Chapter 8

Final Remarks

In this book, we have described a method for using low-density parity-check (LDPC) codes for constructing coded modulation schemes for generic communication channels. The basic idea is to use, at the transmitter side, an LDPC code concatenated with a modulator suitable for the particular channel. A good practical choice is to use a modulator whose behavior on the particular channel is well understood and whose practice of use is consolidated. At the receiver side, a soft demodulator, associated with the modulator and accounting for the communication channel statistical behavior, and a standard LDPC decoder iteratively exchange messages. We have shown how to design LDPC codes optimized for the particular transmission scheme. Depending on the specific choice of channel and modulation scheme, the optimized codes might entail remarkable performance gains with respect to standard LDPC codes, i.e., optimized for memoryless channels. It is interesting to note that LDPC codes optimized for a specific scenario are not, in general, good when applied to a different context. For example, a code optimized for the presence of a differential phase shift keying (PSK) modulator and a noncoherent channel has extremely poor performance if used jointly with a (non-differential) binary PSK (BPSK) modulator for transmission over an additive white Gaussian noise (AWGN) channel.

With the help of the techniques described in this book, it is possible to design family of codes corresponding to respective communication systems which exhibit very good performance. In all the investigated cases, in fact, the performance is very close to the theoretical limit given by the mutual information of the corresponding channel.

Nonetheless, it is important to note that the path to the design of the "perfect" communication system is still unfinished. Several factors should be

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taken into account and two of them may be a concern in practical scenarios.

The first and most important factor is the system complexity. In a relatively slow communication system, e.g., with transmission rate below 10Mbit/s, the technology available today allows to implement an LDPC coded modulation schemes by means of standard general purpose digital signal processors. This obviously guarantees a significant flexibility, which enables:

- the use of codes with a non-optimized structure;
- the use of long codewords;
- high precision arithmetics.

In a high-speed and, possibly, low-latency scenario, properly designed encoding and decoding schemes become a necessity and the use of generic unstructured LDPC codes would result in a prohibitive cost both for storing the code structure itself and for implementing the required ad-hoc interconnection in the LDPC coded modulation transmitter and receiver. Therefore, high-speed, low-latency systems pose challenging tasks such as:

- the design of highly structured and powerful LDPC codes for the LDPC coded modulation scheme of interest;
- the need to devise iterative message passing algorithm that guarantee good convergence properties even though used with low precision messages;
- the design of low complexity soft-input soft-output (SISO) modules for LDPC coded modulations; such a low complexity SISO algorithm for LDPC coded modulations is not necessarily a good SISO algorithm for uncoded modulation.

The second important factor that may be a concern is the sub-optimality of the considered encoding and decoding structures. The discussed analysis methods based on extrinsic information transfer (EXIT) charts give a useful estimate of the performance attainable with a given LDPC coded modulation system. This, however, does not guarantee that the considered scheme can always achieve the channel capacity.

Nevertheless, LDPC coded modulations represent a practical way of achieving good performance in a wide variety of channels with the currently available technology and may be regarded as a medium term flexible intermediate step toward yet-to-come low-complexity capacity-achieving communication schemes.