A Study on Realizing Start Frame Delimiter-Less Communication Using Reed-Solomon Codes

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***Abstract*—In communication systems, accurately identifying the transmitted data requires precise acquisition of the data reading position. The current packet extraction method, which uses a Start Frame Delimiter (SFD), suffers from poor noise resistance, leading to synchronization errors. To address this issue, this study proposes a novel packet extraction method that eliminates the use of SFD. By combining Reed-Solomon (RS) codes with a bit-shifting method, the proposed approach leverages the error-correcting capability of RS codes to identify packets even when bit reading positions are misaligned. Simulation results demonstrate that the proposed method achieves zero packet loss and effectively resolves the synchronization problem.**

Keywords-Frame synchronization; Start Frame Delimiter; Telecommunications; Reed-Solomon.

I. INTRODUCTION

Frame synchronization is particularly critical for packet transmission in cognitive radio networks [1]. The Start Frame Delimiter (SFD) is a key element in frame synchronization. Frame synchronization is achieved by the transmitter appending an SFD to the beginning of the transmitted data frame. The receiver detects the SFD to confirm the arrival of a packet and removes it from the data stream to reconstruct the transmitted message. Thus, the SFD plays a central role in frame synchronization. However, a significant issue arises due to noise superimposed on the SFD, leading to synchronization failures. This issue, known as "frame synchronization loss," becomes particularly problematic when the SFD is falsely detected, potentially causing delays in resynchronization. Frame synchronization loss directly impacts the overall reliability of communication systems, as has been previously demonstrated [2]. Therefore, solutions to further reduce its occurrence are critically needed. Optimizing the SFD design alone has proven insufficient to fully eliminate frame synchronization errors. Consequently, this study aims to address the root cause by proposing a communication algorithm that eliminates the dependency on the SFD altogether. The structure of this paper is as follows: Section II provides an overview of related works on SFD design using Barker codes. Section III explains the objectives and methodology of this research. Section IV presents the simulation settings, results, and discussions. Finally, Section V summarizes the findings and outlines future research directions.

II. RELATED WORK

Approaches to address the issue of frame synchronization loss have included simulation-based performance evaluations of recovery time [2] and methods involving changes to frame length [3]. However, the primary cause of frame synchronization loss lies in the Start Frame Delimiter (SFD), making its design a critical approach. One such approach involves using Barker codes for SFD design. Barker code sequences function as known reference signals for frame synchronization and are known for their excellent autocorrelation properties [4]. Cuji et al. [5] implemented a frame detection algorithm based on the autocorrelation properties of Barker sequences in a digital communication system, comparing simulation results with those obtained in real wireless link environments. These studies confirmed the effectiveness of Barker codes in SFD design and their contribution to improving synchronization accuracy. We further evaluated various SFD patterns (primarily Barker codes) under different noise conditions to examine their impact on synchronization errors. The results showed that shorter SFD patterns, such as "1110," were the most effective in minimizing synchronization errors while maintaining a high success rate. While successfully identified the optimal SFD, synchronization errors have not been entirely eliminated. Thus, further research is needed to explore alternative methods to reduce synchronization loss [6]. We propose a novel communication method that eliminates the use of the SFD, which is the root cause of synchronization errors. This approach aims to fundamentally resolve the limitations of traditional synchronization methods.

III. METHODOLOGY

This section outlines the objectives of this study and the methodologies employed. In this research, a method is proposed to extract only the bit sequences corresponding to packets from the entire received bit sequence. As shown in Figure 1, if the reading position of the bit sequence is misaligned, the interpretation of the data is entirely altered. Therefore, accurately determining the reading position is essential to identify the valid portions of the data. Since even a single-bit misalignment renders the bit sequence meaningless, precise identification of the packet position is indispensable. To achieve this, the proposed method employs coding techniques. Encoded data cannot be correctly decoded

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unless it is read from the correct position. Figure 1 illustrates an example where bit misalignment causes all information to change, emphasizing the importance of proper decoding at the correct position. In the proposed method, bit shifting is performed on the received bit sequence based on the fixed length of the code, and decoding is attempted. The position where decoding succeeds is identified as the packet and extracted accordingly. Reed-Solomon codes, with a parameter (t = (N-K) / 2), can correct up to t symbol errors, where tt is the maximum number of correctable symbol errors, N is the total number of symbols in a codeword, and K is the number of plaintext symbols. Leveraging this property, completely unrelated bit sequences can be discarded, as they inherently contain more errors than RS codes can correct. Conversely, valid bit sequences can be successfully decoded as long as they contain no more than (t) symbol errors. Furthermore, unrelated bit sequences inevitably result in decoding failures because they contain (t) or more symbol errors. This characteristic enables accurate packet extraction.

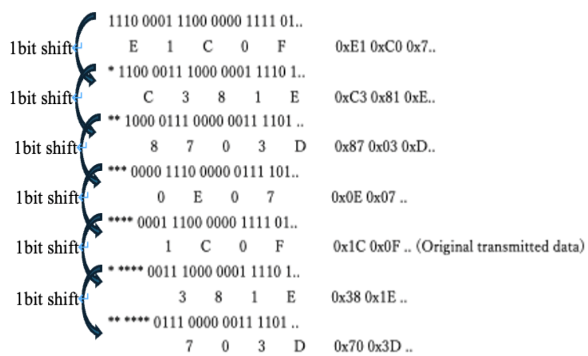

Fig. 1. Flowchart of the proposed method.

IV. Simulation

This section presents the simulation setup and results.

A Simulation setup

The outline of the simulation is as follows. The packet frame consists of a randomly generated data section, and the data section is protected by Forward Error Correction (FEC). Symbol length (n) and error correction capability (t) can be set arbitrarily. The transmission channel is modeled as an Additive White Gaussian Noise (AWGN) channel. The simulation involves sending 1000 packets, with each packet having a data section of 255 bytes. The idling period signal is always set to high, meaning the digital value 1.

B Result and Consideration

Figures 2 and 3 show the simulation results for varying code lengths of the Reed-Solomon (RS) code. It was revealed that both RS (128, 32) and RS (9, 3) achieve zero packet loss within the Bit Error Rate (BER) range that falls within the error-correction capability of the Reed-Solomon code. These results demonstrate the effectiveness of the proposed method. However, it was also observed that, on rare occasions, extra packets were erroneously extracted from incorrect positions.

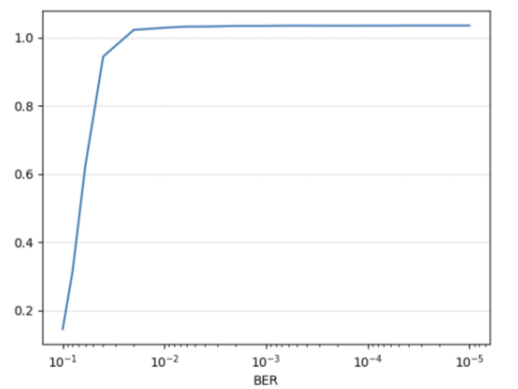

Fig. 2. Packet Extraction Rate RS (128, 32).

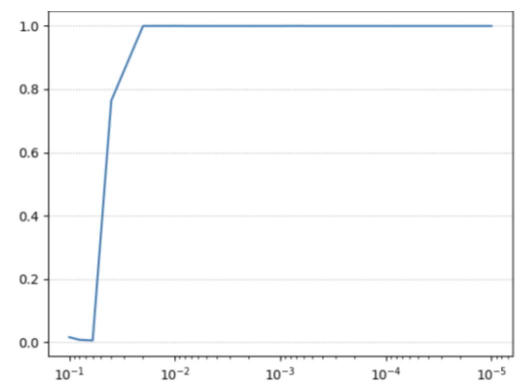

Fig. 3. Packet Extraction Rate RS (9, 3).

V. Conclusion and Future Work

This study proposes a novel synchronization method that does not rely on the Start Frame Delimiter (SFD) to address the issue of synchronization errors. While previous studies have identified optimal SFDs, the problem of frame synchronization errors has not been completely resolved. In this research, a packet extraction method independent of SFD is proposed by extracting decodable sections as packets. Simulation results demonstrate the feasibility of the proposed synchronization method. However, a remaining challenge is the need for measures to address the rare occurrence of erroneously extracted packets from incorrect positions.

References

[1] R. A. Scholtz, “Frame synchronization techniques,” IEEE Trans. Commun., vol. COM-28, no. 8, pp. 1204–1213, Aug. 1980.

[2] K. Makino, “Frame synchronization characteristics evaluation for code errors”, IEICE General Conference, 1996.

[3] W. Suwansantisuk, “Frame Synchronization for Variable-Length Packets”, IEEE Journal on Selected Areas in Communications, vol. 26, no. 1, January 2008.

[4] K.-U. Schmidt and J. Willms, “Barker sequences of odd length,” *[arXiv:1501.06035v1]*, January, 2015.

[5] D. D. A. Cuji, P. A. Chasi, F. Guerrero, and F. Rivera, “Frame synchronization through barker codes using SDRs in a real wireless link”, 2016 International Conference on Electronics, Communications and Computers, 2016.

[6] D. Maeda and M. Naoki, “Reducing Frame Synchronization Loss through Optimized Start Frame Delimiter”, WIRELESS ANALYTICS 2024.

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