3GPP TSG RAN WG1 Meeting #86bis **R1-1610544**
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Agenda Item: 8.1.3.1

Observations on channel codes for NR eMBB data

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Background

From Chairman notes RAN1#86:

Conclusion:

- The eMBB data channel coding scheme will be chosen at RAN1#86bis
    - including agreeing on the **observations** that led to the decision.
- Companies are encouraged to:
    - continue analysis and comparison in order to inform the final decision at RAN1#86bis
    - provide any remaining details, especially focusing on LDPC (in view of the situation in this meeting)
    - provide any remaining details of the flexibility requirements and how they can be satisfied, and corresponding implementation complexity and any impact on performance

Considerations for the selection of NR eMBB channel codes

- Compatibility with **HARQ**
- **Flexibility** to support a wide range of information block lengths, coding rates and channel conditions
- At each supported combination of **block length**, **coding rate** and **channel condition**:
  - **BLER performance**
  - **Information throughput** (Mbps or Gbps)
  - **Latency** (µs or ns)
  - **Area-efficiency** (Mbps/mm^2 or Gbps/mm^2)
  - **Energy-efficiency** (bit/nJ)

Fundamental observations

- **LDPC decoders** recover the encoded bits, then extract the information bits at an information throughput that scales with the coding rate.
- **Turbo decoders** recover the information bits directly, at an information throughput that does not directly depend on the puncturing or repetition rate.
- **Polar decoders** recover the bits in a sub-code-wise serial manner, using successive cancellation or list decoding.
- The information throughput of a flexible channel decoder is reduced when all of the **parallelism** cannot be exploited (e.g. at short block lengths).
- The **latency** associated with a particular information block length is degraded when the information throughput (Gbps) is reduced.
- The **worst-case latency** must be considered when designing a flexible channel decoder to meet a particular latency budget.
- The **area efficiency** (Gbps/mm^2) is degraded when the information throughput (Gbps) is reduced.
- In many cases, the **energy efficiency** (mW/Gbps = nJ/bit) is degraded when the information throughput (Gbps) is reduced.
- Increasing the **flexibility** of a channel decoder degrades its throughput, latency, area efficiency and energy efficiency.
- The **BLER performance** of the LTE turbo code can be enhanced.

Top-level observations

- LDPC codes are **proven, mature and capable**, at least when focusing on achieving **high throughputs**
- LDPC codes can meet the BLER, **throughput**, latency, area-efficiency and energy-efficiency requirements of NR, at least at **medium to high coding rates**
- Turbo codes are **proven, mature and capable**, at least when focusing on achieving **flexibility and HARQ**
- The LTE turbo code and enhanced LTE turbo codes can meet the BLER, **flexibility, HARQ**, latency, area-efficiency and energy-efficiency requirements of NR, at least at **medium to low coding rates.**
- Polar codes are **not mature**.
- Polar codes require **list decoding** to meet the BLER requirements of NR, which degrades the throughput, latency, area-efficiency and energy-efficiency of polar decoders.
- Turbo codes will be a **necessary part** of NR devices supporting non-standalone operation and/or legacy LTE connectivity - efficiency improvements can be achieved by reusing the associated turbo code hardware for NR
- In some circumstances LDPC codes are more favourable than turbo codes. In other circumstances, turbo codes are more favourable than LDPC codes.
- LDPC and turbo codes are complementary, since they have different advantages and disadvantages.