Channel Coding for 5G in Ultra-Low Reliability Communications

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Abstract

The new generation of cellular networks which is in the standardization process cur- rently, is a highly debatable topic. In particular, the channel coding for next-generation cellular networks has to fulfill a large variety of requirements arising from the use cases, enhanced mobile broadband (eMBB), ultra reliable and low latency communi- cation (URLLC), and massive machine-type-communications (mMTC). The URLLC use case poses high demands on the channel code since reliability and low decoding latency constraints with an end-to-end latency under 1 ms have to be achieved.

In this work, we evaluated candidate coding schemes for fifth generation (5G) URLLC and proposed a predictive-HARQ (P-HARQ) scheme based on a decodability evaluation of low-density parity-check (LDPC) subcodes for URLLC. In the first part, we com- pared the block error rate (BLER) performance of the

coding schemes in the URLLC scenarios as proposed in Third Generation Partnership Project (3GPP) Study Item (SI) for fifth generation (5G). In the second part, we evaluated the false positive and false negative performance of decodability prediction based on subcodes for LDPC codes. Additionally, we proposed a P-HARQ scheme based on this prediction and evaluated the performance in a Long Term Evolution (LTE)-like system.

Kurzfassung

Die neue Generation zellulärer Netzwerke, die im Moment standardisiert wird, ist ein sehr umstrittenes Thema. Insbesondere müssen die Kanalcodes ein weites Spektrum an Anforderungen erfüllen, die durch sehr unterschiedliche Applikationen, wie enhanced mobile broadband (eMBB), ultra reliable and low latency communication (URLLC) und massive machine-type-communications (mMTC), zustande kommen. Besonders der URLLC Use Case hat hohe Anforderungen im Sinne der Zuverlässigkeit und niedriger Dekodierlatenz an den Kanalcode, da Ende-zu-Ende Latenzen unter einer Millisekunde erreicht werden müssen.

In dieser Arbeit, haben wir in Third Generation Partnership Project (3GPP) vorgeschlagene Kanalcodes evaluiert und ein predictive-HARQ (P-HARQ) System vorgeschlagen, welches auf der Dekodierbarkeits-Prädiktion anhand von LDPC Subcodes basiert. Im ersten Teil haben wir die BLER Performance der Kodierungsverfahren, die in 3GPP vorgeschlagen wurden, für das URLLC Szenario verglichen. Im zweiten Teil haben wir die False Positive und False Negative Performance der Dekodierbarkeits-Prädiktion für LDPC subcodes ausgewertet. Aurdem haben wir ein P-HARQ System vorgeschlagen, welches in einem LTE-ähnlichen System bewertet wurde.

Patent Applications

- 2016F58809 - HARQ Prediction for LDPC Codes
  Inventors: Baris Göktepe, Thomas Fehrenbach, Cornelius Hellge, Thomas Schierl, Yago Sanchez, Thomas Wiegand
- 2017F59309 - A method for using agressive early HARQ feedback in NR
  Inventors: Baris Göktepe, Cornelius Hellge, Thomas Fehrenbach, Marco Breihling

Conference Papers

- Barış Göktepe, Stephan Fähse, Lars Thiele, Thomas Schierl and Cornelius Hellge:
  Subcode-based Early HARQ for 5G,
  Proceedings of IEEE International Conference on Communications Workshops (ICC Workshops), Kansas City, MO, USA, May 2018.

- Nils Strodthoff, Barış Göktepe, Thomas Schierl, Wojciech Samek and Cornelius Hellge:
  Machine Learning Techniques for Early HARQ Feedback Prediction in 5G,
  Accepted for 2018 GLOBECOM Workshop on Machine Learning, Abu Dabi, UAE, December 2018.

Journal Papers

- Nils Strodthoff, Barış Göktepe, Thomas Schierl, Cornelius Hellge and Wojciech Samek:
  Enhanced Machine Learning Techniques for Early HARQ Feedback Prediction in 5G,
  Submitted 2018 to JSAC Special Issue on Machine Learning in Wireless Communication.

Standardization Contributions

- Barış Göktepe, Thomas Fehrenbach, and Cornelius Hellge:
  R1-1808308, HARQ Processing Timeline Enhancements for NR URLLC,
  3GPP TSG-RAN WG194, Gothenburg, Sweden, August 2018.

- Barış Göktepe, Thomas Fehrenbach, and Cornelius Hellge:
  R1-1720492, Early HARQ for URLLC,
  3GPP TSG-RAN WG191, Reno, USA, November 2017.

- Barış Göktepe, Thomas Fehrenbach, and Cornelius Hellge:
  R1-1718315, Early HARQ for URLLC,
  3GPP TSG-RAN WG190b, Prague, Czech Republic, October 2017.

- Barış Göktepe, Thomas Fehrenbach, and Cornelius Hellge:
  R1-1716136, Early HARQ for URLLC,
  3GPP TSG-RAN WG1-NR3, Nagoya, Japan, September 2017.

- Barış Göktepe, Thomas Fehrenbach, and Cornelius Hellge:
  R1-1703330, HARQ timing and number of HARQ processes for NR,
  3GPP TSG-RAN WG188, Athens, Greece, February 2017.

- Barış Göktepe, Thomas Fehrenbach, and Cornelius Hellge:
  R1-1703309, On HARQ feedback schemes for NR,
  3GPP TSG-RAN WG188, Athens, Greece, February 2017.

- Barış Göktepe, Thomas Fehrenbach, and Cornelius Hellge:
  R1-1700647, Aggressive early Hybrid ARQ for NR,
  3GPP TSG-RAN WG187, Spokane, USA, January 2017.