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

Transport of Large Screen Digital Imagery

Transport of Large Screen Digital Imagery (LSDI) applications for its expanded hierarchy

ITU-T Recommendation J.601

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Transport of Large Screen Digital Imagery (LSDI) applications for its expanded hierarchy

Summary

This Recommendation defines technologies regarding transport of LSDI applications for its expanded hierarchy. It supports the 3840 × 2160 and 7680 × 4320 formats in the expanded hierarchy of LSDI image formats. For transport of these LSDI signals, the following items are defined in this Recommendation:

– Compression coding schemes;
– Multiplexing and framing methods;
– Transmission protocols over non-IP networks;
– Transmission protocols over IP networks.

Source

ITU-T Recommendation J.601 was approved on 29 November 2005 by ITU-T Study Group 9 (2005-2008) under the ITU-T Recommendation A.8 procedure.

FOREWORD

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ITU-T Recommendation J.601

Transport of Large Screen Digital Imagery (LSDI) applications for its expanded hierarchy

1 Scope

This Recommendation defines technologies regarding transport of LSDI applications for its expanded hierarchy. It supports the 3840 × 2160 and 7680 × 4320 formats in the expanded hierarchy of LSDI image formats. For transport of these LSDI signals, the following items are defined in this Recommendation:

– Compression coding schemes;

– Multiplexing and framing methods;

– Transmission protocols over non-IP networks;

– Transmission protocols over IP networks.

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.

[1] ITU-T Recommendation H.264 (2005), *Advanced video coding for generic audiovisual services*.

ISO/IEC 14496-10:2005, *Information technology – Coding of audio-visual objects – Part 10: Advanced Video Coding*.

[2] ITU-T Recommendation H.222.0 (2000) | ISO/IEC 13818-1:2000, *Information technology – Generic coding of moving pictures and associated audio information: Systems*.

[3] ITU-T Recommendation J.120 (2000), *Distribution of sound and television programs over the IP network*.

[4] ITU-T Recommendation J.127 (2004), *Transmission protocol for multimedia webcasting over TCP/IP networks*.

[5] ISO/IEC 14496-15:2004, *Information technology – Coding of audio-visual objects – Part 15: Advanced Video Coding (AVC) file format*.

[6] ISO/IEC 15444-1:2004, *Information technology – JPEG 2000 image coding system: Core coding system*.

[7] ISO/IEC 15444-3:2002, *Information technology – JPEG 2000 image coding system – Part 3: Motion JPEG 2000*.

[8] ISO/IEC 15444-3:2002/Amd.2:2003, *Motion JPEG 2000 derived from ISO base media file format*.

[9] IETF RFC 3550 (2003), *RTP: A Transport Protocol for Real-Time Applications*.

[10] IETF RFC 2250 (1998), *RTP Payload Format for MPEG1/MPEG2 Video*.

[11] ITU-T Recommendation H.262 (2000) | ISO/IEC 13818-2:2000, *Information technology – Generic coding of moving pictures and associated audio information: Video*.

[12] ISO/IEC 14496-14:2003, *Information technology – Coding of audio-visual objects – Part 14: MP4 file format*.

[13] ITU-R Recommendation BT.1361 (1998), *Worldwide unified colorimetry and related characteristics of future television and imaging systems*.

2.2 Informative references

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

3 Terms and definitions

No new terms are defined in this Recommendation.

4 Abbreviation

This Recommendation uses the following abbreviation:

LSDI Large Screen Digital Imagery

5 Target application and system parameters

The target application and system parameters assumed for this Recommendation are described in Appendices I and II.

The psychological impact of wide-screen viewing of programs in these image formats are reported in Appendix III.

Examples of the bit rates required to deliver those programs for contribution and for distribution purposes are provided in Appendix IV, based on the use of a toolset of compression algorithms scaled up from the ones currently specified in ITU-T Recs H.264 and H.262.

6 Compression coding scheme

Table 1 specifies compression coding schemes applicable to LSDI systems of the extended hierarchy.

Table 1/J.601 – Compression coding schemes

Method	Resolution	Chroma format	Maximum bit rate (Mbit/s)	Maximum frame rate (fps)	Lossless coding support	Bits per component	Pred. Type	Hierarchical coding	Num. of aux. plane
A	3840 × 2160	4:2:2	240	30 (Note 1)	No	10	I,P,B	No	0
B	3840 × 2160	4:2:2 4:4:4	240	30 (Note 1)	Yes	10, 12	I,P,B	No	0
C	7680 × 4320	4:2:2	240	7.5 (Note 1)	No	10	I,P,B	No	0
D	7680 × 4320	4:2:2 4:4:4	240	7.5 (Note 1)	Yes	10, 12	I,P,B	No	0
E	3840 × 2160 7680 × 4320	4:2:2 4:4:4	Unlimited	Unlimited	Yes	38	I	Yes	16381
F	3840 x 2160 7680 x 4320	4:2:2	300	30 (Note 1)	No	8	I,P,B	No	0

NOTE 1 – ITU-T Recs H.264 and H.262 should define new, higher levels, that will support 7680 × 4320 with 60 frames/second frame rate.

NOTE 2 – Since ITU-T Recs H.264 and H.262 do not currently support signals in the 3840 × 2160 or 7680 × 4320 image formats, transmission of those formats can currently be implemented by dividing the image in 16 × 9 sub-rasters, each one of them in the 1920 × 1080 format, and each one separately encoded.

Methods A to F are the ones identified below:

Method	Description
A	ITU-T Rec. H.264 High 4:2:2 profile level 5.1
B	ITU-T Rec. H.264 High 4:4:4 profile level 5.1
C	ITU-T Rec. H.264 High 4:2:2 profile level 5.1
D	ITU-T Rec. H.264 High 4:4:4 profile level 5.1
E	ISO/IEC JPEG2000
F	H.262 4:2:2 profile high level

7 Multiplexing or framing of compressed bit-streams for LSDI

Table 2 defines multiplexing or framing methods of compressed bit-streams applicable to the LSDI systems of the extended hierarchy considered in this Recommendation.

Table 2/J.601 – Multiplexing or framing methods

Method	Upper layer	Lower layer	Note
H.222.0 (TS Packet) [2]	H.262 [11] H.264 [1] M-JPEG2000 [6] [7]	Independent	
RTP [9]	H.222.0	UDP/IP TCP/IP	Payload format is defined in [10]
ISO File format [5]	H.264	J.127 [4] HTTP/TCP/IP FTP/TCP/IP etc.	
ISO File format [7] [8]	M-JPEG2000	J.127 [4] HTTP/TCP/IP FTP/TCP/IP etc.	
ISO file format [12]	H.262	J.127 [4] HTTP/TCP/IP FTP/TCP/IP etc.	

8 Transport over non-IP networks

ITU-T Rec. H.222.0 (MPEG-2 TS) should be used as a multiplexing method for transport over non-IP networks. Any lower layer protocol other than IP and/or any lower medium can be used for this transport mode.

9 Transport using Internet Protocols

9.1 Transport over UDP/IP

ITU-T Rec. H.222.0 (MPEG-2 TS) should be used as a multiplexing method also for transport over IP networks.

ITU-T Rec. J.120 should be used for LSDI transport over UDP/IP networks. ITU-T Rec. J.120 uses SDP as presentation description, RTSP as session control, and RTP as media packet format. Transmission of SDP is outside the scope of this Recommendation, TCP/IP should be used for RTSP session control and UDP/IP should be used for RTP packet transmission.

RTP is defined in [9] and its framing format is defined in [10] (See Section 2). Only H.222.0 (MPEG-2 Transport Stream) is defined as an upper layer of the RTP packet in this Recommendation. Therefore, payload type 33 (MP2T) should be used.

9.2 Transport over TCP/IP

In this Recommendation, ISO file formats for H.264, for H.262 and for Motion JPEG2000 should be used as a multiplexing format for LSDI transport over TCP/IP. This Recommendation defines two transport modes over TCP/IP.

For the progressive download mode, ITU-T Rec. J.127 should be used for LSDI over TCP/IP networks. ITU-T Rec. J.127 uses XHTML description for presentation description, HTTP for session control and does not specify multiplexing format for the media.

For the file downloading mode, any other file transmission protocols such as FTP or HTTP may be used; this depends on availability and is outside the scope of this Recommendation.

Appendix I

An example of a film-based system that gives viewers visual experiences of a high-sensation of reality

This appendix provides a graphical representation of the area of application of this Recommendation (see Figure I.1), based on the horizontal viewing angle subtended by the presentation screen at the position of the viewers.

The application is designed on the basis of viewing angles that are typical of IMAX and OMNIMAX theatres.

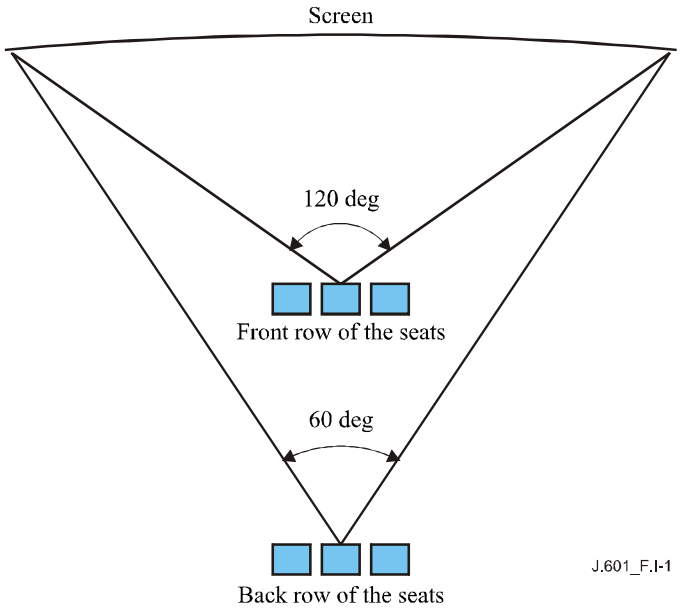

Figure I.1/J.601 – Horizontal viewing angle of the IMAX system

Appendix II

Viewing angles for the hierarchy of LSDI systems

This appendix indicates the horizontal viewing angles and the viewing distances (relative to picture heights) for which the higher formats were designed, which are covered in this Recommendation for the extended hierarchy of the LSDI family of systems (see Table II.1).

Table II.1/J.601 – Horizontal viewing angle for the hierarchy of LSDI systems

LSDI system	1920 × 1080	3840 × 2160	7680 × 4320
Viewing distance (relative to picture height)	3	1.5	0.75
Viewing angle (degrees)	31	58	96

These values are calculated based on the shortest distance at which scanning lines cannot be perceived by people with visual acuity of 1.0.

Appendix III

A study of the psychological effects of wide-screen video systems for LSDI applications

III.1 Introduction

This appendix describes the psychological evaluation results of "sensation of reality" of LSDI covering from HDTV format to expanded format. The results would contribute towards determining system parameter values such as display size, viewing distance and spatial resolution.

III.2 Subjective evaluation experiments

A single stimulus method with a seven-grade categorical scale (1 = no presence at all; 7 = very strong presence) was used for evaluating the "sensation of reality" of images projected on a screen. The size of images was varied by changing the number of scanning lines from 1000 to 4000. The viewing distance was determined to be the point at which viewers with normal vision could no longer discern the scanning line structure. This corresponds to three times the picture height when the image size is 1920 × 1080. The viewing angle varies between 33 and 100 degrees according to the image size. Table III.1 lists the experimental conditions. Forty-one non-expert subjects evaluated five still landscape pictures listed in Table III.2. They were photographed from different camera angles of 60 and 100 degrees to see the effect of spatial distortion resulting from the mismatch between the screen-viewing angle and camera angle, which can result in a reduced "sensation of reality".

Table III.1/J.601 – Experimental conditions

Scanning lines	1000	1143	1333	1600	2000	2667	3200	3556	4000
Picture aspect ratio	16:9								
Picture size diagonally [inch]	75	86	100	120	150	200	240	267	300
Viewing distance [m]	2.8								
Viewing distance [H]	3.0	2.6	2.2	1.9	1.5	1.1	0.93	0.84	0.75
Horizontal viewing angle [deg]	33.2	37.6	43.3	51.0	61.6	76.9	87.3	93.3	100.0

Table III.2/J.601 – Test pictures

Camera angle 60 [deg]	 1	 2	 3	 4	 5
Camera angle 100 [deg]	 1	 2	 3	 4	 5

The display sub-system of ultra-high definition video system with 4000 scanning lines (8k × 4k display system) was used for an experiment apparatus. The system is reported in ITU-R Report BT.2053 (2006), *Large screen digital imagery*. The display is equipped with four 8-million-pixel liquid crystal on silicon devices, and a pixel offset method enhances the resolution as equivalent to 32 million pixels. The screen size is approximately 7 m horizontally and 4 m vertically (320-inch diagonally). Screen brightness is 50 cd/m^2 and contrast ratio is more than 700:1. Table III.3 lists the major items of the system's signal format.

Table III.3/J.601 – Signal format of 8k × 4k display system

Parameter	Value
Picture rate	60 frames per second
Image structure	Progressive
Samples per active line	7680
Active lines per picture	4320
Picture aspect ratio	16:9

III.3 Results

The "sensation of reality" evaluated in seven-grade categorical scale was converted to interval scale to perform a multivariate analysis of variance (MANOVA) with a three-factor within-subject design (screen-viewing angle, camera angle and picture content). Significant values were obtained for the main effect of the screen-viewing angle, the main effect of the picture content, and for screen-viewing angle × camera angle interactions. The main effect of the picture content was significant because picture 1 was rated higher than the other pictures. If MANOVA is performed without the results for picture 1, then significant results are not obtained for the main effect of the picture content. Figure III.1 shows the relationship between the average score of pictures 1-5 and the screen-viewing angle for different camera angles. "Sensation of reality" increases linearly with

viewing angle, although the results for a camera angle of 60 degrees slightly levels off at viewing angles above 90 degrees.

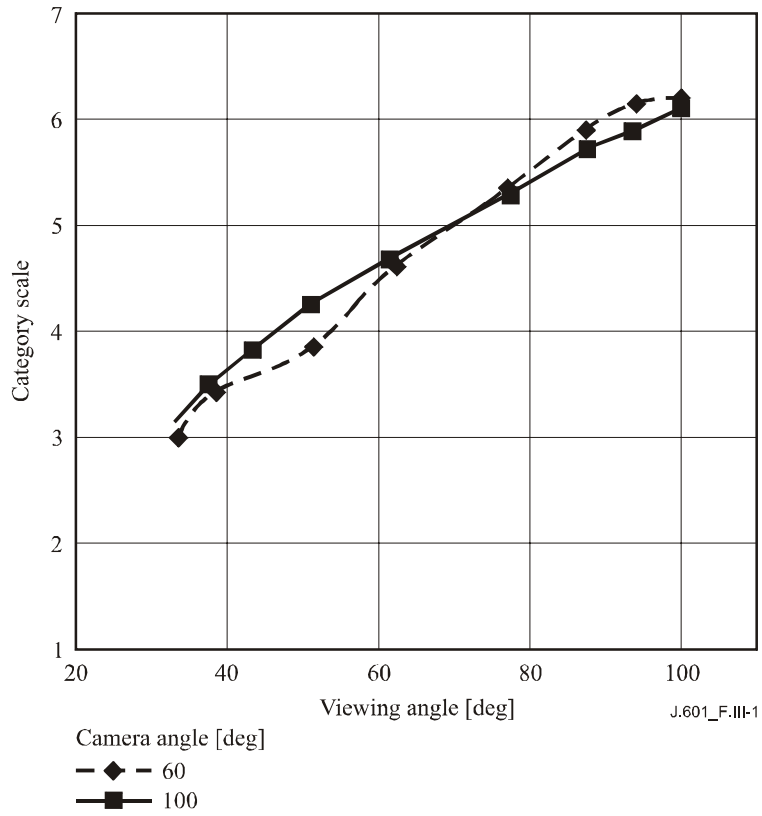

Figure III.1/J.601 – Sensation of reality vs viewing angle

III.4 Conclusion

The results confirm that a wider viewing angle generates a higher "sensation of reality". It also implies that LSDI with higher resolution than HDTV would be needed for applications that require a higher "sensation of reality". On the other hand, it is known that a decrease in comfort levels arises when the viewing position is too close to wide-screen images.

In order to facilitate a wide variety of LSDI applications, study of expanded hierarchy of LSDI systems should be advanced.

Appendix IV

The expanded hierarchy of the LSDI image formats

This appendix provides the fundamental parameter values for the members of the expanded hierarchy of LSDI image formats. It also provides an estimate for the net compressed bit rate required to transport them for contribution and for distribution purposes.

It should be noted that, since ITU-T Recs H.264 and H.262 do not currently support signals in the 3840 × 2160 or 7680 × 4320 image formats, transmission of those formats can currently be implemented by dividing the image in 16 × 9 sub-rasters, each one of them in the 1080 × 1920 format, and each one separately encoded.

Table IV.1/J.601 – Picture and scanning characteristics

Item	Parameter	Values	
		3840 × 2160 LSDI system	**7680 × 4320 LSDI system**
1.1	Picture aspect ratio	16:9	
1.2	Samples per active line	3840	7680
1.3	Active lines per picture	2160	4320
1.4	Sampling lattice	Orthogonal	
1.5	Order of samples	Left to right, top to bottom	
1.6	Pixel aspect ratio	1:1 (square pixels)	
1.7	Sampling structure	4:2:2, 4:4:4	
1.8	Frame rate (Hz)	24*, 25, 30*, 50, 60*	
1.9	Image structure	Progressive	
1.10	Bit/pixel	10, 12	
1.11	Colorimetry	See ITU-R Rec. BT.1361	
* For the 24, 30 and 60 Hz systems, frame rates having those values divided by 1.001 are also specified.			

Table IV.2/J.601 – Estimated net compressed bit rate required to transport expanded hierarchy signals for contribution and for distribution purposes

Parameter	3840 × 2160 LSDI system			7680 × 4320 LSDI system		
Sampling structure for source coding	4:4:4	4:2:2	4:2:0	4:4:4	4:2:2	4:2:0
Frame rate (Note 1)	60	60	60	60	60	60
Bit/pixel (Note 2)	10	10	10	10	10	10
Source bit rate	14.9 Gbit/s	9.95 Gbit/s	7.46 Gbit/s	59.7 Gbit/s	39.8 Gbit/s	29.9 Gbit/s
Approximate Target encoding bit rate for H.264 (Note 3)	100 Mbit/s	66 Mbit/s	50 Mbit/s	400 Mbit/s	265 Mbit/s	200 Mbit/s
Approximate Target encoding bit rate for H.262 (Note 3)	200 Mbit/s	135 Mbit/s	100 Mbit/s	800 Mbit/s	530 Mbit/s	400 Mbit/s
NOTE 1 – An appropriate frame rate should be chosen depending on the application. NOTE 2 – Only the case of 10 Bit/pixel is shown here. NOTE 3 – An appropriate bit rate should be chosen depending on the application.						

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– SHAW, William (C.) and DOUGLAS (J.), IMAX and OMNIMAX Theatre Design, *SMPTE* Journal 92, March 1983.

– MASAOKA (K.), *et al.*, Relationship between Viewing Angles and Presence when Using a Ultrahigh-Definition Wide-Angle Display, *ITE Technical Report*, Vol. 28, No. 31, pp. 17-20, 2004.

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