Turbo Codes implementation in LabView

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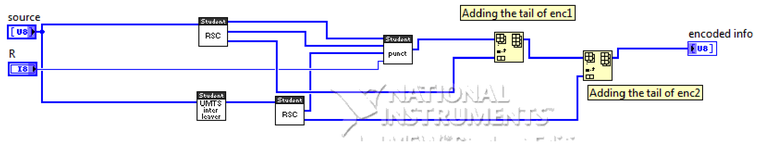
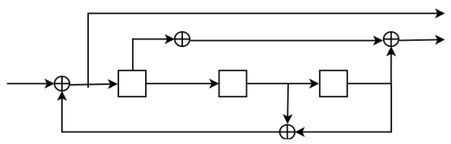
Overview

- Turbo codes are a class of high-performance forward error correction (FEC) codes which were the first practical codes to closely approach the channel capacity.
- Turbo codes are built from a particular concatenation of two recursive systematic codes, linked together by non-uniform interleaving.
- Decoding calls on an iterative process in which each decoder component takes advantage of the other at the previous step, with the aid of original concept of extrinsic information.
- Turbo codes have been implemented in LabView, a system design platform for visual programming language and can interface with USRPs to implement various communication systems.

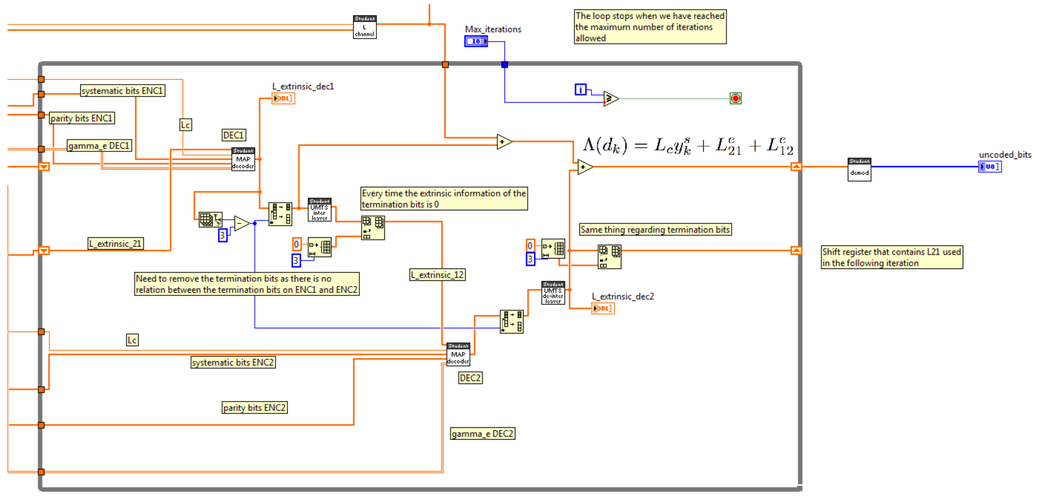
Encoder



- Based on the UMTS 3GPP specifications [1].
- Two Recursive Systematic Encoders in parallel separated by a pseudo-random inter-leaver.
- Two different possible encoding rates: 1/2 and 1/3.
- Specification of the RSC encoders:



Decoder



Implementation of the iterative decoder as defined by Ryan [4] where the Logarithm of Likelihood Ratio is calculated as: $\Lambda(d_k) = L_c y_k^s + L_{21}^e + L_{12}^e$
Where the different elements are:

- L_{12}^e and L_{21}^e are the extrinsic information values calculated by the first and second decoders.
- y_k^s are the systematic bits calculated by the first encoder.
- L_c is the value channel calculated as the energy per channel bit over the PSD.

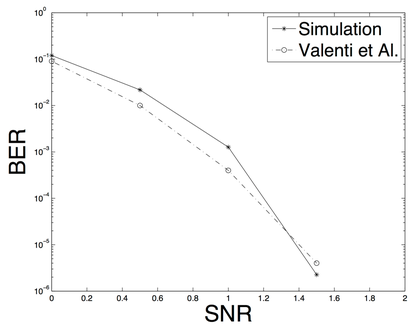
System Evaluation

Evaluation of the system in the simulator using the following parameters:

- Use of Additive White Gaussian Noise.
- Data packets of size 530.
- Up to 14 iterations in the turbo decoder.
- 2 possible encoding rates: 1/2 and 1/3.

Different attributes analyzed:

1. Verification of the system against simulation results by Valenti et Al [3].
2. BER against for a different number of iterations of the decoder.
3. BER against different inter-leavers and different number of decoding iterations.
4. BER against different encoding rates and different number of decoding iterations.



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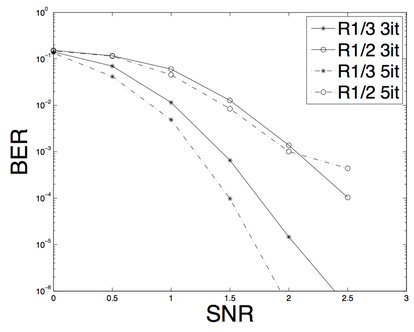

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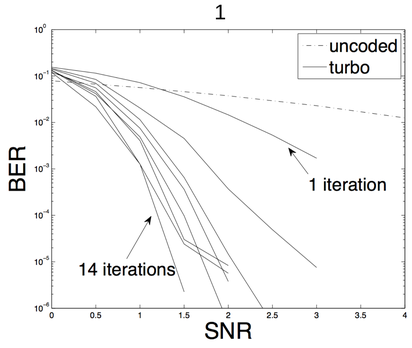

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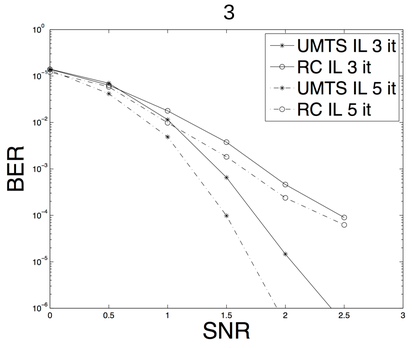

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Conclusions and future work

- Results show the how different attributes can have an impact on system performances.
- Possibility of extending the implementation to run over the air experiments using National Instruments USRPs.
- Improve code performances by exploiting the MAP algorithm intrinsic parallelism.

References

[1] 3rd Generation Partnership Project. Multiplexing and channel coding (fdd). 3GPP Technical Specification 25.212, 1999.

[2] C. Berrou and A. Glavieux. Near optimum error correcting coding and decoding: Turbo-codes. Communications, IEEE Transactions on, 44(10):1261–1271, 1996.

[3] Valenti, Matthew C., and Jian Sun. "Turbo codes." *Handbook of RF and Wireless Technologies* (2004): 375-400.

[4] W.E. Ryan. A turbo code tutorial. In Proceedings of IEEE Globecom, volume 98, 1998.