International Journal of Advanced Research and Multidisciplinary Trends (IJARMT)
An International Open Access, Peer-Reviewed Refereed Journal
Impact Factor: 6.4 Website: https://ijarmt.com ISSN No.: 3048-9458

Resource Management & Scheduling in Wireless Network with Special Reference to Mesh Network & Multi-Access Control

Amit Kumar Paliwal
Research Scholar, Infinity Management & Engineering College, Sagar MP, India
Mail id -amitimec2016@gmail.com

Sarvesh Rai
Assistant Professor, Infinity Management & Engineering College, Sagar MP, India
Mail id- sarvesh.s51@gmail.com

Abstract: The ubiquity of wireless networks in modern communication infrastructures necessitates efficient resource management and scheduling techniques to ensure optimal network performance. This research investigates the intricate dynamics of resource allocation and scheduling within wireless networks, with a particular emphasis on mesh networks and multi-access control. Mesh networks offer a resilient and flexible architecture, enabling enhanced coverage and redundancy. Multi-access control protocols, on the other hand, govern how multiple devices share the network resources. The interplay between these two aspects is critical in determining network efficiency. This research delves into the comprehensive review of wireless network fundamentals, mesh network architecture, and various multi-access control protocols. It scrutinizes existing scheduling algorithms, identifying their strengths and limitations. A novel scheduling framework is proposed, seeking to optimize resource allocation and enhance the overall network performance in mesh environments. The methodology involves data collection, simulation, and analysis of key metrics to evaluate the proposed framework's performance. The results highlight the impact on resource management and scheduling, offering insights into the trade-offs and advantages of different strategies.

Keywords:* *Wireless Networks, Mesh Network, Multi-Access Control, Resource Management, Scheduling Algorithms

INTRODUCTION

The proliferation of wireless communication technologies has revolutionized the way we connect and communicate in the modern world. Wireless networks, in particular, play a pivotal role in enabling seamless connectivity, offering the flexibility to access information and services on the go. However, the efficient management of resources and scheduling within wireless networks poses a significant challenge due to the dynamic and unpredictable nature of the wireless environment. This challenge becomes even more pronounced in the context of emerging network architectures like mesh networks and the need for effective multi-access control mechanisms.

Wireless networks, by their nature, are susceptible to interference, signal attenuation, and varying channel conditions, making resource management a critical aspect of their operation. Resource management involves the allocation and optimization of bandwidth, power, and other network resources to ensure the delivery of reliable and high-quality services. In the context of mesh networks, where nodes collaborate to relay data and create a self-healing infrastructure, resource management becomes a complex task. Mesh networks offer advantages such as increased coverage, fault tolerance, and scalability, but their performance relies heavily on efficient resource allocation.

Scheduling, another crucial component in wireless network management, refers to the process of determining when and how to allocate resources to different users or nodes. In traditional wireless networks, scheduling algorithms are designed to minimize latency, maximize throughput, and enhance overall network performance. However, the dynamics of mesh networks introduce new challenges, as nodes may have varying degrees of influence and connectivity, requiring innovative scheduling strategies to optimize data transmission paths.

1. Wireless Network

A wireless network is a communication system that connects devices, such as computers, smartphones, and IoT sensors, without the need for physical cables. It relies on radio frequency signals to transmit data between devices and to access the internet. These networks are prevalent in homes, businesses, and public spaces, providing the foundation for mobile communication and the Internet of Things (IoT).

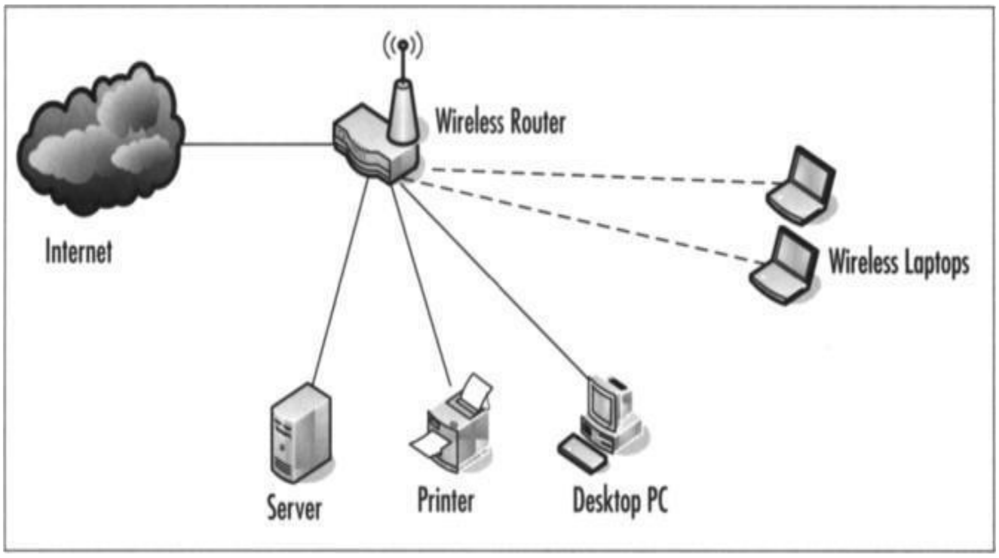

Fig.1 Wireless Network

2. Key Components of Wireless Networks

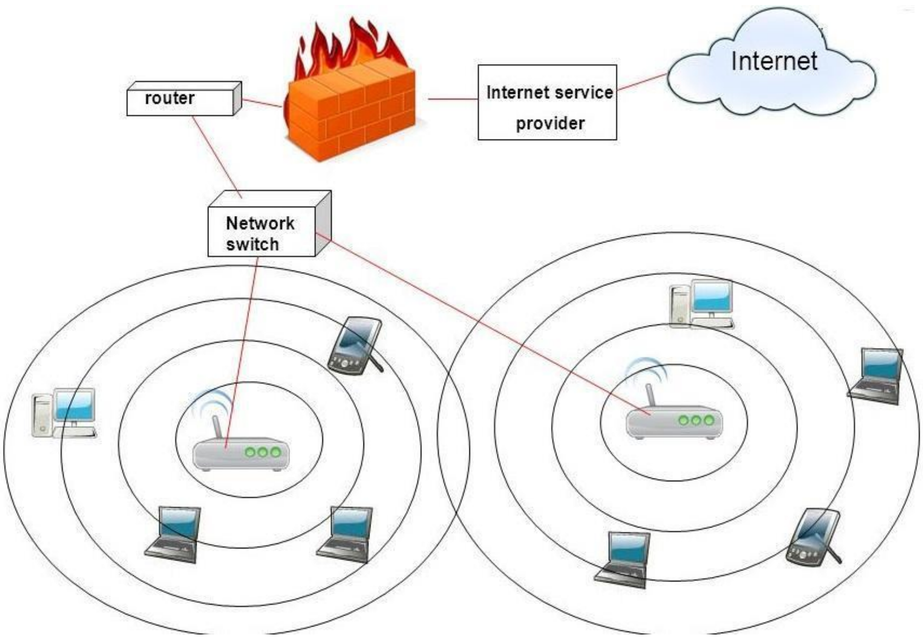

Fig 2 Key Components of a Wireless Network

LITERATURE SURVEY

[1] Helin Yang, Jun Zhao, Zehui Xiong, Kwok-Yan Lam, Sumei Sun, Liang Xiao," Privacy-Preserving Federated Learning for UAV-Enabled Networks: Learning-Based Joint Scheduling and Resource Management", IEEE Xplore 2021.

Unmanned aerial vehicles (UAVs) are capable of serving as flying base stations (BSs) for supporting data collection, machine learning (ML) model training, and wireless communications. However, due to the privacy concerns of devices and limited computation or communication resource of UAVs, it is impractical to send raw data of devices to UAV servers for model training. Moreover, due to the dynamic channel condition and heterogeneous computing capacity of devices in UAV-enabled networks, the reliability and efficiency of data sharing require to be further improved. In this paper, we develop an asynchronous federated learning (AFL) framework for multi-UAV-enabled networks, which can provide asynchronous distributed computing by enabling model training locally without transmitting raw sensitive data to UAV servers. The device selection strategy is also introduced into the AFL framework to keep the low-quality devices from affecting the learning efficiency and accuracy.

[2] Navid Naderializadeh, Jaroslaw J. Sydi, Membe, Meryem Simsek, Senior Member, and Hosein Nikopour "Resource Management in Wireless Networks via Multi-Agent Deep Reinforcement Learning", IEEE Xplore 2021 .

We propose a mechanism for distributed resource management and interference mitigation in wireless networks using multi-agent deep reinforcement learning (RL). We equip each transmitter in the network with a deep RL agent that receives delayed observations from its associated users, while also exchanging observations with its neighboring agents, and decides on which user to serve and what transmit power to use at each scheduling interval. Our proposed framework enables agents to make decisions simultaneously and in a distributed manner, unaware of the concurrent decisions of other agents. Moreover, our design of the agents' observation and action spaces is scalable, in the sense that an agent trained on a scenario with a specific number of transmitters and users can be applied to scenarios with different numbers of transmitters and/or users. Simulation results demonstrate the superiority of our proposed approach compared to decentralized baselines in terms of the tradeoff between average and 5th percentile user rates, while achieving performance close to, and even in certain cases outperforming, that of a centralized information-theoretic baseline.

[3] Muddasar Naeem1· Sajid Bashir2· Zaib Ullah3· Aqeel A. Syed4. "A Near Optimal Scheduling Algorithm for Efficient Radio Resource Management in Multi‑user MIMO Systems," IEEE Xplore 2019 .

Multiple input multiple output (MIMO) systems have high potential to achieve maximum channel capacity in wireless communication systems. Multi-user (MU) MIMO network with transmit antennas Tx at base station can schedule as many single antenna users in one time slot. This necessitates incorporation of a user scheduling strategy. Maximizing sumrate performance without under utilization of channel resources is a primary objective of such scheduling algorithms. Another key design factor for such techniques is to optimize fairness i.e. allowing equal opportunity to all communicating entities. In this paper, we present a simple approach to solve the scheduling problem in MU-MIMO systems while addressing the conficting objectives of sumrate and fairness. Two variants of the proposed method are also discussed that provide options for maximizing the cumulative sumrate and improving the fairness.

[4] NING WANG1,2,3, CHEN HE2, T. AARON GULLIVER3, AND VIJAY K. BHARGAVA2, " Generalized Queue-Aware Resource Management and Scheduling for Wireless Communications," IEEEX 2015 .

The general problem of a queue-aware radio resource management and scheduling design is investigated for wireless communications under quasi-static fading channel conditions. Based on an analysis of the source buffer queuing system, the problem is formulated as a constrained nonlinear discrete programming problem. The state transition matrix of the queuing system determined by the queue-aware scheduler is shown to have a highly dynamic structure, so that the conventional matrix analysis and optimization tools are not applicable. By reformulating the problem into a nonlinear integer programming problem on an integer convex set, a direct search approach is considered. Two types of search algorithms, gradient based and gradient-free, are investigated. An integer steepest-descent search with a sub-sequential interval search algorithm and a constrained discrete Rosenbrock search (CDRS) algorithm is proposed to solve the nonlinear integer problem. Both algorithms are shown to have low complexity and good convergence. The numerical results for a single user resource allocation are presented, which show that both algorithms outperform equal partitioning and random partitioning queue-aware scheduling. The dynamic programming (DP) solution given by the relative value iteration algorithm, which provides the true optima but has high complexity, is used as a benchmark.

[5] Yuhuan Du and Gustavo de Veciana, " "Wireless Networks Without Edges": Dynamic Radio Resource Clustering and User Scheduling" IEEE Xplore 2014 .

Cellular systems using Coordinated Multi-Point (CoMP) transmissions leveraging clusters of spatially distributed radio antennas as Virtual Base Stations (VBSs) have the potential to realize overall throughput gains and, perhaps more importantly, can deliver substantial enhancement to poor performing "edge" users. In this paper we propose a novel framework aimed at fully exploiting the potential of such systems through dynamic radio resource clustering and user scheduling which maximize system utility. The dynamic clustering problem is modeled as a maximum weight clustering problem which is NPhard, however, we show that by structuring the set of possible VBSs to be "2-decomposable" it can be efficiently computed. We also propose to optimize over a class of power allocation policies to radio resources, and thus VBSs, which allow dynamic user scheduling and flexible power allocations depending on instantaneous channel realizations.

[6] Dong Heon Lee, Kae Won Choi, Wha Sook Jeon, and Dong Geun Jeong," Two-Stage Semi-Distributed Resource Management for Device-to-Device Communication in Cellular Networks", IEEE Xplore 2014 .

In cellular networks, the device-to-device (D2D) communication increases the network capacity by spatial reuse of radio resources and prolongs the battery life of devices by reducing the transmission power. In this paper, we propose a two-stage semi-distributed resource management framework for the D2D communication. At the first stage of the framework, the base station (BS) allocates resource blocks (RBs) to BSto-user device (B2D) links and D2D links, in a centralized manner. At the second stage, the BS schedules the transmission using the RBs allocated to B2D links, while the primary user device of each D2D link carries out link adaptation on the RBs allocated to the D2D link, in a distributed fashion. The proposed framework has the advantages of both centralized and distributed design approaches, i.e., high network capacity and low control/computational overhead, respectively. We formulate the problems of RB allocation to maximize the radio resources efficiency, taking account of two different policies on the spatial reuse of RBs. To solve these problems, we suggest a greedy algorithm and a column generation-based algorithm.

[7] Wang Anchun, Xiao Liang? Zhou Shidong Xu Xiiin, Yao Yan, " Dynamic resource management in the fourth generation wireless systems " IEEE Xplore 2013 .

In this text, we consider the problem of fair scheduling in the downlink of Orthogonal Frequency Division (OFDM) systems. Based on be proportional fair scheduling algorithm proposed in the CDMAfHDR, we present three schemes to manage the parallel subcarriers in the OFDM system to utilize the time selectivity and frequency selectivity. Subcarriers in a slot are divided into several nonoverlapped subbands, which are the scheduling objects. The fit scheme is that every subband is placed a scheduler and the average rates are updated independently; the second scheme is that transfer the two-dimensional channel resource into one-dimension equivalent channel, and then schedule the resource like in HDR systems; the third one is that users contend every subband in a same slot using one scheduler without updating the average rates, after finished a slot, the average rates are updated together. Compared to the fit scheme, the third one has the least complexity and its performance degrades little.

RESEARCH METHODOLOGY

- ***Simulation***: Simulation tools, such as ns-3, OMNeT++, and OPNET, allow researchers to create virtual network environments and compare MAC protocols under different conditions. Simulations offer a controlled environment for performance evaluation.
- ***Emulation***: Emulation involves using real devices and network equipment to recreate real-world scenarios. Emulation provides a more realistic testing environment but can be costly and complex.
- ***Testbeds***: Physical testbeds involve deploying real network infrastructure to evaluate MAC protocols in a real-world setting. Testbeds are valuable for assessing practical performance.
- ***Analytical Models***: Analytical models use mathematical equations and calculations to predict the performance of MAC protocols under various scenarios. They provide insights into theoretical performance.

Impact on Diverse Areas:

- ***Business and Operations Management***: In the business realm, resource management affects inventory control, project planning, and workforce allocation. Efficient resource allocation can lead to reduced costs and increased profitability.
- ***Environmental Conservation:*** Sustainable resource management is vital in environmental conservation. This includes responsible forestry practices, efficient energy consumption, and conservation of water resources.
- ***Energy and Utilities***: Efficient resource management in the energy sector involves optimizing the generation, distribution, and consumption of electricity and other energy sources. It impacts both environmental sustainability and cost control.
- ***Project Management***: Project managers rely on resource management to allocate human and material resources effectively. Proper resource allocation can significantly impact a project's success.
- ***Water Resource Management***: Efficient allocation and conservation of water resources are critical in agriculture, industry, and municipal water supply. Sustainable water management ensures an adequate supply for current and future needs.
- ***Human Resources:*** In the context of HR, resource management encompasses workforce planning, talent acquisition, and employee development. Effective human resource management enhances organizational performance.

CONCLUSION

In the ever-evolving landscape of wireless networks, effective resource management and scheduling are paramount to ensure optimal performance, reliability, and scalability. This conclusion reflects on the key insights gained from a focused exploration of resource management and scheduling in wireless networks, with a special emphasis on mesh networks and multi-access control.

The advent of mesh networks has revolutionized wireless communication by introducing a decentralized architecture that enhances coverage, reliability, and flexibility. The distributed nature of mesh networks allows for dynamic adaptation to changing conditions, making them well-suited for diverse applications ranging from smart cities to industrial IoT. However, this decentralized structure brings forth challenges in resource management and scheduling, demanding innovative solutions to efficiently allocate and utilize network resources.

Resource management in mesh networks involves the allocation and optimization of bandwidth, energy, and processing capabilities. Advanced algorithms and protocols play a pivotal role in addressing these challenges. Through the course of our exploration, it became evident that intelligent resource allocation, considering factors such as link quality, traffic patterns, and node capabilities, is crucial for enhancing the overall performance of mesh networks. Machine learning and artificial intelligence techniques have shown promise in dynamically adapting resource allocation strategies, optimizing the network's efficiency in real-time.

Multi-access control, another critical aspect of wireless network management, ensures fair and efficient utilization of the available communication channels. As the number of connected devices continues to rise exponentially, managing access to the network spectrum becomes increasingly complex.

The significance of multi-access control mechanisms, such as Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) and Time Division Multiple Access (TDMA), cannot be overstated. These protocols govern how devices share the communication medium, minimizing collisions and ensuring equitable access to network resources.

REFERENCES

[1] A. J. Goldsmith and S.-G. Chua, ''Adaptive coded modulation for fad-ing channels,'' IEEE Trans. Commun., vol. 46, no. 5, pp. 595–602, May 1998.

[2] F. Babich, ''Considerations on adaptive techniques for time-division mul-tiplexing radio systems,'' IEEE Trans. Veh. Technol., vol. 48, no. 6,pp. 1862–1873, Nov. 1999.

[3] X. Liu, E. K. P. Chong, and N. B. Shroff, ''Opportunistic transmission scheduling with resource-sharing constraints in wireless networks,'' IEEE J. Sel. Areas Commun., vol. 19, no. 10, pp. 2053–2064, Oct. 2001.

[4] L. Bao and J. J. Garcia-Luna-Aceves, ''Transmission scheduling in ad hoc networks with directional antennas,'' in Proc. ACM MobiCom, Atlanta, GA, USA, Sep. 2002, pp. 48–58.

[5] L. Tassiulas and A. Ephremides, ''Dynamic server allocation to parallel queues with randomly varying connectivity,'' IEEE Trans. Inf. Theory, vol. 39, no. 2, pp. 466–478, Mar. 1993.

[6] Q. Wu, L. Liu and R. Zhang, "Fundamental trade-offs in communication and trajectory design for UAV-enabled wireless network," IEEE Wireless Commun., vol. 26, no. 1, pp. 36-44, Feb. 2019.

[7] J. Konecny, H. B. McMahan, F. X. Yu, P. Richtrik, A. T. Suresh, and D. Bacon, "Federated learning: Strategies for improving communication efficiency, 2016. [Online]. Available: https://arxiv.org/abs/1610.05492.

[8] H. B. McMahan et al., "Communication-efficient learning of deep networks from decentralized data," in Proc. 20th Int. Conf. Artif. Intell. Stat., Fort Lauderdale, FL, USA, Apr. 2017, vol. 54, pp. 1273C1282.

[9] S. Ruder, "An overview of gradient descent optimization algorithms," 2016. [Online]. Available: https://arxiv.org/abs/1609.04747.

[10] T. Zeng, O. Semiari, M. Mozaffari, M. Chen, W. Saad, and M. Bennis, "Federated learning in the sky: Joint power allocation and scheduling with UAV swarms," in Proc. IEEE Int. Conf. Commun. (ICC), Dublin, Ireland, 2020, pp. 1-6.

[11] H. Shiri, J. Park, and M. Bennis, "Communication-efficient massive UAV online path control: Federated learning meets mean-field game theory, IEEE Trans. Commun., vol. 68, no. 11, pp. 6840-6857, Nov. 2020.

[12] N. H. Tran, W. Bao, A. Zomaya, and C. S. Hong, "Federated learning over wireless networks: Optimization model design and analysis," in Proc. Int. Conf. Comput. Commun. (INFOCOM), Paris, France, 2019, pp. 1387C1395.

[13] S. Wang, T. Tuor, T. Salonidis, K. K. Leung, C. Makaya, T. He, and K. Chan, "Adaptive federated learning in resource constrained edge computing systems," IEEE J. Sel. Areas Commun., vol. 37, no. 6, pp. 1205C1221, 2019.

[14] S. Wang et al., "When edge meets learning: Adaptive control for resource-constrained distributed machine learning," in Proc. Int. Conf. Comput. Commun. (INFOCOM), Honolulu, HI, 2018, pp. 63-71.

[15] Yang, H. H., Liu, Z., Quek, T. Q., & Poor, H. V. (2019). Scheduling policies for federated learning in wireless networks. IEEE transactions on communications, 68(1), 317-333.