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Title: Comparing Multiplexing Techniques for Area Coverage

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Abstract

This literature review aims to analyze and compare the performance of Frequency Division Multiplexing (FDM), Time Division Multiplexing (TDM), and Code Division Multiple Access (CDMA) in terms of maintaining acceptable signal strength and system performance across a defined coverage area. It discusses the strengths and weaknesses of each technique regarding area coverage. And also this paper publicizes the reader with the concept of path loss models in wireless communication.

Contents

1. Introduction

To increase performance and coverage area of wireless communication it is of utmost importance to use available signal resource efficiently. The three primary multiplexing techniques - Frequency Division Multiplexing (FDM), Time Division Multiplexing (TDM), and Code Division Multiple Access (CDMA) – play very important role in optimizing signal transmission and reception. Each Technique has its own advantages and disadvantages, particularly concerning signal strength and coverage area.

In FDM different carrier frequencies are assigned to different traffic channels (speech) which means one carrier frequency can only carry one single speech channel at one time. This method is widely used in radio and television broadcasting, as well as in early cellular networks. However, its performance can be limited by interference and the need for precise frequency management.

TDM, on the other hand, allocates the entire bandwidth to each user for a short time slot, sequentially cycling through users. This technique is commonly employed in digital telephony and certain networking protocols. While TDM efficiently utilizes the spectrum and reduces interference, it can be affected by timing synchronization issues and may not be suitable for high-speed data applications.

CDMA uses unique code to allow multiple users to share frequency band simultaneously. In order to provide robust performance in terms of capacity and resistance, the modern cellular system uses this method. Even though CDMA has many advancements and benefits, it is known by its complex processing and can suffer from code orthogonality issues.

This literature review aims to analyze and compare the performance of Frequency Division Multiplexing (FDM), Time Division Multiplexing (TDM), and Code Division Multiple Access (CDMA) in terms of maintaining acceptable signal strength and system performance across a defined coverage area. Additionally it discusses the strengths and weaknesses of each technique regarding area coverage. And also this paper publicizes the reader with the concept of path loss models in wireless communication.

2. <u>Review of Related Literature</u>

2.1 Frequency Division Multiplexing (FDM)

For this access to the medium, the bandwidth is divided among multiple users, corresponding to each of them only one or more subcarriers. OFDMA is the version of FDMA in which the subcarriers are orthogonal to each other and is an adaptation of the OFDM modulation technique for multiple access. Single carrier FDMA (SC-FDMA) is the pre-DFT encoded version of FDMA. Although FDMA techniques have the disadvantage of demanding frequency synchronization, ingenious implementations such as OFDMA and SC-FDMA have numerous benefits over TDMA or CDMA, such as multipath robustness or the elimination of costly time-domain equalization for channels with long temporal dispersions like wireless, replacing it with a much simpler frequency equalization. It can be highlighted that the ease of distribution of resources in frequency according to channel conditions, very useful in frequency selective channels such as wireless. For this reason, OFDMA and SC-FDMA are the techniques of choice for the physical layer of the radio interface of the new standard for mobile communications long-term evolution (LTE) for UMTS [1].

Frequency modulation (FM) was used in the first MA wireless communication networks to divide the available frequency spectrum for a given system into some frequency channels. Each channel is assigned to a single user and covers a portion of the total bandwidth utilization. In an FDMA system, the bandwidth per user is entirely determined by the data rate and modulation scheme used [2].

2.2 Time Division Multiplexing (TDM)

This multiple access method is based on the time-division multiplexing (TDM) scheme in which a time slot is allocated to each data stream. In the case of TDMA, each data stream corresponds to a user connected to the shared medium. In mobile communications, TDMA is used in almost all second generation (2G) schemes, highlighting global system for mobile communications (GSM) [1].

TDMA systems start in the digital communications period by subdividing the time axis into time slots designated to a single user for data transmission. The TDMA scheme's operational principles are frame and multi-frame, which means that a user can send a large data file within time slots of periodic frames [2].

TDMA is a well-understood access technology, which has been successfully used in a number of wired and wire- less digital transmission systems. This has no doubt contributed to its adoption in second-generation digital cellular and PCS systems [5].

2.3 Code Division Multiplexing (CDM)

In CDMA, all users can transmit concurrently and in an identical frequency band. It is attained by allocating each user a code that differentiates them from the rest. The most common CDMA model is direct sequence spread spectrum CDMA (DS-CDMA). The code assigned to each user is a pseudorandom number (PN) sequence that multiplies the signal corresponding to a symbol and user. The sequence breaks into chips whose duration is much less than the symbol time. The result is a signal with a noisy appearance and an expanded spectrum [1].
CDMA schemes based on spread spectrum schemes are launched in 3G. Using a high clock chip rate, the comparatively narrowband user's information is spread across a much broader spectrum in CDMA. [2].

2.4 Path Loss Models

Path loss, or path attenuation, is the reduction in power density attenuation of an electromagnetic wave as it propagates through space [3].

Propagation factors for instance reflection, scattering, diffraction, absorption, and atmospheric particles affect the signal of wireless communication when transmitted through a path. The main benefit for the use of the standard path loss models is time-saving and cost, despite the limited accuracy. The following are examples of the path loss propagation - Free Space Path Loss Model, Okumura Model, HATA Path Loss Model, dLHata Model (LHata), COST 231 Extended Hata Model , ECC-33 or Hata – Okumura Extended Model, Walfisch-Ikegami Model, Stanford University Interim (SUI) model, Ericson Mode [4].

3. Findings

This literature review examines the performance of Frequency Division Multiplexing (FDM), Time Division Multiplexing (TDM), and Code Division Multiple Access (CDMA) concerning their ability to maintain signal strength and system performance across defined coverage areas Each technique has its own advantages and disadvantages in elevating signal transmission and reception.

Different carrier frequencies are allocated to individual traffic channel in FDM but it faces challenges with interference and precise frequency management

The entire bandwidths sequentially allocated to users in TDM which leads to reduction of interference but encountering issues with timing synchronization and suitability for high-speed data.

In CDMA in order to differentiate each user it utilizes unique code which enhances efficient utilization of channel by supporting simultaneous transmission on shared frequency band, providing robust performance and resistance to interference but requiring complex processing and encountering challenges with code orthogonality.

This review also address path loss models which is very important for understanding and mitigating signal loss in wireless communication systems.

By comparing the strengths and weaknesses of each multiplexing technique and their impact on coverage, this review aims to provide insights for optimizing wireless communication systems. These findings summarize the core insights from our abstract and introduction, which focused on the comparative analysis of FDM, TDM, and CDMA and their implications for wireless communication systems.

4. Conclusion

In conclusion, in this literature review we have discussed and compared Frequency Division Multiplexing (FDM), Time Division Multiplexing (TDM), and Code Division Multiple Access (CDMA) with regard to their performance across coverage areas in wireless communication systems. FDM, which widely used and characterized by allocating different carrier frequencies to individual channels, but faces challenges with interference management. TDM, which allocates the whole bandwidths sequentially, offers efficient spectrum utilization but is susceptible to timing synchronization issues. CDMA, assigns unique codes for simultaneous transmission, provides robust performance but requires complex processing and can encounter challenges with code orthogonality.

The review also shed light on the importance of path loss models in reducing signal degradation, which are very important for increase area coverage and performance in wireless communication.

By exploring as well as examining the strengths and weaknesses of each multiplexing technique so far, this review contributes critical insights for the design and implementation of efficient wireless communication systems.

We strongly recommend that future research could go deeper into advanced modulation techniques within these multiplexing approaches or explore hybrid approaches that combine the strengths of FDM, TDM, and CDMA to further improve wireless communication capabilities. Such advancements will be critical in meeting the increasing demands for reliable and high-performance wireless networks in diverse operational environments.

References

[1] A. F. M. S. Shah, A. N. Qasim, M. A. Karabulut, H. Ilhan and M. B. Islam, "Survey and Performance Evaluation of Multiple Access Schemes for Next-Generation Wireless Communication Systems," in IEEE Access, vol. 9, pp. 113428-113442, 2021, doi: 10.1109/ACCESS.2021.3104509.

[2] T. Kebede, Y. Wondie, J. Steinbrunn, H. B. Kassa and K. T. Kornegay, "Multi-Carrier Waveforms and Multiple Access Strategies in Wireless Networks: Performance, Applications, and Challenges," in IEEE Access, vol. 10, pp. 21120-21140, 2022, doi: 10.1109/ACCESS.2022.3151360.

[3] Sari, Arif; Alzubi, Ahmed (2018-01-01), Ficco, Massimo; Palmieri, Francesco (eds.), "Chapter 13 - Path Loss Algorithms for Data Resilience in Wireless Body Area Networks for Healthcare Framework", *Security and Resilience in Intelligent Data-Centric Systems and Communication Networks*, Intelligent Data-Centric Systems, Academic Press, p. 303, ISBN 978-0-12-811373-8, retrieved 2023-06-03

[4] Haider Kadhim Hoomod et al 2018 J. Phys.: Conf. Ser. 1003 012028

[5] H. M. Hafezetal., "Fundamental Issuesin Millimeter Wavelndoor Wire-less Networks,"

Conference Record, Wireless'93 Conference,Calaarv.- .July 1993.