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(RESEARCH ARTICLE)

Technical and Strategic Analysis of Error Correction (FEC) and Its Influence on the Performance of Digital Terrestrial Television Systems DVB-T/SD and DVB-T2/SD/HD

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Abstract

Digital terrestrial television relies on advanced transmission mechanisms to ensure reliable broadcasting of audiovisual content over radio channels subject to noise and interference. Among these mechanisms, Forward Error Correction (FEC) plays a central role in improving the robustness and performance of broadcasting systems. This article provides a technical and strategic analysis of FEC in the DVB-T and DVB-T2 standards, highlighting its impact on performance in terms of bit error rate, robustness, and spectral efficiency. A simplified model of OFDM/COFDM transmission is presented to formalize the influence of channel coding schemes. Results show that the evolution towards LDPC and BCH codes integrated into DVB-T2 constitutes a decisive lever for the broadcasting of SD and HD services at a high quality level.

Keywords: Digital terrestrial television; DVB-T; DVB-T2; FEC; OFDM; BER; LDPC; BCH.

1. Introduction

The transition from analog to digital terrestrial television has profoundly transformed audiovisual broadcasting architectures. This evolution aims to improve service quality, optimize the use of the radio spectrum, and increase the robustness of transmissions against disturbances in the radio channel. The standards developed by the DVB consortium have played a key role in this transformation.

In this context, Forward Error Correction (FEC) is a fundamental element of DVB-T and DVB-T2 systems. By introducing controlled redundancy into the transmitted stream, FEC enables the receiver to detect and correct errors without requiring retransmission, which is essential in unidirectional broadcasting systems.

The objective of this article is to comparatively analyze the FEC mechanisms integrated into DVB-T and DVB-T2 and to evaluate their impact on the overall performance of digital terrestrial television systems.

2. State of the Art and Principles of DTT

2.1. State of the Art

Digital terrestrial television systems rely on open standards defined by the DVB consortium, mainly DVB-T and its evolution DVB-T2 [2, 3].

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- DVB-T: Introduced in the 1990s, the DVB-T standard uses COFDM (Coded Orthogonal Frequency Division Multiplexing) modulation, which ensures good resistance to interference and multipath phenomena. It combines external convolutional coding with internal Reed–Solomon coding for error protection.
- DVB-T2: Representing a significant advancement, DVB-T2 improves spectral capacity and robustness. It relies on more modern error correction techniques, notably LDPC (Low-Density Parity Check) codes associated with BCH (Bose–Chaudhuri–Hocquenghem) codes, offering more effective error correction while controlling latency, which is essential for HD broadcasting.

2.2. Principles of DTT

DVB-T and DVB-T2 systems are based on an integrated digital transmission chain comprising source coding, channel coding with error correction, and multi-carrier OFDM modulation. This architecture aims to ensure reliable transmission of audiovisual content in complex propagation environments, as shown in Figure 1.

In DVB-T, the transmission chain is mainly designed for broadcasting standard-definition programs, while DVB-T2 introduces significant improvements enabling the broadcasting of content in both standard definition (SD) and high definition (HD). These improvements mainly concern source coding, error correction, and the optimization of OFDM modulation.

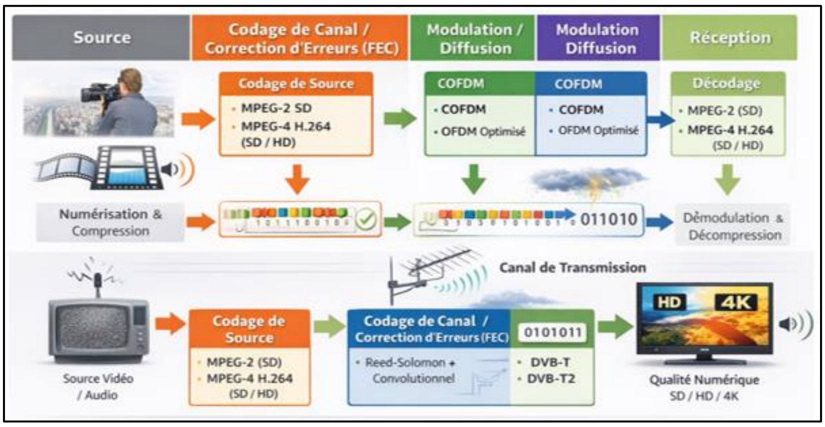

Figure 1 Transmission chain for digital terrestrial television (DVB-T/DVB-T2) [2]

3. Technical Analysis of FEC Mechanisms and Evolution in DVB-T2: BCH and LDPC Codes

3.1. Technical Analysis of FEC Mechanisms

Forward Error Correction (FEC) enables the detection and correction of errors induced by the channel without requiring retransmission. Solutions are deployed across several layers [1]:

- Convolutional Coding (DVB-T): This coding adds redundancy to binary streams, allowing the decoder to reconstruct data despite occasional errors. The coding rate (1/2, 2/3, 3/4, etc.) is chosen to adjust the trade-off between robustness and useful throughput.
- Reed–Solomon (DVB-T): As a block code, Reed–Solomon effectively protects against burst errors by repairing entire sequences of corrupted symbols. Its association with convolutional coding covers different error profiles.
- LDPC + BCH (DVB-T2): LDPC codes, due to their low parity density, approach theoretical performance limits (Shannon limit). Coupled with BCH codes for residual error control, they provide much stronger correction, particularly useful under low signal-to-noise ratio conditions.
- Impact on Complexity and Latency: LDPC decoding requires heavier computational effort, necessitating hardware optimizations. Nevertheless, thanks to efficient algorithms such as belief propagation, latency remains compatible with real-time broadcasting constraints.

The DVB-T standard uses a hierarchical error correction architecture combining Reed–Solomon codes, convolutional codes, and temporal/frequency interleaving techniques. This combination aims to protect the binary stream against burst errors and random errors introduced by the transmission channel.

Figure 2 shows the architecture of error correction (FEC) in a DVB-T system.

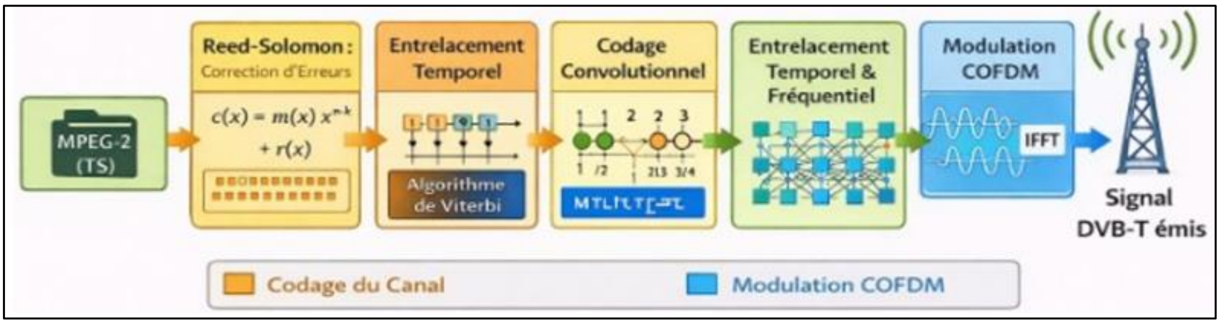

Figure 2 Error correction (FEC) architecture in a DVB-T system [2]

3.2. Evolution of FEC in DVB-T2: BCH and LDPC Codes

The DVB-T2 standard introduces a major evolution in channel coding by replacing the Reed–Solomon/convolutional association with a BCH/LDPC structure. This architecture achieves error correction performance close to the theoretical Shannon limits [4].

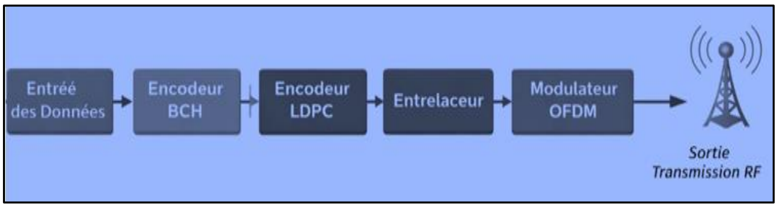

Figure 3 Error correction (FEC) architecture in a DVB-T2 system [4]

The LDPC code provides the majority of error correction through iterative decoding that exploits reliability information, while the BCH code corrects residual errors. This complementarity leads to a significant improvement in bit error rate and overall system robustness [6].

Figure 4 illustrates the complete architecture of an R1 multiplex deployment in digital terrestrial television, from program collection and encoding to DVB-T terrestrial broadcasting. It highlights the different stages of the transmission chain, including multiplexing, encryption, FEC error correction, OFDM modulation, and broadcasting via transmitter sites. The entire process ensures effective territorial coverage while guaranteeing robustness and quality of service in digital broadcasting.

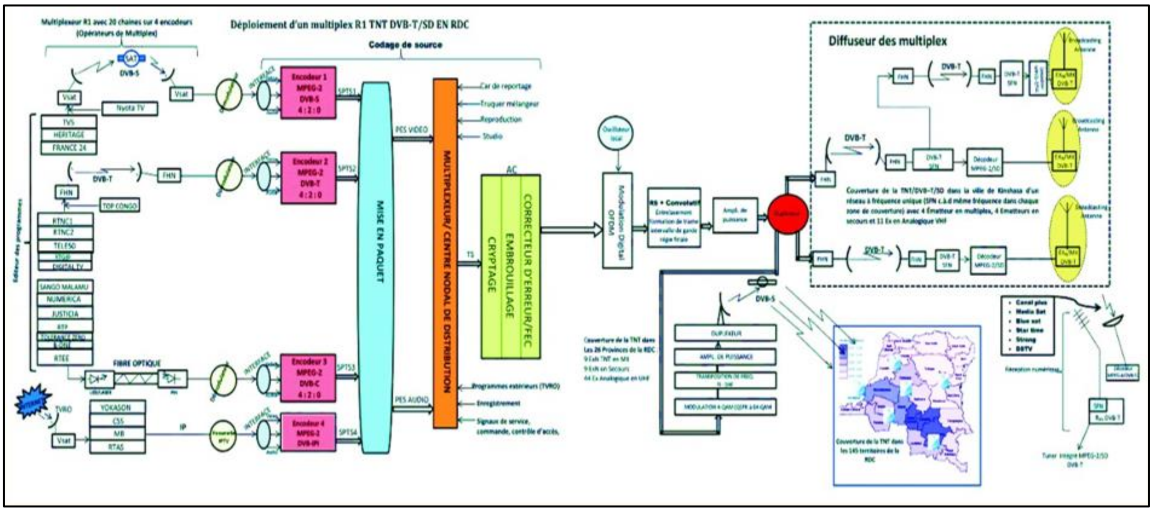

Figure 4 Deployment of an R1 DTT multiplex DVB-T/SD in the Democratic Republic of Congo

4. OFDM/COFDM Modeling and Impact on BER

Transmission in DVB-T and DVB-T2 systems relies on OFDM modulation, which distributes information across a large number of orthogonal subcarriers. This technique effectively combats multipath fading and inter-symbol interference [5].

The influence of error correction on the Bit Error Rate (BER) as a function of the Signal-to-Noise Ratio (SNR) in DVB systems is shown in Figure 5.

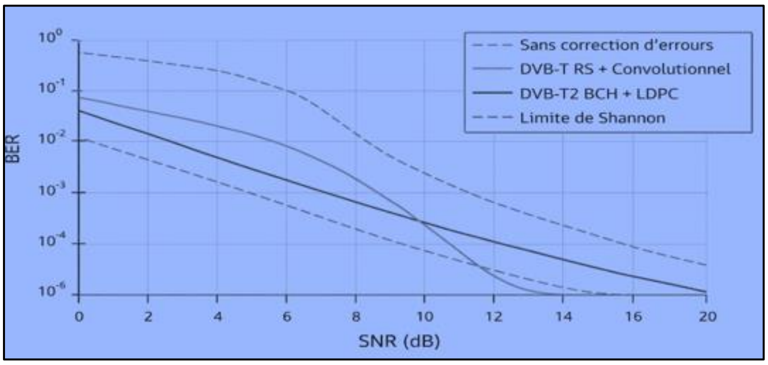

Figure 5 Influence of error correction on BER as a function of SNR in DVB systems

The BER is a fundamental performance indicator. It is defined as the ratio between the number of erroneous bits received and the total number of bits transmitted. The introduction of FEC significantly reduces the BER for a given SNR, representing a coding gain.

Comparative analysis in Figure 6 shows that, under identical propagation conditions, the advanced coding schemes of DVB-T2 provide a higher coding gain than DVB-T, enabling the use of higher-order modulations (e.g., 256-QAM) while maintaining satisfactory service quality.

The DVB-T2 standard, whose overall architecture is illustrated in Figure 6, represents a major evolution of DVB-T. It was designed to meet increased requirements in terms of throughput, service quality, and robustness, particularly for broadcasting SD and HD content.

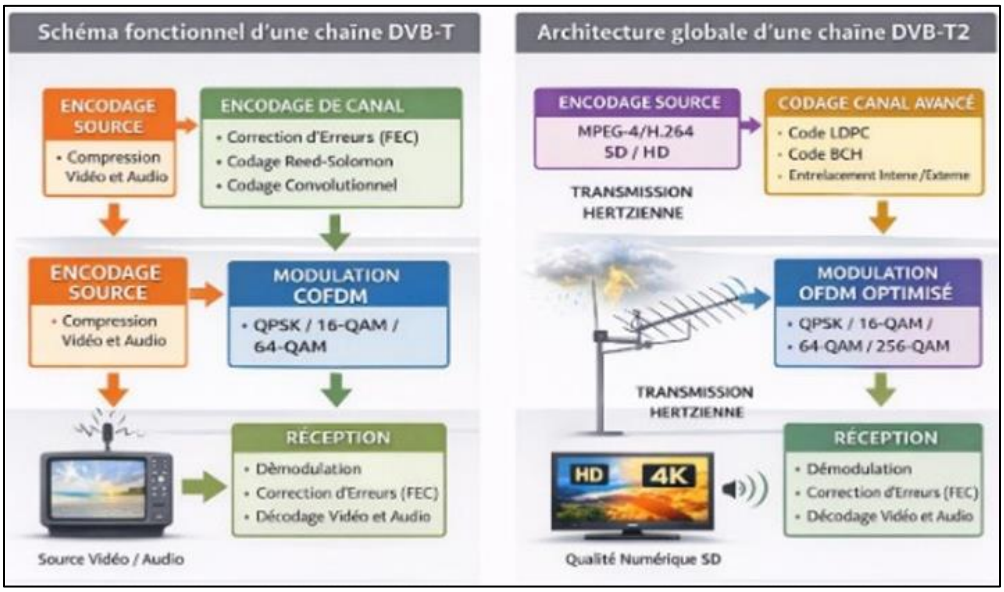

Figure 6 Influence of error correction on BER as a function of SNR in DVB systems [2]

5. Performance Study and Results

Table 1 The comparison between DVB-T and DVB-T2 highlights several key points (Table 1)

Aspect	**Observation**
Error rate as a function of SNR	With LDPC/BCH, DVB-T2 significantly reduces the BER for lower signal-to-noise ratios, improving reception quality in both urban and challenging rural areas.
Useful throughput and spectral efficiency	More efficient error correction allows the use of denser modulations (e.g., 256-QAM), increasing transmission capacity while maintaining acceptable robustness.
Image quality in SD and HD	Advanced FEC mechanisms improve service continuity and reduce transmission-related artifacts, a crucial aspect for HD, where even minor failures are visible to the user.
Resilience to interference and multipath echoes	The combination of COFDM and advanced FEC codes strengthens reception in environments subject to significant reflections or disturbances, ensuring better coverage.

6. Strategic Analysis and Recommendations

The recommended strategy is based on the progressive adoption of DVB-T2 to meet growing capacity and quality demands:

- Progressive migration: Encourage controlled coexistence of both standards, facilitating transition through hybrid equipment capable of decoding both types of FEC.
- Investment in reception infrastructure: Upgrade decoders, set-top boxes, and televisions to integrate LDPC/BCH decoding, ensuring long-term reception quality.
- Optimization of FEC parameters: Dynamically adjust coding rates and modulation schemes according to channel conditions to optimize the trade-off between throughput and reliability.
- Leverage evolution towards HD and UHD: Strengthening FEC is essential to support high-resolution streams without interruption or perceptible degradation.
- Awareness and training: Train operators and installers to ensure proper implementation of the more complex systems associated with DVB-T2.

7. Conclusion

This study highlights the central role of error correction in the performance of digital terrestrial television systems. Comparative analysis of the DVB-T and DVB-T2 standards shows that the evolution towards advanced channel coding schemes, such as LDPC and BCH, is a decisive factor in improving robustness, spectral efficiency, and service quality. Error correction thus appears not only as a key technical mechanism but also as a strategic lever for the sustainability and evolution of digital audiovisual broadcasting systems.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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