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Adaptive Concatenated Coding for Wireless Real-Time Communications

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Abstract

The objective of this thesis is to improve the performance of real-time communication over a wireless channel, by means of specifically tailored channel coding. The deadline dependent coding (DDC) communication protocol presented here lets the timeliness and the reliability of the delivered information constitute quality of service (QoS) parameters requested by the application. The values of these QoS parameters are transformed into actions taken by the link layer protocol in terms of adaptive coding strategies.

Incremental redundancy hybrid automatic repeat request (IR-HARQ) schemes using rate compatible punctured codes are appealing since no repetition of previously transmitted bits is made. Typically, IR-HARQ schemes treat the packet lengths as fixed and maximize the throughput by optimizing the puncturing pattern, i.e. the order in which the coded bits are transmitted. In contrast, we define an IR strategy as the maximum number of allowed transmissions and the number of code bits to include in each transmission. An approach is then suggested to find the optimal IR strategy that maximizes the average code rate, i.e., the optimal partitioning of $n-k$ parity bits over at most M transmissions, assuming a given puncturing pattern. Concatenated coding used in IR-HARQ schemes provides a new array of possibilities for adaptability in terms of decoding complexity and communication time versus reliability. Hence, critical reliability and timing constraints can be readily evaluated as a function of available system resources. This in turn enables quantifiable QoS and thus negotiable QoS. Multiple concatenated single parity check codes are chosen as example codes due to their very low decoding complexity. Specific puncturing patterns for these component codes are obtained using union bounds based on uniform interleavers. The puncturing pattern that has the best performance in terms of frame error rate (FER) at a low signal-to-noise ratio (SNR) is chosen. Further, using extrinsic information transfer (EXIT) analysis, rate compatible puncturing ratios for the constituent component code are found. The puncturing ratios are chosen to minimize the SNR required for convergence.

The applications targeted in this thesis are not necessarily replacement of cables in existing wired systems. Instead the motivation lies in the new services that wireless real-time communication enables. Hence, communication within and between cooperating embedded systems is typically the focus. The resulting IR-HARQ-DDC protocol presented here is an efficient and fault tolerant link layer protocol foundation using adaptive concatenated coding intended specifically for wireless real-time communications.

Keywords: Incremental redundancy hybrid ARQ, multiple concatenated codes, iterative decoding, rate compatible punctured codes, union bounds, EXIT charts, convergence analysis, wireless real-time communication, quality of service.