Investigation and Analysis of the Impact of Interference on Wireless Communication Systems

Nitin Kumar
Department of Electro. & Comm. Engg, Graphic Era Hill University, Dehradun, Uttarakhand, India 248002,

Article Info
Page Number: 1010-1018
Publication Issue:
Vol. 70 No. 2 (2021)

Article History
Article Received: 18 October 2021
Revised: 20 November 2021
Accepted: 22 December 2021

Abstract

Wireless communication systems are widely used in modern society, and their reliability is paramount to ensure effective communication. The aim of this investigation is to analyze the effects of interference on wireless communication systems. Interference is a major issue in wireless communication systems and can significantly degrade the system's performance. This paper presents a survey of investigations into the effect of interference on wireless communication systems. It provides an overview of the various types of interference and their effects on wireless communication systems, as well as techniques used to mitigate interference in wireless communication systems. It also reviews recent research on interference in wireless communication systems, which has shown that interference can significantly degrade the performance of wireless communication systems. The paper also discusses the challenges and future directions in the investigation of interference in wireless communication systems, such as the development of interference models that accurately capture the complex nature of interference, the design of interference mitigation techniques that can adapt to changing interference conditions, and the optimization of wireless communication systems to minimize the impact of interference. Finally, the survey highlights the importance of investigating the effect of interference on wireless communication systems and provides a comprehensive overview of the various techniques used to mitigate interference.

1. Introduction

Wireless communication systems have become an integral part of modern-day communication, with their widespread use in various applications such as mobile phones, Wi-Fi networks, Bluetooth devices, and many more. The uninterrupted and reliable functioning of wireless communication systems is essential for the efficient operation of these applications. However, interference in wireless communication systems is a major challenge that affects their performance and reliability.

Interference can be defined as the presence of unwanted signals in a wireless communication system that disrupts the normal functioning of the system. Interference can occur due to various factors such as environmental factors, electromagnetic radiation from other electronic devices, and interference from other wireless communication systems operating in the same frequency band. The effect of interference on wireless communication systems can range from minor performance degradation to complete disruption of the communication.

The investigation of the effect of interference on wireless communication systems is of significant importance in understanding the behavior of these systems under different operating conditions. The aim of this research is to investigate the impact of interference on wireless communication systems and to identify the factors that contribute to interference in these systems. The research will focus on the following objectives:

- To review the literature on interference in wireless communication systems and the various techniques used to mitigate interference.
- To analyse the factors that contribute to interference in wireless communication systems.
- To investigate the impact of interference on the performance of wireless communication systems, including the bit error rate, signal-to-noise ratio, and throughput.
- To evaluate the effectiveness of various interference mitigation techniques, including frequency hopping, power control, and antenna diversity.
- To propose a model for predicting the impact of interference on wireless communication systems under different operating conditions.

The research methodology will involve a combination of theoretical analysis, simulation studies, and experimental measurements. The theoretical analysis will involve the development of mathematical models to analyze the impact of interference on wireless communication systems. The simulation studies will involve the use of software tools such as MATLAB and NS3 to simulate the behavior of wireless communication systems under different interference scenarios. The experimental measurements will involve the use of testbeds to validate the simulation results and to evaluate the performance of interference mitigation techniques.

The expected outcome of this research is a better understanding of the impact of interference on wireless communication systems and the factors that contribute to interference. The research will also provide insights into the effectiveness of various interference mitigation techniques and their suitability for different operating conditions. The proposed model for predicting the impact of interference on wireless communication systems will be useful for system designers and network operators in optimizing the performance of wireless communication systems.

In conclusion, the investigation of the effect of interference on wireless communication systems is of great significance in understanding the behavior of these systems under different operating conditions. The research proposed in this paper aims to contribute to this field of study by providing a comprehensive analysis of the impact of interference on wireless communication systems and the effectiveness of various interference mitigation techniques.

2. Literature Survey

This paper discusses interference management in cognitive radio networks. It begins with an overview of cognitive radio networks, which are wireless networks that use artificial intelligence to manage the use of available radio spectrum. The paper then discusses the different types of interference that can occur in cognitive radio networks, such as co-channel interference, adjacent-channel interference, and intermodulation interference. The paper then discusses interference management techniques in cognitive radio networks, such as spectrum sensing, power control, and dynamic spectrum allocation. Simulation results show that spectrum sensing and power control are effective techniques for managing interference in cognitive radio networks. Finally, the paper concludes with a discussion of future research

ISSN: 2094-0343
DOI: https://doi.org/10.17762/msea.v70i2.2154
directions for interference management in cognitive radio networks. Overall, Kim and Lee's paper provides a comprehensive overview of interference management in cognitive radio networks [1].

Long-Term Evolution Advanced (LTE-A) is the newest standard for wireless communication systems, and its popularity is increasing rapidly. One of the significant challenges facing LTE-A is interference mitigation in heterogeneous networks. Han, Kim, and Lee (2011) discussed several interference mitigation techniques that can be used in LTE-A heterogeneous networks, such as interference cancellation, interference avoidance, interference coordination, interference alignment, and interference suppression. Simulation results showed that interference cancellation was the most effective technique for mitigating interference in heterogeneous networks, while interference avoidance was effective but not as efficient as interference cancellation. Interference coordination and interference alignment were useful in mitigating interference in heterogeneous networks, but required a high level of coordination between adjacent cells. Finally, interference suppression was not an effective technique for mitigating interference in heterogeneous networks [2].

This paper provides a comprehensive overview of various methods for mitigating the effects of interference in wireless networks. The review covers various interference management techniques, including power control, multiple access techniques, and interference cancellation techniques. Power control is a widely used interference management technique that adjusts the transmission power of the radio transmitter to reduce interference. Multiple access techniques allow multiple users to share the same communication channel. Interference cancellation techniques use signal processing algorithms to remove the interference from the received signal. Other interference management techniques such as smart antenna systems, cognitive radio networks, and cooperative communication are also discussed. Overall, Sharma and Singh's (2012) literature review provides an insightful overview of the various interference management techniques used in wireless communication systems [3].

Wang and Giannakis conducted a literature review on wireless multicell networks, focusing on interference coordination, resource allocation, and propagation. Interference coordination involves adjusting the transmission power of each cell to mitigate interference with neighboring cells. Resource allocation involves dividing the frequency band into several sub-bands, time division into several intervals, and space division into several regions. Propagation is another significant factor in wireless multicell networks, and the authors discuss several propagation models, such as path loss models, shadowing models, and fading models. The review highlights the importance of efficient resource utilization and interference management in achieving high performance in wireless multicell networks [4].

This paper provides a comprehensive overview of various techniques and strategies employed for mitigating the negative impact of interference in wireless communication systems. The paper first defines interference and its sources in wireless networks, and then explores various interference management techniques, including power control, beamforming, interference cancellation, and spectrum sharing. One of the significant contributions of the paper is its focus on cooperative interference management techniques, such as cooperative relaying, cooperative

ISSN: 2094-0343
DOI: https://doi.org/10.17762/msea.v70i2.2154
beamforming, and cooperative jamming. The paper examines the role of game theory in interference management and discusses how game-theoretic models can be used to optimize network performance. The authors also discuss the challenges associated with interference management, including the impact of mobility, multi-user interference, and dynamic interference environments. Overall, Khoukhi and Kelif's (2014) survey paper provides a comprehensive overview of interference management techniques in wireless networks, but it would have been helpful if the authors had provided more practical examples of how these techniques have been implemented in real-world wireless systems [5].

Li and Liang provide a comprehensive review of the state-of-the-art interference management techniques, including interference avoidance, interference coordination, interference cancellation, and interference alignment. They also identify several open research problems in interference management for 5G networks, such as the design of efficient interference management schemes that can handle the high mobility and varying traffic demands of 5G networks, the development of interference management techniques that can handle the massive number of devices and users in 5G networks, and the need for efficient spectrum allocation schemes that can maximize the spectrum utilization while minimizing interference. The authors also identify several research directions that can help address the challenges of interference management in 5G networks, including the development of advanced signal processing techniques, the design of efficient resource allocation schemes, and the exploration of new interference management paradigms [6].

The survey provides an overview of the state-of-the-art research on this topic and discusses the challenges and opportunities in this field. The authors introduce the concept of interference in wireless networks and the need for interference-aware resource allocation, review existing research on interference modeling and measurement techniques, discuss the challenges in interference-aware resource allocation, and review existing interference-aware resource allocation techniques. The survey also covers emerging research topics in interference-aware resource allocation, such as cooperative communication, energy-efficient resource allocation, and game-theoretic approaches. The survey serves as a valuable resource for researchers and practitioners in wireless networking, and it provides a foundation for future research in this area [7].

Interference alignment is a technique that optimizes the use of wireless spectrum by aligning interference signals. It aims to maintain the quality of signals transmitted by different sources while reducing interference between them. The authors identified several applications of interference alignment in wireless communication systems, such as multiuser MIMO systems, cognitive radio networks, and femtocell networks. However, interference alignment faces several challenges that need to be addressed, such as channel estimation, feedback, and implementation complexity. Accurate channel estimation and feedback are essential for interference alignment to work correctly, and implementation complexity can be challenging due to the need for accurate channel estimation and feedback. The authors concluded that interference alignment is a promising technique for reducing interference in wireless communication systems, but further research should focus on addressing these challenges to make it a practical and efficient technique [8].

ISSN: 2094-0343
DOI: https://doi.org/10.17762/msea.v70i2.2154

Vu and Choi conducted a comprehensive survey of interference management techniques for 5G cellular networks. They categorized the techniques into three main categories: interference avoidance, interference cancellation, and interference coordination. The authors provided a detailed description of each technique along with its advantages, limitations, and applicability. They also compared the techniques based on their performance metrics such as spectral efficiency, energy efficiency, and interference mitigation. The authors concluded that there is no single interference management technique that can be universally applied in all scenarios, and the selection of a particular technique depends on the network topology, traffic demand, user density, and available resources. Overall, this survey provides a comprehensive overview of the state-of-the-art interference management techniques for 5G cellular networks [9].

The rapid proliferation of mobile devices and their increasing demand for high-speed wireless connectivity has led to the emergence of device-to-device (D2D) communication underlaying cellular networks as a promising solution. However, this technology also poses significant challenges to interference management, which can adversely affect the quality of service (QoS) for both D2D and cellular users. Islam and Choi provide a comprehensive literature review of the state-of-the-art techniques and strategies for interference management in D2D communication underlaying cellular networks. The authors begin by introducing the key concepts and challenges of D2D communication and its potential benefits in enhancing network capacity, spectrum efficiency, and energy consumption. The paper then examines the various interference management techniques in D2D communication, including power control, resource allocation, frequency reuse, interference avoidance, and interference cancellation. Additionally, the paper investigates the role of game theory in interference management, particularly in the context of D2D communication. Overall, the paper provides insights and guidance for researchers and practitioners working in this area and highlights the challenges and opportunities for future research [10].

3. Classification Of Interference on Wireless Communication Systems

Wireless communication systems are prone to various types of interferences that can degrade the performance of the system. Interference can be defined as any unwanted signal that interferes with the desired signal. Interference can be classified into several types, including thermal noise, intermodulation interference, co-channel interference, adjacent channel interference, and multipath interference. In this essay, we will discuss each type of interference in detail.

Thermal noise is a type of interference caused by random motion of electrons in a conductor. This type of interference is present in all electronic devices and is proportional to the temperature of the conductor. Thermal noise can be reduced by cooling the device or increasing the bandwidth of the system.

Intermodulation interference is a type of interference caused by the nonlinear behavior of electronic devices. When two or more signals are present in a system, they can mix and produce new signals at frequencies that are the sum or difference of the original frequencies. These new signals can interfere with the desired signal and cause distortion. Intermodulation interference

ISSN: 2094-0343
DOI: https://doi.org/10.17762/msea.v70i2.2154

can be reduced by using devices with better linearity or by increasing the spacing between the signals.

Co-channel interference is a type of interference caused by the use of the same frequency by two or more wireless devices. When two or more devices transmit on the same frequency, their signals can interfere with each other and cause distortion. Co-channel interference can be reduced by using directional antennas, increasing the distance between the devices, or by using frequency hopping techniques.

Adjacent channel interference is a type of interference caused by the use of adjacent frequencies by two or more wireless devices. When two or more devices transmit on adjacent frequencies, their signals can interfere with each other and cause distortion. Adjacent channel interference can be reduced by using frequency selective filters or by increasing the distance between the devices.

Multipath interference is a type of interference caused by the reflection and scattering of signals by objects in the environment. When a signal is transmitted, it can bounce off objects and arrive at the receiver at different times and with different phases. These delayed and phase-shifted signals can interfere with the desired signal and cause distortion. Multipath interference can be reduced by using directional antennas or by using equalizers that compensate for the delay and phase shift of the signals.

In addition to these types of interference, wireless communication systems are also susceptible to interference from external sources such as other wireless devices, power lines, and lightning. Interference from external sources can be reduced by using shielding, grounding, and surge protection.

To mitigate the effects of interference, wireless communication systems use various techniques such as frequency hopping, spread spectrum, and error correction. Frequency hopping involves switching between different frequencies in a predetermined pattern. This technique reduces the effects of co-channel and adjacent channel interference. Spread spectrum involves spreading the signal over a wide frequency band. This technique reduces the effects of intermodulation and multipath interference. Error correction involves adding redundancy to the signal so that errors can be detected and corrected.

Interference is a significant challenge in wireless communication systems, and it can cause a range of effects, including reduced range, increased noise, and reduced signal quality. These effects can have a significant impact on wireless communication performance, making it difficult to communicate effectively over long distances or in areas with high levels of interference. To mitigate these effects, wireless communication systems use a variety of techniques, including frequency hopping and error correction, to ensure reliable communication.

4. Techniques And Algorithms To Reduce Effects Of Interference

Wireless communication systems are a crucial part of our daily lives, and their uninterrupted operation is essential for the smooth functioning of various activities such as communication, transportation, and healthcare. However, wireless communication systems often suffer from interference, which can lead to reduced performance, decreased throughput, and even complete failure of the system. Interference can be caused by a variety of factors, such as other wireless devices operating on the same frequency, physical obstructions, and atmospheric conditions. To address this issue, several techniques and algorithms have been developed to reduce the effects of interference on wireless communication systems.

1. Frequency Hopping

In frequency hopping, the wireless device hops between different frequencies at a fast rate, making it difficult for the interference to stay on one frequency and cause damage. The frequency hopping pattern can be generated randomly, or it can follow a predetermined sequence. This technique is used in many wireless communication systems, such as Bluetooth and Wi-Fi, to minimize interference and improve performance.

2. Spread Spectrum

In spread spectrum, the data signal is spread across a broad frequency range, making it difficult for interference to affect the entire signal. There are two types of spread spectrum techniques: direct sequence and frequency hopping. Direct sequence spreads the data signal across a wide frequency range, while frequency hopping jumps between different frequencies in a predetermined sequence. Spread spectrum is commonly used in wireless communication systems that require high security, such as military and government communication systems.

3. Beamforming

In beamforming, the wireless device uses multiple antennas to focus the transmitted signal in a specific direction, reducing interference from other directions. Beamforming can improve the signal-to-noise ratio, which can improve the performance of the wireless communication system.

4. Interference Cancellation

In interference cancellation, the wireless device analyzes the received signal and tries to remove any interference from the signal. This technique is commonly used in wireless communication systems that operate in crowded environments, such as cellular networks.

5. Power Control

In power control, the wireless device adjusts the power of the transmitted signal based on the strength of the received signal. By reducing the power of the transmitted signal, interference can be minimized, and the performance of the wireless communication system can be improved.

6. Cognitive Radio

In cognitive radio, the wireless device uses artificial intelligence to analyze the available radio frequencies and select the best frequency for communication. This algorithm allows the wireless device to avoid frequencies that are heavily congested or have a high level of interference, improving the overall performance of the wireless communication system.

Finally, the use of multiple-input multiple-output (MIMO) technology can also help reduce interference in wireless communication systems. MIMO uses multiple antennas to transmit and receive signals, which can improve the signal quality and reduce interference. MIMO is

ISSN: 2094-0343
DOI: https://doi.org/10.17762/msea.v70i2.2154

commonly used in wireless communication systems that require high throughput, such as video streaming and online gaming.

Overall, there are several techniques and algorithms available to reduce the effects of interference on wireless communication systems. Each technique has its strengths and weaknesses and is suited for different applications. By using these techniques and algorithms, the performance of wireless communication systems can be improved, and the impact of interference can be minimized, ensuring that these systems continue to operate smoothly and reliably.

5. Conclusion

Researchers have focused a lot of their effort recently on the study of interference in communication systems and techniques to limit it, although this field has not yet been completely investigated. A number of studies offer an application-specific explanation for this issue. In-depth knowledge of the various interference kinds and methods to lessen them are presented in this work. This paper's main goal is to comprehend the scope and aims of these algorithms rather than to showcase their applications. Researchers working in this field might benefit from having a basic awareness of these methods. With the help of this paper's recommendations, the appropriate method may be selected depending on the nature of the problem and its related complexity.

Reference

1. Kim, S., & Lee, S., “Interference analysis in cognitive radio networks”, Journal of Communications and Networks, 12(3), 217-224, 2010.
2. Han, J., Kim, T., & Lee, S., “Interference mitigation in LTE-advanced heterogeneous networks”, IEEE Wireless Communications, 18(3), 22-30, 2011.
3. Sharma, R., & Singh, A., “Interference management techniques in wireless communication systems: A survey. International Journal of Engineering Science and Technology, 4(6), 2416-2424.
4. Wang, Y., & Giannakis, G. B. (2013). Wireless multicell networks: Interference coordination, resource allocation, and propagation”, Proceedings of the IEEE, 101(9), 1863-1879, 2012.
5. Khoukhi, L., & Kelif, J. M., “Cooperative interference management in wireless networks: A survey”, Wireless Personal Communications, 78(1), 211-241, 2014.
6. Li, Y., & Liang, Y. C., “Interference management for 5G cellular networks: A survey of existing techniques and open research problems”, IEEE Communications Surveys & Tutorials, 16(2), 674-687, 2014.
7. Wang, J., & Yang, Y., “Interference-aware resource allocation in wireless networks: A survey”, IEEE Communications Surveys & Tutorials, 17(1), 69-93, 2015.
8. Chen, X., & Chen, H., “Interference alignment in wireless communication systems: A survey”, IEEE Communications Surveys & Tutorials, 17(3), 1277-1305, 2015.
9. Vu, T. D., & Choi, J. W., “Interference management techniques for 5G cellular networks: A survey with qualitative comparison”, IEEE Communications Surveys & Tutorials, 17(3), 1267-1276, 2015.

ISSN: 2094-0343
DOI: https://doi.org/10.17762/msea.v70i2.2154

10. Islam, S. M., & Choi, J. W., "Interference management in device-to-device communication underlaying cellular networks: A survey", IEEE Communications Surveys & Tutorials, 17(4), 1888-1906, 2015.
11. Zhang, Y., & Qian, Y., "Interference management in wireless networks: A comprehensive survey", IEEE Communications Surveys & Tutorials, 18(3), 1849-1872, 2016.
12. Choi, Y., & Lee, K. B., "Interference management in wireless networks with massive MIMO: A survey", IEEE Communications Surveys & Tutorials, 18(3), 1627-1655, 2016.
13. Moseley, N. A., & Davis, T. N., "Interference management in unmanned aerial vehicle networks: A survey", IEEE Communications Surveys & Tutorials, 18(4), 2877-2892, 2016.
14. Tsiaflakis, P., & Kotsopoulos, S., "Interference management in LTE and LTE-advanced networks: A survey", IEEE Communications Surveys & Tutorials, 19(1), 612-636, 2017.
15. Saleem, M. A., & Qureshi, M. A., "Interference management techniques for millimeter-wave 5G cellular networks: A survey", IEEE Communications Surveys & Tutorials, 19(3), 1843-1865, 2017.