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Title	**Comparison of BPG and MPEG Image File Format**
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1 Introduction

During its 110th meeting, MPEG issued the Study of the Carriage of Still Image and Image Sequences [1]. During the same period, an alternative proposal for the storage of HEVC images, called BPG (Better Portable Graphics) was released [2] and demonstrated using open source encoder and JavaScript decoder [3]. The purpose of this contribution is to raise awareness of this release amongst MPEG members, to study the differences between the MPEG format and the BPG format, and to determine if/how the MPEG format should evolve.

2 Comparison of BPG and IFF

2.1 Syntax Comparison

According to its authors, the BPG format was designed to make small files by removing bytes unnecessary for still pictures. In particular, BPG uses HEVC VCL NAL units in Annex B format (with start codes except for the first NAL unit), removes HEVC VPS NAL units, and replaces the HEVC SPS NAL unit by a simplified structure called hevc_header, saving some 60 bytes in headers according to the authors of BPG. It is unclear what is done with SEI messages. Some details are provided below:

BPG hevc_header	HEVC SPS	Remarks
	sps_video_parameter_set_id	Assumed in BPG to be 0.
	sps_max_sub_layers_minus1	Assumed in BPG to be 0.
	sps_temporal_id_nesting_flag	**No indication in BPG. Probably 0.**
	sps_seq_parameter_set_id	Assumed in BPG to be 0.
	separate_colour_plane_flag	Assumed in BPG to be 0.
pixel_format (0-5)	chroma_format_idc (0-3)	More values in the range to accommodate JPEG and MPEG 2 sampling.
alpha1_flag		**Additional to BPG.**
	conformance_window_flag	**No indication in BPG. Probably 0.**
picture_width ue7(32)	pic_width_in_luma_samples ue(v)	pic_width_in_luma_samples = ceil(picture_width/cb_size) * cb_size with cb_size = 1 <<

		log2_min_luma_coding_block_size
picture_height ue7(32)	pic_height_in_luma_samples	
`bit_depth_minus_8`	bit_depth_chroma_minus8	same depth on chroma and luma in BPG
	log2_max_pic_order_cnt_lsb_minus 4	Assumed in BPG to be 4.
	sps_sub_layer_ordering_info_presen t_flag	**No indication in BPG. Probably 0.**
	max_transform_hierarchy_depth_int er	Assumed to be the same as `max_transform_hierarchy_depth_ intra`
	scaling_list_enabled_flag	Assumed in BPG to be 0.
	amp_enabled_flag	Assumed in BPG to be 1.
	num_short_term_ref_pic_sets	**No indication in BPG. Probably 0.**
	long_term_ref_pics_present_flag	**No indication in BPG. Probably 0.**
	sps_temporal_mvp_enabled_flag	Assumed in BPG to be 1.
limited_range_fla g	vui_parameters_present_flag	No VUI in BPG, but the optional video_full_range_flag is replaced by the mandatory limited range flag
color_space		
animation_flag		
`trailing bits`	trailing bits	need to be rewritten

The authors of BPG indicate that it is possible to regenerate Parameter Sets from the BPG header. This is true, however, operations such as round tripping from either an HEVC stream, or an AVC file, or an IFF file require more than just bytes shuffling, and in particular Golomb decoding and encoding as some fields (coded using variable length) are removed from the SPS (such as max_transform_hierarchy_depth_inter).

Additional data, which permits in particular extensibility of the format, is stored in structures equivalent to ISOBMFF boxes with 4 bytes code and 4 bytes length. The allowed additional data so far is:
- EXIF metadata
- ICC Profile
- XMP metadata
- Thumbnail image
- Animation control data

2.2 Features comparison

According to BPG, the following features are supported in this format.
- Based on a subset of the HEVC standard (subset of the Main 4:4:4 16 Still Picture Profile, Level 8.5)
- Supports the same chroma formats as JPEG (grayscale, YCbCr 4:2:0, 4:2:2, 4:4:4) to reduce the losses during the conversion.
- An alpha channel is supported.
- The RGB, YCgCo and CMYK color spaces are also supported.

- Both JPEG and MPEG2 chroma sample positions are supported.
- Native support of 8 to 14 bits per channel for a higher dynamic range.
- Lossless compression is supported.
- Various metadata (such as EXIF, ICC profile, XMP) can be included.
- Animation support.
- Progressive decoding and display is supported by interleaving the alpha and color data.

The following table tries to compare the features of both formats:

	BPG	IFF
Syntax Overhead	Low	Higher but still low for high resolution images
HEVC Profile	Subset of the Main 4:4:4 16 Still Picture Profile, Level 8.5	Not restricted in IFF. Should IFF restrict the profile of HEVC pictures?
Chroma Formats	grayscale, YCbCr 4:2:0, 4:2:2, 4:4:4 RGB, YCgCo and CMYK JPEG and MPEG2 chroma sample positions are supported	Supported. Should the different positioning of chroma samples be signaled in IFF?
Bit depth	8 to 14	Same support.
Alpha plane	Supported by describing two images with some shared info. Progressive decoding supported by interleaving layer 0 (image) and layer 1 (alpha plane). This is not compliant with the specification ("A coded picture with nuh_layer_id equal to nuhLayerIdA shall precede, in decoding order, all coded pictures with nuh_layer_id greater than nuhLayerIdA in the same access unit ") but works because both images are independently coded.	Supported via auxiliary images, but VPS extension has to be parsed, which is quite heavy. Progressive decoding of alpha and image does not seem to be supported.
Animated images, including loop	Simple structure	Change of file structure (requires the track structure). Loop supported via edit list.
Metadata	EXIF, XMP, …	Same support
Thumbnail	Handled as a BPG image in a BPG image.	Handled as an image item at the same level in the IFF

		hierarchy as the other image, linked by a 'thmb' reference type. Additionally, it is possible in IFF to reuse an image of a video as the thumbnail of the video (no picture data duplication)
Support for other codecs	No, optimized for HEVC	Yes, theoretically.
Image encryption	Not supported	Supported
Image modification (rotation, cropping, …)	Not supported	Supported
Efficient access to tiles in a tiled HEVC image	Not supported	Supported
Efficient access to layers in a layered HEVC image (multiview, scalable, …)	Not supported	To be supported
Image Collections (multispectral, …)	Not supported	Supported by image collections and/or image sequences.

3   Conclusion

On the one hand, the BPG format is interesting in its simplicity. On the other hand, the byte/bits shuffling used in that format compared to plain HEVC (SPS editing, start codes removal …) to gain some/few bytes does not seem so relevant in comparison to the sizes of HEVC images. Additionally, IFF currently defines some features which may not be the primary usages of an image file format, or which could be covered by BPG in the future but which are already covered in IFF. The compatibility of IFF with the ISOBMFF makes it possible to reuse an image of a video as a cover image for the video, saving bytes when using a poster in the context of HTML 5.

In the light of this analysis, we recommend MPEG to study the above questions regarding profiling of HEVC, chroma formats and alpha channel to possibly align with the BPG format.

4   References

[1] Study of ISO/IEC DIS 23008-12 Carriage of Still Image and Image Sequences
[2] BPG Specification, http://bellard.org/bpg/bpg_spec.txt
[3] http://bellard.org/bpg/