Abstract

A novel UEP (Unequal Error Protection) method is proposed that utilizes the subcarrier positions relative to pilot subcarriers in an OFDM multicarrier frame along with FEC (Forward Error Correction) schemes. With the available physical layer techniques, a prioritized encoding strategy based on the characteristics of the channel fading effects on the proximity data subcarriers to the pilot subcarriers for layered video is developed. The strategy is to efficiently map the bit streams of various priorities into the subcarriers with assisted info on their individual error recovery probability. The proposed technology maintains a minimum QoS for all periods outside outage since the high priority layer is guaranteed to be transmitted under BER constraints. At lower SNR scenarios this difference between the pilot proximate subcarriers are more distinctive.

1. Introduction

Compressed video bit stream transmission over wireless network is addressed in this paper. A new system that integrates video source coding and channel coding for broadband wireless transmission is attempted to explore. Specifically, a system that integrates Orthogonal Frequency Division Multiplexing (OFDM) with unequal error protection channel coding on prioritized subcarriers is proposed for robust video transmission.

The work proposes an Prioritized Subchannels Error Protection (PSEP) scheme by jointly considering the features of NAL layer in H.264/AVC and the characteristics of OFDM channels through sub-channel partitioning, in which a cross-layer allocator is used to allocate channel resources for different priority video data transmission for error resilient encoding. Various FEC schemes are used based on the subcarrier location. The strong impact of the proposed method in terms of video quality is evaluated for H.264 video transmission.

2. Existing UEP with FEC methods

In a multi-carrier system, such as OFDM, a natural way to implement UEP is based on forward error correction (FEC) [1]. Common approaches for UEP are based on channel coding, such as BCH (Bose and Ray-Chaudhuri) code, RS (Reed Solomon) code, rate-compatible punctured convolutional code (RCPC), Turbo coding etc. [2][3][4]. The basic idea is to employ different channel coding schemes to provide different levels of protection to video data with different priorities. Retransmission can also be combined with such schemes for prioritization [5][3]. By employing different channel coding schemes, video data of high-priority (HP) is given more protection than low-priority (LP) data. UEP is classically performed at channel coding level, through convolutional and, more recently, turbo codes. In [1], an UEP method is proposed for an OFDM system by grouping sub-channels according to their channel gains, and power control is employed so that the subchannels belonging to the same group have the same signal-to-noise ratio (SNR).

However factors such as channel estimation errors and channel variations are not considered in [1]. In such an FEC-based UEP scheme, channel knowledge is not exploited for allocating the data of different priorities and rather they are allocated to the fixed set of sub-channels for transmission. Since the uneven fading on sub-channels of OFDM symbols causes the HP data transmitted on sub-channels with deep fades will suffer high probability of error, even with the protection of powerful coding. This may cause a higher sensitivity to signalling errors. The method proposed in this paper maintains a good performance level since the reliability of the HP layer information is held high.
3. Proposed Method

In the proposed technique, the channel estimation in conjunction with error probability of subcarriers proximate to pilot subcarriers had been explored achieved higher UEP.

3.1. Channel Effect Recovery of Proximity Pilot Carriers

The error response on the 1024 bit locations of a 1024 subcarrier OFDM after reception and channel estimation is as shown in Fig 1. The pilots are placed in an interval of 80 subcarriers, excluding the guard interval to form 7 pilots. The Pilot locations, Data locations and Guard intervals are shaded for better visibility in Fig 1. After channel estimation the pilot subcarriers will have comparatively lesser distortion from the channel effects and hence the sharp peaks of BER.

The subcarrier response of data subcarriers excluding the pilot subcarriers are shown in Fig 2. The peaks and troughs are formed in relation with the position of the pilot subcarriers. The data subcarriers near to the pilot subcarriers have lower BER. As the data subcarriers located further from the pilot subcarriers, it is prone to more errors and has higher BER.

The following BER diagram Fig 3 shows the channel responses for near proximity subcarriers and far proximity subcarriers. Any kind of error correction mechanisms including the FEC is not used with the intention of focusing on the study of the channel response with proximity subcarriers.

3.2. Near Field and Far Field Channel Response

Extensive tests had been carried out to opt for the best ratio between the allocation in Near Field Subcarriers and Far Field Subcarriers. Fig 4 shows the PSNR in two different ratios of 30% vs 60%. A ratio of 30% is utilized which in all cases gives a graceful degradation as channel SNR decreases.

Since the probability of the BER is different for Near Field Data Carriers (NFDC) and Far Field Data carriers (FFDC), the FEC rate should be
considered according to the bit mapping on the subcarrier locations.

Actual video quality depends on PER (Packet Error Rate). In video encoding, even if a single bit in a packet is lost the entire packet shall not be used and is assumed lost. Assuming a packet size of 1000 bits and a BER of 10-3, then on an average only 1 bit in a packet will be lost. A very simple but high rate coding mechanism (convolution coding with viterbi decoding) with low complexity that can correct a few bits will be sufficient to further bring down the PER to an acceptable value. Effectively, the FEC ratio will be different for packets with different priorities.

3.3. Prioritization scheme

In prioritized FEC, the subcarriers are divided into three, near subcarriers, mid subcarriers and far subcarriers (Fig 5). Four coding rates in the convolution code are used to encode the source stream as follows 1/2, 2/3, 3/4, 5/6. To carry out UEP there are twelve possible protection level made possible from the three sets of subcarriers and four sets of coding rate (Fig 6).

![Fig 5: Proximity subcarrier grouping](image)

![Fig 6: Protection capability with different coding rates and allocation probability](image)

In a data partitioned coded video by adjusting the quantization parameter in the rate controller, one can control the overall source rate (sPC1 + sPC2 + sPC3) for an acceptable low-delay transmission. However, in a constant bit rate stream, the bit rate of the PC1 layer is still variable under the influence of picture contents and the motion of objects [9]. Therefore, after adding the protection bits to this layer, the total channel data rate (1) is still variable in spite of the efforts of the source rate control.

To maintain a constant channel rate in UEP-DP, the channel coding ratios (RPC1, RPC2 and RPC3) should be frequently adjusted with respect to the size of the PC1, PC2 and PC3 layers (Fig 7). We note that the main priority must be the PC1 layer, thus, we do not compromise its protection (we fix RPC1 whatever the size of the PC1 layer) and only vary RPC2 and RPC3. For example, we can select the mode of RPC1 in 1~5, and switch RPC2 in 4~9 and RPC3 between 8~12 to maintain a fixed total channel rate (1). The Prioritized Bit Loader tries to maintain a constant channel rate with a constant Video Quality under a variety of fading conditions.

4. Results and Comparison

The unequal-error-protected transmission of data-partitioned coded video have been simulated in Gaussian and fading environments with a constant total channel rate, ch = 100 kbps. For forward error correction, we employed convolution
codes with four bitrates, 1/2, 2/3, 3/4, 5/6 (Fig 6) and the viterbi as decoder.

In the following four results are compared. The UEP-PPS (without FEC), UEP-PPS with FEC, UEP scheme from [7]; UEP scheme from [8]

4.1. Video at 64KBPS

The average PSNR of pictures versus channel symbol SNR is depicted in Fig 8 for a Gaussian channel for four all the four UEP scenarios.

Fig 8: Video Quality in 64kbps; UEP-PPS-FEC the proposed scheme; Non-PPS-UEP-1 scheme from [7]; Non-PPS-UEP-2 scheme from [8]

5. References