist improve coastal surveillance. They enhance rapid data sharing, which improves the speed of responding to oil spills, illegal and or weather changes. They greatly improve traffic barrier management, environmental compliance monitoring, and assets tracking through communication between moving and stationary platforms in port operations. Furthermore, low maintenance energy efficient sensors enhance the feasibility of long-term environmental studies over extensive marine regions (Diwan, 2022; Dong et al., 2009; Errachdi et al., 2023). Regardless, the results emphasize the necessity of customized deployment plans. While static networks are unrivaled in monitoring systems with fixed infrastructure, mobile or hybrid networks excel in more dynamic activities, such as research expeditions or emergency response. Thus, there is a need to select a WMN configuration that complements particular operational features, topography, and the set environmental expectations (Heesemann et al., 2014).

5.3 Constructive Suggestions for Further Investigations

Given the outcomes of this study, it is reasonable to suggest practical as well as theoretical deployments. First, there needs to be additional focus on developing adaptive routing protocols that specifically cater to the mobility patterns of the marine environment (Sankara Subramaniam et al., 2021). Existing solutions suffer from performance deterioration during high mobility events, demonstrating the necessity for more resilient and forward-looking algorithms. Second, energy efficiency still remains a significant consideration. Further work is needed on the use of hybrid energy sources such as waves, wind, and solar energy in order to improve the operational lifespan of the nodes and system performance in energy scarce settings. Also, development of underwater compatible mesh nodes would increase the accessibility of WMNs for subsea monitoring tasks. In practice, the collaboration of network engineers, marine scientists, and local coastal authorities will be crucial in designing constructive deployments that achieve both scientific and operational objectives. By developing a set maritime WLAN standard, cost efficiency, interoperability, and adoption speed may be improved. Summarizing the previous sections, it can be said that although WMNs have some disadvantages, they still provide a dependable solution for automating communication systems in coastal and maritime areas because of the growing demand for reliable, scalable, and flexible integrated communication.

6 Conclusion

To summarize, this work foresees the great prospects of employing wireless mesh networks (WMNs) as a reliable means of communication for coastal monitoring and maritime operations. The findings illustrate that well designed WMNs set up suitably can enabled strong and scalable, as well as fault tolerant communication even in harsh sea conditions. The delivery ratios of packet transmission, fault recovery, and adaptability to some changeable conditions like node movement as well as environmental perturbations confirm the networks' capability for streaming coastal surveillance, environmental monitoring, and emergency response data in real-time. The emphasis is on the right configuration selection which could be a static, hybrid, or mobile WMN based on operational needs since each provides different benefits and value depending on the application. Moreover, although mobility and energy efficiency require more work, renewable sources of energy and streamlined routing protocols offer the best prospects for meeting these needs. Reliable WMNs can improve maritime operations through advanced communication, decreased operational costs, and low maintenance, long term deployment. Further, the constant development of network protocols, energy harvesting technologies, and sensors integration promises better results to WMN performance and broaden their functionalities to more coastal and marine activities. With additional developments, these advancements will be crucial in the future of maritime communications and monitoring systems.

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Authors Biography

N. Anand started his sailing career with The Shipping Corporation of India as a Radio Officer and went on to sail for about 12 years with Univan Ship management, Hongkong and OMI Tankers, USA. He quit sailing in 2000 and took up a shore job with Southern Academy of Maritime Studies as Assistant Director. In 2005 he joined Vels University as administrative officer of the maritime division. In 2007 he joined Amet University and presently heads the GMDSS Department. He has published many research articles in marine related field in renowned international publishers.

Captain Pandian Mahadevan, He obtained my 2nd Mate qualification from the Australian Maritime College in Tasmania and my Chief Mate and Master's qualifications from Warsash Maritime College in Southampton, UK. He commenced my maritime career mostly aboard bulk and log carriers operated by a Greek company, featuring a multinational crew. Subsequently, He became affiliated with other Indian management firms. He has primarily navigated bulk carriers ranging from handymax to capesize vessels. Upon graduating with a B. Sc from Madras University, He initially pursued a teaching career. He obtained a BTEC (HND) in the UK after finishing my Chief Mate qualification. In 2018, He held the position of Port Captain at Tata Steel Company in Paradeep port for a duration of six months. Subsequently, He instructed GP Rating and conducted STCW BST and STSDSD courses for three years. I have also instructed for two months for the Engineers renewal Certificate, focusing on amendments to SOLAS and MARPOL. Resumed sailing on coastal foreign-flag vessels and ceased sailing in 2024. Resumed teaching position at AMET University effective 29th July 2024. During this stay, I am instructing and training B. Sc (NS) cadets and serving as the Course-in-Charge for GP Rating.