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Experts Group for ATM Video Coding

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1 October, 1992
Original: English

Special Rapporteur of TG CMTT/2
for Secondary Distribution of Digital TV and HDTV

**LIAISON LETTER FROM CMTT/2-SRG
TO CCITT WP XV/1 EG ACV**

We have received your documents related on the last meetings and thank you for the provided information. We bring to your attention the updated version of our activity report.

Annexe: Revision 6 to Document CMTT/2-SRG-031.

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CCIR Study Groups
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Revision 6 to
Doc. TG CMTT/2-SRG-031
1 October, 1992
Original: English

Subject: Question 25/CMTT

Special Rapporteur of TG CMTT/2 for Secondary Distribution of Digital TV and HDTV

REPORT OF THE ACTIVITIES OF THE GROUP OF EXPERTS ASSISTING THE SPECIAL RAPPORTEUR

1. Introduction

Task Group CMTT-2 is responsible for Question 25/CMTT dealing with standards for secondary distribution of TV and HDTV signals. During the first meeting of TG CMTT-2 (Tokyo, March 1991) a Special Rapporteur was appointed to deal with this matter, assisted by a Group of Experts, known as SRG, i.e. Special Rapporteur's Group.

The background information coming from Report 1239 (CCIR Study Period 1990-1994) is contained in Appendix 1.

SRG met four times in 1991. Several contributions were presented by the members and have been the basis for this report.

After the second meeting of TG CMTT/2 (Geneva, November 1991) four meetings of the SRG were held: the 5th in Singapore (9-11 January 1992), the 6th in Turin, Italy (7-9 April 1992), the 7th in Louvain-la-Neuve, Belgium (8-10 July 1992), and the 8th in Rome, Italy (29 September-1 October 1992).

2. Liaison aspects with other bodies

As stated in doc. TG CMTT/2/TEMP/6 (Tokyo. March 1991) an important aspect of the work of the SRG is to take into account the work in other groups with related objectives and to actively interact with those groups. The groups concerned are: CCITT SG XV WG1 Experts Group for ATM video coding, ISO/IEC JTC1/SC2/WG11-MPEG, CCIR SG 11, in particular WP 11/B, WP 11/E, WP 10-11/S, TG 11/3 and TG 11/4.

Interaction has been obtained by exchange of several liaison letters and attached reports to them. Although the first meeting of SRG was held in Paris just before the MPEG and CCITT SG XV Experts Group meetings and the 5th meeting in Singapore partially overlapped with a MPEG meeting, joint sessions with them have not been held so far and are not considered advantageous for the progress of our work, for the moment. However, many administrations and organisations participating in the SRG are also active in those groups.

Up to now the liaison activities with MPEG and CCITT SG XV Experts Group have been concentrated to the problems of requirements, compatibility and some coding. During the 7th and 8th meetings the Test Model (TM1 and TM2) of MPEG were considered and commented on.

3. Input/Output formats

In secondary distribution different signal formats for Conventional definition TV (CTV), Enhanced Definition TV (EDTV) and High Definition TV (HDTV) have to be considered. Formats for CTV are indicated in Rec. 601, some basic parameter values for HDTV are in Rec. 709 and proposals are listed in

Report 801. Rec. 709 points out that the objective for the system is defined to be progressive scanning, i.e. 1:1 interlace ratio. For current implementations, an interlace ratio of 2:1, or an equivalent sample rate reduction process may be used. Discussions are carried out in various bodies about the introduction of EDTV formats.

As a preliminary basis for our studies the following formats were taken into consideration. However, taking into account the compatibility and related implementation complexity problems, the group believes that a more limited number of formats should be considered for his work. Comments received from the Chairman of the US CMTT Committee (doc. SRG-023) indicate that additional formats are considered in the USA.

Ref.	Aspect Ratio H:V	Dimension of Image			Interlace Ratio	Pel-rate [Mpel/second]
		Horizontal [pels/active line]	Vertical [lines/active frame]	Temporal [fields/second]		
HDTV-P	16:9	1920	1152	50	1:1	110
(Rec. 709)	16:9	1920	1035	60	1:1	120
	16:9	1920	960	59.94	1:1	110
HDTV-I	16:9	1920	1152	50	2:1	55
(Rec. 709)	16:9	1920	1035	60	2:1	60
	16:9	1920	960	59.94	2:1	55
EDTV-P	16:9	960	576	50	1:1	28
	16:9	960	480	59.94	1:1	28
EDTV-I	16:9	960	576	50	2:1	13.8
	16:9	960	480	59.94	2:1	13.8
CTV	4:3	720	576	50	1:1	10.4
	4:3	720	see note	59.94	1:1	10.4

Note: Rec. 601 does not specify the number of active lines for the 525-line format, but Report 624 describes the vertical blanking interval lines for the existing analogue formats and their number is ranging from 19 to 21. On the other hand, Rec. 656 defines the digital TV format specifying that the vertical blanking lines are 18 per frame. Therefore the number of active lines to be considered for the 525-line format should be clarified. It must be noted that, if the number of active lines is 483, the simple ratio of 15/7 is preserved between the 1125-line HDTV format (i.e. the 1035 active line format) and the 525-line CTV format.

The issue of progressive and interlaced formats was discussed: it has an important impact on coding schemes and efficiency. Some coding algorithms, among those discussed by the group, operate on pseudo-progressive formats to encode interlaced pictures. Starting from this approach, it is possible to define a single coding scheme accepting both the progressive and the interlaced formats, although this has implications on the processing complexity and speed. It is however not certain that a decoder able to handle all formats would be economically acceptable. In the continuing discussion there was stated that transmission of picture under progressive format, irrespective to their original format, would probably make easier any processing in the receiving terminal, including re-interlacing if required. Additionally, compatibility aspects (see section 5) would be more efficiently achieved using progressive format. This approach would be attractive and competitive with transmission using interlace format, if the same bit-rate is reached for picture quality with progressive scanning as with interlace scanning, although the number of pixels being twice in the first case.

Doc. SRG-068 (Japan/NHK and Italy/RAI) reports a comparison on coding efficiency between progressive and interlaced formats adopting Intra DCT and Hybrid DCT coding algorithms. The results show that the total amount of bit rate required for coding a progressive image should be comparable to that for an interlaced image using the Hybrid DCT, even though the progressive image has double number of samples, only if both the progressive and interlaced camera have the same spatio-temporal response.

4. Objectives in terms of quality and bit-rates

During the second meeting of the SRG an output document (SRG-014) providing the preliminary functional requirements mentioned that coding algorithms producing approximately 1 bit/pel (where pel includes all bits representing the RGB or Y, C_R, C_B, signals) should achieve the quality levels being considered and the full definition of the input formats. Demonstrations provided during the third meeting seem to confirm that this goal is achievable.

Comments were received from the Chairman of the US CMTT Committee (doc. SRG-023) and from EBU (doc. SRG-020): they point out that current proposals and studies seem indicate that a reduction factor corresponding to about 0.5 bit/pel is a target being studied.

It is evident that a better definition of the quality requirements is necessary and particularly of the absolute quality. Useful indications should come from the EBU (doc. SRG-020) and from the relevant CCIR Sub Groups, 11/B, 11/E and 10-11/S. For the moment Report 1211 can be taken into consideration, since it provides some indication on the requirements for distribution codecs for CTV signals at 34-45 Mbit/s in terms of quality and failure characteristics.

The overall impairment level of a television picture is determined by the addition of a series of "impairment factors". These might be "loss of resolution", "quantization noise", "block artefacts", etc. The viewers perception of the picture is determined by the collectivity of the impairment factors, rather than by any single impairment factor.

The degree of the quantization noise and block artefacts introduced into a picture relates to the picture entropy. In turn, the picture entropy is influenced by the resolution of the source signal that is supplied to the codec. Limiting the resolution of the source format (for example from HDTV to Rec. 601), therefore, can be seen as introducing the impairment factor "loss of resolution" for pictures which otherwise have a high resolution. However, limiting the resolution of the source also reduces the risk of full buffer occupancy, and therefore reduces the risk of quantization noise and block artefact impairment factors. In fact, the introduction of these artefacts could negate the gains on resolution, thus removing the value of the high resolution source.

The important point to note is that a high resolution source does not necessarily mean higher picture quality, and certainly for codecs with high-compression, the overall balance of quality needs to be evaluated in choosing the system which provides optimum quality for the bit-rate. However, reducing the scanning format of the source is a systematic operation which will apply to all parts of all pictures, so the trade-off is a complex one.

Doc. SRG-059 (Special Rapporteur of WP 11/B) points out that further studies are needed to define a reliable test material and to specify the quality criteria for the different formats and the various distribution applications. It also stresses the need to take into account realistic error models for the evaluation of the failure characteristics and to design subjective procedures adapted to low residual error rates. At last, it mentions the necessity to consider the cases in which the distribution codecs are used in cascade with other codecs or after standard conversions.

5. Compatibility aspects

5.1. CTV/HDTV Compatibility

Various picture formats, see section 3, for CTV, EDTV and HDTV (interlaced and progressive) are currently under consideration. The level of compatibility achievable and implementable is not yet defined and further studies are necessary.

The group is confident that a family of formats can be identified for 50 or 59.94/60 Hz systems and that the same algorithm scheme can be adopted for both the families without significant differences in terms of complexity and coding efficiency. Compatibility, at decoder level, between 50 Hz and 59.94/60 Hz is not a requirement.

Compatibility aspects are discussed in docs SRG-018 (Japan) and 019 (Sweden), some technical problems are pointed out:

- Aspect ratio conversion

- Aliasing due to decimation of interlaced lines
- Additional processing due to the interlace structure
- Different requirements in terms of bit-rate for the compatible component in the HDTV stream and for CTV
- Consequences, due to the different aspect ratio for compatible component and CTV, for the clock frequency at the decoder side

Compatible coding schemes are presented in docs SRG-004, 017, 021, 025, 026, 033 and 034: some of them suggest solution for the above problems. However, compatibility requirements were not fully evident when such schemes were devised, therefore they could not be completely taken into account.

To facilitate the processing, the number of active pels and active lines for HDTV and CTV/EDTV should be in an integer ratio. This is verified in the case of the 1152 lines/50 Hz format. In the case of the 1035 lines/60 Hz format, the ratio between the number of active lines for HDTV and for TV is 15/7.

Figure 1 shows an example of a basic compatible coding scheme for CTV, EDTV and HDTV. This scheme is based on two layered pyramid coding and can achieve both downward and upward compatibilities. The following video formats (active portions of the picture) are considered:

CTV: 483 or 576 lines / 720 pels / 4:3 aspect ratio

EDTV: 483 or 576 lines / 960 pels / 16:9 aspect ratio

HDTV: 1035 or 1152 lines / 1920 pels / 16:9 aspect ratio

Compatible Coding scheme (Figure 1)

Input CTV and EDTV formats are adapted to the 518 or 576 lines/960 pels format, i.e., virtual format for digital transmission. Vertical up-sampling is performed to form this format if the input is 60 Hz TV formats. The inverse operation is carried out at the post-processing after decoding transmitted data by DEC1.

Input HDTV format is down-sampled (horizontally and vertically by a factor of 1/2) for both the 50 and 60 Hz systems, and a component compatible with the virtual format for digital transmission is obtained. This component is coded by COD1 and the residual component (difference between input HDTV and locally-decoded output of COD1) is coded by COD2.

At the HDTV decoder, upsampling (H: 2/1, V: 2/1) is carried out for the output of DEC1 and the resulting information, combined with the output of DEC2, reconstructs the whole HDTV picture.

Downward compatibility is achieved when coded data from COD1 of HDTV is decoded by DEC1 of CTV or EDTV. Upward compatibility is achieved when coded data from COD1 of CTV or EDTV is decoded by DEC1 of HDTV.

5.2. Compatibility with other applications

CMTT/2 is charged with the development of Recommendations concerning the Secondary Distribution. In principle CCIR SG 11 would be expected to be responsible for the development of digital emission systems. However, it is quite likely that these two activities will be the two sides of the same coin. The viewer will need a common receiver for both types of service, and in any case the ISDN will carry, among other services, programmes also broadcast. There would thus be clear benefits in a single baseband coding scheme for both ISDN Secondary Distribution and for digital broadcasting. To achieve this, it is essential to start with the most demanding path, i.e. the terrestrial broadcasting network.

MPEG and CCIT SG XV are developing coding standards, namely MPEG-2 and H.26x. These standards are intended to cover a wide range of applications including distribution.

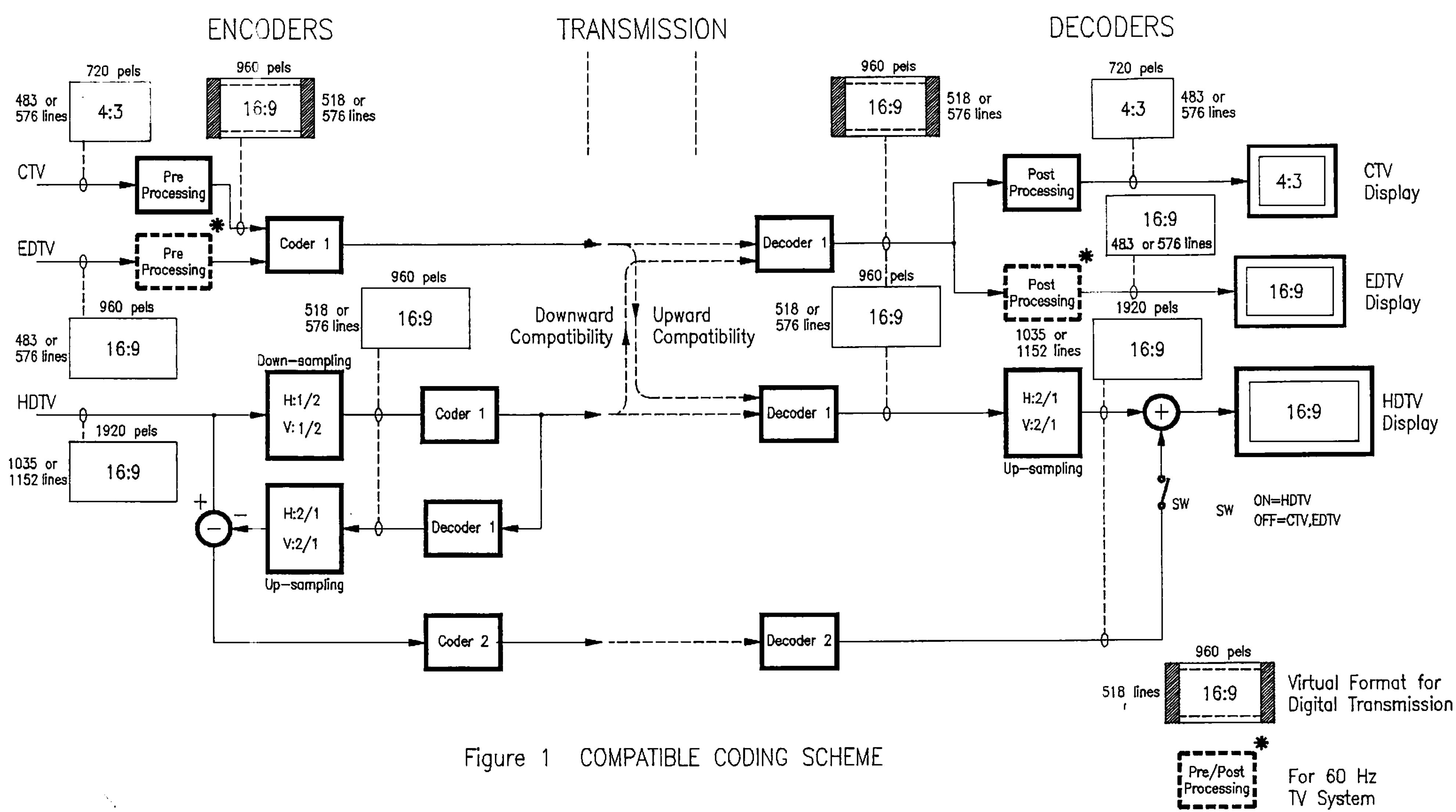
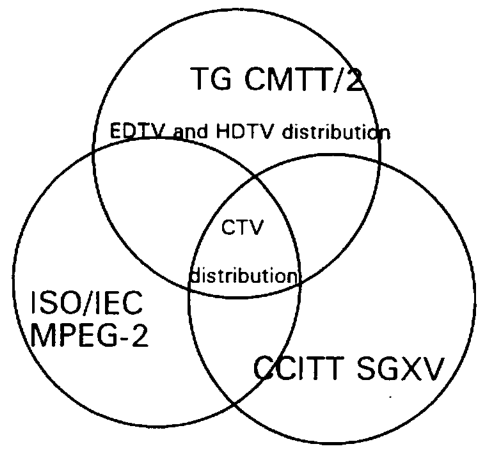


Figure 1 COMPATIBLE CODING SCHEME



In the SRG meeting some doubts were expressed with regard to compatible coding on many (i.e. more than two) resolution levels. This approach may reduce the overall coding efficiency. A CMTT/2-developed distribution codec should take maximum advantage of the generic "toolkit" developed by MPEG2. To make this possible, MPEG2, in turn, needs to take account of CMTT/2 requirements.

Compatibility with standards for contribution quality (Rec. 723) and for lower quality applications (MPEG-1 and H.261) is not considered essential.

6. Network Aspects

6.1. Graceful degradation

Without adequate mechanism, digital codecs will provide seriously damaged images in case of highly degraded transmissions. It would be desirable that distribution codecs exhibits a smooth decrease of video quality after the capacity of the error protection has been exceeded. This feature may be achieved with a compatible embedded bit-stream system in which the channel coding (for terrestrial or satellite broadcasting) or the transfer mode (for ATM networks) is more robust for the compatible information than for the HD complement. In the case of high disturbances affecting the transmission, the HD complement information will become unusable, but the compatible information will still be usable, and the decoder will then be able to display a clean picture with at least low-frequency information.

In an ATM environment, this can be achieved in assigning high priority to the compatible information and low priority to the HD complement: in the case of cell losses due to the overflow of the multiplex queues, only low priority cells will be discarded, but the high priority cells conveying the compatible signal will always be available to the decoder. It will be able to generate images with at least the low frequency information.

6.2. ATM aspects

A permanent concern of the SRG is to develop a coding algorithm suitable for the distribution of television in ATM networks. Specific requirements for this application include the definition of an ATM adaptation layer providing a robust protection against bit errors and cell loss, and possibly video clock synchronisation information needed by the decoders. In addition it is necessary to evaluate the relative merits of the CBR and VBR modes as well as the strategy for using the priority bit.

In order to gather bit rate statistics representative of secondary distribution of TV in the VBR mode, about 20 hours of the TV programmes transmitted by a Belgian Broadcasting Organisation have been recorded in the studio. The codec described in Doc. SRG-50 was then operated on this material for various values of the transmission factor. Statistics of cell inter-arrival times and of cell rates are given and described in document SRG-49 (Belgium). Further work will be performed on this data base to investigate possible policing functions and to evaluate the statistical multiplexing gain for secondary distribution of TV.

7. Algorithms and systems being discussed

Several possible algorithms were submitted by SRG members. Their characteristics are briefly discussed below. At this stage most algorithms are not considered as formal proposals submitted as inputs to a selection process, but rather as outline description of possible solutions. Nevertheless Japan considers its proposal for bit-rate reduction scheme (doc. SRG-024) as a formal one.

Docs SRG-010 and 021 (CCETT) present a motion compensated subband coding scheme using a 8x8 Pseudo Quadrature Minor Filter (PQMF) banks. Doc. SRG-084 (Thomson LER) describes another subband system using a hierarchical subband splitting based on a Quadrature Mirror Filter and an inter prediction in the subband domain. In both cases, compatibility may be achieved by using the same structure for CTV and HDTV decoders, by organising the bit stream with synchronising words allowing the extraction of lower resolution information and by processing the motion compensated prediction on different resolution loops.

Both proposals have been merged into a motion compensated subband coding scheme described in doc. SRG-54 and SRG-70 (France/Thomson-CSF) and commented in doc. SRG-53 (France/Thomson-CSF). The main features of that proposals are: 8x8 PRMF subband splitting, motion compensation using a double loop approach and embedded bit stream. The PRMF band hardware requires only 12 operations per pel close to DCT (10·25 operations per pel). Three field memories (1 for field merging, 2 for prediction) are used. Simulation results for interlaced formats have been demonstrated during the 5th and 6th meeting; it has been shown during the 7th meeting that a bi-directional inter prediction improves the performance of the method.

Doc. SRG-042 and 055 (France) describe an alternative compatible HDTV/TV coding scheme based on a hierarchical spatial subband decomposition of the signal followed by an inter-frame coding of the components. The compatible TV signal is coded with motion compensated hybrid DCT.

In doc. SRG-025 and 066 (Netherlands), studies are reported on HDTV/TV compatible coding schemes in accordance with the functional requirements contained in doc. SRG-014. The coded signal contains an embedded low-resolution channel. The main difference with pyramidal coding schemes is the feedback of a low resolution prediction error signal instead of the low resolution reconstructed signal. In this way the high-resolution decoder only needs one prediction loop. So far this approach has been studied only for the compatible coding of progressive signals.

Simulation results (doc. SRG-066, Nederland and SRG-063, Belgium) show an advantage of compatible coding versus simulcasting, but a disadvantage of compatible coding versus stand-alone coding.

Doc. SRG-047 describes a proposal from Belgium based on Pyramidal DCT coding and supported by Italy, Japan, Spain and Alcatel STR. Simulation results were shown during the SRG meeting held in Singapore (doc. SRG-039, Belgium) for the TV sequences "Mobile and calendar" and "Flower garden" considered as one quarter of an HDTV picture and for the HDTV sequence "Renata". The picture quality obtained is quite promising. The demonstrations showed that the coding errors affecting the compatible TV channel may be considerably more visible when the relevant information is displayed on the full HDTV screen. Some improvements have been proposed in doc. SRG-63 and have been supported by simulations presented during the 7th SRG meeting.

A common feature in docs SRG-025, 026 and 047 is that the quantising and motion accuracies of the low and high-resolution loops are matched to the different viewing angles of TV and HDTV. The quantising error of the low-resolution channel is recirculated in the high-resolution loop. For both cases simulation results were presented at 1 bit/pel.

Doc. SRG-024 (Japan) proposes a source coding scheme to be employed in secondary distribution coding systems, for HDTV and conventional TV, based on Rec. 723. Taking into account HDTV signal characteristics and coding improvement, some modifications are introduced to the coding scheme of Rec. 723. Those are motion compensation for inter-field prediction, loop filter, adaptive quantisation suitable for each coding mode and differential coding of DC coefficients. The proposed scheme does not include specifications of input/output conditions, preprocessing, video framing, error protection and channel framing. These undefined specifications would be completed taking the possibility of compatibility into consideration. For this document, there was an extensive discussion on whether a commonality with Rec. 723 is needed or not and the possibility to adapt this algorithm to lower bit-rates.

Document SRG-064 describes a motion compensation method suitable for the pyramidal DCT coding scheme. For an HD complementary system, motion vectors estimated solely using complementary components, gives the best efficiency, and their VLC codes can be assigned to the difference between them and the related motion vectors of the compatible components.

Doc. SRG-052 (Japan) proposes a subband DCT coding scheme for CTV/HDTV compatible coding. The source coding scheme is an intrafield/MC-interfield/MC-interframe adaptive prediction DCT coding as described in Doc. SRG-024. Two dimensional DCT is applied to the LL component and one dimensional DCT is applied to the LH component, respectively. A coding schema for HL and HH component is under study, considering the necessity of two band-splitting in the horizontal high frequency component. The simulation results were shown during the 6th SRG meeting.

Doc. SRG-051 (Japan) shows comparison results in coding performance between field merged DCT and pure field DCT coding. Three source coding schemes are compared, i.e. (1) MC-interframe/MC-interfield/intrafield adaptive DCT coding, (2) MC-interframe(intraframe adaptive DCT coding and (3) MC-interframe/intrafield adaptive DCT coding. From the results scheme (1) with pure field DCT gives a little better performance in S/N than other two schemes with field merged DCT. Doc. SRG-067 (Japan/NHK and Italy/RAI) also reports comparison of coding efficiency between field and frame coding of intra DCT and Hybrid DCT employing several varieties of prediction schemes. The results do not show an evident difference of coding performance between field and frame coding of Hybrid DCT if they utilise sophisticated prediction schemes. It is suggested that frame coding would cost more memory, delay and complexity than field coding.

Doc. SRG-076 (Japan) shows coding performance comparison results between PRMF and DCT coding. The comparison is carried out assuming a common coding configuration of a motion compensated interframe/intraframe adaptive coding with field merging. From the results, DCT shows higher energy compaction than PRMF for all the sequences employed in the computer simulations.

Doc. SRG-032 (Italy-Spain) and SRG-037 (Eureka 256) are progress-reports on the development of the Eureka 256 HDTV and CTV codecs, based on the algorithm adopted in Rec. 723. The HDTV codec has been successfully demonstrated in various occasions, operating at a transmission rate down to 45 Mbit/s. At this rate the quality was informally evaluated and it is claimed that it is suitable for distribution purposes. Doc. SRG-037 points out elements under study to increase the quality at low bit-rates.

Amongst these suggested algorithms, several were supported by demonstrations based on computer simulations. In some documents a very strong emphasis was put on compatible coding considerations. This helped a lot for a better understanding of the compatibility concept and of its practical implications. Some suggested algorithms are quite close to formal proposals submitted by SRG members to the Kurihama tests performed by MPEG.

Doc. SRG-50 contains a description of the codec developed in the frame of the Belgian Broadcasting Experiment. This codec can be used either in the adjustable fixed bit rate (AFBR) or in the variable bit rate mode (VBR). The basic algorithm is hybrid DCT without motion compensation applied to a pseudo-progressive format obtained by the field merging. The UVLC is used in this codec. The ATM adaptation layer includes the following protections: (1) a forward error correcting code of 10 bits based on a CRC whose generator polynomial is $G(x) = 1 x + x^4 + x^5 + x^9 + x^{10}$ enables to correct one erroneous bit or two correlated bit errors, (2) a 4 bit cell number detects misinserted or missing cells, (3) a parity cell generated every 32 cells allows detection and correction of single cell loss or detectable bursts of bits errors. For networks characterized by a bit error rate and a cell loss rate both smaller than 10^{-6}, a two-hour error free transmission is thereby achieved in the range of 2 Mbit/s to 140 Mbit/s.

8. Test procedures and test material

Useful information for defining test procedures and test material can be inferred by Report 1211 and by the report of the IWP 11/7 ad-hoc groups (doc. CCIR 1986-1990 IWP 11/7-249, CMTT/2-97) who were responsible for the testing of codecs proposed for TV and contribution quality. These documents have been provided to MPEG, as they requested (doc. SRG-027).

8.1. Comments on test results

Doc. SRG-036 concerns the MPEG Kurihama test and outlines the viewing conditions, the test procedure and the results in terms of picture quality at bit-rates of 4 and 9 Mbit/s. The test was set up in accordance with CCIR Rec. 500-4. Although there were some different points from the Recommendation: the smaller monitor size and the shorter display time, which were forced by the monitor availability and the time limitation, the CMTT/2 can note the results of the assessment.

Doc. SRG-040 (CCETT) reports subjective evaluations of some of the 50 Hz proposals made in France with non expert assessors; they have shown that statistically the relative results are similar to those of the Kurihama tests. However, absolute results were found higher and the scores obtained with non experts seem to indicate that it is expectable that the quality requirements expressed by CCIR in Report 1211 can be fulfilled at 9 Mbit/s, but this is not true at 4 Mbit/s.

8.2. Tests of TV/HDTV algorithms

In due time CMTT/2 will have to define tests in view of the final approval of recommendations on the secondary distribution of TV and HDTV. Collaboration with CCIR SG 11 should be sought for this work. The definition of the tests includes the selection and possibly the production of a number of test sequences. Interlaced and progressive scanning formats are requested as needed.

Very few HDTV test sequences are presently available. To carry out this work, the SRG considers that much information can already be obtained by processing existing TV test sequences. These sequences can be used as input either to TV coders or to HDTV coders. In the latter case they are supposed to represent one quarter of an HDTV picture, to be displayed on a full TV screen whereas the compatible TV picture is displayed on one quarter of the TV screen. In order to avoid possible unforeseen effects resulting from this procedure, it was decided to include some available HDTV sequences although they are not necessarily representative of suitable test sequences.

Presently the test sequences used for simulations are the following:

CCIR 601 format:	Mobile and Calendar, 50 Hz (4 sec)
	Flower garden, 60 Hz (4 sec)
HD format:	Renata, 50 Hz (2 sec)
	HD flower, 60 Hz (2 sec)

Notes: The sequence Renata was kindly provided by RAI on magnetic tape. It has 1440 pel/line. Although it is an HDTV sequence with an aspect ratio of 16/9, it will be considered as having an aspect ratio of 4/3, thereby yielding a geometrical compression by a factor 4/3 in the horizontal direction. Another 50 Hz sequence will be used when available. The sequence HD Flower has 1920 pels/line. For display on screens with an aspect ratio of 4/3, only the first 1440 pels of each line will be displayed. HD flower was kindly provided by the Japanese delegation and is available in the Exabyte medium.

Additional HDTV test sequences are requested.

9. Future Work

In order to define a reference model before the meeting of TG CMTT/2 in 1992, the group has adopted the following workplan in three steps:

1. Definition of candidates for the reference model and their evaluation procedure

2. Evaluation of candidates and choice of the model
3. Draft specification of the reference model.

During the 6th meeting of the SRG, the proposed compatible schemes were classified into three classes:

- PRMF subband (see doc. SRG-077)
- pyramidal DCT (see docs. SRG-047+063 and 075)
- hierarchical subband/DCT (see docs. SRG-052 and 055)

The referenced documents presented in the 6th meeting and updated in the 7th and 8th meetings contain the draft outlines of the representatives of each class. Since no further work was carried out to support the third class, during the 8th meeting it was decided to limit our further activities to PRMF subband and pyramidal DCT.

In order to facilitate the convergence process towards the reference model, the following common elements have been identified:

- the coding system is capable of handling HDTV-I and EDTV-I formats: HDTV-I has double the number of active pels per line and active lines per field than that of the EDTV-I format;
- all the Y, C_R, C_B samples are coded, i.e., in the 4:2:2 format
- compatibility is achieved through an embedded bit-stream, with a fixed portion of the stream assigned to the EDTV-I information, the portion is 25% of the total;
- the simulations and comparisons will be carried out at 0.87 bits/pel (corresponding at 9 Mbit/s for CTV) and, possibly, at 0.39 bit/pel (i.e., 4 Mbit/s for CTV).
- Further investigations and advice are required for the following items:
- presently HDTV-I and EDTV-I formats are considered, however HDTV-P and EDTV-P could be adopted in the future. These formats can have an impact on the structure and performance of the coding scheme;
- 4:2:0 could be adopted as signal preprocessing. Advantages in terms of bit-rate reduction and disadvantages in terms of reproduced quality should be investigated; the consequences of using line sequential colour difference signals in the case of embedded bit-stream compatible system may create problems in the interpolation of colour information;
- the consequences of using embedded bit-stream for EDTV information in terms of quality for the HDTV and EDTV pictures must be investigated. Differences in performances can be envisaged if a fixed or a variable portion of the stream is assigned to EDTV; in the former case, the impact of the amount of bit-rate allocated to the EDTV portion must be assessed;
- test material should be extended, particularly for HDTV sequences. Sequences presenting the following features are considered useful: high details, fast motion (possibly obtained with CCD cameras), progressive format.

To facilitate the evaluations, the following elements should be provided:

- description of the system, following the outline of Rec. 723 (doc. CMTT-2/TEMP/20-E, Nov. 1991);
- characteristics from the viewpoint of resilience in the case of non optimum performance of the transmission channels;
- suitability for different distribution applications (e.g., CBR and VBR, in the ATM environment);
- features facilitating the implementation of the decoder (e.g., memory requirements, complexity of the filters).

Candidate algorithm will be evaluated by informal subjective tests of picture quality using the test sequences mentioned in section 8.2. Simulation results without decoding of the bit stream will be allowed for these tests. Doc. SRG-071 contains a detailed description of the test conditions and test results to be presented for this evaluation phase.

TG CMTT/2 will meet on November 1992, it has been agreed that the draft specification of the reference system will be completed by September 1992. Three meetings of SRG were planned at the Singapore meeting to achieve this target.

During the 8th meeting, the group could not finalize the reference model. For the meeting of TG CMTT/2, a demonstration will be prepared to show the picture quality of the scalable systems presently under discussion inside the SRG: a detailed description can be found in doc. SRG-086.

APPENDIX 1

Backgroud Information

1. Introduction

Secondary distribution must be understood as the delivery of television programmes to consumers. Particular attention must be paid to the digital delivery of television signals over future Broadband Integrated Services Digital Network (B-ISDN) which will be used for both communicative and distributive services including a whole range of visual services from videotelephony to television distribution according to future high definition standards.

To ensure that these studies are aligned with those on the broadband ISDN, the Plenary Assembly decided that CMTT should undertake its projected video coding studies for secondary distribution with the objective of consistency with the broadband ISDN being specified in CCITT Study Group XVIII and with coding for videotelephony in CCITT Study Group XV. Consistency with the video coding for broadcasting services should also be considered.

Different picture transmission requirements have hitherto led to the consideration of different bit-rate reduction algorithms for each application and each transmitting channel. For instance, CCITT Study Group XV, IWP CMTT/2 and the ISO have proposed often similar, but not identical algorithms for videotelephony, television contribution and distribution and still picture transmission respectively.

Greater compatibility between bit-rate reduction algorithms will be required for the secondary distribution of pictures (mainly, but not exclusively in the broadband ISDN).

2. Interconnection requirements

There is already an increasing need for interconnection between services and many administrations require the new HDTV service to be compatible with the television service, i.e., for a television receiver to be connectable to an HDTV source as cheaply as possible. This need is likely to develop with the arrival of new visual services in the user's premises (still pictures, videotelephony, etc.). Some terminals will even be of the "multiservice" type and will permit the reception and simultaneous display (by windowing) of several pictures (e.g., videotelephone conference picture insert on a television or HDTV screen). Because it uses ATM technology, the broadband ISDN will in addition permit the interconnection of terminals originally designed to operate at different bit-rates; in other words, terminals (and bit-rate reduction algorithms) will no longer be tied strictly to a single channel bit-rate.

The need for interconnection imposes certain constraints on the picture sampling structure. In particular, practical considerations should, as has been proposed for HDTV, be given to a hierarchy of resolution standards based principally on progressive scanning. According to this proposal, the HDTV image has twice as many lines and points per line as a conventional television image. It is even possible to extend this hierarchy to lower resolutions and consider a 1/4 TV format.

3. Compatibility

In order to meet the need for interconnection between services using different video coding standards or different picture formats, forward and backwards, upwards and downwards compatibility is desirable for secondary distribution standards. Document [CCIR 1990-1994a] gives definitions of compatibility and several compatibility methods.

A video transmission system employing two standards is:

- forward compatible if a new standard decoder is able to decode picture from the signal or part of the signal of an existing standard encoder;
- backward compatible if an existing standard decoder is able to decode pictures from the signal or part of the signal of a new standard encoder;

- upward compatible if a higher-resolution receiver is able to decode pictures from a signal transmitted by a lower-resolution encoder;
- downward compatible if a lower-resolution receiver is able to decode pictures from the signal or part of the signal transmitted by a higher-resolution encoder.

Possible compatibility methods for forward or backward compatibility are:

- simulcasting (backward, forward (optional));
- embedded bit stream (forward and backward);
- syntactic extension (forward);
- switchable encoder (forward and backward).

Standard families are those standards having many commonalities, although they need not be compatible.

Coding methods for secondary distribution of digital television should be defined with the objective of conformity with the features of the B-ISDN developed in CCITT Study Group XVIII.

Some general considerations on digital television coding for primary and secondary distribution are presented in [CCIR 1990-1994b]. An attempt was made to define a general common coding scheme for upward/downward compatible distribution of TV and HDTV in a wide range of conditions: several types of transmission channels, STM and ATM environments, constant and variable bit-rates modes, interlaced and progressive formats. The layered structure of such a coding scheme should also provide a fall-back mode for cell loss in an ATM network.

4. Codecs and display devices

Conformity of video coding studies for secondary distribution by CCITT Study Group XV and CMTT with the B-ISDN studies of Study Group XVIII will allow the advantages available through a multiservices network to be extended to the end user by minimizing the number of video terminals needed to access a range of interactive and distributive video and still image based services. The objective is to achieve the highest level of services integration through minimizing the number of coding techniques used across a wide range of video services and maximizing commonality and display devices.

To achieve this objective there will be a requirement for video terminals to be able to present video and still image material from a range of services other than that of their primary application, but within the limit of the display resolution. Thus, for example, a videotelephone terminal should be able to access and present (at the quality limit imposed by its low resolution display) a video signal originating as high resolution TV quality. The use of layered coding may be necessary to allow a terminal to extract only that part of the coded video signal that is capable of representing. This layered coding structure means that information describing the different levels of image resolution are separately transmitted in a way that permits their selective reception and reconstruction at a decoder. The coding methods may also need to be matched to the characteristics of ATM, the cell-based information transfer mode of B-ISDN.

Use of a common display device goes some way toward rationalization of a user's terminal needs for access to multiple video services. However, when this is combined with a single common decoder utilizing a layered coding structure, the objective of maximizing the commonality between interactive and distributive services can be realized. An important issue however, is where and to what extent is conversion between different video formats to be performed. The question of whether this function should be performed at the source or in the display or a combination of both, requires further study.

Another important issue requiring further study is the definition of an interface between the codec (or other video sources) and the display, including the fundamental issue of whether the interface should be analogue or digital.

5. Conclusion

Given the increasing need for compatibility between various visual services which will be eventually provided over future digital networks for distribution to the home, it will be necessary to ensure that coding algorithms have the following characteristics:

- simple, efficient and compatible coding algorithms in order to minimize the costs of terminal equipment;
- an image quality which is equivalent to, or better than that presently available at the home.

• References

CCIR Documents[1990-1994]: a. TG CMTT.2/10 (Netherlands); b. TG CMTT-2/16 (Belgium).