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

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1. General

The Specialists Group met in Nürnberg from November 11 to 14 1986, at the kind invitation of DBP, FRG. Welcoming address was delivered on behalf of the hosting organization by Mr. Roth.

Before the session, Chairman reported that Norwegian participation in this Specialists Group was approved by SGXV on October 31 and introduced its core member Mr. Bjoentegaard to the meeting.

The list of participants appears at the end of this report.

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

2. Documents for the Meeting

For this meeting, 41 normal documents and 10 temporary documents have been available. Annex 1 shows the outline of each document.

3. Report of the Working Party XV/1 Meeting (TD 103/XV, TD 105/XV)

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

1) Approval of the Specialists Group progress report covering the two meetings held in Tokyo and Montreal

2) Videoconferencing system aspects which should be reflected in the codec design - Control & Indication

3) Resumption of videophone service study

4) Framework for Y series Audiovisual Service Recommendations

5) Draft Recommendation Y.221 on frame structure for a 64 kbit/s channel in audiovisual teleservices

4. Video Source Coding

Along with the presentation of the documents, various demonstrations of simulation results were also given. An overview of the tape demonstration is listed here.

a. Reference Model 2 and improvements by the loop filter (Netherlands: #165, #144)

b. Filter inside the coding loop (Japan: #154)

c. Temporal pre-filter (Japan: #155)

d. Multiple VLCs (Japan: #151)

e. Coding control (Japan: #159)

f. Discarding of higher sequency coefficients (Japan: #158)

g. Overall performance and variable block size (Japan: #156)

h. Scanning classes (Japan: #150)

i. Adaptive quantization (Japan: #149)

j. Transmission error effects (Japan: #160)

k. 64 kbit/s coding and 2 Mbit/s coding (FRG)

l. 64 kbit/s coding - DCT and VQ (France)

4.1 Reference Model 2 (#141, #165)

Europe and Japan reported that the statisitical data obtained from the simulation on RM2 in several laboratories are in conformity, thus we can compare the results of the work carried out using RM2.

In the course of discussion it was recognized that the Reference Model should be as close as possible to the Flexible Hardware Specification. Mr. Guichard undertook to coordinate a small group on simulation to define RM3. The outcome is attached as Annex 2.

4.2 Transformer (#142, #143, #166)

The outcome of the correspondence work on transformer specification by Mr. Morrison and Mr. Koga was approved by the meeting with an amendment to put a note at the end of the 5th paragraph of the transformer specification in Doc. #166, stating that; "The value of -2 is not permitted for use".

As for the clipping in the coding loop, proposals contained in Doc. #143 were agreed to be included in the Flexible Hardware Specification.

- Output of the 1st 1-D inverse transform: -1024 to +32767/32
- Output of the 2nd 1-D inverse transform: - 256 to +255
- Pel values inside the coding loop : 0 to +255
- Decoder output : as necessary

Mr. Haskell provided the following information on the transformer based on the work which has been or is being carried out in AT&T Bell Labs.

- There has been developed a DCT chip for 1x8, 12 bit with different implementation from the one for Flexible Hardware transformer.

- It would be better for transformer chip realization if complete specification of the accuracy is not necessary.

- DCT would not be optimal for motion compensated interframe prediction error.

- Simple truncation seems to be causing problems because of the shift of zero value.

4.3 <u>VLC for Quantized Coefficients</u> (#145, #151, #163, #170)

1) Use of the last non-zero coefficient

This was addressed in Doc. #145, #151 and #163. The general idea of applying a VLC different from the one for other non-zeros to last non-zeros was first agreed. Shifting the position of EOB marker and the use of the EOB code for last non-zero coefficients were discussed. The conclusion is: 'A modified interpretation of the VLC set is used for the last non-zero.'

This proposal will be included in the Flexible Hardware Specification.

Mr. Temime undertook to coordinate a small group for solving the problems of the intra DC alone case raised in Doc. #163 and of the case where all the coefficients in a block should be transmitted. The outcome is that the same strategy as for interframe is used.

2) Intra DC coefficients

Fixed length code of 9 bits is used for intra DC coefficients in Flexible Hardware.

3) Two-dimensional VLC

A two-dimensional VLC and its coding efficiency were presented in Doc. #170. The coding gain of 3 to 4 bits per coded block is obtained with the use of statistical properties concerning run-length of consecutive zeros and correlation between the zero run and its following non-zero amplitude. The contributions of the two factors were explained to be almost equal.

Since the coding efficiency improvement is prominent, further contributions are requested of members to confirm its effect as well as to assess its hardware implication.

4) VLC structure

As for the extent of programmability of the VLC code set, which is raised in Doc. #152, the meeting agreed to use the prefix code of 6 to 9 bits, in addition to the already agreed restriction on the maximum length of codes to 16 bits. All other aspects are left for optimization.

As a working basis, the code set was revised as in Annex 3, which also includes the code assignment for the last non-zero coefficient agreed in 1) above.

5) Related matters

During the discussion, Mr. Haskell recalled the one's density restriction in North American networks and raised a question whether long sequences of zero in VLC code sets should be avoided or not. The meeting confirmed that we should deal with source coding and transmission coding separately, hence we would decide VLCs first and next consider the necessary measures to tackle with the one's density problem based on the statistical property of the codes generated.

As for the inter mode DC coefficients, possibility of applying a separate code set was confirmed in the framework of maximum 4 VLCs on a "future inclusion" basis, subject to the adaptive quantization study.

Mr. Guichard presented an observation based on simulation of Split-Trevor sequence for 2 Mbit/s transmission that the current clipping to +/-70 levels in RM2 cause visible impairments due to the quantization overload.

4.4 Classification (#150, #164)

There were observations indicating that increase of number of classes is not accompanied by increase of coding efficiency. It was agreed, however to continue the study under the present Flexible Hardware Specification of maximum 8 classes.

As for the chrominance signal, application of one of the possible 8 classes in default was agreed according to the result presented in Doc. # 164.

4.5 Loop Filter (#144, #154, #167; TD4, TD5, TD8)

Effects of the filter inside the coding loop were presented with the documents and tape demonstration. The meeting recognized that this loop filter is effective both objectively and subjectively.

As to the Flexible Hardware Specification, however, two proposals from Japan and Europe differed in various aspects as shown in Annex 4. After some discussion, the meeting agreed to ask Mr. Brusewitz to coordinate a small group in order to obtain an agreement.

After extensive discussion and processed picture observation, his efforts resulted in the solution shown in Annex 5. The meeting agreed to include this loop filter in the Flexible Hardware Specification as a core element.

4.6 Quantizer (Section 5.3/#140R, #149)

A preliminary experiment on adaptive quantization was presented in Doc. # 149, where a limited number of inter mode low sequency coefficients, including DC, are quantized more finely. Taking also the following comments into account, the meeting recognized the importance of the adaptive quantization study and encouraged members to make contributions.

- Mr. Guichard supported the idea to quantize inter DC component more finely than other components based on the results contained in Doc. # 174.

- Mr. Chen also supported the idea.

- Mr. Ericsson pointed out the AC components in the neighborhood of DC component cause blocking if quantized coarsely.

Adaptive quantization for luminance/chrominance and intra/inter modes needs also further study. As for Mr. Brusewitz's observation recorded in Section 5.3/#140R, he clarified that it is applied for the picture after a scene cut.

The meeting also recognized the suggestion included in Doc. # 149 that the 'quantizer type information' in the video multiplex should indicate a combination of quantizers instead of a single quantizer if adaptive quantization is adopted.

4.7 Variable Block Size (#156)

Application of variable block size (8x8, 8x4, 4x8, 4x4) was proposed in Doc. # 156 as one of the 'future inclusion' elements. Since some members required further evidence, however, this variable block size aspect was decided to be still open.

4.8 Non-compatibility Items (#156, #157, #158, #159, #174)

The following items which are not relevant to the compatibility but can contribute to improving coding performance were presented for information. After some questions and answers, members were requested to take into account these information in their future work concerning compatibility related items.

- Temporal pre-filter
- Block type identification
- Scene cut detection
- Discarding of higher sequency coefficients
- Coding control
- Intra/inter mode switch

5. Video Multiplex Coding

5.1 Motion Vector Coding (#153)

Comparison data on motion vector coding were presented with respect to absolute/differential vectors and two-dimensional/one-dimensional coding. As for inter-block differential vector coding, it was pointed out that the folding of out-of-bound differential vector may result in inefficient VLC code set due to assigning a code to a vector value which corresponds to integrated occurrence of two events with different statistics.

The meeting agreed on using one-dimensional coding with common code assignment to horizontal and vertical components. Though the use of the same code set as the one for transform coefficient coding was suggested, the specific code set for motion vector coding needs still further study under a constraint of maximum length of 16 bits.

At the end of discussion, it was confirmed that the description in Section 6.2 1)/#140R means;

The Flexible Hardware should be capable of

- previous-block differential vector transmission, and
- differential vector transmission between the current block vector and the Global GOB vector, thus eventually absolute vector transmission for a particular case of setting all Global GOB vectors to zero.

5.2 Block Addressing (#146, Section 2.2.3(1)/#148)

The meeting agreed to adopt coding of the number of blocks from the previous active block for block addressing using the same VLC code set as the one for transform coefficient coding.

5.3 PSC and GBSC Start Codes (#147, Sections 2.2.1 and 2.2.2/#148)

It was agreed to adopt the following bit patterns for the start codes;

GBSC: 0000 0000 0000 0001 (5 bit GBSC number)
PSC : 0000 0000 0000 0001 (forbidden GBSC number)

It was recognized that we should pay attention to these bit assignments when we will improve the VLC code set for transform coefficients, because the above bit assignments are based on the maximum possible number of consecutive zeros in the coded bit stream.

5.4 Specification for Video Multiplex Coding (#148, #173; TD9)

After reviewing the two proposals, the following guiding principles for defining video multiplex coding were agreed.

- The extension mechanism should be the same for the Picture Header and the GOB Header, ie three SI bits possibly followed by three words of a predetermined length (n x 8 bits).

- Picture attributes which are anyhow present in the GOB Header need not be transmitted in the Picture Header.

- A multiple of 8-bit length is allowed for PSC and GBSC Headers.

- On/off mechanism should be avoided.

As for detailed specification, Mr. Temime undetook to coordinate a small group to revise Doc. #173 which is superceding Doc. #148, bearing in mind the above guiding principles as well as the following items agreed or confirmed during the discussion.

- Use of the demand refresh method for error recovery was agreed on an optional basis. Accordingly, 'SPARE 1' in Section 2.2.1/#173 is replaced with 'PARITY' as in Section 2.2.1/Annex 2 to #148.

- Information in Table 2.1/Annex 2 to #148 should be retained in Flexible Hardware Specification.

- For TYPE 2 code words in Table 2.1/#148, more efficient coding should be used.

- For VLCs to encode block attributes, a framework of 'up to three code sets of maximum 8 bit-length' is agreed for Mr. Temime's coordination work.

- As for the zero absolute vector coding, Approach 1 described in Annex 2 to Doc. #140R is used with the first bit in the code dropped due to the adoption of relative block addressing.

The meeting approved the specification drafted by Mr. Temime, which is reproduced as Annex 6.

6. Transmission Coding (#160, #171, #180; TD6)

Various aspects related to transmission coding were discussed with the following summary.

1) Information on effects of transmission error was presented in Doc. #160 with tape demonstration showing various type of picture degradations.

2) Mr. Ericsson introduced Reed-Solomon error correcting code, in particular its code structure and characteristics.

3) Study to cope with the one's density restriction in North America was recalled. Contributions are requested.

4) Mr. Temime provided a proposal on the bit assignment in Application Channel of the frame structure (see Annex 7). The meeting recognized this as a useful working basis for specifying Flexible Hardware. Members are requested to make contributions to complete this specification.

5) It was recalled that this Specialists Group is responsible to define 'Transfer rate' attribute and values in the frame structure Recommendation Y.221.

6) It was pointed out appropriate delay should be inserted in the audio path corresponding to the delay in video coding in order to maintain the lip-sync.

7) In order to detect error performance of the digital portion of the service required by Working Party XV/1, use of the CRC parity bits in the 64 kbit/s frame structure was suggested in Doc. #180. This point will be raised in WP XV/1 so that its study be urgently carried out and incorporated in Recommendation Y.221.

7. Test Equipment (#177)

A possible approach was presented, where PC with a custom designed interface card is used to generate necessary patterns according to the data filed in floppy discs. Another approach to use high speed bus (VME) was also pointed out.

Though GEC is ready to supply the interface card, the problem is we have to find out a volunteer to provide the data file. Resource of '1 person x 3 months' is suggested necessary. AT&T and DIS agreed to jointly investigate the feasibility of developing a data file based upon obtaining software from an administration active in simulation. GEC/FTZ/BT and the AT&T/DIS team (contact Mr. Schaphorst) will communicate before the next meeting to make a decision on test equipment implementation to give some hope that the schedule can be met.

In the course of discussion, this equipment was recognized to be supplied before the compatibility check at laboratories, hopefully by April 1987. Six countries (FRG, USA, France, Japan, Netherlands, UK) expressed they will purchase this equipment.

All the countries were encouraged to continue the work.

8. Intellectual Property (#161, #168, #172, #175, #176, #178, #179)

In response to the 3-stage question concerning the patents covered by the Flexible Hardware Specification, seven countries submitted the patent search result and the patent holder patent policies. The remaining three countries (Canada, Italy, Norway) were requested to respond before the next meeting. From these results, it was felt that serious problems in patents concerning Flexible Hardware Specification are not envisaged at the moment.

The meeting confirmed this exercise would be ongoing as agreed in Montreal (see Section 10/#140R), bearing in mind the following points obtained through discussion.

- The statements of AT&T (Doc. #172) and Siemens (Doc. #176) concerning terms of licensing were recognized as suggestive for future actions.

- Members are requested to inform the relevant patents as soon as possible if they are disclosed.

- In case of holding patents in the pipeline, hence being unable to provide information, the holder is requested to submit a statement on its general patent policy concerning CCITT Recommendations.

- Area for the patent search includes not only source coding but also channel coding as covered by Flexible Hardware Specification.

- It is desirable that agreements will be formulated and signed between participating partners as described in Doc. #178.

9. Future Work Plan (TD3)

Chairman presented a discussion material (the extract is reproduced as Annex 8) to clarify the processes and the time schedule toward making final recommendations. After some discussion, the following conclusions were obtained.

1) Relationship between Flexible Hardware Specification and final Recommendations were understood as depicted in Fig. 1/Annex 8.

2) As general time schedule, Fig. 2/Annex 8 got common understanding.

3) Five countries (FRG, France, Japan, Netherlands, UK) are now constructing their Flexible Hardwares. Since these Hardwares are envisaged to be completed around May to September 1987, the target for the initiation of the compatibility check at laboratories has been set as June 1987 after the Stockholm meeting.

4) When some element is decided as a core element, the initiation date of compatibility check for that element is also decided.

5) To the initial compatibility check described in 3) above, the core elements which have been agreed at this meeting are applied. First version of PROM contents for such programmable elements as quantizers, VLCs etc would be decided at the next meeting with possible improvements to be followed.

6) In order to decide addition of a new core element to Flexible Hardware Specification or addition of a new element to final Recommendations, the proposer is required to convince all the members.

10. Flexible Hardware Specification

A revised version will be issued later as Doc. #182 with agreements of this meeting reflected.

11. m x 64 kbit/s Codec (#162, #169, #172)

Free discussion was held to identify the problems and possible alternatives in the m x 64 kbit/s codec standardization based on the three documents presented. The following general aspects were dealt with.

- Bit rates
- Application
- Video format
- Algorithm and its compatibility with 384 kbit/s
- Hardware architecture
- Frame structure
- Graphics

A summary report is attached as Annex 9 which was drafted from the contents of the three documents as well as the opinions expressed in the discussion.

It was agreed to adopt the strategy to narrow down the alternatives meeting by meeting. Contributions are requested.

12. Next Meetings

1) Eighth meeting

- March 10 - 13, 1987
- San Jose, USA

2) Ninth meeting

- June 2 - 5, 1987
- Stockholm, Sweden

LIST OF PARTICIPANTS
(Nürnberg; November 11 - 14, 1986)

Chairman	S. Okubo	- NTT

Core Members

F. R. of Germany	J. Speidel	- PKI
	G. Zedler	- FTZ
Canada	S. Sabri	- BNR
U.S.A	H. Gharavi	- Bell CORE (acting for J. A. Bellisio)
	B. G. Haskell	- AT&T Bell Labs
	R. A. Schaphorst	- DIS
France	J. Guichard	- CNET
	J. P. Temime	- CNET
Italy	M. Guglielmo	- CSELT (acting for L. Chariglione)
Japan	Y. Hatori	- KDD
	N. Mukawa	- NTT
Norway	G. Bjöntegaard	- Norwegian Telecom
Netherlands	R. Plompen	- DNL (acting for F. Booman)
United Kingdom	D. G. Morrison	- BT (acting for R. Nicol)
	N. Shilston	- GEC (acting for D. Bonnie)
Sweden	H. Brusewitz	- Swedish Telecom Admin. (acting for P. Weiss)

Assisting Experts

F. R. of Germany	W. Geuen	- FTZ-FI
	M. Krieg	- PKI (Secretary)
U.S.A.	W. Chen	- CLI
	S. Ericsson	- Pictel Corp.
	L. Rennick	- CLI
France	J. David	- Alcatel
	D. Devimeux	- SAT
Japan	T. Koga	- NEC
	K. Matsuda	- Fujitsu
United Kingdom	J. R. M. Mason	- GEC
	G. Sexton	- BT

Annexes

Annex 1: Documents for the Nürnberg meeting
Annex 2: Reference Model no. 3
Annex 3: VLC code set
Annex 4: Conflicts in loop filter proposals
Annex 5: Loop filter agreement
Annex 6: Video multiplex coding specification
Annex 7: Service bits in the AC of the Frame Structure
Annex 8: Work plan
Annex 9: Summary report on the m x 64 kbit/s codec discussion

Annex 1 Documents for the Nürnberg Meeting

Normal Documents

#140R : REPORT OF THE SIXTH MEETING IN MONTREAL (CHAIRMAN)

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

#141 : SPECIFICATION FOR REFERENCE MODEL VERSION 2 (CHAIRMAN)

RM2 agreed in Montreal was modified in 'intra/inter mode decision' and 'quantizer step size control'. The numerical data presentation method was also clarified. This document is a revised version for Document #104.

#142 : TABLE OF MULTIPLIER VALUES FOR INVERSE DCT (BT, NEC)

Sixty-four element values of the DCT matrix multiplier are provided in hexadecimal expression.

#143 : THE REQUIREMENT FOR CLIPPING IN THE CODING LOOP (UK)

The following clipping is proposed;

- Output of the 1st 1-D inverse transform: -1024 to +32767/32
- Output of the 2nd 1-D inverse transform: -256 to +255
- Pel values inside the coding loop : 0 to +255
- Decoder output : as necessary

#144 : LOOP FILTER IN THE OKUBO RM2 (UK, NETHERLANDS, SWEDEN)

After examining such loop filter aspects as position, block boundary treatments, filter type, relation with motion compensation, it is proposed that;

a. The filter should be capable of accessing a 10 x 10 area in order to produce a prediction of 8 x 8.
b. The decision for the filter to access either the motion predicted frame data or the previous reconstructed frame data should be made on hardware grounds.
c. The adaptivity should be in switching on/off of a single filter.
d. The type of filter should be decided on hardware grounds.
e. Filter coefficients should be programmable.

#145 : A STUDY OF THE USE OF MULTIPLE VLCS AND SINGLE VLCS IN THE OKUBO REFERENCE MODEL 2 (UK, SWEDEN, NETHERLANDS, GERMANY)

A single VLC is recommended for transform coefficients and block addressing for hardware purposes, after examining multiple VLCs for transform coefficient, EOB modification, addressing of quantized coefficients and relative block addressing.

#146 : A REPORT ON THE MERITS OF USING RELATIVE ADDRESSING FOR BLOCKS WITHIN A GROUP OF BLOCKS (GOB) STRUCTURE (UK)

The following three relative addressing methods are compared in terms of coding efficiency and hardware complexity;

Method 1: encoding run-length of fixed blocks
Method 2: encoding run-length of coded blocks
Method 3: encoding run-length of the both

It is concluded that Method 1 should be used for any hardware implementation of a codec.

#147 : BIT PATTERN FOR PSC AND GBSC (UK)

The following bit patterns are proposed;

GBSC: 0000 0000 0001 (5 bit GBSC number)
PSC : 0000 0000 0001 (00000)
or
0000 0000 0001 (11xxx)

#148 : PROPOSAL OF VIDEO MULTIPLEX CODER STRUCTURE AND SPECIFICATION (NTT, KDD, NEC, FUJITSU)

Introduction of the following structure is proposed;

1. Priority for higher layer attributes in a three-layered structure (picture/GOB/block)
2. Spare information bits in PSC and GBSC for optional and future use
3. A multiple of 8 bit length for PSC and GBSC

Revision of Section 2 in Flexible Hardware Specification is proposed accordingly.

#149 : ADAPTIVE QUANTIZATION (NTT, KDD, NEC, FUJITSU)

From an experiment, adaptive quantization is suggested, where finer quantizers are applied to coefficients of low sequency including DC and coarser quantizers are applied to other coefficients.

#150 : SCANNING CLASSES (NTT, KDD, NEC, FUJITSU)

It is reported that coding efficiency can be improved (900-1800 bits/frame) by using multiple scanning classes. As for the number of classes, its increase from 3 to 8 brings little coding gain due to the increase of overhead information for classification.

#151 : EFFECT OF PLURAL VARIABLE WORD LENGTH CODE (NTT, KDD, NEC, FUJITSU)

Coding efficiency and hardware configuration are compared for single-VWLC vs two-VWLC and optimum Huffman set vs RM2 set. As a conclusion, the following is proposed;

(1) One VWL set is assigned to all coefficients other than previous-to-EOB coefficients.
(2) The same code set with its order modified is applied to previous-to-EOB coefficients.

Fixed length code assignment to DC coefficients of intra mode is also proposed.

#152 : VLC STRUCTURE (NTT, KDD, NEC, FUJITSU)

As to the extent of programmability of the VLC code set for transformed coefficients, use of prefix code with length of 9 bits or less is proposed in addition to the maximum code length of 16 bits. Small modifications to Table 4/#122 are also proposed to make the code set better structured.

#153 : MOTION VECTOR CODING (NTT, KDD, NEC, FUJITSU)

In addition to providing supporting data for differential vector transmission, this document reports the coding efficiency of the three motion vector coding methods.

- Two dimensional encoding
- One dimensional encoding with separate code assignments to horizontal and vertical components
- One dimensional encoding with common code assignment to horizontal and vertical components

The third one if proposed as a conclusion because of its simplicity.

#154 : FILTER INSIDE THE CODING LOOP (NTT, KDD, NEC, FUJITSU)

Comparison in terms of coding efficiency and hardware implication are carried out on the five kind of filters in the coding loop which are adaptively switched on/off by motion vectors.

Method I (Type 1):	before the frame memory, processing restricted inside the block (36 pels filtered)
Method I (Type 2):	before the frame memory, processing restricted inside the block (64 pels filtered)
Method I (Type 3):	before the frame memory, processing extended over neighboring blocks (64 pels filtered)
Method II :	after the frame memory, processing extended over neighboring blocks (64 pels filtered)
Method III :	after the frame memory according to #126, processing restricted inside the block (64 pels filtered)

The proposal is Method I (Type 1) with comparable coding efficiency and simple hardware.

#155 : TEMPORAL PRE-FILTER (NTT, KDD, NEC, FUJITSU)

Effect of the temporal pre-filter is reported, reducing the mean step size thus improving SNR. It is also reported that the effects of this pre-filter and the loop filter discussed in #153 are additive.

#156 : BLOCK TYPE IDENTIFICATION, VARIABLE BLOCK SIZE AND OVERALL PERFORMANCE (NTT, KDD, NEC, FUJITSU)

Information on how to identify significant/insignificant blocks and intra/inter blocks are provided. The identification is based on sub-blocks consisting of 4 x 4 pels. Using the same circuitry, variable block size (8 x 8, 8 x 4, 4 x 8, 4 x 4) processing can be implemented to improve the coding performance for images with large moving parts or for images with much mosquito noise. This variable block size processing is proposed to be one of the 'future inclusion' elements.

#157 : SCENE CUT DETECTION METHOD (NTT, KDD, NEC, FUJITSU)

An example of scene cut detection methods is presented, which utilizes intra/inter mode decision algorithm. Scene cuts are found in the number of intra mode blocks in one GOB becomes larger than a threshold and it continues to be so for a few consecutive GOBs.

#158 : DETERMINATION OF TRANSFORM COEFFICIENTS TO BE QUANTIZED (NTT, KDD, NEC, FUJITSU)

This document presents a method to discard higher sequency transform coefficients by applying a threshold larger than the quantizer dead zone prior to quantization, thus to quantize the transform coefficients more finely if once selected for transmission. This method operates only in the coder without requiring extra overhead information.

#159 : CODING CONTROL METHOD FOR 384 KBIT/S CODEC (NTT, KDD, NEC, FUJITSU)

Effects of picture unit coding control are presented, where a constant step size is used all through the frame. They are best demonstrated in such pictures as Checked Jacket because information generation is not uniformly distributed in the frame.

#160 : EFFECT OF TRANSMISSION ERRORS (NTT, KDD, NEC, FUJITSU)

Effects of the transmission error in motion vector, block address, block type and quantized coefficient are analyzed and demonstrated for provisionally decodable cases. Error concealments are also demonstrated. As an essential solution, the use of forward error correction is suggested in conjunction with forced updating.

#162 : SOME COMMENTS ON m x 64 KBIT/S CODEC STANDARDIZATION (NTT, KDD, NEC, FUJITSU)

The following discussion points are provided with possible range of alternatives: application, video format, algorithm and compatibility to n x 384 kbit/s codec, bit rate, hardware architecture, audio coding, frame structure and time schedule. It is stressed that we should have a common understanding in the application before discussing the codec details.

#163 : A TRICK FOR THE LAST NON-ZERO (SWEDEN)

After examining the possible methods as well as the effect of utilizing the property of last non-zero coefficients, it is proposed that EOB word should be transmitted before the last non-zero, and that a modified interpretation of the VLC set, with no code words allocated for zero level and EOB, should be used for the last non-zero.

#164 : CLASSIFICATION OF QUANTIZED DATA (SWEDEN, NETHERLANDS, FRANCE)

Since less gain is obtained for 8 classes compared with 4 classes, it is proposed that the hardware specification should be changed to allow for a maximum of four scanning classes, and that chrominance should be transmitted with zigzag scanning by default without transmitting side information.

#165 : STATISTICS OF THE RM2 (FRANCE, SWEDEN, UK, NETHERLANDS, FRG)

It is reported that both of the statistical data and the processed pictures for RM2 are practically identical among 5 European countries, thus their results based on RM2 are comparable.

#166 : PROPOSAL FOR THE SPECIFICATION OF THE TRANSFORMER IN THE FLEXIBLE HARDWARE (UK, JAPAN, FRANCE, FRG, ITALY, NETHERLANDS, SWEDEN)

Specification for the transformer in the Flexible Hardware has been elaborated through correspondence after the last Montreal meeting. This document provides a revised text for the Specification.

#167 : PROPOSAL FOR A LOOP FILTER IN THE HARDWARE SPECIFICATION (UK, SWEDEN, NETHERLANDS, ITALY, FRG, FRANCE)

Based on the simulation work described in Doc. #144, the following specification is proposed for the loop filter;

a. Adaptivity: switched on/off on a block by block basis
b. Filter characteristics: 2-D response shape, separable into horizontal and vertical filtering, identical response for the both directions
c. Position: after the fame memory
d. Processing: extended over neighboring blocks
e. Reduction to 8 bits at the filter output: rounding upwards or truncation only
f. Filter coefficients: b) in #144

#168 : INTELLECTUAL PROPERTY - PATENTS (BT)

It is reported that UK organizations including BT do not have patents covering Flexible Hardware Specification.

#169 : SOME QUESTIONS ABOUT m x 64 KBIT/S AND ITS RELATIONSHIP WITH n x 384 KBIT/S CODING (UK)

Discussion material is provided pointing out the questions concerning;

a. Range of value of 'm'
b. Target in a market and technical sense
c. Interconnectability with 384 kbit/s codec

d. Means to obtain interconnectability
e. Video coding compatibility
f. Graphics

It is suggested that the aim of this Group should be to produce an outline recommendation and a fundamental structure for suitable programmable hardware during this study period to make a full recommendation produced sometime in 1989/1990.

#170 : CODING OF COEFFICIENTS WITH A TWO-DIMENSIONAL TABLE (FRG)

A coding method is presented which utilizes the statistical property between the number of consecutive zeros (run-length) and the following non-zero coefficient. Coding gain of 3 - 4 bits per coded block is obtained.

#171 : TRANSMISSION FORMAT FOR m x 64 KBIT/S VIDEO TELEPHONY (PICTEL CORP.)

A packet-based transmission format is defined, which provides easy synchronization, control packets for the call setup, clear down, etc., and a simple means of stuffing when different bit rates need to be interfaced. The overhead, including forward error correction, is 2.8 percent.

#173 : VIDEO MULTIPLEX CODING (FRANCE, SWEDEN)

Applying the following principles to the Japanese proposal distributed last summer, a rewording of Section 2.2 of the Hardware Specification is proposed.

- GBSC and PSC should follow Doc. #147.
- The extension mechanism should be the same for the Picture Header and the GOB Header.
- Picture attributes which are anyhow present in the GOB Header need not be transmitted in the Picture Header.
- On/off mechanism should be avoided.

#174 : INTER/INTRA FRAME SWITCH (FRANCE, FRG)

A reduction of the inter/intra frame switch threshold has been experimented. It is observed that a gain in dB takes place with increased mean value of step size.

#177 : A POSSIBLE APPROACH TO OBTAINING A TEST PATTERN GENERATOR (UK, FRG)

An approach has been investigated which uses a personal computer with a custom designed interface card for the 2/1.5 Mbit/s line. Test video data are derived syntheticly or from real pictures and stored in floppy discs to be downloaded in RAM for the real time output.

#180 : BIT ERROR PERFORMANCE ON THE END-TO-END DIGITAL LINK (FRANCE)

It is proposed to recommend to Working Party XV/1 that the use of CRC parity bits in the frame structure of 64 kbit/s should be urgently studied and incorporated in Recommendation Y.221 in response to the need to make an error performance detection available identified by WP XV/1.

#161 : JAPANESE PATENTS RELEVANT TO FLEXIBLE HARDWARE SPECIFICATION (NTT, KDD, NEC, FUJITSU)

#172 : USA INTELLECTUAL PROPERTY (USA)

#175 : POSITION OF THE FRENCH ADMINISTRATION REGARDING PATENTS (FRANCE)

#176 : INTELLECTUAL PROPERTY (FRG)

#178 : PATENTS (SWEDEN)

#179 : INTELLECTUAL PROPERTY (THE NETHERLANDS)

These six documents describe the patent search results and the patent policy in response to the three stage question charged at the Montreal meeting.

Temporary Documents

No. 1 Agenda (Chairman)
No. 2 Documentation for this meeting (Chairman)
No. 3 Plan toward making recommendations on n x 384 kbit/s coded (Chairman)
No. 4 Conflicts in the loop filter proposals (Chairman)
No. 5 Statistics belonging to the demonstration on filtering in the loop (Netherlands, BTRL, Sweden)
No. 6 Service bits in the AC of the frame structure (France)
No. 7 Draft report of the 7th meeting in Nürnberg (Chairman)
No. 8 Agreements on loop filter (Small Group on Loop Filter)
No. 9 Video multiplex coding specification (Small Group on Video Multiplex)
No. 10 Reference Model no. 3 (France, FRG, Netherlands, Sweden, Japan, USA, UK)

Annex 2 Reference Model no.3

I) General comments

It is accepted to continue to use the same numerical date presentation format (Annex 7 to Doc. #141) for the RM3 and the further improvements. However the figures for the 15th encoded picture are only required for the RM3.

It is recommended, when it is possible, to provide the "saving" as well. By "saving" is meant that, when an improvement is studied, the RM3 is computed and there is an additional program for accumulating the bits which would have been saved by using the proposed improvement. It is not always possible (it does not make sense for all the improvements).

II) Modifications to Document #141

a) Intra/Inter switch

There is an ambiguity when floating point calculation is not employed. So it is suggested to remove the scaling factor and compare

$$\sum_{\text{block}} (x(i) - \bar{x})^2 < \sum_{\text{block}} d(i)^2$$

In this case, the threshold of the corresponding figure becomes 6400 instead of 100.

The average pel value over the block is defined as follows:

$$\bar{x} = \text{INT}\left[\frac{1}{64} \left(\sum_{\text{block}} x(i) + 32 \right) \right]$$

b) VLC for coefficients

There is a slight modification in the VLC used for the coefficients (see VLC 1 in Annex 3 to Doc. #181R). In particular EOB becomes 001.

III) Reference Model no.3

Several modifications have been adopted. The starting point is the RM2 according to Doc. #141 with the previous clarification.

a) Scanning classes technique

The four scanning classes depicted in Doc. #164 (see Appendix) will be incorporated for the luminance blocks only. The ordinary zigzag scan class is used for the chrominance blocks.

A 2-bit FLC is employed to signal the classes for luminance.

b) Last non-zero coefficient

The EOB code remains after the last non-zero coefficient. In Annex 3 to Doc. #181R, VLC 2 is the meaning of the VLC for the last non-zero coefficient, while VLC 1 is the meaning of the VLC for the other non-zero coefficients.

c) Relative addressing

Relative addressing technique is used to encode, by means of a VLC, the number of consecutive fixed blocks between two active blocks.

It has been decided to provisionally use the same VLC as for the coefficients (see Annex 3 to Doc. 181R), except that now it goes from 0 up to 139 instead of 1 up to 140.

The relative address has to be considerd as the block address information (B.A. in Doc. #173, p.5). It is part of the block data of every active block.

Note: When two consecutive blocks are active, the latter block has a relative address of value 0. Similarly if the first block in GOB is active, it has a relative address of value 0.

A block attribute has been removed, so it is suggested to employ the following VLC for the remaining block attributes:

Luminance

Code	block type
1	MC, coded
01	Inter frame
001	MC, not coded
000	Intra frame

Chrominance

1	Inter frame
0	Intra frame

The last string of fixed blocks in a group of blocks is not encoded. The GOBSC will indicate the beginning of the next GOB.

d) Filtering in the loop

The principle of filtering in the loop is adopted.

The filter is located after the frame memory, and is applied within the 8 x 8 block (see Annex 5 to Doc. #181R).

The criterion is based on the prediction error:

If $\sum_{block} |d_f(i)| < \sum_{block} |d(i)| \Rightarrow$ use the filter

d(i) : motion compensated inter frame prediction error
$d_f(i)$: difference between the input pel value and the previous reconstructed picture filtered block shifted according to the motion vector.

Motion vectors are calculated before applying the filter.

One bit side information is used to indicate whether a block is filtered or not. (Note: This side information is used only for inter mode blocks, regardless of being active or not.)

1	filtered block
0	non filtered block

IV) List of action points

Several possible improvements, which should be studied by the next meeting, have been listed.

a) The study of other motion estimation algorithms

b) The comparison, with the RM3, when using two true pictures for the calculation of the motion vectors instead of one true picture and the previous reconstructed picture

c) The quantization techniques including different step sizes and dead zone

d) The increase of the number of code words in the VLC used for the coefficients in order to avoid visible impairments due to clipping (modification of the break point of the actual VLC: 8 bits instead of 9)

e) Temporal pre-filtering

f) Two dimensional VLC approach for the transmission of the non-zero coefficients. In this case the trick for the last non-zero coefficient has to be removed in RM3. Relation to the scanning class is also for study.

g) Variable block size scheme

h) The effect of filtering in the loop over the block boundaries

i) The sensitivity of the RM3 to error

j) VLC for encoding differential motion vectors

k) To incorporate filter side information in the VLC for the type of the block

l) To optimize the three VLCs for the type of block

Appendix to Annex 2

Ordinary zig-zag

1,	2,	6,	7,	15,	16,	28,	29
3,	5,	8,	14,	17,	27,	30,	43
4,	9,	13,	18,	26,	31,	42,	44
10,	12,	19,	25,	32,	41,	45,	54
11,	20,	24,	33,	40,	46,	53,	55
21,	23,	34,	39,	47,	52,	56,	61
22,	35,	38,	48,	51,	57,	60,	62
36,	37,	49,	50,	58,	59,	63,	64

Horizontal class

1,	2,	3,	4,	5,	8,	9,	10
6,	7,	11,	12,	13,	14,	15,	16
17,	18,	19,	20,	21,	22,	23,	24
25,	26,	27,	28,	29,	30,	31,	32
33,	34,	35,	36,	37,	38,	39,	40
41,	42,	43,	44,	45,	46,	47,	48
49,	50,	51,	52,	53,	54,	55,	56
57,	58,	59,	60,	61,	62,	63,	64

Vertical class

1,	6,	17,	25,	33,	41,	49,	57
2,	7,	18,	26,	34,	42,	50,	58
3,	11,	19,	27,	35,	43,	51,	59
4,	12,	20,	28,	36,	44,	52,	60
5,	13,	21,	29,	37,	45,	53,	61
8,	14,	22,	30,	38,	46,	54,	62
9,	15,	23,	31,	39,	47,	55,	63
10,	16,	24,	32,	40,	48,	56,	64

Fourth class

1,	3,	8,	12,	22,	23,	39,	40
4,	2,	6,	13,	21,	24,	38,	41
9,	7,	5,	11,	20,	25,	37,	42
14,	15,	10,	19,	26,	36,	43,	54
16,	17,	18,	27,	35,	44,	53,	55
30,	29,	28,	34,	45,	52,	56,	61
31,	32,	33,	46,	51,	57,	60,	62
49,	48,	47,	50,	58,	59,	63,	64

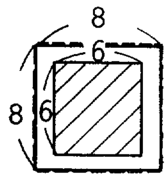
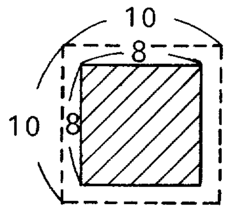
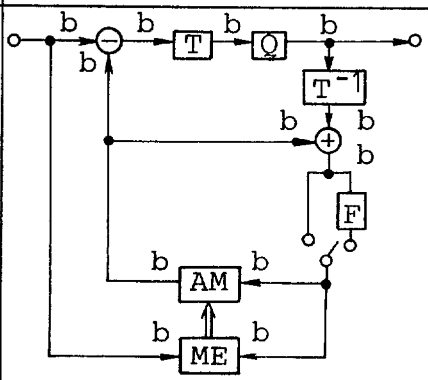
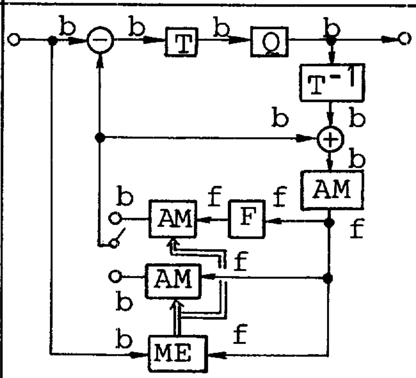
Annex 3 <u>VLC Code Set</u>

Number	Code	Length	Quantizer Level Number VLC 1	VLC 2
1	1	1	0	+1
2	001	3	EOB	not used
3	010	3	+1	-1
4	011	3	-1	+2
5	00010	5	+2	-2
6	00011	5	-2	+3
7	000010	6	+3	-3
8	000011	6	-3	+4
9	0000010	7	+4	-4
10	0000011	7	-4	+5
11	00000010	8	+5	-5
12	00000011	8	-5	+6
13	000000010	9	+6	-6
14	000000011	9	-6	+7
15	0000000011111110	16	+7	-7
16	0000000011111111	16	-7	+8
17	0000000011111100	16	+8	-8
18	0000000011111101	16	-8	+9
19	0000000011111010	16	+9	-9
20	0000000011111011	16	-9	+10
21	0000000011111000	16	+10	-10
22	0000000011111001	16	-10	+11
.	.		.	.
.	.		.	.
.	.		.	.
.	.		.	.
.	.		.	.
.	.		.	.
138	0000000010000101	16	-68	+69
139	0000000010000010	16	+69	-69
140	0000000010000011	16	-69	0

<u>Note:</u> VLC 1 - for coefficients before last non-zero
VLC 2 - for last non-zero coefficients

Annex 4

CONFLICTS IN THE LOOP FILTER PROPOSALS

ITEM	#154 (Japan)	#167 #144 (Europe)
1) Position	before the frame memory	after the frame memory
2) Adaptivity	switched on/off on a block-by-block basis by the control	
3) Control	-motion vector (only for coded blocks)	not described (motion vector or predection error)
4) Filter characteristics	1 1 4 1 1	1 2 1 2 4 2 1 2 1 separable
Ium./Chorm.	Same characteristics	
5) Processing range pels used for filtering filtered pels	inside the block only 	extended over neighboring blocks 
6) Rounding on the filter output	not described	rounding upwards or truncation only
7) Configuration AM:Adressable Memory b:block f:"frame" (longer than a block)		

Annex 5 LOOP FILTER AGREEMENT

It is agreed to incorporate a loop filter in Reference Model no.3 and the Flexible Hardware Specification.

This filter operates after the picture memory and is constructed to use pels within the predicted block.

The filter is separable into horizontal and vertical operations and full arithmetic precision is retained intenally so that the order of these operations is immaterial.

The filter has a single characteristic and is switchable on/off on a block by block basis. The same filter is applicable to luminance and chrominance blocks.

Coefficients

1) Block corner position

9	3
3	1

2) Block edge

3	1
6	2
3	1

3) Inside

1	2	1
2	4	2
1	2	1

Rounding to 8 bit at the filter output is performed by examination of the 2^{-1} bit.

Multi-pel prediction, an example of which is present in Dec. #167, is retained in the Flexible Hardware Specification on a "future inclusion basis". (1)(2)

Reference

(1) Doc. #140R, Section 5.7
(2) Annex 4 to Doc. #140R, Section 1.2.1

Annex 6 Video Multiplex Coding Specification

2.2 VIDEO MULTIPLEX ARRANGEMENT

2.2.1 Picture Header

Configuration of the codes is shown underneath. All PSCs are transmitted. Two successive Picture Headers indicate the intervening picture has been dropped.

PSC	BS	RT	TYPE1	SI	GPMV	PARITY	SPARE
21	6	3	7	3	16	8	m x 8

<-------------- 40 bits ------------>

<------------------------ n x 8 bits --------------------------->

Comment: For easier hardware implementation, the bit length of PSC is a multiple of 8 bits so the shifter circuits which shift the data on a bit-by-bit basis is not necessary. n equals 5. The length of PSC does not change, since all the information is fixed length codes except when spare information is inserted.

(1) Picture Start Code (PSC)

Unique word of 21 bits (value: 0000 0000 0000 0001 xxxxx)
xxxxx is a forbidden GN value (ie 0 or 19 to 31)

(2) Buffer State (BS)

Coder buffer fullness information expressed in the unit of 1 Kbit. The value is sampled at the time of the top of the frame. (Six bits, MSB first)

(3) Temporal Reference (TR)

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

(4) Type information (TYPE1)

Split-screen indicator. (1) on. (0) off.
Document camera. (1) on. (0) off.
5 bits spare for further study.

Comment: In type information, unless specified (1) means active, (0) means inactive.

(5) Spare bit insertion information (SI)

The 3 bit code indicates PGMV, PARITY, SPARE insertion. When one of these bits is set to 1, the corresponding information (eg PGMV, PARITY, SPARE) is inserted in the right order before the first GB Header.

(6) Picture Global Motion Vector (PGMV)

Picture global motion vector consisting of 16 bit code are inserted when it is defined. The motion vectors are transmitted in absolute terms as defined in Section 1.2.2. Eight bit code for each direction. MSB first. Horizontal vector is coded first, then vertical one. Two's complement representation is used.

(7) Parity information (PARITY)

For demand refreshing, parity information consisting of 8 bit code is inserted on an optional basis. MSB plane first. Each bit represents odd parity of each bit plane from the local decoded PCM video signals in the previous frame period. For the dropped frame Picture Header, the same parity data are repeated in this PARITY information.

(8) Spare information (SPARE)

For future use, spare bits are reserved. Definition of the spare information needs further study. Its length is an integer number of octets.

2.2.2 Group of Block Header

GBSC	GN	TYPE2	QUANT1	SI	GGMV	SPARE1	SPARE2
16	5	10	6	3	16	8	m x 8

<------------- 40 bits -------------->

<---------------------- n x 8 bits ---------------------------->

Comment: The bit length from GBSC to SI is 40. See the comment of 2.2.1.

Each GOB consists of two block-lines of Y signal each with 8 lines by 352 pels and a block line of Cr and Cb each with 8 lines by 176 pels. See Figure.

Y_{upper}	Y_{lower}	C_r	C_b

Figure A group of blocks

All GOB Headers are transmitted in non-skipped pictures.

(1) Group of Block Start Code (GBSC)

Unique code of 16 bits (value: 0000 0000 0000 0001)

(2) Group Number (GN)

The group number is a five bit number representing the vertical spatial position, in unit of groups, of the current group of block.

MSB first. For the first GOB, GN=1 or (00001). For the last GOB, GN=18 or (10010).

(3) Type Information (TYPE2)

Intraframe mode. (1) all blocks transmitted thereafter are intraframe coded.

Motion Vectors. (1) Motion Vectors are transmitted normally when needed. (0) MV are set to 0 for the duration of the GB.

Filter in the loop. (0) Filter off, (1) Filter may be on, described on the block level in TYPE3 information.

Seven bits spare for further study. (0 = Inactive)

(4) Quantizer type information (QUANT1)

The first bit indicates an insertion of the information. When the first bit is 0, the quantizer type is not defined in the GOB attribute, but defined in the lower attribute. When the bit is 1, consecutive 5 bit code indicates the quantizer type as GOB attribute.

(5) Spare bit insertion information (SI)

The 3 bit code indicates GGMV, SPARE1, SPARE2 insertion. When one of those bits is set to 1, the corresponding information (eg GGMV, SPARE1, SPARE2) is inserted in the right order before the first Block Header.

(6) Group-of-Blocks Global Motion Vector (GGMV)

GOB global motion vector consisting of 16 bit code is inserted when it is defined. The motion vectors are transmitted in absolute terms is defined in Section 1.1.2. Eight bit code for each direction. MSB first. Horizontal vector is coded first, then vertical one. Two's complement representation is used.

(7) Spare information (SPARE1, SPARE2)

For future use, additional spare bits are reserved. Definition of the information needs further study. SPARE1 is an 8 bit word. SPARE2 is an m x 8 bit word. See 2.2.1 (8).

2.2.3 Block Data Alignment

BA	TYPE3	QUANT2	CLASS	DMV	TCOEFF	EOB

Comment: Data are coded using VLC. The used VLCs require further study. Some of the elements may be dropped depending on higher layer attributes. Future study may change the order and codes of the elements.

(1) Block Address information (BA)

Block Address is a Variable Length Code word indicating the runlength of non-transmitted blocks between the transmitted block and either the previous transmitted block or the beginning of the GOB if it is the first transmitted block in that GOB.

1. Block run is continuous from luminance to chrominance.
2. VWL code pattern is for further study. 16 bits maximum.

The range of absolute block addresses for the upper line of luminance blocks (Y_{upper}) is 0 to 43. The range of absolute block addresses for the lower line of luminance blocks (Y_{lower}) is 44 to 87. The range of absolute block addresses for C_r blocks is 88 to 109. The range of absolute block addresses for C_b blocks is 110 to 131.

(2) Block Type Information (TYPE3)

This variable length codeword indicates block attributes such as:

- Uncoded/Coded
- Inter/Intra
- No MC/MC
- No Filter/Filter
- DMV = 0/DMV ≠ 0

The combination of those attributes yields to the following types of blocks (12 types identified + an extension code)

1. Intraframe coded blocks
2. Interframe coded blocks, no filter
3. Interframe coded blocks, filter with no coded residue
4. Interframe coded blocks, filter with coded residue
5. Motion compensated blocks with no coded residue
   a. No filter DMV = 0
   b. No filter DMV ≠ 0
   c. Filter DMV = 0
   d. Filter DMV ≠ 0
6. Motion estimated blocks with coded residue
   a. No filter DMV = 0
   b. No filter DMV ≠ 0
   c. Filter DMV = 0
   d. Filter DMV ≠ 0
7. Extension on

The following table shows how the TYPE 3 information controls the insertion of the following elements.

Block Type Information	Inserted Elements of Block Data
3, 5a, 5c	Nothing
5b, 5d	DMV
1, 2, 4, 6a, 6c	CLASS, (QUANT2) TCOEFF, EOB
6b, 6d	CLASS, (QUANT2) DMV, TCOEFF, EOB

Note: QUANT2 is skipped when already defined in TYPE2

The VLC to encode the Block Type Information is chosen from up to 3 different VL Code Sets, each of maximum length of 8 bits, depending on the TYPE2 information and whether the block is a luminance one or a chrominance one.

The following table shows how the TYPE2 information controls the number of codewords in TYPE3 for luminance and chrominance blocks.

TYPE 2	LUMINANCE		CHROMINANCE	
	TYPE 3	Number of Codewords	TYPE 3	Number of Codewords
1xx (Intra)	1	0	1	0
000 (No MC No Filter)	1, 2	2	1, 2	2
001 (No MC Filter)	1, 2, 3, 4	4	1, 2, 3, 4	4
010 (MC No Filter)	1, 2, 5a 5b, 6a, 6b	6	1, 2	2
011 (MC Filter)	1, 2, 3, 4, 7 5a, 5b, 5c, 5d 6a, 6b, 6c, 6d	13	1, 2, 3, 4	4

(3) Quantiser type (QUANT2)

A Fixed Length Code of 5 bits indicates the quantiser type. The code "0" represents the finest quantiser. The code "31" represents the coarsest quantiser. MSB first.

Quant2 is not inserted when already defined in QUANT1 of TYPE2.

(4) Classification Index (CLASS)

The Classification Index (8 classes maximum) is variable length coded. Maximum length is 8 bits.

(5) Motion vector information (DMV)

a) Coding method

In the first mode, motion vector is previous block predicted and the difference is variable length coded on a block by block basis. The prediction function is described as:

$$dv(x,y) = v(x,y) - v1(x,y)$$

where v(x,y) and v1(x,y) indicate motion vector of current block and that of previous contiguous block. As the result of the prediction, the motion vector of horizontal and vertical direction is derived separately.

For the first block in each luminance line in a GOB and for previous block where the MV is not defined, (0,0) is used for predictive value v1.

In the second mode, v1(x,y) represents the global motion vector (PGMV or GGMV) as defined in the Picture Header or the GOB Header.

b) Variable length coding

The value of 'dv(x,y)' is variable length coded. Each vector of horizontal and then vertical direction is coded with the same VLC. Motion vectors for chrominance are not transmitted. The code set for motion vector is for further study. Maximum length of VLC is 16 bits.

Only with the DMV of a block is not equal to zero, DMV data is inserted.

(6) Transform coefficient data (TCOEFF)

The transform coefficients are sequentially transmitted according to the scanning class defined in CLASS. Each coefficient except the last one is transmitted using a single VLC with a maximum length of 16 bits. If a prefix is used, it must have 6 to 9 bits. Code 001 is reserved for EOB.

The last coefficient of each block is transmitted using the same VLC but with a different value assignment. (Code 001 is reserved for EOB.)

In the special case of intraframe coded blocks, the first coefficient is FLC coded with 9 bits. The AC coefficients are transmitted as described above.

(7) End-of-Block Marker (EOB)

EOB is one of the codewords in the VLC set used for quantized transform coefficients. It is always present for every block for which coefficients are transmitted. A unique code pattern is used (001).

Annex 7 Service Bits in the AC of the Frame Structure

Introduction

Twenty-four bits are available in the current Frame Structure to transmit side information according to a bit protocol and 40 bits are available to transmit a 4 kbit/s message channel.

Several information have been identified, specific to the codec.

- Fast Update Request (FUR)
- Freeze Picture Request (FPR)
- Synchronous Network Indication (SNI)
- Video Loop Request (VLR) Note 1
- Digital Loop Request (DLR) Note 2
- Loop Detection

Other information, more related to the service itself, eg concerning floor management may also be inserted.

Proposal

The 24 bits are organized in the following way.

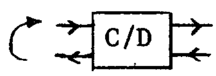
1st byte: eg Floor management (also relevant to audioconference) such as Floor request, Floor assignment, Room number ...

2nd byte: Free (eg Facilities)

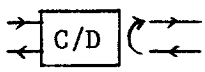
3rd byte: Codec-Information
6 bits used (the above), 2 bits free.

Possibility is left to double the information by using the frame parity.

Note 1:



Note 2:



Annex 8 Work Plan toward Making Recommendations on n x 384 kbit/s Codec

1. Steps until completing the recommendations

1) Determination of coding algorithm framework based on computer simulation results and other considerations
2) Specification of 'Flexible Hardware' for verifying the coding algorithm and for optimizing coding parameters
3) Construction of Flexible Hardware and parameter optimization
4) Compatibility checks at laboratories
5) International field trial
6) Drafting of recommendations
7) Approval by SGXV

2. Relation between Flexible Hardware Specification and final Recommendations

2.1 Three type of elements forming Flexible Hardware

A) 'Core' elements which are defined as 'minimum implementation with which all laboratories will comply' in Flexible Hardware Specification.

- All the elements described Flexible Hardware Specification (latest version is Doc. #181R) except for the following 'future inclusion' elements

Core elements have some flexibility in programmable parts which will be removed at the final recommendation according to the simulation and hardware experiments.

- Transformer
- Quantizers
- VLC code sets
- Tracking range of motion compensation

B) 'Future Inclusion' elements without which the initial hardware is constructed, but the hardware should be extendable to include these elements when their effects will be proved significant. At the moment we have the following four;

- Multiple VLCs
- Fractional motion vectors
- Motion compensation for chrominance
- Multiple-pel prediction

'Future Inclusion' elements should be by-passed in the compatibility checks at laboratories and international field trials.

C) 'New Proposal' elements which are not on the table now but will be proposed in the future meetings. These elements should also be by-passed in compatibility checks and field trials.

2.2 Evolution of 'Future Inclusion' and 'New Proposal' elements

Any of 'Future Inclusion' elements can become one of 'Core' elements if so agreed. Likewise, any of 'New Proposal' elements can become one of 'Future Inclusion' elements if so agreed.

2.3 Final Recommendations

Final Recommendations consist of the followings (see Figure 1).

- All of 'Core' elements
- Some of 'Future Inclusion' elements
- Some of 'New Proposal' elements

3. Time schedule (see Figure 2)

In order to make recommendations at the end of this study period (1984-88), drafts should be approved at the SGXV meeting to be held in April 1988. Looking toward that goal, a future work plan should be established.

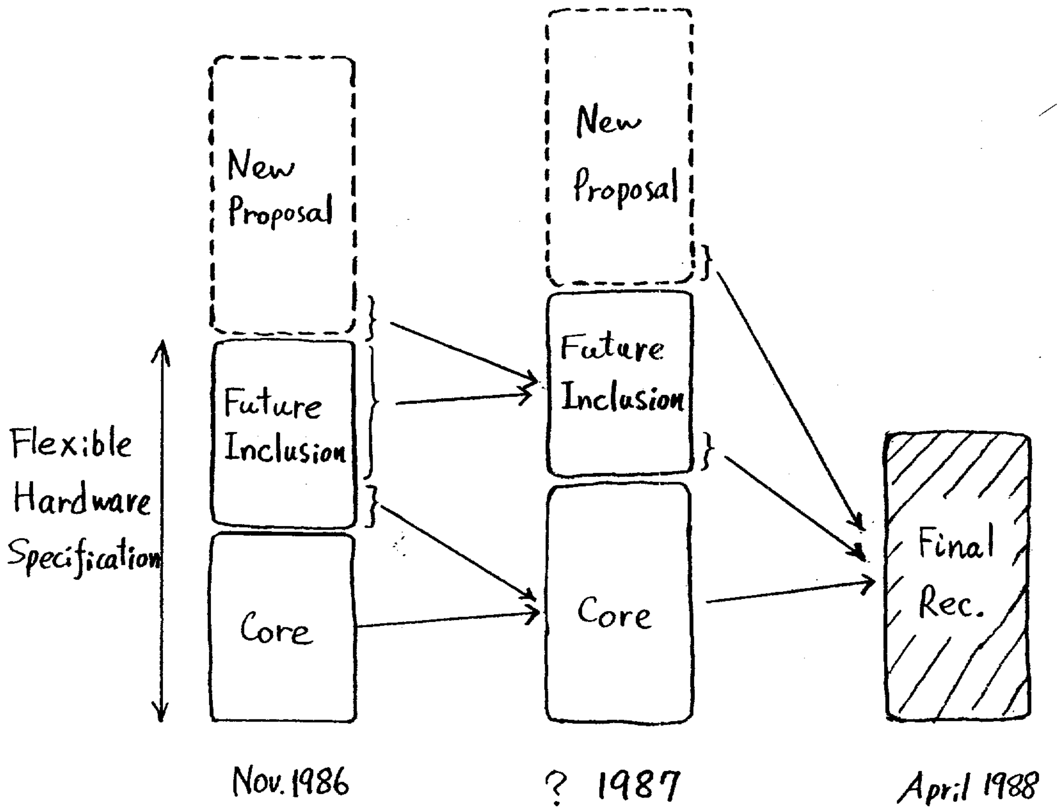
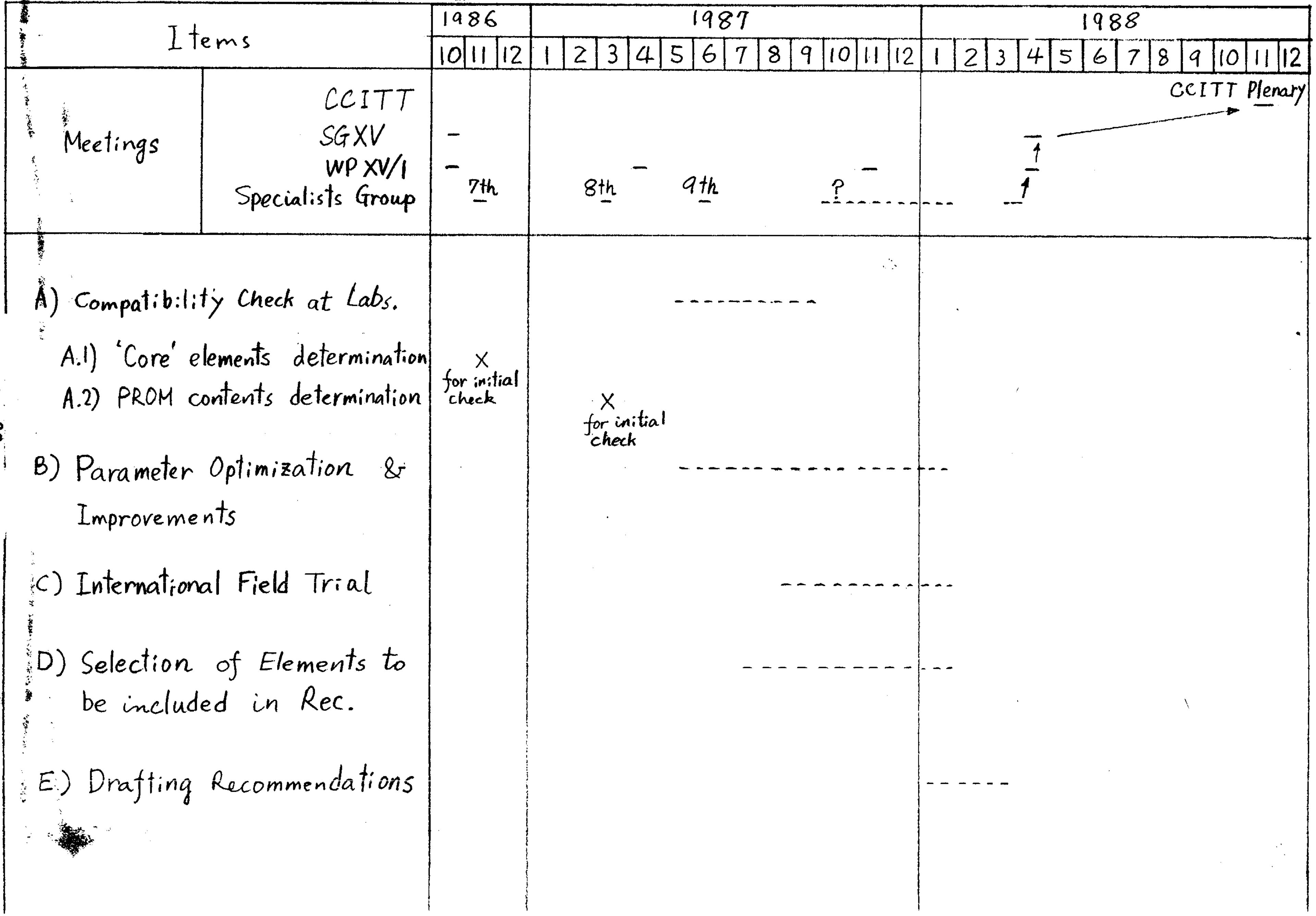


Fig.1 Evolution of Flexible Hardware Specification into final Recommendation

Annex 8

Fig.2 Time schedule



Annex 9 Summary Report on the m x 64 kbit/s Codec Discussion

In this report the terms "64 kbit/s" and "384 kbit/s" are used to denote m x 64 kbit/s and n x 384 kbit/s. They are not intended to imply m=1 and n=1 only.

1. Bit Rates (Values of m)

The following three types have been identified for m=1 and 2.

Type 1: 1B (Example) 48 kbit/s video + 16 kbit/s audio

Type 2: 2B (Example) 64 kbit/s video + 64 kbit/s audio

- Interconnection with 384 kbit/s videoconferencing and other teleconferencing services may be insured by this approach at least in the audio and control part.

- There is uncertainty whether the two channels will have equal delay through some networks. If not, there may be problems in using more than one 64 kbit/s for video.

Type 3: 128 kbit/s (Example) 96 kbit/s video + 32 kbit/s audio

- Picture and audio quality can be improved and be well balanced by this approach. BSI and channel integrity have to be supported by ISDN.

Comments

- When considering bit rates, necessary bits for frame structure to multiplex video, audio and data signals can not be neglected, though they may be of small amount.

- It should not be overlooked that Type 2 makes the compatibility with other services easier.

- In private network environments, m = 3 - 5 is applicable, since the channel capacity can be controlled as a multiple of 56/64 kbit/s.

- Network aspects should be taken into consideration. ISDN is going to provide 2B switched service as a basic service. Hence we could concentrate on Type 2.

- Information is requested of administrations on the network availability concerning 64 kbit/s.

- Cost is important. Type 1 will be cheaper than Type 2.

- Though Type 1 service is provided in pre-ISDN, it may bias the user reactions.

- Considering 64 kbit/s dial up service and pre-ISDN service, study on frame structure to obtain compatibility between Type 1 and Type 2 is necessary.

- If Type 3 is a promising service, then we must request of SGXVIII to provide such network service.

- Videophone service may be more national than videoconferencing. If one region uses Type 2 and another region uses Type 1 for their national videophone services, some transcoding will be necessary for the international service.

2. Application and Performance Requirements

Ideally the market-place would like an inexpensive unit giving broadcast quality moving pictures plus wideband audio in 64 kbit/s. This is unlikely to be possible for some time, if ever, and current approaches tackle the question from two different ends of the spectrum:

1) The complexity (price) versus quality compromise is biased towards getting the best possible picture quality, resulting in equipment aimed at the business market, initially at the higher end of it.

2) A different compromise is reached where price is the dominant factor. Here, picture quality is reduced to what is thought to be the minimum acceptable. The resulting codecs would certainly be attractive at the lower end of the business market right form the start, and the residential sector also though perhaps not immediately.

So, there may be two 64 kbit/s strategies. If so, we need to consider interconnectability between the two of them as well as their relationship to 384 kbit/s.

Possible applications of the 64 kbit/s codec will cover;

Videoconferencing: group-to-group communication
Videophone : person-to-person communication

Spatial and temporal resolution requirements may be CIF or its sub-sets.

Comments

- Videoconferencing may be demanding application for Type 3.

- There are two approaches;

  a. Start with low quality and improve quality as technology advances.

  b. Start with high quality and rely on technology advances to make the price lower

  The second one is preferable.

- If the initial price is high, market size becomes small. Hence, investment for developing cheaper equipment becomes impossible.

- For the compatibility with other services including interactive information service, spatial resolution of CIF is required. In order to obtain lip-sync for person-to-person communication, temporal resolution of at least 10 pictures/second is required. A sophisticated algorithm need be developed to get such spatial and temporal resolution with the 64 kbit/s rate.

- If we start from the 'low end', we have no chance to improve the performance in the future.

- It should be reminded that transmitting 360 pels x 288 lines x 10 pictures/sec through a 64 kbit/s channel means coding efficiency of 5 bits/block.

- We may be too optimistic in performance. Delay will become a restricting factor to very sophisticated algorithms. Long delay necessitates anti-acoustic echo devices to result in higher system cost.

- Cost may be move decisive than performance.

- From the experience in 64 kbit/s coding algorithm, there is a fact that motion vectors are eventually forced to zero after detecting them with complicated methods.

- Block size of 16 x 16 becomes more efficient for 64 kbit/s owing to less overhead information.

3. Video Format

There are three possible formats for 64 kbit/s codec:

(1) The same common intermediate format with 348 kbit/s codec
(2) A common intermediate format specific for 64 kbit/s codec
(3) Other than common intermediate format (Dual approach)

Comments

- Since videophone seems to be mostly for national use, regional standards may be used. In case of international call, picture frequency of approximately 10 Hz will provide a simple way to link with 625/50 and 525/60 systems.

- Cost depends on the number of pixels per picture. Success of the 2 Mbit/s codec is due to the adoption of rather lower resolution. CIF is oriented to graphics application too. Hence the strategy to use somewhat lower resolution graphics mode is recommended.

- It should be noted that CIF takes into account also compatibility with CCIR Rec. 601.

- It may become practical that cameras will output CIF signal.

- The same considerations as those for 384 kbit/s should be applied. A single worldwide standard should be adopted.

4. Algorithm and its compatibility with 384 kbit/s

(1) Algorithm

There may be optimum algorithms depending on different bit-rates and applications, although we have no firm evidence. Therefore, we should start our algorithm study from the beginning. The algorithm of 384 kbit/s codec should be treated as one of the possible candidates.

(2) Interconnectability between 64 kbit/s codecs and 384 kbit/s codecs

It is difficult to argue against int being a laudable aim. However, the costs incurred by doing it and the resulting quality must be weighed against its desirability. This cannot be done unless the means to achieve it are investigated.

Interconnectability can be separated into three topics:

1) Bit transport. This concerns the interconnection of the bit streams from the two codecs and knowing which bits are which at the receiving end. In principle there are no serious problems here. Obviously if a 384 kbit/s coder is connected to a 64 kbit/s decoder than only a fraction of its output bit-stream will be received. Either the coder must be made aware of this so that it will not insert necessary data in the part which will be discarded, or the coding scheme must be tolerant of the loss of bit. (See Option 1 below). In either case there must be network equipment (remultiplexer) which transfers the correct portion of the 384 kbit/s to a 64 kbit/s channel. Similarly data from a 64 kbit/s coder must be inserted into the higher rate channel in the place where the 384 kbit/s decoder expected to find it.

Since some transfer equipment is necessary, it could in principle also perform any reformatting of the data arising from the adoption of different framing structures.

2) Audio coding. This should be relatively straightforward. The same coding algorithm should be used at both transmission rates, unless there are very strong reasons for not doing so, for example only 16 kbit/s available for audio. However, even if different audio bit-rates and coding algorithms are used at 64 kbit/s and 384 kbit/s, it would be possible to convert between them in PCM form at some point in the network. Degradation in sound quality and increased delay, however, should be taken into account. Alternatively, since the audio is likely to be a minor part of the 384 kbit/s codec and since the audio bit-rate in the 64 kbit/s device is unlikely to be higher than for the 384 kbit/s one, the latter could include both types of audio processing.

3) Video coding. This is the crux of the matter.

(3) Methods to achieve video coding compatibility

The exact method will of course depend on the coding schemes that are chosen for each bit-rate. To date, work on 384 kbit/s has not considered compatibility with future 64 kbit/s to be an over-riding factor. Possible options now are:

Option 1 (tightly coupled)

> To urgently consider 64 kbit/s and see if it would be possible to have one coding scheme which could be used at 64 kbit/s and 384 kbit/s (and by implication up to 2 Mbit/s). It is also possible to envisage a scheme of a basic coder operating at 64 kbit/s with extra channel capacity, when available, being used by auxiliary coders to augment the performance. This would give the sort of automatic compatibility that is present in FM stereo radio and colour television.

Option 2 (loosely coupled)

To continue in the current vein with 384 kbit/s and subsequently develop one, or more in the light of the 'bit rate' and 'application' considerations above, 64 kbit/s algorithms under the constraints of compatibility with the 384 kbit/s scheme, which involve minimal changes to 384 kbit/s codecs.

Option 3 (independent)

To develop 64 kbit/s algorithm(s) without being constrained by compatibility. Interconnectability would then be arranged by:

a gateway device, preferably transcoding at a digital level, but in the worst case at analogue. It must be borne in mind that the closer the interface level approaches direct video the higher the processing delay is likely to be.

Or

by adopting an additional coding scheme which was a compromise between the 64 kbit/s and 384 kbit/s methods. This would entail switching of the operation of both types of codec on interconnection calls.

Or

by having both a 64 kbit/s and 384 kbit/s unit available at the "384 end", either as two separate units or integrated. In effect this amounts to be dual mode 384 kbit/s device.

Or

By making the 64 kbit/s device dual mode. The primary mode would be optimised for operation to another 64 kbit/s coded. The secondary mode would be the 384 kbit/s algorithm wound down to 64 kbit/s.

In reality there are grey areas and the solution may be a combination of some of the above.

Comments

- As far as CIF is maintained, algorithm compatibility with 384 kbit/s could be forgot for the moment.

- Demands for 64 kbit/s and 384 kbit/s should be considered. If they are comparable, compatibility is imported. If the demand for 64 kbit/s is overwhelming, then compatibility is less important.

5. Hardware Architecture

In the near future, DSP architecture approach is the most promising for 64 kbit/s codec. Algorithm to be standardized may be influenced by the architecture, where version-up will be easily made and compatibility between the old and new version can be guaranteed when the new version has both versions in it.

Comments

- Standards should not be changed.

- Flexible software approach is supproted in Doc. #169.

- Software based approach is suitable for sophisticated algorithm with a large number of steps.

- The architecture depends on the number of processing steps. A combination of dedicated hardware and software will be the solution.

6. Frame Structure

The frame format used in 384 kbit/s is one of the possible candidates. Packet approach may also become a candidate. An example of packet format is attached as Appendix.

Comments

- The opinion in TD 105/XV that 'Frame structure recommended by Y.221 will be the only one recommended by CCITT' is premature.

- Y.221 will make interworking between Type 1 and Type 2 difficult.

- Y.221 could be applied to Type 1, 2 and 3.

- We have to request of SGXVIII any network functions to realize such audiovisual services as videophone and videoconferencing.

7. Graphics

This will probably be wanted, at least in the "high end" 64 kbit/s codec. It could be provided in several ways:

1) If the moving picture mode has sufficient attainable resolution, then it may be used for graphics, in a similar manner to the philosophy adopted at 384 kbit/s.

2) If the moving picture mode has reduced resolution, then the moving picture algorithm could be applied sequentially to parts of a higher sampling density picture input.

3) By employing any graphics mode emanating from audiographics teleconferencing standardisation studies.

Comments

-CIF provides necessary minimum resolution required by graphics.

8. Time Schedule

The aim of the group should be to produce an outline recommendation for m x 64 kbit/s to include such items as picture format, framing structure etc, not all the details of the coding algorithm, but perhaps a fundamental structure suitable for programmable hardware, by the end of the current plenary. A full recommendation could then be produced, perhaps using the accelerated procedure, sometime in 1989/90.

End

Appendix to Annex 9

An Example of Packet Format

The packet format is illustrated in Figure 1. It consists of 255 octets, each octet being transmitted with the least significant bit first. The sync word is a unique pattern which is used to mark the beginning of the packet. The end of packet is always known because all packets are of fixed length. Bit times between packets if present are filled with ones.

The sync word has the hexadecimal representation 7AC8, where the least significant bit is transmitted first. It was chosen as the 16-bit word that has the maximum autocorrelation peak, i.e., it has properties similar to a Barker sequence.

There are two types of packets: control packets and data packets. The high order bit, i.e., the last transmitted bit, in the control field is set to one to indicate a control packet. In this case, the low order seven bits are interpreted as a control packet type. In the case of a data packet, the seven bits form a sequence number. Sequence numbers of successive data packets are assigned by incrementing modulo 128.

```
+---------------+
|   sync word   |   2 octets
+---------------+
| control field |   1 octet
+---------------+
|   data field  |   248 octets
|       .       |
|       .       |
|       .       |
+---------------+
|     parity    |   4 octets
+---------------+
```

Figure 1. Packet Format.

The forward error correction scheme uses a double error correcting Reed-Solomon code over GF(256). It generates 4 octets of parity, and it allows a maximum blocklength of 255 octets. The data field is chosen to be 248 octets; a multiple of 64 bits gives compatibility with DES encryption.

The parity is calculated based on the contents of the control and data fields. The receiving terminal calculates syndromes based on the control, data and parity fields which will tell whether zero, one, two or more integral octets in the packet were subjected to transmission errors. If only one or two octets are in error, they may be located and corrected. A larger error is uncorrectable.

In the case of the data packet (DT), the data field contains transparent data supplied by the higher layer. The data field is not interpreted by the link layer.

For control packets, the data field contains transparent or protocol related supervisory data. Examples of control packets are packets exchanged during call setup and clearing.

There is also a control packet type to carry transparent supervisory information between the terminals. This packet type is called unnumbered information packets (UI). The data field of the UI packet contains transparent data. In the case of all other control packets, the data field will consist of packet type specific parameter fields.