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Network Performance in Multi-Radio Multi-Channel Wireless Mesh Networks: A Systematic Review

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ABSTRACT

Multi-Radio Multi-Channel (MRMC) wireless mesh networks have surfaced as a critical remedy to address the growing requirements for connectivity in the swiftly changing scope of wireless communications. This systematic literature review undertakes a comprehensive investigation into strategies for optimising network performance in MRMC networks. These networks, distinguished by the complex interaction of multiple radios and channels, necessitate advanced management to maximise efficiency, minimise interference, and improve scalability. Novel opportunities have emerged due to the progress made in network technologies to optimise MRMC configurations. This evaluation critically assesses various methodologies, encompassing inventive network architectures, sophisticated channel allocation algorithms, and interference management techniques through Scopus, Science Direct and IEEE databases. The effectiveness, challenges, and future potential of these optimisation strategies are illuminated in this review by analysing studies encompassing experimental implementations and theoretical models. Moreover, it tackles the ethical ramifications, accessibility concerns, and the imperative for continuous research and standardisation regarding the optimisation of MRMC networks. This systematic review aims to give researchers, network engineers, and policymakers significant insights about wireless communications. This highlights the revolutionary capacity of sophisticated optimisation methods in MRMC networks, which establishes a foundation for wireless mesh networks that are more effective, dependable, and high-performing.

1. Introduction

Wireless mesh networks that utilise Multi-Radio Multi-Channel (MRMC) technology represent a noteworthy advancement in the field of wireless communication, as they offer enhanced functionalities and connectivity. In light of the expanding demand for reliable wireless networks and the proliferation of data-intensive applications, it has become imperative to optimise the operational

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efficiency of MRMC networks. Networks characterised by the utilisation of a multitude of radios and channels present unique challenges with regard to interference management, channel allocation, and overall network efficiency.

The increasing proliferation of wireless networks, particularly with the advent of emerging technologies such as 5G and 6G, has generated a mounting demand for advanced optimization strategies. To facilitate the optimization of MRMC wireless mesh networks, this article conducts a systematic examination and evaluation of the latest advancements and methodologies. An effort is undertaken to elucidate the latest approaches in optimising network performance by conducting an exhaustive synthesis of current research, which includes empirical investigations, theoretical frameworks, and algorithmic developments. The aim of this research is to provide a thorough understanding of the current challenges, potential solutions, and future directions in the optimization of MRMC networks. The primary objective of this systematic review is to provide researchers, network engineers, and policymakers with a wealth of knowledge regarding the development of MRMC wireless mesh networks that are more dependable, effective, and efficient.

2. Methodology

An area of considerable discourse within the field of wireless communications pertains to the enhancement of Multi-Radio Multi-Channel (MRMC) mesh networks. In light of the existing scarcity of research, this study adopts a systematic approach to investigate issues relevant to the optimisation of MRMC. Our investigation on 16th November 2023 categorises and analyses various optimisation strategies in MRMC networks. A key sub-objective is to examine the efficiency of these networks in handling high data rates and reducing interference. We systematically review and summarise scientific literature to highlight and evaluate critical technological advancements in MRMC network optimisation. To address the issues identified, we propose directions for future research. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method, renowned for its rigour, was utilised in this literature review. PRISMA assists in assessing the review's accuracy by providing essential information, particularly in evaluating randomised studies [1]. Databases such as Scopus, IEEE and ScienceDirect were chosen for their reliability in sourcing relevant studies. However, it is acknowledged that these databases are not exhaustive. This section also comprehensively details the four main stages of our methodology: identification, screening, eligibility, and data abstraction.

2.1 Identification

In this study, we employed a systematic review methodology, executed in three distinct phases, to select relevant papers. The initial phase involved identifying key search terms using resources such as thesauri, dictionaries, encyclopedias, and existing literature. We then constructed precise search queries for databases such as IEEE, ScienceDirect and Scopus, as elaborated in Table 1.

Table 1
The search string

Database	Search string
Scopus	(ALL (multi-radio AND multi-channel) AND ALL (wireless AND mesh AND networks) AND TITLE-ABS-KEY (optimisation)) AND PUBYEAR > 2018 AND PUBYEAR < 2024 AND (LIMIT-TO (LANGUAGE, “english”)) AND (LIMIT-TO (DOCTYPE, “ar”)) AND (LIMIT-TO (SUBJAREA, “comp”))
ScienceDirect	(multi-radio multi-channel) AND wireless mesh networks AND optimisation)

IEEE	("All Metadata":multi-radio multi-channel) AND ("All Metadata": wireless mesh networks) AND ("All Metadata": optimisation)

Subsequently, by employing this systematic strategy, we initially retrieved 167 papers from these databases, establishing a strong basis for our exhaustive literature review.

2.2 Screening

We eliminated duplicate papers during the preliminary screening and rejected six papers in the first phase of our review. In the subsequent phase, a comprehensive assessment was conducted on the 161 remaining publications, adhering to precise inclusion and exclusion criteria established by our panel of experts. The primary focus was on peer-reviewed research articles, recognised as the most valuable source of scholarly guidance. Additionally, we limited our review to papers published in English within the last ten years (2019-2024). This approach led to disqualifying 6 publications based on our defined criteria.

2.3 Eligibility

In this study, we employed a systematic review methodology, executed in three distinct phases, to select relevant papers. A total of 161 articles are included in the third level, called eligibility. At this stage, all article titles and important text were carefully scrutinised to confirm that the inclusion criteria were satisfied and that the articles were appropriate for the current study's research objectives. As a result, 124 papers were removed since their title and abstracts were irrelevant to the study's objective based on empirical data. Finally, 36 articles have been made available for review (see Table 2).

Table 2
The selection criterion is searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Timeline	2019-2024	< 2019
Literature type	Journal (articles)	Conference, book, review
Publication stage	Final	In press

2.4 Data Abstraction and Analysis

This study employed an integrative review to investigate and synthesise a range of research designs (quantitative, qualitative, and mixed methodologies) focusing on optimising MRMC wireless mesh networks. The expert study aimed to identify relevant topics and subtopics within this domain. The process began with the data collection phase, where 36 articles, as illustrated in Figure 1, were meticulously examined for insights related to MRMC network optimisation. The authors evaluated the impact of various optimisation strategies on network performance and identified key groupings in the data.

Two principal outcomes emerged: the effectiveness of optimisation techniques on network throughput and the reduction of interference in MRMC configurations. In collaboration with co-authors, the authors developed these themes based on the evidence, maintaining a log throughout the data analysis to record observations and reflections pertinent to the interpretation. In the final stage, discrepancies in theme development were discussed among the authors. The final themes were refined for consistency, and the validity of the findings was assessed by two experts, one specialising in information technology and the other in wireless networking. This expert review process ensured each sub-theme's clarity, relevance, and practical applicability, with adjustments based on feedback and expert insights.

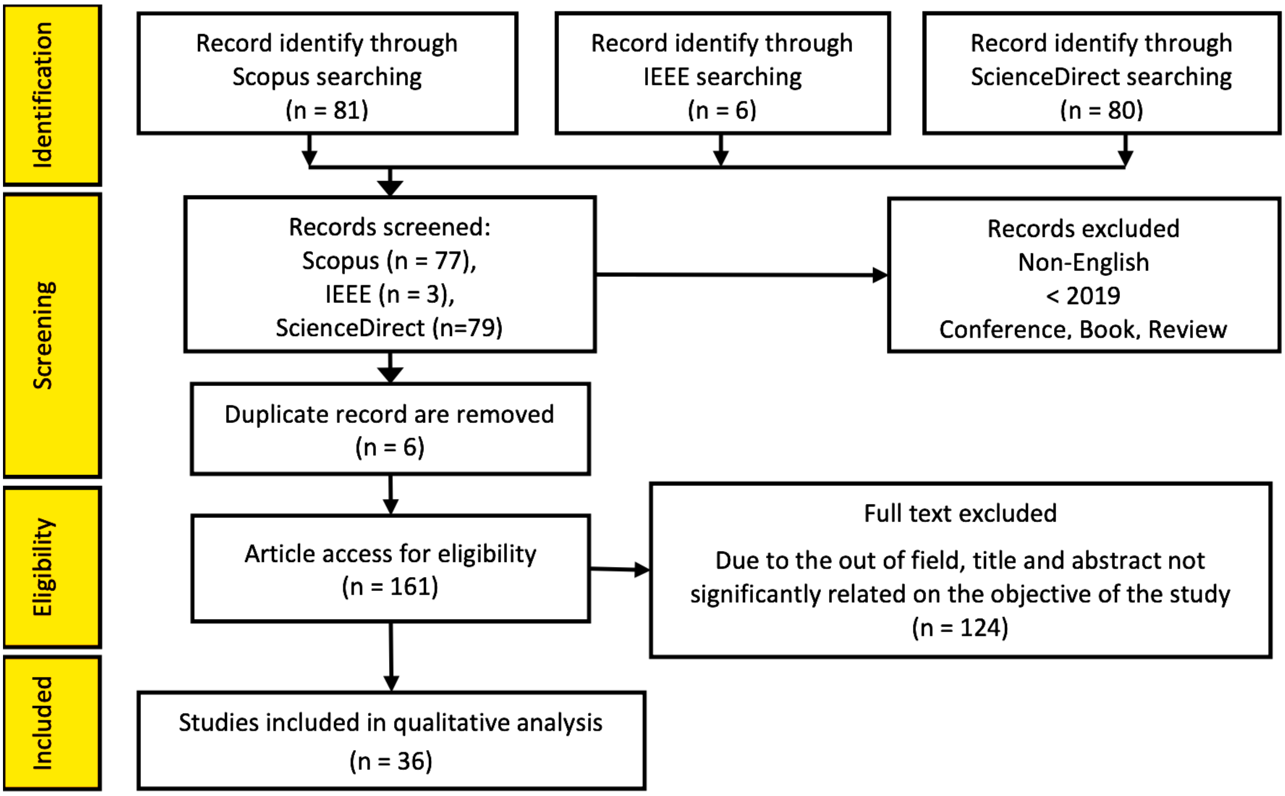

Fig. 1. Flow diagram of the proposed search study

3. Results

Thirty-six (36) articles were meticulously extracted and analysed using the systematic search technique. These papers were categorised based on their primary focus within the MRMC wireless mesh network optimisation to facilitate a structured analysis. The two main categories identified were 'Network Performance Optimization Techniques' and 'Interference Management Strategies', reflecting the core aspects of MRMC network research.

3.1 Network Performance Optimisation Techniques

Technological advancements have profoundly affected the domain of wireless communications, specifically in the optimisation of MRMC wireless mesh networks. Network performance optimisation has historically been accomplished with standard network management protocols and tools. However, as network complexity and demand for high efficiency increase, more sophisticated, technology-driven optimisation strategies are being investigated. These consist of adaptive network protocols, interference management tools, and sophisticated algorithms for channel allocation. As an illustration, machine learning algorithms are utilised to optimise resource allocation and forecast network load.

Similarly, the incorporation of real-time analytics tools has bolstered the ability to adapt to dynamic network conditions promptly. In addition, the advancement of specialised software applications designed for network management has facilitated enhanced control over MRMC configurations, thereby augmenting the performance and dependability of the network. This subsection provides an in-depth analysis of technological progress optimising MRMC wireless mesh networks. It evaluates the merits and drawbacks of these methodologies and offers perspectives on the evolving function of technology in augmenting network efficiency. A summary of the classifications utilised in network optimisation techniques is presented in Table 3.

An exhaustive analysis of twenty distinct studies is presented in Table 3. A range of challenges in WMNs are examined in these studies, encompassing traffic pattern optimisation, efficient energy management, and high data rate processing. Additionally, strategic router placement is also considered. A wide array of methodologies is utilised, including the implementation of innovative hardware designs, multi-channel allocation, and sophisticated algorithmic solutions like the Chemical Reaction Optimization (CRO) algorithm. The results obtained from these investigations are noteworthy, as they provide substantial evidence of enhancements in network throughput, energy efficiency, and packet delivery.

The findings of this study emphasise the extreme importance of ongoing innovation and adaptation in network management approaches in order to address the increasing requirements of wireless networks. With an eye toward the future, Table 3 proposes a number of prospective avenues for research. Incorporating nascent technologies like artificial intelligence and machine learning can significantly enhance the functioning and flexibility of a network. Investigating energy harvesting techniques offers a prospect for developing network solutions that are more ecologically conscious and sustainable. Furthermore, the escalating need for high-speed data services emphasises the necessity for continuous advancements in algorithmic and hardware solutions to handle the surge in data traffic effectively.

Table 3
Summary of network performance optimisation techniques

Authors	Year	Problem	Methodology	Results and advantages
[2]	2019	Efficient energy management. Maintaining quality of service (QoS) during emergencies.	Utilises multi-channel allocation. Prioritises data flows based on their importance.	Better packet delivery. Increased network throughput. Reduced transmission time.
[3]	2019	Hinder performance due to long delays. High power consumption.	Introduction of a novel hardware-efficient wireless network-on-chip (H2WnoC) design.	Reduce hardware usage. Lower network cost. Minimise delay. Decrease energy consumption.
[4]	2020	The problem of router placement in wireless mesh networks.	Use of the Chemical Reaction Optimization (CRO) algorithm. Mimics the behaviour of molecules to find optimal router placements.	Client coverage increase. Network connectivity enhancement.
[5]	2020	Video streaming over multi-radio WMNs.	Ad hoc On-Demand Multipath Distance Vector (AOMDV) routing protocol. Efficient load balancing to manage high client traffic. Dynamic QoS support for video streams in a shared wireless environment.	Enhanced video streaming experience. Efficient load balancing. Robustness to varying network conditions.

[6]	2020	Limitations in node interfaces.	A "coexisting algorithm" that includes:	Increases the network's capacity for high-throughput applications.

Table 3 (continue)
Summary of network performance optimisation techniques

Authors	Year	Problem	Methodology	Results and advantages
		Availability of channels.	i. Channel assignment. ii. Path computation. iii. Scheduling of link transmissions.	
[7]	2020	Overwhelming data rates in next-generation wireless networks.	A hybrid RF/FSO (Radio Frequency/Free Space Optics) MCMR WMN architecture.	Dramatic increase in network throughput. Achieved through strategic Free Space Optics (FSO) link augmentation.
[8]	2021	Unbalanced traffic patterns. Increasing demand for delay-sensitive services in wireless communication.	Utilises both non-congested and high-capacity nodes for route selection. Aims for efficient data transmission. Focuses on minimising energy consumption.	Attains high throughput. Enhances energy efficiency.
[9]	2021	A critical gap in maximising battery lifespan in wireless IoT devices.	A novel approach to extend battery life in critical wireless IoT devices: i. Utilises a cross-layer optimisation framework. ii. Employs a parametric transformation technique.	Optimality in preserving battery life.
[10]	2021	Characterised by rapid expansion. Millions of users. Hundreds of thousands of access points.	Proposed an optimal routing protocol for IoT WMNs: i. Optimised channel and frequency resource allocation. ii. Utilises mathematical calculations for optimisation.	Efficient channel and frequency resource allocation. Reduced data transmission delays.
[11]	2021	Focuses on optimising the placement of routers. Minimise the number of gateways.	Proposed Algorithms for Router Placement in WMNs.	Proven to be more time-efficient. Offers better regional coverage. Achieves reduction in router node count.
[12]	2021	Gateway placement difficulties. Device coordination complexities. Transmission scheduling issues.	Novel Gateway Select Algorithm. Considered fluctuating traffic. Monitors load on each device. Dynamically select optimal gateways.	Demonstrably higher throughput. Efficient load management. Reduced congestion.

[13]	2022	The rapid growth of the IoT. Node placement problem in WMNs.	A hybrid intelligent system using Particle Swarm Optimization (PSO), SA,	superior performance in node placement.

Table 3 (continue)
Summary of network performance optimisation techniques

Authors	Year	Problem	Methodology	Results and advantages
			and Distributed Genetic Algorithm (DGA).	
[14]	2022	Traditional approaches focus only on orthogonal channels. Inefficient utilisation of available spectrum resources.	A novel approach for channel assignment in MRMC WMNs. Uses orthogonal and partially overlapping channels in the IEEE 802.11 2.4 GHz bands.	Significant increase in network throughput. Balanced load distribution. Effective in both grid and random topology networks.
[15]	2022	Ensuring robust connectivity and coverage. Aim to provide the best network accessibility.	Utilises Harris Hawk's Optimisation (HHO) for mesh router placement.	Maximise the number of covered clients and router connections.
[16]	2022	Often, they focus only on optimising a single aspect, like hop count. Leads to complexities when managing multiple dimensions simultaneously.	Integrates radio routing with channel selection. Optimisation of nodes achieved through PSO.	Significant enhancement in network efficiency. Improved energy management in WMNs.
[17]	2022	Node placement problem. Negatively impacts network connectivity and user coverage.	Development of a hybrid intelligent simulation system. Combines DGA and PSO.	Enhances the overall operation of WMNs. Particularly beneficial in the IoT and edge-computing contexts
[18]	2023	Need for enhanced efficiency and effectiveness in operation. Specific focus on router replacement strategies.	A novel hybrid system called WMN-PSOHC for WMNs. i. It combines ii. PSO and hill climbing (HC). iii. Evaluating router replacement methods in WMNs.	Improved data transmission speeds. Reduced latency. Increased reliability. Minimised operational costs.
[19]	2023	Challenge in improving transmission quality through optimal routing. Current research lacks a clear strategy for enhancing transmission quality in WMNs. Consideration is needed for energy and distance in route discovery.	Introducing an efficient approach for congestion awareness and load balancing in WMNs. i. Based on the Ant Colony Optimization (ACO) algorithm. ii. Detecting severe congestion within ideal data transmission paths. iii. Creating ideal secondary paths with	Enhances the overall performance of WMNs. Makes WMNs more efficient, reliable, and capable of handling demanding data traffic.

			updated pheromone values. iv. Distributing traffic load between primary and secondary paths.	

Table 3 (continue)
Summary of network performance optimisation techniques

Authors	Year	Problem	Methodology	Results and advantages
[20]	2023	Enhancing network coverage. Ensuring network connectivity. Mitigating congestion issues caused by router overlay.	Harris Hawks Optimization with Sine Cosine Algorithm (HHOSCA). i. Optimal placement of mesh routers in WMNs. ii. Maximising network coverage and connectivity. iii. Minimising network congestion.	Demonstrated superior network connectivity and coverage. Significant reduction in network congestion. Faster convergence speed compared to other algorithms.
[21]	2023	Overcoming challenges related to network coverage and connectivity. Addressing congestion issues due to the overlay of routers.	To find the optimal placement of mesh routers. Maximise network coverage and connectivity. Minimise congestion in WMNs.	Demonstrated better network connectivity and coverage. Achieved a significant reduction in network congestion. Faster convergence speed compared to other algorithms.

3.2 Interference Management Strategies

In the optimisation of the MRMC wireless mesh network, technological advancements have made numerous sophisticated interventions possible. Referred to as “Technological Interventions” in the context of network optimisation, these tactics comprise advanced algorithmic approaches, software platforms, and sophisticated digital platforms. The ability of these interventions to satisfy the varied and intricate requirements of MRMC network management is a noteworthy characteristic. These encompass streamlining data transmission, minimising network interference, and optimising channel allocation. Advanced routing protocols and dynamic frequency selection techniques, for instance, have significantly increased the efficiency of networks. Interference management is another critical domain which utilises innovative algorithms and machine-learning methods to forecast and alleviate network congestion. In addition, the incorporation of analytics tools powered by artificial intelligence into MRMC networks enables 24/7 surveillance and adaptable network configuration, substantially enhancing the network’s resilience and performance.

Although these technological interventions hold tremendous potential, it is crucial to consider their efficacy, accessibility, and ethical ramifications carefully. In order to successfully integrate these technologies into pre-existing network infrastructures, a comprehensive comprehension of the technical obstacles and user-specific demands is necessary. A summary of the classifications of these interventions is provided in Table 4.

A critical analysis of sixteen distinct studies about interference management strategies in MRMC wireless mesh networks is presented in Table 4. These investigations cover an extensive range of obstacles associated with interference, including signal interference, scalability concerns, mobility, and network congestion. The methodologies utilised in these inquiries exhibit substantial variation.

They encompass both novel topology designs, such as the honeycomb topology, and sophisticated algorithmic approaches, including Integer Linear Programming (ILP) and the implementation of machine learning algorithms. The results obtained from these research studies are crucial, as they illustrate significant progress in addressing interference, increasing network throughput, improving system stability, and optimising channel allocation.

Furthermore, the progression of interference management strategies within these networks is elucidated in Table 4. It provides diverse resolutions for critical challenges such as network congestion and signal interference. These investigations employ a variety of methodologies, including intricate topology designs and sophisticated algorithmic techniques. The results demonstrate significant enhancements in reducing interference, stabilising network performance, and optimising channel allocation. The table illustrates the development of strategies to efficiently and effectively manage interference in wireless networks.

Concerning interference in MRMC WMNs, Table 4 presents an exhaustive synopsis of the innovative approaches and obstacles associated with interference management strategies. The research utilises extensive methodologies, including innovative topological configurations and sophisticated algorithmic models, to tackle critical concerns, including signal interference and network congestion. Significant progress has been made in reducing interference, which will result in more stable and effective network operations, as demonstrated by the findings of these studies. The table underscores the ongoing endeavours to enhance and optimise wireless networks, focusing on effectively handling the intricate element of interference, a critical factor in maintaining exceptional network performance.

Table 4
Summary of interference management strategies

Authors	Year	Problem	Methodology	Results and advantages
[22]	2019	Causes signal interference. Leads to slower data transfer. Results in longer delays. Ineffectiveness due to rigidity.	Adoption of a honeycomb topology. Implementation of depth-based channel allocation. Altering the existing Hybrid Wireless Mesh Protocol (HWMP).	Maintains good throughput under heavy network load. Effectively reduces interference. Optimises channel allocation.
[23]	2019	Scalability challenges. Mobility concerns. Interference management complexities. QoS provision difficulties.	Proposes an efficient Integer Linear Programming (ILP)-based algorithm for resource allocation in software-defined wireless networks. Considers unique wireless characteristics and resource limitations.	Enables improved scalability. Enhances mobility management. Controls interference more effectively. Provides flexible QoS.
[24]	2019	Varying channel conditions. Dynamic traffic flows. Interference issues. Congestion problems.	RLCP (Reinforcement Learning-based system for link selection, channel allocation, and power control). Implemented at each router in the network.	Boosting aggregated throughput. Improving flow fairness. Reducing delivery delays.
[25]	2019	How interference affects transmission quality. Impact on resource utilisation.	CIOMT (Constructing Interference-Optimized Multicast Trees): Aimed at minimising interference.	Improved user coverage. Optimised spectrum utilisation. Reduced co-channel interference.

			CIOCA (Channel Interference-Optimized Channel Assignment): Prioritises user coverage in channel assignment.	

Table 4 (continue)
Summary of interference management strategies

Authors	Year	Problem	Methodology	Results and advantages
[26]	2019	Wireless frequency interference.	Mesh network using multi-radio technology. Utilising a modified PSO algorithm for static channel assignment optimisation.	Improved network performance. Reduced overall interference in maritime communications.
[27]	2020	Delay in data transmission. Interference issues. Transmission failures.	Developing efficient routing protocols for wireless mesh networks. Proposes a novel DIAR method	Minimum end-to-end delays. Simplified process for delay estimation. High adaptability to dynamic network conditions.
[28]	2020	Joint optimisation in cognitive radio wireless mesh networks.	MRCSC (Multicast Routing, Channel Selection, Scheduling, and Call Admission Control) algorithm. Ensure efficient bandwidth allocation. Mitigate interference effectively.	Significant improvement in transmission count. Enhanced stability. Reduced multicast period.
[29]	2020	Interference between nodes utilising the same channels	A hybrid channel assignment (CA) method for Multi-Channel Multi-Radio (MCMR) Wireless Mesh Networks (WMNs).	Improved network connectivity. Enhanced throughput.
[30]	2020	Struggle to achieve collision-free operation. Difficulty in handling diverse traffic demands. Limited channel resources add to the complexity.	Leverages Carrier Sense Multiple Access (CSMA) principles. Incorporates CSMA-aware interference models. Utilises shared link capacity models.	Collision-free communication in MCMR WMNs. High network utilisation, even with limited channels.
[31]	2021	High interference. Reduced throughput. Increased latency. Reduced reliability.	A cross-layer optimisation model for Wireless Mesh Networks (WMNs). i. Utilises all available channels. ii. Exceeds limitations of orthogonal channels. Explores both dynamic and static channel assignments.	Utilising partially overlapping channels in Wireless Mesh Networks (WMNs). Offers a more realistic perspective on the impact of dynamic channel assignment.
[32]	2021	Insufficient number of orthogonal channels and radios. Results in interference and low throughput	CASCA is a novel static channel assignment scheme. i. Utilises a Carrier Sense Multiple Access (CSMA)-	Reduction in collisions. Enhancement of network throughput.

			aware interference model. ii. Employs a partial Maximum Satisfiability (MAX-SAT) formulation.	

Table 4 (continue)
Summary of interference management strategies

Authors	Year	Problem	Methodology	Results and advantages
[33]	2021	Significant interference is caused by multiple radios and channels.	A hybrid approach to optimise channel assignment in Wireless Mesh Networks (WMNs). i. Employing a Q-learning algorithm. ii. Building a multicast tree with minimal interference. iii. Focus on efficient packet delivery.	Outperforms existing approaches in network throughput. Increases packet delivery ratio. Reduces end-to-end delay. Lowers operational cost.
[34]	2022	Geographically dispersed nodes. Distinctive interference levels. Access to varying channels.	Optimising channel assignment in infrastructure DSA-WMNs.	Offers a better alternative to binary conflict-based methods.
[35]	2022	Issues related to reliability. Latency challenges. Channel contention.	A two-pronged approach to optimise mesh network performance. i. Avoids channel contention by allocating bandwidth based on the expected traffic load. ii. Assign dedicated channels to each node. iii. Prevents interference.	Further enhanced network performance. Effectively mitigated channel contention.
[36]	2023	Traditional methods do not comprehensively consider intrusion, congestion load, and bandwidth requirements. Neglect of least significant congestion.	JCABR-IFA (Joint Channel Assignment and Bandwidth Reservation using Improved FireFly Algorithm) Priority determination: i. Assign priority to each node based on Channel usage, Potential future interference, and Link congestion probability. Bandwidth allocation: i. Proportional to the node's priority. ii. Consideration of total traffic flows served by the node.	Effectively minimises traffic congestion. Enhances channel efficiency in Wireless Mesh Networks (WMNs).
[37]	2023	Insufficient resources and interfered links can significantly impair channel capabilities.	PRIority-based Minimum Interference Channel Assignment (PRIMICA) algorithm.	Improved network throughput. Reduction in packet loss ratio. Improvement in end-to-end delay.

	Based on the priority weight of interfering nodes. Preference is given to nodes with the lowest value.	

For the future, the observations presented in Table 4 indicate a pressing requirement for more advanced and adaptable methods of mitigating interference. Subsequent investigations might centre on advancing self-organising networks that can dynamically adjust to changing user requirements and environmental circumstances. Additionally, the potential exists to harness the functionalities of quantum computing to enhance the efficiency of interference management and optimise channel allocation. The criticality of advanced, scalable, and robust interference management techniques grows in tandem with the emergence of technologies like 5G to guarantee the smooth and effective functioning of networks.

4. Conclusions

In conclusion, this systematic review highlights the significant potential of advanced optimisation techniques in MRMC wireless mesh networks. The extensive analysis of current literature reveals that these technologies are crucial in enhancing network efficiency, reducing interference, and improving overall network performance. Despite the promising advancements, the field of MRMC network optimisation is still evolving, with numerous challenges and opportunities for further exploration.

Multi-radio multi-channel wireless mesh networks (MRMC WMNs) are designed to enhance network performance by leveraging the capabilities of multiple radios and channels. Various studies have focused on optimising MRMC WMNs, particularly channel assignment and scheduling algorithms. Key findings from these studies highlight the benefits of exploiting partially overlapping channels, which can significantly boost throughput compared to using only orthogonal channels. The integration of channel assignment with multicast routing emerges as a critical factor in reducing interference. Traditional channel assignment methods for single-radio networks fall short in multi-radio contexts, necessitating a balanced approach to maximise performance. Objectives like improving throughput, minimising delay, reducing energy consumption, and expanding network capacity are central to the algorithms developed for MRMC WMNs. Combining topology control with partially overlapping channel assignments can dramatically improve system throughput. Optimising MRMC WMNs requires a comprehensive approach encompassing channel assignment, multicast routing, interference management, and network capacity considerations, with various proposed algorithms and techniques focused on enhancing throughput, delay, energy efficiency, and overall network capacity.

Researchers and network engineers need to continue collaborating, innovating, and rigorously evaluating these optimisation strategies. This review emphasises the need for high-quality research, such as controlled trials and long-term studies, to deepen our understanding of effectively leveraging these technologies. Issues like network accessibility, ethical considerations, and varying responses to these technological interventions also demand careful attention. By overcoming these challenges and building on the insights from this review, we can work towards a future where MRMC wireless mesh networks are optimised to their fullest potential, significantly enhancing connectivity and communication in various sectors.

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