

libpng.txt - A description on how to use and modify libpng

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Chapter 1

I. Introduction

This file describes how to use and modify the PNG reference library (known as libpng) for your own use. There are five sections to this file: introduction, structures, reading, writing, and modification and configuration notes for various special platforms. In addition to this file, `example.c` is a good starting point for using the library, as it is heavily commented and should include everything most people will need. We assume that libpng is already installed; see the `INSTALL` file for instructions on how to install libpng.

For examples of libpng usage, see the files `"example.c"`, `"pngtest.c"`, and the files in the `"contrib"` directory, all of which are included in the libpng distribution.

Libpng was written as a companion to the PNG specification, as a way of reducing the amount of time and effort it takes to support the PNG file format in application programs.

The PNG specification (second edition), November 2003, is available as a W3C Recommendation and as an ISO Standard (ISO/IEC 15948:2003 (E)) at <http://www.w3.org/TR/2003/REC-PNG-20031110/>. The W3C and ISO documents have identical technical content.

The PNG-1.2 specification is available at <http://www.libpng.org/pub/png/documents/>. It is technically equivalent to the PNG specification (second edition) but has some additional material.

The PNG-1.0 specification is available as RFC 2083 <http://www.libpng.org/pub/png/documents/> and as a W3C Recommendation <http://www.w3.org/TR/REC.png.html>.

Some additional chunks are described in the special-purpose public chunks documents at <http://www.libpng.org/pub/png/documents/>.

Other information about PNG, and the latest version of libpng, can be found at the PNG home page, <http://www.libpng.org/pub/png/>.

Most users will not have to modify the library significantly; advanced users may want to modify it more. All attempts were made to make it as complete as possible, while keeping the code easy to understand. Currently, this library only supports C. Support for other languages is being considered.

Libpng has been designed to handle multiple sessions at one time, to be easily modifiable, to be portable to the vast majority of machines (ANSI, K&R, 16-, 32-, and 64-bit) available, and to be easy to use. The ultimate goal of libpng is to promote the acceptance of the PNG file format in whatever way possible. While there is still work to be done (see the `TODO` file), libpng should cover the majority of the needs of its users.

Libpng uses zlib for its compression and decompression of PNG files. Further information about zlib, and the latest version of zlib, can be found at the zlib home page, <<http://www.info-zip.org/pub/infozip/zlib/>>. The zlib compression utility is a general purpose utility that is useful for more than PNG files, and can be used without libpng. See the documentation delivered with zlib for more details. You can usually find the source files for the zlib utility wherever you find the libpng source files.

Libpng is thread safe, provided the threads are using different instances of the structures. Each thread should have its own `png_struct` and `png_info` instances, and thus its own image. Libpng does not protect itself against two threads using the same instance of a structure.

Chapter 2

II. Structures

There are two main structures that are important to libpng, `png_struct` and `png_info`. The first, `png_struct`, is an internal structure that will not, for the most part, be used by a user except as the first variable passed to every libpng function call.

The `png_info` structure is designed to provide information about the PNG file. At one time, the fields of `png_info` were intended to be directly accessible to the user. However, this tended to cause problems with applications using dynamically loaded libraries, and as a result a set of interface functions for `png_info` (the `png_get_*()` and `png_set_*()` functions) was developed. The fields of `png_info` are still available for older applications, but it is suggested that applications use the new interfaces if at all possible.

Applications that do make direct access to the members of `png_struct` (except for `png_ptr->jmpbuf`) must be recompiled whenever the library is updated, and applications that make direct access to the members of `png_info` must be recompiled if they were compiled or loaded with libpng version 1.0.6, in which the members were in a different order. In version 1.0.7, the members of the `png_info` structure reverted to the old order, as they were in versions 0.97c through 1.0.5. Starting with version 2.0.0, both structures are going to be hidden, and the contents of the structures will only be accessible through the `png_get/png_set` functions.

The `png.h` header file is an invaluable reference for programming with libpng. And while I'm on the topic, make sure you include the libpng header file:

```
#include <png.h>
```

Chapter 3

III. Reading

We'll now walk you through the possible functions to call when reading in a PNG file sequentially, briefly explaining the syntax and purpose of each one. See `example.c` and `png.h` for more detail. While progressive reading is covered in the next section, you will still need some of the functions discussed in this section to read a PNG file.

3.1 Setup

You will want to do the I/O initialization(*) before you get into libpng, so if it doesn't work, you don't have much to undo. Of course, you will also want to insure that you are, in fact, dealing with a PNG file. Libpng provides a simple check to see if a file is a PNG file. To use it, pass in the first 1 to 8 bytes of the file to the function `png_sig_cmp()`, and it will return 0 (false) if the bytes match the corresponding bytes of the PNG signature, or nonzero (true) otherwise. Of course, the more bytes you pass in, the greater the accuracy of the prediction.

If you are intending to keep the file pointer open for use in libpng, you must ensure you don't read more than 8 bytes from the beginning of the file, and you also have to make a call to `png_set_sig_bytes_read()` with the number of bytes you read from the beginning. Libpng will then only check the bytes (if any) that your program didn't read.

(*): If you are not using the standard I/O functions, you will need to replace them with custom functions. See the discussion under Customizing libpng.

```
FILE *fp = fopen(file_name, "rb");
if (!fp)
{
    return (ERROR);
}
fread(header, 1, number, fp);
is_png = !png_sig_cmp(header, 0, number);
if (!is_png)
{
    return (NOT_PNG);
}
```

Next, `png_struct` and `png_info` need to be allocated and initialized. In order to ensure that the size of these structures is correct even with a dynamically linked libpng, there are functions to initialize and allocate the structures. We also pass the

library version, optional pointers to error handling functions, and a pointer to a data struct for use by the error functions, if necessary (the pointer and functions can be NULL if the default error handlers are to be used). See the section on Changes to Libpng below regarding the old initialization functions. The structure allocation functions quietly return NULL if they fail to create the structure, so your application should check for that.

```
png_structp png_ptr = png_create_read_struct
(PNG_LIBPNG_VER_STRING, (png_voidp)user_error_ptr,
 user_error_fn, user_warning_fn);
if (!png_ptr)
    return (ERROR);

png_infop info_ptr = png_create_info_struct(png_ptr);
if (!info_ptr)
{
    png_destroy_read_struct(&png_ptr,
        (png_infopp)NULL, (png_infopp)NULL);
    return (ERROR);
}

png_infop end_info = png_create_info_struct(png_ptr);
if (!end_info)
{
    png_destroy_read_struct(&png_ptr, &info_ptr,
        (png_infopp)NULL);
    return (ERROR);
}
```

If you want to use your own memory allocation routines, define PNG_USER_MEM_SUPPORTED and use `png_create_read_struct_2()` instead of `png_create_read_struct()`:

```
png_structp png_ptr = png_create_read_struct_2
(PNG_LIBPNG_VER_STRING, (png_voidp)user_error_ptr,
 user_error_fn, user_warning_fn, (png_voidp)
 user_mem_ptr, user_malloc_fn, user_free_fn);
```

The error handling routines passed to `png_create_read_struct()` and the memory alloc/free routines passed to `png_create_struct_2()` are only necessary if you are not using the libpng supplied error handling and memory alloc/free functions.

When libpng encounters an error, it expects to `longjmp` back to your routine. Therefore, you will need to call `setjmp` and pass your `png_jmpbuf(png_ptr)`. If you read the file from different routines, you will need to update the `jmpbuf` field every time you enter a new routine that will call a `png_*()` function.

See your documentation of `setjmp/longjmp` for your compiler for more information on `setjmp/longjmp`. See the discussion on libpng error handling in the Customizing Libpng section below for more information on the libpng error handling. If an error occurs, and libpng `longjmp`'s back to your `setjmp`, you will want to call `png_destroy_read_struct()` to free any memory.

```
if (setjmp(png_jmpbuf(png_ptr)))
{
    png_destroy_read_struct(&png_ptr, &info_ptr,
        &end_info);
    fclose(fp);
    return (ERROR);
}
```

```
}
```

If you would rather avoid the complexity of `setjmp/longjmp` issues, you can compile libpng with `PNG_SETJMP_NOT_SUPPORTED`, in which case errors will result in a call to `PNG_ABORT()` which defaults to `abort()`.

Now you need to set up the input code. The default for libpng is to use the C function `fread()`. If you use this, you will need to pass a valid `FILE *` in the function `png_init_io()`. Be sure that the file is opened in binary mode. If you wish to handle reading data in another way, you need not call the `png_init_io()` function, but you must then implement the libpng I/O methods discussed in the Customizing Libpng section below.

```
png_init_io(png_ptr, fp);
```

If you had previously opened the file and read any of the signature from the beginning in order to see if this was a PNG file, you need to let libpng know that there are some bytes missing from the start of the file.

```
png_set_sig_bytes(png_ptr, number);
```

Setting up callback code

You can set up a callback function to handle any unknown chunks in the input stream. You must supply the function

```
read_chunk_callback(png_ptr ptr,
                    png_unknown_chunkp chunk);
{
    /* The unknown chunk structure contains your
       chunk data, along with similar data for any other
       unknown chunks: */

    png_byte name[5];
    png_byte *data;
    png_size_t size;

    /* Note that libpng has already taken care of
       the CRC handling */

    /* put your code here. Search for your chunk in the
       unknown chunk structure, process it, and return one
       of the following: */

    return (-n); /* chunk had an error */
    return (0); /* did not recognize */
    return (n); /* success */
}
```

(You can give your function another name that you like instead of `read_chunk_callback`.)

To inform libpng about your function, use

```
png_set_read_user_chunk_fn(png_ptr, user_chunk_ptr,
                           read_chunk_callback);
```

This names not only the callback function, but also a user pointer that you can retrieve with

```
png_get_user_chunk_ptr(png_ptr);
```

If you call the `png_set_read_user_chunk_fn()` function, then all unknown chunks will be saved when read, in case your callback function will need one or more of them. This behavior can be changed with the `png_set_keep_unknown_chunks()` function, described below.

At this point, you can set up a callback function that will be called after each row has been read, which you can use to control a progress meter or the like. It's demonstrated in `pngtest.c`. You must supply a function

```
void read_row_callback(png_ptr ptr, png_uint_32 row,
    int pass);
{
    /* put your code here */
}
```

(You can give it another name that you like instead of "read_row_callback")
To inform libpng about your function, use

```
png_set_read_status_fn(png_ptr, read_row_callback);
```

Unknown-chunk handling

Now you get to set the way the library processes unknown chunks in the input PNG stream. Both known and unknown chunks will be read. Normal behavior is that known chunks will be parsed into information in various `info_ptr` members while unknown chunks will be discarded. This behavior can be wasteful if your application will never use some known chunk types. To change this, you can call:

```
png_set_keep_unknown_chunks(png_ptr, keep,
    chunk_list, num_chunks);
keep      - 0: default unknown chunk handling
            1: ignore; do not keep
            2: keep only if safe-to-copy
            3: keep even if unsafe-to-copy
You can use these definitions:
PNG_HANDLE_CHUNK_AS_DEFAULT    0
PNG_HANDLE_CHUNK_NEVER        1
PNG_HANDLE_CHUNK_IF_SAFE      2
PNG_HANDLE_CHUNK_ALWAYS       3
chunk_list - list of chunks affected (a byte string,
            five bytes per chunk, NULL or '\0' if
            num_chunks is 0)
num_chunks - number of chunks affected; if 0, all
            unknown chunks are affected. If nonzero,
            only the chunks in the list are affected
```

Unknown chunks declared in this way will be saved as raw data onto a list of `png_unknown_chunk` structures. If a chunk that is normally known to libpng is named in the list, it will be handled as unknown, according to the "keep" directive. If a chunk is named in successive instances of `png_set_keep_unknown_chunks()`, the final instance will take precedence. The IHDR and IEND chunks should not be named in `chunk_list`; if they are, libpng will process them normally anyway.

Here is an example of the usage of `png_set_keep_unknown_chunks()`, where the private "vpAg" chunk will later be processed by a user chunk callback function:

```
png_byte vpAg[5]={118, 112, 65, 103, (png_byte) '\0'};

#ifdef PNG_UNKNOWN_CHUNKS_SUPPORTED
    png_byte unused_chunks[] =
```

```

    {
        104, 73, 83, 84, (png_byte) '\0', /* hIST */
        105, 84, 88, 116, (png_byte) '\0', /* iTXt */
        112, 67, 65, 76, (png_byte) '\0', /* pCAL */
        115, 67, 65, 76, (png_byte) '\0', /* sCAL */
        115, 80, 76, 84, (png_byte) '\0', /* sPLT */
        116, 73, 77, 69, (png_byte) '\0', /* tIME */
    };
#endif

...

#ifdef PNG_UNKNOWN_CHUNKS_SUPPORTED
    /* ignore all unknown chunks: */
    png_set_keep_unknown_chunks(read_ptr, 1, NULL, 0);
    /* except for vpAg: */
    png_set_keep_unknown_chunks(read_ptr, 2, vpAg, 1);
    /* also ignore unused known chunks: */
    png_set_keep_unknown_chunks(read_ptr, 1, unused_chunks,
        (int) sizeof(unused_chunks)/5);
#endif

```

User limits

The PNG specification allows the width and height of an image to be as large as $2^{31}-1$ (0x7fffffff), or about 2.147 billion rows and columns. Since very few applications really need to process such large images, we have imposed an arbitrary 1-million limit on rows and columns. Larger images will be rejected immediately with a `png_error()` call. If you wish to override this limit, you can use

```
png_set_user_limits(png_ptr, width_max, height_max);
```

to set your own limits, or use `width_max = height_max = 0x7fffffffL` to allow all valid dimensions (libpng may reject some very large images anyway because of potential buffer overflow conditions).

You should put this statement after you create the PNG structure and before calling `png_read_info()`, `png_read_png()`, or `png_process_data()`. If you need to retrieve the limits that are being applied, use

```
width_max = png_get_user_width_max(png_ptr);
height_max = png_get_user_height_max(png_ptr);
```

The PNG specification sets no limit on the number of ancillary chunks allowed in a PNG datastream. You can impose a limit on the total number of sPLT, tEXt, iTXt, zTXt, and unknown chunks that will be stored, with

```
png_set_chunk_cache_max(png_ptr, user_chunk_cache_max);
```

where 0x7fffffffL means unlimited. You can retrieve this limit with

```
chunk_cache_max = png_get_chunk_cache_max(png_ptr);
```

This limit also applies to the number of buffers that can be allocated by `png_decompress_chunk()` while decompressing iTXt, zTXt, and iCCP chunks.

The high-level read interface

At this point there are two ways to proceed; through the high-level read interface, or through a sequence of low-level read operations. You can use the high-level interface if (a) you are willing to read the entire image into memory, and (b) the input transformations you want to do are limited to the following set:

PNG_TRANSFORM_IDENTITY	No transformation
PNG_TRANSFORM_STRIP_16	Strip 16-bit samples to 8 bits
PNG_TRANSFORM_STRIP_ALPHA	Discard the alpha channel
PNG_TRANSFORM_PACKING	Expand 1, 2 and 4-bit samples to bytes
PNG_TRANSFORM_PACKSWAP	Change order of packed pixels to LSB first
PNG_TRANSFORM_EXPAND	Perform set_expand()
PNG_TRANSFORM_INVERT_MONO	Invert monochrome images
PNG_TRANSFORM_SHIFT	Normalize pixels to the sBIT depth
PNG_TRANSFORM_BGR	Flip RGB to BGR, RGBA to BGRA
PNG_TRANSFORM_SWAP_ALPHA	Flip RGBA to ARGB or GA to AG
PNG_TRANSFORM_INVERT_ALPHA	Change alpha from opacity to transparency
PNG_TRANSFORM_SWAP_ENDIAN	Byte-swap 16-bit samples
PNG_TRANSFORM_GRAY_TO_RGB	Expand grayscale samples to RGB (or GA to RGBA)

(This excludes setting a background color, doing gamma transformation, dithering, and setting filler.) If this is the case, simply do this:

```
png_read_png(png_ptr, info_ptr, png_transforms, NULL)
```

where `png_transforms` is an integer containing the bitwise OR of some set of transformation flags. This call is equivalent to `png_read_info()`, followed the set of transformations indicated by the transform mask, then `png_read_image()`, and finally `png_read_end()`.

(The final parameter of this call is not yet used. Someday it might point to transformation parameters required by some future input transform.)

You must use `png_transforms` and not call any `png_set_transform()` functions when you use `png_read_png()`.

After you have called `png_read_png()`, you can retrieve the image data with

```
row_pointers = png_get_rows(png_ptr, info_ptr);
```

where `row_pointers` is an array of pointers to the pixel data for each row:

```
png_bytep row_pointers[height];
```

If you know your image size and pixel size ahead of time, you can allocate `row_pointers` prior to calling `png_read_png()` with

```
if (height > PNG_UINT_32_MAX/png_sizeof(png_byte))
    png_error (png_ptr,
        "Image is too tall to process in memory");
if (width > PNG_UINT_32_MAX/pixel_size)
    png_error (png_ptr,
        "Image is too wide to process in memory");
row_pointers = png_malloc(png_ptr,
    height*png_sizeof(png_bytep));
for (int i=0; i<height, i++)
    row_pointers[i]=NULL; /* security precaution */
for (int i=0; i<height, i++)
    row_pointers[i]=png_malloc(png_ptr,
        width*pixel_size);
png_set_rows(png_ptr, info_ptr, &row_pointers);
```

Alternatively you could allocate your image in one big block and define `row_pointers[i]` to point into the proper places in your block.

If you use `png_set_rows()`, the application is responsible for freeing `row_pointers` (and `row_pointers[i]`, if they were separately allocated).

If you don't allocate `row_pointers` ahead of time, `png_read_png()` will do it, and it'll be free'd when you call `png_destroy_*()`.

The low-level read interface

If you are going the low-level route, you are now ready to read all the file information up to the actual image data. You do this with a call to `png_read_info()`.

```
png_read_info(png_ptr, info_ptr);
```

This will process all chunks up to but not including the image data.

Querying the info structure

Functions are used to get the information from the `info_ptr` once it has been read. Note that these fields may not be completely filled in until `png_read_end()` has read the chunk data following the image.

```
png_get_IHDR(png_ptr, info_ptr, &width, &height,
             &bit_depth, &color_type, &interlace_type,
             &compression_type, &filter_method);
```

<code>width</code>	- holds the width of the image in pixels (up to 2^{31}).
<code>height</code>	- holds the height of the image in pixels (up to 2^{31}).
<code>bit_depth</code>	- holds the bit depth of one of the image channels. (valid values are 1, 2, 4, 8, 16 and depend also on the <code>color_type</code> . See also significant bits (sBIT) below).
<code>color_type</code>	- describes which color/alpha channels are present. PNG_COLOR_TYPE_GRAY (bit depths 1, 2, 4, 8, 16) PNG_COLOR_TYPE_GRAY_ALPHA (bit depths 8, 16) PNG_COLOR_TYPE_PALETTE (bit depths 1, 2, 4, 8) PNG_COLOR_TYPE_RGB (bit depths 8, 16) PNG_COLOR_TYPE_RGB_ALPHA (bit depths 8, 16) PNG_COLOR_MASK_PALETTE PNG_COLOR_MASK_COLOR PNG_COLOR_MASK_ALPHA
<code>filter_method</code>	- (must be PNG_FILTER_TYPE_BASE for PNG 1.0, and can also be PNG_INTRAPIXEL_DIFFERENCING if the PNG datastream is embedded in a MNG-1.0 datastream)
<code>compression_type</code>	- (must be PNG_COMPRESSION_TYPE_BASE for PNG 1.0)
<code>interlace_type</code>	- (PNG_INTERLACE_NONE or PNG_INTERLACE_ADAM7)

Any **or** all of `interlace_type`, `compression_type`, **or** `filter_method` can be NULL **if** you are

not interested in their values.

Note that `png_get_IHDR()` returns 32-bit data into the application's width and height variables. This is an unsafe situation if these are 16-bit variables. In such situations, the `png_get_image_width()` and `png_get_image_height()` functions described below are safer.

```
width          = png_get_image_width(png_ptr,
                                     info_ptr);
height         = png_get_image_height(png_ptr,
                                     info_ptr);
bit_depth      = png_get_bit_depth(png_ptr,
                                     info_ptr);
color_type     = png_get_color_type(png_ptr,
                                     info_ptr);
filter_method  = png_get_filter_type(png_ptr,
                                     info_ptr);
compression_type = png_get_compression_type(png_ptr,
                                             info_ptr);
interlace_type  = png_get_interlace_type(png_ptr,
                                          info_ptr);

channels = png_get_channels(png_ptr, info_ptr);
channels - number of channels of info for the
          color type (valid values are 1 (GRAY,
          PALETTE), 2 (GRAY_ALPHA), 3 (RGB),
          4 (RGB_ALPHA or RGB + filler byte))
rowbytes = png_get_rowbytes(png_ptr, info_ptr);
rowbytes  - number of bytes needed to hold a row

signature = png_get_signature(png_ptr, info_ptr);
signature  - holds the signature read from the
            file (if any). The data is kept in
            the same offset it would be if the
            whole signature were read (i.e. if an
            application had already read in 4
            bytes of signature before starting
            libpng, the remaining 4 bytes would
            be in signature[4] through signature[7]
            (see png_set_sig_bytes()).
```

These are also important, but their validity depends on whether the chunk has been read. The `png_get_valid(png_ptr, info_ptr, PNG_INFO_<chunk>)` and `png_get_<chunk>(png_ptr, info_ptr, ...)` functions return non-zero if the data has been read, or zero if it is missing. The parameters to the `png_get_<chunk>` are set directly if they are simple data types, or a pointer into the `info_ptr` is returned for any complex types.

```
png_get_PLTE(png_ptr, info_ptr, &palette,
             &num_palette);
palette      - the palette for the file
              (array of png_color)
num_palette  - number of entries in the palette

png_get_gAMA(png_ptr, info_ptr, &gamma);
gamma        - the gamma the file is written
              at (PNG_INFO_gAMA)

png_get_sRGB(png_ptr, info_ptr, &srgb_intent);
srgb_intent  - the rendering intent (PNG_INFO_sRGB)
```

The presence of the sRGB chunk means that the pixel data is in the sRGB color space. This chunk also implies specific values of gAMA **and** cHRM.

```
png_get_iCCP(png_ptr, info_ptr, &name,
             &compression_type, &profile, &proflen);
name          - The profile name.
compression    - The compression type; always
                  PNG_COMPRESSION_TYPE_BASE for PNG 1.0.
                  You may give NULL to this argument to
                  ignore it.
profile        - International Color Consortium color
                  profile data. May contain NULs.
proflen        - length of profile data in bytes.

png_get_sBIT(png_ptr, info_ptr, &sig_bit);
sig_bit        - the number of significant bits for
                  (PNG_INFO_sBIT) each of the gray,
                  red, green, and blue channels,
                  whichever are appropriate for the
                  given color type (png_color_16)

png_get_tRNS(png_ptr, info_ptr, &trans_alpha,
             &num_trans, &trans_color);
trans_alpha    - array of alpha (transparency)
                  entries for palette (PNG_INFO_tRNS)
trans_color    - graylevel or color sample values of
                  the single transparent color for
                  non-paletted images (PNG_INFO_tRNS)
num_trans      - number of transparent entries
                  (PNG_INFO_tRNS)

png_get_hIST(png_ptr, info_ptr, &hist);
(PNG_INFO_hIST)
hist           - histogram of palette (array of
                  png_uint_16)

png_get_tIME(png_ptr, info_ptr, &mod_time);
mod_time       - time image was last modified
                  (PNG_VALID_tIME)

png_get_bKGD(png_ptr, info_ptr, &background);
background     - background color (PNG_VALID_bKGD)
                  valid 16-bit red, green and blue
                  values, regardless of color_type

num_comments   = png_get_text(png_ptr, info_ptr,
                             &text_ptr, &num_text);
num_comments    - number of comments
text_ptr        - array of png_text holding image
                  comments
text_ptr[i].compression - type of compression used
                  on "text" PNG_TEXT_COMPRESSION_NONE
                  PNG_TEXT_COMPRESSION_zTXt
                  PNG_ITXT_COMPRESSION_NONE
                  PNG_ITXT_COMPRESSION_zTXt
text_ptr[i].key  - keyword for comment. Must contain
                  1-79 characters.
text_ptr[i].text - text comments for current
                  keyword. Can be empty.
```



```

text_ptr[i].text_length - length of text string,
                        after decompression, 0 for iTXt
text_ptr[i].itxt_length - length of itxt string,
                        after decompression, 0 for tEXt/zTXt
text_ptr[i].lang - language of comment (empty
                        string for unknown).
text_ptr[i].lang_key - keyword in UTF-8
                        (empty string for unknown).
Note that the itxt_length, lang, and lang_key
members of the text_ptr structure only exist
when the library is built with iTXt chunk support.

num_text - number of comments (same as
                        num_comments; you can put NULL here
                        to avoid the duplication)
Note while png_set_text() will accept text, language,
and translated keywords that can be NULL pointers, the
structure returned by png_get_text will always contain
regular zero-terminated C strings. They might be
empty strings but they will never be NULL pointers.

num_palettes = png_get_sPLT(png_ptr, info_ptr,
                        &palette_ptr);
palette_ptr - array of palette structures holding
                        contents of one or more sPLT chunks
                        read.
num_palettes - number of sPLT chunks read.

png_get_oFFs(png_ptr, info_ptr, &offset_x, &offset_y,
                        &unit_type);
offset_x - positive offset from the left edge
                        of the screen
offset_y - positive offset from the top edge
                        of the screen
unit_type - PNG_OFFSET_PIXEL, PNG_OFFSET_MICROMETER

png_get_pHYs(png_ptr, info_ptr, &res_x, &res_y,
                        &unit_type);
res_x - pixels/unit physical resolution in
                        x direction
res_y - pixels/unit physical resolution in
                        x direction
unit_type - PNG_RESOLUTION_UNKNOWN,
                        PNG_RESOLUTION_METER

png_get_sCAL(png_ptr, info_ptr, &unit, &width,
                        &height)
unit - physical scale units (an integer)
width - width of a pixel in physical scale units
height - height of a pixel in physical scale units
                        (width and height are doubles)

png_get_sCAL_s(png_ptr, info_ptr, &unit, &width,
                        &height)
unit - physical scale units (an integer)
width - width of a pixel in physical scale units
height - height of a pixel in physical scale units
                        (width and height are strings like "2.54")

num_unknown_chunks = png_get_unknown_chunks(png_ptr,
                        info_ptr, &unknowns)
unknowns - array of png_unknown_chunk

```

```

structures holding unknown chunks
unknowns[i].name - name of unknown chunk
unknowns[i].data - data of unknown chunk
unknowns[i].size - size of unknown chunk's data
unknowns[i].location - position of chunk in file

```

The value of "i" corresponds to the order in which the chunks were read from the PNG file or inserted with the `png_set_unknown_chunks()` function.

The data from the pHYs chunk can be retrieved in several convenient forms:

```

res_x = png_get_x_pixels_per_meter(png_ptr,
    info_ptr)
res_y = png_get_y_pixels_per_meter(png_ptr,
    info_ptr)
res_x_and_y = png_get_pixels_per_meter(png_ptr,
    info_ptr)
res_x = png_get_x_pixels_per_inch(png_ptr,
    info_ptr)
res_y = png_get_y_pixels_per_inch(png_ptr,
    info_ptr)
res_x_and_y = png_get_pixels_per_inch(png_ptr,
    info_ptr)
aspect_ratio = png_get_pixel_aspect_ratio(png_ptr,
    info_ptr)

```

(Each of these returns 0 [signifying "unknown"] **if** the data is **not** present **or if** `res_x` is 0; `res_x_and_y` is 0 **if** `res_x` != `res_y`)

The data from the oFFs chunk can be retrieved in several convenient forms:

```

x_offset = png_get_x_offset_microns(png_ptr, info_ptr);
y_offset = png_get_y_offset_microns(png_ptr, info_ptr);
x_offset = png_get_x_offset_inches(png_ptr, info_ptr);
y_offset = png_get_y_offset_inches(png_ptr, info_ptr);

```

(Each of these returns 0 [signifying "unknown"] **if** both `x` **and** `y` are 0] **if** the data is **not** present **or if** the chunk is present but the unit is the pixel)

For more information, see the `png_info` definition in `png.h` and the PNG specification for chunk contents. Be careful with trusting rowbytes, as some of the transformations could increase the space needed to hold a row (`expand`, `filler`, `gray_to_rgb`, etc.). See `png_read_update_info()`, below.

A quick word about `text_ptr` and `num_text`. PNG stores comments in keyword/text pairs, one pair per chunk, with no limit on the number of text chunks, and a 2^{31} byte limit on their size. While there are suggested keywords, there is no requirement to restrict the use to these strings. It is strongly suggested that keywords and text be sensible to humans (that's the point), so don't use abbreviations. Non-printing symbols are not allowed. See the PNG specification for more details. There is also no requirement to have text after the keyword.

Keywords should be limited to 79 Latin-1 characters without leading or trailing spaces, but non-consecutive spaces are allowed within the keyword. It is possible to have the same keyword any number of times. The `text_ptr` is an array of `png_text` structures, each holding a pointer to a language string, a pointer to a keyword and a pointer to a text string. The text string, language code, and translated keyword may be empty or NULL pointers. The keyword/text pairs are put into the

array in the order that they are received. However, some or all of the text chunks may be after the image, so, to make sure you have read all the text chunks, don't mess with these until after you read the stuff after the image. This will be mentioned again below in the discussion that goes with `png_read_end()`.

3.2 Input transformations

After you've read the header information, you can set up the library to handle any special transformations of the image data. The various ways to transform the data will be described in the order that they should occur. This is important, as some of these change the color type and/or bit depth of the data, and some others only work on certain color types and bit depths. Even though each transformation checks to see if it has data that it can do something with, you should make sure to only enable a transformation if it will be valid for the data. For example, don't swap red and blue on grayscale data.

The colors used for the background and transparency values should be supplied in the same format/depth as the current image data. They are stored in the same format/depth as the image data in a bKGD or tRNS chunk, so this is what libpng expects for this data. The colors are transformed to keep in sync with the image data when an application calls the `png_read_update_info()` routine (see below).

Data will be decoded into the supplied row buffers packed into bytes unless the library has been told to transform it into another format. For example, 4 bit/pixel paletted or grayscale data will be returned 2 pixels/byte with the leftmost pixel in the high-order bits of the byte, unless `png_set_packing()` is called. 8-bit RGB data will be stored in RGB RGB RGB format unless `png_set_filler()` or `png_set_add_alpha()` is called to insert filler bytes, either before or after each RGB triplet. 16-bit RGB data will be returned RRGGBB RRGGBB, with the most significant byte of the color value first, unless `png_set_strip_16()` is called to transform it to regular RGB RGB triplets, or `png_set_filler()` or `png_set_add_alpha()` is called to insert filler bytes, either before or after each RRGGBB triplet. Similarly, 8-bit or 16-bit grayscale data can be modified with `png_set_filler()`, `png_set_add_alpha()`, or `png_set_strip_16()`.

The following code transforms grayscale images of less than 8 to 8 bits, changes paletted images to RGB, and adds a full alpha channel if there is transparency information in a tRNS chunk. This is most useful on grayscale images with bit depths of 2 or 4 or if there is a multiple-image viewing application that wishes to treat all images in the same way.

```
if (color_type == PNG_COLOR_TYPE_PALETTE)
    png_set_palette_to_rgb(png_ptr);

if (color_type == PNG_COLOR_TYPE_GRAY &&
    bit_depth < 8) png_set_expand_gray_1_2_4_to_8(png_ptr);

if (png_get_valid(png_ptr, info_ptr,
    PNG_INFO_tRNS)) png_set_tRNS_to_alpha(png_ptr);
```

These three functions are actually aliases for `png_set_expand()`, added in libpng version 1.0.4, with the function names expanded to improve code readability. In some future version they may actually do different things.

As of libpng version 1.2.9, `png_set_expand_gray_1_2_4_to_8()` was added. It expands the sample depth without changing tRNS to alpha.

As of libpng version 1.4.0, not all possible expansions are supported.

In the following table, the 01 means grayscale with depth;8, 31 means indexed with depth;8, other numerals represent the color type, "T" means the tRNS chunk is present, A means an alpha channel is present, and O means tRNS or alpha is present but all pixels in the image are opaque.

FROM	01	31	0	0T	00	2	2T	2O	3	3T	3O	4A	4O	6A	6O
TO															
01	-														
31		-													
0	1		-												
0T				-											
00					-										
2			GX			-									
2T							-								
2O								-							
3		1							-						
3T										-					
3O											-				
4A				T								-			
4O													-		
6A				GX		TX			TX					-	
6O					GX					TX					-

Within the matrix,

- "-" means the transformation is **not** supported.
- "X" means the transformation is obtained by `png_set_expand()`.
- "1" means the transformation is obtained by `png_set_expand_gray_1_2_4_to_8`
- "G" means the transformation is obtained by `png_set_gray_to_rgb()`.
- "P" means the transformation is obtained by `png_set_expand_palette_to_rgb()`.
- "T" means the transformation is obtained by `png_set_tRNS_to_alpha()`.

PNG can have files with 16 bits per channel. If you only can handle 8 bits per channel, this will strip the pixels down to 8 bit.

```
if (bit_depth == 16)
    png_set_strip_16(png_ptr);
```

If, for some reason, you don't need the alpha channel on an image, and you want to remove it rather than combining it with the background (but the image author certainly had in mind that you *would* combine it with the background, so that's what you should probably do):

```
if (color_type & PNG_COLOR_MASK_ALPHA)
    png_set_strip_alpha(png_ptr);
```

In PNG files, the alpha channel in an image is the level of opacity. If you need the alpha channel in an image to be the level of transparency instead of opacity, you can invert the alpha channel (or the tRNS chunk data) after it's read, so that 0 is fully opaque and 255 (in 8-bit or paletted images) or 65535 (in 16-bit images) is fully transparent, with

```
png_set_invert_alpha(png_ptr);
```

PNG files pack pixels of bit depths 1, 2, and 4 into bytes as small as they can, resulting in, for example, 8 pixels per byte for 1 bit files. This code expands to 1 pixel

per byte without changing the values of the pixels:

```
if (bit_depth < 8)
    png_set_packing(png_ptr);
```

PNG files have possible bit depths of 1, 2, 4, 8, and 16. All pixels stored in a PNG image have been "scaled" or "shifted" up to the next higher possible bit depth (e.g. from 5 bits/sample in the range [0,31] to 8 bits/sample in the range [0, 255]). However, it is also possible to convert the PNG pixel data back to the original bit depth of the image. This call reduces the pixels back down to the original bit depth:

```
png_color_8p sig_bit;

if (png_get_sBIT(png_ptr, info_ptr, &sig_bit))
    png_set_shift(png_ptr, sig_bit);
```

PNG files store 3-color pixels in red, green, blue order. This code changes the storage of the pixels to blue, green, red:

```
if (color_type == PNG_COLOR_TYPE_RGB ||
    color_type == PNG_COLOR_TYPE_RGB_ALPHA)
    png_set_bgr(png_ptr);
```

PNG files store RGB pixels packed into 3 or 6 bytes. This code expands them into 4 or 8 bytes for windowing systems that need them in this format:

```
if (color_type == PNG_COLOR_TYPE_RGB)
    png_set_filler(png_ptr, filler, PNG_FILLER_BEFORE);
```

where "filler" is the 8 or 16-bit number to fill with, and the location is either PNG_FILLER_BEFORE or PNG_FILLER_AFTER, depending upon whether you want the filler before the RGB or after. This transformation does not affect images that already have full alpha channels. To add an opaque alpha channel, use `filler=0xff` or `0xffff` and PNG_FILLER_AFTER which will generate RGBA pixels.

Note that `png_set_filler()` does not change the color type. If you want to do that, you can add a true alpha channel with

```
if (color_type == PNG_COLOR_TYPE_RGB ||
    color_type == PNG_COLOR_TYPE_GRAY)
    png_set_add_alpha(png_ptr, filler, PNG_FILLER_AFTER);
```

where "filler" contains the alpha value to assign to each pixel. This function was added in libpng-1.2.7.

If you are reading an image with an alpha channel, and you need the data as ARGB instead of the normal PNG format RGBA:

```
if (color_type == PNG_COLOR_TYPE_RGB_ALPHA)
    png_set_swap_alpha(png_ptr);
```

For some uses, you may want a grayscale image to be represented as RGB. This code will do that conversion:

```
if (color_type == PNG_COLOR_TYPE_GRAY ||
    color_type == PNG_COLOR_TYPE_GRAY_ALPHA)
    png_set_gray_to_rgb(png_ptr);
```

Conversely, you can convert an RGB or RGBA image to grayscale or grayscale with alpha.

```

if (color_type == PNG_COLOR_TYPE_RGB ||
    color_type == PNG_COLOR_TYPE_RGB_ALPHA)
    png_set_rgb_to_gray_fixed(png_ptr, error_action,
        int red_weight, int green_weight);

error_action = 1: silently do the conversion
error_action = 2: issue a warning if the original
                    image has any pixel where
                    red != green or red != blue
error_action = 3: issue an error and abort the
                    conversion if the original
                    image has any pixel where
                    red != green or red != blue

red_weight:        weight of red component times 100000
green_weight:      weight of green component times 100000
                    If either weight is negative, default
                    weights (21268, 71514) are used.

```

If you have set `error_action = 1` or `2`, you can later check whether the image really was gray, after processing the image rows, with the `png_get_rgb_to_gray_status` (`png_ptr`) function. It will return a `png_byte` that is zero if the image was gray or 1 if there were any non-gray pixels. bKGD and sBIT data will be silently converted to grayscale, using the green channel data, regardless of the `error_action` setting.

With `red_weight+green_weight<=100000`, the normalized graylevel is computed:

```

int rw = red_weight * 65536;
int gw = green_weight * 65536;
int bw = 65536 - (rw + gw);
gray = (rw*red + gw*green + bw*blue)/65536;

```

The default values approximate those recommended in the Charles Poynton's Color FAQ, <<http://www.inforamp.net/poynton/>> Copyright (c) 1998-01-04 Charles Poynton <poynton at inforamp.net>

$$Y = 0.212671 * R + 0.715160 * G + 0.072169 * B$$

Libpng approximates this with

$$Y = 0.21268 * R + 0.7151 * G + 0.07217 * B$$

which can be expressed with integers as

$$Y = (6969 * R + 23434 * G + 2365 * B) / 32768$$

The calculation is done in a linear colorspace, if the image gamma is known.

If you have a grayscale and you are using `png_set_expand_depth()`, `png_set_expand()`, or `png_set_gray_to_rgb` to change to truecolor or to a higher bit-depth, you must either supply the background color as a gray value at the original file bit-depth (`need_expand = 1`) or else supply the background color as an RGB triplet at the final, expanded bit depth (`need_expand = 0`). Similarly, if you are reading a paletted image, you must either supply the background color as a palette index (`need_expand = 1`) or as an RGB triplet that may or may not be in the palette (`need_expand = 0`).

```

png_color_16 my_background;
png_color_16p image_background;

```

```

if (png_get_bKGD(png_ptr, info_ptr, &image_background))
    png_set_background(png_ptr, image_background,
        PNG_BACKGROUND_GAMMA_FILE, 1, 1.0);
else
    png_set_background(png_ptr, &my_background,
        PNG_BACKGROUND_GAMMA_SCREEN, 0, 1.0);

```

The `png_set_background()` function tells libpng to composite images with alpha or simple transparency against the supplied background color. If the PNG file contains a bKGD chunk (PNG_INFO_bKGD valid), you may use this color, or supply another color more suitable for the current display (e.g., the background color from a web page). You need to tell libpng whether the color is in the gamma space of the display (PNG_BACKGROUND_GAMMA_SCREEN for colors you supply), the file (PNG_BACKGROUND_GAMMA_FILE for colors from the bKGD chunk), or one that is neither of these gammas (PNG_BACKGROUND_GAMMA_UNIQUE - I don't know why anyone would use this, but it's here).

To properly display PNG images on any kind of system, the application needs to know what the display gamma is. Ideally, the user will know this, and the application will allow them to set it. One method of allowing the user to set the display gamma separately for each system is to check for a SCREEN_GAMMA or DISPLAY_GAMMA environment variable, which will hopefully be correctly set.

Note that `display_gamma` is the overall gamma correction required to produce pleasing results, which depends on the lighting conditions in the surrounding environment. In a dim or brightly lit room, no compensation other than the physical gamma exponent of the monitor is needed, while in a dark room a slightly smaller exponent is better.

```

double gamma, screen_gamma;

if (/* We have a user-defined screen
    gamma value */)
{
    screen_gamma = user_defined_screen_gamma;
}
/* One way that applications can share the same
    screen gamma value */
else if ((gamma_str = getenv("SCREEN_GAMMA"))
    != NULL)
{
    screen_gamma = (double)atof(gamma_str);
}
/* If we don't have another value */
else
{
    screen_gamma = 2.2; /* A good guess for a
        PC monitor in a bright office or a dim room */
    screen_gamma = 2.0; /* A good guess for a
        PC monitor in a dark room */
    screen_gamma = 1.7 or 1.0; /* A good
        guess for Mac systems */
}

```

The `png_set_gamma()` function handles gamma transformations of the data. Pass both the file gamma and the current `screen_gamma`. If the file does not have a gamma value, you can pass one anyway if you have an idea what it is (usually 0.45455 is a good guess for GIF images on PCs). Note that file gammas are inverted from screen

gammas. See the discussions on gamma in the PNG specification for an excellent description of what gamma is, and why all applications should support it. It is strongly recommended that PNG viewers support gamma correction.

```
if (png_get_gAMA(png_ptr, info_ptr, &gamma))
    png_set_gamma(png_ptr, screen_gamma, gamma);
else
    png_set_gamma(png_ptr, screen_gamma, 0.45455);
```

PNG files describe monochrome as black being zero and white being one. The following code will reverse this (make black be one and white be zero):

```
if (bit_depth == 1 && color_type == PNG_COLOR_TYPE_GRAY)
    png_set_invert_mono(png_ptr);
```

This function can also be used to invert grayscale and gray-alpha images:

```
if (color_type == PNG_COLOR_TYPE_GRAY ||
    color_type == PNG_COLOR_TYPE_GRAY_ALPHA)
    png_set_invert_mono(png_ptr);
```

PNG files store 16 bit pixels in network byte order (big-endian, ie. most significant bits first). This code changes the storage to the other way (little-endian, i.e. least significant bits first, the way PCs store them):

```
if (bit_depth == 16)
    png_set_swap(png_ptr);
```

If you are using packed-pixel images (1, 2, or 4 bits/pixel), and you need to change the order the pixels are packed into bytes, you can use:

```
if (bit_depth < 8)
    png_set_packswap(png_ptr);
```

Finally, you can write your own transformation function if none of the existing ones meets your needs. This is done by setting a callback with

```
png_set_read_user_transform_fn(png_ptr,
    read_transform_fn);
```

You must supply the function

```
void read_transform_fn(png_ptr ptr, row_info_ptr
    row_info, png_bytep data)
```

See `pngtest.c` for a working example. Your function will be called after all of the other transformations have been processed.

You can also set up a pointer to a user structure for use by your callback function, and you can inform libpng that your transform function will change the number of channels or bit depth with the function

```
png_set_user_transform_info(png_ptr, user_ptr,
    user_depth, user_channels);
```

The user's application, not libpng, is responsible for allocating and freeing any memory required for the user structure.

You can retrieve the pointer via the function `png_get_user_transform_ptr()`. For example:


```
voidp read_user_transform_ptr =
    png_get_user_transform_ptr(png_ptr);
```

The last thing to handle is interlacing; this is covered in detail below, but you must call the function here if you want libpng to handle expansion of the interlaced image.

```
number_of_passes = png_set_interlace_handling(png_ptr);
```

After setting the transformations, libpng can update your `png_info` structure to reflect any transformations you've requested with this call. This is most useful to update the info structure's rowbytes field so you can use it to allocate your image memory. This function will also update your palette with the correct screen_gamma and background if these have been given with the calls above.

```
png_read_update_info(png_ptr, info_ptr);
```

After you call `png_read_update_info()`, you can allocate any memory you need to hold the image. The row data is simply raw byte data for all forms of images. As the actual allocation varies among applications, no example will be given. If you are allocating one large chunk, you will need to build an array of pointers to each row, as it will be needed for some of the functions below.

3.3 Reading image data

After you've allocated memory, you can read the image data. The simplest way to do this is in one function call. If you are allocating enough memory to hold the whole image, you can just call `png_read_image()` and libpng will read in all the image data and put it in the memory area supplied. You will need to pass in an array of pointers to each row.

This function automatically handles interlacing, so you don't need to call `png_set_interlace_handling()` or call this function multiple times, or any of that other stuff necessary with `png_read_rows()`.

```
png_read_image(png_ptr, row_pointers);
```

where `row_pointers` is:

```
png_bytep row_pointers[height];
```

You can point to void or char or whatever you use for pixels.

If you don't want to read in the whole image at once, you can use `png_read_rows()` instead. If there is no interlacing (check `interlace_type == PNG_INTERLACE_NONE`), this is simple:

```
png_read_rows(png_ptr, row_pointers, NULL,
    number_of_rows);
```

where `row_pointers` is the same as in the `png_read_image()` call.

If you are doing this just one row at a time, you can do this with a single `row_pointer` instead of an array of `row_pointers`:

```
png_bytep row_pointer = row;
png_read_row(png_ptr, row_pointer, NULL);
```

If the file is interlaced (`interlace_type != 0` in the IHDR chunk), things get somewhat harder. The only current (PNG Specification version 1.2) interlacing type for PNG is (`interlace_type == PNG_INTERLACE_ADAM7`) is a somewhat complicated 2D interlace scheme, known as Adam7, that breaks down an image into seven smaller images of varying size, based on an 8x8 grid.

libpng can fill out those images or it can give them to you "as is". If you want them filled out, there are two ways to do that. The one mentioned in the PNG specification is to expand each pixel to cover those pixels that have not been read yet (the "rectangle" method). This results in a blocky image for the first pass, which gradually smooths out as more pixels are read. The other method is the "sparkle" method, where pixels are drawn only in their final locations, with the rest of the image remaining whatever colors they were initialized to before the start of the read. The first method usually looks better, but tends to be slower, as there are more pixels to put in the rows.

If you don't want libpng to handle the interlacing details, just call `png_read_rows()` seven times to read in all seven images. Each of the images is a valid image by itself, or they can all be combined on an 8x8 grid to form a single image (although if you intend to combine them you would be far better off using the libpng interlace handling).

The first pass will return an image 1/8 as wide as the entire image (every 8th column starting in column 0) and 1/8 as high as the original (every 8th row starting in row 0), the second will be 1/8 as wide (starting in column 4) and 1/8 as high (also starting in row 0). The third pass will be 1/4 as wide (every 4th pixel starting in column 0) and 1/8 as high (every 8th row starting in row 4), and the fourth pass will be 1/4 as wide and 1/4 as high (every 4th column starting in column 2, and every 4th row starting in row 0). The fifth pass will return an image 1/2 as wide, and 1/4 as high (starting at column 0 and row 2), while the sixth pass will be 1/2 as wide and 1/2 as high as the original (starting in column 1 and row 0). The seventh and final pass will be as wide as the original, and 1/2 as high, containing all of the odd numbered scanlines. Phew!

If you want libpng to expand the images, call this before calling `png_start_read_image()` or `png_read_update_info()`:

```
if (interlace_type == PNG_INTERLACE_ADAM7)
    number_of_passes
        = png_set_interlace_handling(png_ptr);
```

This will return the number of passes needed. Currently, this is seven, but may change if another interlace type is added. This function can be called even if the file is not interlaced, where it will return one pass.

If you are not going to display the image after each pass, but are going to wait until the entire image is read in, use the sparkle effect. This effect is faster and the end result of either method is exactly the same. If you are planning on displaying the image after each pass, the "rectangle" effect is generally considered the better looking one.

If you only want the "sparkle" effect, just call `png_read_rows()` as normal, with the third parameter NULL. Make sure you make pass over the image `number_of_passes` times, and you don't change the data in the rows between calls. You can change the locations of the data, just not the data. Each pass only writes the pixels appropriate for that pass, and assumes the data from previous passes is still valid.

```
png_read_rows(png_ptr, row_pointers, NULL,
    number_of_rows);
```

If you only want the first effect (the rectangles), do the same as before except pass

the row buffer in the third parameter, and leave the second parameter NULL.

```
png_read_rows(png_ptr, NULL, row_pointers,
              number_of_rows);
```

3.4 Finishing a sequential read

After you are finished reading the image through the low-level interface, you can finish reading the file. If you are interested in comments or time, which may be stored either before or after the image data, you should pass the separate `png_info` struct if you want to keep the comments from before and after the image separate. If you are not interested, you can pass NULL.

```
png_read_end(png_ptr, end_info);
```

When you are done, you can free all memory allocated by libpng like this:

```
png_destroy_read_struct(&png_ptr, &info_ptr,
                      &end_info);
```

It is also possible to individually free the `info_ptr` members that point to libpng-allocated storage with the following function:

```
png_free_data(png_ptr, info_ptr, mask, seq)
mask - identifies data to be freed, a mask
      containing the bitwise OR of one or
      more of
          PNG_FREE_PLTE, PNG_FREE_TRNS,
          PNG_FREE_HIST, PNG_FREE_ICCP,
          PNG_FREE_PCAL, PNG_FREE_ROWS,
          PNG_FREE_SCAL, PNG_FREE_SPLT,
          PNG_FREE_TEXT, PNG_FREE_UNKN,
or simply PNG_FREE_ALL
seq - sequence number of item to be freed
      (-1 for all items)
```

This function may be safely called when the relevant storage has already been freed, or has not yet been allocated, or was allocated by the user and not by libpng, and will in those cases do nothing. The "seq" parameter is ignored if only one item of the selected data type, such as PLTE, is allowed. If "seq" is not -1, and multiple items are allowed for the data type identified in the mask, such as text or sPLT, only the n'th item in the structure is freed, where n is "seq".

The default behavior is only to free data that was allocated internally by libpng. This can be changed, so that libpng will not free the data, or so that it will free data that was allocated by the user with `png_malloc()` or `png_zalloc()` and passed in via a `png_set_*()` function, with

```
png_data_freer(png_ptr, info_ptr, freer, mask)
mask - which data elements are affected
      same choices as in png_free_data()
freer - one of
          PNG_DESTROY_WILL_FREE_DATA
          PNG_SET_WILL_FREE_DATA
          PNG_USER_WILL_FREE_DATA
```

This function only affects data that has already been allocated. You can call this function after reading the PNG data but before calling any `png_set_*`() functions, to control whether the user or the `png_set_*`() function is responsible for freeing any existing data that might be present, and again after the `png_set_*`() functions to control whether the user or `png_destroy_*`() is supposed to free the data. When the user assumes responsibility for libpng-allocated data, the application must use `png_free()` to free it, and when the user transfers responsibility to libpng for data that the user has allocated, the user must have used `png_malloc()` or `png_zalloc()` to allocate it.

If you allocated your `row_pointers` in a single block, as suggested above in the description of the high level read interface, you must not transfer responsibility for freeing it to the `png_set_rows` or `png_read_destroy` function, because they would also try to free the individual `row_pointers[i]`.

If you allocated `text_ptr.text`, `text_ptr.lang`, and `text_ptr.translated_keyword` separately, do not transfer responsibility for freeing `text_ptr` to libpng, because when libpng fills a `png_text` structure it combines these members with the key member, and `png_free_data()` will free only `text_ptr.key`. Similarly, if you transfer responsibility for freeing `text_ptr` from libpng to your application, your application must not separately free those members.

The `png_free_data()` function will turn off the "valid" flag for anything it frees. If you need to turn the flag off for a chunk that was freed by your application instead of by libpng, you can use

```
png_set_invalid(png_ptr, info_ptr, mask);
mask - identifies the chunks to be made invalid,
      containing the bitwise OR of one or
      more of
          PNG_INFO_gAMA, PNG_INFO_sBIT,
          PNG_INFO_cHRM, PNG_INFO_pLTE,
          PNG_INFO_tRNS, PNG_INFO_bKGD,
          PNG_INFO_hIST, PNG_INFO_pHYs,
          PNG_INFO_oFFs, PNG_INFO_tIME,
          PNG_INFO_pCAL, PNG_INFO_sRGB,
          PNG_INFO_iCCP, PNG_INFO_sPLT,
          PNG_INFO_sCAL, PNG_INFO_IDAT
```

For a more compact example of reading a PNG image, see the file `example.c`.

3.5 Reading PNG files progressively

The progressive reader is slightly different than the non-progressive reader. Instead of calling `png_read_info()`, `png_read_rows()`, and `png_read_end()`, you make one call to `png_process_data()`, which calls callbacks when it has the info, a row, or the end of the image. You set up these callbacks with `png_set_progressive_read_fn()`. You don't have to worry about the input/output functions of libpng, as you are giving the library the data directly in `png_process_data()`. I will assume that you have read the section on reading PNG files above, so I will only highlight the differences (although I will show all of the code).

```
png_structp png_ptr;
png_infop info_ptr;

/* An example code fragment of how you would
   initialize the progressive reader in your
```

```

        application. */
int
initialize_png_reader()
{
    png_ptr = png_create_read_struct
        (PNG_LIBPNG_VER_STRING, (png_voidp)user_error_ptr,
         user_error_fn, user_warning_fn);
    if (!png_ptr)
        return (ERROR);
    info_ptr = png_create_info_struct(png_ptr);
    if (!info_ptr)
    {
        png_destroy_read_struct(&png_ptr, (png_infopp)NULL,
                                (png_infopp)NULL);
        return (ERROR);
    }

    if (setjmp(png_jmpbuf(png_ptr)))
    {
        png_destroy_read_struct(&png_ptr, &info_ptr,
                                (png_infopp)NULL);
        return (ERROR);
    }

    /* This one's new. You can provide functions
       to be called when the header info is valid,
       when each row is completed, and when the image
       is finished. If you aren't using all functions,
       you can specify NULL parameters. Even when all
       three functions are NULL, you need to call
       png_set_progressive_read_fn(). You can use
       any struct as the user_ptr (cast to a void pointer
       for the function call), and retrieve the pointer
       from inside the callbacks using the function

           png_get_progressive_ptr(png_ptr);

       which will return a void pointer, which you have
       to cast appropriately.
    */
    png_set_progressive_read_fn(png_ptr, (void *)user_ptr,
                                info_callback, row_callback, end_callback);

    return 0;
}

/* A code fragment that you call as you receive blocks
   of data */
int
process_data(png_bytep buffer, png_uint_32 length)
{
    if (setjmp(png_jmpbuf(png_ptr)))
    {
        png_destroy_read_struct(&png_ptr, &info_ptr,
                                (png_infopp)NULL);
        return (ERROR);
    }

    /* This one's new also. Simply give it a chunk
       of data from the file stream (in order, of
       course). On machines with segmented memory
       models machines, don't give it any more than

```

```

        64K. The library seems to run fine with sizes
        of 4K. Although you can give it much less if
        necessary (I assume you can give it chunks of
        1 byte, I haven't tried less than 256 bytes
        yet). When this function returns, you may
        want to display any rows that were generated
        in the row callback if you don't already do
        so there.
    */
    png_process_data(png_ptr, info_ptr, buffer, length);
    return 0;
}

/* This function is called (as set by
   png_set_progressive_read_fn() above) when enough data
   has been supplied so all of the header has been
   read.
*/
void
info_callback(png_structp png_ptr, png_info_ptr info)
{
    /* Do any setup here, including setting any of
       the transformations mentioned in the Reading
       PNG files section. For now, you must call
       either png_start_read_image() or
       png_read_update_info() after all the
       transformations are set (even if you don't set
       any). You may start getting rows before
       png_process_data() returns, so this is your
       last chance to prepare for that.
    */
}

/* This function is called when each row of image
   data is complete */
void
row_callback(png_structp png_ptr, png_bytep new_row,
             png_uint_32 row_num, int pass)
{
    /* If the image is interlaced, and you turned
       on the interlace handler, this function will
       be called for every row in every pass. Some
       of these rows will not be changed from the
       previous pass. When the row is not changed,
       the new_row variable will be NULL. The rows
       and passes are called in order, so you don't
       really need the row_num and pass, but I'm
       supplying them because it may make your life
       easier.

       For the non-NULL rows of interlaced images,
       you must call png_progressive_combine_row()
       passing in the row and the old row. You can
       call this function for NULL rows (it will just
       return) and for non-interlaced images (it just
       does the memcpy for you) if it will make the
       code easier. Thus, you can just do this for
       all cases:
    */

    png_progressive_combine_row(png_ptr, old_row,
                               new_row);
}

```

```

        /* where old_row is what was displayed for
           previously for the row. Note that the first
           pass (pass == 0, really) will completely cover
           the old row, so the rows do not have to be
           initialized. After the first pass (and only
           for interlaced images), you will have to pass
           the current row, and the function will combine
           the old row and the new row.
        */
    }

    void
    end_callback(png_structp png_ptr, png_infop info)
    {
        /* This function is called after the whole image
           has been read, including any chunks after the
           image (up to and including the IEND). You
           will usually have the same info chunk as you
           had in the header, although some data may have
           been added to the comments and time fields.

        Most people won't do much here, perhaps setting
           a flag that marks the image as finished.
        */
    }

```

Chapter 4

IV. Writing

Much of this is very similar to reading. However, everything of importance is repeated here, so you won't have to constantly look back up in the reading section to understand writing.

4.1 Setup

You will want to do the I/O initialization before you get into libpng, so if it doesn't work, you don't have anything to undo. If you are not using the standard I/O functions, you will need to replace them with custom writing functions. See the discussion under Customizing libpng.

```
FILE *fp = fopen(file_name, "wb");
if (!fp)
{
    return (ERROR);
}
```

Next, `png_struct` and `png_info` need to be allocated and initialized. As these can be both relatively large, you may not want to store these on the stack, unless you have stack space to spare. Of course, you will want to check if they return NULL. If you are also reading, you won't want to name your read structure and your write structure both "`png_ptr`"; you can call them anything you like, such as "`read_ptr`" and "`write_ptr`". Look at `pngtest.c`, for example.

```
png_structp png_ptr = png_create_write_struct
(PNG_LIBPNG_VER_STRING, (png_voidp)user_error_ptr,
 user_error_fn, user_warning_fn);
if (!png_ptr)
    return (ERROR);

png_infop info_ptr = png_create_info_struct(png_ptr);
if (!info_ptr)
{
    png_destroy_write_struct(&png_ptr,
        (png_infopp) NULL);
    return (ERROR);
}
```


If you want to use your own memory allocation routines, define `PNG_USER_MEM_SUPPORTED` and use `png_create_write_struct_2()` instead of `png_create_write_struct()`:

```
png_structp png_ptr = png_create_write_struct_2
(PNG_LIBPNG_VER_STRING, (png_voidp)user_error_ptr,
 user_error_fn, user_warning_fn, (png_voidp)
 user_mem_ptr, user_malloc_fn, user_free_fn);
```

After you have these structures, you will need to set up the error handling. When libpng encounters an error, it expects to `longjmp()` back to your routine. Therefore, you will need to call `setjmp()` and pass the `png_jmpbuf(png_ptr)`. If you write the file from different routines, you will need to update the `png_jmpbuf(png_ptr)` every time you enter a new routine that will call a `png_*` function. See your documentation of `setjmp/longjmp` for your compiler for more information on `setjmp/longjmp`. See the discussion on libpng error handling in the Customizing Libpng section below for more information on the libpng error handling.

```
if (setjmp(png_jmpbuf(png_ptr)))
{
    png_destroy_write_struct(&png_ptr, &info_ptr);
    fclose(fp);
    return (ERROR);
}
...
return;
```

If you would rather avoid the complexity of `setjmp/longjmp` issues, you can compile libpng with `PNG_SETJMP_NOT_SUPPORTED`, in which case errors will result in a call to `PNG_ABORT()` which defaults to `abort()`.

Now you need to set up the output code. The default for libpng is to use the C function `fwrite()`. If you use this, you will need to pass a valid `FILE *` in the function `png_init_io()`. Be sure that the file is opened in binary mode. Again, if you wish to handle writing data in another way, see the discussion on libpng I/O handling in the Customizing Libpng section below.

```
png_init_io(png_ptr, fp);
```

If you are embedding your PNG into a datastream such as MNG, and don't want libpng to write the 8-byte signature, or if you have already written the signature in your application, use

```
png_set_sig_bytes(png_ptr, 8);
```

to inform libpng that it should not write a signature.

4.2 Write callbacks

At this point, you can set up a callback function that will be called after each row has been written, which you can use to control a progress meter or the like. It's demonstrated in `pngtest.c`. You must supply a function

```
void write_row_callback(png_ptr, png_uint_32 row,
    int pass);
{
    /* put your code here */
}
```

(You can give it another name that you like instead of "write_row_callback")

To inform libpng about your function, use

```
png_set_write_status_fn(png_ptr, write_row_callback);
```

You now have the option of modifying how the compression library will run. The following functions are mainly for testing, but may be useful in some cases, like if you need to write PNG files extremely fast and are willing to give up some compression, or if you want to get the maximum possible compression at the expense of slower writing. If you have no special needs in this area, let the library do what it wants by not calling this function at all, as it has been tuned to deliver a good speed/compression ratio. The second parameter to `png_set_filter()` is the filter method, for which the only valid values are 0 (as of the July 1999 PNG specification, version 1.2) or 64 (if you are writing a PNG datastream that is to be embedded in a MNG datastream). The third parameter is a flag that indicates which filter type(s) are to be tested for each scanline. See the PNG specification for details on the specific filter types.

```
/* turn on or off filtering, and/or choose
specific filters. You can use either a single
PNG_FILTER_VALUE_NAME or the bitwise OR of one
or more PNG_FILTER_NAME masks. */
png_set_filter(png_ptr, 0,
    PNG_FILTER_NONE | PNG_FILTER_VALUE_NONE |
    PNG_FILTER_SUB | PNG_FILTER_VALUE_SUB |
    PNG_FILTER_UP | PNG_FILTER_VALUE_UP |
    PNG_FILTER_AVG | PNG_FILTER_VALUE_AVG |
    PNG_FILTER_PAETH | PNG_FILTER_VALUE_PAETH |
    PNG_ALL_FILTERS);
```

If an application wants to start and stop using particular filters during compression, it should start out with all of the filters (to ensure that the previous row of pixels will be stored in case it's needed later), and then add and remove them after the start of compression.

If you are writing a PNG datastream that is to be embedded in a MNG datastream, the second parameter can be either 0 or 64.

The `png_set_compression_*()` functions interface to the zlib compression library, and should mostly be ignored unless you really know what you are doing. The only generally useful call is `png_set_compression_level()` which changes how much time zlib spends on trying to compress the image data. See the Compression Library (zlib.h and algorithm.txt, distributed with zlib) for details on the compression levels.

```
/* set the zlib compression level */
png_set_compression_level(png_ptr,
    Z_BEST_COMPRESSION);

/* set other zlib parameters */
png_set_compression_mem_level(png_ptr, 8);
png_set_compression_strategy(png_ptr,
    Z_DEFAULT_STRATEGY);
png_set_compression_window_bits(png_ptr, 15);
png_set_compression_method(png_ptr, 8);
png_set_compression_buffer_size(png_ptr, 8192)

extern PNG_EXPORT(void, png_set_zbuf_size)
```

4.3 Setting the contents of info for output

You now need to fill in the `png_info` structure with all the data you wish to write before the actual image. Note that the only thing you are allowed to write after the image is the text chunks and the time chunk (as of PNG Specification 1.2, anyway). See `png_write_end()` and the latest PNG specification for more information on that. If you wish to write them before the image, fill them in now, and flag that data as being valid. If you want to wait until after the data, don't fill them until `png_write_end()`. For all the fields in `png_info` and their data types, see `png.h`. For explanations of what the fields contain, see the PNG specification.

Some of the more important parts of the `png_info` are:

```
png_set_IHDR(png_ptr, info_ptr, width, height,
             bit_depth, color_type, interlace_type,
             compression_type, filter_method)
width        - holds the width of the image
               in pixels (up to 2^31).
height       - holds the height of the image
               in pixels (up to 2^31).
bit_depth    - holds the bit depth of one of the
               image channels.
               (valid values are 1, 2, 4, 8, 16
               and depend also on the
               color_type. See also significant
               bits (sBIT) below).
color_type   - describes which color/alpha
               channels are present.
               PNG_COLOR_TYPE_GRAY
                 (bit depths 1, 2, 4, 8, 16)
               PNG_COLOR_TYPE_GRAY_ALPHA
                 (bit depths 8, 16)
               PNG_COLOR_TYPE_PALETTE
                 (bit depths 1, 2, 4, 8)
               PNG_COLOR_TYPE_RGB
                 (bit depths 8, 16)
               PNG_COLOR_TYPE_RGB_ALPHA
                 (bit depths 8, 16)

               PNG_COLOR_MASK_PALETTE
               PNG_COLOR_MASK_COLOR
               PNG_COLOR_MASK_ALPHA

interlace_type - PNG_INTERLACE_NONE or
                 PNG_INTERLACE_ADAM7
compression_type - (must be
                   PNG_COMPRESSION_TYPE_DEFAULT)
filter_method  - (must be PNG_FILTER_TYPE_DEFAULT
                 or, if you are writing a PNG to
                 be embedded in a MNG datastream,
                 can also be
                 PNG_INTRAPIXEL_DIFFERENCING)
```

If you call `png_set_IHDR()`, the call must appear before any of the other `png_set_*()` functions, because they might require access to some of the IHDR settings. The remaining `png_set_*()` functions can be called in any order.

If you wish, you can reset the `compression_type`, `interlace_type`, or `filter_method` later by calling `png_set_IHDR()` again; if you do this, the `width`, `height`, `bit_depth`, and `color_type` must be the same in each call.

```

png_set_PLTE(png_ptr, info_ptr, palette,
             num_palette);
palette      - the palette for the file
               (array of png_color)
num_palette  - number of entries in the palette

png_set_gAMA(png_ptr, info_ptr, gamma);
gamma        - the gamma the image was created
               at (PNG_INFO_gAMA)

png_set_sRGB(png_ptr, info_ptr, srgb_intent);
srgb_intent  - the rendering intent
               (PNG_INFO_sRGB) The presence of
               the sRGB chunk means that the pixel
               data is in the sRGB color space.
               This chunk also implies specific
               values of gAMA and cHRM. Rendering
               intent is the CSS-1 property that
               has been defined by the International
               Color Consortium
               (http://www.color.org).
               It can be one of
               PNG_sRGB_INTENT_SATURATION,
               PNG_sRGB_INTENT_PERCEPTUAL,
               PNG_sRGB_INTENT_ABSOLUTE, or
               PNG_sRGB_INTENT_RELATIVE.

png_set_sRGB_gAMA_and_cHRM(png_ptr, info_ptr,
                           srgb_intent);
srgb_intent  - the rendering intent
               (PNG_INFO_sRGB) The presence of the
               sRGB chunk means that the pixel
               data is in the sRGB color space.
               This function also causes gAMA and
               cHRM chunks with the specific values
               that are consistent with sRGB to be
               written.

png_set_iCCP(png_ptr, info_ptr, name, compression_type,
             profile, proflen);
name          - The profile name.
compression   - The compression type; always
               PNG_COMPRESSION_TYPE_BASE for PNG 1.0.
               You may give NULL to this argument to
               ignore it.
profile       - International Color Consortium color
               profile data. May contain NULs.
proflen       - length of profile data in bytes.

png_set_sBIT(png_ptr, info_ptr, sig_bit);
sig_bit       - the number of significant bits for
               (PNG_INFO_sBIT) each of the gray, red,
               green, and blue channels, whichever are
               appropriate for the given color type
               (png_color_16)

png_set_tRNS(png_ptr, info_ptr, trans_alpha,
             num_trans, trans_color);
trans_alpha   - array of alpha (transparency)
               entries for palette (PNG_INFO_tRNS)
trans_color   - graylevel or color sample values

```

```

        (in order red, green, blue) of the
        single transparent color for
        non-paletted images (PNG_INFO_tRNS)
num_trans      - number of transparent entries
                  (PNG_INFO_tRNS)

png_set_hIST(png_ptr, info_ptr, hist);
                (PNG_INFO_hIST)
hist           - histogram of palette (array of
                  png_uint_16)

png_set_tIME(png_ptr, info_ptr, mod_time);
mod_time       - time image was last modified
                  (PNG_VALID_tIME)

png_set_bKGD(png_ptr, info_ptr, background);
background     - background color (PNG_VALID_bKGD)

png_set_text(png_ptr, info_ptr, text_ptr, num_text);
text_ptr       - array of png_text holding image
                  comments
text_ptr[i].compression - type of compression used
                        on "text" PNG_TEXT_COMPRESSION_NONE
                        PNG_TEXT_COMPRESSION_zTXt
                        PNG_ITXT_COMPRESSION_NONE
                        PNG_ITXT_COMPRESSION_zTXt
text_ptr[i].key   - keyword for comment. Must contain
                  1-79 characters.
text_ptr[i].text  - text comments for current
                  keyword. Can be NULL or empty.
text_ptr[i].text_length - length of text string,
                  after decompression, 0 for iTXt
text_ptr[i].itxt_length - length of itxt string,
                  after decompression, 0 for tEXt/zTXt
text_ptr[i].lang  - language of comment (NULL or
                  empty for unknown).
text_ptr[i].translated_keyword - keyword in UTF-8 (NULL
                  or empty for unknown).
Note that the itxt_length, lang, and lang_key
members of the text_ptr structure only exist
when the library is built with iTXt chunk support.

num_text       - number of comments

png_set_sPLT(png_ptr, info_ptr, &palette_ptr,
              num_spalettes);
palette_ptr    - array of png_sPLT_struct structures
                  to be added to the list of palettes
                  in the info structure.
num_spalettes  - number of palette structures to be
                  added.

png_set_oFFs(png_ptr, info_ptr, offset_x, offset_y,
              unit_type);
offset_x       - positive offset from the left
                  edge of the screen
offset_y       - positive offset from the top
                  edge of the screen
unit_type      - PNG_OFFSET_PIXEL, PNG_OFFSET_MICROMETER

png_set_pHYs(png_ptr, info_ptr, res_x, res_y,
              unit_type);

```

```

res_x      - pixels/unit physical resolution
             in x direction
res_y      - pixels/unit physical resolution
             in y direction
unit_type  - PNG_RESOLUTION_UNKNOWN,
             PNG_RESOLUTION_METER

png_set_sCAL(png_ptr, info_ptr, unit, width, height)
unit       - physical scale units (an integer)
width      - width of a pixel in physical scale units
height     - height of a pixel in physical scale units
             (width and height are doubles)

png_set_sCAL_s(png_ptr, info_ptr, unit, width, height)
unit       - physical scale units (an integer)
width      - width of a pixel in physical scale units
height     - height of a pixel in physical scale units
             (width and height are strings like "2.54")

png_set_unknown_chunks(png_ptr, info_ptr, &unknowns,
                       num_unknowns)
unknowns    - array of png_unknown_chunk
              structures holding unknown chunks
unknowns[i].name - name of unknown chunk
unknowns[i].data - data of unknown chunk
unknowns[i].size - size of unknown chunk's data
unknowns[i].location - position to write chunk in file
                     0: do not write chunk
                     PNG_HAVE_IHDR: before PLTE
                     PNG_HAVE_PLTE: before IDAT
                     PNG_AFTER_IDAT: after IDAT

```

The "location" member is set automatically according to what part of the output file has already been written. You can change its value after calling `png_set_unknown_chunks()` as demonstrated in `pngtest.c`. Within each of the "locations", the chunks are sequenced according to their position in the structure (that is, the value of "i", which is the order in which the chunk was either read from the input file or defined with `png_set_unknown_chunks`).

A quick word about text and `num_text`. `text` is an array of `png_text` structures. `num_text` is the number of valid structures in the array. Each `png_text` structure holds a language code, a keyword, a text value, and a compression type.

The compression types have the same valid numbers as the compression types of the image data. Currently, the only valid number is zero. However, you can store text either compressed or uncompressed, unlike images, which always have to be compressed. So if you don't want the text compressed, set the compression type to `PNG_TEXT_COMPRESSION_NONE`. Because `tEXt` and `zTXt` chunks don't have a language field, if you specify `PNG_TEXT_COMPRESSION_NONE` or `PNG_TEXT_COMPRESSION_zTXt` any language code or translated keyword will not be written out.

Until text gets around 1000 bytes, it is not worth compressing it. After the text has been written out to the file, the compression type is set to `PNG_TEXT_COMPRESSION_NONE_WR` or `PNG_TEXT_COMPRESSION_zTXt_WR`, so that it isn't written out again at the end (in case you are calling `png_write_end()` with the same struct).

The keywords that are given in the PNG Specification are:

Title	Short (one line) title or caption for image
Author	Name of image's creator

Description	Description of image (possibly long)
Copyright	Copyright notice
Creation Time	Time of original image creation (usually RFC 1123 format, see below)
Software	Software used to create the image
Disclaimer	Legal disclaimer
Warning	Warning of nature of content
Source	Device used to create the image
Comment	Miscellaneous comment; conversion from other image format

The keyword-text pairs work like this. Keywords should be short simple descriptions of what the comment is about. Some typical keywords are found in the PNG specification, as is some recommendations on keywords. You can repeat keywords in a file. You can even write some text before the image and some after. For example, you may want to put a description of the image before the image, but leave the disclaimer until after, so viewers working over modem connections don't have to wait for the disclaimer to go over the modem before they start seeing the image. Finally, keywords should be full words, not abbreviations. Keywords and text are in the ISO 8859-1 (Latin-1) character set (a superset of regular ASCII) and can not contain NUL characters, and should not contain control or other unprintable characters. To make the comments widely readable, stick with basic ASCII, and avoid machine specific character set extensions like the IBM-PC character set. The keyword must be present, but you can leave off the text string on non-compressed pairs. Compressed pairs must have a text string, as only the text string is compressed anyway, so the compression would be meaningless.

PNG supports modification time via the `png_time` structure. Two conversion routines are provided, `png_convert_from_time_t()` for `time_t` and `png_convert_from_struct_tm()` for `struct tm`. The `time_t` routine uses `gmtime()`. You don't have to use either of these, but if you wish to fill in the `png_time` structure directly, you should provide the time in universal time (GMT) if possible instead of your local time. Note that the year number is the full year (e.g. 1998, rather than 98 - PNG is year 2000 compliant!), and that months start with 1.

If you want to **store the time of the original image creation**, you should use a plain tEXt chunk with the "Creation Time" keyword. This is necessary because the "creation time" of a PNG image is somewhat vague, depending on whether you mean the PNG file, the time the image was created in a non-PNG format, a still photo from which the image was scanned, or possibly the subject matter itself. In order to facilitate machine-readable dates, it is recommended that the "Creation Time" tEXt chunk use RFC 1123 format dates (e.g. "22 May 1997 18:07:10 GMT"), although this isn't a requirement. Unlike the tIME chunk, the "Creation Time" tEXt chunk is not expected to be automatically changed by the software. To facilitate the use of RFC 1123 dates, a function `png_convert_to_rfc1123(png_timep)` is provided to convert from PNG time to an RFC 1123 format string.

4.4 Writing unknown chunks

You can use the `png_set_unknown_chunks` function to queue up chunks for writing. You give it a chunk name, **raw data**, and a size; that's all there is to it. The chunks will be written by the next following `png_write_info_before_PLTE`, `png_write_info`, or `png_write_end` function. Any chunks previously read

into the info structure's unknown-chunk list will also be written out in a sequence that satisfies the PNG specification's ordering rules.

4.5 The high-level write interface

At this point there are two ways to proceed; through the high-level write interface, or through a sequence of low-level write operations. You can use the high-level interface if your image data is present in the info structure. All defined output transformations are permitted, enabled by the following masks.

PNG_TRANSFORM_IDENTITY	No transformation
PNG_TRANSFORM_PACKING	Pack 1, 2 and 4-bit samples
PNG_TRANSFORM_PACKSWAP	Change order of packed pixels to LSB first
PNG_TRANSFORM_INVERT_MONO	Invert monochrome images
PNG_TRANSFORM_SHIFT	Normalize pixels to the sBIT depth
PNG_TRANSFORM_BGR	Flip RGB to BGR, RGBA to BGRA
PNG_TRANSFORM_SWAP_ALPHA	Flip RGBA to ARGB or GA to AG
PNG_TRANSFORM_INVERT_ALPHA	Change alpha from opacity to transparency
PNG_TRANSFORM_SWAP_ENDIAN	Byte-swap 16-bit samples
PNG_TRANSFORM_STRIP_FILLER	Strip out filler bytes (deprecated).
PNG_TRANSFORM_STRIP_FILLER_BEFORE	Strip out leading filler bytes
PNG_TRANSFORM_STRIP_FILLER_AFTER	Strip out trailing filler bytes

If you have valid image data in the info structure (you can use `png_set_rows()` to put image data in the info structure), simply do this:

```
png_write_png(png_ptr, info_ptr, png_transforms, NULL)
```

where `png_transforms` is an integer containing the bitwise OR of some set of transformation flags. This call is equivalent to `png_write_info()`, followed the set of transformations indicated by the transform mask, then `png_write_image()`, and finally `png_write_end()`.

(The final parameter of this call is not yet used. Someday it might point to transformation parameters required by some future output transform.)

You must use `png_transforms` and not call any `png_set_transform()` functions when you use `png_write_png()`.

4.6 The low-level write interface

If you are going the low-level route instead, you are now ready to write all the file information up to the actual image data. You do this with a call to `png_write_info()`.

```
png_write_info(png_ptr, info_ptr);
```

Note that there is one transformation you may need to do before `png_write_info()`. In PNG files, the alpha channel in an image is the level of opacity. If your data is

supplied as a level of transparency, you can invert the alpha channel before you write it, so that 0 is fully transparent and 255 (in 8-bit or paletted images) or 65535 (in 16-bit images) is fully opaque, with

```
png_set_invert_alpha(png_ptr);
```

This must appear before `png_write_info()` instead of later with the other transformations because in the case of paletted images the tRNS chunk data has to be inverted before the tRNS chunk is written. If your image is not a paletted image, the tRNS data (which in such cases represents a single color to be rendered as transparent) won't need to be changed, and you can safely do this transformation after your `png_write_info()` call.

If you need to write a private chunk that you want to appear before the PLTE chunk when PLTE is present, you can write the PNG info in two steps, and insert code to write your own chunk between them:

```
png_write_info_before_PLTE(png_ptr, info_ptr);
png_set_unknown_chunks(png_ptr, info_ptr, ...);
png_write_info(png_ptr, info_ptr);
```

After you've written the file information, you can set up the library to handle any special transformations of the image data. The various ways to transform the data will be described in the order that they should occur. This is important, as some of these change the color type and/or bit depth of the data, and some others only work on certain color types and bit depths. Even though each transformation checks to see if it has data that it can do something with, you should make sure to only enable a transformation if it will be valid for the data. For example, don't swap red and blue on grayscale data.

PNG files store RGB pixels packed into 3 or 6 bytes. This code tells the library to strip input data that has 4 or 8 bytes per pixel down to 3 or 6 bytes (or strip 2 or 4-byte grayscale+filler data to 1 or 2 bytes per pixel).

```
png_set_filler(png_ptr, 0, PNG_FILLER_BEFORE);
```

where the 0 is unused, and the location is either `PNG_FILLER_BEFORE` or `PNG_FILLER_AFTER`, depending upon whether the filler byte in the pixel is stored XRGB or RGBX.

PNG files pack pixels of bit depths 1, 2, and 4 into bytes as small as they can, resulting in, for example, 8 pixels per byte for 1 bit files. If the data is supplied at 1 pixel per byte, use this code, which will correctly pack the pixels into a single byte:

```
png_set_packing(png_ptr);
```

PNG files reduce possible bit depths to 1, 2, 4, 8, and 16. If your data is of another bit depth, you can write an sBIT chunk into the file so that decoders can recover the original data if desired.

```
/* Set the true bit depth of the image data */
if (color_type & PNG_COLOR_MASK_COLOR)
{
    sig_bit.red = true_bit_depth;
    sig_bit.green = true_bit_depth;
    sig_bit.blue = true_bit_depth;
}
else
{
    sig_bit.gray = true_bit_depth;
}
if (color_type & PNG_COLOR_MASK_ALPHA)
```

```

{
    sig_bit.alpha = true_bit_depth;
}

png_set_sBIT(png_ptr, info_ptr, &sig_bit);

```

If the data is stored in the row buffer in a bit depth other than one supported by PNG (e.g. 3 bit data in the range 0-7 for a 4-bit PNG), this will scale the values to appear to be the correct bit depth as is required by PNG.

```
png_set_shift(png_ptr, &sig_bit);
```

PNG files store 16 bit pixels in network byte order (big-endian, ie. most significant bits first). This code would be used if they are supplied the other way (little-endian, i.e. least significant bits first, the way PCs store them):

```

if (bit_depth > 8)
    png_set_swap(png_ptr);

```

If you are using packed-pixel images (1, 2, or 4 bits/pixel), and you need to change the order the pixels are packed into bytes, you can use:

```

if (bit_depth < 8)
    png_set_packswap(png_ptr);

```

PNG files store 3 color pixels in red, green, blue order. This code would be used if they are supplied as blue, green, red:

```
png_set_bgr(png_ptr);
```

PNG files describe monochrome as black being zero and white being one. This code would be used if the pixels are supplied with this reversed (black being one and white being zero):

```
png_set_invert_mono(png_ptr);
```

Finally, you can write your own transformation function if none of the existing ones meets your needs. This is done by setting a callback with

```

png_set_write_user_transform_fn(png_ptr,
    write_transform_fn);

```

You must supply the function

```

void write_transform_fn(png_ptr ptr, row_info_ptr
    row_info, png_bytep data)

```

See pngtest.c for a working example. Your function will be called before any of the other transformations are processed.

You can also set up a pointer to a user structure for use by your callback function.

```
png_set_user_transform_info(png_ptr, user_ptr, 0, 0);
```

The `user_channels` and `user_depth` parameters of this function are ignored when writing; you can set them to zero as shown.

You can retrieve the pointer via the function `png_get_user_transform_ptr()`. For example:

```

voidp write_user_transform_ptr =
    png_get_user_transform_ptr(png_ptr);

```

It is possible to have libpng flush any pending output, either manually, or automatically after a certain number of lines have been written. To flush the output stream a single time call:

```
png_write_flush(png_ptr);
```

and to have libpng flush the output stream periodically after a certain number of scanlines have been written, call:

```
png_set_flush(png_ptr, nrows);
```

Note that the distance between rows is from the last time `png_write_flush()` was called, or the first row of the image if it has never been called. So if you write 50 lines, and then `png_set_flush 25`, it will flush the output on the next scanline, and every 25 lines thereafter, unless `png_write_flush()` is called before 25 more lines have been written. If `nrows` is too small (less than about 10 lines for a 640 pixel wide RGB image) the image compression may decrease noticeably (although this may be acceptable for real-time applications). Infrequent flushing will only degrade the compression performance by a few percent over images that do not use flushing.

4.7 Writing the image data

That's it for the transformations. Now you can write the image data. The simplest way to do this is in one function call. If you have the whole image in memory, you can just call `png_write_image()` and libpng will write the image. You will need to pass in an array of pointers to each row. This function automatically handles interlacing, so you don't need to call `png_set_interlace_handling()` or call this function multiple times, or any of that other stuff necessary with `png_write_rows()`.

```
png_write_image(png_ptr, row_pointers);
```

where `row_pointers` is:

```
png_byte *row_pointers[height];
```

You can point to void or char or whatever you use for pixels.

If you don't want to write the whole image at once, you can use `png_write_rows()` instead. If the file is not interlaced, this is simple:

```
png_write_rows(png_ptr, row_pointers,  
               number_of_rows);
```

`row_pointers` is the same as in the `png_write_image()` call.

If you are just writing one row at a time, you can do this with a single `row_pointer` instead of an array of `row_pointers`:

```
png_bytep row_pointer = row;  
  
png_write_row(png_ptr, row_pointer);
```

When the file is interlaced, things can get a good deal more complicated. The only currently (as of the PNG Specification version 1.2, dated July 1999) defined interlacing scheme for PNG files is the "Adam7" interlace scheme, that breaks down an image into seven smaller images of varying size. libpng will build these images for you, or you

can do them yourself. If you want to build them yourself, see the PNG specification for details of which pixels to write when.

If you don't want libpng to handle the interlacing details, just use `png_set_interlace_handling()` and call `png_write_rows()` the correct number of times to write all seven sub-images.

If you want libpng to build the sub-images, call this before you start writing any rows:

```
number_of_passes =  
    png_set_interlace_handling(png_ptr);
```

This will return the number of passes needed. Currently, this is seven, but may change if another interlace type is added.

Then write the complete image `number_of_passes` times.

```
png_write_rows(png_ptr, row_pointers,  
    number_of_rows);
```

As some of these rows are not used, and thus return immediately, you may want to read about interlacing in the PNG specification, and only update the rows that are actually used.

4.8 Finishing a sequential write

After you are finished writing the image, you should finish writing the file. If you are interested in writing comments or time, you should pass an appropriately filled `png_info` pointer. If you are not interested, you can pass `NULL`.

```
png_write_end(png_ptr, info_ptr);
```

When you are done, you can free all memory used by libpng like this:

```
png_destroy_write_struct(&png_ptr, &info_ptr);
```

It is also possible to individually free the `info_ptr` members that point to libpng-allocated storage with the following function:

```
png_free_data(png_ptr, info_ptr, mask, seq)  
mask - identifies data to be freed, a mask  
       containing the bitwise OR of one or  
       more of  
       PNG_FREE_PLTE, PNG_FREE_TRNS,  
       PNG_FREE_HIST, PNG_FREE_ICCP,  
       PNG_FREE_PCAL, PNG_FREE_ROWS,  
       PNG_FREE_SCAL, PNG_FREE_SPLT,  
       PNG_FREE_TEXT, PNG_FREE_UNKN,  
       or simply PNG_FREE_ALL  
seq   - sequence number of item to be freed  
       (-1 for all items)
```

This function may be safely called when the relevant storage has already been freed, or has not yet been allocated, or was allocated by the user and not by libpng, and will in those cases do nothing. The "seq" parameter is ignored if only one item of the selected data type, such as PLTE, is allowed. If "seq" is not -1, and multiple items are allowed for the data type identified in the mask, such as text or sPLT, only the n'th item in the structure is freed, where n is "seq".

If you allocated data such as a palette that you passed in to libpng with `png_set_*`, you must not free it until just before the call to `png_destroy_write_struct()`.

The default behavior is only to free data that was allocated internally by libpng. This can be changed, so that libpng will not free the data, or so that it will free data that was allocated by the user with `png_malloc()` or `png_zalloc()` and passed in via a `png_set_*` function, with

```
png_data_freer(png_ptr, info_ptr, freer, mask)
mask    - which data elements are affected
          same choices as in png_free_data()
freer    - one of
            PNG_DESTROY_WILL_FREE_DATA
            PNG_SET_WILL_FREE_DATA
            PNG_USER_WILL_FREE_DATA
```

For example, to transfer responsibility for some data from a read structure to a write structure, you could use

```
png_data_freer(read_ptr, read_info_ptr,
    PNG_USER_WILL_FREE_DATA,
    PNG_FREE_PLTE|PNG_FREE_tRNS|PNG_FREE_hIST)
png_data_freer(write_ptr, write_info_ptr,
    PNG_DESTROY_WILL_FREE_DATA,
    PNG_FREE_PLTE|PNG_FREE_tRNS|PNG_FREE_hIST)
```

thereby briefly reassigning responsibility for freeing to the user but immediately afterwards reassigning it once more to the `write_destroy` function. Having done this, it would then be safe to destroy the read structure and continue to use the PLTE, tRNS, and hIST data in the write structure.

This function only affects data that has already been allocated. You can call this function before calling after the `png_set_*` functions to control whether the user or `png_destroy_*` is supposed to free the data. When the user assumes responsibility for libpng-allocated data, the application must use `png_free()` to free it, and when the user transfers responsibility to libpng for data that the user has allocated, the user must have used `png_malloc()` or `png_zalloc()` to allocate it.

If you allocated `text_ptr.text`, `text_ptr.lang`, and `text_ptr.translated_keyword` separately, do not transfer responsibility for freeing `text_ptr` to libpng, because when libpng fills a `png_text` structure it combines these members with the key member, and `png_free_data()` will free only `text_ptr.key`. Similarly, if you transfer responsibility for freeing `text_ptr` from libpng to your application, your application must not separately free those members. For a more compact example of writing a PNG image, see the file `example.c`.

Chapter 5

V. Modifying/Customizing libpng:

There are two issues here. The first is changing how libpng does standard things like memory allocation, input/output, and error handling. The second deals with more complicated things like adding new chunks, adding new transformations, and generally changing how libpng works. Both of those are compile-time issues; that is, they are generally determined at the time the code is written, and there is rarely a need to provide the user with a means of changing them.

5.1 Memory allocation, input/output, and error handling

All of the memory allocation, input/output, and error handling in libpng goes through callbacks that are user-settable. The default routines are in `pngmem.c`, `pngrio.c`, `pngwio.c`, and `pngerror.c`, respectively. To change these functions, call the appropriate `png_set_*_fn()` function.

Memory allocation is done through the functions `png_malloc()`, `png_calloc()`, and `png_free()`. These currently just call the standard C functions. `png_calloc()` calls `png_malloc()` and then `png_memset()` to clear the newly allocated memory to zero. If your pointers can't access more than 64K at a time, you will want to set `MAXSEG_64K` in `zlib.h`. Since it is unlikely that the method of handling memory allocation on a platform will change between applications, these functions must be modified in the library at compile time. If you prefer to use a different method of allocating and freeing data, you can use `png_create_read_struct_2()` or `png_create_write_struct_2()` to register your own functions as described above. These functions also provide a void pointer that can be retrieved via

```
mem_ptr=png_get_mem_ptr(png_ptr);
```

Your replacement memory functions must have prototypes as follows:

```
png_voidp malloc_fn(png_structp png_ptr,  
    png_size_t size);  
void free_fn(png_structp png_ptr, png_voidp ptr);
```

Your `malloc_fn()` must return `NULL` in case of failure. The `png_malloc()` function will normally call `png_error()` if it receives a `NULL` from the system memory allocator or from your replacement `malloc_fn()`.

Your `free_fn()` will never be called with a `NULL` ptr, since libpng's `png_free()` checks for `NULL` before calling `free_fn()`.

Input/Output in libpng is done through `png_read()` and `png_write()`, which currently just call `fread()` and `fwrite()`. The `FILE *` is stored in `png_struct` and is initialized via `png_init_io()`. If you wish to change the method of I/O, the library supplies callbacks that you can set through the function `png_set_read_fn()` and `png_set_write_fn()` at run time, instead of calling the `png_init_io()` function. These functions also provide a void pointer that can be retrieved via the function `png_get_io_ptr()`. For example:

```
png_set_read_fn(png_structp read_ptr,
                voidp read_io_ptr, png_rw_ptr read_data_fn)

png_set_write_fn(png_structp write_ptr,
                 voidp write_io_ptr, png_rw_ptr write_data_fn,
                 png_flush_ptr output_flush_fn);

voidp read_io_ptr = png_get_io_ptr(read_ptr);
voidp write_io_ptr = png_get_io_ptr(write_ptr);
```

The replacement I/O functions must have prototypes as follows:

```
void user_read_data(png_structp png_ptr,
                    png_bytep data, png_size_t length);
void user_write_data(png_structp png_ptr,
                     png_bytep data, png_size_t length);
void user_flush_data(png_structp png_ptr);
```

The `user_read_data()` function is responsible for detecting and handling end-of-data errors.

Supplying `NULL` for the read, write, or flush functions sets them back to using the default C stream functions, which expect the `io_ptr` to point to a standard `FILE *` structure. It is probably a mistake to use `NULL` for one of `write_data_fn` and `output_flush_fn` but not both of them, unless you have built libpng with `PNG_NO_WRITE_FLUSH` defined. It is an error to read from a write stream, and vice versa.

Error handling in libpng is done through `png_error()` and `png_warning()`. Errors handled through `png_error()` are fatal, meaning that `png_error()` should never return to its caller. Currently, this is handled via `setjmp()` and `longjmp()` (unless you have compiled libpng with `PNG_SETJMP_NOT_SUPPORTED`, in which case it is handled via `PNG_ABORT()`), but you could change this to do things like `exit()` if you should wish.

On non-fatal errors, `png_warning()` is called to print a warning message, and then control returns to the calling code. By default `png_error()` and `png_warning()` print a message on `stderr` via `fprintf()` unless the library is compiled with `PNG_NO_CONSOLE_IO` defined (because you don't want the messages) or `PNG_NO_STDIO` defined (because `fprintf()` isn't available). If you wish to change the behavior of the error functions, you will need to set up your own message callbacks. These functions are normally supplied at the time that the `png_struct` is created. It is also possible to redirect errors and warnings to your own replacement functions after `png_create_*_struct()` has been called by calling:

```

png_set_error_fn(png_structp png_ptr,
                 png_voidp error_ptr, png_error_ptr error_fn,
                 png_error_ptr warning_fn);

png_voidp error_ptr = png_get_error_ptr(png_ptr);

```

If NULL is supplied for either `error_fn` or `warning_fn`, then the libpng default function will be used, calling `fprintf()` and/or `longjmp()` if a problem is encountered. The replacement error functions should have parameters as follows:

```

void user_error_fn(png_structp png_ptr,
                   png_const_charp error_msg);
void user_warning_fn(png_structp png_ptr,
                     png_const_charp warning_msg);

```

The motivation behind using `setjmp()` and `longjmp()` is the C++ throw and catch exception handling methods. This makes the code much easier to write, as there is no need to check every return code of every function call. However, there are some uncertainties about the status of local variables after a `longjmp`, so the user may want to be careful about doing anything after `setjmp` returns non-zero besides returning itself. Consult your compiler documentation for more details. For an alternative approach, you may wish to use the "cexcept" facility (see <http://cexcept.sourceforge.net>).

5.2 Custom chunks

If you need to read or write custom chunks, you may need to get deeper into the libpng code. The library now has mechanisms for storing and writing chunks of unknown type; you can even declare callbacks for custom chunks. However, this may not be good enough if the library code itself needs to know about interactions between your chunk and existing 'intrinsic' chunks.

If you need to write a new intrinsic chunk, first read the PNG specification. Acquire a first level of understanding of how it works. Pay particular attention to the sections that describe chunk names, and look at how other chunks were designed, so you can do things similarly. Second, check out the sections of libpng that read and write chunks. Try to find a chunk that is similar to yours and use it as a template. More details can be found in the comments inside the code. It is best to handle unknown chunks in a generic method, via callback functions, instead of by modifying libpng functions.

If you wish to write your own transformation for the data, look through the part of the code that does the transformations, and check out some of the simpler ones to get an idea of how they work. Try to find a similar transformation to the one you want to add and copy off of it. More details can be found in the comments inside the code itself.

5.3 Configuring for 16 bit platforms

You will want to look into `zconf.h` to tell zlib (and thus libpng) that it cannot allocate more than 64K at a time. Even if you can, the memory won't be accessible. So limit zlib and libpng to 64K by defining `MAXSEG_64`.

5.4 Configuring for DOS

For DOS users who only have access to the lower 640K, you will have to limit zlib's memory usage via a `png_set_compression_mem_level()` call. See `zlib.h` or `zconf.h` in the zlib library for more information.

5.5 Configuring for Medium Model

Libpng's support for medium model has been tested on most of the popular compilers. Make sure `MAXSEG_64K` gets defined, `USE_FAR_KEYWORD` gets defined, and `FAR` gets defined to `far` in `pngconf.h`, and you should be all set. Everything in the library (except for zlib's structure) is expecting far data. You must use the typedefs with the `p` or `pp` on the end for pointers (or at least look at them and be careful). Make note that the rows of data are defined as `png_bytepp`, which is an unsigned char `far * far *`.

5.6 Configuring for gui/windowing platforms:

You will need to write new error and warning functions that use the GUI interface, as described previously, and set them to be the error and warning functions at the time that `png_create_struct()` is called, in order to have them available during the structure initialization. They can be changed later via `png_set_error_fn()`. On some compilers, you may also have to change the memory allocators (`png_malloc`, etc.).

5.7 Configuring for compiler xxx:

All includes for libpng are in `pngconf.h`. If you need to add, change or delete an include, this is the place to do it. The includes that are not needed outside libpng are placed in `pngpriv.h`, which is only used by the routines inside libpng itself. The files in libpng proper only include `pngpriv.h` and `png.h`, which in turn includes `pngconf.h`.

5.8 Configuring zlib:

There are special functions to configure the compression. Perhaps the most useful one changes the compression level, which currently uses input compression values in the range 0 - 9. The library normally uses the default compression level (`Z_DEFAULT_COMPRESSION` = 6). Tests have shown that for a large majority of images, compression values in the range 3-6 compress nearly as well as higher levels, and do so much faster. For on-line applications it may be desirable to have maximum speed (`Z_BEST_SPEED` = 1). With versions of zlib after v0.99, you can also specify no compression (`Z_NO_COMPRESSION` = 0), but this would create files larger than just storing the raw bitmap. You can specify the compression level by calling:

```
png_set_compression_level(png_ptr, level);
```

Another useful one is to reduce the memory level used by the library. The memory level defaults to 8, but it can be lowered if you are short on memory (running DOS, for example, where you only have 640K). Note that the memory level does have an effect

on compression; among other things, lower levels will result in sections of incompressible data being emitted in smaller stored blocks, with a correspondingly larger relative overhead of up to 15% in the worst case.

```
png_set_compression_mem_level(png_ptr, level);
```

The other functions are for configuring zlib. They are not recommended for normal use and may result in writing an invalid PNG file. See `zlib.h` for more information on what these mean.

```
png_set_compression_strategy(png_ptr,
    strategy);
png_set_compression_window_bits(png_ptr,
    window_bits);
png_set_compression_method(png_ptr, method);
png_set_compression_buffer_size(png_ptr, size);
```

5.9 Controlling row filtering

If you want to control whether libpng uses filtering or not, which filters are used, and how it goes about picking row filters, you can call one of these functions. The selection and configuration of row filters can have a significant impact on the size and encoding speed and a somewhat lesser impact on the decoding speed of an image. Filtering is enabled by default for RGB and grayscale images (with and without alpha), but not for paletted images nor for any images with bit depths less than 8 bits/pixel.

The 'method' parameter sets the main filtering method, which is currently only '0' in the PNG 1.2 specification. The 'filters' parameter sets which filter(s), if any, should be used for each scanline. Possible values are `PNG_ALL_FILTERS` and `PNG_NO_FILTERS` to turn filtering on and off, respectively.

Individual filter types are `PNG_FILTER_NONE`, `PNG_FILTER_SUB`, `PNG_FILTER_UP`, `PNG_FILTER_AVG`, `PNG_FILTER_PAETH`, which can be bitwise ORed together with '—' to specify one or more filters to use. These filters are described in more detail in the PNG specification. If you intend to change the filter type during the course of writing the image, you should start with flags set for all of the filters you intend to use so that libpng can initialize its internal structures appropriately for all of the filter types. (Note that this means the first row must always be adaptively filtered, because libpng currently does not allocate the filter buffers until `png_write_row()` is called for the first time.)

```
filters = PNG_FILTER_NONE | PNG_FILTER_SUB
          PNG_FILTER_UP | PNG_FILTER_AVG |
          PNG_FILTER_PAETH | PNG_ALL_FILTERS;

png_set_filter(png_ptr, PNG_FILTER_TYPE_BASE,
    filters);

    The second parameter can also be
    PNG_INTRAPIXEL_DIFFERENCING if you are
    writing a PNG to be embedded in a MNG
    datastream. This parameter must be the
    same as the value of filter_method used
    in png_set_IHDR().
```

It is also possible to influence how libpng chooses from among the available filters. This is done in one or both of two ways - by telling it how important it is to keep the

same filter for successive rows, and by telling it the relative computational costs of the filters.

```
double weights[3] = {1.5, 1.3, 1.1},
costs[PNG_FILTER_VALUE_LAST] =
{1.0, 1.3, 1.3, 1.5, 1.7};

png_set_filter_heuristics(png_ptr,
    PNG_FILTER_HEURISTIC_WEIGHTED, 3,
    weights, costs);
```

The weights are multiplying factors that indicate to libpng that the row filter should be the same for successive rows unless another row filter is that many times better than the previous filter. In the above example, if the previous 3 filters were SUB, SUB, NONE, the SUB filter could have a "sum of absolute differences" 1.5 x 1.3 times higher than other filters and still be chosen, while the NONE filter could have a sum 1.1 times higher than other filters and still be chosen. Unspecified weights are taken to be 1.0, and the specified weights should probably be declining like those above in order to emphasize recent filters over older filters.

The filter costs specify for each filter type a relative decoding cost to be considered when selecting row filters. This means that filters with higher costs are less likely to be chosen over filters with lower costs, unless their "sum of absolute differences" is that much smaller. The costs do not necessarily reflect the exact computational speeds of the various filters, since this would unduly influence the final image size.

Note that the numbers above were invented purely for this example and are given only to help explain the function usage. Little testing has been done to find optimum values for either the costs or the weights.

5.10 Removing unwanted object code

There are a bunch of **#define**'s in pngconf.h that control what parts of libpng are compiled. All the defines end in **_SUPPORTED**. If you are never going to use a capability, you can change the **#define** to **#undef** before recompiling libpng and save yourself code and data space, or you can turn off individual capabilities with defines that begin with **PNG_NO_**.

You can also turn all of the transforms and ancillary chunk capabilities off en masse with compiler directives that define **PNG_NO_READ[or WRITE]_TRANSFORMS**, or **PNG_NO_READ[or WRITE]_ANCILLARY_CHUNKS**, or all four, along with directives to turn on any of the capabilities that you do want. The **PNG_NO_READ[or WRITE]_TRANSFORMS** directives disable the extra transformations but still leave the library fully capable of reading and writing PNG files with all known public chunks. Use of the **PNG_NO_READ[or WRITE]_ANCILLARY_CHUNKS** directive produces a library that is incapable of reading or writing ancillary chunks. If you are not using the progressive reading capability, you can turn that off with **PNG_NO_PROGRESSIVE_READ** (don't confuse this with the **INTERLACING** capability, which you'll still have).

All the reading and writing specific code are in separate files, so the linker should only grab the files it needs. However, if you want to make sure, or if you are building a stand alone library, all the reading files start with **pngr** and all the writing files start with **pngw**. The files that don't match either (like **png.c**, **pngtrans.c**, etc.) are used for

both reading and writing, and always need to be included. The progressive reader is in `pngpread.c`

If you are creating or distributing a dynamically linked library (a `.so` or `DLL` file), you should not remove or disable any parts of the library, as this will cause applications linked with different versions of the library to fail if they call functions not available in your library. The size of the library itself should not be an issue, because only those sections that are actually used will be loaded into memory.

5.11 Requesting debug printout

The macro definition `PNG_DEBUG` can be used to request debugging printout. Set it to an integer value in the range 0 to 3. Higher numbers result in increasing amounts of debugging information. The information is printed to the `"stderr"` file, unless another file name is specified in the `PNG_DEBUG_FILE` macro definition.

When `PNG_DEBUG > 0`, the following functions (macros) become available:

```
png_debug(level, message)
png_debug1(level, message, p1)
png_debug2(level, message, p1, p2)
```

in which "level" is compared to `PNG_DEBUG` to decide whether to print the message, "message" is the formatted string to be printed, and `p1` and `p2` are parameters that are to be embedded in the string according to `printf`-style formatting directives. For example,

```
png_debug1(2, "foo=%d\n", foo);
```

is expanded to

```
if(PNG_DEBUG > 2)
    fprintf(PNG_DEBUG_FILE, "foo=%d\n", foo);
```

When `PNG_DEBUG` is defined but is zero, the macros aren't defined, but you can still use `PNG_DEBUG` to control your own debugging:

```
#ifdef PNG_DEBUG
    fprintf(stderr, ...
#endif
```

When `PNG_DEBUG = 1`, the macros are defined, but only `png_debug` statements having `level = 0` will be printed. There aren't any such statements in this version of `libpng`, but if you insert some they will be printed.

Chapter 6

VI. MNG support

The MNG specification (available at <http://www.libpng.org/pub/mng>) allows certain extensions to PNG for PNG images that are embedded in MNG datastreams. Libpng can support some of these extensions. To enable them, use the `png_permit_mng_features()` function:

```
feature_set = png_permit_mng_features(png_ptr, mask)
mask is a png_uint_32 containing the bitwise OR of the
features you want to enable. These include
    PNG_FLAG_MNG_EMPTY_PLTE
    PNG_FLAG_MNG_FILTER_64
    PNG_ALL_MNG_FEATURES
feature_set is a png_uint_32 that is the bitwise AND of
your mask with the set of MNG features that is
supported by the version of libpng that you are using.
```

It is an error to use this function when reading or writing a standalone PNG file with the PNG 8-byte signature. The PNG datastream must be wrapped in a MNG datastream. As a minimum, it must have the MNG 8-byte signature and the MHDR and MEND chunks. Libpng does not provide support for these or any other MNG chunks; your application must provide its own support for them. You may wish to consider using libmng (available at <http://www.libmng.com>) instead.

Chapter 7

VII. Changes to Libpng from version 0.88

It should be noted that versions of libpng later than 0.96 are not distributed by the original libpng author, Guy Schlnat, nor by Andreas Dilger, who had taken over from Guy during 1996 and 1997, and distributed versions 0.89 through 0.96, but rather by another member of the original PNG Group, Glenn Randers-Pehrson. Guy and Andreas are still alive and well, but they have moved on to other things.

The old libpng functions `png_read_init()`, `png_write_init()`, `png_info_init()`, `png_read_destroy()`, and `png_write_destroy()` have been moved to `PNG_INTERNAL` in version 0.95 to discourage their use. These functions will be removed from libpng version 2.0.0.

The preferred method of creating and initializing the libpng structures is via the `png_create_read_struct()`, `png_create_write_struct()`, and `png_create_info_struct()` because they isolate the size of the structures from the application, allow version error checking, and also allow the use of custom error handling routines during the initialization, which the old functions do not. The functions `png_read_destroy()` and `png_write_destroy()` do not actually free the memory that libpng allocated for these structs, but just reset the data structures, so they can be used instead of `png_destroy_read_struct()` and `png_destroy_write_struct()` if you feel there is too much system overhead allocating and freeing the `png_struct` for each image read.

Setting the error callbacks via `png_set_message_fn()` before `png_read_init()` as was suggested in libpng-0.88 is no longer supported because this caused applications that do not use custom error functions to fail if the `png_ptr` was not initialized to zero. It is still possible to set the error callbacks AFTER `png_read_init()`, or to change them with `png_set_error_fn()`, which is essentially the same function, but with a new name to force compilation errors with applications that try to use the old method.

Starting with version 1.0.7, you can find out which version of the library you are using at run-time:

```
png_uint_32 libpng_vn = png_access_version_number();
```

The number `libpng_vn` is constructed from the major version, minor version with leading zero, and release number with leading zero, (e.g., `libpng_vn` for version

1.0.7 is 10007).

You can also check which version of png.h you used when compiling your application:

```
png_uint_32 application_vn = PNG_LIBPNG_VER;
```

Chapter 8

VIII. Changes to Libpng from version 1.0.x to 1.2.x

Support for user memory management was enabled by default. To accomplish this, the functions `png_create_read_struct_2()`, `png_create_write_struct_2()`, `png_set_mem_fn()`, `png_get_mem_ptr()`, `png_malloc_default()`, and `png_free_default()` were added.

Support for the iTXt chunk has been enabled by default as of version 1.2.41.

Support for certain MNG features was enabled.

Support for numbered error messages was added. However, we never got around to actually numbering the error messages. The function `png_set_strip_error_numbers()` was added (Note: the prototype for this function was inadvertently removed from `png.h` in `PNG_NO_ASSEMBLER_CODE` builds of libpng-1.2.15. It was restored in libpng-1.2.36).

The `png_malloc_warn()` function was added at libpng-1.2.3. This issues a `png_warning` and returns `NULL` instead of aborting when it fails to acquire the requested memory allocation.

Support for setting user limits on image width and height was enabled by default. The functions `png_set_user_limits()`, `png_get_user_width_max()`, and `png_get_user_height_max()` were added at libpng-1.2.6.

The `png_set_add_alpha()` function was added at libpng-1.2.7.

The function `png_set_expand_gray_1_2_4_to_8()` was added at libpng-1.2.9. Unlike `png_set_gray_1_2_4_to_8()`, the new function does not expand the tRNS chunk to alpha. The `png_set_gray_1_2_4_to_8()` function is deprecated.

A number of macro definitions in support of runtime selection of assembler code features (especially Intel MMX code support) were added at libpng-1.2.0:

```
PNG_ASM_FLAG_MMX_SUPPORT_COMPILED
PNG_ASM_FLAG_MMX_SUPPORT_IN_CPU
PNG_ASM_FLAG_MMX_READ_COMBINE_ROW
PNG_ASM_FLAG_MMX_READ_INTERLACE
PNG_ASM_FLAG_MMX_READ_FILTER_SUB
PNG_ASM_FLAG_MMX_READ_FILTER_UP
PNG_ASM_FLAG_MMX_READ_FILTER_AVG
PNG_ASM_FLAG_MMX_READ_FILTER_PAETH
PNG_ASM_FLAGS_INITIALIZED
PNG_MMX_READ_FLAGS
```



```
PNG_MMX_FLAGS
PNG_MMX_WRITE_FLAGS
PNG_MMX_FLAGS
```

We added the following functions in support of runtime selection of assembler code features:

```
png_get_mmx_flagmask()
png_set_mmx_thresholds()
png_get_asm_flags()
png_get_mmx_bitdepth_threshold()
png_get_mmx_rowbytes_threshold()
png_set_asm_flags()
```

We replaced all of these functions with simple stubs in libpng-1.2.20, when the Intel assembler code was removed due to a licensing issue.

These macros are deprecated:

```
PNG_READ_TRANSFORMS_NOT_SUPPORTED
PNG_PROGRESSIVE_READ_NOT_SUPPORTED
PNG_NO_SEQUENTIAL_READ_SUPPORTED
PNG_WRITE_TRANSFORMS_NOT_SUPPORTED
PNG_READ_ANCILLARY_CHUNKS_NOT_SUPPORTED
PNG_WRITE_ANCILLARY_CHUNKS_NOT_SUPPORTED
```

They have been replaced, respectively, by:

```
PNG_NO_READ_TRANSFORMS
PNG_NO_PROGRESSIVE_READ
PNG_NO_SEQUENTIAL_READ
PNG_NO_WRITE_TRANSFORMS
PNG_NO_READ_ANCILLARY_CHUNKS
PNG_NO_WRITE_ANCILLARY_CHUNKS
```

PNG_MAX_UINT was replaced with PNG_UINT_31_MAX. It has been deprecated since libpng-1.0.16 and libpng-1.2.6.

The function `png_check_sig(sig, num)` was replaced with `!png_sig_cmp(sig, 0, num)`. It has been deprecated since libpng-0.90.

The function `png_set_gray_1_2_4_to_8()` which also expands tRNS to alpha was replaced with `png_set_expand_gray_1_2_4_to_8()` which does not. It has been deprecated since libpng-1.0.18 and 1.2.9.

Chapter 9

IX. Changes to Libpng from version 1.0.x/1.2.x to 1.4.x

Private libpng prototypes and macro definitions were moved from png.h and pngconf.h into a new pngpriv.h header file.

Functions `png_set_benign_errors()`, `png_benign_error()`, and `png_chunk_benign_error()` were added.

Support for setting the maximum amount of memory that the application will allocate for reading chunks was added, as a security measure. The functions `png_set_chunk_cache_max()` and `png_get_chunk_cache_max()` were added to the library.

We implemented support for I/O states by adding `png_ptr` member `io_state` and functions `png_get_io_chunk_name()` and `png_get_io_state()` in `pngget.c`.

We added `PNG_TRANSFORM_GRAY_TO_RGB` to the available high-level input transforms.

Checking for and reporting of errors in the IHDR chunk is more thorough.

Support for global arrays was removed, to improve thread safety.

Some obsolete/deprecated macros and functions have been removed.

Typecasted NULL definitions such as `#define png_voidp_NULL (png_voidp) NULL` were eliminated. If you used these in your application, just use NULL instead.

The `png_struct` and `info_struct` members "trans" and "trans_values" were changed to "trans_alpha" and "trans_color", respectively.

The obsolete, unused `pnggccrd.c` and `pngvcrd.c` files and related makefiles were removed.

The `PNG_1_0_X` and `PNG_1_2_X` macros were eliminated.

The `PNG_LEGACY_SUPPORTED` macro was eliminated.

Many `WIN32_WCE` `#ifdefs` were removed.

The functions `png_read_init(info_ptr)`, `png_write_init(info_ptr)`, `png_info_init(info_ptr)`, `png_read_destroy()`, and `png_write_destroy()` have been removed. They have been deprecated since libpng-0.95.

The `png_permit_empty_plte()` was removed. It has been deprecated since libpng-1.0.9. Use `png_permit_mng_features()` instead.

We removed the obsolete stub functions `png_get_mmx_flagmask()`, `png_set_mmx_thresholds()`, `png_get_asm_flags()`, `png_get_mmx_bitdepth_threshold()`, `png_get_mmx_rowbytes_threshold()`, `png_set_asm_flags()`, and `png_mmx_supported()`.

We removed the obsolete `png_check_sig()`, `png_memcpy_check()`, and `png_memset_check()` functions. Instead use `!png_sig_cmp()`, `png_memcpy()`, and `png_memset()`, respectively.

The function `png_set_gray_1_2_4_to_8()` was removed. It has been deprecated since libpng-1.0.18 and 1.2.9, when it was replaced with `png_set_expand_gray_1_2_4_to_8()` because the former function also expanded palette images.

We changed the prototype for `png_malloc()` from `png_malloc(png_structp png_ptr, png_uint_32 size)` to `png_malloc(png_structp png_ptr, png_alloc_size_t size)`

The `png_calloc()` function was added and is used in place of of "png_malloc(); png_memset();" except in the case in `png_read_png()` where the array consists of pointers; in this case a "for" loop is used after the `png_malloc()` to set the pointers to NULL, to give robust. behavior in case the application runs out of memory part-way through the process.

We changed the prototypes of `png_get_compression_buffer_size()` and `png_set_compression_buffer_size()` to work with `png_size_t` instead of `png_uint_32`.

Support for numbered error messages was removed by default, since we never got around to actually numbering the error messages. The function `png_set_strip_error_numbers()` was removed from the library by default.

The `png_zalloc()` and `png_zfree()` functions are no longer exported. The `png_zalloc()` function no longer zeroes out the memory that it allocates.

We removed the trailing '.' from the warning and error messages.

Chapter 10

X. Detecting libpng

The `png_get_io_ptr()` function has been present since libpng-0.88, has never changed, and is unaffected by conditional compilation macros. It is the best choice for use in configure scripts for detecting the presence of any libpng version since 0.88. In an autoconf "configure.in" you could use

```
AC_CHECK_LIB(png, png_get_io_ptr, ...)
```

Chapter 11

XI. Source code repository

Since about February 2009, version 1.2.34, libpng has been under "git" source control. The git repository was built from old libpng-x.y.z.tar.gz files going back to version 0.70. You can access the git repository (read only) at

`git://libpng.git.sourceforge.net/gitroot/libpng`

or you can browse it via "gitweb" at

`http://libpng.git.sourceforge.net/git/gitweb.cgi?p=libpng`

Patches can be sent to glennrp at users.sourceforge.net or to png-mng-implement at lists.sourceforge.net or you can upload them to the libpng bug tracker at

`http://libpng.sourceforge.net`

Chapter 12

XII. Coding style

Our coding style is similar to the "Allman" style, with curly braces on separate lines:

```
if (condition)
{
    action;
}

else if (another condition)
{
    another action;
}
```

The braces can be omitted from simple one-line actions:

```
if (condition)
    return (0);
```

We use 3-space indentation, except for continued statements which are usually indented the same as the first line of the statement plus four more spaces.

For macro definitions we use 2-space indentation, always leaving the "#" in the first column.

```
#ifndef PNG_NO_FEATURE
#   ifndef PNG_FEATURE_SUPPORTED
#       define PNG_FEATURE_SUPPORTED
#   endif
#endif
```

Comments appear with the leading "/*" at the same indentation as the statement that follows the comment:

```
/* Single-line comment */
statement;

/* Multiple-line
 * comment
 */
statement;
```

Very short comments can be placed at the end of the statement to which they pertain:

```
statement;    /* comment */
```

We don't use C++ style (`/**`) comments. We have, however, used them in the past in some now-abandoned MMX assembler code.

Functions and their curly braces are not indented, and exported functions are marked with PNGAPI:

```
/* This is a public function that is visible to
 * application programmers. It does thus-and-so.
 */
void PNGAPI
png_exported_function(png_ptr, png_info, foo)
{
    body;
}
```

The prototypes for all exported functions appear in `png.h`, above the comment that says

```
/* Maintainer: Put new public prototypes here ... */
```

We mark all non-exported functions with `/* PRIVATE */`:

```
void /* PRIVATE */
png_non_exported_function(png_ptr, png_info, foo)
{
    body;
}
```

The prototypes for non-exported functions (except for those in `pngtest`) appear in `pngpriv.h` above the comment that says

```
/* Maintainer: Put new private prototypes here ^ and in libpngpf.3 */
```

The names of all exported functions and variables begin with `"png_"`, and all publicly visible C preprocessor macros begin with `"PNG_"`.

We put a space after each comma and after each semicolon in `"for"` statments, and we put spaces before and after each C binary operator and after `"for"` or `"while"`. We don't put a space between a typecast and the expression being cast, nor do we put one between a function name and the left parenthesis that follows it:

```
for (i = 2; i > 0; --i)
    y[i] = a(x) + (int)b;
```

We prefer `#ifdef` and `#ifndef` to `#if defined()` and `if !defined()` when there is only one macro being tested.

We do not use the TAB character for indentation in the C sources.

Lines do not exceed 80 characters.

Other rules can be inferred by inspecting the libpng source.

Chapter 13

XIII. Y2K Compliance in libpng

January 3, 2010

Since the PNG Development group is an ad-hoc body, we can't make an official declaration.

This is your unofficial assurance that libpng from version 0.71 and upward through 1.4.0 are Y2K compliant. It is my belief that earlier versions were also Y2K compliant.

Libpng only has three year fields. One is a 2-byte unsigned integer that will hold years up to 65535. The other two hold the date in text format, and will hold years up to 9999.

The integer is "png_uint_16 year" in png_time_struct.

The strings are "png_charp time_buffer" in png_struct and "near_time_buffer", which is a local character string in png.c.

There are seven time-related functions:

```
png_convert_to_rfc_1123() in png.c
  (formerly png_convert_to_rfc_1152() in error)
png_convert_from_struct_tm() in pngwrite.c, called
  in pngwrite.c
png_convert_from_time_t() in pngwrite.c
png_get_tIME() in pngget.c
png_handle_tIME() in pngutil.c, called in pngread.c
png_set_tIME() in pngset.c
png_write_tIME() in pngutil.c, called in pngwrite.c
```

All appear to handle dates properly in a Y2K environment. The png_convert_from_time_t() function calls gmtime() to convert from system clock time, which returns (year - 1900), which we properly convert to the full 4-digit year. There is a possibility that applications using libpng are not passing 4-digit years into the png_convert_to_rfc_1123() function, or that they are incorrectly passing only a 2-digit year instead of "year - 1900" into the png_convert_from_struct_tm() function, but this is not under our control. The libpng documentation has always stated that it works with 4-digit years, and the APIs have been documented as such.

The tIME chunk itself is also Y2K compliant. It uses a 2-byte unsigned integer to hold the year, and can hold years as large as 65535.

zlib, upon which libpng depends, is also Y2K compliant. It contains no date-related code.