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The attached paper is presented to the Experts Group for information. It was published at the Fourth International Conference on Image Processing and its Applications, Maastricht, The Netherlands, 7-9 April 1992.

Experimental hardware for both the video and radio parts has been working for several months. If the Experts Group is sufficiently interested, a live demonstration can be given during the Ipswich meeting, 28-30 October 1992.

Video Transmission over a radio link using H.261 and DECT

Andy Heron & Neil MacDonald

Video Systems Section, MLB4/12, BT Labs, Martlesham Heath, Ipswich, Suffolk, IP5 7RE, U.K.

ABSTRACT

A system for transmitting a compressed video signal over a radio link has been developed. The scheme involves altering the output bitstream of an H.261 videocodec to allow data transmission over a DECT demonstrator system. The system was used to demonstrate acceptable picture quality at bit rates between 32kbit/s and 384kbit/s. The high error rate possible for a radio link requires that techniques for improving the error resilience of the coding scheme be investigated. The resilience may be improved by forward error correction, interleaving of the data stream and by repeating blocks which have been corrupted by transmission. The viability of the system has been proven by hardware trials but further study is required before the system is usable on a real network.

1.0 BACKGROUND

The system designed for transmitting video over radio links was based on the CCITT Recommendation H.261 and the proposed DECT standard. For this study, data rates of 64kbit/s - 384kbit/s were appropriate, ie where H.261 and DECT overlap.

1.1 H.261

Uncompressed video transmission is extremely expensive, broadcast television requiring in excess of 100Mbit/s. The CCITT ratified Recommendation H.261 for audio-visual transmission of videotelephony and videoconference signals at bit rates between 64kbit/s and 2Mbit/s in 1990, after five years of international co-operation. By the combination of appropriate relaxed performance requirements and complex video coding algorithms, H.261 provided both lower transmission costs and a unified standard giving global compatibility which is extremely important for the expansion of audio-visual services. However, H.261 was developed for use over fixed links and is not well suited for use over channels with poor error performance. The large compression ratios can only be obtained by extracting a great deal of redundancy from the input video signal. This leaves the coded data extremely vulnerable to errors and the visible effects of these can persist on screen for several seconds. Whilst it might be possible to develop entirely new coding algorithms with superior error resilience, there is little doubt that these would require higher bit rates than H.261 for the same quality. H.261 currently represents the state of the art in low bit rate video coding and was the obvious choice for the basis of this part of the system.

1.2 DECT

DECT is the emerging Digital European Cordless Telecommunications standard due for ratification by ETSI in 1992. It will be a Time Division Multiple Access (TDMA) system utilising both halves of a duplex link operating on the same frequency and working in the 1.9GHz band. The data part of the bitstream is split up into 10ms frames with each frame consisting of 24 timeslots. Normally the first 12 timeslots are used to transmit from the RFP (Radio Fixed Part) to the CPP (Cordless Portable Part) and the last 12 timeslots are used for transmission in the opposite direction. Each timeslot can be allocated to one of 10 frequencies and can hop to another available frequency, on a frame basis, in the event of the SNR (Signal to Noise Ratio) and BER (Bit Error Rate) on its current frequency becoming too poor for adequate transmission. Each timeslot carries 320 user bits so the maximum channel capacity is 384kbit/s. The BER for a radio link is, typically, between 10^{-2} and 10^{-5}, significantly worse than for a fixed link. To overcome the error problem, the DECT system will have the optional capability to retransmit timeslots in error, increasing the SNR perceived by the user. Implementing this feature reduces the capacity of each slot to 256 bits to allow for a CRC (Cyclic Redundancy Check) code and requires more link capacity to allow for retransmitted timeslots. Our initial trials have not made use of this facility nor of the frequency hopping ability.

2.0 RADIO LINK CHARACTERISTICS

The essential difference between a radio channel and other existing transmission facilities is the error performance. The error characteristics have three main constituents:

1. Random errors occuring as a result of low RF signal levels.

2. Short error bursts coming from certain types of interference and extension of single random errors by modulation techniques.
3. Long error bursts due to deep fading, shielding or frequency hopping.

Fading errors were simulated using the BT Labs Wideband Fading Simulator (WFS). The WFS produces bit error vectors for the performance of DECT in an Additive White Gaussian Noise (AWGN) enviroment with Rayleigh fading. Analysis of the output of the WFS showed that fades had two main characteristics:

1. Fades produced very high intensity bursts of errors with clear periods between fades.
2. The error rate during the fade was very high with possibly more than half the bits in error. Note that, in a full DECT implementation, handover will occur when the error rate exceeds approximately 10^{-3}. In the simulations only about 5% of corrupted blocks had error bursts which were correctable by even a powerful error corrector.

3.0 SYSTEM DESCRIPTION

The system was designed to take the output bitstream from an H.261 encoder, convert the bitstream to a format suitable for DECT to transmit and perform the reverse operation on data received from a DECT system, see figure 1. The output bitstream of the H.261 coder was modified by three processes - FEC, Interleaver and ARQ (Automatic Repeat reQuest), see figure 2. The ARQ scheme for the H.261 bitstream is different and totally separate from the timeslot repeat facility provided by DECT. These processes are performed in a totally reversible manner so that the original bitstream can be reconstructed at the end of the radio part for connection to an H.261 decoder.

3.1 Error Detection andCorrection

The H.261 Recommendation includes a Forward Error Corrector (FEC) to improve its performance in the event of transmission errors. The corrector is BCH(511,493) signifying 493 video bits protected with 18 check bits. This can correct 2 random errors in the resulting 511 bit block or a single burst of length up to and including 6. This may be enough for the first two types of error noted above but is markedly deficient for the longer duration high intensity errors due to fading. No problems are anticipated with channel switching because it is seamless for DECT systems. However, channel switching only occurs after serious degradation in the SNR, so it is anticipated that frequency hopping will be preceded by error bursts.

For the purposes of these tests the BCH(511,493) corrector was removed, but in a real situation it would be needed to correct random errors in the fixed network. It is also needed because its structure and check-bits are part of the H.261 specification and therefore expected by an H.261 decoder which may be unaware of the DECT segment in the end to end connection. It was replaced by an error corrector which was designed to be flexible enough to implement both BCH and Reed-Solomon error correctors with several different block sizes. The FEC could be configured as an error detector and corrector or as an error detector only. The detection facility was used to signal if repeated blocks were required.

3.2 Interleaver

Traditionally, long bursts are dealt with by using interleaving techniques. Suitable rearrangement of the data causes one long burst of errors to be converted into many short ones, each of which is correctable by the FEC . These techniques suffer from the fundamental problem of increased delay which is undesirable from a human factors perspective.

An interleaver was added in an attempt to improve the burst error resilience. The blocks could be interleaved to a depth of 2, 4 or 8. The increase in delay in each direction, in seconds, is given by:

delay = (2 * block size * interleave depth) / bit rate

For example, at 128kbit/s with a block size of 379 the time to transmit a block is about 3ms. If a depth of 4 is selected the processing delay will be eight block periods, 24ms.

3.3 ARQ

The ARQ scheme chosen used the Selective-Repeat technique for repeating blocks which the FEC signals as corrupted. This method requires more complex buffering than other ARQ schemes but is the most efficient ARQ method because only errored blocks are retransmitted. The most efficient scheme was necessary because data rates are limited by the DECT parameters. The 'HOLD' signal, on figure 2 between the H.261 encoder and the ARQ module, is to prevent data being read from the output buffer of the H.261 coder when a retransmit is needed. This signal is only useful at present because no network is connected between the codecs, as shown in figure 1. In a practical system the HOLD signal cannot be sent across the network, because of the delays involved, so other techniques must be used to reduce the output bitrate if retransmits are necessary.

4.0 HARDWARE RESULTS

The modified H.261 bitstream was transmitted across the BT labs DECT demonstrator system. H.261 only specifies data rates above 64kbit/s but the first test conducted was to operate the system with one DECT timeslot, ie 32kbit/s. The video was transmitted with good picture quality, given the low bit rate. The other tests used four DECT timeslots giving a bit rate of 128kbit/s. The FEC chosen was a Reed-Solomon (63,59) code giving a block size of 379 of which 7 bits were required for header information and 24 for check bits leaving 348 bits for data. Initially the system was tried with FEC and Interleaver only. Without the WFS the FEC did not find any errors it could not correct when set up to correct two 6 bit symbols per block. With the WFS connected the picture quality was degraded significantly because there were many errors the FEC could not correct.

The ARQ scheme was then tried on the WFS with the FEC configured as an error detector and corrector to correct two 6 bit symbols per block. In this mode of operation, when many symbols were corrupted in a block, the FEC often wrongly indicated that errors had been corrected and so the ARQ did not repeat the corrupted block, giving much picture degradation. The FEC was then reconfigured for detection only. In this mode the FEC did not try to correct any detected errors and signalled corrupted blocks to the ARQ which repeated them. This arrangement worked well with no errors visible for even a worst case simulated fade. Other error corrector/detector schemes are under investigation.

5.0 CONCLUSIONS

The system constructed was used to demonstrate the viability of transmitting compressed video over a channel with high error probability, at data rates of 32kbit/s - 384kbit/s. It was found that the best solution for overcoming the error problems due to fading was to use error detection with ARQ. Interleaving made the problem worse because the errors due to fading were spread over more blocks which meant that more blocks had to be retransmitted. The system was only used for transmitting over a two way point to point link. If this system is to be connected onto a real network other issues, such as bit rate mis-match between DECT and non-DECT codecs, delay problems and treatment of audio, must be examined.

Acknowledgements

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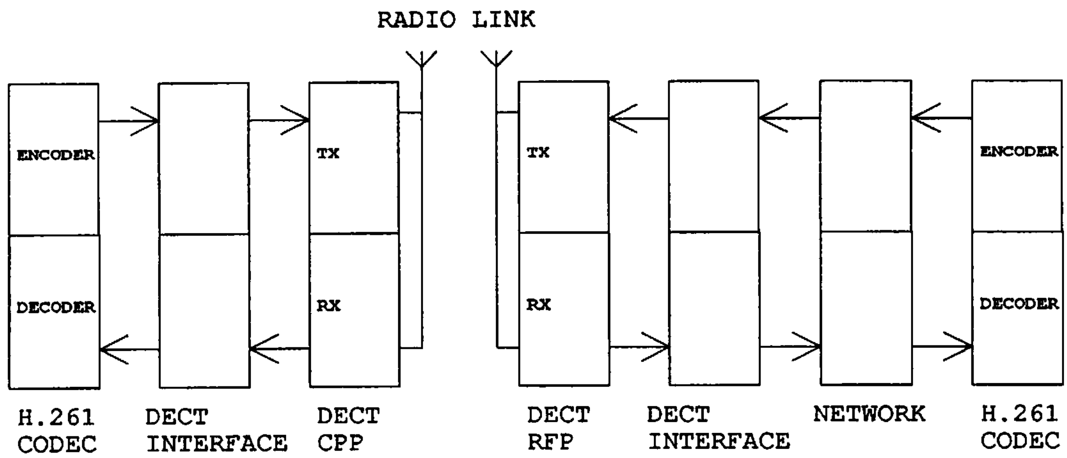

Figure 1: System for transmitting H.261 video over DECT

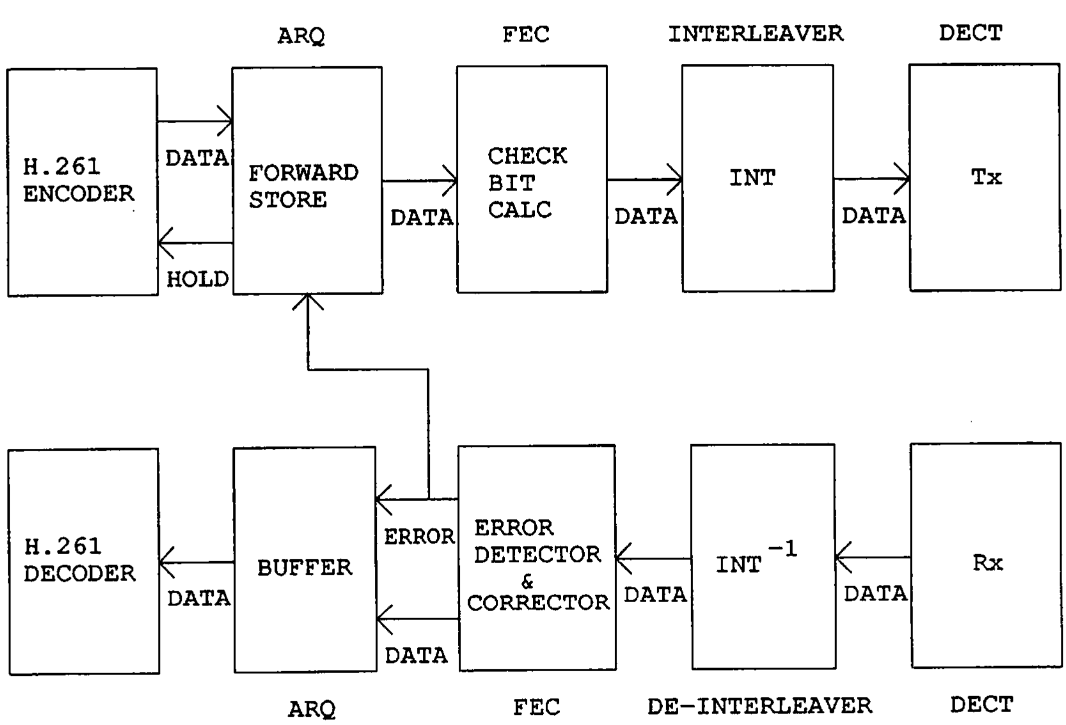

Figure 2 : Modification of H.261 bitstream for DECT operation