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10      **Digital Imaging and Communications in Medicine (DICOM)**

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12                          *Supplement 149:*
13                 *MPEG-4 AVC/H.264 Transfer Syntax*

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22      **DICOM Standards Committee, Working Group 13 Visible Light**

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25

26      VERSION:        Final Text, April 4, 2011

27      Developed in accordance with work item 2008-09-B.

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30 **Table of Contents**

39

40          **Scope and Field of Application**


41    This supplement describes two new Transfer Syntaxes to embed MPEG-4 Advanced Video Coding (AVC)
42    / H.264 High Profile / Level 4.1 (HiP@Level4.1) encoded pixel data in DICOM. It does not introduce any
43    new SOP Classes or IODs.

44    Both Transfer Syntaxes use MPEG-4 AVC/H.264 High Profile / Level 4.1 (HiP@Level4.1) encoding.

45    Transfer Syntax MPEG-4 AVC/H.264 High Profile / Level 4.1 (HiP@Level4.1) will support all resolutions up
46    to 1080x1920 consistent with the ITU-T H.264 HiP@Level4.1.

47    Transfer Syntax MPEG-4 AVC/H.264 BD-compatible High Profile / Level 4.1 (HiP@Level4.1) will be a
48    subset of Transfer Syntax MPEG-4 AVC/H.264 High Profile / Level 4.1 (HiP@Level4.1), supporting only
49    Blu-ray Disc$^{TM}$ (BD) compatible HD (high definition) video resolutions.

50          Note:    "Blu-ray Disc", "Blu-ray", and the "Blu-ray Disc" logo are trademarks of the Blu-ray Disc Association.
51

52    Several different profiles and levels are defined by MPEG-4 AVC/H.264. High Profile is the primary MPEG-
53    4 AVC/H.264 profile for broadcast and disc storage applications (e.g. Blu-ray Disc$^{TM}$), particularly for high
54    definition television applications.

55    This proposed supplement includes Addenda to existing Parts of DICOM:

56          - PS 3.5 Addendum: Data Structures and Encoding

57          - PS 3.6 Addendum: Data Dictionary

58    The demand for high definition and high compression video storage is driven by several developments in
59    the health care community:

60       High definition video sources are being used increasingly for video acquisition by modalities working in
61          the visible light domain. Users have clearly expressed that they want to upgrade their system to
62          HD, mainly to have a better image quality.
63       For storing and playback of HD video content high capacity media formats are required. The Blu-ray
64          Disc$^{TM}$ medium has achieved high acceptance in the market as successor of the DVD format.
65       High end applications in Endoscopic Surgery, Laparoscopy, Gastro-Enterology, Orthopedics,
66          Ophthalmology, Gynecology, Bronchoscopy, and Microscopic Surgery demand more and more
67          archiving of still images and videos to document the performed surgical procedure.
68       At the same time, hospitals feel a strong demand to economize in all areas. Therefore they ask for
69          solutions with small bandwidth and storage demands.
70

71    The following use-cases and technical considerations have been taken into account for introducing MPEG-
72    4 AVC/H.264 as a new Transfer Syntax into DICOM:
73

74          -    The Transfer Syntax has to be compliant to support **high quality image communication** for
75               post-surgery analysis and real-time or after archiving education.
76
77               There are two transfer syntaxes defined in this supplement. The MPEG-4 AVC/H.264 High
78               Profile / Level 4.1 supplement, which allows bitrates of up to 62.5 Mbps and the MPEG-4
79               AVC/H.264 BD-compatible High Profile / Level 4.1 supplement, which allows bitrates of up to
80               40 Mbps as defined in BD.
81

82      Support of different **image aspect ratios** that will display consistently
83
84          MPEG-4 AVC/H.264 supports all HD and SD broadcast formats. The MPEG-4 AVC/H.264
85          standard itself is not limited to only broadcast formats. This supplement will only allow formats with
86          a square pixel aspect ratio. Thus, the display aspect ratio will be explicitly determined by the video
87          picture resolution. The BD-compliant Transfer Syntax restrictions will help to sustain highest
88          compatibility to currently existing encoder and decoder products, while Transfer Syntax one
89          ('MPEG-4 AVC/H.264 High Profile / Level 4.1') will allow a higher level of optimization for network
90          transmission and storage.
91
92      **Transportable media** including Blu-ray Disc$^{TM}$ for HD
93
94          MPEG-4 AVC/H.264 is one of the mandatory standards for Blu-ray$^{TM}$ and has a high coding
95          efficiency. The proposed Transfer Syntax two "MPEG-4 AVC/H.264 BD-compliant" profile and
96          level in this supplement are compliant to Blu-ray$^{TM}$. This is important as it allows the storage of
97          video even outside the scope of DICOM without compromising the compatibility or the quality of
98          the recorded video. A smooth and lossless transition from DICOM embedded video to a video
99          format usable for presentations is therefore also guaranteed.
100
101     **Support of sound** for recording the surgeon comments and patient sounds
102
103         The combination of MPEG-4 AVC/H.264 with LPCM or AC-3 audio is possible. The MPEG-2
104         transport stream mechanism (e.g. as also used by Blu-ray$^{TM}$) will guarantee the synchronization
105         between video and audio.
106
107 MPEG-4 AVC/H.264 is capable of fulfilling the requirements and is a widely adopted standard with the
108 highest video compression ratio for HD video. Since it has been adopted into the HD broadcast and HD
109 optical disc standards, it became the main standard for HD video.

110 It should be noted that audio channel(s), for voice or sound-based physiological information, may be
111 interleaved within the video stream using AC-3 or LPCM.
112 The existing Key Object Selection SOP Class provides a mechanism for referencing individual frames, or
113 multiple frames (such as a video "clip").

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122 **Changes to NEMA Standards Publication PS 3.5-2009**

123 **Digital Imaging and Communications in Medicine (DICOM)**

124 **Part 5: Data Structures and Encoding**

125

126 | **Add references to section 2:**

127 **Section 2    Normative references**

128 …

129  ASTM E-1238-91          Standard Specification for Transferring Clinical Observations Between
130                          Independent Computer Systems; Draft Revision 4.2.1

131  **BDRWP 2.B**               **Blu-ray Disc<sup>TM</sup> Association. White Paper Blu-ray Disc<sup>TM</sup> Format 2.B Audio**
132                          **Visual Application Format Specifications for BD-ROM (March 2005)**

133  **ETSI TS 102 366**         **ETSI TS 102 366, Audio Compression (AC-3, Enhanced AC-3) Standard**
134                          **(Feb. 2005)**

135  IEEE 754:1985           32-bit and 64-bit Floating Point Number Representations

136 …

137  ISO/IS 14495-1          Lossless and near-lossless coding of continuous tone still images (JPEG-LS)

138  **ISO/IEC 1449-10:2009**     **Information technology – Coding of audio-visual objects – Part 10:**
139                          **Advanced Video Coding**

140  ISO/IEC 15444-1         JPEG 2000 Image Coding System

141 …

142

143 | **Add MPEG-4 AVC/H.264 High Profile / Level 4.1 video compression to Section 8.**

144 **8.2.X         MPEG-4 AVC/H.264 High Profile / Level 4.1 Video Compression**

145 MPEG-4 AVC/H.264 High Profile / Level 4.1 corresponds to what is commonly known as HDTV ('High
146 Definition Television'). DICOM provides a mechanism for supporting the use of MPEG-4 AVC/H.264 Image
147 Compression through the Encapsulated Format (see PS 3.3). Annex A defines a Transfer Syntax that
148 references the MPEG-4 AVC/H.264 Standard.

149     Note:    MPEG-4 AVC/H.264 compression @ High Profile compression is inherently lossy. The context where the
150     usage of lossy compression of medical images is clinically acceptable is beyond the scope of the DICOM
151     Standard. The policies associated with the selection of appropriate compression parameters (e.g.
152     compression ratio) for MPEG-4 AVC/H.264 HiP@Level4.1 are also beyond the scope of this standard.

153

154 The use of the DICOM Encapsulated Format to support MPEG-4 AVC/H.264 compressed pixel data
155 requires that the Data Elements which are related to the Pixel Data encoding (e.g. Photometric
156 Interpretation, Samples per Pixel, Planar Configuration, Bits Allocated, Bits Stored, High Bit, Pixel
157 Representation, Rows, Columns, etc.) shall contain values that are consistent with the characteristics of
158 the compressed data stream, with some specific exceptions noted here. The Pixel Data characteristics
159 included in the MPEG-4 AVC/H.264 bit stream shall be used to decode the compressed data stream.

160     Notes:    1. These requirements are specified in terms of consistency with what is encapsulated, rather than in
161     terms of the uncompressed pixel data from which the compressed data stream may have been derived.
162     2. When decompressing, should the characteristics explicitly specified in the compressed data stream be
163     inconsistent with those specified in the DICOM Data Elements, those explicitly specified in the
164     compressed data stream should be used to control the decompression. The DICOM data elements, if
165     inconsistent, can be regarded as suggestions as to the form in which an uncompressed data set might
166     be encoded.

167

168 The requirements are:

169     Planar Configuration (0028,0006) shall be 0

170     Samples per Pixel (0028,0002) shall be 3

171     Photometric Interpretation (0028,0004) shall be YBR_PARTIAL_420

172     Bits Allocated (0028,0100) shall be 8

173     Bits Stored (0028,0101) shall be 8

174     High Bit (0028,0102) shall be 7

175     Pixel Representation (0028,0103) shall be 0

176     The value of MPEG-4 AVC/H.264 sample aspect_ratio_idc shall be 1 in the encapsulated MPEG-4
177     AVC/H.264 bit stream if aspect_ratio_info_present_flag is 1.

178     Pixel Aspect Ratio (0028,0034) shall be absent. This corresponds to a 'Sampling Aspect Ratio' (SAR)
179     of 1:1.

180     The possible values for Rows (0028,0010), Columns (0028,0011), Cine Rate (0018,0040) , and Frame
181     Time (0018,1063) or Frame Time Vector  (0018,1065) depend on the used transfer syntax.

182     o    For MPEG-4 AVC/H.264 High Profile / Level 4.1 transfer syntax, the values for these data
183     elements shall be compliant with the High Profile / Level 4.1 of the MPEG-4 AVC/H.264
184     standard (ISO/IEC 1449-10:2009) and restricted to a square pixel aspect ratio.

185     o    For  MPEG-4 AVC/H.264 BD-compatible High Profile / Level 4.1 transfer syntax, the
186     values for these data elements shall be as specified in Table 8-y.

187

<table>
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188 | | | | **Table 8-y** | | |
189 | | | **Values permitted for MPEG-4 AVC/H.264 BD-compatible High Profile / Level 4.1** | | | |

| Rows | Columns | Frame rate | Video Type | Progressive or Interlace |
|------|---------|-----------|-----------|--------------------------|
| 1080 | 1920 | 25 | 25 Hz HD | I |
| 1080 | 1920 | 29.97 | 30 Hz HD | I |
| 1080 | 1920 | 24 | 24 Hz HD | P |
| 1080 | 1920 | 23.976 | 24 Hz HD | P |
| 720 | 1280 | 50 | 50 Hz HD | P |
| 720 | 1280 | 59.94 | 60 Hz HD | P |
| 720 | 1280 | 24 | 24 Hz HD | P |
| 720 | 1280 | 23.976 | 24 Hz HD | P |

190

191    Notes:   1. The value of Planar Configuration (0028,0006) is irrelevant since the manner of encoding components
192    is specified in the MPEG-4 AVC/H.264 standard, hence it is set to 0.

193    2. The limitation on rows and columns are to maximize interoperability between software environments
194    and commonly available hardware MPEG-4 AVC/H.264 encoder/decoder implementations. Source
195    pictures that have a lower value should be re-formatted by scaling and/or pixel padding prior to MPEG-4
196    AVC/H.264 encoding.

197    3. The frame rate of the acquiring camera for '30 Hz HD' MPEG-4 AVC/H.264 may be either 30 or
198    30/1.001 (approximately 29.97) frames/sec. Similarly, the frame rate in the case of 60 Hz may be either
199    60 or 60/1.001 (approximately 59.94) frames/sec. This may lead to small inconsistencies between the
200    video timebase and real time. The relationship between frame rate and frame time is shown in Table 8-x.

201    4. The Frame Time (0018,1063) may be calculated from the frame rate of the acquiring camera. A frame
202    rate of 29.97 frames per second corresponds to a frame time of 33.367 ms.

203    5. The value of chroma_format for this profile and level is defined by MPEG as 4:2:0.

204    6. Example screen resolutions supported by MPEG-4 AVC/H.264 High Profile / Level 4.1 can be taken
205    from Table 8-y. Frame rates of 50 Hz and 60 Hz (progressive) at the maximum resolution of 1080 by
206    1920 are not supported by MPEG-4 AVC/H.264 High Profile / Level 4.1. Interlace at the maximum
207    resolution is supported at a field rate of 50 Hz or 60 Hz, which corresponds to a frame rate of 25 Hz or 30
208    Hz respectively. Smaller resolutions may be used as long as they comply with the square pixel aspect
209    ratio. An example is XGA resolution with an image resolution of 768 by 1024 pixels. For smaller
210    resolutions there are higher frame rates possible. For example it may be up to 80 Hz for XGA.

211    7. The display aspect ratio is defined implicitly by the pixel resolution of the video picture. Only square
212    pixel aspect ratio is allowed. MPEG-4 AVC/H.264 BD-compatible High Profile / Level 4.1 will only support
213    resolutions that result in a 16:9 display aspect ratio

214    8. The permitted screen resolutions for the MPEG-4 AVC/H.264 BD-compatible High Profile / Level 4.1
215    are listed in Table 8-y. Only HD resolutions and no progressive frame rates for 25 or 29.97 frames per
216    seconds are supported. Frame rates of 50 Hz and 60 Hz (progressive) at the maximum resolution of
217    1080 by 1920 are not supported.

218

219 **Table 8-x**
220 **MPEG-4 AVC/H.264 High Profile / Level 4.1 IMAGE TRANSFER SYNTAX FRAME RATE ATTRIBUTES**

| Video Type | Spatial resolution layer | Frame Rate (see Note 2) | Frame Time (see Note 3) |
|---|---|---|---|
| 30 Hz HD | Single level, Enhancement | 30 | 33.33 ms |
| 25 Hz HD | Single level, Enhancement | 25 | 40.0 ms |
| 60 Hz HD | Single level, Enhancement | 60 | 16.17 ms |
| 50 Hz HD | Single level, Enhancement | 50 | 20.00 ms |

221

222 One fragment shall contain the whole MPEG-4 AVC/H.264 bit stream.

223 Note:    If a video stream exceeds the maximum length of one fragment (approximately 4 GB), it may be sent as
224          multiple SOP Instances.

225

226 The PTS/DTS of the transport stream shall be used in the MPEG coding. Audio components shall be
227 interleaved in either LPCM or AC-3 audio format and shall comply with the following restrictions:

228 - LPCM

229 • Maximum bitrate: 4.608 Mbps

230 • Sampling frequency: 48, 96 kHz

231 • Bits per sample: 16, 20 or 24 bits

232 • Number of channels: 2 channels

233 - AC-3

234 • Maximum bitrate: 640kbps

235 • Sampling frequency: 48kHz

236 • Bits per sample: 16 bits

237 • Number of channels: 2 or 5.1 channels

238 Note:    AC-3 is standardized in ETSI TS 102 366

239

240 **Add TRANSFER SYNTAX FOR MPEG-4 AVC/H.264 High Profile / Level 4.1 COMPRESSION to**
241 **Section 10.**

242 **10.X      TRANSFER SYNTAX FOR MPEG-4 AVC/H.264 HIP@LEVEL4.1 IMAGE**
243 **COMPRESSION**

244 One Transfer Syntax is specified for MPEG-4 AVC/H.264 High Profile / Level 4.1 Image Compression and
245 one Transfer Syntax is specified for MPEG-4 AVC/H.264 BD-compliant High Profile / Level 4.1. Transfer
246 Syntax MPEG-4 AVC/H.264 High Profile / Level 4.1 corresponds to the ITU-T H.264 standard's profile and
247 level specifications. Transfer Syntax MPEG-4 AVC/H.264 BD-compliant High Profile / Level 4.1
248 corresponds to a restricted set of spatial and temporal resolutions described Table 8-y. This Transfer
249 Syntax limits the ITU-T H.264 High Profile / Level 4.1 to HD video formats that are supported by Blu-ray[TM]
250 (BDRWP 2.B).

251 | **Add MPEG-4 AVC/H.264 High Profile / Level 4.1 requirements to Annex A.** |

252 **Annex A**
253 **(Normative)**
254 **Transfer Syntax Specifications**

255 **A.4.X      MPEG-4 AVC/H.264 HIP@LEVEL4.1 VIDEO COMPRESSION**

256 The International Standards Organization ISO/IEC MPEG4 has developed an International Standard,
257 ISO/IEC 14496-10 (MPEG-4 Part 10), for the video compression of generic coding of moving pictures and
258 associated audio information. This standard is jointly maintained and has identical technical content as the
259 ITU-T H.264 standard.

260 A DICOM Transfer Syntax for MPEG-4 AVC/H.264 Image Compression shall be identified by a UID value
261 of either:

262      1.2.840.10008.1.2.4.102 corresponding to the MPEG-4 AVC/H.264 High Profile / Level 4.1 of the ITU-
263          T H.264 Video standard
264      1.2.840.10008.1.2.4.103 corresponding to the MPEG-4 AVC/H.264 BD-compatible High Profile / Level
265          4.1 of the ITU-T H.264 Video standard with the temporal and spatial resolution restrictions defined
266          in
267          PS 3.5 Table 8-y.

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276 **Changes to NEMA Standards Publication PS 3.6-2009**

277 **Digital Imaging and Communications in Medicine (DICOM)**

278 **Part 6: Data Dictionary**

279

280 | **Add new UID to Annex A.**

281

| UID Value | UID Name | UID Type | Part |
|---|---|---|---|
| 1.2.840.10008.1.2.4.102 | MPEG-4 AVC/H.264 High Profile / Level 4.1 | Transfer Syntax | PS 3.5 |
| 1.2.840.10008.1.2.4.103 | MPEG-4 AVC/H.264 BD-compatible High Profile / Level 4.1 | Transfer Syntax | PS 3.5 |

282