Chapter 7
Digital Communications and a Smart World:
Analyzing Turbo Codes With EXIT Charts in Wireless Channels

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ABSTRACT

This chapter is devoted to digital communications in a smart world. The author examines turbo codes that are currently introduced in many international standards and implemented in numerous advanced communication systems, applied in a smart world, and evaluate the process of extrinsic information transfer (EXIT). The convergence properties of the iterative decoding process, associated with a given turbo-coding scheme, are estimated using the analysis technique based on so-called EXIT charts. This approach provides a possibility to predict the bit-error rate (BER) of a turbo code system with only the extrinsic information transfer chart. The idea is to consider the associated soft-input soft-output (SISO) stages as information processors, which map input a priori log likelihood ratios (LLRs) onto output extrinsic LLRs. Compared with other methods, the suggested approach provides insight into the iterative behavior of linear turbo systems with substantial reduction in numerical complexity.

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INTRODUCTION

Digital communications (or, data communication) is defined as data transfer over a communication channel. In a smart world, digital communications support a wide range of multimedia applications, such as audio, video and computer data that differ significantly in their traffic characteristics and performance requirements (Lokshina, 2011a, 2011b; Lokshina, Durkin, & Lanting, 2017; Lokshina & Zhong, 2017, 2019; Sklar, 2002).

Turbo codes have been adopted for providing error correction in several advanced communication systems, such as the 3rd-Generation Wideband Code Division Multiple Access (3G WCDMA) and 4th-generation Long Term Evolution (4G LTE) systems (ETSI TS 136 212 LTE, 2013; Maunder, 2015; Ngo, Maunder, & Hanzo, 2015). Turbo codes comprise a parallel concatenation of two constituent convolutional codes. By iteratively exchanging information between the two corresponding constituent decoders, turbo codes facilitate reliable communication at transmission throughputs that approach the channel capacity (Berrou, Glavieu, & Thitimajshima, 1993; Brink, 2001; Colavolpe, Ferrari, & Raheli, 2001; Hanzo, Liew, Yeap, Tee, & Ng, 2010; Lokshina, 2011a, 2011b; Lokshina & Zhong, 2017, 2019; Maunder, Wang, Ng, Yang, & Hanzo, 2008; Ngo, Maunder, & Hanzo, 2015).

Turbo codes represent a great advancement in the coding theory. Their excellent performance, especially at low and medium signal-to-noise ratios, has attracted an enormous interest for applications in digital communications. Historically, turbo codes were first deployed for satellite links and deep-space missions, where they offered impressive Bit-Error Rate (BER) performance beyond existing levels with no additional power requirement (a premium resource for satellites). Since then, they have made their way in the 3rd-generation wireless phones, Digital Video Broadcasting (DVB) systems, Wireless Metropolitan Area Networks (WMAN) and Wi-Fi networks.

Currently in a smart world, even if several research issues are still open, the success of turbo codes is growing, and their introduction in many international standards is in progress; the 3rd-Generation Partnership Project (3G PP) Universal Mobile Telecommunications System (UMTS) standard for 3rd-Generation Personal Communications and the European Telecommunications Standards Institute (ETSI) Digital Video Broadcasting – Terrestrial (DVB-T) standard for terrestrial digital video broadcasting are among them (Auer, Kryvinska, & Strauss, 2009; Bashah, Kryvinska, & Do, 2012; Brink, 2001; Iliev, Lokshina, & Radev, 2009; Kryvinska, Auer, Zinterhof, & Strauss, 2008; Kryvinska, Strauss, Collini-Nocker, & Zinterhof, 2011; Lokshina, 2011a; Lokshina & Zhong, 2017, 2019).