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PNG Development Group
mpng-list@dworkin.wustl.edu
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Status of this Memo

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

It is a **proposal**, and the format is subject to change.

Comments on this document can be sent to the PNG specification maintainers at one of the following addresses:

- mpng-list@dworkin.wustl.edu
- png-group@w3c.org
- png-info@uunet.uu.net

Distribution of this memo is unlimited.

At present, the latest version of this document is available on the World Wide Web from

`<URL:ftp://swrinde.nde.swri.edu/pub/mng/documents/>.`

Changes from forty-second MNG draft (draft-mng-19971230)

- Added a new entry_type (segment with nominal start time and nominal frame number) to the optional directory in the SAVE chunk, and added a reference to the W3C SMIL Recommendation.
- Revised writeup of “SHOW” chunk with respect to “cycle”
- Corrected several typos

Abstract

This document presents the format of a MNG (Multiple-image Network Graphics) datastream. MNG is a multiple-image member of the PNG (Portable Network Graphics) format family, that can contain animations (slide shows) comprised of PNG single-image datastreams. It can also incorporate images in a highly compressible "Delta-PNG" format, defined herein.

The MNG format provides a mechanism for reusing image data without having to retransmit it. Multiple images can be composed into a "frame," and a group of images can be used as an animated "sprite" that moves from one location to another in subsequent frames.

A MNG frame normally contains a two-dimensional image or a two-dimensional layout of smaller images. It could also contain three-dimensional "voxel" data arranged as a series of two-dimensional planes (or tomographic slices), each plane being represented by a PNG or Delta-PNG datastream.

A Delta-PNG datastream defines an image in terms of a parent PNG or Delta-PNG image and the differences from that image. This has been demonstrated to provide a much more compact way of representing subsequent images than using a complete PNG datastream for each.

The MNG format uses the same chunk structure that is defined in the PNG specification, and shares other features of the PNG format. Any valid PNG datastream is also a valid MNG datastream.

This document includes examples that demonstrate various capabilities of MNG including simple movies, composite frames, loops, fades, tiling, scrolling, storage of voxel data, and converting GIF animations to MNG format.

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1 Introduction

This specification defines the format of the MNG (Multiple-image Network Graphics) datastream.

Note: This specification depends on the PNG Portable Network Graphics specification [PNG]. The PNG specification is available at the PNG home page,

<URL:http://www.cdrom.com/pub/png/>

A MNG datastream describes a sequence of single frames, each of which can be composed of zero or more embedded images or directives to show previously defined images.

A typical MNG datastream consists of

- The 8-byte MNG signature.
- The "MHDR" chunk.
- Frame definitions. A frame can be
  - A single visible image.
  - A group of visible images delimited by "FRAM" chunks.

  - Nothing, between "FRAM" chunks, to display a rectangle filled with the background color (or filled with the underlying screen contents, if the BACK chunk has not appeared defining a "mandatory" background color).

- "LOOP-ENDL" chunks that enclose frame definitions.
- "SEEK" chunks that mark points in the datastream where processing can be restarted.
- Various chunks for creating and manipulating images and other objects.
- The "MEND" chunk.

Images can be "concrete" or "abstract". The distinction allows decoders to use more efficient ways of manipulating images when it is not necessary to retain the image data in its original form or equivalent in order to show it properly on the target display system.

MNG is pronounced "Ming."

When a MNG datastream is stored in a file, it is recommended that ".mng" be used as the file suffix. In network applications, the Media Type "video/x-mng" can be used. Registration of the media type "video/mng" might be pursued at some future date.

The first eight bytes of a MNG datastream are

```
138 77 78 71 13 10 26 10
```

(decimal) which is similar to the PNG signature with "\212 M N G" instead of "\211 P N G" in bytes 1-4.

MNG does not yet accommodate sound or complex sequencing information, but these capabilities might be added at a later date, in a backwards-compatible manner. These issues are being discussed in the mpng-list@dworkin.wustl.edu mailing list. At some future date, support for a lossy image format such as the proposed PNP (Portable Network Photo) format will be added. PNP is under discussion by pnp-list@dworkin.wustl.edu.

Chunk structure (length, name, data, CRC) and the chunk-naming system are identical to those defined in the PNG specification. As in PNG, all integers that require more than one byte must be in network byte order.

The chunk copying rules for MNG employ the same mechanism as PNG, but with rules that are explained more fully in Chapter 6, below. A MNG editor is not permitted to move unknown chunks across the "SAVE" and "SEEK" chunks, across any chunks that can cause images to be displayed, or into or out of a "IHDR-IEND" or similar sequence.

Note that decoders are not required to follow any decoding models described in this specification nor to follow the instructions in this specification, as long as they produce results identical to those that could be produced by a decoder that did use this model and did follow the instructions.

Each chunk of the MNG datastream or of any embedded object is an independent entity, i.e., no chunk is ever enclosed in the data segment of another chunk.

An independent PNG datastream, with a PNG signature, is also a valid MNG datastream that must be recognized and decoded by MNG-compliant decoders. This kind of MNG datastream will contain only a single embedded image.

Because the embedded objects making up a MNG are normally in PNG format, MNG shares the good features of PNG:

- It is unencumbered by patents.
- It is streamable.
- It has excellent, lossless compression.
- It stores up to four channels (red, green, blue, alpha), with up to 16 bits per channel.
- It provides transparency and an alpha channel.
- It provides platform-independent rendition of colors by inclusion of gamma and chromaticity information.
- It provides early detection of common file transmission errors and robust detection of file corruption.
- Single-image GIF files can be losslessly converted to PNG.
- It is complementary to JPEG and does not attempt to replace JPEG for lossy storage of images (however, MNG can accommodate JPEG-encoded images that are wrapped in the PNG-like PNJ format that is defined herein).

In addition,

- It provides animation with variable interframe delays.
- It allows composition of frames containing multiple images.
- It facilitates the use of images as "sprites" or groups of images as "animated sprites" that can be reused in subsequent frames.
- It capitalizes on frame-to-frame similarities to reduce the amount of data that must be included in a datastream.
- It provides "restart" points at which an animation can be safely resumed in case of data loss or corruption, or to which applications can jump if they have random access to the file.
- A "frame priority" chunk allows authors to indicate which frame should be displayed by single-image viewers, and a subset of the frames that should be displayed by slow viewers.
- Images and frames can be given names, allowing authors to mark them for export outside the scope of MNG, where they can be used for icons or similar purposes.
- A series of PNG images can be losslessly converted to MNG and back to a series of equivalent PNG images, even when the delta format is used to store them in the MNG.
- Multiple-image GIF files can be losslessly converted to MNG.

- It is complementary to MPEG and does not attempt to replace MPEG for lossy storage of video (MNG does, however, provide the capability of including JPEG-encoded images that have been wrapped in the PNG format).

2 Terminology

See also the glossary in the PNG specification.

requirement levels

The words "MUST", "MUST NOT", "REQUIRED", "SHOULD", "SHOULD NOT", "RECOMMENDED", and "OPTIONAL" in this document are to be interpreted as described in RFC-2119, and the word "CAN" is equivalent to the word "MAY" as described therein. "NOT ALLOWED" and "NOT PERMITTED" describe conditions that "MUST NOT" occur. "ALLOWED" and "PERMITTED" describe conditions that "CAN" occur.

abstract image or object

An image whose pixels have a hidden representation, and which does not necessarily carry PNG chunk data. An image delta cannot be applied to an abstract image. All abstract objects are viewable.

child, or child image

An image produced by applying an image delta to a parent object.

color encoding

File gamma and chromaticity values, or an sRGB rendering intent, or whatever is involved in mapping between RGB values and colors.

concrete image or object

An image or object whose pixels have a publicly known representation, and which uses a publicly known color encoding. A concrete PNG image also carries data from other known PNG chunks that are present.

embedded object or image

A concrete object or image that appears in-line in a MNG datastream.

frame

A layout of a background and zero or more images that is to be displayed as a still frame or as part of an animation. An animation would ideally appear to a perfect observer (with an inhumanly fast visual system) as a sequence of still frames.

frame area

The portion of the display surface whose pixels are inside the frame clipping boundaries as defined by the "`CLIP`" chunk (see Paragraph 4.3.4, the CLIP chunk specification, below).

frame duration

The amount of time a frame should be visible when an animation is played. In reality, it takes a non-zero amount of time to display a frame. No matter which moment is picked as the "start" of the frame, the frame duration measures the time to the "start" of the next frame.

frame origin

The upper left corner of the output device (frame buffer, screen, window, page, etc.) where the pixels are to be displayed. This is the {0,0} position for the purpose of defining frame clipping boundaries, image locations, and image clipping boundaries. Note that in a windowing system, the frame origin might be moved offscreen, but MOVE and CLIP values would still be measured from this offscreen origin.

frozen object

An object whose object attributes set and object buffer are not allowed to be discarded, replaced, or modified.

image delta

An object that can be applied to a concrete image or object to produce another concrete image. For any two concrete images, there exists an image delta that will produce one from the other.

image N or object N

Shorthand for "the object with the object attribute set pointed to by `'object_id=N'`".

object, object_id

An image or a nonviewable basis object. The object_id is an unsigned sixteen-bit number that serves as the identifier of a set of object attributes.

object attributes

Properties of an object such as its existence, potential visibility, location, clipping boundaries, and a pointer to an object buffer. See Object attributes below.

object buffer

A 2D array of pixels or pixel deltas, each of which has color and transparency information. More than one object can point to a given object buffer. See Object buffers below.

parent, parent object, or parent image

An object to which a delta is applied.

potentially visible image

- An not-yet-defined viewable object that is "marked" for on-the-fly display while the embedded image that defines it is being decoded, by setting its "`do_not_show`" flag to zero.
- An existing viewable object that is potentially visible (i.e. it is "marked" for being made visible by subsequent "`SHOW`" chunks), by setting its "`do_not_show`" flag to zero.

prologue segment

The first segment, when there is more than one segment.

regular segment

Any segment other than the first (also the first segment, when there is only one).

segment

A part of a MNG datastream starting with the "MHDR" chunk or with a "SEEK" chunk and extending to just before the next "SEEK" chunk (or the "MEND" chunk if there is no next "SEEK" chunk). The "MHDR", "MEND", "SAVE", and "SEEK" chunks are not considered to be a part of any segment.

signal

An entity with a number that can arrive asynchronously at the decoder. More detailed semantics, like whether multiple signals of the same number (or even different numbers) can be queued, are beyond the scope of this specification.

viewable image

A stored object that is capable of being made visible. An image is viewable, while some objects resulting from decoding a "BASI" datastream are not viewable.

visible image

Actually drawn on a display. If an object is visible, a person looking at the display can see it.

3 Objects

An "object", which is identified by an "object_id", is an image or a nonviewable basis object. The "object_id" is an unsigned sixteen-bit number that serves as the identifier of a set of object attributes.

An image is a viewable object.

3.1 Embedded objects

An embedded object is

- A PNG datastream ("IHDR", PNG chunks, "IEND").
- A BASI datastream ("BASI", PNG chunks, "IEND").

3.2 Object attributes

Objects have "object attributes" that can be defined and modified by the contents of various MNG chunks. Decoders are responsible for keeping track of them. The simplest decoder might simply establish a

65,536-element array for each attribute, but real applications will undoubtedly use a more memory-efficient method. Object attributes include:

Object exists or does not exist.

An object comes into existence when

- an embedded object appears in the MNG datastream.
- a "CLON" chunk creates it.

An object ceases to exist when it does not have the "frozen" attribute and

- It is the subject of a "DISC" chunk.
- An empty "DISC" chunk appears.
- A "SEEK" chunk appears.
- A new embedded object with the same "object_id" replaces it.

Pointer to an object buffer.

Every object has an object buffer. Multiple objects can point to the same object buffer. The representation of a pointer is decided by the application; pointers never appear explicitly in a MNG datastream.

Frozen or not frozen.

All objects are initially "not frozen". Any objects in existence when the "SAVE" chunk is encountered become "frozen", along with the object buffers that they point to.

Potential visibility.

The "potential visibility" of an object is determined by the "do_not_show" byte of the "DEFI" or "CLON" chunk that introduced it. The "potential visibility" of viewable objects can be changed by the "SHOW" chunk. When an embedded object is "potentially visible" it can be displayed "on-the-fly" as it is being decoded. Later, the "SHOW" chunk can direct that a "potentially visible" object be displayed.

Location.

The X and Y location of an object is determined by the "DEFI" chunk that introduced it, and can be changed by the "MOVE" chunk.

Clipping boundaries.

The clipping boundaries of an object are determined by the "DEFI" chunk that introduced it, and can be changed by means of the "CLIP" chunk.

3.3 Object buffers

An object buffer is created by the appearance of an embedded object in the datastream, or by the appearance of a "CLON" chunk that specifies a "full clone". The contents of an object buffer can be modified by processing an image delta or a "PAST" chunk.

Object buffers contain a 2D array of pixel data and can contain additional information. In addition, decoders are responsible for keeping track of some properties of the data in the object buffer:

Object is viewable.

Any object that points to a viewable object buffer can be made potentially visible, but one that points to a nonviewable one cannot. Any attempt to do so must be ignored.

- A PNG datastream always has the "viewable" attribute.
- The "viewable" attribute of a "BASI" datastream is defined in the "BASI" chunk. Only "BASI" datastreams that produce legal PNG files can be declared "viewable".
- When a Delta-PNG is applied to a parent object, the resulting object buffer always has the "viewable" attribute.

Format of data in the object buffer.

The data format can be

- A concrete PNG.

  A concrete object must be stored by the decoder in a form that retains the complete object description, sufficient to regenerate the original object description or its equivalent without loss. Its pixels have a publicly known representation, and it uses a publicly known color encoding.

  – In the case of a PNG image, the object also carries data from other known PNG chunks that are present. This means that the decoder must store sufficient information to make it possible to restore exactly the original decoded and unfiltered pixel samples as they existed prior to any gamma correction (but not the original compressed datastream or line-by-line filter selections and "zlib" compression flags), and data from the "IHDR" and "PLTE" chunks and any additional recognized PNG chunks such as "gAMA", "cHRM", and "tRNS" that the application plans to use.

  – A decoder that recreates PNG files from a series of PNG and Delta-PNG datastreams will also have to store the contents of any unknown chunks that it finds, in case they turn out to be safe to copy (see Paragraph 5.1.5, DROP, Paragraph 5.1.6, DBYK, and Paragraph 5.1.7, ORDR, below).

- An abstract image.

  An abstract image can be stored by the decoder in any form that is convenient, such as an X Window System "pixmap", even though that form might not have sufficient resolution for exact, lossless conversion. In the case of a PNG image, the pixels could be stored after the gamma and chromaticity corrections have been made, and the sample depth could be the same as the display hardware, even though it is smaller than the original sample depth. It is always safe to store an abstract image as though it were concrete, if decoders do not wish to take advantage of the distinction between abstract and concrete objects.

- At some future time, image data in a lossy format might be allowed.

Frozen or not frozen.

All object buffers are initially "not frozen". Any object buffers in existence when the "SAVE" chunk is encountered become "frozen". Decoders do not actually have to store this flag except as a sanity check, because they can depend on the fact that a "frozen" object buffer will always have at least one "frozen" object whose "object_id" points to it.

A reference count.

When an object buffer is first created, its reference count is set to 1.

When a partial clone is made of an object via the "CLON" chunk, the reference count for the object buffer is incremented, and no new object buffer is created.

When an object is discarded, the reference count of the object buffer that it points to is decremented, and the object buffer is also discarded if the resulting reference count is zero.

4 MNG chunks

This chapter describes chunks that can appear at the top level of a MNG datastream. Unless otherwise specified in the Delta-PNG chapter of this specification, they need not be recognized there.

4.1 Critical MNG control chunks

This section describes critical MNG control chunks. MNG-compliant decoders must recognize and process them.

4.1.1 MHDR MNG datastream header

The "MHDR" chunk is always first in all MNG datastreams except for those that consist of a PNG datastream with a PNG signature. The "MHDR" chunk contains exactly 12 bytes:

```
4 bytes: frame_width  (unsigned integer).

4 bytes: frame_height (unsigned integer).

4 bytes: ticks_per_second  (unsigned integer).
         This is the unit used by the FRAM chunk to
         specify frame_duration and sync_timeout.
```

The "frame_width" and "frame_height" fields give the intended display size (measured in pixels) and provide default clipping boundaries (see Paragraph 4.3.4, below). These can be set to zero if the MNG datastream contains no visible images.

The "ticks_per_second" field must be nonzero if the datastream contains more than one frame. It should be set to zero if the datastream contains exactly one frame, so simple applications that only examine file headers can use this field to identify single-frame MNGs.

4.1.2 MEND End of MNG datastream

The "MEND" chunk's data length is zero. It signifies the end of a MNG datastream.

4.1.3 SAVE Save information

The "SAVE" chunk marks a point in the datastream at which images and other chunk information are "saved"; decoders encountering a "SEEK" must restore this information if it has redefined or discarded it. In addition, it can contain an optional index to the MNG datastream.

The "SAVE" chunk can be empty, or it can contain an index consisting of the following:

```
    1 byte: offset_size (unsigned integer)
         4: offsets and nominal start times are
            expressed as 32-bit integers
         8: offsets and nominal start times are
            expressed as 64-bit integers
```

plus zero or more of the following index entries:

```
1 byte: entry_type (unsigned integer)
     0: segment with nominal start time and
        nominal frame number
     1: segment
     2: frame
     3: exported image
4 or 8 bytes: offset (unsigned integer) Omit if
        entry_type > 1, set equal to zero
        if the offset is unknown.
4 or 8 bytes: nominal_start_time (unsigned
        integer) start time of the segment,
        measured in ticks from the beginning of
        the animation, assuming that all prior
        segments were played as intended on
        an ideal player, ignoring any "fPRI"
        chunks.  Omit if entry_type > 0.
4 bytes: nominal_frame_number (unsigned
        integer) sequence number of the first
        frame in the segment, assuming that all
        prior segments were played as intended
        on an ideal player, ignoring any "fPRI"
        chunks; the first frame of the first
        segment being frame 0. Omit if
        entry_type > 0.
n bytes: name (Latin-1 text) Omit for unnamed
        segments.
1 byte: zero-byte separator (must be omitted from
        the last entry)
```

The "SAVE" chunk must be present when the "SEEK" chunk is present. It appears after the set of chunks that define information that must be retained for the remainder of the datastream. These chunks, collectively referred to as the prologue segment, are no different from chunks in other segments. They can be chunks that define images, or they can be chunks that define other information such as "gAMA", "cHRM", and "sPLT". If any chunks appear between the "SAVE" chunk and the first "SEEK" chunk, these chunks also form a part of the prologue segment, but their contents are lost when the "SEEK" chunk appears.

Only one instance of the "SAVE" chunk is permitted in a MNG datastream. It is not allowed anywhere after the first "SEEK" chunk.

It is not permitted, at any point beyond the "SAVE" chunk, to modify or discard any object that was defined ahead of the "SAVE" chunk.

An object appearing ahead of the "SAVE" chunk can be the subject of a "CLON" chunk. If the clone is a partial clone, modifying it is not permitted, because this would also modify the object buffer that the original object points to.

A chunk like "gAMA" that overwrites a single current value is permitted after the "SAVE" chunk, even if the chunk has appeared ahead of the "SAVE" chunk. Decoders are responsible for saving a copy of the chunk data (in any convenient form) when the "SAVE" chunk is encountered and restoring it when the "SEEK" chunk

is encountered. If no instance of the chunk appeared ahead of the "SAVE" chunk, the decoder must restore the chunk data to its original "unknown" condition when it encounters a "SEEK" chunk. Known chunks in this category include "DEFI", "FRAM", "BACK", "cHRM", "eXPI", "fPRI", "gAMA", "pHYs", "sRGB", and "tERm".

In the case of chunks like "sPLT" that can occur multiple times, with different "purpose" fields, additional instances of the chunk are permitted after the "SAVE" chunk, but not with the same keyword as any instances that occurred ahead of the "SAVE" chunk. The decoder is required to forget such additional instances when it encounters a "SEEK" chunk, but it must retain those instances that were defined prior to the "SAVE" chunk. Known chunks in this category include only "sPLT".

If the optional index is present, every segment, whether named or not, except for the prologue segment, must be listed in it. All entries must appear in the index in the same order that they appear in the MNG datastream. Only named images or frames are permitted, and it is not an error to omit any or all named images or frames from the index.

Offsets are calculated from the first byte of the MNG 8-byte signature, which has offset=0. This is true even if the MNG datastream happens to be embedded in some other file and the signature bytes are not actually present.

Applications with direct access to the datastream can use the index to find segments, frames, and exported images quickly. After processing the prologue segment, they can jump directly to any segment and then process the remaining datastream until the desired frame, image, or time is found. Applications that have only streaming access to the datastream can still use the index to decide whether to decode the chunks in a segment or to skip over them.

Only one instance of the "SAVE" chunk is permitted in a MNG datastream, and, if the "SEEK" chunk is present, the "SAVE" chunk must be present, prior to the first "SEEK" chunk. The only chunks not allowed ahead of the "SAVE" chunk are the "SEEK" chunk and the "MEND" chunk.

4.1.4 SEEK Seek point

The "SEEK" chunk marks positions in the MNG datastream where a restart is possible, and where the decoder must restore certain information to the condition that existed when the "SAVE" chunk was processed.

The "SEEK" can be empty, or it can contain a keyword.

```
n bytes:  keyword (Latin-1 string).
```

The keyword is optional. It need not be terminated by a null byte; if it is, the null byte will be ignored. The keyword must follow the format of a "tEXt" keyword: It must consist only of printable Latin-1 characters and must not have leading or trailing blanks, but can have single embedded blanks. There must be at least one and no more than 79 characters in the keyword. Keywords are case-sensitive. Use caution when printing or displaying keywords (Refer to Security considerations, Chapter 14, below). No specific use for the keyword is specified in this document, but applications can use the keyword for such purposes as constructing a menu

of SEEK points for a slide-show viewer. It can be included in the optional index that can appear in the "SAVE" chunk.

Applications must not use any information preceding the "SEEK" chunk, except for

- data appearing in the "MHDR" chunk
- anything appearing ahead of the "SAVE" chunk.

When the "SEEK" chunk is encountered, the decoder can discard any objects appearing after the "SAVE" chunk, as though an empty "DISC" chunk were present.

In addition to providing a mechanism for skipping frames or backspacing over frames, the "SEEK" chunk provides a means of dealing with a corrupted datastream. The viewer would abandon processing and simply look for the next "SEEK" chunk before resuming. Note that looking for a PNG "IHDR" chunk would not be sufficient because the PNG datastream might be inside a loop or a Delta-PNG datastream, or it might need data from preceding "MOVE" or "CLIP" chunks.

When the "SEEK" chunk is encountered, a decoder must restore the information that it saved when it processed the "SAVE" chunk.

Multiple instances of the "SEEK" chunk are permitted. The "SEEK" chunk must not appear prior to the "SAVE" chunk. The "SAVE" chunk must also be present if the "SEEK" chunk is present.

4.1.5 LOOP, ENDL Define a loop

The "LOOP" chunk provides a "shorthand" notation that can be used to avoid having to repeat identical chunks in a MNG datastream. Its contents are the first three, five, or all six of the following fields:

```
1  byte: nest_level (unsigned integer).
1  byte:termination_condition (unsigned integer).
      0: deterministic.
      1: decoder discretion.
      2: user discretion.
      3: external signal
4 bytes: repeat_count (unsigned integer), range
         [0..2^31-1].
4 bytes: iteration_min (unsigned integer).  Omit
    if termination_condition=0.
4 bytes: iteration_max (unsigned integer).  Omit
    if termination_condition=0.
4 bytes: signal_number (unsigned integer).  Omit
    if termination_condition != 3.
```

Decoders must treat the chunks enclosed in a loop exactly as if they had been repeatedly spelled out. Therefore, during the first iteration of the loop, the parent objects for any Delta-PNG datastreams in the loop are the images in existence prior to entering the "LOOP" chunk, but in subsequent iterations these parent objects

might have been modified. The "termination_condition" field can be used to inform decoders that it is safe to change the number of loop iterations.

Simple decoders can ignore all fields except for the "repeat_count".

When the "LOOP" chunk is present, an "ENDL" chunk with the same "nest_level" must be present later in the MNG datastream. Loops can be nested. Each inner loop must have a higher value of "nest_level" than the loop that encloses it, though not necessarily exactly one greater.

The termination condition specifies how the actual number of iterations is determined. It is very similar to the termination condition field of "FRAM", and can take the same values:

deterministic

The loop terminates after exactly the number of iterations specified by the iteration count. This value must be used if altering the number of repetitions would mess up the MNG stream, but can be used merely to preserve the author's intent.

decoder-discretion

The number of iterations can be chosen by the decoder, and must fall between the "iteration_min" and "iteration_max". If the decoder has no reason to choose its own value, it should use the iteration count. One example of a decoder wishing to choose its own value is a real-time streaming decoder hovering at a loop while waiting for its input buffer to fill to a comfortable level.

user-discretion

The number of iterations should be chosen by the user (e.g. by pressing the <escape> key), but the decoder must enforce the "iteration_min" and "iteration_max" limits. Some decoders might not be able to interact with the user, and many decoders will find that nested user-discretion loops present too great of a user-interface challenge, so the <user-discretion> condition will probably usually degenerate into the <decoder-discretion> condition.

external-signal

The number of iterations must lie between the "iteration_min" and "iteration_max" limits, but the exact number can be determined by the arrival of a signal whose number matches the "signal_number" field.

The "iteration_min" and "iteration_max" can be omitted only if the condition is <deterministic>. The "repeat_count", "iteration_min", and "iteration_max" can be any non-negative integers or <infinity>, but they must satisfy "iteration_min <= repeat_count <= iteration_max".

If "repeat_count" is zero, the loop is done zero times. Upon encountering a "LOOP" chunk with "repeat_count=0", decoders simply skip chunks until the matching "ENDL" chunk is found, and resume processing with the chunk immediately following it.

The "signal_number" can be omitted only if the termination condition is not <external-signal>. "signal_number=0" is reserved to represent a user input from a keyboard or pointing device.

The "ENDL" chunk ends a loop that begins with the "LOOP" chunk. It contains a single one-byte field:

```
1 byte: nest_level (unsigned integer),
        range [0..255].
```

When the "ENDL" chunk is encountered, the loop "repeat_count" is decremented, if it is not already zero. If the result is nonzero, processing resumes at the beginning of the loop. Otherwise processing resumes with the chunk immediately following the "ENDL" chunk.

When the "ENDL" chunk is present, a "LOOP" chunk with the same "nest_level" must be present earlier in the MNG datastream. See below.

The "SEEK" chunk is permitted inside a "LOOP-ENDL" pair, but not when "repeat_count = 0". The "SAVE" chunk is not permitted inside a "LOOP-ENDL" pair. To rerun an entire datastream that includes a "SAVE" chunk, use the "tERm" chunk instead, with termination action 4. See Paragraph 4.4.4, below.

4.2 Critical MNG image defining chunks

4.2.1 DEFI Define an object

The "DEFI" chunk sets the default object attribute set (object_id, potential visibility, concrete_flag, location, and clipping boundaries) for any subsequent images that are defined with "IHDR-IEND" or objects that are defined with "BASI-IEND" datastreams. The "DEFI" chunk contains 2, 3, 4, 12, or 28 bytes:

```
2 bytes: object_id (unsigned integer) identifier
         to be given to the objects that follow the
         DEFI chunk.

1 byte:  do_not_show (unsigned integer)
     0:  Make the objects potentially visible.
     1:  Do not make the objects potentially visible.
     This field can be omitted if the concrete_flag,
     location, and clipping boundary fields
     are also omitted.  When it is omitted, the image
     is potentially visible (do_not_show=0).

1 byte:  concrete_flag (unsigned integer)
     0:  Make the objects "abstract" (image can not
         be the source for a Delta-PNG)
     1:  Make the objects "concrete" (object can be
         modified by a Delta-PNG).
     This field can be omitted if the location and
     clipping boundary fields are also omitted.
     When it is omitted, the object is made "abstract"
     (concrete_flag=0).
```

```
4 bytes: x_location (signed integer).
     The x_location and y_location fields can be
     omitted if the clipping boundaries are also
     omitted.  If so, decoders must assume default
     values {x_location,y_location}={0,0}.

4 bytes: y_location (signed integer).

4 bytes: left_cb (signed integer). Left clipping
     boundary.  The left_cb, right_cb, top_cb, and
     bottom_cb fields can be omitted as a group.
     If so, decoders must assume default values
     {0, frame_width, 0, frame_height}.

4 bytes: right_cb (signed integer).

4 bytes: top_cb (signed integer).

4 bytes: bottom_cb (signed integer).
```

If the object number for an object is nonzero, subsequent chunks can use this number to identify it.

When the object number for an object is zero, the object can be discarded immediately after it has been processed, and it can be treated as an "abstract" image, regardless of the contents of the "concrete_flag" field.

Negative values are permitted for the X and Y location and clipping boundaries. The positive directions are downward and rightward from the frame origin.

The "DEFI" chunk values remain in effect until another "DEFI" chunk or a "SEEK" chunk appears. If no "DEFI" chunk is in effect (either because there is none in the datastream, or because a "SEEK" chunk has caused it to be discarded), the decoder must use the following default values:

```
          object_id = 0
       do_not_show = 0
     concrete_flag = 0
        x_location = 0
        y_location = 0
           left_cb = 0
          right_cb = frame_width
            top_cb = 0
         bottom_cb = frame_height
```

If "object_id" is an identifier that already exists when a "DEFI", "IHDR" or "BASI" chunk is encountered, the contents of the object buffer previously associated with the identifier is replaced with the new embedded object data. Note that if the object has partial clones, the clones will also be affected.

4.2.2 IHDR, PNG chunks, IEND

A PNG (Portable Network Graphics) datastream.

See the PNG specification [PNG] and the PNG Special Purpose Chunks document [PNG-EXT] for the format of the PNG chunks.

Any chunks between "IHDR" and "IEND" are written and decoded according to the PNG specification.

If the PNG "sRGB", "gAMA", or "cHRM" chunks appear in the top-level MNG datastream but none of them appear in the PNG datastream, then the values are inherited from the top level as though the chunks had actually appeared in the PNG datastream. Data from such chunks appearing in the PNG datastream take preference over the inherited values. Note that if any one of these chunks, or any future chunk that defines the color space, appears in the PNG datastream, none of them is inherited. MNG applications that recreate PNG files must write these chunks, if they are inherited, in the output PNG files.

If the PNG "sPLT" chunk appears in the top-level MNG datastream, it takes preference over any "sPLT" chunk appearing in the PNG datastream. MNG applications that recreate PNG files should not copy top-level "sPLT" chunks to the output PNG files.

When "framing_mode = 2,3, or 4" from the MNG "FRAM" chunk, the PNG "oFFs" and "pHYs" chunks and any future chunks that attempt to set the pixel dimensions or the drawing location must be ignored by MNG viewers and simply copied (according to the copying rules) by MNG editors. When "framing_mode=1 or 5" (i.e. when each PNG image is an individual frame), these chunks must be treated as described in the PNG specification.

If "do_not_show=0" for the image when the "IHDR" chunk is encountered, a viewer can choose to display the image while it is being decoded, perhaps taking advantage of the PNG interlacing method, or to display it after decoding is complete.

If "object_id=0", there is no need to store the pixel data after displaying it.

If "concrete_flag=1" and "object_id != 0", the decoder must store the original pixel data losslessly, along with data from other recognized PNG chunks, because it is possible that a subsequent Delta-PNG stream might want to modify it. If "concrete_flag=0", the decoder can store the pixel data in any form that it chooses.

If an object already exists with the same "object_id", the contents of its object buffer are replaced with the new data.

4.2.3 BASI, PNG chunks, IEND

The "BASI" chunk introduces a basis object, which, while it might be incomplete, can serve as a parent object to which a delta image can be applied.

The first 13 bytes of the "BASI" chunk are identical to those of the "IHDR" chunk. An optional 8 additional bytes provide 16-bit {red, green, blue, alpha} values, that are used to fill the entire basis object when the "IDAT" chunk is not present, and a 1-byte "viewable" flag can be present.

```
4 bytes: width (unsigned integer)
4 bytes: height (unsigned integer)
1 byte:  bit_depth (unsigned integer)
1 byte:  color_type (unsigned integer)
1 byte:  compression_method (unsigned integer)
1 byte:  filter_type (unsigned integer)
1 byte:  interlace_type (unsigned integer)
2 bytes: red sample (unsigned integer)
2 bytes: green sample (unsigned integer)
2 bytes: blue sample (unsigned integer)
2 bytes: alpha sample (unsigned integer)
1 byte:  viewable (unsigned integer)
      0: basis object is not viewable
      1: basis object is viewable
```

The alpha sample can be omitted if the "viewable" field is also omitted. If so, and the "color_type" is one that requires alpha, the alpha value corresponding to an opaque pixel will be used. If the color samples are omitted, zeroes will be used. The decoder is responsible for converting the color and alpha samples to the appropriate format and sample depth for the specified "color_type". When "color_type=3", the decoder must generate a palette of length 2^bit_depth, whose first entry contains the given {red, green, blue} triple, and whose remaining entries are filled with zeroes. If the "viewable" field is omitted, the object is not viewable.

The "BASI" a datastream contains PNG chunks, but is not necessarily a PNG datastream. It can be incomplete or it can deviate in certain ways from the PNG specification. It can serve as a parent object for a Delta-PNG datastream, which must supply the missing data or correct the other deviations before the image is displayed. The end of the datastream is denoted by an "IEND" chunk.

The permitted deviations from the PNG format are:

- Multiple instances of some chunks can be present even though the PNG specification allows only one. The subsequent Delta-PNG that uses this as the parent object must select only one, through the "DBYK" or similar mechanism.
- The "IDAT" chunk can be omitted or there can be a single empty "IDAT" chunk. If so, all of the the pixels are filled with the given color and alpha samples. A subsequent Delta-PNG that uses this as the parent object can supply the "IDAT" chunk or chunks.
- The "PLTE" chunk can be omitted or incomplete even when the color_type=3. If so, the subsequent Delta-PNG that uses this as the parent object must supply a complete "PLTE" chunk.

The "BASI" chunk can be used to introduce such things as a library of "faLT" chunks from which one or another can be selected for use with any single image, or it can be used to introduce a simple blank or colored rectangle into which other images will be pasted by means of the "PAST" chunk.

A "BASI" chunk appearing in a MNG datastream must be preceded by a "DEFI" chunk that gives the "object_id", location, and potential visibility for the basis object. The "concrete_flag" can be ei-

ther 0 (abstract) or 1 (concrete), depending on whether the basis image is intended for subsequent use by a Delta-PNG datastream or not. When it is abstract it must also be viewable. When "do_not_show=0" or "viewable=1", the resulting image, after the pixel samples are filled in, must be a legal PNG image.

If an object already exists with the same "object_id", the contents of its object buffer are replaced with the new data.

Top-level "gAMA", "sRGB", "cHRM", and "sPLT" chunks are inherited by a "BASI" datastream in the same manner as by a PNG datastream.

No provision is made in this specification for storing a BASI datastream as a standalone file. A "BASI" datastream will normally be found as a component of a MNG datastream. Applications that need to store a "BASI" datastream separately should use a different file signature and filename extension, or they can wrap it in a MNG datastream consisting of the MNG signature, the "MHDR" chunk, the "BASI" datastream, and the "MEND" chunk.

4.2.4 CLON Clone an object

Create a clone (a new copy) of an image, with a new "object_id". The "CLON" chunk contains 4, 5, 6, 7, or 16 bytes.

```
2 bytes: source_id (nonzero unsigned integer) identifier
         of the parent object to be cloned.

2 bytes: clone_id (nonzero unsigned integer) identifier
         to be given to the clone (new copy) to serve as
         the object_id of the new object.

1  byte: clone_type (unsigned integer)

       0: full clone of the object attributes set and
          the object buffer

       1: partial clone; only object attributes set
          (the location, clipping boundaries, and
          potential visibility) are copied and a link
          is made to the object buffer.

       2: renumber object (this is equivalent to
          "CLON old_id new_id 1 DISC old_id").

       This field can be omitted if the
       "do_not_show" field is also omitted.
       If it is omitted, the clone_type defaults to
       zero (full clone).
```

```
1 byte:  do_not_show (unsigned integer)
     0:  Make the clone potentially visible.
     1:  Do not make the clone potentially visible.
     This field can be omitted if the concrete_flag and
     location fields are also omitted.  When it is
     omitted, the object retains the potential
     visibility of the parent object.

1 byte:  concrete_flag (unsigned integer)
     0:  concrete_flag is the same as that of the parent
         image.
     1:  Make the clone "abstract" (concrete_flag=0).

     This field can be omitted if the location fields
     are also omitted.  When it is omitted, the object
     retains the concrete_flag of the parent object.

1  byte: loca_delta_type (unsigned integer)

       0: location data gives x_location and
          y_location directly.

       1: New positions are determined by adding
          the location data to the position of the
          parent object.

       This field, together with the x_location and
       y_location fields, can be omitted.  When they
       are omitted, the clone has the same location
       as the parent object.

4 bytes: x_location or delta_x_location
         (signed integer).

4 bytes: y_location or delta_y_location
         (signed integer).
```

The "source_id" must be an existing object identifier, and the "clone_id" must not be an existing object identifier.

Negative values are permitted for the X and Y position. The positive directions are downward and rightward from the frame origin.

The clone is initially identical to the parent object except for the location and potential visibility. It has the same clipping boundaries as the parent object. Subsequent "DHDR", "SHOW", "CLON", "CLIP", "MOVE", "PAST", and "DISC" chunks can use the "clone_id" to identify it. If the parent object is not a viewable image, neither is the clone.

Subsequent chunks can modify, show, or discard a full clone or modify its potential visibility, location and clipping boundaries without affecting the parent object, or they can modify, show, or discard the parent object or modify its object attribute set without affecting the clone.

The "concrete_flag" byte must be zero when the "clone_type" byte is nonzero.

If an object has partial clones, and the data in the object buffer of a parent object or any of its partial clones is modified, the parent object and all of its partial clones are changed. Decoders must take care that when the parent object or any partial clone is discarded, the object buffer is not discarded until the last remaining one of them is discarded. Only the location, potential visibility, and clipping boundaries can be changed independently for each partial clone.

4.2.5 DHDR, Delta-PNG chunks, IEND

A Delta-PNG (PNG-Delta) datastream.

See Chapter 5, The Delta-PNG Format, below, for the format of the Delta-PNG datastream. Any chunks between "DHDR" and "IEND" are written and decoded according to the Delta-PNG format. The "object_id" of the Delta-PNG "DHDR" chunk must point to an existing parent object. The resulting image is immediately displayed if its "do_not_show=0". The parent object must be concrete (i.e. it must have "concrete_flag=1").

4.2.6 PAST Paste an image into an another

Paste an image or images identified by "source_id", or part of it, into an existing abstract image identified by "destination_id".

The "PAST" chunk contains a 2-byte "destination_id" and 9 bytes giving a "target location", plus one or more 30-byte source data sequences.

```
2 bytes: destination_id (unsigned integer)

1 byte:  target_delta_type (unsigned integer)
     0:  target_x and target_y are given directly
     1:  target_x and target_y are deltas from
         their previous values in a PAST chunk
         with the same destination_id
     2:  target_x and target_y are deltas from
         their previous values in the immediately
         preceding PAST chunk regardless of its
         destination_id

4 bytes: target_x (signed integer), measured
         rightward from the left edge of the
         destination image
```

```
4 bytes: target_y (signed integer), measured
         downward from the top edge of the
         destination image

2 bytes: source_id (unsigned nonzero integer)
         an image to be pasted in.

1 byte: composition_mode (unsigned integer)
     0: composite_over
     1: replace
     2: composite_under

1 byte: orientation (unsigned integer)
     0: same as source image
     2: flipped left-right, then up-down
     4: flipped left-right
     6: flipped up-down

1 byte:  offset_delta_type (unsigned integer)
     0:  offsets are measured from the {0,0} pixel
         in the destination image
     1:  offsets are measured from the
         {target_x,target_y} pixel in the destination
         image
4 bytes: xoffset or delta xoffset (signed integer)
4 bytes: yoffset or delta yoffset (signed integer)

1 byte:  boundary_delta_type (unsigned integer)
     0:  boundaries are measured from the {0,0} pixel
         in the destination image
     1:  boundaries are measured from the
         {target_x,target_y} pixel in the destination
         image

4 bytes: left_pb or delta left_pb (signed integer)
4 bytes: right_pb or delta right_pb (signed integer)
4 bytes: top_pb or delta top_pb (signed integer)
4 bytes: bottom_pb or delta bottom_pb (signed integer)
etc.
```

The destination image must have the "abstract" property (`concrete_flag=0`). When "`destination_id=0`", the resulting image is "write-only" and therefore only "composite-over" ("`composition_mode=0`") operations are permitted.

The source images can be "abstract" or "concrete" and have any "`color_type`" and "`sample_depth`". They must have the "viewable" property. The number of source images is `((chunk_length-11)/30)`.

The "`xoffset`" and "`yoffset`" distances and the clipping boundaries are measured, in pixels, positive rightward and downward from either the {`0,0`} pixel of the destination image or the {`target_x,`

target_y} position in the destination image. They do not necessarily have to fall within the destination image. Only those pixels of the source image that fall within the destination image and also within the specified clipping boundaries will be copied into the destination image. Note that the coordinate system for offsets and clipping is with respect to the upper lefthand corner of the destination image, which is not necessarily the same coordinate system used by the "MOVE" and "CLIP" chunks. If the source image has been flipped or rotated, "xoffset" and "yoffset" give the location of its new upper left hand corner.

When "composition_mode=0", any non-opaque pixels in the source image are combined with those of the destination image. If the destination pixel is also non-opaque, the resulting pixel will be non-opaque.

When "composition_mode=1", all pixels simply replace those in the destination image. This mode can be used to make a transparent hole in an opaque image.

When "composition_mode=2", any non-opaque pixels in the destination image are combined with those of the source image. If the source pixel is also non-opaque, the resulting pixel will be non-opaque.

The order of composition is the same as the order that the "source_id's" appear in the list (but a decoder can do the composition in any order it pleases, or all at once, provided that the resulting destination image is the same as if it had actually performed each composition in the specified order). Decoders must be careful when the destination image equals the source image–the pixels to be drawn are the ones that existed before the drawing operation began.

The "MOVE" or "CLIP" information associated with the "destination_id" and the "source_id's" is not used in the "PAST" operation (but if a decoder is simultaneously updating and displaying the "destination_id", the "MOVE" and "CLIP" for the "destination_id" is used in the display operation).

4.2.7 DISC Discard objects

The "DISC" chunk can be used to inform the decoder that it can discard the object data associated with the associated object identifiers. Whether the decoder actually discards the data or not, it must not use it after encountering the "DISC" chunk.

The chunk contains a sequence of zero or more two-byte object identifiers. The number of objects to be discarded is the the chunk's data length, divided by two.

```
2 bytes: discard_id (nonzero unsigned integer) identifier
         of object that can be discarded.  All
         information pertaining to the corresponding
         object can be discarded.
etc.
```

If the "DISC" chunk is empty, all objects except those preceding the "SAVE" chunk can be discarded. If a "SAVE" chunk has not been encountered, all objects can be discarded. Note that each appearance of a "SEEK" chunk in the datastream implies an empty "DISC" chunk.

When an object is discarded, any location, potential visibility, and clipping boundary data associated with it is also discarded.

The appearance of an "object_id" in the "discard_id" list, when no such object has been stored, or when the object has already been discarded, should not be treated as an error.

It is an error to explicitly name any "frozen" object in the "DISC" list.

When the object is a partial clone or is the source of a partial clone that has not been discarded, only the object attribute set (location, potential visibility, and clipping boundaries) can be discarded. The data in the object buffer must be retained until the last remaining partial clone is discarded.

4.3 Critical MNG image displaying chunks

4.3.1 BACK Background

The "BACK" chunk suggests a background color against which transparent, clipped, or less-than-full-frame images can be displayed.

```
2 bytes: red_background (unsigned integer).

2 bytes: green_background (unsigned integer).

2 bytes: blue_background (unsigned integer).

1 byte: mandatory_background (unsigned integer)
     0: background color is advisory; applications
        can use it if they choose to.
     1: background color is mandatory; applications
        must use it.
     This byte can be omitted; if so, the background
     color is advisory.
```

Viewers are expected to composite every frame in the MNG datastream against a fresh copy of the background. The images and the background are both clipped to the frame boundaries given in the "FRAM" chunk. Viewers might actually follow some other procedure, but the final appearance of each frame must be the same as if they had.

The "BACK" components are always interpreted in the current color space as defined by any top-level "gAMA", "cHRM", "sRGB" chunks that have appeared prior to the "BACK" chunk in the MNG datastream. If no such chunks appear, the color space is unknown.

When the "BACK" chunk appears between "FRAM" chunks, it applies to the upcoming frame, not to the current one. When "framing_mode=1", it takes effect immediately prior to the next "IHDR", "DHDR", "PAST", or "SHOW" chunk in the datastream.

Multiple instances of the "BACK" chunk are permitted in a MNG datastream.

The "BACK" chunk can be omitted. If a background is required and the "BACK" chunk is omitted, then the viewer must supply its own background.

In practice, most applications that use MNG as part of a larger composition should ignore the "BACK" data if "mandatory_background==0" and the application already has its own background definition. This will frequently be the case in World Wide Web pages, to achieve nonrectangular transparent animations displayed against the page's background.

4.3.2 FRAM Delimit a frame

The "FRAM" chunk marks the beginning of a group of chunks that describe a frame. It also can set parameters that govern how the decoder is to behave when it encounters a "FRAM" chunk.

An empty "FRAM" chunk is just a frame delimiter. A nonempty one is a frame delimiter, and it also changes "FRAM" parameters, either for the upcoming frame or until reset. When the "FRAM" chunk is not empty, it contains a "framing_mode" byte, an optional name string, a zero-byte separator, plus four 1-byte fields plus a variable number of optional fields.

```
1 byte:  framing_mode.

     0:  Don't change framing_mode.

     1:  Each image is an individual frame; the
         frame area background is restored
         and an interframe delay occurs after
         each image.  This is the default
         framing_mode.

     2:  The group of images appearing prior to
         the next "FRAM" chunk form a composite
         frame. Images are caused to appear with
         explicit or implied "SHOW" chunks.  The
         level, or stacking order, of each image
         is given by its order of appearance in the
         datastream.  The frame area background is
         restored prior to displaying the first
         image, and no interframe delay occurs
         between the images.
```

```
        3:  The group of "n" images appearing prior to
            the next "FRAM" chunk define "n" frames as
            they accumulate, and an interframe delay
            occurs after each image is defined or
            appears in a "SHOW" chunk.  The frame area
            background is only restored prior to
            displaying the first image.  Images appear
            one by one and remain visible after being
            explicitly caused to appear.  The level,
            or stacking order, of each image is given
            by its order of appearance in the datastream.

        4: This is the same as framing_mode=1, except
            the frame area background is not restored
            prior to displaying each image.  Use this
            mode to avoid unnecessary clearing of the
            display when the first image covers the
            entire frame area, when the sequence
            consists of a series of full-frame opaque
            images, and when a subsequent frame is
            created by overlaying a smaller, opaque
            image over the existing frame.

        5: This is the same as framing_mode=2, except
            the frame area background is not restored
            prior to displaying the frame.

n bytes: frame_name (Latin-1 Text).  Can be
     omitted; if so, the frame is nameless.

1 byte:  zero-byte separator. Must be omitted
     if all remaining fields are also omitted.

1 byte:  change_interframe_delay
     0:  no.
     1:  yes, for the next frame only.
     2:  yes, also reset default.

     This field and the next three must be omitted
     as a group if no frame parameters other than
     the framing_mode are changed.
```

```
1 byte:  change_sync_timeout_and_termination.
     0:  no.
     1:  deterministic, for the next frame only.
     2:  deterministic, also reset default.
     3:  decoder-discretion, for the next frame only.
     4:  decoder-discretion, also reset default.
     5:  user-discretion, for the next frame only.
     6:  user-discretion, also reset default.
     7:  external-signal, for the next frame only.
     8:  external-signal, also reset default.

1 byte:  change_frame_clipping_boundaries.
     0:  no.
     1:  yes, for the next frame only.
     2:  yes, also reset default.

1 byte:  change_sync_id_list.
     0:  no.
     1:  yes, for this frame only.
     2:  yes, also reset default list.

4 bytes: interframe_delay (unsigned integer) (Must
         be omitted if change_interframe_delay=0).
         The range is [0..2^31-1] ticks.

4 bytes: sync_timeout (unsigned integer) (omit if
         change_sync_timeout=0). The range is
         [0..2^31-1].  The value 2^31-1 (0x7fffffff)
         ticks represents an infinite timeout period.

1  byte: fb_delta_type (unsigned integer).
      0: frame clipping boundary values are given
         directly.
      1: frame clipping boundaries are determined by
         adding the FRAM data to their previous
         values.
      This and the following four fields must be
      omitted if change_frame_clipping_boundaries=0.

4 bytes: left_fb or delta_left_fb (signed integer).

4 bytes: right_fb or delta_right_fb (signed integer).

4 bytes: top_fb or delta_top_fb (signed integer).

4 bytes: bottom_fb or delta_bottom_fb (signed
         integer).
```

```
4 bytes: sync_id (unsigned integer) (omit if
         change_sync_id_list=0 or if the new list is
         empty; repeat until all sync_id's have been
         listed).  The range is [0..2^31-1].
```

When the "FRAM" parameters are changed, the new parameters affect the frame that is about to be defined, not the one that is being terminated by the "FRAM" chunk.

Framing_modes:

Framing_mode = 1.

When"framing_mode=1",each image that appears is a separate frame. "FRAM" chunks need not appear to separate them.

The following events trigger the display of a frame:

- Decoding a "IHDR-IEND" sequence at the MNG level, when it defines a potentially visible image.
- Decoding a "DHDR-IEND" sequence, when it defines a potentially visible image.
- Decoding a "BASI-IEND" sequence, when it defines a potentially visible image.
- Decoding a "PAST" chunk, when it defines a potentially visible image.
- Decoding a "SHOW" chunk, when it directs that a potentially visible image be displayed. When the "SHOW" chunk requests that several images be displayed, each one in turn triggers a separate frame.

Any of these events triggers the display of a frame, even if the visible image is outside the clipping boundaries and no pixels are actually changed.

For example (assuming that objects 1 through 5 are all viewable objects), the sequence

```
FRAM 1
SHOW 1 5
```

will result in the display of five frames, each containing one of the images against the background according to its location and "CLIP" data.

Framing_mode = 2.

When "framing_mode=2", viewers are expected to display all of the images at once, if possible, or as fast as can be managed, without clearing the display and restoring the background between images. For example, the sequence

```
FRAM 2
SHOW 1 5   (shows images 1, 2, 3, 4, and 5)
FRAM
```

will result in a single frame containing five images, each displayed according to its location and "CLIP" data.

When images in a frame overlap, viewers are expected to composite the later images against the partially completed frame that includes all earlier images.

This "framing_mode" is fundamentally declarative; it describes the elements that go into an individual frame. It is up to the decoder to work out an efficient way of making the screen match the desired composition. Simple decoders can handle it as if it were procedural, compositing the images into the frame in the order that they appear, but efficient decoders might do something different, as long as the final appearance of the frame is the same.

Framing_mode = 3.

When "framing_mode=3", a frame boundary occurs after each image appears, but only clearing the frame area and restoring the background between frames when the next "FRAM" chunk is encountered. Frames are triggered by the same events that trigger a frame when "framing_mode=1". A frame is also triggered by the appearance of the next "FRAM" chunk, which does cause the portion of the display inside the frame clipping boundaries to be cleared and restored.

When multiple images are caused to appear with a single "SHOW" chunk, a frame boundary occurs after each one. For example, the sequence

```
FRAM 3
SHOW 1 5   (shows images 1, 2, 3, 4, and 5)
FRAM
```

would result in five frames being displayed, the first with only image 1, the second with images 1 and 2, etc., and the fifth frame with all five images visible. The resulting output is exactly equivalent to what would have been accomplished (but perhaps less efficiently) with

```
FRAM 2
SHOW 1
FRAM
SHOW 1 2   (shows images 1 and 2)
FRAM
SHOW 1 3   (shows images 1, 2, and 3)
FRAM
SHOW 1 4   (shows images 1, 2, 3, and 4)
FRAM
SHOW 1 5   (shows images 1, 2, 3, 4, and 5)
FRAM
```

Framing_mode = 4.

When "framing_mode=4", a frame boundary occurs after each image appears, without clearing the frame area and restoring the background between frames. Otherwise, "framing_mode=4" is identical to "framing_mode=1". Frames are triggered by the same events that trigger a frame when "framing_mode=1". A frame is also triggered by the appearance of the next "FRAM" chunk, but this does not cause any portion of the display to be cleared. Decoders should, however, clear the frame

area when the very first "FRAM" chunk in the datastream is found, or the very first "FRAM" chunk after a "SEEK" chunk is found, even when "framing_mode=4".

Framing_mode = 5.

When "framing_mode=5", a frame boundary occurs only when the next "FRAM" chunk appears, without clearing the frame area and restoring the background. Otherwise, "framing_mode=5" is identical to "framing_mode=2"

The "framing_mode" also affects the way decoders handle the "pHYs" chunk (see Paragraph 4.4.5, below).

The "frame_name" must conform to the same formatting rules as those for a "SEEK" keyword. No specific use for the "frame_name" is specified in this document, except that it can be included in the optional index that can appear in the "SAVE" chunk. Applications can use this field for such purposes as constructing an external list of frames in the datastream. The "frame_name" only applies to the upcoming frame; subsequent frames are unnamed unless they also have their own "frame_name" field.

The "interframe_delay" value is the desired minimum time to elapse from the beginning of displaying one frame until the beginning of displaying the next frame.

The sync_timeout field can be a number or <infinity>.

The termination condition given in the "change_sync_timeout_and_termination" field specifies how much longer, after the normal interframe delay has elapsed, the frame will endure. It can take the following values:

deterministic

The frame endures no longer than the normal interframe delay. Even though this is the default, a streaming encoder talking to a real-time decoder might write a "FRAM" with a termination condition of "deterministic" to force the display to be updated while the encoder decides its next move.

decoder-discretion

The decoder can lengthen the duration of the frame, but by no more than the timeout. A streaming decoder could take the opportunity to wait for its input buffer to fill to a comfortable level.

user-discretion

The decoder should wait for permission from the user (e.g. via a keypress) before proceeding, but must wait no longer than the timeout. If the decoder cannot interact with the user, this condition degenerates into "decoder-discretion".

external-signal

The decoder should wait for the arrival of a signal whose number matches a "sync_id", but must wait no longer than the timeout.

The "sync_id" list can be omitted if the termination condition is not "external-signal".

When the "sync_id" list is changed, the number of "sync_id" entries is determined by the remaining length of the chunk data, divided by four. This number can be zero, which either inactivates the existing "sync_id" list for one frame or deletes it.

The initial values of the "FRAM" parameters are

```
framing_mode      = 1
frame_name        = <empty string>
interframe+delay  = 0
left_fb           = 0
right_fb          = frame_width
top_fb            = 0
bottom_fb         = frame_height
termination       = deterministic
sync_timeout      = 0x7fffffff (infinite)
sync_id           = <empty list>
```

The "MOVE" chunk can be used to specify the placement of each image within the frame. The "CLIP" chunk can be used to specify clipping boundaries for each image. The frame boundaries are only used for clipping. Even when the left and top frame boundaries are nonzero, the image locations are measured with respect to the {0,0} position in the display area. If the images are transparent or do not cover the entire area defined by the frame clippng boundaries, they are composited against the background defined by the "BACK" chunk, or against an application-defined background, if the "BACK" chunk is not present or is not recognized by the decoder. The background, as well as the images, is clipped to the frame clipping boundaries. Any pixels outside the frame clipping boundaries remain unchanged.

The "frame_duration" field gives the duration of display, which is the minimum time that must elapse from the beginning of displaying one frame until the beginning of displaying the next (or between images, when "framing_mode=1"). It is measured in "ticks" using the tick length determined from "ticks_per_second" defined in the "MHDR" chunk.

A viewer does not actually have to follow the procedure of erasing the screen, redisplaying the background, and recompositing the images against it, but what is displayed when the frame is complete must be the same as if it had. It is sufficient to redraw the parts of the display that change from one frame to the next.

The "sync_id" list provides a point at which the processor must wait for all pending processes to reach the synchronization point having the same "sync_id" before resuming, perhaps because of a need to synchronize a sound datastream (not defined in this specification) with the display, to synchronize stereo images, and the like. When the period defined by the sum of the "frame_duration" and the "sync_timeout" fields elapses, processing can resume even though the processor has not received an indication that other processes have reached the synchronization point.

Note that the synchronization point does not occur immediately, but at the end of the frame that follows the "FRAM" chunk. If it is necessary to establish a synchronization point immediately, this can be done by using two consecutive "FRAM" chunks, the first setting a temporary "frame_duration=0", "sync_timeout", and "sync_id", and the second establishing the synchronization point:

```
FRAM 4 0 1 1 0 1 0000 sync_timeout sync_id
FRAM 0 name
```

The identifier "sync_id=0" is reserved to represent synchronization with a user input from a keyboard or pointing device. If multiple channels (not defined in this specification) are not present, viewers can ignore other values appearing in the "sync_id" list.

4.3.3 MOVE New image location

New location of an existing object or objects (replacing or incrementing the location given in the "DEFI" chunk).

The "MOVE" chunk gives the position, measured downward and to the right of the frame origin, in pixels, where the named object or group of objects is to be located.

The chunk's contents are:

```
2 bytes: first_object (nonzero unsigned integer).

2 bytes: last_object (nonzero unsigned integer).

1  byte: loca_delta_type (unsigned integer).
      0: MOVE data gives x_location and
         y_location directly.
      1: New locations are determined by adding
         the MOVE data to the location of the
         parent object.

4 bytes: x_location or delta_x_location
         (signed integer).

4 bytes: y_location or delta_y_location
         (signed integer).
```

The new location applies to a single object, if "first_object = last_object", or to a group of consecutive "object_ids", if they are different. Negative values are permitted for the X and Y location. The positive directions are downward and rightward from the frame origin. The "MOVE" chunk can specify an image placement that is partially or wholly outside the display boundaries. In such cases, the resulting image must be clipped to fit within its clipping boundaries, or not displayed at all if it falls entirely outside its clipping boundaries. The clipping boundaries are determined as described in the specification for the "CLIP" chunk Paragraph 4.3.4, below.

It is not an error for the "MOVE" chunk to name an "image" that has not previously been defined. In such cases, nothing is done to the nonexistent image.

4.3.4 `CLIP` Object clipping boundaries

This chunk gives the new boundaries (replacing or incrementing those from the "DEFI" chunk) to which an existing object or group of objects must be clipped for display. It contains the following 21 bytes:

```
2 bytes: first_object (nonzero unsigned integer).

2 bytes: last_object (nonzero unsigned integer).

1  byte: clip_delta_type (unsigned integer).
      0: CLIP data gives boundary values directly.
      1: CLIP boundaries are determined by adding
         the CLIP data to their previous values
         for this object_id.

4 bytes: left_cb or delta_left_cb (signed integer).

4 bytes: right_cb or delta_right_cb (signed integer).

4 bytes: top_cb or delta_top_cb (signed integer).

4 bytes: bottom_cb or delta_bottom_cb (signed
         integer).
```

The new clipping boundaries apply to a single object, if "first_object = last_object", or to a group of consecutive objects, if they are different.

The clipping boundaries are expressed in pixels, measured rightward and downward from the frame origin.

The left and top clipping boundaries are inclusive and the right and bottom clipping boundaries are exclusive, i.e. the pixel located at {x,y} is only displayed if the pixel falls within the physical limits of the display hardware and all of the following are true:

```
0       <= x < frame_width       (from the MHDR chunk)
0       <= y < frame_height
left_fb <= x < right_fb          (from the FRAM chunk)
top_fb  <= y < bottom_fb
left_cb <= x < right_cb          (from the CLIP chunk)
top_cb  <= y < bottom_cb
```

It is not an error for the "CLIP" chunk to name an "object" that has not previously been defined. In such cases, nothing is done to the nonexistent object.

When an object_id is discarded, its object attribute set, which includes the "CLIP" data, is also discarded.

4.3.5 SHOW Show images

The "SHOW" chunk is used to change the potential visibility of one or more previously-defined objects and to direct that they be displayed. It contains 2, 4, or 5 bytes, or it can be empty.

```
2 bytes: first_image (nonzero unsigned integer).

2 bytes: last_image  (nonzero unsigned integer).
     This field can be omitted if the show_mode
     byte is also omitted.  If so, decoders must
     assume the default values, "show_mode=0"
     and "last_image=first_image."

1 byte:  show_mode (unsigned integer)
     0:  Make the images potentially visible
         and display them (set "do_not_show=0").
     1:  Make the images invisible (set
         "do_not_show=1").
     2:  Don't change "do_not_show" flag;
         display those that are potentially
         visible.
     3:  Mark images "potentially visible"
         ("do_not_show=0") but do not display
         them.
     4:  Toggle "do_not_show" flag; display
         any that are potentially visible after
         toggling.
     5:  Toggle "do_not_show" flag but do
         not display even if potentially visible
         after toggling.
     6:  Step through the images in the given
         range, making the next image potentially
         visible (set "do_not_show=0) and display
         it.  Set "do_not_show=1" for all other
         images in the range.  Cycle back to the
         beginning of the range when reaching the
         end of the range.  Perform one step for
         each SHOW chunk (in reverse order if
         last_image < first_image).
     7.  Make the next image in the range (cycle)
         potentially visible ("do_not_show-0")
         but do not display it.  For all other
         images in the range, set "do_not_show=1.

     This field can be omitted.  If so, decoders
     must assume the default, "show_mode=0".
```

The decoder processes the objects (or images) named in the "SHOW" chunk in the order "first_image" through "last_image", and resets the "do_not_show" flag for each of the objects. If "show_mode" is

even-valued, it also displays the images if they are potentially visible and are viewable images.

When the "SHOW" chunk is empty, the decoder displays all existing potentially visible images, without changing their "do_not_show" status. The empty "SHOW" chunk is equivalent to "SHOW 1 65535 2".

If "first_image > last_image" then the images are processed in reverse order.

When "show_mode" is odd-valued, nothing is displayed unless a subsequent "SHOW" chunk with an even-valued "show_mode" appears.

Interactions with "framing_mode"

When "framing_mode != 2", or when the "FRAM" chunk is not present, each visible image that is displayed triggers a separate frame. When "show_mode" is odd, or when "show_mode=2 or 4" or is empty and no image is visible, no frame is generated.

When "show_mode=1, 4, 5, 6, or 7", images can be made invisible. This is not permitted when "framing_mode != 1" in the "FRAM" chunk and the images have already appeared in the frame, because simple viewers will have already drawn them and have no way to make them invisible again without redrawing the entire frame.

When "show_mode=6 or 7", the decoder must make the next image in the "cycle" visible. To do this, it must examine the "do_not_show" flag for each image in the range "first_image" through "last_image", and make the next one (the one with the next higher value of "image_id" that exists and is "viewable") after the first visible one it finds visible and the rest invisible. If the first visible one was "last_id", or none were visible, it must make "first_image" visible. When "first_image > last_image", the cycle is reversed, and the "next" image is the one with the next lower value of "image_id". These modes are useful for manipulating a group of sequential images that represent different views of an animated icon. See Example 8 Chapter 15, below.

When "show_mode=0, 2, 4, or 6", an instance of each visible image will be displayed at the location specified by the "DEFI", "CLON", or "MOVE" chunk and clipped according to the boundaries specified by the "CLIP" and "FRAM" chunks. When the "MOVE" or "CLON" chunk is used in the delta form, which will frequently be the case, each image must be displaced from its previous position by the values given in the "MOVE" or "CLON" chunk.

Any of the following sequences would cause the image identified by "object_id=6" in a composite frame to blink:

```
LOOP 0 0 10
FRAM 2
SHOW 1 10     # Show images 1 thru 10
FRAM
SHOW 1 5      # Show images 1 thru 5
SHOW 7 10     # Show images 7 thru 10
ENDL
```

```
LOOP 0 0 10
FRAM 2
SHOW 1 5      # Show images 1 thru 5
SHOW 6 6 4    # Toggle potential visibility of image 6
SHOW 7 10     # and show it; show images 7 thru 10
FRAM
ENDL

LOOP 0 0 10
FRAM 2
SHOW 6 6 5    # Toggle potential visibility of image 6
SHOW 1 10 2   # Show potentially visible images in 1
FRAM          # through 10
ENDL
```

It is not necessary to follow an "IHDR-IEND", "BASI-IEND", or "DHDR-IEND" sequence or "PAST" chunk with a "SHOW" chunk to display the resulting image, if it was already caused to appear by "do_not_show=0" in the "DEFI" chunk that introduced the image. Similarly, the "CLON" chunk need not be followed by a "SHOW" chunk, if "do_not_show=0" in the "CLON" chunk.

It is not an error for the "SHOW" chunk to name an "image" that has not previously been defined. In such cases, nothing is done to the nonexistent image. If a nonviewable object is named, its "do_not_show" flag is changed but it is not displayed even if the "SHOW" chunk requests it.

4.4 Ancillary MNG chunks

This section describes ancillary MNG chunks. MNG-compliant decoders are not required to recognize and process them.

4.4.1 eXPI Export image

The "eXPI" chunk takes a snapshot of an object (either concrete or abstract), associates the name with that snapshot, and makes the name available to the "outside world" (like a scripting language).

The chunk contains an object identifier and a name:

```
2 bytes: snapshot_id (unsigned nonzero integer)
n bytes: snapshot_name (Latin-1 text)
```

Note that the "snapshot_name" is associated with the snapshot, not with the "snapshot_id" nor its future contents; discarding the image identified by "snapshot_id" will not affect the snapshot. The "snapshot_name" means nothing inside the scope of the MNG specification, except that it can be included in the optional index that can appear in the "SAVE" chunk.. If two "eXPI" chunks use the same name, it is the outside world's problem (and the outside world's prerogative to regard it as an error). A decoder that knows of no "outside world" can simply ignore the "eXPI" chunk. This chunk could be used in MNG datastreams that define libraries of related images, rather than animations.

Names beginning with the word "thumbnail" are reserved for snapshot images that are intended to make good icons for the MNG. Thumbnail images are regular PNG or Delta-PNG images, but they would normally have smaller dimensions and fewer colors than the MNG frames. They can be defined with the potential visibility field set to "invisible" if they are not intended to be shown as a part of the regular display.

The rules for the "snapshot_name" are the same as those for a PNG "tEXt" keyword.

Multiple instances of the "eXPI" chunk are permitted in a MNG datastream.

4.4.2 fPRI Frame priority

The "fPRI" chunk allows authors to assign a priority to a portion of the MNG datastream. Decoders can decide whether or not to decode and process that part of the datastream based on its "priority" compared to some measure of "cost."

The "fPRI" chunk contains two bytes:

```
1 byte: fPRI_delta_type (unsigned integer).
     0: Priority is given directly.
     1: Priority is determined by adding
        the fPRI data to the previous
        value, modulo 256.

1 byte: priority or delta_priority (signed
        integer). Value to be assigned to
        subsequent frames until another fPRI
        chunk is reached.
```

While 256 distinct values of "priority" are possible, it is recommended that only the values 0 (low priority), 128 (medium priority), and 255 (high priority) be used. Viewers that can only display a single image can look for one with "priority=255" and stop after displaying it. If the datastream contains a large number of frames and includes periodic "initial" frames that do not contain Delta-PNG datastreams, each "initial" frame could be preceded by a "fPRI" with "priority=128" and followed by one with "priority=0", and the best representative initial frame could be preceded by a "fPRI" chunk with "priority=255". Then single-image viewers would just display the representative frame, slow viewers would display just the "initial" frames, and fast viewers would display everything.

If a viewer has established a nonzero "cost," it must skip any portion of the datastream whose priority is less than that "cost." The "cost" must be established prior to processing the proloque segment, and it cannot be changed unless the prologue segment is processed again according to the new "cost."

The "SAVE", "SEEK", and "MEND" chunks always have priority=255; decoders must look for these chunks in addition to the "fPRI" chunk while skipping a low-priority portion of the datastream.

It is not permissible for a portion of the datastream to depend on any portion of the datastream having a lower value, because a decoder might have skipped the lower value portion. Use of the "fPRI" chunk is illustrated in Examples 5 and 9.

Viewers that care about the priority must assume "priority=255" for any portion of the MNG datastream that is processed prior to the first "fPRI" chunk.

Multiple instances of the "fPRI" chunk are permitted.

4.4.3 nEED Resources needed

The "nEED" chunk can be used to specify needed resources, to provide a quick exit path for viewers that are not capable of displaying the MNG datastream.

The "nEED" chunk contains a list of keywords that the decoder must recognize. Keywords are typically private critical chunk names.

```
n bytes: keyword
1  byte: null separator
etc.
```

The "nEED" chunk should be placed early in the MNG datastream, preferably immediately after the "MHDR" chunk.

The keywords are typically 4-character private critical chunk names, but they could be any string that a decoder is required to recognize. No critical chunks defined in this specification or in the PNG specification should be named in a "nEED" chunk, because MNG-compliant decoders are required to recognize all of them, whether they appear in a "nEED" chunk or not. The purpose of the "nEED" chunk is only to identify requirements that are above and beyond the requirements of this document and of the PNG specification.

Each keyword string must follow the format of a "tEXt" keyword: It must consist only of printable Latin-1 characters and must not have leading or trailing blanks, but can have single embedded blanks. There must be at least one and no more than 79 characters in the keyword. Keywords are case-sensitive. A null separator byte must appear after each keyword in the "nEED" chunk except for the last one.

Decoders that do not recognize a chunk name or keyword in the list should abandon the MNG datastream or request user intervention. The normal security precautions should be taken when displaying the keywords.

[During the draft phase of the development of this specification, to specify that the datastream is written in accordance with a certain draft version of MNG, you can use "nEEDdraft nn".]

4.4.4 tERm Termination

The "tERm" chunk suggests how the end of the MNG datastream should be handled, when a "MEND" chunk is found. It contains either a single byte or ten bytes:

```
1 byte: termination_action (unsigned integer)
     0: Show the last frame indefinitely.
     1: Cease displaying anything.
     2: Discard all "nonfrozen" objects and repeat
        the animation starting immediately after
        the SAVE chunk (or immediately after the
        MHDR chunk, if a SAVE chunk is not present).
     3: Repeat the animation starting immediately
        after the last SEEK chunk in the datastream.
        If no SEEK chunk is present, repeat the
        animation starting immediately after the
        SAVE chunk (or immediately after the MHDR
        chunk, if a SAVE chunk is not present).
     4: Reset the decoder to its initial state,
        retaining only the MHDR data, and repeat
        the entire animation starting immediately
        after the MHDR chunk.
1 byte: action_after_iterations
     0: Show the last frame indefinitely after
        iteration_max iterations have been done.
     1: Cease displaying anything.
        This and the remaining fields must be
        omitted if termination_action<=1, and
        must be present otherwise.
4 bytes: delay (unsigned integer) delay, in ticks,
        before repeating the animation.
4 bytes: iteration_max (unsigned integer) maximum
        number of times to repeat the animation.
```

The loop created by processing a "tERm" is always be treated by the decoder as if it were a <user-discretion> loop, with "iteration_min=1".

4.4.5 pHYs Physical pixel size

The MNG "pHYs" chunk is identical in syntax to the PNG "pHYs" chunk, but, when "framing_mode=2, 3, or 5" from the "FRAM" chunk, it applies to complete MNG frames and not to the individual images within them. When "framing_mode=1 or 4", the MNG "pHYs" chunk provides a default value if the subsequent PNG datastreams do not contain one.

The MNG top-level "pHYs" chunk can be nullified by a subsequent empty "pHYs" chunk appearing in the MNG top level.

4.4.6 PNG ancillary chunks

The namespace for MNG chunk names is separate from that of PNG. Only those PNG chunks named in this paragraph are also defined at the MNG top level. They have exactly the same syntax and semantics as when

they appear in a PNG datastream:

- "tEXt"
- "tIME" Same format as in PNG. Can appear at most once in the prologue segment (before the "SAVE" chunk), and at most once per segment (between two consecutive "SEEK" chunks). In the prologue it indicates the last time any part of the MNG was modified. In a regular segment (between "SEEK" chunks), it indicates the last time that segment was modified.
- "zTXt"

A MNG editor that writes PNG datastreams should not include the top-level "tEXt", "tIME", and "zTXt" chunks in the generated PNG datastreams.

The following PNG chunks are also defined at the MNG top level. They provide default values to be used in case they are not provided in subsequent PNG datastreams. Any of these chunks can be nullified by the appearance of a subsequent empty chunk with the same chunk name. Such empty chunks are not legal PNG chunks and must only appear in the MNG top level.

- "cHRM"
- "gAMA"
- "sRGB"

A MNG editor that writes PNG datastreams is expected to include the top-level "cHRM", "gAMA", and "sRGB" chunks in the generated PNG datastreams, if the embedded image does not contain its own chunks that define the color space.

The following PNG chunks are also defined at the MNG top level. They provide values that take precedence over those that might be provided in subsequent PNG datastreams and provide values to be used when they are not provided in subsequent PNG datastreams:

- "sPLT" This chunk also takes precedence over the "PLTE" chunk in a subsequent PNG datastream when the "PLTE" and "hIST" chunks are being used as a suggested palette (i.e. "color_type != 3"). This chunk can appear for any color type. There can be multiple "sPLT" chunks in a MNG datastream. If a "palette_name" is repeated, the previous palette having the same "palette_name" is replaced. It is not permitted, at the MNG top level, to redefine a palette after the "SAVE" chunk with the same "palette_name" as one that appears ahead of the "SAVE" chunk. It is permitted, however, to define and redefine other palettes with other "palette_name" fields. A single empty "sPLT" chunk can be used to nullify all "sPLT" chunks that have been previously defined in the MNG top level, except for those that appeared ahead of the "SAVE" chunk, when the "SAVE" chunk has been read.

  When a decoder needs to chose between a suggested palette defined at the MNG level and a suggested palette defined in the PNG datastream (either with the "sPLT" chunk, or with the "PLTE/hIST" chunks for grayscale or truecolor images), it should give preference to the palette from the MNG level, to avoid spurious frame-to-frame color changes.

  MNG editors that write PNG datastreams should ignore the "sPLT" and "pHYs" data from the MNG level and simply copy any "sPLT" and "pHYs" chunks appearing within the PNG datastreams.

5 The Delta-PNG format

A Delta-PNG datastream describes a single image, by giving the changes from a previous PNG (Portable Network Graphics) or another Delta-PNG image. The Delta-PNG format will be extended at some later date to include a PNP (Portable Network Photo) datastream.

No provision is made in this specification for storing a Delta-PNG datastream as a standalone file. A Delta-PNG datastream will normally be found as a component of a MNG datastream. Applications that need to store a Delta-PNG datastream separately should use a different file signature and filename extension, or they can wrap it in a MNG datastream consisting of the MNG signature, the "MHDR" chunk, a "BASI" chunk with the appropriate dimensions and an "IEND" chunk, the Delta-PNG datastream, and the "MEND" chunk.

The decoder must have available a parent (decoded) object from which the original chunk data is known. The parent object can be the result of decoding a PNG, another Delta-PNG datastream, or it could have been generated by a PNG-like datastream introduced by a "BASI" chunk.

The child image is always of the same basic type (at present only PNG is defined) as the parent object. The child is always a viewable image even if the parent is not.

The decoder must not have modified the pixel data in the parent object by applying output transformations such as "gAMA" or "cHRM", or by compositing the image against a background. Instead, the decoder must make available to the Delta-PNG decoder the unmodified pixel data along with the values for the "gAMA", "cHRM", and any other recognized chunks from the parent object datastream.

A Delta-PNG datastream consists of a "DHDR" and "IEND" enclosing other optional chunks (if there are no other chunks, the decoder simply copies the parent image, and displays it if its "do_not_show=0").

Chunk structure (length, name, CRC) and the chunk-naming system are identical to those defined in the PNG specification. Definitions of "compression_type", "filter_type", and "interlace_type" are also the same as defined in the PNG specification.

5.1 Delta-PNG critical chunks

This section describes critical Delta-PNG chunks. MNG-compliant decoders must recognize and process them.

5.1.1 DHDR Delta-PNG datastream header

The "DHDR" chunk introduces a Delta-PNG datastream. Subsequent chunks, through the next "IEND" chunk, are interpreted according to the Delta-PNG format.

The "DHDR" chunk can contain 4, 12, or 20 bytes:

```
2 bytes: object_id (nonzero unsigned integer).
         Identifies the parent object from which changes
         will be made.  This is also the object_id
         of the child image, which can be used as the
         parent image for a subsequent Delta-PNG.

1  byte: image_type.

       0: Image type is unspecified.  An IHDR or IPNG
          chunk must be present.

       1: Image type is PNG.  IHDR and IPNG can be
          omitted under certain conditions.

1  byte: delta_type.

       0: Entire image replacement.

       1: Block pixel addition, by samples, modulo
          2^bit_depth.

       2: Block alpha addition, by samples, modulo
          2^bit_depth.  Regardless of the color
          type of the parent image, the IDAT data
          are written as a grayscale image (color
          type 0) but the decoded samples are used
          as deltas to the alpha samples in the
          parent image.  The parent image must have
          (or be promoted to via the PROM chunk)
          color type 4 or color type 6.

       3: Block pixel replacement.

       4: Block alpha replacement.

       5: No change to pixel data.

4 bytes: block_width (unsigned integer).  Omit when
         delta_type=5.

4 bytes: block_height (unsigned integer).  Omit when
         delta_type=5.

4 bytes: block_x_location (unsigned integer),
         measured in pixels from the left edge of
         the parent object.  Omit when delta_type=0
         or when delta_type=5.
```

```
4 bytes: block_y_location (unsigned integer),
         measured in pixels from the top edge of
         the parent object.  Omit when delta_type=0
         or when delta_type=5.
```

The "image" must identify an existing object, and the object must be a "concrete" object, i.e. it must have the property "concrete_flag=1".

The image type, whether given explicitly as 1 or implied by the presence of an "IHDR" or "IPNG" chunk, must be the same as that of the parent object.

When "delta_type=0", the width and height of the child image are given by the block_width and block_height fields.

For all other values of "delta_type", the width and height of the child image are inherited from the parent object.

When "delta_type=1, 2, 3, or 4", the "block_width" and "block_height" fields give the size of the block of pixels to be modified or replaced, and "block_x_location" and "block_y_location" give its location with respect to the top left corner of the parent object. The block must fall entirely within the parent object.

Entire image replacement

When "delta_type=0" in the "DHDR" chunk, the pixel data in the "IDAT" chunks represent a completely new image, with dimensions given by the "block_width" and "block_height" fields of the "DHDR" chunk. Data from chunks other than "IDAT" can be inherited from the parent object.

Block pixel addition

When "delta_type=1" in the "DHDR" chunk, the pixel data in the "IDAT" chunks represent deltas from the pixel data in a parent object known to the decoder.

The compression method, filter method, and interlace method need not be the same as those of the parent object.

The "IDAT" chunk data contains a filtered and perhaps interlaced set of delta pixel samples. The delta samples are presented in the order specified by "interlace method", filtered according to the "filter method" and compressed according to the "compression method" given in the "IHDR" chunk. The actual pixel values are calculated using the method defined in the "delta_type" field of the "DHDR" chunk. Only the pixels in the block defined by the block location and dimensions given in the "DHDR" chunk are changed. The size of the "IDAT" data must correspond exactly to this rectangle.

An encoder calculates the new sample values from the samples in the parent object and those in the child image by subtracting the parent object samples from the child image samples, modulo 2^sample_bit_depth. When decoding the "IDAT" chunk, the child image bytes are obtained by adding the delta bytes to the parent object bytes, modulo 2^sample_bit_depth. This is similar in operation to the PNG SUB filter, except that it works by samples instead of by bytes.

When "color_type=3", the deltas are differences between index values, not between color samples.

Block alpha addition

When "delta_type=2" in the "DHDR" chunk, the pixel data in the "IDAT" chunks represent deltas from the alpha data in a parent object known to the decoder. The color samples are not changed, and the updated alpha samples are calculated in the same manner as the updated pixel samples are calculated when "delta_type=1".

The "bit_depth" of the data must match that of the parent object, and "color type" is 0 (grayscale), regardless of the "color_type" of the parent object. The parent object must have an alpha channel or must have been promoted to a type that has an alpha channel. The compression method, filter method, and interlace method need not be the same.

Block pixel replacement

When "delta_type=3" in the "DHDR" chunk, the pixel data in the "IDAT" chunks represent replacement values for the pixel samples in the rectangle given by the block location and dimension fields in the "DHDR" chunk.

The "bit_depth" and "color_type" of the data must match that of the parent object. The compression method, filter method, and interlace method need not be the same.

Block alpha replacement

When "delta_type=4" in the "DHDR" chunk, the pixel data in the "IDAT" chunks represent replacement values of the alpha samples in the rectangle given by the block location and dimension fields in the "DHDR" chunk. The "bit_depth" of the data must match that of the parent object, and "color type" is 0 (grayscale), regardless of the "color_type" of the parent object. The parent object must have an alpha channel or must have been promoted to a type that has an alpha channel. The compression method, filter method, and interlace method need not be the same.

No change to pixel data

When "delta_type=5" in the "DHDR" chunk, there is no change to the pixel data, and it is an error for "IDAT" to appear.

5.1.2 IEND End of Delta-PNG datastream

End of Delta-PNG datastream. A "IEND" chunk must be present for each "DHDR" chunk in a MNG datastream.

The "IEND" chunk is empty.

5.1.3 PROM Promotion of parent object

This chunk is used to "promote" a parent object to a higher bit depth or to add an alpha channel, before making changes to it.

```
1 byte: new color_type.
1 byte: new bit_depth.
1 byte: fill_method
     0: left-bit-replication
     1: zero fill
```

When a decoder encounters the "PROM" chunk, it must promote the pixel data. The cases are:

G -> GA (color_type 0 -> 4)

Don't change the gray values. Set all the alpha values to fully opaque, except for pixels marked transparent by cheap transparency–set their alpha values to fully transparent. Discard the cheap transparency information (the PNG "tRNS" chunk data).

RGB -> RBGA (color_type 2 -> 6)

Don't change the RGB values. Convert the "tRNS" chunk data to alpha values as in the G -> GA promotion.

G -> RGB (color_type 0 -> 2)

Set R, G, and B equal to the gray value. Apply the same operation to the cheap transparency data (if any).

GA -> RGBA (color_type 4 -> 6)

Set R, G, and B equal to the gray value. Don't change the alpha values.

G -> RGBA (color_type 0 -> 6)

Set R, G, and B equal to the gray value. Handle transparency as in the G -> GA promotion.

indexed -> RGB (color_type 3 -> 2)

Set R, G, and B according to the palette entry corresponding to the index. Discard the cheap transparency information (if any).

indexed -> RGBA (color_type 3 -> 6)

Set R, G, and B as in indexed -> RGB. Set the alpha value according to the cheap transparency information (if any). Discard the cheap transparency information.

If the sample depth has been changed, the sample values must be widened. The decoder must use left-bit-replication or zero-fill according to the specified "fill_method" to fill the additional bits of each sample. If cheap transparency information is present in a grayscale or truecolor object, its sample values must also be widened in the same manner. If the "color_type" has been promoted from indexed, the original bit depth is always considered to be 8. See the PNG specification [PNG] for further information on these filling methods.

If the basis object contains data from the PNG "bKGD" chunk, this data must be promoted as well. If a grayscale object is being promoted to a truecolor object, the background RGB samples are set equal to the

grayscale background sample. If the bit depth has been changed, the background samples are widened in accordance with the specified "fill_method".

If the basis object contains data from the PNG "sBIT" chunk, this data must also be promoted. If a grayscale object is being promoted to a truecolor object, the new RGB bytes are set equal to the grayscale byte. When an alpha channel is added, the alpha byte is set equal to the sample depth of the basis image. If the sample depth has been changed, the "sBIT" bytes do not change.

The "PROM" chunk is not permitted to "demote" a parent object to an object with a lesser bit depth or from one with an alpha channel to one without an alpha channel.

The "PROM" chunk must appear ahead of the "IHDR" chunk, if "IHDR" is present, and ahead of any chunks that would have followed "IHDR", if "IHDR" is omitted.

5.1.4 IHDR/IPNG, PNG chunks, IEND

Inside a Delta-PNG datastream, the "IHDR" chunk introduces an incomplete PNG (Portable Network Graphics) datastream. The parent object must be a PNG or PNG-based Delta-PNG. The datastream can be introduced by a complete PNG "IHDR" chunk or by an "IPNG" chunk, which is empty.

IHDR

If the "IHDR" chunk is present, its "width", "height", "bit_depth", and "color_type" fields are ignored. The values for these parameters are inherited from the parent object or from the "PROM" chunk.

The "compression_method", "interlace_type", and "filter_type" fields, if different from those of the parent object, are used in decoding any subsequent "IDAT" chunks, and the new values will be inherited by any subsequent image that uses this object as its parent.

See the PNG specification for the format of the PNG chunks. The PNG datastream must contain at least "IHDR" and "IEND" (whether actually present in the datastream or omitted and included by implication, as described below) but can inherit other chunk data from the parent object. Except for IDAT, any chunks appearing between "IHDR" and "IEND" are always treated as replacements or additions and not as deltas.

IPNG Incomplete PNG

The "IPNG" chunk is empty.

The "IPNG" chunk can be used instead of the "IHDR" chunk if the "IHDR" chunk is not needed for resetting the value of "compression_method", "filter_type", or "interlace_type". The purpose of this chunk is to identify the beginning of the PNG datastream, so decoders can start interpreting PNG chunks instead of Delta-PNG chunks. The decoder must treat this datastream as though the "IHDR" chunk were present in the location occupied by the "IPNG" chunk.

The "IHDR" chunk can also be omitted when "image_type=1" and the PNG stream begins with either a "PLTE" chunk or an "IDAT" chunk. In this case, no "IPNG" chunk is required, either. The

decoder must treat this datastream as though the "IHDR" chunk were present, immediately preceding the first PNG chunk. If the first PNG chunk is neither a "PLTE" chunk nor an "IDAT" chunk, then either the "IPNG" or "IHDR" must be present to introduce the PNG datastream.

PLTE and tRNS

If the "PLTE" chunk is present, it need not have the same length as that inherited from the parent object, but it must contain the complete palette needed in the child image. If it is shorter than the palette of the parent object, decoders can discard the remaining entries and the child image must not refer to them. Decoders can also truncate any "tRNS" data inherited from an indexed-color parent object. If the new palette is longer than the parent palette, and a new "tRNS" chunk is not present in an indexed-color image, the "tRNS" data must be extended with opaque entries.

When processing the "tRNS" chunk, if "color_type=3" and "PLTE" is not supplied, then the number of allowable entries is determined from the number of "PLTE" entries in the parent object. A "tRNS" chunk appearing in a Delta-PNG datastream is always treated as a complete replacement for the "tRNS" chunk data in the parent object. All entries beyond those actually supplied are overwritten with the "opaque" value (255).

IPLT Incomplete palette

If it is desired to only overwrite palette entries without truncating the resulting palette, the IPLT chunk can be used. This might be useful for palette-animation applications. Its format is identical to that of the "PLTE" chunk. If it has a length "n", it overwrites the first "n/3" entries, but does not affect the palette length or the contents and validity of the remaining entries, nor does it affect the "tRNS" chunk data.

gAMA, cHRM, sRGB Color encoding chunks

A "gAMA", "cHRM", "sRGB" or similar chunk existing in the parent object would not affect the pixel data inherited by this Delta-PNG datastream because they are not used in decoding the pixel data. Applications are responsible for ensuring that the pixel values that are inherited from the parent object are the raw pixel data that existed prior to any transformations that were applied while displaying the parent image.

oFFs and pHYs

MNG viewers must ignore "oFFs" and "pHYs" chunks that appear inside a PNG stream, when "framing_mode=2, 3, or 5" from the MNG "FRAM" chunk. When "framing_mode=1 or 4" and when the "FRAM" chunk is not present, viewers must treat these chunks in the same manner as they would treat them in single-image PNG files. MNG editors are expected to treat them as unknown chunks and handle them as described in Paragraph 5.1.7, below.

Chunk ordering requirements

The PNG specification places ordering requirements on many chunks with respect to the "PLTE" and "IDAT" chunks. If neither of these two chunks is present, and the "ORDR" chunk is not present, known chunks (always including all standard chunks described in the PNG specification) are considered to

have appeared in their proper order with respect to the critical chunks. Unknown chunks are ordered as described in Paragraph 5.1.7, below.

5.1.5 DROP Drop chunks

All chunks in the parent object with the specified name are inhibited from being copied into the child image.

```
4 bytes: Chunk name (ASCII text)
etc.
```

If multiple names appear in the "DROP" chunk, it is shorthand for multiple "DROP" chunks.

5.1.6 DBYK Drop chunks by keyword

```
4 bytes: Chunk name (ASCII text)

1  byte: Polarity (unsigned integer)
      0: only
      1: all-but

Keywords (null-separated Latin-1 text strings)
```

The chunk name must be the name of a chunk that begins with a null-terminated text string. Some parent object chunks with the specified chunk name are inhibited from being copied into the child image. If polarity is <only> then any parent chunk whose keyword appears in the keywords list is inhibited. If polarity is <all-but> then any parent object chunk whose keyword does not appear in the keywords list is inhibited.

Use caution when printing or displaying keywords (Refer to Security considerations, Chapter 14, below).

5.1.7 ORDR Ordering restrictions

The "ORDR" chunk informs the applier of the Delta-PNG of the ordering restrictions for chunks. It contains one or more 5-byte sequences:

```
4 bytes: Chunk name
1 byte:  Order type
     0: anywhere
     1: after IDAT
     2: before IDAT
     3: before IDAT, but not before PLTE
     4: before IDAT, but not after PLTE
etc.
```

Critical chunk names must not appear in the "ORDR" chunk. The applier needs to know everything about them anyway.

If a chunk name appears in the "ORDR" chunk, it is a promise that any chunk of that name appearing in the parent object which is not inhibited by "DROP/DBYK" will not be broken by this Delta-PNG, and therefore the applier must copy it into the child image at a location compatible with its ordering restrictions.

If any ancillary chunk appears in the parent object, and it is not inhibited, and its name does not appear in the "ORDR" chunk, then the applier should copy it into the child only if it knows the chunk well enough to be sure that it is consistent with the changes made by the Delta-PNG, and knows where it can be placed in the child. Those conditions are always true of safe-to-copy chunks.

If any critical chunk defined in neither this specification nor the PNG specification appears in the parent object or in the Delta-PNG, it is a fatal error unless the applier knows how to handle it. The specification of the critical chunk can include provisions for this scenario.

6 Chunk copying rules

The chunk copying rules for MNG are the same as those in PNG, except that a MNG editor is not permitted to move unknown chunks across any of the following chunks:

- "SAVE"
- "SEEK"
- "IHDR"
- "IEND"
- "DHDR"
- "BASI"
- "PAST"
- "SHOW"

The copy-safe status of an unknown chunk is determined from the chunk name, just as in PNG. If bit 5 of the first byte of the name is 0 (Normally corresponding to an uppercase ASCII letter), the unknown chunk is critical and cannot be processed or copied. If it is 1 (usually corresponding to a lowercase ASCII letter), the unknown chunk is ancillary and its copy-safe status is determined by bit 5 of the fourth byte of the name, 0 meaning copy-unsafe and 1 meaning copy-safe.

If an editor makes changes to the MNG datastream that render unknown chunks unsafe-to-copy, this does not affect the copy-safe status of any chunks beyond the next "SEEK" chunk or prior to the previous one. However, if it makes such changes prior the the "SAVE" chunk, this affects the copy-safe status of all top-level unknown chunks in the entire MNG datastream.

As in PNG, unsafe-to-copy ancillary chunks in the top-level MNG datastream can have ordering rules only with respect to critical chunks. Safe-to-copy ancillary chunks in the top-level MNG stream can have ordering rules only with respect to the "SAVE", "SEEK", "SHOW", and "PAST" chunks, "IHDR-IEND", "DHDR-IEND", and "BASI-IEND" sequences, or with respect to any other critical "header-end" sequence that might be defined in the future that could contain "IDAT" or similar chunks.

The copying rules for unknown chunks inside "IHDR-IEND", "BASI-IEND", and "DHDR-IEND" sequences is governed by the PNG specification, and any changes inside such sequences have no effect on top-level chunks.

The copy-safe status of chunks inside a "DHDR-IEND" sequence depends on the copy-safe status of its parent object.

7 Minimum requirements for MNG-compliant viewers

[To be written]

8 Recommendations for encoders

8.1 Embedded images in LOOPs

Embedded images should not be enclosed in loops unless absolutely necessary. It is better to store them ahead of time and then use "SHOW" chunks inside the loops. Otherwise, decoders will be forced to repeatedly decode them. See Examples 2, 8, 11, and 12 in Chapter 15, below.

8.2 Including optional index in SAVE chunk

Authors of MNG files that are intended for transmission over a network should consider whether it is more economical for the client to rebuild the index from scratch than it is to transmit it. Web pages that are likely to be downloaded over slow lines, and whose clients are unlikely to use the index anyway, generally should have empty "SAVE" chunks. No information is lost by deleting the index, because the MNG datastream contains all of the information needed to build the index. If an application does build an index, and the file is going to be kept as a local file, the application should replace the empty "SAVE" chunk with one containing the index. See Paragraph 4.1.3, above.

9 Recommendations for decoders

9.1 ENDL without matching LOOP

If a decoder reads an "ENDL" chunk for which the matching "LOOP" chunk is missing, or has been skipped for some reason, any active loops with a higher "nest_level" should be terminated, and processing can resume after the next "SEEK" chunk. See above.

9.2 Note on compositing

The PNG specification gives a good explanation of how to composite a partially transparent image over an opaque image, but things get more complicated when both images are partially transparent.

Pixels in PNG images are represented using gamma-encoded RGB (or gray) samples along with a linear alpha value. Alpha processing can only be performed on linear samples. This chapter assumes that R, G, B, and A values have all been converted to real numbers in the range [0..1], and that any gamma encoding has been undone.

For a top pixel {Rt,Gt,Bt,At} and a bottom pixel {Rb,Gb,Bb,Ab}, the composite pixel {Rc,Gc,Bc,Ac} is given by:

```
Ac = 1 - (1 - At)(1 - Ab)
if (Ac != 0) then
  s = At / Ac
  t = (1 - At) Ab / Ac
else
  s = 0.0
  t = 1.0
endif
Rc = s Rt + t Rb
Gc = s Gt + t Gb
Bc = s Bt + t Bb
```

When the bottom pixel is fully opaque (Ab = 1.0), the function reduces to:

```
Ac = 1
Rc = At Rt + (1 - At) Rb
Gc = At Gt + (1 - At) Gb
Bc = At Bt + (1 - At) Bb
```

When the bottom pixel is not fully opaque, the function is much simpler if premultiplied alpha is used. A pixel that uses non-premultiplied alpha can be converted to premultiplied alpha by multiplying R, G, and B by A.

For a premultiplied top pixel {Rt,Gt,Bt,At} and a premultiplied bottom pixel {Rb,Gb,Bb,Ab}, the premultiplied composite pixel {Rc,Gc,Bc,Ac} is given by:

```
Ac = 1 - (1 - At)(1 - Ab)
Rc = Rt + (1 - At) Rb
Gc = Gt + (1 - At) Gb
Bc = Bt + (1 - At) Bb
```

As mentioned in the PNG specification, the equations become much simpler when all the alpha values are integers, and the RGB samples need not be linear in that case.

9.3 Retaining object data

The decoder must retain information about each object (except for objects with "object_id=0") for possible redisplay with the "SHOW" chunk or for possible use as the parent object for a subsequent Delta-PNG datastream.

The following information must be retained, for each nonzero "object" that is defined and not subsequently discarded:

- The object attribute set (potential visibility, location, clipping boundary data from the "DEFI", "MOVE", "CLIP", and "SHOW" chunks, and pointer to an object buffer).
- The pixel data and the values associated with other recognized PNG chunks such as "PLTE" and "gAMA", subject to the chunk copying rules and the "DROP/DBYK" chunks. If the object is "abstract", the data can be stored in any convenient form. If it is "concrete", it must be stored in an object buffer in a manner that would permit the complete restoration of the original PNG file or its equivalent.
- The most recent values of "target_x" and "target_y", if the object was the destination of a "PAST" chunk.

When the encoder knows that data in the object buffer will not be needed by subsequent frames, it can make life easier for decoders by using "object_id=0" or by using the "DISC" or the "SEEK" chunk. Abstract images rather than concrete objects should be used if the encoder knows that the data will not later be used as the parent object for a Delta-PNG.

9.4 Decoder handling of fatal errors

When a fatal error is encountered, such as a bad CRC or an unknown critical MNG chunk, MNG viewers should attempt to recover gracefully by abandoning processing of the segment and searching for a "SEEK" chunk. If errors occur before the "SAVE" chunk is reached, the viewer should probably just abandon the MNG datastream.

When an error occurs within a image datastream, such as an unknown critical PNG chunk or a missing parent object where one was required, only that image should be abandoned and the associated "image" should be discarded. If a bad CRC is found, indicating a corrupted datastream, the entire segment should be abandoned, as above.

MNG editors, on the other hand, should be more strict and reject any datastream with errors unless the user intervenes.

9.5 Decoder handling of interlaced images

Decoders are required to be able to interpret datastreams that contain interlaced PNG images, but are only required to display the completed frames; they are not required to display the images as they evolve. Viewers that are decoding datastreams coming in over a slow communication link might want to do that, but MNG authors should not assume that the frames will be displayed in other than their final form.

9.6 Decoder handling of palettes

When a "PLTE" chunk is received, it only affects the display of the PNG or Delta-PNG datastream that includes it, and any subsequent Delta-PNG datastreams that depend on it.

If "PLTE" is present in a Delta-PNG datastream, the new palette is used in displaying the image defined by the Delta-PNG; if no "IDAT" chunk is present and the image type is PNG indexed-color, then the resulting image is displayed using the old pixel samples as indices into the new palette, which provides a "palette animation" capability.

If a frame contains two or more images, the "PLTE" chunk in one image does not affect the display of the other, unless one image is a Delta-PNG without a "PLTE" chunk, that has been declared by the "DHDR" "image" field to depend on the other.

A composite frame consisting only of indexed-color images should not be assumed to contain 256 or fewer colors, since the individual palettes do not necessarily contain the same set of colors. Encoders can supply a top-level "sPLT" chunk with a reduced global palette, to help decoders build an appropriate palette when necessary.

9.7 Behavior of single-frame viewers

Viewers that can only display a single frame must display the first frame that they encounter. It is strongly recommended that such viewers understand the "fPRI" chunk Paragraph 4.4.2, above, which will enable them to find and display the best representative frame, if the encoder has identified one.

9.8 Clipping

MNG provides four types of clipping, in addition to any clipping that might be required due to the physical limitations of the display device.

frame_width and frame_height

The "frame_width" and "frame_height" are defined in the "MHDR" chunk and cannot be changed.

Decoders can use these parameters to establish the size of a window in which to display the MNG frames. When the "frame_width" or "frame_height" exceeds the physical dimensions of the display hardware, the contents of the area outside those dimensions is undefined. If a viewer chooses, it can create "scroll bars" or the like, to enable persons to pan and scroll to the offscreen portion of the frame. If this is done, then the viewer is responsible for maintaining and updating the offscreen portion of the frame.

In the case of a MNG datastream that consists of a PNG datastream, with the PNG signature, the "frame_width" and "frame_height" are defined by the "width" and "height" fields of the "IHDR" chunk.

frame clipping boundaries

The frame clipping boundaries are optionally defined in the "FRAM" chunk, and cannot be changed within a frame. Viewers must, prior to displaying each frame, clear the area within the frame clipping boundaries to the background color. Viewers must not change any pixels outside the framing boundaries; encoders must be able to rely on the fact that the part of the display that is outside the frame clipping boundaries (but inside the area defined by "frame_width" and "frame_height") will remain on the display from frame to frame without being explicitly redisplayed. See Example 8 below, which displays a large background image once, and then, in each frame, only redisplays the portion of the background surrounding the moving sprite.

image clipping boundaries

The frame clipping boundaries are defined in the "DEFI" and "CLIP" chunks. They are associated with individual objects, not with the frames, and they can be changed within a frame. They are useful for exposing only a portion of an image in a frame, to achieve effects such as scrolling, panning, or gradual exposure.

"PAST" clipping boundaries

The clipping performed in "PAST" gives a fourth type that has no dependencies on the other types, since the object "CLIP" data is ignored and the destination object defines its own boundaries.

10 Recommendations for editors

11 Editing datastreams with optional index

Editors must recreate or delete the optional "SAVE" chunk index whenever they make any change that affects the offsets of chunks following the portion of the datastream that is changed. If the changes do not involve the addition, deletion, or relocation of segments, frames, and images, then it is sufficient to zero out the offsets.

The "SAVE" chunk is not considered to be in any MNG segment, so changing it has no effect on the copy-safe status of unknown chunks in any other part of the MNG datastream.

When the "SAVE" chunk is expanded to include an index, all chunks that follow will have their offsets changed by an amount equal to the change in the length of the "SAVE" chunk's data segment, so the offset table will have to be adjusted accordingly. If a "SAVE" chunk is already present with zero offsets, the correct offsets can be written without adjustment.

12 Miscellaneous Topics

12.1 File name extension

On systems where file names customarily include an extension signifying file type, the extension ".mng" is recommended for MNG files. Lower case ".mng" is preferred if file names are case-sensitive.

12.2 Internet media type

When and if the MNG format becomes finalized, the MNG authors intend to register "video/mng" as the Internet Media Type for MNG [RFC-2045, RFC-2048]. At the date of this document, the media type registration process had not been started. It is recommended that implementations also recognize the interim media type "video/x-mng".

12.3 Uniform Resource Locator (URL)

[Explanation of the use of externally accessible SEEK, FRAM, and eXPI chunk names as anchors etc., as in SRC=file.mng#segment_name and SRC=file.mng?segment_name]

See [RFC-1738], Uniform Resource Locators (URL) and the W3C SMIL recommendation [SMIL].

13 References

[PNG]

Boutell, T., et. al., PNG (Portable Network Graphics Format Version 1.0), RFC 2083, <URL:ftp://ds.internic.net/rfc/rfc2083.txt> also available at <URL:ftp://swrinde.nde.swri.edu/pub/png/documents/>. This specification has also been published as a W3C Recommendation, which is available at <URL:http://www.w3.org/TR/REC-png.html>.

[PNG-EXT]

PNG Special-Purpose Public Chunks, <URL:ftp://swrinde.nde.swri.edu/pub/png/documents/>.

[RFC-2119]

Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", RFC 2119/BCP 14, Harvard University, March 1997.

[RFC-2045]

Freed, N., and N. Borenstein, "Multipurpose Internet Mail Extensions (MIME) Part One: Format of Internet Message Bodies", RFC 2045, Innosoft, First Virtual, November 1996. <URL:ftp://ds.internic.net/rfc/rfc2045.txt>

[RFC-2048]

Freed, N., Klensin, J., and J. Postel, "Multipurpose Internet Mail Extensions (MIME) Part Four: Registration Procedures", RFC 2048, Innosoft, MCI, USC/Information Sciences Institute, November 1996. <URL:ftp://ds.internic.net/rfc/rfc2048.txt>

[RFC-1738]

Berners-Lee, T., Masinter, L., McCahill, M., "Uniform Resource Locators (URL)", RFC 1738, CERN, Xerox Corporation, University of Minnesota, December 1994. <URL:ftp://ds.internic.net/rfc/rfc1738.txt>

[SMIL]

Hoschka, Philipp, "Synchronized Multimedia Integration Language (SMIL) 1.0 Specification", 15 June 1998, <URL: http:/www.w3.org/TR>

14 Security considerations

Security considerations are addressed in the PNG specification.

An infinite or just overly long loop could give the appearance of having locked up the machine, as could an unreasonably long interframe delay or a misplaced "sync_id" with a long "sync_timeout" value. Therefore a decoder should always provide a simple method for users to escape out of a loop or delay, either by canceling the MNG entirely or just proceeding on to the next "SEEK" chunk. (The "SEEK" chunk makes it safe for a viewer to resume processing after it encounters a corrupted portion of a MNG datastream.)

No known additional security concerns are raised by this format.

15 Appendix: Examples

We use the "#" character to denote commentary in these examples; such comments are not present in actual MNG datastreams.

15.1 Example 1: A single image

The simplest MNG datastream is a single-image PNG datastream. The simplest way to create a MNG from a PNG is:

```
copy file.png file.mng
```

The resulting MNG file looks like:

```
\211 P N G \r \n ^z \n  # PNG signature.
IHDR 720 468 8 0 0 0 0  # Width and height, etc.
IDAT ...
IEND
```

15.2 Example 2: Very simple movie

This example demonstrates a very simple movie, such as might result from directly converting an animated GIF that contains a simple series of full-frame images:

```
\212 M N G \r \n ^z \n  # MNG signature.
MHDR 256 300   # Width and height.
     30        # 30 ticks per second.

tERm 2 0 120 10   # When done, repeat from SAVE 10 times

FRAM 4 0 2 0 0 0 30 # set framing_mode=4 (because the
                    # images are opaque and we don't
                    # need to clear the display between
                    # frames) and the frame_duration to
                    # 1 second.

DEFI 1 IHDR ...  IDAT ...  IEND # Eight PNG datastreams
DEFI 2 IHDR ...  IDAT ...  IEND # are read and stored as
DEFI 3 IHDR ...  IDAT ...  IEND # abstract images, and
DEFI 4 IHDR ...  IDAT ...  IEND # are displayed as they
DEFI 5 IHDR ...  IDAT ...  IEND # are read.
DEFI 6 IHDR ...  IDAT ...  IEND
DEFI 7 IHDR ...  IDAT ...  IEND
DEFI 8 IHDR ...  IDAT ...  IEND
```

```
SAVE
SHOW 1 8
MEND
```

15.3 Example 3: Simple slideshow

```
\212 M N G \r \n ^z \n  # MNG signature.
MHDR 720 468   # Width and height.
     1         # 1 tick per second.
FRAM 4 0 2 2 0  2 0 600 0 # Set frame_duration to 0
  # sync_timeout to 600 sec and sync_id list to {0}.
SAVE
SEEK "Briefing to the Workforce"
IHDR ...  IDAT ...  IEND  # DEFI 0, visible, abstract
SEEK "Outline"            # is implied.
IHDR ...  IDAT ...  IEND
SEEK "Our Vision"       IHDR ...  IDAT ...  IEND
SEEK "Our Mission"      IHDR ...  IDAT ...  IEND
SEEK "Downsizing Plans" IHDR ...  IDAT ...  IEND
MEND
```

15.4 Example 4: A more storage-efficient slideshow

This slideshow gives exactly the same output as Example 3, but the storage in the datastream is more efficient (the IDAT chunks will be smaller) while the memory requirements in the decoder are larger. Image ID 1 is used to store the ornate logos and frame design that appear on every slide. The DHDR-IEND streams only contain deltas due to the text and other information that is unique to each slide.

```
\212 M N G \r \n ^z \n  # MNG signature.
MHDR 720 468   # Width and height.
     1         # 1 tick per second.
DEFI 1 1 1     # Define image 1, invisible, concrete.
IHDR ...  IDAT ...  IEND
FRAM  4 0  2 2 0 2  0 600 0 # set frame_duration to 0
  # sync_timeout to 600 sec and sync_id list to {0}.
SAVE
SEEK "Briefing to the Workforce"
CLON 1 2 DHDR 2 ...  IDAT ...  IEND SHOW 2
SEEK "Outline"
CLON 1 2 DHDR 2 ...  IDAT ...  IEND SHOW 2
SEEK "Our Vision"
CLON 1 2 DHDR 2 ...  IDAT ...  IEND SHOW 2
SEEK "Our Mission"
CLON 1 2 DHDR 2 ...  IDAT ...  IEND SHOW 2
SEEK "Downsizing Plans"
CLON 1 2 DHDR 2 ...  IDAT ...  IEND SHOW 2
MEND
```

15.5 Example 5: Simple movie

This movie is still fairly simple, but it capitalizes on frame-to-frame similarities by use of Delta-PNG datastreams, and also demonstrates the use of the "fPRI" chunk.

```
\212 M N G \r \n ^z \n  # MNG signature.
MHDR 720 468   # Width and height.
     30        # 30 ticks per second.
tEXtTitle\0Sample Movie
fPRI 0 128     # Default frame priority is "medium".
FRAM 1 0  2 0 0 0  3 # Set frame_duration to 1/10 sec.
DEFI 1 0 1       # Set default image to 1 (concrete).
SAVE
SEEK "start"

IHDR 720 468 8 2 0 0 0   # DEFI 1 is implied.
IDAT ...
IEND

DHDR 1 1 1 20 30 100 220   # A PNG-delta frame.
IDAT ...       # The IDAT gives the 20x30 block
IEND           # of deltas.

DHDR 1 1 1 20 30 102 222   # Another PNG-delta frame.
IDAT ...       # This time the deltas are in a 20 x 30
IEND           # block at a slightly different location.

SEEK "frame 3"  # Ok to restart here because a
                # complete PNG frame follows.
fPRI 0 255    # This is the representative frame that
IHDR 720 468 ...# will be displayed by single-frame
IDAT ...        # viewers.
IEND
fPRI 0 128      # Return to medium frame priority.

DHDR 1 1 1 720 468 0 0     # Another PNG-delta frame.
IDAT ...   # The entire 720x468 rectangle changes
IEND       # this time.

SEEK "end"
MEND            # End of MNG datastream.
```

15.6 Example 6: Single composite frame

Here is an example single-composite-frame MNG, with thumbnails, which takes a grayscale image and draws it side-by-side with a false-color version of the same image:

```
\212 M N G \r \n ^z \n # MNG signature.
MHDR 1024 512 1 # Width, height, ticklength.
BACK 16448 16448 52800 1 # Must use sky blue background.

DEFI 1 1     # Define invisible abstract thumbnail image.
IHDR 64 64 4 3 0 0 0
IDAT
IEND
eXPI 1 "thumbnail 1"
DEFI 1 1       # Also define a larger thumbnail.
IHDR 96 96 4 3 0 0 0
IDAT
IEND
eXPI 1 "thumbnail 2"
DISC           # Discard the thumbnail image.

FRAM 2 "Two views of the data"
DEFI 1 0 1 6 6     # Define first (bottom) image.
IHDR 500 500 16 0 .. # A 16-bit graylevel image.
gAMA 50000
IDAT ...
IEND                # End of image.

CLON 1 2 0 0 1 0 518 6 # Make a full "concrete" clone.
DHDR 2 1 5          #  Modify it (no change to pixels).
ORDR faLT 2         #  Establish chunk placement.
gAMA 100000   # Gamma value is 100000 (gamma=1.0).
tEXtComment\0The faLT chunk is described in ftp://swrinde....
faLT ...            # Apply pseudocolor to parent image.
IEND                # End of image.
DEFI 3 0 0 900 400   # Overlay near lower right-hand corner.
IHDR 101 101 2 3 ...
gAMA 50000          # We need a new gAMA because
PLTE ...            # this is not a Delta-PNG datastream.
tRNS ...            # It is transparent (maybe a logo).
IDAT ...            # Note that the color type can differ
IDAT ...            #    from that of the other images.
IEND                # End of image.

MEND                # End of MNG datastream.
```

15.7 Example 7: Movie with sprites

Here is another movie, illustrating the use of Delta-PNG datastreams as sprites

```
\212 M N G \r \n ^z \n  # MNG signature.
MHDR 512 512 30  # Start of MNG datastream.
FRAM 2 "frame 1" 0  2 0 0 0  3 # First frame
                 # sets frame_duration=3 ticks.
DEFI 1           # Define image 1 (abstract, LOCA 0 0).
IHDR 512 512 ... # It is a full-display PNG image.
etc              # Chunks according to PNG spec.
IEND             # SHOW 1 is implied by DEFI 1.
DEFI 2 0 1 300 200 # Define image 2, concrete.
IHDR 32 32 ...   # It is a small PNG.
gAMA 50000
IDAT ...
IEND
FRAM 0 "frame 2"   # Start new frame.
                 # New location for image 1 is still 0,0.
SHOW 1           # Display image 1 from previous frame.
MOVE 2 2 1 10 5  # New (delta) location for image 2.
SHOW 2           # Retrieve image 2 from previous frame,
CLON 2 3 0 0 1   # make a full clone of it as image 3.
     0 400 500   # Location for image 3.
DHDR 3 1 3 0 0 0 0      # Modify image 3.
tRNS ...         # Make it semitransparent.
IEND             # SHOW 3 is implied by CLON visibility.
FRAM 0 "frame 3"   # Next frame (repeat this FRAM-SHOW 1 3
                 #   sequence with different locations to
                 #   move the images around).
                 # New location for image 1 is still 0,0.
MOVE 2 2 1 10 5  # New (delta) location for image 2.
MOVE 3 3 1 5 -2  # New location for image 3.
SHOW 1 3         # Show images 1 through 3.
FRAM 0 "frame 4" #  Another frame.
etc.
FRAM 0 "frame 99"
etc.             # More frames.
MEND             # End of MNG datastream.
```

15.8 Example 8: Movie with an animated sprite

This movie illustres the use of several abstract images with show_mode=6 to describe an animated sprite, and the PAST chunk to turn it around. The sprite runs back and forth across the background ten times. The FRAM clipping boundaries restrict the screen updates to the small region that changes, with a little "wiggle room" to make sure the disturbed part of the background gets updated.

```
\212 M N G \r \n ^z \n  # MNG signature.
MHDR 512 512 30  # Start of MNG datastream.
FRAM 2 "frame 1" 0  2 0 0 0  3 # First frame.
DEFI 1 IHDR 512 512 ... # Background PNG image.
etc ... IEND     # Chunks according to PNG spec.

DEFI 10 1 0 x0 y0 # Static part of sprite.
IHDR 64 64 ...  IDAT ...  IEND
DEFI 11 1 0 x0 y1 # View 1 of animated part.
IHDR 64 32 ...  IDAT ...  IEND # (y1=y0+64)
DEFI 12 1 0 x0 y1 # View 2 of animated part.
IHDR 64 32 ...  IDAT ...  IEND
DEFI 13 1 0 x0 y1 # View 3 of animated part.
IHDR 64 32 ...  IDAT ...  IEND

FRAM 0  0  0 0 2 0  0 x0-dx x0+64+dx y0-dy y1+32+dy
LOOP 0 0 10
LOOP 1 0 150
FRAM 0 "left-to-right" 0 0 2 0 1 dx dx dy dy
MOVE 10 13 1 dx dy # Move animated icon {dx, dy}.
SHOW  1 SHOW 10    # Show background and static part.
SHOW 11 13 6       # Select the next view of the
ENDL 1             # animated part and show it.

FRAM SHOW 1
PAST 10  0 0 0  10  1 4  0 0 0  0 0 64 64
PAST 11  0 0 0  11  1 4  0 0 0  0 0 64 32
PAST 12  0 0 0  12  1 4  0 0 0  0 0 64 32
PAST 13  0 0 0  13  1 4  0 0 0  0 0 64 32
LOOP 1 0 150
FRAM 0 "right-to-left" 0 0 2 0 1 -dx -dx -dy -dy
MOVE 10 13 1 -dx -dy # Move animated icon {-dx, -dy}
SHOW  1 SHOW 10    # Show background and static part.
SHOW 11 13 6       # Select the next view of the
ENDL 1             # animated part and show it.
ENDL 0 FRAM
MEND
```

15.9 Example 9: "Fading in" a transparent image

The opaque parts of this image will "fade in" gradually. This example also illustrates the use of the "PROM", and "fPRI" chunks.

```
\212 M N G \r \n ^z \n # MNG signature.
MHDR 64 64 30     # Width, height, ticklength.
BACK 52800 52800 52800 # "Browser gray" default background.

FRAM 1 0  2 0 0 0  3 #  Set frame_duration=3 ticks.
DEFI 1 1 1  # Invisible and "concrete".
IHDR ...    # PNG header.
PLTE ...
tRNS 0      # Entries are zero for the transparent (0)
            # color and 255 for the nontransparent ones.
IDAT ...
IEND
fPRI 0 0    # Give the fade-in sequence a low priority.
CLON 1 2 1  # Make a working concrete copy of the image
            # that will be modified during the low-priority
            # part of the datastream.  It is a full clone.
DHDR 2 1 5  # No change to pixel data.
PROM 6 8 0  # Promote it to RGBA.
IEND
SHOW 2 2 3  # Make it visible but don't show it now.

LOOP 0 0 15
DHDR 2 1 2 64 64 0 0 # an image delta.
            # Delta-type is block alpha addition.
IDAT ...    # Grayscale IDAT with 0 in transparent pixels
IEND        # and 16 in opaque pixels.
SHOW 2
ENDL 0      # Nontransparent pixel alpha=15, 31, ... 240.

DISC 2      # Discard the working copy.
fPRI 0 255  # Give the final frame the highest value
FRAM 0 0  1 0 0 0  60 # Hold the last frame for at least
  # 60 ticks (2 sec).  Applications might show it longer..
SHOW 1      # This copy still has alpha=255 for the
            # opaque pixels and alpha=0 for the others.
MEND        # End of MNG.
```

15.10 Example 10: Storing three-dimensional images

In this example, we store a series of twenty-four 150 x 150 x 150 blocks of 8-bit voxels. Each block is stored as a composite frame with the first image being a PNG whose pixels represent the top layer of voxels, which is followed by 149 Delta-PNG images representing the rest of the layers of voxels. Only one "`image`" is defined, through which the parent image is passed along from PNG to Delta-PNG to Delta-PNG. This example also illustrates the use of unregistered ancillary chunks that describe the x, y, and z scales and pixel calibration.

```
\212 M N G \r \n ^z \n # MNG signature.
MHDR 150 150 1   # Width, height, ticklength.

tEXtTitle\0Weather modeling results
tEXtComment\0The xxSC, yySC, zzSC, and ttSC chunks
 in this file are written according to the proposed
 chunk specifications version 19970203 and Sci-Vis
 chunks specification version 19970203 available at
 ftp://swrinde.nde.swri.edu/pub/png-group/documents/
xxSC kch\0 [sig\0] kilometers\0 0\0 150
yySC kch\0 [sig\0] kilometers\0 0\0 150
zzSC kch\0 [sig\0] Height (kilometers)\0 0\0 15
ttSC kch\0 [sig\0] Time (hours)\0 0\0 24
pCAL kch\0 0 255 0 2 Degrees Celsius\0 0\0 45
DEFI 1 0 1       # all images will have image = 1
SAVE             # and be visible and "concrete"
SEEK
FRAM 2      # Initial composite image
IHDR 150 150 16  # Width, height, bit depth for top layer.
     0 0 0 0     # Color, comp, filter, interlace.
IDAT ...
IEND             # No DEFI chunk, so it is image 0.
DHDR 1 1 0       # Source=0, PNG, pixel subtraction,
     150 150 0 0 # Block is entire image.
IDAT ...     # IHDR is omitted; everything matches top.
IEND         # IEND is also omitted.
etc.         # Repeat DHDR through IEND 148 more times.
SEEK
FRAM         # End of first block.
etc.         # Repeat FRAM through SEEK 19 more times.
SEEK
MEND         # End of MNG.
```

15.11 Example 11: Tiling

Here is another composite frame, illustrating the use of the LOOP syntax to tile a large (1024 by 768) image area with a small (128 by 64) image.

```
\212 M N G \r \n ^z \n  # MNG signature.
MHDR 1024 768 1 # Start of MNG datastream.
FRAM 2
DEFI 1 1 0 0 -64 # Set up an offscreen "abstract" copy
IHDR 128 64 ... PLTE ... IDAT ... IEND  # of the tile.
LOOP 0 0 12   # Y loop -- make 12 rows of tiles.
MOVE 1 1 1 0 64 # Move the first copy down 64 rows.
SHOW 1        # Display it.
CLON 1 2 1    # Create a partial clone of the tile.
LOOP 1 0 7    # X loop - 7 additional columns.
MOVE 2 2 1 0 128 # Move it to the right 128 columns.
SHOW 2        # Use the second copy.
ENDL 1
ENDL 0
MEND
```

Here is a better approach, which creates a reusable tiled image by pasting the small image into the corner of a large blank image, and then repeatedly pasting the growing image back into itself.

```
\212 M N G \r \n ^z \n  # MNG signature.
MHDR 1024 768 1 # Start of MNG datastream.
DEFI 1 1 0 0 -64 # Set up an offscreen "abstract" copy
IHDR 128 64 ...  PLTE ... IDAT ... IEND  # of the tile.
DEFI 2        # The abstract, visible, viewable image to
BASI 1024 768 8 2 0 0 0 0 0 0 0 1 #  be tiled. Initially
IEND          # a all pixel sre zero.
PAST 2 0 0 0  # Destination and target location.
  # src mod orient  offset        clipping
     1   0    0     0   0   0   0 0  128 0  64
     2   0    0     0 128   0   0 0  256 0  64
     2   0    0     0 256   0   0 0  512 0  64
     2   0    0     0 512   0   0 0 1024 0  64
     2   0    0     0   0  64   0 0 1024 0 128
     2   0    0     0   0 128   0 0 1024 0 258
     2   0    0     0   0 256   0 0 1024 0 512
     2   0    0     0   0 512   0 0 1024 0 768
  #  End of PAST chunk data.
MEND
```

15.12 Example 12: Scrolling

Here is an example of scrolling a 3000-line-high image (perhaps an image of some text, but could be anything) through a 256-line-high window with an alpha-blended border.

```
\212 M N G \r \n ^z \n  # MNG signature.
MHDR 512 256 30   # Width and height on screen.
BACK 50000 50000 50000 0 #  advisory gray background
DEFI 1 1 0 0 256  # Define image 1 but don't display now.
                  # Initially it is offscreen, just
                  # below the 512 by 256 window.
PLTE ...          # text (or whatever) to be scrolled.
IDAT ...
IEND

DEFI 2
IHDR 512 256 8 6 ... # A PNG datastream containing some kind
PLTE ...             # of alpha-blended border that is
tRNS ...             # transparent in the center.
IDAT ...
IEND

LOOP 0 0 3256
MOVE 1 1 1 0 1 # Jack image 1 up one scanline, 3256 times.
           # It ends up just above the 512 by 256 window.
           # The border does not move.
FRAM 4  0  2 0 0 0  0 # Frame_duration = 0 ticks.
           # We use framing_mode=4 to avoid unnecessary
           # screen clearing between frames.
IHDR 512 3000 1 0 ... # A PNG datastream containing the
SHOW 1     # show first image and continue without delay
FRAM 4  0  2 0 0 0  1 # Frame_duration = 1 tick.
SHOW 2     # composite second image over first, wait 1 tick
ENDL 0

MEND
```

15.13 Example 13: Converting a GIF animation to MNG

Outline of a program to convert GIF animations to MNG format:

```
begin
    write "MHDR" and "BACK" chunks
    saved_images := 0
    frame_duration := 0
    first_frame := TRUE
    if(loops>1) "write tERm 2 0 0 loops" chunk
    for subimage in gif89a file do
       if(frame_duration != gif_duration) then
         frame_duration := gif_duration
         write "FRAM 2 0 2 2 0 2 0 frame_duration 0" chunk
         first_frame := FALSE
       else if(first_frame == TRUE)then
         write "FRAM 2" chunk
         first_frame := FALSE
       else
         write "FRAM" chunk
       endif
       if(x_loc == 0 AND y_loc == 0) then
          write "DEFI saved_images 1 1" chunk
       else
          write "DEFI saved_images 1 1 x_loc y_loc" chunk
       write "<image>"
       write "SHOW 0 saved_images" chunk
       if (gif_disposal_method == 0
          OR gif_disposal_method == 2) then
          /* (undefined or restore background) */
             write "DISC" chunk
             saved_images := 0
       else if (gif_disposal_method == 1) then
          /* (keep) */
          saved_images := saved_images + 1
       else if (gif_disposal_method == 3) then
          /* (restore previous) */
          write "DISC saved_images" chunk
       endif
    endfor
    write "FRAM" and "MEND" chunks
end
```

Where "<image>" represents a PNG or Delta-PNG containing a GIF frame converted to PNG format.

Caution: if you write such a program you might have to pay royalties in order to use it or to convey it to anyone else.

16 Credits

Contributors' names are presented in alphabetical order:

- Mark Adler, madler@alumni.caltech.edu
- Thomas Boutell, boutell@boutell.com
- John Bowler, jbowler@acm.org
- Christian Brunschen, cb@df.lth.se
- Glen Chapman, glenc@clark.net
- Adam M. Costello, amc@cs.berkeley.edu
- Lee Daniel Crocker, lee@piclab.com
- Peter da Silva, peter@starbase.neosoft.com
- Andreas Dilger, adilger@enel.ucalgary.ca
- Oliver Fromme, fromme@rz.tu-clausthal.de
- Jean-loup Gailly, gzip@prep.ai.mit.edu
- Chris Herborth, chrish@qnx.com
- Alex Jakulin, alex@hermes.si
- Neal Kettler, kettler@cs.colostate.edu
- 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
- Carl Morris, msftrncs@htcnet.com
- Owen Mortensen, ojm@csi.compuserve.com
- Josh M. Osborne, stripes@va.pubnix.com
- Keith S. Pickens, ksp@swri.edu
- Glenn Randers-Pehrson, randeg@alumni.rpi.edu
- Nancy M. Randers-Pehrson, gr0089@epfl2.epflbalto.org
- Greg Roelofs, newt@pobox.com
- Willem van Schaik, gwillem@ntuvax.ntu.ac.sg

- Guy Schalnat
- Paul Schmidt, pschmidt@photodex.com
- Smarasderagd, smar@reptiles.org
- Thomas R. Tanner, ttehtann@argonet.co.uk
- Guido Vollbeding, guivol@esc.de
- Tim Wegner, 71320.675@compuserve.com
- Alaric B. Williams, png@abwillms.demon.co.uk

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- Windows 3.1 is a trademark of Microsoft Corporation.
- X Window System is a trademark of the Massachusetts Institute of Technology.

Author's Address

Glenn Randers-Pehrson
611 Rivershore Court
Edgewood, MD 21040-3603

Phone: (410) 278-6554

EMail: randeg@alumni.rpi.edu

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