Problems of LDPC decoder architecture:

- Memory cost of Check-to-Variable (Lmn) and Variable-to-check messages (Zmn).
- Complexity of the Check Node Processor for irregular codes.

Solution: $\lambda$-Min Algorithm and its associated architecture

- Sub-optimal algorithm to compute Zmn values.
- Local storage of a compressed version of Lmn messages.
- Serial computation of check node, with on the fly computation of Zmn messages.

$\lambda$-Min Algorithm:

- **Idea**: Use the $\lambda$ incoming messages which have the smallest magnitude, to compute extrinsic information.
- **Example**: a check node of degree 6 with $\lambda = 3$ (signs are omitted)

Using BP algorithm:

$$ a = \{7, 4, 5, 2, 3, 10\} $$

$\lambda = 3$

All information is required

Using $\lambda$-min algorithm algorithm (with $\lambda = 3$):

$$ a = \{0, 2, 3, 4, 5\} $$

$\lambda = 3$

$\rightarrow$ Only $\lambda + 1$ messages have to be saved!

Performance:

Note: the addition of a correcting factor (offset) in operation $\oplus$ allows the 3-Min algorithm to over perform the BP algorithm.

Architecture

Based on "decoder first code design" architecture (Boutillon et al., ISTC&RT'00)

- P memory banks storing variables $Zmn^{(i)}$ and processing $Zmn^{(i+1)}$ by accumulation
- P parity check processors working in parallel.
- Shuffle (and unshuffle) network between memory banks and PC processors.

Parity Check Processor:

- The M parity checks are processed by P parity check processors in Q macro-cycle.
- Each processor features 2 synthesis blocks and 1 pre-processing block

Synthesis:

- Generate each extrinsic information from the $\lambda + 1$ messages computed by the $\lambda$-min algorithm.

Pre-Processing:

- Sign processing
- Sorting the $\lambda$ minimum magnitude

Memory Reduction:

The ratio between the memory used by the $\lambda$-min algorithm and the memory used by the BP algorithm for one parity check is given by:

$$ \lambda + 1 \rangle N(m) \langle N(m) \rangle $$

For $|N(m)| = 20$ and $\lambda = 3$, up to 60 % of memory save compared to classical LDPC decoder.