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| *Title:* | **SEI manifest and prefix indication SEI messages** | | |
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# Abstract

SEI messages for carrying manifest information and prefix indications for SEI messages are proposed. The manifest information includes whether certain types of SEI messages may be assumed to be present or absent, and their essentiality. A prefix indication for a particular type of SEI messages provides a bit string that some or all SEI messages of the particular type may be assumed to start with.

An SEI message is considered as essential by the encoder (i.e., the content producer) when the carried information is considered as essential from the decoder’s side to properly process the content and enable a desirable user experience. It is at the discretion of the encoder (i.e., the content producer) to determine which SEI messages are considered as essential in a particular bitstream. However, some SEI messages, such as the frame packing arrangement, segmented rectangular frame packing arrangement, display orientation, and omnidirectional projection indication SEI messages, should always be considered as essential.

The authors advocate that the two proposed SEI messages should also be considered for inclusion into AVC and future video coding standards.

This contribution is a follow up of JCTVC-AA0026 titled "SEI messages on SEI messages". In the new proposal, we tried to address comments received when reviewing JCTVC-AA0026 at the previous JCT-VC meeting in Hobart. How the comments have been addressed is discussed in Section 4 of JVTVC-AB0025 (the current document).

# Background

In video coding specifications, as long as something does not affect decoding of picture samples, that information can be included in an SEI message.

Some information carried in SEI messages is just for optimization purposes and may be ignored entirely without making the video system performance unacceptable. On the other hand, some other information carried in SEI messages, such as frame packing information, omnidirectional projection indication information, and subtitle/captioning information, is essential to be utilized to ensure acceptable video system performance or user experience. This is because certain post-decoding operations, such as de-packing or de-warping, must be applied before properly displaying frame-packed or 360 degrees omnidirectional projected video. Similarly, subtitle/captioning is absolutely necessary for one to enjoy a movie with audio in a language he/she does not understand.

From a systems and application point of view, information like frame packing information, omnidirectional projection indication information, and subtitle/captioning information is essential for the entire video application system to perform well. Such information should be treated similarly as information that is important for video decoding interoperability such as codec, profile, and level in systems operations, including encapsulating a coded video bitstream into a media file according to the ISO base media file format (ISOBMFF) or a media presentation according to the dynamic adaptive streaming over HTTP (DASH).

When encapsulating a coded video bitstream into an ISOBMFF file or a DASH media presentation, essential information, such as mentioned above, needs to be exposed at a high level, e.g., in the file format sample entry, the DASH media presentation description (MPD), and/or MIME type parameters. It would be highly desirable to have a mechanism that would help a decoder avoid having to scan the entire bitstream in order to figure out what information may be included in the SEI messages in the bitstream, as well as having to categorize SEI messages based on some kind of essentiality conditions. Instead, having such information easily accessible early on in the bitstream, e.g., where profile and level are signalled, or, for existing standards, collectively in one SEI message, could considerably ease the burden of the decoder. In particular, in this way, the decoder would not need to scan the entire bitstream to extract SEI information and would be able to make pre-emptive decisions of how to best handle the decoded video. Furthermore, this would help in avoiding having to make a new and/or different system design in systems standards each time when a new SEI message containing essential information is introduced. For example, signalling schemes for frame packing in ISOBMFF and DASH have been designed after the introduction of frame packing into AVC, and now with the induction of the omnidirectional projection indication SEI message into HEVC a new signalling scheme for omnidirectional projection.

This contribution tries to address this issue by proposing carrying information on presence, absence, and essentiality of SEI messages, herein called the SEI manifest, and SEI prefix indications in newly designed SEI messages. More specifically, two new SEI messages, namely the SEI manifest and SEI prefix indication SEI messages, are proposed in Section 2. A few alternative design choices are discussed in Section 3. Section 5 discusses the essentiality of specific SEI messages specified in HEVC. Finally, Section 6 includes further discussions on systems carriage of the SEI manifest and prefix indication information.

# Proposal

## The SEI manifest SEI message

### SEI manifest SEI message syntax

|  |  |
| --- | --- |
| sei\_manifest( payloadSize ) { | **Descriptor** |
| **manifest\_num\_sei\_msg\_types** | u(16) |
| for( i = 0; i < manifest\_num\_sei\_msg\_types; i++ ) { |  |
| **manifest\_sei\_payload\_type**[ i ] | u(16) |
| **manifest\_sei\_description**[ i ] | u(8) |
| } |  |
| } |  |

### SEI manifest SEI message semantics

The SEI manifest SEI message conveys information on SEI messages that may be assumed by a receiver of the bitstream to be present or not present. Such information may include:

1. A receiver of the bitstream may assume that certain types of SEI messages are present in the CVS.

NOTE 1 – With such an "assume" wording used, it would not be an error when the "promises" are broken and, regardless whether the "promises" are broken, the client assumptions can still be considered as correct.

1. For each type of SEI message that may be assumed to be present in the CVS, the essentiality of the SEI messages of this type.

The essentiality may be indicated as essential, non-essential, or undetermined.

An SEI message is considered as essential by the encoder (i.e., the content producer) when the carried information is considered as essential from the decoder’s side to properly process the content and enable a desirable user experience. It is at the discretion of the encoder to determine which SEI messages are considered as essential in a particular bitstream. However, some SEI messages, such as the frame packing arrangement, segmented rectangular frame packing arrangement, display orientation, and omnidirectional projection indication SEI messages, should always be considered as essential.

1. A receiver of the bitstream may assume that certain types of SEI messages are not present in the CVS.

NOTE 2 – For example, based on the signalled SEI manifest SEI message, a receiver of the bitstream could assume that there is no frame packing arrangement SEI message, segmented rectangular frame packing arrangement SEI message, display orientation SEI message, or omnidirectional projection indication SEI message in the bitstream. Therefore, the decoded video pictures could likely be rendered for viewing without the need of any additional post-processing that is commonly required when such SEI messages are present.

When an SEI manifest SEI message is present in any access unit of a CVS, an SEI manifest SEI message shall be present in the first access unit of the CVS. The SEI manifest SEI message persists in decoding order from the current access unit until the end of the CVS. When there are multiple SEI manifest SEI messages present in a CVS, they shall have the same content.

An SEI NAL unit containing an SEI manifest SEI message shall not contain any other SEI message than SEI prefix indication SEI messages. When present in an SEI NAL unit, the SEI manifest SEI message shall be the first SEI message in the SEI NAL unit.

**manifest\_num\_sei\_msg\_types** specifies the number of types of SEI messages for which information is provided in the SEI manifest SEI message.

**manifest\_sei\_payload\_type**[ i ] indicates the payloadType value of the i-th type of SEI message for which information is provided in the SEI manifest SEI message. The values of manifest\_sei\_payload\_type[ m ] and manifest\_sei\_payload\_type[ n ] shall not be identical when m is not equal to n.

**manifest\_sei\_description**[ i ] provides information on SEI messages with payloadType equal to manifest\_sei\_payload\_type[ i ] as specified in Table D. X.

Table D.X – manifest\_sei\_description[ i ] values

|  |  |
| --- | --- |
| **Value** | **Description** |
| 0 | Indicates that it may be assumed that there is no SEI message with payloadType equal to manifest\_sei\_payload\_type[ i ] in the CVS. |
| 1 | Indicates that 1) it may be assumed that there are SEI messages with payloadType equal to manifest\_sei\_payload\_type[ i ] in the CVS, and 2) these SEI messages are considered as essential. |
| 2 | Indicates that 1) it may be assumed that there are SEI messages with payloadType equal to manifest\_sei\_payload\_type[ i ] in the CVS, and 2) these SEI messages are considered as non-essential. |
| 3 | Indicates that 1) it may be assumed that there are SEI messages with payloadType equal to manifest\_sei\_payload\_type[ i ] in the CVS, and 2) the essentiality of these SEI messages is undetermined. |
| 4-255 | Reserved |

The value of manifest\_sei\_description[ i ] shall be in the range of 0 to 3, inclusive, in bitstreams conforming to this version of this Specification. Other values for manifest\_sei\_description[ i ] are reserved for future use by ITU-T | ISO/IEC. Decoders shall allow the value of manifest\_sei\_description[ i ] greater than or equal to 4 to appear in the syntax and shall ignore all information for payloadType equal to manifest\_sei\_payload\_type[ i ] signalled in the SEI manifest SEI message and shall ignore all SEI prefix indication SEI messages with prefix\_sei\_payload\_type equal to manifest\_sei\_payload\_type[ i ].

## The SEI prefix indication SEI message

### SEI prefix indication SEI message syntax

|  |  |
| --- | --- |
| sei\_prefix\_indication( payloadSize ) { | **Descriptor** |
| **prefix\_sei\_payload\_type** | u(16) |
| **num\_sei\_prefix\_indications\_minus1** | u(8) |
| for( i = 0; i <= num\_sei\_prefix\_indications\_minus1; i++ ) { |  |
| **num\_bits\_in\_prefix\_indication\_minus1**[ i ] | u(16) |
| for( j = 0; j <= num\_bits\_in\_prefix\_indication\_minus1[ i ]; j++ ) |  |
| **sei\_prefix\_databit**[ i ][ j ] | u(1) |
| while( !byte\_aligned( ) ) |  |
| **byte\_alignment\_bit\_equal\_to\_zero** /\* equal to 0 \*/ | f(1) |
| } |  |
| } |  |

### SEI prefix indication SEI message semantics

The SEI prefix indication SEI message carries one or more SEI prefix indications for SEI messages of a particular payloadType. Each SEI prefix indication is a bit string that follows the SEI payload syntax of that payloadType and contains a number of complete syntax elements starting from the first syntax element in the SEI payload.

The receiver may assume that some or all of the SEI messages of this payloadType in the CVS start with these bit strings. A starting bit string typically contains only a true subset of an SEI payload of the type of SEI messages, may contain a full SEI payload, but never contains more than a full SEI payload.

NOTE – It is allowed that some SEI messages of this payloadType do not start with any of the indicated bit strings.

These SEI prefix indications should provide sufficient information for indicating what type of processing is needed or what type of content is included. The former (type of processing) indicates decoder-side processing capability, e.g., whether some type of frame unpacking is needed. The latter (type of content) indicates, for example, whether the bitstream contains subtitle captions in a particular language. Based on the information systems layer, entities can determine whether the decoder side can properly process the bitstream to enable a desirable user experience, or whether the bitstream satisfies the application needs.

In one example, when the payloadType indicates the frame packing arrangement SEI message, an SEI prefix indication should include up to at least the syntax element frame\_packing\_arrangement\_type; when the payloadType indicates the omnidirectional projection indication SEI message, an SEI prefix indication should include up to at least the syntax element projection\_type.

In another example, for user data registered SEI messages that are used to carry captioning information, an SEI prefix indication should include up to at least the language code; and for user data unregistered SEIs messages extended for private use, an SEI prefix indication should include up to at least the UUID.

When an SEI prefix indication SEI message is present in any access unit of a CVS, an SEI prefix indication SEI message shall be present in the first access unit of the CVS. The SEI prefix indication SEI message persists in decoding order from the current access unit until the end of the CVS. When there are multiple SEI prefix indication SEI messages present in a CVS, they shall have the same content.

An SEI NAL unit containing an SEI prefix indication SEI message shall not contain any other SEI message than an SEI manifest SEI message.

**prefix\_sei\_payload\_type** indicates the payloadType value of the SEI messages for which one or more SEI prefix indications are provided in the SEI prefix indication SEI message. The value of prefix\_sei\_payload\_type shall be equal to one of the manifest\_sei\_payload\_type[ m ] values for which manifest\_sei\_description[ m ] is equal to 1 to 3, inclusive, as indicated by an SEI manifest SEI message that applies to the CVS.

**num\_sei\_prefix\_indications\_minus1** plus 1 specifies the number of SEI prefix indications.

**num\_bits\_in\_prefix\_indication\_minus1**[ i ] plus 1 specifies the number of bits in the i-th SEI prefix indication.

**sei\_prefix\_databit**[ i ][ j ] specifies the j-th bit of the i-th SEI prefix indication.

The bits sei\_prefix\_databit[ i ][ j ] for j ranging from 0 to num\_bits\_in\_prefix\_indication\_minus1[ i ], inclusive, follow the syntax of the SEI payload with payloadType equal to prefix\_sei\_payload\_type, and contain a number of complete syntax elements starting from the first syntax element in the SEI payload syntax, and may or may not contain all the syntax elements in the SEI payload syntax. The last bit shall be the last bit of a syntax element in the SEI payload syntax.

**byte\_alignment\_bit\_equal\_to\_zero** shall be equal to 0.

# Discussion on design choices

There are two dimensions of design choices, on syntax and on persistence, respectively.

## Syntax design choices

The following design choices for syntax are possible:

1. As in Sections 2 and 3 above.
2. Instead of defining two separate SEI messages, the SEI manifest description and the SEI prefix indications are all carried in one SEI message, e.g., as follows:

|  |  |
| --- | --- |
| sei\_manifest( payloadSize ) { | **Descriptor** |
| **manifest\_num\_sei\_msg\_types** | u(16) |
| for( i = 0; i < manifest\_num\_sei\_msg\_types; i++ ) { |  |
| **manifest\_sei\_payload\_type**[ i ] | u(16) |
| **manifest\_sei\_description**[ i ] | u(8) |
| } |  |
| for( i = 0; i < manifest\_num\_sei\_msg\_types; i++ ) { |  |
| **num\_sei\_prefix\_indications**[ i ] | u(8) |
| for( j = 0; j < num\_sei\_prefix\_indications[ i ]; j++ ) { |  |
| **num\_bits\_in\_prefix\_indication**[ i ][ j ] | u(16) |
| for( k = 0; k < num\_bits\_in\_prefix\_indication[ i ][ j ]; k++ ) |  |
| **sei\_prefix\_databit**[ i ][ j ][ k ] | u(1) |
| while( !byte\_aligned( ) ) |  |
| **byte\_alignment\_bit\_equal\_to\_zero** /\* equal to 0 \*/ | f(1) |
| } |  |
| } |  |
| } |  |

1. Instead of allowing inclusion of multiple SEI prefix indications in one SEI prefix indication SEI message, only one is allowed. I.e., the syntax of the SEI prefix indication SEI message is changed to be as follows:

|  |  |
| --- | --- |
| sei\_prefix\_indication( payloadSize ) { | **Descriptor** |
| **prefix\_sei\_payload\_type** | u(16) |
| **num\_bits\_in\_prefix\_indication\_minus1** | u(16) |
| for( i = 0; i <= num\_bits\_in\_prefix\_indication\_minus1; i++ ) |  |
| **sei\_prefix\_databit**[ i ] | u(1) |
| } |  |

The all-in-one approach (approach 2) avoids the definition and use of multiple SEI messages for the SEI manifest descriptions and the SEI prefix indications for all SEI types. However, when there is a need of adding some information, the SEI message needs to be changed.

Approach 1 allows the small-sized SEI manifest descriptions to be in a separate SEI message, which can be conveniently carried on at the systems level, e.g., as a MIME type parameter. It also allows addition of prefix indications for an SEI type for which no prefix indication has been signalled yet, by just adding a new SEI message without the need of modifying existing SEI messages. It also avoids use of multiple SEI messages for the SEI prefix indications for one particular SEI type. However, when there is a need of adding some prefix indications for an SEI type for which some prefix indications have been signalled already, a change to the existing SEI message is needed.

Approach 3 avoids changing the existing SEI message when there is a need of adding some prefix indications for an SEI type for which some prefix indications have been signalled already. This comes at the cost of having to use multiple SEI messages for signalling the SEI prefix indications for one particular SEI type. Other aspects of approach 3 are the same as approach 1.

## Persistence design choices

The following design choices for persistence are possible:

1. To specify the persistence scope to be within the CVS (as in Sections 2 and 3 above).
2. To specify the persistence scope to be the same as that of the active SPS.
3. To specify the persistence scope to be the bitstream.

Options 1 and 2 are similar, with the difference being that, when the active SPS applies to multiple CVSs consecutive in decoder, the persistence scope of the SEI message will also be multiple CVSs. Both options 1 and 2 look OK to us, in Sections 2 and 3 above we took option 1 simply because that is more used in the HEVC specification.

Option 3 is less friendly to bitstream slicing, as it would require changing of the SEI messages when splicing of multiple bitstreams into one.

# Responses to Hobart comments

|  |  |  |
| --- | --- | --- |
| **Index** | **Comment** | **Response** |
| 1 | In the discussion, it was noted that the existing general\_non\_packed\_constraint\_ flag somewhat serves the purpose of identifying potential presence of “essential” messages. | In the latest published HEVC spec, the semantics of general\_non\_packed\_constraint\_flag covers the two frame packing SEI messages, and the latest HEVC amendment on additional SEI message further added the omnidirectional projection indication SEI message into the coverage.  The issue with general\_non\_packed\_constraint\_flag is that it can only be used to cover these SEI messages collectively, but not individually. |
| 2 | It was commented that it seems to be trying to rearchitect the syntax architecture years after the “horses have left the barn”.  It was commented that since this wasn’t defined before, removing or editing some SEI messages could cause the “meta SEI message” (its presence indication or its partial copy of the syntax content) to become wrong (indicating presence of things that aren’t there, quoting syntax strings that might not match the actual syntax that is present). Some system designers might not even know that this SEI message has been defined, and could do things to the bitstream that would cause it to become incorrect. | To avoid potential backward compatibility problems associated with the Hobart proposal in JCTVC-AA0026 as mentioned/implied in the comments, in this proposal the semantics use languages such as "A receiver of the bitstream may assume that certain types of SEI messages are present in the CVS."  With such "assume" wording used, it would not be an error when the "promises" are broken, and regardless whether the "promises" are broken, the client assumptions are correct. Consequently, the backward compatibility problems are solved. |
| 3 | It was suggested that if the purpose of this “meta SEI message” is to provide something to be carried at the system level, why not just define it at the system level - if it isn’t really needed for the decoder of the elementary bitstream, where it is just duplicating some information that is already present in the bitstream. | Scanning the bitstream to figure out the information to be carried at systems level when encapsulating a bitstream into a systems format can be burden for the systems encapsulator. What's more, figuring out which information in which SEI messages is essential or not can be difficult, if not impossible, for the systems encapsulators as the essentiality of much information is at the discretion of the encoder. |
| 4 | It was noted that the proposal only supports one SEI message of each payloadType, which seems inadequate (e.g. for user data, and probably for some other types as well). | The proposal in this document now allows inclusion of multiple prefix indications for a particular type of SEI messages. |

# Discussion on essentiality of SEI messages

The authors studied the SEI messages specified in Annex D, including the ones in the published HEVC specification as well as the ones in the draft amendment text in JCTVC-Z1005, but not those SEI messages specified for the multi-layer contexts, i.e., in Annex F and the subsequent annexes. Below is a recommendation for the Annex D SEI messages for forming the lists of essential and non-essential SEI messages.

A critique from JCT-VC experts knowledgeable in the different areas covered by the various different SEI messages are warmly welcomed.

It is suggested that the following SEI messages, which will have a direct impact on the rendering of the decoded pictures, when present (natively present or contained in a nesting SEI message), to be indicated as essential. However, such a decision is still at the discretion of the encoder:

* The frame packing arrangement SEI message
* The display orientation SEI message
* The segmented rectangular frame packing arrangement SEI message
* The omnidirectional projection indication SEI message

The following SEI messages, when present (natively present or contained in a nesting SEI message), which affect the rendering of decoded pictures to some extent, may or may not be indicated as essential, at the discretion of the encoder:

* The film grain characteristics SEI message
* The post-filter hint SEI message
* The tone mapping information SEI message
* The no display SEI message
* The no display SEI message
* The mastering display colour volume SEI message
* The chroma resampling filter hint SEI message
* The knee function information SEI message
* The colour remapping information SEI message
* The deinterlaced picture information SEI message
* The content light level information SEI message
* The alternative transfer characteristics SEI message
* The ambient viewing environment SEI message
* The content colour volume SEI message

Other SEI messages, when present (natively present or contained in a nesting SEI message), are less likely to affect the rendering of the decoded pictures, may or may not be indicated as essential, at the discretion of the encoder. For example, the encoder may determine that a user data registered by Recommendation ITU-T T.35 SEI message or a user data unregistered SEI message carries essential information and consequently indicate that the particular SEI payload type is essential and additionally provide some prefix indications.

# Systems level exposure of essential supplemental information

On the file format level, the essential supplemental information carried in the proposed new SEI messages can be included in the sample entry. For example, the SEI NAL unit containing an SEI manifest SEI message (which may also contain one or more SEI prefix indications SEI messages) can be directly included in the array of SEI NAL units in the decoder configuration record of an HEVC sample entry, as specified in ISO/IEC 14496-15, which specifies the file formats for AVC and its extensions as well as HEVC and its extensions. It is recommended that the SEI NAL unit containing an SEI manifest SEI message should be included as the first SEI NAL unit of the SEI NAL unit array in the decoder configuration record.

ISO/IEC 14496-15 also specifies the sub-parameters for the MIME type ‘codecs’ parameter for AVC and HEVC and their extensions. On the DASH level, the MIME type parameter can be directly exposed as an attribute (i.e., @mimeType) in the MPD. The SEI NAL unit containing an SEI manifest SEI message can be directly included as part of the ‘codecs’ parameter or a different MIME type parameter, thus enabling its exposure to the MPD through the @mimeType attribute.

In MPEG-2 systems, the SEI NAL unit containing an SEI manifest SEI message can be directly included as part of the descriptor that contains the video codec profile and level information, as a similar descriptor.

In applications using RTP for media transport and SDP for signalling, the SEI NAL unit containing an SEI manifest SEI message can be directly included into an SDP file as an SDP attribute.

# Patent rights declaration(s)

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