Python XML processing with `lxml`

John W. Shipman

2011-02-20 17:29

Abstract

Describes the `lxml` package for reading and writing XML files with the Python programming language.

This publication is available in Web form[1] and also as a PDF document[2]. Please forward any comments to **`tcc-doc@nmt.edu`**.

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[1] http://www.nmt.edu/tcc/help/pubs/pylxml/
[2] http://www.nmt.edu/tcc/help/pubs/pylxml/pylxml.pdf

1. Introduction: Python and XML

With the continued growth of both Python and XML, there is a plethora of packages out there that help you read, generate, and modify XML files from Python scripts. Compared to most of them, the `lxml` package has two big advantages:

- Performance. Reading and writing even fairly large XML files takes an almost imperceptible amount of time.
- Ease of programming. The `lxml` package is based on `ElementTree`, which Fredrik Lundh invented to simplify and streamline XML processing.

`lxml` is similar in many ways to two other, earlier packages:

- Fredrik Lundh continues to maintain his original version of `ElementTree`[3].
- `xml.etree.ElementTree`[4] is now an official part of the Python library. There is a C-language version called `cElementTree` which may be even faster than `lxml` for some applications.

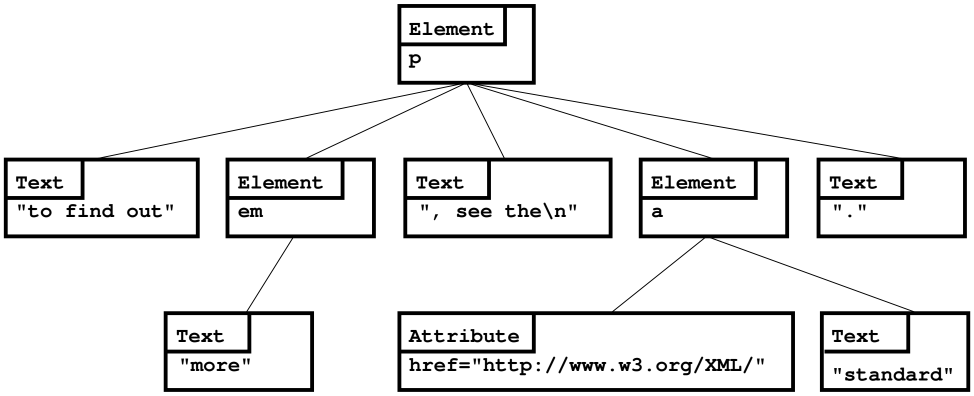
However, the author prefers `lxml` for providing a number of additional features that make life easier. In particular, support for *XPath* makes it considerably easier to manage more complex XML structures.

2. How `ElementTree` represents XML

If you have done XML work using the Document Object Model (DOM), you will find that the `lxml` package has a quite different way of representing documents as trees. In the DOM, trees are build out of nodes represented as `Node` instances. Some nodes are `Element` instances, representing whole elements. Each `Element` has an assortment of child nodes of various types: `Element` nodes for its element children; `Attribute` nodes for its attributes; and `Text` nodes for textual content.

Here is a small fragment of XHTML, and its representation as a DOM tree:

[3] http://effbot.org/zone/element-index.htm
[4] http://docs.python.org/library/xml.etree.elementtree.html




```
<p>To find out <em>more</em>, see the
<a href="http://www.w3.org/XML">standard</a>.</p>
```

The above diagram shows the conceptual structure of the XML. The `lxml` view of an XML document, by contrast, builds a tree of only one node type: the `Element`.

The main difference between the `ElementTree` view used in `lxml`, and the classical view, is the association of text with elements: it is very different in `lxml`.

An instance of `lxml`'s `Element` class contains these attributes:

`.tag`
: The name of the element, such as `"p"` for a paragraph or `"em"` for emphasis.

`.text`
: The text inside the element, if any, *up to the first child element*. This attribute is `None` if the element is empty or has no text before the first child element.

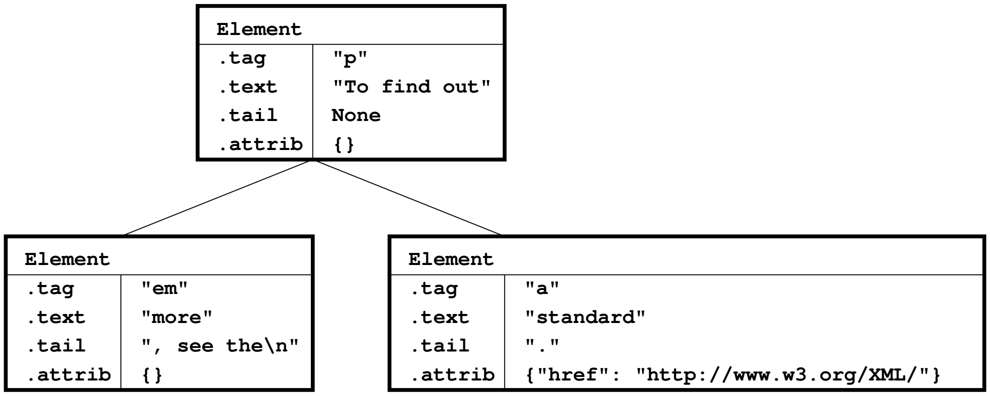
`.tail`
: The text **following** the element. This is the most unusual departure. In the DOM model, any text following an element *E* is associated with the parent of *E*; in `lxml`, that text is considered the “tail” of *E*.

`.attrib`
: A Python dictionary containing the element's XML attribute names and their corresponding values. For example, for the element “`<h2 class="arch" id="N15">`”, that element's `.attrib` would be the dictionary “`{"class": "arch", "id": "N15"}`”.

(element children)
: To access sub-elements, treat an element as a list. For example, if `node` is an `Element` instance, `node[0]` is the first sub-element of `node`. If `node` doesn't have any sub-elements, this operation will raise an `IndexError` exception.

: You can find out the number of sub-elements using the `len()` function. For example, if `node` has five children, `len(node)` will return a value of 5.

One advantage of the `lxml` view is that a tree is now made of only one type of node: each node is an `Element` instance. Here is our XML fragment again, and a picture of its representation in `lxml`.




```
<p>To find out <em>more</em>, see the
<a href="http://www.w3.org/XML">standard</a>.</p>
```

Notice that in the `lxml` view, the text `", see the\n"` (which includes the newline) is contained in the `.tail` attribute of the `em` element, not associated with the `p` element as it would be in the DOM view. Also, the `"."` at the end of the paragraph is in the `.tail` attribute of the `a` (link) element.

Now that you know how XML is represented in `lxml`, there are three general application areas.

- Section 3, "Reading an XML document" (p. 5).
- Section 4, "Creating a new XML document" (p. 6).
- Section 5, "Modifying an existing XML document" (p. 7).

3. Reading an XML document

Suppose you want to extract some information from an XML document. Here's the general procedure:

1. You'll need to import the `lxml` package. Here is one way to do it:

```
from lxml import etree
```

2. Typically your XML document will be in a file somewhere. Suppose your file is named `test.xml`; to read the document, you might say something like:

```
doc = etree.parse ( 'test.xml' )
```

   The returned value `doc` is an instance of the `ElementTree` class that represents your XML document in tree form.

   Once you have your document in this form, refer to Section 7, "`class ElementTree`: A complete XML document" (p. 14) to learn how to navigate around the tree and extract the various parts of its structure.

For other methods of creating an `ElementTree`, refer to Section 6, "Features of the `etree` module" (p. 7).

4. Creating a new XML document

If your program needs to write some output as an XML document, the `lxml` package makes this operation easy.

1. First import the `lxml` package. Here is one way:

   ```
   from lxml import etree
   ```

2. Create the root element. For example, suppose you're creating a Web page; the root element is `html`. Use the `etree.Element()` constructor to build that element.

   ```
   page = etree.Element ( 'html' )
   ```

3. Next, use the `etree.ElementTree()` constructor to make a new document tree, using our `html` element as its root:

   ```
   doc = etree.ElementTree ( page )
   ```

4. The `etree.SubElement()` constructor is perfect for adding new child elements to our document. Here's the code to add a `head` element, and then a `body` as element, as new children of the `html` element:

   ```
   headElt = etree.SubElement ( page, 'head' )
   bodyElt = etree.SubElement ( page, 'body' )
   ```

5. Your page will need a `title` element child under the `head` element. Add text to this element by storing a string in its `.text` attribute:

   ```
   title = etree.SubElement ( headElt, 'title' )
   title.text = 'Your page title here'
   ```

6. To supply attribute values, use keyword arguments to the `SubElement()` constructor. For example, suppose you want a stylesheet link inside the `head` element that looks like this:

   ```
     <link rel='stylesheet' href='mystyle.css' type='text/css'>
   ```

   This code would do it:

   ```
   linkElt = etree.SubElement ( headElt, 'link', rel='stylesheet',
       href='mystyle.css', type='text/css' )
   ```

7. Continue building your new document using the various functions described in Section 6, “Features of the `etree` module” (p. 7) and Section 8, “`class Element`: One element in the tree” (p. 16).

8. When the document is completely built, write it to a file using the `ElementTree` instance's `.write()` method, which takes a file argument.

   ```
   outFile = open ( 'homemade.xml' )
   doc.write ( outFile )
   ```

5. Modifying an existing XML document

If your program needs to read in an XML document, modify it, and write it back out, this operation is straightforward with `lxml`.

1. Start by reading the document using the techniques from Section 3, "Reading an XML document" (p. 5).
2. Modify the document tree by adding, deleting, or replacing elements, attributes, text, and other features.

   For example, suppose your program has a variable `linkNode` that contains an `Element` instance representing an HTML "`a`" (hyperlink) element, and you want to change the value of its `href` attribute to point to a different URL, such as `http://www.nmt.edu/`. This code would do it:

   ```
   linkNode.attrib['href'] = 'http://www.nmt.edu/'
   ```

3. Finally, write the document back out to a file as described in Section 4, "Creating a new XML document" (p. 6).

6. Features of the `etree` module

The `etree` contains numerous functions and class constructors.

6.1. The `Comment()` constructor

To create a comment node, use this constructor:

```
etree.Comment ( text=None )
```

`text`
: The text to be placed within the comment. When serialized back into XML form, this text will be preceded by "`<!-- `" and followed by "` -->`". Note that one space will be added around each end of the text you supply.

The return value is an instance of the `Comment` class. Use the `.append()` method on the parent element to place the comment into your document.

For example, suppose `bodyElt` is an HTML `body` element. To add a comment under this element containing string `s`, you would use this code:

```
newComment = etree.Comment ( s )
bodyElt.append ( newComment )
```

6.2. The `Element()` constructor

This constructor creates and returns a new `Element` instance.

```
etree.Element ( tag, attrib={}, nsmap=None, **extras )
```

`tag`
: A string containing the name of the element to be created.

`attrib`

A dictionary containing attribute names and values to be added to the element. The default is to have no attributes.

`extras`

Any keyword arguments of the form *`name=value`* that you supply to the constructor are added to the element's attributes. For example, this code:

```
newReed = etree.Element ( 'reed', pitch='440', id='a4' )
```

will produce an element that looks like this:

```
<reed pitch='440' id='a4'/>
```

`nsmap`

If your document contains multiple XML namespaces, you can supply a dictionary that defines the namespace prefixes you would like to use when this document is converted to XML.

In this dictionary, the keys are namespace prefixes, and each corresponding value is the URI of that namespace. Use `None` as the key to define the blank namespace's URI.

Here is an example of creation of a document with such a dictionary:

```
from lxml import etree as et

HTML_NS  =  "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd"
XSL_NS   =  "http://www.w3.org/1999/XSL/Transform"
EXSL_NS  =  "http://exslt.org/common"
NS_MAP = {
    None:    HTML_NS,
    "xsl":   XSL_NS,
    "exsl":  EXSL_NS }

def nse(ns, e):
    '''Combine namespace and element name in Clark notation.
    '''
    return '{%s}%s' % (ns, e)

rootName = nse(XSL_NS, 'stylesheet' )
root = et.Element ( rootName, nsmap=NS_MAP )
sheet = et.ElementTree ( root )

top = et.SubElement(root, nse(XSL_NS, "template"), match='/')
html = et.SubElement(top, nse(HTML_NS, "html"))
head = et.SubElement(html, "head")
title = et.SubElement(head, "title")
title.text = "Heading title"
body = et.SubElement(html, "body")
h1 = et.SubElement(body, "h1")
h1.text = "Body heading"
p = et.SubElement(body, "p")
p.text = "Paragraph text"
sheet.write(sys.stdout, pretty_print=True)
```

When this root element is serialized into XML, it will look something like this:

```
<xsl:stylesheet
    xmlns="http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd"
    xmlns:exsl="http://exslt.org/common"
    xmlns:xsl="http://www.nmt.edu/tcc/help/pubs/xslt/">
  <xsl:template match="/">
    <html>
      <head>
        <title>Heading title</title>
      </head>
      <body>
        <h1>Body heading</h1>
        <p>Paragraph text</p>
      </body>
    </html>
  </xsl:template>
</xsl:stylesheet>
```

There is one minor pathology of this constructor. If you pass in a pre-constructed dictionary as the `attrib` argument, and you also supply keyword arguments, the values of the keyword arguments will be added into that dictionary as if you had used the `.update()` method on the `attrib` dictionary. Here is a conversational example showing this side effect:

```
>>> from lxml import etree
>>> d = { 'name': 'Clem', 'clan': 'bozo' }
>>> clownElt = etree.Element ( 'clown', d, attitude='bad' )
>>> d
{'clan': 'bozo', 'attitude': 'bad', 'name': 'Clem'}
>>> etree.tostring ( clownElt )
'<clown clan="bozo" attitude="bad" name="Clem"/>'
>>>
```

6.3. The `ElementTree()` constructor

To create a new, empty document, use this constructor. It returns a new `ElementTree` instance.

```
etree.ElementTree ( element=None, file=None )
```

`element`
An `Element` instance to be used as the root element.

`file`
To construct an `ElementTree` that represents an existing file, pass either a writeable `file` object, or a string containing the name of the file. Do not use the `element` argument; if you do, the `file` argument will be ignored.

For example, to transform a file named `balrog.xml` into an `ElementTree`, use this statement:

```
balrogTree = etree.ElementTree ( file='balrog.xml' )
```

Exceptions that can be raised by this constructor include:

`IOError`
If the file is nonexistent or unreadable.

`etree.XMLSyntaxError`

If the file is readable, but its contents are not well-formed XML.

The returned exception value has an `.error_log` attribute that you can display to find out where in the file errors occurred. Here is an example:

```
>>> try:
...   bad = etree.fromstring ( "<a>\n<<oops>\n</a>" )
... except etree.XMLSyntaxError, detail:
...   pass
...
>>> detail
<etree.XMLSyntaxError instance at 0xb7eba10c>
>>> detail.error_log
<string>:2:FATAL:PARSER:ERR_NAME_REQUIRED: StartTag: invalid element
name
<string>:3:FATAL:PARSER:ERR_TAG_NAME_MISMATCH: Opening and ending tag
mismatch: oops line 2 and a
<string>:3:FATAL:PARSER:ERR_TAG_NOT_FINISHED: Premature end of data in
tag a line 1
>>>
```

6.4. The `fromstring()` function: Create an element from a string

You can create an element or tree of elements from a string containing XML with this function; it returns a new `Element` instance representing all that XML.

```
etree.fromstring ( s )
```

where *`s`* is a string.

Here's an example:

```
>>> milne = '''<monster name='Heffalump'>
...   <trail>Woozle</trail>
...   <eeyore mood='boggy'/>
... </monster>'''
>>> doc = etree.fromstring ( milne )
>>> print etree.tostring ( doc )
<monster name="Heffalump">
  <trail>Woozle</trail>
  <eeyore mood="boggy"/>
</monster>
>>>
```

6.5. The `parse()` function: build an `ElementTree` from a file

The quickest way to convert an XML file into an `ElementTree` is to use this function:

```
etree.parse ( source )
```

where *`source`* is the name of the file, or a `file` object containing the XML. If the file is well-formed, the function returns an `ElementTree` instance.

Exceptions raised include:

IOError
The file is nonexistent or not readable.

etree.XMLSyntaxError
The file is readable, but does not contain well-formed XML. The returned exception contains an `.error_log` attribute that you can print to see where the error occurred. For an example of the display of the `error_log`, see Section 6.3, "The `ElementTree()` constructor" (p. 9).

6.6. The `ProcessingInstruction()` constructor

To add an XML processing instruction to your document, use this constructor. It returns a new `ProcessingInstruction` instance; to place this into a tree, pass that instance to the parent element's `.append()` method.

```
etree.ProcessingInstruction ( target, text=None ):
```

target
A string containing the target portion of the processing instruction.

text
An optional string containing the rest of the processing instruction. The default value is empty.

Here's an example:

```
pi = etree.ProcessingInstruction ( 'decor', 'danish,modern,ducksOnWall'
```

When converted back to XML, this processing instruction would look like this:

```
<?decor danish,modern,ducksOnWall?>
```

6.7. The `QName()` constructor

When you are working with multiple namespaces, the `QName` object is useful for combining the "namespace URI" part with the "local name" part. A `QName` instance can be used for the name part of attributes that are in a different namespace than their containing element.

Although it is not legal in XML element names, there is a convention called "Clark notation" (after James Clark) that combines these two parts in a string of this form:

```
{nsURI}local
```

To construct a new `QName` instance, use a statement of this general form:

```
etree.QName ( text, tag=none )
```

- If the fully qualified element name is already in Clark notation, call the `QName` constructor with this argument alone.
- If you would like to pass the namespace URI and the local name separately, call `QName` with the namespace URI as the `text` argument, and the local name as the `tag` argument.

Here are two examples for creating a `QName` instance representing a qualified name in the XSL namespace with a local name of `template`:

- In Clark notation:

```
qn = etree.QName ( "{http://www.w3.org/1999/XSL/Transform}template" )
```

- With the namespace URI and local name supplied separately:

```
qn = etree.QName ( "http://www.w3.org/1999/XSL/Transform", "template" )
```

6.8. The `SubElement()` constructor

This is a handy constructor that accomplishes the two basic operations in adding an element to a tree:

- creating a new `Element` instance, and
- adding that new `Element` as the next child of its parent element.

Here is the general form:

```
SubElement ( parent, tag, attrib={}, **extras ):
```

The first argument, `parent`, is the `Element` instance under which the newly created `Element` instance is to be added as its next child.

The `tag`, `attrib`, and `**extras` arguments work exactly the same as they do in the call to `Element()` described in Section 6.2, “The `Element()` constructor” (p. 7).

If you are working with multiple namespaces, you may also include an `nsmap` keyword argument defining your preferred namespace prefixes. For more on the `nsmap` argument, see Section 6.3, “The `ElementTree()` constructor” (p. 9).

Here's an example. Suppose you want to build this XML:

```
<state name="New Mexico">
  <county name="Socorro">
    <ppl name="Luis Lopez"/>
  </county>
</state>
```

Here's the code to build it, and then display it, interactively:

```
>>> st=etree.Element('state', name='New Mexico')
>>> co=etree.SubElement(st, 'county', name='Socorro')
>>> ppl=etree.SubElement(co, 'ppl', name='Luis Lopez')
>>> print etree.tostring(st)
<state name="New Mexico"><county name="Socorro"><ppl name="Luis Lopez"/>
</county></state>
>>>
```

6.9. The `tostring()` function: Serialize as XML

To convert an `Element` and its content back to XML, use a function call of this form:

```
etree.tostring ( elt, pretty_print=False )
```

where `elt` is an `Element` instance. The function returns a string containing the XML. For an example, see Section 6.8, “The `SubElement()` constructor” (p. 12).

If you set the optional `pretty_print` argument to `True`, the method will attempt to insert line breaks to keep line lengths short where possible.

6.10. The `XMLID()` function: Convert text to XML with a dictionary of `id` values

To convert XML in the form of a string into an `Element` structure, use Section 6.4, “The `fromstring()` function: Create an element from a string” (p. 10). However, there is a similar function named `etree.XMLID()` that does this and also provides a dictionary that allows you to find elements in a tree by their unique `id` attribute values.

The XML standard stipulates that any element in any document can have an `id` attribute, but each value of this attribute must be unique within the document. The intent of this feature is that applications can refer to any element using its `id` value.

Here is the general form for this function:

```
etree.XMLID ( text )
```

The return value is a tuple `(E, D)`, where:

- `E` is the converted XML as an `Element` instance rooting the converted tree, just as if you had called `etree.fromstring(text)`.
- `D` is a dictionary whose keys are the values of `id` attributes in the converted tree, and each corresponding value is the `Element` instance that carried that `id` value.

Here's an example:

```
>>> SOURCE = '''<dog id="Fido">
...  Woof!
...  <cat id="Fluff">
...    Mao?
...  </cat>
...  <rhino id="ZR"/>
...</dog>'''
>>>    tree, idMap = etree.XMLID(SOURCE)
>>>    idList = idMap.keys()
>>>    idList.sort()
>>>    for  id in idList:
...        elt  =  idMap[id]
...        if  elt.text is None:
...            display = "None"
...        else:
...            display = elt.text.strip()
...        print "Tag %s, text is '%s'" % (elt.tag, display)
Tag dog, text is 'Woof!'
Tag cat, text is 'Mao?'
Tag rhino, text is 'None'
>>>
```

7. `class ElementTree`: A complete XML document

Once you have used the `etree.ElementTree` constructor to instantiate an XML document, you can use these attributes on methods on that instance.

7.1. `ElementTree.find()`

This method searches the tree for matching elements, and returns the first one that matches, or `None` if there are no matches. For an instance *ET* of an `ElementTree`:

```
ET.find ( path )
```

The `path` argument is a string describing the element for which you are searching. Possible values include:

"*tag*"
Find the first child element whose name is "*tag*".

"tag_1/tag_2/.../tag_n"
Find the first child element whose name is tag_1; then, under that child element, find its first child named tag_2; and so forth.

For example, suppose you have an `ElementTree` instance named `page`, containing an XHTML page. Further suppose you want to find the `link` element inside the `head` element inside the root `html` element. This statement would set the variable `linkElt` to that `link` element:

```
linkElt = page.find ( "html/head/link" )
```

7.2. `ElementTree.findall()`: Find matching elements

This method searches the document in an `ElementTree` and returns a sequence of all the matching elements.

In general, for some `ElementTree` instance *ET*, this method will return a sequence of zero or more `Elements`:

```
ET.findall ( path )
```

The syntax of the `path` argument is the same as for the `path` argument in Section 7.1, "`ElementTree.find()`" (p. 14). The only difference is that this method returns a sequence containing *all* the elements that match `path`.

7.3. `ElementTree.findtext()`: Retrieve the text content from an element

To retrieve the text inside some element, use this method on some `ElementTree` instance `ET`:

```
ET.findtext ( path, default=None ):
```

`path`
The syntax for describing the location of the desired element is the same as in Section 7.1, "`ElementTree.find()`" (p. 14).

`default`
The value to be returned if there is no element at that path.

If there is a child at the indicated path, the method returns its text content as a string. If there is a matching child, but it has no content, the return value is `""` (the empty string). If there is no such child, the method returns `None`.

7.4. `ElementTree.getiterator()`: Make an iterator

In many applications, you will want to visit every element in a document, or perhaps to retrieve information from all the tags of a certain kind. This method, on some `ElementTree` instance *ET*, will return an iterator that visits all matching tags.

```
ET.getiterator ( tag=None )
```

If you omit the argument, you will get an iterator that generates every element in the tree, in document order.

If you want to visit only tags with a certain name, pass that name as the argument.

Here are some examples. In these examples, assume that `page` is an `ElementTree` instance that contains an XHTML page. The first example would print every tag name in the page, in document order.

```
for  elt in page.getiterator():
    print elt.tag
```

The second example would look at every `div` element in the page, and for those that have a `class` attribute, it prints those attributes.

```
for  elt in page.getiterator ( 'div' ):
    if  elt.attrib.has_key ( 'class' ):
        print elt.get('class')
```

7.5. `ElementTree.getroot()`: Find the root element

To obtain the root element of a document contained in an `ElementTree` instance *ET*, use this method call:

```
ET.getroot()
```

The return value will normally be the `Element` instance at the root of the tree. However, if you have created your `ElementTree` instance without specifying either a root element or an input file, this method will return `None`.

7.6. `ElementTree.xpath()`: Evaluate an *XPath* expression

For an `ElementTree` instance *ET*, use this method call to evaluate an *XPath* expression *s*, using the tree's root element as the context node.

```
ET.xpath ( s )
```

This methods returns the result of the *XPath* expression. For a general discussion of *XPath*, see Section 9, “*XPath* processing” (p. 25).

7.7. `ElementTree.write()`: Translate back to XML

To serialize (convert to XML) the content of a document contained in some `ElementTree` instance *ET*, use this method call:

```
ET.write ( file, pretty_print=False )
```

You must supply a writeable file object, or the name of a file to be written. If you set argument `pretty_print=True`, the method will attempt to fold long lines and indent the XML for legibility.

For example, if you have an `ElementTree` instance in a variable `page` containing an XHTML page, and you want to write it to the standard output stream, this statement would do it:

```
import sys
page.write ( sys.stdout )
```

8. `class Element`: One element in the tree

Each XML element is represented by an instance of the `Element` class.

- See Section 8.1, "Attributes of an `Element` instance" (p. 16) for attributes of an `Element` instance in the *Python* sense, as opposed to XML attributes.
- See Section 8.2, "Accessing the list of child elements" (p. 16) for the various ways to access the element children of an element.
- The various methods on `Element` instances follow in alphabetical order, starting with Section 8.3, "`Element.append()`: Add a new element child" (p. 17).

8.1. Attributes of an `Element` instance

Each instance of the `Element` class has these attributes.

`.tag`
The element's name.

`.attrib`
A dictionary containing the element's attributes. The keys are the attribute names, and each corresponding value is the attribute's value.

`.tail`
The text following this element's closing tag, up to the start tag of the next sibling element. If there was no text there, this attribute will have the value `None`.

This way of associating text with elements is not really typical of the way most XML processing models work; see Section 2, "How `ElementTree` represents XML" (p. 3).

`.text`
The text inside the element, up to the start tag of the first child element. If there was no text there, this attribute will have the value `None`.

8.2. Accessing the list of child elements

In many ways, an `Element` instance acts like a Python list, with its XML child elements acting as the members of that list.

You can use the Python `len()` function to determine how many children an element has. For example, if `node` is an `Element` instance with five element children, `len(node)` will return the value 5.

You can add, replace, or delete children of an element using regular Python list operations. For example, if an `Element` instance `node` has three child elements, `node[0]` is the first child, and `node[2]` is the third child.

In the examples that follow, assume that *`E`* is an `Element` instance.

- *`E`*`[`*`i`*`]` returns the child element of *`E`* at position *`i`*, if there is one. If there is no child element at that position, this operation raises an `IndexError` exception.
- *`E`*`[`*`i`*`:`*`j`*`]` returns a list of the child elements between positions *`i`* and *`j`*.

  For example, `node[2:4]` returns a list containing the third and fourth children of `node`.
- You can replace one child of an element *`E`* with a new element `c` using a statement of this form:

  ```
  E[i] = c
  ```

  If *`i`* is not the position of an existing child, this operation will raise an `IndexError`.
- You can replace a sequence of adjacent children of an element *`E`* using slice assignment:

  ```
  E[i:j] = seq
  ```

  where *`seq`* is a sequence of `Element` instances.

  If the slice `[`*`i`*`:`*`j`*`]` does not specify an existing set of children, this operation will raise an `IndexError` exception.
- You can delete one child of an element like this:

  ```
  del E[i]
  ```

  where *`i`* is the index of that child.
- You can delete a slice out of the list of element children like this:

  ```
  del E[i:j]
  ```

8.3. `Element.append()`: Add a new element child

To add a new child *`c`* to an element *`E`*, use this method:

```
E.append ( c )
```

You can use this method to add `Comment` and `ProcessingInstruction` instances as children of an element, as well as `Element` instances.

Here is a conversational example:

```
>>> st = etree.Element ( "state", name="New Mexico" )
>>> etree.tostring(st)
'<state name="New Mexico"/>'
>>> co = etree.Element ( "county", name="Socorro" )
>>> st.append(co)
>>> etree.tostring(st)
'<state name="New Mexico"><county name="Socorro"/></state>'
```

```
>>> rem = etree.Comment ( "Just another day in paradise." )
>>> st.append ( rem )
>>> etree.tostring(st)
'<state name="New Mexico"><county name="Socorro"/><!-- Just another day in
paradise. --></state>'
>>>
```

8.4. `Element.clear()`: Make an element empty

Calling the `.clear()` method on an `Element` instance removes all its content:

- All values are removed from the `.attrib` dictionary.
- The `.text` and `.tail` attributes are both set to `None`.
- Any child elements are deleted.

8.5. `Element.find()`: Find a matching sub-element

You can search for sub-elements of an `Element` instance *E* using this method call:

```
E.find ( path )
```

The possible values of the *path* argument use the same syntax as the *path* argument in Section 7.1, "`ElementTree.find()`" (p. 14). However, the search starts at element *E*, rather than at the top of the document.

If there are any matching elements, this method returns the matching element that is first in document order. If there are no matching elements, the method returns `None`.

For example, if `node` is an `Element` instance that has an element child with a tag `"county"`, and that child in turn has an element child with tag `"ppl"`, this expression will return the `Element` corresponding to the `"ppl"` child:

```
node.find ( "county/ppl" )
```

8.6. `Element.findall()`: Find all matching sub-elements

The `.findall()` method on an `Element` instance is very similar to Section 7.2, "`ElementTree.findall()`: Find matching elements" (p. 14): it uses the same `path` description, and returns a sequence containing all the matching elements. However, the search starts at the given `Element` instead of starting at the top of the document. Syntax:

```
E.findall ( path )
```

8.7. `Element.findtext()`: Extract text content

Every `Element` instance *E* has a `.findtext()` method that works very similarly to Section 7.3, "`ElementTree.findtext()`: Retrieve the text content from an element" (p. 14). Here is the general form:

```
E.findtext ( path, default=None )
```

If any child elements of *E* exist that match the given `path`, this method returns the text content of the first matching element. If the element exists but has no text content, the method returns `""`, the empty string. If there are no matching child elements, the method returns `None`.

8.8. `Element.get()`: Retrieve an attribute value with defaulting

There are two ways you can try to get an attribute value from an `Element` instance. See also the `.attrib` dictionary in Section 8.1, "Attributes of an `Element` instance" (p. 16).

The `.get()` method on an `Element` instance also attempts to retrieve an attribute value. The advantage of this method is that you can provide a default value that is returned if the element in question does not actually have an attribute by the given name.

Here is the general form, for some `Element` instance *E*.

```
E.get ( key, default=None )
```

The `key` argument is the name of the attribute whose value you want to retrieve.

- If *E* has an attribute by that name, the method returns that attribute's value as a string.
- If *E* has no such attribute, the method returns the `default` argument, which itself has a default value of `None`.

Here's an example:

```
>>> from lxml import etree
>>> node = etree.fromstring('<mount species="Jackalope"/>')
>>> print node.get('species')
Jackalope
>>> print node.get('source')
None
>>> print node.get('source', 'Unknown')
Unknown
>>>
```

8.9. `Element.getchildren()`: Get element children

For an `Element` instance *E*, this method returns a list of all *E*'s element children:

```
E.getchildren()
```

Here's an example:

```
>>> xml = '''<corral><horse n="2"/><cow n="17"/>
...  <cowboy n="2"/></corral>'''
>>> pen = etree.fromstring ( xml )
>>> penContents = pen.getchildren()
>>> for  content in penContents:
...     print "%-10s %3s" % (content.tag, content.get("n", "0"))
...
horse        2
cow         17
cowboy       2
>>>
```

8.10. `Element.getiterator()`: Make an iterator to walk a subtree

Sometimes you want to walk through all or part of a document, looking at all the elements in document order. Similarly, you may want to walk through all or part of a document and look for all the occurrences of a specific kind of element.

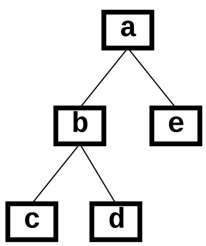
The `.getiterator()` method on an `Element` instance produces a Python iterator that tells Python how to visit elements in these ways. Here is the general form, for an `Element` instance *`E`*:

```
E.getiterator ( tag=None )
```

- If you omit the argument, you will get an iterator that visits *`E`* first, then all its element children and their children, in a *preorder traversal* of that subtree.
- If you want to visit only elements with a certain tag name, pass the desired tag name as the argument.

Preorder traversal of a tree means that we visit the root first, then the subtrees from left to right (that is, in document order). This is also called a `depth-first` traversal: we visit the root, then its first child, then its first child's first child, and so on until we run out of descendants. Then we move back up to the last element with more children, and repeat.

Here is an example showing the traversal of an entire tree. First, a diagram showing the tree structure:



A preorder traversal of this tree goes in this order: a, b, c, d, e.

```
>>> xml = '''<a><b><c/><d/></b><e/></a>'''
>>> tree = etree.fromstring ( xml )
>>> walkAll = tree.getiterator()
>>> for  elt in walkAll:
...     print elt.tag,
...
a b c d e
>>>
```

In this example, we visit only the `bird` nodes.

```
>>> xml = '''<bio>
...   <bird type="Bushtit"/>
...   <butterfly type="Mourning Cloak"/>
...   <bird type="Mew Gull"/>
...   <group site="Water Canyon">
...     <snake type="Sidewinder"/>
...     <bird type="Verdin"/>
...   </group>
...   <bird type="Pygmy Nuthatch"/>
... </bio>'''
>>> root = etree.fromstring(xml)
>>> for  elt in root.getiterator('bird'):
```

```
...     print elt.get('type', 'Unknown')
...
Bushtit
Mew Gull
Verdin
Pygmy Nuthatch
>>>
```

Note in the above example that the iterator visits the Verdin element even though it is not a direct child of the root element.

8.11. `Element.getroottree()`: Find the `ElementTree` containing this element

For any `Element` instance *E*, this method call returns the `ElementTree` instance that contains *E*:

```
E.getroottree()
```

8.12. `Element.insert()`: Insert a new child element

Use the `.insert()` method on an `Element` instance *E* to add a new element child `elt` in an arbitrary position. (To append a new element child at the last position, see Section 8.3, "`Element.append()`: Add a new element child" (p. 17).)

```
E.insert ( index, elt )
```

The `index` argument specifies the position into which element `elt` is inserted. For example, if you specify index 0, the new child will be inserted before any other children of *E*.

The `lxml` module is quite permissive about the values of the `index` argument: if it is negative, or greater than the position of the last existing child, the new child is added after all existing children.

Here is an example showing insertions at positions 0 and 2.

```
>>> node = etree.fromstring('<a><c0/><c1/><c2/></a>')
>>> newKid = etree.Element('c-1', laugh="Hi!")
>>> node.insert(0, newKid)
>>> etree.tostring(node)
'<a><c-1 laugh="Hi!"/><c0/><c1/><c2/></a>'
>>> newerKid = etree.Element('cn')
>>> node.insert(2, newerKid)
>>> etree.tostring(node)
'<a><c-1 laugh="Hi!"/><c0/><cn/><c1/><c2/></a>'
>>>
```

8.13. `Element.items()`: Produce attribute names and values

For any `Element` instance *E*, the `.items()` method returns the attributes as if they were a dictionary and you had called the `.items()` method on that dictionary: the result is a list of two-element tuples `(`*name*`, `*value*`)`, one for each XML attribute of *E*.

Attribute values are returned in no particular order.

Here's an example.

```
>>> node = etree.fromstring ( "<event time='1830' cost='3.50'
rating='nc-03'/>" )
>>> node.items()
[('cost', '3.50'), ('time', '1830'), ('rating', 'nc-03')]
>>>
```

8.14. `Element.iterancestors()`: Find an element's ancestors

The *ancestors* of an element are its parent, its parent's parent, and so on up to the root element of the tree. For any `Element` instance *E*, this method returns an iterator that visits *E*'s ancestors in reverse document order:

```
E.iterancestors(tag=None)
```

If you omit the argument, the iterator will visit all ancestors. If you wish to visit only ancestors with a specific tag name, pass that tag name as an argument.

Examples:

```
>>> xml = '''<class sci='Aves' eng='Birds'>
...   <order sci='Strigiformes' eng='Owls'>
...     <family sci='Tytonidae' eng='Barn-Owls'>
...       <genus sci='Tyto'>
...         <species sci='Tyto alba' eng='Barn Owl'/>
...       </genus>
...     </family>
...   </order>
... </class>'''
>>> root = etree.fromstring ( xml )
>>> barney = root.xpath ( '//species' ) [0]
>>> print "%s: %s" % (barney.get('sci'), barney.get('eng'))
Tyto alba: Barn Owl
>>> for  ancestor in barney.iterancestors():
...     print ancestor.tag,
genus family order class
>>> for  fam in barney.iterancestors('family'):
...    print "%s: %s" % (fam.get('sci'), fam.get('eng'))
Tytonidae: Barn-Owls
```

8.15. `Element.iterchildren()`: Find all children

For an `Element` instance *E*, this method returns an iterator that iterates over all of *E*'s children.

```
E.iterchildren(reversed=False, tag=None)
```

Normally, the resulting iterator will visit the children in document order. However, if you pass `reversed=True`, it will visit them in the opposite order.

If you want the iterator to visit only children with a specific name *N*, pass an argument `tag=N`.

Example:

```
>>> root=et.fromstring("<mom><aaron/><betty/><clarence/><dana/></mom>")
>>> for kid in root.getchildren():
...     print kid.tag
aaron
betty
clarence
dana
>>> for kid in root.iterchildren(reversed=True):
...     print kid.tag
...
dana
clarence
betty
aaron
>>>
```

8.16. `Element.iterdescendants()`: Find all descendants

The term *descendants* refers to an element's children, their children, and so on all the way to the leaves of the document tree.

For an `Element` instance *`E`*, this method returns an iterator that visits all of *`E`*'s descendants in document order.

```
E.iterdescendants(tag=None)
```

If you want the iterator to visit only elements with a specific tag name *`N`*, pass an argument `tag=N`.

Example:

```
>>> xml = '''<root>
...   <grandpa>
...     <dad>
...       <yuo/>
...     </dad>
...   </grandpa>
... </root>'''
>>> root = etree.fromstring(xml)
>>> you = root.xpath('.//yuo')[0]
>>> for  anc in you.iterancestors():
...    print anc.tag,
dad grandpa root
>>>
```

8.17. `Element.itersiblings()`: Find other children of the same parent

For any `Element` instance *`E`*, this method returns an iterator that visits all of *`E`*'s siblings, that is, the element children of its parent, in document order, but omitting *`E`*.

```
E.itersiblings(preceding=False)
```

If the `preceding` argument is false, the iterator will visit the siblings following *`E`* in document order. If you pass `preceding=True`, the iterator will visit the siblings that precede *`E`* in document order.

Example:

```
>>> root=etree.fromstring(
...   "<mom><aaron/><betty/><clarence/><dana/></mom>")
>>> betty=root.find('betty')
>>> for sib in betty.itersiblings(preceding=True):
...     print sib.tag
...
aaron
>>> for sib in betty.itersiblings():
...     print sib.tag
...
clarence
dana
>>>
```

8.18. `Element.keys()`: Find all attribute names

For any `Element` instance `E`, this method returns a list of the element's XML attribute names, in no particular order.

```
E.keys()
```

Here's an example:

```
>>> node = etree.fromstring ( "<event time='1830' cost='3.50'
rating='nc-03'/>" )
>>> node.keys()
['time', 'rating', 'cost']
>>>
```

8.19. `Element.remove()`: Remove a child element

To remove an element child *`C`* from an `Element` instance *`E`*, use this method call.

```
E.remove(C)
```

If *`C`* is not a child of *`E`*, this method will raise a `ValueError` exception.

8.20. `Element.set()`: Set an attribute value

To create or change an attribute named *`A`* to value *`V`* in an `Element` instance *`E`*, use this method:

```
E.set ( A, V )
```

Here's an example.

```
>>> node = etree.Element ( 'div', id='u401' )
>>> etree.tostring(node)
'<div id="u401"/>'
>>> node.set ( 'class', 'flyer' )
>>> etree.tostring(node)
'<div id="u401" class="flyer"/>'
```

```
>>> node.set ( 'class', 'broadside' )
>>> etree.tostring ( node )
'<div id="u401" class="broadside"/>'
>>>
```

This method is one of two ways to create or change an attribute value. The other method is to store values into the `.attrib` dictionary of the `Element` instance.

8.21. `Element.xpath()`: Evaluate an *XPath* expression

To evaluate an *XPath* expression *s* using some `Element` instance *E* as the context node:

```
E.xpath ( s )
```

For a general discussion of the use of *XPath*, see Section 9, “*XPath* processing” (p. 25).

9. *XPath* processing

One of the most significant advantages of the `lxml` package over the other `ElementTree`-style packages is its support for the full *XPath* language. *XPath* expressions give you a much more powerful mechanism for selecting and retrieving parts of a document, compared to the relatively simple “`path`” syntax used in Section 7.1, “`ElementTree.find()`” (p. 14).

If you are not familiar with *XPath*, see these sources:

- *XSLT reference*[5], specifically the section entitled “XPath reference”[6].
- The standard, *XML Path Language (XPath), Version 1.0*[7].

Keep in mind that every *XPath* expression is evaluated using three items of context:

- The *context node* is the starting point for any operations whose meaning is relative to some point in the tree.
- The *context size* is the number of elements that are children of the context node's parent, that is, the context node and all its siblings.
- The *context position* is the context node's position relative to its siblings, counting the first sibling as position 1.

You can evaluate an *XPath* expression *s* by using the `.xpath(s)` method on either an `Element` instance or an `ElementTree` instance. See Section 8.21, “`Element.xpath()`: Evaluate an *XPath* expression” (p. 25) and Section 7.6, “`ElementTree.xpath()`: Evaluate an *XPath* expression” (p. 15).

Depending on the *XPath* expression you use, these `.xpath()` methods may return one of several kinds of values:

- For expressions that return a Boolean value, the `.xpath()` method will return `True` or `False`.
- Expressions with a numeric result will return a Python `float` (*never* an `int`).
- Expressions with a string result will return a Python `str` (string) or `unicode` value.
- Expressions that produce a list of values, such as node-sets, will return a Python `list`. Elements of this list may in turn be any of several types:

[5] http://www.nmt.edu/tcc/help/pubs/xslt/
[6] http://www.nmt.edu/tcc/help/pubs/xslt/xpath-sect.html
[7] http://www.w3.org/TR/xpath

- Elements, comments, and processing instructions will be represented as `lxml` `Element`, `Comment`, and `ProcessingInstruction` instances.
- Text content and attribute values are returned as Python `str` (string) instances.
- Namespace declarations are returned as a two-tuple `(`*`prefix`*`, `*`namespaceURI`*`)`.

For further information on `lxml`'s *XPath* features, see *XPath and XSLT with lxml*[8].

9.1. An *XPath* example

Here is an example of a situation where an *XPath* expression can save you a lot of work. Suppose you have a document with an element called `para` that represents a paragraph of text. Further suppose that your `para` has a mixed-content model, so its content is a free mixture of text and several kinds of inline markup. Your application, however, needs to extract just the text in the paragraph, discarding any and all tags.

Using just the classic `ElementTree` interface, this would require you to write some kind of function that recursively walks the `para` element and its subtree, extracting the `.text` and `.tail` attributes at each level and eventually gluing them all together.

However, there is a relatively simple *XPath* expression that does all this for you:

```
descendant-or-self::text()
```

The “`descendant-or-self::`” is an axis selector that limits the search to the context node, its children, their children, and so on out to the leaves of the tree. The “`text()`” function selects only text nodes, discarding any elements, comments, and other non-textual content. The return value is a list of strings.

Here's an example of this expression in practice.

```
>>> node=etree.fromstring('''<a>
...   a-text <b>b-text</b> b-tail <c>c-text</c> c-tail
... </a>''')
>>> alltext = node.xpath ( 'descendant-or-self::text()' )
>>> alltext
['\n  a-text ', 'b-text', ' b-tail ', 'c-text', ' c-tail\n']
>>> clump = "".join(alltext)
>>> clump
'\n  a-text b-text b-tail c-text c-tail\n'
>>>
```

10. Automated validation of input files

What happens to your application if you read a file that does not conform to the schema? There are two ways to deal with error handling.

- If you are a careful and defensive programmer, you will always check for the presence and validity of every part of the XML document you are reading, and issue an appropriate error message. If you aren't careful or defensive enough, your application may crash.
- It can make your application a lot simpler if you mechanically validate the input file against the schema that defines its document type.

[8] http://www.w3.org/TR/xpathxpathxslt.html

With the `lxml` module, the latter approach is inexpensive both in programming effort and in runtime. You can validate a document using either of these major schema languages:

- Section 10.1, "Validation with a Relax NG schema" (p. 27).
- Section 10.2, "Validation with an XSchema (XSD) schema" (p. 27).

10.1. Validation with a Relax NG schema

The `lxml` module can validate a document, in the form of an `ElementTree`, against a schema expressed in the Relax NG notation. For more information about Relax NG, see *Relax NG Compact Syntax (RNC)*[9].

A Relax NG schema can use two forms: the compact syntax (RNC), or an XML document type (RNG). If your schema uses RNC, you must translate it to RNG format. The *trang* utility does this conversion for you. Use a command of this form:

```
trang file.rnc file.rng
```

Once you have the schema available as an `.rng` file, use these steps to valid an element tree *`ET`*.

1. Parse the `.rng` file into its own `ElementTree`, as described in Section 6.3, "The `ElementTree()` constructor" (p. 9).
2. Use the constructor `etree.RelaxNG(S)` to convert that tree into a "schema instance," where *`S`* is the `ElementTree` instance, containing the schema, from the previous step.

   If the tree is not a valid Relax NG schema, the constructor will raise an `etree.RelaxNGParseError` exception.
3. Use the `.validate(ET)` method of the schema instance to validate *`ET`*.

   This method returns `1` if *`ET`* validates against the schema, or `0` if it does not.

   If the method returns `0`, the schema instance has an attribute named `.error_log` containing all the errors detected by the schema instance. You can print `.error_log.last_error` to see the most recent error detected.

Presented later in this document are two examples of the use of this validation technique:

- Section 13, "`rnc_validate`: A module to validate XML against a Relax NG schema" (p. 39).
- Section 14, "*rnck*: A standalone script to validate XML against a Relax NG schema" (p. 46).

10.2. Validation with an XSchema (XSD) schema

To validate a document against a schema written in the XSchema language, follow the steps shown in Section 10.1, "Validation with a Relax NG schema" (p. 27), with one variation.

Instead of using `etree.RelaxNG()` to parse your schema tree *`S`*, use `etree.XMLSchema(S)`.

11. `etbuilder.py`: A simplified XML builder module

If you are building a lot of XML, it can be somewhat cumbersome to take several lines of code to build a single element. For elements with text content, you'll write a lot of two-line sequences like this:

[9] http://www.nmt.edu/tcc/help/pubs/rnc/

```
    mainTitle  =  et.Element('h1')
    mainTitle.text  =  "Welcome to Your Title Here!"
```

The brilliant and productive Fredrik Lundh has written a very nice module called `builder.py` that makes building XML a lot easier.

- See Lundh's original page, *An `ElementTree` Builder*[10], for an older version of his module, with documentation and examples.
- You may wish to use the current version of `builder.py` from Lundh's SVN repository page[11].
- The author has written a modified version based heavily on Lundh's version. The source for this `etbuilder.py` module is available online[12].

  For the instructions for use of the author's version, see Section 11.1, "Using the `etbuilder` module" (p. 28).

  For the actual implementation in lightweight literate programming form[13], see Section 12, "Implementation of `etbuilder`" (p. 30).

11.1. Using the `etbuilder` module

Instead of importing the `ElementTree` package as `et`, use this importation:

```
from etbuilder import et, E
```

The name `E` is a factory object that creates `et.Element` instances.

Here is the calling sequence for `E`:

```
E(tag, *p, **kw)
```

The first argument, *`tag`*, is the element's name as a string. The return value is a new `et.Element` instance.

You can supply any number of positional arguments *`p`*, followed by any number of keyword arguments. The interpretation of each argument depends on its type. The displays with "`>>>`" prompts are interactive examples.

- Any keyword argument of the form "*`name`*`=`*`value`*" becomes an XML attribute "*`name`*`='`*`value`*`'`" of the new element.

  ```
  >>> colElt=E('col', valign='top', align='left')
  >>> et.tostring(colElt)
  '<col align="left" valign="top" />'
  ```

- String arguments are added to the content of the tag.

  ```
  >>> p14 = E("p", "Welcome to ", "Your Paragraph Here.")
  >>> et.tostring(p14)
  '<p>Welcome to Your Paragraph Here.</p>'
  ```

- An argument of type `int` is converted to a string and added to the tag's content.

[10] http://effbot.org/zone/element-builder.htm
[11] http://svn.effbot.org/public/stuff/sandbox/elementlib/
[12] http://www.nmt.edu/tcc/help/pubs/pylxml/etbuilder.py
[13] http://www.nmt.edu/~shipman/soft/litprog/

- If you pass a dictionary to the factory, its members also become XML attributes. For instance, you might create an XHTML table cell element like this:

```
>>> cell = E('td', {'valign': 'top', 'align': 'right'}, 14)
>>> et.tostring(cell)
'<td align="right" valign="top">14</td>'
```

- You can pass in an `et.Element` instance, and it becomes a child element of the element being built. This allows you to nest calls within calls, like this:

```
>>> head = E('head',
...     E('title', 'Your Page Title Here'),
...     E('link', rel='stylesheet', href='/tcc/style.css'))
>>> print et.tostring(head, pretty_print=True)
<head>
  <title>Your Page Title Here</title>
  <link href="/tcc/style.css" rel="stylesheet" />
</head>
```

This module has one more nice wrinkle. If the name of the tag you are creating is also a valid Python name, you can use that name as the name of a method call on the `E` instance. That is,

```
E.name(...)
```

is functionally equivalent to

```
E("name", ...)
```

Here is an example:

```
>>> head = E.head(
...     E.title('Your title'),
...     E.link(rel='stylesheet', href='/tcc/style.css'))
>>> print et.tostring(head, pretty_print=True)
<head>
  <title>Your title</title>
  <link href="/tcc/style.css" rel="stylesheet" />
</head>
```

11.2. `CLASS()`: Adding `class` attributes

One of the commonest operations is to attach a `class` attribute to an XML tag. For instance, suppose you want to generate this content:

```
<div class='warning'>
  Your brain may not be the boss!
</div>
```

The obvious way to do this *does not work*:

```
  E.div("Your brain may not be the boss!", class='warning')  # Fails!
```

Because `class` is a reserved word in Python, you can't use it as an argument keyword. Therefore, the package includes a helper function named `CLASS()` that takes one or more names as arguments, and returns a dictionary that can be passed to the `E()` constructor to add a `class=` attribute with the argument value. This example does work to generate the above XML:

```
  E.div("Your brain may not be the boss!", CLASS('warning'))  # Works.
```

Here's another example, this time with multiple class names.

```
   E.span(CLASS('ref', 'index'), "Pie, whole.")
```

This generates:

```
  <span class='ref index'>Pie, whole.</span>
```

11.3. `subElement()`: Adding a child element

This function combines the two common operations of creating an element and adding it as the next child of some parent node. The general calling sequence is:

```
subNode = subElement ( parent, child )
```

This function adds `child` as the next child of `parent`, and returns the `child`.

11.4. `addText()`: Adding text content to an element

This convenience function handles the special logic used to add text content to an `ElementTree`-style node. The problem is that if the node does not have any children, the new text is appended to the node's `.text` attribute, but if there are any children, the new text must be appended to the `.tail` attribute of the last child. Refer to Section 2, "How `ElementTree` represents XML" (p. 3) for a discussion of why this is necessary.

Here is the general calling sequence to add some text string *`s`* to an existing *`node`*:

```
addText ( node, s )
```

12. Implementation of `etbuilder`

Here is the author's `etbuilder.py` module, with narrative.

12.1. Features differing from Lundh's original

The author's version differs from Lundh's version in these respects:

- It requires the `lxml` package. Lundh's version did not use `lxml`; it uses `cElementTree`, or `elementtree` if that is not available.
- It requires Python 2.5 or later. Lundh's version will work with earlier versions, probably back to at least 2.2.
- The author's version also permits `int` values in the call to the `E` instance.

12.2. Prologue

The module begins with a comment pointing back to this documentation, and acknowledging Fredrik Lundh's work.

etbuilder.py

```
"""etbuilder.py: An element builder for lxml.etree
================================================================
    $Revision: 1.39 $  $Date: 2011/02/21 00:29:12 $
================================================================
For documentation, see:
    http://www.nmt.edu/tcc/help/pubs/pylxml/
Borrows heavily from the work of Fredrik Lundh; see:
    http://effbot.org/zone/
"""
```

The `et` module is `lxml.etree`.

etbuilder.py

```
#================================================================
# Imports
#----------------------------------------------------------------

from lxml import etree as et
```

The `functools.partial()` function[14] is used to curry a function call in Section 12.10, "`Element-Maker.__getattr__()`: Handle arbitrary method calls" (p. 38).

However, the `functools` module is new in Python 2.5. In order to make this module work in a Python 2.4 install, we will anticipate a possible failure to import `functools`, providing that functionality with a substitute `partial()` function. This function is stolen directly from the *Python Library Reference*[15].

etbuilder.py

```
try:
    from functools import partial
except ImportError:
    def partial(func, *args, **keywords):
        def newfunc(*fargs, **fkeywords):
            newkeywords = keywords.copy()
            newkeywords.update(fkeywords)
            return func(*(args + fargs), **newkeywords)
        newfunc.func  =  func
        newfunc.args  =  args
        newfunc.keywords  =  keywords
        return newfunc
```

12.3. `CLASS()`: Helper function for adding CSS `class` attributes

Next comes the definition of the `CLASS()` helper function discussed in Section 11.2, "`CLASS()`: Adding `class` attributes" (p. 29).

etbuilder.py

```
# - - -   C L A S S
```

[14] http://docs.python.org/library/functools.html
[15] http://docs.python.org/library/functools.html

```
def CLASS(*names):
    '''Helper function for adding 'class=...' attributes to tags.

      [ names is a list of strings ->
          return a dictionary with one key 'class' and the related
          value the concatenation of (names) with one space between
          them ]
    '''
    return {'class': ' '.join(names)}
```

12.4. `subElement()`: Add a child element

See Section 11.3, "`subElement()`: Adding a child element" (p. 30).

etbuilder.py

```
# - - -   s u b E l e m e n t

def subElement ( parent, child ):
    '''Add a child node to the parent and return the child.

      [ (parent is an Element) and
        (child is an Element with no parent) ->
          parent  :=  parent with child added as its new last child
          return child ]
    '''
    #-- 1 --
    parent.append ( child )

    #-- 2 --
    return child
```

12.5. `addText()`: Add text content to an element

See Section 11.4, "`addText()`: Adding text content to an element" (p. 30). To simplify the caller's job, we do nothing if `s` is `None`, as may be the case with the `.text` or `.tail` attribute of an `et.Element`.

etbuilder.py

```
# - - -   a d d T e x t

def addText ( node, s ):
    '''Add text content to an element.

      [ (node is an Element) and (s is a string) ->
          if node has any children ->
              last child's .tail  +:=  s
          else ->
              node.text +:= s ]
    '''
    #-- 1 --
    if not s:
        return

    #-- 2 --
```

```
    if len(node) == 0:
        node.text = (node.text or "") + s
    else:
        lastChild = node[-1]
        lastChild.tail = (lastChild.tail or "") + s
```

12.6. `class ElementMaker`: The factory class

The name `E` that the user imports is not a class. It is a factory object, that is, an instance of the `ElementMaker` factory class.

etbuilder.py

```
# - - - - -   c l a s s   E l e m e n t M a k e r

class ElementMaker(object):
    '''ElementTree element factory class

      Exports:
        ElementMaker ( typeMap=None ):
          [ (typeMap is an optional dictionary whose keys are
            type objects T, and each corresponding value is a
            function with calling sequence
              f(elt, item)
            and generic intended function
              [ (elt is an et.Element) and
                (item has type T) ->
                  elt  :=  elt with item added ]) ->
              return a new ElementMaker instance that has
              calling sequence
                E(*p, **kw)
              and intended function
                [ p[0] exists and is a str ->
                    return a new et.Element instance whose name
                    is p[0], and remaining elements of p become
                    string content of that element (for types
                    str, unicode, and int) or attributes (for
                    type dict, and members of kw) or children
                    (for type et.Element), plus additional
                    handling from typeMap if it is provided ]
              and allows arbitrary method calls of the form
                E.tag(*p, **kw)
              with intended function
                [ return a new et.Element instance whose name
                  is (tag), and elements of p and kw have
                  the same effects as E(*(p[1:]), **kw) ]
    '''
```

For a discussion of intended functions and the Cleanroom software development methodology, see the author's Cleanroom page[16].

[16] http://www.nmt.edu/~shipman/soft/clean/

You can use the optional `typeMap` argument to provide logic to handle types other than the ones defined in Section 11.1, "Using the `etbuilder` module" (p. 28). Refer to the constructor for a discussion of the internal state item `.__typeMap` and how it works in element construction.

12.7. `ElementMaker.__init__()`: Constructor

The factory instance returned by the `ElementMaker` constructor must look at the type of each of its positional arguments in order to know what to do with it. Python's dictionary type makes this easy to do: we use a dictionary whose keys are Python type objects. Each of the corresponding values in this dictionary is a function that can be called to process arguments of that type.

The dictionary is a private attribute `.__typeMap`, and all the constructor does is set this dictionary up.

The functions that process arguments all have this generic calling sequence:

```
f(elt, item)
```

where `elt` is the `et.Element` being built, and `item` is the argument to be processed.

The first step is to initialize the `.__typeMap` dictionary. In most cases, the user will be satisfied with the type set described in Section 11.1, "Using the `etbuilder` module" (p. 28). However, as a convenience, Lundh's original `builder.py` design allows the caller to supply a dictionary of additional type-function pairs as an optional argument; in that case, we will copy the supplied dictionary as the initial value of `self.__typeMap`.

etbuilder.py

```
# - - -   E l e m e n t M a k e r . _ _ i n i t _ _

    def __init__ ( self, typeMap=None ):
        '''Constructor for the ElementMaker factory class.
        '''
        #-- 1 --
        # [ if typeMap is None ->
        #     self.__typeMap  :=  a new, empty dictionary
        #   else ->
        #     self.__typeMap  :=  a copy of typeMap ]
        if typeMap is None:
            self.__typeMap  =  {}
        else:
            self.__typeMap  =  typeMap.copy()
```

The first types we'll need to handle are the `str` and `unicode` types. These types will use a function we define locally named `addText()`. Adding text to an element in the `ElementTree` world has two cases. If the element has no children, the text is added to the element's `.text` attribute. If the element has any children, the new text is added to the last child's `.tail` attribute. See Section 2, "How `ElementTree` represents XML" (p. 3) for a review of text handling.

etbuilder.py

```
        #-- 2 --
        # [ self.__typeMap[str], self.__typeMap[unicode]  :=
        #     a function with calling sequence
        #       addText(elt, item)
        #     and intended function
        #       [ (elt is an et.Element) and
        #         (item is a str or unicode instance) ->
        #           if elt has no children and elt.text is None ->
```

```
        #            elt.text  :=  item
        #          else if elt has no children ->
        #            elt.text  +:=  item
        #          else if elt's last child has .text==None ->
        #            that child's .text  :=  item
        #          else ->
        #            that child's .text  +:=  item ]
        def addText ( elt, item ):
            if len(elt):
                elt[-1].tail  =  (elt[-1].tail or "") + item
            else:
                elt.text  =  (elt.text or "") + item
        self.__typeMap[str]  =  self.__typeMap[unicode]  =  addText
```

Lundh's original module did not handle arguments of type `int`, but this ability is handy for many common tags, such as "`<table border='8'>`", which becomes "`E.table(border=8)`".

A little deviousness is required here. The `addInt()` function can't call the `addText()` function above directly, because the name `addText` is bound to that function only inside the constructor. The instance does not know that name. However, we can assume that `self.__typeMap[str]` is bound to that function, so we call it from there.

etbuilder.py

```
        #-- 3 --
        # [ self.__typeMap[str], self.__typeMap[unicode]  :=
        #     a function with calling sequence
        #       addInt(elt, item)
        #     and intended function
        #       [ (elt is an et.Element) and
        #         (item is an int instance) ->
        #           if elt has no children and elt.text is None ->
        #             elt.text  :=  str(item)
        #           else if elt has no children ->
        #             elt.text  +:=  str(item)
        #           else if elt's last child has .text==None ->
        #             that child's .text  :=  str(item)
        #           else ->
        #             that child's .text  +:=  str(item) ]
        def addInt ( elt, item ):
            self.__typeMap[str](elt, str(item))
        self.__typeMap[int]  =  addInt
```

The next type we need to handle is `dict`. Each key-value pair from the dictionary becomes an XML attribute. For user convenience, if the value is not a string, we'll use the `str()` function on it, allowing constructs like "`E({border: 1})`".

etbuilder.py

```
        #-- 4 --
        # [ self.__typeMap[dict]  :=  a function with calling
        #       sequence
        #         addDict(elt, item)
        #       and intended function
        #         [ (elt is an et.Element) and
        #           (item is a dictionary) ->
        #             elt  :=  elt with an attribute made from
```

```
        #                      each key-value pair from item ]
        def addDict ( elt, item ):
            for key, value in item.items():
                if isinstance(value, basestring):
                    elt.attrib[key]  =  value
                else:
                    elt.attrib[key]  =  str(value)
        self.__typeMap[dict]  =  addDict
```

> **Note**
>
> In Lundh's original, the last line of the previous block was the equivalent of this:
>
> ```
>                     elt.attrib[key]  =  \
>                          self.__typeMap[type(value)](None, value)
> ```
>
> I'm not entirely sure what he had in mind here. If you have any good theories, please forward them to `<tcc-doc@nmt.edu>`.

Next up is the handler for arguments that are instances of `et.Element`. We'll actually create an `et.Element` to be sure that `self.__typeMap` uses the correct key.

etbuilder.py

```
        #-- 5 --
        # [ self.__typeMap[type(et.Element instances)]  :=  a
        #       function with calling sequence
        #         addElt(elt, item)
        #       and intended function
        #         [ (elt and item are et.Element instances) ->
        #             elt  :=  elt with item added as its next
        #                      child element ]
        def addElement ( elt, item ):
            elt.append ( item )
        sample  =  et.Element ( 'sample' )
        self.__typeMap[type(sample)]  =  addElement
```

12.8. `ElementMaker.__call__()`: Handle calls to the factory instance

This method is called when the user calls the factory instance `E`.

etbuilder.py

```
# - - -   E l e m e n t M a k e r . _ _ c a l l _ _

    def __call__ ( self, tag, *argList, **attr):
        '''Handle calls to a factory instance.
        '''
```

First we create a new, empty element with the given tag name.

etbuilder.py

```
        #-- 1 --
        # [ elt  :=  a new et.Element with name (tag) ]
        elt  =  et.Element ( tag )
```

If the attr dictionary has anything in it, we can use the function stored in self.__typeMap[dict] to process those attributes.

etbuilder.py

```
        #-- 2 --
        # [ elt  :=  elt with attributes made from the key-value
        #            pairs in attr ]
        #   else -> I ]
        if attr:
            self.__typeMap[dict](elt, attr)
```

Next, process the positional arguments in a loop, using each argument's type to extract from self.__typeMap the proper handler for that type. For this logic, see Section 12.9, “ElementMaker.__handleArg(): Process one positional argument” (p. 37).

etbuilder.py

```
        #-- 3 --
        # [ if the types of all the members of pos are also
        #   keys in self.__typeMap ->
        #       elt  :=  elt modified as per the corresponding
        #                functions from self.__typeMap
        #   else -> raise TypeError ]
        for arg in argList:
            #-- 3 body --
            # [ if type(arg) is a key in self.__typeMap ->
            #     elt  :=  elt modified as per self.__typeMap[type(arg)]
            #   else -> raise TypeError ]
            self.__handleArg ( elt, arg )
```

Finally, return the shiny new element to the caller.

etbuilder.py

```
        #-- 4 --
        return elt
```

12.9. ElementMaker.__handleArg(): Process one positional argument

This method processes one of the positional arguments when the factory instance is called.

etbuilder.py

```
# - - -   E l e m e n t M a k e r . _ _ h a n d l e A r g

    def __handleArg ( self, elt, arg ):
        '''Process one positional argument to the factory instance.

          [ (elt is an et.Element) ->
              if type(arg) is a key in self.__typeMap ->
                elt  :=  elt modified as per self.__typeMap[type(arg)]
              else -> raise TypeError ]
        '''
```

As a convenience, if the caller passes some callable object, we'll call that object and use its result. Otherwise we'll use the object itself. (This is another Lundh feature, the utility of which I don't fully understand.)

etbuilder.py

```
        #-- 1 --
        # [ if arg is callable ->
        #     value  :=  arg()
        #   else ->
        #     value  :=  arg ]
        if callable(arg):
            value  =  arg()
        else:
            value  =  arg
```

Next we look up the value's type in `self.__typeMap`, and call the corresponding function.

etbuilder.py

```
        #-- 2 --
        # [ if type(value) is a key in self.__typeMap ->
        #     elt  :=  elt modified as per self.__typeMap[type(value)]
        #   else -> raise TypeError ]
        try:
            handler  =  self.__typeMap[type(value)]
            handler(elt, value)
        except KeyError:
            raise TypeError ( "Invalid argument type: %r" % value )
```

12.10. `ElementMaker.__getattr__()`: Handle arbitrary method calls

This method is called whenever the caller invokes an undefined method of a factory instance. It implements the feature that you can use an element name as a method name so that "`E.`*`tag`*`(...)`" is the equivalent of "`E(`*`tag`*`, ...)`".

The method is a one-liner, but it's a rather abstruse one-liner for anyone that has never studied functional programming. See the `functools.partial` documentation[17]. The method returns a callable object that acts the same as a call to the factory instance, except with `tag` inserted before its other positional arguments.

The Wikipedia article on currying[18] explains this technique in depth.

etbuilder.py

```
# - - -   E l e m e n t M a k e r . _ _ g e t a t t r _ _

    def __getattr__ ( self, tag ):
        '''Handle arbitrary method calls.

          [ tag is a string ->
              return a new et.Element instance whose name
              is (tag), and elements of p and kw have
              the same effects as E(*(p[1:]), **kw) ]
        '''
        return partial ( self, tag )
```

[17] http://docs.python.org/library/functools.html
[18] http://en.wikipedia.org/wiki/Currying

12.11. Epilogue

The last step is to create the factory instance E.

etbuilder.py

```
# - - - - -   m a i n

E  =  ElementMaker()
```

12.12. testetbuilder: A test driver for etbuilder

Here is a small script that exercises the etbuilder module.

This script generates a small XHTML page that looks like this:

```
<html>
  <head>
    <title>Sample page<title>
    <link href="/tcc/style.css" rel="stylesheet"/>
  </head>
  <body>
    <h1 class='big-title'>Sample page title</h1>
    <p>A paragraph containing a <a href='http://www.nmt.edu/'
    >link to the NMT homepage</a>.</p>
  </body>
</html>
```

The script follows.

testetbuilder

```
#!/usr/bin/env python
from etbuilder import E, et, CLASS

page = E.html(
    E.head(
      E.title("Sample page"),
      E.link(href='/tcc/style.css', rel='stylesheet')),
    E.body(
      E.h1(CLASS('big-title'), "Sample page title"),
      E.p("A paragraph containing ", 1, " ",
        E.a("link to the NMT homepage",
            href='http://www.nmt.edu/'),
        ".")))
print et.tostring(page, pretty_print=True)
```

13. rnc_validate: A module to validate XML against a Relax NG schema

Here we present a Python module to validate XML files against a Relax NG schema using the techniques described in Section 10, “Automated validation of input files” (p. 26).

13.1. Design of the `rnc_validate` module

This module will work from a schema file in either Relax NG Compact Form (`.rnc`) or XML syntax (`.rng`).

However, because `lxml`'s validation machinery cannot read `.rnc` files directly, our module must take its input from an `.rng` file.

If the schema file name ends in `.rnc`, we make these assumptions:

- If there is an `.rng` file with the same basename as the `.rnc`, and provided that it is up-to-date (with a newer file modification timestamp), we will use the `.rng` version.
- If there is no corresponding `.rng` version, or if the `.rng` file is out of date, we assume that the *trang*[19] utility is locally installed. This utility can translate from `.rnc` to `.rng` format.

  We also assume that we have write access so that we can create or recreate the `.rng` file.

13.2. Interface to the `rnc_validate` module

Our module `rnc_validate.py` exports this interface.

`RelaxException`
: An exception class that inherits from Python's standard Exception class. This exception will be raised when an XML file is found not to be valid against the given Relax NG schema. The `str()` function, applied to an instance of this exception, returns a textual description of the validity error.

`RelaxValidator(`*`schemaPath`*`)`
: This class constructor takes one argument, a path name to a schema in either `.rnc` or `.rng` format. Assuming that the situation meets all the assumptions enumerated in Section 13.1, "Design of the `rnc_validate` module" (p. 40), it returns a new `RelaxValidator` instance that can be used to validate XML files against that schema.

  If anything goes wrong, the constructor raises a `ValueError` exception. This can happen for several reasons, for example: failure to read the schema; failure to write the `.rng` file if translating from `.rnc` format; if the `.rng` file is not well-formed or not a valid Relax NG schema.

***`RV`*`.validate(`*`tree`*`)`**
: For a `RelaxValidator` instance *`RV`*, this method takes as its argument an `ElementTree` instance containing an XML document. If that document is valid against the schema, this method returns `None`. If there is a validation problem, it raises `RelaxException`.

13.3. `rnc_validate.py`: Prologue

The actual code for this module starts here, with the customary documentation string, which points back to this documentation. The block also contains Cleanroom[20] intended function notation for the interface described above.

rnc_validate.py

```
'''rnc_validate.py: An XML validator for Relax NG schemas.
  For documentation, see:
    http://www.nmt.edu/tcc/help/pubs/pylxml/

  Exports:
```

[19] http://www.thaiopensource.com/relaxng/trang.html
[20] http://www.nmt.edu/~shipman/soft/clean/

```
    class RelaxException(Exception)
    class RelaxValidator
      RelaxValidator(schemaPath):
        [ schemaPath is a string ->
            if schemaPath names a readable, valid .rng schema ->
              return a RelaxValidator that validates against that schema
            else if (schemaPath, with .rnc appended if there is no
            extension, names a readable, valid .rnc schema) ->
              if the corresponding .rng schema is readable, valid, and
              newer than the .rnc schema ->
                return a RelaxValidator that validates against the
                .rng schema
              else if (we have write access to the corresponding .rng
              schema) and (trang is locally installed) ->
                corresponding .rng schema  :=  trang's translation of
                    the .rnc schema into .rng
                return a RelaxValidator that validates against the
                translated schema
              else -> raise ValueError ]
      .validate(tree):
        [ tree is an etree.ElementTree ->
            if tree validates against self -> I
            else -> raise RelaxException ]
'''
```

Next come module imports. We need the standard Python `os` and `stat` modules to check file modification times.

rnc_validate.py

```
# - - - - -   I m p o r t s

import os
import stat
```

We import the `lxml` module's `etree` implementation but call it `et`.

rnc_validate.py

```
from lxml import etree as et
```

The `pexpect`[21] module is a third-party library for spawning and controlling subprocesses. We need it to run *trang*.

rnc_validate.py

```
import pexpect
```

We'll need two constants for the characteristic file suffixes.

rnc_validate.py

```

# - - - - -   M a n i f e s t   c o n s t a n t s

RNC_SUFFIX = '.rnc'
RNG_SUFFIX = '.rng'
```

[21] http://www.noah.org/wiki/Pexpect

13.4. RelaxException

This pro-forma exception is used to signal validity problem.

rnc_validate.py

```
# - - - - -   c l a s s   R e l a x E x c e p t i o n

class RelaxException(Exception):
    pass
```

13.5. class RelaxValidator

Within an instance of this class, we keep one internal state item, the `RelaxNG` instance representing the `.rng` schema.

rnc_validate.py

```
# - - - - -   c l a s s   R e l a x V a l i d a t o r

class RelaxValidator(object):
    '''Represents an XML validator for a given Relax NG schema.

      State/Invariants:
        .__schema:
          [ an etree.RelaxNG instance representing the effective schema ]
    '''
```

13.6. RelaxValidator.validate()

This method passes the `ElementTree` to the `.validate()` method of the stored `RelaxNG` instance, which returns a `bool` value, `True` iff the tree is valid. We translate a `False` return value to an exception.

rnc_validate.py

```
# - - -   R e l a x V a l i d a t o r . v a l i d a t e

    def validate(self, tree):
        '''Validate tree against self.
        '''
        if not self.__schema.validate ( tree ):
            raise RelaxException(self.__schema.error_log)
```

13.7. RelaxValidator.__init__(): Constructor

The first step is to remove the file suffix so we know which kind of schema we're using, and then derive the full path names of both the `.rnc` and `.rng` (potential) versions of the schema.

rnc_validate.py

```
# - - -   R e l a x V a l i d a t o r . _ _ i n i t _ _

    def __init__ ( self, schemaPath ):
        '''Constructor.
        '''
```

```
        #-- 1 --
        # [ basePath  :=  schemaPath without its extension
        #   suffix  :=  schemaPath's extension, defaulting to RNC_SUFFIX
        #   cName  :=  (schemaPath without its extension)+RNC_SUFFIX
        #   gName  :=  (schemaPath without its extension)+RNG_SUFFIX ]
        basePath, suffix = os.path.splitext(schemaPath)
        if suffix == '':
            suffix = RNC_SUFFIX
        gName = basePath + RNG_SUFFIX
        cName = basePath + RNC_SUFFIX
```

If the desired schema is in `.rng` form, we're ready to proceed. If it is an `.rnc` schema, though, we need an `.rng` version that is up to date. See Section 13.8, “`RelaxValidator.__makeRNG()`: Find or create an `.rng` file” (p. 44). If the file suffix isn't either, that's an error.

rnc_validate.py

```
        #-- 2 --
        # [ if suffix == RNG_SUFFIX ->
        #     I
        #   else if (file cName is readable) and (gName names a
        #   readable file that is newer than cName) ->
        #     I
        #   else if (cName names a readable, valid RNC file) and
        #   (we have write access to path gName) and
        #   (trang is locally installed) ->
        #     file gName  :=  trang's translation of file cName into RNG
        #   else -> raise ValueError ]
        if suffix == RNC_SUFFIX:
            self.__makeRNG ( cName, gName )
        elif suffix != RNG_SUFFIX:
            raise ValueError("File suffix not %s or %s: %s" %
                (RNC_SUFFIX, RNG_SUFFIX, suffix) )
```

At this point we have a known good `.rng` version of the schema. Read that, make it into a `RelaxNG` instance (assuming it is valid Relax NG), and store it in `self.__schema`.

rnc_validate.py

```
        #-- 3 --
        # if gName names a readable, valid XML file ->
        #   doc  :=  an et.ElementTree representing that file
        # else -> raise ValueError ]
        try:
            doc = et.parse ( gName )
        except IOError, details:
            raise ValueError("Can't open the schema file '%s': %s" %
                (gName, str(details)) )

        #-- 4 --
        # [ if doc is a valid RNG schema ->
        #     self.__schema  :=  an et.RelaxNG instance that represents
        #                        doc
        #   else -> raise ValueError ]
        try:
            self.__schema = et.RelaxNG ( doc )
        except et.RelaxNGParseError, details:
```

```
            raise ValueError("Schema file '%s' is not valid: %s" %
                (gName, str(details)) )
```

13.8. `RelaxValidator.__makeRNG()`: Find or create an `.rng` file

rnc_validate.py

```
# - - -   R e l a x V a l i d a t o r . _ _ m a k e R N G

    def __makeRNG ( self, cName, gName ):
        '''Insure that a current RNG file exists.

          [ (cName names an RNC file) and (gName names an RNG file) ->
              if (file cName is readable) and (gName names a
              readable file that is newer than cName) ->
                I
              else if (cName names a readable, valid RNC file) and
              (we have write access to path gName) and
              (trang is locally installed) ->
                file gName  :=  trang's translation of file cName into RNG

              else -> raise ValueError ]
        '''
```

First we get the modification time of the `.rnc` file. See Section 13.9, "`RelaxValidator.__getModTime()`: When was this file last changed?" (p. 45). If anything goes wrong, we raise a `ValueError`.

rnc_validate.py

```
        #-- 1 --
        # [ if we can stat file (cName) ->
        #     cTime  :=  epoch modification timestamp of that file
        #   else -> raise ValueError ]
        try:
            cTime = self.__getModTime ( cName )
        except (IOError, OSError), details:
            raise ValueError("Can't read the RNC file '%s': %s" %
                (cName, str(details)) )
```

Then we try to get the modification time of the `.rng` file. If that file exists and the modification time is newer, we're done, because the `.rng` is up to date against the requested `.rnc` schema. If either the file doesn't exist or it's out of date, fall through to the next step.

rnc_validate.py

```
        #-- 2 --
        # [ if (we can stat file (gName)) and
        #   (that file's modification time is more recent than cTime) ->
        #     return
        #   else -> I ]
        try:
            gTime = self.__getModTime ( gName )
            if gTime > cTime:
                return
        except (IOError, OSError):
            pass
```

Now, try to recreate the `.rng` file by running the `.rnc` file through *trang*. See Section 13.10, "`RelaxValidator.__trang()`: Translate `.rnc` to `.rng` format" (p. 45).

rnc_validate.py

```
        #-- 3 --
        # [ if (file (cName) is a valid RNC file) and
        #   (we have write access to path gName) and
        #   (trang is locally installed) ->
        #     file (gName)  :=  an RNG representation of file (cName)
        #   else -> raise ValueError ]
        self.__trang(cName, gName)
```

13.9. `RelaxValidator.__getModTime()`: When was this file last changed?

The returned value is an epoch time, the number of seconds since January 0, 1970.

rnc_validate.py

```
# - - -   R e l a x V a l i d a t o r . _ _ g e t M o d T i m e

    def __getModTime ( self, fileName ):
        '''Try to retrieve a file's modification timestamp.

          [ fileName is a string ->
              if fileName does not exist ->
                raise OSError
              if we can stat fileName ->
                return that file's modification epoch time
              else -> raise IOError ]
        '''
        return os.stat(fileName)[stat.ST_MTIME]
```

13.10. `RelaxValidator.__trang()`: Translate `.rnc` to `.rng` format

We use the `pexpect` module's `run()` function to execute the *trang* script with command line arguments of this form:

```
trang F.rnc F.rng
```

That function returns the entire output of the run as a string. The output from *trang* is empty if the translation succeeded; otherwise it contains the error message.

rnc_validate.py

```
# - - -   R e l a x V a l i d a t o r . _ _ t r a n g

    def __trang(self, cName, gName):
        '''Translate an RNC schema to RNG format.

          [ if (file (cName) is a valid RNC file) and
            (we have write access to path gName) and
            (trang is locally installed) ->
              file (gName)  :=  an RNG representation of file (cName)
            else -> raise ValueError ]
        '''
```

rnc_validate.py

```
        #-- 1 --
        # [ output  :=  all output from the execution of the command
        #               "trang (cName) (gName)" ]
        output = pexpect.run ( "trang %s %s" % (cName, gName) )

        #-- 2 --
        if len(output) > 0:
            raise ValueError ( "Could not create '%s' from '%s':/n%s" %
                (gName, cName, output) )
```

14. *rnck*: A standalone script to validate XML against a Relax NG schema

Here we present a script that uses the `rnc_validate` module to validate one or more XML files against a given Relax NG schema.

Command line arguments take this form:

```
rnck schema file ...
```

schema
: Names a Relax NG schema as either an `.rnc` file or an `.rng` file.

file
: Names of one or more XML files to be validated against *`schema`*.

14.1. *rnck*: Prologue

Here begins the actual *rnck* script in literate form[22]. First is the usual “pound-bang line” to make the script self-executing under Unix-based systems, followed by an opening comment pointing back at this documentation.

rnck

```
#!/usr/bin/env python
#================================================================
# rnck:  Validate XML files against an RNC schema.
#   For documentation, see:
#     http://www.nmt.edu/tcc/help/pubs/pylxml/
#----------------------------------------------------------------
```

Next come module imports. We need the standard Python `sys` module for standard I/O streams and command line arguments.

rnck

```

# - - - - -   I m p o r t s

import sys
```

We'll need the `lxml.etree` module to read the XML files, but we'll call it `et` for short.

[22] http://www.nmt.edu/~shipman/soft/litprog/

rnck

```
import lxml.etree as et
```

Finally, import the `rnc_validate` module described in Section 13, "`rnc_validate`: A module to validate XML against a Relax NG schema" (p. 39).

rnck

```
import rnc_validate
```

14.2. *rnck*: `main()`

rnck

```
# - - - - -   m a i n

def main():
    """Validate one or more files against an RNC schema.

      [ if (command line arguments are valid) ->
          if (.rnc and .rng are readable, valid, and up to date) and
          (all FILE arguments are valid against that .rng) ->
            I
          else (if .rnc is readable and valid and .rng can be updated
          from the .rnc) and
          (all FILE arguments are valid against that .rng) ->
            the .rng file  :=  an RNG version of the .rnc
          else ->
            sys.stderr  +:=  error message
        else ->
            sys.stderr  +:=  error message ]
    """
```

Processing of the arguments is handled in Section 14.3, "*rnck*: `checkArgs()`" (p. 48). We get back two items: the path to the schema, and a list of XML file names to be validated.

rnck

```
    #-- 1 --
    # [ if sys.argv is a valid command line ->
    #     schemaPath  :=  the SCHEMA argument
    #     fileList  :=  list of FILE arguments
    #   else ->
    #     sys.stderr  +:=  error message
    #     stop execution ]
    schemaPath, fileList = checkArgs()
```

Next we try to build a `RelaxValidator` instance from the specified schema.

rnck

```
    #-- 2 --
    # [ if schemaPath names a readable, valid .rng schema ->
    #       return a RelaxValidator that validates against that schema
    #   else if (schemaPath, with .rnc appended if there is no
    #   extension, names a readable, valid .rnc schema) ->
    #     if the corresponding .rng schema is readable, valid, and
    #     newer than the .rnc
    #       return a RelaxValidator that validates against the
```

```
    #       .rng schema
    #     else if (we have write access to the corresponding .rng
    #     schema) and (trang is locally installed) ->
    #       corresponding .rng schema  :=  trang's translation of
    #           the .rnc schema into .rng
    #       return a RelaxValidator that validates against
    #       translated schema
    #      else ->
    #       sys.stderr  +:=  error message
    #       stop execution ]
    validator = rnc_validate.RelaxValidator ( schemaPath )
```

For the logic that validates one XML file against our `validator`, see Section 14.7, "*rnck*: `validateFile()`" (p. 50).

rnck

```
    #-- 3 --
    # [ sys.stderr  +:=  messages about any files from (fileList) that
    #       are unreadable or not valid against (validator) ]
    for fileName in fileList:
        validateFile ( validator, fileName )
```

14.3. *rnck*: `checkArgs()`

Argument processing is pretty basic. There must be at least two positional arguments; the first is the schema path, the rest are files to be checked.

rnck

```
# - - -   c h e c k A r g s

def checkArgs():
    '''Check the command line arguments.

      [ if sys.argv is a valid command line ->
          return (the SCHEMA argument, a list of the FILE arguments)
        else ->
          sys.stderr  +:=  error message
          stop execution ]
    '''
    #-- 1 --
    argList = sys.argv[1:]
```

For the usage message, see Section 14.4, "*rnck*: `usage()`" (p. 49).

rnck

```
    #-- 2 --
    if len(argList) < 2:
        usage ( "You must supply at least two arguments." )
    else:
        schemaPath, fileList = argList[0], argList[1:]

    #-- 3 --
    return (schemaPath, fileList)
```

14.4. *rnck*: `usage()`

See Section 14.5, "*rnck*: `fatal()`" (p. 49).

rnck

```
# - - -   u s a g e

def usage ( *L ) :
    '''Write an error message and terminate.

      [ L is a list of strings ->
          sys.stderr  +:=  (concatenation of elements of L)
          stop execution ]
    '''
    fatal ( "*** Usage:\n"
            "***   %s SCHEMA FILE ...\n"
            "*** %s" %
            (sys.argv[0], ''.join(L)) )
    raise SystemExit
```

14.5. *rnck*: `fatal()`

Deliver the death poem, then commit seppuku. See also Section 14.6, "*rnck*: `message()`" (p. 49).

rnck

```
# - - -   f a t a l

def fatal(*L):
    '''Write an error message and terminate.

      [ L is a list of strings ->
          sys.stderr  +:=  concatenation of elements of L
          stop execution ]
    '''
    message(*L)
    raise SystemExit
```

14.6. *rnck*: `message()`

rnck

```
# - - -   m e s s a g e

def message(*L):
    '''Write an error message to stderr.

      [ L is a list of strings ->
          sys.stderr  +:=  concatenation of elements of L
    '''
    print >>sys.stderr, ''.join(L)
```

14.7. *rnck*: `validateFile()`

rnck

```
# - - -   v a l i d a t e F i l e

def validateFile ( validator, fileName ):
    '''Validate one file against the schema.

      [ validator is an rnc_validate.RelaxValidator instance ->
          if fileName is readable and valid against validator ->
            I
          else ->
            sys.stderr  +:=  error message ]
    '''
    #-- 1 --
    # [ if fileName names a readable, well-formed XML file ->
    #     doc  :=  an et.ElementTree instance representing that file
    #   else ->
    #     sys.stderr  +:=  error message
    #     return ]
    try:
        doc = et.parse ( fileName )
    except et.XMLSyntaxError, details:
        message ( "*** File '%s' not well-formed: %s" %
                 (fileName, str(details)) )
        return
    except IOError, details:
        message ( "*** Can't read file '%s': %s" %
                  (fileName, str(details)) )
        return

    #-- 2 --
    # [ if doc is valid against validator ->
    #     I
    #   else ->
    #     sys.stdout  +:=  failure report ]
    try:
        validator.validate ( doc )
    except rnc_validate.RelaxException, details:
        message ( "*** File '%s' is not valid:\n%s" %
                  (fileName, details) )
```

14.8. *rnck*: Epilogue

rnck

```
# - - - - -   E p i l o g u e

if __name__ == "__main__":
    main()
```