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SERIES J: CABLE NETWORKS AND TRANSMISSION OF TELEVISION, SOUND PROGRAMME AND OTHER MULTIMEDIA SIGNALS

Transport of Large Screen Digital Imagery

Network service operator's requirements for real-time transmission of exLSDI signals under parallel processing functionality

Recommendation ITU-T J.602

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Network service operator's requirements for real-time transmission of exLSDI signals under parallel processing functionality

Summary

Recommendation ITU-T J.602 describes network operator's requirements with regard to a real-time transmission system applicable to signals in the extended LSDI hierarchy according to Recommendation ITU-T J.601.

Source

Recommendation ITU-T J.602 was approved on 13 June 2008 by ITU-T Study Group 9 (2005-2008) under Recommendation ITU-T A.8 procedure.

FOREWORD

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Introduction

The general information about an encoding scheme, a multiplexing scheme and a transport protocol for signals in the extended LSDI hierarchy is listed in Recommendation ITU-T J.601. On the other hand, several trials are currently conducted to evaluate a number of systems for the transmission of such signals, and an international standard which recommends a transmission system is required to maintain functionality and interoperability at a sufficient level. This Recommendation describes network operator's requirements with regard to a real-time transmission system applicable to signals in the extended LSDI hierarchy based on the technologies defined in Recommendation ITU-T J.601.

Recommendation ITU-T J.602

Network service operator's requirements for real-time transmission of exLSDI signals under parallel processing functionality

1 Scope

This Recommendation specifies network service operator's requirements for a real-time transmission system for signals in the extended LSDI hierarchy, including an encoder and a decoder. Appendix II describes, for information purposes, a method based on the use of parallel processing for encoding images in the extended LSDI hierarchy. The described parallel processing includes a spatially segmented method, a temporally interleaved method, a frequency sub-band division method and possible hybrid schemes of those methods.

NOTE – The structure and content of this Recommendation have been organized for ease of use by those familiar with the original source material; as such, the usual style of ITU-T recommendations has not been applied.

2 References

2.1 Normative References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T J.601] Recommendation ITU-T J.601 (2005), *Transport of Large Screen Digital Imagery (LSDI) applications for its expanded hierarchy*.

[ITU-R BT.1769] Recommendation ITU-R BT.1769 (2006), *Parameter values for an expanded hierarchy of LSDI image formats for production and international programme exchange*.

[ITU-R BT.1121-1] Recommendation ITU-R BT.1121-1 (1995), *User requirements for the transmission through contribution and primary distribution networks of digital HDTV signals*.

[ITU-R BS.1548-2] Recommendation ITU-R BS.1548-2 (2006), *User requirements for audio coding systems for digital broadcasting*.

2.2 Informative References

[ITU-T J.600] Recommendation ITU-T J.600 (2004), *Transport of Large Screen Digital Imagery (LSDI) applications that employ MPEG-2 encoded HDTV signals*.

3 Terms and definitions

This Recommendation defines no additional term.

4 Abbreviations

This Recommendation uses no new abbreviations.

5 Target applications

This Recommendation focuses on a transmission of signals in the extended LSDI hierarchy for contribution and primary distribution purposes.

6 Requirements

The network operator's requirements below apply, from the stand point of transmission service operators. The network operator's requirements focus on operator's aspects regarding network interoperability and operation functionality including service provisioning and monitoring in addition to the fundamental requirements to maintain the transmission service quality itself.

6.1 Performance

1) *Encoder processing time*

   The overall encoder process including image and audio buffering, video encoding, audio encoding and system multiplexing should be completed at a speed corresponding to real-time processing.

2) *Coding efficiency*

   For video encoding and audio encoding, the coding bit rate should be selected to satisfy contribution and primary distribution quality. Those required quality level should be determined by further study. As the starting point of this study, [ITU-R BT.1121-1] and [ITU-R BS.1548-2] are appropriate references for video and audio, respectively. In the case that parallel processing is employed for video encoding, motion compensated prediction and rate control should be employed across image processing boundaries to improve coding efficiency. For video encoding, picture quality discontinuities should be negligible along boundaries among segmented images, if a parallel processing is adopted for spatially segmented images.

3) *Encoding latency*

   For video encoding and audio encoding, the latency due to processing time for encoding a picture and corresponding audio should be uniform and independent of the image resolution in order to achieve a capability of a seamless switching between different hierarchies of the extended LSDI.

4) *Video and audio synchronization*

   Video and audio streams should be synchronized within a sufficient accuracy. Especially, lip synchronization should be accomplished when audio and video streams are encoded simultaneously.

5) *Error performance and recovery time*

   Error performance and recovery time should be determined by further study. As the starting point of this study, [ITU-R BT.1121-1] and [ITU-R BS.1548-2] are appropriate references for video and audio, respectively.

6.2 Functionality

To achieve a transmission functionality and a reliable service monitoring, the following requirements apply.

1) *Multi-format support*

   A common processing platform may be utilized to support several image resolutions within the range of image system in the extended LSDI hierarchy, specified in [ITU-R BT.1769].

2) *Notification of spatial dependency*

The transmission process should be capable of notifying a spatial dependency in a full resolution picture if parallel processing is adopted for spatially segmented images.

3) *Notification of resolution layer dependency*

The transmission process should be capable of notifying a resolution layer dependency if a functionality of a spatial scalability is utilized in a video coding process.

4) *Single bitstream support*

For video signals, a single resolution layer should be transmitted by a single bitstream as long as applied video coding standard can support the corresponding image resolution, in order to maintain the monitoring precision when commercial measuring equipments fully compliant with a video coding standard are employed.

6.3 Interoperability

1) *Bitstream conformance*

The transmitted bitstream should comply with international video coding standards as those listed in [ITU-T J.601].

Appendix I

Example of functional components for Transmission System for signals in the extended LSDI hierarchy

(This appendix does not form an integral part of this Recommendation)

I.1 Functional Components formulation

To specify the scope of this Recommendation, functional components are formulated as shown in Figure I.1. Each function and implementation example is described. The interface boundary between a network service operator and a service user corresponds to A and D.

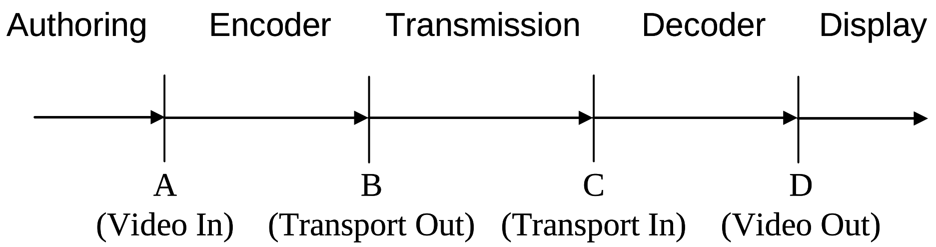

Figure I.1 – Interface among transmission equipments

I.2 Encoder

The encoder compresses the input video signal in real time, and emits the processed data as a transport format. [ITU-T J.601] lists some coding schemes applicable to signals in the extended LSDI hierarchy.

Some implementations employ a parallel processing due to the large amount of video data in the considered signals.

I.3 Transmission system

[ITU-T J.601] lists some transmission mechanism applicable for the transmission of signals in the extended LSDI hierarchy, such as multiplexing or framing methods as well as transport methods.

I.4 Decoder

The decoder decompresses the received data and outputs the video signal in real time. [ITU-T J.601] lists some coding schemes applicable to signals in the extended LSDI hierarchy.

Appendix II

Example of software encoder implementation

(This appendix does not form an integral part of this Recommendation)

The system architecture of software real-time encoder using distributed computing technology is addressed here. In Figure II.1, the assumed process configuration of coding node is along the MC+DCT coding framework just as in the case of MPEG coding standards. However, the reference architecture itself does not restrict the coding scheme. Since the process conducted by a coding node is provided by software module, shifting to another new coding scheme can be realized as well as enabling unsupported coding function within a specific coding scheme just by reloading the proper software module. In order to maintain a high coding efficiency, following framework is introduced.

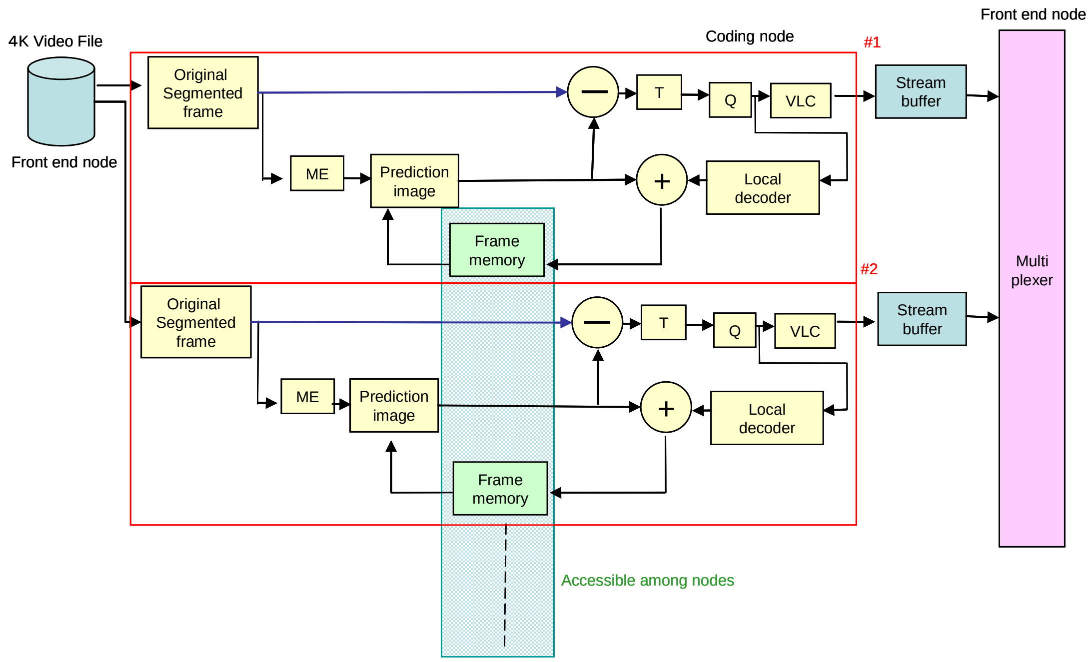

Figure II.I – Block diagram of the example encoder system

a) To maintain the high performance in motion compensated prediction, local decoded images stored in a coding node can be referred from the other coding nodes which handle adjacent image segment.

b) In order to suppress the picture quality difference among neighbouring image segments, the front end node conducts the bit assignment for every image segment prior to initializing encoder process for the current video frame. As the additional advantage introduced by applying this mechanism, the active bit allocation among segmented images can be realized, this may achieve a kind of statistical multiplexing gain.

For the prototype encoder, preliminary experiments are conducted on the typical PC cluster equipped with 12 CPUs. In this experiment, the encoder software is based on MPEG-2. As the test sequence for 4K digital cinema (4096 × 2160, 24 Hz, progressive scan: DCI spec.), DCI StEM (Standard Evaluation Material) is utilized for the experiment. As a pre-process for MPEG-2 based encoding, input signals are converted into YUV format with 4:2:0 chroma sub-sampling.

For simplifying a problem, 4K resolution image is divided into 8 segments whose size is 2048 pixels × 540 lines, and a coding node is applied for every segments. In order to evaluate the scalability of this scheme, the relation between the number of coding nodes operating simultaneously and the total system performance is observed. At the maximum case, 8 coding nodes are operated for handling 4K resolution. As the intermediate example, the case of 4 coding nodes is also evaluated. The relation between the number of coding nodes and the total processing time for a video frame is shown in Table II.1. From the result, performance degradation on the processing time for a video frame is limited, when the number of coding nodes operating simultaneously increases. This means the system performance increases almost linearly according to the number of coding nodes. In this experiment, the target frame rate is 24 Hz due to the input video format, but the architecture is applicable for other frame rate formats.

Table II.1 – Processing time for the number of coding nodes

Number of coding nodes	Processing time for 1 frame [ms]			
	I-picture		P-picture	
	Average	Max	Average	Max
1	25.61	27.93	25.63	34.65
4	25.72	28.74	26.01	36.24
8	25.15	30.97	26.05	38.92

Furthermore, in order to evaluate the significance of the interaction among coding nodes as mentioned above, coding performance is observed. The rate distortion curve is shown in Figure II.2. The result when encoding without the interaction is also shown in the Figure. In order to focus on the prediction gain, the rate control is centralized by the front end node in both cases. The PSNR was calculated as a temporally average value for Y component signals. From the result, the PSNR gain could be achieved by this scheme. This result illustrates the significance of the interaction among nodes in the sense of sharing the reference image for motion compensated prediction.

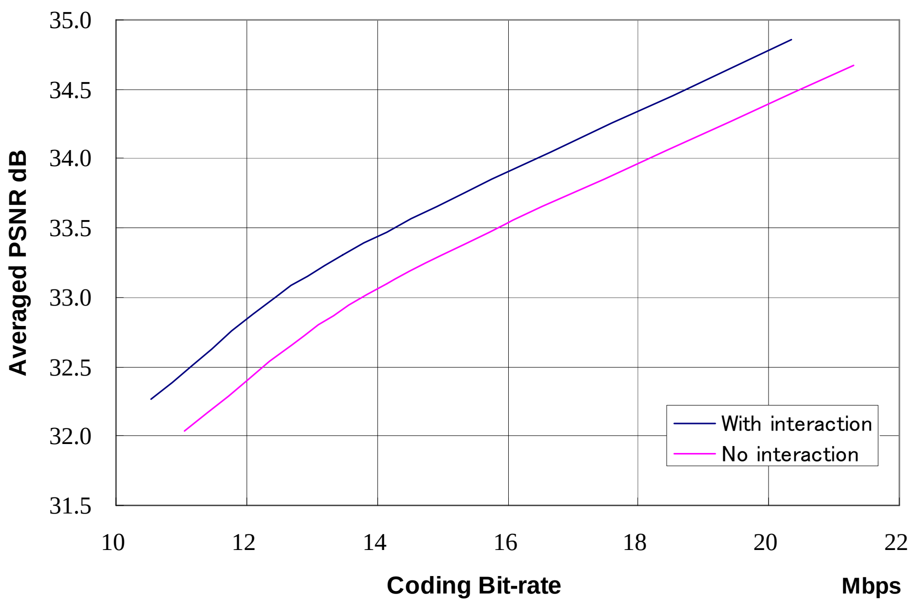

Figure II.2 – Averaged PSNR obtained by the encoder in this Appendix

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