Mini-XML Programmers Manual
Version 2.12

MICHAEL R. SWEET

Mini-XML Programmers Manual, Version 2.12

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Introduction

This programmers manual describes Mini-XML version 2.12, a small XML parsing library that you can use to read and write XML data files in your C and C++ applications.

Mini-XML was initially developed for the Gutenprint project to replace the rather large and unwieldy `libxml2` library with something substantially smaller and easier-to-use. It all began one morning in June of 2003 when Robert posted the following sentence to the developer's list:

> *It's bad enough that we require libxml2, but rolling our own XML parser is a bit more than we can handle.*

I then replied with:

> *Given the limited scope of what you use in XML, it should be trivial to code a mini-XML API in a few hundred lines of code.*

I took my own challenge and coded furiously for two days to produced the initial public release of Mini-XML, total lines of code: 696. Robert promptly integrated Mini-XML into Gutenprint and removed libxml2.

Thanks to lots of feedback and support from various developers, Mini-XML has evolved since then to provide a more complete XML implementation and now stands at a whopping 3,792 lines of code, compared to 140,410 lines of code for libxml2 version 2.9.1.

Aside from Gutenprint, Mini-XML is used for the following projects/software applications:

- CUPS
- ZynAddSubFX

Please file a bug on Github if you would like your project added or removed from this list, or if you have any comments/quotes you would like me to publish about your experiences with Mini-XML.

Organization of This Document

This manual is organized into the following chapters and appendices:

- Chapter 1, "Building, Installing, and Packaging Mini-XML", provides compilation, installation, and packaging instructions for Mini-XML.
- Chapter 2, "Getting Started with Mini-XML", shows how to use the Mini-XML library in your programs.
- Chapter 3, "More Mini-XML Programming Techniques", shows additional ways to use the Mini-XML library.
- Chapter 4, "Using the mxmldoc Utility", describes how to use the `mxmldoc(1)` program to generate software documentation.
- Appendix A, "Mini-XML License", provides the terms and conditions for using and distributing Mini-XML.
- Appendix B, "Library Reference", contains a complete reference for Mini-XML, generated by `mxmldoc`.
- Appendix C, "XML Schema", shows the XML schema used for the XML files produced by `mxmldoc`.

Notation Conventions

Various font and syntax conventions are used in this guide. Examples and their meanings and uses are explained below:

`mxmldoc`
`mxmldoc(1)`
: The names of commands; the first mention of a command or function in a chapter is followed by a manual page section number.

/var
/etc/hosts
: File and directory names.

```
Request ID is Printer-123
```
: Screen output.

`lp -d printer filename ENTER`
: Literal user input; special keys like **`ENTER`** are in ALL CAPS.

12.3
: Numbers in the text are written using the period (.) to indicate the decimal point.

Abbreviations

The following abbreviations are used throughout this manual:

Gb
: Gigabytes, or 1073741824 bytes

kb
: Kilobytes, or 1024 bytes

Mb
: Megabytes, or 1048576 bytes

UTF-8, UTF-16
: Unicode Transformation Format, 8-bit or 16-bit

W3C
: World Wide Web Consortium

XML
: Extensible Markup Language

Other References

The Unicode Standard, Version 4.0, Addison-Wesley, ISBN 0-321-18578-1

: The definition of the Unicode character set which is used for XML.

Extensible Markup Language (XML) 1.0 (Third Edition)

: The XML specification from the World Wide Web Consortium (W3C)

Legal Stuff

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Chapter 1 - Building, Installing, and Packaging Mini-XML

This chapter describes how to build, install, and package Mini-XML on your system from the source archive. You will need an ANSI/ISO-C compatible compiler to build Mini-XML - GCC works, as do most vendors' C compilers. If you are building Mini-XML on Windows, we recommend using the Visual C++ environment with the supplied solution file. For other operating systems, you'll need a POSIX-compatible shell and `make` program in addition to the C compiler.

Compiling Mini-XML

Mini-XML comes with both an autoconf-based configure script and a Visual C++ solution that can be used to compile the library and associated tools.

Compiling with Visual C++

Open the *mxml.sln* solution in the *vcnet* folder. Choose the desired build configuration, "Debug" (the default) or "Release", and then choose *Build Solution* from the *Build* menu.

Compiling with Command-Line Tools

Type the following command to configure the Mini-XML source code for your system:

```
./configure ENTER
```

The default install prefix is */usr/local*, which can be overridden using the **--prefix** option:

```
./configure --prefix=/foo ENTER
```

Other configure options can be found using the **--help** option:

```
./configure --help ENTER
```

Once you have configured the software, use the `make(1)` program to do the build and run the test program to verify that things are working, as follows:

```
make ENTER
```

Installing Mini-XML

If you are using Visual C++, copy the *mxml.lib* and and *mxml.h* files to the Visual C++ *lib* and *include directories, respectively.*

Otherwise, use the `make` command with the **`install`** target to install Mini-XML in the configured directories:

```
make install ENTER
```

Chapter 2 - Getting Started with Mini-XML

This chapter describes how to write programs that use Mini-XML to access data in an XML file. Mini-XML provides the following functionality:

- Reading of UTF-8 and UTF-16 and writing of UTF-8 encoded XML files and strings.
- Data is stored in a linked-list tree structure, preserving the XML data hierarchy.
- SAX (streamed) reading of XML files and strings to minimize memory usage.
- Supports arbitrary element names, attributes, and attribute values with no preset limits, just available memory.
- Supports integer, real, opaque ("cdata"), and text data types in "leaf" nodes.
- Functions for creating and managing trees of data.

- "Find" and "walk" functions for easily locating and navigating trees of data.

Mini-XML doesn't do validation or other types of processing on the data based upon schema files or other sources of definition information.

The Basics

Mini-XML provides a single header file which you include:

```
#include <mxml.h>
```

The Mini-XML library is included with your program using the **-lmxml** option:

```
gcc -o myprogram myprogram.c -lmxml ENTER
```

If you have the `pkg-config(1)` software installed, you can use it to determine the proper compiler and linker options for your installation:

```
pkg-config --cflags mxml ENTER
pkg-config --libs mxml ENTER
```

Nodes

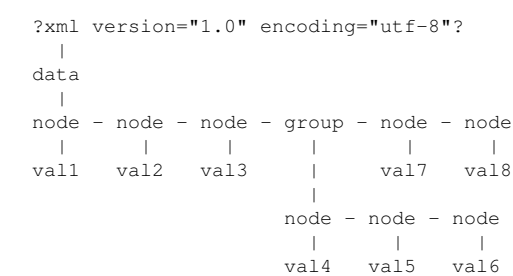
Every piece of information in an XML file is stored in memory in "nodes". Nodes are defined by the `mxml_node_t` structure. Each node has a typed value, optional user data, a parent node, sibling nodes (previous and next), and potentially child nodes.

For example, if you have an XML file like the

following:

```
<?xml version="1.0" encoding="utf-8"?>
<data>
    <node>val1</node>
    <node>val2</node>
    <node>val3</node>
    <group>
        <node>val4</node>
        <node>val5</node>
        <node>val6</node>
    </group>
    <node>val7</node>
    <node>val8</node>
</data>
```

the node tree for the file would look like the following in memory:



where "-" is a pointer to the sibling node and "|" is a pointer to the first child or parent node.

The `mxmlGetType` function gets the type of a node, one of `MXML_CUSTOM`, `MXML_ELEMENT`, `MXML_INTEGER`, `MXML_OPAQUE`, `MXML_REAL`, or `MXML_TEXT`. The parent and sibling nodes are accessed using the `mxmlGetParent`, `mxmlGetNext`, and `mxmlGetPrevious` functions. The `mxmlGetUserData` function gets any

user data associated with the node.

CDATA Nodes

CDATA (`MXML_ELEMENT`) nodes are created using the `mxmlNewCDATA` function. The `mxmlGetCDATA` function retrieves the CDATA string pointer for a node.

> **Note:**
>
> CDATA nodes are currently stored in memory as special elements. This will be changed in a future major release of Mini-XML.

Custom Nodes

Custom (`MXML_CUSTOM`) nodes are created using the `mxmlNewCustom` function or using a custom load callback specified using the `mxmlSetCustomHandlers` function. The `mxmlGetCustom` function retrieves the custom value pointer for a node.

Comment Nodes

Comment (`MXML_ELEMENT`) nodes are created using the `mxmlNewElement` function. The `mxmlGetElement` function retrieves the comment string pointer for a node, including the surrounding "!--" and "--" characters.

> **Note:**
>
> Comment nodes are currently stored in memory as special

elements. This will be changed in a future major release of Mini-XML.

Element Nodes

Element (`MXML_ELEMENT`) nodes are created using the `mxmlNewElement` function. The `mxmlGetElement` function retrieves the element name, the `mxmlElementGetAttr` function retrieves the value string for a named attribute associated with the element, and the `mxmlGetFirstChild` and `mxmlGetLastChild` functions retrieve the first and last child nodes for the element, respectively.

Integer Nodes

Integer (`MXML_INTEGER`) nodes are created using the `mxmlNewInteger` function. The `mxmlGetInteger` function retrieves the integer value for a node.

Opaque String Nodes

Opaque string (`MXML_OPAQUE`) nodes are created using the `mxmlNewOpaque` function. The `mxmlGetOpaque` function retrieves the opaque string pointer for a node. Opaque nodes are like string nodes but preserve all whitespace between nodes.

Text String Nodes

Text string (`MXML_TEXT`) nodes are created using the `mxmlNewText` and `mxmlNewTextf` functions. Each text node consists of a single word string and (leading) whitespace value - the `mxmlGetText` function retrieves the string pointer and whitespace value for a node.

Processing Instruction Nodes

Processing instruction (`MXML_ELEMENT`) nodes are created using the `mxmlNewElement` function. The `mxmlGetElement` function retrieves the processing instruction string for a node, including the surrounding "?" characters.

> **Note:**
>
> Processing instruction nodes are currently stored in memory as special elements. This will be changed in a future major release of Mini-XML.

Real Number Nodes

Real number (`MXML_REAL`) nodes are created using the `mxmlNewReal` function. The `mxmlGetReal` function retrieves the CDATA string pointer for a node.

XML Declaration Nodes

XML declaration (`MXML_ELEMENT`) nodes are created using the `mxmlNewXML` function. The `mxmlGetElement` function retrieves the XML declaration string for a node, including the surrounding "?" characters.

> **Note:**
>
> XML declaration nodes are currently stored in memory as special elements. This will be changed in a future major release of Mini-XML.

Creating XML Documents

You can create and update XML documents in memory using the various `mxmlNew` functions. The following code will create the XML document described in the previous section:

```
mxml_node_t *xml;    /* <?xml ... ?> */
mxml_node_t *data;   /* <data> */
mxml_node_t *node;   /* <node> */
mxml_node_t *group;  /* <group> */

xml = mxmlNewXML("1.0");

data = mxmlNewElement(xml, "data");

    node = mxmlNewElement(data, "node");
    mxmlNewText(node, 0, "val1");
    node = mxmlNewElement(data, "node");
    mxmlNewText(node, 0, "val2");
    node = mxmlNewElement(data, "node");
    mxmlNewText(node, 0, "val3");

    group = mxmlNewElement(data, "group");

        node = mxmlNewElement(group, "node");
        mxmlNewText(node, 0, "val4");
        node = mxmlNewElement(group, "node");
        mxmlNewText(node, 0, "val5");
        node = mxmlNewElement(group, "node");
        mxmlNewText(node, 0, "val6");

    node = mxmlNewElement(data, "node");
    mxmlNewText(node, 0, "val7");
    node = mxmlNewElement(data, "node");
    mxmlNewText(node, 0, "val8");
```

We start by creating the declaration node common to all XML files using the `mxmlNewXML` function:

```
xml = mxmlNewXML("1.0");
```

We then create the `<data>` node used for this document using the `mxmlNewElement` function. The first argument specifies the parent node (`xml`) while the second specifies the element name (`data`):

```
data = mxmlNewElement(xml, "data");
```

Each `<node>...</node>` in the file is created using the `mxmlNewElement` and `mxmlNewText` functions. The first argument of `mxmlNewText` specifies the parent node (`node`). The second argument specifies whether whitespace appears before the text - 0 or false in this case. The last argument specifies the actual text to add:

```
node = mxmlNewElement(data, "node");
mxmlNewText(node, 0, "val1");
```

The resulting in-memory XML document can then be saved or processed just like one loaded from disk or a string.

Loading XML

You load an XML file using the `mxmlLoadFile` function:

```
FILE *fp;
mxml_node_t *tree;

fp = fopen("filename.xml", "r");
tree = mxmlLoadFile(NULL, fp,
                    MXML_OPAQUE_CALLBACK);
fclose(fp);
```

The first argument specifies an existing XML parent node, if any. Normally you will pass `NULL` for this argument unless you are combining multiple XML sources. The XML file must contain a complete XML document including the `?xml` element if the parent node is `NULL`.

The second argument specifies the stdio file to read from, as opened by `fopen()` or `popen()`. You can also use `stdin` if you are implementing an XML filter program.

The third argument specifies a callback function which returns the value type of the immediate children for a new element node: `MXML_CUSTOM`, `MXML_IGNORE`, `MXML_INTEGER`, `MXML_OPAQUE`, `MXML_REAL`, or `MXML_TEXT`. Load callbacks are described in detail in Chapter 3. The example code uses the `MXML_OPAQUE_CALLBACK` constant which specifies that all data nodes in the document contain opaque string values with whitespace preserved. Other standard callbacks include `MXML_IGNORE_CALLBACK`, `MXML_INTEGER_CALLBACK`, `MXML_REAL_CALLBACK`, and `MXML_TEXT_CALLBACK`.

The `mxmlLoadString` function loads XML node trees from a string:

```
char buffer[8192];
mxml_node_t *tree;

...
tree = mxmlLoadString(NULL, buffer,
                      MXML_OPAQUE_CALLBACK);
```

The first and third arguments are the same as used for `mxmlLoadFile()`. The second argument specifies the string or character buffer to load and must be a complete XML document including the `?xml` element if the parent node is `NULL`.

Saving XML

You save an XML file using the `mxmlSaveFile` function:

```
FILE *fp;
mxml_node_t *tree;

fp = fopen("filename.xml", "w");
mxmlSaveFile(tree, fp, MXML_NO_CALLBACK);
fclose(fp);
```

The first argument is the XML node tree to save. It should normally be a pointer to the top-level `?xml` node in your XML document.

The second argument is the stdio file to write to, as opened by `fopen()` or `popen()`. You can also use `stdout` if you are implementing an XML filter program.

The third argument is the whitespace callback to use when saving the file. Whitespace callbacks are covered in detail in Chapter 3. The previous example code uses the `MXML_NO_CALLBACK` constant to specify that no special whitespace handling is required.

The `mxmlSaveAllocString`, and `mxmlSaveString` functions save XML node trees to strings:

```
char buffer[8192];
char *ptr;
mxml_node_t *tree;

...
mxmlSaveString(tree, buffer, sizeof(buffer),
               MXML_NO_CALLBACK);

...
ptr = mxmlSaveAllocString(tree, MXML_NO_CALLBACK);
```

The first and last arguments are the same as used for `mxmlSaveFile()`. The `mxmlSaveString` function takes pointer and size arguments for saving the XML document to a fixed-size buffer, while `mxmlSaveAllocString()` returns a string buffer that was allocated using `malloc()`.

Controlling Line Wrapping

When saving XML documents, Mini-XML normally wraps output lines at column 75 so that the text is readable in terminal windows. The `mxmlSetWrapMargin` function overrides the default wrap margin:

```
/* Set the margin to 132 columns */
mxmlSetWrapMargin(132);

/* Disable wrapping */
mxmlSetWrapMargin(0);
```

Memory Management

Once you are done with the XML data, use the `mxmlDelete` function to recursively free the memory that is used for a particular node or the entire tree:

```
mxmlDelete(tree);
```

You can also use reference counting to manage memory usage. The `mxmlRetain` and `mxmlRelease` functions increment and decrement a node's use count, respectively. When the use count goes to 0, `mxmlRelease` will automatically call `mxmlDelete` to actually free the memory used by the node tree. New nodes automatically start with a use count of 1.

Finding and Iterating Nodes

The `mxmlWalkPrev` and `mxmlWalkNext`functions can be used to iterate through the XML node tree:

```
mxml_node_t *node;

node = mxmlWalkPrev(current, tree,
                    MXML_DESCEND);

node = mxmlWalkNext(current, tree,
                    MXML_DESCEND);
```

In addition, you can find a named element/node using the `mxmlFindElement` function:

```
mxml_node_t *node;

node = mxmlFindElement(tree, tree, "name",
                       "attr", "value",
                       MXML_DESCEND);
```

The `name`, `attr`, and `value` arguments can be passed as `NULL` to act as wildcards, e.g.:

```
/* Find the first "a" element */
node = mxmlFindElement(tree, tree, "a",
                       NULL, NULL,
                       MXML_DESCEND);

/* Find the first "a" element with "href"
   attribute */
node = mxmlFindElement(tree, tree, "a",
                       "href", NULL,
                       MXML_DESCEND);
```

```
/* Find the first "a" element with "href"
   to a URL */
node = mxmlFindElement(tree, tree, "a",
                       "href",
                       "http://www.example.com/"
                       MXML_DESCEND);

/* Find the first element with a "src"
   attribute */
node = mxmlFindElement(tree, tree, NULL,
                       "src", NULL,
                       MXML_DESCEND);

/* Find the first element with a "src"
   = "foo.jpg" */
node = mxmlFindElement(tree, tree, NULL,
                       "src", "foo.jpg",
                       MXML_DESCEND);
```

You can also iterate with the same function:

```
mxml_node_t *node;

for (node = mxmlFindElement(tree, tree,
                            "name",
                            NULL, NULL,
                            MXML_DESCEND);
     node != NULL;
     node = mxmlFindElement(node, tree,
                            "name",
                            NULL, NULL,
                            MXML_DESCEND))
{
  ... do something ...
}
```

The MXML_DESCEND argument can actually be one of three constants:

- MXML_NO_DESCEND means to not to look at any child nodes in the element hierarchy, just look at siblings at the same level or parent nodes until the top node or top-of-tree is reached.

  The previous node from "group" would be the "node" element to the left, while the next node from "group" would be the "node" element to the right.

- MXML_DESCEND_FIRST means that it is OK to descend to the first child of a node, but not to descend further when searching. You'll normally use this when iterating through direct children of a parent node, e.g. all of the "node" and "group" elements under the "?xml" parent node in the example above.

  This mode is only applicable to the search function; the walk functions treat this as MXML_DESCEND since every call is a first time.

- MXML_DESCEND means to keep descending until you hit the bottom of the tree. The previous node from "group" would be the "val3" node and the next node would be the first node element under "group".

  If you were to walk from the root node "?xml" to the end of the tree with mxmlWalkNext(), the order would be:

```
?xml data node val1 node val2 node val3
group node val4 node val5 node val6 node
val7 node val8
```

If you started at "val8" and walked using `mxmlWalkPrev()`, the order would be reversed, ending at "?xml".

Finding Specific Nodes

You can find specific nodes in the tree using the `mxmlFindPath`, for example:

```
mxml_node_t *value;

value = mxmlFindPath(tree, "path/to/*/foo/bar");
```

The second argument is a "path" to the parent node. Each component of the path is separated by a slash (/) and represents a named element in the document tree or a wildcard (*) path representing 0 or more intervening nodes.

Chapter 3 - More Mini-XML Programming Techniques

This chapter shows additional ways to use the Mini-XML library in your programs.

Load Callbacks

Chapter 2 introduced the `mxmlLoadFile()` and `mxmlLoadString()` functions. The last argument to these functions is a callback function which is used to determine the value type of each data node in an XML document.

Mini-XML defines several standard callbacks for simple XML data files:

- `MXML_INTEGER_CALLBACK` - All data nodes contain whitespace-separated integers.

- MXML_OPAQUE_CALLBACK - All data nodes contain opaque strings ("CDATA").
- MXML_REAL_CALLBACK - All data nodes contain whitespace-separated floating-point numbers.
- MXML_TEXT_CALLBACK - All data nodes contain whitespace-separated strings.

You can provide your own callback functions for more complex XML documents. Your callback function will receive a pointer to the current element node and must return the value type of the immediate children for that element node: MXML_INTEGER, MXML_OPAQUE, MXML_REAL, or MXML_TEXT. The function is called *after* the element and its attributes have been read, so you can look at the element name, attributes, and attribute values to determine the proper value type to return.

The following callback function looks for an attribute named "type" or the element name to determine the value type for its child nodes:

```
mxml_type_t
type_cb(mxml_node_t *node)
{
  const char *type;

 /*
  * You can lookup attributes and/or use the
  * element name, hierarchy, etc...
  */

  type = mxmlElementGetAttr(node, "type");
  if (type == NULL)
    type = mxmlGetElement(node);

  if (!strcmp(type, "integer"))
    return (MXML_INTEGER);
  else if (!strcmp(type, "opaque"))
```

```
    return (MXML_OPAQUE);
  else if (!strcmp(type, "real"))
    return (MXML_REAL);
  else
    return (MXML_TEXT);
}
```

To use this callback function, simply use the name when you call any of the load functions:

```
FILE *fp;
mxml_node_t *tree;

fp = fopen("filename.xml", "r");
tree = mxmlLoadFile(NULL, fp, type_cb);
fclose(fp);
```

Save Callbacks

Chapter 2 also introduced the `mxmlSaveFile()`, `mxmlSaveString()`, and `mxmlSaveAllocString()` functions. The last argument to these functions is a callback function which is used to automatically insert whitespace in an XML document.

Your callback function will be called up to four times for each element node with a pointer to the node and a "where" value of `MXML_WS_BEFORE_OPEN`, `MXML_WS_AFTER_OPEN`, `MXML_WS_BEFORE_CLOSE`, or `MXML_WS_AFTER_CLOSE`. The callback function should return `NULL` if no whitespace should be added and the string to insert (spaces, tabs, carriage returns, and newlines) otherwise.

The following whitespace callback can be used to add whitespace to XHTML output to make it more readable in a standard text editor:

```
const char *
whitespace_cb(mxml_node_t *node,
              int where)
{
  const char *name;

 /*
  * We can conditionally break to a new line
  * before or after any element. These are
  * just common HTML elements...
  */

  name = mxmlGetElement(node);

  if (!strcmp(name, "html") ||
      !strcmp(name, "head") ||
      !strcmp(name, "body") ||
      !strcmp(name, "pre") ||
      !strcmp(name, "p") ||
      !strcmp(name, "h1") ||
      !strcmp(name, "h2") ||
      !strcmp(name, "h3") ||
      !strcmp(name, "h4") ||
      !strcmp(name, "h5") ||
      !strcmp(name, "h6"))
  {
   /*
    * Newlines before open and after
    * close...
    */

    if (where == MXML_WS_BEFORE_OPEN ||
        where == MXML_WS_AFTER_CLOSE)
      return ("\n");
  }
  else if (!strcmp(name, "dl") ||
           !strcmp(name, "ol") ||
           !strcmp(name, "ul"))
  {
   /*
    * Put a newline before and after list
    * elements...
    */
```

```
    return ("\n");
  }
  else if (!strcmp(name, "dd") ||
           !strcmp(name, "dt") ||
           !strcmp(name, "li"))
  {
   /*
    * Put a tab before <li>'s, * <dd>'s,
    * and <dt>'s, and a newline after them...
    */

    if (where == MXML_WS_BEFORE_OPEN)
      return ("\t");
    else if (where == MXML_WS_AFTER_CLOSE)
      return ("\n");
  }

 /*
  * Return NULL for no added whitespace...
  */

  return (NULL);
}
```

To use this callback function, simply use the name when you call any of the save functions:

```
FILE *fp;
mxml_node_t *tree;

fp = fopen("filename.xml", "w");
mxmlSaveFile(tree, fp, whitespace_cb);
fclose(fp);
```

Custom Data Types

Mini-XML supports custom data types via global load and save callbacks. Only a single set of callbacks can be active at any time, however your callbacks can store additional information in order to support multiple custom data types as needed. The `MXML_CUSTOM` node type identifies custom data nodes.

The load callback receives a pointer to the current data node and a string of opaque character data from the XML source with character entities converted to the corresponding UTF-8 characters. For example, if we wanted to support a custom date/time type whose value is encoded as "yyyy-mm-ddThh:mm:ssZ" (ISO format), the load callback would look like the following:

```
typedef struct
{
  unsigned      year,    /* Year */
                month,   /* Month */
                day,     /* Day */
                hour,    /* Hour */
                minute,  /* Minute */
                second;  /* Second */
  time_t        unix;    /* UNIX time */
} iso_date_time_t;

int
load_custom(mxml_node_t *node,
            const char *data)
{
  iso_date_time_t *dt;
  struct tm tmdata;

 /*
  * Allocate data structure...
  */
```

```
  dt = calloc(1, sizeof(iso_date_time_t));

 /*
  * Try reading 6 unsigned integers from the
  * data string...
  */

  if (sscanf(data, "%u-%u-%uT%u:%u:%uZ",
             &(dt->year), &(dt->month),
             &(dt->day), &(dt->hour),
             &(dt->minute),
             &(dt->second)) != 6)
  {
   /*
    * Unable to read numbers, free the data
    * structure and return an error...
    */

    free(dt);

    return (-1);
  }

 /*
  * Range check values...
  */

  if (dt->month <1 || dt->month > 12 ||
      dt->day  <1 || dt->day > 31 ||
      dt->hour  <0 || dt->hour > 23 ||
      dt->minute  <0 || dt->minute > 59 ||
      dt->second  <0 || dt->second > 59)
  {
   /*
    * Date information is out of range...
    */

    free(dt);

    return (-1);
  }
```

```
  /*
   * Convert ISO time to UNIX time in
   * seconds...
   */

   tmdata.tm_year = dt->year - 1900;
   tmdata.tm_mon  = dt->month - 1;
   tmdata.tm_day  = dt->day;
   tmdata.tm_hour = dt->hour;
   tmdata.tm_min  = dt->minute;
   tmdata.tm_sec  = dt->second;

   dt->unix = gmtime(&tmdata);

  /*
   * Assign custom node data and destroy
   * function pointers...
   */

   mxmlSetCustom(node, data, destroy);

  /*
   * Return with no errors...
   */

   return (0);
}
```

The function itself can return 0 on success or -1 if it is unable to decode the custom data or the data contains an error. Custom data nodes contain a `void` pointer to the allocated custom data for the node and a pointer to a destructor function which will free the custom data when the node is deleted.

The save callback receives the node pointer and returns an allocated string containing the custom data value. The following save callback could be used for our ISO date/time type:

```
char *
save_custom(mxml_node_t *node)
{
  char data[255];
  iso_date_time_t *dt;


  dt = (iso_date_time_t *)mxmlGetCustom(node);

  snprintf(data, sizeof(data),
           "%04u-%02u-%02uT%02u:%02u:%02uZ",
           dt->year, dt->month, dt->day,
           dt->hour, dt->minute, dt->second);

  return (strdup(data));
}
```

You register the callback functions using the `mxmlSetCustomHandlers()` function:

```
mxmlSetCustomHandlers(load_custom,
                      save_custom);
```

Changing Node Values

All of the examples so far have concentrated on creating and loading new XML data nodes. Many applications, however, need to manipulate or change the nodes during their operation, so Mini-XML provides functions to change node values safely and without leaking memory.

Existing nodes can be changed using the `mxmlSetElement()`, `mxmlSetInteger()`, `mxmlSetOpaque()`, `mxmlSetReal()`, `mxmlSetText()`, and `mxmlSetTextf()` functions. For example, use the following function call to change a text node to contain the text "new" with leading whitespace:

```
mxml_node_t *node;

mxmlSetText(node, 1, "new");
```

Formatted Text

The `mxmlNewTextf()` and `mxmlSetTextf()` functions create and change text nodes, respectively, using `printf`-style format strings and arguments. For example, use the following function call to create a new text node containing a constructed filename:

```
mxml_node_t *node;

node = mxmlNewTextf(node, 1, "%s/%s",
                    path, filename);
```

Indexing

Mini-XML provides functions for managing indices of nodes. The current implementation provides the same functionality as `mxmlFindElement()`. The advantage of using an index is that searching and enumeration of elements is significantly faster. The only disadvantage is that each index is a static snapshot of the XML document, so indices are not well suited to XML data that is updated more often than it is searched. The overhead of creating an index is approximately equal to walking the XML document tree. Nodes in the index are sorted by element name and attribute value.

Indices are stored in `mxml_index_t` structures. The `mxmlIndexNew()` function creates a new index:

```
mxml_node_t *tree;
mxml_index_t *ind;

ind = mxmlIndexNew(tree, "element",
                   "attribute");
```

The first argument is the XML node tree to index. Normally this will be a pointer to the `?xml` element.

The second argument contains the element to index; passing `NULL` indexes all element nodes alphabetically.

The third argument contains the attribute to index; passing `NULL` causes only the element name to be indexed.

Once the index is created, the `mxmlIndexEnum()`, `mxmlIndexFind()`, and `mxmlIndexReset()` functions

are used to access the nodes in the index. The `mxmlIndexReset()` function resets the "current" node pointer in the index, allowing you to do new searches and enumerations on the same index. Typically you will call this function prior to your calls to `mxmlIndexEnum()` and `mxmlIndexFind()`.

The `mxmlIndexEnum()` function enumerates each of the nodes in the index and can be used in a loop as follows:

```
mxml_node_t *node;

mxmlIndexReset(ind);

while ((node = mxmlIndexEnum(ind)) != NULL)
{
  // do something with node
}
```

The `mxmlIndexFind()` function locates the next occurrence of the named element and attribute value in the index. It can be used to find all matching elements in an index, as follows:

```
mxml_node_t *node;

mxmlIndexReset(ind);

while ((node = mxmlIndexFind(ind, "element",
                             "attr-value"))
            != NULL)
{
  // do something with node
}
```

The second and third arguments represent the element name and attribute value, respectively. A `NULL` pointer is used to return all elements or attributes

in the index. Passing `NULL` for both the element name and attribute value is equivalent to calling `mxmlIndexEnum`.

When you are done using the index, delete it using the `mxmlIndexDelete()` function:

```
mxmlIndexDelete(ind);
```

SAX (Stream) Loading of Documents

Mini-XML supports an implementation of the Simple API for XML (SAX) which allows you to load and process an XML document as a stream of nodes. Aside from allowing you to process XML documents of any size, the Mini-XML implementation also allows you to retain portions of the document in memory for later processing.

The `mxmlSAXLoadFd`, `mxmlSAXLoadFile`, and `mxmlSAXLoadString` functions provide the SAX loading APIs. Each function works like the corresponding `mxmlLoad` function but uses a callback to process each node as it is read.

The callback function receives the node, an event code, and a user data pointer you supply:

```
void
sax_cb(mxml_node_t *node,
       mxml_sax_event_t event,
       void *data)
{
  ... do something ...
}
```

The event will be one of the following:

- MXML_SAX_CDATA - CDATA was just read
- MXML_SAX_COMMENT - A comment was just read
- MXML_SAX_DATA - Data (custom, integer, opaque, real, or text) was just read
- MXML_SAX_DIRECTIVE - A processing directive was just read
- MXML_SAX_ELEMENT_CLOSE - A close element was just read (</element>)
- MXML_SAX_ELEMENT_OPEN - An open element was just read (<element>)

Elements are *released* after the close element is processed. All other nodes are released after they are processed. The SAX callback can *retain* the node using the mxmlRetain function. For example, the following SAX callback will retain all nodes, effectively simulating a normal in-memory load:

```
void
sax_cb(mxml_node_t *node,
       mxml_sax_event_t event,
       void *data)
{
  if (event != MXML_SAX_ELEMENT_CLOSE)
    mxmlRetain(node);
}
```

More typically the SAX callback will only retain a small portion of the document that is needed for post-processing. For example, the following SAX callback will retain the title and headings in an XHTML file. It also retains the (parent) elements like <html>, <head>, and <body>, and processing directives like <?xml ... ?> and <!DOCTYPE ... >:

```
void
sax_cb(mxml_node_t *node,
       mxml_sax_event_t event,
       void *data)
{
  if (event == MXML_SAX_ELEMENT_OPEN)
  {
   /*
    * Retain headings and titles...
    */

    char *name = mxmlGetElement(node);

    if (!strcmp(name, "html") ||
        !strcmp(name, "head") ||
        !strcmp(name, "title") ||
        !strcmp(name, "body") ||
        !strcmp(name, "h1") ||
        !strcmp(name, "h2") ||
        !strcmp(name, "h3") ||
        !strcmp(name, "h4") ||
        !strcmp(name, "h5") ||
        !strcmp(name, "h6"))
      mxmlRetain(node);
  }
  else if (event == MXML_SAX_DIRECTIVE)
    mxmlRetain(node);
  else if (event == MXML_SAX_DATA)
  {
    if (mxmlGetRefCount(mxmlGetParent(node)) > 1
    {
     /*
      * If the parent was retained, then retain
      * this data node as well.
      */

      mxmlRetain(node);
    }
  }
}
```

The resulting skeleton document tree can then be

searched just like one loaded using the `mxmlLoad` functions. For example, a filter that reads an XHTML document from stdin and then shows the title and headings in the document would look like:

```
mxml_node_t *doc, *title, *body, *heading;

doc = mxmlSAXLoadFd(NULL, 0,
                    MXML_TEXT_CALLBACK,
                    sax_cb, NULL);

title = mxmlFindElement(doc, doc, "title",
                        NULL, NULL,
                        MXML_DESCEND);

if (title)
  print_children(title);

body = mxmlFindElement(doc, doc, "body",
                       NULL, NULL,
                       MXML_DESCEND);

if (body)
{
  for (heading = mxmlGetFirstChild(body);
       heading;
       heading = mxmlGetNextSibling(heading))
    print_children(heading);
}
```

Chapter 4 - Using the mxmldoc Utility

This chapter describes how to use `mxmldoc(1)` program to automatically generate documentation from C and C++ source files.

The Basics

Originally developed to generate the Mini-XML and CUPS API documentation, `mxmldoc` is now a general-purpose utility which scans C and C++ source files to produce HTML and man page documentation along with an XML file representing the functions, types, and definitions in those source files. Unlike popular documentation generators like Doxygen or Javadoc, `mxmldoc` uses in-line comments rather than comment headers, allowing for more "natural" code documentation.

By default, `mxmldoc` produces HTML documentation. For example, the following command will scan all of the C source and header files in the current directory and produce a HTML documentation file called *filename.html*:

```
mxmldoc *.h *.c >filename.html ENTER
```

You can also specify an XML file to create which contains all of the information from the source files. For example, the following command creates an XML file called *filename.xml* in addition to the HTML file:

```
mxmldoc filename.xml *.h *.c >filename.html ENTER
```

The `--no-output` option disables the normal HTML output:

```
mxmldoc --no-output filename.xml *.h *.c ENTER
```

You can then run `mxmldoc` again with the XML file alone to generate the HTML documentation:

```
mxmldoc filename.xml >filename.html ENTER
```

Creating Man Pages

The `--man filename` option tells `mxmldoc` to create a man page instead of HTML documentation, for example:

```
mxmldoc --man filename filename.xml \
    >filename.man ENTER

mxmldoc --man filename *.h *.c \
    >filename.man ENTER
```

Creating EPUB Books

The `--epub filename.epub` option tells `mxmldoc` to create an EPUB book containing the HTML documentation, for example:

```
mxmldoc --epub foo.epub *.h *.c foo.xml ENTER
```

Commenting Your Code

As noted previously, `mxmldoc` looks for in-line comments to describe the functions, types, and constants in your code. `Mxmldoc` will document all public names it finds in your source files - any names starting with the underscore character (_) or names that are documented with the @private@ directive are treated as private and are not documented.

Comments appearing directly before a function or type definition are used to document that function or type. Comments appearing after argument, definition, return type, or variable declarations are used to document that argument, definition, return type, or variable. For example, the following code excerpt defines a key/value structure and a function that creates a new instance of that structure:

```
/* A key/value pair. This is used with the
   dictionary structure. */

struct keyval
{
  char *key; /* Key string */
  char *val; /* Value string */
};

/* Create a new key/value pair. */
```

```
struct keyval * /* New key/value pair */
new_keyval(
    const char *key, /* Key string */
    const char *val) /* Value string */
{
  ...
}
```

`Mxmldoc` also knows to remove extra asterisks (*) from the comment string, so the comment string:

```
/*
 * Compute the value of PI.
 *
 * The function connects to an Internet server
 * that streams audio of mathematical monks
 * chanting the first 100 digits of PI.
 */
```

will be shown as:

```
Compute the value of PI.

The function connects to an Internet server
that streams audio of mathematical monks
chanting the first 100 digits of PI.
```

Comments can also include the following special `@name ...@` directive strings:

- `@deprecated@` - flags the item as deprecated to discourage its use
- `@exclude format[,...,format]@` - excludes the item from the documentation in the specified formats: "all" for all formats, "epub" for EPUB books, "html" for HTML output, and "man" for man page output

- `@private@` - flags the item as private so it will not be included in the documentation
- `@since ...@` - flags the item as new since a particular release. The text following the `@since` up to the closing `@` is highlighted in the generated documentation, e.g. `@since Mini-XML 2.7@`.

Titles, Sections, and Introductions

`Mxmldoc` also provides options to set the title, section, and introduction text for the generated documentation. The `--title text` option specifies the title for the documentation. The title string is usually put in quotes:

```
mxmldoc filename.xml \
    --title "My Famous Documentation" \
    >filename.html ENTER
```

The `--section name` option specifies the section for the documentation. For HTML documentation, the name is placed in a HTML comment such as:

```
<!-- SECTION: name -->
```

For man pages, the section name is usually just a number ("3"), or a number followed by a vendor name ("3acme"). The section name is used in the `.TH` directive in the man page:

```
.TH mylibrary 3acme "My Title" ...
```

The default section name for man page output is "3". There is no default section name for HTML output.

Finally, the `--intro filename` option specifies a file to embed after the title and section but before the generated documentation. For HTML documentation, the file must consist of valid HTML without the usual `DOCTYPE`, `html`, and `body` elements. For man page documentation, the file must consist of valid `nroff(1)` text.

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>
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>
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That's all there is to it!

Appendix B - Library Reference

Contents

- mxml_type_t
- Enumerations
  - mxml_sax_event_e
  - mxml_type_e

Functions

mxmlAdd

Add a node to a tree.

void mxmlAdd(mxml_node_t *parent, int where, mxml_node_t *child, mxml_node_t *node);

Parameters

parent	Parent node
where	Where to add, `MXML_ADD_BEFORE` or `MXML_ADD_AFTER`
child	Child node for where or `MXML_ADD_TO_PARENT`
node	Node to add

Discussion

Adds the specified node to the parent. If the child argument is not `NULL`, puts the new node before or after the specified child depending on the value of the where argument. If the child argument is `NULL`, puts the new node at the beginning of the child list (`MXML_ADD_BEFORE`) or at the end of the child list (`MXML_ADD_AFTER`). The constant `MXML_ADD_TO_PARENT` can be used to specify a `NULL` child pointer.

mxmlDelete

Delete a node and all of its children.

void mxmlDelete(mxml_node_t *node);

Parameters

node Node to delete

Discussion

If the specified node has a parent, this function first removes the node from its parent using the `mxmlRemove` function.

Mini-XML 2.4 mxmlElementDeleteAttr

Delete an attribute.

void mxmlElementDeleteAttr(mxml_node_t *node, const char *name);

Parameters

node Element

name Attribute name

mxmlElementGetAttr

Get an attribute.

const char *mxmlElementGetAttr(mxml_node_t *node, const char *name);

Parameters

node Element node

name Name of attribute

Return Value

Attribute value or `NULL`

Discussion

This function returns `NULL` if the node is not an element or the named attribute does not exist.

Mini-XML 2.11 mxmlElementGetAttrByIndex

Get an element attribute by index.

```
const char
*mxmlElementGetAttrByIndex(mxml_node_t *node,
int idx, const char **name);
```

Parameters

node Node

idx Attribute index, starting at 0

name Attribute name

Return Value

Attribute value

Discussion

The index ("idx") is 0-based. `NULL` is returned if the specified index is out of range.

Mini-XML
2.11 mxmlElementGetAttrCount

Get the number of element attributes.

int mxmlElementGetAttrCount(mxml_node_t *node);

Parameters

node Node
Return Value

Number of attributes

mxmlElementSetAttr

Set an attribute.

void mxmlElementSetAttr(mxml_node_t *node, const char *name, const char *value);

Parameters

node Element node
name Name of attribute
value Attribute value

Discussion

If the named attribute already exists, the value of the attribute is replaced by the new string value. The string value is copied into the element node. This function does nothing if the node is not an element.

Mini-XML 2.3 mxmlElementSetAttrf

Set an attribute with a formatted value.

void mxmlElementSetAttrf(mxml_node_t *node, const char *name, const char *format, ...);

Parameters

node	Element node
name	Name of attribute
format	Printf-style attribute value
...	Additional arguments as needed

Discussion

If the named attribute already exists, the value of the attribute is replaced by the new formatted string. The formatted string value is copied into the element node. This function does nothing if the node is not an element.

mxmlEntityAddCallback

Add a callback to convert entities to Unicode.

int mxmlEntityAddCallback(mxml_entity_cb_t cb);

Parameters

cb Callback function to add

Return Value

0 on success, -1 on failure

mxmlEntityGetName

Get the name that corresponds to the character value.

const char *mxmlEntityGetName(int val);

Parameters

val Character value

Return Value

Entity name or `NULL`

Discussion

If val does not need to be represented by a named entity, `NULL` is returned.

mxmlEntityGetValue

Get the character corresponding to a named entity.

int mxmlEntityGetValue(const char *name);

Parameters

name Entity name

Return Value

Character value or -1 on error

Discussion

The entity name can also be a numeric constant. -1 is returned if the name is not known.

mxmlEntityRemoveCallback

Remove a callback.

void mxmlEntityRemoveCallback(mxml_entity_cb_t cb);

Parameters

cb Callback function to remove

mxmlFindElement

Find the named element.

mxml_node_t *mxmlFindElement(mxml_node_t *node, mxml_node_t *top, const char *element, const char *attr, const char *value, int descend);

Parameters

node	Current node
top	Top node
element	Element name or `NULL` for any
attr	Attribute name, or `NULL` for none
value	Attribute value, or `NULL` for any

node Current node

descend Descend into tree - `MXML_DESCEND`, `MXML_NO_DESCEND`, or `MXML_DESCEND_FIRST`

Return Value

Element node or `NULL`

Discussion

The search is constrained by the name, attribute name, and value; any `NULL` names or values are treated as wildcards, so different kinds of searches can be implemented by looking for all elements of a given name or all elements with a specific attribute. The descend argument determines whether the search descends into child nodes; normally you will use `MXML_DESCEND_FIRST` for the initial search and `MXML_NO_DESCEND` to find additional direct descendents of the node. The top node argument constrains the search to a particular node's children.

Mini-XML 2.7 mxmlFindPath

Find a node with the given path.

mxml_node_t *mxmlFindPath(mxml_node_t *top, const char *path);

Parameters

top Top node

path Path to element

Return Value

Found node or `NULL`

Discussion

The "path" is a slash-separated list of element names. The name "*" is considered a wildcard for one or more levels of elements. For example, "foo/one/two", "bar/two/one", "*/one", and so forth.

The first child node of the found node is returned if the given node has children and the first child is a value node.

Mini-XML 2.7 mxmlGetCDATA

Get the value for a CDATA node.

const char *mxmlGetCDATA(mxml_node_t *node);

Parameters

node Node to get
Return Value

CDATA value or `NULL`

Discussion

`NULL` is returned if the node is not a CDATA element.

Mini-XML 2.7 mxmlGetCustom

Get the value for a custom node.

const void *mxmlGetCustom(mxml_node_t *node);

Parameters

node Node to get
Return Value

Custom value or `NULL`

Discussion

`NULL` is returned if the node (or its first child) is not a custom value node.

Mini-XML 2.7 mxmlGetElement

Get the name for an element node.

const char *mxmlGetElement(mxml_node_t *node);

Parameters

node Node to get
Return Value

Element name or `NULL`

Discussion

`NULL` is returned if the node is not an element node.

Mini-XML 2.7 mxmlGetFirstChild

Get the first child of an element node.

mxml_node_t *mxmlGetFirstChild(mxml_node_t *node);

Parameters

node Node to get

Return Value

First child or `NULL`

Discussion

`NULL` is returned if the node is not an element node or if the node has no children.

Mini-XML 2.7 mxmlGetInteger

Get the integer value from the specified node or its first child.

int mxmlGetInteger(mxml_node_t *node);

Parameters

node Node to get

Return Value

Integer value or 0

Discussion

0 is returned if the node (or its first child) is not an integer value node.

Mini-XML 2.7 mxmlGetLastChild

Get the last child of an element node.

mxml_node_t *mxmlGetLastChild(mxml_node_t *node);

Parameters

node Node to get

Return Value

Last child or `NULL`

Discussion

`NULL` is returned if the node is not an element node or if the node has no children.

mxmlGetNextSibling

mxml_node_t *mxmlGetNextSibling(mxml_node_t *node);

Parameters

node Node to get

Return Value

Get the next node for the current parent.

`NULL` is returned if this is the last child for the current parent.

Mini-XML 2.7 mxmlGetOpaque

Get an opaque string value for a node or its first child.

const char *mxmlGetOpaque(mxml_node_t *node);

Parameters

node Node to get

Return Value

Opaque string or `NULL`

Discussion

`NULL` is returned if the node (or its first child) is not an opaque value node.

Mini-XML 2.7 mxmlGetParent

Get the parent node.

mxml_node_t *mxmlGetParent(mxml_node_t *node);

Parameters

node Node to get

Return Value

Parent node or NULL

Discussion

NULL is returned for a root node.

Mini-XML 2.7 mxmlGetPrevSibling

Get the previous node for the current parent.

mxml_node_t *mxmlGetPrevSibling(mxml_node_t *node);

Parameters

node Node to get

Return Value

Previous node or NULL

Discussion

NULL is returned if this is the first child for the current parent.

Mini-XML 2.7 mxmlGetReal

Get the real value for a node or its first child.

double mxmlGetReal(mxml_node_t *node);

Parameters

node Node to get
Return Value

Real value or 0.0

Discussion

0.0 is returned if the node (or its first child) is not a real value node.

Mini-XML 2.7 mxmlGetRefCount

Get the current reference (use) count for a node.

int mxmlGetRefCount(mxml_node_t *node);

Parameters

node Node
Return Value

Reference count

Discussion

The initial reference count of new nodes is 1. Use the `mxmlRetain` and `mxmlRelease` functions to increment and decrement a node's reference count. .

Mini-XML 2.7 mxmlGetText

Get the text value for a node or its first child.

const char *mxmlGetText(mxml_node_t *node, int *whitespace);

Parameters

node	Node to get
whitespace	1 if string is preceded by whitespace, 0 otherwise

Return Value

Text string or `NULL`

Discussion

`NULL` is returned if the node (or its first child) is not a text node. The "whitespace" argument can be `NULL`.

Note: Text nodes consist of whitespace-delimited words. You will only get single words of text when reading an XML file with `MXML_TEXT` nodes. If you want the entire string between elements in the XML file, you MUST read the XML file with `MXML_OPAQUE` nodes and get the resulting strings using the `mxmlGetOpaque` function instead.

Mini-XML 2.7 mxmlGetType

Get the node type.

mxml_type_t mxmlGetType(mxml_node_t *node);

Parameters

node	Node to get

Return Value

Type of node

Discussion

`MXML_IGNORE` is returned if "node" is `NULL`.

Mini-XML 2.7 mxmlGetUserData

Get the user data pointer for a node.

void *mxmlGetUserData(mxml_node_t *node);

Parameters

node Node to get

Return Value

User data pointer

mxmlIndexDelete

Delete an index.

void mxmlIndexDelete(mxml_index_t *ind);

Parameters

ind Index to delete

mxmlIndexEnum

Return the next node in the index.

mxml_node_t *mxmlIndexEnum(mxml_index_t *ind);

Parameters

ind Index to enumerate

Return Value

Next node or `NULL` if there is none

Discussion

You should call `mxmlIndexReset` prior to using this function to get the first node in the index. Nodes are returned in the sorted order of the index.

mxmlIndexFind

Find the next matching node.

mxml_node_t *mxmlIndexFind(mxml_index_t *ind, const char *element, const char *value);

Parameters

ind Index to search

element Element name to find, if any

value Attribute value, if any

Return Value

Node or `NULL` if none found

Discussion

You should call `mxmlIndexReset` prior to using this function for the first time with a particular set of "element" and "value" strings. Passing `NULL` for both

"element" and "value" is equivalent to calling `mxmlIndexEnum`.

Mini-XML 2.7 mxmlIndexGetCount

Get the number of nodes in an index.

int mxmlIndexGetCount(mxml_index_t *ind);

Parameters

ind Index of nodes

Return Value

Number of nodes in index

mxmlIndexNew

Create a new index.

mxml_index_t *mxmlIndexNew(mxml_node_t *node, const char *element, const char *attr);

Parameters

node XML node tree

element Element to index or `NULL` for all

attr Attribute to index or `NULL` for none

Return Value

New index

Discussion

The index will contain all nodes that contain the named element and/or attribute. If both "element" and "attr" are `NULL`, then the index will contain a sorted list of the elements in the node tree. Nodes are sorted by element name and optionally by attribute value if the "attr" argument is not NULL.

mxmlIndexReset

Reset the enumeration/find pointer in the index and return the first node in the index.

mxml_node_t *mxmlIndexReset(mxml_index_t *ind);

Parameters

ind Index to reset

Return Value

First node or `NULL` if there is none

Discussion

This function should be called prior to using `mxmlIndexEnum` or `mxmlIndexFind` for the first time.

mxmlLoadFd

Load a file descriptor into an XML node tree.

mxml_node_t *mxmlLoadFd(mxml_node_t *top, int fd, mxml_load_cb_t cb);

Parameters

top Top node
fd File descriptor to read from
cb Callback function or constant

Return Value

First node or `NULL` if the file could not be read.

Discussion

The nodes in the specified file are added to the specified top node. If no top node is provided, the XML file MUST be well-formed with a single parent node like <?xml> for the entire file. The callback function returns the value type that should be used for child nodes. The constants `MXML_INTEGER_CALLBACK`, `MXML_OPAQUE_CALLBACK`, `MXML_REAL_CALLBACK`, and `MXML_TEXT_CALLBACK` are defined for loading child (data) nodes of the specified type.

Note: The most common programming error when using the Mini-XML library is to load an XML file using the `MXML_TEXT_CALLBACK`, which returns inline text as a series of whitespace-delimited words, instead of using the `MXML_OPAQUE_CALLBACK` which returns the inline text as a single string (including whitespace).

mxmlLoadFile

Load a file into an XML node tree.

mxml_node_t *mxmlLoadFile(mxml_node_t *top, FILE *fp, mxml_load_cb_t cb);

Parameters

top Top node
fp File to read from
cb Callback function or constant

Return Value

First node or `NULL` if the file could not be read.

Discussion

The nodes in the specified file are added to the specified top node. If no top node is provided, the XML file MUST be well-formed with a single parent node like <?xml> for the entire file. The callback function returns the value type that should be used for child nodes. The constants `MXML_INTEGER_CALLBACK`, `MXML_OPAQUE_CALLBACK`, `MXML_REAL_CALLBACK`, and `MXML_TEXT_CALLBACK` are defined for loading child (data) nodes of the specified type.

Note: The most common programming error when using the Mini-XML library is to load an XML file using the `MXML_TEXT_CALLBACK`, which returns inline text as a series of whitespace-delimited words, instead of using the `MXML_OPAQUE_CALLBACK` which returns the inline text as a single string (including whitespace).

mxmlLoadString

Load a string into an XML node tree.

mxml_node_t *mxmlLoadString(mxml_node_t *top, const char *s, mxml_load_cb_t cb);

Parameters

top Top node
s String to load
cb Callback function or constant

Return Value

First node or `NULL` if the string has errors.

Discussion

The nodes in the specified string are added to the specified top node. If no top node is provided, the XML string MUST be well-formed with a single parent node like <?xml> for the entire string. The callback function returns the value type that should be used for child nodes. The constants `MXML_INTEGER_CALLBACK`, `MXML_OPAQUE_CALLBACK`, `MXML_REAL_CALLBACK`, and `MXML_TEXT_CALLBACK` are defined for loading child (data) nodes of the specified type.

Note: The most common programming error when using the Mini-XML library is to load an XML file using the `MXML_TEXT_CALLBACK`, which returns inline text as a series of whitespace-delimited words, instead of using the `MXML_OPAQUE_CALLBACK` which returns the inline text as a single string (including whitespace).

Mini-XML 2.3 mxmlNewCDATA

Create a new CDATA node.

mxml_node_t *mxmlNewCDATA(mxml_node_t *parent, const char *data);

Parameters

parent Parent node or `MXML_NO_PARENT`

data Data string

Return Value

New node

Discussion

The new CDATA node is added to the end of the specified parent's child list. The constant `MXML_NO_PARENT` can be used to specify that the new CDATA node has no parent. The data string must be nul-terminated and is copied into the new node. CDATA nodes currently use the `MXML_ELEMENT` type.

Mini-XML 2.1 mxmlNewCustom

Create a new custom data node.

mxml_node_t *mxmlNewCustom(mxml_node_t *parent, void *data, mxml_custom_destroy_cb_t destroy);

Parameters

parent Parent node or `MXML_NO_PARENT`

data Pointer to data

destroy Function to destroy data

Return Value

New node

Discussion

The new custom node is added to the end of the specified parent's child list. The constant `MXML_NO_PARENT` can be used to specify that the new element node has no parent. `NULL` can be passed when the data in the node is not dynamically allocated or is separately managed.

mxmlNewElement

Create a new element node.

mxml_node_t *mxmlNewElement(mxml_node_t *parent, const char *name);

Parameters

parent Parent node or `MXML_NO_PARENT`

name Name of element

Return Value

New node

Discussion

The new element node is added to the end of the specified parent's child list. The constant `MXML_NO_PARENT` can be used to specify that the new element node has no parent.

mxmlNewInteger

Create a new integer node.

mxml_node_t *mxmlNewInteger(mxml_node_t *parent, int integer);

Parameters

parent Parent node or `MXML_NO_PARENT`

integer Integer value

Return Value

New node

Discussion

The new integer node is added to the end of the specified parent's child list. The constant `MXML_NO_PARENT` can be used to specify that the new integer node has no parent.

mxmlNewOpaque

Create a new opaque string.

mxml_node_t *mxmlNewOpaque(mxml_node_t *parent, const char *opaque);

Parameters

parent Parent node or `MXML_NO_PARENT`

opaque Opaque string

Return Value

New node

Discussion

The new opaque string node is added to the end of the specified parent's child list. The constant `MXML_NO_PARENT` can be used to specify that the new opaque string node has no parent. The opaque string must be nul- terminated and is copied into the new node.

mxmlNewOpaquef

Create a new formatted opaque string node.

mxml_node_t *mxmlNewOpaquef(mxml_node_t *parent, const char *format, ...);

Parameters

parent Parent node or `MXML_NO_PARENT`

format Printf-style format string

... Additional args as needed

Return Value

New node

Discussion

The new opaque string node is added to the end of the specified parent's child list. The constant `MXML_NO_PARENT` can be used to specify that the new opaque string node has no parent. The format string

must be nul-terminated and is formatted into the new node.

mxmlNewReal

Create a new real number node.

mxml_node_t *mxmlNewReal(mxml_node_t *parent, double real);

Parameters

parent Parent node or `MXML_NO_PARENT`

real Real number value

Return Value

New node

Discussion

The new real number node is added to the end of the specified parent's child list. The constant `MXML_NO_PARENT` can be used to specify that the new real number node has no parent.

mxmlNewText

Create a new text fragment node.

mxml_node_t *mxmlNewText(mxml_node_t *parent, int whitespace, const char *string);

Parameters

parent	Parent node or `MXML_NO_PARENT`
whitespace	1 = leading whitespace, 0 = no whitespace
string	String

Return Value

New node

Discussion

The new text node is added to the end of the specified parent's child list. The constant `MXML_NO_PARENT` can be used to specify that the new text node has no parent. The whitespace parameter is used to specify whether leading whitespace is present before the node. The text string must be nul-terminated and is copied into the new node.

mxmlNewTextf

Create a new formatted text fragment node.

mxml_node_t *mxmlNewTextf(mxml_node_t *parent, int whitespace, const char *format, ...);

Parameters

parent	Parent node or `MXML_NO_PARENT`
whitespace	1 = leading whitespace, 0 = no whitespace
format	Printf-style format string
...	Additional args as needed

parent Parent node or `MXML_NO_PARENT`

Return Value

New node

Discussion

The new text node is added to the end of the specified parent's child list. The constant `MXML_NO_PARENT` can be used to specify that the new text node has no parent. The whitespace parameter is used to specify whether leading whitespace is present before the node. The format string must be nul-terminated and is formatted into the new node.

Mini-XML 2.3 mxmlNewXML

Create a new XML document tree.

mxml_node_t *mxmlNewXML(const char *version);

Parameters

version Version number to use

Return Value

New ?xml node

Discussion

The "version" argument specifies the version number to put in the ?xml element node. If `NULL`, version "1.0" is assumed.

Mini-XML 2.3 mxmlRelease

Release a node.

int mxmlRelease(mxml_node_t *node);

Parameters

node Node
Return Value

New reference count

Discussion

When the reference count reaches zero, the node (and any children) is deleted via `mxmlDelete`.

mxmlRemove

Remove a node from its parent.

void mxmlRemove(mxml_node_t *node);

Parameters

node Node to remove
Discussion

This function does not free memory used by the node - use `mxmlDelete` for that. This function does nothing if the node has no parent.

Mini-XML 2.3 mxmlRetain

Retain a node.

int mxmlRetain(mxml_node_t *node);

Parameters

node Node
Return Value

New reference count

Mini-XML 2.3 mxmlSAXLoadFd

Load a file descriptor into an XML node tree using a SAX callback.

mxml_node_t *mxmlSAXLoadFd(mxml_node_t *top, int fd, mxml_load_cb_t cb, mxml_sax_cb_t sax_cb, void *sax_data);

Parameters

top	Top node
fd	File descriptor to read from
cb	Callback function or constant
sax_cb	SAX callback or `MXML_NO_CALLBACK`
sax_data	SAX user data

Return Value

First node or `NULL` if the file could not be read.

Discussion

The nodes in the specified file are added to the specified top node. If no top node is provided, the XML file MUST be well-formed with a single parent node like <?xml> for the entire file. The callback function returns the value type that should be used for child nodes. The constants `MXML_INTEGER_CALLBACK`, `MXML_OPAQUE_CALLBACK`, `MXML_REAL_CALLBACK`, and `MXML_TEXT_CALLBACK` are defined for loading child nodes of the specified type.

The SAX callback must call `mxmlRetain` for any nodes that need to be kept for later use. Otherwise, nodes are deleted when the parent node is closed or after each data, comment, CDATA, or directive node.

Mini-XML 2.3 mxmlSAXLoadFile

Load a file into an XML node tree using a SAX callback.

mxml_node_t *mxmlSAXLoadFile(mxml_node_t *top, FILE *fp, mxml_load_cb_t cb, mxml_sax_cb_t sax_cb, void *sax_data);

Parameters

top	Top node
fp	File to read from
cb	Callback function or constant
sax_cb	SAX callback or `MXML_NO_CALLBACK`
sax_data	SAX user data

Return Value

First node or `NULL` if the file could not be read.

Discussion

The nodes in the specified file are added to the specified top node. If no top node is provided, the XML file MUST be well-formed with a single parent node like <?xml> for the entire file. The callback function returns the value type that should be used for child nodes. The constants `MXML_INTEGER_CALLBACK`, `MXML_OPAQUE_CALLBACK`, `MXML_REAL_CALLBACK`, and `MXML_TEXT_CALLBACK` are defined for loading child nodes of the specified type.

The SAX callback must call `mxmlRetain` for any nodes that need to be kept for later use. Otherwise, nodes are deleted when the parent node is closed or after each data, comment, CDATA, or directive node.

Mini-XML 2.3 mxmlSAXLoadString

Load a string into an XML node tree using a SAX callback.

mxml_node_t *mxmlSAXLoadString(mxml_node_t *top, const char *s, mxml_load_cb_t cb, mxml_sax_cb_t sax_cb, void *sax_data);

Parameters

top	Top node
s	String to load
cb	Callback function or constant

top Top node

sax_cb SAX callback or `MXML_NO_CALLBACK`

sax_data SAX user data

Return Value

First node or `NULL` if the string has errors.

Discussion

The nodes in the specified string are added to the specified top node. If no top node is provided, the XML string MUST be well-formed with a single parent node like <?xml> for the entire string. The callback function returns the value type that should be used for child nodes. The constants `MXML_INTEGER_CALLBACK`, `MXML_OPAQUE_CALLBACK`, `MXML_REAL_CALLBACK`, and `MXML_TEXT_CALLBACK` are defined for loading child nodes of the specified type.

The SAX callback must call `mxmlRetain` for any nodes that need to be kept for later use. Otherwise, nodes are deleted when the parent node is closed or after each data, comment, CDATA, or directive node.

mxmlSaveAllocString

Save an XML tree to an allocated string.

char *mxmlSaveAllocString(mxml_node_t *node, mxml_save_cb_t cb);

Parameters

node Node to write

cb Whitespace callback or `MXML_NO_CALLBACK`

Return Value

Allocated string or `NULL`

Discussion

This function returns a pointer to a string containing the textual representation of the XML node tree. The string should be freed using the free() function when you are done with it. `NULL` is returned if the node would produce an empty string or if the string cannot be allocated.

The callback argument specifies a function that returns a whitespace string or NULL before and after each element. If `MXML_NO_CALLBACK` is specified, whitespace will only be added before `MXML_TEXT` nodes with leading whitespace and before attribute names inside opening element tags.

mxmlSaveFd

Save an XML tree to a file descriptor.

int mxmlSaveFd(mxml_node_t *node, int fd, mxml_save_cb_t cb);

Parameters

node Node to write

node Node to write
fd File descriptor to write to
cb Whitespace callback or MXML_NO_CALLBACK

Return Value

0 on success, -1 on error.

Discussion

The callback argument specifies a function that returns a whitespace string or NULL before and after each element. If MXML_NO_CALLBACK is specified, whitespace will only be added before MXML_TEXT nodes with leading whitespace and before attribute names inside opening element tags.

mxmlSaveFile

Save an XML tree to a file.

int mxmlSaveFile(mxml_node_t *node, FILE *fp, mxml_save_cb_t cb);

Parameters

node Node to write
fp File to write to
cb Whitespace callback or MXML_NO_CALLBACK

Return Value

0 on success, -1 on error.

Discussion

The callback argument specifies a function that returns a whitespace string or NULL before and after each element. If `MXML_NO_CALLBACK` is specified, whitespace will only be added before `MXML_TEXT` nodes with leading whitespace and before attribute names inside opening element tags.

mxmlSaveString

Save an XML node tree to a string.

int mxmlSaveString(mxml_node_t *node, char *buffer, int bufsize, mxml_save_cb_t cb);

Parameters

node	Node to write
buffer	String buffer
bufsize	Size of string buffer
cb	Whitespace callback or `MXML_NO_CALLBACK`

Return Value

Size of string

Discussion

This function returns the total number of bytes that would be required for the string but only copies (bufsize - 1) characters into the specified buffer.

The callback argument specifies a function that returns a whitespace string or NULL before and after

each element. If MXML_NO_CALLBACK is specified, whitespace will only be added before MXML_TEXT nodes with leading whitespace and before attribute names inside opening element tags.

Mini-XML 2.3 mxmlSetCDATA

Set the element name of a CDATA node.

int mxmlSetCDATA(mxml_node_t *node, const char *data);

Parameters

node Node to set

data New data string

Return Value

0 on success, -1 on failure

Discussion

The node is not changed if it (or its first child) is not a CDATA element node.

Mini-XML 2.1 mxmlSetCustom

Set the data and destructor of a custom data node.

int mxmlSetCustom(mxml_node_t *node, void *data, mxml_custom_destroy_cb_t destroy);

Parameters

node	Node to set
data	New data pointer
destroy	New destructor function

Return Value

0 on success, -1 on failure

Discussion

The node is not changed if it (or its first child) is not a custom node.

mxmlSetCustomHandlers

Set the handling functions for custom data.

void
mxmlSetCustomHandlers(mxml_custom_load_cb_t load, mxml_custom_save_cb_t save);

Parameters

load	Load function
save	Save function

Discussion

The load function accepts a node pointer and a data string and must return 0 on success and non-zero on error.

The save function accepts a node pointer and must return a malloc'd string on success and `NULL` on error.

mxmlSetElement

Set the name of an element node.

int mxmlSetElement(mxml_node_t *node, const char *name);

Parameters

node Node to set
name New name string

Return Value

0 on success, -1 on failure

Discussion

The node is not changed if it is not an element node.

mxmlSetErrorCallback

Set the error message callback.

void mxmlSetErrorCallback(mxml_error_cb_t cb);

Parameters

cb Error callback function

mxmlSetInteger

Set the value of an integer node.

int mxmlSetInteger(mxml_node_t *node, int integer);

Parameters

node Node to set
integer Integer value

Return Value

0 on success, -1 on failure

Discussion

The node is not changed if it (or its first child) is not an integer node.

mxmlSetOpaque

Set the value of an opaque node.

int mxmlSetOpaque(mxml_node_t *node, const char *opaque);

Parameters

node Node to set
opaque Opaque string

Return Value

0 on success, -1 on failure

Discussion

The node is not changed if it (or its first child) is not an opaque node.

Mini-XML 2.11 mxmlSetOpaquef

Set the value of an opaque string node to a formatted string.

int mxmlSetOpaquef(mxml_node_t *node, const char *format, ...);

Parameters

node Node to set
format Printf-style format string
... Additional arguments as needed

Return Value

0 on success, -1 on failure

Discussion

The node is not changed if it (or its first child) is not an opaque node.

mxmlSetReal

Set the value of a real number node.

int mxmlSetReal(mxml_node_t *node, double real);

Parameters

node Node to set
real Real number value

Return Value

0 on success, -1 on failure

Discussion

The node is not changed if it (or its first child) is not a real number node.

mxmlSetText

Set the value of a text node.

int mxmlSetText(mxml_node_t *node, int whitespace, const char *string);

Parameters

node	Node to set
whitespace	1 = leading whitespace, 0 = no whitespace
string	String

Return Value

0 on success, -1 on failure

Discussion

The node is not changed if it (or its first child) is not a text node.

mxmlSetTextf

Set the value of a text node to a formatted string.

int mxmlSetTextf(mxml_node_t *node, int whitespace, const char *format, ...);

Parameters

node	Node to set
whitespace	1 = leading whitespace, 0 = no whitespace
format	Printf-style format string
...	Additional arguments as needed

Return Value

0 on success, -1 on failure

Discussion

The node is not changed if it (or its first child) is not a text node.

Mini-XML 2.7 mxmlSetUserData

Set the user data pointer for a node.

int mxmlSetUserData(mxml_node_t *node, void *data);

Parameters

node	Node to set
data	User data pointer

Return Value

0 on success, -1 on failure

Mini-XML 2.3 mxmlSetWrapMargin

Set the wrap margin when saving XML data.

void mxmlSetWrapMargin(int column);

Parameters

column Column for wrapping, 0 to disable wrapping

Discussion

Wrapping is disabled when "column" is 0.

mxmlWalkNext

Walk to the next logical node in the tree.

mxml_node_t *mxmlWalkNext(mxml_node_t *node, mxml_node_t *top, int descend);

Parameters

node	Current node
top	Top node
descend	Descend into tree - `MXML_DESCEND`, `MXML_NO_DESCEND`, or `MXML_DESCEND_FIRST`

Return Value

Next node or `NULL`

Discussion

The descend argument controls whether the first child is considered to be the next node. The top node argument constrains the walk to the node's children.

mxmlWalkPrev

Walk to the previous logical node in the tree.

```
mxml_node_t *mxmlWalkPrev(mxml_node_t *node,
mxml_node_t *top, int descend);
```

Parameters

node	Current node
top	Top node
descend	Descend into tree - `MXML_DESCEND`, `MXML_NO_DESCEND`, or `MXML_DESCEND_FIRST`

Return Value

Previous node or `NULL`

Discussion

The descend argument controls whether the previous node's last child is considered to be the previous node. The top node argument constrains the walk to the node's children.

Data Types

mxml_custom_destroy_cb_t

Custom data destructor

typedef void (*mxml_custom_destroy_cb_t)(void *);

mxml_custom_load_cb_t

Custom data load callback function

typedef int (*mxml_custom_load_cb_t)(mxml_node_t *, const char *);

mxml_custom_save_cb_t

Custom data save callback function

typedef char *(*mxml_custom_save_cb_t)(mxml_node_t *);

mxml_entity_cb_t

Entity callback function

typedef int (*mxml_entity_cb_t)(const char *);

mxml_error_cb_t

Error callback function

typedef void (*mxml_error_cb_t)(const char *);

mxml_index_t

An XML node index.

typedef struct mxml_index_s mxml_index_t;

mxml_load_cb_t

Load callback function

typedef mxml_type_t
(*mxml_load_cb_t)(mxml_node_t *);

mxml_node_t

An XML node.

typedef struct mxml_node_s mxml_node_t;

mxml_save_cb_t

Save callback function

typedef const char *(*mxml_save_cb_t)(mxml_node_t
*, int);

mxml_sax_cb_t

SAX callback function

typedef void (*mxml_sax_cb_t)(mxml_node_t *,
mxml_sax_event_t, void *);

mxml_sax_event_t

SAX event type.

typedef enum mxml_sax_event_e mxml_sax_event_t;

mxml_type_t

The XML node type.

typedef enum mxml_type_e mxml_type_t;

Constants

mxml_sax_event_e

SAX event type.

Constants

MXML_SAX_CDATA	CDATA node
MXML_SAX_COMMENT	Comment node
MXML_SAX_DATA	Data node
MXML_SAX_DIRECTIVE	Processing directive node
MXML_SAX_ELEMENT_CLOSE	Element closed
MXML_SAX_ELEMENT_OPEN	Element opened

mxml_type_e

The XML node type.

Constants

MXML_CUSTOM Mini-XML 2.1	Custom data
MXML_ELEMENT	XML element with attributes
MXML_IGNORE Mini-XML 2.3	Ignore/throw away node
MXML_INTEGER	Integer value
MXML_OPAQUE	Opaque string
MXML_REAL	Real value
MXML_TEXT	Text fragment

Appendix C - XML Schema

This appendix provides the XML schema that is used for the XML files produced by `mxmldoc`. This schema is available on-line at:

`https://michaelrsweet.github.io/mxml/mxmldoc`

mxmldoc.xsd

```
<?xml version="1.0"?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">
  <xsd:annotation>
    <xsd:documentation xml:lang="en">
      Mini-XML 2.11 documentation schema for mxmldoc output.
      Copyright 2003-2017 by Michael R Sweet.
    </xsd:documentation>
  </xsd:annotation>

  <!-- basic element definitions -->
  <xsd:element name="argument" type="argumentType"/>
  <xsd:element name="class" type="classType"/>
  <xsd:element name="constant" type="constantType"/>
  <xsd:element name="description" type="xsd:string"/>
```

```
<xsd:element name="enumeration" type="enumerationType"/>
<xsd:element name="function" type="functionType"/>
<xsd:element name="mxmldoc" type="mxmldocType"/>
<xsd:element name="namespace" type="namespaceType"/>
<xsd:element name="returnvalue" type="returnvalueType"/>
<xsd:element name="seealso" type="identifierList"/>
<xsd:element name="struct" type="structType"/>
<xsd:element name="typedef" type="typedefType"/>
<xsd:element name="type" type="xsd:string"/>
<xsd:element name="union" type="unionType"/>
<xsd:element name="variable" type="variableType"/>

<!-- descriptions of complex elements -->
<xsd:complexType name="argumentType">
  <xsd:sequence>
    <xsd:element ref="type" minOccurs="1" maxOccurs="1"/>
    <xsd:element ref="description" minOccurs="0" maxOccurs="1"/>
  </xsd:sequence>
  <xsd:attribute name="default" type="xsd:string" use="optional"/>
  <xsd:attribute name="name" type="identifier" use="required"/>
  <xsd:attribute name="direction" type="direction" use="optional"
   default="I"/>
</xsd:complexType>

<xsd:complexType name="classType">
  <xsd:sequence>
    <xsd:element ref="description" minOccurs="0" maxOccurs="1"/>
    <xsd:choice minOccurs="0" maxOccurs="unbounded">
      <xsd:element ref="class"/>
      <xsd:element ref="enumeration"/>
      <xsd:element ref="function"/>
      <xsd:element ref="struct"/>
      <xsd:element ref="typedef"/>
      <xsd:element ref="union"/>
      <xsd:element ref="variable"/>
    </xsd:choice>
  </xsd:sequence>
  <xsd:attribute name="name" type="identifier" use="required"/>
  <xsd:attribute name="parent" type="xsd:string" use="optional"/>
</xsd:complexType>

<xsd:complexType name="constantType">
  <xsd:sequence>
    <xsd:element ref="description" minOccurs="0" maxOccurs="1"/>
  </xsd:sequence>
  <xsd:attribute name="name" type="identifier" use="required"/>
</xsd:complexType>

<xsd:complexType name="enumerationType">
  <xsd:sequence>
    <xsd:element ref="description" minOccurs="0" maxOccurs="1"/>
    <xsd:element ref="constant" minOccurs="1" maxOccurs="unbounded"/>
  </xsd:sequence>
  <xsd:attribute name="name" type="identifier" use="required"/>
</xsd:complexType>

<xsd:complexType name="functionType">
  <xsd:sequence>
```

```
      <xsd:element ref="returnvalue" minOccurs="0" maxOccurs="1"/>
      <xsd:element ref="description" minOccurs="0" maxOccurs="1"/>
      <xsd:element ref="argument" minOccurs="1" maxOccurs="unbounded"
      <xsd:element ref="seealso" minOccurs="0" maxOccurs="1"/>
    </xsd:sequence>
    <xsd:attribute name="name" type="identifier" use="required"/>
    <xsd:attribute name="scope" type="scope" use="optional"/>
  </xsd:complexType>

  <xsd:complexType name="mxmldocType">
    <xsd:choice minOccurs="0" maxOccurs="unbounded">
      <xsd:element ref="class"/>
      <xsd:element ref="enumeration"/>
      <xsd:element ref="function"/>
      <xsd:element ref="namespace"/>
      <xsd:element ref="struct"/>
      <xsd:element ref="typedef"/>
      <xsd:element ref="union"/>
      <xsd:element ref="variable"/>
    </xsd:choice>
  </xsd:complexType>

  <xsd:complexType name="namespaceType">
    <xsd:sequence>
      <xsd:element ref="description" minOccurs="0" maxOccurs="1"/>
      <xsd:choice minOccurs="0" maxOccurs="unbounded">
        <xsd:element ref="class"/>
        <xsd:element ref="enumeration"/>
        <xsd:element ref="function"/>
        <xsd:element ref="struct"/>
        <xsd:element ref="typedef"/>
        <xsd:element ref="union"/>
        <xsd:element ref="variable"/>
      </xsd:choice>
    </xsd:sequence>
    <xsd:attribute name="name" type="identifier" use="required"/>
  </xsd:complexType>

  <xsd:complexType name="returnvalueType">
    <xsd:sequence>
      <xsd:element ref="type" minOccurs="1" maxOccurs="1"/>
      <xsd:element ref="description" minOccurs="0" maxOccurs="1"/>
    </xsd:sequence>
  </xsd:complexType>

  <xsd:complexType name="structType">
    <xsd:sequence>
      <xsd:element ref="description" minOccurs="0" maxOccurs="1"/>
      <xsd:choice minOccurs="0" maxOccurs="unbounded">
        <xsd:element ref="variable"/>
        <xsd:element ref="function"/>
      </xsd:choice>
    </xsd:sequence>
    <xsd:attribute name="name" type="identifier" use="required"/>
  </xsd:complexType>

  <xsd:complexType name="typedefType">
    <xsd:sequence>
```

```
      <xsd:element ref="type" minOccurs="1" maxOccurs="1"/>
      <xsd:element ref="description" minOccurs="0" maxOccurs="1"/>
    </xsd:sequence>
    <xsd:attribute name="name" type="identifier" use="required"/>
  </xsd:complexType>

  <xsd:complexType name="unionType">
    <xsd:sequence>
      <xsd:element ref="description" minOccurs="0" maxOccurs="1"/>
      <xsd:element ref="variable" minOccurs="0" maxOccurs="unbounded"/>
    </xsd:sequence>
    <xsd:attribute name="name" type="identifier" use="required"/>
  </xsd:complexType>

  <xsd:complexType name="variableType">
    <xsd:sequence>
      <xsd:element ref="type" minOccurs="1" maxOccurs="1"/>
      <xsd:element ref="description" minOccurs="0" maxOccurs="1"/>
    </xsd:sequence>
    <xsd:attribute name="name" type="identifier" use="required"/>
  </xsd:complexType>

  <!-- data types -->
  <xsd:simpleType name="direction">
    <xsd:restriction base="xsd:string">
      <xsd:enumeration value="I"/>
      <xsd:enumeration value="O"/>
      <xsd:enumeration value="IO"/>
    </xsd:restriction>
  </xsd:simpleType>

  <xsd:simpleType name="identifier">
    <xsd:restriction base="xsd:string">
      <xsd:pattern value="[a-zA-Z_(.]([a-zA-Z_(.,)* 0-9])*"/>
    </xsd:restriction>
  </xsd:simpleType>

  <xsd:simpleType name="identifierList">
    <xsd:list itemType="identifier"/>
  </xsd:simpleType>

  <xsd:simpleType name="scope">
    <xsd:restriction base="xsd:string">
      <xsd:enumeration value=""/>
      <xsd:enumeration value="private"/>
      <xsd:enumeration value="protected"/>
      <xsd:enumeration value="public"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:schema>
```