EE290C Project Proposal
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# A Combined Turbo and LDPC Decoder for an LTE/WLAN SDR

**Motivation:** Ben and Stevo hope to combine their existing digital design knowledge with the literature on decoder resource sharing to develop a low-power, low-overhead combined Turbo and LDPC decoder in Chisel.

**Constraints:** This project will focus only on the decoder blocks for Turbo and LDPC because its iterative algorithm is amenable to pipelining, loop unrolling, and resource sharing. The design will be limited to support the LTE and 802.11ac standards (although a path forward to additional standards could be proposed). A host processor will control context-switching between the two modes, as well as settings relevant to each standard.

**Goal:** We will explore the resource sharing design space between the Turbo and LDPC decoders. We will prescribe architectures optimized for lowest energy per iteration, lowest area, and lowest latency.

**Methodology:** The decoding algorithms and constants for each standard will be defined in MATLAB with floating-point precision. We will also enumerate possible resources to share, including those suggested by literature [1][2]. Next, the Turbo and LDPC decoders will be designed separately in Chisel. This will provide an energy/area reference point against which to compare subsequent designs, as well as allowing us to develop expertise with each DSP block. Then we will explore combining the decoders via aggressive resource sharing. We will functionally verify and synthesize each design point to get metric and accuracy data. Finally, these data will be used to prescribe a specific architecture for each given constraint.

**Milestones:**

*April 4* – decoders implemented in MATLAB, list of resources to share finalized, intermediate review

*April 18* – decoders implemented separately in Chisel

*May 2* – resource sharing explored, report written, presentation prepared

**References:**

[1] Sun, Y., & Cavallaro, J. R. (2008). Unified decoder architecture for LDPC/Turbo codes. In IEEE Workshop on Signal Processing Systems (SIPS). pp 13-18.

[2] Kuntz et. al., Combining LDPC, Turbo and Viterbi decoders: Benefits and costs, https://mns.ifn.et.tu-dresden.de/Lists/nPublications/Attachments/790/Kunze.pdf

[3] Sun, Y., & Cavallaro, J. R. (2012). High-Throughput Soft-Output MIMO Detector Based on Path-Preserving Trellis- Search Algorithm. IEEE Transactions on Very Large Scale Integration (VLSI), Vol 20, No 7, pp 1235-1247.