# New Work Item Proposal: Frame Level Segmentation Compression

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## On Behalf of Working Group 4 - Compression

## Introduction/Scope

This work item proposes to add a new Transfer Syntax primarily for single bit segmentation encoding, which is otherwise not well supported. There is a need to be able to store and transfer encoded single frames (such as for DICOMweb) rather than the entire dataset for those applications where only selected frames are required (such as for selected tiles at selected resolutions for whole slide images, or multi-organ segmentation of large volumetric CT or MR datasets).

## Limitations of Current Standard

Currently, the DICOM standard supports a means of single bit representation of binary segmentations with a Bits Stored and Bits Allocated of 1, and these can grow extremely large, especially when segmenting at the full resolution of the underlying image (e.g., for whole slide imaging). If compressed, they need to be mathematically reversibly (losslessly) compressed. The existing Deflate Transfer Syntax (algorithm used in zip and gzip) is reasonably effective, but applies to the entire data set (including the "metadata" and all the frames treated as a single stream).

Frame-based pixel data compression schemes currently in the standard generally do not support single-bit, with the exception of RLE and J2K (CP 2301), neither of which achieves as high a compression ratio as Deflate does for this data.

Other alternative lossless compression codecs designed for single bit use (such as for fax using CCITT Group 4 (ITU-T T.6), JBIG, or JBIG2) were considered, which though they compress more effectively, were not considered widely enough supported to justify the complexity for this use case at this time. Other general purpose compressors do slightly better than Deflate, but again, not so much better that they justify their addition to the standard at this time, though they may be considered in future if other use cases justify them. See Appendix for examples.

## Description of Proposal

Frame-level Deflate is suggested as the sweet spot between effectiveness, performance, complexity, interoperability and lack of patent issues. A new Transfer Syntax is proposed that will use the Deflate algorithm already present in the standard for the entire dataset, but apply it to individual encapsulated frames, to allow them to be stored and indexed in that form, and requested in that form using the single frame retrieval DIMSE and DICOMweb services. This will require no changes to the existing services beyond adding the Transfer Syntax, and no change to the Basic and Extended Offset Table mechanisms already used for other forms of compressed image pixel data.

## Parts of Standard Affected

This work item will affect Parts 5, 6, and 18 of the DICOM standard.

## Resources & Time Line

David Clunie from PixelMed will be editing this supplement, and is supported by a group of implementers from various research and software groups involved in WSI segmentation, including the NCI Imaging Data Commons (IDC), the highdicom project, and the Slim viewer project. It is estimated that the work will take about 12 months, and the supplement will be approximately 10 pages. A first draft will be available by late-2023.

It is anticipated that two hours of WG-06 meeting time will be required on each of four occasions during 2023 and 2024 to review and approve an early draft as well as public comment, letter ballot, and final text versions of the supplement.

# Appendix: Binary WSI Segmentation Compression Effectiveness

Image from "[doi:10.1038/s41597-019-0332-y](http://dx.doi.org/10.1038/s41597-019-0332-y)":

 18905792 LUNG-1-LN\_40X\_Field\_01\_01\_Seg.tiff

 72000828 LUNG-1-LN\_40X\_Field\_01\_01\_Seg.dcm

 4502682 LUNG-1-LN\_40X\_Field\_01\_01\_Seg\_ASDICOMSEG.dcm

 4500146 LUNG-1-LN\_40X\_Field\_01\_01\_Seg\_ASDICOMSEG.swapped.none.tif

 4500013 LUNG-1-LN\_40X\_Field\_01\_01\_Seg\_ASDICOMSEG.swapped.pbm

 4500013 LUNG-1-LN\_40X\_Field\_01\_01\_Seg\_ASDICOMSEG.unswapped.pbm

 4500000 LUNG-1-LN\_40X\_Field\_01\_01\_Seg\_ASDICOMSEG.raw

 2856378 LUNG-1-LN\_40X\_Field\_01\_01\_Seg\_ASDICOMSEG.swapped.packbits.tif

 1376238 LUNG-1-LN\_40X\_Field\_01\_01\_Seg\_ASDICOMSEG.swapped.j2k

 1339778 LUNG-1-LN\_40X\_Field\_01\_01\_Seg.dcm.bz2

 1275828 LUNG-1-LN\_40X\_Field\_01\_01\_Seg\_ASDICOMSEG.swapped.g3.tif

 1275679 LUNG-1-LN\_40X\_Field\_01\_01\_Seg\_ASDICOMSEG.swapped.g3

 1229770 LUNG-1-LN\_40X\_Field\_01\_01\_Seg\_ASDICOMSEG.swapped.png

 1224130 LUNG-1-LN\_40X\_Field\_01\_01\_Seg\_ASDICOMSEG.swapped.pbm.zip

 1187631 LUNG-1-LN\_40X\_Field\_01\_01\_Seg\_ASDICOMSEG.dcm.bz2

 1181790 LUNG-1-LN\_40X\_Field\_01\_01\_Seg\_ASDICOMSEG.swapped.pbm.bz2

 556038 LUNG-1-LN\_40X\_Field\_01\_01\_Seg\_ASDICOMSEG.swapped.g4.tif

 424846 LUNG-1-LN\_40X\_Field\_01\_01\_Seg\_ASDICOMSEG.swapped.jbg2

 422627 LUNG-1-LN\_40X\_Field\_01\_01\_Seg\_ASDICOMSEG.swapped.jbg

Notes:

1. The original TIFF PackBits (RLE) image ([LUNG-1-LN\_40X\_Field\_01\_01\_Seg.tiff](https://www.synapse.org/#!Synapse:syn18912571)) converted to uncompressed DICOM used a 16 bit word to encode a single bit per pixel, hence is artificially large, compared to the uncompressed single bit ("ASDICOMSEG") form, which is 16 times smaller, obviously. Compressing the 1 in 16 bit form is not as effective as compressing the single bit form, e.g., using bzip2 as illustrated.

2. "Swapped" refers to the need to swap the bit order within the byte depending on what the compression tool tested natively supported (from least significant to most significant within the byte).

3. Deflate is simulated using zip on the pbm (negligible header) format, resulting in 4500000 / 1224130 = 3.68 compression ratio (cf. 3.27 using J2K, 3.80 using bzip2 and 10.6 using JBIG).