Redundant codes in hybrid networks

Hybrid networks consisting of satellite links and mobile *ad hoc* networks present a series of challenges due to different packet-loss patterns, delay, and, usually, scarce available bandwidth. In this scenario, redundant encoding, in the form of *Forward Erasure Correction* (FZC) codes [1],[2], can provide an effective protection against losses in multicast videoconferencing and video streaming applications. The use of efficient encoding techniques can provide further reduction on bandwidth requirements.

A real test-bed based on a remote video streaming server interconnected via a GEO-satellite pipe to a local wireless LAN is presented in [3], by adopting the multicast network protocol. The satellite pipe is based on the commercial Skyplex network [4] that operates in the Ka-band with the Hot Bird 6 transponder. The developed platform, described in [5], is shown in Figure 8.15. The purpose is to provide users with a low-cost, high-availability platform for performing experiments with IP packets over the Skyplex platform. Such devices have been used to experiment the FZC encoding too.

The obtained experimental measurements show the performance of FZC codes based on Vandermonde matrix [6], for multicast video streaming applications. Basically, k blocks of source data are encoded to produce n blocks of encoded data, such that any subset of k-encoded blocks suffices to reconstruct all source data (with $n > k$). Considering the real implementation, the encoder works at the transport layer by fetching blocks of k information packets from the video stream and then transmitting $k+l$ UDP packets (k of information + l of redundancy) towards the receiving host. The encoder adds a preamble of 4 bytes for the sequence number, which is then cancelled by the decoder. The decoder fetches k of the $k+l$ packets per block and recovers the information, provided that no more than l packets are lost in a single block of packets. The receiver then feeds the MPEG-4 decoder with the received stream. Different MPEG-4 movies have been broadcast toward the terrestrial WLAN through the satellite channel by using a standard video decoder and home-made FZC encoding/decoding software. The authors in [3] used this software to work between the application layer and the UDP transport layer, but it may be used between layer 2 and 3 as well.

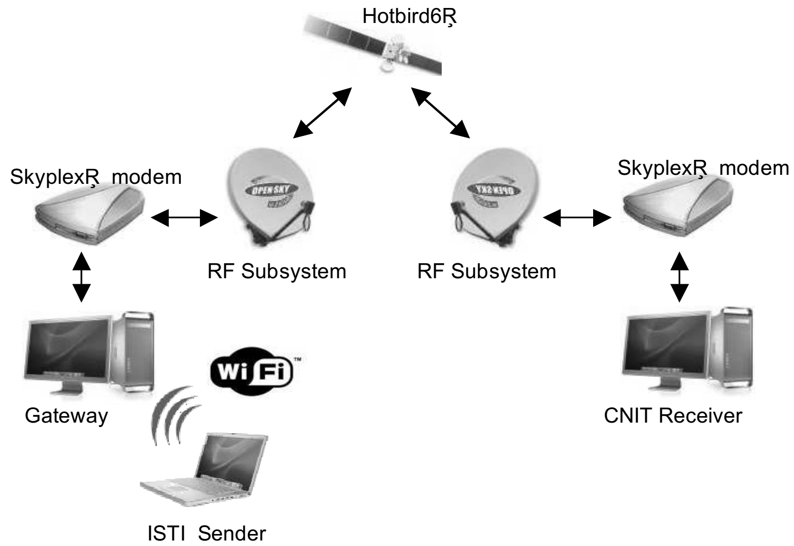

Fig. 8.1: Test-bed platform architecture.

The performance evaluation has been based both on subjective perception of QoS and on objective parameters of QoS. The used subjective assessment has been the perceptual quality, called the *Mean Opinion Score* (MOS)[1], which requires several observers and many tests in order to provide a reasonable statistical spread of results.

The reference measure used for an objective video quality assessment has been the *Peak Signal to Noise Ratio* (PSNR), calculated on the difference signal between the original error-free sequence and the received decoded sequence. Other general objective parameters of QoS, such as packet delivery delay and packet loss, have been considered in [3]. In what follows the numerical results obtained in [3] are presented.

Packet Loss - The experiment in un-coded mode (no FZC) shows that packet loss can be reduced from 13% to about 6% by changing the transmission rate from 11 to 5.5 Mbit/s. In this case, the channel occupancy increases by 56%. Interestingly, we can note that with FZC and 200/100 coding ratio the packet loss is almost zero.

Coding ratio	**Packet loss**	**Residual bandwidth [Mbit/s]**
Uncoded 11 Mbit/s	14.80%	4.155

[1]ITU-R Recommendation 500-5. MOS values are: imperceptible (5), perceptible but not annoying (4), slightly annoying (3), annoying (2), very annoying (1).

110/100	11.30%	4.001
Uncoded 5.5 Mbit/s	5.90%	2.174
120/100	4.80%	3.845
130/100	2.70%	3.691
200/100	0.0%	2.605

Table 8.1: Packet loss and residual bandwidth after FZC encoding.

Packet delivery delay - The maximum packet delivery delay is evaluated as the time necessary to recover all the information when a number of packets equal to the redundancy packets are lost. Table 8.2 shows the packet delivery delay versus the coding ratio.

Coding ratio	**Max [ms]**	**Mean [ms]**	**Var. [ms^2]**
110/100	105.6	52.149	0.769
120/100	115.2	54.99	0.792
130/100	124.8	52.637	0.805
200/100	192	53.805	1.675

Table 8.2: Maximum, mean and variance of delivery delay.

Mean Opinion Score (MOS) - Thirty persons have answered to three quality questions (overall, video, and audio quality) for each considered coding ratio; MOSs have been calculated. The percentages of people, who have considered the video acceptable, are shown in Table 8.3.

Uncoded 11 Mbit/s	**110/100 11 Mbit/s**	**Uncoded 5.5 Mbit/s**	**120/100 11 Mbit/s**	**130/100 11 Mbit/s**	**200/100 11 Mbit/s**
7.7%	15.4%	26.9%	34.6%	100%	100%

Table 8.3: Acceptability of received video.

PSNR - The PSNR-based video quality metric model (henceforth denoted as VQM_P - *Peak Video Quality Measurement*) uses a form of the logistics function that is recommended in references [7],[8] and evaluates the mean of how much transmitted frames differ from the original ones. Sixty seconds of the transmitted video have been compared with the receiver video to evaluate the VQM_P parameter. Results are presented in Figure 8.16, where VQM_P is compared for coding ratio values.

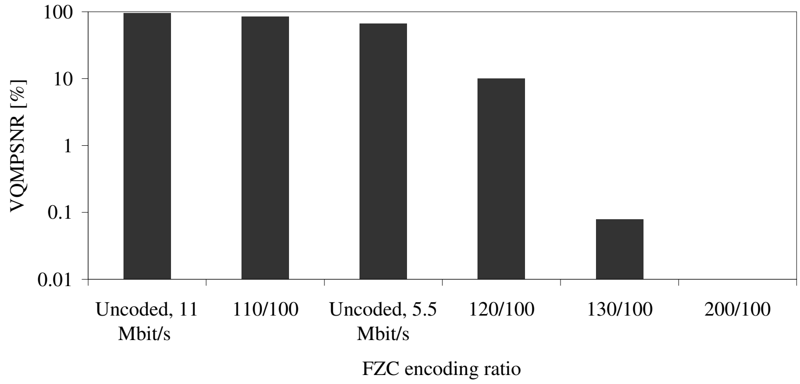

Fig. 8.2: Peak video quality measurement.

8.8 References

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