Chapter 1

Joint Source Channel Coding and Diversity Techniques for 3G/4G/LTE-A:
A Review of Current Trends and Technologies

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ABSTRACT

There has been a tremendous growth in the joint source channel coding techniques of recent wireless communication system. The main objective of this technique is to simplify the architecture which eliminates the network errors and instability. This chapter mainly focuses on Joint Source Channel Coding (JSCC) in Multiple Input Multiple Output (MIMO) diversity to minimize the effects of noise, distortion and related phenomena for better reception of the signal with increased efficiency and spectrum utilization with link reliability. JSCC techniques in presence of 3G/4G/LTE-A for high data rate communication with the carrier aggregation is an important element for communication over wireless channel. In this chapter, the authors shall discuss the current state of research, the challenges related to the deployment of JSCC, the likely solutions and the usefulness as part of upcoming communication networks. A major part of the work shall focus on their suitability in LTE-A frameworks so essential for sustaining the current growth in wireless communication.

INTRODUCTION

The expansion of wireless networks and increasing use of high data rate mobile communication has constantly driven new innovations. One primary factor is the increasing demand of channel capacity. Adding to this demand is an even present requirement of link reliability and continuously improving quality of service (QoS). Qos is an issue which suffers for wireless communication channel due to the stochastic nature of it. Stochastic behaviour of wireless communication channel is linked to fading which becomes severe with mobility of the transceiver sets. Diversity schemes like multi-input multi output (MIMO) have been successful in mitigating the ill-effects of fading and have also enhanced capacity of channels. Yet there are certain issues like application of coding which can be used effectively to improve QoS and link reliability. Of late joint source and channel coding (JSCC) has been accepted as important addition to the wireless/mobile communication framework which have shown considerable amount of promise to improve QoS and mitigate the ill-effects of stochastic behaviour of the wireless channel. One of the benefits of the use of JSCC is the optimization achieved while being part of transceiver systems used in LTE/LTE-A frameworks. JSCC have received attention due to the promise demonstrated by them in improving the channel capacity utilization in current and upcoming topologies (Guillemot & Christ, 2003).

Basically for the data compression process, source coding is necessary that eliminates possible redundancy from the corresponding input source signals. On the other hand, perfect redundancy insertion is related to channel coding. Perfect redundancy insertion is a process that creates a special kind of protection from the ill-effects of noise related to the channel. Shannon's theorem of joint source-channel coding consists of two parts (Shannon, 2001): first part depicts that if a specific source with a source coding rate R is less than the channel capacity C, i.e., $R < C$ then a reliable means of transmission of the source signal through the channel is possible; second part or the converse part states that if $R > C$ then reliable communication of the source signal through the channel is impossible. These two parts of Shannons' theorem depicts the separate consideration scenario for both the source and channel coding for overall system performance without any loss of information (AZAMI, Duhamel & Rioul, 1997).

This separability for both the source and channel coding holds if the communication corresponds to point to point communication, i.e. single channel. However, with multi-path fading broadcasting communication this phenomenon is not realistic. In a broadcasting source-channel coding system, the clear distinction between the source coding problem and the channel coding problem already disappears, and hence the usual concept of achievable rates so popular in the field of multi-user information theory becomes irrelevant.

Moreover, a tandem source-channel coding may, in practice necessitate very long blocks of source symbols and very complex coders. Suppose that for a simple transmission scheme, a *binary schematic channel* (BSC) is associated with the transition probability, $\in$=0.01. For this purpose, transmission of an input signal from a binary symmetric source (BSS) through this channel of average distortion, $D \leq$ *0.1* is required. With the consideration of Shannon's theorem for joint source-channel coding, design of a specific source code for the binary symmetric source (BSS) with average distortion ≈ 0.1 is essential first, and then design an analogous channel code for the binary symmetric channel (BSC) with small error probability (AZAMI, Duhamel & Rioul, 1997).

Inclusion of both the source and channel coding modules together in the same processing block in order to reduce the overall system complexity, compared to the tandem scheme is the main objective of the joint source channel coding techniques.

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