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## Information technology — Coding of audio-visual objects —

### Part 16: Animation Framework eXtension (AFX)

AMENDMENT 1: Scalable complexity 3D

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*Technologies de l'information — Codage des objets audiovisuels —*

*ISO/IEC 14496-16:2009/FDAM Amend 1*

*Partie 16: Extension du cadre d'animation (AFX)*

*<https://standards.iteh.ai/catalog/standards/sist/3ec42155-ec29-42a7-8159-b38c37127807/iso-iec-14496-16-2009-fdas-amend-1>*

*AMENDEMENT 1: Codage de maillage 3D de complexité échelonnable*

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Amendment 1 to ISO/IEC 14496-16:2009 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information*.

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# Information technology — Coding of audio-visual objects —

## Part 16: Animation Framework eXtension (AFX)

### AMENDMENT 1: Scalable complexity 3D mesh coding

*Page 2, immediately before 3.1*

Add the following:

4C 4-bits-based coding

AC Arithmetic Coding

BPC Bit Precision Coding  
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TFAN Triangle FAN [ISO/IEC 14496-16:2009/FDIS Amd 1](#)

QBCR Quantization Based Compact Representation <https://standards.iteh.ai/catalog/standards/sist/3ec42155-ec29-42a7-8159-0009-fdis-amd-1>

The mathematical operators used to describe this part of ISO/IEC 14496 are similar to those used in the C programming language. However, integer divisions with truncation and rounding are specifically defined. Numbering and counting loops generally begin from zero.

#### Arithmetic operators

+ Addition.

- Subtraction (as a binary operator) or negation (as a unary operator).

++ Increment. i.e.  $x++$  is equivalent to  $x = x + 1$

-- Decrement. i.e.  $x--$  is equivalent to  $x = x - 1$

$\times$  Multiplication.  
 $*$

$^$  Power.

/ Integer division with truncation of the result toward zero. For example,  $7/4$  and  $-7/-4$  are truncated to 1 and  $-7/4$  and  $7/-4$  are truncated to -1.

$\div$  Used to denote division in mathematical equations where no truncation or rounding is intended.

% Modulus operator. Defined only for positive numbers.

$$\text{Abs}( ) \quad \text{Abs}(x) = \begin{cases} x & x \geq 0 \\ -x & x < 0 \end{cases}$$

### Logical operators

|| Logical OR.

&& Logical AND.

! Logical NOT.

### Relational operators

> Greater than.

>= Greater than or equal to.

≥ Greater than or equal to.

< Less than.

<= Less than or equal to.

≤ Less than or equal to.  
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== Equal to.

!= Not equal to. [ISO/IEC 14496-16:2009/FDIS Amd 1](#)  
<https://standards.iteh.ai/catalog/standards/sist/3ec42155-ec29-42a7-8159-b38c37127801/iso-iec-14496-16-2009-fdis-amd-1>

max [, ... ,] the maximum value in the argument list.

min [, ... ,] the minimum value in the argument list.

### Bitwise operators

& AND

| OR

>> Shift right with sign extension.

<< Shift left with zero fill.

### Assignment

= Assignment operator.

*Page 182, immediately before 4.3*

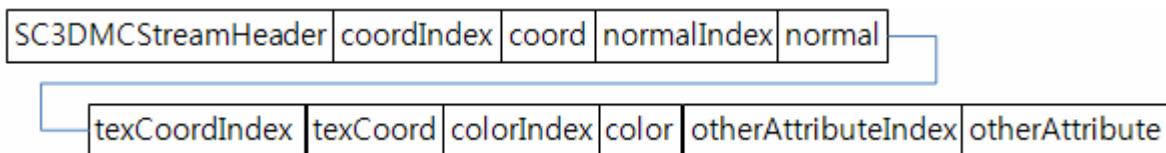
Add the following new subclause.

## 4.2.5 Scalable Complexity 3D Mesh Coding

### 4.2.5.1 SC3DMC Bitstream structure

The Scalable Compression 3D Mesh Coding (SC3DMC) stream describes any triangular mesh represented as an IndexedFaceSet, with single or multiple attributes defined per vertex or per triangle. The bitstream is composed of two main components (*cf.* Figure AMD1.1):

- The header: describing general information about the coded mesh.
- The data stream: describing the connectivity and the geometry information of the mesh.



**Figure AMD1.1 — SC3DMC stream structure.**  
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The SC3DMCStream is encapsulated in an AFX stream and has the following AFX object code:

[ISO/IEC 14496-16:2009/FDIS Amd 1  
Table AMD1.1 — AFX object code](https://standards.iteh.ai/catalog/standards/sc3dmc-stream-142a7-8159-b38c3712/804/iso-iec-14496-16-2009-fdis-amd-1)

AFX object code	Object	Associated node	Type value of bitwrapper
0x0C	Scalable complexity Based Representation	IndexedFaceSet	2

When used in a BIFS scene, the value of the field "type" is 2.

### 4.2.5.2 SC3DMC Bitstream syntax and semantics

#### 4.2.5.2.1 SC3DMCStream class

##### 4.2.5.2.1.1 Syntax

```
class SC3DMCStream{
    SC3DMCStreamHeader header;
    SC3DMCStreamData data;
}
```

##### 4.2.5.2.1.2 Semantics

**SC3DMCStreamHeader:** This is the header buffer of SC3DMC.

**SC3DMCStreamData:** This is the data buffer of SC3DMC.

#### 4.2.5.2.2 SC3DMCStreamHeader class

##### 4.2.5.2.2.1 Syntax

```
class SC3DMCStreamHeader{
```

```
    unsigned int (32) streamSize;
    bit (8) encodingMode;
    float (32) creaseAngle;
    bit (1) ccw;
    bit (1) solid;
    bit (1) convex;
    bit (1) colorPerVertex;
    bit (1) normalPerVertex;
    bit (1) otherAttributesPerVertex;
    bit (1) isTriangularMesh;
    bit (1) markerBit // always set as 1
```

```
    unsigned int (32) numberOfCoord;
    unsigned int (32) numberOfNormal
    unsigned int (32) numberTexCoord;
    unsigned int (32) numberColor;
    unsigned int (32) numberOtherAttributes;
```

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<https://standards.iteh.ai/catalog/standards/sist/3ec42155-ec29-42a7-8159-b38c37127804/iso-iec-14496-16-2009-fdis-amd-1>

```
if (numberOfOtherAttributes >0)
    unsigned int (8) dimensionOfOtherAttributes;
if (numberOfCoord >0) {
    unsigned int (32) numberOfCoordIndex;
    bit(8) QPforGeometry;           ISO/IEC 14496-16:2009/FDIS Amd 1
}
if (numberOfNormal >0) {
    unsigned int (32) numberOfNormalIndex;
    bit(8) QPforNormal;
}

if (numberOfColor >0) {
    unsigned int (32) numberOfColorIndex;
    bit(8) QPforColor;
}

if (numberOfTexCoord >0) {
    unsigned int (32) numberOfTexCoordIndex;
    bit(8) QPforTexCoord;
    unsigned int (32) TexCoordWidth;
    unsigned int (32) TexCoordHeight;

}

if (numberOfOtherAttributes >0) {
    unsigned int (32) numberOfOtherAttributesIndex;
    bit(8) QPforOtherAttributes
}

if (numberOfCoord >0) {
    for(i=0;i<3;i++) {
        float(32) quantMinGeometry[i];
        float(32) quantRangeGeometry[i];
    }
}
```

```

    If(numberOfNormal>0){
        for(i=0;i<3;i++) {
            float(32) quantMinNormal[i];
            float(32) quantRangeNormal[i];
        }
    }
    If(numberOfColor>0){
        for(i=0;i<3;i++) {
            float(32) quantMinColor[i];
            float(32) quantRangeColor[i];
        }
    }
    If(numberOfTexCoord>0){
    {
        for(i=0;i<2;i++) {
            float(32) quantMinTexCoord[i];
            float(32) quantRangeTexCoord[i];
        }
    }

    If(numberOfOtherAttributes>0)
    {
        for(i=0;i< dimensionOfOtherAttributes;i++) {
            float(32) quantMinOtherAttributes[i];
            float(32) quantRangeOtherAttributes[i];
        }
    }
}
};
```

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### 4.2.5.2.2.2 Semantics

[ISO/IEC 14496-16:2009/FDIS Amd 1](#)

**streamSize:** A 32-bit unsigned integer describing the size in bytes of the current SC3DMC stream.  
<https://standards.iteh.ai/catalog/standards/sist/3ec42155-e29-42a7-8159-b38c37127804/iso-iec-14496-16-2009-fdis-amd-1>

**encodingMode:** A 8-bit unsigned integer indicating the encoding method for the connectivity

**Table AMD1.2 — SC3DMC encoding modes**

encodingMode	Method
0	QBCR
1	SVA
2	TFAN
3-255	ISO reserved

**creaseAngle:** A 32-bit float indicating the IFS *creaseAngle* parameter which controls the default normal generation process.

**ccw:** 1-bit flag describing the IFS *ccw* parameter, which indicates whether the vertices are ordered in a counter-clockwise direction when the mesh is viewed from the outside.

**solid:** 1-bit flag describing the IFS *solid* parameter which indicates whether the shape encloses a volume.

**convex:** 1-bit flag describing the IFS *solid* parameter which indicates whether all faces in the shape are convex (should be always 1 for triangular meshes).

**colorPerVertex**: 1-bit flag describing the IFS *colorPerVertex* parameter which indicates whether the colors are defined per vertex.

**normalPerVertex**: 1-bit flag describing the IFS *normalPerVertex* parameter which indicates whether the normals are defined per vertex.

**otherAttributesPerVertex**: 1-bit flag describing whether the other attributes are defined per vertex.

**isTriangularMesh**: 1-bit flag describing whether the mesh is triangular (should be always 1).

**markerBit**: Always set as 1

**numberOfCoord**: A 32-bit unsigned integer indicating the number of position coordinates.

**numberOfNormal**: A 32-bit unsigned integer indicating the number of normal coordinates.

**numberOfTexCoord**: A 32-bit unsigned integer indicating the number of texture coordinates.

**numberOfColor**: A 32-bit unsigned integer indicating the number of color coordinates.

**numberOfOtherAttributes**: A 32-bit unsigned integer indicating the number of the other attributes.

**dimensionOfOtherAttributes**: A 32-bit unsigned integer indicating the dimension (i.e., number of attributes) of the other attributes.

**numberOfCoordIndex**: A 32-bit unsigned integer indicating the number of faces associated to the position coordinates.

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**numberOfNormalIndex**: A 32-bit unsigned integer indicating the number of indices associated to the normals.

[ISO/IEC 14496-16:2009/FDIS Amd 1](https://standards.iteh.ai/catalog/standards/sist/3ec42155-ec29-42a7-8159-058c3712780#ISO-IEC-14496-16-2009-fdis-and-1)

**numberOfColorIndex**: A 32-bit unsigned integer indicating the number of indices associated to the colors.

**numberOfTexCoordIndex**: A 32-bit unsigned integer indicating the number of indices associated to the texture coordinates.

**numberOfOtherAttributesIndex**: A 32-bit unsigned integer indicating the number of indices associated to the other attributes.

**QPforGeometry**: A 8-bit data indicating quantization parameter for geometry.

**QPforNormal**: A 8-bit data indicating quantization parameter for normals.

**QPforColor**: A 8-bit data indicating quantization parameter for colour.

**QPforTexCoord**: A 8-bit data indicating quantization parameter for texture coordinate.

**TexCoordWidth**: A 32-bit unsigned integer indicating the width size of texture image.

**TexCoordHeight**: A 32-bit unsigned integer indicating the height size of texture image.

**QPforOtherAttributes**: A 8-bit data indicating quantization parameter for other attributes

**quantMinGeometry[]:1** by 3 array containing 32 bit floating data indicating minimum value used for geometry quantization

**quantRangeGeometry**: A 32-bit floating point data indicating range value used for geometry quantization

**quantRangeGeometryArr[]**: 1 by 3 array containing 32 bit floating data indicating range value for each axes used for geometry quantization

**quantMinNormal[]**: 1 by 3 array containing 32 bit floating data indicating minimum value used for normal quantization

**quantRangeNormal**: A 32-bit floating point data indicating range value used for normal quantization

**quantMinColor[]**: 1 by 3 array containing 32 bit floating data indicating minimum value used for color quantization

**quantRangeColor**: A 32-bit floating point data indicating range value used for color quantization

**quantMinTexCoord[]**: 1 by 2 array containing 32 bit floating data indicating minimum value used for texcoord quantization

**quantRangeTexCoord**: A 32-bit floating point data indicating range value used for texcoord quantization

**quantRangeOtherAttributes**: A 32-bit floating point indicating range value used for normal quantization

#### 4.2.5.2.3 SC3DMCStreamData class

##### 4.2.5.2.3.1 Syntax

class SC3DMCStreamData

## Ifh STANDARD PREVIEW (standards.iteh.ai)

```

if(encodingMode = 0)
{
    DecodeIntArray (numberOfGeometry, numberOfCoordIndex*3, 1) decodedCoordIndex;
    ISO/IEC 14496-16:2009/FDIS Amd 1
    if(numberOfNormalIndex != 0) /catalog/standards/sist/3ec42155-ec29-42a7-8159-
    {
        b38c37127804/iso-iec-14496-16-2009-fdis-amd-1
        if (normalPerVertex == 1)
            DecodeIntArray (numberOfNormal, numberOfNormalIndex*3, 1) decodedNormalIndex;
        else
            DecodeIntArray (numberOfNormal, numberOfNormalIndex, 1) decodedNormalIndex;
    }

    if(numberOfColorIndex != 0)
    {
        if (colorPerVertex == 1)
            DecodeIntArray (numberOfColor, numberOfColorIndex*3, 1) decodedColorIndex;
        else
            DecodeIntArray (numberOfColor, numberOfColorIndex, 1) decodedColorIndex;
    }

    If(numberOfTexCoord != 0)
    {
        DecodeIntArray (numberOfTexCoord, numberOfOTexCoordIndex*3, 1)
        decodedTexCoordIndex;
    }

    If(numberOfOtherAttributeIndex != 0)
    {
        if (otherAttributesPerVertex == 1)
            DecodeIntArray (numberOfOtherAttributes, numberOfOtherAttributesIndex*
                dimensionOfOtherAttributes , 1) decodedOtherAttributesIndex;
        else
            DecodeIntArray (numberOfOtherAttributesIndex, 1) decodedOtherAttributesIndex;
    }
}

```

```

If(numberOfCoord!= 0)
    DecodefloatArray (numberOfCoord, 3, quantMinGeometry, quantRangeGeometry, tQP)
decodedCoord:

    If (numberOfNormal != 0)
        DecodefloatArray(numberOfNormal, 3, quantMinNormal, quantRangeNormal, tQP)
decodedNormal:
        If (numberOfColor !=0)
            DecodefloatArray (numberOfColor, 3, quantMinColor, quantRangeColor, tQP) decodedColor;
    If (numberOfTexCoord !=0)
        DecodefloatArray (numberOfTexCoord, 3, quantMinTexCoord, quantRangeTexCoord, tQP)
decodedColor;

    If (numberOfOtherAttributes != 0)
        DecodefloatArray (numberOfOtherAttributes, dimensionOfOtherAttributes,
                        quantMinOtherAttributes, quantRangeOtherAttributs, tQP)decodedOtherAttributes
}
else if (encodingMode = 1)
{
    SVAIndexDecoder (numberOfGeometry, numberOfCoordIndex) decodedCoordIndex;

    if(numberOfNormalIndex != 0)
    {
        SVAIndexDecoder (numberOfNormal, numberOfNormalIndex) decodedNormalIndex;
    }
    if(numberOfColorIndex != 0)
    {
        SVAIndexDecoder (numberOfColor, numberOfColorIndex) decodedColorIndex;
    }
    If(numberOfTexCoord != 0)      ISO/IEC 14496-16:2009/FDIS Amd 1
    {                          https://standards.iteh.ai/catalog/standards/sist/3ec42155-ec29-42a7-8159-
        SVAIndexDecoder (numberOftexCoord,numberOfOTexCoordIndex)
        decodedTexCoordIndex;
    }
    If(numberOfOtherAttributeIndex != 0)
    {
        SVAIndexDecoder (numberOfotherAttributes, numberOfotherAttributesIndex* dimensionOfOtherAttributes
, 1) decodedOtherAttributesIndex;
    }

    If(numberOfCoord!= 0)
        DecodefloatArray (numberOfCoord, 3, quantMinGeometry, quantRangeGeometry, tQP)
decodedCoord:

        If (numberOfNormal != 0)
            DecodefloatArray(numberOfNormal, 3, quantMinNormal, quantRangeNormal, tQP)
decodedNormal:
            If (numberOfColor !=0)
                DecodefloatArray (numberOfColor, 3, quantMinColor, quantRangeColor, tQP) decodedColor;
        If (numberOfTexCoord !=0)
            DecodefloatArray (numberOfTexCoord, 3, quantMinTexCoord, quantRangeTexCoord, tQP)
decodedColor;

        If (numberOfOtherAttributes != 0)
            DecodefloatArray (numberOfOtherAttributes, dimensionOfOtherAttributes,
                            quantMinOtherAttributes, quantRangeOtherAttributs, tQP)decodedOtherAttributes
}
else if (encodingMode = 2)
{

```

```

TFANIndexDecoder(3, numberOfCoord, numberOfCoordIndex, triangleOrderPres, 0)
decodedCoordIndex;

if(numberOfNormalIndex != 0)
{
    if (normalPerVertex == 1)
        TFANIndexDecoder(3, numberOfNormal, numberOfNormalIndex, 1, 1)
        decodedNormalIndex;
else
    SC3DMCDataDecoder(numberOfNormalIndex, 1) decodedNormalIndex;
}

if(numberOfColorIndex != 0)
{
    if (colorPerVertex == 1)
        TFANIndexDecoder(3, numberOfColor, numberOfColorIndex, 1, 1) decodedColorIndex;
    else
        SC3DMCDataDecoder(numberOfColorIndex, 1) decodedColorIndex;
}

if(numberOfTexCoord != 0)
{
    TFANIndexDecoder(3, numberOfTexCoord, numberOfOtherAttributesIndex, 1, 1)
    decodedTexCoordIndex;
}

if(numberOfOtherAttributeIndex != 0)
{
    if (otherAttributesPerVertex == 1)
        TFANIndexDecoder(3, numberOfOtherAttributes, numberOfOtherAttributesIndex, 1, 1)
        decodedOtherAttributesIndex;
    else
        SC3DMCDataDecoder(numberOfOtherAttributesIndex, 1) decodedOtherAttributesIndex;
}
https://standards.iteh.ai/catalog/standards/sist/3ec42155-ec29-42a7-8159

If(numberOfCoord!= 0) b38c37127804/iso-iec-14496-16-2009-fdis-amd-1
    DecodefloatArray (numberOfCoord, 3, quantMinGeometry, quantRangeGeometry, tQP)
decodedCoord;

    If (numberOfNormal != 0)
        DecodefloatArray(numberOfNormal, 3, quantMinNormal, quantRangeNormal, tQP)
decodedNormal;
        If (numberOfColor !=0)
            DecodefloatArray (numberOfColor, 3, quantMinColor, quantRangeColor, tQP) decodedColor;
        If (numberOfTexCoord !=0)
            DecodefloatArray (numberOfTexCoord, 3, quantMinTexCoord, quantRangeTexCoord, tQP)
decodedColor;

        If (numberOfOtherAttributes != 0)
            DecodefloatArray (numberOfOtherAttributes, dimensionOfOtherAttributes,
            quantMinOtherAttributes, quantRangeOtherAttributs, tQP)decodedOtherAttributes
}

}

```

#### 4.2.5.2.3.2 Semantics

**decodedCoord**: A reconstructed coordinate whose size is 1 by  $\text{numberOfCoord} \times 3$ .

**decodedCoordIndex**: A reconstructed coordIndex whose size is 1 by  $\text{numberOfCoordIndex} \times 3$ .

**decodedNormal**: A reconstructed normal whose size is 1 by  $\text{numberOfNormal} \times 3$ .

**decodedNormalIndex**: A reconstructed noramlIndex whose size is 1 by `numberOfNormalIndex*3`.

**decodedTexCoord**: A reconstructed texcoord whose size is 1 by `numberOfTexCoord*2`.

**decodedTexCoordIndex**: A reconstructed texcoordIndex whose size is 1 by `numberOfTexCoordIndex*3`.

**decodedColor**: A reconstructed color whose size is 1 by `numberOfColor*3`.

**decodedColorIndex**: A reconstructed colorIndex whose size is 1 by `numberOfColorIndex*3`.

**decodedOtherAttributes**: A reconstructed otherAttributes whose size is 1 by `dimensionOfOtherAttributes*OfOtherAttributes`.

**decodedOtherAttributesIndex**: A reconstructed otherAttributesIndex whose size is 1 by `numberOfColorIndex*3`.

**tQP**: 3 integer array containing data for quantization containing QP, width, and height values

**DecodefloatArray**: A decoding function for geometry, color, normal, and texture coordinate.

**DecodeIntArray**: A decoding function of Index depending on SC3DMC prediction mode for geometry, color, normal, and texture coordinate.

**SVAIndexDecoder**: A decoding function of index data using SVA algorithm.

**TFANIndexDecoder**: A decoding function of index data using TFAN algorithm.

#### 4.2.5.2.4 DecodeFloatArray Class

##### 4.2.5.2.4.1 Syntax

[ISO/IEC 14496-16:2009/FDIS Amd 1](#)

<https://standards.iteh.ai/catalog/standards/sist/3ec42155-ec29-42a7-8159-b38c37127804/iso-iec-14496-16-2009-fdis-xml-1>

```
DecodefloatArray(numberOfData1, dim, quantMin, quantRange, quantizationMode, tQP)
{
    DecodeIntArray ((1<<QP[0]), numberOfData, dim)
    InverseQauntization(quatizationMode, tQP, quantMin, quantRange)
}
```

##### 4.2.5.2.4.2 Semantics

**InverQuantization**: A decoding process of inverse quantization depending on the quantization mode as follows:

**Table AMD1.3 — Quantization modes**

Quantization Mode	Quantization method
0	<code>result = quantMin + (1&lt;&lt;QP)*quantRange*input</code>
1	<code>nbins = 1 &lt;&lt; ((normal_quant - 3) / 2);</code> <code>y0 = nbins - ceil(sqrt(nbins*nbins - i));</code> <code>x0 = i + y0*y0;</code> <code>skew = (x0 &amp; 1)*2.0/3.0;</code> <code>x0 = (x0 &gt;&gt; 1) &amp; (nbins - 1);</code> <code>x = (float)x0 + skew;</code> <code>y = (float)y0 + skew;</code> <code>z = (float)nbins - x - y;</code> <code>n = 1.0/sqrt(x*x + y*y + z*z);</code> <code>x = (sx) ? -x*n : x*n;</code> <code>y = (sy) ? -y*n : y*n;</code> <code>z = (sz) ? -z*n : z*n;</code>
2	<code>x = texture_image_width *input</code> <code>y = texture_image_height *input</code>

#### 4.2.5.2.5 DecodeFloatArray Class

##### 4.2.5.2.5.1 Syntax

```
DecodefloatArray(numberOfData, dim, quantMin, quantRange, quantizationMode, tQP)
{
    InverseBinarizeIntArray(numberOfdata, dim, binarizationMode);
    InversePredictIntArray(numberOfdata, dim, predictionMode, sizeOfData);
}
```

##### 4.2.5.2.5.2 Semantics

**InverseBinarizeIntArray:** decoding process of inverse binarization depending on binarization mode

**InversePredictIntArray:** decoding process of inverse prediction depending on prediction mode

#### 4.2.5.2.6 SC3DMCDataDecoder class

##### 4.2.5.2.6.1 Syntax

```
InverseBinarizeIntArray (numberOfdata, dim)
{
    Bit(4) predictionMode;
    Bit(4) BinarizationMode; - IEC STANDARD REVIEW
    If ((binarizationMode == 0) && (predictionMode == 0)) // FL
    {
        Bit(8) QP;
        for(i=0;i< numberOfdata *dim;i++)
        {
            bit (QP) nData; // simple QBCR
            ISO/IEC 14496-16:2009/FDIS Amd 1
            https://standards.iec.ch/catalog/standards/sist/3ec42155-ec29-42a7-8159-
            b38c37127804/iso-iec-14496-16-2009-fdis-amd-1
        }
        else if (binarizationMode == 1)// BPC
        {
            If(prediction = 1)
            If (predictionMode==3)      bit(1-7) predictor
                bit (5) prefixSize
                for(i=0;i< numberOfdata *dim;i++)
                {
                    BPDecoder(prefix_size) nDiffData
                    If (predictionMode==1 || predictionMode==4)      bit(1) nSign
                }
            }
            else if (binarizationMode == 2) // 4C
            {
                for(i=0;i< numberOfdata *dim;i++)
                {
                    If (predictionMode==3)
                    {
                        bit(3) predictor;
                        bit (1) terminationBit
                        while (terminationBit)
                        {
                            bit(3) threeBitsFL;
                            bit(1) terminationBit;
                        }
                    }
                    else
                    {
                }
            }
        }
    }
}
```