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Early Decoding: Reducing Latency in Downlink-NOMA with Heterogeneous Service Classes

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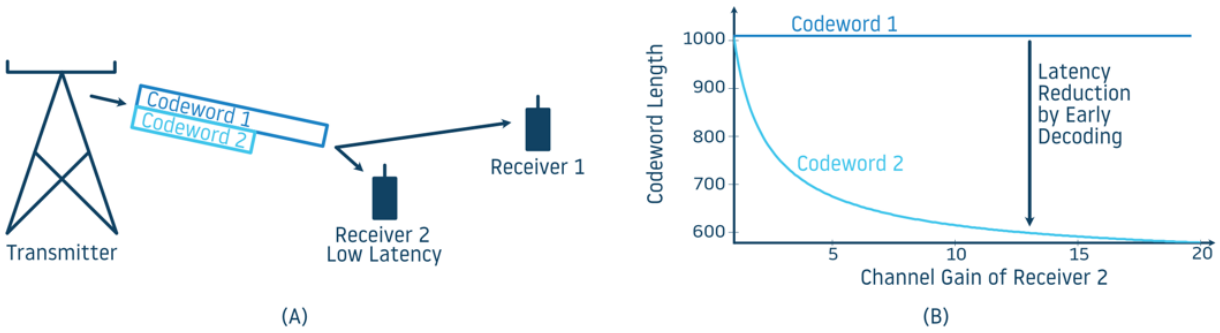
How can we accommodate services with different latency requirements in Downlink-Networks? Can we still retain the advantages of non-orthogonal multiple access in such a scenario?



(A) Illustration of a system where Early Decoding can be used. Receiver 2 has a stricter latency requirement than receiver 1, while having a better channel to the transmitter. He can now use Early Decoding to remove the interference from codeword 1. (B) It is shown how much the length of codeword 2 can be reduced compared to codeword 1 when Early Decoding is used. The channel gain of receiver 1 is normalized to one. As the channel gain of user 2 increases, the minimum codeword length of user 2 decreases, resulting in a further reduction in latency.

KEY FINDINGS

In modern communication systems, heterogeneous services with different latency requirements must coexist. Strict latency requirements require short codewords, which result in lower communication rates than long codewords. Therefore, it would be desirable to use short codewords for services with strict latency requirements while using longer codewords for services with looser latency requirements. We investigate the Early Decoding technique, which allows the transmission of two codewords of different lengths in a downlink non-orthogonal multiple access (NOMA) scheme. Early Decoding means that the receiver with the stricter latency requirement can decode the interference from the other user's codeword before the interfering codeword is fully received. For the first time, we can state the conditions under which Early Decoding is possible in the finite blocklength regime. We show that under heterogeneous channel conditions, Early Decoding supports a fair rate allocation between the users. At the same time, the latency of the stronger user can be significantly reduced compared to a system where all users have to use longer codewords. Our results also include the first outer bound for this setup, proving

P. -H. Lin, S. -C. Lin, P. -W. Chen, M. A. Mross and E. A. Jorswieck, "Second Order Rate Regions of Gaussian Broadcast Channels Under Heterogeneous Blocklength Constraints," in IEEE Transactions on Communications, vol. 72, no. 2, pp. 801-814, Feb. 2024

M. A. Mross, P. -H. Lin and E. A. Jorswieck, "Gaussian Broadcast Channels with Heterogeneous Finite Blocklength Constraints: Inner and Outer Bounds," in IEEE Transactions on Communications (Early Access)