International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

Resource Optimization using the Taguchi Technique for Channel Allocation

Radhika Purandare[1], Archana Ratnaparkhi[2], Arti Bang[3]

Submitted: 02/11/2022 **Revised**: 13/01/2023 **Accepted**: 01/02/2023

Abstract: Configuration settings that use physical as well as medium access control layers are increasing to enhance system performance. A channel is a medium for communication between nodes in a network. The uncertainty in environmental conditions affects the Quality-of-Service (QoS) performance of the network. It hinders the speed, coverage as well as reliability of transmission. Hence there is a need to enhance QoS as well as the Quality of Experience for users. In this paper, an algorithm is proposed for channel allocation. It correlates signal-to-noise ratio with throughput and packet-dropping ratio. The simulation result shows an enhancement of throughput is 40 %. Further, the packet drop ratio was reduced by 8.18 %. The performance of the algorithm is evaluated with a network simulator tool.

Keywords: *ANOVA, PDR, QoS, QoE, channel allocation*

1. Introduction

Presently, designing and optimization of the wireless network are user-centric. Thus, radio resource management is still an emerging area for future-generation wireless networks. Further, the channel allocation algorithm helps to optimize bandwidth and power. It allocates available channels to users as well as access points to enhance resource utilization. Various challenges in resource management for channel allocation are to achieve better spectral efficiency and enhance the Quality of Service to network and users. There are two basic strategies for channel allocation in future-generation networks. One is known as the static allocation method. It is adopted in local area networks for proper utilization of network resources. The second is the dynamic allocation method. Here, the decision is based on channel occupancy, traffic distribution, and received signal strength. Thus, able to optimize bandwidth and achieves faster transmission speed.

Presently, there is exponential growth in mobile users as well as data service necessity. Thus, QoE is considered a fitness function. It acts as a performance marker for users, operators as well as service providers. Nowadays, more base stations are required to save energy consumption at the network and user end. It improves cell coverage by providing a good fitness channel for communication. In general, effective work considering the management of power, load as well as channel allocation is still a thrust area. Thus, the task of enhancing service quality in wireless networks is continuous research. It demands to design intelligent algorithm for channel allocation. It should assure seamless transmission with the required quality of service.

Department of Electronics and Telecommunication Engineering
Vishwakarma Institute of Information Technology, Pune, Maharashtra
rpurandare81@gmail.com

2. Literature Survey

Resource allocation is an important role in the design and management of the future-generation network. In a wireless network, existing radio resources like time slots, power, and channels must be intelligently allocated to accomplish guaranteed user fairness and quality of service. It is observed that the fifth-generation wireless system provides an improved mobile service as well as enhanced QoS to the user. In [1], energy restrictions of devices play a crucial role to enhance the performance of wireless sensor networks. Here, a heuristic clustering scheme with the help of hypergraph theory is presented to optimize node energy. In [2] resource allocation, as well as interference management schemes, are described for heterogeneous networks. Here, dense deployment of nodes is considered. Several methods are described for various radio access networks. A coordination technique to coordinate multipoint transmission is presented in [3]. It is observed that network optimization helps to reduce cost and energy consumption. Taguchi's method can reduce 22.7% power. Further, a throughput enhancement of 41.5% is achieved. A resource optimization by convex method for device-to-device communication is explained in [4]. Here, results show that total throughput and interference among the users are optimized effectively. 5G network is promising enhanced QoS performance as compared with the Wi network. Here, different optimization techniques are presented to address resource allocation in 5G as well as the Internet of Things [5]. An improvement in resource management has increased network productivity.

In [6], a scheme to optimize energy for D2D is described. A multicasting approach can optimize power and resource block allocation in mobile networks. An optimization scheme is proposed to design medium access control as well as resource allocation is presented in [7] for a cloud access network. A deep reinforcement learning approach is described for channel allocation. This scheme achieved enhanced quality of experience [8]. It is observed that throughput is enhanced in the dense wireless local area network. In [9], resource management for power selection as well as channel allocation is discussed. An iterative approach scheme to achieve the quality of experience with the cloud is also described. A network Slicing scheme to handle services in the next generation 5G network is presented in [10]. It is developing business opportunities for service providers. In [11], the computing intelligence approach is presented for deciding channel allocation using fuzzy logic. The fitness function considered is the mean square error. It achieved an increase in network capacity and

quality of experience. A neighborhood area with a wi-fi network is described in [12]. A cuckoo search scheme is also presented to reduce power consumption. AN reinforcement method is presented [13] that performs channel allocation intelligently. The system learns and is trained from the previous data. It is observed that there is an enhancement in system performance. Resource allocation scheme is presented based on the traffic pattern in the network in [14]. It makes resources available against unused channels

. It is observed from the literature survey that resource allocation is still of much importance in next-generation 5G as well as 6G networks. In this paper, the Taguchi technique proposed to achieve better resource management is presented. Further, an algorithm helps to allocate channels for next-generation wireless communication.

3. Resource Optimization using Taguchi technique for channel allocation

Taguchi technique consists of a total of three steps. The first step involves identifying control factors and their levels to create an orthogonal array. It is known as experiment planning. Performing to experiment on obtained array matrix is the second step. At the last, experimental results are to be analyzed and verified. A formal layout of experiments is prepared to find experimental runs and factor combinations. In this paper, the objective is to enhance the performance of the 5G network with the help of a channel allocation algorithm. Further, Sir Ronald Alymer Fisher proposed ANOVA on experimental data for statistical analysis. The design parameters in process design are known as the control factor. Following are the benefits of the Taguchi technique.

- Easy application and data analysis
- Option to confirm predicted improvement
- Improve customer satisfaction and profitability

The algorithm to allocate channels at the physical level is explained. Further, the Taguchi approach is used for resource optimization in terms of power and bandwidth.

Algorithm: Resource Optimization using the Taguchi technique for channel allocation

---

Input: SNR, Offset values, Number of Interleavers and Channel Bandwidth
Output: Bit Error Rate, Packet Delivery Ratio, Throughput

---

1. Initialize the scenario in the network simulator
2. Select Modulation technique as 16QAM, OFDM system with Turbo as Error control code
3. The routing protocol selected is AODV and the distribution of node station are random
4. Simulate the environment to obtain the QoS parameter value
5. Apply the Taguchi technique to find the solution for selecting the best channel for communication
6. Validate the result with obtain optimum settings
7. If not, then jump to step5
8. End

Table 1 presents Optimization with Taguchi Method. Robust parameter design uses orthogonal arrays in Taguchi designs for analyzing factors such as the number of users, Eb/N0, and CFO with few experimental runs.

Table 1 Taguchi Orthogonal Array Design L9

Experimental Runs	Interleavers	SNR	Offset	Bit Error Rate
1	1	15	0.0	0.0000138
2	4	15	0.1	0.000018
3	8	15	0.2	0.0000126
4	4	19	0.0	0.0000054
5	8	19	0.1	0.0000222
6	1	19	0.2	0.0000144
7	8	24	0.0	0.000015
8	1	24	0.1	0.00000108
9	4	24	0.2	0.0000018

4. Results and Discussion

A total of five QoS parameters with values are considered for simulation in the Network Simulator environment. The network performance is evaluated with throughput at the data link layer and bit error rate at the physical layer. Various steps considered to decide channel allocation for communication are as follows.

- Obtain parameter value from the simulation.
- Select-control parameters for the channel allocation algorithm
- Measure weighted value to decide channel allocation for communication as shown in Table 2.

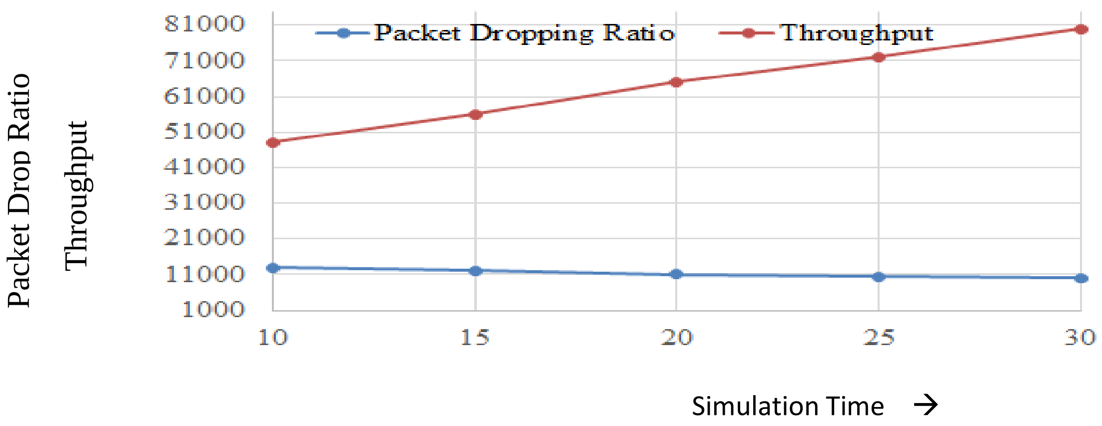
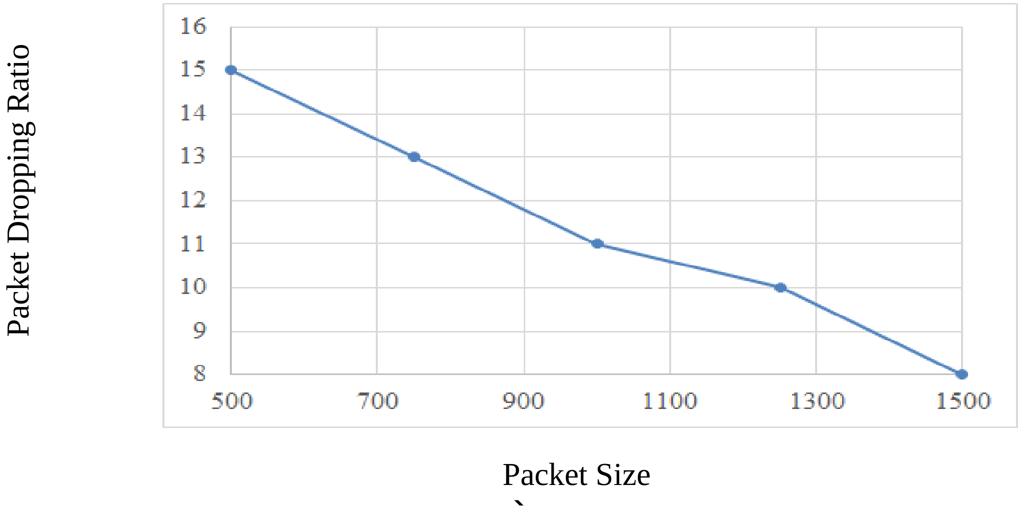
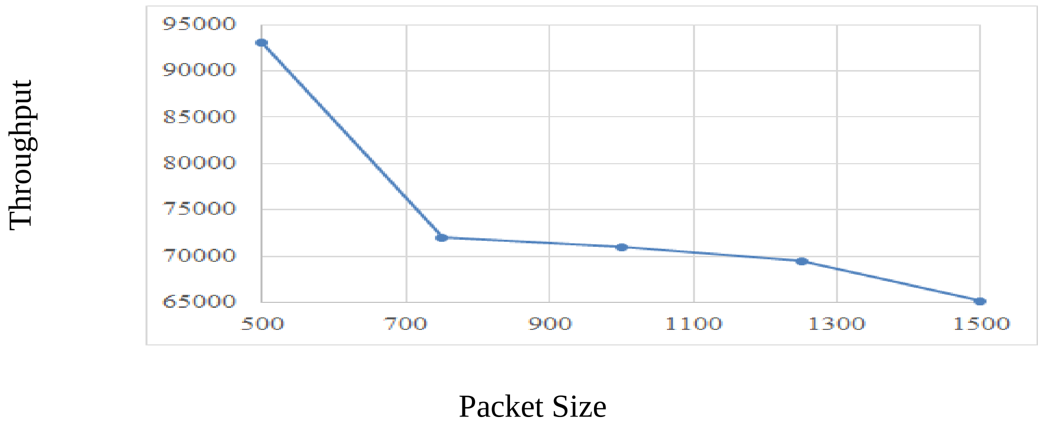


Figure 1 : Comparison of Throughput and Packet Drop Ratio against Simulation Time

Figure 1 represents the packet-dropping ratio against simulation time. It also shows throughput with the same axis parameter. As the simulation time is changed from 10 to 30 sec, the packet dropping ratio starts from 11000 and ends at 10100. The overall drop of 8.18 %. Similarly, with some variation in simulation time, an enhancement of throughput is 40 %.



(a)



(b)

Fig 2 : Comparison of Throughput and Packet Drop Ratio against Packet size

Figure 2 expresses the significance of changing the size of the packet on QoS parameters. The size is changed from 500 to 1500 bytes. An improvement in throughput is 21.68 %. Similarly, the packet drop ratio increased by 23.5 %. The simulation was also performed to evaluate error rate performance as displayed in Figure 3. Here, signal to noise value was varied from 0 to 25 dB. Thereafter, the impact of frequency offset was also observed. It has increased the bit error rate by 8.9 %. In the end, the interleaver size also had an impact on error.

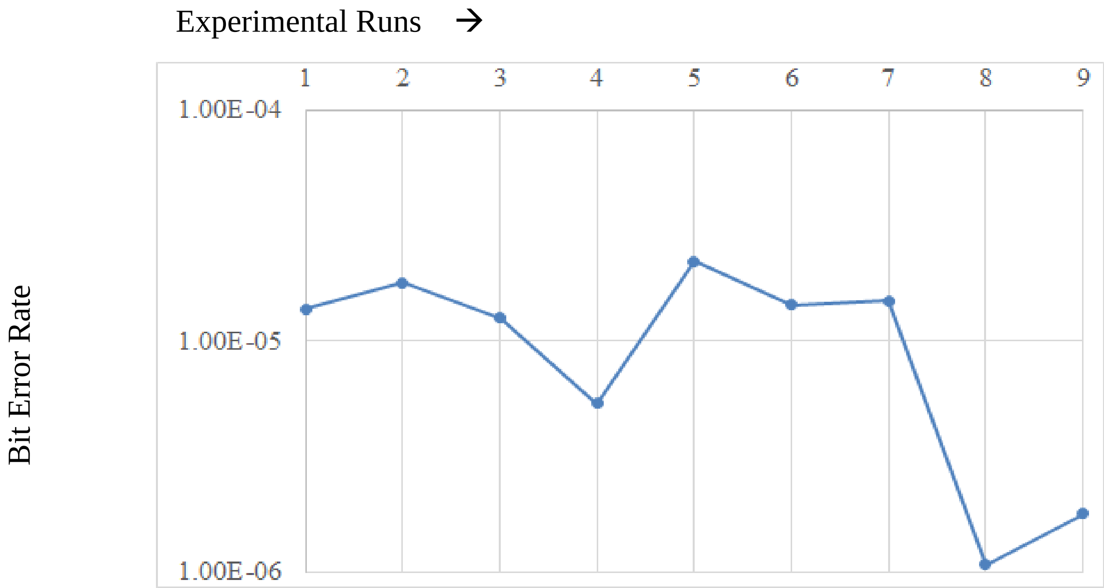


Fig. 3 : Comparison of Bit Error Rate against Experimental Runs

5. Conclusion

In this paper, a channel allocation algorithm is implemented for the wireless network. An analysis of variance shows the significance of control parameters on QoS performance. The algorithm proposed succeeded in the allocation of good channels for communication. Further, the Taguchi optimization method is also considered to validate the results. The following are the observations:

- Resource Optimization using the Taguchi technique is proposed for channel allocation with a model accuracy of 98.96 %
- Throughput enhancement of 40 % and 23.5 % is achieved against simulation time and packet size variation
- Bit Error Rate enhancement of 8.9 % at the physical layer implies that the proposed algorithm can cater to the impact of Carrier Frequency Offset

Future Scope

Deep learning and machine learning approach can be used to train the network. Such network will be able to allocate and recommend best channel for communication.

Table 2: Channel Allocation

Bit Error Rate	Signal to Noise Ratio	Channel Utilization	Interference	Channel Throughput	Delay	Jitter	Channel Allocation
0.0000018	78	15	100	24	283	22	18
0.000003	40	23	75	69	245	180	5
0.0000054	49	71	64	2	38	297	43
0.0000084	244	29	63	21	183	100	14
0.0000108	45	6	63	33	165	124	02
0.0000138	167	72	57	32	27	185	23
0.0000144	293	60	30	100	249	225	01
0.000015	141	55	5	78	188	73	25
0.0000168	152	81	61	42	225	204	02
0.0000174	101	34	67	22	33	41	29
0.000018	63	12	76	26	213	55	09
0.0000186	255	11	16	79	188	133	31
0.000021	44	16	6	25	91	238	07
0.0000216	174	27	68	46	3	153	36
0.0000222	31	0	4	72	164	137	04
0.0000228	154	19	14	57	224	170	38
0.000024	219	84	62	74	22	106	40
0.0000246	262	11	45	13	15	194	17
0.0000126	134	0	82	51	72	149	21
0.0000252	60	68	81	49	272	98	02

Conflict of Interest

All authors declare that they have no conflicts of interest.

References

[1] Gbadouissa, J. E. Z., Ari, A. A. A., Titouna, C., Gueroui, A. M., & Thiare, O. (2020). HGC: HyperGraph-based Clustering scheme for power-aware wireless sensor networks. Future Generation Computer Systems, 105, 175-183.

[2] Shanmugavel, G., & Vasanthi, M. S. (2021). Resource Allocation for 5G RAN—A Survey. In Advances in Computing and Network Communications (pp. 33-42). Springer, Singapore.

[3] Dastoor, S. K., Dalal, U., & Sarvaiya, J. (2020). Optimization of comp-based cellular network design and its radio network parameters for next-generation hetnet using Taguchi's method. International Journal of Innovative Computing and Applications, 11(2-3), 147-158.

[4] Li, J., Lei, G., Manogaran, G., Mastorakis, G., & Mavromoustakis, C. X. (2019). D2D communication mode selection and resource optimization algorithm with optimal throughput in 5G network. IEEE Access, 7, 25263-25273.

[5] Awoyemi, B. S., Alfa, A. S., & Maharaj, B. T. (2020). Resource optimization in 5G and internet-of-things networking. Wireless Personal Communications, 111(4), 2671-2702.

[6] Hmila, M., Fernández-Veiga, M., Rodríguez-Pérez, M., & Herrería-Alonso, S. (2019). Energy-efficient power and channel allocation in underlay device to multi-device communications. IEEE Transactions on Communications, 67(8), 5817-5832.

[7] Yu, G., Wen, D., & Qu, F. (2016). Joint user scheduling and channel allocation for cellular

networks with full duplex base stations. IET Communications, 10(5), 479-486.
[8] Nakashima, K., Kamiya, S., Ohtsu, K., Yamamoto, K., Nishio, T., & Morikura, M. (2020). Deep reinforcement learning-based channel allocation for wireless lans with graph convolutional networks. IEEE Access, 8, 31823-31834.
[9] Wu, D., Wu, Q., Xu, Y., & Liang, Y. C. (2017). QoE and energy-aware resource allocation in small cell networks with power selection, load management, and channel allocation. IEEE Transactions on Vehicular Technology, 66(8), 7461-7473.
[10] Datar, M., & Altman, E. (2021, August). Strategic Resource Management in 5G Network Slicing. In ITC 33.
[11] Asuquo, D., Ekpenyong, M., Udoh, S., Robinson, S., & Attai, K. (2020). Optimized channel allocation in emerging mobile cellular networks. Soft Computing, 24, 16361-16382.
[12] Alam, S., Aqdas, N., Qureshi, I. M., Ghauri, S. A., & Sarfraz, M. (2019). Joint power and channel allocation scheme for IEEE 802.11 RF-based smart grid communication network. Future Generation Computer Systems, 95, 694-712.
[13] Guan, M., Wu, Z., Cui, Y., Cao, X., Wang, L., Ye, J., & Peng, B. (2019). An intelligent wireless channel allocation in HAPS 5G communication system based on reinforcement learning. EURASIP Journal on Wireless Communications and Networking, 2019(1), 1-9.
[14] Zeng, B., & Yao, L. (2017, October). Traffic pattern based resource allocation algorithm for hybrid transmission in LTE networks. In 2017 IEEE 3rd Information Technology and Mechatronics Engineering Conference (ITOEC) (pp. 81-85). IEEE.
[15] Zhao, S., & Yu, G. (2021). Channel allocation optimization algorithm for hybrid wireless mesh networks for information physical fusion system. Computer Communications, 178, 212-220.
[16] Pratima Amol Kalyankar, Altaf O. Mulani, Sampada P. Thigale, Pranali Gajanan Chavhan and Makarand M. Jadhav, “Scalable face image retrieval using AESC technique”, Journal Of Algebraic Statistics Volume 13, No. 3, p. 173 – 176, 2022
[17] Dr. P. B. Mane and A. O. Mulani, “High throughput and area efficient FPGA implementation of AES algorithm”, International Journal of Engineering and Advanced Technology, Vol. 8, Issue 4, April 2019
A. O. Mulani and Dr. P. B. Mane, “Secure and area Efficient Implementation of Digital Image Watermarking on Reconfigurable Platform”, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, Issue 2,Dec. 2018
[18] Kulkarni P.R., Mulani A.O. and Mane P. B., “Robust Invisible Watermarking for Image Authentication”, In Emerging Trends in Electrical, Communications and Information Technologies, Lecture Notes in Electrical Engineering, vol. 394,pp. 193-200, Springer, Singapore, 2017.
[19] A.O.Mulani and Dr.P.B.Mane, “Watermarking and Cryptography Based Image Authentication on Reconfigurable Platform”, Bulletin of Electrical Engineering and Informatics, Vol.6 No.2, pp 181- 187,2017
[20] A.O.Mulani and Dr.P.B.Mane, “Area Efficient High Speed FPGA Based Invisible Watermarking for Image Authentication”, Indian Journal of Science and Technology, Vol.9. No.39, Oct. 2016. ISSN 0974-5645
[21] Kashid, M.M., Karande, K.J., Mulani, A.O. (2022). IoT-Based Environmental Parameter Monitoring Using Machine Learning Approach. In: Kumar, A., Ghinea, G., Merugu, S., Hashimoto, T. (eds) Proceedings of the International Conference on Cognitive and Intelligent Computing. Cognitive Science and Technology. Springer, Singapore. https://doi.org/10.1007/978-981-19-2350-0_5