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A Model-Based Analytic Approach for Evaluating End-to-End Error Correction with Interleaving in IP Networks

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Abstract: This paper outlines a model-based analytic approach designed to evaluate the effectiveness of End-to-End Error Correction (EEEC) coding combined with interleaving in mitigating packet losses within IP networks. It introduces a recursive procedure for precisely assessing packet-loss statistics and integrates a discrete-time Markov chain (DTMC) to account for interleaving effects. The framework supports both single-session and complex multiple-session scenarios, offering a unified approach to explore tradeoffs between key coding parameters like interleaving depths, channel coding rates, and block lengths. The aim is to facilitate optimal coding strategy selection for diverse multimedia application with varying Quality of Service(Qos) requirements.

I. INTRODUCTION

Packet transport in modern packet-switched networks, including IP networks, is inherently unreliable due to factors like network congestion, buffer overflows, and link errors, leading to packet loss. For multimedia and real-time applications, such unreliability significantly degrades user experience.

While traditional retransmission-based error recovery methods exist, they often introduce unacceptable delays or are impractical in certain high-latency environments. This necessitates robust forward error correction mechanisms to ensure data reliability without incurring retransmission overhead.

A. The Problem of Packet Loss and the Role of EEEC

Packet loss occurs when data packets fail to reach their destination, diminishing network reliability. End-to-End Error Correction (EEEC) offers a solution by embedding redundant information (check bits) into the data before transmission. This redundancy allows the receiver to detect and often correct lost or corrupted packets without requesting retransmissions from the sender. While beneficial for data recovery, excessive redundancy can paradoxically increase network load, potentially exacerbating packet loss from the network's perspective. Balancing this "double-edged sword" effect is crucial.

B. Interleaving for Burst Error Mitigation

Interleaving is a technique employed in conjunction with EEEC to improve resilience against "burst errors," where multiple consecutive bits or packets are lost. Instead of sending data bits sequentially, an interleaver shuffles bits from different data blocks. This spreads out a burst error across multiple blocks, transforming what would be a catastrophic loss in one block into a few scattered errors across several blocks, making them much more manageable for the EEEC decoder. For example, if data "aaaabbbbcccc" suffers a burst error and becomes "aa**bbcccc," without interleaving, 'a' and 'b' are lost. With interleaving, where data is ordered as "abcabcabcabc," a similar burst error would result in "ab**cabcabc," meaning the error is distributed and more easily corrected.

EEEC typically employs two main types of coding:

- Block Coding: Operates on fixed-size blocks of data (e.g., Reed-Solomon codes).
- Convolutional Coding: Works on continuous data streams.

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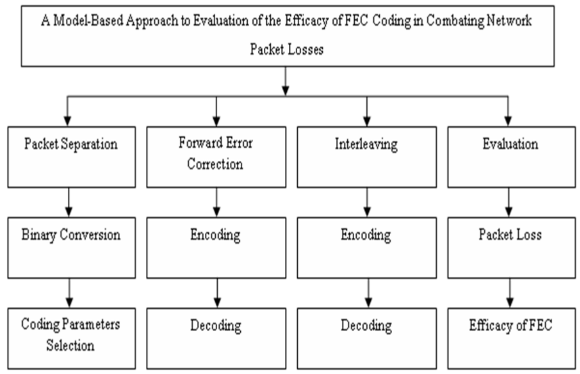


System Architecture Design

C. Proposed Model-Based Analytic System

The document proposes a system that utilizes a model-based analytic approach to evaluate the efficacy of EEEC and interleaving. This approach aims to provide a comprehensive framework for understanding the trade-offs between various coding parameters.

The system comprises several key modules:

- EEEC Encoder: This module takes the input text, converts it to a binary format, and applies the chosen EEEC coding scheme by adding redundant check bits. It also incorporates user interface design using Java Swing.
- Interleaver: It rearranges the bits within data packets according to a predefined interleaving pattern. This transformation helps convert burst errors, which are common in real-world networks, into more randomly distributed errors that EEEC decoders can more effectively correct.
- Queue: This module simulates the network environment. It receives the interleaved data and introduces packet loss by randomly deleting packets, mimicking real network conditions before forwarding the remaining packets to the destination.
- De-Interleaver: At the receiving end, the de-interleaver reverses the interleaving process, restoring the data packets to their original sequence.
- EEEC Decoder: This module processes the de-interleaved packets. Utilizing the redundant information added by the encoder, it attempts to detect and correct any errors or recover lost packets, ultimately restoring the original data. The recovered data is then written to a text file.
- Performance Evaluation: This critical module calculates the overall performance of the EEEC system. It assesses the effectiveness of packet recovery under different coding parameters and network conditions.

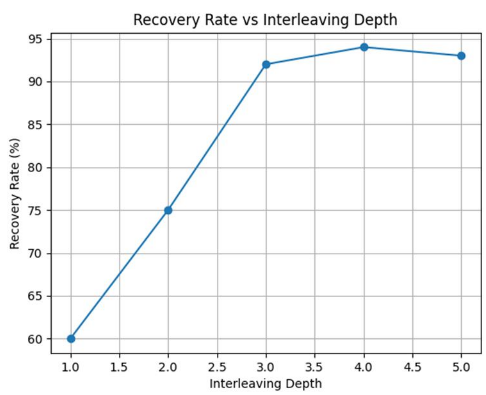
The approach simplifies the more complex multiple-session scenario through a dedicated algorithm and provides a unified framework for exploring the interdependencies between interleaving depths, channel coding rates, and block lengths.

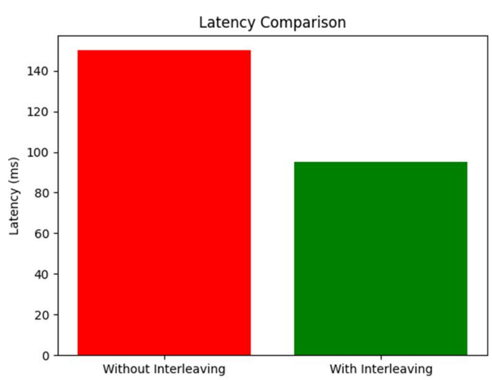
II. ADVANTAGES AND APPLICATIONS

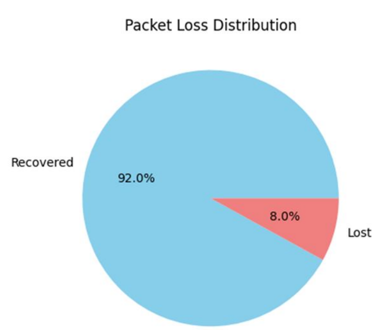
The proposed EEEC coding system, particularly when combined with interleaving, offers significant advantages:

1) High Data Reliability: It enables achieving high data reliability even in noisy or lossy communication channels.
2) Improved Error Control: It provides a robust method for error control and can significantly enhance performance in situations where retransmission methods are impractical or costly (e.g., satellite communications due to high latency).
3) Avoidance of Retransmissions: By correcting errors at the receiver, it eliminates the need for retransmissions, reducing end-to-end delay and network overhead.

These benefits make such systems highly applicable in various domains, including ATM networks for data transmission and digital communication systems (especially those used in military applications) where accurate and reliable data delivery despite interference is paramount







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III. EVALUATION & RESULTS

A. Source

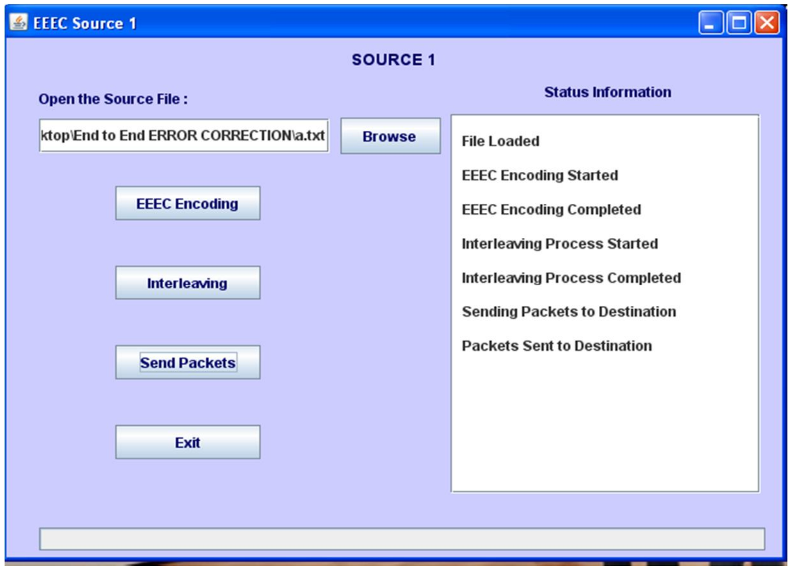

Fig1: Source GUI.

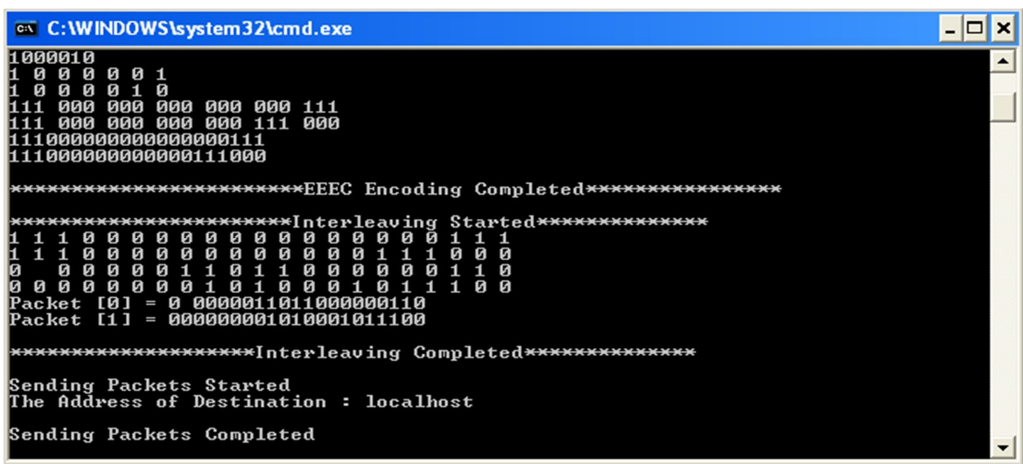

Fig2: Encoding and Interleaving.

B. Queue

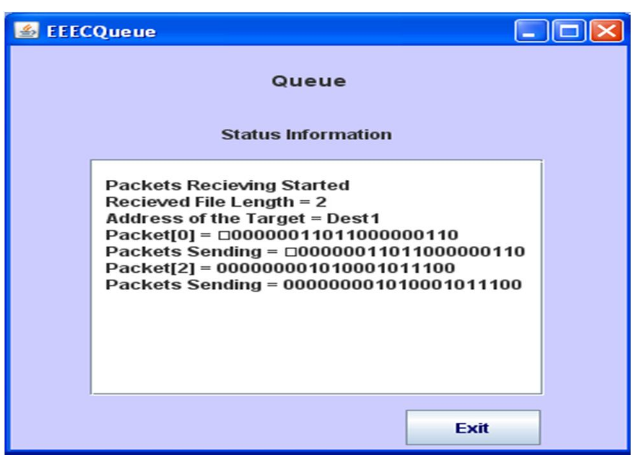

Fig3: Queue GUI.

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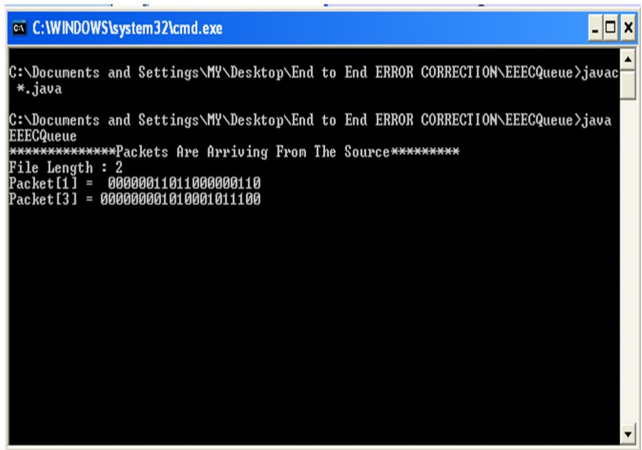

Fig4: Packets at the Queue

C. Destination

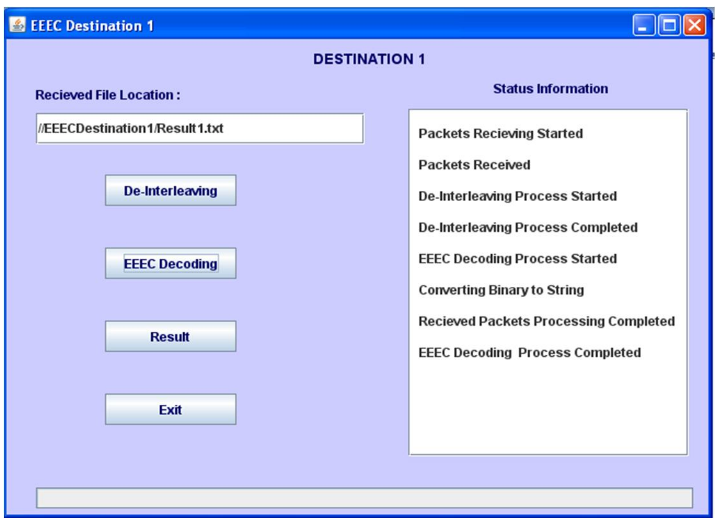

Fig5: Destination GUI.

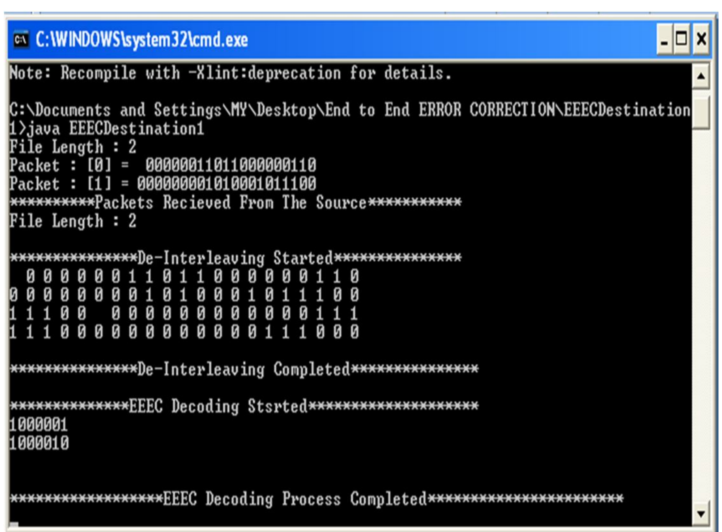

Fig6: De-interleaving and Decoding.

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D. Output

Fig7: Result GUI.

IV. CONCLUSION

The model-based analytic approach presented provides a valuable framework for understanding and evaluating the efficacy of EEEC coding combined with interleaving in combating packet losses in IP networks. By offering insights into the interplay of key coding parameters and supporting different session scenarios, this work contributes to the design of more robust and reliable communication systems for multimedia and other critical applications. The ability to adapt coding strategies to dynamic network conditions remains a key area for future development.

REFERENCES

[1] A Model-Based Approach to Evaluation of the Efficacy of EEEC Coding in Combating Network Packet Losses IEEE/ACM TRANSACTIONS ON NETWORKING, VOL. 16, NO. 3, JUNE 2008
[2] O. J. Boxma, "Sojourn times in cyclic queues—The influence of the slowest server," n Proc. 2nd Int. MCPR Workshop on Computer Performance and Reliability, Rome, Italy, May 1988. YU et al.:
[3] D. Y. Eun and N. B. Shroff, "Network decomposition: Theory and practice," IEEE/ACM Trans. Networking, vol. 13, no. 3, pp. 526–539, Jun. 2005.
[4] J. Bolot, "End-to-end delay and loss behavior in the Internet," in Proc. ACM SIGCOMM 1993, San Francisco, CA, Sep. 1993, pp. 289–298.
[5] N. Shacham and P. Mckenney, "Packet recovery in high-speed networks using coding and buffer management," in Proc. IEEE INFOCOM 1990, San Francisco, CA, Jun. 1990, vol. 1, pp. 124–131.
[6] I. Cidon, A. Khamisy, and M. Sidi, "Analysis of packet loss processes in high-speed networks," IEEE Trans. Inf. Theory, vol. 39, no. 1, pp. 98–108, Jan. 1993.
[7] R. Kurceren, "Joint source-channel coding approach to transport of digital video on lossy networks," Ph.D. dissertation, Rensselaer Polytechnic Inst., Troy, NY, May 2001.
[8] R. Kurceren and J. W. Modestino, "Optimum EEEC coding rate allocation for video transport over ATM networks," in Proc. IEEE Int. Symp. Information Theory (ISIT 1998), Cambridge, MA, Aug. 1998, p. 251