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PNG Development Group
png-list@dworkin.wustl.edu
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PNG Proposed Scientific Visualization Chunks, draft 19961011

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Status of this Memo

This document is an informal draft of the PNG development group.

Comments on this document can be sent to the PNG specification maintainers at `png-info@uunet.uu.net` or at `png-list@dworkin.wustl.edu`.

Distribution of this memo is unlimited.

At present, the latest version of this document is available on the World Wide Web from `ftp://swrinde.nde.swri.edu/pub/png-group/documents/`.

Notices

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Changes from the 14 September 1996 draft (version 19960914):

- minor formatting and spelling fixes
- Added statement that a non-draft version of this document will be created to contain registered versions of the chunk specificatons.
- Deleted statement about using drNG to correct for sBIT LBZ scaling.
- Changed “bit_depth” to “output_bit_depth” in dRNG algorithm.
- Added “purpose” field to xxSC, yySC, zzSC, and ttSC chunks.
- Changed “ASCII” to “Latin-1” in description of “purpose” fields

Abstract

This document describes some special-purpose chunk types that have been proposed for use in various PNG (Portable Network Graphics) and related multi-image applications. They have not yet been approved for registration by the PNG developers, and therefore are experimental and their format is subject to change. The proposed chunks are drNG/DrNG, faLT, loGE/LoGE, pcAL, ttSC, xxSC, yySC, and zzSC.

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1 Introduction

Chunks described here have been proposed to the PNG development group for use by the scientific visualization community. Their definitions are subject to change until such time as the group formally registers them. No decoder is required or expected to implement these chunks except for experimental or evaluation purposes. Comments on these proposals, and new proposals for additional chunk types, should be sent to the PNG specification maintainers at png-info@uunet.uu.net. The basic PNG specification is available from the W3C archive at http://www.w3.org/pub/WWW/TR/WD-png.

2 Documentation of registered PNG Sci-Vis chunks

When the first of these chunks is registered, a non-draft version of this document will be created, in which the registered chunk specification will reside, along with the specifications for any subsequently registered chunks from this proposal. The names of the registered chunks will be listed in the "PNG extensions" document.

3 Using Proposed PNG Sci-Vis Chunks

No chunks described in this document have yet been registered by the PNG maintainers. Therefore they have a lower-case letter in the second position of the chunkname. They are **experimental** chunks and the format is subject to change. If and when any become registered, the second letter of the chunk name will become uppercase, the "signature" field and it zero-byte terminator will be deleted, and there will be no further change to the format.

Whenever you use any of these unregistered chunks you should also include a `tEXt` chunk describing it, for example:

```
tEXtComment\0
This file contains a pcAL chunk written according to the
format given in Version 19960914 of the PNG Proposed Chunks
document.
```

For those proposed chunks that have a "signature" field, decoders should check to ensure that the signature field is present and that its contents exactly match the specified string.

4 Summary of Proposed Sci-Vis Chunks

This table summarizes some properties of the proposed chunks described in this document.

Chunk name	Multiple OK?	Ordering constraints
drNG/DrNG	No	Before IDAT
faLT	No	Before IDAT
loGE/LoGE	No	Before IDAT
ttSC	(used in multi-image format)	
xxSC	No	Before IDAT
yySC	No	Before IDAT
zzSC	(used in multi-image format)	
pcAL	No	Before IDAT

5 Proposed PNG Sci-Vis Chunk Specifications

This section provides the detailed specifications for the proposed chunks.

5.1 `drNG/DrNG` Pixel display range

Format last changed 06 April 1996 (Version 19960406). Minor changes to the explanatory material for this chunk were made in version 19960927. The proposed registered name for this chunk is `dRNG/DRNG`.

This chunk can be used when the pixel values do not occupy the full range of possible values, and when bit depth scaling is not appropriate. It can also be used to enhance contrast by scaling to a larger range than the actual range of pixel values. The chunk defines the pixel values that correspond to minimum and maximum intensity, to which the pixel data is to be scaled.

The chunk can be used as a critical chunk, named `DrNG`, or as an ancillary chunk, named `drNG`. The syntax and function is exactly the same whichever name is used. The critical version should only be used if the image cannot be meaningfully displayed without performing `DrNG` scaling. Decoders not recognizing `DrNG` will not attempt to display the image at all. Encoders are strongly encouraged to scale the image data properly and to use the noncritical version, `drNG`, if at all possible.

This chunk's contents are

```
min_sample   m bytes   Raw sample value corresponding to
                        minimum intensity of the graylevel
                        or red channel, written as a text
                        floating-point value [link to
                        Floating-Point Values in extensions
                        document]

0             1 byte    a zero byte to separate fields

max_sample   n bytes   Raw sample value corresponding to
                        maximum intensity for the graylevel
                        or red channel
```

(The following entries can be omitted for grayscale images, or for color images where identical values are to be applied to all three color channels)

```
0           1 byte     a zero byte to separate fields

min_green   m bytes    raw sample value corresponding to
                       minimum green intensity

0           1 byte     a zero byte to separate fields

max_green   m bytes    raw sample value corresponding to
                       maximum green intensity

0           1 byte     a zero byte to separate fields
```

```
min_blue    m bytes     raw sample value corresponding to
                        minimum blue intensity

0           1 byte      a zero byte to separate fields

max_blue    m bytes     raw sample value corresponding to
                        maximum blue intensity
```

If this chunk is present, graylevel or color sample values are to be scaled for display between minimum and maximum intensity by linear interpolation. When the sample value falls outside the range min_value..max_value, it is to be set to min_value or max_value as appropriate. For each graylevel or color sample, the conversion is

```
ratio := (2^output_bit_depth - 1)/(max_value - min_value)
result := (input_sample - min_value) * ratio
output_sample := LIMIT (0, result, 2^output_bit_depth-1)

in which

LIMIT (low, x, high) = MAX (MIN (x, high), low).
```

In indexed-color images, `output_bit_depth == 8` in this calculation, regardless of the bit depth actully used to store the indices. For other color types, output_bit_depth is the same as the `bit_depth` given in the `IHDR` chunk.

Note that min_value and max_value are permitted to be negative, positive, or zero. The only restriction is that they be different from each other.

Encoders **should not** use `drNG/DrNG` in lieu of reasonably scaling the samples. For example, if the sample values range from 0 (black) to 1000 (white), it would be an extremely bad idea to use the `drNG` chunk to request the decoder to scale 1000 up to 65535, because a PNG viewer that does not understand `drNG/DrNG` (and, since this is an extension chunk, most viewers will probably not understand `drNG/DrNG`) would simply display a very dark rectangle. Instead, multiply your samples by 64, and use `drNG` with max_sample=64000 to request the decoder to do the final adjustment.

If the `tRNS` chunk is present, its value is compared to the unscaled pixel value, prior to applying the `drNG/DrNG` scaling. The `faLT`, `gAMA`, `cHRM`, and alpha conversions, if present, are applied to the scaled sample values.

If present, this chunk must appear before the first `IDAT` chunk. Only one `drNG/DrNG` chunk is permitted in a PNG file.

5.2 `faLT` False-color Palette

Format last changed in version 19960914 of this document (September 1996). There have been no changes to any part of the specification for this chunk since then. The name has been changed from `faLS` to `faLT`

to distinguish the versions; the proposed name of the registered chunk is fALS. The "signature" field and its null separator will not be included in the registered chunk.

This chunk is used with grayscale data, where the pixels are to be rendered in a false color according to the grayscale value. The grayscale sample of each pixel serves as a pointer into the false-color palette.

This chunk's contents are a zero-byte-terminated text string (purpose) that names the palette, followed (after the 20-byte signature and its null-byte separator) by a series of false-color palette entries:

```
purpose:         n bytes (Latin-1 text)
separator:       1 byte, null
signature:      20 bytes ("PNG group 1996-09-14")
separator:       1 byte, null
index:           2 bytes, range 0 .. (2^bitdepth) -1)
red:             2 bytes, range 0 .. 65535
green:           2 bytes, range 0 .. 65535
blue:            2 bytes, range 0 .. 65535

etc.
```

The number of entries is determined from the remaining chunk length after the signature field and the null separator. This length not divisible by 8 is an error.

The "purpose" identifies the palette, which can permit applications or people to choose the appropriate one when more than one false-color palette is stored in a multiple-image file. The "purpose" string must follow the format of a tEXt keyword, i.e. 1-79 printable Latin-1 characters.

The gamma field gives the value of gamma, times 100000, that is associated with the false-color palette entries.

This chunk can appear for color type 0 or color type 4. If it appears for any other color type, it will be ignored.

The complete 2^bitdepth-entry false-color palette can be built from the chunk data. If the first entry (index value 0) is missing, it will be assumed to be {0, 0, 0} (black). If the last entry (index value 2^bitdepth - 1) is missing, it will be assumed to be {65535, 65535, 65535} (white). The red, green, blue samples for other missing entries are filled in by linearly interpolating between the samples that are present, independently for each of the three color components.

Once the complete false-color palette is established, it is used similarly to PLTE. The first entry in the completed false-color palette is referenced by the grayscale value 0, the second by grayscale value 1, etc.

If the tRNS chunk is present, its value is compared to the graylevel, not to the converted false-color of the pixels. If the bKGD chunk is present, background pixels will be displayed in the false-color corresponding to the grayscale value found in the bKGD chunk. The cHRM and alpha conversions, if present, are applied to the color samples in the converted false-color pixels. The gAMA chunk is ignored when the faLT chunk is processed, and the supplied gamma value is used instead.

Note that the gAMA and other values must be selected so that the grayscale image is meaningfully displayed when the faLT chunk is unrecognized or ignored.

If this chunk does appear, it must precede the first IDAT chunk. There can be only one faLT chunk in a PNG file.

5.3 loGE/LoGE Logarithmic Encoding

Format last changed 06 April 1996 (Version 19960406). There have been no changes to any part of the specification for this chunk since then. The proposed registered name for this chunk is lOGE/LOGE.

The loGE/LoGE chunk is used to decode image data whose grayscale or color samples have been logarithmically encoded.

The chunk can be used as a critical chunk, named LoGE, or as an ancillary chunk, named loGE. The syntax and function is exactly the same whichever name is used. The critical version should only be used if the image cannot be meaningfully displayed without performing LoGE scaling. Decoders not recognizing LoGE will not attempt to display the image at all. Encoders are strongly encouraged to include a gAMA chunk that permits a meaningful if not completely accurate display, and use the noncritical version, loGE, if at all possible.

The loGE/LoGE chunk's contents are

```
P0              n0 bytes    (First parameter, a real number
                            written as a text floating-point
                            value [link to Floating-Point
                            Values in extensions document]
Null separator: 1 byte

P1              n1 bytes    (Second parameter)

Null separator: 1 byte

P2              n2 bytes    (Third parameter)
```

There is no trailing zero for the final string.

The scaling algorithm is

```
normalized_sample_value := input_sample/(2^input_bitdepth-1)
scaled_value := P0 + P1 * P2^normalized_sample_value
output_sample := LIMIT (0, scaled_value, 2^output_bitdepth-1)

in which

LIMIT (low, x, high) = MAX (MIN (x, high), low).
```

For color_types 0 and 4, the normalized sample value is the grayscale value of the pixel normalized to the range [0.0:1.0] by dividing it by the maximum value for the input bit depth, using floating point arithmetic.

For color_types 2, 3, and 6, the scaling algorithm is applied independently to each of the color samples similarly normalized to [0.0:1.0].

The alpha channel, if present, is not affected by the loGE/LoGE transformation. Alpha compositing is done in the normal manner, with the transformed pixels forming the foreground image [link to Decoders: Alpha Processing in core spec]

Pure logarithmic data can be expressed with

```
P0 := 0
P1 := min_val
P2 := max_val/min_val
```

In which the range [min_val..max_val] includes the minimum and maximum values appearing in the source data.

When the image is decoded using the loGE/LoGE data, the gamma calculation for the decoded samples should be done as though the file_gamma were 1.0, regardless of the contents of the gAMA chunk.

It is advisable to include a gAMA chunk with logarithmic data, in case a viewer does not use the loGE data to decode it. A value of gamma should be chosen that allows the image to be displayed as well as it can be with a viewer that supports gAMA but not loGE.

You can select a value of gamma (also called file_gamma) by eye as described in [link to Gamma Tutorial: General Gamma Handling in core spec], or you can calculate one as follows:

If the maximum value of the logarithmically decoded pixels can reasonably be displayed as white on the monitor, then specifying a value of gamma given by

```
gamma := LN( LN(0.2) / LN(max_val/min_val) + 1) / LN(0.2)
(in which LN() is the natural logarithm function)
```

causes the two values max_val and 0.2*max_val to be reproduced at correct brightness on screen - these can be thought of as white and mid-grey. Tones between white and mid-grey will be a bit too bright, ones darker than mid-grey will be increasingly too dark, but it's a reasonable approximation for viewable display. A max_val/min_val ratio of 64 gives a gamma of about 0.3, a max_val/min_val of 1000 gives a gamma of about 0.165, so a viewer assuming a default gamma of 0.45 is going to give a bright, washed-out image for any log-encoded image.

In cases where the maximum sample value is many times brighter than scene white (i.e. the image is encoded to retain specular highlight information), the formula above doesn't apply, but there's probably no way of getting such an image to display reasonably anyway with a viewer that doesn't understand loGE.

If present, the loGE/LoGE chunk must appear before the first IDAT chunk. Only one instance of the loGE/LoGE chunk is permitted in a PNG datastream.

5.4 pcAL Scale of Pixel Values

Format last changed in version 19960914) In the previous version, this chunk was called zsCL. The proposed registered name for this chunk is pCAL.

When a PNG file is being used to store physical data other than color values, such as a two-dimensional temperature field, the pcAL chunk can be used to record the relationship between pixel values and actual physical values. The pcAL data might be used to construct a reference color bar beside the image. It is not expected to affect the way the image is displayed.

The pcAL chunk's contents are are a zero-byte-terminated text string (purpose) that names the equation, followed (after the 20-byte signature and its null-byte separator) by an equation type and a set of parameters for the equation:

```
purpose:         n bytes (Latin-1 text)

separator:       1 byte, null

signature:      20 bytes ("PNG group 1996-10-11")

separator:       1 byte, null

Equation type    1 byte   (0 for linear scaling,
                           1 for base-e exponential scaling,
                           2 for arbitrary-base exponential
                             scaling,
                           3 for hypberbolic scaling)

N                1 byte   (Number of parameters)

Unit             u bytes  (Latin-1 symbol or description of
                           the unit, eg. K, Population Density,
                           MPa, etc).  A zero-length string can
                           be used if the data is dimensionless.

Null separator: 1 byte

P0              p0 bytes  (First parameter, a real number
                           written as a text floating-point
                           value [link to Floating-Point Values
                           in PNG extensions document]

Null separator: 1 byte

P1              p1 bytes  (Second parameter)

Null separator: 1 byte    (must appear if P2 is present)

P2              p2 bytes  (Third parameter, optional)
```

```
etc.

Null separator: 1 byte   (must appear if PM is present)

PM             pm bytes  (M+1 parameter, optional, where
                          M < N.  If PM is present, P[M-1]
                          must also be present)
```

There is no trailing zero for the final string.

The "purpose" identifies the equation, which can permit applications or people to choose the appropriate one when more than one scaling equation is stored in a multiple-image file. The "purpose" string must follow the format of a `tEXt` keyword, i.e. 1-79 printable Latin-1 characters. One way the "purpose" field could be used is to identify the system of units. A "purpose" string such as "SI" or "English" could be used in the `pcAL` chunk as well as in the `xxSC` and `yySC` chunks, to permit a decoder to select an appropriate set of chunks based on the contents of their "purpose" fields.

The scaling algorithm is

```
if equation_type == 0 then
scaled_value := P0 + P1 * normalized_sample_value

else if equation_type == 1 then
scaled_value := P0 + P1 * EXP(P2 * normalized_sample_value)

else if equation_type == 2 then
scaled_value := P0 + P1 * P2^normalized_sample_value

else if equation_type == 3 then
scaled_value := P0 + P1*SINH((normalized_sample_value - P2)/P3)
```

in which

- EXP(x) is the exponential function, e^x, in which "e" is the base of natural logarithms (approximately 2.718282)
- SINH(x) is the hyperbolic sine of x,

```
SINH(x) = 0.5 * ( EXP(x) - EXP(-x) )
```

For color_types 0 and 4, the normalized sample value is the grayscale sample value of the pixel normalized to the range [0.0:1.0] by dividing it by the maximum value for the bit depth, using floating point arithmetic.

For color_types 2, 3, and 6, the scaling algorithm is applied independently to each of the color sample values similarly normalized to [0.0:1.0].

Pure logarithmic data can be expressed either with

```
Equation_type =: 1                Equation_type := 2
N  =: 3                 or with    N  := 3
P0 =: 0                           P0 := 0
P1 =: min                         P1 := min
P2 =: LOGe(max/min)               P2 := max/min
```

The pcAL data is not intended to be used by a decoder to affect the way the pixels are displayed. pcAL is simply a comment, and could be used, for example, to construct a reference color bar scale beside the image, or to extract the original physical values recorded in the file. The drNG/DrNG or loGE/LoGE chunk should be used if the encoder wants the decoder to modify the sample values for display purposes.

If present, the pcAL chunk must appear before the first IDAT chunk. Only one instance of the pcAL chunk is permitted in a PNG stream.

5.5 ttSC Physical time scale

New proposed chunk, 16 August 1996 (Version 19960816). 19960914 version. The chunk name was changed from tsCL to ttSC in the 19961011 version because the "purpose" and "signature" fields were added. The proposed registered name for this chunk is tSCL.

This is like xxSC chunk except that it gives the scale and offset in the frame-to-frame direction, which would normally be the physical time scale. It would be meaningless in a PNG stream, but in a multi-image format it could be used at the top level, to provide the physical scale (rather than the display frame rate) in the frame-to-frame direction.

5.6 xxSC X-Scale of Image Subject

New chunk, 16 August 1996 (Version 19960816). This chunk was formerly included in the xySC chunk and was called xSCL in the 19960914 version. The chunk name was changed in the 19961011 version because the "purpose" and "signature" fields were added. The proposed registered name for this chunk is xSCL.

This chunk relates the actual dimension of the image subject in the "x" (width) direction to the column position of a pixel. It provides some additional capability beyond that available in the sCAL [link to sCAL in PNG extensions document] chunk, which does not provide for an offset, and does not provide for different units in the width and height directions. The latter could be useful, for example, in racing photo-finish "streak" images, where one of the dimensions is time and the other is length. The chunk does not affect the image display, but could be used to construct scaled axes adjacent to the image.

The xxSC chunk's contents are

```
purpose:        n bytes (Latin-1 text)

separator:      1 byte, null

signature:     20 bytes ("PNG group 1996-10-11")
```

```
separator:      1 byte, null

Xunit          xu bytes  (Latin-1 symbol or description of
                         the width unit, eg. milliseconds,
                         degrees West Longitude,  etc).
                         A zero-length string can be used if
                         the data is dimensionless.

Null separator: 1 byte

Xoffset        xo bytes  X offset, a real number written as a
                         text floating-point value [link to
                         Floating-Point Values in PNG
                         extensions document] This is the
                         physical value of "x" corresponding
                         to the left edge of the image.

Null separator: 1 byte


Xscale         xs bytes  X scale, the x-distance corresponding
                         to the width of a pixel.  Must be
                         non-zero.
```

There is no trailing zero for the final string.

The scaling algorithm for finding the physical x-value of the middle of a pixel is

```
physical_x_value := Xoffset + Xscale * (column_number + 0.5)
```

If present, the `xxSC` chunk must appear before the first `IDAT` chunk. Only one instance of the `xxSC` chunk is permitted in a PNG stream.

5.7 `yySC` Y-Scale of Image Subject

New chunk, 16 August 1996 (Version 19960816). This chunk was formerly included in the `xySC` chunk and was called `ySCL` in the 19960914 version. The chunk name was changed in the 19961011 version because the "purpose" and "signature" fields were added. The proposed registered name for this chunk is `ySCL`.

This chunk is similar to the `xxSC` chunk. It relates the actual dimension of the image subject in the "y" (height) direction to the row position of a pixel, positive downward from the top.

The `yySC` chunk's contents are

```
purpose:        n bytes (Latin-1 text)
```

```
separator:      1 byte, null

signature:     20 bytes ("PNG group 1996-10-11")

separator:      1 byte, null

Yunit          yu bytes  (Latin-1 symbol or description of
                         the width unit, eg. milliseconds,
                         degrees North Latitude, etc).
                         A zero-length string can be used if
                         the data is dimensionless.

Null separator: 1 byte

Yoffset        yo bytes  Y offset, a real number written as a
                         text floating-point value [link to
                         Floating-Point Values in extensions
                         document] This is the physical value
                         of "y" corresponding to the top
                         edge of the image.

Null separator: 1 byte

Yscale         ys bytes  Y scale, the y-distance corresponding
                         to the height of a pixel.  Must be
                         non-zero.  The positive direction is
                         downward.
```

There is no trailing zero for the final string.

The scaling algorithm for finding the physical y-value of the middle of a pixel is

```
physical_y_value := Yoffset + Yscale * (row_number + 0.5)
```

If present, the `yySC` chunk must appear before the first `IDAT` chunk. Only one instance of the `yySC` chunk is permitted in a PNG stream.

5.8 `zzSC` Z scale

New chunk, 16 August 1996 (Version 19960816). This chunk was was called `zsCA` in the 19960914 version. The chunk name was changed in the 19961011 version because the "purpose" and "signature" fields were added. The proposed registered name for this chunk is `zSCL`.

This is like `xxSC` chunk except that it gives the z-scale and offset in the thickness direction, when a series of images are considered to be layers of voxels (tomographic slices). It would be meaningless in a PNG stream, but in a multi-image format it could be used to provide the physical dimension in the frame-to-frame

direction, or when images are grouped as in a composite frame, to give the dimension in the plane-to-plane direction within the group.

6 Security considerations

Security considerations are addressed in the basic PNG specification, `http://www.w3.org/pub/WWW/TR/WD-png`.

The same precautions taken when displaying `tEXt` data should be taken when displaying the text contained in the "unit" strings of the `xxSC` and `pcAL` chunks and the "purpose" string of various chunks. Viewers should not display these strings directly without first checking for the presence of nonprintable characters, and for the <ESC> character in particular.

No known additional security hazards are posed by the chunks described here.

7 Credits

Contributors

Contributors' names are presented in alphabetical order:

- Mark Adler, madler@alumni.caltech.edu
- Thomas Boutell, boutell@boutell.com
- Christian Brunschen, cb@df.lth.se
- Adam M. Costello, amc@cs.berkeley.edu
- Lee Daniel Crocker, lee@piclab.com
- Andreas Dilger, adilger@enel.ucalgary.ca
- Oliver Fromme, fromme@rz.tu-clausthal.de
- Todd French, tfrench@sandia.gov
- Jean-loup Gailly, gzip@prep.ai.mit.edu
- Chris Herborth, chrish@qnx.com
- Alex Jakulin, alex@hermes.si
- Neal Kettler, kettler@cs.colostate.edu
- Jim King, jimk@mathtype.com
- Tom Lane, tgl@sss.pgh.pa.us

- Alexander Lehmann, alex@hal.rhein-main.de
- Chris Lilley, chris@w3.org
- Dave Martindale, davem@cs.ubc.ca
- Owen Mortensen
- Robert P. Poole, lionboy@primenet.com
- Glenn Randers-Pehrson, glennrp@arl.mil or randeg@alumni.rpi.edu
- Greg Roelofs, newt@pobox.com
- Willem van Schaik, gwillem@ntuvax.ntu.ac.sg
- Guy Schalnat
- Paul Schmidt, pschmidt@photodex.com
- Tim Wegner, 71320.675@compuserve.com

Editor

- Glenn Randers-Pehrson, glennrp@arl.mil or randeg@alumni.rpi.edu

End of PNG Sci-Vis Chunks Specification. Expires 11 Apr 1997.