Forward Aware Quantization and Decoding for Non-Terrestrial Networks with Regenerative Payload

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We consider the uplink of a non-terrestrial network where a relay node is forwarding digitized signals via a rate limited forward link to the serving satellite [1]. The serving satellite has a regenerative payload configuration, i.e., it has to decode the transmitted message of the User Equipment (UE). We observed that this system setup is similar to the uplink of a Cloud Radio Access Network (Cloud-RAN), where small cells forward UE messages to the Central Processing Unit (CPU) [2]. The considered communications setup is a classical two-hop compress-and-forward transmission consisting of an access link, a relay and a forward link. In order to compress the signals at the relay, we utilize the Information Bottleneck method [3] to design scalar quantizers, which maximize the mutual information between the source signal and the relay signal. Moreover, we investigate the Forward Aware Vector Information Bottleneck (FAVIB) algorithm [4] to design quantizers, which maximize the end-to-end (e2e) mutual information between the source signal and the receive signal of the serving satellite. This approach improves the e2e performance with an increased robustness against transmission errors on the forward link. The largest amount of computational complexity of the physical layer processing is allocated for the iterative decoding of modern forward error correction codes such as Turbo-Codes or Low-Density-Party Check (LDPC). In order to reduce the decoder complexity at the serving satellite in the considered scenario, we extend the recently introduced lookup-table based Message Passing (LUT-MP) decoder [5] by considering the statistic of the e2e channel comprising the access link, the FAVIB quantizer and the forward link. The implementation of this LUT-MP decoder in suitable hardware architectures promises a high throughput as all internal decoder operations are replaced by LUTs of small size. We show by numerical evaluations that the performance of a 3-bit compression on the forward link in combination with a LUT-MP decoder using only 3-bit per messages and LUTs with 64 memory locations achieves performance results close to double precision floating-point relay transmissions and MP decoding. Thus, a complementary communication setup with low data rate on the forward link and low complexity decoding at the serving satellite is proposed.

References:

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