2006년도 대한전자공학회 하계종합학술대회 제29권 제1호

# AMC with predicted CQI in packet-based wireless systems

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## Abstract

In a packet based wireless system, an adaptive modulation and coding (AMC) scheme is often employed with the use of channel quality information (CQI). However, the AMC can be operated improperly due to delayed CQI, causing performance degradation. In this paper, we consider the use of predicted CQI for the AMC considering the feedback delay and channel characteristics. We also consider the use of a hybrid automatic repeat request scheme with the proposed AMC for further improvement in high mobility environments.

## I. Introduction

Link adaptation techniques enable efficient utilization of radio resources by adaptively changing the transceiver parameters in response to the change of channel condition [1]. Adaptive modulation and coding (AMC) is a link adaptation technique that chooses a modulation and coding set (MCS) based on the reported channel quality information (CQI) [2]. However, the reported CQI may not be valid at the time of signal transmission due to the feedback delay, causing noticeable performance degradation. In particular, as the mobility increases, the throughput performance can further be deteriorated. We consider the use of predicted CQI to mitigate the performance degradation in addition to the use of hybrid automatic repeat request (HARQ). In this paper, we propose an optimum AMC strategy with HARQ by exploiting statistical characteristics of the channel.

In Chapter II, the system model is described. Previous link adaptation methods are briefly discussed and then the proposed method is described in Chapter III. The performance of the proposed scheme is evaluated in Chapter IV. Finally, conclusions are summarized in Chapter V.

This work was partially supported by the Ministry of Information & Communications, Korea, under the Information Technology Research Center (ITRC) Program.

## II. System model

We consider the transmission of a packet-based OFDM signal over a flat fading channel. We assume that the CQI and reception of acknowledge (ACK) information are reported to the base station (BS) through an uplink channel. In a time-division duplex scheme, the BS can get the CQI after a delay of at least one frame time (e.g., 5ms in WiBro).

## III. Proposed method

A recent work considers the adjustment of CQI to maximize the throughput by determining the MCS according to the channel condition [6]. However, the CQI is adjusted experimentally in channel environments in consideration. The CQI offset value is heuristically determined to maximize the throughput. To alleviate this problem, we consider the use of predicted CQI considering the channel characteristics.

The channel gain $h(t+\tau)$ at the time of transmission can be predicted from $h(t)$ as [3]

$$h(t+\tau) = \rho h(t) + \sqrt{1-\rho^2}\, z\ . \qquad (1)$$

where $z$ is a zero mean complex Gaussian random variable with the same variance as $h(t)$ and $\rho$ is the correlation coefficient between $h(t+\tau)$ and $h(t)$. In rich scattered environments, it can be represented as [4]

$$\rho = J_o(2\pi f_D \tau)\ . \qquad (2)$$

where $J_o(\cdot)$ is the zero-th order Bessel function of the first kind, and $f_d$ and $\tau$ respectively denote the maximum Doppler frequency and time difference between the channels.

The error rate with the use of predicted CQI can be calculated using the distribution of $h(t+\tau)$ in (1). Assuming that the CQI is unchanged within a packet, the error rate can be estimated by integrating the multiplication of the AWGN error function and the probability distribution function of the signal-to noise power ratio (SNR) [5]. The estimated error rate is

$$E[P(\gamma)] = \int_{-\infty}^{\infty} p_{\gamma}(\gamma) P_e(\gamma) d\gamma . \quad (3)$$

where $\gamma$ is the reported CQI, $p_{\gamma}(\gamma)$ is the distribution of the SNR which is derived from (1) and $P_e(\gamma)$ is the AWGN error function.

Once the error rate for each MCS is estimated, the MCS can be determined according to the reported CQI. However, the predicted CQI may be backed-off significantly from the reported CQI when the mobility is high. This problem can be alleviated by employing an HARQ technique together. In this case, it may be desirable to determine the MCS aggressively considering the SNR gain due to the use of HARQ. The proposed scheme selects the MCS to maximize the throughput by calculating the expected throughput for all available MCSs.

## IV. Performance evaluation

The performance of the proposed method is verified by computer simulation. We consider the use of HARQ with a maximum retransmission of 7. Fig. 1 depicts the spectral efficiency of the two schemes when the average SNR is 10 dB. The previous method in [6] selects the MCS with a CQI offset determined from experiments in an average sense. It can be seen that the spectral efficiency of the previous method varies according to the CQI offset since the same CQI offset is applied to a given average SNR and user mobility. On the other hand, the proposed method determines the MCS for each frame based on adjusted CQI offset determined from the reported CQI, providing performance robust to the CQI offset. As a result, the proposed scheme outperforms the previous one in a wide range of CQI offset.

## IV. Conclusion

In this paper, we have investigated a link adaptation scheme that uses AMC and HARQ together. The use of reported CQI always encounters a channel mismatch problem due to the feedback delay. To alleviate this problem, we consider the use of predicted CQI with HARQ. To guarantee the desired error rate, we also consider a back-off of the CQI which is analytically determined to maximize the system capacity. The AMC is determined in an aggressive manner considering the SNR gain through retransmissions, improving the system throughput in high mobility environments. The simulation results show that the proposed method provides stable performance in a wide range of CQI offset.

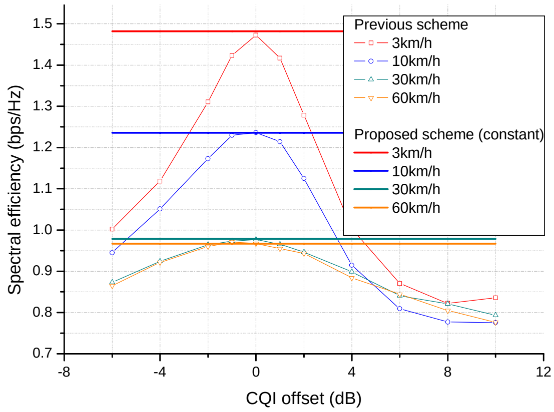


Fig. 1: Throughput of the proposed scheme when the average SNR is 10dB

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