Channel-Adaptive Channel Quality Indication (CQI) Reporting Scheme for UMTS High-Speed Downlink Packet Access

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Abstract

HSDPA (High-Speed Downlink Packet Access) is an evolved UMTS packet scheme that delivers increased user peak data rates and quality of service. A key technique supporting HSDPA is adaptive modulation and coding (AMC), in which the modulation scheme and the coding rate are changed adaptively according to the downlink channel quality reported by the user equipment (UE). Therefore, the channel quality indication (CQI) reporting scheme is directly related to the accuracy of AMC and the performance of HSDPA. This paper proposes channel adaptive CQI reporting schemes in which UEs report the CQI value intelligently by using information about channel quality. With the proposed schemes, the battery capacity of UE can be conserved and the uplink interference can be lowered by filtering off redundant CQI reports or the transmission error rate can be lowered by fast CQI reports.

1. Introduction

HSDPA is a packet-based data service in W-CDMA and it was specified in the 3rd generation partnership project (3GPP). The main target of high-speed downlink packet access (HSDPA) is to increase user peak data rates and quality of service, and to improve spectral efficiency for downlink asymmetrical and bursty packet data services. HSDPA offers theoretical peak data rates on the order of 10 Mbps over a 5MHz bandwidth in WCDMA downlink. HSDPA implementations include Adaptive Modulation and Coding (AMC) as well as Hybrid Automatic Request (HARQ). With the AMC technique, the modulation scheme and the coding rate are changed adaptively according to the CQI reported by the UE. So, exact channel quality estimation through a proper CQI reporting scheme and a channel quality prediction method are essential in AMC. In [1], the channel quality prediction method was proposed for the reliable adaptive modulation with limited channel quality feedbacks in a correlated fading channel.

In the current specification of HSDPA, each UE must periodically report to Node B the CQI indicating the downlink channel quality. The CQI value is transmitted by using a High-Speed Dedicated Physical Control Channel (HS-DPCCH). If UEs report the CQI periodically, they must report the same CQI value repeatedly when the channel quality is unchanged. Obviously, this is the waste of the UE's battery power. To solve this problem, a new CQI reporting scheme was proposed in [2]. In this scheme, the UE reports the CQI value to the Node B only when the value difference between new measured channel quality and last reported one becomes larger than delta value which is a certain threshold decided by higher layer. With this scheme, the uplink signalling overhead is reduced efficiently. However, if the Node B receives the CQI value with error, it has incorrect channel quality information for a long time until it receives next CQI value.

In this paper, we propose channel adaptive CQI reporting schemes motivated by the same idea as above scheme. Our schemes behave intelligently to prevent the Node B from keeping incorrect channel quality information for a long time by using a timer and an efficient CQI report timing criterion. Thus, with the proposed schemes, either the number of redundant CQI reports is decreased, maintaining the performance of a periodic CQI reporting scheme, or the accuracy of AMC is increased by reducing the probability of transmission error.

The rest of this paper is organized as follows: Section 2 introduces the CQI reporting schemes in the 3GPP specification and section 3 explains the proposed CQI reporting schemes. In section 4, we describe the simulation environments and evaluate the performance of the proposed schemes. The last section makes conclusions.

2. 3GPP-Specified CQI Reporting Schemes

In the specification Release 5 of HSDPA, a periodic CQI reporting scheme is included. The definition of the CQI and UE procedure for reporting CQI are described in [3]. According to the specification, each UE measures downlink channel quality and selects suitable CQI values to indicate transport block size, number of High-speed Physical Downlink Shared Channel (HS-PDSCH) codes and modulation schemes. The selected CQI values must be such that the transport block error probability would not exceed 0.1 under the measured downlink channel condition. After the selection of suitable CQI values, the UE reports the selected CQI value to Node B at its own CQI report timing. The CQI report timing is determined by each UE's connection frame number (CFN) given by the radio link establishment procedure. According to the specification [4], the report cycle of CQI is defined as 0, 1, 2, 4, 5, 10, 20, 40, 80 subframes, where the subframe length is 2ms. The report cycle of CQI is informed to each UE by higher-layer signalling.

Clearly, the short report cycle of CQI gives better through-