mini XML

Mini-XML Programmers Manual
Version 2.11

MICHAEL R. SWEET

Mini-XML Programmers Manual, Version 2.11

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Introduction

This programmers manual describes Mini-XML
version 2.11, 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

The Mini-XML library is copyright 2003-2017 by Michael R Sweet. License terms are described in Appendix A - Mini-XML License.

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
```

Creating Mini-XML Packages

Mini-XML includes two files that can be used to create binary packages. The first file is *mxml.spec* which is used by the `rpmbuild(8)` software to create Red Hat Package Manager ("RPM") packages which are commonly used on Linux. Since `rpmbuild` wants to compile the software on its own, you can provide it with the Mini-XML tar file to build the package:

```
rpmbuild -ta mxml-version.tar.gz ENTER
```

The second file is *mxml.list* which is used by the `epm(1)` program to create software packages in a variety of formats. The `epm` program is available from the following URL:

```
http://www.epmhome.org/
```

Use the `make` command with the **epm** target to create portable and native packages for your system:

```
make epm ENTER
```

The packages are stored in a subdirectory named *dist* for your convenience. The portable packages utilize scripts and tar files to install the software on the target system. After extracting the package archive, use the *mxml.install* script to install the software.

The native packages will be in the local OS's native format: RPM for Red Hat Linux, DPKG for Debian Linux, PKG for Solaris, and so forth. Use the corresponding commands to install the native packages.

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:

- Functions for creating and managing XML documents in memory.
- Reading of UTF-8 and UTF-16 encoded XML files and strings.
- Writing of UTF-8 encoded XML files and strings.
- Support for arbitrary element names, attributes, and attribute values with no preset limits, just available memory.
- Support for integer, real, opaque ("CDATA"), and text data types in "leaf" nodes.
- "Find", "index", and "walk" functions for easily accessing data in an XML document.

Mini-XML doesn't do validation or other types of processing on the data based upon schema files or other sources of definition information, nor does it support character entities other than those required by the XML specification.

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:

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

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 Nodes

Opaque (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 Nodes

Text (MXML_TEXT) nodes are created using the mxmlNewText and mxmlNewTextf functions. Each text node consists of a text string and (leading) whitespace value - the mxmlGetText function retrieves the text 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_TEXT_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_TEXT_CALLBACK constant which specifies that all data nodes in the document contain whitespace-separated text values. Other standard callbacks include MXML_IGNORE_CALLBACK, MXML_INTEGER_CALLBACK, MXML_OPAQUE_CALLBACK, and MXML_REAL_CALLBACK.

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

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

...
tree = mxmlLoadString(NULL, buffer,
                      MXML_TEXT_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.easysw.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 Xcode Documentation Sets

The `--docset directory.docset` option tells `mxmldoc` to create an Xcode documentation set containing the HTML documentation, for example:

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

Xcode documentation sets can only be built on Mac OS X with Xcode 3.0 or higher installed.

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
- @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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That's all there is to it!

Appendix B - Library Reference

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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.

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.

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.

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 *name,
    const char *attr,
    const char *value,
    int descend
);
```

Parameters

node

　　　Current node

top

      Top node

name

      Element name or NULL for any

attr

      Attribute name, or NULL for none

value

      Attribute value, or NULL for any

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.

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.

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.

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.

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.

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.

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.

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

Return the node type...

```
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.

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.

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.

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.

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.

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. .

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.

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.

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

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().

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 MXML_NO_CALLBACK

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. If MXML_NO_CALLBACK is specified then all child nodes will be either MXML_ELEMENT or MXML_TEXT 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.

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 MXML_NO_CALLBACK

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. If MXML_NO_CALLBACK is specified
then all child nodes will be either MXML_ELEMENT

or MXML_TEXT 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.

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 MXML_NO_CALLBACK

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. If MXML_NO_CALLBACK is specified then all child nodes will be either MXML_ELEMENT or MXML_TEXT 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.

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 use the MXML_ELEMENT type.

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 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 node has no parent. The opaque string must be nul-terminated and is copied 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 frmat string
...
          Additional args as needed

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.

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.

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

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

mxmlRetain

Retain a node.

```
int mxmlRetain (
   mxml_node_t *node
);
```

Parameters

node
        Node

Return Value

New reference count

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 MXML_NO_CALLBACK

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. If MXML_NO_CALLBACK is specified then all child nodes will be either MXML_ELEMENT or MXML_TEXT 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.

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 MXML_NO_CALLBACK

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. If MXML_NO_CALLBACK is specified then all child nodes will be either MXML_ELEMENT or MXML_TEXT 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.

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 MXML_NO_CALLBACK

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. If MXML_NO_CALLBACK is specified then all child nodes will be either MXML_ELEMENT or MXML_TEXT 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

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.

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.

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.

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.

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

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.xsd

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
<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
    <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
      <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>
```