CCITT SGXV
Working Party XV/1
Specialists Group on Coding for Visual Telephony

Document #103R
March 25, 1986

SOURCE: CHAIRMAN OF THE SPECIALISTS GROUP ON CODING FOR VISUAL TELEPHONY

TITLE : REPORT OF THE FIFTH MEETING IN TOKYO (MARCH 25-28, 1986)

CONTENTS

1. General

The Specialists Group met in Tokyo, Japan from March 25 to 28, 1986, at the kind invitation of KDD with the support of NTT. The list of participants appears at the end of this report.

At the final session, Chairman thanked the inviting organizations for the meeting facilities and services provided and the excellent organization.

2. Documents for the Meeting

2.1 Normal Documents

#74R: REPORT OF THE FOURTH MEETING IN IPSWICH (CHAIRMAN)

Points agreed upon and/or for further study are recorded for all the aspects in order to provide backgrounds for the discussion in this meeting.

#75 : EXTRACTS FROM THE REPORT OF THE WORKING PARTY XV/1 MEETING HELD IN GENEVA (CHAIRMAN)

Items relevant to the work of the Specialists Group are presented.

#76 : SECOND REPORT ON REFERENCE SIMULATION (CHAIRMAN)

Reports participated organizations, simulation results of r.m.s. error and some suggestions to the future work.

#77 : FRAME STRUCTURE AND USER-TO-NETWORK INTERFACE FOR A m x 384 kbit/s VIDEOCONFERENCING CODECS (F.R.G.)

Usage of primary rate interface conforming to I.431, G.703 and G.704 is proposed to transmit m x 384 kbit/s signals for all m = 1, 2, ..., 5 and for both user-network application and digital link application. An indication bit for switching of the timing mode is proposed to be in bit 1 of time slot 0 of 2048 kbit/s frame structure. Time slot assignment of H_0 channels is also proposed.

#78 : A PROPOSAL FOR GENERIC STRUCTURE OF n x 384 kbit/s CODEC (NTT, KDD, NEC, FUJITSU)

Proposes a generic structure of n x 384 kbit/s codec with Transform-based coding algorithm. Introduction of an adaptive quantization and coding scheme is proposed. Other aspects such as block size, F-coder, conditional motion-compensated frame interpolation and color difference signal processing are discussed.

#79 : ADAPTIVE QUANTIZATION AND CODING (NTT, KDD, NEC, FUJITSU)

Comparing three adaptive processing algorithms, a general scheme consisting of

a. use of classification method for adaptive control,
b. adaptive selection of parameters based on the classification, and
c. use of the psycho-visual perception characteristics

is proposed.

#80 : PERFORMANCE OF F-CODER IN DCT-BASED ALGORITHM (NTT, KDD, NEC, FUJITSU)

Describes the experimental results on picture quality improvement by the F-coder for motion video as well as graphics sequences. Hardware implication is discussed. It is concluded that further study is still necessary. If time does not allow, it is suggested that F-coder be dealt with so as not to affect the essential coding part.

#81 : COMMENTS ON CONDITIONAL MOTION COMPENSATED FRAME INTERPOLATION (NTT, KDD, NEC, FUJITSU)

Discusses advantages and disadvantages of conditional motion compensated frame interpolation (CMI) in terms of coding efficiency, hardware and delay. It is proposed that adoption of CMI be decided by the evaluation of whether picture improvement is really necessary or not.

#82 : SPECIFICATION FOR THE FLEXIBLE PROTOTYPE 2ND GENERATION VIDEOCONFERENCING CODEC (U.K., F.R.G., FRANCE, ITALY, NETHERLANDS, SWEDEN)

Provides a specification which essentially the minimum implementation with which all laboratories participating in hardware construction will comply. The specification is intended to allow considerable future optimization and experimentation.

#83 : COMPARISON OF DISCRETE COSINE TRANSFORM WITH OTHER TRANSFORMS - SOME COMPUTER SIMULATION RESULTS (AT&T BELL LABORATORIES)

Presents computer simulation results with videotape demonstrations on the two methods of block quantization, one being classical DCT and the other being linear combinations of other pels. Relative implementation simplicity is sought.

#84 : BUFFER SIZE FOR THE n x 384 kbit/s CODECS (U.K., ITALY, FRANCE, F.R.G.)

Discusses several factors to determine the buffer size, decoder buffer control and delay. It is proposed that

a. minimum encoder buffer state be 50 kb,
b. clock justification not be transmitted,
c. minimum frame frequency at 384 kbit/s be 10 Hz, and
d. buffer state be transmitted in video multiplex.

#85 : VIDEO MULTIPLEX FOR n x 384 kbit/s (U.K., SWEDEN, FRANCE)

Proposes a possible video multiplex arrangement to transmit attributes defining each picture, group of block, block and image information. Variable length coding of attribute information is also considered.

#86 : CONSIDERATIONS ON THE RELATIONSHIP BETWEEN LUMINANCE AND CHROMINANCE BLOCK SIZE (CSELT, FRANCE, BT)

Compares the two approaches, one being same block size for luminance and chrominance, the other being same physical block size for luminance and chrominance. The former is preferred.

#87 : MOTION ADAPTIVE INTERPOLATION, BASED ON THE TRANSMITTED DISPLACEMENT VECTORS (F.R.G.)

Presents an example of DCT hybrid coding scheme based on a combination of object matching and block matching at 300 kbit/s.

#88 : STATISTICAL PROPERTIES AND ENCODING OF DISPLACEMENT VECTORS OBTAINED BY A BLOCK-BASED METHOD (F.R.G.)

Comparing the following three approaches;

a. Fixed wordlength coding of the displacement vector,
b. Variable wordlength coding of the displacement vector, and
c. Variable wordlength coding of the differences of horizontally adjacent vectors,

concludes that a coding standard for the transmission of displacement vectors on a block-by-block basis should allow both a transmission of vector amplitude values and vector difference values with variable word length coding.

#89 : TRACKING RANGE OF DISPLACEMENT VECTOR FOR MOVEMENT COMPENSATING PREDICTION (F.R.G., NETHERLANDS)

Compares 8 x 8 and 16 x 16 block matching displacement vector search methods for a tracking range of 8 - 24 pels to conclude that a maximum displacement of 8 is sufficient from hardware complexity viewpoint. As regards to the flexible hardware, a large maximum displacement such as 16 is suggested for real time investigations.

#90 : SWEDISH HYBRID CODING ALGORITHM (SWEDEN)

Presents details concerning the latest simulation for videoconferencing at 60 and 300 kbit/s using 8 x 8 DCT-based coding with motion compensation.

#91 : EXAMPLE OF SIMULATIONS OF THE DUTCH HYBRID CODING CONFIGURATION AT 384 kbit/s AND 64 kbit/s (THE NETHERLANDS)

Presents details concerning the latest simulation for videoconferencing at 60 and 300 kbit/s using a DCT-based coding with motion compensation.

#92 : BASICS OF CODING ALGORITHM (FRANCE, SWEDEN, THE NETHERLANDS)

Proposes basics of the coding algorithm. Pure VQ systems are abandoned and attention is focused on hybrid DPCM/Transform coding scheme. General structure of coding algorithm is described.

#93 : THE USE OF A N-DCT DEVICE TO PERFORM A N/2-DCT (FRANCE)

Describes the four possible methods to apply the same N-DCT device to both N x N blocks and N/2 x N/2 blocks. From compatibility consideration, the method to obtain the N x N block by completing the N/2 x N/2 block with zero values is favored.

#94 : VARIABLE BLOCKSIZE HYBRID CODING SCHEME (FRANCE)

Proposes a variable block size hybrid coding scheme in order to reduce 'mosquito' effect and take into account that only few pels are moving in a block. In case of 16 x 16 variable block size scheme, the effective block size after motion detection and motion compensation becomes 16 x 16, 16 x 8, 8 x 16 or 8 x 8. The technique described in Document #93 is used.

#95 : EXAMPLES OF SIMULATION WITH VARIABLE BLOCKSIZE HYBRID CODING SCHEME (DCT) AT 300 kbit/s (FRANCE)

Presents a detailed method, parameters and simulation results for the variable block size scheme described in Document #94 when applied to 300 kbit/s coding.

#96 : EXAMPLES OF SIMULATION WITH VARIABLE BLOCKSIZE HYBRID CODING SCHEME (DCT) AT 64 kbit/s (FRANCE)

Presents a detailed method, parameters and simulation results for the variable block size scheme described in Document #94 when applied to 64 kbit/s coding.

#97 : EXAMPLE OF SEQUENCES AT THE COMMON INTERMEDIATE FORMAT AND BLUR - SUPPORTING DOCUMENT FOR VIDEO TAPES FROM FRANCE AND UK (FRANCE)

Demonstrates the CIF pictures for the Split-Trevor sequence using two different spatio-temporal filters. It is pointed out that the absolute picture performance in terms of the apparent spatial definition is dependent upon not only the source coding method but also the pre- and post-processing implementation.

#98 : FORCED UPDATING (FRANCE, SWEDEN)

Analyzes the purpose, basic requirements and compression method for the forced updating. Some guidelines are proposed to include this forced updating in the source coding algorithm.

#99 : SOME CONSIDERATIONS ON QUALITY REQUIREMENTS AND NETWORK PERFORMANCE (FRANCE)

Discusses videoconference service requirements by applying G.821 error performance recommendation to a two hour session. Some points are raised as needing further study.

#100: COMPARATIVE ANALYSIS OF PRE- AND POST-CODING BUFFERS (CSELT)

Presents merits and drawbacks to the following two basic philosophies for the buffering function.

a. A buffer is placed before the coder thus containing uncoded data.
b. A buffer is placed after the coder thus containing coded data.

#101: MOTION VECTOR CODING (U.K., FRANCE, F.R.G., NETHERLANDS, SWEDEN)

Expresses the European view to the problem of whether motion vectors should be transmitted as interblock motion vector difference (relative) or as independent values (absolute), requesting further consideration before formal proposals be made at the next meeting.

#102: VIDEO MULTIPLEX FOR n x 384 kbit/s (U.K., SWEDEN, FRANCE)

Revised version of Document #85 reflecting the discussion at the present meeting.

2.2 Temporary Documents

No. 1	Agenda (Chairman)
No. 2	Available Documents and Discussion Points (Chairman)
No. 3	Discrete Cosine Transform Equations (Chairman)
No. 4	Comparison of Coding Algorithms (France)
No. 5	Framework of Adaptive Quantization and Coding Strategy (France)
No. 6	List of Attributes (France)
No. 7	An Example of Encoding of Block Attributes (France)
No. 8	Draft Report of the Fifth Meeting in Tokyo (Chairman)
No. 9	32 Quantization Strategies and One Reference Model (Coding Algorithm Sub-group)
No. 10	Specification for the Flexible Prototype 2nd Generation Videoconferencing Codec (Flexible Hardware Sub-group)
No. 11	Intellectual Property Issue (Chairman)

3. Report of the Working Party Meeting (# 75)

Chairman reported the results of the Working Party XV/1 meeting held in Geneva last February, selecting the following items relevant to the work of the Specialists Group.

1) Approval of the Specialists Group progress report covering the two meetings held in Torino and Ipswich

2) Functional requirements for videoconferencing system, especially the principle established to select essential and optional functions

3) Framework for multipoint videoconferencing study

In addition to these, exclusive use of notations n x 384 kbit/s for bit rate and MCU for multipoint control unit were reported.

4. Report of Reference Simulation (#76)

Chairman reported the participated organizations, simulation results of r.m.s. error and comments concerning calculation accuracy, concluding that the objective of this reference simulation to ensure we are carrying out computer simulation on the same basis was achieved.

5. Video Source Coding

Reference was made to Documents #78-81, #83, #86-98. After presentation of the documents, various demonstrations of source coding simulation results were also given. An overview of these tape demonstrations is listed here.

a. Pre- and post-processing concerning TSC to and from CIF (France and UK; #87)
b. DCT-based algorithm (Japan; #78)
c. VQ-based algorithm (Japan; #78)
d. Comparison of adaptive processing (Japan; #79)
e. Effectiveness of F-coder (Japan; #80)
f. Effectiveness of conditional motion-compensated interpolation (Japan; #81)
g. Comparison of DCT and an easily implementable transform (U.S.A.; #83)
h. Motion adaptive interpolation base on a combination of object matching and block matching (F.R.G.; #87)
i. DCT-based algorithm at 60 and 300 kbit/s (Sweden; #90)
j. Comparison of DCT and HCT (Sweden; for information)
k. DCT-based algorithm at 60 and 300 kbit/s (The Netherlands; #91)
l. Variable blocksize DCT-based algorithm at 64 and 300 kbit/s (France; #95, 96)

A number of topics, related to the source coding, have been discussed toward defining the prototype hardware specifications. The outcome of this discussion is summarized here.

5.1 Basic Algorithm (#78, #90, #91, #92, #94, #95, #96)

It was agreed to use 'interframe/intraframe prediction + Transform' as a basic algorithm for the second generation n x 384 kbit/s codec (n = 1-5) at this meeting, since all proposals converged into that one starting from the agreement at the Ipswich meeting, 'interframe prediction + Transform and/or VQ'.

5.2 Transform (#83)

Since the specification for Transform is closely related to block size, which is the most influential factor for designing prototype hardware, these two items were discussed together.

Considering that we are going to construct a flexible hardware which enables us to reflect the advances expected during 1986/87, we agreed to take a matrix multiplication approach. The flexible transformer consists of;

- 2 one dimensional separable transforms with 8 x 8 matrix multiplication
- programmable coefficients
  - independent horizontal and vertical coefficients
  - independent forward and inverse transform coefficients
- As a preliminary specification the inverse transformer hardware should allow for 12 bit resolution in (ie coefficients) and 9 bits out.

It was also agreed to start with DCT for compatibility check. If new proposals will be made during the optimization work using the flexible hardware, then DCT will be replaced by the new transform at the final CCITT recommendation.

5.3 Block Size (#78, #86, #93)

An extensive discussion was carried out on the problems of whether the block size be:

- fixed size or variable size,
- 8 x 8 or 16 x 16,

taking into account the various factors such as coding efficiency, picture quality, hardware complexity, compatibility with m x 64 kbit/s codec, relation with motion compensation.

The meeting agreed on

- fixed size
- 8 x 8

as the results of discussion.

As to the block size choice for luminance block and chrominance block, the use of the same block size for both was decided. This implies that the chrominance block is 4 times larger than the luminance block in physical size when applied to full resolution Common Intermediate Format.

5.4 Adaptive Processing (#79, #90, #91, #94-96; TD No. 3-5, 9)

Adaptive processing means both adaptive quantization and adaptive variable length coding. Though this processing constitutes the core part of the coding algorithm, a divergence is found among various schemes simulated. In order to identify the commonality and difference among them, Mr. Guichard provided a comparison table (TD NO. 4).

After discussion using this table and also presented documents, it was recognized that establishing a framework for further study is useful to make convergence as quickly as possible on this important issue. Mr. Temime provided a draft (TD NO. 5), which was approved by the meeting and reproduced as Annex 1 to this report.

In order to further clarify the problems and the tasks to be completed toward the next meeting, a sub-group was coordinated by Mr. Guichard. The report of this sub-group meeting is included in this document as Annex 2.

5.5 F-coder (#80)

A follow-up work was presented on the evaluation of effectiveness and hardware implication of the F-coder. The meeting agreed on the proposal that this F-coder be dealt with as an option and that a detailed scheme would be provided before the next meeting.

5.6 Chrominance Signal Processing (#78, #90, #91, #94-96)

It was confirmed in Ipswich that the compatibility among different design codecs be ensured through the specification to the video multiplex. However, methods of chrominance signal processing, whether it is processed in time series or in parallel with luminance signal, are related to the order of multiplexing.

Two methods of chrominance signal processing were compared: one using the TDM format approach as shown in Fig. 2/#78 and the other using the Group of Blocks approach as shown in p.6/#90.

From delay point of view, the meeting concluded that the second method is preferable and agreed on such order of multiplexing in the video multiplex coder as shown in Figure 1.

A consideration for selecting the order of C_R and C_B is that the component more sensitive to human observers should come first.

Though the number of pels per line for chrominance signals in Common Intermediate Format was decided as 180 in Ipswich, subsampling may be practical for moving pictures. The issue was recalled which of pel domain processing or transform domain processing be more suitable. It was pointed out that blocking may appear if transform domain processing is introduced while video multiplex may become complex if pel domain processing is introduced. The crucial data on percentage of chrominance bits to total bits for coded pictures are lacking. Contributions are requested toward the next meeting to make a decision on this matter.

As a consequence of the choice of 8 x 8 block size, an inconvenience was pointed out that the number of chrominance samples per line, 180, can not be divided by 8. It was also suggested that if number of chrominance blocks is reduced to 22 per line, that of luminance blocks should better be reduced to 44 accordingly, implying a slight modification to the effective basic parameters. This point is for further study till the next meeting.

5.7 Forced Updating (#98)

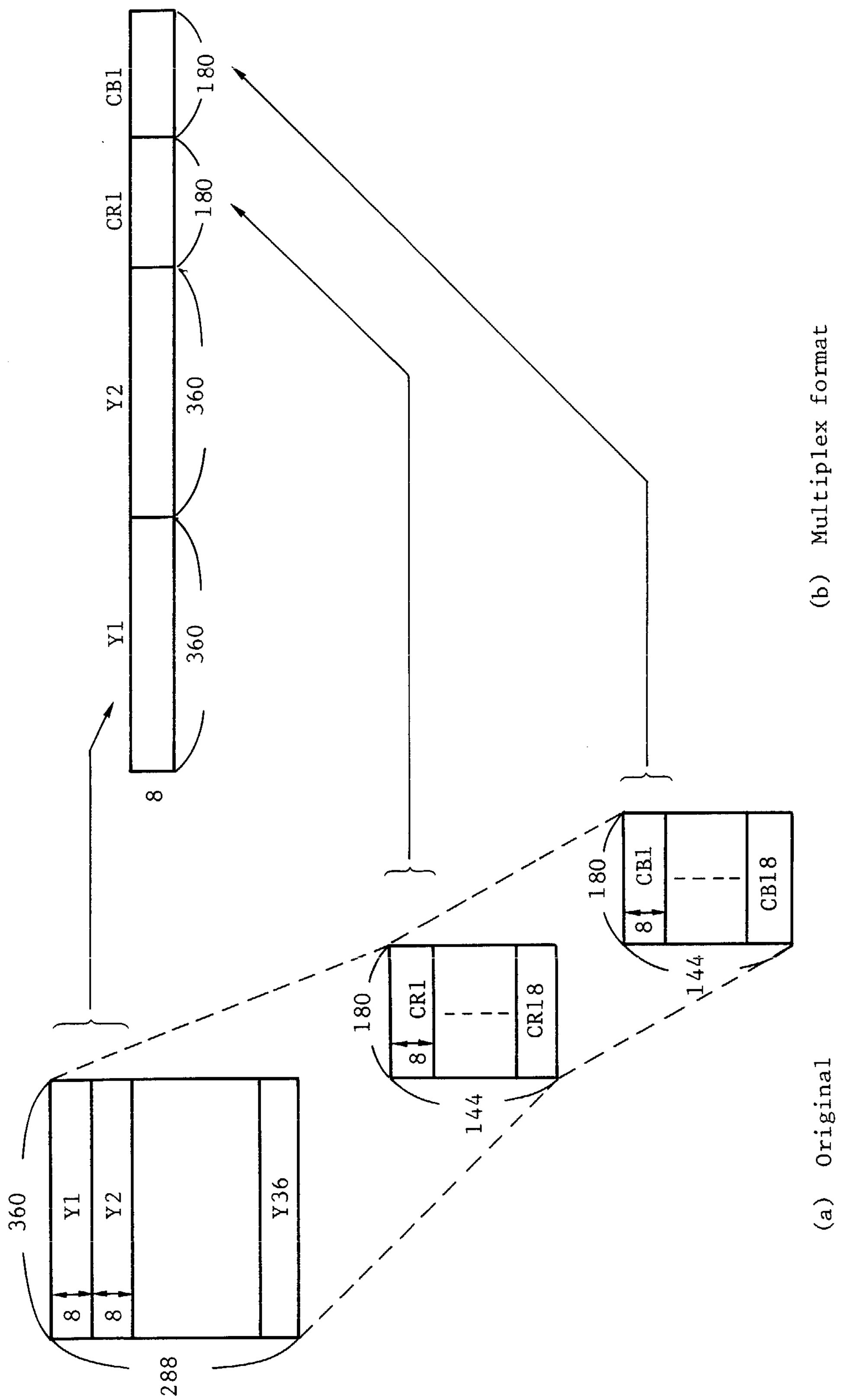


Figure 1. Video multiplex format

The conclusion of Document #98 was recognized as a common understanding of the meeting.

- Forced update is necessary and should not require a special mode or extra signalling.
- Block encoding should be made using intraframe coding with a sufficient quality.
- In the coding strategy of the encoder, the potential quality and its corresponding coding parameters (ie number of bits per block, quantizer stepsize, scanning patterns) may not depend on the buffer state but be used and signalled independently.

It was also understood that various updating patterns should be tried with the flexible prototype hardware and an appropriate pattern may be recommended, though it is not concerned with compatibility.

Further study is requested to define the details of the fast update based on the above principles.

5.8 Motion Estimation (#88, #89, #101)

After consideration of the data shown in the documents, error resilience, panning situations expected at n = 1 of n x 384 kbit/s and simplicity, the meeting agreed that;

1) Variable length coding is used for the motion vector transmission.
2) Though the simulation results show a maximum displacement of 8 is sufficient, tracking range for prototype should be $\pm 15 \times \pm 15$. After real time hardware investigations, it is envisaged that the final specification will eventually be less than that, say $\pm 8 \times \pm 8$.

On whether motion vectors are transmitted as interblock motion vector differences (relative) or as independent values (absolute), the following summary was provisionally prepared as a working basis. Further contributions are requested so that we can make a decision at the next meeting.

"Motion vectors should be transmitted on a per block basis in absolute terms. A motion vector may be contained in both the Picture Start Code and the Group of Blocks Start Codes to cope with the case of correlated motion in a large part of the picture (e.g. panning). The relationship between the block motion vectors and the vectors in the Picture and Group of Blocks Start Codes is for further study."

5.9 Pre-processing (#97)

With document and tape demonstration, two methods of television standards conversion to and from the Common Intermediate Format were compared. It was observed that with a 35 tap horizontal low pass filter, the stripes in Trevor White's shirts can be reproduced, while with a 5 tap horizontal low pass filter the stripes are present but less visible. This fact suggests that we should be careful of what temporal and spatial filtering is used in pre- and post-processing when we discuss the resolution of coded pictures.

5.10 Motion-compensated Interpolation (#81, #83, #87)

Since motion-compensated interpolation at the decoder alone is a kind of post-processing and does not affect the compatibility, conditional motion-compensated interpolation (CMI) was discussed where interpolation error is transmitted. The followings were agreed upon.

- CMI may be an optional function. The decoder without CMI should be able to disregard the interpolation error information received.
- CMI should not affect the content of the frame memory inside the essential coding loop.
- Video multiplex structure will be capable of transmitting this data if CMI is agreed as an option.

5.11 Coding Mode Control

It was confirmed that coding mode control is left to each codec design.

6. Video Multiplex Coding (#85, #102; TD No. 6, 7)

Document #85, Temporary Documents No. 6 and No. 7 were recognized as good input to the Group, and the meeting supported the concept of video multiplex coding using attribute method. The materials, however, are rather new to members outside Europe, and some time is necessary for reviewing.

Mr. Carr undertook a work to revise Document #85 taking into account the suggestions contained in Temporary Documents No. 6 and 7 to issue Document #102, which was reproduced as Annex 3 to this meeting report. This document forms a working basis for further study. Full examination is requested of all members to complete the specifications for flexible prototype hardware at the next meeting.

7. Transmission Buffer (#84, #100)

Several aspects concerning buffering were presented with documents. After some discussion, the following points were recognized as common understanding.

1) Encoder channel buffer size should be 64 Kbits for the flexible prototype hardware (Notes 1, 2, 3).
2) Clock justification should not be transmitted.
3) Encoder channel buffer state should be transmitted in the video multiplex.

Note 1: K=1024
Note 2: From buffer point of view, this 64 Kbits size implies minimum of approximately 7.5 Hz picture frequency.
Note 3: This consideration is applied to n = 1 only for n x 384 kbit/s. For higher values of n, further study is needed.

8. Transmission Coding

8.1 Error Performance (#99)

Mr. Temime introduced an error performance consideration in which Recommendation G.821 was applied to a two hour session of videoconference. Implications are;

BER = 0	at least 6600 error free seconds,
$10^{-6} <$ BER $< 10^{-3}$	no more than 12 degraded minutes,
BER $> 10^{-3}$	no more than 15 severely errored seconds.

The meeting took note of this consideration and recognized the following points needing further study.

1) Is G.821 appropriate for videoconferencing application from service providing point of view? If no, we should request SGXVIII to give an alternative standard.

2) Types of error should be clarified. Behavior of codecs may be different to random errors and burst errors.

3) Is use of the longest HRX of 27500 km appropriate for videoconferencing?

4) Should error resilience approach better be taken than error correction approach?

8.2 Frame Structure (#77)

Use of 2048 kbit/s interface conforming to I.431, G.703 and G.704 was proposed to transmit n x 384 kbit/s videoconferencing signals for all n = 1, 2, ..., 5 and for both user-network application and digital link application. An indication bit for switching of the timing mode was proposed to be in bit 1 of time slot 0.

The meeting confirmed that;

1) Primary rate interface will be used at the output of the transmission coder of the n x 384 kbit/s codec to both the network and the digital link.

2) An indication bit for switching of the timing, synchronous or asynchronous with the network timing, is necessary.

3) Proposed time slot assignment (Table 2/#77) for Ho channels has been agreed in Europe.

As for the indication bit, however, it was pointed out that in 1544 kbit/s interface, there is no room for such an outslot end-to-end signalling bit. Further considerations and corresponding proposals are requested of countries using 1544 kbit/s as digital primary rate. Mr. Zedler stated that F.R.G. will raise this issue also in SGXVIII.

9. Experimental Hardware Specifications (#82; TD No. 10)

Document #82 was introduced as a first step to specify the flexible prototype hardware. To reflect all the items discussed during this meeting, review of this document was carried out item by item. The following comments were given during the discussion, excluding those points already recorded in the previous sections of this meeting report.

1) 'Minimum implementation' means the things everybody must do who participates in the compatibility check. Any additional functions tried by each participating member should be able to be by-passed.

2) Effectiveness of fractional motion vectors should be considered by the next meeting.

3) The priority to the three methods concerning chrominance motion vectors suggested in the document may be;

   i) derived from luminance
   ii) none
   iii) independent.

   Contributions are requested to make a decision at the next meeting.

4) Addressing methods of blocks, whether absolute or relative, should be compared. BT undertook to make a contribution toward the next meeting.

In order to draft a specification for the flexible prototype hardware, a sub-group was coordinated by Mr. Morrison. The outcome of the sub-group meeting is included in this report as Annex 4.

Since it is intended to complete this draft at the next meeting, each member is requested to provide sufficient information for specifying the items left for further study and also to propose the missing items with contents.

10. Others

10.1 Intellectual Property (TD No. 11)

Each country/organization was asked;

a. If they had patents covering fundamental aspects of the group's work, and
b. Their policy in the case that they had or would have such patents.

U.S.A.

CLI
a. Have 3 patents in general area but believe are not applicable to fundamental algorithm at the present time. Believe possible for group to navigate around. No patents in the pipeline either, affecting this group.
b. No statement on infringement policy.

PICTEL
a. Patents being processed do not conflict with work of this group at the present time.
b. No statement on infringement policy.

AT&T
a. Have several patents but mostly covering DPCM schemes. Many will expire soon. One on Motion Compensated Interpolation, but this is optional feature and does not impinge on compatibility.
b. Fair and reasonable terms.

General U.S. position has been to support the licensing arrangements used by the ANSI organization; i.e. that licensing should be on a non-discriminatory basis with fair and reasonable royalties.

Italy (CSELT)

a. Have some patents on transform implementation and classification. Difficult to judge if they relate to the group.
b. In principle would like to follow CCITT practice.

France (CNET)

a. Two patents relate to DCT implementation. One related to use of post decision on inter or intra coding but not fundamental aspect of group's study.
b. Will follow general guidelines on this issue which are decided at a higher level.

The Netherlands

a. No patents.
b. In principle would like to follow CCITT practice.

U.K.

a. BT may have patents which are relevant but depend on future work in group.
b. BT would expect that free license would apply to any item which was fundamental. Fundamental meant affecting commercial viability of product.

Sweden

a. No patents which would affect the group.
b. In principle would like to follow CCITT practice.

Japan

a. May have some patents.
b. Non exclusive license with reasonable terms.

F.R.G.

a. DBP does not have any such patents.
b. Support policy of free license on standardization and compatibility issues.

Canada

a. Thought no problem with existing or pending patents.
b. No statement on infringement policy.

10.2 Future Work Plan (Annex 4/TD No. 1)

It is envisaged that compatibility check at laboratories will be commenced in spring, 1987. Those who participate in this compatibility check are also expected to join the international field trial.

10.3 Future Meetings

1) Sixth meeting

- June 17-20, 1986
- BNR (Montreal)
- Topics
  - Source coding algorithm
  - Video multiplex coding
  - Transmission coding
  - Multipoint aspects (new item, contributions requested)
  - Completion of specification of the flexible prototype hardware

2) Seventh meeting

- September 23-26, 1986 (tentative, subject to change according to the achievements in Montreal)
- Nürnberg

Annex 1: Framework of Adaptive Quantization and Coding

Annex 2: 32 Quantization Strategies and One Reference Model

Annex 3: Video Multiplex for n x 384 kbit/s

Annex 4: Specifications for the Flexible Prototype 2nd Generation Videoconferencing Codec

LIST OF PARTICIPANTS
(Tokyo, March 25 - 28, 1986)

Chairman	S. Okubo	- NTT
Core Members		
F. R. of Germany	J. Speidel	- PKI/TEKADE
	G. Zedler	- FTZ
Canada	S. Sabri	- BNR
U.S.A.	B. G. Haskell	- AT&T Bell Lab.
	R. A. Schaphorst	- DIS
France	J. Guichard	- CNET
	J. P. Temime	- CNET
Italy	L. Chariglione	- CSELT
Japan	Y. Hatori	- KDD
	N. Mukawa	- NTT
Netherlands	F. Booman	- DNL
United Kingdom	D. Bonnie	- GEC Video Systems
	D. G. Morrison	- BT (acting for R. Nicol)
Sweden	H. Brusewitz	- Swedish Telecom Admin. (acting for R. V. Campenhausen)
	P. Weiss	- Swedish Telecom Admin.
Assisting Experts		
F. R. of Germany	W. Geuen	- FTZ-FI
U.S.A.	S. Ericsson	- Pictel Corp.
	G. J. Pearson	- CLI
Japan	M. Kaneko	- KDD (Secretary)
	Y. Kato	- NTT
	T. Koga	- NEC
	K. Matsuda	- Fujitsu
United Kingdom	M. Carr	- BT
	J. Mason	- GEC Research

Annex 1: FRAMEWORK OF ADAPTIVE QUANTIZATION AND CODING STRATEGY

In the encoder, several steps are performed in addition to prediction and transform:

- classification process which is not subject to standardization and may be left to each implementation
- quantization
- variable length coding
- transmission of coefficients and side information

For a coder working of the decoder, it is necessary to standardize:

- what is transmitted
- which quantizer is used
- which code set of VLC is used
- which class is used

1. Transmission

Class number
Quantizer stepsize/scaling factor
Coefficients
End-of-block (EOB)

2. Quantizer

Each quantizer is characterized by:

Its structure (linear, non-linear)
Its stepsize
Its number of levels (consequently the VLC attached to it)

3. Variable Length Coding

Each VLC code set is characterized by the quantization index vs code word.

4. Class

Each class is characterized by:

The way the block is scanned
The quantizer assignment for each coefficients
The VLC code set assignment for each coefficient

Further considerations:

a) The classification, ie how the number is chosen for a given block, does not require standardization.

b) The buffer control can be used together with the classification to determine the choice of the quantizer stepsize and the number of coefficients to be transmitted (ie the place of EOB).

c) Forced update blocks can be transmitted with a sufficient quality independently of the buffer control. A class has to be chosen with a small stepsize and a large number of transmitted coefficients. The way the class and the stepsize are chosen and also the blocklength need not to be standardized.

d) The same quantizer stepsize may be used for the whole frame or a whole group of blocks. In that case, the corresponding attribute is transmitted in the PSC or the GBSC and need not to be transmitted anymore with each block.

Annex 2: 32 QUANTIZATION STRATEGIES AND ONE REFERENCE MODEL

Five pairs of items have been identified. Either one element of a pair must be used or the other one. It leads to 32 quantization strategies which will have to be compared to a reference model.

Item 1
- a) Zonal technique
  Maximum number of zones: 64
- b) Scanning technique + end of block
  Maximum number of class: 8 (scanning) x 64 (EOB)

Item 2
- a) The quantization is independent of the classification
- b) The quantization is related to the class

Item 3
- a) The use of one quantizer per block
- b) The use of several quantizers per block

Item 4
- a) The quantization is related to the buffer fullness only
- b) The use of an adaptive quantization

Item 5
- a) A single VLC is used per block
- b) Several VLCs are used per block
  Maximum number: 8

It has been decided that 1b-2a-3a-4a-5a is the reference model assuming that;

1. Item 1b: The diagonal scanning is used (see Appendix 1). The non-zero coefficients are obtained after thresholding: the threshold is the first step of the quantizer.

2. Item 3a: The quantizer is uniform.

3. For 'step size + threshold + VLC', see Appendix 3.

4. Motion estimation is achieved by block matching technique with a window search of $\pm$ 7.
   - Integer displacement only.
   - Coarse-fine 3 steps algorithm (see Appendix 2) is used.
   - Non-zero motion vectors are transmitted by using an 8 bit FLC.

5. Absolute addressing: 1 bit per block.

6. Inter/intra modes and how to handle a scene cut: see Appendix 4.

7. Overhead according to Temporary Documents No. 6 and 7. The FLC (3 bits) depicted in Section 3/Temporary Document No. 6 must be used.

8. No pre-processing, no post-processing is allowed.

9. No filtering in the loop is allowed.

10. Classical DCT (a) of Temporary Document No. 3.

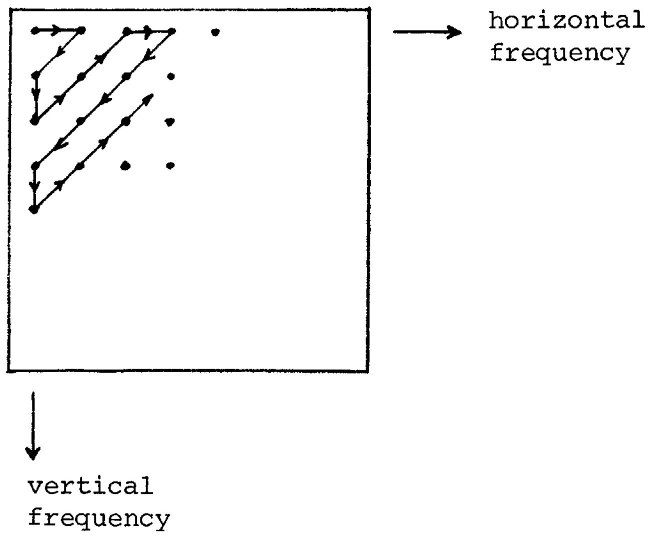
11. The same sequences at the Common Intermediate Format must be used: Miss America is OK; Checked Jacket will be provided by Japan; Split-Trevor will be provided by Europe.

12. Buffer size: 30 kbits.

13. No motion vector for chrominance.

Appendix 1: Diagonal Scanning

The transform coefficients are transmitted in the following way:



That means:

DC, first horizontal frequency, first vertical frequency, ...

Horizontal frequency corresponds to vertical lines in the picture.

Appendix 2: Motion Estimation

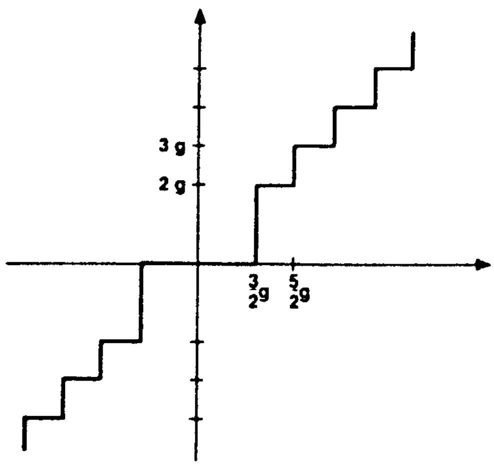
1	1	1		1				1
			2	2		2		
					3	3	3	
1	1	1	2	1	3	2	3	1
					3	3	3	
			2	2		2		
1	1	1		1				1

Coarse-fine 3 steps algorithm

1: first step
2: second step
3: third step

Appendix 3: Quantizer, VLC and EOB

Uniform quantizer is defined by the step size g. The quantizer has a threshold with value 1.5g.



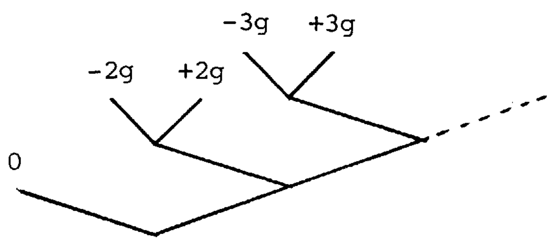
Example: A transform coefficient F

$$1.5g \leq F < 2.5g$$

is quantized to the value $\hat{F} = 2g$.

The dynamic range is + 2048. Step size is related to uniform transform, alternative (a)/Temporary Document No. 3.

The same quantizer is used in both inter- and intra-frame coding and also in both luminance and chrominance coding. Quantized transform components are coded with the following VLC.



0	→ 0
-2g	→ 100
+2g	→ 101
-3g	→ 1100
+3g	→ 1101
	.
	.
	.

EOB (End Of Block) is transmitted by indicating the number of non-zero components in each block with the following VLC.

1 non-zero	1 bit
2 non-zeroes	2 bits
3 non-zeroes	3 bits
.	
.	
.	

Appendix 4: Inter/intra Mode Switch and Scene Cut

1. Inter/intra-frame switch

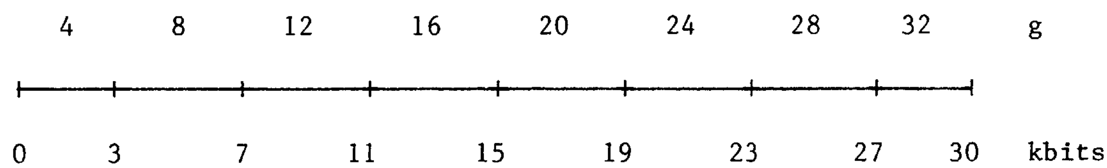
   a) Block based.
   b) The block values are first subtracted from a median grey level (level 128) and then squared. If the resulting value is greater than the prediction error squared of the corresponding block, then interframe mode is used.

2. Scene cut

   In the case of scene cut, intraframe mode is used. To overcome the problem of a buffer overflow, the previous picture should be repeated, that means, for the first picture after the scene cut, the amount of bits available is twice compared with the average amount of bits per picture.

Appendix 5: Buffer Control

Quantizer step size g is chosen for each block, and indicated with 3 bits. Step size is chosen as a function of buffer content:



Annex 3: VIDEO MULTIPLEX FOR n x 384 kbit/s

1. Introduction

In the design of any video multiplex there is a compromise between absolute efficiency and error performance. Most simulations to date have been concerned only with efficiency. An example of this is to simply allocate one bit per block to indicate whether any particular block has data associated with it. In the case of a transmission error whole fields of data are lost which is catastrophic in a codec which relies heavily on interframe coding. The opposite extreme is to give each block an absolute address within each field. In this case efficiency suffers.

The following proposal is a fairly simple compromise where absolute addressing is used for each line of blocks and a more efficient relative addressing mode is used between blocks. This will contain errors to within one or two lines of blocks without significantly reducing efficiency.

2. Possible Video Multiplex Arrangement

i. Picture Start Code (PSC)

1000 0000 0000 0000 0000 [Buffer State] [Temporal Ref.] [Type]

Buffer State:- 6 bit number representing the encoder buffer fullness in 1Kbit intervals at the beginning of the current picture.

Temporal Ref.:- A three bit number representing the time sequence in 1/30 sec. intervals of a particular picture. All Picture Start Codes should be transmitted.

Type:- This is a VLC code which allows block attributes to be applied to all blocks within a field (eg. all blocks may be intraframe coded or non-motion compensated). This saves overhead by removing the requirement to signal Block Type on a per block basis. Possible attributes are shown in Appendix 1.

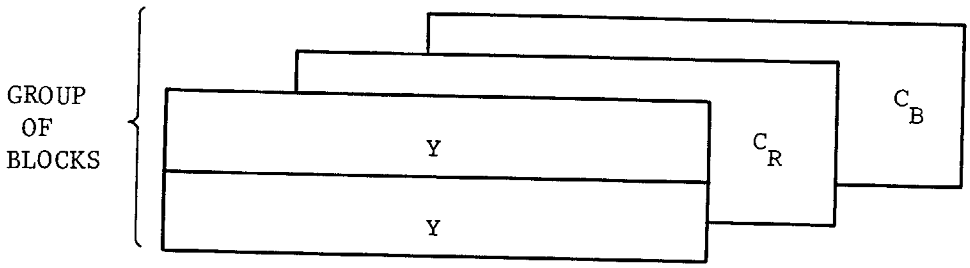
NB: The exact bit pattern and the word length of the Picture Start Code will depend on the VLC code set chosen and is for further study.

ii. Group of Blocks Start Code (GBSC)

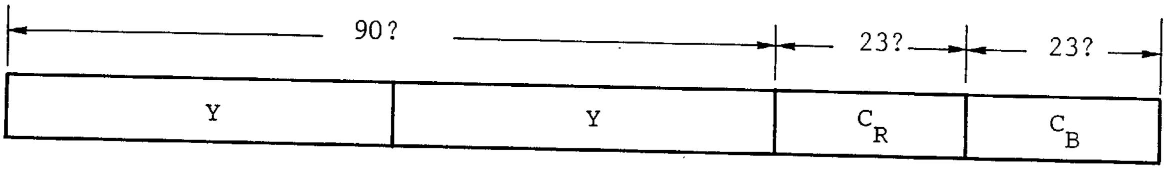
1000 0000 0000 1111 [GBSC Number] [Type]

Block Line Number:- A six bit number representing the vertical spatial position in blocks of the current group of blocks. All line of block codes should be transmitted.

NB: A group of blocks consists of two lines of luminance blocks, one line of C_R blocks and one line of C_B blocks. This will mean that a Group of Block Start Code defines the beginning of a physical region of picture (luminance and colour differences) outside of which errors are unlikely to extend. (See below).



PICTURE INFORMATION CONTAINED IN A GROUP OF BLOCKS



ORDER OF BLOCKS TRANSMISSION

NB: C_R and C_B are colour differences.

The exact bit pattern and the word length of the Group of Blocks Start Code will depend on the VLC code set chosen and is for further study.

Type:- This is a VLC code which allows block attributes to be applied to all blocks within a group of blocks (eg. all blocks may be intraframe coded or non-motion compensated). This saves overhead by removing the requirement to signal Block Type on a per block basis. Possible attributes are shown in Appendix 1.

iii. Block Address

[Block Address]

A VLC code indicating the relative position of a moving block (relative to the previous block or picture boundary).
Addresses of absolute position greater than 90? are considered to be chrominance blocks.

iv. Block Type

[Block type]

A VLC code representing the type of the block (possible attributes are described in Document #69). Possible types are:-

- i. Intraframe coded block
- ii. Interframe coded block
- iii. Motion compensated block
- iv. Motion compensated with coded residue
- v. Future expansion on
- vi. Future expansion off

Codecs should be designed to ignore all data between types v. and vi., also between type v. and the next GBSC. This will allow us to efficiently include some enhancements at a later date without affecting compatibility. (NB: to do this we must define some limitations on the structure of the future expansion data.) Possible block attributes are shown in Appendix 1. An example of how to encode the block attributes is shown in Appendix 2.

v. Block Data

[Data]

The exact form of this is for further study.

3. Typical Data Structure

[PICTURE START CODE 1] [PICTURE START CODE 2] [PICTURE START CODE 3] ... [GBSC1] [GBSC2] [GBSC3] [BLOCK ADDRESS]...
... [BLOCK TYPE] [BLOCK DATA] [BLOCK ADDRESS]...
... [BLOCK TYPE] [BLOCK DATA] [GBSC4] [GBSC5]...
... [GBSC6] ... etc.

4. Generalized VLC

It would be highly desirable to be fixed on one VLC code book which can be used for all situations where VLC occurs. This will both simplify hardware and aid retracking when transmission errors occur.

Appendix 1: LIST OF ATTRIBUTES

1. Picture Attributes

Buffer state
Temporal reference
Use of motion compensation
Intraframe mode
Global motion vectors
Global quantizer stepsize

2. GOB Attributes

GOB number
Global motion vector
Global quantizer stepsize

3. Block Attributes

Fixed/Non fixed block
No MC/MC (+ motion vector)
Non coded/Coded
Interframe/Intraframe
Class number
Quantizer stepsize
EOB (or block length)

Appendix 2: AN EXAMPLE OF ENCODING OF BLOCK ATTRIBUTES

Block type	Attributes (Doc. #69) ≠1	≠2 (Note 1)	≠3	≠4	FLC	Example of VLC (Note 2)
1. Fixed	0	-	-	-	000	0
2. Intraframe	1	0	1	0	001	11100
3. Interframe/No MC	1	0	1	1	010	110
4. MC - No coding	1	1	0	-	100+MV	11110+MV
5. MCw/coding	1	1	1	-	101+MV	10+MV
6. MC - No coding + global MV	1	1	0	-	110	11101
7. MCw/coding + global MV	1	1	1	-	111	11111

Note 1: Attributes according to Document #69

≠1: Fixed/Non Fixed ≠2: No MC/MC
≠3: Non coded/Coded ≠4: Intra/Inter

Note 2: If relative addressing is used then the first bit of the VLC set may be removed.

Annex 4: SPECIFICATION FOR THE FLEXIBLE PROTOTYPE 2ND GENERATION VIDEOCONFERENCE CODEC

The aim has been to produce a specification which essentially is the minimum implementation with which all laboratories will comply. The specification will provide considerable scope for optimization and experimentation.

We would expect that the final Recommendation to be produced in early 1988 would be significantly different as it would reflect advances made during 1986/87. It would also have the areas of flexibility removed.

An outline block diagram of the codec is given in Fig. 1.

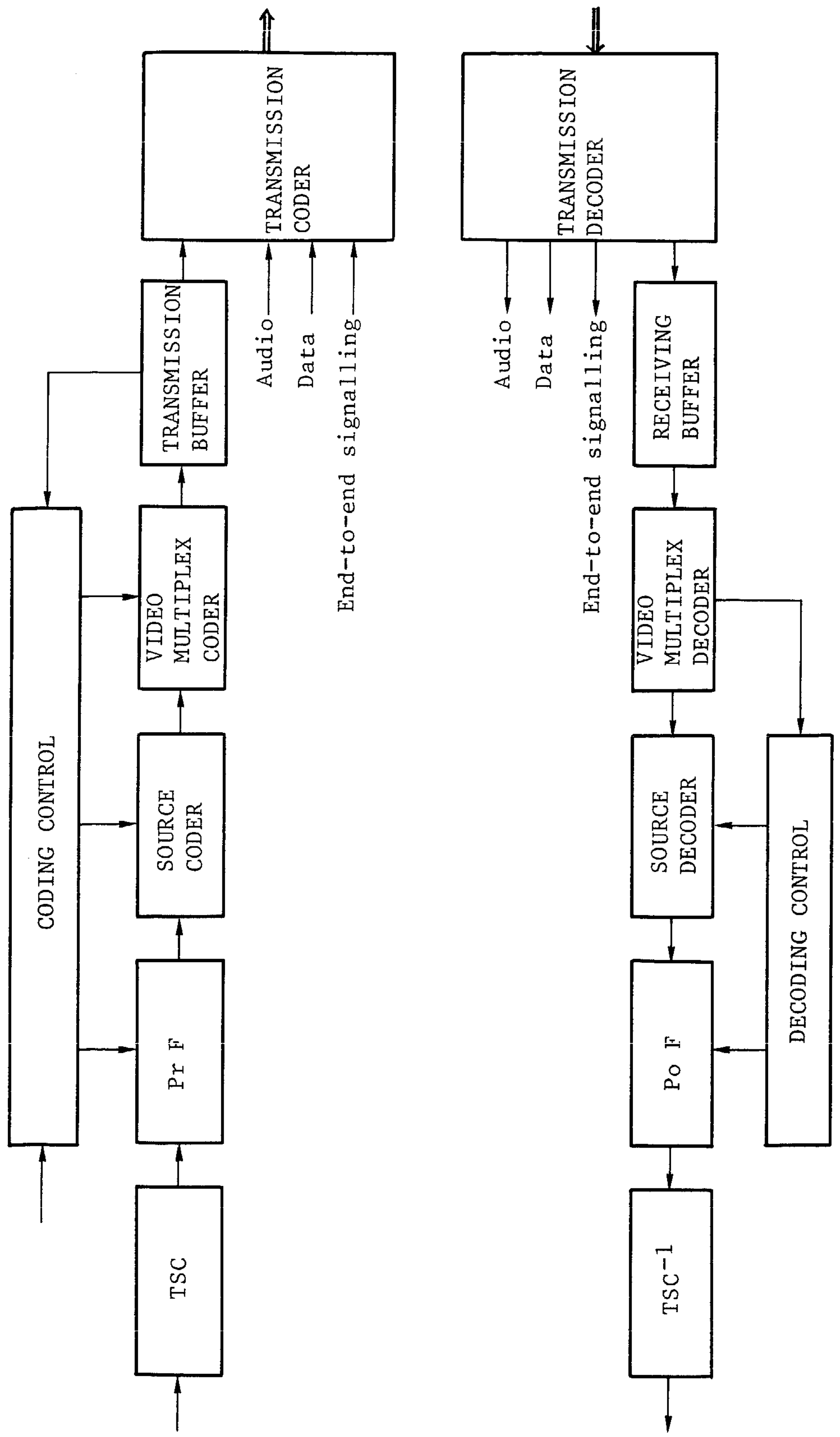

TRANSMISSION CODER
TRANSMISSION DECODER
TRANSMISSION BUFFER
Audio
Data
End-to-end signalling
Audio
Data
End-to-end signalling
RECEIVING BUFFER
CODING CONTROL
VIDEO MULTIPLEX CODER
VIDEO MULTIPLEX DECODER
SOURCE CODER
SOURCE DECODER
DECODING CONTROL
Pr F
Po F
TSC
TSC-1

Fig. 1

CONTENTS

1. Source Coder

1.1 Source Format

1.1.1 The format to be coded is 288 lines, 30000/1001 (approximately 29.97) non-interlaced pictures per second - the Common Intermediate Format. The tolerance on the picture frequency is ± 50 ppm.

1.1.2 Pictures are coded in component form, these components being luminance (Y) and two colour difference signals C_R, C_B.
There are 360* luminance pels per line with an orthogonal sampling pattern. The colour difference sampling parameters are 180* samples per line, 144 lines, orthogonal. Both C_R and C_B samples are sited such that their block boundaries coincide with luminance block boundaries. (See Table 1 and Fig. 2)

* The number of effectively transmitted pels may be changed to 352 and 176 respectively.

1.1.3 Source format codes correspond to CCIR Recommendation 601:

Black = 16
White = 235
Zero colour difference = 128
Peak colour difference = 16 and 240

Codes outside the above ranges will be accepted but may be modified by the coder to avoid emulation of reserved codewords.

1.2 Video Coding Algorithm

1.2.1 The video coder algorithm is shown in a generalized form in Figure 3. The coding scheme utilizes a block transform. The predictor may incorporate motion compensation.

1.2.2 Motion compensation is optional at the coder. The decoder will accept one motion vector for each luminance block of size 8 pels by 8 lines. The maximum motion vector is ± 15 pels and ± 15 lines. Only integer values of the horizontal and vertical components of the vector are currently considered. Fractional values will be considered for possible inclusion at the Montreal meeting 1986. (Note: The encoding method for transmission of motion vectors may restrict the vectors to a subset of all these possible values that the decoder hardware can accommodate. This will be specified later.)

Chrominance displacement vectors?
(None, independent or derived from luminance.)

Table 1. Basic parameters for the new generation n x 384 kbit/s CODEC

Items	Parameters
1. Reference point	Point B in Fig. 1/Annex 1 to COM XV-R 4
2. Baseband signals and their levels	Y, R-Y, B-Y, as defined in CCIR Rec. 601
3. Number of pels per line	Y: 360 (Note 1) R-Y: 180 B-Y: 180
4. Number of lines per field	Y: 288 (Note 2) R-Y: 144 B-Y: 144
5. Field frequency	Y, R-Y, B-Y: 29.97 Hz
6. Interlace	Y, R-Y, B-Y: 1:1
7. Sampling structure	Y, R-Y, B-Y: orthogonal, positioning of R-Y and B-Y samples share the same block boundaries with Y samples as shown in Fig. 2

Note 1: Active line duration is approximately 53 us.

Note 2: Active field duration is approximately 18.4 ms (for 625/50 systems) and approximately 15.2 ms (for 525/60 systems).

Note 3: The common intermediate format defines the maximum attainable spatial and temporal resolution in the codec. Effective resolution may eventually be reduced by some coding operating modes.

Note 4: The common intermediate format is a logical specification to ensure compatibility among codecs. Hence, it might not appear at the physical interface points in the codec.

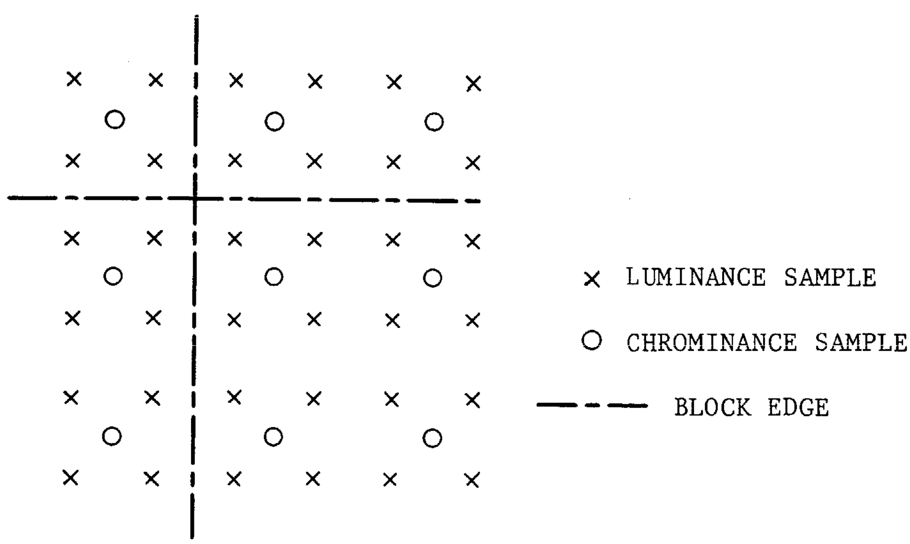
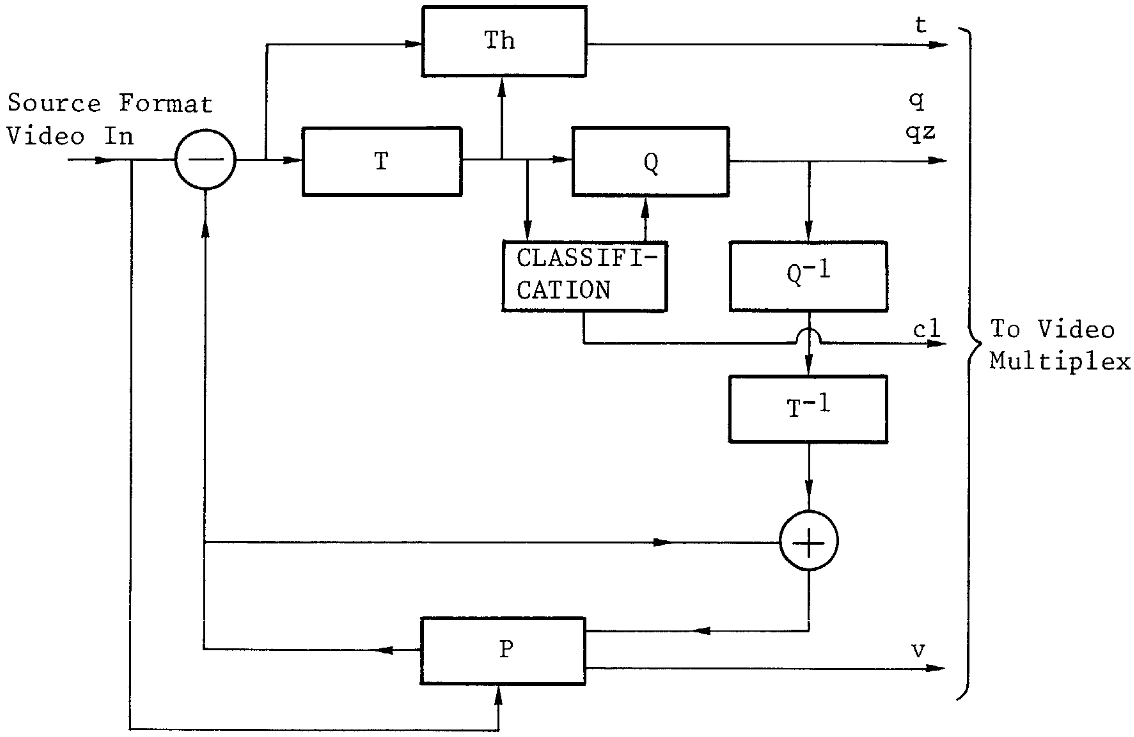


Fig. 2 Positioning of Luminance and Chrominance Samples



Th	Threshold
T	Transform
Q	Quantizer
Q^{-1}	Inverse Quantizer
T^{-1}	Inverse Transform
P	Predictor
t	Flag for transmitted/not transmitted block
q	Quantizing index for transform coefficients
qz	Quantizer indication
v	Motion vector
cl	Classification index

Figure 3

A positive value of the horizontal component of the displacement vector signifies that the prediction is formed from pels in the previous picture which are spatially to the right of the pels being predicted.

A positive value of the vertical component of the displacement vector signifies that the prediction is formed from pels in the previous picture which are spatially below the pels being predicted.

1.2.3 Coder

After prediction, the resulting difference picture or the original picture is subdivided into blocks which are segmented as transmitted or non-transmitted. The segmentation criterion is not part of the specification, being left free to equipment designers and may be varied dynamically as part of the data rate control strategy. Transmitted blocks are coded by a transform based scheme. Coding block size for luminance is 8 by 8 sample values.

Chrominance transform blocks contain the same number of pels as luminance ones.

1.2.4 Transformer

The transformer shall be implemented in a flexible manner so that a number of different transforms, or configurations of a particular transform in terms of bits per stage, can be investigated. All hardware should be equivalent in performance to classical matrix multiplication, so fast algorithms are not excluded provided they can be constructed to be as flexible.

The 2D transform is implemented as the equivalent of 2 independent 1-D transforms.

All coefficients in the forward and inverse transforms shall be programmable.

For the purposes of compatibility it is only necessary to specify the inverse transform. As a preliminary specification the hardware should allow for 12 bit resolution in (ie coefficients) and 9 bits out. (This is subject to verification that it does not imply a greater accuracy than 16 by 16 bit multiplications.)

1.2.5 Classification

See Annex 1 to this Document.

1.2.6 Quantizer

The number of inverse quantizers provided in the decoder shall be 32. Each quantizer has 12 bits input and up to 12 bits out.
(The same or different for luminance/chrominance?
Adaptive/non-adaptive)

1.2.7 VLC

See Annex 1 to this Document.

1.3 Data Rate Control and Subsampling Modes

The exact method of assessing the encoder data generation rate need not be specified but the specified maximum size of encoder buffer must incorporate an allowance for latency in the assessment and control loop. Hence, any requirement to constrain overall system delay may effectively preclude some schemes.

Control information is carried by side information - not derived recursively from received data.

Horizontal subsampling	- picture, group of blocks or block basis?
Vertical subsampling	- picture, group of blocks or block basis?
Temporal subsampling	- picture basis only. Interpolated pictures are not placed in the picture memory.
Quantizer selection	- see also §1.4.
Block significance criterion	- not part of the specification

The coding algorithm will automatically permit the full quality of the source format specified in §1.1 to be realized on still pictures.

1.4 Forced Updating

There is no separate coding scheme for forced update. This function is achieved merely by forcing the use of the intra-picture mode of the coding algorithm. Since the decoder cannot distinguish between normal and forced update blocks, then there are no parameters to specify which are unique to forced update. The bitrate allotted to forced updating, the sequence in which blocks are updated etc, are not specified.

In order that the quality of forced update blocks can be sufficiently high at all times, quantizer selection must not be dependent solely on buffer fill state.

2. Video Multiplex Coder

2.1 Tasks

The video multiplex coder has the following tasks:

1) Block address coding
2) Video data formatting and serializing
3) Synchronization - picture/line
4) Motion vector coding
   (Absolute, differential, run length etc)
5) Side channels for indicating dynamic coding parameters eg subsampling modes, quantizers, buffer state etc. (Permanent or transient channels? Transient channels require care in switched multipoint.)

2.2 Video Multiplex Arrangement

2.2.1 Picture Start Code (PSC)

Unique sequence of f bits [Buffer state] [Temporal ref.] [Type]

The buffer state is a 6 bit number representing the encoder buffer fullness in 1Kbit units at the beginning of this picture.

The temporal reference is a 3 bit number representing the time sequence, in Common Intermediate Format picture periods, of a particular picture.

Type is a Variable Length Code which allows block attributes to be applied to all blocks within a picture.

All PSCs are transmitted.

2.2.2 Group of Blocks Start Code (GBSC)

Unique sequence of g bits [Group Number] [Type]

A group of blocks consists of two lines of luminance blocks, one line of C_R blocks and one line of C_B blocks. See Fig. 4.

Y	Y	C_R	C_B

Fig. 4

Subsampling aspects are open for further consideration.

The group number is a x bit number representing the vertical spatial position, in units of groups, of the current group of blocks.

Type is a Variable Length Code which allows block attributes to be applied to all blocks within a group of blocks.

All GBSCs are transmitted.

2.2.3 [Block Address]

Block Address is a Variable Length Code indicating the relative position of a transmitted block relative to the previous transmitted block or the absolute position within the group of blocks if it is the first transmitted block in that group.

The range of absolute block addresses for luminance block is ? to ?.

The range of absolute block addresses for chrominance block is ? to ?.

2.2.4 Block Type

A Variable Length Code representing the type of the block.

1) Intra-picture coded block
2) Inter-picture coded block
3) Motion compensated block
4) Motion compensated with coded residue
5) Future expansion on
6) Future expansion off

The decoder shall be designed to ignore all data between types 5) and 6) and also between type 5) and the next GBSC.

2.2.5 Block Data

Data specifying motion vectors, scanning class, quantizer type and transform coefficients.

2.2.6 Block Delimiter Information

The means to identify the end of all data pertinent to one block. (This may be contained in the block data.) Specific codeword?

2.3 Multipoint Considerations

(Fast updates etc)

3. Transmission Coder

3.1 The transmission coder assembles all data and interfaces to the digital line transmission system.

3.1.1 The data rate is n x 384 kbit/s where n is an integer between 1 and 5, both inclusive.

3.1.2 The coder channel output clock rate source shall be switchable between either a free running internal source or a source synchronized to the received data from the network. The mechanism for this switching is ....? (Bit ... of timeslot ..?)

3.1.3 When in free running mode the tolerance on output clock rate will be $\pm$ 50 ppm of nominal.

3.1.4 When in synchronized mode the synchronism should be maintained when the frequency of the received data clock is within $\pm$ 50 ppm of nominal.

3.2 Framing Structure (See Fig. 5)

As per CCITT Study Group XV WP XV/1 Doc. #58 plus the following coding for the applications channel:

List of codec attributes/facilities/parameters needing transmission from transmitter to receiver. No return path is assumed. Currently this list includes only encryption.

Operability with audioconferencing. Timeslot positioning to CCITT Rec I.431.

3.3 Video Data Buffering

The size of the transmission buffer at the transmitter is switchable from 8 Kbits to 64 Kbits, both inclusive, in steps of 8Kbits. Buffer size should be related to the transmission rate (overall - not video) to ensure acceptable system delay.

3.4 Video clock justification

Not provided.

3.5 Optional full spatial resolution mode data for quasi-stationary pictures.

To be specified later if required.

3.6 Audio

As per CCITT Draft Rec. G.72X type 2 terminal.

The audio channel is carried by the first time slot.

Flexible testbed hardware need only incorporate?

(64 kbit/s A-law
64 kbit/s u-law
56 kbit/s sub-band ADPCM according to CCITT Draft Rec. G.72X)

3.7 Error Handling

Video coding strategy to be error resilient without internal or external error corrector. Note that demand refresh for error correction requires back channel.

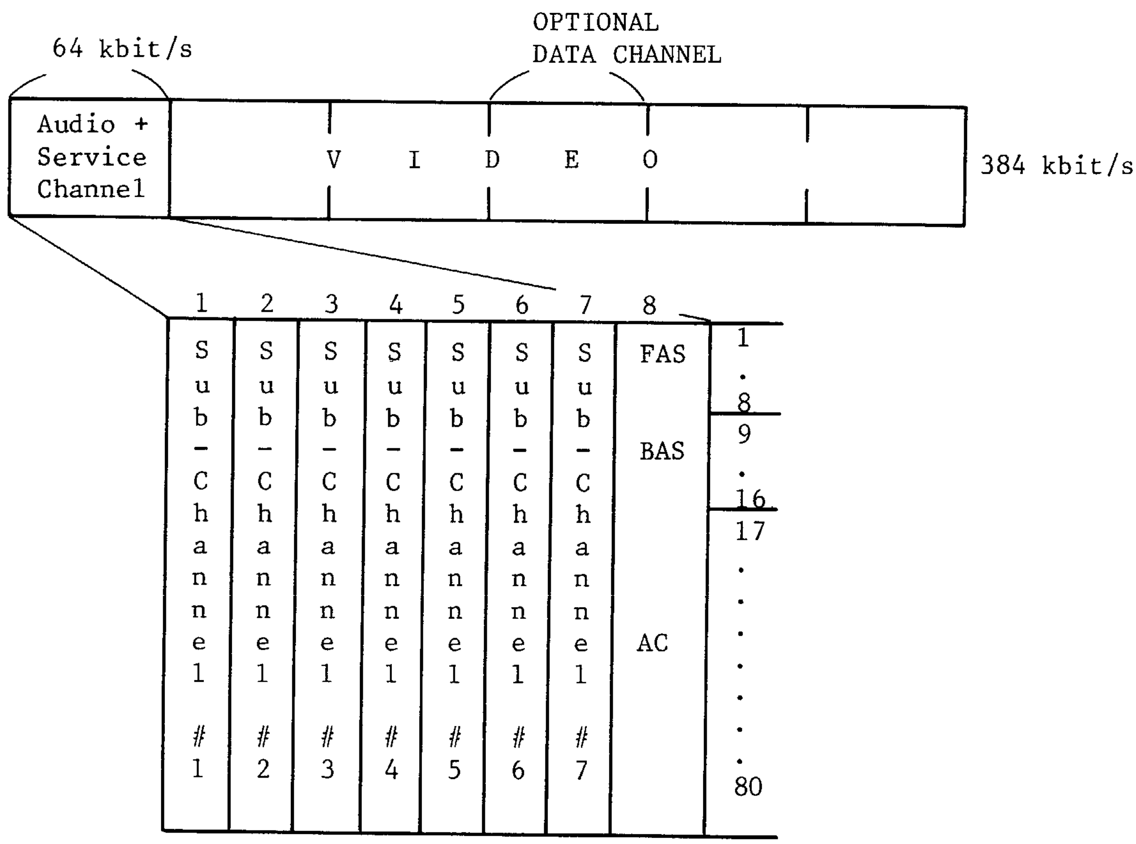
3.8 Encryption

3.9 Data transmission

Framing structure to allow 2 data ports of 64 kbit/s each, though picture quality constraints may require only one to be available at 384 kbit/s. In this case time slot 4 is used.

3.10 Network Interface

Access will be at the primary rate interface with vacated time slots. CCITT Recommendation I.431.



FAS: Frame Alignment Signal (note 1)
BAS: Bitrate Allocation Signal
AC: Applicaion Channel

<u>Note 1</u>: The block termed as FAS contains also other information than for frame alignment purposes.

Fig. 5 Frame Structure for n x 384 kbit/s codec (in case of n = 1)